FIRE PROTECTION.

A Complete Manual

OF THE

ORGANIZATION, MACHINERY, DISCIPLINE,

AND GENERAL WORKING,

OF THE

FIRE BRIGADE OF LONDON.

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INTRODUCTION.

FROM the remotest periods of antiquity to the present time, the business of extinguishing fires has attracted a certain amount of attention; but it is a most curious fact that, even now, there is so little method in it, that it is a very rare circumstance to find any two countries, or even any two cities in one country, adopting the same means, or calling their appliances by the same names. This defect may, no doubt, be in the main attributable to the excitement which so commonly prevails during fires; but in such a city as London, where excitement of this kind is not permitted in the brigade, it appears to me to be only fair to claim credit for a complete system of management, with organization, discipline, knowledge, and whatever else may be essential to that end. Other cities may, no doubt, make similar claims, and when they have done so, and proved them, we shall have great pleasure in acknowledging them, and giving them the necessary credit; but if they do so at present, or even within a limited time, it will be seen that, with very few exceptions, no two are alike, and that where there is a similarity, it will be found to arise from the fact that the men in charge have been either wholly or partially brought up in the same school, and consequently subjected to the same training and instruction.

The system of management adopted in London comprises not only a thorough organization on what are supposed to be sound principles, but also a system of working, which involves, on the part of all concerned, a complete practical and theoretical knowledge of every necessary detail; and the object of this Work is to present to its readers a comprehensive account of the points referred to, in the form of a series of chapters on the several subjects named in the List of Contents.

I do not for a moment attempt to disguise the fact, that my principal motive in writing the following pages was to provide a manual for the use of professional firemen; but, while fully acknowledging this, I desire at the same time to claim for the Work that it is the only one yet written, in this or any other language, which gives private persons a full and exhaustive description of all the appliances in use for extinguishing fires and saving lives, and that it is therefore peculiarly suited for the use of docks, wharves, warehouses, and other places in which large quantities of merchandize are deposited, as well as private houses, ships, theatres, and places of entertainment; in short, for all places in which life and property are at stake. It will, moreover, be useful to hospitals, work-houses, gaols, asylums, garrisons, police forces, and all bodies charged with the protection of goods, stores, or persons—perhaps also to others; but I have mentioned here only those who most frequently apply to me for information.

Such are the merits which I claim for this Work; they may not be great—indeed, I do not myself rate them very highly; but they are at least so far genuine of their kind, that they have not been practically aimed at until now; on the contrary, every semblance of an attempt in that direction, at least in this country, has proved to be nothing more or less than an indirect and scarcely-disguised advertisement of something to be sold, and has consequently turned out to be of little use for practical purposes.

And now, before proceeding further, I wish to make a few explanatory remarks.

Those whose lot has fallen in the pleasant places of an established profession—such as the army or the navy, in which the duties and relative positions of all ranks and individuals are clearly defined and thoroughly known—however great and varied their experience has been, may, nevertheless, know but little of the weary struggles, and unceasing toil and anxiety, of those who undertake to form a new profession. To collect small and scattered particles of information previously existing; to apply true first principles to these, and separate them into their two great divisions of useful and useless; to set aside the latter, with all empirical, corrupt, and unmeaning terms; to lay down a code of fixed principles; to establish a nomenclature; and, working from this small but sound foundation, to build up the fabric of a whole profession, and fill in all details, so that nothing shall be forgotten, nothing unforeseen, nothing unprovided for; this is a labour which falls to the lot of few men, and which ought to constitute a claim to forbearance and favourable consideration on the part of others, even when the object is indifferently or imperfectly accomplished.

Then, in a new profession, all measures are necessarily in some degree tentative. It is only the superficial and half-educated who, in such cases, announce everything in detail beforehand, and thus find themselves, for years afterwards, working in a false position, endeavouring, contrary to experience and their improved information, to justify announcements made by them while labouring under that most unsatisfactory, but perhaps most common, form of ignorance, which consists of practical knowledge, absolutely alone, without the aid of theory, and which is consequently to a great extent antagonistic to all useful development.

To those who have not studied the principles of true and useful progress, this statement may seem a paradox, but it really is nothing of the kind. Theoretical knowledge is essentially progressive; it suggests new modes of doing everything; and, even where absolutely new modes are proved to be impracticable, it suggests modifications and alterations of existing modes, and devises schemes for meeting every possible objection which can be urged. Practical knowledge alone, unaided by theory, is, on the contrary, from its very nature, obstructive to the last degree; it makes objections to everything not actually proved to demonstration, and, in short, considers nothing possible that has not been already accomplished. Then there are the innumerable imperfect combinations of theory and practice, which, as long as they remain imperfect, produce perhaps the worst consequences of all.

How often do we see a man, eminently practical in all respects, and whose opinion on any practical matter connected with his ordinary business is worthy of the highest consideration, suddenly seized with an idea, which, being unaided by education, develops itself into a theory of the wildest kind, involving those who follow it in utter ruin—and all because the supposed theory turns out to be no true theory at all, and nothing better than the excrescence of an uneducated or eccentric intellect. And again, how often do we see theory alone, however sound in itself, utterly prostrate and rendered worthless, through flying too wildly, for want of the obstructive and steadying power of practice.

The following pages contain an account of the system which I have adopted, to produce the required combination of theory and practice; and it is only fair to all concerned to claim, that a very large proportion of the members of this brigade have attained so advanced a position in their profession, as to be able to work all appliances entrusted to them to the best advantage, to improve their appliances according to such financial and other latitude as may be allowed them, and to detect instantly fallacies in theories, or defects in finished work submitted to them.

These qualifications have been largely recognized of late years in the honourable positions offered to our firemen elsewhere; and I have no doubt that, wherever our trained men are employed, they will be found, if not interfered with to too great an extent, able to do the work entrusted to them with as much efficiency as the means at their disposal permit, and at the same time with as much economy as is consistent with real efficiency.

It is probable that there never was a period in the history of the world when superficial knowledge was so rampant and aggressive as at the present hour. Persons with a mere power of articulation, and no other qualification whatever, do not hesitate to impeach, in the strongest and most unequivocal language, the acts of thoughtful, honourable, learned, and devoted men, who have spent their whole lives in the study of their professions, and have brought the experience of years to bear on the very matter denounced. In the church, in law, in politics, in war, in engineering, in chymistry, in every branch of every business, however abstruse and little known to the world at large, the same thing is found. No difficult question is so difficult, no abstruse point so abstruse, no speciality so special, but that thousands, wholly unacquainted with the principles, the practice, or even the expressions and terms in use, and simply gifted with the unwise self-confidence of superficial knowledge, will be found ready to rush in and offer to teach the oldest and most experienced professionals what they should have done or ought to do.

I do not say that this should not be so. In our day we all acknowledge the value of free thought and free speech, and, to a great extent, the importance of public men so conducting their business that their acts may safely be reviewed by the unwise as well as by the wise; but any man whose unhappy fate it has been to toil for years in turning true principles into sound practice, under the strong and never-ceasing light of public observation, is justified in claiming some consideration for mistakes or short-comings, and more especially for the delay of an outgrowth fostered under such desolating influences. A plant would hardly be expected to flourish, if it were pulled up every morning to see whether its roots were sprouting.

If all professions, old and new, high and humble, make the same complaint, it may perhaps be thought that no reason exists for urging it in any special case; but there is the question of degree which may be pleaded, and I do not hesitate to say that, if half the world believe that they know all about the church, the bar, the army, the navy, and the other old professions, nine-tenths of the world think they understand all about fires, and are prepared to offer their advice in season and out of season on the subject.

The evil worked in the business of extinguishing fires by this baneful influence has been in almost all cases great, in some altogether overwhelming; and the result is that, in many important cities which could be named, the system of protection from fire is but little more than the merest semblance of what it ought to be; and the inhabitants suffer accordingly, either by the constant presence of danger, or the almost as serious calamity of a constant payment of high rates of insurance.

The remedy for this evil is to employ a trained, skilled, and well-disciplined force, and to follow the advice of the responsible officers in matters of arrangement and detail, subject, of course, to such limits of expenditure as may be laid down for the guidance of all concerned.

A safe principle would be, for the inhabitants of a town to consider—first, what amount of insurance would cover their losses if they had no protection at all; secondly, what amount of protection would afford them almost complete security from loss; and then, working from these two points, to decide for themselves how much they would be inclined to spend directly on defensive measures, and how much indirectly on the payment of losses. There is no greater or more common delusion than to suppose that the intervention of an insurance company has any thing to do with this matter. Every town has certain risks, and, when losses occur, they are paid for by the town itself, either directly or through an insurance company drawing its premiums from the town. The business of insurance companies is simply to receive premiums and pay losses, and, of course, they assess the former so as to cover the latter, and leave a margin for profit. Many persons insure, and it is most proper and praiseworthy that they should do so, as they may not have capital to repair such losses as they are liable to; but this does not in any way affect the principle here laid down, that each community has, in some way or other, to pay for its own losses, and should therefore take the necessary precautions for its own interests, which brings us back to the point from which we started—namely, the advantage of employing skilled professional persons to advise as to the several apportionments of direct and indirect payments, and to work and be responsible for all matters connected with the system of protection.

These were the first points which forcibly struck me in connection with the subject of reducing losses by fire; and their importance led me on imperceptibly, until eventually I found myself engaged in the business as a speciality.

My connection with the business is told in a few words, and may be instructive.

Happening, some sixteen years ago, to be engaged in re-organizing the municipal forces of a large commercial city, I was entrusted, among other duties, with the charge of the fire brigade, which was not at that time in a satisfactory condition; and I immediately set to work to ascertain what knowledge existed on the subject, but merely for the purpose of showing others what to do, and without any intention at the time of devoting myself permanently to the business. To my great surprise, I found that there was no published information to be obtained; and I accordingly proceeded to some of the principal cities in which I thought I might have the advantage of learning something by personal observation; but I was sorely disappointed, and returned to the scene of my duties altogether disheartened at my failure. I had found in most places some practical knowledge existing, but not what appeared to me sufficient method for a work in itself of so much importance, and always requiring to be transacted rapidly and without mistakes; and there seemed to be nowhere the theoretical knowledge, without which no business or profession can keep pace with the growing requirements of our time.

I first studied the practical details of the appliances used in extinguishing fires, and with this very small stock of special information, and such mechanical and scientific knowledge as remained to me from a university career, I entered on the duties. At first a habitude of dealing with men, and a knowledge of the principles and practice of organization, coming after a management deficient in these particulars, brought some credit, and when, in difficult or important cases, a success occurred, there was the usual kind and quantity of commendation which a public servant doing his best is pretty sure always to receive. Many and great were the congratulations, and very highly they were prized; but after the lapse of so many years I may now frankly acknowledge that some of the most painful humiliations of my life were undergone at that very period. I could not but accept expressions of kindness as they were offered, yet I felt they were but half deserved. None knew as I did how very nearly the great successes had been great disasters. Even as I write these lines, I can recall distinctly to my recollection cases in which I had all but sacrificed the whole of my little band in the attempt to do what was almost impossible, and only corrected the error at the exact critical moment when further delay would have made it irrevocable. Then would follow the explanations in the form of a lecture—for even in those early days I had adopted this mode of conveying instruction—and, during the lecture, a recapitulation of the orders given and the reasons for them, particularly those which either seemed contradictory or were actually so; for, in practical work of this kind, it is often necessary to change the orders very suddenly; and by degrees there would creep out from me some kind of acknowledgment that such and such a move had been a mistake, as it involved a great risk for a small gain, but that at the moment it seemed to be the proper course, and so forth; and then would come from the auditors the condonation—not perhaps in words, as that might have interfered with discipline, but yet clearly, distinctly, and unmistakeably expressed—in short, a direct encouragement to do the same again. Such are the ways of men; the desire for success is always present, and, if properly encouraged, becomes paramount; and it appears to me that there is no order which they will not obey with alacrity, if given steadily by a superior *present with them.*

When we read of men showing the white feather in the hour of peril, we should be very careful how we judge them. I can only say, that any instances which have ever come under my personal notice in this way, in the various cities and countries which I have visited, have been invariably traceable to want of discipline, want of knowledge, absence of organization, indistinctness of orders, or some other fault, not of the men themselves, but of those in charge of them.

Men seldom desert a superior who thoroughly knows his business, whatever it may be, and who is steady; but, if they find themselves, as we know they do in many places, working under a man without these qualifications, and are consequently driven to take care of themselves, who shall blame them?

If there had been any sound practical treatise in print on the subject of extinguishing fires, or if I had anywhere found such a combination of theoretical and practical knowledge as the work appeared to me to demand, I should simply have followed in the beaten track, and have been most thankful to be relieved from a great addition to labours which, in other directions, were sufficient to tax all the energies of a man. As such, however, was not the case, I found myself compelled to enter on a complete study of everything connected with the business, and, aided only by a sound mechanical and scientific education, I succeeded at an early stage in rejecting all useless, unmeaning, and erroneous terms—a most important work, and one absolutely necessary to eventual success, inasmuch as there existed an amount of what may be called empirical slang, sufficient to obscure, if not altogether to stifle, every principle of sound progress.

Those days have long since passed away, and it might be thought that any mention of them at present is unnecessary, if it were not explained that, in many other countries and in many cities of this country, most of the terms still in use are no better than what I have ventured to call empirical slang, and that, in my judgment, wherever an unsound nomenclature prevails, it is little less than impossible to instil sound principles, which are the only true foundation for sound practice.

After the rejection of corrupt and misleading terms and expressions, the work became comparatively simple; proper terms and expressions were easily introduced; circumstances happened to give large opportunity for practical working; then came the adoption of method and order; after that, a systematic course of instruction, and eventually an improved efficiency of all concerned. All this, happening in the midst of local disturbances, and the transaction of the general business of a large commercial city, naturally occupied a considerable time; but no part of the work was omitted or hurried over, and the result was that I became identified with the institution, and eventually abandoned my general business, and adopted the profession of a fireman as a speciality in an enlarged sphere of action. Thus it will be seen that, without any intention on my own part, beyond a general desire to carry out effectually an unavoidable duty, I drifted or was drawn into the business by a combination of circumstances, and especially by the absence of any practical treatise or methodized information, such as that which I now offer for the use of those interested in the subject.

The object of the following pages is to convey to those interested in the business of extinguishing fires the necessary information concerning the organization, training, and duties of firemen, and all the appliances which they have, or ought to have, in use; comprising, in a condensed and methodized form, the principal portions of the course of instruction which I have employed for many years, and by means of which I have succeeded in training hundreds of men, of whom some may now be found in other cities, some even in other countries, many still remaining with me as fellow-labourers and friends, but all, according to their opportunities and length of service, provided with a general knowledge of sound principles and of the mode in which these principles can be reduced to practice.

No man who has thoroughly studied and mastered these instructions, can be led away by wild and unmeaning assertions of interested persons offering machinery and other appliances for adoption in a brigade, and this alone ought to justify the publication of the present Work; but there is a further and a stronger reason, and that is that the time has arrived when it seems to me to be desirable, in the interests of true economy, to assert that the art of extinguishing fires has now attained the rank of a profession.

It must be owned that no attempt has hitherto been made, in this or any other country, to embody, in anything approaching to a complete or comprehensive scheme, the principles and practice so essential to our work. It is true that in France, Germany, and other countries, printed manuals of some kind have been in use for many years in the fire brigades; but they are meagre in the extreme, and, however suited to the countries in which they are found, and to the appliances adopted in those countries, would be altogether useless for the instruction of fire brigades charged with the protection of great commercial cities.

In conclusion, I need not hesitate to say that, if such a Work as this had been published some sixteen years ago, it would have saved me very much labour; and I have therefore every confidence that it will be of service to all who are interested in the preservation of life and property, and especially to those who have devoted themselves to the practical work of extinguishing fires, and who, whether their claim be conceded or not, consider, with my fellow-labourers and myself, that the business, if properly studied and understood, is worthy of being regarded as a profession.

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AIR AND WATER.

INTRODUCTORY.

A FAIR general knowledge of the laws of nature is essential to the proper transaction of the practical work of our profession.

It is not at all necessary that every Fireman should be profoundly versed in the higher branches of the study of the atmosphere known as pneumatics, or of that of water known as hydraulics; but, as he has to deal constantly with those substances, it is absolutely indispensable that he should thoroughly understand their nature and properties, and the general working of certain principles by means of which he is enabled to control them to his use.

The following pages contain only a summary of these two subjects, my object being merely to place before those interested, in a simple and compendious form, a statement of some important general principles which will enable them to avoid the errors so numerous among uninformed persons in working Fire Appliances, and at the same time to provide such an amount of technical information as will be sufficient for practical purposes.

GENERAL EXPLANATION.

SUBSTANCES are either solid, liquid, or gaseous.

A solid substance is one which naturally preserves a uniform size and permanent form, and the several parts of which, unless subjected to great pressure or other exceptional causes, keep their positions relatively to each other unchanged, even when the whole mass is in motion.

A liquid or fluid is a substance which naturally preserves its bulk, but not its form, and the several parts of which change their places relatively to each other with very slight cause, so that the whole mass readily accommodates itself to the shape of any channel, vessel, or receptacle, in which it is placed, and, in case of the receptacle not being sufficient, fills such space as is afforded, and then simply overflows, if allowed to do so.

A gas or gaseous substance is one which naturally does not preserve either its bulk or its form under any circumstances whatever. It has a certain quality or power called elasticity, which exerts its influence under all circumstances, unless controlled by a stronger power. This elasticity causes it to expand into any space which it finds unoccupied, and consequently to change both its bulk and its form with the slightest cause.

There is reason to believe that this power of elasticity is not without limits, as there are supposed to be places in the universe, such as the moon and others, which are not surrounded with air, and, according to the foregoing theory, the air, which surrounds the earth on which we live, should expand and fill up the empty space; but, so far as our practical knowledge on the subject goes, there is equal reason to believe that there is no limit whatever to the elastic power of the atmosphere, except such as may be applied by force.

It is no part of the question now before us to attempt to reconcile these two apparently discordant theories. We are told that there is somewhere a limit to the expansive power of the air, and we believe it, partly because we are told it by those whose business it is to instruct us in such matters, but chiefly because our own reason and powers of observation convince us that, if this theory were not correct, certain phenomena which we witness could not be accounted for. While, therefore, we cannot deny, but on the contrary freely acknowledge, the entire correctness of the theory which lays down that the atmosphere does not extend beyond a certain distance from the earth, we must at the same time insist on the positive certainty that, so far as our practical powers of testing and observing extend, the expansive power of the air within such distances from the surface of the earth as we have access to is absolutely without any limit whatever, except that applied to it by force or pressure from without, and that consequently within these distances a cubic inch of air, or any other quantity, however small, if placed in a chamber with a capacity of a million cubic feet, from which the air has been previously removed, will instantly expand and fill the whole space.

Substances may be found under such conditions that it may be difficult to decide which of the heads here given they should be classed under. This difficulty arises chiefly when they are in a state of transition, as when a solid has been partly melted, or a liquid partly vapourized.

Such cases are governed by no general rules, and must be dealt with according to the attending circumstances; they are only mentioned here for the purpose of guarding against any misconception which might otherwise arise from the apparently rigid definition of substances at the commencement of this chapter, as being either solid, liquid, or gaseous.

AIR.

THE ordinary air which surrounds the earth on which we live, is said to extend to a height or distance of about forty-five miles. It is commonly designated by the term atmosphere, which is derived from a Greek word, "*atmos*" (gas), and signifies literally a sphere or globe of gases.

The air, or atmosphere, though not obviously apparent to some of the senses—as hearing, seeing, tasting, or smelling—is yet an absolute substance as much as timber, lead, water, or the earth itself; and, though it differs in certain qualities from all of these, still it is no more unlike any of them than they are unlike each other, and in many points it exactly resembles them all; in fact it possesses in a certain degree the properties of all matter of whatsoever kind, solid or liquid.

It has weight, as all substances have, in a different degree certainly, but still absolute weight, which is thoroughly known, and it presses on everything exactly according to its weight in the same manner as any other substance would do. It is true that, being to a certain extent of the nature of a fluid, it has also a pressure additional to that which solids have; but the first point to be impressed on the student is the fact that the air is an actual substance, with many of the qualities and properties of all other substances of every kind whatsoever.

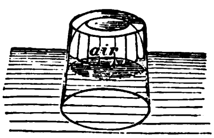
The next point of importance in connexion with the atmosphere is its impenetrability, a quality which it has in common with all other matter, whether solid or liquid.

Impenetrability may be defined as the property, in virtue of which a body occupies a certain space to the exclusion of all other bodies, the meaning of which is that it cannot occupy the same place at the same time as any other substance, and that, if a substance of any kind be placed in a vessel containing another substance, a portion of the latter must leave the vessel to make room for the former, or in a confined vessel the latter may become compressed into a smaller space, and so allow room for the other substance.

The following simple illustration will serve as a proof. If a vessel be filled to the brim with water, and a body of any kind, measuring say a cubic inch, be immersed in it, a cubic inch of water will be driven out of the vessel.

Now if the vessel be what is commonly called empty, that is to say, filled only with atmospheric air, and the cubic inch be placed in it, precisely the same result happens, though invisibly, and one cubic inch of air is driven out.

That the air is an actual substance is very clearly shown by immersing in water an inverted tumbler, when it will be found, that, no matter how much pressure be caused by the depth, the water inside cannot reach the top of the tumbler, thus proving that it is prevented by a body or substance.



It has also a quality by means of which it is capable of a considerable amount of expansion and compression.

This is a property which exists in all substances, but to very different extents, being in ordinary solids and liquids confined within narrow bounds, whereas in gases and air it is almost, if not altogether, without limit.

Every body or substance is composed of a number of small particles.

In solid substances these particles are held together by what is called cohesion. This word is derived from a Latin verb, which signifies to stick together, and it is used to express the attractive power by which the particles composing any substance are held together.

In solids there are scarcely any two substances which have an exactly similar cohesive power. Thus, if a lump of sugar be compared with a flint, it will be found that the sugar has a very small cohesive power, while the particles of flint can be separated only by great force. Again, compare a lump of salt and a lump of steel, and the cohesive power of the salt will be found so slight that the particles are only kept in their places when the lump is at rest, while on the contrary the cohesive power of the steel is so great that it is almost impossible to crush it or alter its shape at all until its nature and qualities have first been altered by the application of heat.

In liquids the attraction of cohesion is so weak, that the particles pass over and by each other with perfect ease, and instantly take the mould or shape of any vessel in which they are placed. It has been sometimes said that liquids have no cohesion, but it is evident that they have some by their forming, when scattered, into drops.

In atmospheric air, and all other gases and vapours, their is no cohesion whatever, but on the contrary there is a positive repulsion, or force, by which the particles comprising these substances endeavour to get away and separate from each other.

This is the quality of gases known by the name of elasticity.

There are many elastic solids, and other similar substances, possessed of this quality, so far that by the application of force they may be made to contract or expand, but they have each a point of rest, at which they appear to have no tendency to become either greater or less, and in this they differ very materially from gases, which have a constant tendency to expand, under all circumstances whatever, until controlled by a greater power; and this tendency is the same, whether the air be enclosed in a vessel and separated from the outer atmosphere or not. It differs under certain circumstances in degree, but the tendency within those regions to which we have access remains always the same.

The more a volume of air is allowed to dilate, the more attenuated it becomes, and with its loss of density it also loses a proportional quantity of its specific gravity, pressure, and elasticity.

Thus, if a volume of air equal to one cubic foot weigh ·08 lb., and the same quantity be allowed to expand to a bulk of two cubic feet, the whole will weigh only the same, ·08 lb. after expansion, and its specific gravity in the attenuated state will consequently be reduced to half. In this case the pressure and elasticity would also be reduced by one half.

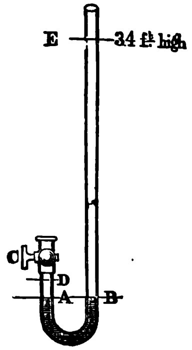
The air is also compressible; a volume of any size can, on the application of force, be compressed into a smaller bulk, its specific gravity, pressure, and elasticity increasing in direct proportion with the increase in its density.

Thus, if a cubic foot, weighing as before, ·08 lb., be compressed into a bulk equal to half a cubic foot, it will still weigh ·08 lb., but, as it occupies only half the space, it has twice the density and twice the specific gravity, and its pressure and elasticity are also doubled.

If a vessel be filled with atmospheric air of the same density as that of the outer atmosphere, the pressure on the inside will be equal to that on the outside; but if a greater quantity of air be added by forcing it in, the inner air, though occupying only the same space, is then of greater quantity, and, in consequence of its greater density, has a greater pressure, and, if the forcing be continued, the air will become so dense, and consequently so elastic, that it will eventually burst the vessel.

The existence of this curious and extremely important law of air, namely, the exact proportion between its specific gravity, elasticity, density, and pressure, when of the same temperature, is proved by the following very simple experiments.

Fill an inverted syphon with water to a certain height, A B, both ends being open; then cut off the connection with the atmosphere at either end, and the water in both arms of the syphon will still be on a level, thus showing that, though one arm is pressed down with the whole weight of the atmosphere, it is exactly balanced by the other, which is cut off altogether from the outer atmosphere, and has no power of pressure or weight, except that imparted to the enclosed air by its own elasticity.



The next point to consider will be the proportion which the elasticity and the density of the atmosphere bear to each other, and here again we can be guided by a very simple experiment.

Fill an inverted syphon to any height, A B, and the water will be found level in both arms; then shut the stop-cock, C, in one arm, and fill up the water in the other arm to E, a height of 34 feet, thus placing in it a column of water with a pressure of about one atmosphere, and it will be found that the water which before stood at A, has been raised by the pressure to D, half way up to C, and that the air which before occupied the space A C, now only occupies the space D C; in short, that it occupies only half the space, or in other words, as none has escaped, that it has twice the density, and, consequently, twice the specific gravity.

Now, at first it only supported the weight of the atmosphere, but we have since added a column of water equal to the weight of the atmosphere, so that it now supports the weight of two atmospheres; or, in other words, it exerts twice the pressure and has twice the elasticity; and it has been already shown that it has twice the density and twice the specific gravity, thus proving that these four qualities are in direct proportion to each other.

In the case of the inverted tumbler, also, to which allusion was made for the purpose of showing that air is a substance, it will be found that the lower the tumbler is placed in the water the greater will be the pressure, and the air inside will become proportionately reduced in volume. Thus at the surface of the water the air fills the tumbler, while at a distance of 34 feet below the surface the pressure of the water will have forced the air into half the bulk, so that the vessel will contain half water and half air.

The pressure of the atmosphere on top of the water is about 15 lbs. on every square inch, and the weight or pressure of the water 34 feet above the vessel is also 15 lbs., that is 30 lbs. altogether; while inside the tumbler there is at first only a pressure of 15 lbs. to resist this 30. The water being 30 lbs., therefore, at first forces the air, which is only 15 lbs., into a smaller space, and as the air becomes less in bulk it becomes more elastic, in fact stronger; so that, when it comes to only half its original bulk, it is able to resist twice the pressure; in short, the pressure of the air within, which at first was only 15 lbs. on every square inch, has now become 30 lbs., and therefore can resist a pressure of that amount from any other body.

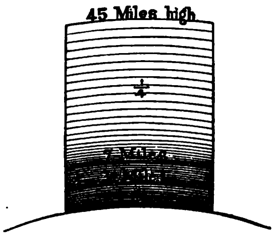
The atmosphere varies in weight, and consequently in pressure and the other properties already alluded to, according to its distance from the surface of the earth.

It is heaviest at the lowest levels, and lightest at the highest, the lower strata or layers being compressed by those above, in the same way as other substances would be.

For instance, if a large number of bales or parcels be piled one above the other, the lower bales sustain the weight of the upper, and, if the pile be raised to a great height, the lower bales will become compressed, and will occupy a smaller space than those above; or, to put it in another way, if a great quantity of wool, or other light substance, be piled up, it will be found that, although at the top it lies so loosely as to be blown about by the wind, yet at the bottom of the pile it lies almost as close and solid as timber; and, if a cubic foot cut out at the top, and another cubic foot cut out at the bottom, be weighed separately, it will be found that that taken from the base will be much the heavier.

At the same time the wool has undergone no change whatever, and, if the cubic foot taken at the bottom be removed to the top, it will be found to fill much more than a cubic foot, inasmuch as it will be relieved from the pressure, while the foot taken from the top and subjected to pressure below will be found not to fill more than a few cubic inches.

Now, it is precisely the same with the atmosphere. So far as we know, the whole height of the atmosphere is, as already mentioned, about 45 miles, and yet one-half of the whole quantity is contained in the 3½ miles nearest to the earth, and about one-fourth in the next 3½ miles, that is about three-fourths in the first 7 miles, leaving only one-fourth for the remaining 38 miles.



We next come to consider the pressure of the atmosphere on the several objects which it touches.

On the level of the sea the pressure of the atmosphere is as nearly as possible 15 lbs. on every square inch of surface; on higher levels it is less, but on the level of London the pressure may be assumed to be about the same as on the sea.

Thus it will be seen that the pressure on the body of a man amounts in all to several tons.

The body of an ordinary man of 5 feet 8 inches in height, and of average bulk, has a surface of about 2,500 square inches exposed to the external atmosphere, and on each square inch there is a constant pressure of about 15 lbs., so that the whole pressure, $2,500 \times 15$, amounts to 37,500 lbs., or upwards of 16 tons.

It may be asked how it happens that a man is able to sustain the weight of several tons; but this is easily answered.

The air, as already explained, consists of a collection of small particles, and these particles are so minute, and from their elastic nature so penetrating, that they find their way into every opening, however small.

They are, moreover, possessed of the property of gases, one of the distinguishing and characteristic laws of which is, that they press equally in all directions, up, down, and sideways.

Now, the air penetrates all through the body of a man; it permeates his blood, and fills the pores of his skin, and by its elasticity inside it exactly counteracts the pressure on the outside, so that, although the man is actually bearing on his outer surface the weight of several tons, he is, as it were, supported from the inside by a compensating power, which does not allow his body to become compressed or otherwise injured.

If it were possible to exhaust from the inside of a man's body all the air, he would be crushed in a moment; and again, if it were possible to exhaust from the outside all the air which encircles him, the air inside him would swell to such an extent, that he would burst in a moment.

Both these cases may be partially tested, by going down into the sea in a diving-bell, or ascending into the air in a baloon.

In the case of the diving-bell, as soon as it has descended about 34 feet below the surface of the water, the man inside it begins to suffer from the pressure of the atmosphere, which is then double that which he is accustomed to; and, if he goes down further, he suffers still more, from subjecting his body to a pressure which it has not been intended or formed to bear up against.

In the case of the balloon, as soon as a height of 3½ miles has been attained, the man's body begins to suffer from the removal of the outside pressure of 7½ lbs. on each square inch.

In both these cases he is supported from within, but not to the same extent, as the structure of his body is suited chiefly to the ordinary atmospheric pressure on the earth's surface, and cannot readily adapt itself to violent changes.

BAROMETER.

THERE is an instrument in common use, called the barometer, the working of which must be explained, not for its ordinary purpose as a machine for telling or foretelling the state of the weather, but because the principles on which it acts are the same which influence some of the most important operations not only of a fire engine, but of our business generally.

The word barometer means simply "measure of weight," though it is commonly used to signify the instrument in ordinary use for measuring the weight of the atmosphere.

First, it should be explained how it happens that the air has not always the same weight, or specific gravity, at least at any one spot.

It has been already said that the density, weight, and elasticity of the atmosphere, are in direct proportion to each other. Now, everything increases in bulk by the application of heat, and an increase of any given body in bulk is only another name for a decrease in density. This is the case with all solids and liquids to a slight degree; but an increase of temperature has a much more marked effect on gases and air than on solids.

When the sun's rays have increased the temperature of any spot on the earth's surface, the air over that spot becomes increased in bulk, or, in other words, decreased in density; and, in consequence of the law previously explained, it continues to rise, until it reaches such a height that its density and that of the surrounding atmosphere are alike. That is to say, on the application of heat it immediately begins to ascend, and continues to do so during the continuance of the heat. The air directly over that spot then extends to a greater height than that of the air surrounding it, but being only the same quantity, it weighs no more in its altered condition than it did before. But now a law of liquids, that of finding their own level, comes into force, and endeavours to make the upper surface even, which is effected by causing the higher or rarefied air to overflow on the top of the air adjoining. The adjoining air is made heavier by the addition, and being heavier is, for the reasons already explained, more elastic or stronger, while that deprived of a certain amount of its weight by the overflowing has become less elastic or weaker; the consequence of which is, that the air rushes from the cold place to the place which has been heated. This air in motion is the familiar effect known as wind, and, though subject to many disturbing influences, it comes in certain places, and at certain seasons, with the utmost regularity.

The sea has a much more equable temperature than the land. When the sun heats the land by day, the air over the land ascends, and that from the sea, which is then colder, rushes in, and forms the sea breeze; but at night, when the land, after the withdrawal of the sun's heat, has become colder than the sea, the air from the land, being more condensed, forces its way to the comparatively rarefied air on the sea, and forms the land breeze.

There are numerous other causes which act unceasingly on the atmosphere in such a manner as to affect its weight; but it is not necessary, at this stage of the instructions, to do more than simply point out the general principles on which these variations of the weight of the atmosphere depend.

The barometer is an instrument made for measuring these changes of weight of the atmosphere, and it is ordinarily formed in either of two ways; but in principle, both are alike. A quantity of liquid, commonly mercury, is placed in a tube, which is open at one end and closed at the other, and contains no air whatever.

The column of liquid is therefore pressed on at one end by the weight of the atmosphere, and at the other end by nothing at all; and consequently its length, or head, which is the vertical difference between its two levels, is an exact measure of the weight which causes equilibrium or balance with the atmosphere.

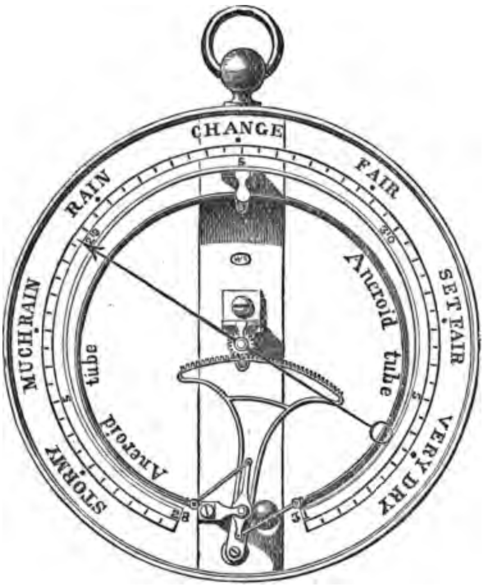
There are two other instruments in use for this purpose, called respectively the aneroid and the metallic barometers.

The word aneroid means "without fluid," and the word metallic "formed of metal," and, therefore, as far as regards the absence of fluid or the presence of metal, the names are equally applicable to both, and might be used indifferently.

The instruments, however, to which it has been the custom to attach these names, are somewhat different.

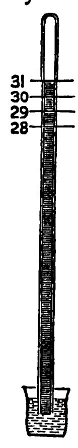
The aneroid consists of a flat metal box, generally about half an inch thick, and two inches in diameter, from which nearly all the air is exhausted. The top and bottom are corrugated so as to yield to external pressure, and to return when the external pressure is removed or partly removed. This movement, though almost too slight to be perceptible to the unaided senses, is made apparent by means of a very delicate spring communicating motion to a hand which moves on the face of a dial graduated to points corresponding to the inches of a column of mercury in a tube.

A metallic barometer consists of a long slender flattened metallic tube, from which a portion of the air is exhausted. This flattened tube is bent in the form of a ring. Its principle of action is that the external atmosphere, when it increases in pressure, tends to close or coil the tube, and, when it decreases in pressure, tends to allow the ends to separate. One end is fixed, and, consequently, the other receives the effects of the whole movement, and there is a system of small levers and a rack, which communicate this movement to a pinion wheel in the centre, and by that means to a spindle, on the end of which is placed a revolving hand to indicate the pressure on the face of a dial graduated in the same way as that of the aneroid.



The machinery and general system of arrangement may seem somewhat complicated, but these are very favourite instruments notwithstanding, and are as much relied on as the others by sailors and all persons whose business is considerably affected by atmospheric influences.

The mercurial instruments are those about to be described; they are of two kinds, called respectively the Tube Barometer and the Wheel Barometer; and although, as previously stated, the same law governs the action of both, they are for simplicity, and to avoid confusion, described separately as follows:—



TUBE BAROMETER.

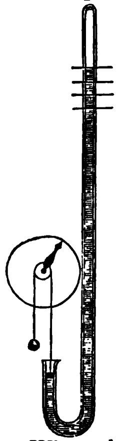
The tube is first inverted and filled, and its open end then turned down into a cup or vessel containing a portion of the same liquid, or it is made with room for this extra quantity in the bottom of the same tube.

At the upper end there is a vacuum—that is, a space not containing air—and the liquid is therefore pressed at one end by the weight of the atmosphere, and at the other end by nothing at all, and when the atmosphere is heavy it drives the liquid up to a greater height than when it is light. Several substances have been tried for this purpose, but the weight of the atmosphere, being about 15 lbs. to every square inch, would support a column of almost any ordinary liquid to a considerable height, and very few houses would contain pipes of sufficient length. It has, therefore, been found more convenient to use quicksilver, which is a liquid of about 13½ times the weight of water, and which cannot be raised by ordinary atmospheric pressure to a greater height than about 31 inches, the height being measured from the level of the mercury in the cup to that of the top of the column of mercury in the tube.

WHEEL BAROMETER.

This is on precisely the same principle, being a column of mercury supported by atmospheric pressure, as in the tube, but its working is somewhat different, and the gauge on which the inches are marked is a dial, instead of a common scale of inches.

A bent tube is first filled with quicksilver, and then inverted. A small float is placed on the surface of the liquid in the tube, and a line from this passes over and round a spindle, and is balanced at the other end by a counterweight.



To the end of the spindle there is attached a hand, to which motion is communicated by the rising and falling of the float and the consequent movement of the line; and there is in front a dial, which is graduated in such a way that the length or head of the column of mercury can be read off by observing the hand.

It must be mentioned that the marking of any barometer for "rain," "fair weather," and so forth, is most unmeaning, as the function of the instrument is simply to register the number of inches of mercury which the atmosphere will support, or, in other words, the pressure of the atmosphere; and any observant person can see, by every day watching, that rain falls sometimes when the atmosphere is heavy and sometimes when it is light, and that naming certain weights of the atmosphere as indicating rain or fair weather is mere assumption.

When the barometer falls, the only thing indicated is that the atmosphere is lighter than it was; and the only inference to be drawn from this is, that the heavier atmosphere in some other quarter may be expected, if not interfered with, to rush in and become mixed with the rarefied air—in other words, that there may be a breeze of wind shortly; but even this is not always the case, as it is well known that the barometer constantly rises before easterly winds in this country. The fact is, that the painting of these words "rain," "changeable," "fair," &c., &c., is only a device to sell the instruments, and has really no meaning besides. Every place has its local peculiarities, and it requires an observant person, with a proper knowledge of his instrument, and a constant study of it, to tell, even in any one place, what the barometer signifies as to rain and fair weather, and in his decision he is guided almost entirely by local circumstances and local knowledge, which will show him what happened at the same place under the same conditions at some previous time; and it is of much more importance to observe generally whether the mercury in the barometer is rising or falling than to note the point at which it stands.

This part of the subject has been treated at considerable length for the purpose of impressing on the student the true principles of atmospheric pressure, and removing from the barometer that mystery which so many attach to its working.

As a matter of fact, the weight or pressure of the atmosphere is constantly varying, and the barometer is merely a simple instrument used to indicate the variation, and subject to the same laws of nature which govern many of the most ordinary operations of our lives, such as breathing, drinking, and others.

The extent of the variation in England is about from 28½ to 30½ inches, that is, a variation of about 2 inches.

Now, a column of mercury of 1 inch square and 30½ inches high weighs almost exactly 15 lbs., while a column of the same area 28½ inches high weighs only 14 lbs., so that the atmosphere presses at certain times with a pound more weight on every square inch exposed to it than it does at other times; but this greater weight of the atmosphere is found at the time when it is usually spoken of as being very light and exhilarating, while the atmosphere on a dull day, when it is generally called heavy, is in reality much lighter, as may be seen by the reduced height of the column of mercury in a barometer.

Now supposing that, in addition to the mercurial barometer, a water barometer be also used, it will be found that on a clear bright day, when the column of mercury stands at a height of 30½ inches, that of water will stand at a height of 34 feet 6½ inches; and when the mercury is at 28½ inches, the water will be at about 32 feet 3½ inches.

As this branch of the subject is most important in connection with the feeding of our pumps by means of atmospheric pressure, or as it is commonly called suction, a table is appended giving the pressure of the atmosphere for every inch of a column of mercury, and the corresponding height of a column of water under the same conditions.

VACUUM TABLE *showing the Pressure of Mercury under certain Heads, and the Corresponding Column of Water.*

Mercury in inches.	Pressure on each square inch, in lbs. avoirdupois.	Corresponding column of water.		Mercury in inches.	Pressure on each square inch, in lbs. avoirdupois.	Corresponding column of water.	
		In feet and decimals, exact.	In feet and inches, approximate.			In feet and decimals, exact.	In feet and inches, approximate.
1	·49	1·13	1 ft. 1½ in.	17	8·35	19·26	19 ft. 3 in.
2	·98	2·27	2 ,, 3 ,,	18	8·84	20·39	20 ,, 4¾ ,,
3	1·47	3·40	3 ,, 4¾ ,,	19	9·33	21·53	21 ,, 6¼ ,,
4	1·96	4·53	4 ,, 6¼ ,,	20	9·82	22·66	22 ,, 7¾ ,,
5	2·46	5·67	5 ,, 7¾ ,,	21	10·31	23·79	23 ,, 9½ ,,
6	2·95	6·80	6 ,, 9½ ,,	22	10·81	24·93	24 ,, 11 ,,
7	3·44	7·93	7 ,, 11 ,,	23	11·30	26·06	26 ,, 0¾ ,,
8	3·93	9·06	9 ,, 0¾ ,,	24	11·79	27·19	27 ,, 2¼ ,,
9	4·42	10·20	10 ,, 2¼ ,,	25	12·28	28·33	28 ,, 3¾ ,,
0	4·91	11·33	11 ,, 3¾ ,,	26	12·77	29·46	29 ,, 5½ ,,
1	5·40	12·46	12 ,, 5½ ,,	27	13·26	30·59	30 ,, 7 ,,
12	5·89	13·60	13 ,, 7 ,,	28	13·75	31·72	31 ,, 8¾ ,,
13	6·39	14·73	14 ,, 8¾ ,,	29	14·24	32·86	32 ,, 10¼ ,,
14	6·88	15·86	15 ,, 10¼ ,,	30	14·74	33·99	33 ,, 11¾ ,,
15	7·37	17·00	16 ,, 11¾ ,,	31	15·23	35·13	35 ,, 1½ ,,
16	7·86	18·13	18 ,, 1½ ,,				

It will be perceived that the pressures here indicated are only those necessary for keeping columns of water of various heads stationary, and that if it be desired to give the water any velocity in addition, as in the case of feeding a pump, an additional force or power must be applied.

In feeding a pump by atmospheric pressure, the greatest force which can be applied is obtained by withdrawing the air from the inside of the pipes, and so disturbing the balance or equilibrium between the internal and external pressure. Thus it will be seen that in no case can there be a greater power than the actual pressure of the atmosphere at the moment.

Now if it be necessary to raise the water to any given height, this pressure or force has, as it were, two functions to perform; the one to raise the column of water, the other to keep it running; and consequently the latter must always be the balance between the former and the total pressure.

Thus, if the minimum pressure of the atmosphere this year, 28·5 inches of mercury, or 14 lbs. on each square inch, be assumed as the available force, it will be found that the following figures represent the mode in which it is divided for the purpose of the two functions above referred to.

TABLE *showing the force available for feeding a Pump at various Heights by means of Atmospheric Pressure.*

Height of Column in feet.	Pressure of ditto in lbs.	Balance in lbs. to cause Velocity.	Height of Column in feet.	Pressure of ditto in lbs.	Balance in lbs. to cause Velocity.
1	0·43	13·57	18	7·80	6·20
2	0·87	13·13	19	8·24	5·76
3	1·30	12·70	20	8·67	5·33
4	1·73	12·27	21	9·10	4·90
5	2·17	11·83	22	9·54	4·46
6	2·60	11·40	23	9·97	4·03
7	3·03	10·97	24	10·40	3·60
8	3·47	10·53	25	11·84	3·16
9	3·90	10·10	26	11·27	2·73
10	4·34	9·66	27	11·70	2·30
11	4·77	9·23	28	12·14	1·86
12	5·20	8·80	29	12·57	1·43
13	5·64	8·36	30	13·01	0·99
14	6·07	7·93	31	13·44	0·56
15	6·50	7·50	32	13·87	0·13
16	6·94	7·06	32·3	14·00	0·00
17	7·37	6·63			

In the calculations here given, the weight of the atmosphere at the sea level alone is taken into account. This will be quite sufficient for our purposes so long as we remain in the ordinary levels of this or almost any other country; but if an experiment be tried at a considerable height on a mountain, or at a considerable depth down a cave, the pressure of the atmosphere on the height will be found much less, and in the pit much greater, and this will be shown by the shorter or longer column supported.

Again, if the atmosphere be altered by mechanical means, as by withdrawing a portion of the air, or by adding some to the air, it will be found that the lighter atmosphere will support a shorter column, and the heavier atmosphere a longer column. As these are the operations performed by the common fire engine on the ordinary atmospheric air, it is of great importance to remember the principles on which they depend.

While these operations vary according to the height at which they are performed, the proportion of the column of mercury to that of water is found constant, being in fact as the weight of the two substances, about 13½ to 1, so that for every inch of mercury supported by the atmosphere it will be found that 13½ inches of water will be held up.

The following are the absolute maxima and minima readings of the barometer, with the mean and range for each month in the years 1865, 1866, 1867, 1868, at the height of 160 feet above the sea :—

	Reading of the Barometer.			Range of Reading in each Month.	Column of Mercury in inches.	Corresponding Column of Water.	
	Maxima.	Minima.	Mean.			ft.	in.
1865.							
January	30·207	28·390	29·404	1·817			
February	30·432	28·718	29·722	1·714			
March	30·204	29·042	29·722	1·162			
April	30·170	29·680	29·954	0·490			
May	30·225	29·343	29·769	0·882			
June	30·358	29·120	30·031	1·238			
July	30·202	29·416	29·797	0·786			
August	30·172	29·300	29·711	0·872			
September	30·323	29·750	30·071	0·573			
October...	30·081	28·824	29·440	1·257			
November	30·325	28·794	29·720	1·531			
December	30·610	29·005	30·055	1·605			
Highest reading, Dec. ...	...	...	...	...	30·610	34	7
Lowest reading, January ...	...	...	...	...	28·390	32	1
Range of reading	...	...	...	...	2·220	2	6
1866.							
January	30·506	28·643	29·702	1·863			
February	30·197	28·450	29·529	1·747			
March	30·240	28·896	29·527	1·344			
April	30·294	29·178	29·743	1·116			
May	30·252	29·278	29·813	0·974			
June	30·118	29·200	29·774	0·918			
July	30·174	29·097	29·770	1·077			
August	29·970	29·120	29·638	0·850			
September	29·938	29·025	29·575	0·913			
October...	30·344	29·488	29·927	0·856			
November	30·169	29·053	29·786	1·116			
December	30·355	29·078	29·784	1·277			
Highest reading, January ...	...	...	...	...	30·506	34	5½
Lowest reading, February ...	...	...	...	...	28·450	32	1¾
Range of reading	...	...	...	...	2·056	2	3¾
1867.							
January...	30·061	28·579	29·514	1·482			
February	30·390	28·701	29·911	1·689			
March	30·608	29·016	29·624	1·592			
April	30·304	28·895	29·629	1·409			
May	30·003	29·225	29·738	0·778			
June	30·411	29·551	29·935	0·860			
July	30·156	29·256	29·730	0·900			
August	30·041	29·501	29·829	0·540			
September	30·332	29·605	29·915	0·727			
October...	30·306	29·275	29·758	1·031			
November	30·493	29·394	30·119	1·099			
December	30·225	28·746	29·854	1·479			
Highest reading, March ...	...	...	...	...	30·608	34	7
Lowest reading, January ...	...	...	...	...	28·579	32	3½
Range of reading	...	...	...	...	2·029	2	3½

1868.	Reading of the Barometer.			Range of Reading in each Month.	Column of Mercury in inches.	Corresponding Column of Water.	
	Maxima.	Minima.	Mean.			ft.	in.
January	30·220	28·866	29·741	1·354			
February	30·404	29·116	29·970	1·288			
March	30·443	28·997	29·824	1·446			
April	30·278	28·749	29·782	1·529			
May	30·175	29·375	29·845	0·800			
June	30·205	29·538	29·980	0·667			
July	30·253	29·509	29·891	0·744			
August	30·159	29·047	29·736	1·112			
September	30·206	29·077	29·693	1·129			
October...	30·241	29·203	29·792	1·038			
November	30·463	28·936	29·836	1·527			
December	30·171	28·530	29·379	1·641			
Highest reading, Nov. ...	...	...	...	...	30·463	34	5
Lowest reading, Dec. ...	...	...	...	...	28·530	32	2¾
Range of reading	...	..	...	...	1·933	2	2¼

BUOYANCY.

THE next point to be noticed in connexion with the question before us is the subject of buoyancy, or that quality by means of which bodies have a tendency to float or sink.

When a body of any kind, whether solid, liquid, or gaseous, is placed in a liquid or gas which is unconfined, it displaces a certain portion of the latter; if it be of less specific gravity than the latter, it floats on the top, and in that case it displaces a quantity equivalent to it in weight, but if it be of greater specific gravity, it sinks, and displaces a quantity equivalent to it in bulk.

If any substance lighter than water be placed in a vessel containing water, it will remain on the top, and will not sink unless you apply to it a force or weight greater than that of a corresponding bulk of water; and the same result occurs with air, if a lighter substance be placed in it, even when that other substance is itself a gas or vapour.

This is one of the laws of liquids and gases, and is that made use of in the balloon, which is filled with a gas much lighter than the common atmospheric air, and will, therefore, rise in the atmosphere until it attains a height at which the specific gravity of the atmosphere is no greater than that of the gas it contains.

A cubic foot of water weighs 62·425 lbs., or 999 ozs.

A cubic foot of air taken at the level of the sea weighs ·08 lbs., or 1·28 ozs., in other words the 786th part of the weight of the same quantity of water.

Thus, on the principle already explained, if water and air be placed together in the same vessel, the water will occupy the lower and the air the upper part.

Some explanation is necessary concerning the fact that smoke rises, whereas it is known to be heavier than common air.

Almost all substances, when subjected to the action of heat, undergo a change: some are transformed into charcoal, some into vapour, and others seem to disappear altogether; but it is well known that none are absolutely annihilated or destroyed.

Smoke is merely a mixture of air with a collection of particles commonly known as the products of combustion, or, in other words, the partly consumed remains of a combustible substance which has been subjected to the action of fire.

These particles are mixed through a considerable quantity of air, and, being hot when they are first formed, they communicate heat to the air, which, becoming consequently attenuated, instantly rises, on the principle already explained, and, forming a draught or current upwards, carries with it the small particles formed by imperfect combustion, in the same way as a river carries with it mud, sand, and salt, all of which are of greater specific gravity than itself.

But as the river, when it reaches the sea, or when from any cause it discontinues its motion, ceases to act on these substances, and almost instantly deposits them, so the air from the scene of a fire, after travelling upwards to a point at which it and the surrounding atmosphere are of the same specific gravity, loses its motion, and, when it does so, it allows the charred particles to descend, and they accordingly return to the earth again by their own gravitation.

In other words, hot smoke ascends and cold smoke goes downwards, and on this account we invariably endeavour, when working in smoky places, to make an opening at the top for its exit and at the bottom for a supply of pure air to replace it, and at the same time, when it is possible, we light the gas, and keep up the heat in every available way, until the whole of the particles have been removed by the current thus formed.

If we neglect or are unable to do this while the smoke is hot, much inconvenience and danger may ensue, and goods of certain kinds—such as silks and other wearing apparel, groceries, spices, and almost all articles of food, besides many other substances with which we have to deal—are liable to be deteriorated in value almost as much as if they were consumed by fire.

It of course requires a considerable amount of discretion to determine the proper time for performing this important act, of replacing a substance in which fire cannot exist by a supporter of combustion, but it is to be presumed that those entrusted with the important duty of extinguishing fires understand their business sufficiently to judge of the proportion between the end to be attained and the means at their disposal, and will not admit air to increase the fury of the flames until they have first satisfied themselves that, either by being enabled to approach the flames, or in some other way, they are likely to gain an advantage by doing so.

It is on the same principle as that here explained that the best kind of ventilation is accomplished, the foul air being discharged through an opening in the upper part of a room, notwithstanding that it is ordinarily of greater specific gravity than pure air, and consequently ought to descend.

The substance which passes into the lungs is a mixture of nitrogen with oxygen, and that which is breathed out again is a mixture of nitrogen with a deadly poison called carbonic acid gas, which has about once and-a-half the specific gravity of oxygen.

Thus it will be seen that the foul air exhaled is of greater specific gravity than the surrounding atmosphere from which it is inhaled, and that, consequently, if there were no disturbing cause, it should seek the lowest and not the highest part of the room.

It so happens, however, that in passing through the lungs, it is raised in temperature by the heat of the body, and by its simple increase in bulk becomes momentarily of less specific gravity, and on its discharge from the mouth has an immediate tendency to rise. This tendency remains only so long as the heat is retained, and, as the foul air is every moment losing its heat, it would quickly descend again unless allowed to escape immediately after it rises.

When, however, there is a proper opening made on top, the foul air rises towards and passes through it in a constant current, and is replaced by cooler air passing in below through such openings as are allowed for its admission.

In very large rooms, in which the foul air has to rise to a great height, it is likely to lose its heat before reaching the point of discharge; the best mode of obviating this is to add some artificial heat, such as that of a gas jet, to assist the upward current.

These are points which it is of special importance to all persons of our profession to understand thoroughly, as without a sound practical knowledge of them fatal errors may constantly be committed.

CHYMICAL ANALYSIS.

THE air consists chiefly of two kinds of gas, called respectively oxygen and nitrogen, the valuable part of it being the oxygen, to which the nitrogen appears to be added only for the purpose of weakening or diluting it to suit our requirements for breathing and so forth, as pure oxygen is too strong for animal life, and causes death if used alone.

As far as our present knowledge extends, it seems that precisely the same kind of air is necessary to support respiration, or the act of breathing, and combustion, or the act of burning, or, in other words, the same species of air is required to feed the lungs of a man or other animal as that necessary for feeding a fire, and that species of air is the oxygen already referred to.

The nitrogen does not in any way, except that mentioned, assist in respiration, and it used for this reason to be called by the ancients "Azote," which is derived from two Greek words, signifying without life, by which they probably meant, not that it had any injurious qualities of its own, which it certainly has not, but simply that by itself it did not suffice for respiration, or the act of breathing, without which life cannot exist.

In practice it is found useful for a man always to carry a lamp when in a dangerous place, as a well or mine, where there is likely to be either foul air or air without oxygen in it, and, when the lamp goes out, it is necessary for the man to retire.

A curious and important circumstance in connection with this part of the subject is the fact that the proportion of nitrogen to oxygen is always as about four to one; that is to say, that every quart of oxygen is mixed up with a gallon (or four quarts) of nitrogen. This law is universal, the proportions being found about as one to four alike in the purest or foulest air, and in the healthiest or most unhealthy places, in the most stormy and exposed regions, and in the bottoms of pits and badly-ventilated houses—wherever there is air, the same exact proportion is found; and this is the more remarkable, when we consider what a quantity of oxygen must be what we call consumed, or in other words used, and chymically speaking changed.

The extraordinary circumstance that, although this valuable substance is being continually used up, there is nevertheless, always, or almost always, a sufficient quantity forthcoming, is accounted for in the following way.

The oxygen, after assisting in the act of respiration by contributing nourishment to the lungs, or assisting in combustion, passes off, at least partly, in the gas known as carbonic acid, which resembles nitrogen in that it does not assist respiration, but differs from nitrogen in that it is a much more active agent, and contains certain injurious properties. This carbonic acid, which in large quantities or proportions in the air would be dangerous, is in its turn consumed or changed by becoming the food of vegetables—that is to say, of everything in the nature of plants, herbs, trees, &c.—the vegetable world, in its turn, restores to the air pure oxygen, and thus the supply is kept up. In short, oxygen, when used for respiration or combustion, is changed into carbonic acid gas; and carbonic acid gas, when used for contributing life to the vegetable world, becomes oxygen, the nitrogen, though always present, remaining unused and unchanged in either case.

The atmosphere contains some other very trifling ingredients, but they vary so much, and are altogether in such exceedingly small quantities, that no particular mention of them is necessary.

WATER.

ALL water comes, in the first instance, from the sea, which occupies two-thirds of the whole surface of the globe, and supplies the moisture necessary for vegetation and other purposes. It is raised from the surface by the heat of the sun's rays, ascends into the air in the form of vapour, and is carried along by the wind in clouds, until, by meeting a mountain top or any high land, or from some other cause—probably, in some cases, merely attraction to the earth—the vapour becomes chilled, when it condenses and falls in dew, mist, rain, hail, sleet, or snow, which in course of time finds its way back to the sea in streams or springs, and so keeps up a constant circulation.

There is a system of currents, or constant horizontal circulation, going on in the sea itself; whether caused by heat on the surface, or by the rotation of the earth, it is no part of the present subject to consider; but there does not, at first sight, appear to be any vertical circulation, such as that caused by ordinary ebullition or boiling, when the heat is applied from below, and bubbles of steam formed at or near the bottom rise in consequence of their lightness to the top, and are replaced by the colder water from above.

On examination, however, it becomes plain that there is a most complete and perfect provision for this kind of circulation, or interchange of levels, caused by the salt which is in the sea.

This salt is of greater specific gravity than water, and when heat is applied, although contrary to the ordinary custom, above, instead of underneath, a portion of water becomes vapourized, but leaves behind the salt with which it was impregnated. The salt, therefore, becomes mixed with the remaining water, and overcharges it, thus making it considerably heavier than before, and consequently causing it to move downwards by gravitation.

If the salt were of less specific gravity than the water, the effect would be that in calm weather a crust of salt would, in course of time, be formed on the top, and there would remain no water exposed to the vapourizing power of the sun's heat; and, if there were no salt or similar substance mixed through the water, no vertical circulation would take place.

In the first of these supposed cases the supply of water in streams and rivers would either cease, or at least be seriously diminished, and in the second the vapour would rise from a source which, even in ordinary weather, would be liable to every kind of pollution or contamination, and at times would probably be putrid and certainly unwholesome.

All this, however, is obviated by the provision before mentioned, and, consequently, a complete circulation is kept up in all directions, and a fresh supply of salt is continually brought down by rivers, and takes the place of that which becomes exhausted.

In general, water acts on a fire with an energy almost in direct proportion to its impurity, but there are exceptions to this rule. For instance, newly-fallen rain, unless it has passed through a foul atmosphere, or been subjected to other exceptional influences, is perhaps the purest of all natural water. It contains in it very little atmospheric air, and, consequently, is disagreeable and flat to the taste, but the absence of this ingredient makes it very well suited for our purposes.

Dew water differs very little from rain, but contains in any given volume more atmospheric air.

Ice water and snow water, when first thawed, contain no atmospheric air at all, and cannot support life in fishes; they are exceedingly well adapted for our work.

All water, however, in time absorbs air, and consequently there is no difference in this respect between any of the different kinds a few days after they have been exposed to the influence of the atmosphere.

Sea water, strongly impregnated with salt, is more effective than almost any other kind for extinguishing fire.

The water which falls on any part of the earth's surface has an immediate tendency to seek the lowest spot available for its reception. This is the quality known as gravitation, and, according to circumstances, it tends to the formation of rivers, lakes, marshes, springs, and wells, all of which are subject, equally with the sea, to evaporation by the effects of heat.

A river is merely a quantity of water running in a groove or cleft of the earth. It is supplied by rain falling on a high level, commonly known as a watershed, inclined on one or more sides towards the cleft, and during the whole of its downward progress to the sea it is subject to diminution from evaporation. It might be supposed that it is also diminished in quantity by being used for drinking, manufacturing, and moistening the earth, and there may be some semblance of correctness in such a supposition; but it is known to those practically conversant with the subject, that as a general rule the whole quantity used for domestic, agricultural, and other purposes, is returned again almost, if not altogether, in full, into the same channel, so that for all ordinary practical purposes a river may be considered to consist of the excess of the rainfall on a certain district, over the evaporation from the same district, and from the surface of the stream, some allowance being made for the absorption by the soil.

River water is of various degrees of purity or impurity, according to the nature of the ground from which it is collected and over which it runs. Filtration removes from it mud and other mechanical or solid substances; boiling also separates or precipitates solid impurities, but sometimes does not succeed in effecting even this. There are, however, occasionally in water other foreign substances, which are held in solution, and which it is most difficult, and in many cases wholly impossible, to remove.

The mechanical impurity of water is called hardness, and is usually reckoned by the number of grains in a gallon.

Thus, when there are 10 grains of salts, or other foreign matter, in a gallon, the water is said to be of 10 degrees of hardness or impurity.

There is no recognised measure or definition for the degree of chymical impurity which, in certain cases—as, for instance, in that of peat water—appears to defy all attempts hitherto made either in the way of analysis or removal.

A lake is formed in precisely the same way as a river, but the water, getting into a basin or hollow of the earth's surface, which has no outlet, or an outlet above its lowest level, accumulates, until it is relieved, either by simple evaporation—in which case the water is almost stagnant—or by an overflow into some level below that of its surface.

Lake water is almost the same as river water, except when the lake has too small an outlet, in which case it is harder; or when the lake has no outlet at all, in which case it becomes salt, like that of the sea.

A marsh is formed either in the same way as a river or lake, or by the direct rainfall on its surface, and usually consists of water mixed through a soft or spongy soil in a quantity sufficient to moisten it in a greater or less degree, according to circumstances, but not to overflow it or run freely off. It is therefore commonly a stagnant basin of mingled water and vegetation, and the liquid portion of it consists of the whole rainfall of the watershed, with the exception of that portion which is removed by evaporation.

The organic substances, such as animal and vegetable matter, are usually more or less in a state of decomposition, and make the water disagreeable to the taste and smell, but, so far as can be ascertained, they have no important effect on it with regard to our business.

A spring is formed by water running from some higher level in an enclosed cleft or channel, and cropping out at some spot below the level of its original source.

All spring water contains a certain quantity of salts or other impurities.

A well is a hollow in the earth, into which water runs from either a surface stream or an underground spring.

The water furnished for the use of towns is procured from one or more of these sources, and sometimes from them all; but the supply obtainable is generally in indirect proportion to the requirements, being least in summer, when most is wanted, and greatest in winter, when comparatively less is needed; it is moreover at any given period delivered, to a certain extent, in somewhat regular quantities throughout the whole 24 hours of a day, whereas the daily requirements of an ordinary town are only spread over a period varying from 10 to 14 hours.

STORAGE.

FOR these reasons it is customary to impound the water in a reservoir, varying in capacity according to the demands of the place, but generally intended to be of sufficient size to meet all the ordinary and most of the extraordinary emergencies—such as heavy demands for domestic, manufacturing, and other purposes, long continued periods of drought, large fires, and other exceptional casualties.

A reservoir of this kind is supplied either by a pump, which drives water up into it from a lower level, or by a stream or lake on a higher level, from which water runs into it by gravitation.

The water sent up by a pump must always travel in an enclosed pipe, but the water from a stream or lake on a higher level, may, in some instances, come in an open stream, thus saving considerable expense.

In every case, however, of a supply coming from a higher level, if any portion of the intervening ground be lower than the inlet of the reservoir, it is necessary either to bridge over that part with an aqueduct, or to convey the water in an enclosed pipe, which may, if desired, be allowed to follow the undulations of the ground, provided that no part be above the level either of the original source or of any open part of the intervening conduit or channel.

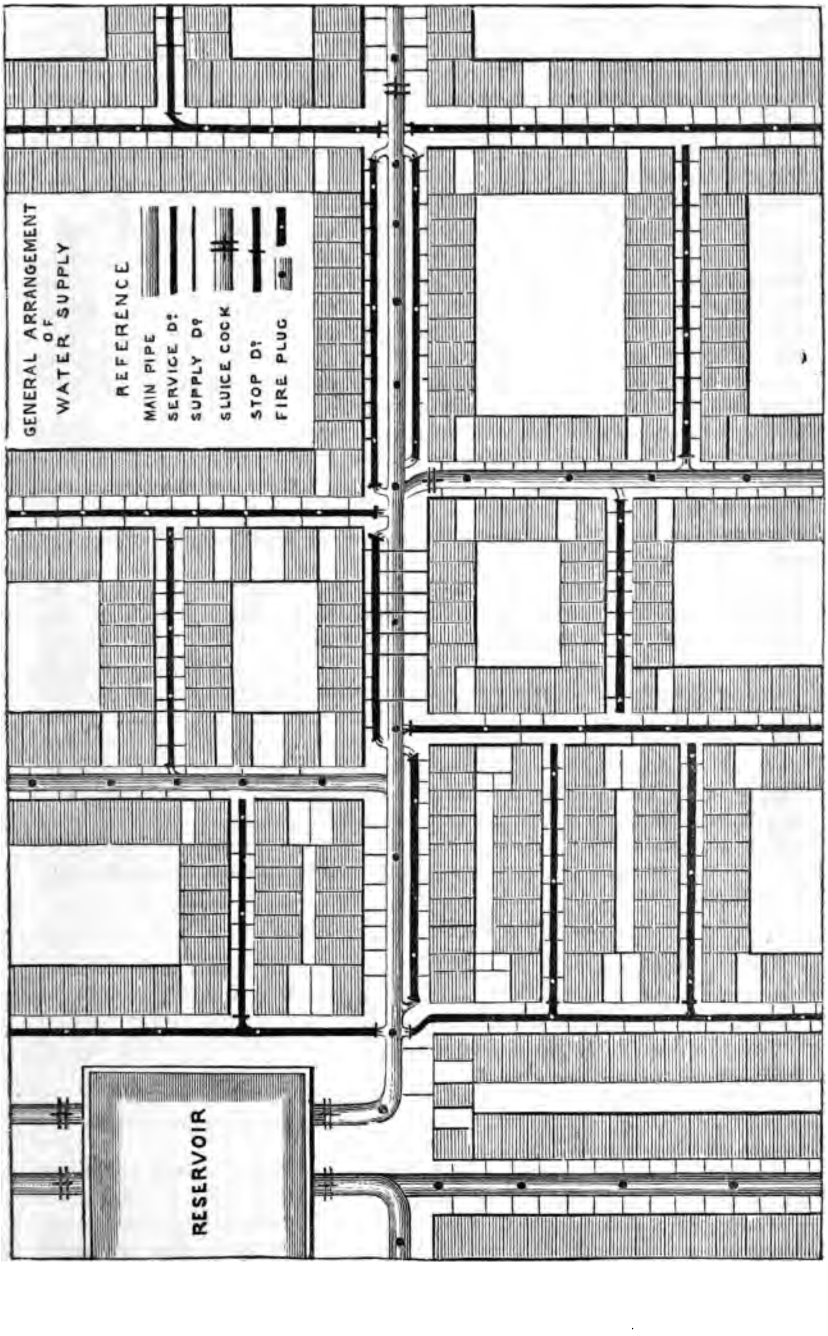
DISTRIBUTION.

FROM the reservoir, the water is distributed throughout the town or district by means of a series of pipes, which we term respectively mains, services, and supply-pipes.

The mains, or main-pipes, are the principal pipes which convey the water directly from the reservoir into the most central and important parts; the services, or service-pipes, are those which convey the water from the mains into the districts adjoining; and the supply-pipes are those which convey the water from the services into the houses.

A main-pipe, as a general rule, has no sluice-cocks, stop-cocks, or valves for shutting off the water, except such as are necessary for occasional use in case of repairs or other emergencies. In ordinary language, therefore, a main is understood to be a pipe always full of water under the full pressure of the source from which it is supplied.

A service-pipe usually passes through the streets of a block of buildings or other small district. It is attached directly to the main, but in the pipe which connects it, and close to the point of junction, there is a sluice, or stop-cock, by which the flow of water can be regulated, and if necessary stopped altogether.


GENERAL ARRANGEMENT
OF
WATER SUPPLY
REFERENCE
MAIN PIPE
SERVICE Dº
SUPPLY Dº
SLUICE COCK
STOP Dº
FIRE PLUG
RESERVOIR

A supply-pipe is a small pipe, generally of lead, connected directly with the service or the mains, and leading into the cistern of a house. It has, at its junction with the large pipe, no sluice-cock or other regulating apparatus, and is consequently, on almost all occasions, in about the same condition as the service-pipe. It has, however, generally at its upper end a cock, to which is attached a lever, with a hollow ball which floats on the water. This ball regulates the flow of the water into the cistern, allowing it to run freely while that in the cistern is low, but, when the latter rises, rising with it and shutting off the cock.

Such are the three kinds of pipe in ordinary use for conveying water from a reservoir to the houses of a town or district, and their arrangement, so far as it has been yet explained, would seem to be reasonably calculated to produce the desired result; but, unfortunately, few towns are constructed on any uniform plan or system which would ensure anything like similar advantages to their several parts, or which would render it easy to make provision for the supply of even an article of such universal and paramount necessity as water.

The consequence of this want of system is, that when a new district is created, there is usually but a choice between two courses in the matter now under consideration. The one is to run a new main from the reservoir through the district, and to connect with this main a sufficient number of service-pipes. The other is to attach a service-pipe to another service-pipe previously laid down.

The first cost of the former method may be heavy, and that of the latter comparatively trifling, and when such is the case, a saving of outlay in the first instance is almost invariably mistaken for true economy. Thus, in new districts, services are added on to services, and frequently, in direct opposition to all reasonable theory and sound practice, large pipes are added on to small, until, as time rolls on, neither the inhabitants of the houses, the municipal authorities, or even the officials of the waterworks, have any idea at all, however remote, as to the real state of the supply in any particular spot at any given time, and when an emergency occurs, the number and variety of measures to be adopted, every one of which may be of vital importance, tend to a confusion and liability to error, which at such a time may be attended with most disastrous consequences.

DURATION OF SUPPLY.

When the sluice-cocks are all kept open in the mains and services, the reservoir is continually supplying every cistern and tap connected with it, and consequently the latter, notwithstanding the numerous and sometimes heavy demands made on them, are always either full or partly full.

This is what is known as constant supply, and, where it prevails, the pipes may usually be assumed to be under the full pressure due to the height of the reservoir.

In many towns, however—whether from ignorance, sound economy, or mistaken parsimony, it is no part of the present subject to decide—the supply is not constant; that is to say, the sluice-cocks on the service-pipes are usually kept shut, and are opened only for one or two hours in every 24, or for such other period as those in charge consider necessary, with reference either to the capabilities of the supply, or the requirements of the locality, or, in the case of private companies supplying the water, as is frequently the case, with special reference to the time which they are paid for keeping it on.

The quantity required for each house, factory, or other place, being generally within certain limits about the same from day to day, it follows, as a matter of course, that the size of the supply-pipe and cock should be in indirect proportion to the duration of the supply. Thus, if the supply be constant, a pipe of any given size, running freely for 24 hours, may provide a sufficient quantity for the requirements during 12 hours, or such other period as may be allotted to the work; but if the water be allowed to run for only 12 hours, or half the time, it will require a pipe of twice the area to fill the cistern. The same rule holds good for any other period of time, so that, if the water be on for only one hour out of the 24, it would be necessary to have a pipe of 24 times the area or discharging capacity to accomplish the same result.

This is only one, and perhaps the least, of all the evils of an intermittent supply.

Another consequence of the intermittent system, and one much more serious when considered from our point of view, is the emptying or partial emptying of the cisterns at certain times, the effect of which is, that when water is suddenly allowed to run into the service-pipe from the main, instead of at once giving a full supply to the stand-pipes, hydrants, or fire-plugs on the ground level, it furnishes to these at first only a diminished quantity; the remainder passes on to fill the cisterns, and, until the last cistern has been filled to such a height that the ball has been floated up so as to close the cock, the full quantity is not delivered on the ground level.

As an example of one of the most prominent evils of the intermittent system, suppose a service-pipe to lead round a district or block of 200 buildings, each with a cistern capable of containing a supply of 250 gallons. Such a district would probably have the water turned on once in every twenty-four hours, and left running about one hour. In the ordinary course, it may be assumed that each cistern is only large enough to contain a sufficient supply for the house during the time when the water is turned off.

Now, supposing that the regular time for turning on the water were 10 o'clock in the morning, and a fire should happen at 9, let us see what the consequence would be. A turncock would immediately proceed to the sluice-cock and charge the service; a plug would be drawn or a hydrant opened on the ground level, and water would be seen to issue from it immediately, but instead of flowing as abundantly as might be expected, judging from the height of the reservoir and the size of the pipes, it would come with diminished pressure and velocity, and in reduced quantity, owing to a large portion finding its way into the 200 empty cisterns; for it must be remembered that water will rise to a great height in a pipe even when there is an opening on a low level, unless the opening be of considerable size in proportion to the area of the pipe.

Thus, in ordinary practice, in such a case as that assumed, the plug or hydrant, though commencing to discharge water immediately on being opened, would not deliver its full quantity until after it had first filled the whole of the 200 cisterns on various levels up to the points at which their respective ball-cocks would shut off the supply—in other words, the pipe would not yield a full and proper discharge through the plug or hydrant until it had first allowed some 50,000 gallons to escape into the cisterns.

It may be said, and, perhaps, with some approach to correctness, that so extreme a case as that here represented as an example does not often occur, at least to the full extent in all particulars; but it cannot be denied that it does occasionally happen, and it is an absolute certainty that, wherever there is an intermittent water supply, the *risk* occurs periodically, whether once or twice in each day, or at such other times as the local management arranges.

Much is done to obviate the consequences of this tremendous danger. The service-pipes are short and numerous, so that each one supplies only a small number of houses; they are made large in proportion to the size of the openings or hydrants; they are fitted with large sluice-cocks, the positions of which are marked by placards or signs in conspicuous places on the walls of houses opposite; skilled turncocks are provided, who, at the first alarm of fire, proceed at once to the spot indicated, open certain sluice-cocks, shut others, and take all such steps as in their judgment seems necessary; engines, with experienced men, are provided to pump up the water delivered on the ground levels, and thus supplement or supply over again a power which, almost invariably, is already supplied by the height of the reservoir, though not in an available form.

These, and other numerous devices, have been adopted for the purpose of reducing the dangers consequent on an intermittent supply; and many, if not all, have been attended with as much success as might be expected from any measures which deal with consequences only, and leave the cause untouched. But while full credit is given for all the efforts made to obviate the dangers, there still remains the fact that there are dangers to be obviated. In short, an intermittent supply involves dangers which, with great watchfulness, considerable expense, and unvarying good luck, may be to some extent reduced, but the system, as a system, is fatal to success in dealing with fires.

FIRE-PLUGS, HYDRANTS, &c.

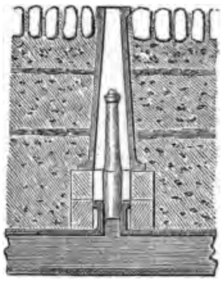
THE next point for consideration is the mode of obtaining access to the water.

The pipes are placed underground, and, in order to be safe from the effects of frost, ought to be at least four feet below the surface.

Those with which we have to deal in London are mounted at irregular distances, varying from 40 or 50 feet to 500 feet, or in some instances 1000 feet apart, with what are known as fire-plugs.

These fire-plugs consist, as their name expresses, of plugs or conical pieces of wood, which, when in use, are stuck into corresponding hollow iron sockets, cast on and forming part of the pipes, and these sockets communicate directly with the waterway inside.

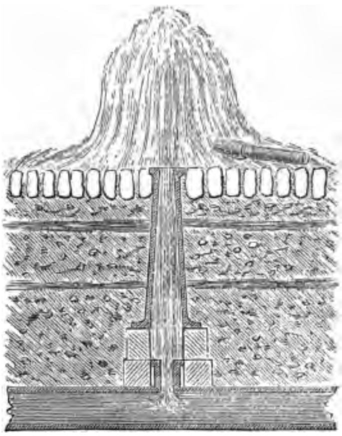
The socket is generally some two feet or so below the ground level, and the water is kept in simply by the conical plug being hammered



tightly into the tapered opening, but without any other fastening whatever. The top of the wooden plug stands below the street level, and is protected from injury above by a small iron plate or paving box, which, either partially or completely, covers the hole leading to the socket. The plug is also supposed to receive additional steadiness in its position and protection from frost by the hole being stuffed all round the head, and up to the street level, with horse litter or some such material, assumed to be a non-conductor; but, unfortunately for this theory, it occasionally happens that not only the pipe and plug become frozen together into a compact and rigid mass, but even, under certain circumstances—as when some water or damp has obtained access into the hole—the filthy stuffing itself becomes congealed into a solid block of ice, with something like the consistency of flint, which, placed as it is underground, can turn the point or end of any crowbar, and can frequently withstand all efforts made to break through it, until after the time has passed at which any advantage could be derived from obtaining access to the water.

In order to draw a plug, it is necessary for the turncock, as a general rule, first to pick out the stuffing, and after this to insert an end of one of the tools, and to pinch the head of the plug to either side, until the lower end or conical part becomes loose in the socket.

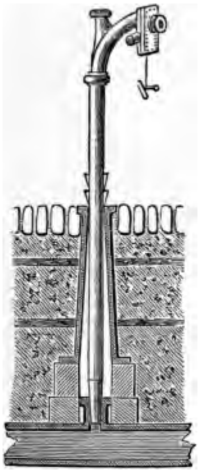
Then, if the pipe be charged under pressure, the wooden plug will fly out; but if the pipe be not charged, it is necessary to stick the pointed end of the tool known as the spoon into the top of the head, and by this means draw the plug within reach of the hand, and so remove it, after which the sluice-cock is opened to admit the water from the main.



For our ordinary purposes, it is usual to place over the plug-hole a canvass cistern or dam, with a hole in the bottom of about the same size as the street opening, to allow the water to run in and fill the dam, and then to pump it into an engine and out again, through hose, to wherever it is wanted.

When the water is used with the pressure of the main only, a stand-pipe is inserted, the lower end or shoe-piece fitting into the socket, and being secured by wedges driven in round it at the ground level or paving box; a hose is attached to the stand-pipe, and the water is forced through it by the pressure due to the height of the reservoir or source.

For the reasons already assigned, it is usually unsafe to trust to the pressure of the pipes in London during the early stages of a fire, and the custom is to let such water as is delivered on the ground level run into a dam, from which a pump can be supplied; and, after



a fire has been in some degree subdued, then to remove the dam and to insert a stand-pipe for cooling the ruins.

Cases occur when it is almost certain that the pipe is under sufficient pressure to do the required work, and when, nevertheless, a Fireman will, without a moment's hesitation or delay, allow the water to run into his dam, and pump it out again with such means as he has at his command, rather than risk the responsibility of adopting a course which might lead to consequences of a most disastrous character.

It may be that engines are sometimes set to work when the pressure of the pipes is quite sufficient without them; but I have always sedulously avoided giving any orders whatever on the subject, as I consider it a matter specially for the judgment and discretion of the senior present at the moment to decide what course he should adopt.

GENERAL PRINCIPLES.

WATER, like every other substance, is composed of a number of small particles, and, as already explained, these particles change their positions relatively to each other with the greatest possible ease, so that the whole readily takes any shape that may be required.

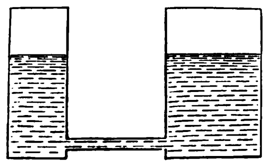
In this it differs considerably from solids, the particles of which do not readily change their relative positions; but there is another point in which it differs still more from solids, and that is the power of cohesion.

The power of cohesion is that force by which the particles composing a body are held together and kept in their places. It varies in degree to a very large extent in different substances, but it nevertheless exists absolutely in all solids of whatever kind.

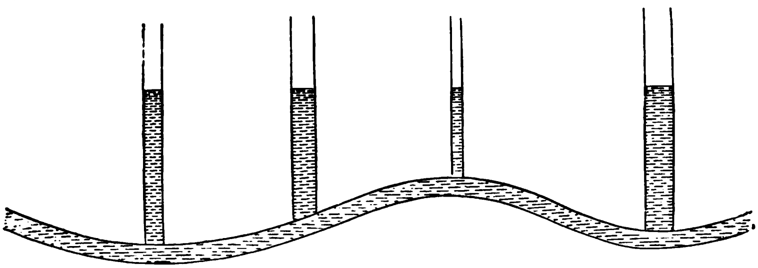
Now, in water, and all other liquids, the strength of the cohesion is so small, that very grave doubts exist as to whether there is any at all. In fact, the only proof that can be found of the presence of this power is the fact previously mentioned, that liquids, when scattered, form into drops.

Any liquid, when placed in a vessel or other enclosed space, has a tendency to arrange itself in such a way that all the particles composing its surface are at the same distance from the centre of the earth. This is what is commonly spoken of as the tendency of liquids to find their own level, and the law which governs it is one of considerable importance and universal application.

Thus, if two cisterns, at any distance apart, but on the same level, be connected together by an enclosed pipe, any liquid poured into one will



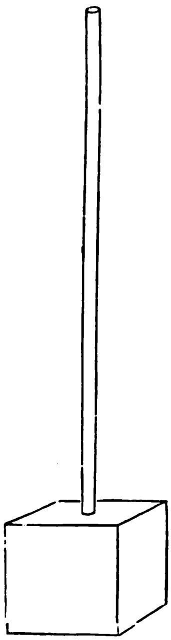
find its way into the other, provided that the connecting pipe does not rise too high, and when the supply is cut off, the surface will be found at the same level in both. This effect takes place even when the cisterns or vessels are of altogether different sizes, as, for instance, when one has an area of only a square inch, and the other an area of a square mile. Again, if water be placed in a pipe, or a set of pipes, connected throughout, and a set of rising or



vertical pipes be led out of these, the water will be found at the same level in all the vertical pipes.

The pressure of water at any spot is exactly in accordance with the height of the surface above that level, whether such height can be measured vertically or not.

A cubic inch of water weighs ·036,125 lb., and, if placed in a vessel with an area of 1 square inch, presses on the bottom of that vessel with a force equivalent to its weight. If a second cubic inch be added in the same vessel, the pressure is doubled; if a third be added the pressure is trebled, and so on for any other number. Thus it will be found that for each foot added the pressure is increased by ·434 lb., and that in such a vessel as that here described the pressure on the bottom is in fact exactly equal to the weight of the water.



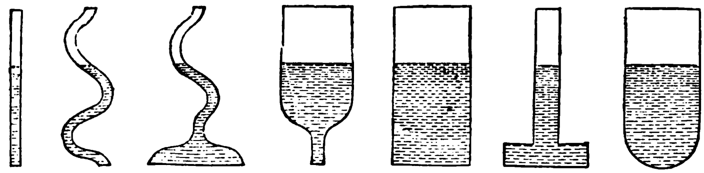
In addition, however, to the weight of the column on the base of the vessel, there is another force brought into operation by the tendency of liquid to spread sideways, and this force is always found at any particular depth to coincide exactly with that of the downward pressure. The effect of this is that, in such a vessel as that described, there is a pressure greatly in excess of the actual weight of the water.

Again, if the vessel be filled up and the top be closed in, a jet of water introduced under any given pressure will communicate that pressure to the whole of the interior.

This is a most important law of liquids, and is that made use of for the hydraulic press, in which a very small jet, easily worked by one man, is made to accumulate any required pressure upon a large surface.

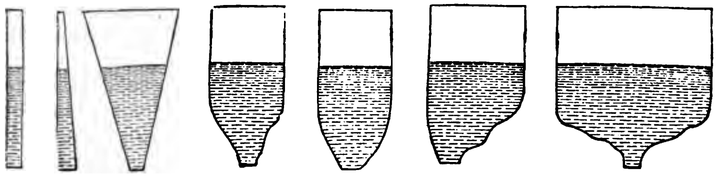
The pressure in an open vessel depends solely on the depth or difference of level, and, as before explained, this depth is calculated not alone vertically, but in any other way which will show the true difference of level between the surface of the vessel or reservoir and the point at which the pressure is to be taken.

Thus, if there be vessels of an infinite number of different shapes and capacities, all standing together on a table, and all filled with water to



the same level, the pressure on each square inch, or any other given superficial space, will be the same for each at the same height.

Again, if there be a thousand vessels standing together on the same level, each with an area of say one square inch at the lowest point, but all of different capacities—some narrowing to an almost imperceptible area on top, and others spreading to any imaginable size, say many



square miles—and they be all filled with water to the same height, the pressure will be found precisely alike on the bottoms of all, notwithstanding that some may contain only a few ounces of water, and others thousands of tons, the pressure of water, not covered in on the top, on the spot of any given space being due only to the difference of level between that spot and the surface, and not to any other cause whatever.

The total pressure of water on an open vessel of any regular shape, such as a cylinder or other vessel with parallel sides, is ascertained by multiplying that found at half the depth, which is the mean, by the area of that portion of the sides touched by the water, and adding to this that found at the bottom multiplied by the area of the base.

Thus, if a vessel of 6 inches square be filled with water to a height of 100 feet, there would be a pressure of 43·35 lbs. on each square inch of the bottom, and a mean pressure of half that, or 21·7, on each square inch of the sides, the pressure at half the depth being in any regular-sided vessel equal to the mean of the pressures at all the several depths.

A 6-inch square has an area of 36 inches, and this multiplied by the pressure, 43·35 lbs., comes to 1,560 lbs.

The quantity of water contained in the vessel is 36 × 1,200 = 43,200 cubic inches; which, multiplied by the weight of a cubic inch, ·0361,256 lbs., comes to 1,560 lbs.

Thus, it will be seen that there is on the bottom of the vessel a pressure exactly equal to the whole weight of the water, in the same way as if a solid substance of this weight were resting on the same space.

This, however, is by no means the whole pressure sustained by the vessel, as there is on the four sides combined an area of 28,800 square inches; and on the principle already explained the average or

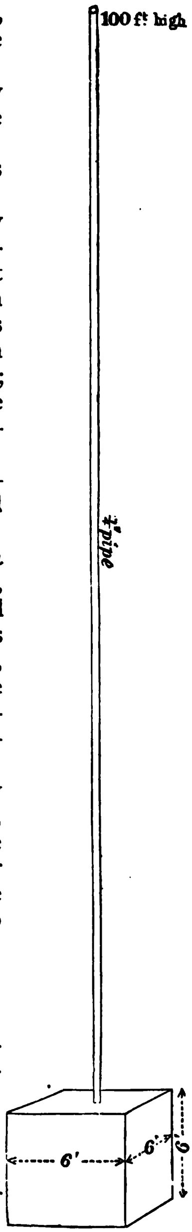
mean pressure on each square inch is 21·7 lbs., making altogether on the sides only, without the base, a pressure of 624,960 lbs.

Thus, while the total weight of the water is only 1,560 lbs., the pressure exerted by it under the circumstances here indicated would be 1,560 + 624,960 = 626,520 lbs., or upwards of 400 times the actual weight.

Again, if an enclosed vessel, of any capacity, say 6 feet cubic, be simply filled with water, the quantity contained would be 216 cubic feet; its weight would be 13,483 lbs.; its pressure on the bottom would be the area of the base in square inches multiplied by the pressure due to a 6-foot column of water, that is to say, 5,184 × 2·601 = 13,483 lbs.; its pressure on the sides would be the area of the four sides combined multiplied by the mean pressure on each square inch, that is to say, 20,736 × 1·3005 = 26,967 lbs., and there would be no pressure on the top. Thus, there would be a total pressure of 13,483 + 26,966 = 40,449 lbs.

If, when the vessel is under these conditions, a pipe be introduced, of any size, however minute, say with an area equal to ¼ of a square inch, and of indefinite length, and water be poured into this pipe until its surface stands at any given height, say 100 feet above the level of the base of the vessel, the pressure due to that height is conveyed to the base of the vessel, and a corresponding portion to the sides and top.

Thus it will be found that while the quantity added, namely 1,200 × ·25 = 300 cubic inches, weighs only 10·84, or under 11 lbs., a pressure has been produced equal to the area of the four sides, the bottom and the top, multiplied by the pressure of the column,—in other words, 7,776 × 43·35 = 337,090 lbs.



SUMMARY OF THE FOREGOING.

A quantity of water weighing under three-fourths of a ton, exerts, under certain circumstances, a pressure of about 370 tons.

A quantity of water weighing a little over 6 tons, and exerting a pressure of about 18 tons, can, by the addition of about 11 lbs. weight, in a certain manner be made to exert a pressure of upwards of 150 tons.

The two following tables give particulars concerning heads and pressures :—

TABLE *showing the heads of water due to certain pressures.*

Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.
1	2·31	51	117·65	101	232·98	151	348·32
2	4·61	52	119·95	102	235·29	152	350·63
3	6·92	53	122·26	103	237·60	153	352·94
4	9·23	54	124·57	104	239·90	154	355·24
5	11·53	55	126·87	105	242·21	155	357·55
6	13·84	56	129·18	106	244·52	156	359·86
7	16·15	57	131·49	107	246·82	157	362·16
8	18·45	58	133·79	108	249·13	158	364·47
9	20·76	59	136·10	109	251·44	159	366·78
10	23·07	60	138·41	110	253·74	160	369·08
11	25·37	61	140·71	111	256·05	161	371·39
12	27·68	62	143·02	112	258·36	162	373·70
13	29·99	63	145·33	113	260·66	163	376·00
14	32·29	64	147·63	114	262·97	164	378·31
15	34·60	65	149·94	115	265·28	165	380·62
16	36·91	66	152·25	116	267·59	166	382·92
17	39·22	67	154·55	117	269·89	167	385·23
18	41·52	68	156·86	118	272·20	168	387·54
19	43·83	69	159·17	119	274·51	169	389·84
20	46·14	70	161·47	120	276·81	170	392·15
21	48·44	71	163·78	121	279·12	171	394·46
22	50·75	72	166·09	122	281·43	172	396·76
23	53·06	73	168·39	123	283·73	173	399·07
24	55·36	74	170·70	124	286·04	174	401·38
25	57·67	75	173·00	125	288·35	175	403·68
26	59·98	76	175·31	126	290·65	176	405·99
27	62·28	77	177·62	127	292·96	177	408·30
28	64·59	78	179·93	128	295·27	178	410·60
29	66·90	79	182·23	129	297·57	179	412·91
30	69·20	80	184·54	130	299·88	180	415·22
31	71·51	81	186·85	131	302·19	181	417·53
32	73·82	82	189·15	132	304·49	182	419·83
33	76·12	83	191·46	133	306·80	183	422·14
34	78·43	84	193·77	134	309·11	184	424·45
35	80·74	85	196·07	135	311·41	185	426·75
36	83·04	86	198·38	136	313·72	186	429·06
37	85·35	87	200·69	137	316·03	187	431·37
38	87·66	88	203·00	138	318·33	188	433·67
39	89·96	89	205·30	139	320·64	189	435·98
40	92·27	90	207·61	140	322·95	190	438·29
41	94·58	91	209·92	141	325·25	191	440·59
42	96·88	92	212·22	142	327·56	192	442·90
43	99·19	93	214·53	143	329·87	193	445·21
44	101·50	94	216·84	144	332·17	194	447·51
45	103·80	95	219·14	145	334·48	195	449·82
46	106·11	96	221·45	146	336·79	196	452·13
47	108·42	97	223·76	147	339·09	197	454·43
48	110·72	98	226·06	148	341·40	198	456·74
49	113·03	99	228·37	149	343·71	199	459·05
50	115·34	100	230·68	150	346·02	200	461·35

Pressure in decimal parts of a lb. avoirdupois.	Head.		Pressure in decimal parts of a lb. avoirdupois.	Head.	
	In Feet.	In Inches.		In Feet.	In Inches.
·1	·23	2·76	·6	1·38	16·56
·2	·46	5·52	·7	1·61	19·32
·3	·69	8·28	·8	1·85	22·20
·4	·92	11·04	·9	2·08	24·96
·5	1·15	13·80			

TABLE *showing the pressure of water, under various heads.*

Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.
1	0·43	51	22·11	101	43·78	151	65·46
2	0·87	52	22·54	102	44·22	152	65·89
3	1·30	53	22·98	103	44·65	153	66·33
4	1·73	54	23·41	104	45·08	154	66·76
5	2·17	55	23·84	105	45·52	155	67·19
6	2·60	56	24·28	106	45·95	156	67·63
7	3·03	57	24·71	107	46·39	157	68·06
8	3·47	58	25·14	108	46·82	158	68·49
9	3·90	59	25·58	109	47·25	159	68·93
10	4·34	60	26·01	110	47·69	160	69·36
11	4·77	61	26·44	111	48·12	161	69·79
12	5·20	62	26·88	112	48·55	162	70·23
13	5·64	63	27·31	113	48·99	163	70·66
14	6·07	64	27·74	114	49·42	164	71·10
15	6·50	65	28·18	115	49·85	165	71·53
16	6·94	66	28·61	116	50·29	166	71·96
17	7·37	67	29·04	117	50·72	167	72·40
18	7·80	68	29·48	118	51·15	168	72·83
19	8·24	69	29·91	119	51·59	169	73·26
20	8·67	70	30·35	120	52·02	170	73·70
21	9·10	71	30·78	121	52·45	171	74·13
22	9·54	72	31·21	122	52·89	172	74·56
23	9·97	73	31·65	123	53·32	173	75·00
24	10·40	74	32·08	124	53·75	174	75·43
25	10·84	75	32·51	125	54·19	175	75·86
26	11·27	76	32·95	126	54·62	176	76·30
27	11·70	77	33·38	127	55·06	177	76·73
28	12·14	78	33·81	128	55·49	178	77·16
29	12·57	79	34·25	129	55·92	179	77·60
30	13·01	80	34·68	130	56·36	180	78·03
31	13·44	81	35·11	131	56·79	181	78·46
32	13·87	82	35·55	132	57·22	182	78·90
33	14·31	83	35·98	133	57·66	183	79·33
34	14·74	84	36·41	134	58·09	184	79·77
35	15·17	85	36·85	135	58·52	185	80·20
36	15·61	86	37·28	136	58·96	186	80·63
37	16·04	87	37·72	137	59·39	187	81·07
38	16·47	88	38·15	138	59·82	188	81·50
39	16·91	89	38·58	139	60·26	189	81·93
40	17·34	90	39·02	140	60·69	190	82·37
41	17·77	91	39·45	141	61·12	191	82·80
42	18·21	92	39·88	142	61·56	192	83·23
43	18·64	93	40·32	143	61·99	193	83·67
44	19·07	94	40·75	144	62·43	194	84·10
45	19·51	95	41·18	145	62·86	195	84·53
46	19·94	96	41·62	146	63·29	196	84·97
47	20·37	97	42·05	147	63·73	197	85·40
48	20·81	98	42·48	148	64·16	198	85·83
49	21·24	99	42·92	149	64·59	199	86·27
50	21·68	100	43·35	150	65·03	200	86·70

TABLE *showing the pressure of water, under various heads.—Continued.*

Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.	Height in feet.	Pressure in lbs.
201	87·13	251	108·81	301	130·49	351	152·16
202	87·57	252	109·24	302	130·92	352	152·59
203	88·00	253	109·68	303	131·35	353	153·03
204	88·44	254	110·11	304	131·79	354	153·46
205	88·87	255	110·54	305	132·22	355	153·90
206	89·30	256	110·98	306	132·65	356	154·33
207	89·74	257	111·41	307	133·09	357	154·76
208	90·17	258	111·84	308	133·52	358	155·20
209	90·60	259	112·28	309	133·95	359	155·63
210	91·04	260	112·71	310	134·39	360	156·06
211	91·47	261	113·15	311	134·82	361	156·50
212	91·90	262	113·58	312	135·25	362	156·93
213	92·34	263	114·01	313	135·69	363	157·36
214	92·77	264	114·45	314	136·12	364	157·80
215	93·20	265	114·88	315	136·55	365	158·23
216	93·64	266	115·31	316	136·99	366	158·66
217	94·07	267	115·75	317	137·42	367	159·10
218	94·50	268	116·18	318	137·86	368	159·53
219	94·94	269	116·61	319	138·29	369	159·96
220	95·37	270	117·05	320	138·72	370	160·40
221	95·81	271	117·48	321	139·16	371	160·83
222	96·24	272	117·91	322	139·59	372	161·26
223	96·67	273	118·35	323	140·02	373	161·70
224	97·11	274	118·78	324	140·46	374	162·13
225	97·54	275	119·21	325	140·89	375	162·57
226	97·97	276	119·65	326	141·32	376	163·00
227	98·41	277	120·08	327	141·76	377	163·43
228	98·84	278	120·52	328	142·19	378	163·87
229	99·27	279	120·95	329	142·62	379	164·30
230	99·71	280	121·38	330	143·06	380	164·73
231	100·14	281	121·82	331	143·49	381	165·17
232	100·57	282	122·25	332	143·92	382	165·60
233	101·00	283	122·68	333	144·36	383	166·03
234	101·44	284	123·12	334	144·80	384	166·47
235	101·87	285	123·55	335	145·23	385	166·90
236	102·31	286	123·98	336	145·66	386	167·33
237	102·74	287	124·42	337	146·09	387	167·77
238	103·17	288	124·85	338	146·53	388	168·20
239	103·61	289	125·28	339	146·96	389	168·63
240	104·04	290	125·72	340	147·39	390	169·07
241	104·48	291	126·19	341	147·83	391	169·50
242	104·91	292	126·58	342	148·26	392	169·93
243	105·34	293	127·02	343	148·69	393	170·37
244	105·78	294	127·45	344	149·13	394	170·80
245	106·21	295	127·88	345	149·56	395	171·24
246	106·64	296	128·32	346	149·99	396	171·67
247	107·08	297	128·75	347	150·43	397	172·10
248	107·51	298	129·19	348	150·86	398	172·54
249	107·94	299	129·62	349	151·29	399	172·97
250	108·38	300	130·05	350	151·73	400	173·40

Height in inches.	Pressure. Lbs. avoirdupois.	Height in inches.	Pressure. Lbs. avoirdupois.
1	·04	7	·25
2	·07	8	·29
3	·11	9	·33
4	·14	10	·36
5	·18	11	·40
6	·22	12	·43

This part of the subject has been treated at great length, and in considerable detail, for the purpose of explaining thoroughly the principles on which the transmission of force or pressure through a liquid body depends, and thus facilitating the general comprehension of certain natural laws, by which many of the most important operations of our business are regulated.

THE FLOW OF WATER IN PIPES.

THE quantity of water passing through a pipe is in all cases equal to the area of the pipe at its smallest part, multiplied by the velocity of the water at the same spot.

In ordinary cases the area is easily ascertained, but the velocity depends on many conditions—such as the pressure, the height of the head, the lay of the pipe, the smoothness or roughness of the internal surface of the pipe, the perfection or imperfection of the joints, and the constancy or inconstancy of the supply.

The supply in any given pipe is in direct proportion to the head—that is to say—the higher the head is, the greater will be the quantity of water delivered. The quantity, however, though in direct proportion, is by no means in full proportion to the height of the head; on the contrary, it will be in the proportion of the square root of the head: thus, if there be two heads, one with an elevation of 9 feet, and the other with an elevation of 16 feet, the velocities in pipes of any given area and position will be in the proportion, not of 9 to 16, but of about 3 to 4.

The velocity is also much influenced by the lay of the pipe, being greatest when the pipe is altogether vertical, least when the pipe is most nearly horizontal, and intermediate for all intermediate positions, such as those which are found when a pipe is laid with bends of greater or less magnitude, angles of greater or less sharpness or obtusity, zig-zag, spiral, or other turns, whether in a horizontal or vertical direction, but more particularly the latter, and sudden or easy reductions of area. It is also very considerably influenced by the length of the pipe, being in inverse proportion to it in all cases in which the pipe is not vertical.

The cause of this influence is one which does not readily strike the student approaching the subject for the first time, but which becomes very soon apparent when the nature of the several objects in question is duly considered.

If a body of any kind be set in motion with any given velocity, it has a natural tendency to travel in a certain direction, as the result of the excess of force or combination of forces propelling it over those which counteract or retard its progress, and unless the propelling power is kept up continuously, or in some degree, the tendency of the body to continue its motion undergoes a gradual diminution until finally it ceases altogether. Now a change of direction cannot be effected without the introduction of another force to counteract, in some degree, that previously employed, and, consequently, to reduce its power.

The change of direction in a stream of the kind now under consideration is usually effected by making a bend in the pipe, and the water, by impinging on this bend, becomes to a certain extent obstructed, and not only moves forward at a reduced rate of speed, but also retards the remaining portion of the stream between the obstruction and the source, and thus diminishes the velocity of the whole, and consequently the quantity passing through.

Thus it will be seen that the obstruction is in direct proportion to the number and nature of the turns of the pipe, and that it is greatest when the direction of the channel is most changed, and when the change is effected in the most abrupt manner, as in the case of a very acute angle in a pipe.

A sudden reduction of area also causes an obstruction, by making the particles composing the water form into eddies and cross-currents not parallel to the axis of the whole stream.

The length of the pipe causes obstruction in the following way:—

When two bodies of any kind are placed in contact, there is a certain tendency in them to adhere to each other, or at least to remain together and to resist any attempts made to move them one on the other. This is the force or power commonly known as friction, and its influence, though varying in degree with the nature, position, and other circumstances of various materials, is, nevertheless, universally felt with all substances, of whatever kind, whether solid, liquid, or gaseous.

This retarding force is usually in direct proportion to the surface of contact, and the force by which the two bodies are pressed together. There are exceptions to this rule, as in the case of one body having a point or sharp edge, which, though occupying a small area at the point of contact, nevertheless causes an extreme obstruction or resistance. Such exceptions, however, occur only with solids, and need not be taken into account when dealing with liquids or gases, both of which are invariably obstructed in direct proportion to their surface of contact with any other body, over or by which they have to pass.

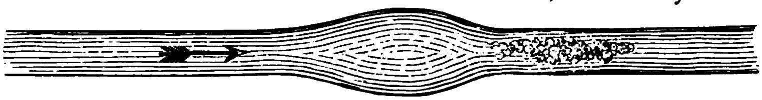
Water flowing in a pipe is obstructed by friction at every portion which it touches, and consequently, in a full pipe, it is retarded by a power equal to the internal circumference of the pipe multiplied by the length, and, therefore, the longer the pipe is, the greater must be the obstruction. It is true, as already mentioned, this force does not appear to diminish the quantity of water delivered by a straight vertical pipe; it exists, however, in a pipe thus situated, precisely as in any other, but in this case there is another force—namely, the accelerating effect of gravity in a falling body—which is so much in excess of the retarding power of friction, that, in such a case as that here represented the latter is likely to be ignored unless special attention is called to it.

The circumferences of circles are in direct proportion to their respective diameters, but their areas are in proportion to the squares of their diameters; thus, if there be two circles, one with a diameter of six inches, and the other with a diameter of three inches, the proportions of their circumferences will be as 6 to 3, or as 2 to 1, whereas their areas will be in the proportion of 36 to 9, or as 4 to 1.

From this it will be seen, that when the diameter of a circular pipe is doubled, the circumference or surface of contact is only doubled, whereas the area or space allowed for the volume of water to pass through is quadrupled, the result being that the friction is reduced by one-half.

Thus, it will be seen that, the larger a pipe is, the less effect the friction will have on water with any given head.

It is, however, to be observed that the enlargement of a pipe for a short distance is an expedient of very doubtful advantage, inasmuch as its primary effect is to make certain particles of the water change their direction, and consequently lose some portion of their force; and this is more particularly the case when the area has to be again reduced to its original size, as the particles have then not only to change their direction a second time, but in doing so have to cross each other, and thereby cause a



disturbance or obstruction which retards the progress of the whole stream.

From what has already been said, it will also be apparent that if a pipe be roughly or unevenly formed inside, or if the inner edges of the joints be not truly fitted and smoothly finished off, much obstruction may be produced, and the velocity, and consequently the quantity passing through, may be diminished in a corresponding degree.

It has been previously mentioned that the pressure of water in a vessel, pipe, or reservoir, open at the top, is in exact proportion to the height of the head or difference of level between the surface and the point at which the pressure is taken. It has also been mentioned that the quantity of water delivered from any given pipe will be in direct, though not full, proportion to the head.

It must, however, be remembered that the first of these rules refers to water in a state of rest, and the second to the same substance in a state of motion; and that if water at any given spot be set running free, as through a cock or tap, the pressure becomes thereby to a considerable extent relieved, and unless a corresponding increase of force, whether by gravitation, machinery, or other cause, be added, the velocity of the issuing stream may be much less than might be expected from the original pressure. Again, if any of the causes previously mentioned exist —such as sudden contractions, reduced areas, or excessive friction—the delivery may not be at all in proportion to the original pressure.

Thus, in a vertical pipe 100 feet long, with an area of 3 square feet, mounted with a sluice-valve at the upper end leading from a reservoir, and stopped with a cap and pressure-gauge below, if the sluice-valve be opened to the extent of a thousandth part of an inch, it will be found that the pressure on the gauge will show 43·35 lbs. in precisely the same manner as if the sluice-valve were removed; the quantity of water, however, which would run out in any given time after the removal of the cap would be very much less than if the valve were full open.

There is an empirical calculation for the velocity of water under various heads, which, though on no account to be relied on in cases of any importance, may, nevertheless, serve as a rough guide for approximate maximum quantities under certain circumstances. It is to the effect that the velocity in feet per second is equal to eight times the square root of the head.

Thus, if there be a head of 36 feet, it is calculated that the velocity of the issuing stream should be $6 \times 8 = 48$ feet per second; or if there be a head of 25 feet, the velocity shou.d be $5 \times 8 = 40$ feet per second.

The quantity delivered is then calculated, as already pointed out, by multiplying the area of the pipe by the velocity; but it is obvious that, unless the whole of the inside of the pipe were examined, and all bends and other obstructions fully taken into consideration and allowed for, the result arrived at would be almost certain to prove erroneous.

TABLE OF THE DISCHARGE OF WATER FROM PIPES.

Calculated on the Empirical Rule that 8 times the square root of the head in feet will be the velocity in feet per second.

Head.	Velocity.	Head.	Velocity.	Head.	Velocity.	Head.	Velocity.	Head.	Velocity.	Head.	Velocity.
1	8·00	51	57·13	101	80·40	151	98·31	201	113·42	251	126·74
2	11·31	52	57·69	102	80·80	152	98·63	202	113·70	252	127·00
3	13·86	53	58·24	103	81·19	153	98·95	203	113·98	253	127·25
4	16·00	54	58·79	104	81·58	154	99·28	204	114·26	254	127·50
5	17·89	55	59·33	105	81·98	155	99·60	205	114·54	255	127·75
6	19·60	56	59·87	106	82·37	156	99·92	206	114·82	256	128·00
7	21·17	57	60·40	107	82·75	157	100·24	207	115·10	257	128·25
8	22·63	58	60·93	108	83·14	158	100·56	208	115·38	258	128·50
9	24·00	59	61·45	109	83·52	159	100·88	209	115·65	259	128·75
10	25·30	60	61·97	110	83·90	160	101·19	210	115·93	260	129·00
11	26·53	61	62·48	111	84·29	161	101·51	211	116·21	261	129·24
12	27·71	62	62·99	112	84·66	162	101·82	212	116·48	262	129·49
13	28·84	63	63·50	113	85·04	163	102·14	213	116·76	263	129·74
14	29·93	64	64·00	114	85·42	164	102·45	214	117·03	254	129·98
15	30·98	65	64·50	115	85·79	165	102·76	215	117·30	265	130·23
16	32·00	66	64·99	116	86·16	166	103·07	216	117·58	266	130·48
17	32·98	67	65·48	117	86·53	167	103·38	217	117·85	267	130·72
18	33·94	68	65·97	118	86·90	168	103·69	218	118·12	268	130·97
19	34·87	69	66·45	119	87·27	169	104·00	219	118·39	269	131·21
20	35·78	70	66·93	120	87·64	170	104·31	220	118·66	270	131·45
21	36·66	71	67·41	121	88·00	171	104·61	221	118·93	271	131·70
22	37·52	72	67·88	122	88·36	172	104·92	222	119·20	272	131·94
23	38·05	73	68·35	123	88·72	173	105·22	223	119·47	273	132·18
24	39·19	74	68·82	124	89·08	174	105·53	224	119·73	274	132·42
25	40·00	75	69·28	125	89·44	175	105·83	225	120·00	275	132·66
26	40·79	76	69·74	126	89·80	176	106·13	226	120·27	276	132·91
27	41·57	77	70·20	127	90·16	177	106·43	227	120·53	277	133·15
28	42·33	78	70·65	128	90·51	178	106·73	228	120·80	278	133·43
29	43·08	79	71·11	129	90·86	179	107·03	229	121·06	279	133·63
30	43·82	80	71·55	130	91·21	180	107·33	230	121·33	280	133·87
31	44·54	81	72·00	131	91·56	181	107·63	231	121·59	281	134·10
32	45·25	82	72·44	132	91·91	182	107·93	232	121·85	282	134·34
33	45·96	83	72·88	133	92·26	183	108·22	233	122·11	283	134·58
34	46·65	84	73·32	134	92·61	184	108·52	234	122·38	284	134·82
35	47·33	85	73·76	135	92·95	185	108·81	235	122·64	285	135·06
36	48·00	86	74·19	136	93·30	186	109·11	236	122·90	286	135·29
37	48·66	87	74·62	137	93·64	187	109·40	237	123·16	287	135·53
38	49·32	88	75·05	138	93·98	188	109·69	238	123·42	288	135·76
39	49·96	89	75·47	139	94·32	189	109·98	239	123·68	289	136·00
40	50·60	90	75·89	140	94·66	190	110·27	240	123·94	290	136·24
41	51·22	91	76·32	141	94·99	191	110·56	241	124·19	291	136·47
42	51·85	92	76·73	142	95·33	192	110·85	242	124·45	292	136·70
43	52·46	93	77·15	143	95·67	193	111·14	243	124·71	293	136·94
44	53·07	94	77·56	144	96·00	194	111·43	244	124·96	294	137·17
45	53·67	95	77·97	145	96·33	195	111·71	245	125·22	295	137·40
46	54·26	96	78·38	146	96·66	196	112·00	246	125·48	296	137·64
47	54·85	97	78·79	147	96·99	197	112·29	247	125·73	297	137·87
48	55·43	98	79·20	148	97·32	198	112·57	248	125·98	298	138·10
49	56·00	99	79·60	149	97·65	199	112·85	249	126·24	299	138·33
50	56·57	100	80·00	150	97·98	200	113·14	250	126·49	300	138·56

This table shows the quantities which straight pipes of certain sizes may be expected to deliver under various heads, but it is to be particularly understood, that the figures express only the maximum quantities which, under favourable circumstances, may be expected to be discharged, and that no deductions should be made from them concerning any given pipe, unless it is known to be placed under conditions of the most favourable kind.

The amount of obstruction from oxydation, accumulation of dirt, and other causes, in a pipe which has been a long time under the ground, is quite incalculable; in fact, there are cases in which it amounts to a complete stoppage.

The only safe mode, therefore, of calculating what quantity of water any given pipe will vent, is to let the water run into a gauged tank, and at fixed periods of time to read off the gauge, and thus actually see the quantity delivered.

ELASTICITY OR COMPRESSIBILITY.

It has been already mentioned that there is, in almost all substances, a certain amount of elasticity or compressibility.

Many solids can, on the application of force, be made to contract or expand, some very slightly, others to a considerable degree; and all gaseous bodies are easily acted on in this way.

Water can, on the application or withdrawal of heat, be made to change its volume to some extent; thus, the bulk of a body of water raised from the temperature of melting ice, 39°·1 Fahrenheit, to that of boiling, 212° Fahrenheit, is increased by an addition of ·04775, or nearly 1/20th of its original volume; and water lowered in temperature from 212° to 39°·1 undergoes a corresponding diminution in bulk.

It is said by some that water is compressible, in fact, one of the greatest modern authorities on the subject goes so far as to assert that the vertical circulation of the sea depends, not altogether, but to some extent, on the tendency which the water in the depths of the ocean has to expand, in consequence of the compression to which it has been subjected by the mass above. But, besides this, which can be only mere theory, and may possibly be incorrect, there is the authority resulting from experiments, which go to prove that water has been compressed by mechanical power.

It is said that, on the application of a great force on the surface, water will undergo a compression to a very small extent.

The mere statement, however, of the extremely small result effected by an enormous amount of power, must in itself suggest grave doubts as to the precise accuracy of the experiment, if made with machinery constructed of metal, or any material in ordinary use for such purposes.

It is hardly too much to say, that nearly all these materials with which we are acquainted are, to a certain extent, porous. Gas easily finds its way through metal of almost any thickness—not to any great extent, certainly, but in sufficient quantity to be plainly perceptible to at least one of the senses; and water is known to ooze freely through iron and steel boiler-plates under certain pressures, and to leave on the outside a damp perceptible to the sight and touch. Similar results also take place in glass and glazed vessels, not perhaps to the same extent, but sufficiently to show that they are porous. Thus, when it is necessary to make a calculation of their contents to an extreme point of minuteness, although the principle may be proved, it is impossible to accept the details without a certain feeling of distrust. Again, it must be stated, that other authorities concur in asserting that water is not compressible at all, but, as their meaning probably is that they have never seen it compressed, it is as necessary to caution the student against placing reliance on this theory as on the details of the other. In order to arrive at an accurate conclusion on a subject of this kind, other elements of the question must be taken into consideration. First of all comes the known fact, or at least the universally adopted opinion, that in almost all water there is a certain admixture of air, however small, and if this be correct, it follows, as a matter of course, that the substance compressed is not water, but a mixture of water and air. Secondly, there must be a doubt as to the perfection or imperfection of the mechanical appliances used for the experiment, of whatever material they be made, as it is not only quite possible to suppose, but it is moreover in accordance with our own experience, that a metal or other material composing the vessel might allow a portion of water to leak through, or might itself stretch to the very small extent necessary for giving the increased capacity within. For these and other reasons which will suggest themselves, it is advisable for the student neither to accept blindly nor reject absolutely either of these two discordant views, but simply to remember that there are advocates of both, and that, however widely these differ in principle or theory, they nevertheless all agree in believing that, in order to effect a change in the bulk of water at ordinary temperatures, it is necessary to apply to it a pressure enormously in excess of any which we use in the course of our business. After this detailed statement of such information as it is necessary to give on the subject, it may be laid down as a rule, which every Fireman may safely act upon, that, so far as refers to our business, cold water is absolutely incompressible.

Memoranda.—By an old Act of Parliament, which has been repealed, a gallon was that quantity of water which had a volume or capacity of 277·274 cubic inches. *Now* a standard or imperial gallon is that volume of distilled or pure water which, when the thermometer stands at 62° Fahrenheit, and the barometer at 30 inches of mercury, weighs 10lbs. avoirdupois.

It contains 277·123 cubic inches, or 0·160372 of a cubic foot.

Specific gravity of pure water	... ...	1·000
——— Do. ——— ice	... ...	0·94
——— Do. sea water	... ...	1·026

Mud and excessive quantities of salt increase the specific gravity.

The greatest density of water is at a temperature of 39° 38′ Fahrenheit, after which it becomes lighter, until it is reduced to the freezing point, 32° Fahrenheit, and then ice is formed. The least density of water is at 212° Fahrenheit, or boiling point, after which it becomes converted into vapour.

Water expands $\frac{1}{3808}$ of its bulk for every degree of heat, and $\frac{1}{17}$th of its bulk in freezing.

If an enclosed vessel be filled with water at a temperature of 39° 38′ Fahrenheit, and afterwards subjected to such conditions that the temperature is raised to 212°, or lowered to 32°, the vessel must either expand or burst.

Weights of distilled or pure water at the temperature of the atmosphere:

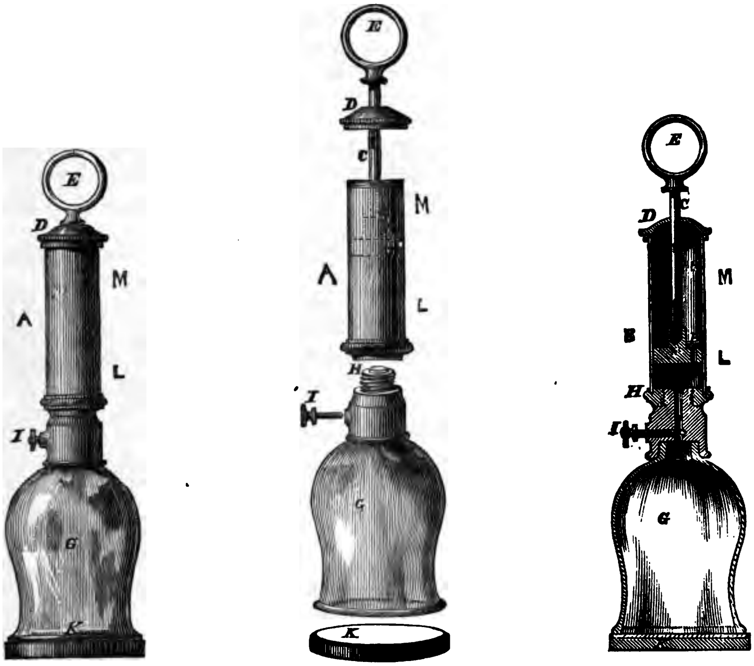
1 cubic inch	0·036·125 lbs.	11·2 gallons	1 cwt.
1 cubic foot	62·425 lbs.	224 gallons	1 ton.
1 gallon	10 lbs.		

PUMPS

PUMPS are machines for the removal and transmission of fluid substances. Air pumps are principally used for the former of these purposes only, but water pumps are in general available for both.

AIR PUMP.

The following is a description of an air pump of the most simple kind, which I have been in the habit of using for the purpose of instruction :—



It consists of a brass cylinder A, with an internal diameter of $\frac{11}{16}$ths of an inch, inside which a closely-fitting piston or plug B can be moved up and down by means of a rod C, which passes through a loose stuffing-box or guide piece D on top, and is mounted at its end with a ring handle E.

In the piston there is a small valve or door F, which opens freely upwards when pressed from below, and allows liquid or fluid substances to pass through, but, when the pressure ceases, falls back into its place, and allows nothing to return.

There is a glass chamber or vessel G fitted on top with a similar valve H, which allows anything to pass upwards but not to return, and underneath this valve there is a small screwed plug I for the admission of air, when necessary.

The lower edge or lip of the chamber is truly ground, and there is a circular piece of glass K also truly ground, which, if placed over the lower end, touches the lip all round.

The cylinder has at its lower end a small female screw, which fits on a corresponding male screw on the top of the chamber.

To use the Pump.—Screw the cylinder on to the upper end of the chamber, place the ground glass over the lower opening, and move the piston to the lowest point L. The enclosed space from the glass cover K to the piston B will contain air of the same consistency and pressure as the external atmosphere.

Move the piston up to its highest point M, and this air expands and fills the chamber, and the whole of the cylinder up to that point, but, as the ground glass K prevents any air passing in below, that which is enclosed becomes attenuated, and consequently there is a greater pressure on the outside of the vessel than on the inside.

Move the piston down to L, and the attenuated air between M and L, being prevented by the valve H from returning into the large chamber, will escape through the valve in the piston, and there will then remain in the chamber and the lower part of the cylinder a quantity of air equal in bulk to that which was there at first, but of less density.

Move the piston upwards again to M, and the air becomes further attenuated, and move it down again to allow a portion to escape.

If this movement be continued, the air at each upward stroke will become more attenuated, and at each downward stroke will partly escape, until after some time the remaining quantity will become attenuated to such a degree that it will be too weak any longer to lift the lower valve.

When this has been accomplished the pump ceases to act, as its sole power consists in taking advantage of the elasticity of the air, and, when this becomes reduced to such a point that it will no longer lift the lower valve, the vacuum, though by no means perfect, is as complete as it can be made with machinery of the kind here described.

The pump may now be unscrewed from the top and removed, and it will be found that the glass cover K is firmly attached to the chamber, and cannot be pulled off without considerable difficulty, being forced against the lip with a power equal to the area of the lower end of the chamber in square inches multiplied by the pressure of the external atmosphere in lbs. on each square inch.

Thus, if the area of the opening or lower end of the chamber be, as in the present case, equal to a space of $3\frac{1}{2}$ square inches, and the atmosphere be assumed to be at its lowest point of pressure, 14 lbs. on each square inch, it will be found that the removal of the air from the chamber has the effect of causing an unbalanced pressure of about 49 lbs. on the outside above that on the inside, and that consequently the glass cover K is firmly fixed on to the lip, and cannot be removed or with. drawn without the application of a force of almost that amount (49 lbs-) exerted in an opposite direction. The reason of the necessary force being somewhat less than 49 lbs., is that, as already explained, the air cannot be altogether removed by a pump arranged in the way here described, and that consequently the vacuum inside is not quite perfect.

This experiment should be frequently repeated, the student each time pulling off the glass cover, until he becomes practically acquainted with the pressure by observing the force which he is obliged to exert in order to counteract it.

After this a vacuum should be again formed inside, but, instead of the lid being pulled off by force, the small plug I should be slowly unscrewed, and it will be found that, before it has been withdrawn to the very trifling extent of the space between two or three of its small threads, and long before its inner end or point is visible, the lid will fall off, thus plainly showing the elastic power of the atmosphere, and the extreme minuteness of its particles, which can instantly penetrate through an opening so small as to be quite imperceptible to the senses, and can fill the chamber in less time than would be consumed in pouring a similar quantity of water into an open vessel of the same size.

This experiment also should be repeated, until the student thoroughly understands the rapid action and penetrating power of the atmosphere in such a case.

The air pump may then be worked with the plug-hole imperfectly closed—that is to say, with the plug I not fully screwed home—and it will be found that a vacuum, or partial vacuum, will be formed sufficient to keep the lid on so long as the pump is kept working, but that, the moment the pump stops, the lid will fall off.

Again, the pump may be worked with the plug I drawn, and, although the pump itself is performing precisely the same operation as before —namely, passing upwards all the air which it receives—it will be found that, notwithstanding this, no vacuum is formed, inasmuch as the plug-hole allows the air to pass in more rapidly than the pump discharges it.

These latter experiments will show that, under certain circumstances, a pump may be able to overcome a very slight leak so long as the piston is kept moving rapidly, but that practically there is a point beyond which it has no power to counteract the effects of the atmosphere rushing in through a hole.

A complete knowledge of the use of this little apparatus will greatly facilitate some of the subsequent studies, particularly those connected with the feeding of pumps by atmospheric pressure, or, as it is commonly called, suction.

Pumps for Water and other Liquids.

Machines for the removal and transmission of water and other liquids are commonly known as pumps.

Every pump performs two actions, namely, receiving and delivering.

Pumps are principally of two kinds with regard to their supply, but of many kinds with regard to their discharge or delivery.

A pump is filled with water either by the pressure of the atmosphere or by gravitation. In the former case it is called an atmospheric or suction pump, and in the latter case a pump not fed by means of atmospheric pressure.

With regard to its discharge, a pump may consist of a hollow piston moving in a fixed cylinder, a solid piston moving in a fixed cylinder, a projection from a central axis moving round a partly cylindrical chamber, a wheel flying round a circular-chamber, and discharging the liquid by centrifugal force, and a variety of other contrivances, some the mere converse of those mentioned, as for instance a cylinder moving on a fixed piston, and some a combination of several others, as a hollow and solid piston combined, a mere rod or trunk working through a hole and causing displacement by its bulk, and many others which, though apparently different, are in reality dependent on the same principles.

A hollow piston is a piston or plug containing in it a valve through which water or other liquid may pass freely in one direction, usually upwards, but may not return, and a machine worked with a piston of this kind is commonly called a lift-pump, inasmuch as the liquid gets above the piston and is lifted away. This kind of piston is occasionally called a bucket.

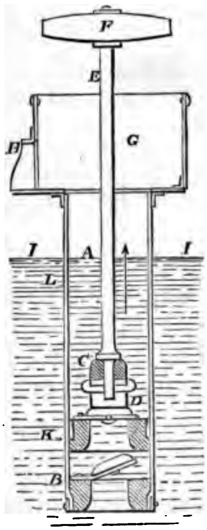
A solid piston is one which does not allow the water to pass through it, but which, when pushed downward or inward, as the case may be, forces away the water from the cylinder by displacing it to make room for its own bulk. A machine worked with this kind of piston is called a force-pump, and the piston itself is occasionally called a plunger.

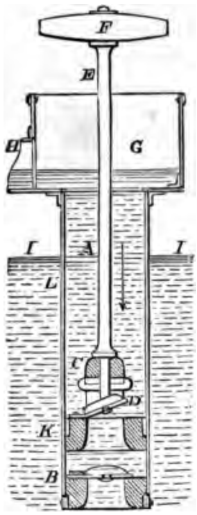
A machine worked by means of a projection from a central axis moving round a partly cylindrical chamber is called a rotary pump, by which is to be understood, not specially a machine to which motion is communicated through a rotary medium such as a crank and flywheel, or a crank alone, as this may or may not be the case with a rotary pump, but one which receives and communicates its power on a rotating part.

A machine worked with a wheel receiving its supply in the centre and discharging it from the circumference is called a centrifugal pump.

I shall first describe a pump of the simplest possible kind, namely, a lift-pump not fed by atmospheric pressure, but placed under the water, and filled by the gravitation of the liquid, which tends to force it into any opening below the level of its upper surface.

LIFT-PUMP NOT FED BY MEANS OF ATMOSPHERIC PRESSURE.





This pump consists of a cylinder A with a valve B, which will allow water to pass in, but not to return; and a piston C containing a valve D, which will allow water to pass upwards, but not to return. Motion is communicated to the piston by means of the piston-rod E and handle F.

Above the cylinder there is a chamber G, with a spout H.

The cylinder is placed below the water level I, and consequently the water will, by its own gravitation, force its way inside up to the same level at which it stands on the outside. The piston travels from K at the bottom to L at the top, and, as this latter is below the water level I, the cylinder is filled without any action of the piston.

When the piston moves upward, it lifts on it a certain quantity of water, and consequently makes room for a similar quantity to find its way in; and when it moves downward, the water in the cylinder not being able to pass back through the lower or foot valve B, opens the valve D in the piston, and by rushing through makes room for the piston to descend as it were through it.

It will thus be perceived that, at each upward movement, the piston not only lifts away all the water contained in that part of the cylinder through which it travels, namely from K to L, but at the same time makes room for the water on the outside to force its way in as far as the point L.

Assuming that the quantity of water contained in that part is a gallon, it will be found that, at each upward movement, a gallon is lifted into the upper chamber, and a gallon poured in from the outside to replace it; and at each downward movement the water, being prevented by the foot-valve from escaping below, but not stopped by the valve in the piston, escapes through the latter, and thus allows the piston to find its way down again so as to be in the proper place for performing the same operation on the next upward movement.

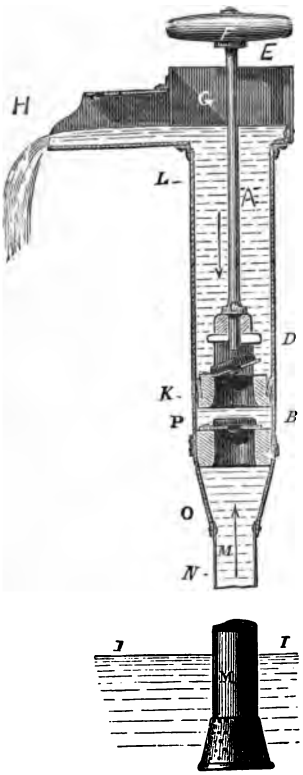
After the movement of the piston has been continued for some time, the water is lifted into the chamber G, until it reaches to the level of the outlet H, from which it is allowed to overflow into whatever channel or reservoir it is required in.

If the water has to be lifted to a greater height, or to be projected with force, the top of the chamber may be covered in, and an enclosed pipe led from the outlet to the required spot.

It is to be observed, that precisely the same principles apply to all cases of feeding pumps under pressure, whether the pressure be imparted by natural gravitation, as in the case just described, or by another machine driving the water in with force.

The next machine to be described is precisely tne same with regard to its delivery, being a lift-pump, which allows the water to pass through the piston ; but it is different in its supply, as it is fed, not by gravitation, but by atmospheric pressure or suction.

LIFT-PUMP FED BY MEANS OF ATMOSPHERIC PRESSURE.



To the bottom of a pump precisely similar to that last described, there is attached an air-tight pipe M, of sufficient strength to resist an external pressure of at least 15 lbs. on each square inch. The lower end of this pipe is placed under the surface of the water I, and the piston is moved down to its lowest point K.

This pipe will now contain water up to the point I, and all the rest of the enclosed space up to the bottom of the piston will contain air of the same density and pressure as the external atmosphere.

Move the piston up to its highest point L, and the enclosed air, on the principles already explained, will expand and fill this increased space ; and as it will then be of less density than before, it will not balance the external pressure, and consequently the water will be found at a higher level inside the pipe than outside—say the point N.

Next move the piston down to its lowest point, and the air contained in the cylinder, not being able to return through the foot-valve, will force its way through the valve in the piston, and escape forward.

There will now be in the pipe and the lower end .of the cylinder a smaller air space than before, and the air will be of less density than at first.

Move the piston again up to its highest point, and the air will again expand, and fill the space allowed to it, and will consequently lose still more of its density and pressure, the effect of which will be that the column of water inside the pipe will be forced by the external atmosphere to a higher point—say O.

Move the piston down again, and the air in the cylinder will escape forward, as before, leaving only that portion of the enclosed space between K and O filled with air, and the remaining portion between O and I filled with water.

Move the piston up again, and the enclosed air, becoming still further attenuated, will allow the water to be forced up by the external atmosphere through the foot-valve, and up to a higher point in the cylinder—say P.

When the piston descends again, all the remaining air escapes, and the water will be found above the valve in the piston; and, when it is again raised, the water is raised with it, being forced up by the external atmosphere, which has now no pressure inside to resist it, and consequently exerts its full power up to the point at which the piston stands.

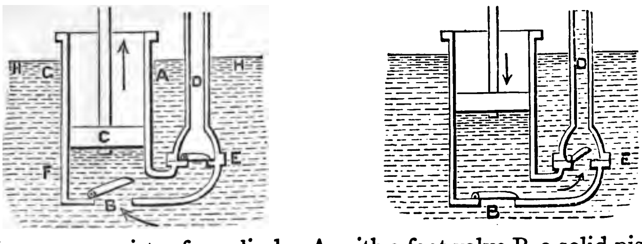
At each upward movement after this, the water above the piston is lifted into the upper chamber, and the water from outside follows the piston up, and fills the cylinder, and at each downward movement the water in the cylinder, being unable to return through the foot-valve, lifts the valve in the piston, and so allows sufficient displacement for the piston to make its way down again for the next movement.

As long as the piston is kept in motion, the water on top is lifted away, and the water below follows it, and fills the cylinder.

It is of course to be understood, that the experiment is not tried above the height to which the atmosphere can lift a column of water, as already explained, and that the piston is not moved at so great a speed that the water has not time to run up the pipe and fill the cylinder during the upward movement

The next machine to be described is a single-acting force-pump, supplied by means of gravitation.

Single-acting Force-Pump, supplied by means of Gravitation.



This pump consists of a cylinder A, with a foot-valve B, a solid piston C, through which no water can pass, and a pipe D leading out from some part of the cylinder below the lowest point which the piston reaches, and fitted with a valve E, which will allow water to pass up, but not back.

The travel of the piston is from F to G, both of which points are below the surface of the water H.

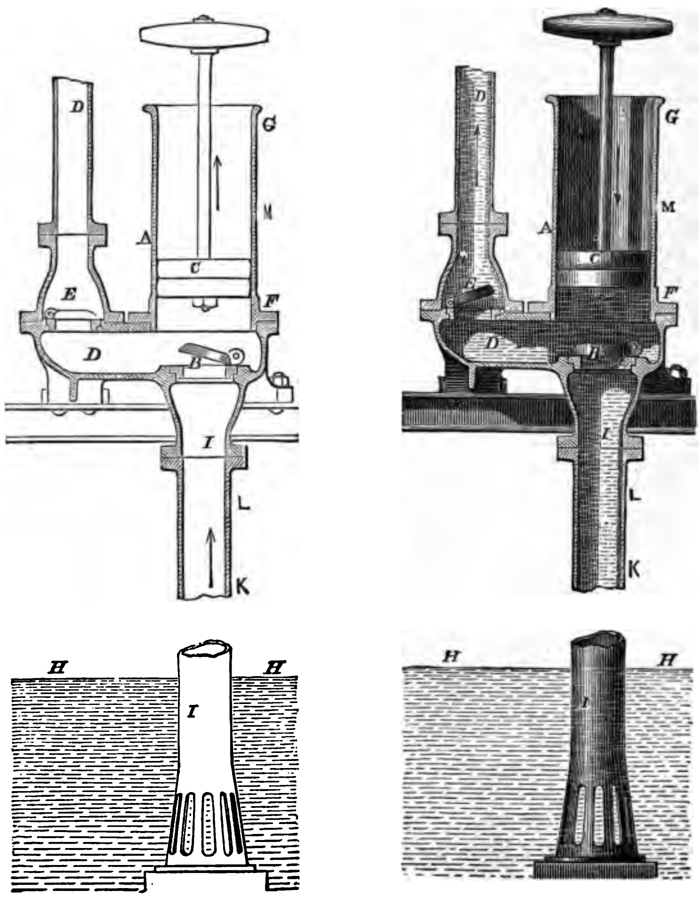
When the piston moves upwards it acts in precisely the same manner as that of a lift-pump, by making room for the water underneath to enter, but nothing passes through it, and consequently its only operation in the upward movement is to make room for the water to fill the cylinder, and, when it has reached the top, it descends again, and in doing so forces the water through the valve E into the pipe D, and so empties the cylinder.

This machine performs only one action at a time; first filling, and then emptying; and it is on this account that it is called a single-acting pump, to distinguish it from other machines to be hereafter described, which perform both actions together at every part of their stroke.

It will be perceived that, if the cylinder be of the same size as that of the lift-pump, and the stroke or travel of the piston be the same length, the quantity of water delivered will be precisely the same in both, although the mode of discharge will be different.

The next machine to be described is precisely the same as the last with regard to its delivery, but it is different in its supply, as it is fed by means of atmospheric pressure or suction.

Single-acting Force-Pump, supplied by means of Atmospheric Pressure.



To the bottom of a pump precisely similar to that last described there is attached an air-tight pipe I, of the same kind as that used with the lift-pump. The lower end of this pipe is placed under the surface of the water H, and the piston is moved down to its lowest point F.

This pipe will now contain water up to the point H, and all the rest of the enclosed space up to the bottom of the piston, and as far as the valve E, on the outlet pipe, will contain air of the same density and pressure as the external atmosphere.

Move the piston up to its highest point G, and the enclosed air will expand as before, and its balance with the external pressure being destroyed, the water will rise in the pipe to a certain height—say K.

Next, move the piston down to its lowest point F, and the air in the cylinder, being unable to return through the foot valve, will force its way through the valve on the outlet-pipe, and so escape forward.

There will now be in the pipe, the lower part of the cylinder, and that part of the outlet-pipe inside the valve E, a quantity of air of less density than at first.

Move the piston up to its highest point, and the air, expanding and losing its pressure as before, will allow the column of water in the pipe to be raised to a higher point—say L.

Move the piston down again, and the air in the cylinder will escape forward, as before, leaving only the enclosed space between F and L.

Move the piston up again, and the air, becoming still further attenuated, will allow the water to be forced up through the foot-valve and into the cylinder—say to the point M.

When the piston descends again, the remaining air is driven forward, and with it the water in the cylinder; and there being no longer any air in the cylinder or pipes, the external atmosphere keeps the water pressed against the bottom of the piston, so that when the piston rises the water rises with it, and fills the cylinder, and when the piston moves downward, the water, being unable to get back through the foot-valve, is forced forward through the valve E into the outlet-pipe, and thence to the point of final discharge.

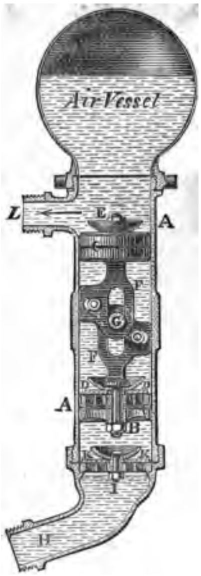
So long as the piston continues in motion, its upward movement will have the effect of allowing the cylinder to be filled, and its downward movement will force the water forward, thus finally accomplishing the same result as in the case of the gravitation pump last described, but by different means so far as regards the supply.

This pump is, of course, subject to the same conditions with regard to height of lift and velocity of piston as the other suction-pump previously described.

Duplex Lift-Pump.

Another kind of pump, and one likely always to attract a certain amount of attention, is a duplex or two-throw lift-pump.

It has one cylinder A, and working within it two hollow pistons B and C, fitted with valves D and E, through which the water can pass upwards, but not back. Motion is communicated to the pistons by means of the piston-rods or levers F F working off a spindle G, which passes through the cylinder and receives its power from the outside.



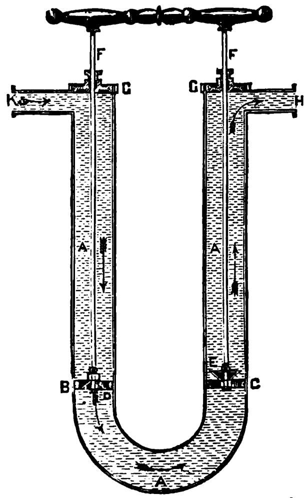
The working is arranged in such a manner that the pistons alternately recede from and approach each other. In short, the machine consists of two lift-pumps placed one above the other, and when the pistons are set in motion, that which is moving upwards from the suction and towards the delivery, is always doing the whole of the useful work, and passing the water through the other.

When the pistons are receding from each other, the upper piston C moves in the direction from the suction and towards the delivery; its valve E closes, and this piston lifts away any water that is above it, and at the same time allows the atmosphere to force in water through the suction-pipe H, and fill the cylinder, passing through the stationary foot-valve K and the valve D in the descending piston B.

When the pistons change their direction, and approach each other, the lower piston B moves in the direction from the suction and towards the delivery; its valve D closes, and this piston lifts away any water that is above it, forcing it through the valve E in the descending piston C, and out through the exit L, and at the same time allows the atmosphere to force in water through the suction-pipe H until it fills the cylinder.

The water is taken in at the bottom by means of the suction-pipe H, passes through the foot-plate I, and the foot-valve K, and is discharged through the delivery-pipe L, without returning on its course at any time during its passage through the pump.

Another Duplex or Two-throw Lift-Pump.

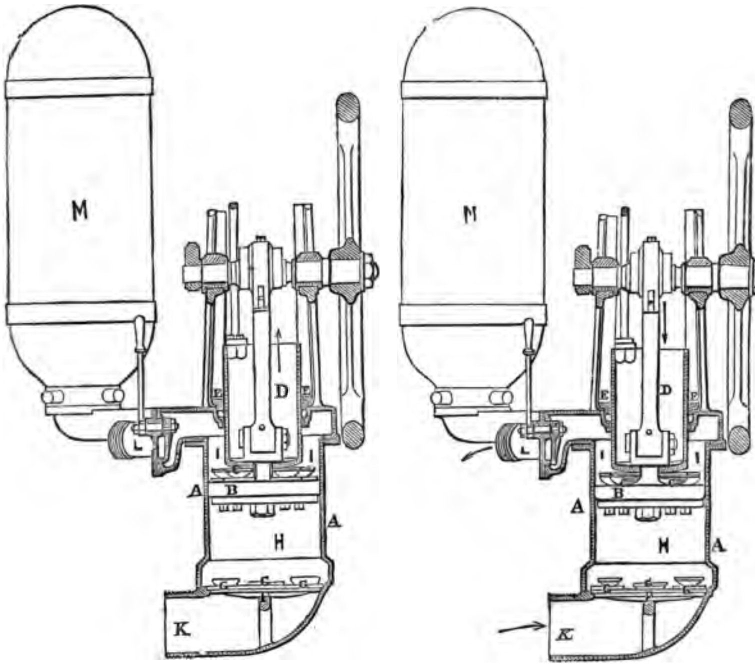


The principle on which this pump acts is precisely the same as that last described, but the application of the power is somewhat different.

The cylinder, instead of being an ordinary circular chamber, as before, is in the form of a bent cylindrical tube or pipe A A A, and it is fitted with two pistons B and C, each mounted with a valve D and E, which will allow the water to pass in the direction from the suction and towards the delivery, but not back. Motion is communicated to the pistons by means of two piston rods F F, connected by a handle and working through stuffing-boxes G G in the upper ends of the bent tube or cylinder. When the piston-rods move downwards, the valve D in the piston B is closed and the valve E in the piston C is open, and the water in front of the piston B is forced forward through the valve E until it passes out through the delivery-pipe H, and, while this is being done, the piston B, by causing a vacuum, allows the cylinder behind it to be filled with water from the suction inlet K; and when the piston-rods move upwards, the valve E in the piston C is closed, and the valve D in the piston B is open, and the water in front of the piston C is forced forward until it passes out through the delivery H, and, while this is being done, the piston C, by causing a vacuum, allows both arms of the cylinder to be filled with water from the suction inlet K. Thus it will be seen that, whenever the pump is set in motion, one of the two pistons must be passing in a direction from the suction and towards the delivery, and that this one—whichever it may be at the moment—is always doing at that moment the whole of the work, and doing it through the other, either drawing the water direct by suction through the inlet and forcing forward through the other piston and valve to the delivery, or, as the case may be, drawing the water through the inlet and the first piston, and forcing it forward direct through the delivery

With this machine the water is received in at one part, and is forced out from another, without at any time having to return on its own course while passing through the pump.

BUCKET AND PLUNGER PUMP.



There is another kind of machine, called a Bucket and Plunger Pump, which is a combination of lift and force-pumps. It consists of a cylinder A, with a hollow piston B, fitted with valves CCC, which allow the water to pass upwards, but not back. This piston, instead of being connected to the moving power by means of an ordinary piston-rod, has mounted on and attached to it a trunk D, working through a stuffing-box E, in the top of the cylinder. There is at the bottom of the cylinder a foot-valve, or rather a foot-plate F, with a set of valves G G G, which allow the water to pass up, but not back.

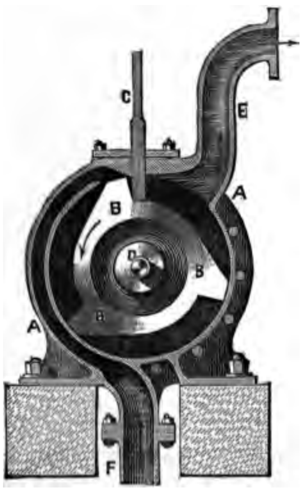
When the piston B moves upward, it allows the cylinder to fill below it in the space H, and at the same time lifts away the water in the space above it I I I; and when the piston B moves downward, it allows the water in H to pass through the piston valves C C C, and at the same time displaces or forces away a portion of this water by means of the trunk D. Thus, it will be seen that, on the upward movement, the whole of the space H within the cylinder is filled from the suction-pipe K, and that at the same time the contents of the space I are discharged through the exit-pipe L; and that on the downward movement of the piston the trunk D displaces a quantity of water, and forces it forward through the exit-pipe L.

The cubical contents of the trunk are equal to about half the cubical contents of the cylinder, and the result consequently is that nearly similar quantities are discharged on the up and down movements.

This pump is single acting in its suction and double acting in its delivery, and the water in passing through it does not at any time return on its course, as in an ordinary force-pump, but keeps the same direction after entering the suction inlet until it is discharged through the delivery outlet.

The next machine to be described is what is commonly known as a rotary, or rotatory pump, by which is to be understood a machine which imparts velocity to the water by the movement of a rotating part.

ROTARY PUMP.



There is a cylindrical vessel A, inside which moves a solid piece or piston B, with three projections, or cams, all of which touch the inner part of the cylinder at their extremities, but are graduated off to some distance, leaving a space between each intermediate part and the circumference.

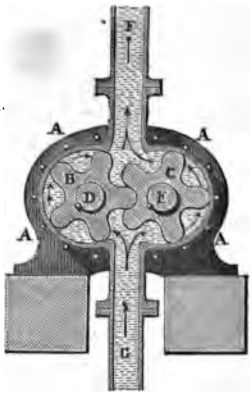
There is a sliding butment or stop C, which moves freely up when pushed from below, and which, when the pressure ceases, drops back instantly into its place.

When the solid part B is made to rotate on its centre D, the projections drive before them the water in the case, which moves on until it is stopped by the sliding butment from going altogether round, and escapes by the outlet E, and is replaced by a fresh supply coming through the suction-pipe F.

When this pump is fed by means of atmospheric pressure, there should be a valve in the suction pipe F.

It will be perceived that the shape of the rotating part, or cam piston, is such as to lift the stop and pass by, but not to let any water escape in the same direction, as the sliding stop instantly drops again by its own weight after each projection has passed it.

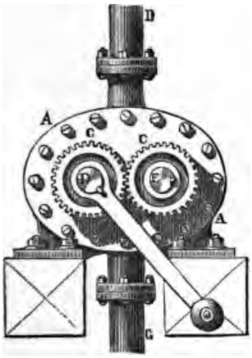
Another kind, and, perhaps, the oldest and best of all, is as follows:—



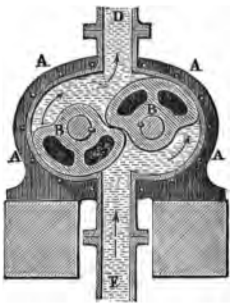
There is an oval chamber A, containing two cog wheels, B and C, the teeth of which touch the inner part of the chamber as they pass round and work in each other where they meet. They work on their own centres, D and E, and when set in motion travel in opposite directions, as shown by the arrows, carrying up round the sides whatever water is between the cogs; and, as this is not allowed to return through the centre, owing to the contact of the cogs at that part, it is driven forward through the outlet F, and a fresh supply brought up through the suction-pipe G.

Another form of rotary pump is as follows:—

There is an oval chamber A, as before, and in it are placed two solid



metal pieces B B, shaped as in the drawing, and touching in the centre by means of a species of cam or projection.



These are set in motion by a pair of spur wheels C C on the outside, the centres of which are fixed on the same spindles.

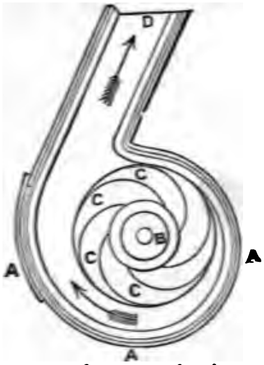
These spur wheels may be made, where desirable, of the same diameter as the pump wheels, or internal parts, which they drive. They gear into each other, and their teeth are made as small as is consistent with the necessary strength, and fitted as accurately as possible, so as to work without any play or back lash. By this arrangement the heavy wear is taken off the pumps, and thrown almost entirely on the outside driving wheels.

When they are set in motion they travel in opposite directions, as shown by the arrows, carrying with them the water on the outside, but not letting it return down the middle.

The water is then forced upward or forward through the outlet D, and is replaced by a fresh supply coming up the suction-pipe G.

The next machine to be described is that known as the centrifugal pump.

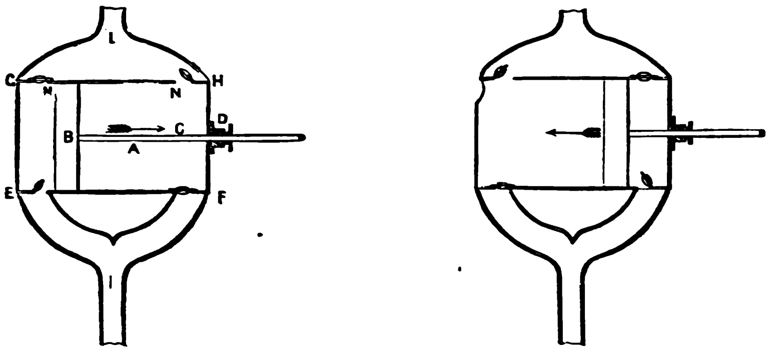
This machine consists of an outer case A, and concentric with it a hollow drum B, from the outside of which a number of arms,



C C C C, project, in the form of curved vanes, without touching the pump case. The drum communicates with the supply by means of a pipe, and, when it is set in motion, the centrifugal force drives out the water between the arms in the same way as the wringing of a mop drives the water out of the threads, and the water passes up the outlet D, and is continually replaced by a fresh supply through the hollow part of the drum B, which is, in fact, the suction-pipe.

The next machine to be described is a double-acting force-pump. The principles concerning gravitation supply are so simple that they will not be repeated here, or in future cases, and this description consequently refers chiefly to a pump fed by means of atmospheric pressure; but, with some slight modifications and a few obvious omissions, it can, if necessary, be made equally applicable to a gravitation pump.

Double-Acting Force-Pump.



This machine consists of a horizontal cylinder A, closed at both ends, with a piston B travelling in it, the latter being worked by means of a rod C passing through a stuffing-box D in one of the covers.

The cylinder is mounted close to its ends with four valves, E F G and H—two, E and F, below, and the other two, G and H, above.

There is attached to the cylinder, underneath, a pipe I, the lower end of which is placed under the surface of the water, and the upper end of which branches off to the entrances into the cylinder by the valves E and F respectively.

There is attached to the cylinder on top a similar pipe or a chamber L, the lower end of which communicates with the valves G and H, and the upper end or delivery of which is led wherever necessary.

The piston travels in the cylinder between the points M and N.

When the piston is at rest all the valves are closed.

When the piston is first moved from M to N, it has two valves behind it, of which the underneath one is opened by the expansion of the air in the pipe, and the upper one remains closed by its own weight; and it has also two valves in front of it, of which the lower one remains closed by its own weight, and the upper one is forced open to allow the air in front of the piston to pass out.

This motion of the piston discharges the quantity of air contained in that part of the cylinder between M and N.

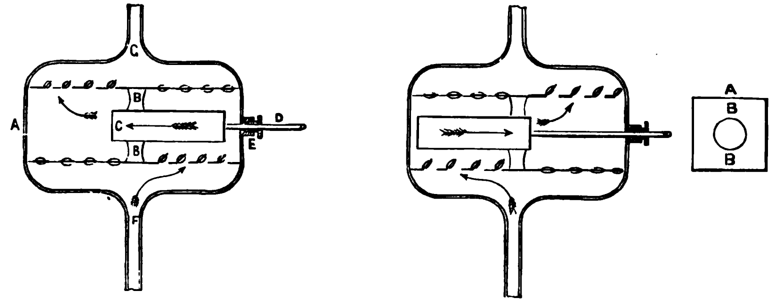
When the piston is next moved from N to M, it has, as in the previous movement, two valves behind it, of which the lower is open and the upper shut, and two valves in front of it, of which the lower is shut and the upper open, and this motion discharges a quantity of air equal in bulk to that driven out by the previous movement, but of less density.

The positions of the valves are shown in the accompanying drawings.

The piston is again moved in each direction, and at each motion discharges a further quantity of air, until the water, on the principles before explained, is driven up the suction-pipe, and follows the motion of the piston, filling the cylinder alternately through whichever of the lower valves is behind the piston, and being discharged alternately through whichever of the two upper valves is in front of the piston.

It will be remembered that, in the lift-pump, the piston when moving up does the whole of its work, both filling and emptying, and when moving down, does nothing, and that in the single-acting force-pump the piston when moving up fills the cylinder, and when moving down empties it; but the double-acting force-pump differs from these in the fact that, whenever the piston is in motion, it is both filling and emptying the cylinder at the same time.

Another form of double-acting force-pump is as follows :—



There is a large chamber A, of any shape, but usually for convenience rectangular, and inside it a cylindrical or annular projection B, called the pillar or bush, which stands in the middle, and completely separates the two ends when the piston is in its place.

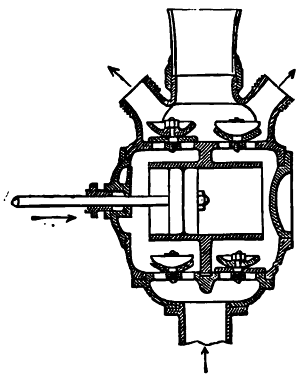
The piston C is a circular piece of metal, either solid or not, according to convenience, and motion is communicated to it by means of a piston rod D, working through a stuffing-box E.

The water is received through the suction-pipe F, and discharged through the outlet-pipe G.

When the piston is driven in either direction, the lower valves behind it open to allow that part of the chamber to fill, and the upper valves in front open to allow that part of the chamber to discharge. The position of the valves and direction of the water during the motions of the pistons are shown on the drawing.

The advantage of this pump is, that it has a very large valve area; the disadvantages are, that the piston and bush are metal to metal, and that the piston does not in its movement search every portion of the chamber, as commonly in the case of a piston moving in a cylinder, and that, consequently, it is difficult to make a vacuum and to keep it when made. This pump, when raising water 10 or 12 feet by atmospheric pressure, generally requires to be primed or filled with water from above, so as to expel the air, after which it can be made to work until once stopped.

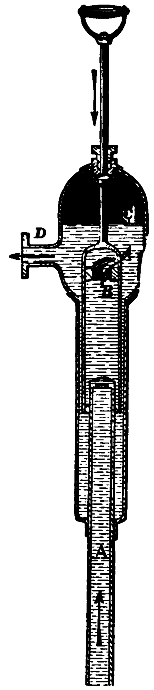
The lift-pump and single-acting force-pump have been drawn and treated of as placed vertically, and the double-acting force-pump as placed horizontally, these being the positions in which they are most commonly used. The valves also have been drawn and treated of as for the most part within the cylinder—a position which, in practice, they do not always occupy, being more frequently in the adjoining pipe, or in chambers intermediate between the pipe and the cylinder, as shown in the following illustration.



This arrangement of the subject has been adopted for simplicity and general convenience; but the student will do well to remember, that there is no law of nature which would materially affect either the supply or the discharge, in whatever position the pumps may be placed, so long as the valves can be made to act properly, as here explained.

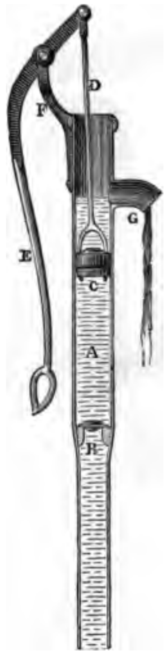
It is needless to follow the subject of piston-pumps through the infinite number and variety of forms which in this and other countries they have been made to take, in order to adapt them to the numerous requirements of commerce and domestic life, and at the same time to the surrounding circumstances or necessities of each case, including among many other matters the important consideration of first cost, which may itself be further sub-divided under several heads, such as material, manufacture, and so forth, and of working cost, which is subject to endless subdivisions of all kinds.

A few drawings, however, of other pumps are added, and these, if studied with the help of previous explanations, should enable the student to understand the general working of any piston-pump likely to be met with.



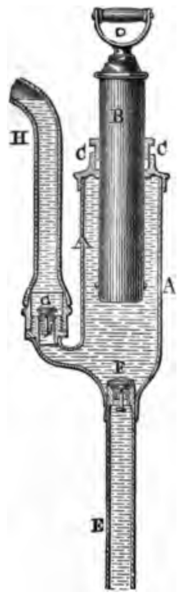
LIFT PUMP.

A.—Suction Pipe.
B.—Valve in Piston.
C.—Air Chamber.
D.—Exit Pipe.



LIFT PUMP.

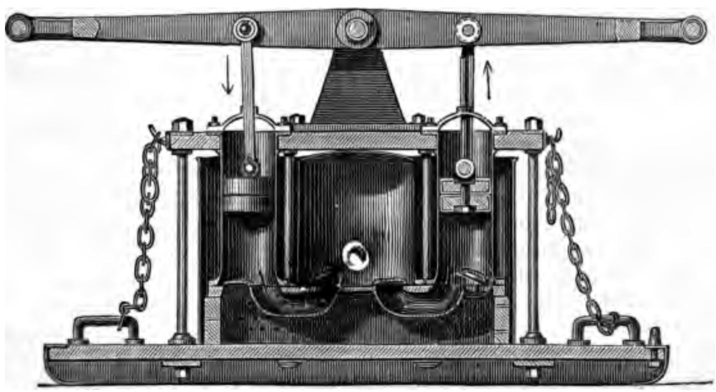
A.—Cylinder.
B.—Foot Valve.
C.—Piston with Valve.
D.—Piston Rod.
E.—Handle.
F.—Fulcrum or Stay.
G.—Exit Pipe.



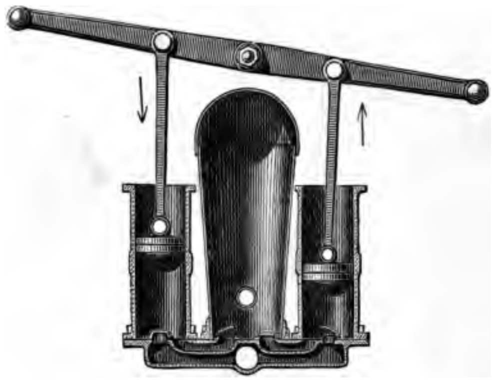
FORCE PUMP.

A.—Cylinder.
B.—Trunk or Piston.
C.—Stuffing Box.
D.—Handle.
E.—Suction Pipe.
F.—Foot Valve.
G.—Delivery Valve.
H.—Exit Pipe.

SINGLE-ACTING FORCE-PUMPS, MOUNTED IN PAIRS.



Single-Acting Force-Pumps, mounted in Pairs.



Air Vessels.

It will be perceived that in almost all the pumps here described there is, at some time or other, a cessation of useful action. Thus, the lift-pump gives its whole result on the upward movement, and no result at all on the downward movement, and consequently, if the piston be kept moving as it usually is at a somewhat equable velocity, its useful result is obtained only during one-half of the whole time. Again, the single-acting force-pump, when considered with regard to its supply or discharge separately, also loses half its time, and even the double-acting force-pump loses that moment, however brief it may be, during which the piston pauses at the end of the cylinder, before returning on its course. The effect of these pauses is an intermittent action of the stream passing through, an undue strain and jerk on the whole of the machinery and appliances, and, what is most important of all in our business, an irregularly sustained pressure on the issuing jet, which consequently scatters into spray much sooner than it would otherwise do.

It has always been the object of pump makers to reduce or obviate this inconvenience, and for this purpose many devices have been tried, the most common being, mounting two pumps together in such a way that when one ceases to act the other commences.

Three, four, five, and other numbers have also been mounted together, and the result has, of course, been a much more constant stream; but with no pump, not even the rotary, has it been possible to produce a really steady constant stream.

Thus a three-throw or a four-throw pump is, as far as steadiness of the issuing stream is concerned, more efficacious than a two-throw pump or a single pump; but, however numerous the throws may be, there is need for a steadying power to equalize the whole operation, and reduce the effect of such shocks as result from the rapid movement of an incompressible liquid in a series of chambers formed of rigid metal.

This regulating or steadying power is obtained by fixing on the delivery part of the pump a chamber communicating with the pipe below, and closed in on top, called an air vessel.

When the pump or pumps first commence to work, this chamber contains only air at the ordinary pressure; but, after some water has been forced forward, a portion enters the chamber, and, the air being lighter than the water, rises to the top and is compressed, and in this condition has a force or power greater than the external atmosphere, and consequently has a tendency to drive the water out again when the pumps are not acting.

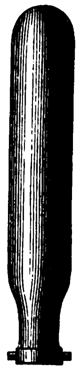
This power would be exhausted in a very short time, but it is nevertheless quite sufficient for all ordinary requirements, even with a single pump, and affords an effectual cushion or buffer to prevent the jars and shocks which might otherwise take place.

It is to be observed, that an air vessel neither adds nor withdraws power, but that it simply acts as a chamber in which power can be stored until it is required.

Air vessels are used both on suction and delivery-pipes, but their action on the former is chiefly the steadying of the pipes by allowing the water when checked to run up into a vacuum, and thus preventing the shock caused by the sudden closing of the valves.

The form, capacity, and position of an air vessel are all matters of importance. There can be no special rule laid down concerning these points, as the requirements of nearly all pumps are different, but the following general principles should be, as much possible, adhered to.

B

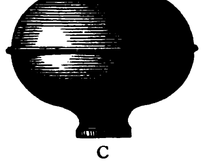


A

With regard to the form, experience shows that it is most useful when circular in area or transverse section, and either cylindrical all through, with a round or egg-shaped top, or cylindrical at bottom, and spreading towards the upper end, as in A and B.

The advantage of the latter of these is, that the large quantity of air contained in it is less liable to become exhausted, and that the surface of the water exposed to the compressed air is very small towards the bottom, and only increases as it rises and the pressure becomes greater.

In some of our manual engines the air vessel is of the worst possible form, being in fact a globe flattened on the top, as in C.



C

This form has been adopted merely for the purpose of getting the chamber below the spindle or rocking shaft, and, in so far as it serves this purpose, it may be considered a useful form; but, so far as the ordinary purposes of an air chamber are taken into consideration, it cannot but be denounced as one of the worst known forms.

As to the capacity, the great point is to allow as much elasticity as possible to all the parts when under pressure, so that when any obstruction occurs, such as that caused by shifting hose, or by a carriage or engine passing over the hose, there will be a sufficient space within the chamber to allow the water forced forward to enter, and thus save the bursting of the hose or damage of the machinery, which would be unavoidable if there were no air vessel or other space to receive the water when suddenly checked.

As a general rule, with a fast-running pump the capacity of the air vessel should be not less than about six times that of the pumps.

As to the position of the air vessel, it is of particular importance to have it clear of the wash of the pumps. If this be not attended to, the result would be that, at each stroke of the pumps, the water driven forward would rush up to or towards the top of the vessel, and at each wash would carry forward with it towards the delivery a quantity of air, until, after a short time, the vessel would contain all water and no air, and would consequently cease to perform the function of an air chamber.

There is also practically another point, more or less connected with those already mentioned, which is worthy of consideration. It is this. When air and water are placed in contact, there is a tendency in the water to vapourise and become mixed with the air, or—to put it in the converse way—there is a tendency in the air to absorb a portion of the water, and the greater the exposed surface of the water is, the more quickly the absorption takes place. When these two substances are placed under pressure, the water becomes still more rapidly absorbed; and when, in addition to this, the surface of the water becomes agitated, the absorption is still further increased.

Thus it will be seen that with a fast-running engine the small ill-shaped air vessel of an ordinary manual engine, being within the wash of the pumps, would be emptied of air in a few strokes, and, becoming filled with water, would cease to act as an air chamber almost from the commencement. Even with the high, capacious, and well-placed air vessels on our steam engines, the air disappears after a time, when the pumps have been working under a heavy pressure, and this, when it happens, becomes quickly known to the man working the engine by the roughness of the motion, and to the man at the branch by the jet becoming to a certain extent intermittent, and scattering at a short distance.

Whenever these signs are observed, the air vessel can be replenished by lifting the suction-pipe out of the water, and working the pumps with air only for a few strokes. The air then fills the chamber, and after this the suction-pipe can be dropped into the water, and the engine started again as before.

So far, I have been describing the general action of pumps of various kinds; I shall now explain certain matters for the most part common to them all, or the greater number of them, and after that I shall proceed to describe the general action of such combinations of pumps, carriages, hose carts, &c., &c., as we commonly call Fire Engines.

Stroke of Piston.—By this term is always understood a complete movement, whether circular, reciprocating, single, double, or any other which commences and ends at the same spot. Thus, in a lift-pump, or a single-acting or double-acting force-pump, a stroke is a movement of the piston once up and once down, and in a rotary or centrifugal pump a stroke is a complete circular movement.

The terms "up-stroke" and "down-stroke" are occasionally used, but they are mere conventional abbreviations, and are not intended to convey the idea that either of these movements is more than a half-stroke.

The Length of Stroke is expressed in different terms, being in all piston-pumps the half-movement, or the distance travelled by the piston in either direction, but not in both.

The travel of the piston is the double or complete movement, and the velocity is usually expressed by the number of strokes in a minute, or any other fixed space of time, multiplied by the travel; or the number of strokes multiplied by twice the length of stroke.

Valves.—The mere term "valve" has been hitherto used to express the door or gate through which water is allowed to pass in one direction, but not to return; but this is not intended to convey the idea that all valves are of one kind; on the contrary, they are of infinite variety with regard to material, position, amount of area, and many other particulars.

Almost all valves are of one or other of two principal kinds, called respectively mechanical and self-acting.

A mechanical valve is one attached to a moving part of the machinery, and moving with it. It can be used with any machine, but is seldom necessary in common pumps, and is consequently found chiefly in steam-engines and other more complicated machines. It is attached to a disc, crank, eccentric, or some other moving part, in such a way as to be opened at certain parts of the movement, and to be closed at others, as for the slide-valve, which admits steam alternately to both ends of a cylinder.

The valves used in any ordinary pump are almost invariably self-acting, by which it is understood, that when the moving parts are at rest they are closed, and when the moving parts are in motion the valves rise sufficiently to allow a passage to the liquid in one direction only.

They are made of every variety of material—wood, metal, leather, India-rubber, and occasionally of a combination of several or all of these.

They are, moreover, placed in every variety of position—vertical, horizontal, and inclined; the soft or flexible valves, however, are not always very well suited for the inclined position, but require to be in some way strengthened or stiffened for the purpose.

A very simple common valve is formed by a frame of metal, on which is hinged a lid, which rests on a part of the frame called the face. This is usually fixed in such a way as to fall readily when the water has passed, and for this purpose it is loaded to a certain extent, if not heavy enough, and is fitted with a stop, which prevents it rising beyond a certain distance, which is regulated according to the following principle.

The speed with which a valve opens perfectly and closes perfectly, is in exact accordance with the height to which the valve rises, and this height is called the lift.

It need hardly be mentioned that this rule refers to any one valve, and not to several valves of different dimensions.

If any given valve, with a lift of say three inches, can be so fitted as to open and shut perfectly 60 times in each minute, and the stop be increased to such an extent as to reduce the lift to one inch, the valve ought to open and shut perfectly 120 times in a minute; and if the lift be reduced to half-an-inch, the valve should open and shut perfectly 240 times in a minute.

Metal, wooden, and other stiff valves, can be placed over an open space, and rest on the edges of the opening, but the seat of leather, rubber, and other soft valves, is usually a grating, which allows the water to pass freely through, but supports the soft material when pressed on it.

Soft or flexible valves are usually stopped by a grating or guard of metal placed over them, touching at the centre or other part, and inclining upwards to allow sufficient lift.

The area of a valve is not that of the metal, rubber, or other material, or that of the grating or space underneath; it is the actual waterway, or space left open, when the valve is at its full lift, and consequently varies with the size of the valve and the height of the lift.

Thus, in a circular valve of 3 inches in diameter and 1 inch lift, the area is equal to 7·1 square inches, being the circumference multiplied by the lift; and in a butterfly valve, 8 inches by 6, with 2 inches lift, it is 44 inches, being the length of the sides multiplied by the actual lift, and the length of the ends multiplied by the average lift, which in this case is half that of the sides.

It will be observed that the area of the waterway in a valve is calculated without any reference to that of the waterways leading to and from it, which may be, and frequently are, very seriously diminished by gratings, sharp bends, and defective arrangement of parts, and other causes.

Suction.—Wherever it has been necessary to treat of the feeding of pumps by atmospheric pressure, I have hitherto generally used the full expression, as here, but I have occasionally allowed the word suction to appear for the purpose of identifying the terms.

Now, however, after the true principles of the feeding of pumps by atmospheric pressure have been explained, there can be no objection to this term; and as it is frequently used in the course of our business, it may be well to give the following short explanation of it.

The word suction has been much objected to by almost all writers on the subject of pumps, inasmuch as, according to their statements, it conveys to a student a wrong impression of the operation actually performed, and leads him to believe that a certain movement of a part of a machine has a direct effect on water or other liquid which is at a distance, and which has no connexion whatever between it and the moving part, beyond the fact that there is a pipe leading from one to the other, which pipe performs no act whatever of itself, and merely carries the water up when the latter is set in motion by sufficient cause.

This view has been at all times and in all countries so much insisted on, that it was impossible for me to avoid yielding to it to the extent which I have hitherto done. I have, however, myself no such strong prejudices against the use of the word suction; on the contrary, I have always found it a most convenient term, as it enabled me to avoid the use of a long roundabout expression. It is a somewhat remarkable fact, that no other term has ever been substituted for it by even the strongest and most violent of the objectors; and as the idea has to be conveyed very frequently, not only in these pages, but in the course of our business generally, I shall give here a short explanation of the actual operation performed, and after that I shall use the term suction freely, to convey the idea of feeding or supplying a pump with liquid by means of the pressure of the atmosphere acting as a motive power to drive it up into the cylinder or chamber.

The operation known as sucking consists simply in expanding the mouth, lungs, or other cavities of the body, and connecting the expanded part, whether directly or indirectly, with a liquid under the pressure of the atmosphere, the effect of which, on the principles already explained, is that the expanded air is reduced in pressure, and the external atmosphere acting on the liquid, and being unbalanced, drives the latter into the mouth.

If an opening be made into one part of the mouth, so as to admit air, the attenuation of the air within does not take place, and consequently the liquid is not driven up.

An experiment can easily be made with two hollow quills, both leading into the mouth, but one in water and the other out, and it will be found that no water will run into the mouth, whereas if the inlet for the air be stopped the water will be raised instantly.

This is the operation known in animals as sucking, and in machinery as suction; it is performed in accordance with the same laws of nature already explained in the descriptions of the barometer and the air-pump respectively.

Concerning Pumps Worked by Steam.

After the foregoing explanations, it is almost needless to observe that, in principle, there is no difference in the action of a pump, whether the motive power be produced by men, by water, by steam, or in any other way. In practice, pumps driven by steam are run somewhat faster than those driven by hand-power, and consequently the valves are generally arranged to work quickly, and for the sake of silence, as well as to avoid the risk arising from constant blows, they are generally made either of some soft material, or of metal mounted with a soft facing of leather or rubber.

Within the limits of the present work, it would be impossible to give even an outline of the several steam-worked pumps hitherto proposed or brought into use as fire-engines; but it may be stated in general terms that the best of these machines for such work as ours are those which are of the simplest construction, and the parts of which are the most visible and accessible. As to the absurd powers attributed to steam fire-engines by ignorant or interested persons, it is only necessary to say that the real capabilities of the machines can be tested by any engineer in the ordinary way by having their horse-power indicated, and that the equivalent man-power can be obtained by multiplying the horse-power by 5.

If an engineer cannot be got for this purpose, the necessary information can be obtained by getting a number of manual engines together, and working them by hand-power until their combined delivery is equal to that of the steam-engine. Then divide the number of men by 5, and the result will be the horse-power of the steamer. Thus, if the manuals worked by 50 men give a discharge equal to that of the steamer, it may be assumed that the latter is of 10-horse power, and so on.

There is another point concerning steam fire-engines which, to prevent mistakes, it is necessary here to touch on, although it does not strictly belong to this part of the subject—that is, the time which they take to get up steam. Now, I have seen, probably, more than any living man of these machines, as many even of the makers have only seen their own and one or two of other kinds; whereas I have travelled thousands of miles for the purpose, and seen, I believe, every kind of steam fire-engine that has been made, and, probably, the drawings of every kind that has been thought of, and yet I take a very strong view in direct opposition to nearly all those whom I have come in contact with concerning the time of getting up steam.

I own frankly that I have seen steam got up, after a fashion, in 6 or 7 minutes, and it might be assumed that what can be done at one time can be repeated at another; but this is the very point which I altogether deny, unless the element of risk be very largely taken into consideration. If that be allowed, of course I acknowledge that a sort of steam-power may be got up in about 6 or 7 minutes, but even in that case I deny that it is real working steam-power, at least of the kind in which I am in the habit of trusting.

My experience is simply this:—One of these little boilers filled with what I consider a proper quantity of water—that is to say, not less than six inches above the upper tube-plate—can be made to get up steam, with a pressure of 100lbs. on the square inch, from cold water in 14 minutes. Of this time, 11 minutes are spent in making the water boil, and the remaining three minutes in producing 100lbs. of steam from boiling water.

There are numerous devices, or—so to speak—tricks, for getting up steam in these little machines in less time, but in my judgment they are unsound in principle, and dangerous in practice, and ought not to be permitted. In the early days of steam fire-engines, and for aught I know in the present day, interested persons used to light the fire in an empty boiler, and as the boiler-plates and tubes became warm, used to inject small quantities of water, which almost instantly flashed into a vapour which they were pleased to call steam, but which I should call a highly explosive and most dangerous gas. Even now it is by no means unusual for such persons to fire up with the water when cold only just on a level with the tube-plates, and consequently, when expanded by the heat only an inch or so above, the result of which is, that after the engine has been at work one or two minutes, it becomes necessary to use the feed-pump, which instantly lowers the steam below the proper working point, and at the same time causes serious danger of an explosion.

The number of ways in which men have deceived themselves and others about steam fire-engines is infinite, and has tended very considerably to delay these most valuable little machines being more adopted than hitherto for the use of large cities. At the present day, in many cities which could be named, a steam fire-engine is run out to a fire, and attached at once, by means of the suction-pipe, direct to a hydrant before working steam has been raised; the whistle blows, the pump is put to work, water issues from the nozzle, a cheer is heard from the crowd, and all concerned are highly gratified at the supposed efficacy of the arrangements, whereas in reality there is no reason whatever for satisfaction, but, on the contrary, a very considerable cause for a feeling of a precisely opposite kind, as the steamer, instead of helping the discharge of the water in any way, is only obstructing it, and at the same time delaying its own production of a proper working pressure of steam, the water being forced through the pipes, valves, and pump only by the pressure from the main, and any steam which the boiler would, if allowed to rest, accumulate, being absorbed in running the pump for no good. In such a case the proper course would be to attach the hose first direct to the hydrant, and work from the latter, using, at the same time, all possible measures for the production of the necessary steam-power, and, as soon as this has been attained, to remove the hose to the steamer, and attach the steamer's suction-pipe to the hydrant; any other course is not only deceptive but injurious.

Where steam fire-engines are used, there appears to me to be a choice of only two courses with respect to their getting to work; one is to wait 14 minutes while raising steam from water at the temperature of the atmosphere, the other to keep the water boiling in the engine-house, so that the engine when called out will have a sufficient working pressure of steam in 3 minutes. The latter of these is the one which I have in most cases adopted, and which after the test of years I have no reason to be dissatisfied with, as it is has always answered well, enables me to keep a very large quantity of water in the boilers, and certainly obviates the risk inseparable from changing the temperature of all the metal composing the boiler and parts adjacent to it from that of the atmosphere to several hundred degrees within a few minutes.

The mode of keeping the water hot is a matter of detail, but there are various ways in which it can be done. One is to keep the fire always burning in the fire-box; but this, though perhaps the most economical, is attended with a very great drawback, as smoke and soot accumulate on the plates and tubes, and seriously affect the steaming of the machine at work. Another way is to have in the engine-house a small fixed boiler, with circulating tubes leading to and from the steamer's boiler, and capable of being disconnected when the engine is run out. The mode which I have adopted, and which has answered very well for many years, has been to place inside the fire-box, at a distance of about 2 inches below the lower tube-plate, a small coil or ring gas-burner connected by means of a flexible tube with the ordinary gas-pipe of the engine-house. This keeps the water always boiling without causing smoke or soot to accumulate, and the burner can be instantly removed when necessary.

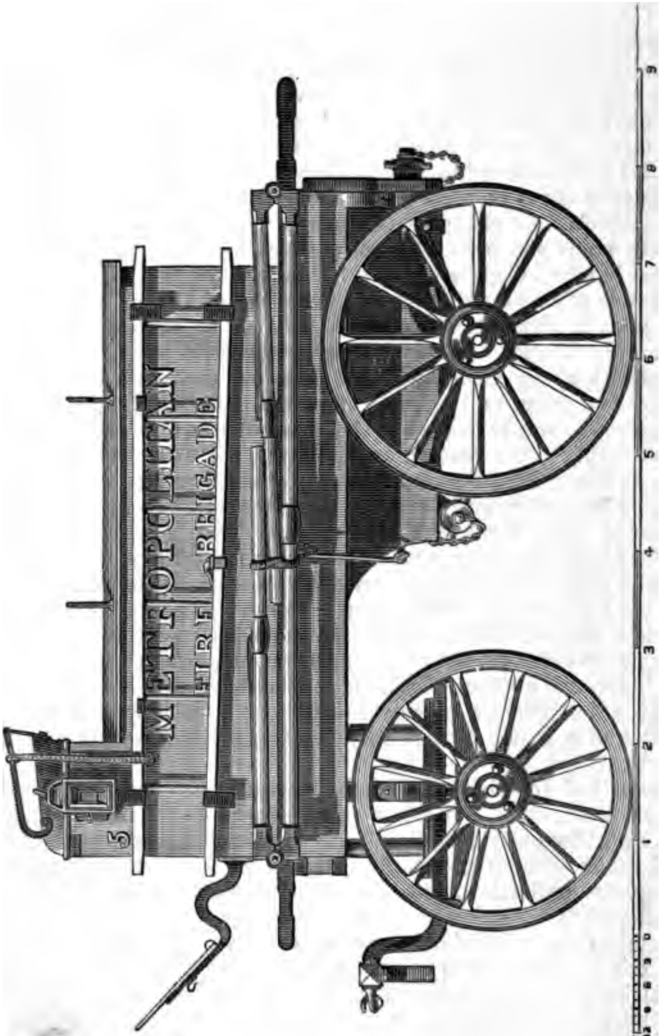
Whether, however, the water be boiled directly, as with a gas-burner, or indirectly through another vessel, the fuel in the fire-box is in either case raised to a temperature of 212° Fahrenheit, and consequently on the application of a match ignites very quickly, which is not the case with cold fuel.

The best fuel for these machines consists of dry shavings, dry firewood, and steam coal. No oil or spirit should ever be used either for lighting up or for quickening a dull fire, as, even if it produce the desired effect at the moment, it is certain to leave a deposit of smoke and soot on the plates and tubes, and thus to interfere with the steaming of the boiler afterwards.

The management of boilers is, as already explained, in no way directly connected with that of pumps; but in the little machines known as steam fire-engines, the boilers are inextricably mixed up with the other parts, and, as the subject must be mentioned somewhere, it is for convenience brought in here.

DESCRIPTION OF A SIX-INCH

MANUAL FIRE-ENGINE.



Side Elevation.

INTRODUCTORY.

In order to carry on our business properly, it is necessary for those who practise it to understand not only what they have to do, but why they have to do it; and the whole course of my instructions is framed to lead to this end.

No Fireman can ever be considered to have attained a real proficiency in his business, until he has thoroughly mastered this combination of theory and practice.

The steps, however, by which alone he can advance in this necessary task, are numerous and difficult, and any attempt to shorten or remove them can have but one effect, that of substituting superficial for real knowledge.

While, therefore, the rule is laid down, as already stated, that theory and practice are both absolutely necessary, and that their eventual combination is the end to be attained; still, in order to classify the subjects properly, and to avoid confusion, I consider it most essential that these two branches should at first be taught separately, not together.

This view of the best mode of imparting instruction in the business of our profession will be more clearly understood, if I mention that, with some few and very slight modifications, precisely the same principles apply to the working of the engine now under consideration, and to that of many other machines which we have in use, and some of which at least a superficial observer might suppose to be of a totally different kind.

For these reasons I have devoted the following pages to a simple detail of the several parts of an engine in common use, with an explanation of their respective functions, avoiding as far as possible any reference to the principles on which their working depends, inasmuch as all such information is comprised in another branch of instruction, and any lengthened reference to it here would not only lead to a confusion of ideas, which it is most desirable to avoid, but would also prove to be an unnecessary and useless repetition.

Fire-engines are of various kinds. Some are fixed in walls or other stationary places, and cannot be moved at all; some are fixed in ships or barges on the water, and others in carriages on land; some are in themselves moveable, and, whether on fixed or moveable foundations, can be mounted or dismounted at pleasure; some are worked by water, some by steam, some by manual power, and others in a variety of ways.

The following is a description of what is commonly known as a six-inch manual fire-engine of the pattern now used by the Metropolitan Fire Brigade.

This engine consists of a pair of single-acting force-pumps, mounted on a carriage with four wheels, and worked by levers, which are attached to a spindle passing through bearings in the carriage frame. It is, therefore, so far a fixture that the pumps cannot be separated from the carriage without delay and difficulty; but the whole machine, including the travelling and working parts, is moveable, and is made as light and portable as is consistent with the necessary strength.

This description is divided into two heads, the one having reference to the carriage and the other to the machinery, and the two are kept as distinct as it is possible to do, when treating of a machine, which is in point of fact a combination in itself, and contains several parts common to both the carriage and the works.

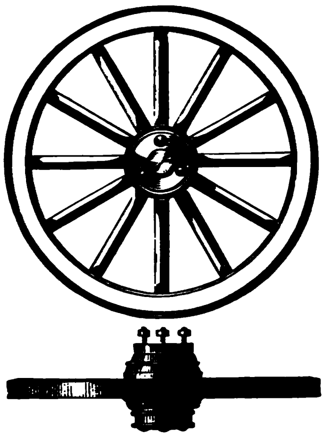
THE CARRIAGE.

Wheels.

This engine has four wooden wheels, with iron tires, two hind and two fore. The spokes are of oak, the felloes ash, and the naves or stocks elm; and inside each nave there is a cast-iron patent axle box, which receives the end of the axle, and is covered by a screw-cap to prevent the oil escaping.

The wheels are dished to such a point that the bottom spoke stands upright. This is effected partly by the dish of the wheels and partly by the set of the axle.

Hind Wheels.



Hind Wheels.

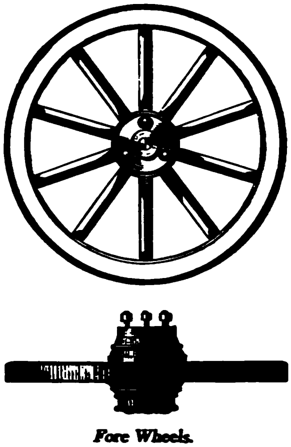
Each of the hind wheels is composed of the following parts, namely:—

One nave or stock, $8\frac{3}{4}$ inches deep, $8\frac{3}{4}$ inches in diameter at the centre, $7\frac{1}{2}$ inches in diameter at the inside end, and 7 inches in diameter at the outside, bound on the inner and the outer ends with brass hoops to prevent it splitting, and covered on the outside with a plate to protect the end of the axle and the axle-box and cap.

Twelve spokes, $1\frac{1}{2}$ inches wide, $2\frac{1}{4}$ inches deep, rounded off at the edges, and $12\frac{1}{2}$ inches long between the nave and the felloes.

The turned top of the spoke which enters the felloe is called the pin; the rectangular part which enters the stock is called the tennon; and the part between the stock and felloe is called the leg.

Six felloes, $2\frac{3}{8}$ inches wide, $2\frac{1}{4}$ inches deep, and $19\frac{1}{4}$ inches long, and fastened at the joints with round oak dowels.



Fore Wheels.

The parts are kept together, and protected when travelling, by a strong wrought-iron tire $1\frac{3}{4}$ inches wide and $\frac{1}{2}$ inch thick, fastened on to the felloes with six wrought-iron bolts, called tire rivets, which pass through from the outside, and are burred down on the inside over iron washers, countersunk flush with the inside of the felloes. One of these rivets is in the middle of each felloe.

The height of the hind wheels, including the tires, is 3 feet 3 inches.

Fore Wheels.

Each of the fore wheels is composed of the following parts, namely:—

One nave or stock, $8\frac{3}{4}$ inches deep, $8\frac{1}{8}$ inches in diameter at the centre, $7\frac{1}{2}$ inches in diameter at the inside end, and 7 inches in diameter at the outside, bound and covered in the same way as the hind wheels.

Ten spokes, 1½ inches wide, 2¼ inches deep, rounded off at the edges, and 10¾ inches long between the nave and the felloes.

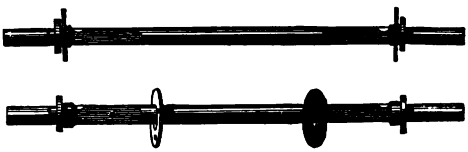
Five felloes, 2¼ inches wide, 2¼ inches deep, and 20 inches long.

The tire is 1¾ inches wide, and ½-inch thick, and it is fastened on the felloes with five rivets, one in the middle of each of the felloes.

The height of the fore wheels, including the tire, is 2 feet 11 inches.

Axles.

The axles are of the kind known as long bolted mail axles. They are of best faggotted iron, round for about 2 feet in the middle underneath the carriage, square for a few inches where the springs rest, and round in the wheels.


Axles.

Each of the wheels is fastened on to an arm of an axle by three wrought-iron bolts, with heads at one end and screws at the other. These bolts pass through the outer wheel-plate, the wooden nave, and the inner wheel-plate, and are secured on the inside by nuts screwed on to the projecting ends. The inside wheel-plates are prevented by a shoulder on the axle from moving out, and consequently the heaving up of the nuts on the bolts secures the wheels in their places, without the aid of lynch-pins, or any other fastening, on the ends of the axle. There are also leather washers inside the wheel-plate at both sides of the collar.

There are two axles, one hind and one fore, and both are of the same dimensions, namely, 2 inches in diameter at the round part under the carriage, 2 inches square under the springs, and 1¾ inches in the wheels. The distance between the shoulders is 3 feet 7½ inches, and the total length to the ends 4 feet 9¾ inches.

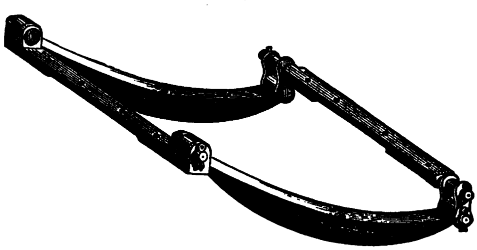
The width of the wheels when fixed on the axles is 4 feet 7½ inches to outside the tires, and 5 feet 1½ inches to outside the naves.

Springs.

The carriage is hung on two pairs of best town-made steel springs, fixed at one end and moveable at the other.

Hind Springs.

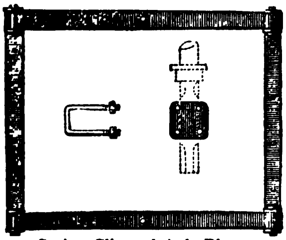
Each of the hind springs consists of 10 steel plates 2¼ inches wide, each plate a quarter of an inch thick, and consequently the whole 2½ inches thick at the centre, and with an average spread of 2 feet 8 inches from end to end.


Hind Springs and Cross-bars.—Perspective.

The hind springs are fastened to fixed shackles at the hind end, and moving shackles in front. The shackles are not attached direct to the wood-work of the carriage, but to wrought-iron bars which pass across under the bottom, and are called respectively the front and hind cross-bars of the springs.

The hind cross-bar has at each end a pair of lugs projecting upwards, and forming a shackle to hold the bolt, which also passes through the scrolled top plate, and so fixes the spring at the hind end. The front cross-bar is rounded at each end so as to form a bolt or pin to pass through the lower ends of a pair of moving shackles 4¾ inches long, 2 inches wide, and ½-inch thick, to the upper ends of which the scrolled top plate is attached by a short bolt, which secures the spring at that end, but allows it sufficient play by the moving of the shackles.

The cross-bars are 2 inches in width, and are made of ½-inch iron in the middle, but are somewhat thicker towards the ends where the strain is heaviest on them.


Spring Clip and Axle Plate.
Hind Springs and Cross-bars.—Plan.

The plates of the springs are fastened in the centre with a small wrought-iron bolt, which passes from the bottom upwards through a hole cut for the purpose, and so keeps them together, and they are also kept in their places by projecting studs working in slots in each other. A small hole is counter-sunk in the top of the axle to take the head of the bolt which passes through.

The springs are attached to the axles by bent pieces of half-round iron, with screw ends, called the spring clips.

The springs are first laid over a small leather washer on the axles at a right angle, and with their middle over the part of the axle squared for the purpose. The clips are then placed over the springs with their screw ends downwards. A flat plate of metal, called the axle-plate, with four holes drilled in it to take the four screwed ends, is then slipped up from underneath the axle; nuts are placed on the screws, and the whole hove up tight with a spanner, so as not to shift when the carriage is subjected to heavy strains in travelling.

The hind cross-bar of the springs is pierced with four drilled holes, and the bottom of that part of the carriage, called the cistern, with a corresponding number; the carriage is then placed on the cross-bars; screw bolts with square heads are driven through the holes from above, and secured underneath with nuts, which are hove up tight with a spanner, and keep the whole together.

The front cross-bar of the springs is pierced with the same number of holes, and fastened at the two inner holes in the same way as the hind cross-bar. It is, however, fastened at each end, not by a bolt merely driven through the bottom, but by a nut screwed on to the projecting end of a flat strengthening plate, which passes up inside the carriage frame, and is bent round over the top.

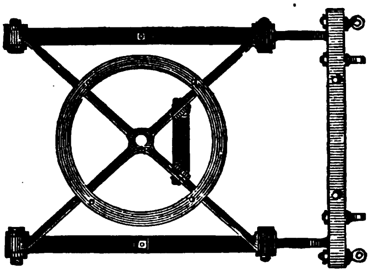
The pins, which take the scrolled plate of the hind springs in both the front and hind shackles, are for greater safety driven in from the inside towards the outside, and consequently, when it is necessary to remove or dismount a spring, the cross-bar bolts must be drawn, and the cross-bar removed from its place under the carriage, in order to get room to drive the pins back.

The hind axle is fixed at a right angle to the central or fore and aft line of the carriage, and consequently the hind wheels run in lines parallel to each other, and to the central line.

Fore Springs.

Each of the fore springs consists of eight steel plates $2\frac{1}{4}$ inches wide, each plate $\frac{1}{4}$ inch thick, and the whole 2 inches thick at the centre, and with an average spread of 2 feet 7 inches from end to end.

The plates of the fore springs are fastened together in the same way as those of the hind, and the springs themselves are secured on the axles with plates, clips, washers, and nuts, as before described.



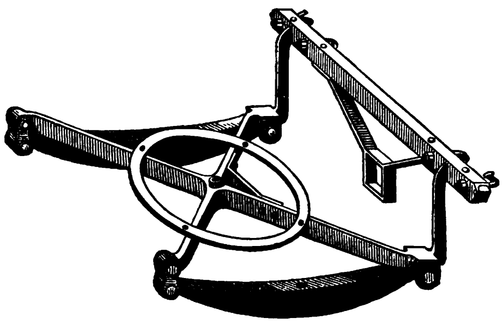
Fore Carriage Plan.

They are attached to fixed shackles in front, and to moveable shackles at the hind end, and are, so far, nearly the same in most points as the hind springs, but here all similarity ceases, as the function of the fore wheels is in many respects essentially different from that of the hind, and the general arrangement by which they are attached to the carriage is altered accordingly.

The fore wheels are not fixed to travel in lines parallel to the central line of the carriage. They are attached to the axle in such a way as to keep lines parallel to each other, but they are arranged on a centre or pivot, so as to turn in every direction. The frame or structure by which this is accomplished is commonly called

The Fore Carriage, or Locking Carriage.

The fore carriage consists of two flat bars of wrought-iron laid on edge, crossing each other at a right angle, and welded into one piece. It presents the appearance of four arms springing from a common centre, where it is perforated with a hole to take a round wrought-iron bar, called the perch bolt, by means of which it is connected with the front of the main carriage. The total length of the cross arms from end to end is 3 feet 9 inches, and their average depth 2 inches, slightly increased towards the centre, and diminished towards the ends; their thickness is $\frac{5}{8}$-inch. The diameter of the perch-bolt is $1\frac{1}{2}$ inches bare, and that of the hole in the centre which receives it $1\frac{1}{2}$ inches full.



Fore Carriage.—Perspective.

At each of the hind ends the extremity of the arm is pierced with a hole running horizontally and athwart to take the upper pin of a pair ot moving spring shackles; and at each of the front ends, the extremity of the arm is fitted with a pair of lugs turned downwards, and pierced with a hole running horizontally and athwart through both sides, thus forming a pair of fixed shackles to carry the pin which passes through the scrolled plate of the springs.

From outside these lugs two flat pieces of iron, of about the same dimensions as the arms before described, rise with a sweep to a height of 8½ inches; these are called the heads of the locking carriage.

Across the top of these there is attached a cross-piece made of an angle iron, filled up with wood inside to stiffen it, the whole bolted together and forming a bar of 2 feet 9½ inches long and 2 inches square, called the splinter bar.

Each of the fore springs is fastened at the front end by an ordinary bolt passing through the pair of fixed shackles on one of the front cross arms of the locking carriage, and at the hind end by a bolt passing through the lower ends of a pair of moving shackles, the upper ends of which are attached to the eye in one of the hind cross-arms by a bolt or pin in the usual way.

The dimensions of these shackles in inches are as follows:—

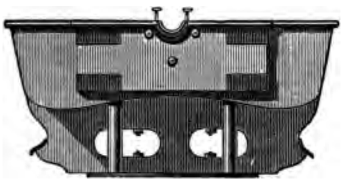
	Wide.		Long.		Thick.
Fixed shackles on hind cross-bar . . .	2⅛	×	2⅝	×	½
Moving " on front " . . .	2¼	×	4½	×	½
Fixed " on front cross-arm . . .	2⅛	×	3¾	×	½
Moving " on hind "	2	×	4½	×	½

It will be observed that the springs are fixed at their outer ends, and moveable at their inner ends. That is to say, the fore springs are stationary at their fore ends and moveable at their hind ends, and the hind springs stationary at their hind ends and moveable at their fore ends. The effect of this is, that when a weight comes on the carriage, the springs spread inwards, and the axles move slightly towards each other.

On the cross-arms of the locking carriage, and concentric with them, there is placed a pair of circular flat rings of iron ½ inch thick, 1½ inches wide, 1 foot 9¼ inches in diameter on the outside, and 1 foot 6¼ inches on the inside. These are called the transom-wheel plates, and they are distinguished from each other as the lower and upper rings.

The lower ring is secured to the cross-arms by bolts driven from the top. The heads of these are flush with the top face of the plate, and the lower parts have screw ends, which pass through perforated projecting lugs forged on the arms, and are hove tight with screw-nuts.

The upper ring is attached to the main carriage by means of four turned ash supports, called pedestals, and by a strong wooden block, which carries the front part of the main carriage.



Front Beat Blocks, Pedestals, &c.

The following are the dimensions of the pedestals:—

Diameter . . .	1¾	inches.
Length in front .	8¼	"
Length behind . .	9½	"

The difference in length is caused by the two hind pedestals being fastened direct to the bottom of the carriage, and the two in front to the bottom of the connecting piece which joins the two front brackets.

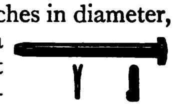
There is a hole completely through each of the pedestals, and a bolt is passed up from below, where its head is flush with the lower part of the top ring of the transom-plate, and fastened at the upper end by a screw-nut, hove up tight over an iron washer. There are also holes in the block which receive bolts, passing through the top ring and secured above by a nut over an iron plate.

The wooden block is of oak, 9½ inches deep, 2¼ inches thick, 3 feet 1½ inches long above, and 2 feet 9½ inches long below.

There are projections on the lower parts of the ends of this block for receiving the blow of the pump-levers when at work, and it is consequently called the front-beat block.

In the centre of this block there is a circular vertical hole, through which the perch-bolt passes, so as to keep the centres of the transom-plates together.

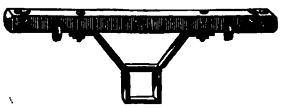
The perch-bolt is a circular bar of wrought iron, 1½ inches in diameter, with a head on top to keep it from falling through, and a split-key below to keep it from jumping out. The exact length necessary as a pivot for the transom-plates, allowing for an iron washer above and below, is 1 foot 2½ inches, but the perch-bolt is made 1 foot 3½ inches long from the head to the key, to allow some play on the rings, and thus, to a certain extent, relieve the fore part of the carriage from jerks when travelling rapidly over uneven ground.

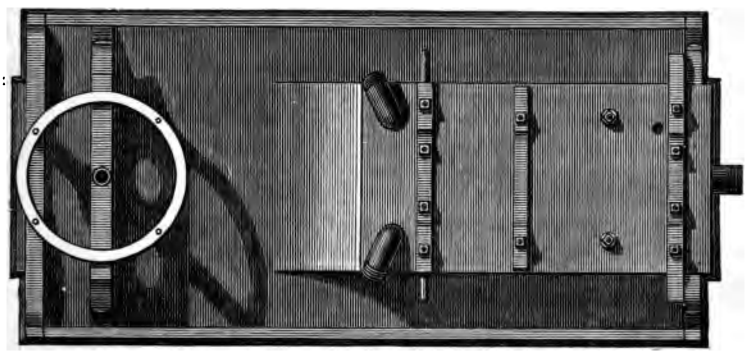

Perch-Bolt and Split-Key.

The total length of the perch-bolt, including head and end, is 1 foot 6 inches.

On the ends of the splinter-bar are fixed a pair of hooks, which carry the sway-bars, and inside these a pair of eye-bolts, to take the pin which attaches the drag-handle.

Under the middle part of the splinter-bar is fixed a wrought-iron frame, 1½ inches wide, ½ inch thick, and about 4 inches square, through which the pole passes. This is bolted on underneath the splinter-bar, and is called the front pole-iron. And underneath the front cross-arms of the fore carriage, between the transom-plates and the perch-bolt, is fixed a corresponding piece of the same width and thickness, but only about 3 inches square. This


Splinter-Bar, with front Pole-Iron.


Plan of underside.

receives the thin end of the pole, and is called the hind pole-iron. Both these irons are on the underneath or locking carriage, and not on the main carriage above; and the moving of the pole to either side consequently has the effect of turning the whole of the fore carriage and the front axle and wheels in the same direction.

Underneath the front beat-block there is a strengthening-plate, extending across and perforated with five holes—one for the perch-bolt, two for bolts which pass through the bottom of the carriage, and two at the ends, with the holes previously mentioned, which take two of the bolts of the top ring. This is called the cross-bar of the transom-plates.

Inside the bottom, at the front end, where the perch-bolt passes through, there is a flat bar of iron, $1\frac{1}{2}$ inches wide, $\frac{7}{16}$ inch thick, and 1 foot 9 inches long, which goes completely across, from side to side. This is called the perch-bolt plate, and it serves not only to hold the top iron washer and head of the perch-bolt, but also to secure the bolts which fasten the front beat block to the main carriage.

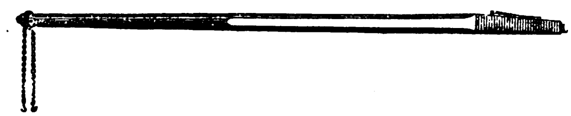
The heads of the locking carriage are made to such a height, and the splinter-bar cut to such a length, that the whole may be turned completely round underneath the body of the carriage, passing in at one side and coming out at the other, and no engine likely to be used in the narrow streets of a town can be considered really effective unless the locking carriage can do this, with a clear space of two inches between it and any part of the main carriage.

There are holes cut through the rings or transom-plates, in such places that when they come together the front wheels are perfectly square, and there is a pin, hanging by a chain close by, which can be dropped into these holes, and keep the transom-plates fixed. This is called the locking-pin.

Pole, Shafts, &c.

This engine is supplied with a pole and a pair of sway-bars for two horses, a pair of shafts for one horse, and a drag-handle for men.

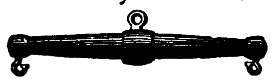
The pole is of ash, 11 feet 3 inches long, about $3\frac{1}{2} \times 3\frac{1}{4}$ at the lower end where it enters the socket, but tapered away at the front end to $2\frac{1}{2}$ inches round.



Pole.

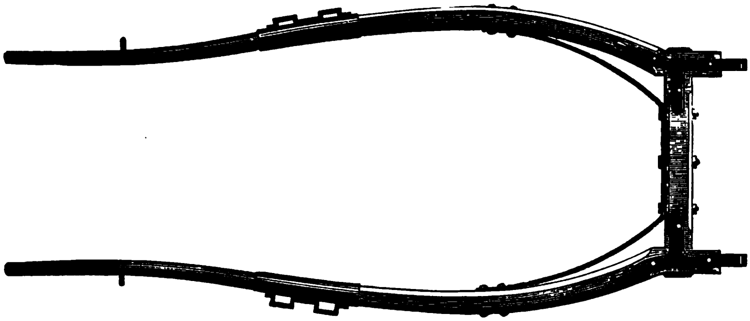
It is fixed in the pole-irons by a spring mounted at the hind end, and has a square wrought-iron shoe at the inner end to take the hind pole-iron. It is also fitted at the outer end with a ferrule, a staple or spike, and a swivel with chains and hooks 3 feet long to take the rings on the collars of the horses.

The sway-bars are of ash, rounded, 2 feet 7 inches long, $2\frac{1}{2}$ inches diameter in the centre, tapered to 2 inches at the ends. They are each mounted with three wrought-iron sockets, the centre with a forged eye to take the hook on the end of the splinter bar, and the end ones with hooks to take the traces.



Sway Bar.

The shafts are of ash, 7 feet 6 inches long, made of 2-inch plank.



Shafts—Perspective.

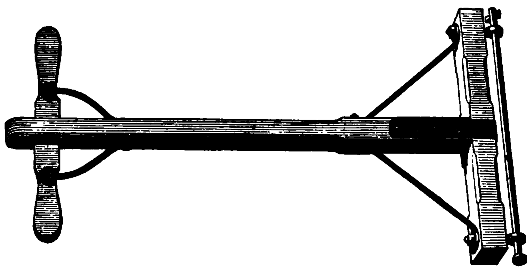
They are 2 feet apart at front, 3 feet in the middle, and a little under 2

Shafts—Side view.

feet at the hind end, and are fastened on to the splinter bar by a bolt passing through eyes.

The drag handle is also of ash, 5 feet long, 3 inches by $2\frac{1}{2}$ at the inner end, and tapered away to $2\frac{1}{4}$ inches square at the outer end.

It has at the bottom a T end, 2 feet long and 3 inches square, slightly tapered towards the extremities, and mounted with eyes to correspond with those on the splinter bar, a pin passing through all to keep it in its place when in use.



Drag Handle.

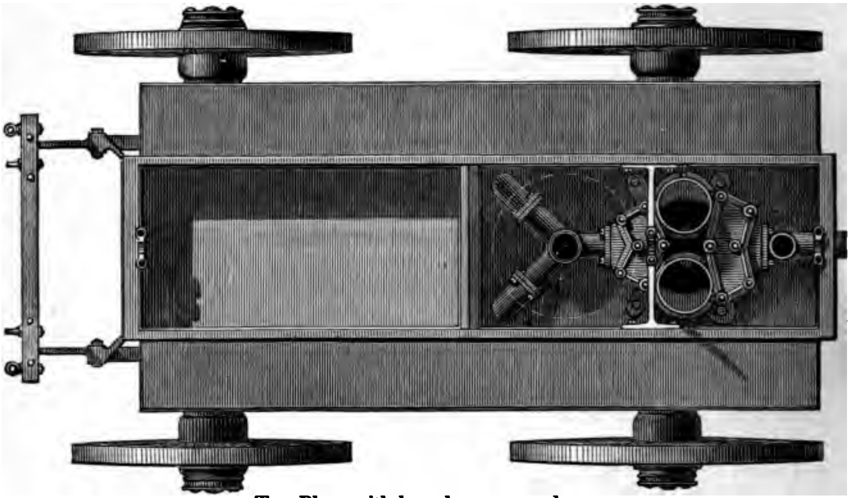
The pole part of the drag handle is morticed in to the cross part, and secured by a bent wrought-iron plate, which passes round the bottom and up the pole to a distance of 12 inches. This plate is fastened to the wood with nails.

The drag handle is kept square by two stay irons from the ends of the cross piece to the pole part at a distance of 15 inches from the joint.

At the top there is a flat handle 2 feet 6 inches long, 1 inch thick, and 3 inches wide, morticed through the front end of the pole part, supported by two iron stays fastened with screws, and the end of the pole part kept from splitting by another bent flat bar or strap, passing over the top, and coming down about 12 inches.

Main Carriage.

The main carriage proper consists of a rectangular frame of well-seasoned mahogany, rabbitted at the corners, and grooved to half depth at sides and bottom. It is fastened by nails, driven in at both sides, and bound with twelve wrought-iron angle or corner plates, six behind, two in front of the break, or fore part of the cistern, and four in front of all. It is on the outside 7 feet 3 inches long, and 1 foot 11½ inches wide. It is 8 inches deep from the front end for a distance of 3 feet 7½ inches, and 1 foot 7½ inches deep for the remaining distance, 3 feet 7½ inches, to the hind end or stern.



Top Plan, with hose-box removed.

The sides and ends are 1¼ inches thick, and the bottom 1½ inches.

It is separated in the centre by a mahogany cross-piece, 1 inch thick on the top, and 2¼ inches below. This lower part forms the front end of the cistern, and is called the break-piece.

The deep part is called the cistern, and the shallow part in front forms the bottom of the hose-box.

In the bottom of the cistern there is a hole, which, when not required for letting water out, is stopped by a wooden plug.

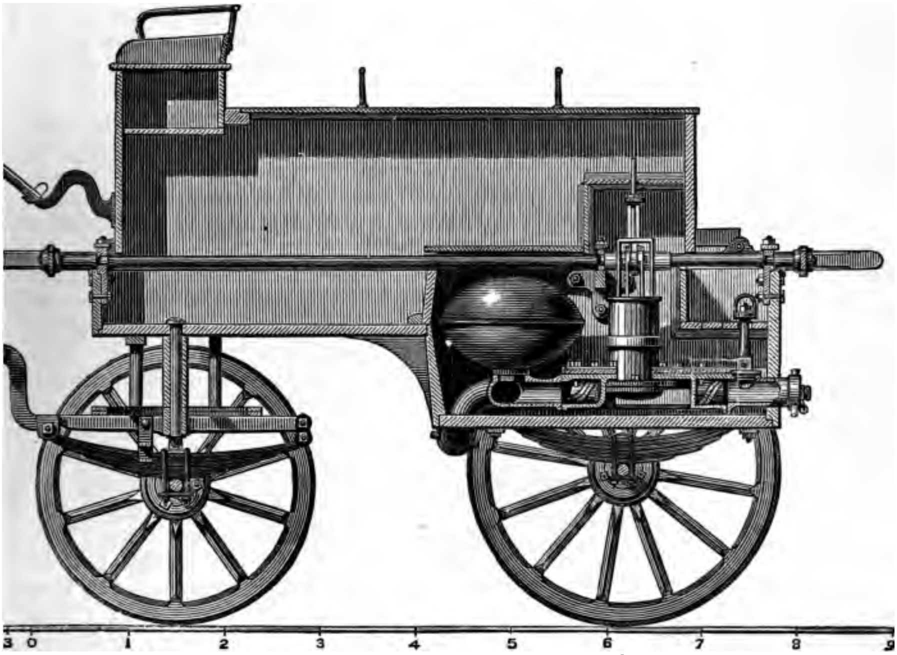
Underneath, and at the sides of the front end, there is bolted on a pair of 2⅛-inch oak brackets, 8½ inches wide above, and 7 inches below. These form the front ends of a pair of side pockets, which hold two lengths of suction-pipe each, and they are strengthened by a tie-piece, also of oak, which passes underneath the carriage, and is dovetailed on to them.

The hind ends of these pockets are formed by another pair of 2⅛-inch oak brackets, 8½ inches wide above, and 1 foot 6 inches long, bolted on to the hind end of the side.

The lower part of these brackets is curved so as to form a striking bed for the pump-levers at the hind end, and, where it is so shaped, is called the hind-beat block.

The bottom and sides of these pockets are of ⅝-inch white deal, and the lid or flap is a rectangular piece of 1-inch white deal, 7 feet long, and 8¾ inches wide, fastened with three cranked back-flap hinges, and strengthened with two flat plates screwed on inside, and so placed as to divide the length into three parts. On the outer sides there are placed small studs, which enter corresponding holes in these strengthening-plates, and serve to keep the sides and top in their places.

At the bottom of the suction-pockets there are several grooves leading to a set of ½-inch holes, through which any water that enters is allowed to run off.



Longitudinal section through valve chambers, &c.

Hose Box.

Above the main carriage there is a large square case, called the hose box, but including also the driving seat.

This is 6 feet 1 inch long, and 1 foot 10¾ inches wide. It is 1 foot 7 inches deep for a distance of 4 feet 11 inches from the hind end, and 2 feet 3½ inches for the remaining distance where it forms the driving seat.

The sides and ends are of mahogany, 1 inch thick.

The lid is of white deal, 1 inch thick, and strengthened with 3 battens or ledges, each 3 inches wide, 1 inch thick, and 1 foot 8¼ inches long.

It is fastened to the sides by 2 chest hinges, and is hung when open by a piece of chain, with staples, which prevents it going back too far.

About 2 inches below the level of the lid of the hose box, there is a false bottom under the driver's seat, and a small hinged lid on top. This place serves to keep tools and other small gear, and is called the fore pocket.

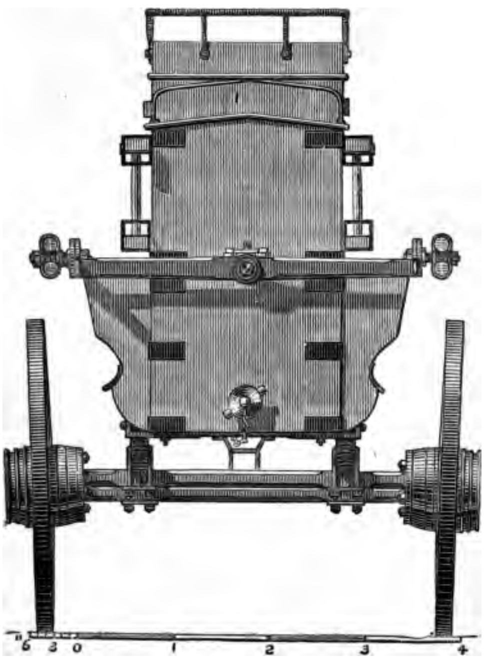
Round the top of this pocket there is a raised mahogany ledge, about 4 inches high at the back, surmounted by a small rail of ½-inch round iron 3 inches high, called the driving seat rail.

On each side of the fore pocket, nearly on a level with the driving seat, there is fastened a block, which holds the lamp socket or lamp iron.

From the front end of the hose box, 1 foot 8 inches below the driving seat, two irons project forward to carry the driver's foot-board, which is a piece of mahogany 1 foot 7 inches wide, 1 foot 3 inches deep, 1 inch thick, and strengthened at the hind end by a quarter round baton running across, called the heel-piece. The foot-board irons do not spring straight from the front, but are bent round with a sweep to allow room for the movement of the cross arms of the front lever, the use of which will be explained further on.

The lid of the hose box is mounted on top with two round bent bars of wrought iron, ½-inch thick, which stand across, and are called the hand-rails; and each of the sides of the box is mounted with two bent flat pieces of iron 1½ inches wide and ¼-inch thick, bolted on, projecting outwards 4 inches and bent up at the ends 1 inch to carry the ladders; these are called the ladder hooks.

This box is mitre-dovetailed at the angles, and is further secured by being strongly bound on the outside with six wrought-iron angle or corner-plates, 4 behind and 2 in front. These plates are 2 inches wide, ⅛-inch thick, and run 5 inches in each direction from the angle. The box is further strengthened by 2 wrought-iron angle-plates inside, the same width as the outer angle-plates, but ¼-inch thick, running 6 inches in each direction, and taking in front the bolts which fasten the foot-board irons. The wood-work at this part is further strengthened by two battens inside, each 1 foot 5½ inches long, 7 inches wide, and 1 inch thick.



Back elevation.

The hose box is carried on the frame of the main carriage, and is attached to it by 4 plates or stay-irons, ¼-inch thick and 1¼ inches wide, firmly bolted on to the box above and to the inside of the frame below.

Inside the carriage frame, at the hind end, there are placed perforated boards, which allow water to pass through, but prevent stones or dirt getting into the machinery when the pumps are worked from the cistern;

and inside the hose box, over the cylinders, there are placed covering boards to protect the works from above.

All these boards are loosely fitted in, and having no fastening, can be removed whenever it is necessary to get at the pistons, cylinders, or any other part of the machinery.

The capacity of this engine for stowage is as follows :—

Side Pockets.	1·7	cubic feet.
Fore Pocket.	1·4	„
Hose Box	17·6	„
Total . . .	20·7	

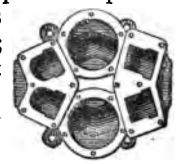
or about 20¾ cubic feet.

THE WORKS.

THE works consist of a pair of single-acting force-pumps, with an inlet-pipe, four valves, an air vessel, two delivery-pipes, a rocking shaft, levers, and handles.

SOLE PLATE.

The sole plate on which the works are fixed is a box or bed of cast iron, comprising the bottom, sides, and part of the top of two pairs of valve-boxes, one pair behind and one in front; flanges to receive the corresponding flanges of the cylinders; and the bottom and sides of two waterways, one at each side.



Valve-Box, without Valves.

On the bottom of the sole-plate there are cast four projecting lugs, two at each side, with a hole in each, through which square-headed screw-bolts are passed from above, and, going through the bottom of the cistern, are fastened underneath with nuts over iron washers. These bolts serve to keep the works in their place, and are called the holding-down bolts. The front pair, which have a greater strain, are further strengthened by passing through a flat bar of iron, $\frac{3}{16}$-inch thick and 1¾ inches wide, which goes across underneath that part of the cistern.

The waterways commence at the hind or stern end of the valve-box, where they are separated, and pass forward, each through one part of the hind valve-box, underneath the cylinder at the same side, and through the front valve-box, in front of which they come together again, thus forming two curved channels, starting from the same point behind, and joining again in front.

SUCTION INLET.

On the hind end of the sole-plate there is a flange, which takes the corresponding flange of a short gun-metal pipe, leading from the outside of the cistern, and called the suction inlet-pipe. The flanges are firmly fastened together with four strong gun-metal screws, a leather washer being placed between to make the joint air-tight. On the end of the suction inlet, which protrudes from the hind part of the cistern 2 inches, there is a male screw to take the corresponding female screw of a flexible suction-pipe, and, when the pumps are not at work, this is protected by a screw-cap of gun-metal, which is attached to the outside of the cistern by a small chain or staple. Inside the cistern the suction piece is perforated with a screw-hole, 2½ inches in diameter, to admit water from the cistern, and when the engine is working by atmospheric pressure, or, as it is called, suction, this hole is closed by a gun-metal cap, with a leather washer and a male screw, worked by a wrought-iron rod and handle from the top. The suction inlet has a clear round waterway of 2½ inches in diameter.

Key and Cap for suction-pipe inside cistern.

Suction-Valves.

The suction-valves, two in number, are made of gun-metal, and are of the kind commonly known as hinged inclined metallic valves. Each valve consists of the following parts, namely :—

Valves.

A frame or seat, on which an inclined flat surface is formed by planing.

A lid, with a corresponding surface to rest on the face.

These two surfaces are ground together, so as to be perfectly air and water-tight.

A brass pin, which passes through two lugs on the top of the frame and the top of the lid, thus forming the two into a hinge. The pin is slightly tapered, fitting tight in the lugs of the frame and slack in the lid, and, to prevent it moving round in the frame, it is stopped by a small projection at the large end, fitting in a corresponding recess, and called the joggle.

A stop, cast on the back of the lid, and cut to the correct size to allow the exact opening necessary for the water to pass through freely, but not to return.

The frames of the valves are rectangular, nearly square on the outside and round inside, and they are dropped into corresponding slots in the sole-plate, and firmly fixed in their places by two gun-metal wedges, called keys, which are driven in from above, and filed off flush with the top.

They are dropped in to such a distance, that the round internal part over which the lid rests is almost exactly opposite or in front of the remainder of the round waterway, and the lid is allowed to lift to such a height as to form a waterway, with the necessary area.

These valves are self-acting—that is to say, they are not fastened by means of connecting rods or otherwise to any of the moving parts, and consequently not set in motion by any direct action of machinery, as is the case with mechanical valves, but are opened by the pressure of the fluid, whether air, water, or any other substance, which is passed through the pump, and when this pressure ceases, close of their own accord by gravitation.

The lift of these valves is 1¼ inches, and the area of the opening is 4·9 square inches.

The force necessary to open them is a pressure of ·254 lbs., or in round numbers about ¼ lb. on the square inch.

Valve-Box Covers.

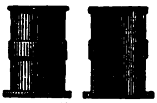
Those parts of the sole-plate which form the valve-boxes are smoothly planed on the top or surface, and the covers, which, like the boxes, are of cast-iron, are also planed.

A leather washer is placed between, and the lids are fitted on with 6 gun-metal turned screw-bolts, with slit heads, hove firmly down, so as to form a thoroughly air-tight and water-tight joint.

Each of these lids covers a double valve-box, separated in the middle, and holding the valves for both sides, but without any connection together beyond the fact that the two boxes are for convenience made in one casting.

The front and hind valve-boxes are somewhat different in this point, the hind one being completely divided into two parts, and the front only divided up to the point at which the valves are fixed; both, however, are so arranged as to keep the waterways perfectly distinct and separate for the two pumps.

Cylinders.


Cylinders.

The cylinders, or barrels, of which there are two, are of gun-metal, 11 inches long, $\frac{3}{16}$-inch thick, with a flange at the lower end projecting $\frac{7}{8}$ths of an inch, to take the corresponding flange on the sole-plate, a strengthening bead or projection $\frac{1}{2}$ an inch wide on top, and a strengthening band in the middle $1\frac{3}{4}$ inches wide and $\frac{3}{8}$-inch thick. Each cylinder is in one casting, and this arrangement of flange, band, and bead, is made for the purpose of combining strength with lightness.

They are accurately bored out to a diameter of 6 inches inside, and turned and polished on the outside.

They are fastened down to the sole-plate, each with 5 gun-metal screw-bolts.

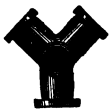
The barrels are, as before mentioned, 11 inches in length, but they are cylindrical for a distance of only 10 inches from the bottom, the remaining inch at the top end being somewhat bevilled off for the freer admission of the pistons.

Delivery-Valves.

The front or delivery-valves, with their boxes and covers, are almost precisely the same as the hind or suction-valves already described, except in the point previously mentioned.

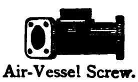
The area of the opening of these valves is 3·9 square inches.

Delivery-Branch Piece.


Delivery-Branch Piece.

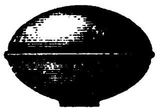
On the front part of the delivery-valve box there is a vertical flange, to which is attached, by means of 4 screw bolts with a leather washer intervening, another flange on a gun-metal casting, which receives the water from both cylinders. This gun-metal pipe has a water-way of 3 inches in diameter. It runs forward in a straight line 6 inches, and is there separated into two branches, each 6 inches long, and terminating in a flange. This is called the delivery-branch piece.

Air-Vessel Screw.


Air-Vessel Screw.

In about the middle of this pipe, or at the point where the straight part separates into branches, there is on the top a circular opening of $2\frac{1}{4}$ inches in diameter, and above this there is a ledge or ridge of metal 1 inch high, with a male screw cut on its outside. This is called the air-vessel screw.

AIR VESSEL.



Air Vessel.

On this there is screwed, with the usual intervention of a leather washer, a chamber of hammered copper, made in two pieces, lapped and closed in the middle, so as to form a horizontal joint, and with a gun-metal female screw below. This is called the air vessel. In order to obtain the greatest capacity, and at the same time the best shape of which the available space admits, the air vessel is made somewhat in the form of a globe, slightly flattened on the top and bottom, so as to clear the rocking-shaft or spindle, which passes along over the whole of the works, from the hind to the fore part of the engine frame, and the use of which is described further on.

The height of the air vessel is 13 inches; its greatest diameter is 17 inches; and its capacity 1,870 cubic inches, or 6¾ gallons.

OUTLET-PIPES.

Outlet-Pipes.

On the flanged ends of the delivery-branch piece there are fastened, by means of corresponding flanges with washers, and four gun-metal screw-bolts each, short pieces of gun-metal pipe, with a waterway of 2½ inches in diameter. These pipes pass through the wood-work underneath, and extend outside to a distance of 5 inches, where they terminate in male screws, which, when not in use, are covered by gun-metal caps hung on chains and staples for the purpose. These are called the outlet or exit-pipes.

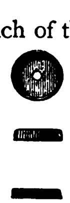
They are placed one at each side in front, and for general convenience are turned slightly downwards.

Both these pipes receive equally any water that may come from the branch-piece under the air vessel, and, although at opposite sides, they are in direct communication with each other, without the intervention of valves; consequently, if it be desired to draw the water off from only one side, it is necessary to close the other exit-pipe with the cap.

It will be perceived that, up to a certain point, there is a single inlet, which branches off into two channels—one passing through the left-hand or near side suction-valve, under the left-hand cylinder, and through the left-hand delivery-valve, the other passing through the right-hand suction-valve, under the right-hand cylinder, and through the right-hand delivery-valve—and that, after passing the delivery-valves, these two channels join into one, and, after going a short distance in this way, again separate into branches, and terminate one at each side of the cistern in front.

PISTONS.

Each of the pistons consists of two parts, made of turned gun-metal.



Piston Cups.

These parts are 5⅞ inches in diameter, ⅝-inch deep at the edge, and a little thicker in the centre round the piston-rod hole, but cut away from within half-an-inch of this hole to within ¼ of an inch of the outer rim, and filled up with a small block of wood, thus making a smooth surface at each side, and leaving the whole nearly the same thickness as the edge and centre. In the lower part this cutting is at the top, and in the upper part it is at the bottom, so that when the two parts are brought together, they present the appearance of two solid discs or circular plates of gun-metal, with a 1-inch hole through the centre.

The pistons are mounted on the outside with leather coverings, to make them fill the cylinders, touching at every part round the edge, but not fitting so tightly as to cause heavy friction when they are put in motion. These leather coverings are called cups, and they are formed in the following way.

A flat piece of $\frac{3}{16}$-inch leather is softened by being soaked in oil, and is pressed down into a mould of the required size, so as to form a hollow chamber or cup, consisting of an end or bottom and a rim. In both parts the end is placed inside; that is to say, it is on top of the lower part and under the upper part; and the rim goes round outside. This has the effect of making a complete covering round the edge, without any joint at all, and of securing this covering in its place without any fastening beyond that by which the two parts of the piston are kept together. The leather cups on the top are trimmed off flush with the surface of the upper part of the piston, and so allow oil or other lubricating substances to get access to the inside of the cylinder, and consequently, to a certain extent, to the whole of the rim of both cups when the pistons are in motion. The lower cups are differently fitted; they are allowed to protrude $\frac{1}{8}$ of an inch below the lower part of the piston, and the protruding part is bevilled off from the inside, leaving the extreme or lower part a thin lip or feather edge, which is easily forced outwards towards the cylinder, so as to touch in every part with only such pressure as is required.

When a piston becomes slack in the cylinder, it can be tightened by a packing in the following way:—

It is first drawn out, and the rim of the cup pressed outwards, so as to leave a space between it and the metal block. A thin piece of soft hemp or cotton, somewhat in the form of a piece of small twine, but with the fibres straight, not twisted, is passed round the metal block several times on the slack part until the requisite thickness is attained, after which the leather is pressed back into its proper position, and the piston replaced in the cylinder. It is impossible to make a proper packing with twisted twine, or with hemp, or other material containing lumps. It is also impossible, or very nearly so, to make a proper packing by a single piece of any substance passed once round, as there must in such a case be a rough spot somewhere near where the two ends come, and wherever there is a rough spot there must be either a leak or an undue amount of friction.

The depth of the metal part of a piston is $1\frac{1}{4}$ inches, and of the whole piston, including the ends of both cups and the protruding part of the lower one, is $1\frac{5}{8}$ inches, which makes a total touching surface of $30\frac{1}{2}$ square inches.

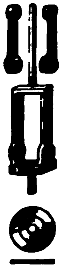
The two parts of the piston are held together by the lower part of the piston-rod, which passes through from the top, and has a nut firmly screwed on below and hove up tight over an iron washer.

PISTON-ROD.

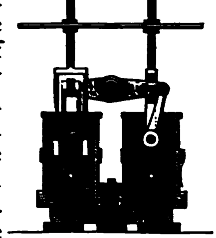
In ordinary cases a piston-rod is the connecting piece which is attached to a piston for the purpose of either receiving motion from it or imparting motion to it, but in a fire-engine of the kind in question the piston-rod can be hardly said to perform such a duty, as it merely serves to hold the ends of the rods by which the motion is applied, and in other respects is entirely unlike what is usually known as a piston-rod.

Each of the piston-rods of this engine consists of a rectangular metal frame 9¼ inches long, and 3¼ inches wide on the inside, with a screwed stem of 1 inch in diameter and 3 inches in length below, and a round rod ¾ of an inch in diameter and 10½ inches in length above.

The frame is of malleable cast-iron 1 inch wide, and 5/16-inch thick in the sides, but swelled considerably both in width and thickness near the lower end, where it is pierced horizontally with a pair of holes to carry a bolt or pin, which will be described further on. The top end is 1 inch wide and 7/16-inch thick, and the bottom end swells to a width of 2¼ inches in the centre, and has a thickness of 11/16 of an inch throughout.



Slings, Piston-Rod, and Piston.



Vertical section of Pumps.

The lower part or stem is passed through the two parts which form the piston. It rests on the lower end of the frame, and is secured, as previously described, by a nut screwed on over an iron washer. The width and length of the bottom serve to keep the whole frame perfectly upright, and the round piece at the top is consequently in a straight line with the centre of the piston, and, in fact, occupies exactly the same position as it would if it were made to spring from the centre of the piston itself, and not from the top of the rectangular frame. This round piece is called the guide-rod.

Guide-Bar.

At a height of 11 inches above the cylinders there is a flat bar of iron ⅜-inch thick, and for the most part 1⅛ inches wide, running across over the centre of the cylinders, and supported at its ends by the extremities of a pair of the same stays, which are used for connecting the hose box to the carriage frame, and to the screwed ends of which it is fastened with nuts.

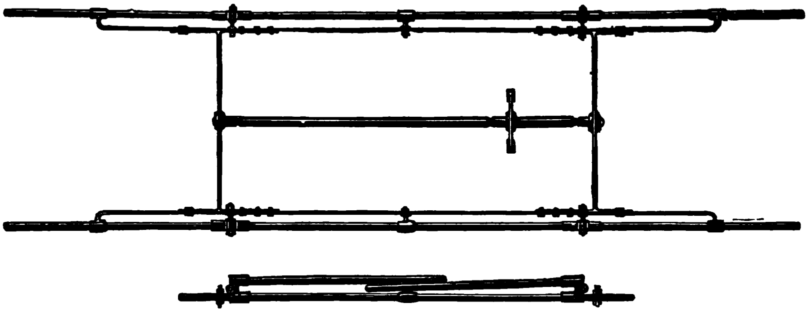
This bar is somewhat swelled in width over the centre of each cylinder, and is there pierced vertically with a hole fitted with a bushing of gun-metal ¼ of an inch thick and ⅝ of an inch deep. These are called the guides, and that part of the piston-rod called the guide-rod passes through them, and when in motion works up and down in them, thus keeping the pistons always straight in the cylinders. The cross-bar here described is called the guide-bar.

Slings.

Inside the frame there are placed two flat connecting-rods called links or slings. These are pierced above and below with transverse holes, which carry turned wrought-iron ¾-inch pins to connect them at the lower end with the piston-rod frame, and at the upper end with the extremity of a short cross-lever or working beam, through which motion is applied. These pins are called respectively the upper and lower sling pins, and they are secured in their places by having a head at one end and a hole with a split key through it at the other. The split keys are half let in to the slings and frames to prevent the pins turning.

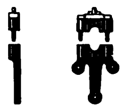
SPINDLE.

Motion is communicated to the pistons in the following way.



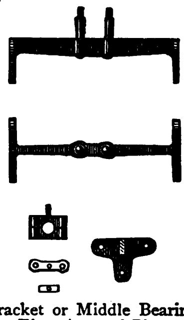
Levers, Handles, and Rocking-Shaft.

There is a spindle or rocking-shaft of wrought iron, $1\frac{5}{8}$ inches in diameter and 7 feet 11 inches in length, running along through the middle part of the carriage, from back to front, and supported on three gun-metal journals, those at the ends being secured to the frame of the carriage with three turned bolts and nuts each, and the remaining one fixed on a strong wrought-iron bracket, which passes across the carriage frame, and is fastened at each of its ends with three turned bolts and nuts, thus binding the frame firmly at that part. This bracket is flat, and placed on edge; it is $\frac{3}{4}$ inch thick and $1\frac{3}{4}$ inches deep, and is fixed within $4\frac{1}{2}$ inches of a line passing across the centres of both cylinders.



Front and hind Bearing Brasses.

Each of these journals, or, as they are more commonly called, bearing brasses, consists of two parts, called respectively the upper and the lower bearing brass. The lower ones at the ends are attached to the frame with bolts and nuts, and the middle one is laid in a place made for the purpose on the bracket. The spindle is then laid on, and after that the top brass is put in its place. Over this there is put a small iron plate, about $\frac{1}{16}$ inch thick, with holes at the ends corresponding with those in the bearing, and a small round standard, $\frac{1}{2}$ inch in diameter, which rises to a height of 1 inch in the centre, and is pierced with a small hole for a split key at the top.



Bracket or Middle Bearing. Elevation and Plan.

After this, two wrought-iron bolts with square heads are inserted in the holes in the bearings, and screwed down until the top and bottom brasses are made sufficiently tight.

The heads of these bolts are then, if necessary, slightly turned, to bring them exactly square. A rectangular stop-nut or keeper, with a hole in the centre, is slipped over the standard previously mentioned, dropping into and filling the whole of the space between the square heads of the screw bolts, and so keeping them firm in their places without driving them in tight or unduly forcing together the bearings, as it might be necessary to do if the bolt heads were to be kept in their places without a stop-nut. A split key is then put through the hole in the top of the standard, and the ends opened out, after which the bearing is complete.

The spindle or rocking-shaft is turned in six places, one for each of the three bearings, one for each of the two end levers, and one for the cross axe.

Working-Beam.

The spindle is connected with the pistons by means of a short wrought-iron lever, or pair of levers, called the cross axe or working-beam.

This is 14 inches long, 3½ inches deep in the centre, and tapered down towards the ends. It is for the most part 11/16-inch thick, but is swelled at the centre to a boss of 2½ inches. Inside this boss there is a horizontal hole fore and aft, through which the spindle passes, and the cross axe is fixed in its place directly over a line passing across over the centres of both cylinders by a feather fixed in a groove on the shaft, and filling a corresponding slot cut for the purpose inside the boss.

At the ends of the cross axe there are horizontal holes running fore and aft, which take the upper sling-pins, and so attach the ends of this short lever to the pistons.

The distance from the centre of the spindle to the centre of the holes which carry the upper sling-pins is 6¼ inches, and the distance of the centre of the spindle from a central vertical line through either of the cylinders is 5 inches.

Levers.

At each of the ends of the spindle, outside the bearings, there is fixed a cross lever of wrought-iron, with an arm to each side. These levers are of flat wrought-iron placed on edge. They are for the most part ⅝-inch thick and 2 inches deep, but are swelled to a boss of 3¼ inches, where they are secured on the ends of the spindle with steel keys or wedges driven into slots, cut both in the spindle and the boss.

Each arm at the outer end is formed into a T piece fore and aft. On the hind cross-lever the forward part of each of the T ends is 15 inches long, and is perforated with three half-inch holes, and the hind part, which is 9 inches long, is smooth, and on the inside slightly tapered.

On the front cross-lever the hind part is similarly pierced, and the front part is smooth and on the inside slightly tapered.

In addition to the holes above mentioned, there is also a ¾-inch hole, which takes a pin, the use of which will be described further on.

Outside and along the T ends of each of the cross-levers there is bolted, through the holes already mentioned, a flat bar of wrought iron, placed on edge. These are ½-inch thick, 2 inches deep, and 7 feet 3 inches long, and are called the side-levers.

To each T end of the cross-levers there is attached, by means of a pin or spindle, a corresponding additional part, of the same dimensions as the side lever with regard to thickness and depth, and 2 feet 5 inches long. This has an eye to match the eye on the side lever, and the pin forms the two parts into a hinge, thus allowing the folding lever to turn either out or in. When the folding lever is turned outward, it is stopped by the shape of the hinge from falling below a horizontal line from the side lever, and it is fixed in its place by a rectangular piece of wrought iron, called the lever-clip, which is fitted loosely on the folding part and slipped over the tapered extremity of the projecting arm of the T end, so as to keep the folding lever out in a straight line with the side part. This hinged connection is called the rule-joint; the hole in the side and folding levers is called the joint-eye, and the bolt which connects the two together is called the joint eye-pin. At the end of the folding lever there is an eye, called the flat-eye, to receive a folding handle, the use of which is described further on.

Handles.

In the centre of the side lever there is a $\frac{3}{4}$-inch hole, through which the end of an eye-bolt is passed from the outside. The stem of the bolt is stopped by a projection or collar on the outside, and fastened by a nut driven on the screwed part inside, so as to keep the whole bolt firm in its place. On the outer end of this bolt there is a horizontal socket, $1\frac{3}{4}$ inches in diameter, spreading $3\frac{1}{2}$ inches in length fore and aft, and through this eye there is passed a round wooden handle, the same length as the side lever, and terminating at both ends in wrought-iron sockets, which are fastened to the side levers by the joint eye-pin before mentioned.

The horizontal socket on the bolt in the centre of the handles and levers is called the collared-eye, and it serves to strengthen both the lever and handle, and to keep them in their relative positions, with a space of 2 inches between for the hands of the men working the pumps. The handle is of rounded ash, 7 feet 3 inches long and $1\frac{3}{4}$ inches in diameter, and it is called the side handle.

The socket-pieces at the ends of the side handles are made with corresponding sockets outside, in such a way as to form a hinge, and so contrived that when the hinge is opened it is stopped at such a point that the two sockets form as nearly as possible a straight line. This hinge is called the knuckle-joint, and its parts turn on the same spindle previously described, called the joint eye-pin. Into this socket there is fitted a handle of precisely the same material and thickness as the side handle, but 4 feet 5 inches long. This passes through and is supported by the flat-eye on the folding lever, and is called the folding handle.

The iron folding lever and the wooden folding handle being connected at the same distance and almost in the same manner as the side lever and side handle, and moving on the same spindle or pin, can be made to turn either in or out together. When they are in use for pumping they are turned outwards, so as to lengthen the space available for the men's hands, and when they are not in use they are folded back and secured in their places by small projecting iron pegs or studs, which fit into corresponding holes. These handles, when turned in, overlap each other to a distance of 1 foot 7 inches, and are usually kept fastened in this position by leather straps and buckles.

The hole for the peg of the hind folding handle is in the collared-eye on the top of the side handle, and that for the peg of the front folding handle is in a plate on the top of the hind folding handle; the object of which arrangement is, that the hind handle should always be turned over first and the other after, so that in the event of a collision, when travelling rapidly to a fire, there should be no projection likely to catch obstacles, as would be the case if the handles were made to fold with the hind end on top.

The same object—that of avoiding the consequences of collision—is aimed at in several parts of these engines, as in the splinter-bar-hooks and trace-hooks, all of which are turned inward, so as not to catch in anything which the engine may happen to touch.

When the levers are not in use for pumping, they are kept on a level with the lids of the suction-pockets by means of a bent bar of iron, attached below to an eye fixed in the front end of the cistern, and with two projecting lugs above, through which a split key passes. The side lever is placed between these lugs, and the pin inserted, and the levers are then firmly fixed so as to bear the weight of men standing on them. This bar is called the lever-stay or lever-lock.

Stroke.

When the handles are set in motion, the cross-levers make an angle of 80° between their highest and lowest points. They have a radius of 25½ inches, and consequently travel through an arc of 35½ inches in length. The chord of this arc, or the distance in a straight line from top to bottom, is 33 inches.

At the same time the arm of the working beam, with a radius of 6¼ inches, and moving to the before-mentioned angle, travels through an arc of 8¾ inches in length. The chord of this arc is 8 inches.

In other words, the movement of the handles with a radius of 25½ inches is communicated to the arms of the cross-axe with a radius of 6¼ inches, and both being on the same spindle, move to the same angle, 80°.

The men's hands on the handles travel a distance of 35½ inches on the circumference of a circle, but the length of stroke, or actual distance made good, is only 33 inches; and the arms of the cross-axe travel a distance of 8¾ inches on the circumference of a circle, but their length of stroke, or actual distance made good, is only 8 inches.

Each of the pistons is attached, as before described, to an end of one of the arms of the cross-axe, and is kept straight by the guide-rod in the guide-bar, and the result is, that while the end of the arm is travelling with a circular motion through an arc of 8¾ inches in length, the piston in the cylinder is moving in a straight line along a chord of 8 inches in length.

A stroke of either piston or handle is a complete double movement, once in each direction, but the length of stroke is the distance in a straight line from the extreme points occupied in a single movement or half-stroke.

The length of stroke of handles of the pumps now under consideration is 33 inches, and the length of stroke of piston is 8 inches.

Leverage.

The distance between the centre of the spindle and the centre of the handle is 25½ inches.

When the handles are set in motion, they move through an arc of a circle, and they are stopped by the one below, whichever it may be, striking on the beat-block.

A lever is a mechanical contrivance consisting of a bar, a frame, or other rigid structure, with a place for the application of motive power, a place to which a load is attached, and a place on which it rests; and levers are of three different kinds, according to the positions which these places occupy relatively to each other.

A lever of the first kind has the power at one end, the load at the other, and the fulcrum or support between the two.

A lever of the second kind has the power at one end, the fulcrum at the other, and the load between the two.

A lever of the third kind has the load at one end, the fulcrum at the other, and the power between the two.

The mechanical power, commonly known as leverage, is measured by the difference between the distances at which the moving power and the load respectively stand from the nearest point of a vertical line passing through the centre of the fulcrum.

The lever of the fire-engine under consideration is either of the first or second kind, but never of the third.

This engine has, as already explained, two complete pumps, each with its own valves, water-ways, and piston, quite separate and distinct from the other, but with only one lever, or rather two arms of one lever, to work both pistons.

The men working the left or near side handle consequently use a lever of the first kind on the right-hand piston, and a lever of the second kind on the left-hand piston; and the men working the right or off-side handle use a lever of the first kind on the left-hand piston, and a lever of the second kind on the right-hand piston.

During the working of these pumps the leverage undergoes a constant change, inasmuch as the handles to which the motive power is applied are continually changing their distance from the vertical line rising from the centre of the spindle, while at the same time the pistons, which are in point of fact the load, keep the same distance from that line at all parts of the stroke.

The distance at which the centre of the handles stands from the vertical line before mentioned, is greatest when the cross-levers are horizontal, and least when they are at their highest and lowest points. Thus, when the cross-levers are placed horizontally, the distance is 25½ inches, and when they are at the top or bottom of their stroke it is 19½ inches, that of the pistons remaining at 5 inches.

The result is that—

The greatest leverage is 25½ to 5, or a little over 5 to 1,
The least leverage is 19½ to 5, or a little less than 4 to 1,
And the main leverage 22½ to 5, or exactly 4½ to 1.

Capacity.

The quantity of water received into one of these pumps during the upward movement of the piston, or discharged from it on the downward movement, is that which can be contained in 8 inches long of a 6-inch cylinder.

The area of a 6-inch circle is 28·274 superficial square inches, which, multiplied by the length of stroke, 8 inches, gives a capacity of 226·192 cubic inches for 8 inches long of a 6-inch cylinder.

There are 277·123 cubic inches in a gallon, and consequently the capacity of one of the pumps in question is ·816 gallons.

The fire-engine now under consideration has a pair of cylinders on opposite sides of a rocking shaft, with pistons driven by a reciprocating movement of the arms of the working beam. It has, in fact, a pair of such pumps as those described, and consequently the united capacity of the two, or the quantity of water received and discharged on a stroke of the engine, is 452·38 cubic inches, or 1·63 gallons. In round numbers, the capacity of the engine is a little over a gallon and a half.

When the engine is in proper order, and worked at reasonable speed, the quantities of water delivered are in exact proportion to the number of strokes made, without reference to the force applied, the speed at which the handles are worked, the pressure, or any other circumstance.

The engine can be worked to the best advantage by 30 men, and the harder they work the greater will be the result; but the quantities of water delivered are measured, not by the amount of their labour, but by the actual result made good in number of strokes.

These quantities will be as follows, whether the engine is working at a pressure of 100 lbs. on the square inch, or at a mere nominal pressure of 2 or 3 lbs. The labour of the men is heavier when the greater pressure is attained, but the quantities of water are not in any way affected—1 stroke 1·63 gallons.

Strokes.	Gallons.	Strokes.	Gallons.	Strokes.	Gallons.	Strokes.	Gallons.
10	16	260	424	510	831	760	1,239
20	33	270	440	520	848	770	1,255
30	49	280	456	530	864	780	1,271
40	65	290	473	540	880	790	1,288
50	82	300	489	550	897	800	1,304
60	98	310	505	560	913	810	1,320
70	114	320	522	570	929	820	1,337
80	130	330	538	580	945	830	1,353
90	147	340	554	590	962	840	1,369
100	163	350	570	600	978	850	1,386
110	179	360	587	610	994	860	1,402
120	196	370	603	620	1,011	870	1,418
130	212	380	619	630	1,027	880	1,434
140	228	390	636	640	1,043	890	1,451
150	245	400	652	650	1,060	900	1,467
160	261	410	668	660	1,076	910	1,483
170	277	420	685	670	1,092	920	1,500
180	293	430	701	680	1,108	930	1,516
190	310	440	717	690	1,125	940	1,532
200	326	450	734	700	1,141	950	1,549
210	342	460	750	710	1,157	960	1,565
220	359	470	766	720	1,174	970	1,581
230	375	480	782	730	1,190	980	1,597
240	391	490	799	740	1,206	990	1,613
250	408	500	815	750	1,223	1000	1,630

It is very common with unskilled persons to mention as the capacity of a pump, not the actual quantity of water received and discharged on a single stroke, but the quantity delivered in a minute, or some other fixed period of time; but this mode of calculating is based on a misconception; it confuses together two totally distinct branches of the subject, and consequently leads to conclusions in many cases wholly erroneous.

The two distinct points alluded to are the size of the pump and the power applied. The pump of itself does nothing, and consequently produces no result; but if a power be applied to it, so as to obtain from it any given number of strokes, then the quantity of water delivered should be in accordance with that mentioned in the foregoing table, without reference to the time occupied.

It is true that, if a pump be worked at too high a speed, the valves will not rise and fall fast enough, and the consequence will be, either that they will not admit a sufficient quantity of water to fill the cylinders during the upward movement of the pistons, or that, having admitted it, they will let by a certain portion, which will consequently escape back, and so render the actual delivery short of what it would be if the valves were acting properly; but this is a circumstance of very rare occurrence with any good hand-worked pump, and consequently need not be taken into consideration at all with reference to the delivery of the engine here described.

As a matter of fact, it will be found that, if a certain number of men be put to work the pumps, they will accomplish in any given time a certain number of strokes, and consequently a certain delivery of water; and that if the number of men be increased, the result will be increased in a precisely similar proportion; or that if, without having their number increased, the men work harder, the quantity of water delivered will be in proportion to the increased power applied by the same men.

The foregoing table has been carried to the extent of a thousand strokes, without reference to the time employed, and this has been done for the purpose of giving special prominence to the fact that, if the pumps be in proper working order, the result will be in exact proportion to the number of strokes realised, whether in one minute, one hour, or any other fixed period of time.

To Test an Engine.

A machine of this kind should be tested in two distinct ways: first, as to the condition of the works alone; and secondly, as to that of the works and carriage together, or engine complete; and these tests are applied in the following manner.

The Works alone.

Inspection of Parts.—All the parts should be carefully examined after completion, but before being fitted together; and those parts which are approved should be stamped by the inspecting officer in such a manner that the marks may be seen after the joints have been made.

When the parts have been put together, the whole of the works should again be carefully examined, with a view to ascertaining that those used are the same which have been previously approved, and that they appear to fit properly in their respective places.

The valves, cylinders, pistons, waterways, and joints of the works, should invariably be tested by pressure before being mounted on the carriage.

This is done in the following manner.

For Strength, Tightness, and Finish.—Place the sole-plate, with the cylinders, air-vessel, and delivery-pipes attached, on a table or bench, at such an elevation that the whole of the parts may be conveniently seen. Move all the valves, either by hand or with a piece of wood. An iron or other hard bar should not be used for this purpose, as it might injure the faces or seats.

Observe that when the valves drop they make a solid sound, and do not seem to be either stiff or gritty.

After this, raise the front valves by placing a piece of wood under them, so as to leave a space through which water will pass freely.

Insert the pistons into the cylinders, and push them down to the lowest point, so as to leave as little air as possible inside.

Put on the clamp-irons and frame for stopping the pistons when they are forced to the top.

Fasten on one arm of the delivery-pipe a solid cap, or a cap with a pressure-gauge on it, and on the other arm a cap to take the hose of a force-pump.

Attach the force-pump by this means, and work it with water, until a pressure of 150 lbs. on the square inch has been raised inside. Continue this pressure for a few minutes, carefully observing all the parts affected, and, if the joints do not blow, and the pistons and suction-valves do not let water pass, it may be considered that the delivery-pipes, the air-vessel, the delivery-valve-box-cover, the pistons, the suction-valves, the suction-valve-box-cover, and all other parts of the works, except the front valves, are properly fitted, of sound workmanship, and sufficient strength.

After this, let off the pressure, draw the pistons, empty the cylinders and waterways, remove the wedges, and work the force-pump again until the same pressure as before has been raised.

Continue the pressure for a few minutes, carefully observing the result as before, and, if the delivery-valves do not let any water pass, they may be considered all right.

After these tests have been applied with satisfactory results, and a certificate to that effect signed by a responsible officer, the works may be mounted on the carriage.

The Engine Complete.

For Suction.—Remove the suction and delivery-caps, and put the handles down at one side, say the left or near side. Screw on to the suction inlet a piece of pipe with a vacuum-gauge and an air-cock.

The vacuum-gauge may be marked either for inches of a column of mercury, or for pressure in lbs. on each square inch.

The suction-valves are numbered 1 and 2, and the delivery-valves 3 and 4, the odd numbers being on the near side and the even numbers on the off side; that is to say, the valves of the left-hand pump are No. 1 and No. 3, and the valves of the right-hand pump No. 2 and No. 4.

Close the air-cock, and raise the near side handle to the highest point, and stop it there, watching the gauge both during the movement and afterwards.

Should the gauge show a vacuum of about 15 inches, or $7\frac{1}{2}$ lbs. on the square inch, and hold it, this will be a sign that No. 2 and No. 3 valves are tight, and that the cylinder, the piston, the valve-boxes, valve-box lids, and the waterway of the left-hand pump, are in complete working order.

Should the pressure go back quickly, it will show that there is a leak somewhere, and all the joints must be carefully examined, and the same experiment continued until the leak has been found and stopped. Before repeating this test, it is necessary to open the air-cock full, so as to allow the air to enter, and then to close it before putting the levers in motion.

The same test may then be applied to the right-hand pump for the purpose of ascertaining that No. 1 and No. 4 valves are tight, and that all the parts of that pump are in complete working order.

When both pumps have been separately tested in this way, the air-cock may be again shut off, and the handles put in continuous motion, in order to ascertain what vacuum can be made; and they should be occasionally stopped, for the purpose of more effectually ascertaining the exact tightness of the several parts under the maximum pressure of the atmosphere.

If the engine, when worked in this way, can raise a vacuum pressure of about 23 inches, or $11\frac{1}{2}$ lbs. on the square inch, and can sustain a pressure of about 20 inches, or 10 per cent. less, it may be considered fit to work by suction.

Any person of experience can apply this test, by means of his hand, with results sufficiently accurate for almost all practical purposes; but in passing a new engine it is advisable to use a vacuum-gauge.

For Delivery.—The vacuum-gauge may then be removed, and the suction inlet left open; one of the outlets of the delivery-pipe may be closed with a cap, and the short pipe previously used may be screwed on the other. An ordinary pressure-gauge may be put on, the air-cock closed, and the handles put in continuous motion, until a pressure of about 35 lbs. on the square inch has been attained. The handles may then be stopped, and the gauge carefully watched, to see that it does not fall below 32 lbs., or about 10 per cent. less than the highest point which it reached when the handles were in motion.

During this experiment it is of advantage occasionally to open the air-cock suddenly, so as to relieve the pressure altogether, and then to close it, and continue the working of the handles; this will cause a sufficient amount of shock to test the several parts.

This test also may be applied by hand, except when passing a new engine, in which case it is advisable to use a pressure-gauge.

For finding a Leak.—Should it be found, on raising the left-hand piston, that there is a leak, the probability will be that either No. 2 or No. 3 valve is slack, or that the left-hand piston does not fit; but there may be a difficulty in ascertaining in which of these three parts the leak is; and should it be found, on raising the right-hand piston, that there is a leak, the probability will be that either No. 1 or No. 4 valve is slack, or that the right-hand piston does not fit, and a similar difficulty may arise. There are several ways of detecting such a fault.

The simplest way is to close both deliveries, putting a pressure-gauge on one or both, and to force in air to the front by working the pumps; then to lift the two hind valves by means of thin pieces of wood pushed in from the suction-pipe, and, if the pressure continue, it will be a sign that the front valves are both tight, and that it must be one of the hind valves that is slack. There is no difficulty in getting a piece of wood under one of the hind valves if the levers be kept moving, as the raising of the pistons relieves the pressure.

If, however, the fault cannot be detected in this way, the best course to pursue will be to work the pumps separately, by removing the piston first from one cylinder and afterwards from the other.

If the off-side or right-hand piston be drawn, and the left-hand pump worked alone, the result of the first upward movement should be a vacuum of about 15 inches, or 7½ lbs. on each square inch, and of a continuous working of the piston a vacuum of about 23 inches, or 11½ lbs. on each square inch.

After this the hind valve of the pump not in use should be raised, the vacuum-gauge removed, and the pump set to work, until a pressure of about 35 lbs. on the square inch has been raised.

If the near-side or left-hand piston be drawn, and the right-hand pump worked alone, the same results should be obtained, only on the other valves.

In this way, by closely observing the effects of the several movements, any leak or defect in the parts may easily be detected, the inspecting officer being always careful to remember that, when the valves are not set up in the above-mentioned way, the upward movement of either piston tests the front valve of its own cylinder and the hind valve of the other, and the downward movement of either piston tests the hind valve of its own cylinder, and the front valve of the other; and that when one of the hind valves is set up, and the pump at the other side is put to work, the upward movement of the piston tests only the front valve, the downward movement tests only the hind valve, and a continuous movement tests its own two valves and the front valve of the other pump.

SUMMARY.

When none of the valves are set up—

The left-hand	piston	moving up	tests	No. 3 & No. 2.	
Ditto	ditto	down	„	No. 1 & No. 4.	
The right-hand	piston	moving up	tests	No. 4 & No. 1.	
Ditto	ditto	down	„	No. 2 & No. 3.	

When the right-hand piston is drawn, and No. 2 valve set up—

The left-hand	piston	moving up	tests	No. 3	„
Ditto	ditto	down	„	No. 1	„

When the left-hand piston is drawn, and No. 1 valve set up—

The right-hand	piston	moving up	tests	No. 4	„
Ditto	ditto	down	„	No. 2	„

Continuous working of either piston, with or without the valve of the other being set up, will test its own hind valve, and both the front valves.

The lifting of both the hind valves, after a pressure has been got up, tests both the front valves.

When either piston is being worked with its own hind valve set up, the vacuum-gauge can be used; but when it is worked with the other piston drawn, and the hind valve of the other set up, the vacuum-gauge cannot be used.

For Strength.

The air may next be let off, after which the air-cock may be again closed. Water may then be introduced, and the pumps set to work, until a pressure of 150 lbs. on the square inch has been attained.

Should there be no undue straining of any of the parts, and no leaking at this pressure, the works may be considered sufficiently strong.

For Capacity.

After all these experiments have been tried, the pumps should be tested for capacity in the following manner :—

Set the engine in close to a water supply, as nearly as possible on the level of the pumps, with the outer end of the suction-pipe well immersed. Screw on to one of the outlet-pipes a pressure-gauge, according to convenience, with or without the short piece of pipe previously used, and to the other outlet a length of hose.

Into the side of a properly gauged tank or trough fasten one of the delivery parts of a breeching with a two-way cock, the other part being turned outside.

Screw on the female swivel part to the end of the length of hose leading from the engine, and turn the handle of the two-way cock so as to deliver the water outside the tank.

Set the pumps to work, and, as soon as they have begun to run steadily, and the hose has been completely filled with water, turn the handle sharply, so as to deliver the water inside the tank, taking an exact account of the number of strokes, and, after about a minute or so, sharply turning the handle again, so as to deliver the water outside. Then multiply the known capacity of the pumps by the number of strokes, and see that the result agrees exactly with the quantity shown on the gauge.

During this experiment, great care must be taken to ensure a steady working of the pumps throughout. If the pressure be raised to a considerable height before the commencement, and allowed to become less during the working, the effect will be that a quantity of water, which has been forced into the air vessel, will escape forward, in addition to that passed through the pumps; and if the pressure be very low at the commencement, and be raised during the work, the effect will be that a portion of the water passed through the pumps will be delivered into the air vessel and not into the tank, thus decreasing the quantity. In either of these cases an incorrect result would be attained; but if the pressure be carefully watched, and the work regulated accordingly, so as not either to increase or diminish the quantity of water in the air vessel while the delivery into the tank is going on, the calculated quantity should exactly agree with that shown on the gauge.

This experiment should be repeated with the water supply at several different levels below that of the engine, and also with a branch, and with nozzles of various sizes, the same principle being observed throughout. In this way the engine can be proved to every necessary pressure, but, for the reasons previously given, it should on no account be tested to more than one pressure in any one experiment.

After this, the engine should again be carefully examined, and if no straining, leaks, or other defects be found, it may be considered fit for general work.

The following articles are carried on this engine:—

Articles.	No.
Axes, large	1
Branch tallies	2
Branches	2
Breechings, delivery, 1 into 2, 2½ and 2½	1
Breechings, delivery, 1 into 2, 2½ and 1½	1
Breechings, delivery, 2 into 1, 2½ and 2½	1
Buckets, canvas	6
Chisels, cold	1
Cisterns, canvas	1
Crowbars	1
Double connecting screws ...	1
Double reduction screws	1
Elbows, delivery, 2½ and 2½	*According to circumstances and locality.*
Elbows, delivery, 2½ and 1½	*According to circumstances and locality.*
Elbows, delivery, 2¼ and 1½	*According to circumstances and locality.*
Files	1
Hammers, iron	1
Hammers, tin	1
Hand-loops	2
Hand-pumps complete	1
Hose, 2½-in. 40-feet lengths of ...	8
Hose wrenches, 2½-in.	2
Hose wrenches, 1½-in.	2

Articles.	No.
Hydrants, ball	*According to circumstances and locality.*
Hydrants, sluice	*According to circumstances and locality.*
Ladders	2
Lamps, carriage	2
Leathers, lapping	6
Lines, lapping	6
Lines, long	1
Lines, short	1
Mattocks	1
Nozzles, ¾	1
Nozzles, ⅝	1
Nozzles, ½	1
Preventers	1
Saws	1
Smoke caps, complete	*According to circumstances.*
Spades	1
Spanners, branch and nozzle ...	1
Spanners, shifting	1
Standpipes	1
Straps, bucket	1
Straps, ladder	2
Straps, lever	2
Straps, preventer	1
Suction-pipes	4
Suction-strainers	1
Tin cases, with working lists ...	1
Turncocks' tools, sets of	1
Wedges, bundles of	1

The total weight of the above may be estimated at an average of 6cwt. 3qrs. 14lbs.

In many stations, the advantage of using lighter hose is found so great, that the following change is made.

Instead of eight 40-feet lengths of 2½-in. hose, fifteen lengths of 1½-in. hose are carried, and a few trifling alterations are made in the number and size of spanners, and other small gear.

The proper crew for this engine consists of four firemen and a coachman, and their total weight in full uniform may be taken at an average of about 7½ cwt.

The total weight, therefore, of this engine when proceeding to a fire may be estimated as follows:—

	Ton.	Cwt.	Qrs.	Lbs.
Works	0	4	2	2
Carriage	0	11	2	26
Pole and 2 sway-bars ...	0	0	1	14
Engine ...	0	16	2	14
Gear	0	6	3	14
Men	0	7	2	0
Total	1	11	0	0

LEATHER HOSE.

INTRODUCTORY.

So much of the most active part of a Fireman's work is connected with the laying out and handling of the flexible pipes or hose which convey water, that it is necessary for him to understand thoroughly every particular concerning them.

These pipes are principally of two kinds, the one commonly called suction-pipes, which convey the water from the reservoir or hydrant to the pumps; the other delivery-pipes, or hose, which convey the water from the pumps to the fire.

They are essentially different in almost all particulars, the first being made to resist a pressure of about 15 lbs. on the square inch on its outside, tending to make it collapse; and the other to withstand ten times that pressure on its inside, tending to make it burst.

Particulars concerning both kinds will be found in the following pages.

SUCTION-PIPES.

SUCTION-PIPES are made of leather, india rubber, or other material, stretched over a metal spiral, which prevents it from collapsing when a vacuum is formed inside.

This spiral is made either round, half-round, or flat, and is firmly soldered on to the shanks of the screws at both ends. The round spiral is more flexible and less likely to break when subjected to sharp bends; the flat spiral forms a much smoother and better water-way, but cannot be bent to a right angle without considerable difficulty and some risk of breaking; the intermediate, or half-round kind, combines the advantages and disadvantages of the other two.

When leather is the material employed, it is usual to place a bandage of tarred or pitched canvas between it and the spiral, to exclude the air, which would otherwise find its way through the pores of the leather and prevent the formation of a vacuum.

Suction-pipes are carried on the engines in short pieces, the length of which is usually determined by that of the side pockets, and being mounted with screws of an exactly uniform pattern, they can be used singly or with several joined together.

They have hardly any wear or tear, and under ordinary circumstances last for years, and give very little trouble beyond that of dressing the leather with an occasional light coat of oil or dubbing, and keeping the couplings clean and free from grit.

They vary, as before mentioned, in material, size, and general details, and it is consequently impossible to describe them all within the limits of these pages. I have therefore selected one of the kind most commonly in use, namely, a leather suction-pipe with a water-way of 2½ inches in diameter.

LEATHER SUCTION-PIPE.

THE following is a description of the several parts of a 6-foot 6-inch length of leather suction-pipe, used with a manual fire-engine, worked by 28 or 30 men.

It consists of—

- A pair of gun-metal couplings.
- A coil of metal spiral.
- A bandage of tarred canvas.
- A riveted leather cover.
- A lapping of wire at each end.
- A leather washer.

COUPLING SCREWS.

These are precisely the same as those used with delivery-hose in every particular, except the threads, which in the suction-pipes are round and not **V** shaped.

A pair of coupling screws is composed of the following parts, namely:—

A male part, with a screw at one end, a shank at the other, and a pair of lugs between. The inner end or shank has five ridges cut on it for the purpose of preventing the hose slipping off when under pressure. The outer end beyond the screw is cut perfectly smooth and even, so as to rest on any flat surface.

A female part, which is double, and consists of a swivel, and a shank or ferrule. The female screw is cut inside the swivel. The ferrule, like the shank of the male screw, is grooved below in five ridges, and is mounted near its end with a collar or shoulder, which brings up on a corresponding collar in the swivel, and keeps the parts together. The lower threads of the female screw are cut away, and a recess sunk which holds a leather washer, the inside of which is kept in its place by a thin projecting piece of metal rising above the collar of the ferrule.

When the couplings are put together, the joint is formed, not by the threads of one screw fitting closely in the threads of the other, but by the outer end or face of the male part pressing against the washer in the female part. It is to obtain leverage for effecting this pressure that the lugs are made; and if the screws be entered fair, not driven across thread, and no dirt or grit admitted, they can be forced together by means of hose-wrenches, or dog-tails, until the face of the male part rests solid on the washer in the female part in such a way as to be perfectly air and water-tight.

The pitch of these screws, or distance between the centres of two consecutive threads, is ·2 inch, and consequently the number of threads to an inch is 5; the depth of the threads is about 1-8th of an inch.

The distance which the male screw goes into the female screw is about 5-8ths of an inch, and the number of complete or round turns of the swivel part, necessary for the making of the joint, is consequently about three. This, of course, depends to a certain extent on the thickness of the washer, but the number of turns here mentioned will be found sufficiently near accuracy for all practical purposes.

SPIRAL.

There are 4 feet 4 inches long of close spiral, made of half-round galvanized iron wire $\frac{1}{4}$ of an inch wide, $\frac{3}{32}$-inch thick, with the round part outside, and the flat part inside. This is fastened on at both ends to the shank of one part of the coupling with soft solder. For this purpose rivets should never be used, as they do not hold the spiral firmly, and besides project inside and interfere with the water-way.

After the couplings are soldered, a mandrel is passed inside the spiral, and the screws are drawn apart to a distance of 6 feet 6 inches, measuring from outside to outside. This is effected by stretching the spiral, and the screws are then tied on to the mandrel with light pieces of cord to prevent them springing back.

CANVASS.

A quantity of canvass strip, 4 inches wide, is then soaked in boiling pitch and tar.

If the pipes are to be used in England, or any similar climate, the best mixture for this purpose is in the proportion of 2 pints of tar to 14 lbs. of pitch; if they are to be used in the tropics, there should be only 1 pint of tar to the same quantity of pitch; and, for intermediate climates, the quantity of tar may be regulated on somewhat the same principle.

The whole of the canvass is first dipped in the hot mixture, and then slowly drawn out and carefully wound on a stick, rubbing the whole of the outside during the winding on a flat surface, to remove lumps or other inequalities.

The mandrel is then placed on two trestles, in such a way as to be supported only at the ends, and the canvass is wound off the stick and on to the spiral in the same way as a horse-bandage. It is usual to commence first at the end next the female screw, and to wind it in such a way that it may overlap itself 2 inches at every turn, thus making a complete double covering of the spiral, and ending at the male screw; then to commence at the end next the male screw, and work back, making the turns in the opposite direction, so as to cross the first folds at a wide angle, and finishing at the female screw. The strips being 4 inches wide, and the overlap of each part 2 inches, when the whole is completed, there are four folds of the tarred canvass over every part, and, if the work be quickly and properly done before the mixture has had time to cool, the pipe should be perfectly air-tight without the leather covering.

LEATHER COVER.

The leather coat or cover is next put on with the grain inside and the flesh outside. When the pipe does not exceed 8 feet, as in the case in question, the leather is always in one piece. It is cut to an exact width of 11 inches for a water-way of $2\frac{1}{2}$ inches inside the spiral, and is punched with holes for No. 6 rivets, allowing 20 for each foot. The rivets are of best tinned copper punched in a single machine, which leaves no mark or score, as is the case when a double punch is used, and they are almost as round as if turned in a lathe. The heads of the rivets should be at least ½ an inch in diameter, in order not to pass through the spiral, and the washers should be of a corresponding size.

The inner part of the leather coat is shaved to a feather edge, so as to lay perfectly close to the canvass; the rivets are then inserted from the inside, the first being 2¼ inches from the female screw, and the remainder at the distances before mentioned; the outer part is then drawn over, and the rivets forced, by means of a grab-awl, through the holes made for them. The washers are then driven on and the ends of the rivets burred down over them, the iron mandrel inside supporting the spiral and so taking the heads of the rivets during the hammering. If any lumps or inequalities be found in the canvass bandage, a hot iron can be placed inside the spiral for a moment to soften them, after which they can be at once smoothed down and the leather put over. The rivets and washers are continued in this way throughout the whole length up to within 3¼ inches of the lower thread of the male screw, where the leather is cut longitudinally to allow it to be drawn past the lugs.

Wire Lapping.

The leather coat is secured in its place by wire ties or lappings at both ends, each lapping being composed of three distinct pieces of wire, with a corresponding number of independent fastenings, so that the breaking of one, or even two, will not necessarily disable the pipe. These lappings are commenced inside close to the washer of the first rivet, and finished within a quarter of an inch of the end of the leather next the female screw, and touching the lugs of the male screw.

Washer.

A leather washer is inserted with its outer edge in the recess cut in the female swivel, and its inner edge against the lip which projects from the collar of the ferrule or shank, and the suction-pipe is then ready for immediate use.

In the ordinary manual fire-engines there is room for four 6-ft. 6-in. lengths of suction-pipe, two in each pocket. It is, however, found convenient in practice to keep a strainer always screwed on, and, as this occupies a space of about 14 inches, it is usual to carry only three 6-ft. 6-in. lengths and one 5-ft. 4-in. length.

The average weights of the pipes are:—6-ft. 6-in. lengths, 31 lbs.; 5-ft. 4-in. lengths, 27½ lbs.

Curricle Suction-pipe.

A curricle engine has a suction-pipe attached to it 12 feet long, which is always ready for use, being screwed on to the suction-inlet with the strainer attached, and all complete. It is formed into a coil, and strapped to the levers when not in use.

The following is a description of a curricle suction-pipe :—

It consists of a pair of gun-metal couplings, a coil of metal spiral, a canvass and vulcanized india-rubber covering, a lapping of wire at each end, and a leather washer.

The coupling screws of a curricle suction-pipe are of the same construction as those used for other suction-pipes, and differ only in dimensions. They have a water-way of 2 inches in diameter. The pitch of these screws, or distance between the centres of two consecutive threads, is ·16 inch, and consequently the number of threads to an inch is 6·25, or 6¼; the depth of the threads is nearly 1-8th of an inch.

There is a length of close metal spiral, made of galvanized iron wire, about 1-8th of an inch in diameter; this is soldered on at each end to the shank of one part of the coupling; it is then secured on a mandrel, and so made ready to receive the covering.

The covering is made of a mixture of canvass and india-rubber, there being four layers of canvass imbedded, and covered on both sides with india-rubber, and this composition is commonly known as 4-ply. This is formed into a large sheet, and while hot is stretched over the spiral, and when it has properly shaped, and the joints made perfect, it is put into a stove as a finishing process. This is called curing, or, in other words, vulcanizing or hardening, which is chiefly done with sulphur, but the exact process is known only to the manufacturers.

This covering is then secured by copper wire ties or lappings at both ends, each lapping being composed of three distinct pieces, with a corresponding number of independent fastenings, so that the breaking of one, or even two, will not necessarily disable the pipe.

A leather washer is fitted to the female screw in the same manner as that described in the instructions concerning leather hose.

Before taking this suction-pipe into use, great care should be taken that it is provided with a covering of No. 1 canvass, to prevent it from being chafed, or from grease getting to it, either being highly injurious and likely to destroy it in a short space of time.

Especial care should be taken, when cleaning the couplings, that none of the oil used for that purpose comes in contact with the india-rubber covering, nothing being more calculated to rot or destroy it.

The weight of a curricle suction-pipe complete, as here described, is 26 lbs.

A 20-foot Length of Steamer's Suction-Pipe.

Most steamers carry one 20-foot length of suction-pipe always ready for use, it being screwed on to the suction-inlet, bent round, and laid along on the brackets placed for that purpose, and brought round either in front or behind the engine to the other side, according to circumstances, with the strainer attached to it.

The following is a description of a 20-foot length of steamer's suction pipe :—

It consists of a pair of gun-metal couplings, a coil of metal spiral, a canvass and vulcanized india-rubber covering, a lapping of copper wire at each end, and a leather washer.

The coupling screws attached to a steamer's suction-pipe are of precisely the same description as those used for manuals, and fully described in the instructions for leather hose, with the exception of the size and weight, which depend on the necessary diameter of water-way, in accordance with the size of the engine. Those now in use for steamers have a water-way of 3½ inches in diameter, and the screws are of the new pattern round thread; the pitch of these screws, or distance between the centres of two consecutive threads, is 1-5th of an inch, and consequently the number of threads to an inch is 5; the depth of the thread is 1-8th of an inch.

The weight of a pair of couplings is as follows:—male part 5 lbs. 11 oz.; female part—swivel 3 lbs. 11 oz., ferrule 2 lbs. 3 oz.—5 lbs. 14 oz.; total, 11 lbs. 9 oz.

There is in each a length of close metal spiral of galvanized wrought round iron, known as No. 3 Birmingham Wire Gauge, or commonly called ¼-round iron. This is fastened on at each end to the shank of one part of the coupling; it is then secured on a mandrel, and so made ready to receive the covering.

The covering is made of a mixture of canvass and india-rubber, there being 4 layers of canvass, imbedded and covered on both sides with india-rubber; this composition is commonly known as 4-ply. It is formed into a large sheet, and while hot is stretched over the spiral; and when properly shaped, and the joints made perfect, it is put into a stove as a finishing process. This is called curing, as previously mentioned.

The covering is then secured at both ends by copper ties, or lappings, of the wire known as No. 12 Birmingham Wire Gauge, each lapping being composed of three distinct pieces of wire, with a corresponding number of independent fastenings, so that the breaking of one, or even two, will not necessarily disable the pipe.

A leather washer is fitted to the female screw in the same manner as described in the instructions concerning leather hose.

Before these suction-pipes are taken into use, they should be provided with a covering of No. 1 canvass, and the other precautions, as before described, should be adopted.

The weight of a 20-foot suction-pipe for a steamer is about as follows:—suction with couplings 1 cwt. 1 qr. 1 lb., canvass 6 lbs.; total, 1 cwt. 1 qr. 7 lbs.

TO TEST SUCTION HOSE.

Screw on the pipe to an ordinary fire-engine, previously ascertained to be tight, and on its outer end place a cap with a vacuum-gauge attached. Then set the pump to work, watching the gauge closely at every stroke; after which stop the pumps, and observe whether the gauge goes back. If the gauge advance steadily with the strokes, and remain at about 14 lbs. after the pumps have been stopped, the pipe may be passed, but otherwise it should be rejected.

As a general rule it is not advisable to test suction hose by means of internal pressure, but if it be discovered that there is a leak somewhere and its exact spot be not apparent, the suction may be removed from the inlet-pipe of the engine, screwed on to a force-pump at one end, stopped by a cap at the other, and then forced with air, and the hand passed along the outside to ascertain where the escape is. Should this not succeed, the same pumping may be continued, and a lighted candle moved along the outside; and should the flame of the candle fail to point out the position of the leak, water may be introduced into the pump, and a pressure may be got up inside not exceeding 10 lbs. on the square inch, after which the exact spot of the leak will probably be indicated by a jet of water issuing from it.

It is not, however, very usual to find leaks of any importance in these pipes, and in almost all cases a mere adjustment or change of the washer will be sufficient to make them perfectly tight.

DELIVERY HOSE.

Delivery pipes or hose are made of leather, india-rubber, canvass, or other materials, but the first-mentioned is that principally in use here, and it is to this description of pipes only that the present instructions refer.

There are two principal kinds of delivery hose in use, one with a water-way of 2½ inches in diameter in the couplings, the other with a water-way of 1½ inches. Particulars of both kinds are here given.

The couplings for 2½-inch delivery hose are precisely the same as those used with 2½-inch suction-pipe in all particulars, except the threads, which in the delivery hose are **V** shaped and not round.

How the particular pattern of 2½-inch screws which we now have in use for delivery hose ever came to be adopted, I cannot understand, as it has no exact number of threads to the inch; the threads are exceedingly sharp—in fact, have a knife edge, which is turned by striking against anything hard—and the difficulty of making the joints on dark nights, and in muddy streets, is much greater than it ought to be for such a business as ours.

In all probability, this peculiar screw may have been largely in use in some one factory, or perhaps some town, and may have been accidentally adopted in the first instance by persons obtaining new hose in the same neighbourhood in order to match, and so by degrees have crept into general use. At all events it has been here for many years, and although I still hope that the time will come when it may be condemned, and a bolder and more rounded thread substituted for it, yet for the present we must make the best of it, and this can only be done by carefully examining and studying the advantages and disadvantages of every detail connected with the couplings.

Specification for 2½-inch Delivery Hose.

1. To be made from best English butts, not exceeding 4 feet 9 inches long, cut from steer or heifer hides.

2. The leather to be tanned with oak bark, to be shaved level, and to be well curried.

3. The strips to be cut from the hind or prime part of the butt, excluding all neck and belly.

4. The strips to be free from flaws and warble holes.

5. The strips to be $9\frac{5}{8}$ inches wide.

6. Each strip to have half-an-inch along each end shaved to $\frac{1}{16}$th of an inch thick; this shaving being at the end next the male screw on the grain side, and at the end next the female screw on the flesh side.

7. The edges of the strips at the longitudinal seam not to be shaved at all, except for a length not exceeding 2 inches at the cross-joints.

8. The strips to be not less than $\frac{3}{16}$ths of an inch thick in any part, except where shaved down at the cross-joints.

9. The strips to be cut to an angle of 120° at one side, and 60° at the other, and to be closed with 10 rivets on the longer side beyond the right angle.

10. Each strip, when prepared, shaved, and punched, to be examined by an officer of the Fire Brigade, and to be duly marked, and no strip to be used which has not been so marked.

11. The strips to be closed at the cross-joints with 17 rivets, independently of those which form part also of the longitudinal seam. Four of these rivets on each side to be cut and filed so as to prevent the heads penetrating the leather in the fold.

12. The obtuse angle of each strip, at the end next the female screw, to be on the left from the female screw; and each strip at that end to be closed for the cross-joint with the obtuse angle on the outside.

13. The obtuse angle of each strip, at the end next the male screw, to be on the right from the female screw; and each strip at that end to be closed for the cross-joint with the obtuse angle on the inside.

14. The hose to be made up with the grain of the leather inside, and the flesh outside. It is also to be closed right-handed—that is to say, the right hand edge of the strips, looking from the female towards the male screw, is to be on the outside, and the left-hand edge on the inside.

15. The rivets and washers to be of the best wrought copper, properly tinned, to prevent verdigris.

16. The rivets for the longitudinal seam to be those commonly known as No. 8, and the rivets for the cross-joints and the beckets to be those commonly known as No. 6.

17. The rivets in the longitudinal seam to be half-an-inch apart, measuring from centre to centre.

18. The centres of the lines of rivets to be $\frac{7}{16}$ths of an inch from the edge for the longitudinal seam, and one inch from the edge for the cross-joints.

19. The hose to be made up in lengths of 40 feet each, measured on delivery, and before testing by pressure.

20. Each 40-feet length of hose to have not less than 9 or more than 10 strips.

21. Each length of hose to be provided with a pair of union coupling-screws.

22. The couplings to be of the best gun-metal, and to be made to the prescribed gauge, with a clear water-way of $2\frac{1}{2}$ inches diameter throughout.

23. The couplings to be made with a swivel on the female part.

24. Each double coupling, without washers, to weigh not less than 5 lbs. 4 ounces.

25. Each female coupling to be provided on the swivel with two strong lugs, each 7-8ths of an inch long.

26. Each female screw to have the lower threads of the swivel cut way, and a chamber sunk for the leather washer.

27. Each male coupling to be provided with two strong lugs, each 1¼ inch long.

28. Each male screw to have 1-8th of an inch of plain metal projecting beyond the end of the thread, the sharp end of the thread removed, and the extreme point left rounded.

29. All the couplings to be delivered to the Fire Brigade for examination before being fixed in the hose, and only those to be fixed that are marked as approved.

30. The couplings to be fixed in the hose with the best copper wire of No. 16 gauge, hove on without the use of pliers, pincers, or any other implement which would crush or injure it. The end of the coupling to come between the first and second rivets, and the wire lapping to come to the first rivet.

31. The lugs of the male screw to be so placed as to stand across or at right angles to the longitudinal seam.

32. The wire for each half-coupling to be in three pieces, each piece with an independent fastening.

33. Each 40-feet length of hose to have four hand loops fitted to it. The first to be 5 feet from the coupling-screw, the second 15, the third 25, and the fourth 35 feet; or the first to be 8 feet from the female screw, the second 18, the third 28, and the fourth 38 feet.

34. The hand-loops to be 2⅝ inches wide, and of the same material and substance as the strips.

35. The hand-loops to be cut at the ends to angles of 45°, and to be of the following dimensions, in inches, namely:—21 × 3¾ × 15¾ × 3¾, with the extreme points cut or rounded off to a distance not exceeding half-an-inch.

36. The hand-loops to be riveted to the hose with 6 tinned rivets and washers, 3 on each end; the ends to be on the opposite side from the longitudinal seam, and the points towards the female screw; the ends to meet, but not to overlap each other.

37. Each 40-ft. length to be provided with a leather strap 3 ft. 3 in. long and 1¼-inch wide, with a roller buckle riveted to it, and a collar to slide along the hose.

38. The internal diameter to be full 2⅝ths inches in the clear, and the examiner to be at liberty to cut any length, in order to test the same.

39. The inspecting officer to be at liberty to cut any lengths of hose at any part, and if no defect as to size or any other particular be found, the Brigade to be at the expense of re-jointing.

40. The hose to be proved to a continuous pressure, not exceeding 100 lbs. on the square inch, at the discretion of the inspecting officer, and to his satisfaction.

41. Should any length, while being proved, show a swelling of 8 inches long, such length to be rejected.

42. The whole to be finished in a workmanlike manner, to the satisfaction of the chief officer of the Fire Brigade, who shall be at liberty to reject any length of hose that may be supplied, without assigning any reason for so doing.

43. The manufacturer is cautioned not to hammer the rivets hard; the joints when new should be merely closed, and the rivet heads and washers should not be flush with the leather.

44. For the convenience of parties tendering, there are sealed patterns of the following parts, which can be seen on application, namely:—

1. A forty-feet length of hose, with couplings and other fittings complete.
2. A pair of couplings, without a washer, and not tied in.
3. A washer.
4. A cross-joint laid open for the purpose of examining the mode of filing some of the rivet heads.
5. A longitudinal seam.
6. A hand-loop or becket, not fastened on.
7. A riveted collar and strap.

45. No length of hose will be accepted, any portion of which is of inferior quality or workmanship to these patterns.

Details of a New Length of 2½-inch Hose.

The following are the exact details of the parts of a new length never used:—

	lbs.	oz.
Number of rivets in longitudinal seam, No. 8 gauge, 24 to the foot, 944.		
Weight of do. with washers	13	0
Number of rivets in 9 cross-joints, No. 6 gauge, 17 in each, 153.		
Weight of do. with washers	1	9
Diameter of lugs in inches, 13-16ths.		
Pitch of screw ·196 inch.		
Number of threads to each inch, about 5⅛.		
Depth between threads in inches, about 1-8th.		
Number of complete turns necessary to make a joint, about 3.		
Weight of a pair of couplings—		
Male part ... ... 2 lb. 9¾ oz.		
Female part { Swivel, 1 lb. 9¾ oz. / Ferrule, 1 1¾ } ... 2 11½		
	5	5¼
Length of wire-lapping, in feet, 28 at each end, 56.		
Weight of do., 5½ oz. at each end	0	11
Weight of a riveted collar and strap	0	7¾
Number of rivets in 4 beckets, No. 6 gauge, 6 in each, 24.		
Weight of do., including washers, 1¼ oz. each	0	5
Number of strips of leather, 10.		
Weight of do., including the beckets	30	10

Total weight when made up for use, 52 lbs.

This was an unusually heavy length, and was selected for weighing on that account. It had the maximum number of strips allowed, and consequently the greatest number of cross-joints with overlaps and rivets; it was also perfectly new, and had therefore not been reduced in weight by wear and tear.

The average weight of new 2½-inch leather hose, made according to the foregoing specification, is 48½ lbs. a length.

In a recent inspection of upwards of 1,300 lengths, or about 10 miles, of leather hose, varying in age from a few weeks to 22 years, it was found that the average weight of a length was 47½ lbs.

The average dimensions of a coil of 2½-inch leather hose made up ready for use are 20 inches in diameter by 4½ inches in thickness.

The quantity of water contained in a 40-feet length of new hose under pressure, varies slightly according to the elasticity of the leather, but it is found on an average to be almost exactly 10 gallons, or 100 lbs. The total weight, therefore, of each length of hose when in operation may be roughly estimated at about 1½ cwt.; and when it is remembered that in certain cases, as when working on houses of 70 or 80 feet in height, the total fixed weight suspended by the line is about 3 cwt., which may be further increased by the strokes of the pump or the jerks caused by pulling and adjusting the pipes, it will be seen that it is of the utmost importance to have the beckets cut and fixed on a correct principle, as explained in the specification, so that each of the six rivets shall bear its proper share of the weight.

1½-inch Delivery Hose.

The couplings for 1½-inch delivery hose are the same in principle as those already described for suction-pipes and 2½-inch delivery hose, but differ from the former in diameter and from the latter in the thread, which, not requiring to be adapted to a previously existing pattern, is made round and not **V** shaped.

The pitch of these screws, or distance between the centres of two consecutive threads, is ·2-inch, and consequently the number of threads to an inch is 5; the depth of the threads is about 1-8th of an inch.

The distance which the male screw goes into the female screw is about 2-5ths of an inch, and the number of complete or round turns of the swivel part, necessary for the making of the joint, is consequently about two.

It is not necessary to give in full a specification for 1½-inch delivery hose.

Details of a New Length of 1½-inch Hose.

The following are the exact details of the parts of a new length never used:—

	lbs.	oz.
Number of rivets in longitudinal seam, No. 10 gauge, 27½ to the foot, 1090.		
Weight of do. with washers	5	2
Number of rivets in 9 cross-joints, No. 8 gauge, 12 in each, 108.		
Weight of do. with washers	0	14
Diameter of lugs in inches, 7-12ths.		
Pitch of screw, ·2-inch.		
Number of threads to each inch, 5.		
Depth between threads in inches, about 1-8th.		

Number of complete turns necessary to make a joint, about 2.

Weight of a pair of couplings—

			lbs.	oz.
Male part	0 lbs.	15 oz.		
Female part { Swivel, 0 lb. 13 oz. / Ferrule, 0 6 } ...	1	3	2	2
Length of wire-lapping, in feet, 24 at each end, 48.				
Weight of do., 4 oz. at each end			0	8
Weight of a riveted collar and strap			0	5
Number of rivets in 4 beckets, No. 8 gauge, 6 in. each, 24.				
Weight of do., including washers, ⅛ oz. each			0	3
Number of strips of leather, 10.				
Weight of do., including the beckets			16	14

Total weight when made up for use, 26 lbs.

The average weight of new 1½-inch leather hose made according to the foregoing specification is 25½ lbs.

The average dimensions of a coil of 1½-inch leather hose, made up ready for use, are 18 inches in diameter by 2¾ inches in thickness.

The quantity of water contained in a 40-feet length of new 1½-inch hose under pressure, varies slightly, according to the elasticity of the leather, but it is found on an average to be almost exactly 4 gallons, or 40 lbs. The total weight, therefore, of a length full of water is about 66 lbs., or a little more than a third of the weight of 2½-inch hose.

This hose has several great advantages over that of a larger size; it can be worked with only a nozzle and without a branch; is light to handle when full of water; and nearly a double quantity can be carried on an engine. It does not, however, give as good a result as that of greater diameter when used with the large pumps, or when worked with a nozzle over ¾ of an inch in diameter.

The quantity of hose at present in use in the London Brigade is as follows:—

Size.	No. of lengths.	Total length in feet.
2½	1,317	52,680
1½	639	25,560
Total	1,956	78,240

or almost exactly 15 miles.

No new 2½-inch hose has been made for the Brigade for several years, nor is it probable that any will be made for many years to come, as the present stock is more than sufficient for the steam-engines; and when supplies are wanted to keep up the necessary quantity, they are made of the smaller size, which is found much more convenient for general work, and is greatly preferred for use at the commencement of fires, particularly in outlying or short-handed stations.

TO TEST DELIVERY HOSE.

Delivery hose is tested in the following manner:—

It is attached by means of the female screw to a common force-pump with an air-vessel and a pressure-gauge; it is laid out in a perfectly straight line with the rivets upwards, so that the whole seam can be watched at the same time; and to its male screw there is attached a piece of copper pipe, with a corresponding female swivel screw. On the side of this copper pipe is screwed another pressure-gauge, and at its end there is a cap which closes it up. In the centre of the cap there is an air-cock, which can be opened and shut at pleasure. When the pump commences to fill the pipe with water, the cock at the end should be kept open, so as to allow the air to escape, and, as soon as water is seen to run out, the air-cock may be closed, and the gauges carefully watched at both ends until the desired pressure is obtained.

All new hose leaks or "sweats" through the pores of the leather, and no length should be rejected for this cause alone, unless the leakage be excessive; small warble or insect holes not exceeding 1-16th of an inch are of no consequence, as they are certain to close in a short time, and short swellings of one or two inches may usually be passed unnoticed; but badly-closed seams or cross-joints—broken rivets, or rivets imperfect in the head, washer, or any other part—cuts in the leather, which may be found notwithstanding that the strips have been examined and marked before being made up—warble holes too large to be closed by a rivet—swellings exceeding 8 inches in length—or the fact of the longitudinal seam taking a spiral form when under pressure—all these are signs of a bad hose, and should insure its rejection.

The mere blowing out of a screw under pressure, though causing trouble in the inspection, and showing carelessness or ignorance on the part of the manufacturer, need not necessarily involve the rejection of the length to which it belongs. The inspecting officer will, in most cases, do well to have the screw tied in again under his own supervision on the spot, and if it blow out a second time under pressure, which it will not be likely to do, he will then be sure that there must be a defect either in the leather, the wire, or the shank of the screw—most probably the latter—and he should reject the length accordingly.

It should be thoroughly understood that any pressure is injurious to hose, and that, as a general rule, no test should be carried beyond such a point as to satisfy an experienced person that the material, workmanship, and strength, are in accordance with the necessary requirements, and with the conditions specified in the contract.

The dangers to be apprehended from the use of the hydraulic test are twofold. One is, that the fibres of the leather may be unduly strained, and the hose in consequence permanently deteriorated. This can, of course, be easily avoided by attention on the part of the inspecting officer, whose experience will guide him as to how far he is safe to go. In examining new hose, however, it may be his duty to apply the maximum test by keeping on a continuous pressure at the highest point named in the tender, and, when such is the case, he is of course bound to go on, leaving the consequences, if unfavourable, to fall on the manufacturer. The other risk is, that the internal pressure tends to force the stuffing or dressing out of the pores of the leather when it is new and green, and that it is extremely difficult to get the grease in again; the leather may consequently become hard and dry, the fibre may crack, and, when this happens, the hose is certain to burst under pressure.

These are serious drawbacks to testing by hydraulic pressure, but I am clearly of opinion, notwithstanding, that new leather pipes should never be accepted from a manufacturer without some portion being proved by forcing, and that consequently in every agreement for the supply of hose there should be a clause giving the inspecting officer full power to use his own discretion in the matter, without any limit, except that of the maximum pressure named in the tender.

If the inspecting officer have full confidence in his own judgment and experience, his best course will be to select a few lengths indiscriminately for the maximum pressure, and, if these stand the test well, he might put the remaining lengths under a slight pressure, not exceeding 10 or 15 lbs. on the square inch, for the purpose of ascertaining that the seams and joints are properly closed.

After being tested, new hose should be carefully dressed, according to the mode pointed out further on, and should be laid up and not brought into use for a considerable time. Every hour during which hose can be spared from work while it is green will be of permanent advantage to it; and if it can be laid by for about twelve months after it has been made up, and carefully attended to during that time, there is no reason, so far as I know, why it should not last for 40 or 50 years.

INSTRUCTIONS FOR THE CARE AND MANAGEMENT OF LEATHER DELIVERY HOSE.

Receipt for Dubbing.

Melt $2\frac{1}{4}$ lbs. of perfectly clean tallow, free from salt, and mix with it, when hot, 1 gallon or 9 lbs. of Cod oil.

The best mode of clearing tallow for this purpose is to boil it in water, which will take up the salt and other impurities, and can be poured away when cold.

Care must be taken not to boil the oil, as this would deprive it of some of its principal qualities.

The tallow must be first melted, and, when it is warm, the oil is to be poured on, and stirred into it until the whole mixture is perfectly cold. This will make a good stiff dubbing.

To apply the Dubbing.—Thoroughly wet the hose with clean fresh water, and brush it well, so as to leave no dirt on it; then hang it up to dry, either by the centre, or, if there be room enough, by one end, but not on any account by both ends, as in this latter way it would not drain itself properly.

When it is about half dry, which it should be in a day or a day and a-half after it has been hung up, rub it well on the outside with the dubbing, and hang it up again in a dry airy place, but not under the sun or near a fire, and, as the remaining water evaporates, the dressing will enter the leather and make it soft and pliable.

To keep the Couplings in order.—The coupling-screws should always be kept perfectly clean, and free from grit or dirt, and in cleaning them great care must be taken not to damage the threads.

The outside of the swivel ring, containing the female screw, and the lugs of both screws, should be highly polished with brick-dust or rotten stone; but the threads and water-ways should be merely rubbed bright with a brush dipped in oil, and wiped off afterwards with cotton waste, or some other soft substance.

This, if done properly, will remove all dirt from the screws without injuring the thread, as brick-dust or any other gritty substance would do.

Should there be any reason to suppose that a screw is damaged, however slightly, in any way that may cause delay or difficulty in making the joints, the length of hose to which it belongs must be laid aside, and on no account brought out to a fire again until the couplings have been carefully tested with the steel gauge kept for the purpose, and, if necessary, adjusted to the proper standard.

Particular care must be taken to see that the leather washers are clean and free from grit, and, when this has been ascertained, they should be well rubbed with pure oil, so as to keep them soft and in good order, and the swivel ring should be so slack that the female screw should revolve freely.

If these rules be strictly observed, the difficulty of making perfectly tight joints when laying out the hose will be much reduced.

To make up the Hose for use.—After the first coat of dressing has been absorbed, give the whole of the leather a light brush over with a small additional quantity of dubbing, and then roll up the hose in coils, commencing at the male screw, and taking particular care to have all the rivets in the centre of the outside, so that when the coils are afterwards unrolled for use, the hose will come off in straight lines without kinks or twists.

On the attention which is paid to this point depends almost entirely the success of Firemen in the proper laying out of long lines of hose with the quickness and accuracy necessary for fire service.

In making up the hose the hand-loops or beckets should be folded up, and turned in, so as not to protrude from the coil.

The collar of the leather strap should be slipped up to within six or eight inches of the female screw, and so turned that the rivet and strap shall be on the outside, and care must be taken to avoid allowing the collar to come too near the end, as in such a case the heaving up of the strap in the buckle might damage the shank of the screw.

To preserve the Hose.—The coils must be occasionally examined, and, if the slightest appearance of mould or damp be found on them, they should be opened, carefully brushed over with a dry brush, and hung up for a short time, after which they may, if very dry, be again brushed over with a light coat of dubbing, previously to being rolled up for use as before.

The strength of the leather is in the fibre, and, if this be allowed to become hard, it cracks, and the hose consequently bursts when put under pressure.

Constant attention therefore is required to keep the hose soft and pliable, and to prevent it becoming dry and hard, which it is certain to do, either if it does not receive a good coat of dressing at the proper time, as before explained, or if it is left too long without dressing.

Leather hose should, if possible, be kept in a warm dry place with free ventilation, and, where this cannot be done, as in the hose-box of a fire-engine, it is advisable to keep the hose-box lid occasionally open, so as to admit a sufficient quantity of fresh air to prevent the dressing becoming rancid.

BRANCHES & NOZZLES.

INTRODUCTORY.

THE distance to which a stream or jet of water can be projected through a still atmosphere depends on a variety of conditions, such as its size, form, steadiness, and velocity at the point of exit.

Every jet has its limit, beyond which no increase of force can drive it. Thus, a stream passing through a hole of an hundredth of an inch in diameter cannot be made to go more than a few feet from the orifice, even though subjected to a pressure of 1000 lbs. on the square inch; whereas a stream of 1 inch in diameter may be forced to a considerable distance under a tenth of the same pressure.

The distances to which jets of different sizes can be projected under various circumstances form the subject of a separate branch of study, and are specially excluded from that now under consideration.

The following pages contain simply an account of the mode adopted for reducing a circular stream of water by means of a pipe, called a branch, from an area of 2½ inches in diameter to an area of 1½ inches in diameter, and by means of a pipe, called a nozzle, from an area of 1½ inches in diameter to several smaller sizes; with an explanation of the general principles on which the reduction or contraction is effected; some mechanical details concerning the material and workmanship of the pipes employed for the purpose; the ordinary rules to be observed for keeping the pipes in order; and a few other particulars incidental to the subject.

GENERAL PRINCIPLES.

THE flow of a stream of water in an enclosed pipe is uniform, notwithstanding that the pipe itself may be of various sizes at different parts; that is to say, when the water is in motion, a similar quantity passes every part of the pipe in the same time.

If, therefore, the area of the pipe at any spot be only half the area at any other spot, the water must pass the former with twice the velocity with which it passes the latter.

The velocity may be increased to almost any extent at any spot by a contraction of the pipe, provided that the water continues to flow as before; but if the contraction of the pipe retard the flow of the whole stream, a result in proportion to the diminution of the area is not attained.

Now, the throttling or contracting of a stream has always a tendency to retard the flow, and consequently to reduce the quantity; and if it be necessary to overcome the increased resistance of the contracted part, a power of some kind must be applied or added.

Thus it will be perceived, that many difficulties are encountered when an attempt is made so to shape and otherwise arrange a pipe as to obtain the maximum of contraction with the minimum of obstruction—or, in other words, the greatest possible velocity with the least possible diminution of quantity.

These difficulties, however, can be to a considerable extent obviated by a proper application of the true principles by means of which the desired result should be attained.

The general object of reducing a stream of water inside a pipe to a smaller area is to increase its velocity, and so give it a greater force to propel it through the atmosphere; and, if the velocity of the rest of the stream within the pipe be kept up, whether by gravitation, machinery, or any other means, it is obvious that this general object may be to a great extent attained.

If, however, the throttling or diminishing of the water-way be carried out in such a way as to cause heavy loss by friction or obstruction, the result will be, either the delivery of a reduced quantity of water, or the necessity for a greater power to overcome the increased resistance.

The directing pipe at the end of a hose is intended to effect this object, and much depends on its proper formation and accuracy, so as to ensure the delivery of the largest possible quantity of water at any spot within its range.

Circular streams are found more effective as jets than those of any other form, and, when reduction pieces are used, it is found a great advantage to place them in such a position that they may be concentric with that part of the pipe to which they are attached.

Thus, the branch should be concentric with the end coupling of the hose, and the nozzle concentric with the branch.

For a long time it has been the custom of ignorant or interested persons in this and other countries to treat the maximum height or distance to which a portion of a jet of water can be thrown as the true measure of the efficiency of the jet, but the most superficial consideration of the subject will suffice to show that any deductions from the results of such a test must almost always prove erroneous.

The mere maximum distance reached by any part of a stream driven through the air affords no trustworthy criterion whatever of the merits either of the nozzle itself or of the power by which the water is projected. It is well known to all practical persons, that engines of different powers and capacities, and nozzles of almost the best and worst forms, prove very nearly alike when subjected only to this fallacious test.

Thus, if there be two streams projected from nozzles through the air, both delivering the same quantity of water, and reaching the same maximum distance, and if one deposit half the quantity passing through it at the extreme point, and the other deposit only one-fourth of the quantity at the same distance, the efficacy of the two would be very different.

There is but one way of ascertaining accurately the efficiency of a nozzle, and that is, to test it under various pressures, and in each case to measure the quantity of water which it delivers at the several points within its range.

The hose in ordinary use terminates in a male screw, with an internal water-way of either 2½ inches or 1½ inches in diameter, and water passing through it at the rate of some 200 gallons a minute would be projected to a distance of only about 10 or 20 feet.

As such a stream, though perhaps in many cases abundant, so far as quantity is concerned, would be useless for the general purposes of a fire brigade, it is necessary to obtain a greater propelling power in some way, and the simplest mode of effecting this object is to attach to the end of the hose a reduction-piece, which, by causing a contraction in the area of the stream at the point of exit, increases its velocity, and so enables it to travel to a greater distance.

The requirements of a fire brigade in this way are so variable, that it is sometimes necessary to change the velocity or the quantity of a stream many times during the progress of a single fire, and in many cases this has to be done by means of the reduction-piece only.

Now the reduction-pieces are also the directing pipes, and being made long enough for the latter purpose, are somewhat cumbrous to carry; it would therefore be exceedingly inconvenient to have a separate directing pipe for each jet required.

This difficulty is obviated by making the directing pipe in two parts, called respectively the branch and the nozzle.

The branch has a fixed length, and reduces the area to a certain point, which is about one-third of that in the hose. The nozzles are all made to commence at this point; they fit on the end of the branch, or the end of the 1½-inch hose, and terminate in various sizes, any of which can be used to effect such further reduction as may be required.

Thus, in order to obtain jets of several different sizes, it is not necessary to carry about a corresponding number of complete directing pipes, as the same result can be attained by having only one branch and the necessary number of nozzles.

For convenience and simplicity, these two parts of the directing pipe are described separately under the head of branches and nozzles respectively.

THE BRANCH.

It was formerly the practice to carry on each engine one branch of about a foot in length, and another of about four feet in length. These were called respectively the long and short branches, and it was supposed that the former delivered a better stream than the latter; a simple experiment however proved that, if any difference in efficiency existed, it was so slight that it could not be discovered by any ordinary test. The inconvenient custom of carrying two different sizes has consequently long since been discontinued, and a standard branch established, 15 inches long in the internal pipe, or 16 inches including the extremities of both bosses.

Each engine which is fitted for 2½-inch hose carries two such branches.

A branch of the pattern in use is a circular tapered pipe, of the length already mentioned, namely 15 inches, with a water-way of 2½ inches in diameter at one end, and of 1½ inches in diameter at the other. It is of copper, of 1-16th of an inch thick, No. 17 Birmingham wire gauge, or a little under, and is mounted at each end with a gun-metal boss.

The pipe is made in the following manner:—

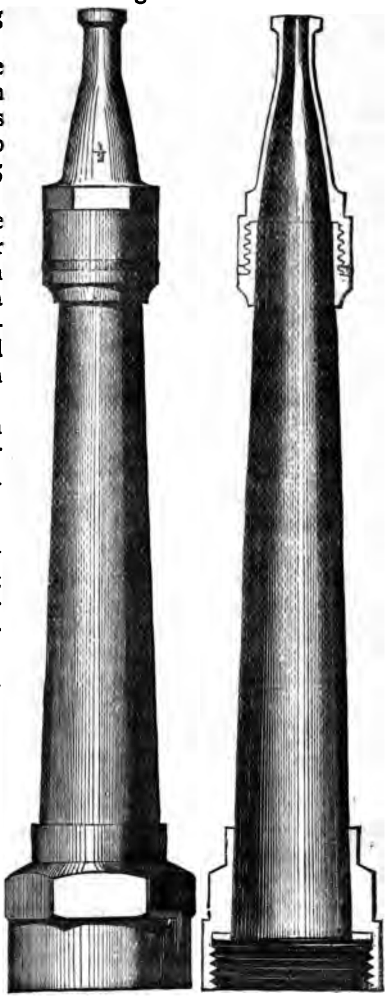
A piece of sheet copper, of the substance already mentioned, which weighs 2½ lbs. to the square foot, is cut to a length of 15 inches, and to a width of 10 inches, tapering to 5 inches.

It is bent over a mandrel, until the edges meet, and overlap each other about 3-16ths of an inch, and when in this position it is bound with a piece of wire to keep the parts together. The joint is then soldered along the whole of the inside with a spoon.

The solder is of the kind known as brazing solder; it is of copper and zinc, with some borax mixed through it to make it run.

After the solder has been run in, the pipe is first subjected to a slow heat, in order to dry the water out of the solder, and it is then put over a strong fire; at this stage the copper is brought to nearly a melting heat, and, in order to run off any unnecessary quantity of solder, and leave only enough to cover the seam, the pipe is held on a slight incline, and finally shaken, to get rid of any surplus that remains.

It is then put on another mandrel and hammered to a correct circular taper, after which the ends are cleaned and tinned to receive the bosses.



¼ Scale.

Both bosses are of gun metal, bored to a taper to match the taper of the pipe; and, when the latter is fixed inside them, the larger boss has a clear round water-way of 2½ inches in diameter, and the smaller one a water-way of 1½ inches in diameter.

The proportions of metal are—16 oz. of clean copper, 1½ oz. of tin, ½ oz. of brass, or copper and zinc.

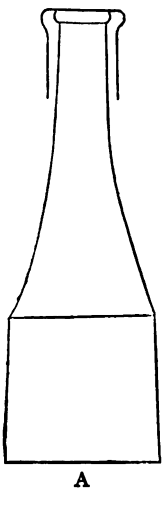
This mixture should be fused twice, being first poured out into an ingot, and afterwards melted for use; this gives a perfect granulation of the metal.

The boss at the larger end projects one inch beyond the end of the copper pipe, and has a female screw cut inside the projecting part. This female screw is precisely the same as that on the swivel of the couplings, and can therefore be attached to the male screw of the hose; and for the purpose of forming a water-tight joint it is mounted on the inside with a washer in a recess formed for the purpose by cutting away the bottom threads of the screw. The copper pipe overlaps the washer to the extent of 1-8th of an inch, and thus secures it firmly in its place. Outside the screw this boss is round; in that part which is attached to the copper pipe it is cut for a depth of one inch to a hexagon, or six-sided shape, to take a spanner, by means of which the branch can be forced on or off; and for about $\frac{3}{4}$ of an inch it is again round, and at this latter part it is only 3-16ths of an inch thick. The boss at the smaller end has a male screw cut on its outside to take the female screw of the nozzles. It is mounted with a leather washer, which encircles the lower threads of the male screw, and, resting on the projecting shoulder of the boss, receives the lower face of the nozzle screw, thus forming a water-tight joint.

The bosses are tinned inside by dipping, and the ends of the pipe are tinned outside, those parts being whitened where the tin is not to adhere. The tin is allowed to cool, after which the bosses are slipped on into their exact places, and the whole held over a clear fire until hot enough to melt the solder thoroughly, and an ordinary stick of soft solder, of two parts of tin and one part of lead, is touched to the upper part of the joint, so as to run in. The whole is then allowed to cool, after which the whitening is brushed off, leaving only the solder in the joint, and any which remains on the outside is cleaned off in the lathe.

The delivery at the end of the branch inside the smaller boss is made cylindrical by means of a tool in the lathe for a distance of $2\frac{1}{4}$ inches, or once and a half the diameter of the opening, so as to deliver an average good $1\frac{1}{2}$-inch jet, without a separate nozzle. The branch, when in the lathe, is cleaned off by a float file, which merely touches it lightly, so as to remove the marks of the hammer, and it is finally polished by means of emery cloth and oil. Each branch has the number of the engine to which it belongs stamped in small figures across one of the sides of the hexagonal part.

NOZZLES.



A

A nozzle, or nose pipe, is, as before mentioned, a short additional reduction-piece, which can be attached to the end of the branch.

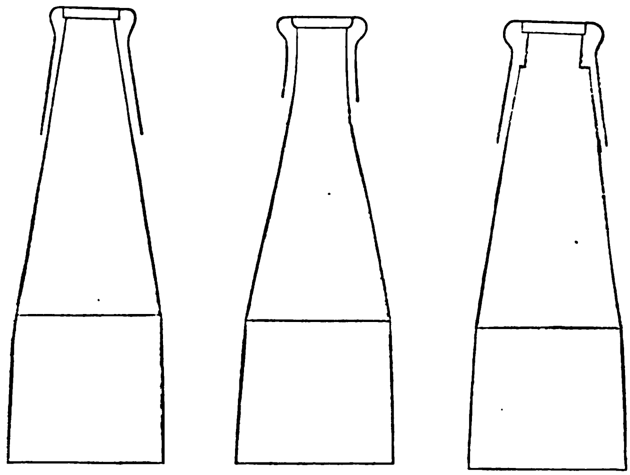
Its object is to reduce the area of the water-way from a circle of $1\frac{1}{2}$ inches in diameter at the end of the branch, to a circle of smaller dimensions at the extremity or orifice from which the jet is discharged.

In order to accomplish this object with the least possible obstruction, jerk, or friction, and to allow the water to pass out in a firm steady stream, which will keep its shape for the longest possible time when projected into the atmosphere, many forms have been tried at various times and in several countries.

That which is known as the contracted vein A has been much used in England, but it is, in my opinion, adapted only for drawing water out of tanks, or delivering under very low pressures, in which cases no difficulty is ever experienced in obtaining a clean jet, as may be seen by watching water running out of a bung-hole of a barrel, when it will be observed that a perfectly clear, transparent, and steady stream passes out of a comparatively rough opening, formed by a common auger, and not truly rounded or finished off beyond what is necessary for the reception of a coarse bung.

This kind of nozzle has the disadvantage of suddenly changing the form of the stream within a few inches of the orifice, and thereby creating a considerable unnecessary amount of jerk and friction.

A better description of nozzle than this is a plain taper B, or continuation of the taper of the branch, but this has the disadvantage of delivering the water in a wire-drawn stream, which at the point of exit is of somewhat smaller area than that of the extremity of the pipe.



B C D

Such a stream has a tendency to resume its proper size immediately after leaving the orifice, and, having nothing to limit its expansion, spreads to an undue extent, thereby exposing an increased surface to the resistance of the atmosphere, and consequently delivering a proportionately reduced quantity at any spot which it reaches.

A still better description of nozzle is a plain taper, as last described, with the addition of a short cylindrical piece at the end.

Such a nozzle C will deliver a stream of the full size of the orifice, but the reduction of area in a tapered pipe is irregular, and in those usually made the disturbance and friction are somewhat considerable at the point where the conical and cylindrical portions of the pipe join, and consequently the stream, though clear and steady, issues from the nozzle with a somewhat reduced velocity.

There is another nozzle D, which though at one time much used in America, particularly for trials of engines, appears to me to be so deceptive in its character as to be worthy of little notice beyond an indication of the errors likely to result from its use.

It is formed of a plain taper or other reduction-piece, with a projection or ring of the supposed size of the jet placed within a short distance of the orifice.

The water passing through the reduction-piece strikes against the inner shoulder of the ring, and is there formed into a stream, which issues from the orifice in a sufficiently clear jet, but which is never, under any circumstances, of the full size of the ring through which it passes. If the pressure be very low, such as that due to a head or column of one or two feet, the issuing stream very nearly fills the ring, without, however, so far as I have been able to observe, ever wetting the whole of it; but when a heavy pressure, such as 100 lbs. or 150 lbs. on the square inch, is applied, the deception is perfectly obvious, as there is no difficulty in seeing a clear space between the water and the outer end of the ring. There is also another fault in these nozzles, namely, the collecting inside the inner shoulder of the ring of a small quantity of air, which, being compressed, is constantly forced against the water, and disturbs it to a somewhat serious extent until the air is exhausted, which sometimes does not happen for several minutes after commencing.

I have a very distinct recollection of an attempt made to deceive me some years ago with jets of this description. I had myself gauged the nozzles accurately, and found them to be exactly one inch in diameter inside the rings; but when I saw the jets I found them somewhat smaller than I expected. I then examined them carefully close by the nozzle, and, looking inside, I perceived a clear space of about $\frac{1}{16}$th of an inch between the water and the outer end of the ring, showing that the diameter of the stream was $\frac{1}{8}$th of an inch less than that of the ring. In fact, the jets, instead of being 1 inch, were only $\frac{7}{8}$ths of an inch in diameter, or about three-fourths of the size which they were represented to be. The nozzles, on examination, proved to be of somewhat rough workmanship and finish, and this may in some degree account for the large difference between the size of the stream and that of the ring; but I have no doubt that when a ring of this kind is used, however well it may be finished, the stream which issues from it is in all cases smaller than the ring itself, and spreads sooner than a stream of the same size projected from a nozzle with a cylindrical end.

The nozzle which I have found most adapted for projecting a stream of water through the atmosphere to the best advantage is formed in the following manner:—

Draw an axial or central line through the branch, and at its opening and at a distant point outside the opening draw lines cutting the axial line at right angles.

On each of these cross lines on either side of the axial line set off a part equal to half the diameter of the required nozzle.

Draw a line between the two points on the one side of the axial line, and another line similarly between the two points on the other side, thus forming a pair of parallel lines to mark the direction and magnitude of the jet.

Along each of these lines lay off seven points, at distances equal to half the difference between the diameter of the end of the branch and that of the nozzle, and across each of these pairs of points draw lines at right angles to the centre line or axis.

Calculate the area of the end of the branch, and that of the nozzle, and determine the area at each of the five intermediate points in such manner that they may diminish gradually in proportion to their distance from the end of the branch, the area at the sixth line being equal to that of the required opening at the outlet end of the nozzle.

The seventh cross-line should be of the same length as the diameter of the nozzle.

Calculate the diameter for each area, and lay it off on the corresponding cross-line, half being on each side of the longitudinal central line or axis of the pipe.

Connect the ends of these cross-lines by a curved line commencing at the first and terminating at the fifth. This will reduce the area gradually to very nearly the required size; but if the reduction were continued, there would be a sharp angle at the point where the curved and parallel lines meet, and consequently a disturbance of the water close to the point of exit.

The junction of these two lines with an easy curve is effected in the following manner:—

Extend the seventh cross-line indefinitely on both sides of the axial line. From any point on this line as a centre, and with the distance between that point and the point at which the line crosses the nearer parallel line as a radius, an arc of a circle may be described, to which the parallel line will be in the direction of a tangent.

Through the points at which the fourth and fifth cross-lines are intersected by the curve, draw right lines indefinitely, intersecting the parallel lines which represent the bore, and, to ensure their accuracy, observe that they intersect the axial line at the same point.

Bisect the angle formed at each side by the intersection of these lines, and produce this bisecting line until it cuts the seventh cross-line, or its production.

From this point as a centre, and with the distance between it and the point at which it crosses the nearer parallel line as a radius, describe an arc of a circle. This will be the required curve, to which the final direction of the reduction curve, and the whole of the cylindrical part, will both be tangential.

The length of the cylindrical portion of the pipe should be once and a half the diameter of the opening.

This form of nozzle is founded on the principles, that water should, previously to its delivery, be subjected to the least possible jerk or disturbance, and that it should before its final exit pass through a sufficient length of pipe to bring it into the exact shape and condition in which it is to be delivered.

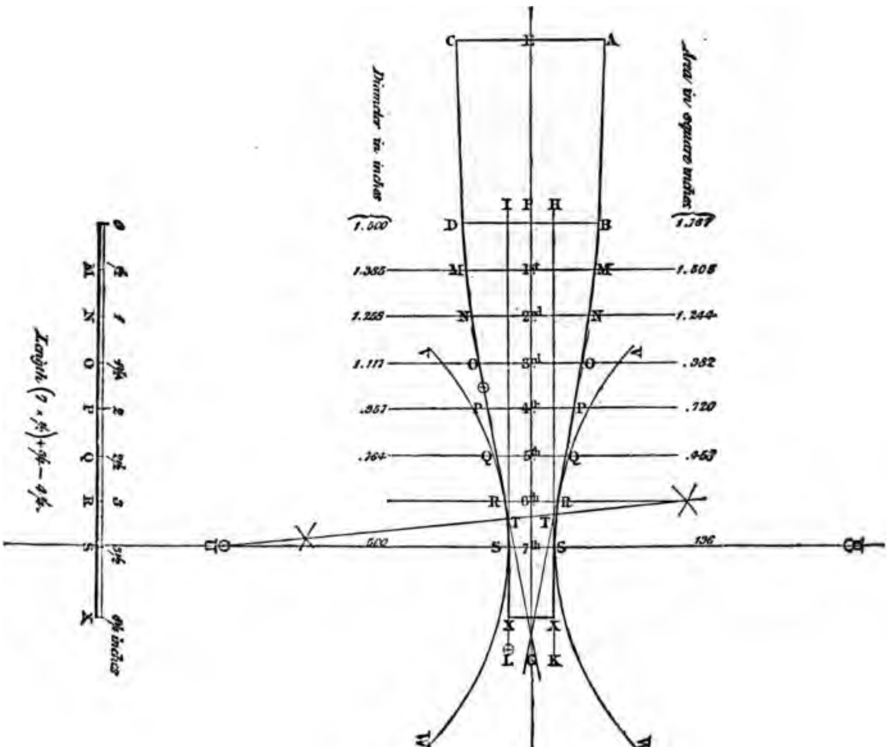
The avoidance of unnecessary disturbance is effected by a gradual diminution of area to a certain point, which is connected to the cylindrical part at the end by an easy curve formed chiefly on a portion of the circumference of a circle, to which the final direction of the reduction-pipe and the whole direction of the cylindrical part are tangents; and the bringing of the water into shape previously to its delivery is effected by having the end of the nozzle cylindrical.

The length of the reduction-piece, including the curve, in one direction for diminishing the area, and in the other direction for forming a junction, and the length of the cylindrical part, have been determined by experiment as those best adapted to produce with the smallest loss of power the desired result, namely, a jet or stream of water which can be projected through the air in the largest possible quantities to any given distance within its range.

The following illustration shows the mode of forming the several nozzles on the principles here laid down, and the description gives a detailed explanation of one, and by changing the dimensions is equally applicable to all the others.

Mode of Forming a ½-inch Nozzle.

½ Scale.



The figure A B C D, shows the end of an ordinary branch, consisting of a tapered pipe, 15 inches long, 2½ inches in diameter at one end, and 1½ inches at the other.

The latter is represented by the line B D.

Through the centre of the figure draw the line E F, which will be at right angles to the diameter B D, and prolong it to a distant point G.

On the diameter B D, at each side of the line F G, lay off points H and I distant from the point F ¼ of an inch, or half the diameter of the required nozzle, and opposite G, on a line at right angles to F G, lay off points K and L at the same distance, ¼ of an inch.

Connect these points by a pair of parallel lines H K and I L, which will represent the direction and magnitude of the water-way.

Along each of these lines, commencing from the line B D, lay off 7 points at distances of ½ an inch, or half the difference between the diameter of the end of the branch and that of the nozzle, and across each of these pairs of points, and consequently at right angles to the centre or axis, draw lines which may be called 1st, 2nd, 3rd, 4th, 5th, 6th, and 7th cross-lines.

The area of the end of the branch in square inches is 1·767, and that at the end of the nozzle ·196, and a gradual reduction will show at five intermediate and equi-distant points the following areas, namely, 1·505, 1·244, ·982, ·720, ·458.

From these areas the proper diameters in inches are calculated in the ordinary way, and found to be as follows, namely—

Area.	Diameter.
1·767	1·500
1·505	1·385
1·244	1·258
·982	1·117
·720	·957
·458	·764
·196	·500

Lay off on each cross-line, except the sixth, the proper diameter M M, N N, O O, P P, Q Q, half on each side of the central side, and connect the ends of these lines by a curve. This will reduce the area gradually to this point. Lay off on the seventh line, the diameter of the nozzle S S, ½ an inch.

Extend the seventh line indefinitely at both its ends.

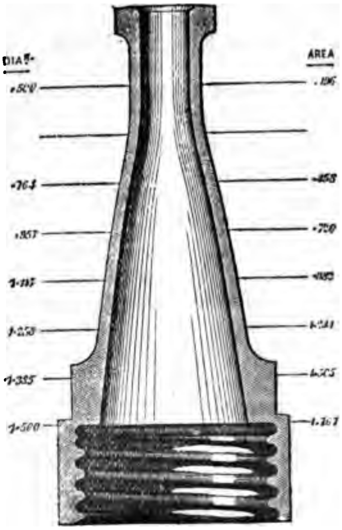
Through the points P and Q draw right lines intersecting the parallel lines at T, and, to ensure their accuracy, observe that they cut the axial line at the same point.

Bisect the angle Q T S, and prolong the bisecting line until it cuts the extended part of the seventh cross-line at U.

From this point U, as a centre, and with the distance U S, as a radius, describe an arc of a circle V W, which will form the required curve to join the right lines at either end, thus connecting the gradually diminishing pipe to the cylindrical part by an arc of a circle, to which the final direction of the former and the whole direction of the latter are both tangents.

On each of the lines H K and I L, lay off from the point S a portion S X, ¾ of an inch in length, or once and a half the diameter of the nozzle, and draw the line X X which represents the orifice.

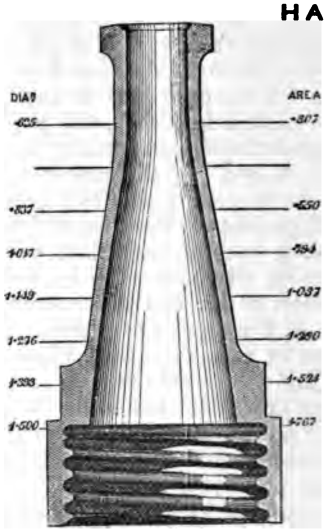
This completes the figure B D X X, which should be $7 \times \frac{1}{2} + \frac{3}{4} = 4\frac{1}{4}$ inches long.



½ In.

Length $(7 \times \frac{1}{2}) + \frac{3}{4} = 4\frac{1}{4}$ inches.

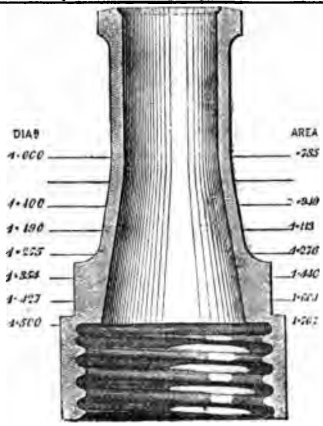
Diameter.	Area.
1·500	1·767
1·385	1·505
1·258	1·244
1·117	·982
·957	·720
·764	·458
·500	·196



⅝ In.

Length $(7 \times \frac{7}{16}) + \frac{15}{16} = 4$ inches.

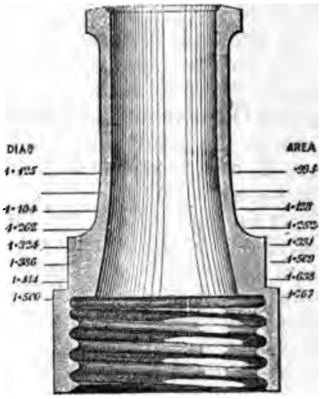
Diameter.	Area.
1·500	1·767
1·393	1·524
1·276	1·280
1·149	1·037
1·017	·794
·837	·550
·625	·307



1 In.

Length $(7 \times \frac{1}{4}) + 1\frac{1}{2} = 3\frac{1}{4}$ inches.

Diameter.	Area.
1·500	1·767
1·427	1·604
1·354	1·440
1·275	1·276
1·190	1·113
1·100	·949
1·000	·785

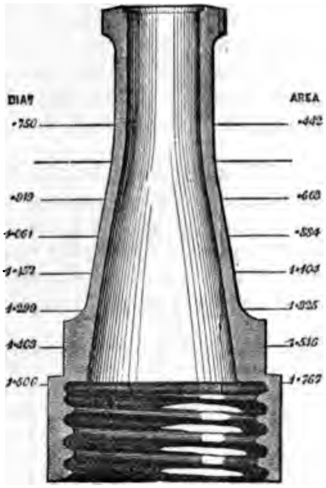


1⅛ In.

Length $(7 \times \frac{3}{16}) + 1\frac{11}{16} = 3$ inches.

Diameter.	Area.
1·500	1·767
1·444	1·638
1·386	1·509
1·324	1·381
1·262	1·252
1·194	1·123
1·125	·994

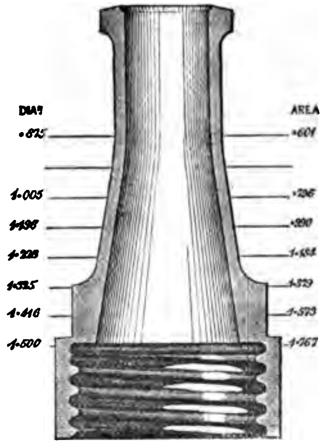
SCALE.



¾ In.

Length $(7 \times \frac{3}{8}) + 1\frac{1}{8} = 3\frac{3}{4}$ inches.

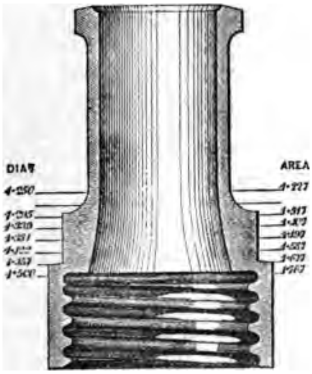
Diameter.	Area.
1·500	1·767
1·403	1·546
1·299	1·325
1·152	1·104
1·061	·884
·919	·663
·750	·442



⅞ In.

Length $(7 \times \frac{5}{16}) + 1\frac{5}{16} = 3\frac{1}{2}$ inches.

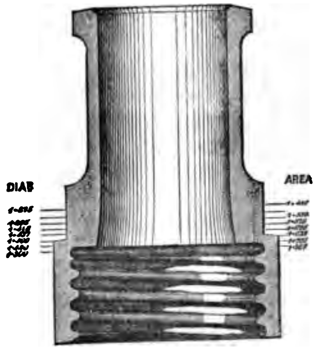
Diameter.	Area.
1·500	1·767
1·416	1·573
1·325	1·379
1·228	1·184
1·136	·990
1·005	·796
·875	·601



1¼ In.

Length $(7 \times \frac{1}{8}) + 1\frac{7}{8} = 2\frac{3}{4}$ inches.

Diameter.	Area.
1·500	1·767
1·457	1·677
1·422	1·587
1·381	1·497
1·339	1·407
1·295	1·317
1·250	1·227



1⅜ In.

Length $(7 \times \frac{1}{16}) + 2\frac{1}{16} = 2\frac{1}{2}$ inches.

Diameter.	Area.
1·500	1·767
1·480	1·720
1·460	1·673
1·437	1·626
1·418	1·579
1·395	1·532
1·375	1·485

The areas of circles are in the relative proportions, not of their respective diameters, but of the squares of those diameters. Thus, if one circle have a diameter of 2 inches, and another of 3 inches, the former, instead of having 2-3rds of the area, has only 4-9ths, or less than half. Again, if one circle have a diameter of 3 inches, and another of 6 inches, the former has a relative proportion to the latter, not of 3 to 6, or one-half, but of 9 to 36, or one-fourth.

A table is added, showing the proportions of the several nozzles relatively to each other. This is, for simplicity, calculated only to quarters, that being sufficiently exact for almost all practical purposes; but it contains also the actual proportions of the areas of the end of the hose, the end of the branch, and each of the nozzles respectively; and from these the relative proportions may be calculated to any greater degree of accuracy required.

APPROXIMATE RELATIVE PROPORTIONS OF AREAS OF NOZZLES.

No.	Diameter.		½	⅝	¾	⅞	1	1⅛	1¼	1⅜
1	½-inch.	Equal to	1	...	...	...	...	...	...	..
1	⅝ ,,	,,	1½	1	...	...	...	...	...	...
1	¾ ,,	,,	2¼	1½	1	...	...	...	...	...
1	⅞ ,,	,,	3	2	1¼	1	...	...	...	...
1	1 ,,	,,	4	2½	1¾	1¼	1	...	...	...
1	1⅛ ,,	,,	5	3¼	2¼	1¾	1¼	1	...	...
1	1¼ ,,	,,	6¼	4	2¾	2	1½	1¼	1	...
1	1⅜ ,,	,,	7½	5	3¼	2¼	2	1½	1¼	1

EXACT PROPORTIONS OF AREAS.

½	16	⅞	49	1¼	100	1½	144
⅝	25	1	64	1⅜	121	2½	400
¾	36	1⅛	81				

Areas of circles of the diameters mentioned in the first column stand to each other in the relative proportion of the numbers in the second column.

The nozzles are of gun-metal, of the same mixture as that used for the bosses. They consist at the larger end of a circular piece, with a screw inside and a hexagon above to take a spanner; the remaining part is a mere pipe of sufficient thickness to ensure the required strength, and of the requisite form for delivering a jet of water to the best advantage.

The extremity for a distance of one and a half times the orifice is cylindrical, and at the outer end there is a bevilled part or lip cut away in a hollow, leaving a sufficient projection to protect the edge of the orifice. At this point it is also strengthened by a bead, which extends externally ¼ of an inch round the end.

The distance to which water can be projected through the air depends very materially on the formation of the whole nozzle, but more especially on that of its termination. If the cylindrical part be in any way made rough, or if it be in the smallest degree damaged, even by a mere scratch so small as to be almost invisible, the issuing stream becomes injuriously affected, and scatters and falls much sooner than it otherwise would. If, again, the edge or angle of that part where the cylindrical portion ends be not left sharp and well defined, the same result takes place to a still greater extent. For these reasons the lip is cut with the most perfect accuracy in the first instance, and protected in the manner before mentioned, but the greatest care and attention are necessary to keep it in proper condition. The branches and nozzles should always be kept perfectly clean and free from grit or dirt, and in cleaning them great care must be taken not to damage the threads of the screws or any part of the water-way. The whole of the outside, with the exception of the male screw on the smaller boss, should be highly polished with brick dust or rotten stone; the threads and water-ways of the branch may be rubbed bright with a brush dipped in oil, and wiped off afterwards with cotton waste or some other soft material; but the threads only of the nozzle should be treated in this way, and the water-way, if possible, left untouched. A nozzle should never, under any circumstances, be touched on the inside with a metal tool, sand-paper, or any other hard substance, for the purpose of cleaning it. If it become dirty inside, which is very rarely the case, it can be sufficiently cleaned by a small piece of soft leather or cotton waste dipped in oil; but even this it is desirable, as far as possible, to avoid, as the rubbing off of the oil with a dry cloth has a tendency to scratch the inner surface, and the oil, if not carefully rubbed off, will adhere to the metal, and will not be removed by the water, but will continue to roughen the sides and injuriously affect the jet for any length of time. In almost all ordinary cases it is quite sufficient to rub the inside round with a man's finger.

So delicate is this part of the pipe, that in common practice it is found almost impossible to repair it after it has been once injured. When it is put out of shape by a fall, or scratched or otherwise damaged, however slightly, it is usually found cheaper and more satisfactory in the end to melt the metal, make a fresh casting, and turn out the whole nozzle again as new. Even in case of the angle of the lip becoming worn or rounded away, it is often necessary to condemn the whole nozzle, as after a few months of the rough usage unavoidable in our business it is almost impossible to place it in a lathe with sufficient accuracy to cut a fresh lip which will be quite true to all the other parts. Should there be any reason to suppose that one of the screws has received an injury, however slight, which may cause delay or difficulty in making a joint, the branch or nozzle to which it belongs must be laid aside, and on no account brought out to a fire again until the part affected has been carefully tested with the steel gauge kept for the purpose, and, if necessary, adjusted to the proper standard.

Particular care must be taken to see that the leather washers on the branch are clean and free from grit, and, when this has been ascertained, they should be well rubbed with pure oil, to keep them soft and in good order.

If these rules be strictly observed, the difficulty of making perfectly tight joints will be much reduced.

The diameter of each nozzle is legibly marked in large plain figures along the outside of the reduction part of the pipe, and the number of the engine to which it belongs is stamped in small figures across one of the sides of the hexagonal part.

The weight of a branch is 5 lbs. 6 oz., and the average weight ot a nozzle about 1 lb. 6 oz., making a total of about 6 lbs. 12 oz., or in round numbers, a little less than 7 lbs. for a directing-pipe complete, consisting of a branch and nozzle together.

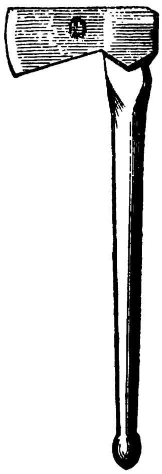
With 2½-inch hose both branches and nozzles are used; but with 1½-inch hose nozzles only.

GEAR

CARRIED ON AN ENGINE.

Large Axe.

A large axe is somewhat of the kind commonly known as a felling hatchet, and consists of two parts, called respectively the head and the handle.



The head is of wrought iron, 10 inches long, and formed somewhat in the shape of a large wedge. It has at one end a knife or cutting edge, steeled and tempered, and at the other end a solid rectangular block, 2½ by 1½ inches. The cutting edge extends 4½ inches, and is slightly curved and inclined towards the handle for the purpose of allowing the axe to clear itself quickly when in use. At a distance of ¾ of an inch from its rectangular end there is a longitudinal hole or socket; this is also wedge-shaped, and is made to receive the handle.

The handle is of well-seasoned ash, 3 feet long, and of varying substance, being shouldered and thickened at the part which enters the head, and gradually tapered down in somewhat of an oval form nearly to the other end, where it is again slightly shouldered to prevent it slipping out of a man's hands.

The upper end of the handle is driven into the socket, and firmly secured in its place by a wedge let in from the top, which prevents the head flying off when in use.

The weight of a large axe is :—Head 6 lbs., handle 1 lb. 8 oz.; total, 7 lbs. 8 oz.

Branch Tally.

A branch tally is the badge fastened on to a branch for the purpose of showing what engine the water is coming from, and what delivery of that engine, and it is marked accordingly—as 25 N. for No. 25 engine, near-side delivery; 38 O. for No. 38 engine, off-side delivery; or for the floating engines, A. F. 2, B. F. 6, meaning the A. float, No. 2 delivery, the B. float No. 6 delivery, and so on.

A branch tally is made of No. 1 flax canvass, 9 inches in length and 3 inches wide, tapered off at each end, and near the point fitted with a brass eyelet hole, to receive a small hemp cord for fastening it round the branch or hose.

Every engine carries one branch tally for each of its deliveries, with the necessary marking painted on it in black letters 1½ inches deep.

The weight of a branch tally, with cord complete, is 1 ounce.

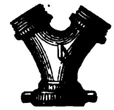
.Branch and Nozzle.

These are described in full detail in the preceding section, and are entered here only for the purpose of making the lists of gear agree.

Breechings.

Breechings, or junction-pieces, are of two kinds, the one kind for dividing one stream into two or more, and the other for concentrating two or more streams into one. They are alike in consisting of the necessary number of arms leading from, or to, a point of junction with the main line of the stream to be affected; but as they are essentially different in many other points, and particularly in the uses to which they are applied, they are separately described under the respective heads of 1 into 2 and 2 into 1, those being the principal ones which we have in common use.

Delivery Breeching.—1 into 2, 2½ and 2½.



A breeching of this kind is cast in gun metal, and consists of a pipe about 5 inches long, branching off at angles of about 60° into two others about 3 inches long. At the end of the main-pipe it is mounted with a female swivel screw, and at the ends of the two other parts with male screws, all of the ordinary pattern. The male screws are protected with metal or leather caps when not in use.

It may be attached either to an engine, a stand-pipe, or a length of hose, and is sometimes very useful in economizing both the time of getting to work and the quantity of hose necessary to reach two separate places.

The weight of a delivery breeching, 1 into 2, 2½ and 2½, is 8 lbs. 1 oz.

Delivery Breeching—1 into 2, 2½ and 1½.

A breeching of this kind is also cast in gun metal, and consists of a pipe about 3½ inches long, branching off at angles of about 60° into two 1½-inch pipes, about 2½ inches long. At the end of the main pipe it is mounted with a 2½-inch female swivel screw of the V thread pattern, and at the end of each of the two other parts with a 1½-inch male screw of the round thread pattern; gun-metal caps are attached by pieces of wrought-iron chain, to protect the male screws when not in use.

One of these breechings may be attached either to an engine, a stand-pipe, or a length of hose.

A delivery breeching, 1 into 2, 2½ and 1½, weighs 7 lbs. 9 oz.

Delivery Breeching—2 into 1, 2½ and 2½.

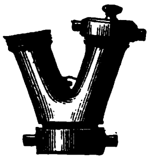
A breeching of this kind is also cast in gun metal, and consists of two pipes about 3 inches long, each with a female swivel screw joining at angles of about 45 degrees; and a third pipe of about the same length, mounted with a male screw, which, when not in use, is protected by a cap.

It can be attached to two lines of hose, so as to lead the water from both into one stream.

A delivery breeching, 2 into 1, 2½ and 2½, weighs 10 lbs. 1 oz.

SUCTION BREECHINGS—1 into 2, 3½ and 2½.

A breeching or junction-piece of the above kind is cast in gun metal, and has a female screw, with a recess for a leather washer, corresponding with and to be attached to the inlet of an engine; also two male inlets, for attaching two or more manual-size suction-pipes to a steam fire-engine at one time. A gun-metal cap is attached by a piece of wrought-iron chain to each of the male screws, to be used when only one of the two inlets is required, and also to protect the male screws when not in use.



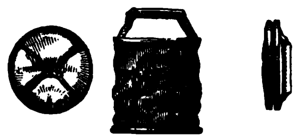
This breeching is used for lengthening the suction-pipe of an engine, where the distance of the water is more than usual, by enabling manual suction-pipes to be attached either to the end of the large suctions, or directly to the inlet of the pumps.

The female screw of this kind of breeching has an internal water-way of 3½ inches in diameter, to fit the suction inlet of the engine to which it is attached, and the male screws are of the ordinary 2½-inch pattern, with round threads to fit the manual suction-pipes.

A suction breeching of this kind weighs 17 lbs. 13 oz.

CANVASS BUCKET.

Canvass buckets are adopted on account of their lightness and portability, and because a great number can be stowed in a very small compass.



A canvass bucket of the pattern in use is 8½ inches in diameter, and 12 inches deep. It is made of the best hemp, duck, or canvass, and at the top and bottom is spread by cane hoops let in, and covered over by the canvass, and strongly sewn round to keep them in their places. The handle is formed by a double strip of duck, 12 inches long and 1½ inches wide, sewn on to the inner part of the upper hoop at opposite sides, and stiffened in the centre by a piece of wood, 6 inches long, 1 inch wide, and ½ inch thick. The strip is stitched at the ends, and nailed in that part which covers the wood, and being loose at the ends and stiff in the centre, can be firmly grasped without either causing the hoops to collapse or the hand to dip in the water, as would be the case if there were no wood, or if the wood extended all the way across.

Underneath, on the outside, there are sewn at right angles two cross-lines, which serve to stay the bottom, and also to hang the bucket by.

When not in use, it is slightly twisted, and doubled down until the bottom and top hoops meet, in which position it occupies a circular space of 9 inches in diameter and about 1 inch in depth; thus it will be seen that a dozen made up in this way occupy only about the same space as one wooden bucket.

It weighs, when empty, 13 ounces, or about ⅘ of a lb., and has an internal capacity of 680 cubic inches, or nearly 2½ gallons—so that when full of water it weighs about 25 lbs.

Each engine carries six of these buckets, fastened together with a leather strap and buckle, called the bucket strap.

Weight as above, 13 oz.

Chafing Leather.

A chafing leather is made of a strip of leather about 18 inches long and 8 inches wide, with 2 straps and buckles rivetted to it, for the purpose of fastening it round a suction-pipe or hose to prevent chafing.

A chafing leather weighs 1 lb. 7 oz.

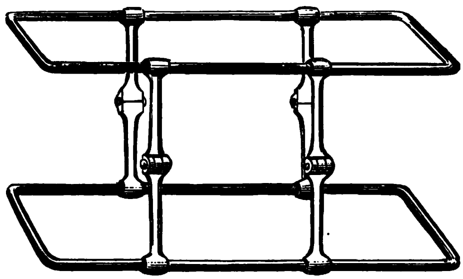
Cold Chisel.

A cold chisel is made of bar steel, octagon shaped, and about 1 inch in diameter for a distance of 4 inches at one end; it is drawn out to a flat taper, and terminates in a chisel point of $\frac{3}{16}$ths of an inch thick, but bevelled down for $\frac{1}{8}$th of an inch to a fine edge at the extreme point.

A cold chisel weighs 1 lb. 1 oz.

Dam.

A portable cistern or dam is composed of the following parts, namely:



Dam Frame.

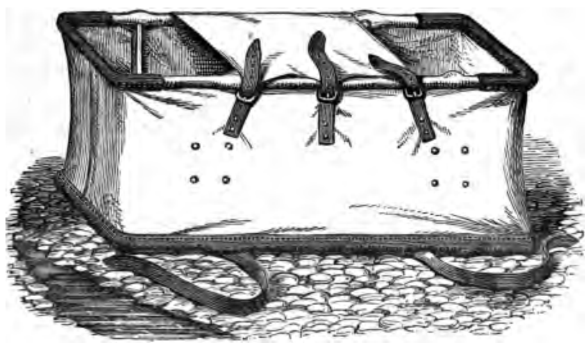
Two rectangular frames of 5-8ths inch galvanized iron gas-tubing, 32 inches long and 13 inches wide.

Four arms or uprights.

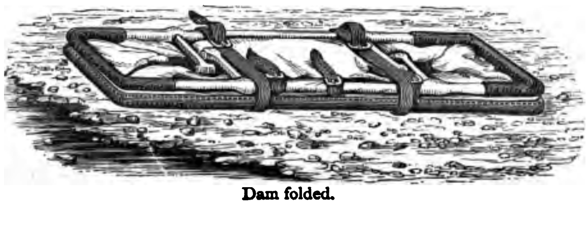
A canvass covering.

The frames are precisely the same size, and are fixed by means of the uprights, one on top of the other.

The arms or uprights are made of best gun metal, $\frac{1}{2}$ an inch thick, 17 inches long, and hinged in the middle. They have at each end a socket or eye, which is passed over the sides of each of the frames at a distance of $4\frac{1}{2}$ inches from the end at one side, and 5 inches at the other, and connect the top to the lower frame. Each of these uprights has at the centre a knuckle-joint, fixed so that the arms, when lowered, may incline inwards and allow the frames to fold together, thus making the whole compact for stowing in



Dam open.



Dam folded.

the engine when not in use. Each dam is fitted with a pair of straps and buckles to fasten it when stowed.

The bottom is of No. 1 canvass, turned over and sewn to the lower rectangular frame, with two pieces of leather rivetted on to its upper side, to prevent the canvass being worn through from the chafing of the strainer.

In the bottom is a hole made to go over the plug-hole, and this is encircled on both sides with wash-leather, leaving an opening of not less than 2½ inches. The wash-leather is used to prevent the water from getting away from between the plug-box and the cistern, leather being found the most suitable for this purpose, in consequence of its tendency to adhere when wet.

The sides are also made of No. 1 canvass, which is in one piece, with a seam 1½ inches wide, one edge being stitched on the top rectangular frame, and bound with cow-hide dressed in oil at the two ends, with a slight return to the sides to protect the canvass from the chafe of the suction-pipe.

The lower edge is sewn on to the outer edge of the bottom already described, the stitching being protected by a covering of cow-hide dressed in oil, one edge being attached to the bottom and the other to the side by means of a strong waxed thread.

There is also a piece of No. 1 canvass sewn on one side, and secured on the other by three leather straps and buckles. This is called the top flap or bonnet, and its use is to prevent the water overflowing, in consequence of its force or pressure, when the head of water exceeds the height of the dam or cistern. This flap may be attached either to the top or about half way down, in which latter case it serves to keep the suction-pipe steady when the engine is at work.

This description of dam, or portable cistern, refers to those carried in the manual engines; but there are larger ones used for steamers, which are precisely the same, in every respect, so far as material and workmanship are concerned, and differ only in dimensions.

An ordinary dam of the dimensions here given weighs 27 lbs. 2 oz. Other dams in use weigh 29 lbs. and 42 lbs. respectively.

Crowbar.

A crowbar is a bar of wrought iron 2 feet 11 inches long and somewhat about 1 inch in diameter, chisel-shaped at one end and pick-pointed at the other. Both ends are steeled and tempered.

A crowbar weighs 10 lbs. 5 oz.

Double Connecting Screws.

A double connecting screw is cast in gun metal, and is a contrivance for connecting the 2½-inch round threads to the 2½-inch V thread screws; namely, a male of 2½-inch round thread and female of 2½-inch V thread on one part, and a male of 2½-inch V thread and female of 2½-inch round thread on the other part.

A pair of double connecting screws weighs 2 lbs. 10 oz.

Double Reduction Screws.

A double reduction screw is a contrivance for connecting large and small hose together; it is in two parts, and has four screws, namely, a male of the 1½-inch round thread pattern, and a female of the 2½-inch V thread pattern on one part, and a male of the 2½-inch pattern and a female of the 1½-inch pattern on the other.

When it is necessary to add 1½-inch to 2½-inch hose, the 2½-inch female screw is first attached, and the 1½-inch male screw takes the smaller hose; and when it is necessary to add large to small hose, the 1½-inch female screw is first attached, which leaves the 2½-inch male screw for the larger hose.

The weight of a pair of double reduction screws is—large into small 3 lbs. 2 oz., small into large 2 lbs. 10 oz.; total, 5 lbs. 12 oz.

Delivery Elbow—2½ and 2½.

A delivery elbow is merely a bent copper pipe about 19 inches long, with a female screw on the bottom end to fix on to hydrants, and a male screw on the upper or bent end, to which the hose can be attached.

This elbow weighs 7 lbs. 5 oz.

Delivery Elbow—2½ and 1½.

This elbow is almost precisely the same as the 2½ previously described, with the exception of the copper tube, which is tapered from 2½ to 1½ inches, and has a male screw of 1½ inch round thread pattern on the upper or bent end.

This elbow weighs 4 lbs.

Delivery Elbow—2¼ and 1½.

This kind of elbow is made of cast gun metal, about 9 inches long, tapered from 2¼ female V thread to 1½ male round thread; it is used only for screwing on some water posts, which unfortunately happen to have a 2¼ inch outlet.

This elbow weighs 3 lbs. 11 oz.

There is another kind of elbow, which, though very rarely used, deserves some notice; it is known as a

Nozzle Elbow.

A nozzle elbow is a bent piece of 1½-inch pipe 5 inches long. It is cast in gun metal, with a female screw at one end for attaching it to the branch-pipe, and a male screw with a leather washer at the other end to take the nozzle.

This is used in getting at a fire in the basement of a house, or a ship's hold, when, owing to the density of the smoke or other sufficient cause, it is not possible for the firemen to get down to it. The stream takes a horizontal direction, and enables the fireman to subject a much larger area to its effects.

The general rule is, that a fireman should never pour water on any spot which he cannot actually see, so as to be able to judge of the effect of his work; but there are cases in which it is found necessary to depart in some measure from this rule. These cases, however, are very rare, and the nozzle elbow is an implement which should never be used except in cases of absolute necessity, and under the orders of an officer of experience and discretion.

A nozzle elbow weighs 1 lb. 2 oz.

Files.

These are ordinary files, 12 inches long, and are of two kinds, known respectively as half-round and three-cornered bastard files.

Either kind weighs a little less than 1 lb.

Spare Gauge Glass.

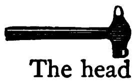
A gauge glass is a glass tube $\frac{3}{8}$ths of an inch internal diameter, $\frac{1}{2}$ inch external diameter, and 12 inches in length.

When in use it is packed, with vulcanized india-rubber rings, into the glands of the cock previously fitted to the boiler with vulcanized india-rubber rings, and it shows the quantity of water in the boiler.

These glasses or tubes are very finely annealed or tempered to stand great heat; but they are likely to break from a sudden chill from cold water coming in contact with them, or from sudden heating, and consequently it is found necessary to carry spare ones.

The weight of a gauge glass is 3 oz.

Iron Hammer.



An iron hammer consists of two parts, called respectively the head and the handle.

The head is of wrought iron, at one end round, with a diameter of $1\frac{1}{2}$ inches, and at the other brought down to a flat taper $1\frac{1}{4}$ inches wide. Both ends are faced with steel, and there is a hole cut through the centre to take the handle.

The handle is of ash, 14 inches long, about $1\frac{1}{4}$-inch wide, and 7-8ths of an inch thick, with the corners rounded off. It is passed through the hole in the head, and secured by means of a wooden wedge driven in from the top, to prevent the head flying off when in use.

An iron hammer weighs—head 1 lb. 6 oz., handle 6 oz.; total, 1 lb. 12 oz.

Tin Hammer.

A tin hammer is composed of two parts, called respectively the head and the handle.

The head is of mallet shape, $3\frac{1}{4}$ inches long, and for the most part $1\frac{1}{2}$ inch in diameter, but slightly enlarged at the centre, where it has a hole bored through to take the handle. It is cast in tin, which, being a soft metal, takes all the dents caused by the blows, and does not leave any marks on the bright steel or gun-metal work.

The handle is of ash, 13 inches long, $1\frac{1}{4}$-inch wide, and 7-8ths of an inch thick, with the corners rounded off; it is attached to the head by being passed through the hole already mentioned, and is further secured by means of a wooden wedge driven in from the top, which prevents the head flying off when in use.

A tin hammer weighs—head 2 lbs. 1 oz., handle 4 oz.; total, 2 lbs. 5 oz.

Hand-Loop.

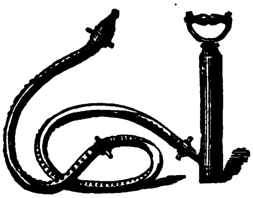
A hand-loop, or shifting becket, is made of leather similar to that used for hose, and is composed of three parts, as follows:—A strap, 16 inches long and 1¼ inches wide, with a tinned buckle and roller complete, secured to it with one rivet. One loop is 1½ inches from the buckle, and the other 5½ inches.

This is used as an additional hand-hold for a man with a branch, from which a powerful jet of water is being projected, and should be secured by means of the strap immediately under the lugs of a male screw, the lugs acting as a stop, and so forming an additional security from the fact of the hose always having a tendency to go backward, and consequently requiring a forward pressure to counteract it.

The weight of a hand-loop is as follows:—buckle 1 oz., rivets 1 oz., leather 5 oz.; total, 7 oz.

Hand-Pump, Complete.

A hand-pump of the pattern now in use is a single-acting force-pump of the simplest possible description, fed by gravitation, and encircled by an outer case which serves the double purpose of protecting the pump cylinder and of forming an air chamber.



It is constructed in the following manner:—

There are two pieces of brass tubing, the outside one 2¼ inches in diameter, and the inner one 1¼ inches in diameter, with a semi-circular piece 2 inches long soldered on to the bottom, and fitted with an angular piece of sheet copper, which acts as a stop to the delivery-valve. The inner tube forms the pump cylinder, and is attached to the outer one on the top by a cast gun-metal cap, which has a female thread to receive another cap to secure the piston-rod, and form a guide for the same, and at the bottom by another casting in gun metal, on which is the seating for the delivery-valve, and a semi-circular opening to receive the cylinder, and also a female screw. The whole of these parts are thoroughly sweated together with soft solder.

To this is connected a gun-metal suction valve-box, which has a plate fitted into the bottom. This valve-box has 26 holes or inlets round it, each 1-16th of an inch in diameter, and about 1-8th of an inch from the bottom, so that the pump can be worked with a very small depth of water. The exit-pipe is 3 inches from the bottom, and has cut on its extremity a male screw with an internal diameter of 5-8ths of an inch.

There are two valves, both of metal, and of the kind commonly known as conical spindle-valves.

The suction-valve is 1¼ inches in diameter, with a lift of 3-8ths of an inch, and the delivery-valve is 7-8ths of an inch in diameter, with a lift of 1-4th of an inch.

The outer tube or case, which is of brass of No. 17 gauge, has, as already mentioned, two purposes, the first to form an air vessel, and thereby produce a continuous stream of water; the second to protect the inner tube, so that with an ordinary blow, making a dent of 3-8ths or even half an inch, the cylinder or actual pump remains uninjured.

The piston consists of two parts made of gun metal, 1 inch in diameter, 3-16ths of an inch deep at the edge, and a little thicker at the centre round the piston-rod hole, which is 3-8ths of an inch in diameter. The parts are secured to the rod by two nuts, and the rod is slightly burred to prevent the bottom nut from coming off. The piston is mounted on the outside with a leather covering to make it fill the cylinder, touching at every part round the edge, but not fitting so tightly as to cause heavy friction when in motion.

The leather covering is made in two cups, formed in the same manner as those adopted for the ordinary manual fire-engine.

There are some small holes in the upper cap or stuffing-box to allow an escape for any water that may happen to get above the piston.

The piston-rod is of wrought iron, 3-8ths of an inch in diameter; its extreme length is $12\frac{1}{2}$ inches, and it has welded on to it at one end a semi-circular piece of iron 1-8th of an inch thick and 5-8ths of an inch wide, and a turned wood cross-bar, with an iron pin running through it, rivetted to the semi-circular piece of iron, and so forming a handle.

The weights of the parts are as follows, namely:—air vessel, outside casing of, 1 lb. 9 oz., cylinder $13\frac{1}{2}$ oz., top-cap and stuffing-box 5 oz., gun-metal casting, with the seating for delivery-valve attached, &c. $4\frac{1}{2}$ oz., suction valve-box $9\frac{1}{2}$ oz., bottom of valve-box $1\frac{1}{2}$ oz., delivery-valve 1 oz., suction-valve $1\frac{1}{2}$ oz., piston-rod and handle 14 oz., piston with nuts and caps complete $2\frac{1}{2}$ oz.; total, 4 lbs. 14 oz., or, in round numbers $4\frac{3}{4}$ lbs.

The length of stroke of piston is $10\frac{3}{4}$ inches, and consequently the quantity of water received into one of these pumps during the upward movement of the piston, or discharged from it on the downward movement, is that which can be contained in $10\frac{3}{4}$ inches long of a $1\frac{1}{4}$-inch cylinder.

The area of a $1\frac{1}{4}$-inch circle is 1·277 superficial square inches, which, multiplied by the length of stroke, $10\frac{3}{4}$ inches, gives a capacity of 13·19 cubic inches, or ·0476 gallons—in round numbers, the 1-12th part of a gallon.

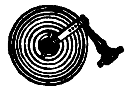
The quantities of water delivered by this pump will be found in the following table—1 stroke ·0476 gallon:—

No. of Strokes.	Quantity delivered in Gallons.	No. of Strokes.	Quantity delivered in Gallons.	No. of Strokes.	Quantity delivered in Gallons.	No. of Strokes.	Quantity delivered in Gallons.	No. of Strokes.	Quantity delivered in Gallons.
10	·476	210	9·996	410	19·516	610	29·036	810	38·556
20	·952	220	10·472	420	19·992	620	29·512	820	39·032
30	1·428	230	10·948	430	20·468	630	29·998	830	39·508
40	1·904	240	11·424	440	20·944	640	30·464	840	39·984
50	2·380	250	11·900	450	21·420	650	30·940	850	40·460
60	2·856	260	12·376	460	21·896	660	31·416	860	40·936
70	3·332	270	12·852	470	22·372	670	31·892	870	41·412
80	3·808	280	13·328	480	22·848	680	32·368	880	41·888
90	4·284	290	13·804	490	23·324	690	32·844	890	42·364
100	4·760	300	14·280	500	23·800	700	33·320	900	42·840
110	5·236	310	14·756	510	24·276	710	33·796	910	43·316
120	5·712	320	15·232	520	24·752	720	34·272	920	43·792
130	6·188	330	15·708	530	25·228	730	34·748	930	44·268
140	6·664	340	16·184	540	25·704	740	35·224	940	44·744
150	7·140	350	16·660	550	26·180	750	35·700	950	45·220
160	7·616	360	17·136	560	26·656	760	36·176	960	45·696
170	8·092	370	17·612	570	27·132	770	36·652	970	46·172
180	8·568	380	18·088	580	27·608	780	37·128	980	46·648
190	9·044	390	18·564	590	28·084	790	37·604	990	47·124
200	9·520	400	19·040	600	28·560	800	38·080	1000	47·600

This pump can be worked for a considerable time by one man at 100 strokes per minute, and the above table shows that in that time 4·76 gallons of water would be delivered, or in the space of ten minutes at the same rate of working 47·6 gallons.

These pumps can be made to project water through a 3-16ths of an inch orifice to a height of about 30 feet, and they are found invaluable at small fires, from the fact of their performing a large amount of work with great economy of water; indeed, rooms well on fire are continually extinguished by the aid of these pumps, supplied from taps, basins, or buckets, and hardly any water can be perceived in the rooms immediately underneath.

To each of these pumps there are attached two 10-feet lengths of rivetted hose, made of leather, cut from English butts, dressed and made up in the same manner as described in the instructions concerning leather hose.

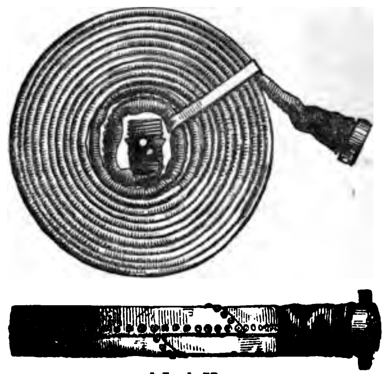


Each length of hose is composed of three strips of leather, and has 284 No. 12-gauge rivets in the longitudinal seam, and 7 of the same size in each of the two joints. It has also a strap 24 inches long, and ½ an inch wide, which has a half-inch tinned wrought-iron buckle secured to it by one rivet, and it is mounted on the hose with a collar 4½ inches long, made from the same kind of leather, and fastened to the strap by one rivet. Each length is fitted with a male and female coupling-screw, tied in with copper wire. The waterway in the screws is 7-8ths of an inch in diameter, and in the hose about 1 inch. The lengths of hand-pump hose, with couplings and straps complete, weigh 3 lbs. each.

A hand-pump nozzle is cast in gun metal, and afterwards bored out from 7-8ths of an inch at one end to an orifice of 3-16ths of an inch at the other, and it has cut inside its larger end a female screw with a shoulder, formed to receive a leather washer. This nozzle weighs 3 ounces.

Hand-pump Bag.

What is known as a hand-pump, complete, consists of a hand-pump, two lengths of hose, with straps, &c., a nozzle, and a canvass bag, in which the several articles are carried. The weight of a hand-pump, complete, is therefore—hand-pump 4 lb. 14 oz., two lengths of hose 6 lbs., nozzle 3 oz., canvass bag 15 oz.; total, 12 lbs.



2½-Inch Hose.

Hose—2½ inch.

These are fully described elsewhere, but are entered here to complete the list.

The weight of a forty-feet length of 2½-inch leather hose is 48 lbs.

Hose—1½ inch.

Described elsewhere.

The weight of a forty-feet length of 1½-inch leather hose is 26 lbs.

Hose-Wrench—2½ inches.

A 2½-inch hose-wrench is made of wrought iron, and has a hole at one end ¾ of an inch in diameter, to take the gun-metal lug of the hose-screw.

It is formed into a half circle, 3½ inches in diameter, to fit the round of the screws, and is continued with a rounded handle 10 inches in length, making a total length of 13½ inches.

This is used for tightening up the screws, and making a sound joint with the ordinary 2½-inch couplings.

A 2½-inch hose-wrench weighs 1 lb. 13 oz.

Hose-Wrench—1½ inch.

A 1½-inch hose-wrench is made of wrought iron, and has a hole at one end 5-8ths of an inch in diameter, to take the gun-metal lug of a 1½-inch hose-screw.

It is formed into a half circle 2½ inches in diameter, to fit the outside round of the screws, and is continued with a handle 7 inches in length, making a total length of 9½ inches.

This is used for tightening up screws, and making sound joints with the 1½-inch couplings.

A 1½-inch hose-wrench weighs 14 oz.

Hydrants.

These are special appliances, suitable at present only to certain localities, and they need not be separately described here.

They are each about 3 feet 2 inches long, and generally weigh about 26 lbs. 3 oz.

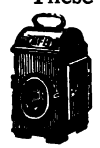
Ladders.

Described elsewhere.

A length of ladder weighs 20 lbs.

Carriage or Side Lamps.

These lamps are 7 inches high, 5 inches wide, and 4 inches deep.



They are of strong sheet copper, No. 20 gauge, folded and lapped at the joints, and not fastened with solder or other material likely to be affected by heat. A little solder is used in one or two parts, but only for a finish; the strength of the lamp does not depend on it. They have underneath angular pieces of brass, ¼ of an inch deep, to keep the bottom from touching when the lamp is on the ground; and in the bottom there are holes for the admission of air. They have also, on the top, two semi-circular pieces of copper-plate, at right angles, and one above the other, with a space between to allow the hot air to escape.

The handle is of ⅛th-of-an-inch brass wire.

The door is hung on brass hinges, and has a circular piece of bevelled plate glass 4 inches in diameter in the centre, forming a sort of bull's eye, inside which is fitted a silver electro-plated reflector of No. 22 gauge sheet copper, bevelled outwards. One side has a piece of bevelled plate glass 4½ inches by 2¼ inches, and the other has a tinned wrought-iron plate 2 inches wide and ⅛th thick, screwed with 3 copper rivets, which is used for affixing the lamp to the socket on the side of the engine.

The cistern or reservoir for the oil is made of block tin, and has an opening formed on the top in brass, with a female screw, and also a shoulder to receive a burner for a flat wick ¾ of an inch in width, which is secured by a brass ring with a male screw. There is also a small air shaft in the side of the cistern, with a tapered brass tube screwed to it, which can be taken off when fresh oil is required in the cistern.

The cistern slides in from the front, underneath the flaps, which prevent it rising when in its place, so that the closing of the door fixes it firmly. The back reflector is also of No. 22 gauge copper and silver electro-plated.

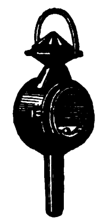
The whole of the inside is tinned, to assist the radiation.

The initial letters of the Brigade are cast on an oval plate, which is rivetted on the front over the door; and the station to which the lamp belongs is indicated by brass numbers rivetted on the doors above the circular glass.

Each engine carries two side-lamps.

A carriage lamp weighs 4 lb. 14 oz. without oil, or 5 lbs. 4 oz. with oil.

GAUGE-LAMPS.



The main portion or body of a gauge-lamp, such as that shown in the drawing, is made of tin tube, 3½ inches in diameter and 3 inches in length, with a piece of tin slightly hollowed out and soldered on at one end, and a door, having a circular piece of bevelled plate glass 3½ inches in diameter, at the other.

To the top of this is fitted and soldered a conical piece of tin, with a cap, which has sufficient opening to it to allow the hot air to escape, the cold air being admitted at the bottom by some holes underneath the cistern.

To the cap or ventilator is soldered a semi-circular piece of brass wire, about 3-16ths of an inch thick, which forms a handle; and to the bottom is fitted and soldered a brass socket, which receives a piece of brass tube 3¼ inches long and ¾ of an inch in diameter. This tube is made to fit into the socket fixed on a steamer for that purpose.

Inside, and at the back part, is fitted a plated reflector, and a cistern, made of tin, and of a semi-circular form, 3 inches in diameter, is also fitted, and it has a brass ring soldered on to the centre, with a female screw, and a shoulder to receive the burner, which is made for a flat wick ⅜ths of an inch wide, the burner being secured by another brass ring, which has a male screw.

The cistern is secured at the top by two stops, soldered on to the body of the lamp, and at the bottom by a spring, which slides over and drops into a stud. To this spring there is fitted a ring for pulling the cistern out.

The weight is as follows, viz.:—lamp 1 lb. 7 oz., cistern 3 oz., oil 2 oz.; total, 1 lb. 12 oz.

There is also another kind of gauge-lamp in use, which is made of tin, and is 4¼ inches high and 2¾ inches wide, with a piece of bevelled plate glass 3¾ inches by 2½ inches, fitted on each side, and a door with a piece of plate glass of the same dimensions at the front.

On the top are fitted two semi-circular pieces of tin, at right angles, and at a sufficient distance from each other to allow the hot air to escape, the cold air being admitted at the bottom by some holes at the back and sides.

A piece of brass wire, 3-16ths of an inch thick, is soldered on to the top for a handle.

On to the back there is fitted a piece of 3-8ths-inch brass tube, which forms a socket to correspond with a spindle attached to the engine to which this lamp belongs, and to this socket is fitted a small brass bolt, which, when hardened up to the spindle, firmly secures the lamp.

The cistern is of tin, and has a brass ring soldered on to the centre, with a female screw, and a shoulder to receive the burner, which is made for a flat wick about 3-8ths of an inch wide, the burner being secured by another brass ring, with a male screw. The cistern is secured by a stop soldered on to each side of the lamp, and by the door shutting close on to it.

Inside the lamp, and on the right hand, is fitted a 1-16th of an inch tube, ½ an inch in length, and a piece of 1-16th of an inch iron wire, pointed at one end, is supplied and kept there, for the purpose of pricking up the wick when necessary.

A gauge-lamp of this kind weighs 1 lb. 5 oz.

Lapping-Leathers.

A lapping-leather is cut from sheep's skin, and is usually about 3 feet long and 2¼ inches broad.

It is used for binding round hose to stop a leak during a fire, when it is not convenient to shift the damaged length.

A lapping-leather weighs 3 oz.

Each engine carries a bundle of 6 lapping-leathers, which weigh together 1 lb. 2 oz.

Lapping-Lines.

A lapping-line is of hemp, made up as what is known as box-cord.

It is 6 feet long, and is chiefly used for securing the lapping-leathers over a leak.

A lapping-line weighs 1 oz.

Each engine carries a bundle of 6 lapping-lines, which weigh together 6 oz.

Long Line.

A long line is a piece of 2-inch patent laid rope, commonly known as signal halliards line. It is 80 feet long, and is whipped with strong twine at each end, to keep it from opening or fraying.

Each long line is marked at both ends with the number of the station to which it belongs stamped on a rivet, the stem of which is driven through and burred down over a washer.

A long line weighs 7 lbs. 14 oz.

Short Line.

A short line is of tarred hemp, made up as what is commonly known as 1½-inch hawser-laid rope.

It is 36 feet long, and is whipped and marked in the same way as the long lines.

A short line weighs 2 lbs. 2 oz.

Pocket-Line.

A pocket-line is of hemp, made up as what is commonly called three-stranded cord or seizing stuff.

It is 12 feet long, and is used for a variety of purposes; such as taking the weight of the hose on a staircase, or at any inside work, or wherever a line is required to carry only a slight weight.

A pocket-line is also frequently used when it is necessary to put up lashings.

The weight of a pocket line is 4 oz.

Mattock.

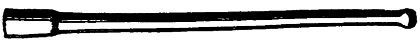
A mattock is composed of two parts, called respectively the head and the handle.

The head is of wrought iron, 22 inches long,

and is of the same shape and size as the head of an ordinary pick-axe, with the exception that one end of it is chisel-shaped. It is steeled and tempered at both ends.

In the centre of the head there is a longitudinal hole, which is slightly tapered to receive the handle.

The handle is of well-seasoned ash, 3 feet long, oval shaped, thickened at one end to fit the hole in the head, which is



jammed on to it; the other end is slightly shouldered, to prevent it slipping out of a man's hand when in use.

The weight of a mattock is—head 4 lbs. 12 oz., handle 1 lb. 4 oz.; total, 6 lbs.

Small Nippers.

Small nippers are made of steel, and resemble a pair of pincers.

They have a jaw, straight on the outside and semi-circular on the inside, and 2 inches long; and the handles are straight, and 5 inches long: making a total length of 7 inches.

They are used to lift out the valves of a feed-pump attached to a steamer, or to put them back again in their places.

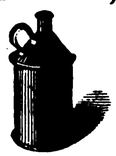
The weight of a pair of small nippers is $1\frac{1}{2}$ oz.

Nozzles.

Described elsewhere.

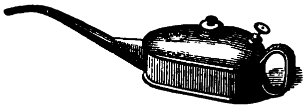
Small Oil-Can.

A small oil-can is made of tin, the joints being lapped and soldered; and for a height of $4\frac{3}{4}$ inches it is of a cylindrical form, and 4 inches in diameter, the upper part being conical, and terminating with an opening $\frac{3}{4}$ of an inch in height and 1 inch in diameter to admit the oil.



This can will hold about a quart, and it is usually carried in a steam-engine.

A small oil-can, when empty, weighs 10 oz., the oil contained in it weighs 2 lbs. 6 oz.; the can, when full, weighs 3 lbs.



Oil-Feeder.

An oil-feeder is a tin vessel, with a handle soldered on at one end, and a long spout at the other. It is somewhat of an oval form, but rather wider at the handle end than at the spout end.

The body of the vessel is 1¾ inches deep, 5¼ inches long, and 2½ inches wide in the centre; and the spout has a shoulder about 1½ inches long, and contracting from 1½ inches to ½ an inch; the remaining portion is round and slightly curved, and tapers to 1-8th of an inch in diameter.

There is fitted to the inner end of the spout a valve, faced with leather, called the safety-lever valve; and the lever is so placed that in taking hold of the handle with the two forefingers the thumb comes in contact with it, and can press on it so as to open the outlet and let the oil run.

The advantage of this kind is, that in travelling, or in case of its getting upset, the oil cannot flow out. There is a cylindrical opening on the top 3-8ths of an inch high, and 3-4ths in diameter, which is fitted with a brass cap with a leather washer. The cap can be screwed on and off at pleasure, and the opening is used for filling the vessel.

The weight of an oil-feeder is—feeder 5 oz., oil 4 oz.; total, 9 oz.

Set of Packing-Irons.

A set of packing-irons is composed of the following, namely—1 worm, 1 hook or pricker, and 1 pushing-iron.

A worm is made of steel wire, of about No. 6 B W gauge, with a turned eye at one end for the hand, and the other drawn out to a taper, and formed in shape of a worm; it is used for drawing old packing from the glands of an engine.

A hook, or pricker, is also made of wire of the same gauge, with an eye at one end and the other pointed and turned in the shape of a hook; it is used for packing as well as drawing out old packing.

A pushing-iron is also made of the same gauge steel wire, with a turned eye at one end for the hand, and the other flattened out; it is about 7 inches long, and is used for pushing new or fresh packing into the glands of an engine.

A set of packing-irons weighs 6 oz.

Preventer.

Preventer.

A preventer, or fire-hook, is very nearly the same kind of implement which is commonly known as a boat-hook, and consists of two parts, called respectively the head and the handle.

The head is of wrought iron, 17 inches long. At its upper end it has a straight spike or prong 5 inches long, ½ inch thick at its commencement, and gradually reduced at the extremity. At a distance of 5½ inches from the top it has another spike or spur of the same length, which stands at about a right angle from the prong, and has on its lower side a cutting edge. The lower part of the head for about 5 inches forms a tapered socket, ¾ of an inch in diameter at the top, and widening to about 1½ inches in diameter at the bottom, the head terminates in a side or clamp, 6 inches long and about 2 inches wide, slightly curved so as to fit the wooden handle.

Through the socket there are drilled two holes for rivets, and through the side or clamp two holes for screws, one at the top and the other at the bottom.

The handle is of best ash, 8 feet long, and 1½ inches in diameter, tapered at one end to fit into the socket of the head, and secured in its place by rivets and screws passing through the holes cut for the purpose.

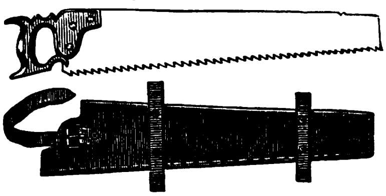
Its principal uses are pricking ceilings, pulling down burning embers, and doing other work out of reach of the men's hands or the shorter implements.

The weight of a preventer is—head, rivets, and screws, 2 lbs. 8 oz., handle 4 lbs.; total, 6 lbs. 8 oz.

SAW.

A saw consists of two parts, called respectively the blade and the handle.

The blade is of steel plate, 26 inches long, 4½ inches wide at one end to which the handle is attached, and gradually tapered to 2½ inches on that edge on which the teeth are formed. There are 95 teeth, which are slightly set out alternately and at reverse sides, to enable it to form a sufficient space in the wood to clear itself, and thereby reduce the work.



Saw and Saw-Case.

The handle is made of beech-wood, and is secured to the steel plate by 3 counter-sunk brass rivets, which have a screw at one end to take a slot-headed washer at the other, which is also counter-sunk, and can be hardened up at any time.

The weight of a saw is 2 lbs. 11 oz.

SAW-CASE.

A saw-case is a leather sheath, 2 feet 2 inches long, 5½ inches wide at its wide end, and 3½ inches wide at its narrow end; it is made of bridle butts, with the flesh side inwards, sewn with wax end, and made in the shape of a saw. The wider end of it is left open for the purpose of receiving the blade of the saw, thus completely covering it and protecting it from damage when not in use. It is fitted at the open end with a small leather strap on one side, and a roller-buckle on the other; the strap is passed through the handle of the saw and fastened by the buckle, thus keeping the saw firmly in its place. It has also two pieces of leather, 8 inches long and 1 inch wide, placed across one side of the case at about 7 inches from the ends. The cross-strips and the strap and buckle are fastened to the case with tinned copper rivets and washers.

The leather case is carried on the underneath or inner side of the hose-box lid of the engine, and is secured in its place by means of screws passing through both ends of the cross-strips, and entering battens placed on the lid to form a flat surface.

The case, without the saw, weighs 1 lb. 4 oz.

Smoke Cap.

Described elsewhere.
Weight, 4 lbs.

Spade.

A spade is composed of two parts, namely, the blade and the handle.

The blade is made of wrought iron, and tipped with steel; it is 11½ inches long and 7¼ inches broad, and varies in thickness from 1-16th to 1-8th of an inch.

It has an iron socket, 10 inches long and slightly curved, welded on to it to receive the handle, and it has also a piece of 1-8th of an inch iron rivetted on to the top of the blade and each side of the handle, to receive the foot when forcing it into earth or rubbish.

The handle is of wood, generally ash, and is 26 inches long and 1½ inches thick, with a semi-circular 3½-inch bend at the top to take a man's hand.

The handle is fitted into the iron socket, and secured by 3 iron rivets. The total length is 37½ inches.

The spade complete, including blade and handle, weighs 5 lbs.

Branch-and-Nozzle Spanner.

A branch-and-nozzle spanner is made of burnished wrought iron, and in a form at one end to fit the sides of the hexagon part of a branch-pipe, and at the other end the hexagon part of a nozzle.

The weight of a branch-and-nozzle spanner is 2 lbs. 11 oz.

Shifting Spanner.

A shifting spanner is made of steel, and has two jaws, the upper one fixed to the handle or lever, and the lower one moveable; both are at right angles to the handle.

The handle has a worm rack cut in the back for a length of 3 inches, being the length of travel of the lower jaw, which is made to slide accurately but easily upon it.

To effect the travel, the moveable jaw is furnished at the back with a screw gearing on to the worm rack, and rotating on a pin passing through the body of the jaw. This screw is turned by the finger and thumb, for which purpose the tops of the threads are milled.

The weight of a shifting spanner is 2 lbs. 3 oz.

Other Spanners.

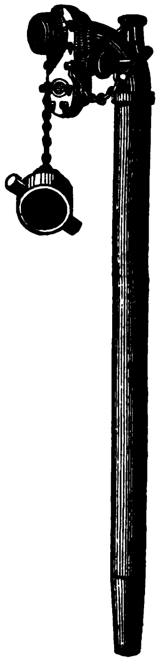
Most of the other spanners are of steel. They are chiefly carried in the steam-engines, and are of various sizes, differing according to the nuts and bolts of the engine to which they are attached.

They also differ considerably in shape, some being S shaped and some straight; some having a jaw at each end, and others only a jaw at one end, the arrangement in each case being determined by the positions of the nuts and bolts of the engine.

Their weight is variable, but seldom exceeds 1 lb. for each.

A Stand-pipe.

A stand-pipe, or portable hydrant, is composed of three principal parts, namely, a head, a shaft, and a shoe.



The head is cast in gun metal, and forms a short bend or round elbow, with a clear water-way of 2½ inches throughout. The lower end is finished off with a collar 1⅝ inches in depth, which receives the iron shaft. The upper or delivery end has a chamber cast on it 6 inches deep and 3 inches wide, and is faced with a flange ½ inch wide, pierced with 16 holes, to take a corresponding number of ¼-inch steel screws. In this chamber there is a slight seating, for the purpose of receiving and steadying a nearly circular flat valve. This valve is cast with a rack at one side, consisting of 11 teeth, ¾ inch wide, 3-16ths of an inch deep, and 5-8ths of an inch apart from centre to centre. The other side has a raised face of 3-8ths of an inch all round.

This valve faces on to the inner side of a flat cover, which fits over the chamber, and has at the upper part of it, corresponding with the water-way of the elbow, a projecting-pipe, with a male screw cut on it to take the hose. The male screw is protected by a cap when not in use.

Between the flanges of the cover and the chamber a leather washer, pierced with the necessary holes, is placed, and the screws are passed through the flanges and hove up, so as to make a water-tight joint.

Across the centre of the chamber, but below the water-way, a slight recess or space is left, to allow a gun-metal spindle or pinion to be worked. To support and steady this pinion the chamber has, at one side, a hole 3-8ths of an inch in diameter and 3-8ths of an inch in depth, which receives the end of it, and at the other side a stuffing-box cast on to it, through which the spindle is passed, and the screw of the stuffing-box then hove tight to prevent it leaking.

The spindle has a ½-inch square formed on the end, outside the stuffing-box, to take a strong gun-metal key, which raises or lowers the valve, thus opening or shutting off the water when necessary, and acting as a command-cock to the hydrant.

Above the bend or elbow there is cast on a solid piece of gun metal, with a flat hammer-shaped top, strengthened by small angle-pieces or wings, also cast on to it. This is made to receive the blow of a hammer, axe, or other implement used for driving the shoe or stem of the stand-pipe into the plug-hole or outlet of the main.

The shaft is formed of a drawn wrought-iron tube of 1-8th of an inch thick, 2⅝ inches in diameter, and 3 feet 3 inches in length, fitted to the head at one end, and to the shoe at the other, and galvanized to prevent rust.

The shoe is a gun-metal tapered piece of tubing, 6½ inches long, 2⅝ inches in diameter at the end which is fitted to the shaft, and 1½ inches in diameter at its lower end. The end of the shoe is shaped in this way because the size of the outlets in the mains vary. It is therefore tapered so as to fit loosely the smallest of the outlets. When in use it is jammed down until firmly fixed, and is secured at the street level by means of wooden wedges, which are driven in between the shaft and the plug-hole.

A stand-pipe, as here described, is a most imperfect implement; but it is the only one which can at present be made effectively available in London.

One of these stand-pipes is carried on each engine, and it is used either when the officer in charge considers that there is likely to be a sufficient pressure of water in the main for his requirements, or in certain cases for cooling ruins after the engines have extinguished the principal part of a fire.

The weight of a stand-pipe, with the key and cap, is 28 lbs. 4 oz.

Stoking, Irons.

Stoking irons are composed of the following articles, namely, 1 shovel, 1 rake, 1 pricker.

A shovel is made of wrought iron, the handle being round, 5-8ths of an inch in diameter and 2 feet 12 inches long, with a semi-circular form at one end for the hand, and at the other a pan formed of sheet iron, 1-8th of an inch thick, 14 inches long, and 7¾ inches wide, giving an extreme length of 3 feet 10 inches.

The pan is welded on the handle.

The weight of a shovel is 6 lbs. 3 oz.

A rake is made of wrought iron, the handle being round and ½ an inch in diameter, with, at one end, a semi-circular form for the hand, and at the other a piece of sheet iron, 4½ inches long and 2½ inches wide, welded on, giving a total length of 3 feet 10 inches.

Its weight is 3 lbs. 6 oz.

A pricker is made of wrought iron, the handle being ½ inch round iron, with, at one end, a semi-circular form for the hand, and at the other a chisel end, welded on at right angles, giving a total length of 3 feet 10 inches.

Its weight is 3 lbs. 4 oz.

The total weight of the stoking irons carried on a steamer is as follows, namely:—shovel 6 lbs. 3 oz., rake 3 lbs. 6 oz., pricker 3 lbs. 4 oz.; total, 12 lbs. 13 oz.

Bucket and Suction-pipe Straps.

These straps are made from English butt, dressed in the same manner as that used for hose.

They are respectively 44 inches long, 1¼ inches wide, and have a wrought-iron buckle, with a tinned roller, secured to them by means of a copper rivet.

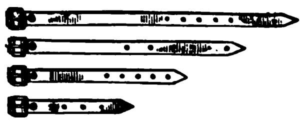
The weight of each of these straps is as follows:—Buckle and rivet 1 oz., leather 5 oz.; total, 6 oz.

Ladder Straps.

These straps differ from the before-mentioned only in the length, which is 17 inches.

The weight of a ladder strap is as follows, viz. :—

		oz.
Buckle and rivet	...	1
Leather ...	...	3
Total ...	...	4



PREVENTER, LEVER, STAND-PIPE, AND STOKING-IRON STRAPS.

These straps are exactly the same as those before mentioned, with the exception of the length, which is 36 inches.

The weight of each of the above straps is about as follows :—Buckle and rivet 1 oz., leather 5 oz. ; total, 6 oz.

SUCTION-PIPE CRUTCH.

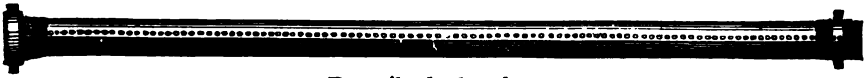
A suction-pipe crutch is made of either wood or wrought iron, and is used to support a suction-pipe either at the back or front of an engine, and also, when the pipe is in use, to prevent the strainer rising from the bottom of the canvass cistern under the water when working from a plug, and thus preventing the engine from drawing air.

The weight of a suction-pipe crutch is from about 6 to 10 lbs.

CURRICLE SUCTION-PIPE.

Described elsewhere.

MANUAL SUCTION-PIPES.



Described elsewhere.

A 20-FOOT LENGTH OF STEAMER'S SUCTION-PIPE.

Described elsewhere.

CURRICLE SUCTION-STRAINER.

A curricle suction-strainer is of the same material and workmanship as all other strainers, and only differs in the dimensions.

The female screw attached to this is 2 inches in diameter.

The weight of a curricle suction-strainer is 2 lbs. 9 oz.

MANUAL SUCTION-STRAINER.

A strainer of this kind is an oblong box, covered in at the top and bottom, and pierced with holes at both sides and one end.

From the other end there is a piece of pipe about 4 inches long, with a 2½-inch water-way, and terminating in a female swivel-screw of the usual pattern, with round thread. This pipe inclines upwards, at an angle of about 20°, so that when the bottom of the strainer is laid flat, the end of a straight pipe leading from it may be at an elevation.

It is of sheet copper, in two parts ; the bottom, sides, and outer end, are made in one piece folded over and brazed in the seams. The top is brazed on to the sides and ends. The sides and outer end are punched with 256 ¼-inch holes, with an aggregate area of about 12½ square inches, or more than twice the water-way of the 2½-inch pipe which is supplied through them.

As the holes in a strainer cause considerable friction, it is always desirable to have their aggregate area considerably in excess of that of the pipes through which the water has to pass, and it will generally be found best to give them three times the water-way, allowing one-third for friction, one-third for dirt, and the remaining third for filling the pipe. In our work, however, there are such frequent opportunities of examining and clearing the strainers, and the advantage of having all the appliances as light and portable as possible is so great, that the smaller proportions here given are for convenience adopted; and in almost all ordinary cases they prove fairly sufficient for the purpose.

It was formerly the custom to use round strainers perforated all over, and this form had the undoubted advantage of combining the greatest possible aggregate of area with the smallest weight and bulk of metal; but in practice great difficulty was experienced in keeping them covered on top when drawing water from street gutters and other shallow places, and they were continually getting choked with mud, gravel, and other dirt drawn in from underneath; in short, whenever they were placed in water of even 5 or 6 inches in depth, which was fully twice their diameter, it was found that they passed mud and air into the pumps with the water, and on this account they have long since been given up, and flat strainers only are now used, which have no tendency either to draw in air by depressing the surface of the water, or to let mud pass through from underneath, and which only receive their supply through the sides, where the water is purest.

The weight of a manual suction-strainer is 4 lbs. 8 oz.

STEAM SUCTION-STRAINER.

Steam suction-strainers are in every respect the same as those for manual engines, with the exception of the dimensions, which are adapted to the size of the suction-pipe used, with a water-way of 3½ inches in diameter in the screws.

The female swivel-screw is fitted with round threads of the usual pattern.

The weight of a steam suction-strainer is 9 lbs. 4 oz.

SUCTION-PIPE WRENCH—3½ inches.

This is of wrought iron, of precisely the same material and workmanship as those described under the head of small hose-wrenches. Its dimensions are, however, somewhat different, as it is used for heaving up the joints of the suction-pipes of the steam-engines.

The weight of a steam suction-pipe wrench is 3 lbs. 13 oz.

SWAY-BARS.

Described elsewhere.

TIN CASE, WITH STRANGERS' WORKING LISTS.

A case for strangers' working lists is of tin, $7\frac{3}{4}$ inches long, 4 inches wide, and 5-8ths of an inch between the sides. It has a piece of 3-8th inch tube, soldered on one side, for a lead pencil, and the remaining space holds the working lists.

It is covered with a lid of somewhat over the above dimensions in width, and $1\frac{1}{2}$ inches long.

An eye is soldered on the sides of the case and the lid respectively, through this there is spliced a small piece of line to secure the lid when open.

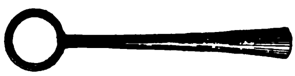
It contains 6 working lists of the prescribed form, and 1 lead pencil.

The weight of a tin case with strangers' working lists is—case 12 oz., lists and pencil 2 oz.; total, 14 oz.

TURNCOCK'S TOOLS.

A set of turncock's tools consists of three implements, called respectively a key, a bar, and a spoon.

The key is a round tapered piece of iron, $1\frac{1}{4}$ inches in diameter at the top, and terminating in a key-shaped handle, and at the bottom end gradually thickened to a diameter of 2 inches, and hollowed for a space of 4 inches into a socket 1 inch square, to fit over the spindle in the mains. There is a slot $1\frac{1}{2}$ by $\frac{1}{4}$ inch cut in the side of the socket to let dirt or water escape. By passing the end of the bar through the handle of the key the cock can be turned either on or off, as may be required.



The bar is a piece of round wrought iron, 3 feet 2 inches long, 1 inch in diameter, with a plain round head at one end, and a chisel-shaped point at the other. It is chiefly used for obtaining leverage, by passing it through the head or opening of the key.

The spoon is a piece of wrought iron, 3 feet 3 inches long, and $\frac{1}{2}$ inch in diameter, its top end is spiked, and at a distance of 4 inches from the end it has a lug or spur 1 inch long, $\frac{1}{4}$ inch thick, and $\frac{3}{8}$ inch wide, which stands out at a right angle from the bar.

The lower end, for a distance of 7 inches, is made into a half-round scoop, at the bottom of which there is a circular piece of iron, $1\frac{1}{8}$ inch in diameter, at a right angle from the scoop.

Its uses are various; the spiked end is for driving into the plug, and placing it into the outlet, and for loosening any rubbish which may have accumulated in the plug-hole; and the scoop part is for lifting out any dirt that may collect round the head of the plug.

The spur is for the purpose of getting leverage when the spike is in.

The weight of a set of turncock's tools is as follows:—key 10 lbs., bar 8 lbs. 2 oz., spoon 2 lbs. 5 oz.; total, 20 lbs. 7 oz.

SPARE VALVES.

Spare valves are carried in each steamer, and those used for some of the steamers are of vulcanized india-rubber, and are round. They are 3 inches in diameter, and $\frac{1}{2}$-an-inch thick, and have a hole in the centre 5-8ths of an inch in diameter.

They are dished or hollowed out on the under side about 1-8th of an inch.

This description of valve does for either suction or delivery.

Those carried in others of the steamers are of the same material, but oblong and of a different size, those for the suction being 8¾ inches long and 2¾ inches broad, and 3-8ths of an inch thick; and those for the delivery, 5¼ inches long, 2¾ inches broad, and 3-8ths of an inch thick, each being dished or hollowed out on the under side about ¼ of an inch.

In packing these for stowage, great care should be taken in not using any twine or string, but merely pack them in paper, the twine or string being liable to cut the edge of the valve, and so destroy it.

Their weight varies very considerably, some being only 2 oz., some 7, and some 8¾ oz.

Bundle of Wedges.

A wedge, such as we use, is a piece of wood, commonly fir, 8 inches  long, 1½ by 1¼ inches at one end, and brought down to a flat taper at the other. It is merely cut with a saw, and then cleaned and bevelled for about half an inch below with a chisel.

Wedges are used for securing a stand-pipe at the street level, and are driven between the plug-box and the stand-pipe for that purpose.

The weight of one wedge is 2 oz.

Each engine carries a bundle containing 6 wedges, which weigh together 12 oz.

Wheel-Cloths.

A wheel-cloth is made of a piece of No. 1 canvass, 7 feet long and 2 feet wide.

It is doubled together and sewn with strong twine at one end and the bottom respectively, thereby reducing the length to 3 feet 6 inches, and it is then sewn together 3 inches from the top and 1 inch from the bottom, at intervals of 6 inches, thus forming at the middle a series of compartments, but the entire space is left open at top and bottom, and consequently there is a communication of the water throughout.

Three lanyards are spliced into holes on the top, one being at each corner, and one in the middle.

When in use, it is fastened by means of these lanyards to the hand irons or other fixed parts, with the bottom resting on the ground, and then filled with water.

They are used to prevent a steamer's hind wheels being burned by the heat from the fire-box, when the engine is at work, and for this purpose two are carried in each steamer.

The weight of a wheel-cloth is 3 lbs., or 6 lbs. the pair.

Damper.

A damper is made of wood or iron, according to circumstances, and fits the top of a steamer's funnel.

It is used for checking the draft, and thus regulating the fire when the engine is not working. It has a hole of 1 inch in diameter, to let air or smoke pass through, thus allowing sufficient upward draft to prevent the flame bursting out underneath the fire-box, and burning the cocks and other fittings.

The weight of a damper is generally about 3 lbs.

ENGINE DRILL.

INDEX TO DETAILS OF DRILL INSTRUCTIONS.

37.—To shift a damaged length of hose.
38.—To make up a damaged length of hose.
39.—To take off a length of hose when there is only one on.
40.—To take off a length of hose when there are two or more on.
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45.—To take off all the hose.
46.—To make up a length of hose.
47.—To lay out hose back and forward.
48.—To range down a quantity of hose.
49.—To flake down hose in loops.
50.—To pile hose.
51.—To lay out hose round a corner, up a staircase, into a room, or over a roof.
52.—To shoulder hose.
53.—To get hose in a window, or over a wall, parapet, or other eminence.
54.—To lower down hose.
55.—To turn over and secure the levers, and place the preventer on the ground.
56.—To lock the levers.
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58.—To fold and strap the levers, and replace the preventer.
59.—To make out strangers' list.
60.—To blow out an engine.
61.—To unlock the fore carriage and hook on the sway-bars.
62.—Places of men on an engine.

DETAILS OF DRILL INSTRUCTIONS.

THE following operations are essential to the transaction of the practical business of a Fireman, and each must be separately mastered before a young hand is allowed to serve at a fire.

The paragraphs are numbered chiefly for convenience of reference, and not because it is always or frequently necessary to do the work in the order here laid down, or in any other particular order.

For the purposes of this instruction the men are designated as follows:—Nos. 1, 2, 3, 4, 5 and 6.

STOWAGE OF A 6-INCH MANUAL ENGINE.

1. *To stow the gear.*—When all the gear has been got together close to the engine, mount and stow the several articles in their proper places, putting in the dam last, then close the lid, and jump down, coming to the ground lightly.

The following will generally be found a convenient order for the stowage of a manual:—

A. Place the ladders on the hooks, and fasten them down to the staples, with the straps and buckles.

B. Fix the side-lamps on the sockets or lamp-irons.

C. Place the four suction-pipes in the side-pockets, two long ones at the near side, and one long and one short at the off side, with the strainer screwed on the short one.

D. Place the blade or head of the large axe in the leather case fitted on the inside of the hose-box.

E. Place the spade and saw in the leather cases fixed on the inside of the hose-box lid.

F. Place the turncock's tools in the two leather beckets, fitted for them on the off side.

G. Place the mattock and handle and the crowbar in the two leather beckets, fitted for them on the near side.

H. In the fore part of the hose-box, under the driving seat, stow four lengths of hose rolled up, placing the coils fore and aft, vertically, or on end, with the female screws uppermost, and facing towards the hind part.

I. Place the remaining lengths of hose in the same way next to the first four.

J. Next place the stand-pipe in with the shoe part forward, and, if possible, stuck in between the four coils, with the head aft, and laid flat, to avoid injury in travelling.

K. Place the two branches with a $\frac{3}{4}$ and a $\frac{5}{8}$ths-inch nozzle respectively connected, in the rack or leather straps fitted inside the hind end of the hose box, over the covering boards of the cylinders, the one with the $\frac{3}{4}$-inch or ordinary working nozzle on top, and the one with the $\frac{5}{8}$ths-inch nozzle underneath, and turned in the opposite direction.

L. Place the hand-pump made up complete in a canvass bag on the covering board abaft the guide-rods.

M. Place the six buckets strapped together, and the long and short lines between the hose and the covering boards.

N. Place the canvass dam on the top in such a way as not to prevent the lid closing, and the hose-box is complete.

O. Place one of the hose-wrenches in the leather beckets, fixed for the purpose behind the hose-box on the outside.

P. All the remaining articles are carried in the fore-pocket, under the driving seat.

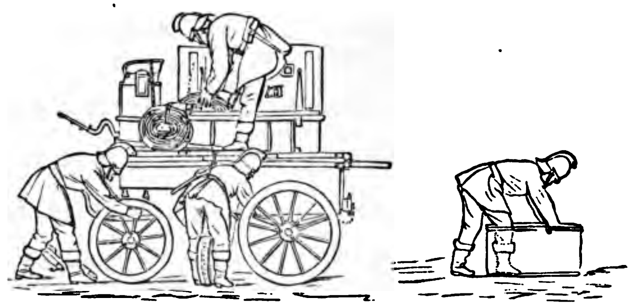
Note.—It is often found an advantage to substitute the following for H and I.

In the fore part of the hose-box, under the driving seat, *at the off side*, stow two lengths of hose, as already described, and behind them, towards the after-end of the engine, stow two other lengths; then in the remaining space range or flake down four lengths coupled together, and with the branch and $\frac{3}{4}$-inch or working-nozzle, and the shifting becket or hand-loop attached, taking special care in the flaking down to avoid round turns, as each round turn would cause a kink when the hose is hauled out.

When hose is stowed in this way, the coiled lengths can be got at without interfering with the others.

Whenever this mode of stowage is adopted, K is modified so far as the second branch is concerned.

2. *To square and lock the fore-carriage, and place the sway-bars on the ground.*—Take hold of the near side fore-wheel by one of the spokes



with the right hand, and square the fore-carriage so that the holes in the transom-plates shall be in a line with each other; then take the locking-pin out of the socket on the front beat block, and drop it into the holes, thus fixing the front wheels and splinter-bar, so that the levers and handles may go clear when set in motion.

3. *To mount the engine and open the hose-box lid.*—Place the left foot on the box of the near side fore-wheel, and spring up, catching hold of the driving-seat rail, or the man-rope, with the left hand, swing the right foot on to the flap of the suction-pocket; then take hold of the hand-rails, and open the lid of the hose-box.

4. *To take out the dam, hose, &c.*—Lift the dam, and push it over the stern until its lower end rests on the spindle, inside and close to the bearing brasses, or, when the bearing brasses are covered, inside and close to the hind cross lever, and lay its upper part against the hind end of the hose-box. Take out the necessary lengths of hose, placing the coils on the near side handle towards the front end, and allowing them on the inside to touch, but not to rest on the iron of the lever; this will steady them in their places, and the upper parts of the coils may be laid against the ladder or the side of the hose-box. If this be properly done, the coils should be quite safe from falling down, and should stand in such a position as to allow the lid of the side pockets to open freely, so that the suction-pipes could be taken out or put in without disturbing the hose. Take out the branch and such spanners and other tools as may be required.

5. *To close the lid and get down.*—Take hold of the upper end of the dam with the right hand, and, holding it clear, shut the lid down with the left hand, after which the dam may be laid, as before, against the hind end of the hose-box. Then place a hand on the side levers, or some other convenient place, and jump down, taking care to place considerable weight on the hand, so as to check the fall, and come to the ground lightly.

6. *To take the dam off and set it up.*—Take hold of the dam with both hands, and place it on the ground as near the plug as convenient, with the bottom side down. Unfasten both straps from the buckles, place one foot inside the dam on the bottom frame to keep it down; grasp with both hands the top frame, and raise it up smartly. Then with one

hand tap the uprights from the inside, just below the knuckle-joints, to ensure that the setting up is complete.

If the dam is very slack, and sets up quickly, it is often found useful to keep both feet outside, and when the top frame has been lifted, to hold it between the legs while adjusting the upright.

7. *To place the dam over the plug.*—Seize the dam by the top frame with both hands, and push it directly over the plug, taking care that the hole in the bottom is placed fairly over the hole in the paving-box.

8. *To make up and replace the dam.*—Empty the dam by tapping the knuckle-joints of the upright stays from the outside, and when it has collapsed, turn it over to drain the remaining water out. Then turn it again on its bottom, adjust the frames and the canvass, folding the latter carefully inwards, and buckle both the straps firmly. Then take it up and stand it with its lower end resting on the spindle, close to the bearing brasses, and its upper end laying against the hind part of the hose-box. If the hose-box lid requires to be opened or shut while the dam is in this position, it is necessary to hold the head of the dam clear with one hand during the operation.

The dam is always carried with the bottom downwards, as in this way the straps and buckles do not interfere with the moving. When all the other articles of gear have been stowed in the hose-box, put the dam on top and shut down the lid.

To put on and take off the Suction-Pipes.

This is done in several ways, according to circumstances; each of the different ways is therefore explained separately.

In order to get out a length of suction-pipe from the pocket, it is always necessary that the handles and levers should be stationary.

9. *To put on one length of suction-pipe.*—Run round to the off-side of the engine, near the front lever, and facing the hose-box. With the left hand open the lid of the side-pocket, and with the right hand grasp the working suction-pipe (which has the strainer attached) near the female screw, and draw it partly out; then with the left hand grasp the pipe towards the other end, draw it completely out of the pocket, and walk with it to the stern of the engine. Place the strainer under the bonnet or canvass cover of the dam, and the female screw close to the suction inlet. Throw the left leg over the suction, and hold the pipe firmly between the legs a little above the knees, at the same time withdrawing both hands. Take the cap off the suction inlet, and screw on the suction-pipe, making sure that the screws are properly entered, and that they are not in the position known as "across thread." Then heave up the joint with a hose wrench, and, before making the last turn, see that the rivets of the suction are uppermost, or on the outside of the bend which the flexible pipe makes over the ridge of the dam.

10. *To put on two lengths of suction-pipe.*—Stand at the hind part of the engine on the near side, within the lever ends, and open the lid of the side-pocket with the right hand, draw out one length of suction-pipe

with the left hand, and let the lid drop down; then, holding the pipe with both hands, go to the stern of the engine, and place the male screw carefully on the ground, and the female screw close to the suction inlet. Throw the left leg over the suction, and hold the pipe firmly between the legs, a little above the knees, at the same time withdrawing both hands. Take the cap off the suction inlet, and screw on the suction-pipe, taking the usual precautions to prevent the screw getting across thread. Heave up the joint with a hose-wrench, and before making the last turn, see that the rivets are underneath, so as to be on the outside of the bend formed by this length resting on the ground. Then go round to the off side, and, taking out the working length as before, bring it to the stern, place the strainer in the dam, and the female screw close to the male screw of the length previously connected to the engine. Throw the left leg over, and grasp the pipe between the legs, at the same time withdrawing the hands. Stoop down, and pick up the male screw of the first length with the left hand, placing the fingers under and the thumb over the shoulder of the screw, then with the right hand on the female swivel screw of the second length make the joint complete, leaving the rivets of this length uppermost.

In heaving up this joint to make it tight, it is desirable to use two hose-wrenches, one on the male screw of the first length, and the other on the female screw of the second length, as the use of one only might have the effect of breaking away the shank of the male screw of the first length from the spiral inside, and so disabling the pipe.

11. *To put on three lengths of suction-pipe.*—Stand at the hind part of the engine on the near side, draw out one length, and, throwing the right leg over, screw it on as before, laying the male screw gently on the ground. From either pocket take out another length without the strainer, and screw it on to the first, and from the off-side pocket take out the working length with the strainer, and screw it on, placing the strainer in the dam as before. When using three lengths, it is generally advisable to place the rivets of the first and second lengths underneath, and those of the third or last on top, and it is most important to use two hose-wrenches for each of the joints, except that between the female screw of the first length and the male screw of the suction inlet.

12. *To put on four lengths of suction-pipe.*—This hardly differs from the mode of putting on three lengths, and therefore does not need to be explained in detail. It is usually desirable to have the rivets of the first three lengths underneath, and those of the last or working length on top.

13. *To add a length of suction-pipe to one already on.*—In all cases, after adding suction-pipes to those previously on, it is necessary to see that the engine is placed in a proper position, by running either ahead or astern, according to circumstances. Take out a length from either pocket, and bring it to the necessary place; remove the strainer from the first length, attach the female screw to the male screw of the first length, and place the strainer on the end of the second length.

14. *To add more than one length of suction-pipe to one already on.*—This is almost exactly the same as adding one length, and need not be explained separately. It may sometimes be convenient to make the joints between the lengths to be added, before stopping the pumping.

15. *To put in a length of suction-pipe between the engine and one already on.*—Get out a length as before, and bring it close to that already on, placing the female screw near the suction inlet, and holding the pipe between the legs. Break the joint of the first length, and lay the pipe gently on the ground; screw on the new length, and heave up the joint with a hose-wrench; then to the end of the new length attach the length previously on, and heave up the joint with two hose-wrenches.

16. *To put in a length of suction-pipe between two other lengths.*—Get the new length and two hose-wrenches ready, and bring them to the most convenient spot, close to the joint to be broken. Open the joint and attach the female screw of the new length to the male screw of the broken joint, and the female screw of the broken joint to the male screw of the new length. Heave up both joints with two hose-wrenches.

17. *To put on two or more lengths of suction-pipe between others already on.*—This operation is almost the same as that last described, the only difference being that it may be desirable to screw together all the new lengths before breaking the joints of those already on.

18. *To take off a length of suction-pipe when there is only one on.*—Get over the suction-pipe, close to the suction inlet, with one leg on each side, and hold the pipe firmly between the legs to prevent it falling when the screws are separated. Take the swivel screw with both hands, or if necessary with a hose-wrench, and turn it round to the left until the joint has been broken. Before leaving, replace the cap and screw it home by hand. Hold the suction-pipe with the right hand in front, and throw the left leg over backwards, so that no turning will be required when the pipe is brought to the engine. Then catch it in a convenient place with the left hand, and replace it in the off-side pocket.

In all cases of taking off the first length of suction-pipe, it will be found convenient for the man who does it to turn over the off-side hind lever, whether he has been specially detailed to do it or not.

19. *To take off a length of suction-pipe when there are two or more on.*—Lift the strainer out of the dam, and remove it from the last length; break the joint of the last length, holding the latter firmly between the legs while doing so; then lay the removed length down, and attach the female screw of the strainer to the male screw of the length then furthest from the engine. Adjust the engine by running it back, or otherwise, so that the strainer shall be covered with water; replace the suction-pipe taken off in the proper pocket, and the hose-wrenches in the places assigned for them, and all is ready for work again.

20. *To take off the first length of suction-pipe when there are two or more on.*—Hold the end of the second length between both legs, and with two hose-wrenches break the joint between the first and second. Lay the male screw of the first on the ground, and bring the female screw of the second up to the engine, or the engine back to the female screw. Open the joint between the first length and the engine, and lay the first length on the ground; then attach the female screw of the second length to the male screw of the suction inlet; heave up the joint with a hose-wrench, put the length taken off and the hose-wrenches in their proper places, and the engine is again ready for work.

21. *To take out an intermediate length of suction-pipe.*—Break first the joint between the second and third lengths, and then that between

the second and first. Bring the female screw of the third length to the male screw of the first, join them together, heave up with hose-wrenches, stow away the removed length and the tools, and the engine is again ready for work.

If the order is given to remove the third, or any other length except the first or last, the work is done as already described, the joint being broken first at the outer end of the length to be removed, and afterwards at the inner end, and the removed length and wrenches put in their proper places before the engine is set to work again.

22. *To take off the suction-pipes altogether.*—This operation is commenced at the furthest length from the engine, unless there is some special reason to the contrary.

Get close over the joint to be broken, facing towards the engine, and, holding the length to be removed firmly between the legs, to prevent it falling when the screws are separated, fix both hose-wrenches, one on each half coupling; hold steady with that on the lug of the male screw, and turn that on the lug of the female screw round to the left to start it; as soon as it is observed to move, the use of the wrenches may be discontinued, as the rest of the work can be better and more rapidly done with the hands only; before the joint has been completely broken, seize the male screw with the left hand, and when it is released lay it gently on the ground.

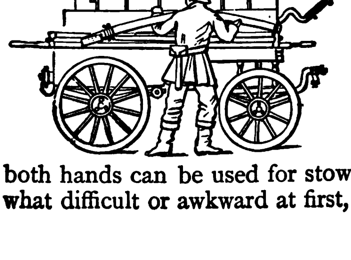
In stowing the suction-pipes for making up, proceed as shown in the previous instructions, putting two lengths in the near-side pocket, and one long length, and the working length with the strainer on, in the off-side pocket.

After removing any length of suction previously to putting it in its place, throw over the proper leg, so as to leave the pipe in the right position when brought to the engine. Thus, for instance, if there be four lengths on, as soon as the last or working length has been detached, and the male screw of the third length laid on the ground, throw the left leg over backwards, so that no turning shall be required when it is brought up to the engine.

If the third length is to be put in the off-side pocket, throw the left leg over in the same way; and when the other lengths are taken off, if they are to go into the near-side pocket, throw the right leg over backwards instead of the left.

When the length next the engine has been removed, replace the cap on the suction-inlet before putting the pipe away.

In taking a length of suction to the engine, hold it firmly in both hands, with the fingers below and the thumbs on top; and when close to it release one hand by tossing the pipe on to the bend of the arm, at the same time preserving the grasp with the other hand. Then with the released hand open the pocket, and after removing the lever straps, insert one end of the pipe; this will keep the lid up, after which,



both hands can be used for stowing the pipe. This will be found somewhat difficult or awkward at first, but it is the only way in which the work can be done quickly without help, and after a little practice will be found comparatively easy.

Suction-pipes should always be stowed away with their female screws forward.

When more than one length has to be taken off, and the engine started again, it is usual to break only the joints between those to be removed and those remaining, and not those between the lengths to be removed. This is done to save time, and in such cases it is customary to start the engine at once, and to break the joints of the removed lengths, and put the pipes and tools away at the first convenient opportunity afterwards; but when the order is given to make up the engine, it is almost always advisable to commence breaking the joints and removing the lengths furthest from the engine first.

It is to be observed, that all these changes may involve the necessity for shifting the rivets of one or more lengths. The simplest guide for this in practice is to remember the principle of always getting the rivets on the outside of a bend. Thus, for instance, if there be only one length on, and the engine working out of a dam on the street level, the rivets will be uppermost, so as to be on the outside of the bend of the pipe over the ridge of the dam; if there be two lengths on, and the engine working as before, the rivets of the first length should be below, the bend being downwards, and those of the second on top; but if the engine be working over the side of a pier, both lengths might have the rivets on top, the bend of the first being then the other way; if there be many lengths on, so that one or more lay flat on the ground, it is usually advisable to have the rivets of the straight lengths downwards, to avoid the wear and tear caused by the chafe on the ground, when the pump is at work, and communicates a vibration to the pipes.

Even when the couplings of suction-pipes are in perfect order, with good washers of fresh soft leather, and clean well-oiled screws, it is by no means an easy matter to make all the joints of a long line quite perfect; and, when it is remembered how essential their perfect working is to the supply of water for the pumps, it is obvious that too much care cannot be taken in screwing them up. A hose-wrench should never, under any circumstances, be used until the screws have been first fairly entered and hove up by hand, at least two turns or so, in order to make sure that they are on the right threads. Any man of experience can *feel* in a moment, by the way in which the swivel turns, whether the screws are rightly entered or not, and it is even possible occasionally for a looker on to see this. If the couplings be found rough in turning, and a hose-wrench be used to heave up the joint, the effect must inevitably be to injure the threads, either by cutting them on each other, or in some cases by stripping one or both altogether, and it is to be especially remembered that with such couplings as we use, which admit of only a thin washer when the screws are not accurately closed on the proper threads, the joints cannot under these circumstances be tight, and, when the pumps are set to work, they are quite certain to draw air. In practice, it is found very nearly impossible to make a tight joint when any portion of a suction-pipe, even at the other end, is bent; and on this account it is customary, when preparing to work over a pier, or out of a well or river, with several lengths, to run the engine ahead, and screw on each pipe in a perfectly straight line with the suction inlet, and, when all are on, then to run the engine back to the necessary place, bending the line of pipes gradually. In all cases of working from such depths as cannot be easily reached by the men, it is necessary, before lowering down the pipes, to fasten a line to the strainer, for the purpose of shifting it about, bringing it up to be examined occasionally, and so forth; the best way of doing this is to put up a clove hitch on the neck of the strainer, turning in the end of the line by a half hitch on the standing part, and taking care that neither the end nor any other part can get near the holes, as this would have the effect of checking the supply of water to the pumps.

23. *To put a suction-pipe in the pocket.*—If the suction is to go into the off-side pocket, take hold of it near the female screw with the right hand, and throw the left leg backwards over the pipe; stoop down, and with the left hand grasp the pipe in a convenient place; go with it to the off-side of the engine, and when close to it release one hand by tossing the pipe on to the bend of the arm, at the same time preserving the grasp with the other hand. Then with the released hand open the pocket, and after removing the lever straps, insert one end of the pipe; this will keep the lid up, after which, both hands can be used for stowing the pipe. After this, let the lid fall, and the sound will indicate whether the pipe lies properly in the pocket.

When hose is lying on the side handles, it is necessary to go to an end and push the suction-pipes in, which is more troublesome.

If the suction-pipe is to go into the near-side pocket, the hands should be changed, the female screw being grasped by the left, and the right leg being thrown backwards over the pipe.

To put on and take off the Branch.

To avoid repetition, the mode of attaching and removing the branches and nozzles is entered here; but it is needless to say, that this cannot be done until the hose has been run out.

24. *To put on the Branch.*—Get the branch from the engine, and see, before going away with it, that the proper nozzle is on; take also the shifting-becket and the branch and nozzle spanner. Go to the male screw of the hose run out, place the left foot on the leather near the lower end of the shank of the male screw, and press firmly on it until the face of the screw rises about 2 inches from the ground. Hold the nozzle end of the branch in the right hand, and with the left, grasping the middle or lower part, screw the branch on to the hose; then, to make the joint tight, harden it up with the branch spanner. To make this joint perfect, it is occasionally, but not always, necessary to use a hose-wrench for the purpose of steadying the male screw when the branch spanner is on. Strap on the shifting-becket over the lapping of the male screw, at the end of the hose. Before the engine commences to work, care should be taken that the proper tally is attached to the branch, so that a man relieving another shall know what delivery he is working from. Return the tools to their proper places.

25. *To take off the branch.*—Lay the end of the hose on the ground, and place the left foot on it, in the same manner as when attaching the branch. With the right hand take hold of the small end of the branch by the boss, *not by the nozzle*, and with the left grasp the branch in the middle, and unscrew. If the joint is too tight to be broken in this way, use the tools, either the branch spanner alone, or the branch spanner and hose-wrench together, according to circumstances. Put away the branch, the shifting-becket, and the tools in their proper places.

26. *To shift nozzles.*—Get the required nozzle and the necessary tools from the engine, and take them to the branch; stop the delivery, hold the hose close to the branch firmly between the legs, remove the nozzle on the branch, and screw on the other, after which the delivery may be again started. The removed nozzle and the tools can then be put away in their proper places.

To put on and take off the Hose.

This is done in several ways, according to circumstances; each of which is, therefore, explained separately.

27. *To put on one length of hose.*—Take a length of hose off the near-side front lever, and place it vertically on the ground opposite to the delivery outlet, to which it is to be attached, with the female screw on the top, and facing outwards from the engine. Hold the hose firmly between the knees, and unbuckle the strap, at the same time taking care not to break the coil. (*See* illustration, page 150). Stoop down, take the cap off the delivery screw, and let it hang by the chain; hold the shank of the female screw of the hose with the left hand, and screw the swivel on to the delivery with the right, making sure that the threads are properly entered; and after about two turns by hand, tighten the joint up, if necessary, with a hose-wrench.

Whenever a hose is not laid out in a straight line, the rivets should, if possible, be placed in such a position as to be on the outside of the bend. Thus, for instance, if the hose be run out at right angles from the engine, the rivets should be underneath; if it be run forward, the rivets should be turned aft; and if it be run backward from the engine, the rivets should be towards the front. If a hose be laid straight along the ground, the rivets should be underneath.

When the bends are not sharp and the working pressure not heavy, the arrangement of the rivets is to a certain extent immaterial, and consequently, when dragging the hose about, it is not always customary to slack the joints and shift the rivets; but in laying out hose it is always desirable, as far as convenient, to attend to this point, and this is done by turning the hose with the hand just before the joint is hove up tight, and taking the last turn of the screw with the rivets in the required position.

Next reverse the position, turning round to the left, and at the same time taking a step back with the left foot; take the lugs of the male screw between the fingers and thumbs of both hands, and raise the coil up until an upright position is attained; walk away from the engine in the necessary direction with the hose at either side, generally the right, allowing it to uncoil freely; and when the whole has been run out, lay the male screw gently on the ground.

Repeat this operation with the hose in different directions, as forward, backward, and at right angles to the engine, sometimes using the near-side and sometimes the off-side delivery, and occasionally shifting the hose and varying the direction after it has been laid out. It has already been explained that, under certain circumstances, it is not absolutely necessary to shift the rivets, but when practising for the purpose of instruction this should never be omitted. At every change the necessary joints should be slacked, the hose turned by hand, until the rivets come in the required direction outside the bends, and the joints hove up tightly again.

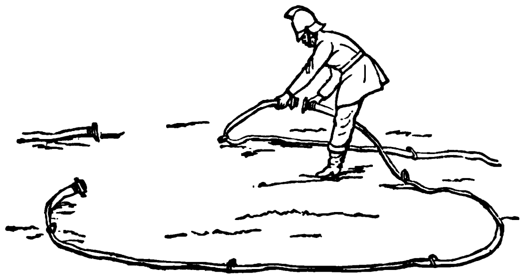
28. *To put on two or more lengths of hose.*—After proceeding as directed in last instruction (No. 27) get a second length, and bring it to the male screw of the first; lay it down vertically, as before, with the female screw turned away from the engine, and, holding the coil firmly between the legs, unbuckle and remove the strap. Pick up the male screw of the first length with the left hand, and taking the female screw of the second length in the right hand, make the joint; then turn round, and run out the hose in the required direction. This is precisely the same for any number of lengths.

29. *To add another length of hose to one already on.*—Go to the engine, and, without stopping the pumping, climb up over either the front or hind end, taking care not to touch any of the moving parts.. It is somewhat awkward climbing in front over the driver's footboard, and this is consequently seldom done; but there is no difficulty in mounting at the other end, by placing a foot on the suction-inlet, springing up and grasping the handrail on the hose-box lid. Get out a length of hose, a branch, a hose-wrench, and the branch-and-nozzle-spanner, and bring them to where the other branch is at work. Lay down the hose vertically, as before, with the female screw turned away from the engine, and, holding the coil firmly between the legs, unbuckle and remove the strap. Lay the female screw on the ground, and turning round, run the hose out in the necessary direction; screw on the branch with the hand-becket and tally, and harden up as before. Then return to to the inner end of the new length, get the engine knocked off, and, as soon as the water has ceased to run, unscrew the branch, and attach the female screw of the new length to the male screw from which the branch has been removed, holding the male screw with the left hand and the female screw of the new length with the right hand. As soon as about two turns by hand have been made, the engine may be started again, and the joint afterwards, if necessary, hove up with one or two hose-wrenches. Bring back the removed branch and the tools to the engine, and stow them away in their proper places, climbing up as before in such a way as not to interfere with the pumping.

When the water is not running, it is usual to make the joint before laying out the new length. This is done in the following way. Bring out the new length and lay it down as before; remove the branch, if there be one on; hold the hose between the legs, and unstrap it; take the female screw in the right hand, pick up the male screw of the other length with the left, and make the joint. Then run out the hose as already shown, and, if necessary, put the branch on the end. When there are two branches, it often saves time to bring out the second, and to remove the first, instead of shifting it.

30. *To add other lengths of hose.*—This is done precisely as described in the last paragraph, except that, in the case of adding on several lengths at the same time, they should all be coupled together before the engine is stopped, in order that the pumping may be discontinued as short a time as possible.

31. *To add a length of hose in a special place, not at the end.*—If the order be given to put in a length between the first and second, get the hose and necessary tools out of the engine without stopping the pumping, and bring them to within about six feet of the joint which is to be broken. Lay the hose vertically on the ground, with the female screw on top, and facing back in the direction of the engine; hold the coil between the legs, and unstrap it, laying the female screw gently on the ground at a distance of not less than four feet from the joint. Turn round, and either lifting the hose by the lugs of the male screw, or rolling it on the ground, walk round in a circle commencing by going towards the engine,



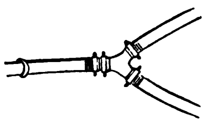
gradually turning forward, and ending by coming towards the engine again, being careful to go far enough round to bring the male screw not nearer than four feet to the joint. Get the delivery stopped, and, when the water has ceased to run, break the joint between the first and second lengths; bring the male screw of the first out to the female screw of the new length, and the female screw of the second length out to the male screw of the new length, and make the joints as already explained. Lay the couplings on the ground, and the engine may be started again. In this operation it is most important to keep the screws of the new length at a distance from the line of the other hose; where this is neglected there are certain to be sharp bends or angles, involving loss of time in drawing them out and clearing them, or the still worse risk of bursting the hose. On this account, notwithstanding the repetition, it is again enjoined, that the screws of the old line should always be brought out to meet those of the new length, and that those of the new length should on no account be brought in to meet those of the old line.

32. *To put a length of hose on next the Engine.*—If the order be given to put a length on next the engine, get the hose and tools out, as already explained; commence laying out the new length close to the engine, and going round in a circle, precisely as in the last instruction, finishing with the male screw within about four feet of the delivery. Then stop the pumping, unscrew the hose from the delivery, and screw on the new

length; bring the female screw of the old line out to meet the male screw of the new length; make the joint, and the engine may be again started.

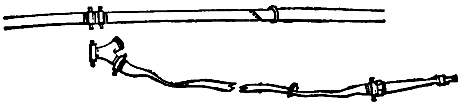
33. *To put on two or more lengths of hose in a special place.*—If the order be given to put on two lengths between the first and second, get the necessary hose out, take one and go round, as already explained, but making a large half-circle; then add on the other, and, after closing the joint, make the other half-circle, and conclude within about 4 feet of the joint.

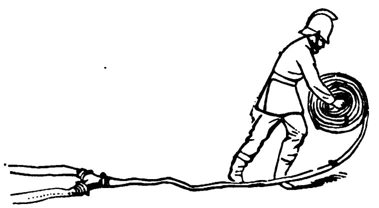
If the order be given to put on any other number of lengths, precisely the same mode is adopted, except that the size of the circle varies according to the number of lengths added.



34. *To separate one line of hose into two.*—At the point where the line is to be divided, screw on a 1 into 2 breeching, and from each arm run out hose, as already described, and, if necessary, put on a branch at the end of each.

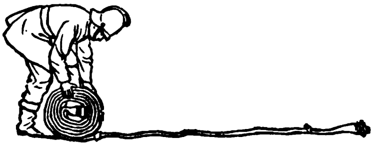
35. *To add another line of hose by means of a breeching.*—Get out the 1 into 2 breeching, and the necessary hose, branch, and tools, and, without stopping the delivery, place the breeching close by the coupling at which the stream is to be divided; attach the hose, run it out, and put on the branch. When all is ready, stop the delivery, break the joint, attach the male screw of the broken joint to the female screw of the breeching, and the female screw of the broken joint to the male screw of the breeching, and start the delivery again.





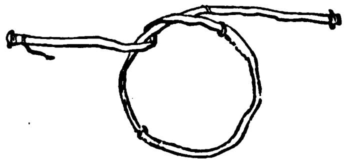
36. *To join two lines of hose together.*—At the point where the lines are to be joined, screw on a 2 into 1 breeching, and from the outer arm run out hose as required. Any number of lines can of course be joined together in the same way.

37. *To shift a damaged length of hose.*—When a length of hose is burst, or otherwise injured, bring another length, with the necessary tools, and run it out in the line of and alongside the damaged length. Then stop the engine, disconnect the damaged length at both ends, make the new joints, and the engine may be started again.



38. *To make up a damaged length of hose.*—Lay the hose on the ground with the rivets downwards, and, commencing at the female screw, roll it up and strap it in precisely the same way as described in instruction 46; this will leave the male screw on the outside, which will instantly attract observation, and will consequently prevent it being brought out again for use.

When there is not time to roll it up properly, a large overhand knot should be put up in the middle to prevent it being used, and, when time admits, the length can be made up as here described, with the male screw on the outside.



In the event of a length of hose bursting, it is desirable before shifting it to haul the pipe out in a direct line.

39. *To take off a length of hose when there is only one on.*—Get ready the necessary tools, and take them to the branch. Then stop the delivery, take off the branch, and run in with it to the engine. Unscrew the hose from the exit-pipe, lay it clear on the ground for making up, and screw on the cap. Make up the hose and place it in the engine. Also replace the tools.

40. *To take off a length of hose when there are two or more on.*

N.B.—When the order is given simply to take off a length of hose, it refers to the last length only.

Get ready the necessary tools and take them to the branch. Then stop the delivery; unscrew the branch, run in with it to the other end of the last length of hose, break the joint connecting this with the second last; screw on the branch to the male screw of the latter, and start the delivery again. After this make up the removed length, and put it in the engine. Also replace the tools. When a second branch can be conveniently obtained, it will save time to use it instead of the one on the end.

41. *To take off two or more lengths of hose.*—Get ready the tools, and take them to the branch, as before. Stop the delivery, unscrew the branch, and run in with it to the female screw of the inner length to be removed; break the joint, attach the branch to the male screw of the last length remaining on, and start the delivery again. After this, separate the removed lengths, and roll them up; put them in the engine, and replace the tools.

42.—*To take off a length of hose in a special place, not at the end.*

N.B.—The order should be, as "Take off the second length of hose," "Take off the third length of hose."

Get the necessary tools, and go to the joint at the outer end of the length to be removed. Stop the delivery, break the joint, and haul in the female screw of the next length until it reaches the joint at the inner end of the length to be removed. Break this joint, attach the female screw of the length hauled in to the male screw of the remaining length, and start the delivery again. Then make up the removed length, and put it in the engine. Also replace the tools.

43.—*To take off a length of hose next the engine.*

N.B.—The order in this case should be "Take off the first length of hose," or "Take off the length of hose next the engine."

Get the tools ready, go with them to the joint between the first and second lengths, and stop the pumping. Break this joint, and haul the female screw of the second length in towards the engine. When close to the delivery-pipe outlet, throw a leg over the hose hauled in, and clasp it between the knees; then unscrew the first length from the engine, lay the female screw gently on the ground, in such a way as to be clear for making up; then, if there are other lengths on, screw the coupling of the second length on the delivery, and start the engine again. Make up the removed length, and put it and the tools in their proper places.

44. *To take off two or more lengths of hose in a special place, not at the end.*

N.B.—The order would be, as "Take off the second and third lengths of hose," or "Take off the fourth, fifth, and sixth lengths of hose."

This is done in almost precisely the same manner as already described in No. 42, the only material difference being that, before making up the removed lengths, the joint or joints between them must first be broken.

45. *To take off all the hose.*—Stop the delivery, and get ready the necessary tools. When making up all, the following operations must be performed, in such order as may be most convenient at the moment. Unscrew the branch and put it in its place, and break all the joints, generally commencing with the one next the engine. After unscrewing the length next the engine, hold it a moment between the legs, and replace the cap on the delivery-outlet; then lay the hose down clear for making up. Then roll up each length separately, and place it on the handles, and, when all are made up, mount the engine and stow the whole of the gear, as previously directed; then jump down.

46. *To make up a length of hose.*—Lay the hose out in as nearly as convenient a straight line, with the rivets downwards. Take hold of the male screw with both hands, and bend it over as sharply and tightly as possible on the leather part of the pipe, with the lugs projecting outwards. Continue to roll up in the same way, taking care to have all the rivets in the centre of the outside, so that, when the hose is afterwards unrolled for use, it will come off free of kinks or twists; at each turn press heavily on the leather, to force the water out, and when near the end, on no account pick up the female screw in the hand, as this would have the effect of leaving water in, but continue to roll the coil over and over until it passes on top of the female screw, and thus drains the last drop of water out. Adjust the collar of the leather strap by slipping it up to within six or eight inches of the female screw, turning it so as to bring the rivet and strap on the outside. Care must be taken to avoid bringing the collar too near the end, as in this case the heaving up of the strap might damage the shank of the screw, and also to avoid leaving it too far from the end, in which case the screw would hang loose, and strike a man on the back when throwing the coil quickly on his shoulder. Get the strap rove through the centre of the coil, and bring the end through the buckle, but leave it perfectly slack, and, while it is in this way, lay the coil on the ground and stamp on it with the feet until it becomes quite flat. Then, with one foot, or both, on the coil to steady it, take the female screw in the hand, and pull it once or twice sharply in to harden the coil; after which tighten the strap, first hauling in the slack underneath by a pull, which will also adjust the collar, and afterwards hauling it through the buckle, and securing it in the usual way by means of the tongue.

In rolling up a coil, tuck in the beckets, so that they may not protrude; and whenever a fold of the hose projects, which is frequently the case, lay the coil down, and stamp on it for a moment to flatten it, after which the rolling up may be continued as before.

When a hose with much water in it has to be made up, it is often convenient first to under-run it to get some of the water out; this is done in the following way:—Raise one end well above the level of the other, and walk towards the other end, passing the hose over the hands, and letting it come to the ground after; this will pass almost all the water out, and then the rolling up can be done, as already shown, and the remaining quantity got rid of in that way. As a general rule, it is a great mistake for one man to under-run a hose while another is making it up, as the effect is that any remaining water is driven back towards the coiled part, and cannot be forced forward, but remains, and is in fact rolled up in the coil.

In very confined places, it is not unusual to roll up a length without moving forward, the man drawing the hose towards him as he rolls. This makes a very tight coil, but it has the disadvantage of causing unnecessary wear to the leather and rivets, and in certain cases it is difficult to get rid of the water in this way, as any kink may prevent it going forward.

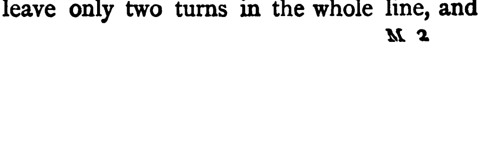
When the hose is coiled, as a general rule it should not be left lying about, but should be stowed at once in the hose-box. This can be done, when the pumps are at work, by passing over the stern, and, when the pumps are at rest, by first placing the coils on the near-side handles, with the top inside resting against the ladder or the hose-box, and the bottom clear of the suction-pocket, which should be able to open and shut freely with the hose in this position.

To Lay out Back and Forward, to Range Down, to Flake Down in Loops, or to Pile a Quantity of Hose for Hauling Forward or Hoisting Up.

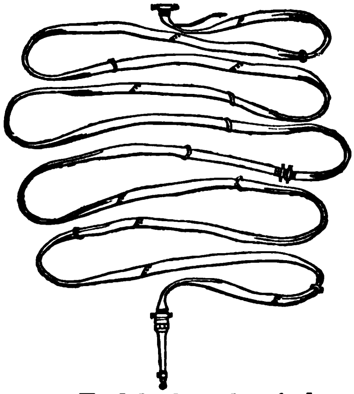
47. *To lay out hose back and forward.*—This can be done in either of two ways, at the discretion of the officer in charge, who will be guided in his judgment by the nature of the locality and the number of men at his disposal.

When the ground admits of it, the hose may be led first away from where the branch is to be, and then back again, thus causing only one bend, and consequently very slight obstruction, but when laid out in this way it needs considerable help for hauling it forward, and it requires to be attended to by a man at the bend during the operation of hauling, as otherwise there would be a sharp kink at this point.

When there is plenty of help at hand, a good way is to run the hose from the engine, or hydrant, close to the door or entrance of the building, then make a wide turn, and go back with it in the opposite direction to such a distance that, after turning round and coming

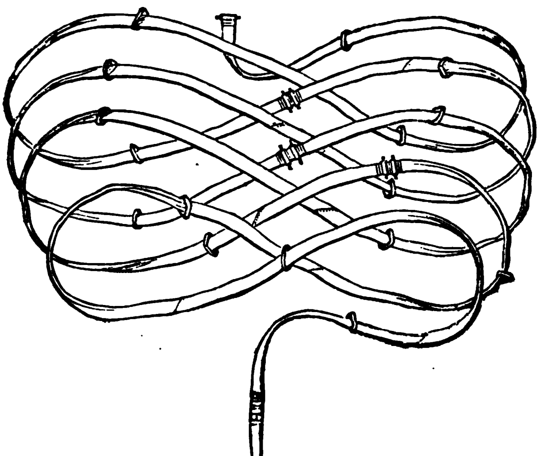


to the entrance again, there will be a sufficient length for the required purpose. This mode will leave only two turns in the whole line, and consequently the water-way will be very slightly obstructed; but the two turns must be closely watched when the hose is being hauled on, and, besides, the great length and distance to which the pipe extends in this way cause considerable difficulty in pulling on when full of water. When there is plenty of help at hand, either of these is a good way to lay out the hose.



48. *To range down a quantity of hose.*—This is done in the same way as a cable chain is ranged down for letting go. Take up the hose by the lugs in the usual way, and make all the bends in one direction—that is to say, all out from the engine, and none backward, and consequently no round turns. Make the bends as wide as possible, and take care that no part overlaps any other part. In this way a large quantity of hose may be laid down in a very small space, but it is not very good for passing water through before it is hauled out.

49. *To flake down hose in loops.*—Another and better way is to flake it down in loops like a figure of 8, with the loops in circles of not less than



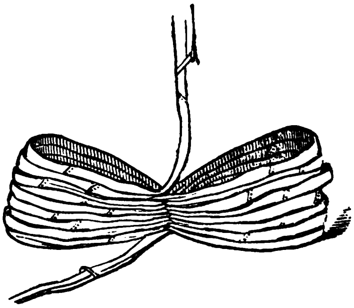
6 or 8 feet in diameter, each turn being in advance of the previous one, crossing its own part between the loops, but so arranged as not to catch or trip the parts underneath. This is done by making each loop a little smaller than the previous one, crossing to the front close by the outside, but not going outside in any part. In order to arrange it so as that all the turns, when hauled on, shall go clear without being attended to, screw on a length of hose to the off-side delivery, and instead of running

it out direct from the engine, take the coil up in the hands and walk with it about 6 feet from the engine; turn half round to the left, at the same time, if necessary, putting one foot on the hose to assist the uncoiling, then take two steps forward, and turn gently round to the right, uncoiling at the same time. Walk back to the engine, and then bear round to the left, forming with the hose a series of flakes, resembling a figure of 8, one over the other, and so arranging that the hose shall neither kink or foul when suddenly required.

If the bends or turns of the pipe are made in circles, with a diameter of about 6 or 8 feet, the water will pass freely through the pipe, and, when it is running, the men can haul away as much hose as they want without leaving any one to attend to the clearing of the turns, as every pull tends to straighten the bends, and not, as in some of the other arrangements, to cause kinks unless cleared by hand.

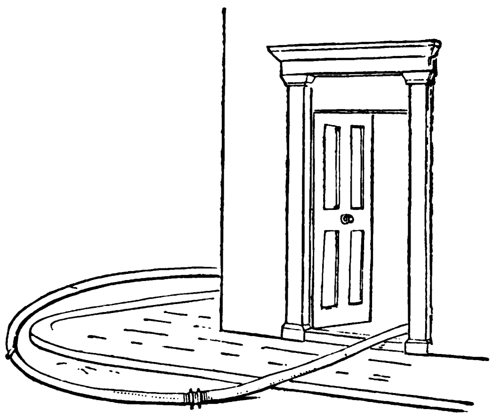
This mode has the disadvantage of making several bends in the pipe, and consequently obstructing or reducing the water-way; it is, however, that usually adopted as most suitable for our narrow streets, and most generally available when we are short-handed; and the disadvantage of the bends is but momentary.

This arrangement is also available for laying out hose for going up ladders or on heights.



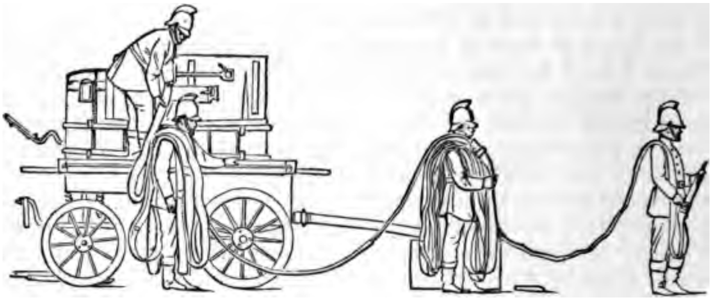
50. *To pile hose.*—On the same principle hose may be put up in a pile, each part being directly over the previous one, and all the bends in one direction without any round turns. Water may be passed through it, and it can be hoisted up without being attended to, whether the water is running or not.

51. *To lay out hose round a corner, up a staircase, into a room, or over a roof.*—In taking hose round corners, over walls, or into any places where it has to bend much, it is most important to make the bends as wide as possible; for this reason, when hose has to pass up a staircase, it is always well to avoid placing it too close to the bannisters, and to keep it towards that part of the stairs where it will have the widest possible bend. Even in going through a gateway on the ground level, the hose should not be placed tight against the corner, and the same rule applies



to hose carried up a staircase, into a room, or over a roof. When it is likely to become tight near a bend, it is always necessary to relieve it by attaching a line to a convenient becket in a straight part, so as to leave no pressure at the bend.

52. *To shoulder hose.*—Several lengths of hose are first coupled together, and one man takes the branch, and putting some of the hose over his



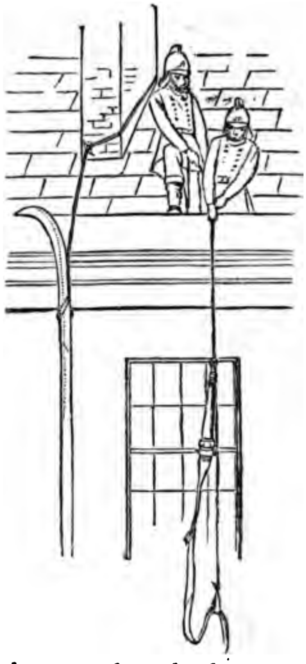
shoulder, moves out about 10 or 12 feet. Another man, standing nearer to the engine, takes the hose at that part over his shoulder, and as much as he can carry—generally about a length or a length and a half is flaked on him—hanging down in bights before and behind within about a foot of the ground; another man does the same, and so on until the necessary quantity has been shouldered. The whole then move forward, the man nearest the engine throwing off the bights as he proceeds, and when he is done, singing out to the next man in front, who then commences to throw off, and when done, sings out to the man in front, who does the same, until the whole has been run off.

In practice it is found most convenient to let the leading man carry only the branch and 8 or 10 feet of hose.

This is, on certain occasions—as, for instance, in large warehouses with narrow complicated staircases—a much quicker way of laying out a large quantity of hose, than running it out in separate lengths, which afterwards have to be screwed together; or than hauling it out and up, in which case it becomes obstructed at all corners and turns. It, however, requires some judgment to calculate the quantity required, as it may be sometimes inconvenient for the man with the branch to reach the required place before the whole of the hose has been thrown off. Even in this case, however, the difficulty can be got over, as it is generally easy to light hose back or downwards.

53. *To get hose in a window, or over a wall, parapet, or other eminence.*—The necessary number of men mount the height, either by ladders or otherwise, taking with them a line, which they will lower down to their assistants below, at the same time giving directions as to the becket to which they wish it to be attached.

The assistants below will have a sufficient quantity of hose flaked down, piled or ranged along, with the branch on, and will make fast the end of the line to the proper becket with one round turn and two half hitches. They will then take a clove hitch over the nozzle, with one turn below the boss and the other close to the end, so as to prevent the nozzle catching in obstructions or being injured as it goes up. The length of line



between the becket and the nozzle is a matter entirely for their own judgment and discretion at the moment, but it should never be less than 5 or 6 feet, or more than the length of the hose itself between the becket and the nozzle, as in the first instance it would not allow the men above to get their hands on the line between the branch and the becket so as to take the weight of the hose while casting off the hitch on the nozzle, and in the second instance, would put the whole weight of the hose on the nozzle instead of the becket. In most cases, the best way of adjusting the line is to leave the part between the becket and the nozzle about a foot or so shorter than the actual distance between them, so that the hose will go up without a hanging loop, which would be liable to catch in window sills, or other obstructions, and moreover to throw an undue weight on the men above, as it would require them to lift a greater quantity before getting hold of the branch.

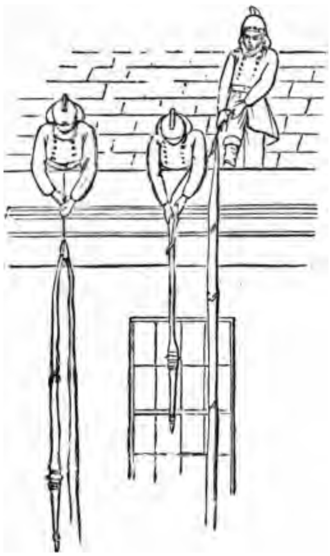
The man below lights in the hose, and the men above haul away on the line, until the branch is close to the top of the wall or other eminence over which the hose is to be passed. They then put their hands over, and seize the line below the branch, taking the whole weight of the hose, after which the branch can be released and taken in. They then haul on the line until the becket is within about a foot or two of the top, and, if they have sufficient hose, they make the line fast to a chimney, or anything else they can find strong enough to bear the weight of the hose when the water is in it.

If they have not enough hose in, they must haul up more, but they must on no account leave the line on the same becket, as this would have the effect of throwing the whole combined weight of the hose and water on that part of the pipe passing over the wall, thus stopping or seriously diminishing the water-way, and consequently causing the hose to burst.

The proper way of adjusting the hose is to take the whole weight on a becket in a straight part of the pipe, at such a distance from the parapet, or other eminence over which it has to pass, as to leave a free swing for a few inches in both directions, and to cause no strain or pressure whatever on the bent part passing over. For this reason, when the men have hauled up as much as they want above, they should never make fast by a becket inside a room, or on a roof, but should continue to haul until they can make fast the line to the next becket outside, and then lower away again until they have brought the whole weight on that becket, leaving none at all on the bent part passing over. In passing a hose over a height in this way, care must be taken to keep the rivets on the top or outside of the bend, and not to allow the rope or line to pass over the hose in such a way as to cause a pressure on it, which would reduce the water-way.

When the line has been made fast—but not till then—the engine may be started.

54. *To lower down hose.*—Haul away on the line until the becket to which it is attached is close up to the parapet; bring the branch to that spot, and lower it away steadily until it swings; then let go the line from the chimney or other part to which it is secured, and lower away gently until the branch and all the couplings are on the ground; after which the rest of the leather pipe and the whole of the line may be let go by the run, the men first singing out, in the usual way, "Below," to warn those underneath.



In all this movement a man below can give considerable assistance, letting the water out of the hose, either by opening a sluice-cock in the engine or by breaking a joint in the couplings, hauling the hose out and guiding it clear of obstructions, letting the men above know when all the metal is on the ground, and in several other ways.

55. *To turn over and secure the levers, and place the preventer on the ground.*—Go to the off-side of the engine; take off the strap from the prong of the preventer, and also the strap from the off-side handle, and place them in the suction-pocket nearest to them; then, still standing at the off-side, facing the hose-box, seize the clip of the front folding handle with the right hand, the fingers being inside and the thumb out, and with the left hand throw the lever up. Then take a step sideways to the right, with the right foot, and throw the lever briskly over, taking care, however, not to let it come down with such force as to break the hinge of the joint; then bear all the weight of the body on it until it is pulled down by the right hand into its place. When this has been done, spring sideways to the left, so as to gain an upright position, still holding the lever clip with the right hand. This movement, if properly made, will have the effect of forcing the clip on to the tapered piece called the T end of the cross lever, and so fixing the folding lever in line with the side lever. This, however, would hardly be sufficiently firm for working at fires, and it is therefore usual to give the clip a smart tap with a hammer or the end of a hose-wrench, for the purpose of hardening it up. Next take the preventer off the levers, and lay it fore and aft under the engine; then place the left hand on the clip of the hind folding lever, and throw the handle up with the right hand; take a side step to the left, and bringing the weight of the body on to the hind folding lever, force it down into its place; then, still holding the clip with the left hand, draw the left foot back; bring the body to an upright position, and so, as before, force the clip on

to the T end of the hind cross lever, and harden it up as already explained. Then pass round to the near side, take the strap of the near-side handles and place it in the suction-pocket. Take the front lever clip in the left hand, throw the folding handle over with the right, swaying the body first to the left and then back to its upright position, still retaining hold of the clip with the left hand. Force the clip on as far as it will go, and harden up with a tool as before. Then take the hind folding lever clip with the right hand, throw the lever handle over with the left, swaying the body first to the right, and then back to an upright position; and when the lever has been forced into line, harden up the clip as before.

56. *To lock the levers.*—Go to the near side of the engine, and put the levers straight; take up the lever-stay with the left hand, and force it on to the side levers, with one leg above and the other below; pass up the split key between the lever and handle, not between the lever and engine; receive it with the right hand, and force it into the holes in the lugs.

57. *To unlock the levers.*—Hold the lever-stay with the left hand, below the levers, and withdraw with the right hand the iron pin which keeps it in its place. Then pull the lever-stay outwards, until the projecting lugs clear the iron of the side lever. When dropping the stay, take care that it hangs clear of the lowest point reached by the side levers, as otherwise it may prevent the levers travelling their full stroke, or in some cases may injure the hands of the men pumping. The engine is then ready for work.

The unfolding of the handles and unlocking of the levers are almost always left to the last, as in small streets it is most difficult to do the other necessary work with the levers projecting in both directions; and it is very awkward turning over and securing the folding parts after they have been unlocked. It is, moreover, somewhat dangerous climbing on and jumping off the engine when the handles are not fixed; and in the midst of an excited crowd, the strangers employed for pumping might start the engine before all is ready, and perhaps, by doing so, break the legs of the firemen getting the gear out. For these reasons, it is usual for the fireman left in charge of the engine to keep the levers locked until he receives the order to commence pumping.

58. *To fold and strap the levers, and replace the preventer.*—Take hold of the near-side hind folding lever-clip with the right hand, pull it off from the T end of the cross lever, and, holding it still in the right hand, turn the folding lever over, assisting it with the left hand; and place the stud of the folding handle in the socket on top of the side handle. Then go to the near-side front folding lever, and, pulling off the clip with the left hand, turn over the folding lever, assisting it with the right hand, and place the stud of the front folding handle in the socket, which will then be on the upper side of the hind folding handle. Take the lever-strap from the side-pocket, and strap the levers together, as nearly as convenient, in the middle of the overlap, making two round turns, and securing the end with the buckle. Pass round the fore part of the engine, and, taking up the preventer, place it on the off-side lever-pins, between the lever and the handle, with the head forward, the prong resting on the joint eye-pin, and the spur inside and downwards. Go to the hind folding lever at the same side, and, pulling off the clip with the left hand, turn over the folding lever, assisting with the right hand; and

place the stud of the folding handle in the socket on top of the side handle. Go to the front folding lever, and, pulling off the clip with the right hand, turn over the folding lever, assisting with the left hand, and place the stud of the front folding handle in the socket, which will then be on the upper side of the hind folding handle. Take the straps from the side-pocket, and, with one, secure the lever handles in about the middle of the overlap, taking one round turn on the preventer, and two round turns on the side and folding handles. Fasten the other strap round the fore part of the levers and round the head of the preventer, taking several turns, and buckling the whole together tightly to prevent it shifting.

59. *To make out strangers' list.*—The fireman who remains in charge of the engine should make out what is known as the strangers' list, on the form supplied for the purpose, taking care that every man's name is placed opposite the proper number, so that, in the event of an inquiry at any time, the position of each man can be ascertained from the working list. The fireman should also take the time of commencing and discontinuing work as far as he is able to do so.

60. *To blow out an engine.*—An engine, after having had water passed through it, should invariably be thoroughly dried before being laid by, as, even in moderate temperatures, damp very seriously affects the metal, and in cases of severe frost makes the valves and other parts rigid, and the whole machine consequently useless.

The simplest way of drying an engine is to "blow it out," which is done in the following way. Open the suction-inlet, and close the deliveries, except at one point. Place the engine in such a position that any water inside will tend towards the open delivery, and put a man underneath. The man should hold his hand over the open delivery, and the handles should be worked until the man feels the compressed air so strong as almost to force his hand off. He should then withdraw his hand very suddenly, and a portion of the water will be forced out with the compressed air. The same operation should be repeated until it is observed that no more water is forced out, and that the air is perfectly dry. A few moments are sufficient for this purpose; but even if a longer time were required, the work should on no account be neglected.

In former times, fire-engines were made with leather valves; and it was the custom to leave the works full of water, in order that the valves might be kept flexible. This unsatisfactory mode of construction has long fallen into disuse, and it might be supposed that the filling of the pumps with water would have disappeared with it. Such, however, strange to say, has not been the case; on the contrary, engines can be found in many important cities of this and other countries in an advanced state of inefficiency, or in some cases of positive decay, from adherence to the old practice, which, with metal-valved pumps, is always useless and injurious, and as already explained, is in case of frost, positively dangerous.

61. *To unlock the fore carriage and hook on the sway-bars.*—Take hold of one of the upper spokes of the near-side fore wheel with the right hand, and, moving the wheel slightly so as to loosen the transom plates, withdraw the locking-pin with the left hand, and replace it in its socket on the front beat block. Swing the fore carriage slightly round to make sure that the plates are free, and hook on the sway-bars.

62. *Places of men on the engine.*—When an engine is about to move, the men will take the following places, unless the senior present shall order otherwise:—The coachman on the driving-seat, the senior officer or fireman standing up on the near side of the coachman, the next senior standing up on the off side of the coachman, the third in seniority sitting next to the second, the fourth next to the third, and so on to the last or junior, who should be seated next to the senior. The two men standing will keep a look-out for the coachman, and will, when necessary, shout, to warn persons and vehicles of their approach, and the men sitting will keep their weight low down, and as much as possible in the centre of the engine. It must be remembered, that it is exceedingly dangerous for several men to stand up at the same time when an engine is moving rapidly, as they are likely to overbalance it. In either mounting or dismounting, the juniors should, in all cases, give precedence to their seniors, unless otherwise ordered.

When it is necessary to carry strangers on an engine—as, for instance, Police, persons who have brought a call, or others—they should be placed in such positions as not to attract attention, and they should be invariably seated. In all ordinary cases, it is desirable to avoid carrying on an engine persons in light-coloured clothing, or shirt sleeves, or in fact any costume which would give the engine the smallest appearance of irregularity.

As a general rule, no talking is permitted on an engine beyond what is absolutely necessary.

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Getting to Work.				Making Up.			
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5	1	3 &c.	1	6	1	3 &c.	1
7	1	1	2	8	1	1	2
9	1	2	2	10	1	2	2
11	1	3 &c.	2	12	1	3 &c.	2
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21	1	2	4	22	1	2	4
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27	2	2	1	28	2	2	1
29	2	3 &c.	1	30	2	3 &c.	1
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33	2	2	2	34	2	2	2
35	2	3 &c.	2	36	2	3 &c.	2
37	2	1	3	38	2	1	3
39	2	2	3	40	2	2	3
41	2	3 &c.	3	42	2	3 &c.	3
43	2	1	4	44	2	1	4
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Getting to Work.

No.	Men.	Hose.	Suction-Pipes.
47	2	3 &c.	4
49	3	1	1
51	3	2	1
53	3	3 &c.	1
55	3	1	2
57	3	2	2
59	3	3 &c.	2
61	3	1	3
63	3	2	3
65	3	3 &c.	3
67	3	1	4
69	3	2	4
71	3	3 &c.	4
73	4	1	1
75	4	2	1
77	4	3 &c.	1
79	4	1	2
81	4	2	2
83	4	3 &c.	2
85	4	1	3
87	4	2	3
89	4	3 &c.	3
91	4	1	4
93	4	2	4
95	4	3 &c.	4
97	5	1	1
99	5	2	1
101	5	3 &c.	1
103	5	1	2
105	5	2	2
107	5	3 &c.	2
109	5	1	3
111	5	2	3
113	5	3 &c.	3
115	5	1	4
117	5	2	4
119	5	3 &c.	4
121	6	1	1
123	6	2	1
125	6	3 &c.	1
127	6	1	2
129	6	2	2
131	6	3 &c.	2
133	6	1	3
135	6	2	3
137	6	3 &c.	3
139	6	1	4
141	6	2	4
143	6	3 &c.	4

Making Up.

No.	Men.	Hose.	Suction-Pipes.
48	2	3 &c.	4
50	3	1	1
52	3	2	1
54	3	3 &c.	1
56	3	1	2
58	3	2	2
60	3	3 &c.	2
62	3	1	3
64	3	2	3
66	3	3 &c.	3
68	3	1	4
70	3	2	4
72	3	3 &c.	4
74	4	1	1
76	4	2	1
78	4	3 &c.	1
80	4	1	2
82	4	2	2
84	4	3 &c.	2
86	4	1	3
88	4	2	3
90	4	3 &c.	3
92	4	1	4
94	4	2	4
96	4	3 &c.	4
98	5	1	1
100	5	2	1
102	5	3 &c.	1
104	5	1	2
106	5	2	2
108	5	3 &c.	2
110	5	1	3
112	5	2	3
114	5	3 &c.	3
116	5	1	4
118	5	2	4
120	5	3 &c.	4
122	6	1	1
124	6	2	1
126	6	3 &c.	1
128	6	1	2
130	6	2	2
132	6	3 &c.	2
134	6	1	3
136	6	2	3
138	6	3 &c.	3
140	6	1	4
142	6	2	4
144	6	3 &c.	4

No. 1.

1 MAN.—*Getting an engine to work, with* 1 *length of hose and* 1 *length of suction-pipe.*

When told to "stand by," the Fireman places himself close to the near-side fore wheel.

When told to "go on," he proceeds as follows; not necessarily, however, in the order here given, or any other special order, but when practising for the purpose of instruction only, generally following the order here given.

- Set in to the plug.
- Square and lock the fore-carriage, and place the sway-bars on the ground . . . 2
- Mount the engine and open the hose-box lid 3
- Take out the dam, hose, &c. . 4
- Close the lid and get down . . 5
- Take the dam off and set it up 6
- Place the dam over the plug . 7
- Put on a length of suction-pipe 9
- Put on a length of hose . . . 27
- Put on the branch 24
- Turn over and secure the levers, and place the preventer on the ground 55
- Unlock the levers 57

If necessary, take two hose-wrenches, and a branch-and-nozzle spanner, and harden up all the joints.

No. 2.

1 MAN.—*Making up an engine, with* 1 *length of hose and* 1 *length of suction-pipe.*

- Take off the branch 25
- Lock the levers 56
- Take off the length of hose . 39
- Fold and strap the near-side levers 58
- Get astern of the engine, and turn over the hind folding-handle of the off-side lever . 58
- Take off the suction-pipe . . 18
- Put the suction-pipe in the pocket 23
- Replace the preventer, and fold and strap the off-side levers . 58
- Make up and replace the dam . 8
- Make up the hose 46
- Mount the engine and open the hose-box lid 3
- Stow the gear 1
- Close the lid and get down . . 5
- Unlock the fore-carriage and hook on the sway-bars . . 61

No. 3.

1 MAN.—*Getting an engine to work, with* 2 *lengths of hose and* 1 *length of suction-pipe.*

- Set in to the plug.
- Square and lock the fore-carriage, and place the sway-bars on the ground 2
- Mount the engine, and open the hose-box lid 3
- Take out the dam, hose, &c. . 4
- Close the lid and get down . . 5
- Take the dam off and set it up 6
- Place the dam over the plug . 7
- Put on a length of suction-pipe 9
- Put on two lengths of hose 27, 28
- Put on the branch 24
- Turn over and secure the levers, and place the preventer on the ground 55
- Unlock the levers 57

If necessary, harden up the joints.

No. 4.

1 MAN.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipe . . 18
Put the suction-pipe in the pocket 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5
Unlock the fore-carriage and hook on the sway-bars . . 61

No. 5.

1 MAN.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground . . . 2
Mount the engine and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down. . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on a length of suction-pipe 9
Put on the necessary lengths of hose 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers. 57

If necessary, harden up the joints.

No. 6.

1 MAN.—*Making up an engine, with 3 or more lengths of hose and 1 length of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipe . . 18
Put the suction-pipe in the pocket 23
Replace the preventer, and fold and strap the off-side levers. 58
Make up and replace the dam. 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5
Unlock the fore-carriage and hook on the sway-bars . . 61

No. 7.

1 MAN.—*Getting an engine to work, with 1 length of hose and 2 lengths of suction-pipe.*

Set into the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground 2
Mount the engine, and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down. . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on two lengths of suction-pipe 9, 10
Put on a length of hose . . . 27
Put on the branch 24
Turn over and secure the levers, and place the preventer on ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 8.

1 MAN.—*Making up an engine, with 1 length of hose and 2 lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose 39
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pocket 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . . 5

Unlock the fore-carriage and hook on the sway-bars, 61

No. 9.

1 MAN.—*Getting an engine to work, with 2 lengths of hose and 2 lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground . . . 2
Mount the engine and open the horse-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on two lengths of suction-pipe 9, 10
Put on two lengths of hose . 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 10.

1 MAN.—*Making up an engine, with 2 lengths of hose and 2 lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the horse-box lid 3
Stow the gear 1
Close the lid and get down . 5

Unlock the fore-carriage and hook on the sway-bars, 61

No. 11.

1 MAN.—*Getting an engine to work, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground . . . 2
Mount the engine and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down. . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on two lengths of suction-pipe 9, 10
Put on the necessary lengths of hose 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 12.

1 Man.—*Making up an engine, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Take off the branch 25	Make up and replace the dam. 8
Lock the levers 56	Make up the hose 46
Take off the hose. . 39, 41, 45	Mount the engine and open the hose-box lid 3
Fold and strap the near-side levers 58	Stow the gear 1
Take off the suction-pipes . 18, 22	Close the lid and get down . 5
Put the suction-pipes in the pockets 23	Unlock the fore-carriage and hook on the sway-bars . . 61
Replace the preventer, and fold and strap the off-side levers. 58	

No. 13.

1 Man.—*Getting an engine to work, with 1 length of hose and 3 lengths of suction-pipe.*

Set in to the plug.	Place the dam over the plug . 7
Square and lock the fore-carriage and place the sway-bars on the ground . . . 2	Put on three lengths of suction-pipe 9, 10, 11
Mount the engine, and open the hose-box lid 3	Put on one length of hose . . 27
Take out the dam, hose, &c. . 4	Put on the branch 24
Close the lid and get down . 5	Turn over and secure the levers, and place the preventer on the ground 55
Take the dam off and set it up 6	Unlock the levers. 57

If necessary, harden up the joints.

No. 14.

1 Man.—*Making up an engine, with 1 length of hose and 3 lengths of suction-pipe.*

Take off the branch 25	Make up and replace the dam. 8
Lock the levers 56	Make up the hose. 46
Take off the hose 39	Mount the engine and open the hose-box lid 3
Fold and strap the near-side levers 58	Stow the gear 1
Take off the suction-pipes . 18, 22	Close the lid and get down. . 5
Put the suction-pipes in the pockets 23	Unlock the fore-carriage and hook on the sway-bars . . 61
Replace the preventer, and fold and strap the off-side levers. 58	

No. 15.

1 Man.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Set in to the plug.	Place the dam over the plug . 7
Square and lock the fore-carriage, and place the sway-bars on the ground 2	Put on three lengths of suction-pipe 9, 10, 11
Mount the engine and open the hose-box lid 3	Put on two lengths of hose 27, 28
Take out the dam, hose, &c. . 4	Put on the branch 24
Close the lid and get down . 5	Turn over and secure the levers, and place the preventer on the ground 55
Take off the dam and set it up 6	Unlock the levers. 57

If necessary, harden up the joints.

No. 16.

1 Man.—*Making up an engine, with* 2 *lengths of hose and* 3 *lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . . 5

Unlock the fore-carriage and hook on the sway-bars, 61

No. 17.

1 Man.—*Getting an engine to work, with* 3 *or more lengths of hose and* 3 *lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground 2
Mount the engine and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down . 5
Take the dam off and set it up . 6
Place the dam over the plug . 7
Put on three lengths of suction-pipe 9, 10, 11
Put on three or more lengths of hose 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 18.

1 Man.—*Making up an engine, with* 3 *or more lengths of hose and* 3 *lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5

Unlock the fore-carriage and hook on the sway-bars, 61

No. 19.

1 Man.—*Getting an engine to work, with* 1 *length of hose and* 4 *lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground 2
Mount the engine, and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on four lengths of suction-pipe 9, 10, 11, 12
Put on one length of hose . . 27
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 20.

1 MAN.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose 39
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer and fold and strap the off-side levers . 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5

Unlock the fore-carriage and hook on the sway-bars 61

No. 21.

1 MAN.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage and place the sway-bars on the ground . . . 2
Mount the engine and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down . 5
Take the dam off and set it up 6
Place the dam over the plug . 7
Put on four lengths of suction-pipe 9, 10, 11, 12
Put on two lengths of hose 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 22.

1 MAN.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipes . 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer and fold and strap the off-side levers. 58
Make up and replace the dam . 8
Make up the hose 46
Mount the engine and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5

Unlock the fore-carriage and hook on the sway-bars 61

No. 23.

1 MAN.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Set in to the plug.
Square and lock the fore-carriage, and place the sway-bars on the ground 2
Mount the engine, and open the hose-box lid 3
Take out the dam, hose, &c. . 4
Close the lid and get down . 5
Take the dam off, and set it up 6
Place the dam over the plug . 7
Put on four lengths of suction-pipe 9, 10, 11, 12
Put on three or more lengths of hose 27, 28
Put on the branch 24
Turn over and secure the levers, and place the preventer on the ground 55
Unlock the levers 57

If necessary, harden up the joints.

No. 24.

1 MAN.—*Making up an engine, with* 3 *or more lengths of hose and* 4 *lengths of suction-pipe.*

Take off the branch 25
Lock the levers 56
Take off the hose . 39, 41, 45
Fold and strap the near-side levers 58
Take off the suction-pipes 18, 22
Put the suction-pipes in the pockets 23
Replace the preventer, and fold and strap the off-side levers . 58
Make up and replace the dam 8
Make up the hose 46
Mount the engine, and open the hose-box lid 3
Stow the gear 1
Close the lid and get down . 5
Unlock the fore-carriage and hook on the sway-bars . . 61

No. 25.

2 MEN.—*Getting an engine to work, with* 1 *length of hose and* 1 *length of suction-pipe.*

For the purpose of instruction, the men are designated No. 1 and No. 2.

At the order to "stand by," the men place themselves on the engine, 62.

At the order to "go on," they jump down and set the engine in over the plug.

No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ sets up the dam, and places it over the plug 6, 7
„ puts on the hose . . . 27
„ puts on the branch, and takes charge of it . . 24
No. 2 mounts the engine, and opens the hose-box lid 3
No. 2 takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the suction-pipe 9
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 26.

2 MEN.—*Making up an engine, with* 1 *length of hose and* 1 *length of suction-pipe.*

At the order "knock off and make up," No. 1 gives the word to stop the delivery as "Avast No. 5" engine.

No. 1 takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose . . 39
„ folds and straps the near-side levers 58
No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine, and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 27.

2 MEN.—*Getting an engine to work, with 2 lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage, and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on two lengths of hose 27, 28
„ puts on the branch . . 24

No. 2 mounts the engine, and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on one length of suction-pipe . . . 9
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 28.

2 MEN.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up the dam and replaces it 8
„ unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose, 39, 41, 45
„ folds and straps the near-side levers 58

No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine, and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid, and gets down 5

Both men drag the engine away from the plug.

No. 29.

2 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the second and third lengths of hose . 28
„ puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3

No. 2 takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on one length of suction-pipe . . . 9
„ puts on the first length of hose 27
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 30.

2 Men.—*Making up an engine, with* 3 *or more lengths of hose and* 1 *length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second and third lengths of hose . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58

No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ makes up the first length of hose 46
„ mounts the engine and opens the hose-box lid 3
„ stows the gear . . . 1
„ closes the lid and gets down 5

Both the men drag the engine away from the plug.

No. 31.

2 Men.—*Getting an engine to work, with* 1 *length of hose and* 2 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on one length of hose 27
„ puts on the branch . . 24

No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on two lengths of suction-pipe . . . 9, 10
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 32.

2 Men.—*Making up an engine, with* 1 *length of hose and* 2 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose . . 39
„ folds and straps the near-side levers 58

No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear . . . 1
„ closes the lid and gets down 5

Both the men drag the engine away from the plug.

No. 33.

2 Men.—*Getting an engine to work, with 2 lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the hose . 27, 28
„ puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3
No. 2 takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the suction-pipes 9, 10
„ turns over and secures the levers, and places the preventer on the ground 55
„ Unlocks the levers . . 57

If necessary, harden up the joints.

No. 34.

2 Men.—*Making up an engine, with 2 lengths of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58
No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear . . . 1
„ closes the lid and gets down 5

Both the men drag the engine away from the plug.

No. 35.

2 Men.—*Getting an engine to work, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set into the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the hose . . 27, 28
„ puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3
No. 2 takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the suction-pipes 9, 10
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 36.

2 MEN.—*Making up an engine, with* 3 *or more lengths of hose and* 2 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58
„ takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets . . . 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear. . . . 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 37.

2 MEN.—*Getting an engine to work, with* 1 *length of hose and* 3 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the third length of suction-pipe 9, 10, 11
„ puts on the hose . . . 27
„ puts on the branch . . 24

No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the first and second lengths of suction-pipe . . 9, 10, 11
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 38.

2 MEN.—*Making up an engine, with* 1 *length of hose and* 3 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ takes off the third length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose . . 39
„ folds and straps the near-side levers 58
„ takes off the first and second lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pocket 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear . . . 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 39.

2 Men.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62

Set in to the plug.

No. 1 locks the fore-carriage and places the sway-bars on the ground . 2

" sets up the dam . . . 6

" places the dam over the plug 7

" puts on two lengths of hose 27, 28

" puts on the branch . . 24

No. 2 mounts the engine and opens the hose-box lid 3

" takes out the dam, hose, &c. 4

" closes the lid and gets down 5

" puts on three lengths of suction-pipe . . 9, 10, 11

" turns over and secures the levers, and places the preventer on the ground 55

" unlocks the levers . . 57

If necessary, harden up the joints.

No. 40.

2 Men.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.

" takes off the branch . . 25

" makes up the hose . . 46

" makes up and replaces the dam 8

" unlocks the fore-carriage and hooks-on the sway-bars 61

No. 2 locks the levers . . . 56

" takes off the hose 39, 41, 45

" folds and straps the near-side levers 58

No. 2 takes off the suction-pipes 18, 22

" puts the suction-pipes in the pockets 23

" replaces the preventer and folds and straps the off-side levers . . 58

" mounts the engine and opens the hose-box lid 3

" stows the gear . . . 1

" closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 41.

2 Men.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62

Set in to the plug.

No. 1 locks the fore-carriage and places the sway-bars on the ground . 2

" sets up the dam . . . 6

" places the dam over the plug 7

" puts on the hose . 27, 28

" puts on the branch . . 24

No. 2 mounts the engine, and opens the hose-box lid 3

No. 2 takes out the dam, hose, &c. 4

" closes the lid and gets down 5

" puts on the suction-pipes 9, 10, 11

" turns over and secures the levers, and places the preventer on the ground 55

" unlocks the levers . . 57

If necessary, harden up the joints.

No. 42.

2 Men.—*Making up an engine, with* 3 *or more lengths of hose and* 3 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose, 39, 41, 45
„ folds and straps the near-side levers 58

No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 43.

2 Men.—*Getting an engine to work, with* 1 *length of hose and* 4 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the fourth length of suction-pipe . . . 12
„ puts on the hose . . . 27
„ puts on the branch . . 24

No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the first, second, and third lengths of suction-pipe . . 9, 10, 11
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 44.

2 Men.—*Making up an engine, with* 1 *length of hose and* 4 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ takes off the fourth length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose . . . 39

No. 2 folds and straps the near-side levers 58
„ takes off the first, second, and third lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 45.

2 MEN.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the fourth length of suction-pipe . . . 12
„ puts on the first and second lengths of hose 27, 28

No. 1 puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the first, second and third lengths of suction-pipe . . 9, 10, 11
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 46.

2 MEN.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ takes off the fourth length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose, 39, 41, 45

No. 2 folds and straps the near-side levers 58
„ takes off the first, second, and third lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid, and gets down 5

Both men drag the engine away from the plug.

No. 47.

2 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug . . , . . . 7
„ puts on three lengths of hose 27, 28
„ puts on the branch . . 24

No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on four lengths of suction-pipe 9, 10, 11, 12
„ turns over and secures the levers and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 48.

2 MEN.—*Making up an engine, with* 3 *or more lengths of hose and* 4 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58
No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 49.

3 MEN.—*Getting an engine to work, with* 1 *length of hose and* 1 *length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the length of hose 27
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
No. 2 puts on the suction-pipe 9
No. 3 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 50.

3 MEN.—*Making up an engine, with* 1 *length of hose and* 1 *length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
„ takes off the hose . . 39
„ folds and straps the near-side levers 58
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 45.

2 MEN.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the fourth length of suction-pipe . . . 12
„ puts on the first and second lengths of hose 27, 28
No. 1 puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the first, second and third lengths of suction-pipe . . 9, 10, 11
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 46.

2 MEN.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ takes off the fourth length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 locks the levers . . . 56
„ takes off the hose, 39, 41, 45
No. 2 folds and straps the near-side levers 58
„ takes off the first, second, and third lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid, and gets down 5

Both men drag the engine away from the plug.

No. 47.

2 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 locks the fore-carriage and places the sway-bars on the ground . 2
„ sets up the dam . . . 6
„ places the dam over the plug . . , ... 7
„ puts on three lengths of hose 27, 28
„ puts on the branch . . 24
No. 2 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on four lengths of suction-pipe 9, 10, 11, 12
„ turns over and secures the levers and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 48.

2 Men.—*Making up an engine, with* 3 *or more lengths of hose and* 4 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ makes up and replaces the dam 8
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58

No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ replaces the preventer and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

Both men drag the engine away from the plug.

No. 49.

3 Men.—*Getting an engine to work, with* 1 *length of hose and* 1 *length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the length of hose 27
„ puts on the branch . . 24

No. 2 sets up the dam . . . 6
„ places the dam over the plug 7

No. 2 puts on the suction-pipe 9

No. 3 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 50.

3 Men.—*Making up an engine, with* 1 *length of hose and* 1 *length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8

No. 3 locks the levers . . . 56
„ takes off the hose . . 39
„ folds and straps the near-side levers 58
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 51.

3 Men.—*Getting an engine to work, with 2 lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bar on the ground 2
„ puts on the hose . . 27, 28
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the suction pipe 9
No. 3 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 52.

3 Men.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58
„ replaces the preventer, and folds and straps the off-side levers . . 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear . . . 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 53.

3 Men.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground . . . 2
„ puts on the second and third lengths of hose, 27, 28
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the suction-pipe 9
No. 2 puts on the first length of hose 27
No. 3 mounts the engine, and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 54.

3 MEN.—*Making up an engine, with 3 or more lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
,, takes off the branch, &c. 25
,, makes up the second and third lengths of hose . 46
,, unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 makes up the first length of hose 46
,, takes off the suction-pipe 18
,, puts the suction-pipe in the pocket 23
No. 2 makes up and replaces the dam 8
No. 3 locks the levers . . . 56
,, takes off the hose, 39, 41, 45
,, folds and straps the near-side levers 58
,, replaces the preventer, and folds and straps the off-side levers . . 58
,, mounts the engine, and opens the hose-box lid 3
,, stows the gear 1
,, closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 55.

3 MEN.—*Getting an engine to work, with 1 length of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground . . . 2
,, puts on the length of hose 27
,, puts on the branch . . 24
No. 2 sets up the dam . . . 6
,, places the dam over the plug 7
No. 2 puts on two lengths of suction-pipe . . . 9, 10
No. 3 mounts the engine, and opens the hose-box lid 3
,, takes out the dam, hose, &c. 4
,, closes the lid and gets down 5
,, turns over and secures the levers, and places the preventer on the ground 55
,, unlocks the levers . . 57

If necessary, harden up the joints.

No. 56.

3 MEN.—*Making up an engine, with 1 length of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
,, takes off the branch . . 25
,, makes up the hose . . 46
,, unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipes 18, 22
,, puts the suction-pipes in the pocket 23
,, makes up and replaces the dam 8
No. 3 locks the levers . . . 56
,, takes off the hose . . . 39
,, folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers . . . 58
,, mounts the engine and opens the hose-box lid 3
,, stows the gear 1
,, closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 57.

3 MEN.—*Getting an engine to work, with 2 lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground . . . 2
" puts on the hose . . 27, 28
" puts on the branch . . 24
No. 2 sets up the dam . . . 6
" places the dam over the plug 7
No. 2 puts on the suction-pipes 9, 10
No. 3 mounts the engine, and opens the hose-box lid 3
" takes out the dam, hose, &c. 4
" closes the lid and gets down 5
" turns over and secures the levers, and places the preventer on the ground 55
" unlocks the levers . . 57

If necessary, harden up the joints.

No. 58.

3 MEN.—*Making up an engine, with 2 lengths of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
" takes off the branch . . 25
" makes up the hose . . 46
" unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipes 18, 22
" puts the suction-pipes in the pockets 23
" makes up and replaces the dam 8
No. 3 locks the levers . . . 56
" takes off all the hose 39, 41, 45
" folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers . . . 58
" mounts the engine and opens the hose-box lid 3
" stows the gear . . . 1
" closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 59.

3 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
" puts on the second and third lengths of hose 27, 28
" puts on the branch . . 24
No. 2 sets up the dam . . . 6
" places the dam over the plug 7
" puts on two lengths of suction-pipe . . . 9, 10
No. 3 mounts the engine and opens the hose-box lid 3
" takes out the dam, hose, &c. 4
" closes the lid and gets down 5
" puts on the first length of hose 27
" turns over and secures the levers, and places the preventer on the ground 55
" unlocks the levers . . 57

If necessary, harden up the joints.

No. 60.

3 Men.—*Making up an engine, with* 3 *or more lengths of hose and* 2 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second and third lengths of hose . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers . . . 58
„ makes up the first length of hose 46
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 61.

3 Men.—*Getting an engine to work, with* 1 *length of hose and* 3 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the length of hose 27
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10
No. 3 mounts the engine and opens the hose-box lid 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the third length of suction-pipe . . . 11
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 62.

3 Men.—*Making up an engine, with* 1 *length of hose, and* 3 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the first and second lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
„ takes off the hose. . . 39
„ folds and straps the near-side levers 58
„ takes off the third length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ replaces the preventer and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 63.

3 Men.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
" puts on the first and second lengths of hose 27, 28
" puts on the branch . . 24
No. 2 sets up the dam . . . 6
" places the dam over the plug 7
" puts on the first and second lengths of suction-pipe 9, 10
No. 3 mounts the engine and opens the hose-box lid . 3
" takes out the dam, hose, &c. 4
" closes the lid and gets down 5
" puts on the third length of suction-pipe . . . 11
" turns over and secures the levers and places the preventer on the ground 55
" unlocks the levers . . . 57

If necessary, harden up the joints.

No. 64.

3 Men.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
" takes off the branch . . 25
" makes up the hose . . 46
" unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the first and second lengths of suction-pipe 18, 22
" puts the suction-pipes in the pockets 23
" makes up and replaces the dam 8
No. 3 locks the levers . . . 56
No. 3 takes off the hose 39, 41, 45
" folds and straps the near-side levers 58
" takes off the third length of suction-pipe . . 18, 22
" puts the suction-pipe in the pocket 23
" replaces the preventer and folds and straps the off-side levers 58
" mounts the engine and opens the hose-box lid . 3
" stows the gear 1
" closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 65.

3 Men.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
" puts on the first and third lengths of hose . 27, 28
" puts on the branch . . 24
No. 2 sets up the dam . . . 6
" places the dam over the plug 7
" puts on the suction-pipes 9, 10, 11
No. 3 mounts the engine and opens the hose-box lid . 3
" takes out the dam, hose, &c. 4
" closes the lid and gets down 5
" puts on the second length of hose 27, 28
" turns over and secures the levers and places the preventer on the ground . 55
" unlocks the levers . . . 57

If necessary, harden up the joints.

When several men are engaged together in laying out a line of hose in separate lengths, each one must make an allowance of forty feet for every length nearer the engine.

No. 66.

3 MEN.—*Making up an engine, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the first and third lengths of hose . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
„ takes off all the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ makes up the second length of hose . . . 46
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 67.

3 MEN.—*Getting an engine to work, with 1 length of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the length of hose 27
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first, second, and third lengths of suction-pipe . . . 9, 10, 11
No. 3 mounts the engine, and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the fourth length of suction-pipe . . . 12
„ turns over and secures the levers, and places the preventer on the ground . 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 68.

3 MEN.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the first, second, and third lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 3 locks the levers 56
No. 3 takes off the hose . . . 39
„ folds and straps the near-side levers 58
„ takes off the fourth length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 69.

3 Men.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-
„ carriage, and places the sway-bars on the ground 2
„ puts on the first and second lengths of hose 27, 28
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first, second and third lengths of suction-pipe . . . 9, 10, 11
No. 3 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the fourth length of suction-pipe . . . 12
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 70.

3 Men.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the first, second and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 3 locks the levers . . . 56
No. 3 takes off the hose 39, 41, 45
„ folds and straps the near-side levers 58
„ takes off the fourth length of suction-pipe . 18, 22
„ puts the suction-pipe in pocket 23
„ replaces the preventer and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 71.

3 Men.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the second and third lengths of hose 27, 28
„ puts on the branch . . 24
No. 2 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first, second and third lengths of suction-pipe . . 9, 10, 11
No. 3 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ puts on the first length of hose 27
„ puts on the fourth length of suction-pipe . . . 12
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 72.

3 MEN.—*Making up an engine, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second and third lengths of hose . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 takes off the first, second and third lengths of suction-pipe . . . 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8

No. 3 locks the levers . . . 56
„ takes off the hose 39, 41, 45

No. 3 folds and straps the near-side levers 58
„ takes off the fourth length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ replaces the preventer and folds and straps the off-side levers 58
„ makes up the first length of hose 46
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 73.

4 MEN.—*Getting an engine to work, with 1 length of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set into the plug.

No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24

No. 2 puts on the hose . . . 27

No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the suction-pipe . 9

No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 74.

4 MEN.—*Making up an engine, with 1 length of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 makes up the hose . . 46

No. 3 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8

No. 4 locks the levers . . . 56
„ takes off the hose . . . 39
„ folds and straps the near-side levers; replaces the preventer and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 75.

4 MEN.—*Getting an engine to work, with 2 lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
,, puts on the second length of hose 27, 28
,, puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
,, puts on one length of suction-pipe 9
No. 4 mounts the engine and opens the hose-box lid . 3
,, takes out the dam, hose, &c. 4
,, closes the lid and gets down 5
,, turns over and secures the levers and places the preventer on the ground . 55
,, unlocks the levers . . . 57

If necessary, harden up the joints.

No. 76.

4 MEN.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
,, takes off the branch . . 25
,, makes up the second length of hose . . . 46
,, unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first length of hose 46
No. 3 takes off the suction-pipe 18
,, puts the suction-pipe in the pocket 23
No. 3 makes up and replaces the dam 8
No. 4 locks the levers . . . 56
,, takes off the hose 39, 41, 45
,, folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
,, mounts the engine and opens the hose-box lid . 3
,, stows the gear 1
,, closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 77.

4 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
,, puts on the third length of hose 27, 28
,, puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
,, puts on a length of suction-pipe 9
No. 4 mounts the engine and opens the hose-box lid . 3
,, takes out the dam, hose, &c. 4
,, closes the lid and gets down 5
,, turns over and secures the levers and places the preventer on the ground . 55
,, unlocks the levers . . . 57

If necessary, harden up the joints.

No. 78.

4 MEN.—*Making up an engine, with 3 or more lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
No. 3 makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers; replaces the preventer and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 79.

4 MEN.—*Getting an engine to work, with 1 length of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27
„ puts on the second length of suction-pipe . . 9, 10
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the first length of suction-pipe . . . 9, 10
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 80.

4 MEN.—*Making up an engine, with 1 length of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the second length of suction-pipe 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up the first length of hose 46
No. 3 takes off the first length of suction-pipe . 18, 22
No. 3 puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off the hose . . . 39
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 81.

4 MEN.—*Getting an engine to work, with 2 lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the second length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
„ puts on the second length of suction-pipe . . 9, 10
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first length of suction-pipe . . 9, 10
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 82.

4 MEN.—*Making up an engine, with 2 lengths of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second length of hose . . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the second length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up the first length of hose 46
No. 3 takes off the first length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off all the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers. 58
„ mounts the engine, and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 83.

4 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose . 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 84.

4 MEN.—*Making up an engine, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the first and second lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
No. 3 makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off the hose, 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 85.

4 MEN.—*Getting an engine to work, with 1 length of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the length of hose 27
„ puts on the branch . . 24
No. 2 puts on the first and third lengths of suction-pipe 9, 10, 11
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the second length of suction-pipe . 9, 10, 11
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 86.

4 MEN.—*Making up an engine, with 1 length of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
No. 3 takes off the second length of suction-pipe . 18, 22
„ puts the suction-pipes in the pockets 23
No. 3 makes up and replaces the dam 8
No. 4 locks the levers. . . . 56
„ takes off the hose . . . 39
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 87.

4 MEN.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the second length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
„ puts on the third length of suction-pipe . . 9, 10, 11
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10, 11
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground . 55
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 88.

4 MEN.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second length of hose . . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up the first length of hose 46
No. 3 takes off the first and second lengths of suction-pipe 18, 22
No. 3 puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 89.

4 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
„ puts on the third length of suction-pipe . 9, 10, 11
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10, 11
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 90.

4 MEN.—*Making up an engine, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 makes up the first and se-second lengths of hose . 46
„ takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23

No. 3 takes off the first and second lengths of suction-pipe 18, 22

No. 3 puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8

No. 4 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 91.

4 MEN.—*Getting an engine to work, with 1 length of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on one length of hose 27
„ puts on the branch . . 24

No. 2 puts on the first and third lengths of suction-pipe 9, 10, 11

No. 3 sets up the dam . . . 6
„ places the dam over the plug 7

No. 3 puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12

No. 4 mounts the engine, and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 92.

4 MEN.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket. 23

No. 3 takes off the second and fourth lengths of suction-pipe 18, 22

No. 3 puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8

No. 4 locks the levers . . . 56
„ takes off the hose . . . 39
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 87.

4 MEN.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the second length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
„ puts on the third length of suction-pipe . . 9, 10, 11
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10, 11
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground . 55
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 88.

4 MEN.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the second length of hose . . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up the first length of hose 46
No. 3 takes off the first and second lengths of suction-pipe 18, 22
No. 3 puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 4 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 89.

4 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
„ puts on the third length of suction-pipe . 9, 10, 11
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
„ puts on the first and second lengths of suction-pipe 9, 10, 11
No. 4 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 90.

4 MEN.—*Making up an engine, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 makes up the first and se-second lengths of hose . 46
„ takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23

No. 3 takes off the first and second lengths of suction-pipe 18, 22

No. 3 puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8

No. 4 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 91.

4 MEN.—*Getting an engine to work, with 1 length of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.

No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on one length of hose 27
„ puts on the branch . . 24

No. 2 puts on the first and third lengths of suction-pipe 9, 10, 11

No. 3 sets up the dam . . . 6
„ places the dam over the plug 7

No. 3 puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12

No. 4 mounts the engine, and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 92.

4 MEN.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the hose . . 46
„ unlocks the fore-carriage and hooks on the sway-bars 61

No. 2 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket. 23

No. 3 takes off the second and fourth lengths of suction-pipe 18, 22

No. 3 puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8

No. 4 locks the levers . . . 56
„ takes off the hose . . . 39
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 99.

5 MEN.—*Getting an engine to work, with 2 lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set into the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
No. 3 puts on the second length of hose 27, 28
No. 4 sets up the dam . . . 6
No. 4 places the dam over the plug 7
„ puts on a length of suction-pipe 9
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 100.

5 MEN.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first length of hose 46
No. 3 makes up the second length of hose 46
No. 4 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
No. 4 makes up and replaces the dam 8
No. 5 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 101.

5 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose . 27, 28
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
No. 4 puts on one length of suction-pipe 9
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 102.

5 MEN.—*Making up an engine, with 3 or more lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
" takes off the branch . . 25
" makes up the third length of hose 46
" unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipe 18
No. 4 puts the suction-pipe in the pocket 23
No. 5 locks the levers . . . 56
" takes off the hose 39, 41, 45
" folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
" mounts the engine and opens the hose-box lid . 3
" stows the gear 1
" closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 103.

5 MEN.—*Getting an engine to work, with 1 length of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
" puts on the branch . . 24
No. 2 puts on a length of hose 27
No. 3 sets up the dam . . . 6
" places the dam over the plug 7
No. 4 puts on the first and second lengths of suction-pipe 9, 10
No. 5 mounts the engine and opens the hose-box lid . 3
" takes out the dam, hose, &c. 4
" closes the lid and gets down 5
" turns over and secures the levers, and places the preventer on the ground 55
" unlocks the levers . . . 57

If necessary, harden up the joints.

No. 104.

5 MEN.—*Making up an engine, with 1 length of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
" takes off the branch . . 25
" unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipes 18, 22
" puts the suction-pipes in the pocket 23
No. 5 locks the levers . . . 56
" takes off the hose . . . 39
" folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
" mounts the engine and opens the hose-box lid . 3
" stows the gear 1
" closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 111.

5 MEN.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the third length of suction-pipe . 9, 10, 11
No. 4 puts on the first and second lengths of suction-pipe 9, 10, 11
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 112.

5 MEN.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and second lengths of suction-pipe 18, 22
No. 4 puts the suction-pipes in the pocket 23
No. 5 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine, and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 113.

5 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 3 puts on the third length of suction-pipe 9, 10, 11
No. 4 puts on the first and second lengths of suction-pipe 9, 10, 11
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers and places the preventer on the ground . 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 114.

5 MEN.—*Making up an engine, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
,, takes off the branch . . 25
,, makes up the third length of hose 46
,, unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the third length of suction-pipe . 18, 22
,, puts the suction-pipe in the pocket 23
,, makes up and replaces the dam 8
No. 4 takes off the first and second lengths of suction-pipe 18, 22
,, puts the suction-pipes in the pockets 23
No. 5 locks the levers . . . 56
,, takes off all the hose 39, 41, 45
,, folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
,, mounts the engine, and opens the hose-box lid . 3
,, stows the gear 1
,, closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 115.

5 MEN.—*Getting an engine to work, with 1 length of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
,, puts on the branch . . 24
No. 2 puts on one length of hose 27
No. 3 sets up the dam . . . 6
,, places the dam over the plug 7
,, puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe . . . 9, 10, 11, 12
No. 5 mounts the engine and opens the hose-box lid . 3
,, takes out the dam, hose, &c. 4
,, closes the lid and gets down 5
,, turns over and secures the levers and places the preventer on the ground . 55
,, unlocks the levers . . . 57
If necessary, harden up the joints.

No. 116.

5 MEN.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
,, takes off the branch . . 25
,, unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
,, puts the suction-pipes in the pockets. 23
,, makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
,, puts the suction-pipes in the pockets 23
No. 5 locks the levers . . . 56
,, takes off the hose . . . 39
,, folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers . 58
,, mounts the engine and opens the hose-box lid . 3
,, stows the gear 1
,, closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 117.

5 Men.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe 9, 10, 11, 12
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 118.

5 Men.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 locks the levers. . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 119.

5 Men.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose . 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe 9, 10, 11, 12
No. 5 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ turns over and secures the levers, and places the preventer on the ground 55
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 120.

5 MEN.—*Making up an engine, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 locks the levers. . . . 56
„ takes off the hose 39, 41, 45
„ folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 121.

6 MEN.—*Getting an engine to work, with 1 length of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the hose . . . 27
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 4 puts on the suction-pipe . 9
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 122.

6 MEN.—*Making up an engine, with 1 length of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose . . . 39
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 123.

6 Men.—*Getting an engine to work, with 2 lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the first length of hose 27, 28
No. 3 puts on the second length of hose 27, 28
No. 4 sets up the dam . . . 6
No. 4 places the dam over the plug 7
„ puts on one length of suction-pipe 9
No. 5 turns over and secures the levers, and places the preventer on the ground 55
No. 6 mounts the engine, and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 124.

6 Men.—*Making up an engine, with 2 lengths of hose and 1 length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first length of hose 46
No. 3 makes up the second length of hose . . . 46
No. 4 takes off the suction-pipe 18
„ puts the suction-pipe in the pocket 23
No. 4 makes up and replaces the dam 8
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 125.

6 Men.—*Getting an engine to work, with 3 or more lengths of hose and 1 length of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
No. 4 puts on one length of suction-pipe 9
No. 5 turns over and secures the levers, and places the preventer on the ground 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 126.

6 Men.—*Making up an engine, with* 3 *or more lengths of hose and* 1 *length of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipe 18
No. 4 puts the suction-pipe in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 127.

6 Men.—*Getting an engine to work, with* 1 *length of hose and* 2 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on one length of hose 27
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 4 puts on two lengths of suction-pipe . . . 9, 10
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 128.

6 Men.—*Making up an engine, with* 1 *length of hose and* 2 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose . . . 39
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 129.

6 Men.—*Getting an engine to work, with 2 lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the hose . 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 4 puts on the suction-pipes 9, 10
No. 5 turns over and secures the levers, and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 130.

6 Men.—*Making up an engine, with 2 lengths of hose and 2 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipes 18, 22
„ puts the suction-pipes in the pockets 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 131.

6 Men.—*Getting an engine to work, with 3 or more lengths of hose and 2 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
No. 3 places the dam over the plug 7
No. 4 puts on the suction-pipes 9, 10
No. 5 turns over and secures the levers, and places the preventer on the ground 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 132.

6 MEN.—*Making up an engine, with* 3 *or more lengths of hose and* 2 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 makes up and replaces the dam 8
No. 4 takes off the suction-pipes 18, 22
No. 4 puts the suction-pipes in the pockets 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 133.

6 MEN.—*Getting an engine to work, with* 1 *length of hose and* 3 *lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on one length of hose 27
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the third length of suction-pipe . 9, 10, 11
No. 4 puts on the first and second lengths of suction-pipe 9, 10, 11
No. 5 turns over and secures the levers, and places the preventer on the ground . 55
No. 6 mounts the engine, and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 134.

6 MEN.—*Making up an engine, with* 1 *length of hose and* 3 *lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the third length of suction-pipe . . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and second lengths of suction-pipe 18, 22
No. 4 puts the suction-pipes in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers. . . . 56
„ takes off the hose . . . 39
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 135.

6 MEN.—*Getting an engine to work, with 2 lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the hose . 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the third length of suction-pipe . 9, 10, 11
No. 4 puts on the first and second lengths of suction-pipe 9, 10, 11
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . 57

If necessary, harden up the joints.

No. 136.

6 MEN.—*Making up an engine, with 2 lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage, and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and second lengths of suction-pipe 18, 22
No. 4 puts the suction-pipes in the pockets 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine, and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 137.

6 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 3 puts on the third length of suction-pipe 9, 10, 11
No. 4 puts on the first and second lengths of suction-pipe 9, 10, 11
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 138.

6 Men.—*Making up an engine, with 3 or more lengths of hose and 3 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the third length of suction-pipe . 18, 22
„ puts the suction-pipe in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and second lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 139.

6 Men.—*Getting an engine to work, with 1 length of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on one length of hose 27
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe 9, 10, 11, 12
No. 5 turns over and secures the levers, and places the preventer on the ground 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 140.

6 Men.—*Making up an engine, with 1 length of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
„ makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pockets 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose . . . 39
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 141.

6 MEN.—*Getting an engine to work, with 2 lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage and places the sway-bars on the ground 2
„ puts on the branch . . 24
No. 2 puts on the hose . 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
„ puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe 9, 10, 11, 12
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57
If necessary, harden up the joints.

No. 142.

6 MEN.—*Making up an engine, with 2 lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the hose . . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 folds and straps the near-side levers, replaces the preventer, and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

No. 143.

6 MEN.—*Getting an engine to work, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

Places of men on the engine . 62
Set in to the plug.
No. 1 squares and locks the fore-carriage, and places the sway-bars on the ground 2
„ puts on the third length of hose 27, 28
„ puts on the branch . . 24
No. 2 puts on the first and second lengths of hose 27, 28
No. 3 sets up the dam . . . 6
„ places the dam over the plug 7
No. 3 puts on the second and fourth lengths of suction-pipe . . . 9, 10, 11, 12
No. 4 puts on the first and third lengths of suction-pipe 9, 10, 11, 12
No. 5 turns over and secures the levers and places the preventer on the ground . 55
No. 6 mounts the engine and opens the hose-box lid . 3
„ takes out the dam, hose, &c. 4
„ closes the lid and gets down 5
„ unlocks the levers . . . 57

If necessary, harden up the joints.

No. 144.

6 Men.—*Making up an engine, with 3 or more lengths of hose and 4 lengths of suction-pipe.*

No. 1 gives the word to stop pumping.
„ takes off the branch . . 25
„ makes up the third length of hose 46
„ unlocks the fore-carriage and hooks on the sway-bars 61
No. 2 makes up the first and second lengths of hose . 46
No. 3 takes off the second and fourth lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
„ makes up and replaces the dam 8
No. 4 takes off the first and third lengths of suction-pipe 18, 22
„ puts the suction-pipes in the pocket 23
No. 5 folds and straps the near-side levers; replaces the preventer and folds and straps the off-side levers 58
No. 6 locks the levers . . . 56
„ takes off the hose 39, 41, 45
„ mounts the engine and opens the hose-box lid . 3
„ stows the gear 1
„ closes the lid and gets down 5

All the men drag the engine away from the plug.

SCALING LADDERS.

INTRODUCTORY.

In order to extinguish a fire properly, it is necessary for the firemen to approach it for the purpose of putting the water wherever it is most wanted. Any attempt to extinguish a fire from a distance, almost invariably proves a failure.

The stairs of a house on fire, if made of stone, as is most common in London, usually fall down at an early stage, and, even when they do not fall down, are never safe after having once been subjected to heat; and, if made of wood, they seldom last very long after the fire has caught them.

If, therefore, the firemen are not provided with some other means of access to upper stories, every staircase fire would result in the total destruction of the building.

The following instructions are issued for the purpose of meeting this great and constantly recurring emergency, and special attention is directed to a careful study of the subject, which is one of paramount importance in the business of a Fire Brigade.

General Description of Scaling Ladders.

Scaling ladders are of two kinds, the one commonly called Italian, and the other Military.

They are alike in consisting of a number of short lengths, which fit into each other, and can be made to reach a considerable height, but they differ very materially in construction, and in the mode of forming the joints. The same drill, however, can, with a very trifling modification, be used with both.

Each of the Italian ladders consists of 2 legs or sides and 6 steps, of which the top and bottom are flat, and the remainder round. The flat step at the top passes through the legs of the ladder and projects on the outside, and both ends of the legs have slots cut athwart them to receive the flat steps of other lengths.

Italian ladders have never been adopted in this country, but as they are very strong and serviceable, and in some respects probably superior to those in use, they are certain at some time or other to be brought into notice. Any course of ladder instruction, therefore, which omits to notice the Italian ladders, would be to a certain extent imperfect, and it is on this account that they are mentioned here.

The scaling ladders at present used by the Metropolitan Fire Brigade are those hitherto commonly known as Military, and their general description is as follows :—

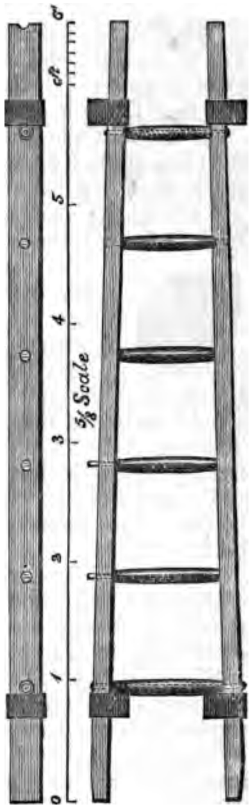
Each ladder consists of 2 legs or sides, 6 spokes or rounds, and 4 sockets.

The sides are of the best spruce deal, perfectly dry and well seasoned, and free from sap and dead or loose knots. They are 6 feet 6 inches long, $3\frac{1}{4}$ inches deep, and half that, or 1 inch and $\frac{5}{8}$, wide.

They are fitted together so as to form a taper, the top of which is $3\frac{1}{4}$ inches narrower than the bottom.

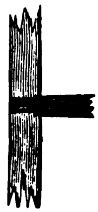
They are slightly champered off on the outside of the foot, and on the inside of the head, for about 3 inches, and there is a semi-circular groove, about $\frac{3}{4}$ of an inch deep, cut across the top, to receive the round of another length. To prevent the ends splitting, a wrought-iron rivet is let into each side from back to front, $1\frac{1}{2}$ inch from the top, and is burred down, without a washer, perfectly flush with the sides.

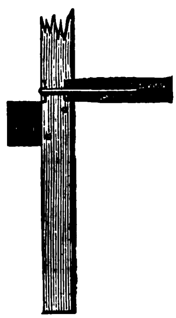
The rounds are of turned oak, well seasoned, with the ends properly fitted into and secured in the sides, with oak wedges driven in from the outside. These wedges should be driven in horizontally, and should cross the grain of the sides, so as to avoid splitting the timber. The rounds should invariably be turned from cleft, *not sawn*, pieces of oak, so as to ensure their not being cross-grained in any part.



Side and Front View.

The rounds are $\frac{7}{8}$ths of an inch in diameter where they enter the sides, and about 1 inch and $\frac{1}{8}$th in the centre. They are continued full size ($\frac{7}{8}$ths) into the sides for $\frac{5}{8}$ths of an inch, after which, for the remaining distance ($1\frac{1}{4}$ inches) to the outside, they are reduced to $\frac{5}{8}$ths of an inch. Each of the end rounds, top and bottom, is hollowed out, and contains within it a small rod or bar of iron, called a rivet, which goes through all, and is burred down at the ends over iron washers, countersunk flush with the outside. These rounds are carefully bored out, so as to allow sufficient space for strong $\frac{1}{4}$-inch wrought-iron rivets.


Showing oak wedge in end of round.


1/2" Scale

Showing iron rivet through round.

The following are the lengths of the respective rounds, taken between the sides, and not including the portion which goes through, viz.:—

6th, or top round, $8\frac{1}{4}$ in.; 5th round, $8\frac{3}{4}$ in.; 4th round, $9\frac{1}{4}$ in.; 3rd round, $9\frac{3}{4}$ in.; 2nd round, $10\frac{1}{4}$ in.; 1st, or bottom round, $10\frac{3}{4}$ in.

The distance between the rounds, measured from centre to centre, is $11\frac{1}{8}$ inches, and the distance from the top and bottom rounds to the ends is also $11\frac{1}{8}$ inches, making seven spaces of $11\frac{1}{8}$ each, or almost exactly 6 feet 6 inches altogether.

At the foot the width inside the legs or sides is $11\frac{1}{4}$ inches, and at the level of the top round, the width outside is $11\frac{1}{4}$ inches, consequently the head of any one length exactly fits in the foot of every other.

Each length is mounted with four sockets, made to a prescribed gauge, so as to fit universally.

Socket.

The sockets are of best wrought iron, 2 inches deep, nearly $\frac{1}{8}$ of an inch thick, and showing at the top an exact square of $3\frac{1}{4}$ inches on the inside, and at the bottom about $\frac{1}{16}$ less.

The end of the socket furthest from the round is $3\frac{1}{4}$ inches square, and the end next the round is $3\frac{1}{4}$ by $3\frac{1}{16}$ inches. The weld should be in the middle of the side which touches the side of the leg. The angles should be very sharp on the inside, and perfectly sound and free from flaws both inside and out.

Each socket has four holes drilled in it, and is fastened to the sides by four 1-inch screws, placed diagonally, two at the front and two at the back.

These screws are so arranged as to resist strains, those on the top of each socket being in every case near the inner edge of the timber, so as to be able to bear a strain outwards, and those at the bottom, near the outer edge, so as to be able to bear a strain inwards.

The sockets at the foot are slipped up from the bottom, as far as the first round, and are so fastened as to project and show the opening on the inside of the leg of the ladder.

Those at the head are slipped down from the top as far as the top round, and are so fastened as to project and show the opening on the outside.

The inside of the projecting portion of the lower sockets is bevelled off with a file on the bottom, and the inside of the top sockets is bevelled off at the top to assist the entry of other lengths.

The ladders measure almost exactly 6 feet 6 inches, but when they are put together, as hereafter described, they overlap each other to the extent of 11 inches.

Each additional one, therefore, after the first, adds only 5 feet 7 inches, not 6 feet 6 inches, and the lengths are consequently as follows, viz.:—

Lengths.	Ft.	In.	Lengths.	Ft.	In.
1	6	6	6	34	5
2	12	1	7	40	0
3	17	8	8	45	7
4	23	3	9	51	2
5	28	10	10	56	9

LADDER DRILL.

The proper number of men for working scaling ladders is three, and the first course of drill is arranged for that number; but as these ladders can be used in a great variety of ways, and under a great many different circumstances, and there may not always be three or even two men present, instructions are also issued explaining the mode of raising them by two men, and after that the course to be adopted by one man alone.

Everything connected with ladders is counted upwards from the ground; thus, when several lengths are put together, the bottom length is the 1st, the next length is the 2nd, the next the 3rd, and so on to the top; also, in spokes or rounds, the bottom spoke is the 1st, the next spoke the 2nd, and so on to the highest, which is called the top round.

When several ladders, however, are attached together, it may not be convenient to count all the spokes from the ground to any of the high points; and it will be found sufficient, when defining any particular one, to name merely the length to which it belongs, and the round of that length, as, "top round of 2nd length," "3rd round of 5th length," "lower round of 6th length," and so on.

Ladder Drill for Three Men.

Names of Men.	1st time.	2nd time.	3rd time.	4th time.	5th time.	6th time.
A	1	1	2	2	3	3
B	2	3	1	3	1	2
C	3	2	3	1	2	1

Before commencing, get together the necessary number of ladders in a convenient place.

"*Stand by to raise ladders.*"—On receiving this order, the men call their numbers, 1, 2, and 3.

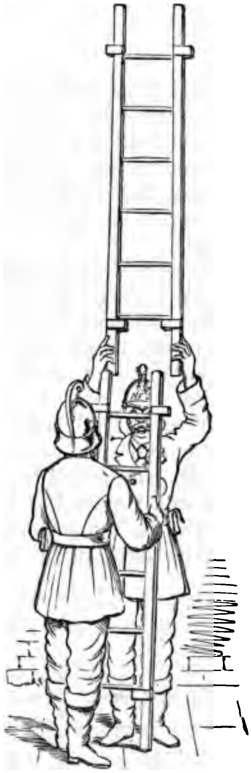
No. 1 and No. 2 then stand with their backs to the wall, about a foot out, No. 1 on the right hand side of No. 2.

"*Go on.*"—At this order No. 3 places a length of ladder in front of No. 1, with the head, or narrow end, upwards.

"*One.*"—At this word, No. 1, without stooping, seizes the sides of the ladder with both hands, fingers to the front, and thumbs behind.

Preparing to raise.

First length raised.



Adding a length.

"*Two.*"—At this word No. 1 tosses the ladder upwards, catching it again by the sides about 6 inches below the bottom round, and letting the head of it fall back against the wall, hands as before with fingers to the front and thumbs behind, the fingers slightly overlapping the inside so as to form a guide for the next length, but not turned so much round as to clutch the inside, as in this case they would obstruct the entrance of the next length; the thumbs straight up at the back.

"*Three.*"—At this word No. 3 takes another length, and, holding it by the sides a little above the centre, inserts the head of it into the sockets of the length in No. 1's hands.

"*Four.*"—At this word No. 1 removes his hands.

No. 3 then raises the ladders an inch or two off the ground by the rounds, and lets them drop again with a gentle tap so as to ensure the lower round of the top length coming home on the groove cut in the top of the sides of the lower length; and before any one is allowed to go up the ladders, No. 3 must either feel with his hands or see that this has been done, as, unless these parts touch, the joint is not properly made, and the ladders are not safe.

Should the ladders now be in a proper position for work, they may be at once used, or others added to them, according to circumstances; but should they not be right, No. 3 must adjust them before anything further is done. This is accomplished in the following manner:—

If the head is in the right place, and the foot out of line, No. 3 catches the ladders by the sides or rounds, and lifts the foot across to the required position.

If the foot is right and the head wrong, No. 3 places one foot on the lower round, so as to steady the ladders on the ground, and, catching the lower length by both sides, lifts the head a little off the wall, and places it in the necessary position.

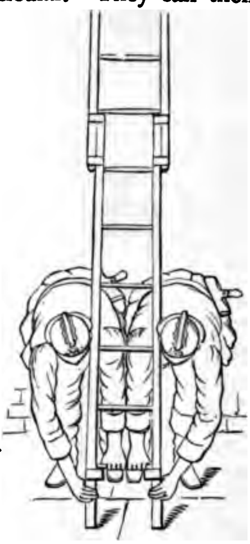
Should the whole of the ladders above and below require shifting along the wall, they may be turned over three or four times, after which it will be found that, in consequence of the difference in width between the bottom and top, the former will have gone further than the latter, and thus thrown the ladders out of the perpendicular. They can then be adjusted as previously explained, and afterwards, if necessary, move on further in the same way by turning over; the same precaution being attended to after every three or four turns.

"*Add another Length.*"—At this order No. 1 and No. 2 get into their places and prepare to raise the two lengths in the following manner, working exactly together, and being particularly careful not to shift their hands during the operation.

"*One.*"—At this word No. 1 and No. 2 stoop down; No. 1 catches the lower round near the centre with his left hand, and the side next him, about six inches below the lower round, with his right hand.

No. 2 catches the lower round near the centre with his right hand, and the side next him, about 6 inches below the lower round, with his left hand.

The left hand of No. 1 and the right hand of No. 2 should now be touching, and these hands should be clutched on the lower round, knuckles on the top and to the front, fingers passed under from the front and thumbs from behind, and the left elbow of No. 1 and the right elbow of No. 2 should touch.



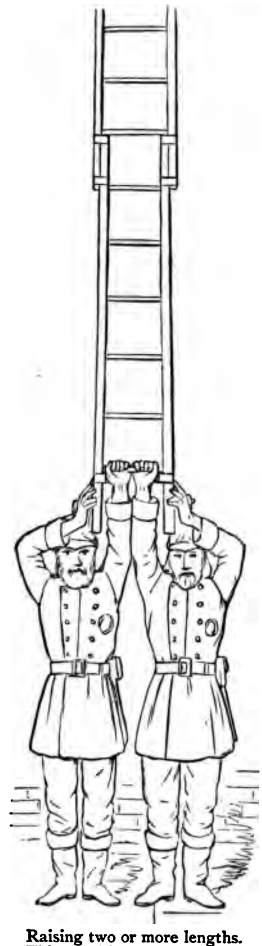
Raising two or more lengths.
First Position—Stooping down.

The right hand of No. 1 and the left hand of No. 2 should be so placed on the sides that in each case the thumb and fore-finger should be about on a level, the thumb behind and all the fingers in front, and slightly overlapping the inside, so as to form a guide for the next length, but not turned so much round as to clutch the inside, as in this case they would obstruct the entrance of the next length.

"*Two.*"—At this word the left shoulder of No. 1 and the right shoulder of No. 2 should be pressed lightly against the sides of the ladders, and as soon as the men feel the weight, they should bring themselves steadily, gradually, and without jerking, to an upright position, raising the ladders with them; and in case of roughness, projections, or other obstructions on the wall, lifting the head of the top length clear by supporting the weight on their shoulders, at the same time taking a short step forward, so as to keep the ladders at the same angle from the wall as before.

After the men have raised themselves to an upright position, by straightening their backs and legs, the bottom of the ladders will be about 2 feet off the ground.

Raising two or more lengths.
Second position—Standing up.



Raising two or more lengths. Third position.—Pushing up.

"*Three.*"—At this word No. 1 and No. 2 will push the ladders up about four-and-a-half feet higher by means of the arms alone, casting their eyes aloft, and, in case of the head of the ladders not going up straight, following it with the foot in the same direction, and moving about as may be required, so as to keep the ladders as much as possible in a vertical position.

As this is the most important of all the operations in ladder practice, and the slightest irregularity or awkwardness in it may cause delay or danger, the greatest care is enjoined in carrying it out precisely as here directed; and, as in many cases plaster or other substances falling from the wall may prevent No. 1 and No. 2 from seeing the head of the ladders properly, No. 3 must carefully watch the proceedings, and must tell them which way to move, "to the right" or "to the left," as the case may be.

In both these lifts the greatest care is necessary to keep the hands steady and the elbows touching, as, in the event of the slightest neglect occurring in either of these particulars, the ladders will either turn out of the perpendicular on the wall, or under certain circumstances may fall down altogether, and be broken.

"*Four.*"—At this word No. 3 inserts another length as before.

"*Five.*"—No. 1 and No. 2 remove their hands, and No. 3 takes the same precautions as before to ensure that the joint is properly made, and also that the ladders are in a proper position either for immediate use or for adding others on.

"*Add another length.*"—Should this be required, it will be done exactly as before, in five movements, viz.:—1. Stoop down. 2. Stand up. 3. Push up. 4. Insert the other length. 5. Remove the hands and adjust.

This may be quite safely continued as far as five lengths, and with great care and caution as far as seven, or perhaps eight, but with more than this last-mentioned number common scaling ladders are not safe.

Directions for Using the Ladders.

When the ladders are used merely for the men to pass up or down, one man will place his right foot on the lower round touching the right hand side, or his left foot on the same round touching the left hand side. His knee or leg should press lightly but firmly against the next round, and his hands should clutch the sides with a strong firm grasp. If this be properly done, he can counteract the spring of the ladders very considerably, and increase their strength in a corresponding degree. As the men go up or down, he may remove one hand to let them pass, but so long as any man is on the ladders, he should not remove either his foot, or, unless absolutely necessary, his second hand.

"*Get a length of hose up.*"—At this order, No. 3 will take a line up, and will pass the end from the front over the highest available round below the point at which the ladders are supported, letting the end come to the ground at the back.

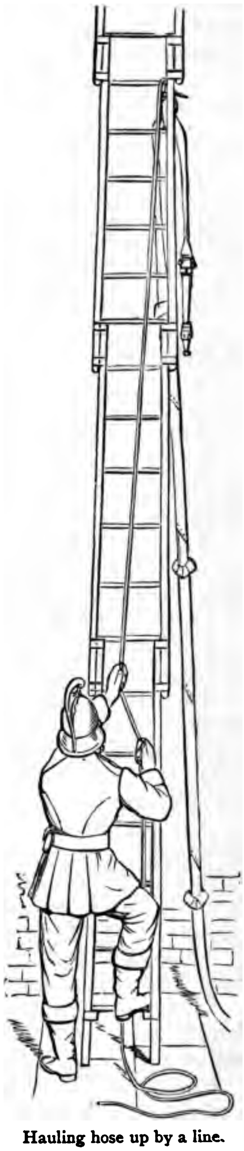
He must ascertain at which side the branch is to be used, and he must keep the line close to that side, so as not to cross the ladders with it, or obstruct the men passing up or down. He will then immediately come down far enough to be able to take hold of the branch when the hose has been hauled up, but he must be careful not to move while No. 1 is hauling on the line.

No. 1 will take the place which No. 3 had when the ladders were being raised; he will light up the line to No. 3, keeping, all through, the fall in his hand, so as to be ready to haul up when the hose is laid out.

No. 2 will lay out a length of hose on the ground in a convenient way for hauling up; he will then screw on the branch, and make fast the line with two round turns and two half-hitches to the proper becket; and when this has been done, he will give the word "haul up" to No. 1, and will light in the hose under the ladders, so that the drag may be as nearly as possible vertical, and on no account sideways.

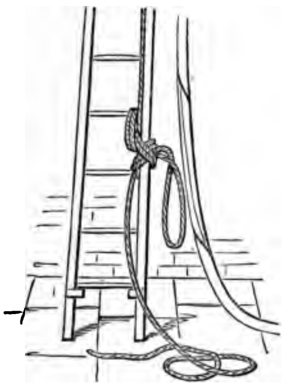
No. 1 will now let go the sides with his hands, but without removing his foot off the lower round, and will haul on the fall of the line until he has got the hose sufficiently high, and in doing this he must be careful to keep his hands and arms, and the whole weight of his body, close to the ladders. By this he will increase the friction of the line passing over the round, and will consequently lose a certain amount of power; but he must be careful to remember that, if he draws back his body at all, he may pull the head of the ladders off the wall, and he must therefore on no account neglect the precaution here enjoined.

While No. 1 is hauling on the fall of the line, he may be materially assisted by No. 3, who, without moving his body or feet, may throw his arms round to the back of the ladders, and help to light up the line.


Hauling hose up by a line.

When the hose has been hauled up sufficiently high for No. 3 to take hold of the branch, No. 1 should take a turn of the line on some convenient round, and, still keeping the fall in his hand, take hold of the sides again, and secure the ladders as previously for No. 3 to pass up with the branch; and as soon as No. 3 has done this, he will probably give the order to No. 1 to lower a little, so as to give the becket a swing clear of the round, and also to take out any bends or loops between the branch and the becket.

As soon as No. 3 has called out that all is right, No. 1 will for a moment remove his hands from the sides, and will pass the line, or a bight of it, from the front to the back under some convenient round, then from the back to the front over the next or second next round above, and secure it by a clove hitch on the side about half way between the rounds. No. 1 will then take hold of the sides, as before, and as long as any man is on the ladder, he must continue to keep charge, unless he is properly relieved. No. 2 must see that the hose has a straight and proper lead up to the ladder, as any neglect in this particular may have the effect of dragging the head sideways or outwards when the engine gets to work. He will then, if necessary, go up the ladder and assist No. 3; and, as soon as all is ready, the engine may be started in the usual way.



Line made fast.

No. 1 must be careful to keep a firm hold of the sides whenever a man is moving on the ladders, and he must, if necessary, caution them not to move more than one at a time.

"*Lower the hose down.*"—At this order, send word to stop the engine, and, when the jet ceases, No. 1 should haul on the line until the becket touches the round over which the line passes.

No. 3 then comes down with the branch, and when his hands are about on a level with that round, he lowers the branch hand-over-hand, until it swings by the hose.

He then sings out "Lower away," and himself remains steady. No. 1, on receiving this order, casts off the knot, and lowers down the hose by paying out line, and, as soon as the branch and screws are on the ground, he lets go by the run. The line should then be cast off the becket and unrove, and the men on the ladders should come down one by one; No. 1, in the meanwhile, keeping charge, and never leaving his post as long as there is a man on the ladders.

"*Strike the Ladders.*"—At this order the three men take their places as at first; No. 1 and No. 2 under the ladders, and No. 3 in front.

"*One.*"—At this word No. 1 catches the lower round of the second length, near the centre, with his left hand, and the side next him, about six inches below the lower round, with his right hand.

No. 2 catches the same round near the centre with his right hand, and the side next him about six inches below the lower round with his left hand.

The left hand of No. 1 and the right hand of No. 2 should now be touching, and these hands should be clutched on the lower round of the second length, knuckles to the back, fingers passed over, and thumbs under, to the front, and the left elbow of No. 1, and the right elbow of No. 2, should touch.

The right hand of No. 1 and the left hand of No. 2, should be so placed on the sides that in each case the thumb and fore finger should be about on a level, the thumb behind, and all the fingers in front, with the hands firmly holding the sides of the outer or second length, but the points of the fingers not pressed on the sides of the inner or lower length.

"*Two.*"—At this word, No. 1 and No. 2 raise the ladders, by means of their arms, about four inches off the ground.

"*Three.*"—At this word, No. 3 strikes off the lower length by a sharp tap of his foot; in performing this operation considerable skill and practice are necessary, to avoid throwing down, or unduly straining, the men who are holding up the ladders. A steady pressure is of no use at all. It must be done by a sharp, quick tap of the foot, and without any of the weight of the body being brought upon it.

"*Four.*"—At this word, No. 1 and No. 2 lower their hands very slowly, until the ladders come to their shoulders, casting their eyes as much as possible aloft, and taking a short pace back, so as to keep the ladders at the same angle from the wall as before.

"*Five.*"—At this word, No. 1 and No. 2, still keeping their eyes aloft, stoop down, until the foot of the ladder touches the ground, bearing the weight all through on their hands and shoulders, and as little as possible on the wall; and at the same time being careful not to allow the top length to get unshipped by the sockets or rounds catching in projections above.

"*Six.*"—At this word, No. 1 and No. 2 let go the ladders, and rise up.

The same process is continued until there are only two remaining; and, as in raising the ladders, No. 3 is responsible for seeing that before each change they are in a proper position. No. 3 must also, during the movement, watch the head of the ladders, and, in case of its going to the right or left, must advise No. 1 and No. 2 accordingly.

When there are only two lengths remaining, No. 2 stands aside.

"*One.*"—At this word, No. 1 catches the upper length with both hands by the sides, about six inches below the bottom round.

"*Two.*"—At this word, No. 1 raises the ladders, by means of his arms, about four inches off the ground.

"*Three.*"—At this word, No. 3 strikes off the lower length, as before.

"*Four.*"—At this word, No. 1 opens his hands, and lets the ladder drop, catching it again, a little above the middle, before it reaches the ground.

SUMMARY.

Raising two lengths.	*Striking two lengths.*
Go on.	Strike.
1. Take hold.	1. Take hold.
2. Toss up.	2. Raise up about 4 inches.
3. Add on the length.	3. Kick off the length.
4. Remove the hands.	4. Drop down.

Raising more than two lengths.
1. Stoop down.
2. Rise up.
3. Push up.
4. Add the length.
5. Remove the hands.

Striking more than two lengths.
1. Take hold.
2. Raise up.
3. Kick off.
4. Lower down.
5. Stoop down.
6. Remove the hands.

LADDER DRILL FOR TWO MEN.

Names of Men.	1st time.	2nd time.
A	1	2
B	2	1

This is almost a precise copy of the drill for three men.

In the heavy lifts, No. 1 and No. 2 act together, as before; and in all the other movements they take the work of the third man between them.

This, as hereafter described, involves three additional movements; but on examination these will be found to be merely the unavoidable changes of the men's hands. The principles are so exactly the same as those already explained, that when once the men have acquired a knowledge of the drill with three working together, they will have very little difficulty in carrying it out with two.

"*Stand by to raise Ladders.*"—On receiving this order, the men call their numbers 1 and 2. No. 1 stands with his back to the wall, and No. 2 gets ready the ladders.

"*Go on.*"—At this word No. 2 places a length of ladder in front of No. 1.

"*One.*"—As before.

"*Two.*"—As before.

"*Three.*"—As before, except that No. 2 does all that No. 3 was there ordered to do.

"*Four.*"—As before. No. 2 then sees that the ladders are safe, as No. 3 did in the previous drill.

"*Add another length.*"—No. 1 and No. 2 get ready as before.

"*One.*"—As before.

"*Two.*"—As before.

"*Three.*"—As before.

"*Four.*"—At this word No. 2, without jerking the ladders, quickly moves his left hand about four inches down the side, to make room for No. 1's left hand.

"*Five.*"—At this word, No. 1 moves his left hand quickly but steadily to the left side of the ladder, at the same time, if necessary, taking a short pace in that direction, and as soon as he has got a firm hold, he says "All right."

"*Six.*"—At this word—which should never be given until after No. 1 has said "All right"—No. 2 slowly and steadily removes his hands, at the same time taking every precaution not to jerk or shake the ladders.

"*Seven*."—At this word, No. 2 adds another length, as No. 3 did in the previous drill.

"*Eight*."—No. 1 removes his hands, and No. 2 adjusts the ladders.

"*Add another length*."—As before, in eight movements, viz.:—1. Stoop down. 2. Stand up. 3. Push up. 4. No. 2 shifts left hand. 5. No. 1 shifts left hand. 6. No. 2 lets go. 7. Add another length. 8. Remove hands, and adjust.

This, with great care, may be continued as far as five or six lengths; but No. 1, having only the sides to hold by, can scarcely bear the weight of a greater number.

Whenever the ladders are being raised by only two men, there will be no objection to bringing the foot out to a considerable distance from the wall, in order to reduce the weight or downward pressure, and, as soon as a sufficient height has been obtained, the foot can be carried in so as to place the whole at any angle that may be most convenient for use.

"*Strike Ladders*."—At this word, No. 1 stands behind, and No. 2 in front.

"*One*."—At this word, No. 1 catches the second length with both hands by the sides, about 6 inches below the lower round.

"*Two*."—At this word, No. 1 raises the ladders about 4 inches off the ground, and he may, if necessary, be assisted in this operation by No. 2 lifting the lower length.

"*Three*."—At this word, No 2 strikes off a length, as before, and laying it down as quickly as possible, takes hold of the foot of the remaining lengths, so as to assist No. 1.

"*Four*."—At this word, both men lower the ladders hand-over-hand until they reach the ground. This will be found an exceedingly awkward and dangerous movement, and the greatest care will be necessary to prevent the head from going to one side, as, in the event of this happening, it is almost impossible for the men to keep the ladders from falling.

"*Five*."—Let go the ladders, and adjust.

The same process is continued until there are only two lengths remaining, after which the men proceed as in the previous drill, No. 2 taking the place assigned there to No. 3.

Ladder Drill for one Man.

This is hardly worthy of the name of drill, and is added here chiefly for the purpose of warning the men that they should never attempt to raise the ladders, in either of the modes previously described, except when they have at least two skilled firemen present.

When one fireman finds himself obliged to raise ladders single handed, his only safe course is to lay the lengths flat on the ground, to join them together in that position, and to secure each joint with a proper lashing of pocket line or other cord.

When he has got a sufficient number of lengths together, he should bring the heel of the ladders to the wall, and, getting under the head, should move inwards towards the heel, pushing up the ladder as he goes until it is in an upright position, and then drawing the foot out as far as necessary.

This is called butting ladders, and it is a very safe and convenient mode of raising them where there is room enough.

The disadvantage of it obviously is, that one man alone could not raise more than about four lengths, if so many. To counterbalance this, however, it has one very great advantage, which is, that it is generally understood by everyone, and that any persons, however unskilled, who might happen to be present, even women and children, would be able to give the fireman all the aid which he would require for butting any reasonable number of lengths.

For Getting down from an Elevation.

Firemen frequently find themselves on the top of a wall, in the upper stories of a house, or on some other elevation, from which it is necessary for them to find their way down by means of ladders, and this operation is performed in the following manner:—

If they have plenty of small line handy, they can put on the lengths and lash them together until they have a sufficient number to reach the ground, or the level to which they wish to get access; and, if the room or other place in which they have to work be small, they will have to launch the lengths out as they are attached, holding on fast to the top length.

If, however, they have not enough small cord, and have to use a large line, they must make it fast to one of the rounds of the lower length, and merely pass it through, but not make it fast to any of the others; and they must launch the ladders over with great care and steadiness, keeping a strain on the line so as not to let the lengths get unshipped as they go down.

The utmost caution is necessary before getting on ladders let down in this way, particularly at night, or in dense smoke, when it is impossible to know whether the sides are home in the sockets, until a weight is put on them.

GENERAL REMARKS.

The strength of timber is greatest in the direction of the grain, and least across the grain. Ladders, therefore, are strongest when perfectly upright, and weakest when horizontal; and in all intermediate positions they have degrees of strength corresponding to the angle at which they are placed.

If, therefore, a very heavy weight of men and hose is to be carried, the foot should be brought in as close as possible to the wall; and then a very serious danger arises, which, if not thoroughly understood and guarded against, may lead to bad consequences.

If the ladders are perfectly upright, or nearly so, the pressure of the head against the wall is so slight, that the smallest drag outwards on the hose or line, or even an awkward movement on the part of the man who is on them, may have the effect of pulling them down altogether. It will, therefore, be seen that the greatest strength cannot be got out of the ladders without incurring a very considerable risk, and at the same time sacrificing nearly all the advantage of having them at a convenient angle.

Again, if it is impossible—in consequence of areas, uneven ground, or other causes—to bring in the foot to a reasonable distance, and the ladders are consequently at a wide angle from the wall, great additional care will be necessary to avoid breaking them, as the strain will then be thrown on their weakest part, which is across the grain. Under such circumstances, therefore, especial care must be taken to see that the ladders are not overloaded.

From these explanations, it will be perceived that it would be at least undesirable, if not altogether impossible, to lay down a precise rule which would be applicable to every case, and that it must always depend on the discretion of the senior present to place the ladders in such a position as to obtain from them the best combination of advantages in the way of strength, safety, and general convenience, according to the circumstances of the movement.

A ladder laid horizontally on two walls, or other supports, not more than four feet apart, may safely be relied on for men to cross by, one at a time; but if the walls are so far apart that the ladder is supported only by its ends, it is hardly safe. In such a case—which should only be resorted to in great extremity—the best way of proceeding will be for the man to lie down altogether on the ladder, so as to distribute his weight over as much as possible of the sides, and to creep over very slowly and steadily. A very light plank, however, even a half-inch piece of deal laid over a ladder in this position, will have the effect of so distributing the load, as to make it perfectly safe for a man to walk across.

Should the walls be so far apart that one length of ladder will not reach across, two may be put together and a third laid along, with its middle under the joint of the first two, and securely lashed at the ends with strong lines, so as to keep the whole together, and to counteract the spring, which it would not do if placed above, unless fastened at every round, which would involve considerable time and trouble, and perhaps require more line than it would be convenient to provide at the moment.

With ladders arranged in this way, a man may, by creeping very steadily and carefully, cross over a space of about nine feet; or if he can procure a good one-inch plank to lay over the ladders, he may venture over a space of about eleven feet.

Under certain circumstances, when two lengths are put together, three others, also attached, may be fastened under or over them, so as to break joint—that is to say, the joint of the two lengths would come in the middle of the centre length of the three—and the whole, properly lashed together, may be thrown across a space of eleven or twelve feet. This arrangement, however, owing to the number of ladders required and the consequent weight, will be found somewhat difficult, except when there is plenty of help on the spot.

For distances greater than twelve feet across, ladders laid horizontally are not safe.

A ladder has its greatest strength (either with or across the grain) at the point at which it is supported; its least strength at the centre, between the supports; and at the intermediate points it has degrees of strength exactly corresponding to the distance from the supports.

Thus, a single length placed on the ground, with its head resting against a wall in the usual way, has its greatest available strength either at the 1st or 6th round, its least strength at the 3rd or 4th round, and an intermediate degree of strength at the 2nd or 5th round.

Again, if two lengths be put together in the usual way, and placed against a wall about 10 feet high, so that the upper length will rest on the top of the wall above the 5th round, there will be eleven rounds between the supports, and the strength will be as follows, viz. :— Greatest at the 1st or 11th round; next greatest, 2nd or 10th round; next greatest, 3rd or 9th round; next greatest, 4th or 8th round; next greatest, 5th or 7th round; least of all, 6th round, that being in the middle, between the supports.

The 12th round, being in this case above the point of support, should not be calculated on as having any strength at all, inasmuch as any weight placed on it might have the effect of tripping the heel of the ladders and throwing the whole down; and, in all cases of ladders projecting beyond the points at which they are supported, care must be taken to avoid placing any weight whatever, either by lines or otherwise, above the supports.

The best round over which to pass a line is the next below the point of support; or, if that round be very near the wall, and any difficulty is experienced in getting the line over it, the next round lower down may be used; but it must always be remembered, that the further the round is from the point of support, the weaker the ladder is at that spot.

Precisely the same principle holds good with regard to the rounds themselves, their weakest part being the centre, and their strongest part at the point next the sides.

For this reason the line must always be kept close to the side where it passes over the round, and for general convenience it is carried down and made fast along the same side.

When time admits, the strength of these ladders can be very considerably increased by the addition of a strut on one of the middle lengths, with a line passing over it from the highest round of the top length to the lowest round of the bottom length, and hauled taut.

If the strut be placed underneath, the line becomes a pair of ties, and takes the tension, and by so doing it throws the sides into a state of compression; in short, the whole ladder is converted into a species of trussed girder, the strength of which depends on that of the ties.

With this simple trussing, scaling ladders may be safely used to almost any height.

The peculiar characteristics, which distinguish these ladders from all others, are the number and variety of uses to which they can be applied. Of these, a few of the most prominent are :—

1st.—That they are of the most convenient and portable description, being only 6 feet 6 inches long and about 20 lbs. weight each.

2nd.—That they can be carried in through houses, courts, narrow passages, and many other places into which it would be impossible to bring fire escapes or other long ladders, and, after being brought through, they can be run up to a height of some 40 or 50 feet in a short time, without much risk or trouble.

3rd.—That they can be so arranged and adapted as to form a safe and strong medium of communication between the ground and any floor or level above, and can also be passed over the eaves of a roof.

4th.—That they can be used within rooms or on landings, roofs, or leads of houses.

5th.—That, in case of the men being obliged to pass from one wall to another, they can be so arranged as to form a safe platform on which to cross, and so adapted as to fit any reasonable span.

6th.—That after having been put into position, they may, to a very large extent, be used by unskilled persons.

Some of these advantages can be obtained from the ordinary builders' and fire escape ladders, and others from the hook ladders used by the French, and other foreign fire brigades; but the builders' and escape ladders cannot be brought through houses or narrow courts, and the hook ladders cannot be used inside rooms, except under the most favourable conditions; cannot be passed over eaves of roofs at all; and, being suspended and therefore perpendicular, cannot be made available for the use of unskilled persons under any circumstances whatever; whereas the scaling ladders can, under proper management, be made available for almost everything that either or both of the other kinds can accomplish.

The disadvantages and dangers connected with scaling ladders are:—

1st.—That, in order to have them portable, they are made so light as not to be able to carry heavy weights, except in a very upright position.

2nd.—That, for convenience and general adaptability, they are fastened together without any cross stay, or other means of resisting the effects of an unequal pressure on the two sides; and, in the event of a slight fall, if one leg strikes the ground before the other, the whole ladder is likely to be wrenched out of shape.

3rd.—That, if they be raised to 30 or 40 feet, the whole height must consist of several short lengths, with a corresponding number of joints, and consequently an irregular strength and an unequal spring throughout.

Taking, however, all things into consideration, there does not, up to the present time, appear to be any description of ladder so suitable for the general purposes of a fire brigade; and with properly trained firemen, who know how to avail themselves of the advantages and to avoid or neutralise the disadvantages, they may be so managed as in a great degree to combine the merits of all the other ladders hitherto brought into use.

FIRE ESCAPES

AND THE

RESCUE OF LIFE FROM FIRE.

INTRODUCTORY.

THE business of saving life from fire is one embracing so many and such various branches, not only of professional knowledge, but also of personal qualities, that any instructions laid down for the purpose, however carefully and skilfully prepared, must under particular conditions necessarily prove imperfect.

Notwithstanding, however, this unavoidable drawback, there are certain general directions, which under ordinary circumstances may prove useful to men entrusted with this responsible duty; and which, if thoroughly understood in their true spirit—not as absolute rules, but rather as a species of suggestive instruction—may assist men placed under difficult circumstances in deciding quickly and accurately as to the best course to be pursued according to the exigencies of the moment.

If all houses were exactly alike, with the same contents, the same number of inmates, those persons of the same ages, the same conditions of activity or helplessness, and occupying the same parts of the houses, it might be possible to lay down precise rules for their rescue; but, when it is remembered that not only are these circumstances never alike in any two cases, but that the time of the call being sent away from the house on fire, the time of its being received at the escape station, and the time of the arrival of the escape, all depend on a number of contingencies, which differ most materially, and can never in any way be foreseen, it will at once be obvious that, in almost all cases, everything depends on the quickness, presence of mind, and personal activity of the fireman in charge, who, of course, before being placed on such a duty, must have received complete instructions as to the use and management of the machine under all circumstances, of whatever kind.

The following general instructions have been prepared for the purpose of reducing to regularity and method the several distinct branches of knowledge connected with the use and management of fire escapes:—

They consist of four parts, namely—

1st.—A description of a fire escape, giving in detail the names and uses of the several parts.

2nd.—A course of drill.

3rd.—The method of making an inspection.

4th.—The general mode of carrying on the duty of saving life from fire—which is, in fact, the practical application of the information contained in the three other parts.

The modes of rescue here indicated are those which, in ordinary cases, may be expected to be successful; but it is obvious that there may be, under certain circumstances, many others, and many combinations or adaptations of these; and the fireman in charge of an escape should not on any account follow any part of the directions here given, unless it commend itself in every particular to his judgment and discretion at the moment.

It is to be distinctly understood that this is a book of instructions, not of orders; that a fireman should be considered responsible for doing the best according to his judgment; and that the fact of his following any one or more of the modes here pointed out will not relieve him in the smallest degree from that responsibility, unless he is able to testify absolutely, and without reservation, that the course pursued by him was that which *he himself* considered best at the moment of adopting it.

If these instructions be thoroughly understood in this light, and diligently and thoughtfully studied during the hours of rest and leisure, they cannot fail to become the means of assisting firemen in that most important part of their business, which consists in forming quick and sound judgments as to the best practical means of saving life under difficult circumstances and in great emergencies.

GENERAL DESCRIPTION.

A Fire Escape is a ladder mounted on a carriage with four wheels, two high and two low. When all the wheels are on the ground, it stands at an angle of about 25 degrees from the perpendicular, and would fall over unless supported either by being pitched against a wall, or balanced by a pressure at the end of the folding lever attached to the carriage.

Fire escapes are of various sizes and patterns, and differ considerably in certain small matters of arrangement of parts, and so forth; but the best of those in use are for the most part similar in all the essential points.

Description of a Fire Escape,

with ladders, of the following dimensions, namely—

	Feet.	Inches.
Main ladder	31	0
Fly ladder	19	2
First floor ladder	15	10
Supplementary length ...	10	1

High Wheels.

This machine has two high wooden wheels, with iron tires 1½ inches wide and 7-16ths of an inch thick; the spokes are of oak, the felloes ash, and the stocks elm; the height is 5 feet 6 inches, the width outside the tires 6 feet, and outside the naves or stocks 6 feet 5 inches; the naves are 9½ inches long; each wheel has an iron box 7½ inches long, and 7-16ths of an inch thick.

AXLE.

The axle is of best fagotted iron, 2⅛ inches in diameter at the centre, 1¾ inches square under the springs, and 1¾ inches in diameter in the arm at the shoulder, and fitted with flaps 2 inches wide, ½ inch thick, and 6 inches from end to end, to take the spring blocks; the length of the axle is 4 feet 10 inches from shoulder to shoulder, and the total length 6 feet 4 inches; the axle is fitted at the ends with right and left handed screwed nuts and linch-pins.

SPRINGS.

The machine is hung by means of scroll irons on a pair of the best town-made steel springs without joggle plates, 4 feet long, with a single sweep; the springs consist of 7 plates, each 2 inches wide, and the whole 2 inches thick at the centre; the top or tension plate is of No. 2 Birmingham gauge, and the others of No. 3 gauge; the top plates, at both ends, are bent round into 5-8th inch eyes so as to clutch the bolts by which they are secured; the springs are attached, at the front end, direct to the scroll irons, and, at the hind end, to a pair of double spring shackles 4 inches in length, 1¾ inches wide at the ends, 1 inch at the centre, and 7-16ths of an inch thick.

FRONT SCROLL IRONS.

The front scroll irons are of best wrought iron, 1½ inches wide by 7-8ths of an inch thick, bent round to a proper arc; they are partly flattened where they are secured to the frame, and are secured by two screw bolts and nuts; the lower end is flattened out to 3⅜ inches wide and 1 inch thick, and is made with a slot, 2⅛ inches inside, to take the fore end of the springs, and is fitted with two eyes 1¾ inches outside; the inside is made to take a 5-8th inch bolt.

HIND SCROLL IRONS.

The hind scroll irons are of best wrought iron, of the same substance as the front scroll irons, and made and secured at the top in the same manner; the bottom is 2 inches wide and 1⅞ inches in diameter, with 5-8th inch eyes to take the hind cross-bar and the shackles of the springs.

SPRING BLOCKS.

Blocks of wood about 2½ inches in depth are placed between the springs and the axle, so as to raise the whole carriage, and are fastened on with a plate, clip, and nuts in front, and a bolt passing through the block behind.

FRONT CROSS-BAR OF SPRINGS.

The front cross-bar of the springs is a straight wrought-iron bar, 3 feet 4¾ inches long, and ¾ inch in diameter, with turned flaps to fit inside the two scroll irons, and eyes to take the front spring bolt, and to keep the springs firmly in their places.

HIND CROSS-BAR OF SPRINGS.

The hind cross-bar of springs is a wrought-iron bar, 4 feet and ¾ inch long, and 1¼ inches in diameter, cranked to a depth of about 6 inches, for the purpose of taking the men's feet when getting on or off the carriage lever while the main ladder is lowered; this bar is fitted loose in the eyes of the hind shackles, so as to allow the crank to change its position.

CARRIAGE.

The carriage is composed of two parts, called respectively the top and bottom carriage frames; the bottom frame is attached to the axle of the high wheels by scroll irons and springs; the top frame is supported from the bottom frame by a system of stays, and is on a level with the main ladder.

BOTTOM CARRIAGE FRAME.

The bottom carriage frame is a rectangular wooden frame 4 feet 4 inches long, and 3 feet 10 inches wide, the two sides projecting about 2¾ inches at each end beyond the transverse bars; it is of best well-seasoned ash, and is secured by morticed joints at the angles; the front part is slightly cut away or dipped in the centre, so as to clear the shoot and hammock; the whole of this frame is underneath the main ladder.

SHIPPING HOOKS.

On the front bar of the lower carriage frame two shipping hooks are fitted, of sufficient strength to carry the 1st floor ladder when not in use.

UPRIGHT STAYS.

At each side of the bottom carriage there is one straight bar of wrought iron 1 foot 5 inches in length, bent at the ends, and secured to the carriage frame by bolts and nuts, for the purpose of supporting the top carriage frame; the bar should be of sufficient strength for the purpose.

HIND OR BENT STAYS.

At the hind or lower end of the bottom carriage there are four bars of wrought iron, curved so as to meet the lower end of the main ladder and the hind end of the top carriage frame, which protrudes about 2 feet beyond the corresponding part of the bottom frame; the bars should be of sufficient strength for the purpose.

CROSS-BAR OF HIND STAYS.

There is a wrought-iron bar, 3 feet 10 inches long and 1 inch in diameter, fitted across the centre of the bent stays, and secured to them by bolts and nuts to keep them in their places.

SPLIT STAYS.

There are two wrought-iron bars, 1¼ inches wide and 7-8ths of an inch thick, each attached in two places to the front part of the bottom carriage frame: these stays are curved at the top; the bottom is split and curved, and fastened to the bottom carriage frame with two bolts and nuts, for the purpose of supporting the main ladder, to the sides of which they are firmly fastened with one bolt and one screw.

Long Side Stays.

There are two wrought-iron bars, 5 feet 4 inches long and $\frac{3}{4}$ inch in diameter, flattened at each end, and extending from the fore part of the bottom carriage to the sides of the main ladder, at a distance of about 10 feet from the heel-board, each secured to the front end of the side of the lower carriage by two bolts and nuts and one screw, and to the side of the main ladder by one bolt and nut and two screws; these bars are to take the side thrust of the main ladder when loaded or travelling.

Top Carriage Frame.

The top carriage frame is a rectangular frame, consisting of two wooden sides, a wooden heel-board, and an iron cross-bar; the sides are of ash, 3 inches deep and $1\frac{1}{4}$ inches thick, and the cross-bar is a strong bar of best wrought iron, $\frac{3}{4}$ inch in diameter, passing through the sides of the main ladder, of which it forms the lower round; this bar is cut with screws at each end to receive the lever line cleets and ferrules, which also form nuts to keep the bar in its place; the cleets are 6 inches long, $1\frac{1}{8}$ inches wide, and 5-8ths of an inch thick, and are tapered at the ends.

Heel-Board.

The heel-board, or lower part of the top carriage frame, is of ash, 8 inches deep and $1\frac{1}{4}$ inches thick; this acts as the lower support of the main ladder.

Side Ladders.

The top frame is on a level with the main ladder, its sides forming the outer legs of two side ladders, the inner legs of which are formed of the lower part of the main ladder, which should have no inside spokes for about 7 feet from the bottom; in addition to the top and bottom supports, by means of the cross-bar and heel-board, it is further strengthened on each side by 5 oak rounds, with two bolts or rivets on the second and fourth respectively from the bottom.

Side-Ladder Handles.

On the outside of each of the side ladders is a fixed bent iron bar, $\frac{3}{4}$ inch in diameter and about 2 feet 6 inches in length, secured to the top carriage frame by two bolts and nuts passing through T flaps at each end; these are used as handles for the men to hold on by, and prevent them from falling on the high wheels.

Lug Irons.

At the lower end of the sides of the top carriage frame, there are fixed 3-8th inch plates, 3 feet 3 inches long, $1\frac{1}{4}$ inches wide, bent so as to form a clamp round the bottom end of the top carriage frame, and extending upwards about 1 foot 6 inches both at the back and front; there are welded to the same, at a distance of 5 inches from the bottom, a pair of lug irons, $1\frac{1}{4}$ inches wide, and 3-8ths of an inch thick, to act as a part of the hinge attaching the carriage lever; the other part is formed of the corresponding irons on the carriage lever.

Small or Lever-Wheel Axle.

There is fitted to the lower end of the top carriage frame an axle for the small or lever wheels, made of the best wrought iron, 1½ inches wide, and ½ inch thick; the arm of the axle is 5 inches long, 1 inch in diameter at the shoulder, and tapered to 7-8ths of an inch at the outer end, and it is fitted with washers and linch-pins; the length between the shoulders is 4 feet 1 inch, and the total length 4 feet 11 inches.

Small or Lever Wheels.

On the axle above mentioned, there are fixed two small wheels, made of best cast iron, 1 foot 3 inches in diameter.

Scotch Blocks.

There are four wooden blocks, 9 inches long and 4 inches thick, two for each of the high wheels, attached to the spring blocks of the large axle by chains, and made to hang up when not in use; the hind blocks are fitted with iron shoes to take the felloes of the wheels, and with chains, 1 foot long, to keep them steady.

Hind Scotch Hooks.

On the side ladder, at a distance of about 2 feet 6 inches from the bottom, there are fixed a pair of small iron hooks, for the purpose of hanging up the hind Scotch blocks.

Front Scotch Hooks.

There are mounted on the front cross-bar of the springs a pair of small S hooks, for the purpose of hanging up the front Scotch blocks.

Bucket Hook.

A strong wrought-iron S hook is secured round the centre of the axle for hanging a bucket on.

Carriage Lever.

There is attached at the lower end of the top carriage a hinged folding frame, 6 feet long and 3 feet 10 inches wide, consisting of two outer sides, two inner sides, a foot-board, and a top or hand iron; both outer and inner sides are 3 inches by 1¾ inches at the bottom, where they are hinged, and slightly tapered towards the outer ends; the foot-board is 5 inches deep and 1¼ inches thick; the sides and foot-board are of ash; the hand iron is a bar of wrought iron, 1 inch in diameter at each end, and 1¼ inches in the centre, extending along the top or hind end, bent at the ends about 8 inches, and secured by bolts and screws to the outer sides, and by iron clamps to the ends of the inner sides; the whole frame is firmly joined together at the angles, and further strengthened by three oak rounds between each pair of sides, which form a pair of side-ladders for the carriage lever; the top and bottom rounds of these side-ladders are strengthened by wrought-iron rivets or bolts, to keep the sides securely together; the lever frame has, between the two inner sides, an open space corresponding to the lower part of the main ladder.

Sliding Bolt Sockets.

On the two outer sides of the carriage lever there are fitted a pair of iron sockets, 2¼ inches wide and ¼ inch thick, to take the lever slides.

Clips for Handspike Lever-Chains.

There are fitted to the outer sides of the carriage lever a pair of iron clips, 1½ inches wide and ¼ inch thick; each clip is fastened with a bolt and nut, projecting about 1¼ inches on the under side, and fitted with eyes to take the bolts and chains of the handspike levers.

T Plates for Lever Stays or Hooks.

On the outer face of the inner sides of the carriage lever frame, there are fitted, at about 3 feet from the lower end, a pair of T plates, 6 inches long, 1¼ inches wide, and 3-8ths of an inch thick; these T plates are about 3 inches long; they are slightly curved, pierced at the end with an eye to take a 7-8th inch stay, and fastened with two bolts and nuts.

Carriage-Lever Hinge.

The lever frame is attached to the top carriage frame by means of a pair of lug irons, through which a ½-inch bolt is passed, thus forming a complete hinge; the lug irons are welded to a flat wrought-iron plate, 3 feet 3 inches long, 1½ inches wide, and ½ inch thick; this plate is bent so as to form a clamp round the bottom of the carriage lever, and extends up the sides about 1 foot 6 inches, both at back and front; there are also a pair of lug irons, welded on the same plate, about 3 inches from the bottom, which form part of the hinge of the handspike levers.

Lever Irons or Stays.

The carriage lever is set up by two wrought-iron bars or stays, 3 feet 9 inches long and 7-8ths of an inch in diameter, which are attached loosely to the lower part of the main ladder by means of strong bolts; they are bent at their outer ends to a right angle, and enter two eyes in the T plates, where they are secured by split keys, which are attached by chains fitted for the purpose; the carriage lever, when set up, is out at a right angle from the foot of the main ladder, and acts as a sufficient lever for one man to keep the main ladder in its proper position when not travelling.

Sliding Bolts.

On the outer sides of the carriage lever there are fitted a pair of flat slides, each 5 feet by 2½ inches by ¾ inch, plated with iron 4 feet 6 inches by 2¼ inches by ¼ inch, made to move up and down in iron sockets fitted to the carriage lever, for the purpose of steadying the lower part of the main ladder when the lever wheels are off the ground; the upper ends of the slides are fitted with leather straps to slip over hooks screwed into the side of the lever, so that they can be fastened up when not in use.

Extra or Handspike Levers.

The escape is mounted with a pair of extra levers below the carriage lever; these handspike or assistant levers are of ash, 6 feet long, 2 inches wide, and 4 inches deep; at a distance of about 1 foot 5 inches from the hinge the depth tapers from this point to about 2 inches at each end; they are attached to the underneath part of the carriage lever by means of plates and lug irons similar to the lever lug irons; each of the lug irons is fitted with a hole for the bolt to take the assistant lever-chain; this chain is attached to the carriage lever frame by clips, which pass round the outer sides, to which they are secured by two bolts each; the hand-spike levers, when not in use, are secured by a chain to a hook on the inner face of the outer sides of the carriage lever.

These are for the purpose of providing greater leverage, when the head of the machine is near the ground.

Main Ladder.

The main ladder is 31 feet in length, and is 1 foot 5 inches wide between the sides.

Sides.

The sides are of the best Swedish fir, 4½ inches deep and 2½ inches thick at the bottom, and 3 inches deep and 2 inches thick at the top; free from objectionable knots, and strengthened with the best homogeneous steel-wire rope, galvanized and consisting of one strand of seven wires let in from the top to the bottom, both at back and front; each wire is of No. 15, Birmingham Wire Gauge.

Rounds.

The wooden rounds of the main ladder are 20 in number, of best oak, with double shoulders where they enter the sides, and further strengthened by wrought-iron rivets or bolts at the 1st, 6th, 11th, 15th, and 20th rounds respectively; the 7th and 8th rounds from the top have a space of 1 foot 10 inches between them, the 8th and 9th a space of 1 foot 3½ inches, and all the other rounds a space of 1 foot; the rounds are turned from cleft—*not sawn*—pieces of oak, so as to insure their not being cross grained in any part.

Manhole.

The remaining part of the main ladder at the bottom is without rounds, for the purpose of getting persons out quickly.

Heel Plates.

The main ladder is attached at the lower part to the heel-board of the top carriage frame by wrought-iron plates, 1 foot 7 inches long, 1¾ inches wide, and 5-8ths of an inch thick, fastened with three screw bolts and nuts, and at the upper end of the top carriage frame by the iron cross-bar previously mentioned, which passes through both sides about 6 feet from the bottom, and forms the lower round; the bent iron plates project 3 inches beyond the top of the heel-board, so as to form a stay for the carriage lever.

Trussing Irons.

The main ladder has, at suitable distances apart, two semi-circular trussing irons of ½-inch round iron, each with 4 slots, and secured to the main ladder by each end clipping the ladder side, the ends of the clip being connected by a bolt and nut through the sides of the ladder; these trussing irons are secured from moving from their proper position by diagonal side stays, 3-8th inch iron, 1 foot 8 inches in length, flattened at the upper end and secured to the main ladder by 3 screws; the lower end is pierced with an eye, and secured to the first slot of the trussing iron by a bolt and nut; the struts, when made in this shape, help, together with the wire rope, to preserve the shoot from injury.

Parallel Trusses.

The main ladder is strengthened from underneath by two galvanized homogeneous steel-wire ropes, 3-16ths of an inch in diameter, made of 7 wires of No. 16 B. W. G., fastened at the bottom to straining hooks of 5-8th inch round iron, with a screw and nut, set in lug irons or holdfasts, 1½ inches wide, 5-8ths of an inch thick and 7¼ inches long, bent to a right angle at 2 inches, and pierced with an eye to receive the bar of the straining hook; these holdfasts are bolted on to the sides of the main ladder at a distance of about 4 feet from the heel-board; the trusses, starting from this point, pass through the upper slots in the semi-circular struts or trussing irons, and are fastened to the top of the main ladder by bolts passing through the sockets of the head iron; they have thimbles at both ends, and chains at the lower ends.

Crossed Trusses.

The main ladder is also further strengthened by two galvanized homogeneous steel-wire ropes, of the same size as the parallel trusses, fastened at the bottom with ½-inch round iron straining hooks and chains to the top bar of the lower carriage frame, passing then through the lower slots in the before-mentioned trussing irons, and crossing from the upper trussing irons diagonally to opposite ends of the head iron cross-bar, where they are secured.

Head Iron.

Under the top of the main ladder there is fitted a nearly rectangular wrought-iron frame or head iron, with wheels of about 6 inches in diameter, to facilitate the raising or lowering of the machine when touching a wall; the head iron consists of two round upright stays, 1 foot 8 inches long and 9-16ths of an inch thick, with sockets to fit over the head of the main ladder; from the front of these sockets there are bent irons, 3 inches long, with eyes through the ends, to which are attached shackles to receive the man-ropes extending from the head of the main ladder to the outer end of the carriage lever; these sockets are secured in their places by bolts, which also serve for the trussing lines; the rectangular frame is supported by two diagonal stays, 9-16ths of an inch in diameter, 2 feet 6 inches long, each stay being secured to the main ladder side by a clip, which passes round the side, and the two ends of which are connected by a bolt over the top; the bottom of the head iron forms a cross-bar or axle for the two small wheels, and is of ¾-inch round iron, 2 feet 4 inches in length, fitted with shoulders and arms 3⅛th inches long, with a screw and nut at each end.

Spreading Iron.

On the inside of the head iron there is a semi-circular round rod or spreading iron, 9-16ths of an inch in diameter; the ends are bolted on to the upright stays, and the outer bend is secured in its place by a wrought-iron bolt, with ferrule about 2½ inches long, to the cross-bar.

T Plates for Fly Ladders.

The main ladder has bolted on it, at a distance of about 23 feet from the bottom, four T plates, 10 inches long, 5½ inches deep in the bends, 1½ inches wide, and 5-16ths of an inch thick, two at each side; these T plates are perforated with eyes, through which is passed a cross-bar, 5-8ths of an inch thick, screwed at each end and fitted with nuts; this cross-bar acts as a spindle on which to hinge the fly ladder, and on its ends are placed two levers, described further on, made to move freely with and on the bar.

Guy Lines.

The main ladder is strengthened by two galvanized malleable iron-wire ropes, 5-16ths of an inch in diameter, made of 35 wires of No. 20 B. W. G., with thimbles at each end, attached to bolts fitted for the purpose over plates 2½ inches square, at a distance of about 20 feet 6 inches from the bottom of the main ladder, and to hooks placed on the extremity of the carriage lever set up by means of double screw swivels, made to turn round with a small bar; the swivels have fitted on them a pair of galvanized iron S hooks to fasten the outer ends of the hammock to.

Man-ropes.

Two man-ropes, extending from the head iron to the extremity of the carriage lever, are fitted so as to serve as a hand-rail for the main ladder. These man-ropes are of 2½-inch hemp rope; the upper end of each is fitted with an eye, a thimble, and one link of chain, and is shackled to the head iron; the lower end is fitted with an eye, a thimble, and a chain, by which it is attached to a hook on the outside of the carriage lever.

Swinging Lamp Irons.

At a distance of about 11 feet from the bottom there are fitted a pair of plates, 3 inches square, with swivel arms screwed on to the outer sides of the main ladder with 4 screws, so as to carry a pair of copper lamps in an upright position whether the machine is pitched or lowered; the arm is 8½ inches long, ¾ inch thick, and the outer end is slotted.

Double-Sheave Blocks.

On the sides of the main ladder there are fixed, at about 2 feet 6 inches from the top, a pair of double-sheave cheek blocks, the inner plates are 1 foot 6 inches in length, ⅛ inch thick, and 3 inches wide; the outer plates are about 1 foot 4 inches in length, ⅛ inch thick, 3 inches wide, and bent at right angles to the right and left, so as to form the outer side of the block; the sheaves are 4 inches in diameter and ⅝ inch thick, and are so placed that the extra hauling-lines pass freely between them.

Hanging Irons.

The main ladder has fixed underneath it, at a distance of about 19 feet from the bottom, a hanging iron, consisting of two round iron bars

½ inch in diameter, 2 feet 6 inches long, flattened at the upper ends and secured to the outer sides of the main ladder by means of a bolt and nut and 4 screws; the lower end is fitted with an eye to receive a ½-inch bolt about 1 foot 8 inches long, on which is fitted a roller, each end is provided with a screw and nut; this hanging iron is adapted to hold the head of the first-floor ladder.

Main Ladder Props.

The main ladder has fitted to it, at about its centre, a pair of wooden bars, or props, hung on staples, for the purpose of supporting that part when the machine is lowered, and made to fasten to the sides of the main ladder when not in use; the staples are not driven into the sides of the main ladder, but are rivetted on to plates 5½ inches long and 2½ inches wide, ⅛ inch thick, which are attached to the sides by means of 4 wood screws.

Wire Shoot.

Underneath the main ladder, extending from the top to within about 5 feet 6 inches from the bottom, there is a semi-circular or trough-shaped shoot, made of woven copper wirework; the mesh is rectangular, and 3-8ths of an inch wide, and each wire is of No. 16 B. W. G.; each piece of wirework is selvedged all round with tinned copper wire of No. 9 B. W. G.; each wire is attached to the selvedge by being passed once round it, and then twisted round itself; the shoot is attached to the sides of the main ladder by staples, clipping the selvedge, and driven into the ladder sides at intervals of about 1 foot; for additional security, strips of copper plate are looped round the selvedge at intervals of about 1 foot, and firmly secured by screws to the ladder sides; the shoot is attached at the top and kept open by being lashed securely with copper wire to the spreading iron; the wirework is put on in three separate pieces; the two upper pieces are each 10 feet by 3 feet 8 inches, and the lower one 5 feet by 3 feet 8 inches; the pieces are connected by being bound with copper wire, and each joint is covered with a strip of canvas closely sewn all round; the bottom end of the wirework is bound with canvas.

Apron Hammock.

At the bottom of the wirework there is a moveable hammock or apron, made of the best No. 1 canvas, to receive and break the shock of a person descending the shoot; this hammock is 9 feet 10 inches by 3 feet 6 inches, and fitted with eyelet holes to enable it to be laced to the escape; the hammock is gusseted in such a manner as to give it when in use an easy sweep, and is secured at the upper end by being laced with cord to the main ladder, and at the lower end by being hooked to the guy lines about 2 feet from the bottom; the centre of the hammock has also 2 eyelet holes to allow the water to escape; the hammock has also 3 eyelet holes at each side of the lever end about 4 inches apart; the canvas is strengthened at this part with lining pieces.

Fly Ladder.

The fly ladder is about 19 feet long, and is 1 foot 5 inches wide between the sides.

Sides.

The sides are of the best young Swedish fir, or white Christiania, 3 inches by 2 inches where hinged on, and slightly tapering towards the upper end, free from objectionable knots, and strengthened by galvanized homogeneous steel-wire rope let in throughout the whole length, both at back and front; the top ends are protected by zinc plates, to prevent the wood being split or damaged by rough walls.

Rounds.

The rounds of the fly ladder are 17 in number, and are of the best oak, turned from cleft—*not sawn*—pieces, with double shoulders where they enter the sides, and further strengthened by wrought-iron rivets or bolts at the 1st, 5th, 9th, 13th, and 17th respectively, to keep the sides firmly together.

Trussing Lines.

To prevent the fly ladder from being strained, the two sides are trussed underneath with homogeneous steel-wire rope, galvanized; the upper end of each rope is secured to a holdfast 1 inch wide, 3-8ths of an inch thick, and 5½ inches in length, bent to a right angle at 1½ inches, and pierced with an eye to take a 3-8th inch screwed hook, to enable it to be tightened; the rope thence passes through the eyes of two struts to the lower extremity of the ladder, where it is secured to the ends of the 3-8th inch iron bolt of the first round; these struts, of which there are four to each fly ladder, are not bolted to the ladder side, but are made to clip round it, and are fastened by a bolt connecting the two sides of the clip without passing through the wood; the struts are 1 inch wide, ¼ inch thick, and project 4½ inches below the sides of the ladder; the eyes in the struts, through which the trussing lines pass, are fitted with bolts, nuts, and rollers.

Clamp Irons.

The sides are fitted with two pairs of clamp irons or sockets to receive other ladders; these clamp irons are 6 inches long, 5 inches in the bend, ½ inch thick, 1 inch wide, half round in the centre, and they are turned to a right angle at about 2 inches from the end, and secured with bolts and nuts; one pair is fixed about 1 foot 5 inches from the top, and the other pair about 2 feet 1 inch lower.

Side-Plates and Cheek-Plates.

At the lower end of the sides there are screwed two outer side-plates, or strong pieces of flat metal, 3 feet 4 inches long and ¼ inch thick, and two inner side-plates, about 1 foot long and 1-8th of an inch thick; the outer side-plates have rivetted on to them cheek-plates, 8 inches long, 1 inch wide, and ½ inch thick, morticed out to receive the tongues of the fly-ladder levers; on the end of each side-plate there is cut a diagonal opening to receive the lever spindle.

Fly-Ladder Levers.

The fly-ladder levers are of wrought iron, of sufficient strength, about 4 feet in length from the cross-bar or spindle, and are pierced at the outer ends by a hole or eye, to which the hoisting ropes or lever lines are hooked on; the levers are kept in their places by thumb-screws passing through the cheek-plates and ladder sides; the thumb-screws are hung loosely on chains fitted for the purpose.

Fittings.

The fly ladder is so fitted that, when it is not in use, it can be folded over and carried with its head downwards, supported by the lever hinge before mentioned, and resting on the sides of the main ladder; it is set free from the main ladder by withdrawing the thumb-screws, and shifting the lever out of the cheeks, so that it can be used alone.

Lever Lines and Cross-heads.

To equalize the strain on the fly-ladder levers, when in use, the two extremities are connected by a strong wrought-iron bar or cross-head, of the same length as the width apart or distance between the extremities of the fly-ladder levers; this bar is hung underneath the shoot by two pieces of galvanized wire rope, each 4 feet 6 inches long; the centre of the horizontal portion of the cross-head, or hanging bar, has an eye, to which the hauling ropes are made fast over a thimble.

Extra Hauling Lines for Fly Ladder.

On the outer sides of the fly ladder there are fixed, at a distance of 11 feet from the bottom, two clamped lugs, with eyes, to which are attached, by means of spring hooks, two 2½-inch rope hauling lines; these lines pass through double sheaves, the plates of which are bolted on, as previously described, to the sides of the main ladder, at about 2 feet 6 inches from the top; to equalize the strain, the lines are spliced underneath the main ladder to the ends of an iron bar, or cross-head, and to an eye in the centre of this cross-head the upper hauling line or bell rope is attached.

First-Floor Ladder.

The first-floor ladder is about 16 feet long, and 1 foot 1 inch wide between the sides, and is capable of being pushed into the sockets of the fly ladder, or hooked on to the rounds of the main ladder.

Sides.

The sides are of the best young Swedish fir, or white Christiania, 2½ inches deep and 1¾ inches thick, free from objectionable knots, strengthened by galvanized homogeneous steel-wire ropes let in throughout the whole length, both at back and front, and protected at the top ends by zinc plates.

Rounds.

The rounds of the first-floor ladder are 14 in number, made of the best oak, turned from cleft—*not sawn*—pieces, with double shoulders where they enter the sides, and further strengthened by wrought-iron rivets or bolts at the 1st, 6th, 10th, and 14th respectively.

Spring Hooks.

The first-floor ladder has fixed to it, at a distance of about 3 feet 3 inches from the bottom, a pair of spring hooks, of sufficient strength, made to fix on the rounds of the fly ladder or main ladder.

Stay Iron.

There is fixed, at a distance of about 6 feet 10 inches from the bottom, and above the 6th round, a rectangular metal frame, with cross-bar and plates, made so that it can be fastened to the sides by a leather strap, and when the ladder is attached, the strap is let loose and the stay falls out to a right angle from the ladder, at which point it is fixed by a projecting metal lug or bolt; the plates are 4 inches long, 2 inches deep, and $\frac{1}{8}$ inch thick, fastened with screws to the side of the first-floor ladder; when the ladder is loaded, this stay touches the wall, and thus prevents the sides springing or bending too much; the stay iron is made of the best wrought iron, 2 feet 2 inches long, 1 foot 8 inches wide, and 5-8ths of an inch in diameter.

Fittings.

The first-floor ladder, when not in use, is carried underneath the main ladder; its head being supported by the hanging-iron before mentioned, and its lower end fixed by the bottom round resting on the two shipping hooks projecting from the top of the lower carriage frame.

Supplemental, or Short Length.

The supplemental length is about 10 feet 2 inches long, and 1 foot 1 inch wide between the sides, and is capable of being pushed into the sockets of the fly ladder, or hooked on to the rounds of the main ladder.

Sides.

The sides are of the best young Swedish fir, or white Christiania, $2\frac{1}{2}$ inches deep and $1\frac{3}{4}$ inches thick, free from objectionable knots, strengthened by galvanized homogeneous steel-wire rope let in throughout the whole length, both at back and front, and protected at the top ends by zinc plates.

Rounds.

The rounds of the supplemental length are 9 in number, made of the best oak, turned from cleft—*not sawn*—pieces, with double shoulders where they enter the sides, and further strengthened by wrought-iron rivets or bolts at the 1st, 5th, and 9th respectively.

Spring Hooks.

A pair of spring hooks, of sufficient strength, are fixed at a distance of 2 feet 8 inches from the bottom, and are made to fix on the rounds of the fly or main ladder.

Fittings.

The supplemental length, when not in use, is carried in front of the main ladder, on the lower round of which it is supported by its spring hooks.

Bolts.

All bolts passing through woodwork are fitted with plates or washers, to prevent the heads or nuts drawing through the wood.

Hand-pump Box.

There is fitted within one or both sides of the bottom carriage frame, or in such other place as directed, a box for a hand-pump and other gear; the hand-pump box is 3 feet 6 inches long, 9 inches deep, and 10½ inches wide, or of such other size as may be directed by the chief or other officer, and is made of the best yellow deal, 1 inch thick, and fitted with a lid on hinges, and a clasp, staple, and padlock.

Brass Plates.

Each escape used in London has two brass or enamelled iron plates, 3 feet by 3½ inches, with the words "Metropolitan Fire Brigade" engraved upon them in Roman letters 1¼ inches deep; one of these plates is placed on each side of the main ladder at a place pointed out by the chief or other responsible officer of the Brigade.

Painting and Varnishing.

All the work, both iron and wood, is painted vermillion, with 4 coats of the best oil colour, each coat being allowed to become thoroughly dry before the next is laid on; the wheels and iron work are picked out as directed by the chief or other officer, and the whole receive 2 coats of the best body varnish.

Jumping Sheet.

Each escape is furnished with a jumping sheet 10 feet square, made of the best No. 1 canvas, bound with 2-inch bolt rope, and fitted with hand-beckets of the same material, placed at intervals of 1 foot apart, and not opposite each other; the strips of canvas are sewn together with tarred twine, and the seams are covered underneath with strong webbing 2 inches wide; the jumping sheet is further strengthened underneath with 8 strips of the same kind of webbing, 4 sewn on each way at right angles from each other.

Tarpaulin.

Each escape is supplied with one strong tarpaulin, to cover it completely and protect it from the weather, fitted with proper fastenings.

Life Lines.

There is a 2-inch hemp rope, with an eye spliced in one end and rove with the other end passed through the eye around the top round of the main ladder, to hang down inside the shoot to the foot of the main ladder.

Tow Rope.

A 2½-inch hemp rope, about 15 feet long, is rove round the axle in the same way as the life line on the ladder round.

Mooring Chain.

Each escape has fitted to it a lever or mooring chain, about 6 feet long, or such other length as may be directed, fitted at one end with a hook, and at the other end with a ring.

Workmanship and Materials.

The whole of the workmanship and materials are of the best character, and subject to the approval of the Chief or other Officer of the Fire Brigade, or such other person as may be appointed to examine the same, and the makers are made responsible for any defects that are noticed or objected to.

Tackle and Fall.

Each escape is supplied with a tackle, formed of two metal blocks, one with two and the other with three sheaves, and a strong hemp rope or fall, for raising and lowering the machine.

Other Appliances.

Each escape is supplied with a pair of strong copper lamps, a rattle, a crowbar, a hand-pump with two 10-feet lengths of hose and a nozzle complete in a bag; a bucket, a long line, and a hemp strop.

Stone and Ring.

At each escape station, where convenient, there is a stone embedded in the ground, with a ring, into which one of the tackle blocks can be hooked, so as to enable the man in charge to lower or raise the machine, according to circumstances.

Heights to which the Machine will throw.

This machine, at the safest angle, which is under 25 deg. from the perpendicular, is capable of throwing to the following heights, and with a slight alteration of the angle to somewhat greater and less heights—

	Feet.	Inches.
Supplemental length	9	8
First-floor ladder	15	2
Fly ladder	18	2
Fly ladder and supplemental length ...	24	6
Main ladder	28	9
Fly ladder and first-floor ladder	29	9
Main ladder and supplemental length ...	34	3
Main ladder and first-floor length	39	1
Main ladder and fly ladder	39	10
Main ladder, fly ladder, and supplemental length	46	0
Main ladder, fly ladder, and first-floor ladder	51	4

Fire escapes for other heights should be of proportionately greater or less dimensions.

Weight.

The running weight of the machine here described, with everything complete for work, is 13 cwt. 2 qrs., and the weight on the extreme end of the carriage lever necessary to keep the machine standing is about 10 lbs.

Leverage.

The whole machine may be considered a bent lever of the simplest possible kind, with two arms, marked in the illustration respectively B and C, and a fulcrum or support between them, marked A. One of the arms, B, receives the power; the other, C, carries the load.

The fulcrum, or support, is the box of the wheel, in which the axle moves freely; one arm of the lever is the main ladder, and the other arm is the folding frame or carriage lever.

The centre of gravity of the main ladder is about at the point where the fly ladder is hinged on, 23 feet from the bottom; and the centre of gravity of the moving power, or men, may be taken to be in line with the end of the carriage lever.

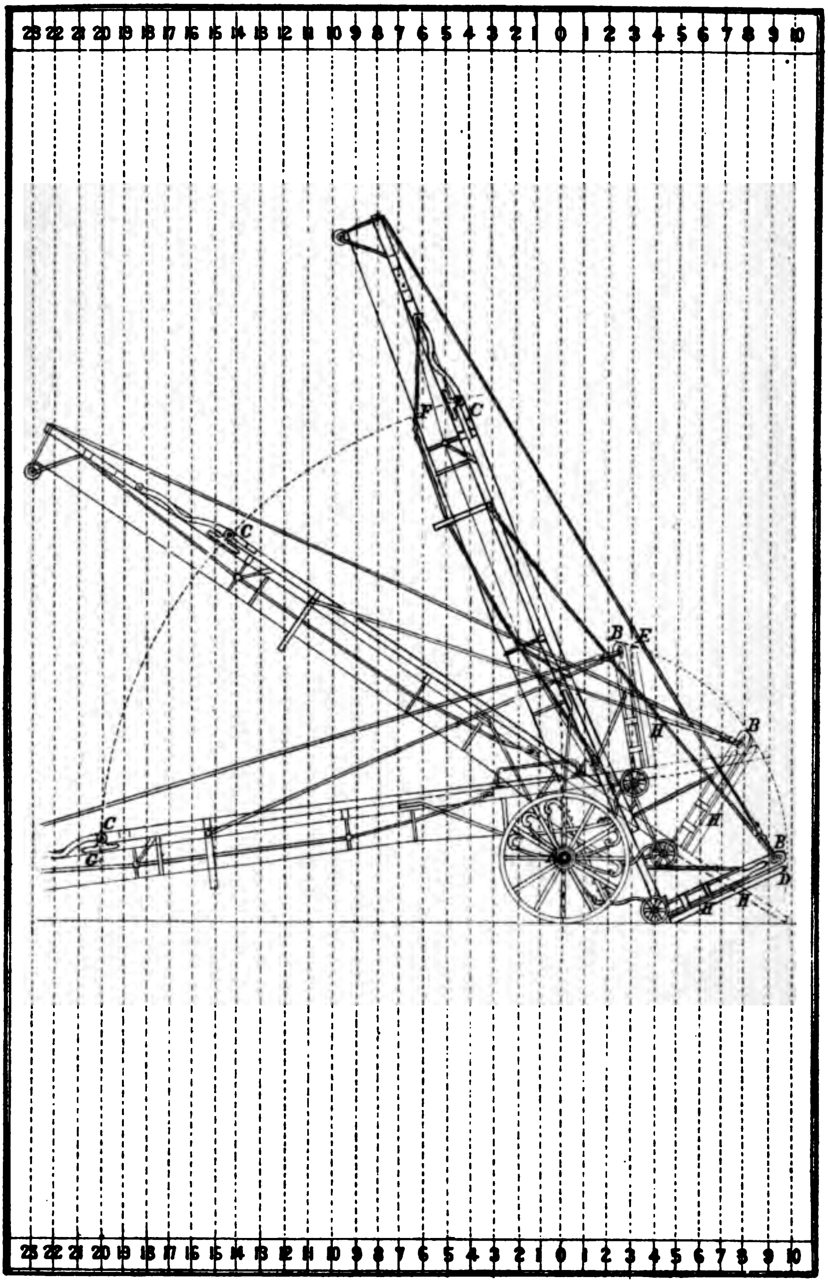
In order to make the moving power balance the load, the weight of each multiplied by its horizontal distance from the support must be equal to that of the other. Thus, if one cwt. be placed at a distance of 4 feet from the support, it will exactly balance 2 cwt. at 2 feet distance, or $\frac{1}{2}$ cwt. at 8 feet distance. In all these cases the figures would be alike, viz.:—

1 multiplied by 4 is 4.
2 " " 2 " 4.
$\frac{1}{2}$ " " 8 " 4.

The practical application of this to the leverage of the fire escape is as follows, viz.:—When the hind or lever wheels are on the ground, a man at the end of the carriage lever is 10 feet from the line of the support, and the centre of gravity of the main ladder is about 5 feet from the same line; consequently the man has a leverage in his favour of 10 to 5, or, in other words, of 2 to 1, so that, by pressing down on that point, he is able to support about twice his own weight. When, however, he raises the carriage lever for the purpose of lowering the head of the machine, he immediately commences to approach towards the line of the support, and consequently to lose his advantage in leverage, while at the same time the centre of gravity of the main ladder is getting further from the line of support. Calling the man the power, and the centre of gravity the load, it will be found that in lowering the machine, the power moves from D to E in an arc of a small circle of which the axle is the centre, and during the whole movement is continually approaching the line of the support, and consequently losing leverage; while at the same time the load is moving from F to G in an arc of a larger circle with the same centre, and during the whole movement is continually receding from the line of the support, and consequently on its side gaining leverage—in other words, while the power is becoming less, the load is becoming greater. Thus, if the power, say 10 lbs., at a distance of 10 feet from the line of support, be able to keep the machine up in its proper position with the hind wheels on the ground, the pressure of the load must be 100 lbs., which, divided by the distance in feet from the line of support, 5, makes 20 lbs.

In order, therefore, to obtain the weight of the load at the lowest or any intermediate point, it is only necessary to multiply this figure, 20 lbs., by the number of feet from the line of the support. Thus, at the lowest point it will be found to be not less than 19 feet from the line of the sup-

DIAGRAM SHOWING THE LEVERAGE OF A FIRE ESCAPE.



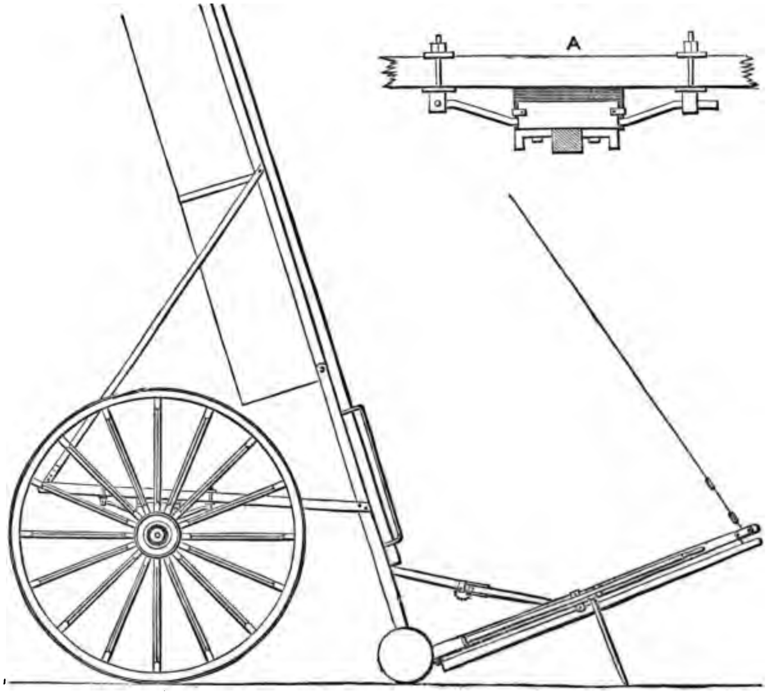
port, and consequently to weigh about $3\frac{1}{2}$ cwt. more than the weight of two heavy men at the same distance, 19 feet, or about thirteen men on the top of the carriage lever, which has then only 3 feet of leverage.

It is on this account that it is so necessary for a man to look after the head, both when raising or lowering, as he is able to do as much as ten or twelve men at the levers, and with judicious management can relieve the machine of nearly all the heavy strains. It will also be seen that, when the machine is down, if the men throw their bodies back from the lever hand iron, they exert a greater power, and that for the same reason one man on the end of one of the handspike levers, H, can do as much as several men on the carriage lever.

When a fire escape which has been lowered down is left short-handed, as with only one man, and it becomes necessary to raise it, the man will do well to reverse the tackle, so that the hauling part shall come direct from the lower block; he will then mount the carriage lever on the inside, and will haul from the top instead of from below. In this way he will avail himself of the advantage of his muscle as well as his weight, and will consequently more than double his power.

New Machines.

Some of the most recently-made escapes are altered very considerably from the pattern here described; the springs, bottom carriage, stays, cross-bars, scroll irons, and several other heavy parts, being altogether removed, and a simple triangular wooden frame, with rubber blocks for springs, substituted for them.



A Wrought-iron spring stay, with India-rubber block, clips, and nuts.

The carriage lever in these is set up with a pair of hinged wooden stays, instead of the iron stays, and is fitted on the outside with a pair of wrought-iron props, instead of the sliding bolts, and there are a few changes in matters of detail.

It will probably turn out that these alterations are considerable improvements, as they reduce the gross weight of the machine; but they have not yet stood the test of time, and therefore it would be premature to pronounce any very positive opinion about them at present; but as they will certainly occupy much attention during the next few years, the illustration is given for the purpose of conveying a general idea of the altered machines.

DRILL.

No. 1.

To run, turn, and pitch the machine, pass men up the ladder and down the shoot, and remove the machine.—Place the machine upright, with all four wheels on the ground, and one man at each side-ladder handle; half the remainder of the party take hold of the carriage lever by the hand iron, and the other half pull by the tow rope; run the machine along a street, then quickly turn it at a right angle, and pitch it against a wall with the head iron touching.

Block the high wheels behind, and, if the lever wheels are not on the ground, push down the sliding bolts, so as to get a firm hind bearing.

Then send all hands up the main ladder, and let them come down the shoot as fast as possible, every second man with his head downwards.

When all are down, remove the sliding bolts and bring the machine on the lever wheels, remove the scotch blocks, and run back the machine to the same place as at first.

No. 2.

To pitch the machine, take insensible persons off, pass them down the shoot, and remove the machine.—Bring up the machine and pitch it as before, with the head close to a window or roof.

Send all hands up, and let them get on the floor or roof.

One half should then lie down, and the other half should lift them up, put them into the shoot, and pass them down; after which they should themselves come down as quickly as possible, remove the sliding bolts and blocks, and run the machine away as before.

The whole of this practice, including the bringing up and removing of the machine, should be gone through twice, changing the men, and making those who were passed down the shoot the first time pass the others down afterwards.

No. 3.

To pitch the machine, throw up the fly ladder, take insensible persons off, carry them down outside the ladders, lower the fly ladder, and remove the machine.—Bring up and pitch the machine as before, after which throw up the fly ladder in the following manner:—

Cast off the upper and lever lines from the cleets, pass them forward, and let them hang straight down. Let a sufficient number of hands take hold of them, and haul steadily downwards, taking care at the same time to keep as nearly as possible in the centre between the high wheels, so as to bring a direct and not a side strain on the levers. When the fly ladder is about upright, the men with the lever lines should move in towards the foot of the main ladder, still keeping in the centre between the wheels; the men with the upper lines should haul gently so as to throw the head of the fly ladder forward, and the other men will then ease up the lever lines slowly until the ladder touches the wall.

During the latter part of this operation some care is necessary to prevent the ladder striking with force against the wall and being broken. The head should first be thrown forward a little beyond the perpendicular, and the line should be slacked up slowly, hand over hand, so as to let the ladder fall very gently, and without a blow. The upper lines are then made fast hand taut to the axle, or to a cleet fixed for the purpose, and so prevent the fly ladder coming out from the wall; and the lever lines are pulled out of the way and secured by a loose turn round one of the side cleets.

All hands will then run up on the roof, and one half will carry the other half down.

In stepping from a roof or high level on to a top ladder, the men must be careful to keep their balance at all times, but more particularly when carrying a load.

When all are down, cast off the lower ends of the upper and lever lines, and bring them to the centre, between the wheels; leave the upper lines at first perfectly slack, and move slowly forward with the lever lines, keeping a strain on them all through; and as soon as the head of the ladder has got beyond the perpendicular, slack up both lines very slowly, hand over hand, keeping a sufficient strain on them during the operation, to prevent the fly ladder coming down with too much force and breaking something.

As soon as the fly ladder is in its place, take a turn of the lines on the cleets, and remove the machine as before.

This also should be repeated in every part, for the purpose of changing the men.

No. 4.

To pitch the machine, throw up the fly ladder with supplemental length added, take insensible persons off, carry them down outside the ladders, lower the fly and supplemental ladders, and remove the machine.—Bring up and pitch the machine as before; let one man jump on the carriage lever, and, taking hold of the fly ladder, hold the end up as high as possible at arms' length; another man in the meanwhile takes hold of the supplemental length, and runs out beyond the extremity of the carriage lever, reversing the ladder as he goes, so as to get the head outwards. He then inserts the supplemental length into the sockets of the fly ladder until it brings up in the spring hooks, at which point the joint may be considered to be made. The man on the carriage lever then jumps down; several hands take hold of the lever lines; the man who has inserted the supplemental length sings out "One," at the same time raising the head to the full extent of his arms, and lowering it again as far as it will go. He then raises it up again, at the same time singing out "Two," and letting it go. The men at the lever lines then swing it upwards, in the same way and with the same precautions as before.

When the lever lines have been made fast, all hands run up, and one half carry the other half down.

The fly ladder should then be lowered as before, one man standing outside the carriage lever to catch the supplemental length as it comes down. This man should then pull off the supplemental length, reverse it, and put it in its place on the main ladder, with its head upwards, and its spring hooks resting on the lower round; after which the men at the upper and lever lines should slack up still further, so as to let the fly ladder drop into its place on the main ladder. Next take a turn of the lines, as before, and remove the machine.

This practice should be repeated in every part, for the purpose of changing the men.

No. 5.

To pitch the machine, throw up the fly ladder with first-floor length added, take insensible persons off, carry them down outside the ladders, lower the fly and first-floor ladders, and remove the machine.—Bring up and pitch the machine as before.

One hand jumps up on the carriage lever, and lifts the end of the fly ladder, as before. Another runs round to the back, and, lifting the first floor ladder a few inches to release the hooks, lowers it to the ground, keeping the heel close to the main ladder, so as to allow the head to clear the hanging iron. He then runs round with it to the front of the carriage lever, reversing it as he goes, so as to bring the head outwards; inserts the lower end in the sockets of the fly ladder, as in the case of the supplemental length, and slips the strap which holds the stay iron. The man on the lever then jumps off; all spare hands then take hold of the upper and lever lines; the man who inserted the first-floor ladder raises up the head twice, singing out "One," "Two," and then letting it go, and the men at the lines haul away, and swing it up as before.

When the lever lines have been made fast, all hands run up, and one half carry the other half down as before.

After this the fly ladder should be lowered, as in the last practice, one man catching the first-floor ladder towards the end, pulling it off, and running round again, reversing it as he goes. He should then fasten the stay by buckling the strap, bring the heel close to the main ladder, let the head go through the hanging iron, and push up until the first or second round is above the shipping hooks, fitted on the front bar of the lower carriage; then drop it gently until the round brings up on the hooks.

In the meanwhile the men at the lines can slack up until the fly ladder rests in its proper place on the main ladder, after which the sliding bolts and scotch blocks should be removed, and the machine run away as before.

The whole of this practice should also be repeated, for the purpose of changing the men.

No. 6.

To unship the fly ladder with the machine pitched.—Cast off the lines from the cleets, and let them hang, and unhook the upper lines from the fly ladder; withdraw the thumb-screws from the fly-ladder levers, and move the ends of the levers until the tongues are free from the slots in the cheek-plates, and the fly ladder will then drop clear of the spindle, Lower the levers slowly, so as not to damage the shoot, and let them hang. A man below will take hold of the fly ladder by the sides, and lift it clear; and the man above will take hold of the round next him, and walk down with it.

In practice it is sometimes found convenient to slide the small ladders down on one of the guy lines, but this should always be done with caution, to prevent accidents.

No. 7.

To ship the fly ladder with the machine pitched.—This is almost precisely the converse of the operation previously described; but owing to the position of the levers when hanging, it is always difficult, and in many cases cannot be accomplished by a single man aloft.

No. 8.

To unship the fly ladder with the machine lowered.—Cast off all the lines from the cleets, and unhook the upper lines from the fly ladder; withdraw the thumb-screws from the fly-ladder levers, and raise the ends of the levers until the tongues are free from the slots in the cheek-plate; raise the head of the fly ladder about a foot or two; lift the diagonal opening off the lever spindle, and as soon as the fly ladder is clear, lower the ends of the levers until they rest on the ground.

No. 9.

To ship the fly ladder with the machine lowered.—This is almost precisely the converse of the previous operation, and does not need a detailed description.

No. 10.

To lower the machine by means of men, detach the ladders and use them all separately, remove and replace all.—Run up the machine to a convenient place, not pitching it, but letting it stand fore-and-aft in the street; scotch the high wheels before and behind, and lower the main ladder in the following manner:—

Some hands catch the top iron of the carriage lever, and lift it slowly, and, as it goes up, several others catch hold of the hand-spike levers and the underneath part to steady the machine. As it goes up at the lower end, the men on the hand iron and levers go up with it; and one hand runs out, catches the head iron as it comes down, so as not to let it strike the ground heavily, and lowers it down slowly; after which the men on the levers jump down.

One hand then detaches the first-floor ladder, butts it against a wall, with the foot downwards, and, after raising the head and drawing out the heel to a safe distance, runs up to the top, and, if convenient, enters the room or level to which the ladder reaches; after which he comes down again, and replaces the ladder on the hanging iron and shipping hooks. Another man does precisely the same with the supplemental length.

In the meanwhile a sufficient number of the others get about the fly ladder, cast off and unhook the lines, and, after drawing the thumb-screws, release the lever irons by lifting the ends. They then remove the fly ladder, and carrying it to the house or wall, butt it with the heel downwards, and, raising the head, proceed in precisely the same way as with the other short ladders.

When it is not convenient to have the heel of the ladder against a wall during the process of lifting, one or two men should place their feet on the lower round, or against the lower end of the sides, and hold firmly while the others get under the head, and, walking inwards, lift the whole slowly and steadily without jerking.

The main ladder may then be raised by several men on the hand iron and lever handspikes, and one man under the head iron. The man at the head iron sings out "One," swinging the head up to the extent of his arms, and bringing it down again within about 2 feet of the ground; he then sings out "Two," at the same time throwing it up with force, and letting it go; and, as the head goes up, the levers come down, and the men jump off. They then remove the scotch blocks, run it in, and pitch it as before, blocking up the high wheels behind, and all hands, or any convenient number, can pass up and down. In this way four different levels of a building can be reached in a few seconds.

When the men have come down, the machine can be run back and lowered in the same way as before; and the fly ladder can be replaced, by first raising the outer ends of the lever irons to get them out of the way, next dropping the slotted end of the fly ladder on to the cross-bar, and then lowering the ends of the lever irons until the tongues enter the cheek-pieces; after which the thumb-screws can be inserted, and hove up, so as to secure all, and the lines made fast in their proper places. The machine can then be thrown up and run away to a distance as before.

No. 11.

To use the main ladder alone, the first-floor ladder alone, and the fly ladder and supplemental lengths together.—Run the machine up, and lower it as before. Detach the three ladders, set up the first-floor ladder by itself, insert the supplemental length into the sockets of the fly ladder, and raise the fly ladder; send the men up and down. Lower and separate the ladders. Raise the main ladder, and send the men up all three ladders, and down again, as before. Run back the machine, lower it, replace the ladders, raise up, and run away as before.

No. 12.

To use the main ladder alone, the fly ladder and first-floor lengths together, and the supplemental length alone.—Precisely the same as the eleventh, except that the first-floor ladder is used with the fly ladder, and that the supplemental length is used by itself. In this it is neces sary to slip the strap and free the stay iron before butting the fly ladder.

No. 13.

To throw up the fly ladder with the machine not pitched.—Run the machine up close to the wall on which it is to be used, but do not turn or pitch it; block the high wheels before and behind. Place five or six men at the carriage lever to steady the machine; send three or four others to raise the fly ladder by means of the upper and lever lines, taking great care not to let it fall heavily against the top of the main ladder when it gets beyond the perpendicular. This is a very dangerous movement, as any jerk may have the effect of breaking off the fly ladder, above the head of the main ladder, and even, in certain cases, of breaking the main ladder.

When the fly ladder is up, bring the lines to the axle or the cleet fitted for the purpose, and make them fast, leaving them rather slack, so as not to strain anything when the machine is pitched. Then remove the scotch blocks, turn and pitch the machine, scotch the high wheels behind; if necessary drop the slide bolts, and let the men pass up and down as before. When all the men are down, remove the slide bolts and scotch blocks, and, placing a sufficient number of men at the hand-iron, remove and turn the machine, scotch the wheels before and behind, lower the fly ladder, remove the scotch blocks, and run the machine away.

No. 14.

To throw up the fly ladder and supplemental length with the machine not pitched.—This is precisely the same as the thirteenth, with the addition of the supplemental length on the end of the fly ladder, and consequently the necessity of additional caution.

No. 15.

To throw up the fly ladder and first-floor ladder with the machine not pitched.—This is the same as the fourteenth, except that the first-floor ladder is used instead of the supplemental length. This is a most difficult and dangerous movement, and should never be attempted when short handed, or with awkward men.

No. 16.

To hook the supplemental length on one of the upper rounds of the main ladder.—When the machine is pitched, take off the supplemental length from its place on the lower round of the main ladder, put one arm between the rounds, so that one side shall rest on the shoulder, at the same time taking care that the ladder is properly balanced; then carry it up and hook it on by its spring hooks to one of the upper rounds of the main ladder, turning the hooks to the back or front, according to convenience, and, if necessary, lash it in its place with a pocket line or any loose rope.

No. 17.

To hook the first-floor ladder on one of the upper rounds of the main ladder.—This is almost the same as the sixteenth practice, except that the hooks should generally be on the outside, so as to bring the stay iron on the side next the wall; the stay iron in this case is of no use, and when on the outside of the ladder is often very inconvenient for men passing up and down; but whether on the inside or outside, it should be kept strapped up out of the way.

No. 18.

To run the machine lowered.—Let one or two hands take hold of the head iron, a few others hang on to the heel-board and hand-spike levers, and the remainder move the machine by pushing the high wheels.

In the event of having to pass under a very low arch, or other obstruction, it may become necessary to fold the carriage levers, and in this case the hand-spike levers are not available, and consequently a greater number should hang on to the heel board, and, if possible, one or two additional hands should go to the head iron.

INSPECTION OF FIRE ESCAPES.

In order to make a proper inspection of a fire escape, it is advisable to follow some fixed plan or method, so as to ensure the complete and thorough examination of every part, however minute. If this be not done, something is almost certain to be omitted.

The following rules are therefore laid down, not necessarily for adoption in every case, but as a guide for officers and firemen when inspecting the machines, and to assist them when called on to make a thorough examination.

Get the machine into its regular upright position, with all the four wheels on the ground, and a sufficient weight, either by means of men or otherwise, on the end of the carriage lever, to keep the whole machine steady; and block the wheels with the scotch blocks before and behind.

Commence the inspection at the centre of the top hand iron of the carriage lever, and walk round to the left, carefully examining the whole of the levers, top and bottom carriage frames, wheels, springs, axles, and all other parts, which cannot be so well seen when the machine is lowered, such as the bottom of the main ladder, with its corner irons, &c.—in fact, every part of the machine which is within about six feet from the ground when in this position—and finishing in front at the same place. If not thoroughly satisfied that all is right, repeat the inspection, walking round in the opposite direction. It will also be necessary to get inside the lever, and to examine the lever and side ladders, the staple, straps, and copper of the shoot, and all other parts not equally accessible when the main ladder is down.

Next lower the machine, either by the tackle or by a number of men on the end of the carriage and hand-spike levers, until the head iron of the main ladder rests on the ground.

Commence at the centre, underneath the heel-board, and walk round to the left, finishing at the same spot, and examining every portion of the sides, rounds, copper shoot, fixed and moveable irons, and all other parts, drawing the thumb-screws, shipping and unshipping the fly-ladder levers, trying by hand the strength of the head iron and any other parts that can be tested in this way, seeing that the rollers are free and the copper shoot properly secured to the spreading irons; also carefully inspecting the splices and thimbles in both the standing and running gear, and making sure that these, and all the wood and iron work, are in proper working order, and appear to be of sufficient strength; and also, that the machine is fully supplied with all necessary appliances, such as apron hammock, jumping sheet, lever chains, bucket, life line, tow rope, crow-bar, hand-pump, long line, strop, &c., &c.

After this has been done, should any doubt exist concerning finish, strength, material, or any other matter, it will be well to repeat the inspection, commencing and ending at the same spot, but going round the opposite way—namely, to the right—and carefully examining every part again.

Next, withdraw the props, watching whether the main ladder bends much, and after this put a man on the main ladder, close to the props, and see that it bears his weight well, both steady and jerking.

Next, remove the fly ladder, the first-floor ladder, and the supplemental length; examine them carefully on the ground, and then place them against a wall, and test each separately in the following manner:—Send a man up with a pair of strong boots on, and let him, as he descends, kick each of the rounds in the centre, bringing the whole weight of his body to bear on it. After this, lower the fly ladder, insert the supplemental length into the sockets, set the two up together, and send a man up to see that they bear the weight. Then lower them down, remove the supplemental length, replace it by the first-floor ladder, and test the two together in the same way as before; after which, lower them down and remove the first-floor length.

Should the separate parts bear all this portion of the inspection satisfactorily, the next thing will be to raise the machine up, either with the tackle or by men on the hand-spike and carriage levers, not placing a man to lift the head iron off the ground, as this would relieve the strain, and consequently render the test for strength imperfect.

When the machine is up, remove the scotch blocks, and pitch the head against a wall, bringing the lever wheels to the ground, and again scotching the high wheels, so as to prevent them running back; and test the rounds of the main ladder in the same way as those of the other lengths.

Next, take the supplemental length up, and ship it, by means of its hooks, on the top round of the main ladder, the hooks being turned either to the back or front, according to convenience. Let a man mount it, and test it as before, after which it can be unshipped and put in its proper place for travelling. After this take the first-floor ladder up, and ship it on the same round of the main ladder, with its hooks outside, so as to bring the stay iron on the side next the wall; let a man mount and test it, and then remove and replace it.

Next, remove the scotch blocks, withdraw the machine, fix the scotch blocks again before and behind, lower the main ladder, put the fly ladder in its place, raise the machine, remove the scotch blocks; pitch the machine again as before, carefully blocking the high wheels before allowing anything else to be done, or any one to go up.

Next, throw up the fly ladder, by hauling on the upper and lever lines, the men being careful to keep towards the centre, between the wheels, so as to have a direct pull on the levers, and thus avoid putting a side strain on them. When the fly ladder is being raised, the part next the lever must be closely watched from below, and, if it show too much bend during the operation, it must be taken off again, and closely examined on the ground.

If it show no sign of being sprung, or otherwise injured, it may be put into its place again, and thrown up in the same way as before; and, when it is perpendicular, the men with the lines should take a step towards the axle, and allow the head of the fly ladder to fall gently against the wall. After the head or upper part has touched, the lines must be made fast as before.

Then two men should mount to about the middle of the fly ladder, and jerk it a little, so as to test the strength, not only of the lever joints, lug irons, and other fittings, but also of the main ladder itself at that point. During this operation, as a general rule, the officer should make his observations from the ground; but occasions may arise when he will find it better to go up, and watch the spring from the upper part of the main ladder, a little above the lever joint.

Should these parts prove satisfactory, the fly ladder should be again lowered, and the supplemental length attached to it; after which it should be thrown up again in the same way as before, without any assistance from the man who puts on the extra length. This is a more severe test than the previous one, and all the parts should be closely watched during the operation, and again examined after it.

Should all be right so far, the fly ladder should be again lowered, the supplemental length removed, and the first-floor ladder added on in its place; after which the fly ladder should be again thrown up as before, without any help from the man at the end. This is the most severe test of all, and the whole of the ladders must be most minutely watched during and after it.

Next, lower the fly ladder, remove the first-floor length, and let the fly ladder fall into its place in front of the main ladder.

After this, withdraw the scotch blocks, run the machine back about 6 feet, block the wheels up again at that point, let the head iron fall forward against the wall, as before, and drop the sliding bolts of the lever, at the same time driving them, by means of the foot, as far as possible into the ground, so as to form a bearing for the hind part of the machine.

Next, repeat the same operations which were previously performed with all the wheels on the ground, throwing up and lowering, first, the fly ladder alone; secondly, the fly and short length; and thirdly, the fly and first-floor ladder, at each part sending up men to test the strength, and watching the result carefully both from above and below.

Next, withdraw the machine about 6 feet further from the wall, and repeat the experiments in precisely the same way as before.

The more the ladders are removed from a perpendicular position, the less weight they will be able to bear; and as in these last-mentioned experiments there will be a very heavy strain thrown on the main ladder near the fly-ladder joint, care must be taken not to endanger the men during the operation, in the event of the sides or other parts giving way. The best way to ensure the safety of the men above will be to have them slung on loose ropes from the top of the wall, so that, in the event of the ladders giving way, they will only fall the length of the slack of the line, which need not exceed a few inches.

Next, withdraw the bolts, bring the hind wheels to the ground, and run the machine into the same position as at first, the head resting against the wall, the high wheels scotched behind, and the lever wheels taking the back bearing.

Send a man up the main ladder, and let him go into the copper shoot with his feet downwards, and come slowly to the bottom, stopping himself at every two feet or so, and jerking outwards as hard as possible with his back and elbows, so as to test the strength of the copper itself and its fastenings.

Next, remove the scotch blocks, withdraw the machine into an open space, bring the lever wheels to the ground, scotch the high wheels before and behind, place a number of men on the carriage lever to keep it down; and, when the machine is in this position, first send two men to the top of the main ladder, and, if all seems right, bring them down again, and then throw up and lower all the ladders successively as before: first, the fly ladder alone, secondly, the fly and supplemental length, thirdly, the fly and first-floor. These operations will throw a heavy strain on the trussing lines and the whole of the standing gear, but most of all on the guy lines, and those parts of the carriage lever to which they are attached.

As the carrying out of this test is attended with some danger, the inspecting officer must keep his attention fixed on everything that is done, and should the slightest symptom of weakness appear in the guys, the guy-line hooks, the lever, or any other parts affected, he must immediately suspend the operation.

Next, withdraw the top lengths, and put them in their places for travelling; drop the fly ladder into its proper position on the front of the main ladder, and lower the machine by means of the tackle, not placing a man to catch the head iron or otherwise to relieve the strain.

Next, walk round and carefully examine all the parts, particularly those which have been subjected to heavy strains—such as the fly-ladder levers, the carriage lever, the trussing lines, the guy lines, &c., &c.—and observe if the whole or any part has been wrenched or strained during the inspection.

Should the ladder undergo all these tests satisfactorily, it may be considered perfectly safe and trustworthy.

GENERAL INSTRUCTIONS.

Taking Duty.

When a fireman goes out in charge of an escape, his first duty is to examine it carefully, for the purpose of ascertaining that it is supplied with all the usual appliances, and also that it is in complete working order in every part. He must make an inspection, either partially or thoroughly, according to the mode previously explained, and he must be entirely satisfied as to its efficiency in every particular before trusting it for a duty.

It is to be clearly understood, that no excuse can be accepted for any imperfection in the machine after the duty has commenced, unless the same shall have been duly entered in the book kept for that purpose, and also reported at the earliest possible opportunity to the senior officer of the station to which the escape belongs.

When it is necessary to make a report of this kind during the hours of duty, the fireman must not leave his post to go with it himself, but should hire a stranger to run to the nearest station and inform the officer in charge; and the latter should lose no time in either proceeding in person, or sending a competent fireman, to examine the machine, and take such steps as may be necessary, reporting the same through the usual channels to head-quarters at the earliest possible moment.

Securing the Machine for Duty.

After inspecting the machine, and finding that it is all right in every particular, and fully supplied with all the necessary gear, fittings, and other appliances, the fireman should place it in such a position as to ensure its quick departure in case of a call.

The best mode of accomplishing this will be to pitch it against a wall, and to secure it with loose scotch blocks, not those which are attached to it by chains; an escape placed in this way requires nothing to be done except to kick away the loose blocks, and can be got away instantly.

If, owing to the position of the station, or any other cause, this cannot be done, the machine may be moored by attaching the hand iron of the carriage lever, by means of the chain, to the ring set in the stone for the purpose, or to the lower part of a strong lamp-post or railing. The mooring chains are fitted with hooks, to facilitate the operation of making them fast or slipping them in a moment.

In windy weather it is very rarely safe to keep a fire escape upright, and it should therefore be lowered down; but care must be taken to place it in such a position that it can be raised in as short a time as possible.

When the machine is lowered, the tackle should be kept overhauled, and, if possible, hooked on at both ends. In certain cases, however, owing to the position of the escapes on footways, or in crowded thoroughfares, it may not be convenient to do this; but there never can be any difficulty in getting the tackle overhauled to the proper length, and keeping the upper block hooked on to the hand-iron of the carriage lever, and the other stowed away in such a position underneath the machine, that it can be got at and hooked on to the mooring ring in a moment.

Concerning The Tackle and Fall.

Whenever a machine is lowered down, the tackle should be kept overhauled; and whenever a machine is standing, either pitched, moored, or in charge of the men at the lever, the tackle should be shortened up with the blocks touching, in the position commonly known as "two blocks."

It is of particular importance that this should be remembered, as on raising a fire escape by means of a tackle, when the machine has reached to very nearly its proper upright position, it comes up more quickly than the last few feet of the fall can be gathered in; and if the blocks are left in this way, about two or three feet apart, when they have to be hooked on again for lowering, there may not be time to haul them close, and the hooks may slip and let the main ladder down by the run.

The tackle, when not in use, should be hauled taut "two blocks," the fall should be made up in a separate coil, and the whole secured by a simple knot, which can be cast adrift in a moment.

Receiving a Call.

When a fireman in charge of a fire escape receives a direct call from a place on fire, he must first satisfy himself that it is not a false alarm. This can be done in a moment by a few short questions, as to what the messenger himself has seen, or what he has been told by the person who sent him.

If this be not done, the machine may be frequently drawn off its station for chimneys on fire or false alarms, and most disastrous consequences might result from its absence at a critical moment.

While, therefore, it is important that the fireman should exercise a certain amount of discretion in accepting a call, he must be careful not to carry his inquiry so far as to cause loss of time; always remembering that, if there be any reasonable cause, however slight, for supposing that there is a fire within a quarter of a mile or so of his post, his duty is to proceed without delay, and give such help as may be required; and that it is much better to attend in a hundred cases unnecessarily, than to be absent once if wanted.

A fireman very soon acquires the kind of experience which enables him to judge correctly of the nature of any call coming direct from a fire; but great difficulties frequently arise in forming an opinion as to calls which come through two or three different hands. In such cases, therefore, it is well to lay down the general principle, that almost all messages coming from owners of premises concerning their own places, or from police officers on the spot, should be at once attended to.

Even in this way false alarms are frequently given; and, when they are, the fireman must bear the inconvenience and annoyance of unnecessary labour with patience and good temper, remembering that the spirit which incites owners of property to send away immediate calls in all cases of alarm of fire, however slight, is one to be greatly fostered and encouraged; inasmuch as it is only by receiving timely information that we are enabled to cope successfully with fires, and any extra work or trouble incurred in individual cases is much more than counterbalanced in the end by the saving of labour in all warehouse, dock, wharf, or other fires, of which we get intelligence before they have attained considerable magnitude.

Caution about leaving an Escape.

Firemen must always use the greatest discretion in leaving their escapes, even for a moment. There are cases in which a fireman is justified in running away with a hand-pump, or one of the small ladders—as, for instance, when a fire is discovered within a few feet of his post, and within sight—but even under these circumstances he ought to be very cautious, as in the event of anything serious happening, he is sure to be called on to justify his conduct.

Proceeding to a Fire.

The proper number of persons to convey and work a fire escape is four. Of these one at least should be a thoroughly trained man, with a complete knowledge of everything connected with the machine, and the others should work under his orders.

It is not, however, always possible for the fireman to obtain so much help, and he must therefore, in certain cases, do with less. He must, however, under no circumstances attempt to move his machine single handed, and, no matter how urgent the call may be, if the person giving it will not accompany him, and if after the springing of his rattle no other help be forthcoming, the fireman is bound either to remain at his post, or to unship his moveable lengths and run away with them to the fire. Even in the calmest weather it is a hopeless task for one man to move a fire escape more than a few feet, and nothing can compensate for the risk of making the attempt.

With one other person, however, to assist him, the fireman is justified in starting, and in almost all cases he will be sure to meet further help on the road.

Arriving at a Fire.

On arriving at the scene of a fire, the fireman's first duty is to attend to the safety of his escape, as without this he may be of no use. No special directions are given concerning the position in which he is to place it, but as a general rule he will do well to pitch it against one of the walls of the house on fire, or the house next adjoining, and not to leave it standing fore and aft in the street under the charge of strangers.

Searching a House.

After ensuring the safety of the machine, his next duty will be to search the house thoroughly, according to his discretion, not necessarily entering, or even looking into every room, if he sees that by doing so he would cause extra risk, and is satisfied from the statements of inmates or others on the spot that there is no one inside.

If, however, he does not feel thoroughly convinced on this point, he is bound to examine every room and passage of the house, so far as it is possible to do so, carefully shutting every door and window after him, and thus, in some degree, reducing the danger inseparable from such a search.

For examining a house on fire, no precise rules are laid down; everything must depend on the circumstances of the moment, and on the presence of mind and the skill and energy of the first fireman who arrives.

The proper mode of proceeding from one storey or level of a house to another is obviously to go by the stairs, and it is well that firemen should always recollect this. It is true that they are provided with a set of ladders, and that they are carefully instructed and drilled in the uses to which these ladders can be applied, under many circumstances, both difficult and various, but it is by no means intended to be supposed that a fire escape can always, or even often, supersede the use of stairs; on the contrary, I am strongly of opinion that many heavy losses, in past times, may be traced to the injudicious breaking of windows, for the purpose of entering by means of ladders, when it might have been quite possible to pass up and down the stairs, and at the same time to exclude from the rooms in danger all air except the small quantity unavoidably admitted during the momentary opening of the door for the purpose of looking round.

Caution about Outside Work.

A crowd looking on at a fire is very ready to applaud a fireman who pitches his escape in front of a burning building, and, rushing up, cuts through window after window from the outside, steps in for a moment to see if any one is there, and then goes on to the next, leaving behind him, in every case, broken glass, damaged shutters, or other open spaces of some kind.

Occasions have arisen when this kind of applause may have been well deserved, but, so far as my experience goes, they have been very few and far between; and no fireman who understands his business, and is animated with the true spirit of his profession, should ever lend himself to such a proceeding as seeking for applause from any but his own superiors.

It cannot be too generally known, or too often impressed on those who undertake the responsible duty of saving life from fire, that if they have been thoroughly instructed in the duties of their profession, and are personally and otherwise competent to do the work, their success will be on almost all occasions in exact proportion to the risk they run.

Now, a man who merely runs up a ladder and cuts through a front window runs no risk at all; on the contrary, he does that which is the safest *for himself*, but, in looking out for his own safety, he is doing that which is most dangerous for any persons who happen to be in the other rooms of the house, particularly those above and at the back, into which, after once a front window has been cut through, it is probable, if not almost certain, that the fire will penetrate before the fireman can reach them.

When the stairs are burned, and when there is reason to suppose that all the persons are in one room, and that room in a position accessible to the escape, it is of course the duty of the fireman to cut through the windows from the outside, and to bring the inmates down either in the shoot or on the ladder, but he must not forget that in doing so he consigns the house to almost certain immediate destruction, and that, if there happen to be other persons inside, he cuts off from these latter very nearly every hope of escape. Besides, in taking such a course, he would, as a general rule, be doing that which is easiest and safest for himself, and subjecting to unnecessary danger the very persons whom it is his special duty to protect.

Entering from Below.

The best way for entering a house on fire is by the street door, and a fireman who knows his business, and receives an early call, can usually effect an entrance in the ordinary way, and search all the rooms, according to his discretion, carefully shutting every door after him.

When circumstances admit, it is advisable to commence a search of this kind at the top, and work downwards, as the entering of each room necessarily involves the momentary opening of the door, and consequently the escape of a certain amount of heat and smoke; and if it be commenced at the bottom, the accumulation of smoke about the stairs and top landings may become so great as to smother persons in the upper rooms, or, even when this is not the case, to prevent the fireman reaching them.

The danger to the fireman himself is, of course, greater the further he goes from the point of exit; but the sooner he commences his work the less the danger is; and if he take the end of the life-line in with him, to guide him on his return, the risk is much less than is commonly supposed.

Whether, however, the danger be great or small, there can be no doubt that it is the duty of a fireman to incur it; and that his success in saving life will, in all difficult cases, be in exact proportion to the risk he runs in performing his duty.

Entering from an Upper Window.

When it is not practicable to enter by the street door, the fireman should go in by some convenient window, if possible without breaking anything.

Should it, however, be necessary—as it usually is when entering by a window—to make an opening of some kind, the fireman will do well to break a small piece of glass close to the hasp, and then insert his hand and open the window in the ordinary way, so that whether he remains in the room, or passes from it to the stairs, or comes out again on the ladder, he can shut the window down after him, and thus reduce the danger of the persons inside, and finally of the building itself.

If the fireman hears from any trustworthy person that the inmates are in any particular room, or set of rooms, he should at once proceed in the direction indicated, if possible by the ordinary means of communication, which are the stairs, but if not, then by the ladders, or any other means which may happen to be at hand; but he must on no account fail to keep continually before his mind the fact—so well known in our business—that the information obtained from inmates or neighbours is almost invariably to some extent incorrect; and that it is his duty, even when availing himself of it, at the same time to use his own discretion, and to act on the dictates of his own experience and professional knowledge.

Should it be found difficult to breathe in a room on fire or full of smoke, it will be found an advantage to go on the hands and knees, with the head low down, as there is often pure air close to the floor even when it is impossible to see across the room; and by placing in the mouth a pocket-handkerchief, or any substance through which the air can be filtered, it is quite possible to remain for several seconds in a room under these conditions; and, if the pocket-handkerchief or other article be previously dipped in water, it will be found a still more efficient respirator. The best guide for a fireman under these circumstances will be the lamp he carries; so long as this continues alight, there will be sufficient air for him to breathe, but the moment it goes out he should retire, or move towards a window, or other opening, from which he can obtain a supply.

To relieve a room of smoke, it is best to open a small portion of the window, by breaking the glass, or otherwise, both above and below, in which case the cool air will come in underneath, and the hot air and smoke will pass off from the top.

If the window be opened in only one place, the hot and cold currents of air will meet and obstruct each other, and it will consequently take a much longer time to clear or relieve the room.

In practice, scarcely any amount of heat, without actual flame, prevents a fireman moving about and working as he thinks proper. He may get his hair singed, his clothes scorched, and the outside of his helmet too hot to be touched, without any particular danger of his being seriously injured.

It cannot be too often impressed on a fireman, that so long as there is flame there must be plenty of oxygen to support it, and that consequently there can be no difficulty in finding plenty of air to breathe—in other words, that so long as the fire is burning brightly, a man cannot be smothered. He may, it is true, be burned, blinded, or otherwise injured, but it is impossible, under such circumstances, that he can suffer from want of air; on the contrary, so long as he can keep his head below the seat of the fire, he will feel a very considerable draught, and will experience no difficulty whatever in breathing.

It may occasionally happen that a fireman may reach persons in danger, but, owing to heat and smoke, may be unable to lift or drag them out; in such cases he will do well to make fast the end of the life-line round them, and going to a door, or window, or the top of his ladder, he may be able to haul them out safely.

Saving Life with the Escape.

If the fireman see the inmates at a front window, and has ascertained that the stairs are impassable, he should at once pitch his machine in front, placing the top part—whether main, fly, first-floor, or other ladder—close to, but below, the window.

Should it be necessary to throw up the top ladders in a narrow street, in which there is not room for them when standing athwart, the machine must be placed fore and aft, and the ladders thrown up as described in the inspection and drill instructions; after which it can be run in wherever required, and pitched in the usual way. This is rather a difficult operation, and requires a good deal of help.

When this has been done, the fireman should himself run up, and as a general rule should, in the first instance, go inside the room, from which he should then pass them down, one by one, either by the shoot, by a line, on the ladder, or in any other way that appears most convenient at the moment, always commencing with the children, then taking the women, and last of all the men.

It is desirable for the fireman, as far as possible, to avoid carrying persons down on the ladders; but under certain circumstances it is necessary to do so, as in the case of a person insensible, or injured on one of the high levels above the reach of the main ladder. When such occasions arise, the fireman should, as a general rule, take up the person to be rescued, as described further on, leaving one or both of his own hands almost entirely free, as the weight to be carried in front will be very trifling, and the legs can be held with sufficient firmness by a mere pressure of the arm.

In carrying persons down in this way, it is not desirable to put up lashings of any kind, except under very peculiar circumstances. When, however, it becomes necessary to do so, the fireman should place the person altogether on his back, and should pass the lashing round under his own shoulders, leaving both his arms and hands perfectly free.

A fireman, if alone, will do well to get on the floor or roof on which the persons to be rescued are, and not remain on the ladder, while placing them on his back. He should then get on very slowly and steadily, and taking particular care to keep his balance at all times, but especially at the moment of placing his weight on the ladder. In moving either up or down with a load, the fireman should tread as wide as possible, keeping his right foot close to the right-hand side, and his left foot close to the left-hand side, as the strength of the spokes is greater in these parts than in the centre.

Dealing with Excited Persons.

Occasions may arise when the maddening influence, which the scene of a fire seems to have on persons unaccustomed to it, may place serious obstacles in the way of a fireman carrying out his duty in the mode here indicated—namely, commencing with the rescue of those who are most helpless, and leaving to the last those who may be supposed to be in some degree capable of taking care of themselves; but at such times a fireman must be resolute and determined in having his commands obeyed, and nothing must induce him to allow the men, of their own accord, to take precedence, as they will almost always try to do.

If he be perfectly cool and collected, as he ought to be, his mere command will generally be sufficient, as there is a sort of instinct in most persons which, even in the agony and madness of a panic, teaches them to follow and obey a man who speaks and acts with the resolution, and power, and confidence of knowledge.

At such a moment there is an important duty to be performed, that of saving the greatest possible number of lives; and very little time in which to carry out that duty, probably not more than one or two minutes at the utmost; and there is also a principle at stake, that of giving the first help to those who need it most; and if the fireman hesitate or vacillate in the smallest degree, he throws away the very power on which alone his success in saving life depends, and that at the critical moment for coping with the exigencies of which he has been specially appointed, trained, and trusted.

Although the general rule is here laid down, that the rescue of women and children is to take precedence of that of men, nothing is said which is intended to limit the discretion of the fireman in any way, and he is therefore bound to exercise his own judgment in all cases. For instance, if a man, a woman, and a child were to be saved, and time were not pressing—as at the very early stages of a fire—he might find it convenient to keep the child to the last, and after passing down first the woman and then the man, by means of the shoot or otherwise, he might carry the child down in his own arms. This, and all such arrangements, are entirely matters for his own discretion at the moment; but he must remember that he is bound to be able afterwards to justify to his superiors whatever he has done, or permitted others to do, and that he renders himself liable to severe censure if, through any act or omission on his part, the work is improperly or imperfectly done, or the persons connected with it—whether those imperilled or those assisting—break away from his control, and take the matter into their own hands.

To do this work properly, a fireman must be strong, active, quick, fearless, and intelligent; but, above all, he must be resolute. He may, if he choose, leave himself open to advice, but he must not adopt it unless it commends itself to his judgment. If he accept it blindly, and act upon it, he is responsible for his act, and if he refuse it, he is no doubt responsible for his refusal also; but as advice offered on occasions of fire is almost invariably wrong, even when coming from the owners or occupiers of the premises in danger, the safest course for the fireman will generally be, neither to accept it nor reject it absolutely, but, if time permit, to listen to what is said, then to form his own independent judgment, and instantly and resolutely act upon it.

Mode of Picking up Insensible Persons for Passing them down the Shoot, or Carrying them down the Ladders.

First turn the person face downwards, and take hold close up under each armpit; then raise the body as high as it can be lifted in that position, and allow it to rest on one of the knees; then shift the arms round the waist, and, after interlocking the hands, lift the person in an upright position. After this, take hold of one of the wrists with one hand, and drop into a stooping position; at the same time pass the arm that is free between or around the legs, and the person will then fall

across the shoulders; then rise in an upright position, and balance the body well on both shoulders. In this manner, carry the person to the window where the escape is pitched, and raise the feet to the mouth of the shoot with one arm; then take hold of one of the wrists, and ease the body gently off the shoulders into the shoot, always taking care to keep the face uppermost. As a rule, women should be passed down a shoot head foremost, and men either way. When women are passed down the shoot feet first, a small line should invariably be used to tie round their clothing, in order to prevent it from catching in the shoot.

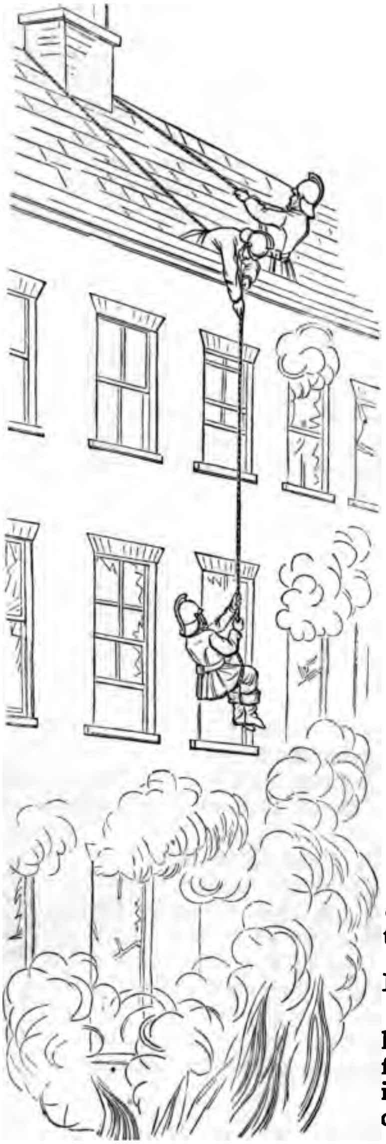
The following methods are found to be most convenient for carrying children down the ladders. Place a child under each arm, and grip each tightly by the elbow and forearm, in such a way as to leave both hands quite free to take hold of the sides of the ladder. Another way, is to place one child under the arm, and the other over the same shoulder, and lay hold of the latter with that hand, which leaves the other arm and hand quite free for taking hold of the ladder in descending.

RESCUING PERSONS BEYOND THE REACH OF LADDERS.

In the event of a person, or number of persons, being seen or known to be in the upper parts of a house on fire, beyond the reach of fire escapes or other ladders, several courses are open for their rescue.

BREAKING THROUGH A WALL.

If it be possible to break through the wall of an adjoining house on the same level, this should be at once tried, more particularly as it can be entrusted to any intelligent bystander, who can be supplied with the crow-bar for the purpose. In the upper parts of houses the walls are not very thick, and, if new, would yield to the work of one good man with a crow-bar in about a quarter of an hour, if some of the women or other inmates of the house in which he is working remove the bricks and rubbish.



Much delay would result from attempting to make a hole of 18 inches in diameter all at one time, and the man should be instructed first to make a small hole through, so as to get an entry for the crow-bar, after which he will have no difficulty or trouble in removing as many bricks as he wishes, one by one.

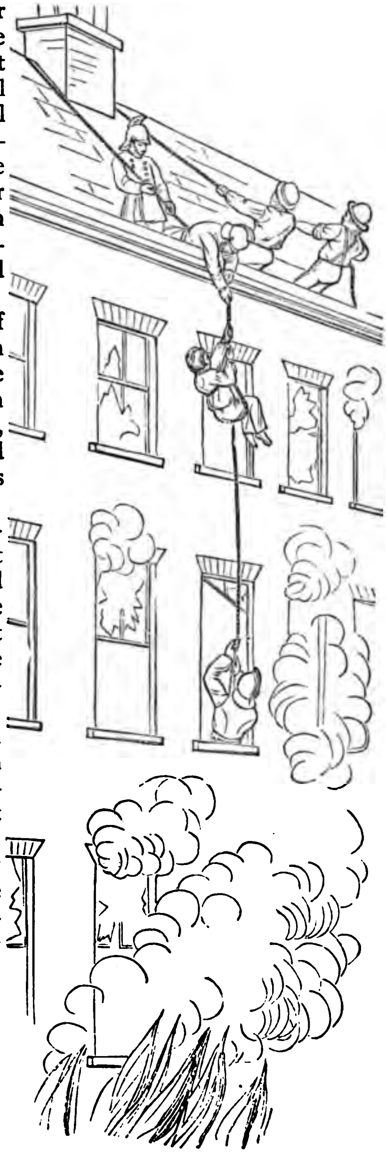
BREAKING THROUGH A ROOF.

While the assistant is at work in this way, the fireman may either mount through the trap, or otherwise, to the roof of one of the adjoining houses, from which he may be enabled to reach the roof of the house on fire, and to enter, either in the usual way by the dormer windows or trap, or, if this cannot be done, he may succeed in cutting through and removing the slates or other covering, after which he may be able to enter and bring the inmates up through the same opening.

RESCUING BY A LINE FROM ABOVE.

Should this prove impracticable, he may be able to lower down a line from the roof, either of the house itself or the house adjoining, and to draw the inmates up by the line.

If the fireman have a competent assistant with him, such as another fireman who would thoroughly understand the proper mode of proceeding, his best course would be to get himself lowered down by the line to the necessary level, to enter by the window or other opening, and to place the inmates in a chair knot, and allow his mate on the roof to haul them up or lower them down one at a time, he himself keeping, all through, an end by which he could guide the persons on the line clear of the window-sills or other obstructions, and also get back the knot, without the delay which might occur if he were to part with the fall of the line. After having passed all the inmates out in this way, the fireman should, if possible, examine the adjoining rooms, and take such other steps as may be necessary, either in the way of shutting doors, or otherwise, before getting himself hauled up.



Should the fireman find himself without a skilled assistant on such an occasion, he should obtain the help of any persons who may happen to be near; and for this purpose, women and children will be found perfectly available, and almost as useful as men.

He should, under these circumstances, remain on the roof, and not on any account get himself lowered down, as his doing so would have the effect of rendering him almost powerless, and of putting the whole of the work into the hands of unskilled persons.

He should pass the line round a chimney, or some other fixture, which would relieve the hands of the persons holding the end from the direct pressure of the load.

This, with a party of firemen, or other skilled persons, would not be absolutely necessary, but it is an indispensable precaution when the assistance of unskilled persons is made available.

The effect will be that the fireman on the roof will have to do the whole of the lifting or hauling up alone, and his assistants will merely have to gather in the slack of the line.

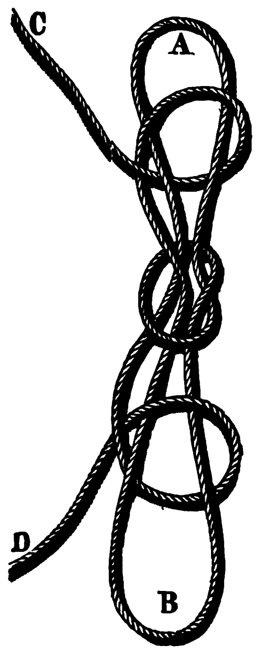
In many cases, however, some one will be found with sufficient steadiness and courage to join the fireman on the roof, and the two together ought to have no difficulty in hauling up any ordinary person, provided their assistants are quick and steady in taking in the slack.

Concerning Knots.

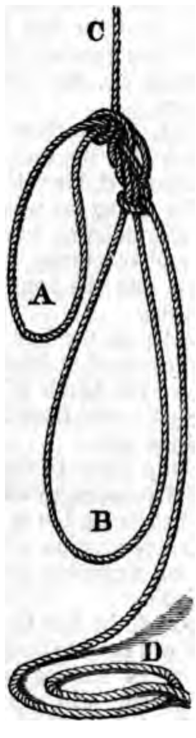
As to the knot to be put up, no special directions are given. This must be entirely left to the judgment and discretion of the fireman; but, as a general rule, he will do well not to trust the inmates in a chair-knot, unless he goes down to the room and puts them in himself. Should he be unable to do this, his best course will be to put up a running bowline, or other slip-knot, which will close on the person round whom it is placed, and then to lower down the line with the knot loose, so that, if the inmates have any sense or presence of mind left, they will *see* what they ought to do in order to avail themselves in the most convenient way of the help that is offered to them.

The accompanying description and illustration will explain the formation and use of the chair-knot.

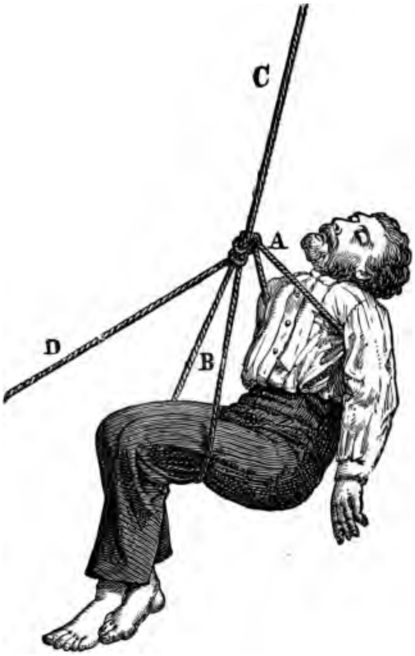
The Knot in Course of Formation.



The Knot Hardened up and Ready for Use.



THE KNOT IN USE.



A. The arm loop. B. The leg loop. C. The hauling part. D. The guy.

A chair-knot may be formed in the middle or towards an end of a rope, and consists of two loops or bights of a combined length (for a grown up person) of about 6 feet, one about $2\frac{1}{2}$, and the other about $3\frac{1}{2}$ feet, with the knotted part between them, and the hauling part and the guy both leading from the knot. It may be formed in a variety of ways, one of the simplest and quickest of which will be as follows:—

On that part of the rope which is to be used, put up a common double over-hand knot, hauling the bights through to about the length before mentioned, and measuring the whole length by the ordinary span of the arms. Then over each bight pass a half-hitch of the rope, in the same way as for a sheepshank, and slip the hitch close down to the knot; use one end for the hauling part, and the other for the guy.

This knot does not require the use of an end in forming it; it uses very little of the rope; it can be put up in a moment; and will never, under any circumstances, render. To adjust the chair-knot on a person to be rescued, slip both loops over the shoulders and arms, let the longer loop come into the bend at the back of the knees, the smaller loop close up under the arms, and the fall and guy in front of the chest. The adjustment is made in a few seconds, and, when the weight comes on the hauling part, the person in the knot is about in the same position as if seated in a chair. A person lowered by this knot, though not subjected to any pressure or inconvenience, is effectually pinioned, and, however violent and excited, cannot struggle out after having been once properly slung.

I am clearly of opinion, that a chair-knot is in every way the safest, provided the person to be moved is once properly placed in it, but I hardly think it is safe otherwise; and it is on this account that I have recommended, under certain circumstances, the use of a slip-knot, which, though in other points very much inferior, has the important merits of being likely to be understood by the persons to be rescued, and of closing on any one suspended by it with a force exactly in proportion to the weight of the load, and consequently in such a way as very considerably to reduce the chance of falling out of it. If the circumstances admit of giving directions, the person to be rescued should be instructed to slip the knot up underneath the arms, and then to draw it tight and hold on with the hands to the line outside the knot, which will have the effect of keeping the head upwards, and the whole body in a safe position during the jerks which are inseparable from such an operation as hauling up a heavy body by intermittent efforts, and about a foot at a time, with a line passed over a rough parapet.

Lowering Lines from Adjoining Premises.

When it is impossible to get on the roof of the house on fire, the fireman may be able to find his way to some part of any adjoining premises above the level of the window in which the persons to be rescued are, or are supposed to be. He can lower a line down to the street, and his assistants can carry the end below in such a direction as to bring a part of the line across the window. The fireman above may then take a turn of the line, the persons to be rescued may get on it, one by one, the end of the line below may then be hauled out clear of burning windows or other dangerous places, and the persons removed, either by being taken into the windows of the adjoining houses, or by being lowered down to the street level, and the same process may be repeated until all are saved.

As this is an operation requiring effort on the part of the persons to be rescued, it would be well, whenever practicable, for the fireman to relieve them of that effort by himself going down on the line in the first instance, and entering the room in which they are, so as to be able to place them safely in a proper chair-knot out of which they could not fall; but where, owing to want of skilled assistance, the fireman cannot do this, his best course will be to put up a chair-knot, a running bow-line, or some other safe knot, and lower the line to such an extent that the knot will come in front of the window.

It has been explained that there are certain dangers attending the use of a chair-knot by unskilled persons; but when both ends of a line have to be hauled taut, a slip-knot would render, and the use of a chair or other fixed knot is consequently, in such a case, unavoidable.

It may also be occasionally possible to lower down a loop or bight of a line from two adjoining premises, one at either side, keeping an end above in each, and allowing the centre of the bight to come in front of the window or opening from which the rescue is to be made. If plenty of help be forthcoming, this mode of rescue may be considerably assisted by a line with a standing bow-line, or other fixed knot, which will slip along on the line lowered down, and so enable persons in the street to take hold of the hanging end, and guide the persons to be rescued clear ot burning windows, projections, or other obstructions.

THROWING A LINE BY WHICH PERSONS MAY LOWER THEMSELVES.

When, in consequence of the height, or from any other cause, it is impossible to get on the roof or into the upper stories of the house on fire, a line may be thrown from the roof or upper part of premises adjoining, and the persons in danger may be hauled out and saved in that way; or, if they have sufficient presence of mind and enterprise, they may take the whole line, when it is thrown to them, and, making fast one end within the room, they may lower themselves down to the street; the persons outside meanwhile watching to receive them below, and hauling the hanging end of the line sideways, if necessary, to keep them clear of obstructions or of flame issuing from the windows during their descent.

THE COURSE TO BE PURSUED IN NARROW STREETS

Hauling by a line from an opposite house.—In narrow streets several devices may be made available. A line may be thrown across, and the persons in danger may be hauled out direct. This would be a dangerous proceeding, as they might receive a heavy blow on striking the wall opposite; but, even if this did occur, it would be better than abandoning them to the flames. In case it is necessary to do this, the fireman should endeavour to make fast the part of the line which he holds at as high a point as possible, for the purpose of reducing the blow caused by the fall.

Thus, in a street 12 feet wide, if there be a difference of level of only 6 feet between the point over which the line passes and the window from which the persons are to be rescued, they would receive a heavy blow against the wall on the opposite side, unless precautions were taken to prevent it; whereas, if there be a difference of level of 40 or 50 feet, they would scarcely receive any shock at all, even if no precautions were taken.

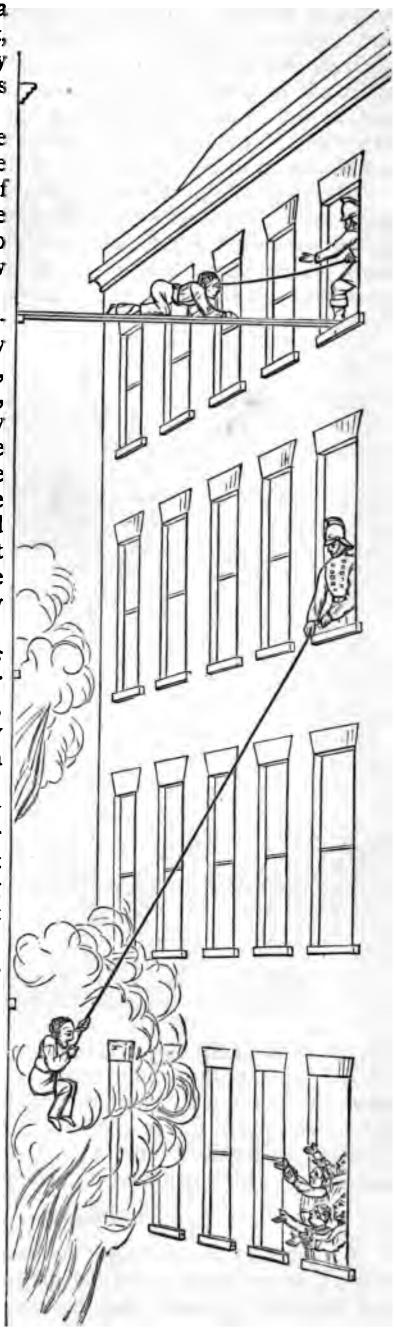
If, however, they happen to have any presence of mind, a second line may be thrown to them, one end of which they might make fast inside the room, and, by holding on to the part outside, escape the blow altogether.

Should this, however, be impracticable, an intelligent fireman may find other means of breaking the fall, such as by holding out a preventer, or a plank, to check the line; by hanging a bed or other soft substance on the wall against which they are to fall; or by so adjusting his line that the persons to be rescued should fall towards an open window, at which they may be caught in the arms of the inmates, and thereby escape the shock altogether.

Rescuing by Planks or Ladders thrown across.—Planks, poles, or ladders also may be passed across, and placed horizontally from window to window as a bridge, on which persons may walk or creep over.

In most houses, it might hardly be possible to bring ladders or other long appliances upstairs inside; but there can be no difficulty in hauling them up on the outside by a line let down from a window or the roof.

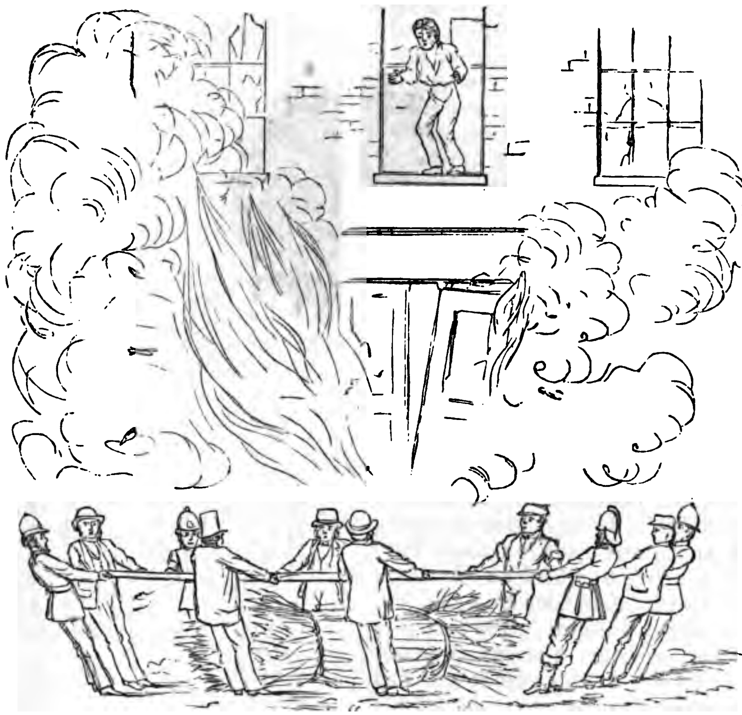
When rescuing persons from a house on fire in this way, it will be well, as a precaution, to make a line fast to them, as they are likely to lose nerve, and, when they do, they will either stop in the middle or fall off.



RESCUING BY THE JUMPING-SHEET.

Should all the previously-mentioned means turn out impracticable, the fireman should prepare his jumping-sheet, getting as many persons as possible to hold it by the hand-loops or beckets, at a height of about three feet from the ground, putting at the corners those who are most accustomed to deal with emergencies—such as policemen, who are almost always certain to be present; and, when all is ready, he should order the persons in the house to jump out, at the same time watching the whole proceeding with the utmost attention, and taking care to move the party holding the jumping-sheet a little, so as to ensure the body falling in the centre.

The best mode of placing the jumping-sheet will be to make the persons holding it take the beckets with both hands, their arms being at full stretch, their feet forward, and their heads and bodies thrown well back, so as to stretch and tighten the centre of the canvas as much as possible. Even when the jumping-sheet is properly arranged, with



plenty of help for holding it, it is very difficult to support it against the weight of a body coming from a considerable height; it is therefore most desirable, whenever practicable—and it will generally be found to be so—to place under the whole of the jumping-sheet, but more particularly under the centre, a bed, carpet, truss of hay, or any other soft substance, which will have the effect of breaking the fall.

Returning from a Fire.

As soon as the fireman has ascertained, either by his own observation, if he be alone, or by the orders of his superiors, if there be any of his superiors present, that he can be of no further service, he must return to his station with reasonable speed, and must get the escape ready for another run, making whatever inspection may be necessary, securing the machine, and using all other precautions, in the same way as when first taking duty.

Mode of Proceeding in Cases of Burns or Scalds.

In case of burns and scalds, however slight, medical aid should be obtained on the spot as soon as possible, and in the meanwhile the fireman must be very careful not to allow water to be thrown on the patient, or any other step to be taken which may cause a shock to the system.

The best course to pursue while waiting for the arrival of the medical attendant, will be to cover the patient with a layer of wadding or cotton wool saturated with common linseed oil, or, if none of this be available, then with the cotton alone. This will exclude the air, and, if the lotion be used, it will not stick to the skin.

Should there be any difficulty in obtaining the aid of a medical man, the fireman should take such measures as may seem best to remove the patient at the earliest possible moment, either in a cab or otherwise, to some hospital.

In conveying a patient to a hospital, it is always advisable to use a covered conveyance; and in removing the clothing of a person much burned or scalded, the greatest possible care should be taken not to strip off the skin with the garments.

It is important to remember, that the greater the amount of surface injured, however slightly, the more severe will be the effect on the system.

In the country, or other places in which medical aid cannot be immediately obtained, every fire-engine might be provided with a small quantity of cotton and a quart bottle of lotion, marked, "Lotion for Burns and Scalds." This is made by mixing equal parts of lime water and linseed oil; it costs very little, and keeps for any length of time. This lotion should be well shaken before being poured out for use.

Payments for Assistance.

In London, the following are the authorised rates of payment for assistance in going to and returning from a fire:—

	s.	d.
A call to a fire	1	0
Assistance with the escape	1	0
A call, and assistance given by the same person	2	6
Additional reward for the person giving the call, if a life is saved by the fireman ...	2	6
A message sent by the fireman	1	0

The fireman may obtain the assistance of three persons when proceeding to a fire.

Most of the directions here given have reference chiefly to the case of a fireman arriving before the engines, and finding himself alone; but it is of course to be understood that in the event of his getting up after others, he should take the earliest available opportunity of reporting his arrival to the senior present—whether an officer or not—and placing himself in the ordinary way under his orders. It is also to be understood, that no fireman of any rank ever leaves the scene of a fire except by order of the senior present.

APPLIANCES

FOR

ENABLING PERSONS TO BREATHE IN DENSE SMOKE OR POISONOUS VAPOURS.

NUMEROUS attempts have been made, both in ancient and modern times, to enable persons to enter safely into places full of smoke or noxious vapours, but very few of the appliances employed for the purpose, even though apparently successful during experiments, have received the sanction of permanent use. Means have been invented to enable persons to pass through the flames of a furnace at nearly white heat, but they have been troublesome and expensive, and obviously so seldom likely to be of any use, except for purposes of display or public entertainment, that they have naturally fallen below the level of practical criticism, and are only mentioned here as matters of scientific curiosity.

Our great enemies in this way are smoke, and those innumerable poisonous vapours created by intense heat, under certain combinations, well known to chemists, but too abstruse to be explained here, which we designate under the general title of mephitic gases.

The vapours which we find dangerous probably include azote, sulphurised hydrogen, carbonic acid gas, choke damp, and numerous other defined and well-known gases; but it is unnecessary to enter here into the chemical details, or to be very precise as to the terms by which these vapours are designated in laboratories, as I mean simply to include under the general head of mephitic gases all those vapours we meet in our business which will not permit respiration to continue within their range.

To enable a man to enter into and remain in a place strongly impregnated with mephitic or noxious gases, two courses are open. One is to supply him with pure air from an external source; the other to provide him with the means of filtering for himself such air as he finds, admitting to his lungs only that which is pure and useful, and rejecting the rest.

I will now endeavour to describe a few of the best known appliances for this purpose, including breathing tubes, air bag and tubes, smoke jacket, smoke cap, woollen filter, and fire-proof clothing; and I will take them in the order here given, commencing with the breathing tubes.

BREATHING TUBES.

For supplying air from external sources several modes have been tried, among others what were known as breathing tubes, one leading from the external air into the mouth, the other leading outward from the nose, and a mouth-piece and nose-valve arranged for the purpose. This, in certain cases, has proved efficacious, but the working of it requires not only practice, but an amount of attention which it is difficult to keep up, and when the inlet or air-pipe has to be very long, and to go round curves, the labour involved in breathing is sometimes considerable. Why this should be so I cannot say, as the pressure of the external atmosphere ought to be ample, and more than ample, to overcome the friction in the pipe; but it has occurred, and does occur, and therefore ought to be mentioned. Another application by these tubes is by means of a mouth-piece alone, with two openings, which can be closed alternately by the tongue, the nose being stopped with a nose-pincers. This also has proved successful in very simple cases, and for short periods, but it is evident that it would not do for our rough work and rapid movements. It is quite correct in principle, but is probably best adapted, in practice, to the purpose for which it has been much used abroad, namely, to enable persons to breathe under water in certain baths which require the immersion of the head. Attempts have also been made to work with a pipe leading merely from the man's mouth to the ground, but they have been for the most part unsuccessful, and when not unsuccessful have been useless, as a man generally is on his hands and knees on such occasions, and then does not require the pipe, or, if he is standing up, he has only to stoop down and obtain such clear air as there may happen to be available.

Although these long breathing tubes have been in partial use for many years, and an illustration of them appears in an old French manual, there are several very essential points in connection with them which have never been sufficiently attended to in order to adapt them to our work.

One is, that it is absolutely necessary to have full use of the nose as well as the mouth for breathing, when hard work has to be done; another, that there ought not to be any part of the apparatus within the mouth, as this causes an accumulation of saliva and mucus, which has a most injurious effect on a man engaged in heavy labour; another, that the whole should go on and off together, and not in separate pieces, as hitherto; and another, that all the materials and workmanship should be of such a kind as to give those who use the apparatus confidence.

There seems to be no reason why the requirements of firemen in this way should not be met by a mask of a partially flexible material, such as thin lead or stiff leather, and with thick soft padding or air and water tubes, containing, in one piece which could be instantly slipped on, a pair of eye-glasses, a nose and mouth-piece together, and a valve chamber, of the same pattern as that used for the smoke cap, and described further on. In fact, I have made such a mask, and it works very well, and is satisfactory in all respects except cost; and even in this point I am not without hope, as I think some of the fittings may yet be reduced in such a way, that the little apparatus may not be too expensive for general use.

Air Bags and Tubes.

Another mode is to carry into the smoky place an inflated bag of air, with two tubes, of the kind already described, connecting it with the mouth, one tube leading from the bottom of the bag or reservoir, and the other to the top, the tongue acting as a valve. In this case the man inhales through the tube leading from the bottom, and exhales through that leading into the top, and the discharged air being warmed, and consequently lighter, remains for a time on the top, and, mixing with the remaining air, may be inhaled again several times. With such an apparatus working properly, a man can remain in the foulest air several minutes, but it is obvious that he must be very careful in the management of the tubes.

Smoke Jacket.

One of the safest appliances for the supply of air to a person working in a smoky or vitiated atmosphere is that known for many years in most English fire brigades as the smoke jacket, and abroad as the *blouse contre l'asphyxie*, *appareil à feu de cave*, or in some places as the *appareil Paulin*, from the name of its supposed inventor. The smoke jacket consists of a blouse of cow-hide, pliable, light, and mounted with a hood which completely envelopes the man's head. It is mounted in front of the face with a pair of eye-glasses, on a half cylindrical sheet of glass, firmly fitted to the front of the hood, so that the wearer can see everything in the place to which he has penetrated; and underneath the mask there is a whistle fitted with a valve, which serves for giving signals. Straps and buckles, called bracelets, hold the sleeves round the wrists; and a thong, called a *cuissiere*, or leg-strap, which is fixed in front, and, after passing between the legs, is buckled behind, prevents the blouse rising. It is, besides, held over the hips with a leather girdle, on the front of which a lamp can be carried when required. On the left side is fixed a screw, to receive the corresponding screw of a hose which is of the same pattern as those of the fire-engines, and communicates at the other end with one of these engines. The pump of the fire-engine being set to work, of course without water, drives air into the jacket, swells it out, and keeps the man in a compressed atmosphere, which is continually renewed. The surrounding air cannot penetrate, being continually driven back by that escaping at the wrists and other openings. Once inflated, the blouse holds enough air for a man to be able to breathe in it without difficulty for six or eight minutes, but it is necessary to continue working the pumps, in order to enable him to remain inside any length of time. When the lamp is lighted, air is introduced to it by means of a little pipe communicating with the inside of the jacket.

This smoke jacket is very useful for extinguishing fires in vaults, stopping conflagrations in the holds of ships, and penetrating wells, quarries, mines, cesspools, &c.; any place, in short, where the air has become unfit for respiration. The special advantages of this jacket are its great simplicity, its facility for use, and the rapidity with which it can be carried about and put on; but its drawback is, that it requires the use of an engine, or air-pump, and consequently is of no service to one man alone. For this latter reason, smoke jackets, although very effective for enabling us to get into convenient places for extinguishing fires, have very rarely proved of any avail for saving life.

Wherever vulcanised india-rubber tubes are used for the purpose of conveying air to the lungs, I should recommend very great caution, as it is undoubted that, at least in some cases, men have been known to suffer serious inconvenience, if not to incur considerable danger, from inhaling through this material. This is, however, a very trifling difficulty, and I have no doubt has only to be pointed out to be speedily obviated.

Smoke Cap.

Another apparatus, and one free from the disadvantage of being dependent on aid for its use, is the smoke cap, which is very light and portable, and can be brought into use almost instantaneously by a man working alone.

A smoke cap is an apparatus by means of which a man is able to breathe when working in dense or poisonous vapours. It provides for the mouth and nose a light, closely-fitting filter with valves, and for the eyes a complete cover, which will act as a protection without obstructing the sight, the whole being capable of being put on and completely adjusted for use in a few seconds by the man who is to wear it, without aid from any one else.

It is desirable that it should be strong and fit for rough work, also that it should contain no delicate parts likely to get out of order, and no material parts inaccessible for immediate examination.

Every one of these requirements may be separately carried out without much trouble, where the questions of time and rough usage can be put out of consideration; but the combination of the whole for rough work, and the shortness of the time available at our business for adjustment, have hitherto constituted very serious difficulties, which, however, it may be hoped, are now to a great extent, if not altogether, overcome.

The filter, which separates the pure air from smoke of noxious vapours, and which constitutes the speciality of the apparatus, is the invention of Professor Tyndall, who has in the kindest and most liberal manner placed it at our disposal solely from public spirit, and without fee or reward of any kind whatever.

The first complete apparatus, as now issued, was designed and made up by ourselves in the workshops of the fire brigade, and served as the pattern for those afterwards furnished by contractors.

The smoke-cap consists mainly of two parts, called respectively the hood and the respirator.

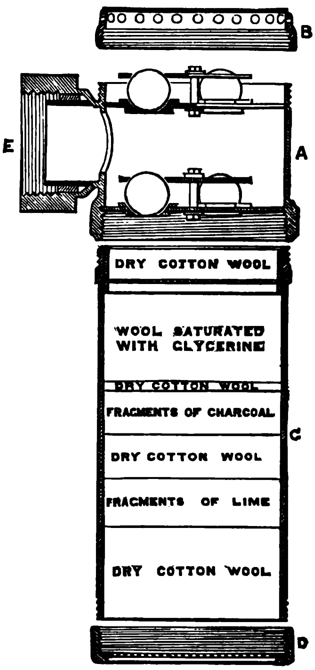
The hood is made of the best dressed calfskin, blacked, cut in sections, and closed with air-tight joints, each part overlapping the next to an extent of half-an-inch, and the sections strongly sewn together with two separate rows of saddlers' stitching. The skull part is fitted to the shape of a man's head, and is about 24 inches in circumference at the widest part; underneath this there is a band about 2 inches deep, forming a collar, to the lower edge of which there is attached a kind of yoke or apron-piece about 6 inches deep, shaped to fit on a man's chest and shoulders under a tunic.

To facilitate the putting on and taking off of the hood, there is an opening down the whole of the back part, from the crown to the neck, and on each side a row of four eyelet holes with brass bushes, through which there is rove as a lacing a leather thong, the ends of which go round to the front, and, after passing through a small metal ring, are knotted at the ends below two hard wood knobs, to prevent their being pulled back through the ring. When the hood has been put on, the thongs are pulled in front, and, rendering through the eyelet holes, draw the whole of the skull part close to the head. The opening at the back is fitted with a piece of what is commonly known as waterproof sheeting—a thin, air-tight material, which occupies very little space, and although wide enough to allow the head to enter freely, is easily folded away by the drawing of the thongs. The lower flap or apron part is tucked in under the collar of a tunic, so as to form an air-tight joint sufficient for the purpose.

To the front of the hood, inside, is attached, by means of round-headed brass rivets, a frame or piece of tinned sheet metal, shaped to fit the front of a man's face, from the bridge of the nose to the chin, and fitted with a rubber tube, containing air and water. Opposite the mouth, there is attached to this frame a piece of brass, with a circular opening, cut on the outside with a male thread to take the swivel screw of a respirator. The male screw to which this swivel is coupled has cut inside it a recess, in which a leather washer is placed, so as to make an air-tight joint when the coupling is screwed up.

At a distance of about four inches above the mouth-piece there are fixed a pair of curved eye-glasses of the best clear glass, set with cement in brass rims with lugs, which are attached by screws to curved metal frames, rivetted on the inside of the hood. The respirator consists of two parts, the valve chamber and the filter tube.

The valve chamber **A** is formed of a piece of best drawn brass tube, 2 inches long and 2 inches in diameter, with an upper and lower valve plate, and between the two a slotted horizontal opening, to which is soldered on and rivetted a brass connecting piece **E**, about half-an-inch long, fitted on the end with a swivel screw to match the outer mouth-piece screw on the hood.



HALF-SCALE.

Each of the valve-plates is fitted with three ebonite ball valves, two only being seen in the diagram, ½-inch in diameter, turned perfectly round, and without the slightest projection or rim in any part. The openings in the plates are 5/10ths of an inch in diameter, and are so cut that the seatings embrace at least one-third of the valves. The seatings, which are separate pieces, are screwed into the plates, and are most carefully bevelled out so that the valves shall make an exact fit, being neither so tight as to stick nor so loose as to allow leakage. The valves are properly protected above by metal guards, which allow a lift of 1/8th of an inch for suction, and a shade less for delivery.

Above the delivery valves there is screwed on a nut or cap plate **B**, which protects the valves and guards from injury, and is pierced round the edge with 28 holes for the escape of the discharged air.

The filter tube **C** is also of brass, of the same diameter as that used for the valve chamber, and is four inches long. Across the upper end, inside, there is soldered on a piece of fine copper-wire gauze, with 1/16th of an inch mesh, to prevent wool or other light substances passing, and over the lower end there is screwed on a brass ring or cap **D** with a similar piece of wire gauze.

The whole of the respirator is tinned inside and lacquered outside.

The following parts of the respirator are screwed on to each other, and are therefore capable of being quickly and easily separated for examination and cleaning when necessary:—

1. The top nut or cap plate, which has a female screw to receive the male screw at the upper end of the valve-chamber.

2. The valve-chamber tube, which has two male screws, of the cylindrical part of the suction-valve plate, and the one at the top to join the covering plate or top cap.

3. The suction-valve plate, which has two female screws, the one at the bottom to take the top male screw of the filter tube, and the one at the top to join a male screw cut on the lower end of the valve-chamber tube.

4. The whole of the filter tube, which has two male screws, the one at the bottom to take the cap, and the one at the top to join a female screw cut underneath in the cylindrical or outside part of the suction-valve plate.

5. The lower cap, which has a female screw, and is joined to the male screw on the bottom end of the filter tube.

The charge for the filter consists of the following materials, which are put in with the tube turned upside down, and, of course, the lower cap removed :—Half-an-inch deep of dry cotton wool, an inch deep of the same wool saturated with glycerine, a thin layer of dry wool, half-an-inch deep of fragments of charcoal, half-an-inch deep of dry wool, half-an-inch deep of fragments of lime, and about an inch deep of dry wool.

These should be packed so closely as to fill every part of the chamber, and they should be pressed down as tightly as experience shows to be compatible with facility of breathing through them when in use. After this the lower grating cap is screwed on, and the filter is then ready for use.

Alteration in Arrangement of Charge for Smoke-cap Filter.

The following changes may be made in the arrangement of the charge for the smoke-cap filter, as previously explained.

Experience has shown that the fragments of lime, which are put in for the purpose of absorbing carbonic acid, become reduced to powder merely from the effects of the atmosphere, and are often quickly slaked by a man's breath. As these particles, when pulverised, render breathing very difficult—and it has been thoroughly ascertained that in fires carbonic acid is very seldom present in sufficiently large quantities to cause actual danger—it has been determined to remove the lime altogether, and to re-arrange the other materials.

The following is found a good arrangement :—Half-an-inch deep of dry cotton wool, an inch deep of the same wool saturated with glycerine, half-an-inch deep of dry wool, an inch deep of fragments of charcoal, and an inch deep of dry wool.

It will, of course, be understood that, whenever carbonic acid is known or suspected to be present, a layer of fragments of lime may with advantage be added for immediate use, a corresponding portion of dry wool being removed for the purpose; but in such cases it is advisable to remove the lime shortly after use, and to replace the wool as before.

Each particle of smoke is in fact a piece of solid carbon or charcoal, carrying in it, and with it, a small load of noxious vapour, which produces greater irritation in the throat and lungs than even the solid particles; and there is always present in smoke some carbonic acid, which, though generally at work in small quantities, is occasionally found sufficient to cause both trouble and risk to those inhaling it.

The dry cotton wool acts with great effect as a filter, arresting the larger portion and coarser particles of the opaque smoke.

The wool, moistened with glycerine, acts as a finer filter, arresting that portion of the opaque matter of the smoke which, from its tenuity, escapes arrest by the dry wool.

The charcoal arrests the invisible pungent vapours existing in the smoke, which no mere mechanical filtration would effect.

The lime absorbs the carbonic acid produced by the combustion of burning.

The succession of the layers may be changed without prejudice to the action, but for such rough business as ours it is well to have some dry wool in at least the following places, namely: on top, to prevent the taste of the glycerine, charcoal, or lime penetrating into the mouth; between the charcoal and lime, to prevent their mixing; and at the bottom, to prevent the charcoal or lime falling out.

To prepare for putting on the smoke-cap, take off the helmet, open a few of the top buttons of the tunic, and turn over the collar, breast, and back, as low as possible, without interfering with the free movements of the arms.

To put on the cap, hold it with the face part downwards, open the lacing sufficiently to allow the head to pass in, and, taking the lower part of the sides or flaps in both hands, with the knobs and the ends of the thong hanging down, slip the hood over the head, and, as soon as the top rests on the crown of the head, adjust the nose and mouth-piece over the nose and mouth, which will bring the eye-glasses and other parts into their proper places; tuck in the lower flaps under the tunic, take hold of the thongs in front, and pull on them until the lacing at the back draws the skull part close to the head all round.

It is not actually necessary to knot the ends of the thong in front, but it is convenient to do so, and in any case they ought to be tucked inside the breast of the tunic, lest they should catch in anything when at work. After this, turn up and button the tunic, put on the helmet, and then all is ready.

Care should be taken to fasten the nose and mouth-piece so tightly as to prevent the escape of exhalations, which would dim the eye-glasses.

It is almost needless to mention that the hood may be put on with or without the respirator, as the latter can be coupled on and removed equally well whether the hood is on or off.

For practice the whole should be done by the man himself, without any help whatever.

With valves so very small and light as those necessarily used in an apparatus which is carried on a man's head, there is always more or less danger of their sticking in the seats or guards, especially when subjected to the combined action of heat, and of the vapour and water from a man's mouth; but this danger is generally obviated without any difficulty by the man either tapping the side of the respirator with his hand, or jerking his breath and blowing out any water which may have accumulated in the valve-chamber.

The cap, with all fittings complete, is carried in a circular tin case, about 10 inches long, and 6 inches in diameter, with a capacity of 282 cubic inches, or less than one-sixth of a cubic foot.

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The weights of the several parts are as follows:—

	ozs.	lbs.	ozs.
Hood, with mouth-piece, thong, &c. ...		1	4
Respirator—			
Top cap	1¼		
Valve-chamber tube, with top valve-plate, valves, guards, connecting-piece and swivel coupling ...	7¼		
Lower valve-plate, with valves, guards, and cylindrical part	2½		
Filter tube, with top grating	5		
Lower cap of filter tube	1		
	—	1	1
Charge		0	3
Tin case		1	8
Total		4	0

SUMMARY OF WEIGHTS.

	lbs.
Hood and fittings	1¼
Respirator (charged)	1¼
Total as worn	2½
Tin case	1½
Total as carried	4

WOOLLEN FILTER.

This is a very simple contrivance, but one more frequently used than perhaps all the others together. When some of the appliances previously mentioned cannot be obtained, a man who has to enter smoky places will find a great advantage in placing over his mouth and nose any woollen or other substance which will act as a filter, and intercept the grosser sooty particles of the smoke.

FIRE-PROOF CLOTHING.

In connection with this part of the subject—though, as already explained, rather as a matter of scientific interest than of practical usefulness—the following description is given of an apparatus for enabling a man to pass through a furnace, and even to remain in it for several minutes.

DESCRIPTION OF THE "APPAREIL ALDINI."

In certain cases it may be indispensable to traverse the flames in order to reach some particular spot, and it was for the purpose of preserving persons who find themselves in such circumstances that the Chevalier Aldini, an Italian physician, thought of the apparatus which bears his name.

This preservative apparatus consists of two vestments, one composed of a thick tissue of asbestos (*amianthus*), or woollen stuff, made incombustible by means of a saline solution, the other of a metallic cloth of iron wire, covering the first garment, and mounted with a helmet on its upper part.

A person enveloped in these two garments can withstand the action of flames for some minutes without experiencing any dangerous effects, for on the one hand the external metallic tissue cools the flames, and on the other hand the internal tissue transmits the heat very slowly, on account of the want of conductibility in the substances of which it is composed.

Aldini's apparatus dates at least from the year 1825, but notwithstanding the good results which it has shown in the numerous experiments to which it has been submitted, it has never been adopted to any considerable extent, either because the circumstances in which it could be really of service are much too rare in comparison with the expense of its manufacture and maintenance, or because—as happens with a number of inventions—it presented in serious practice considerable inconveniences, such as rarely occur in experiments for mere show, where everything is generally arranged for the success of the operation.

The following is an account of one of the experiments made in Paris, in 1829, by some *sapeurs pompiers*, or firemen, with Aldini's clothing on:—Two piles were erected of thin wood, covered with straw, ten yards long, two yards high, and distant from each other about a yard and a-half; two lateral openings allowed the firemen to go out from the flames, if they were compelled to do so, and in other ways facilitated the experiment, which consisted in traversing half the length of the burning heap, going out by one of the lateral openings and entering again by the opposite end, and then repeating the same experiment from the other side of the heap. The four firemen who were to make this trial were clothed in the new garment of metallic tissue; two carried, besides, a clothing of asbestos (*amianthus*) over a cloth garment, rendered incombustible by borax, alum, and phosphate of ammonia; the two others had a double clothing of prepared cloth; each man had boots of asbestos, and under the foot a piece of cardboard of that substance; and one of them carried on his back a child, ten years of age, whose head was enveloped in a helmet of asbestos. The firemen penetrated together into the interior of the double pile of flames, and, walking slowly, traversed it several times. At the end of 60 seconds, the child enclosed in the basket cried out, so that the man who was carrying him was forced to retreat precipitately. They made haste to take out the child, who had in no way suffered; his skin was tresh, and his pulse, which beat 84 before the experiment, was only 96 after it. He could, without any doubt, have remained much longer in this wrapping, were it not for the fear which seized him, and which was caused by one of the straps supporting the basket having slipped a little on the shoulder of the fireman who carried it. The child, at the sight of the flames which roared below them, thought he had been thrown into them. A few minutes after he was as merry as usual, and felt no uncomfortable sensation. The fireman who carried the child had, before the experiment, 92 pulsations a minute, and after it 116. The three others remained in the flames two minutes and forty-four seconds, and came out without having experienced anything except a sharp heat. The pulsations were before 88, 84, and 72 a minute, and after 152, 138, and 124 a minute. The flame was continually fed with straw thrown upon that which was burning. There was very soon formed an enclosure of fire, in which the firemen were shut up; and as a portion of the straw scattered on the ground threw up a flame which at times enveloped their legs, it was certain that the bodies of the men were exposed to the direct action of the flames. At a distance of more than six yards from the focus of the fire, the heat was so intense that none of the numerous assembly could remain there. In other experiments the firemen were furnished with large shields, which they made use of to keep back the flames. It is obvious that such an apparatus as this could be of very little use for general work.

I have now gone through the principal appliances I can remember for the purpose of enabling men to work in smoke and other dangerous places, confining myself chiefly to some of those which have been to a certain extent brought into practical use, but adding one instance of what I must own to be rather a scientific curiosity than anything else.

There are thousands of other inventions which have been brought under my notice of late years in several countries, but none that I can remember at present which would be worthy of consideration in such a work as this. It may be that, in the criticisms which may be expected to follow the issue of these pages, some new idea will be suggested, and, if so, I can only say that it will be heartily welcomed as an addition to the very small stock of knowledge which at present exists on the subject, and which, so far as my corps and I are concerned, would have been smaller still but for the cordial assistance we have received from Professor Tyndall, to whom our most sincere acknowledgements are due for his generosity in giving us valuable information, which we have been enabled to turn to practical use.

CONSTITUTION.

THE brigade is constituted under an Act of Parliament, 28 & 29 Vict., cap. 90, which entrusts the duty of extinguishing fires, and protecting life and property in case of fire, to the Metropolitan Board of Works; and authorises the Board to provide and maintain an efficient force of firemen, fire-engines, horses, accoutrements, tools, and implements, as may be necessary for the complete equipment of the force, or conducive to the efficient performance of their duties.

Also to provide fire-engine stations, to establish telegraphic communication, to appoint and remove at their pleasure the members of the brigade, to pay such salaries as they think expedient, and to make such regulations as they think fit with respect to the compensation to be made to them in case of accident, or to their wives or families in case of their death; also with respect to the pensions or allowances to be paid to them in case of retirement; also with respect to the gratuities to be paid to persons giving notices of fires; also with respect to gratuities by way of a gross sum or annual payment to be from time to time awarded to any member of the said force, or to any other person, for extraordinary services performed in cases of fires; also with respect to gratuities to turncocks belonging to waterworks, from which a supply of water is quickly derived.

The Act lays down that the brigade shall be under the command of an officer, to be called the Chief Officer of the Metropolitan Fire Brigade, and it gives the following very large powers to him or his representative.

On the occasion of a fire the chief or other officer in charge of the fire brigade may, in his discretion, take the command of any volunteer fire brigade, or other persons who voluntarily place their services at his disposal, and may remove, or order any fireman to remove, any persons who interfere by their presence with the operations of the fire brigade, and generally he may take any measures that appear expedient for the protection of life and property, with power by himself or his men to break into or through, or take possession of, or pull down, any premises for the purpose of putting an end to a fire, doing as little damage as possible; he may also on any such occasion cause the water to be shut off from the mains and pipes of any district, in order to give a greater supply and pressure of water in the district in which the fire has occurred; and no Water Company shall be liable to any penalty or claim by reason of any interruption of the supply of water occasioned only by compliance with the provisions of this section.

All police constables shall be authorised to aid the fire brigade in the execution of their duties. They may close any street in or near which a fire is burning, and they may of their own motion, or on the request of the chief or other officer of the fire brigade, remove any persons who interfere by their presence with the operations of the fire brigade.

Any damage occasioned by the fire brigade in the due execution of their duties shall be deemed to be damage by fire within the meaning of any policy of insurance against fire.

The power here described is probably the largest ever granted to any individual in this country, and it of course requires to be used with great discretion; but it is to be observed, that it has been in force now for upwards of ten years, and that, although it has been brought into active operation about 16,000 times, no serious question has yet arisen as to the mode in which it has been exercised.

The funds for the maintenance of the brigade are provided from three distinct sources, namely, the insurance companies doing business in the metropolis, the treasury, and the ratepayers.

The insurance companies pay at the rate of thirty-five pounds per million pounds of gross annual insurances, and, as they insure at present 517 millions' worth of property, this contribution now amounts to £18,000 a year; the treasury contributes a fixed sum of £10,000 a year for the general protection of the national buildings; and the inhabitants pay a rate of a halfpenny in the pound on property assessed at 21 millions, which brings in £43,500, thus making at present a total of £71,500.

ORGANIZATION.

THE Metropolitan Fire Brigade consists of a number of fire-engine stations distributed about London; each station containing a certain number of engines, generally one or more escapes; the necessary force of firemen to man these, and to perform such other duties in the way of watches or assistance elsewhere, as may be required; at least one coachman and one pair of horses, and an officer in charge of the whole.

These stations are grouped together into districts, each district being under the charge of an officer, who conducts the whole business of it either by orders from a superior, or, in the event of no orders being given, entirely on his own responsibility.

The districts again are grouped together into a common centre for the whole establishment, under the charge of a superior executive officer, who conducts the whole business under orders issued in the form of resolutions by the Board of Management.

The officer in charge of a station is called an engineer; the officer in charge of a district or group of stations is called a superintendent; and the principal executive in charge of the whole is called the chief officer.

Each engineer has a separate line of telegraphic communication to his own superintendent, and each superintendent has a separate line to the chief officer. The arrangement of these lines is shown on the map.

All ranks live in the stations, or close by, the married men and their families having rooms set apart for them, and the single men generally living and messing together in parties, ranging from two to about ten.

The ranks in the establishment are as follows, namely:—Chief officer; superintendents; first class engineers; second class engineers; first class firemen; second class firemen; third class firemen; and fourth class firemen.

The following is a copy of the proposal originally made to the Home Office, and printed by order of the House of Commons in 1864:—

"SCHEME BY CAPTAIN SHAW FOR A METROPOLITAN FIRE BRIGADE.

"London Fire Brigade.

"The following scheme for the protection of the metropolis, within a circle of over twelve miles in diameter, with Charing Cross as a centre, is based on a practical knowledge of the actual condition of London at the present time with regard to risk of fire. The following points being taken into special consideration:—

"1. Population; 2. Superficial area; 3. Nature of buildings; 4. Massed property; 5. Hazardous trades.

"To meet every contingency, it is obviously most important that the distribution of a fire brigade should be widely extended, in order that the first engine, with a skilled fireman, should reach the scene of a fire in the shortest possible time, in comparison with which all other points are of minor importance.

"The next matter for careful consideration is the undoubted fact that in this metropolis destructive fires have for the last thirty or forty years taken place, and still continue to take place, in close vicinity to fire-engine stations, thus proving that, even under the most favourable circumstances, complete security against fire cannot be obtained in the existing condition of London.

"While, therefore, I have placed the distribution first, as a matter of paramount importance, I consider it absolutely necessary, and secondary only to the distribution, to provide the means of massing together a large and powerful force at any given spot in the shortest possible time.

"In order to carry out effectively both these objects at the same time, with the same force, and therefore in the most economical manner, I propose to divide London into six districts, each to be provided with a force of properly-trained firemen under the charge of a foreman or district engineer, the whole being under the command of one officer, to be styled Chief Officer of the London Fire Brigade.

"Each foreman's district should contain a sufficient number of large stations, in which the firemen would reside, and each large station would have attached to it one or more auxiliary stations, to which the men would go on duty, by turns, for twelve hours at a time.

"I consider it desirable to provide four different classes of fire-engines, viz.:—

"1. Floating steam, delivering about 4,000 gallons of water per minute.

"2. Large land steam, delivering about 500 gallons of water per minute.

"3. Small land steam, delivering about 200 gallons of water per minute.

"4. Under six-inch cylinder manual, worked by four men, and delivering about twenty gallons of water per minute.

"For the first three classes the same sized hose and other gear at present in use would suffice, and the arrangement for drawing to fires, &c., would be also somewhat the same; but I think the engines under six inches should be made almost as light as wheel-barrows, and should be provided with canvas hose and coupling screws, with a water-way not exceeding one inch and a half, the whole of the gear being of corresponding lightness, so that one man would be able not only to run this class of engine to a fire at the rate of six or seven miles an hour for the short distance he would have to go, but he could on arrival get to work by himself without waiting for further assistance than what is required, and always forthcoming, for driving the pumps.

"The foreman of each district should reside in the central station of his command, and the chief should reside in the central station of the whole, and these centres should be calculated, not geographically alone, but on the basis of the five important points already mentioned.

"Each foreman's station should be connected, by alphabetical telegraph, with every large station in his district, and also with the principal station occupied by the chief; and each large station should be connected with its own auxiliaries, by bell telegraph, with about six different sounds.

"The proposed London fire brigade would consist of 1 chief and 574 officers and firemen, 4 steam-floating fire-engines, 6 large land steamers, 66 small land steamers, and 154 small manual engines, with horses, drivers, &c., distributed among 54 large and 103 small fire-engine stations, and extending over an area of about 120 square miles.

"This organization I believe to be the most sound and effective for the present condition of London, and it is decidedly economical as compared with fire brigades either in Europe or America, the total cost being only £70,000 a-year for efficiently protecting property valued at £900,000,000 sterling from the ravages of fire.

"It is also capable at a trifling expense of being sufficiently modified, from time to time, to suit the changing requirements of trade and the varying exigencies of the metropolis generally.

"In order to be more brief and intelligible, I omit here all details of duties, discipline, instruction, &c., but I append a series of tables giving full particulars of the original cost and annual expense of every article necessary for the service of an efficient London fire brigade, with salaries of officers, wages of engineers and firemen, charge for drawing engines to fires, &c."

Then follow the tables, which it is unnecessary to reproduce here, as the scheme was not carried out in its entirety.

Arrangement of Districts and Numbering of Stations in London.

The whole of the metropolis is divided into four districts, called respectively by the letters A, B, C, and D—the three first being on the north side of the river, and the fourth on the south side.

The A district includes that portion of London within what is known as the metropolitan area, bounded on the south by the river, on the west and north by the limits of the jurisdiction of the Metropolitan Board of Works, and on the east by a line of streets commencing near Hungerford bridge, and ending at Highgate, including

Northumberland-street.	Tottenham Court-road.
Trafalgar-square (east side).	Hampstead-road.
St. Martin's-lane.	High-street, Camden Town.
Upper St. Martin's-lane.	Kentish Town-road.
West-street.	Junction-road.
Crown-street.	Highgate Archway-road.

The B district is bounded on the south by the river, on the west by the before-mentioned line of streets, on the north by the limits of the Board of Works' jurisdiction, and on the east by a line of streets, commencing at London Bridge, and ending at Upper Holloway, including

King William-street.	New North-road.
Princes-street.	Mintern-street.
Moorgate-street.	Bridport-place.
Finsbury-pavement.	Southgate-road.
Finsbury-place.	Mildmay-park.
Finsbury-square (west side).	Newington-green (south and west sides).
City-road.	Green-lanes.
East-road.	

The C district is bounded on the south by the river, on the west by the before-mentioned line of streets, and on the north and east by the limits of the Board of Works' jurisdiction.

The D district is bounded on the north by the river, and on the other sides by the limits of the Board of Works' jurisdiction.

The principle of numbering the stations is as follows:—

The chief station is numbered 1. This is not yet built.

In the A district the superintendent's station is numbered 2, and the other fire-engine stations bear consecutive numbers up to and including 14.

In the B district the superintendent's station is numbered 15, and the other fire-engine stations bear consecutive numbers up to and including 24.

In the C district the superintendent's station is numbered 25, and the other fire-engine stations bear consecutive numbers up to and including 37.

In the D district the superintendent's station is numbered 38, and the other fire-engine stations bear consecutive numbers up to and including 54.

There are a few omissions of numbers, but these are owing to accidental circumstances, and do not interfere with the general principles of the scheme.

The numbering of the stations within each district is arranged in the following way:—

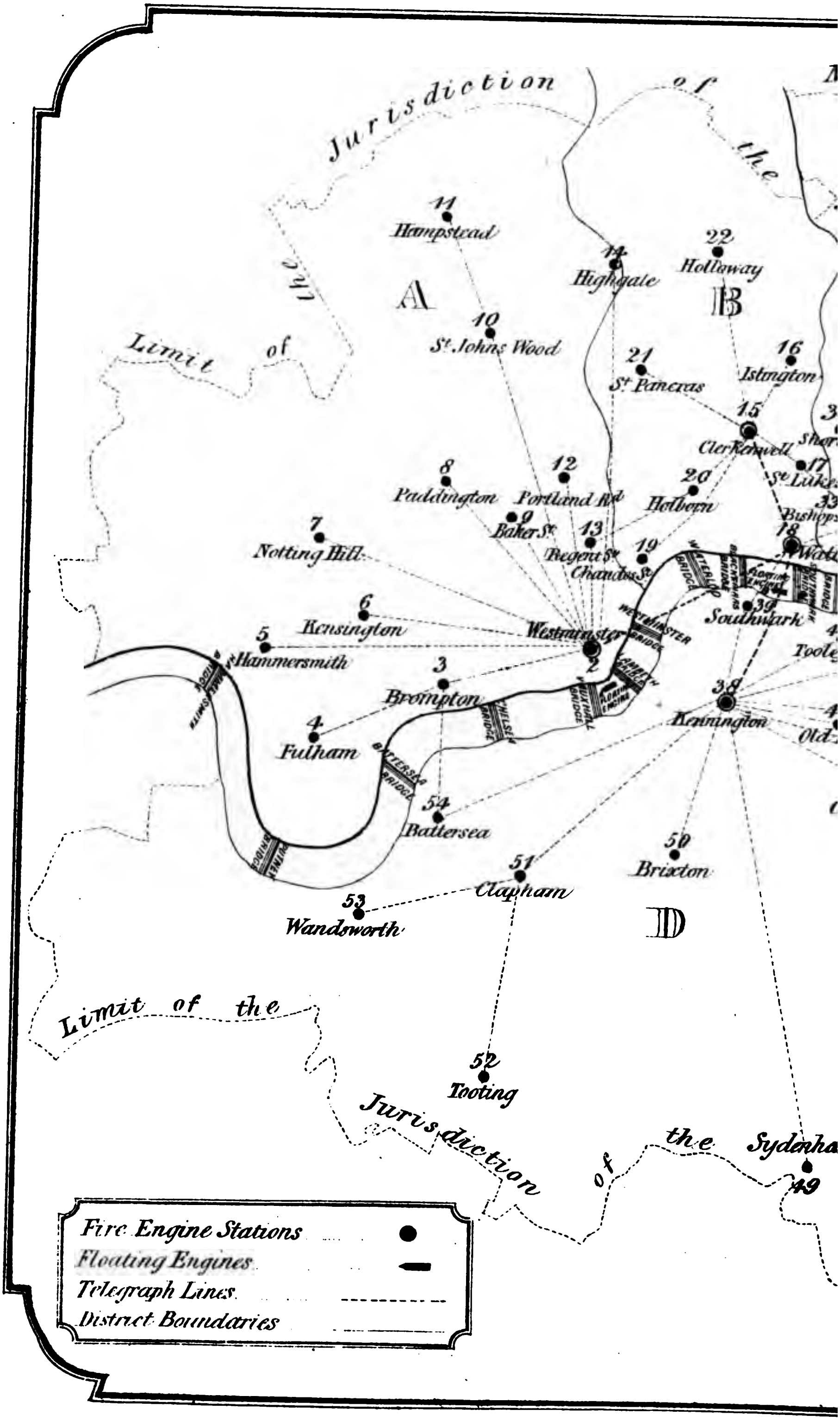
A line is struck north on the map from the superintendent's station, and the first fire-engine station on the right of that line, looking from the superintendent's station, takes the next number; the next on the right, still looking from the superintendent's station, takes the following number, and so on to the last.

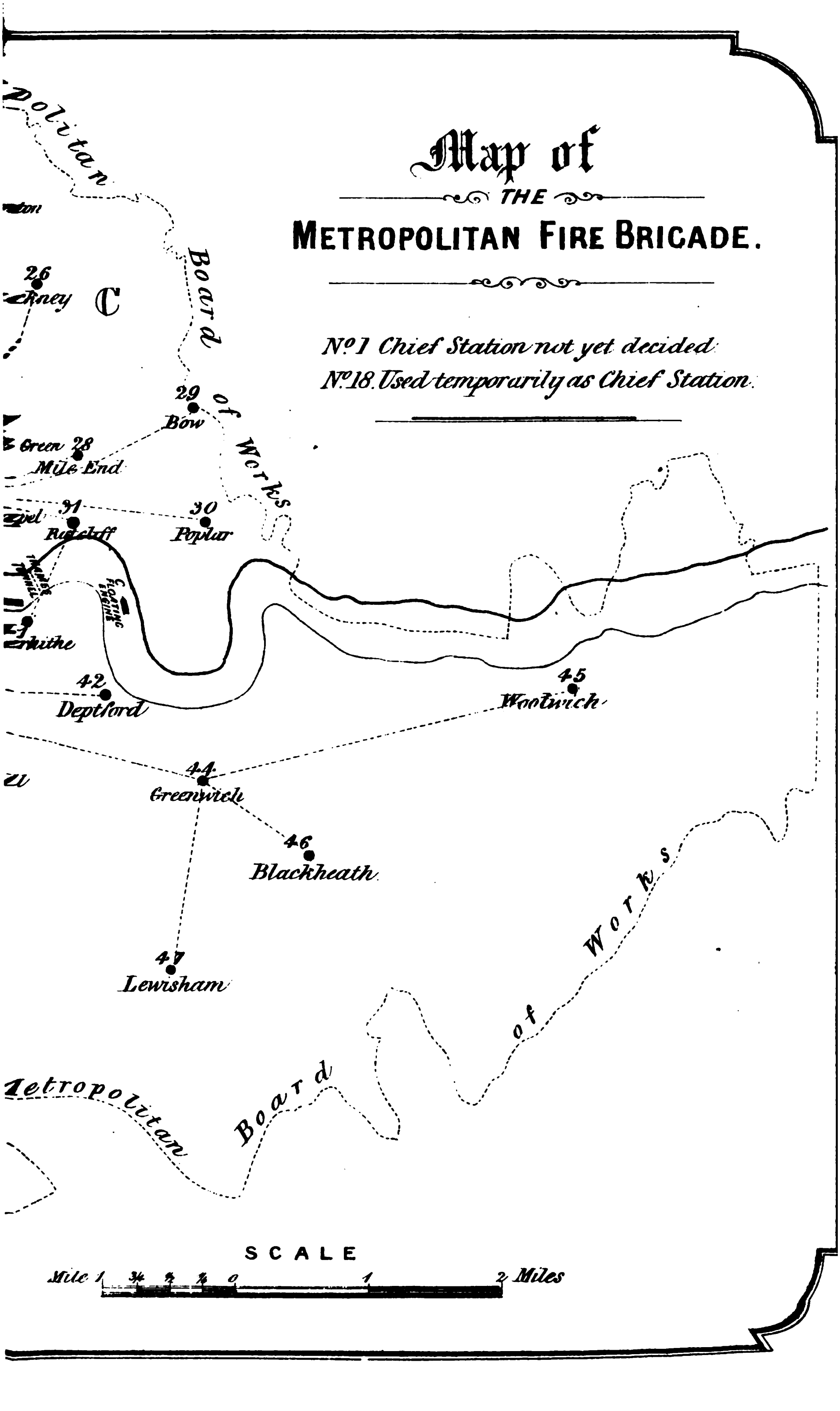
The fire-escape stations are both numbered and lettered, the number being that of the fire-engine station to which they are attached, and the letter the distinguishing mark for the escape. Every escape which stands at the door of a fire-engine station, and the watch of which can be carried on from the engine house, is lettered A; the first on the right of a north line from the engine station, looking from the engine station, takes the next letter; the next on the right of that, still looking from the engine station, takes the following letter, and so on to the end.

As a rule it is not desirable to have more than two fire escapes attached to one engine station, but circumstances have made it necessary in some cases to have four. So large a number, however, involves an amount of labour in travelling and supervision, which it is almost impossible for an officer to carry out thoroughly.

An intelligible principle of designating by numbers and letters is the true basis of an effective and business-like organization, and the intention in the case now under consideration has been to carry out this principle in the simplest possible way, so that the youngest hands can without difficulty master it within a short time of joining.

The experience of many years in this, as in all other countries, leads to the conclusion, now fully established and undoubted among the educated men of my profession, that the two principal objects to be attained in the organization of a fire brigade are the greatest possible


Jurisdiction of the
Limit of the
11 Hampstead
14 Highgate
22 Holloway
A
B
10 St. Johns Wood
21 St. Pancras
16 Islington
15 Clerkenwell
17 St. Lukes
8 Paddington
12 Portland Rd.
20 Holborn
9 Baker St.
13 Regent St.
19 Chandos St.
7 Notting Hill
18
6 Kensington
5 Hammersmith
2 Westminster
39 Southwark
3 Brompton
38 Kennington
4 Fulham
54 Battersea
50 Brixton
51 Clapham
53 Wandsworth
D
Limit of the
52 Tooting
Jurisdiction of the Sydenha
49
Waterloo Bridge
Westminster Bridge
Lambeth Bridge
Vauxhall Bridge
Chelsea Bridge
Battersea Bridge
Putney Bridge
Hammersmith Bridge
Fire Engine Stations
Floating Engines
Telegraph Lines
District Boundaries


Map of
THE
METROPOLITAN FIRE BRIGADE.
No. 1 Chief Station not yet decided.
No. 18. Used temporarily as Chief Station.
Metropolitan Board of Works
Metropolitan Board of Works
26
C
29
Bow
28
Mile End
31
30
Poplar
Floating Engine
42
Deptford
45
Woolwich
44
Greenwich
46
Blackheath
47
Lewisham
SCALE
Mile 1 3/4 1/2 1/4 0 1 2 Miles

distribution of the men and engines, and at the same time the power of concentrating and consolidating the whole force at the shortest possible notice, whenever occasion may arise for such a necessity.

It is, perhaps, not surprising that these most desirable objects have never yet been combined in any one city, when it is remembered that until of late years but little attention has been paid to the subject. It is now, however, thoroughly understood by the leading men of the profession, and many of them lament most sincerely that in their respective cities either concentration has been carried out to the exclusion of distribution, or that the distribution has been carried to such a degree as to render concentration and consolidation within anything like a reasonable time impossible; and that now, either the apathy caused through the distribution of losses over a large area by means of insurance, or the fear of multiplying taxes, makes it out of their power to induce their municipalities to undergo expense, even for so great an advantage as the reduction of loss by fire.

To recapitulate. The first and most important point is, that a fire brigade should be so widely spread that the first engine with a skilled fireman should reach the scene of a fire in the shortest possible time.

This is provided for by the proposed distribution of the force into a number of stations.

The next point is, that in London destructive fires take place in all parts, even in the vicinity of fire-engine stations, and that consequently it is necessary to have the means of massing together a powerful force wherever required in the shortest possible time.

This is provided for by massing the reserve men for duty in the central depôts, and not scattering them through the small stations.

THE present Arrangement of Stations of the Metropolitan Fire Brigade will be found in the following pages.

No. 1, Chief Station, *not yet decided.*

The Stations printed in large type are Engine Stations, those in small type, Escape Stations.

A DISTRICT.

No.	NAME.	ADDRESS. Night Station.	ADDRESS. Day Station.
2	Westminster	Tothill-fields, Westminster	
2a	Westminster	At the Engine Station	At the Engine Station
2b	Broad Sanctuary	South front of Westminster Hospital	At the Engine Station
2c	Warwick-square	S.E. side of St. Gabriel's Church	St. Gabriel's churchyard
3	Brompton	Trafalgar-square, Brompton	
3a	Pelham-crescent	S. side of Pelham-crescent, Fulham-road	Trafalgar-square, Brompton
3b	Eaton-square	N.W. side of St. Peter's Church	N.W. side of St. Peter's-church
3c	Sloane-square	S.E. side of Sloane-square	S.E. side of Sloane-square
3d	King's-road	In a private road, opposite Glebe-place, King's-road	In a private-road, opposite Glebe-place, Kings-road
4	Fulham	Percy-cross, Walham-green	
4a	Fulham	At the Engine Station	At the Engine Station
4b	West Brompton	St. Luke's Church, Redcliffe-sq.	St. Luke's Church, Redcliffe-sq.
5	Hammersmith	Brook-green-road, Broadway	
5a	Hammersmith	At the Engine Station	At the Engine Station
6	Kensington	King-street	
6a	Kensington	At the Engine Station	At the Engine Station
6b	Knightsbridge	Opposite All Saints National Schools, Knightsbridge-green	Knightsbridge Barracks
7	Notting-hill	Ladbroke-road	
7a	Ladbroke-road	Horbury Chapel-yard, Ladbroke-road	Horbury Chapel-yard, Ladbroke-road
7b	Lancaster-gate	W. side of Christ's Church	W. side of Christ's Church
8	Paddington	Hermitage-street, Paddington-green	
8a	Aberdeen-place	S.W. corner of Christ's Chapel	Christ's Chapel-yard, Aberdeen-place
8b	Cambridge-terrace	N.E. corner of Grand Junction-road	N.W. side of St. Mary's Vestry Hall
8c	Bishop's-road	S.W. corner of Trinity Church	Trinity-churchyard, Bishop's-rd.
9	Baker-street	33, King-street, Baker-street	
9a	Baker-street	At the Engine Station	Bryanston-mews, Bryanston-sq.
9b	South Audley-street	N. side of Grosvenor Chapel	Chapel-place, South Audley-st.
9c	Connaught-place	About 150 yards from Marble Arch	Connaught-place, Edgware-road
10	St. John's Wood	Adelaide-road, close to Finchley-road	
10a	Adelaide-road	At the Engine Station	Blind School-yard, Swiss Cottage
10b	Eyre Arms	S.E. side of Eyre Arms	All Saints' churchyard, Wellington-road
10c	Kilburn	Bridge-terrace	Bridge-terrace
11	Hampstead	Heath-street, corner of High-street	
11a	Heath-street	At the Engine Station	At the Engine Station
12	Portland-road	171, Great Portland-street, W.	
12a	Albany-street	S.W. corner of Trinity Church, Marylebone-road	Trinity churchyard
12b	Tottenham-court-road	Opposite Tottenham Chapel	Middlesex Hospital
12c	Oxford-street	Between Winsley-st. and Market-street, Oxford-street	Ditto
12d	Great Portland-street	S.E. corner of St. Paul's Chapel	At the Engine Station
13	Regent-street	39, King-street, Golden-square	
13a	Argyll-place	Argyll-place, Regent-street	Argyll-place, Regent-street
13b	Golden-square	S.E. side of Golden-square	Argyll-place, Regent-street
13c	Piccadilly	N.E. corner of St. James's Church	S.E. corner of St. James's Church
13d	Marylebone-lane	S.E. side of St. Marylebone Court-house	St. George's churchyard, Hanover-square
14	Highgate	8, Highgate-road, Kentish-town	
14a	Highgate	At the Engine Station	S.W. corner of St. John the Baptist Church, Highgate-road
14b	Camden-town	S.E. end of High-street	W. side of St. Martin's Chapel, Pratt-street
14c	Kentish-town	S. end of Kentish-town-road	Kelly-street, Kentish-town-road
	Floating	Off Millbank, near Lambeth-bridge	

B DISTRICT.

No.	NAME.	ADDRESS. Night Station.	Day Station.
15	Clerkenwell	Farringdon-road, corner of Mount-pleasant	
15a	Farringdon-street	Obelisk, New Bridge-street	Grand Junction Wharf, White-friars
15b	Holborn-circus	Holborn-circus	St. Andrew's Street, Holborn-circus
16	Islington	Essex-road	
16a	Balls-pond	At the Relief Offices, Newington Green-road	At the Relief Offices, Newington Green-road
16b	Islington-green	By the "Myddelton" Statue	Vestry Hall-yard, Upper-street, Islington
16c	Barnsbury	Cloudesley-road, near the Richmond-road, Barnsbury	At the Fever Hospital, Liverpool-road
17	St. Luke's	64, Whitecross-street	
17a	Goswell-road	Near Charterhouse Church	St. Luke's churchyard, Old-street
17b	St. John-street-road	By the Cab-rank, opposite Corporation-row	At the Engine Station, Farringdon-road
17c	Old-street	Opposite St. Luke's Church	St. Luke's churchyard, Old-street
18	Watling-street	66 to 69, Watling-street	
18a	Cheapside	General Post Office-yard, Cheapside end	General Post Office-yard, Cheapside end
19	Chandos-street	44, Chandos-street, Covent-garden	
19a	Chandos-street	At the Engine Station	St. George's Barracks
19b	Long-acre	At the corner of Bow-street	Bloomsbury churchyard
19c	St. Clement's	At the W. entrance to St. Clement Danes Church, Strand	St. Clement Danes churchyard
20	Holborn	254, High Holborn	
20a	Bedford-row	Bedford-street, top of Brownlow-street, Holborn	At the Engine Station
20b	Bloomsbury	At the Hart-street entrance of Bloomsbury Church	Bloomsbury churchyard
20c	Foundling	Guilford-street, opposite the Foundling Hospital	At the Foundling Hospital
21	St. Pancras	King's-road, corner of Pratt-street	
21a	Claremont-square	N.W. corner of the New River Reservoir, Pentonville-hill	New River-yard, Amwell-street, Pentonville
21b	King's-cross	Corner of Liverpool-street	Great Northern Railway
21c	Euston-square	By St. Pancras Church, Euston-road	St. Pancras churchyard, Euston-road
22	Holloway	Seven Sisters'-road, near the Holloway-road	
22a	Holloway	At the Station	At the Station
22b	Highbury	Chapel of Ease, Holloway-road	Chapel of Ease, Holloway-road
22c	New Cattle-market	N.W. Gate of New Cattle-market	N.W. Gate of New Cattle-market
23	Drill Class	Grand Junction Wharf, Tudor-street, Whitefriars	
24	Workshops	142, Waterloo-road	
	Floating	Off Southwark-bridge	

C DISTRICT.

No.	NAME.	ADDRESS. Night Station.	ADDRESS. Day Station.
25	**Whitechapel**	Commercial-road East	
25a	Whitechapel	At the Engine Station	At the Engine Station
25b	Tower-hill	Opposite Royal Mint, bottom of Minories	Royal Mint-yard, Tower-hill
25c	Aldgate	Aldgate High-st., at the corner of Fenchurch-st. & Leadenhall-st.	At the Engine Station, Commercial-road East
26	**Hackney**	Amhurst-road, at the back of the Congregational Church	
26a	Hackney	At the Engine Station	At the Engine Station
26b	Kingsland	Ridley-road, High-street, Kingsland	North London Coal Depôt, Dalston Junction
27	**Bethnal-green**	283, Bethnal-green-road	
27a	Bethnal-green	St. John's Church, Bethnal-green, at the corner of Green-street	St. John's Church, Bethnal-green, at the corner of Green-street
27b	Kingsland-road	Columbia Church, Kingsland-rd.	Columbia Church, Kingsland-rd.
28	**Mile-end**	263, Mile-end-road	
28a	Stepney	Near the Stepney Railway Station, Commercial-road	Near the Railway-arch, White Horse-street, Stepney
28b	Mile-end-road	Opposite Stepney-green	Charrington's Brwry., Mile-end-rd.
29	**Bow**	Glebe-road, High-street, Bow	
29a	Bow	At the Engine Station	At the Engine Station
29b	Old Ford	St. Stephen's-road, Old Ford, near the Roman-road	Stafford-road North, Bow
30	**Poplar**	West India Dock-road	
30a	Poplar	Poplar-churchyard	Poplar-churchyard
30b	Limehouse	Corner of E. & W. India Dock-rd.	At the Engine Station
31	**Ratcliff**	19, Broad-street	
31a	Wapping	Near the Church, Church-street, Wapping	Workhouse-yard, Green Bank, Wapping
31b	Shadwell	Near the Church, High-street, Shadwell	Shadwell-churchyard
31c	Cannon-street-road	St. George's Church, Cannon-street-road, St. George's, East	St. George's Church, Cannon-street-road, St. George's, East
32	**Millwall**	In course of construction	
32a	.. ..	*Not yet decided*	
33	**Bishopsgate**	23, Bishopsgate-street Without	
33a	Bishopsgate	At the Engine Station	Alderman's-walk, Bishopsgate-street
33b	Eastcheap	E. of Rood-lane	Ditto ditto
33c	Royal Exchange	On the Pavement opposite Royal Exchange	Ditto ditto
34	**Shoreditch**	380, Old-street, near the new Town-hall	
34a	Shoreditch	At the Engine Station	At the Town Hall
34b	Finsbury-circus	Albion Chapel, at the corner of London-wall and Moorgate-st.	Albion Chapel, at the corner of London-wall and Moorgate-st.
34c	Hoxton	At the corner of Bookham-street and New North-road	Stone-yard, Hoxton-st., Hoxton
35	**Stoke Newington**	98, High-street	
35a	Stoke Newington	At the Engine Station	94, High-street
	Floating	Off Torrington-stairs, Limehouse-reach	

D DISTRICT.

No.	NAME.	ADDRESS. Night Station.	Day Station.
38	Kennington	Renfrew-road, Lower Kennington-lane	
38a	Elephant and Castle	At the Drinking Fountain opposite Tarn's and the S. E. corner of London-road, Southwark	At Kennington Engine Station
38b	Kennington-cross	S.W. end of Lower Kennington-lane	At Kennington Engine Station
38c	Westminster Bridge-road	N. end of Kennington-road	King Edward School-yard, St. George's-road, Southwark
39	Southwark	Southwark-street	
39a	Southwark Bridge-road	Corner of Union-street, Southwark Bridge-road	Messrs. Potts' Yard, Southwark Bridge-road
39b	St. George's Ch., Borough	Corner of White-street, Borough	Trinity-churchyard, Trinity-sq., Borough
39c	Blackfriars-road	Surrey Chapel-yard, corner of Charlotte-st., Blackfriars-rd.	Surrey Chapel-yard, corner of Charlotte-st., Blackfriars-rd.
40	Tooley-street	164 and 165, Tooley-street	
40a	Tooley-street	N. side, opposite College-street, Tooley-street	N. side, opposite College-street, Tooley-street
40b	Star-corner, Bermondsey	S. end of Bermondsey-street	Bermondsey churchyard
41	Rotherhithe	Gomm-road, Rotherhithe Lower-road	
41a	Rotherhithe	Opposite St. Mary's Workhouse, Lower-road, Rotherhithe	Rotherhithe Workhouse
41b	Bermondsey, St. James's Church	N.E. end of Spa-road	St. James's churchyard
42	Deptford	Evelyn-street, Deptford	
42a	Commercial Docks	Opposite Trinity Church, in Trinity-street, Rotherhithe	Trinity churchyard
42b	Deptford Broadway	Deptford Broadway	Tanner's-hill, Deptford
42c	New Cross	South side of New Cross-road, opposite Hatcham-terrace	The Mews, Hatcham Park-road, New Cross-road
43	Old Kent-road	Corner of Thomas-street, Old Kent-road	
43a	Old Kent-road	At the Engine Station	At the Engine Station
43b	Camberwell-gate	N.E. corner of Arthur-st., Camberwell-road	Walworth Police Station
44	Greenwich	44, Blisset-street	
44a	Greenwich	Obelisk, opposite Greenwich Church	Back of the Baths, Royal-hill, London-street, Greenwich
45	Woolwich	Sun-street	
45a	Woolwich	At the Engine Station	At the Engine Station
46	Blackheath	Tranquil-vale, near All Saints' Church	
46a	Blackheath	At the Engine Station	At the Engine Station
47	Lewisham	Rushey-green	
47a	Lewisham	At the corner of Avenue-road, Lewisham-road	At the corner of Avenue-road, Lewisham-road
48	Camberwell	Peckham-road, opposite Southampton-street	
48a	Peckham	S.E. end of Hill-street, High-street, Peckham	At Camberwell Engine Station
48b	Camberwell-green	N. end of Camberwell-green	N. end of Camberwell-green
49	Sydenham	Crystal Palace, opposite the High Level Railway Station	
49a	Sydenham High-street	At Mr. Elkington's, High-street, Sydenham	At Mr. Elkington's, High-street, Sydenham
50	Brixton	10, Shepherd's-lane, Brixton-road	
50a	Brixton	At the Engine Station	At the Engine Station
50b	Stockwell	Stockwell Orphanage, Clapham-rd.	Stockwell Orphanage, Clapham-rd.
51	Clapham	Near Trinity Church, Clapham Common	
51a	Clapham	At the Engine Station	At the Engine Station
52	Tooting	Balham-hill-road, Upper Tooting	
52a	Tooting	At the Engine Station	At the Engine Station
53	Wandsworth	123, High-street, Wandsworth	
53a	Wandsworth	At the Engine Station	At the Engine Station
54	Battersea	Battersea-road, opposite Christ Church	
54a	.. ..	*Not yet decided*	
	Floating	Off the Platform Wharf, Rotherhithe	

APPOINTMENT OF MEN.

THE arrangements for appointing men are as follows:—

The chief officer sees all candidates for the situation of firemen at the principal station.

Candidates for appointment as firemen must be seamen; they should be under the age of 25, must measure not less than 37 inches round the chest, and are generally preferred at least 5 feet 5 inches in height. They must be men of general intelligence, and able to read and write; and they have to produce certificates of birth and testimonials as to character, service, &c.

Each man has to prove his strength by raising a fire escape single-handed with the tackle reversed.

After they have been measured, had their strength tested, and been approved by the chief officer as stout, strong, healthy looking, intelligent, and in all other respects apparently eligible, they are sent for medical examination before the surgeon, who, according to his judgment, either rejects or passes them, in either case giving a certificate.

The following is a copy of the certificate given in the case of a man who passes:—

" This is to certify that I have examined A.B., and believe him to be " free from disease, and well suited for the situation of a fireman in the " Metropolitan Fire Brigade."

In such a service as a fire brigade, which requires all the energies of a man, it is desirable to appoint men at first only temporarily—say for three months or so—and at the end of that period, before finally confirming the appointment, to submit every man again to the examining surgeon for a fresh certificate, stating the condition of his health at that time, and giving any reasons which may have been discovered during his probation tending to alter the opinion originally given.

TRAINING.

THE system adopted for training is as follows:—

There is a drill class, under the charge of an instructor and two assistant instructors. One of the assistants generally teaches the management of engines and engine gear, and the other that of escapes, and the principal instructor superintends the whole.

Each man on appointment joins this class, and learns the use and manipulation of all the appliances, as explained in the foregoing pages. At the same time, he lives in the station, and by degrees is taught the general working of the brigade; but during this period never attends a fire, except on an emergency, and then only under the personal charge of his instructors. Nothing is so destructive of sound education in this way as permitting men to attend fires before they know how to handle the appliances properly, and the youngest hands are therefore brought out as little as possible.

A smart man, who has served at sea for a few years, and has a taste for the work of a fireman, can be brought forward for duty within an average period of about six or eight weeks; a man equally smart, but without the advantage of a seaman's training, may possibly be brought forward within about as many months, but even at the end of that time he would hardly be as expert as a seaman in climbing and the use of ropes.

While a man is passing through the drill class, it is generally discovered whether he is fit for the service, or not, and in the latter case his services are discontinued.

When a man is pronounced competent by the instructor, he is removed from the drill class, and posted to a station, where he receives further training and instruction from the officer in charge, who entrusts him, at first, with only work of the simplest kind, and by degrees, as he gains experience, with all the duties of his position.

Notwithstanding that the greatest possible care is taken in the drill class to teach everything thoroughly, it occasionally happens that, owing to the urgent requirements of the brigade for help, the young hands are prematurely called out to fires, and get into a hurried or imperfect way of doing work. This may escape detection at the moment, but it is sure to be discovered later on, and, when it is, the man is either returned altogether to the class to complete his drill, or, as more commonly happens, is ordered to attend by day until his proficiency is established.

The importance which I attach to a sound system of training will probably be understood, when I state my conviction, founded on what appears to me the clearest and most positive evidence, that some of the greatest losses by fire which the world has ever experienced, have been owing to want of skill on the part of firemen. It is true that want of discipline may justly be credited with a considerable portion of the blame, but, as a practical man, I do not hesitate to assert that, where there is no skill, discipline becomes almost impossible, and is, at least under such circumstances, of very little use, so far as the extinguishing of the fire is concerned.

It may perhaps be said that great numerical strength will make up for deficiency of skill and knowledge; and this may, no doubt, be to some extent correct; at least it appears to be the theory established in many places; but I am inclined to believe that, for dealing with great emergencies, no amount of numerical strength, even when combined with discipline, can compensate for the absence of skill and knowledge, and on this account I consider a proper system of training, *before attending fires*, the only true method for making men real firemen.

INTERNAL MANAGEMENT.

PROMOTIONS.

THE principles which I have always practised for the advancement and management of men are as follows:—

When a vacancy occurs, I select from the seniors of the next rank the first man fit for the position, taking into consideration his age, length of service, education, habits, character, and every other particular calculated to guide me in a decision, and I receive a written testimonial from every officer he has served under since his last promotion.

As it frequently happens that a man may be perfectly suited to the duties of one rank, and yet unfit for more enlarged responsibilities—and as it is essential to the efficiency of the brigade to have thoroughly competent men in every rank—it occasionally becomes a duty to pass over some of the seniors, who may be most worthy, respectable men, and skilful and efficient at their work, in all possible respects, except, perhaps, the very points most important to the proper discharge of the duties of the vacant post. In such cases, every particular concerning each of those passed over is prepared for the purpose of being, if necessary, laid before the Board, at the same time with the recommendation. As a simple mode of carrying out these principles, I have been in the habit of making a formal announcement—that a post is vacant, and that I am prepared to receive written applications for it from the ten or twenty seniors of the rank next below.

Thus, for instance, a first class engineer may be wanted, and I allow all the second class engineers (about 30) to apply for it; one of these is appointed, and then a vacancy occurs for the post of a second class engineer, when I again announce my readiness to receive applications. The last first class engineer is at present numbered 30; I would, therefore, in making the announcement, intimate that none below No. 50 should apply; this would give 20 the opportunity of applying, and out of the 20 I should, probably, have 10 or 12 applications, the remainder, for various reasons, not sending in their names, and thus, in point of fact, saving me and the Board what might occasionally prove a serious cause of anxiety, as it is no light matter to pass over a worthy servant; and yet the very existence of such an establishment as a fire brigade must depend on a firm and unswerving adoption of this course under certain circumstances. I may mention that the mode which I have here pointed out has hitherto worked satisfactorily in difficult cases, and that I am generally, if not always, able to recommend the promotion of the senior applicant. The present arrangement, briefly stated, is somewhat as follows. A man is appointed to a position in a certain rank, and by simply doing the work assigned to him, and keeping out of trouble, but without any particular merit on his part, he naturally drifts up into the highest position of that rank. This, however, is not considered to give him the smallest title to a higher post, unless he has, during his period of service, shown some particular merits—such as a thorough knowledge of his business, a strong zeal in the service, and, at the same time, an honest, unceasing, and successful endeavour to qualify himself for the duties of the rank he aims at; such conduct as this is considered to constitute a claim which should not be passed over, and an encouragement to a steady perseverance in it forms an essential part of the policy which regulates the whole question of promotions in the brigade.

REDUCTIONS.

These are treated of under the head of punishments, and are mentioned here only for the purpose of showing that they are not forgotten.

PUNISHMENTS.

The mode of enforcing discipline by punishments has been as follows, namely:—

The chief officer has the power of fining any one in the force a sum not exceeding forty shillings, and he accounts for this power by laying the fine book on the table at every meeting of the committee.

In cases which appear to require a heavier punishment than a fine of forty shillings, the chief officer brings the offender before the committee, either suspending him in the meanwhile, or not, according to the circumstances.

During the time of suspension a man receives no pay.

Serious offences requiring the heavy penalty of dismissal are exceedingly rare; others are frequent, but being promptly dealt with are expiated by small fines, each case, however, being carefully weighed and settled on its own merits, the offender's length of service and general conduct being, however, always taken into consideration in making the award.

Thus, a man who has served ten years without being late for an engine, if at the end of the time brought up for this offence, would probably only be admonished, whereas another who had served a shorter time, and offended in this way frequently, would suffer a heavy penalty. This is somewhat the general mode of punishing, and it is found ample for enforcing discipline, while, at the same time, it does not expose the men to the humiliation of appearing frequently before their employers as offenders—a position which most working men, who respect themselves, particularly shrink from.

GENERAL WORKING.

Every man is always supposed to be either on duty, for duty, on leave, sick, or suspended.

Those on duty are in full dress, with the exception of their helmets.

Those for duty are ready to turn out at a moment's notice, and are, therefore, not permitted to go outside the station, except within view.

Those requiring leave obtain it as follows, namely:—

An engineer, or senior in charge of a station, has the power of granting six hours' leave to any man of his own station, no part of the time being after ten o'clock at night, or before six o'clock in the morning.

A superintendent has the power of granting twelve hours' leave on the same conditions.

Any leave which exceeds twelve hours, or any portion of which is between 10 p.m. and 6 a.m., must be obtained from the chief officer.

In all cases of emergency, such as the occurrence of a succession of heavy fires, or any other circumstance likely to weaken the brigade, men on leave, or those who have obtained permission to go, but have not yet started, are expected to throw up their leaves, and return to their stations with as little delay as possible; and they are invariably repaid every expense incurred, and allowed to conclude their leaves as soon as they can be spared.

When a man feels ill, he immediately reports the same to his engineer, whose duty it is to instruct him as to the course to be pursued. The usual custom is to send the man at once to the surgeon of the district, or to order him to attend the surgeon at his next regular visit; but, if the man is unable to go, the officer sends a message to the surgeon to come and visit him. In all cases of emergency, however, it is usual to apply for help to the nearest medical man, and not to wait for the regular surgeon.

Although it is customary to give all ranks full pay during illness, the right is reserved of withholding payment of wages under certain circumstances, as in the case of a man concealing his illness too long, and suffering in consequence, or committing any irregularity likely to prolong his illness.

At a fire it is a strict injunction to the senior present, whatever rank he may occupy, to give the men under his charge such refreshment as in his judgment is necessary, so as to deprive them of any possible excuse for taking it from any other person. Any man, therefore, who takes refreshments from occupiers of houses on fire, or those in the vicinity, or from any other person, except his own officers, is liable to very severe punishment.

The Board issues its orders, in the form of resolutions, to the chief officer, who is expected to keep them acquainted, at all times, with the working of the brigade.

The chief officer has the entire responsibility, and consequently he has the entire command of the whole.

Each superintendent has the entire command of his own district, except when the chief officer is present.

The engineers and firemen have command, according to their position and standing; thus—A superintendent in his own district may command any one in the brigade, excepting only the chief officer; the senior first class engineer may command the second, third, and fourth, and all the second class engineers and firemen; and the command of one engineer over the one next below him in the list, is as complete as that of the chief officer. The ordinary firemen have command according to their numbers. In point of fact, the senior present, whatever rank he may fill, has the entire responsibility, and there is no option left to any member of the brigade but to obey his orders, the only exception being as mentioned above, under the head of superintendents.

Every man must obey, without a moment's hesitation, all orders he may receive from his superiors in the brigade.

Should he receive an order from any other person, he is *strictly forbidden to obey it;* but, if it appears of sufficient importance, he can request permission of the chief officer, or senior present, to act on it.

On arriving at the scene of a fire, the senior present takes immediate command, and on him rests the entire responsibility of controlling and directing the firemen, until the arrival of some one of his superior officers, to whom he instantly hands over the command, at the same time explaining exactly what he has done during the time he has been in charge.

Nothing tends in a greater degree to the efficiency of a fire brigade then silence, strict discipline, and perfect steadiness on duty; and it is enjoined on all ranks that in proportion to the danger or urgency of the moment is the necessity to prove, by as close as possible an observance of this rule, that they are equal to the emergency.

The saving and carrying out of property at a fire is chiefly the business of a salvage corps; but the firemen give every assistance in their power to facilitate this object, provided it does not interfere with their other duties.

No man in the brigade is permitted to receive money for any service connected with his duty, without an order from the chief officer.

The Board reserves to itself the power of dismissing any man in the fire brigade without assigning a reason.

Perhaps it would be well that I should here explain some views which I have adopted on this subject from practical observation.

In almost all public establishments in this country attempts have been made to work on some known general principles, but in every case with which I am acquainted, these principles have been determined before the complete formation of the body to which they were to apply, and have, consequently, proved incorrect in every-day practice, thus reducing the establishments in question to the anomalous position of endeavouring to reconcile their daily business, on, perhaps, urgent occasions involving important interests, with preconceived theories of an opposing tendency.

In order to avoid such a difficulty, most of my first orders were originally made as general as possible, and the main working business of the brigade was conducted, for a time, by means of the daily order book, so as to lay a foundation for a set of rules, which it may be possible to adopt in practice without involving all concerned in such difficulties, contradictions, obstructions, and misunderstandings, as appear to be common in other establishments.

An order book is indispensable to the proper management of any body of men. It acts as a means of instruction and education to all ranks; as a record of the manner of performing all ordinary and special duties; and as an authentic account of the whole distribution of duties, privileges, punishments, casualties, appointments, promotions, reductions, resignations, dismissals, &c., &c.

Real efficiency cannot exist in any force, unless the seniors of each rank are competent to perform, not only their own ordinary duties, but also, in cases of emergency, the duties of the rank next above them; and, if the order book be carefully written up, it must materially assist to this end by showing, at a glance, how any particular duties have been carried on in times past, and thus aiding officers, who may be unexpectedly called on to act out of their ordinary sphere.

DISCIPLINE.

The general principle for which discipline is established is that of obtaining unity of action from large bodies—in other words, producing instantly at will such combinations or distributions of force and labour as the nature of the business in hand may render necessary.

This general principle is equally applicable to all kinds of discipline, including those of the army, the navy, the mercantile marine, railway companies, large shops, schools, public offices, workhouses, charitable societies, factories, and workshops, &c., &c.—in fact every kind of institution which requires order or method in the transaction of its business.

The modes in which this principle is carried out vary considerably, according to those by whom and to whom it is applied, but the object to be attained is professedly the same with all; namely, the establishment of a complete chain of communication between all concerned, from the highest to the lowest, and of clearly-defined duties and responsibilities for those of every position.

It is not necessary to enter into a full detail of each of the modes here alluded to, but a general reference to some of them may help to elucidate the views which I am desirous of setting forth on the subject.

In the army there is doubtless the perfection of discipline, in the sense of strict obedience to orders, but this advantage is obtained by subordinating the thoughts and feelings of all to a system, or to the will of one man. Soldiers are clothed, fed, nursed, and cared for; their duties are assigned with a clearness and precision which, although involving much labour and forethought in the superiors, can hardly be said, in most cases, to require either one or the other in the subordinates; and altogether the necessities and conditions of the service are such, that, although the chain of communication undoubtedly exists, it assumes a form of rigidity not conducive to great freedom or intercourse of thought between those far removed from each other in point of rank.

In the navy there is also the perfection of discipline in the sense already referred to, but without that marked obstruction of intercourse observable in the army, the conditions of the service precluding all possibility of regulating the daily and hourly work by written orders from an office, and consequently requiring more exercise of individual though and action on the part of the inferiors, and more frequent comment and advice, and more constant, and, if such a term may be used, more friendly interference on the part of the superiors, thus bringing all ranks into a much closer union and fellowship.

There is perhaps nothing in the world in the way of discipline so entirely admirable in theory and practice as that of a man-of-war on a long cruise, or on a distant station away from other vessels; but here again the exigencies of the service in time of war, and other exceptional circumstances, compel an observance of many rigid forms and regulations incompatible with complete freedom between all ranks.

In the mercantile marine there can hardly be said to be any discipline of the kind already referred to, partly because it is not in the nature of a regular service at all, but rather a series of distinct and separate engagements for limited periods. There is, however, frequently to be found in merchant vessels, particularly in late years, a certain community of thought and feeling between all concerned, founded on the personal character of superiors who know how to deal with those who serve under them. The constant change of crews, however, and more particularly the want of power in many merchant captains to deal in a firm and, at the same time, a frank and friendly manner with their men, have placed the mercantile marine in such a condition, that at present it cannot be accepted on the whole as a model, so far as discipline is concerned.

In railway companies, shops, schools, public offices, workhouses and charitable societies, discipline assumes the simple form of obedience to all orders that are issued; but the work in these places not being generally of a very urgent nature, the obedience is not necessarily of that immediate kind so essential in some services. There is commonly in these institutions a large amount of routine, and, as a natural consequence of this, a certain tardiness of thought and action, and a degree of caution, which, though perhaps necessary to the proper management of their business, would be altogether fatal in its results to such a service as ours.

In great factories and workshops there is, during working hours, what may be called a fair system of discipline, and this is combined with almost complete freedom of action in the men, encouraging every species of ingenuity on their part, and thus tending to the mutual interests of employers and employed. This system is eminently calculated to improve and educate all concerned, by producing in them habits of order and regularity, without any corresponding disadvantage, such as the restriction or annihilation of individual efforts apparent in some services. There is, however, a drawback of another kind, which is hardly less important, and that is the shortness of the period of labour in comparison with that of freedom. Indeed, it is not too much to say, that in many factories the men do not ordinarily work more than one-fourth of their whole time, and even at the busiest seasons not more than one-third; and during all the remaining time they are free from the improving influences alluded to, and open to others of at least a very different kind, and in some instances of an opposing tendency.

While, therefore, conceding to the services here referred to in general terms, all the advantages which they severally claim for their respective ways of transacting business, I am at the same time clearly of opinion that none of these modes are altogether applicable to our work, but that the best model is to be found in that part of the factory system included in the hours of labour. Happily for the carrying out of this view, experience has long since demonstrated the advantage of providing accommodation for our men in the stations of the establishment, and consequently we are enabled to apply the system constantly, and thus avoid the drawback inseparable from the intermittent nature of the work in factories.

The officers of the department are entrusted with sufficient powers of reward and punishment to meet all ordinary cases, and can make reports and recommendations to their employers on all matters beyond their jurisdiction. These, no doubt, are sufficient to produce, to a certain extent, the desired unity of management and action; but with us there is a stronger bond of union than any which the laws can make, founded on the confidence which those who serve never fail to have in superiors who thoroughly understand their business, and are able to advise and instruct them in all matters connected with it, supported and kept alive by constant, unrestricted freedom of intercourse and community of labour, and of those risks attendant on our special work, and producing such a result, that although each individual has his distinct and separate position, and discipline is carried to the highest point, there is yet the most complete community of feeling between all concerned, and a pervading conviction on the part of the superiors, that, while the general body of the force are in one sense their servants and subordinates, they are at the same time, in another and much stronger sense, their fellow-servants and their friends.

In a force situated as ours is, with small bodies scattered over a large area, the difficulties of producing the necessary unity of management and action for instantly dealing with emergencies of every kind, both great and small, are sometimes almost insurmountable, and the strictest discipline is absolutely necessary; but discipline alone is not enough, there must also be that confidence and fellow-feeling between all ranks, which make the failure or success of individuals a source of regret or congratulation to the whole body.

It is in the possession of this spirit that our force is now so fortunate, and, as long as the superiors base their positions on the only true source of power—knowledge—and support it by constant attention, strict discipline, and at the same time kind and free intercourse with the subordinates, so long the same spirit is certain to characterize our institution, and to result in that unity of management and action which can alone command success in great emergencies.

DUTIES.

General Duties of a First-class Engineer, or Officer in Charge of a Fire-engine Station.

To reside at any station he may be appointed to.

To take charge of the houses, stables, or other premises belonging to his station.

To take charge of the fire engines, fire escapes, and all gear belonging to the station.

To keep all the premises and fire-extinguishing appliances clean and in proper order, as far as lies in his power; and, in cases beyond his power, to make immediate reports to his superior officer in the district.

To take charge of all men, horses and coachmen, attached to his station, and to keep up a strict system of discipline among them.

To see that all the men of his station are within hail, and available for duty at all times, unless specially booked as sick, absent on account of duty or leave, or otherwise engaged.

To instruct his men in drill exercise and the performance of all their duties.

To regulate the duties to be performed by the men of his station, and to see that those at the station and with the escapes are properly done.

To call the roll at 9 a.m. and 9 p.m. respectively; to see that all the men at home are present and fit for duty; and to enter the same in the occurrence book, accounting for all the men at his station, and stating where they are—whether at home, on station duty, on out-duty, on leave, sick, or otherwise.

To report to his superior officer in the district at the appointed time every night and morning all the business that has been done by the station during the previous twelve hours; the names of the men on duty at the station, or elsewhere, and those on leave, sick, &c.; and as far as possible to account for the men and duties for the succeeding twelve hours.

To see that the necessary number of men are placed on duty in the watch room, that they are properly clothed, and are acquainted with the details of station duty.

To see that the men for out-duty go away in time, and are properly clothed, and in every way fit for duty, and that their departure and return are correctly entered in the occurrence book.

To grant leave of absence, according to his discretion, for periods not exceeding six hours, between 6 a.m. and 10 p.m.; and to make recommendations, according to his discretion, to the principal officers of his district, for leave of absence for himself or his men, for periods longer than six hours, or any portion of which falls between 10 p.m. and 6 a.m., it being distinctly understood that, in such cases, he is responsible that his station is sufficiently manned, and all the duties properly provided for, and further that he not only has the power, but that it may occasionally become his duty, to stop men going on leave, whether the leave has been granted by himself or by any of his superiors.

To suspend immediately any man guilty of disobedience of orders, or other serious misconduct, whenever he thinks it necessary or advisable to do so.

To enter the names of the men on duty at the station in the occurrence book, at 7 a.m. and 7 p.m. respectively.

To see that the occurrence books at his station, and at the escapes attached to his station, are kept in a proper manner; and that entries are made of all calls, stops, taking duty, being relieved from duty, going on leave, returning from leave, and all other matters requiring to be recorded.

N.B. With regard to the entries of calls, it is to be distinctly understood that the first duty is to take the necessary steps for sending help away immediately, and for transmitting the calls when necessary; and that the entry is to be made at the earliest convenient opportunity afterwards, and not to be allowed to interfere with, or cause delay in, the arrangements for getting a sufficient force of men and engines to the scene of a fire at the earliest possible moment. As, however, in all instances of inquests on persons burned to death, and in many other cases, we are liable to be called on to testify on oath as to the exact time at which a call has been received, it is desirable that the man on duty should, while receiving the message, look up at his clock, and that, having seen the exact time, he should enter it in figures on the slate kept for that purpose, close by the occurrence book on the desk. It is well known among us, that an intelligent man can always make this entry without any loss of time whatever, as it is in itself but a momentary transaction, and can easily be done while taking in the message.

To take charge of the petty cash supplied for the station, and to enter all sums received and expended in a petty cash book supplied for the purpose.

To make monthly returns on forms, supplied to him, stating the names, ranks, and brigade numbers of his men, the state of their uniform as to quantity and condition, the number and designations of all engines and escapes attached to his station, the condition of the same and of their gear, and of all other appliances and gear belonging to his station.

To keep the following books supplied to him in a proper manner, namely—The petty cash book; the occurrence book; the carman's book; the order book; the red books of the several engines and escapes; the leave book; or any others which it may be necessary to keep at his station.

To keep an inventory of all articles, of every kind, belonging to his station, and a list of his men.

To see that the engines are properly stowed, properly placed, and in every way ready to proceed to fires in the shortest possible time.

To see that the escapes are mounted with the proper appliances, and in every way ready to proceed to fires in the shortest possible time.

To see that all the gear belonging to his station is kept in thoroughly clean and proper order, and in the places and conditions most available for its immediate use.

To see that the stables are kept clean and in proper order; that the horses are fit for the work; that the coachman is steady, respectable, and sober; and that everything connected with that department of the station is in a thoroughly efficient condition for taking the engines to and from fires in the shortest possible time.

To see that the telegraphic communication is in proper working order, or to send an immediate report to his superior officer when it is not so.

To see that the watch-room clock is set at least once in every twenty-four hours by telegraph from head-quarters, and as often as necessary besides.

N.B. The ordinary time for setting all the clocks is 9 p.m.

When receiving a first call,—that is to say, a call from a stranger coming from a fire, and not transmitted by telegraph from another station, as, for instance, for a place in the vicinity of his own station,—to send a fireman or other responsible person to call the turncock, to turn out an engine, a hand-pump, an escape, or such other appliances, with a sufficient number of men, as in his judgment may be most available for extinguishing the fire; to forward the call on to the superior officer of the district, stating the nature of the fire, as far as he is able to form an opinion from the intelligence which he has received, and mentioning what steps he has taken with reference to it; also to take any other measures in his power which may tend to the speedy extinguishing of the fire, according to the best of his judgment and ability.

When receiving a call by telegraph, or otherwise, from another station, to be prepared to take or send the appliances and men ordered with the least possible delay.

In all cases of irregular calls,—such as messages coming from distant fires, with stations intervening, and consequently nearer, or calls for lights only, without further information,—to use his own discretion altogether, as to going at once or making inquiries first.

To see that all calls for chimneys on fire are immediately attended to, and that stops for the same are sent away at once, by telegraph or otherwise. A stop is a message to the effect that help is not required.

Upon arriving at a fire before a turncock, to use his best endeavours to obtain water, if there is need of it.

Upon arriving at a fire before any other engine, to ascertain, as soon as possible, the nature and extent of the fire, and to send the intelligence to the nearest station, with a view to its being communicated to the principal station of the district, and thence to the chief station of the whole brigade.

Upon arriving after another engine, the officer of which is junior to him, to inquire, and make sure, whether a message has gone away, and, if not, to send one at the earliest convenient moment.

N.B.—A message of this kind is always best delivered by a fireman, who is certain to be conversant with the terms we use, and consequently to word his communication correctly, and, whenever a fireman can be spared, it is much better to employ one for the purpose; but when a fireman cannot well be spared,—as, for instance, in the early stages of a threatening fire,—it is much safer to employ a policeman, or if a policeman cannot be got for this purpose, then to employ a stranger; and in either of these latter cases, considerable care must be taken to word the message in such a manner that the messenger himself will understand it, and not be likely to make mistakes in the transmission.

When arriving after other engines, to ascertain, as soon as convenient, who is the senior present; if he be himself the senior, to take immediate command of all present, and adopt all such measures as seem best to him; if he be not the senior, to report his arrival to, and place himself under the orders of, whoever is the senior.

When he is the senior present at a fire, to send away a stop for it as soon as it is expedient to do so, stating the general nature of the fire, and what appliances have been used to extinguish it.

To report the departure and return of his engine by telegraph to the principal officer of the district, and to inform him when men are left on duty, or otherwise.

To visit the men on duty with the escapes, &c., or to take measures to have them properly visited.

To write requisitions for all stores, repairs, &c., &c., that may be required at his station.

To obey implicitly all orders of his superiors, and to exact the strictest obedience and respect from those serving under him.

To see that all orders issued by his superiors, as far as they refer to matters under his control, are carried out in a proper manner.

To report to the principal officer of his district any irregularities that may occur at his station.

To hold himself in readiness for any duties he may be called on by his superiors to perform.

To keep his superiors acquainted with all matters coming to his knowledge affecting either his own station or the general business of the brigade.

To study the characters and abilities of the men under his charge, and to be ready at all times to give his superiors correct information concerning them, with a view to influencing the apportionment of rewards, promotions, and punishments, as well as of the special duties and labours of the brigade.

To set an example to his men by his sobriety, cleanliness, promptitude, civility, and general attention to his duties.

To make himself, as far as possible, acquainted with the whole of the locality in his neighbourhood, and the trades carried on there; and to instruct all his men as to the best course to be pursued with regard to the various premises.

To make himself, as far as possible, acquainted with the fire-cocks, fire-plugs, and other means of obtaining water in his neighbourhood, and to instruct his men in the same.

To make himself acquainted with the police stations and turncocks' residences in his neighbourhood, and to keep their addresses always hung up in a prominent position in the watchroom, as near as convenient to the desk on which the occurrence book is kept.

It will be observed that the duties here assigned to an engineer are so numerous that it would be impossible for him to perform them all himself, and therefore, to prevent any misunderstanding of the terms in which these instructions are conveyed, it is specially mentioned, that, even if it were possible, it would be by no means desirable for him to do so. He is provided with certain appliances in the way of engines, escapes, horses, coachmen, firemen, &c., &c., and it is his duty to work them to the best advantage, according to his discretion and ability, and, not only that, but also to be able to satisfy his superiors at all times that he has done so.

The general idea intended to be conveyed is, that the engineer or officer in charge of a station is absolutely responsible for everything connected with his station, and that consequently the whole control and management are vested in his hands. It is, of course, understood that he is bound to act fairly and discreetly with his men, and all concerned, and he may at any time be called to account for his actions; but practically his judgment and discretion are left unfettered in any way, in order that there may be no limit to his responsibility in the execution of the duties entrusted to him.

General Duties of a Second-class Engineer, not in charge of a Station.

To reside at any station he may be appointed to, and to be at all times within hail, and available for any duty, unless specially booked otherwise.

To visit the men on duty with the escapes, attached to his station.

To take his turn in watching at the station, and other duties.

To superintend the cleaning and other work of the station, and if necessary to assist in the same.

To assist the engineer in the management of the station, and, in the absence of the engineer, to take charge of the station, and be responsible that the business is carried on in a proper manner, and in accordance with the rules laid down for the guidance of an officer in charge of a station.

To obey implicitly all orders of his superiors, and to exact the strictest obedience and respect from those serving under him.

To hold himself in readiness for any duty he may be called on by his superiors to perform.

To keep his superiors acquainted with all matters coming to his knowledge, affecting either his own station or the general business of the brigade.

To study the characters and abilities of the men under him, and to be ready at all times to give his superiors correct information concerning them.

To set an example to those under him by his sobriety, cleanliness, promptitude, civility, and general attention to his duties.

To make himself thorough master of the duties of an engineer, in all points, so that in the absence of an engineer, or in the event of being appointed in charge of a station without an engineer, he may be able to carry on all the duties in an efficient manner.

GENERAL DUTIES OF A FIREMAN, NOT AN OFFICER.

To reside at the station to which he is appointed, and to be at all times within hail, and available for any duty, unless specially booked otherwise.

To take his turn in watching at the station, taking charge of escapes, attending fires, and all other duties, when ordered by his superiors.

To assist in the cleaning and other work at the station, relieving the men on duty to meals, &c.

To be civil and respectful in his demeanour and clean in appearance.

To perform all duties entrusted to him in a prompt and efficient manner.

To hold himself in readiness for any duty he may be called upon by his superiors to perform.

To obey implicitly all orders of his superiors, and to exact the strictest obedience and respect from those under him.

To study and otherwise endeavour to qualify himself to perform the duties of his superiors when called to do so.

N.B. There are four distinct ranks of firemen, not officers, namely—the first class; the second class; the third-class, and the fourth class; and the above, as *general* rules, apply equally to them all. It happens, however, that in the carrying out of the laborious work of a fire brigade, there are many duties requiring special qualifications and capacities, and these naturally fall in most cases to the lot of those who have served longest, and worked most. These duties consist of taking charge of the floating steam-engines, and the land steam-engines, keeping watch in public buildings, theatres, &c., mechanical work at the factory, repairing engines, and so forth, drilling and instructing the young hands, keeping the accounts, books, and records of the establishment, carrying on the correspondence, preparing reports for the board of management, &c.

In the carrying out of these indispensable special duties, most of the men of the first and second classes, and a few of other classes, are very frequently employed, and these are consequently, to a limited extent, relieved from a portion of what are designated as general duties.

In this way there are certain occasional differences in the duties done by the several ranks; and again in the very common case of men of the first class having, in the absence of their engineers to carry on the duties of those officers, and perhaps to take charge, not only of their own men, but also of the men of other stations, at fires; but, with these exceptions, the same rules, as already explained, apply equally to all, and are therefore not detailed separately for the four separate ranks.

Indeed, if it were possible to define absolutely the separate duties of these four ranks, it would be unadvisable to do so, inasmuch as there is never a moment in which several are not employed in carrying on the duties properly devolving on their superiors; and there is never a whole day during which, in some one or more of our stations, a third-class or even a fourth-class fireman does not find himself the senior at home, and consequently responsible for everything that is done. It is therefore incumbent on all ranks to study and thoroughly understand, not only their own ordinary duties, but also those of their superiors, in order that, when called upon—as in our business may at any moment happen—they may be found equal to the performance of any duty devolving on them.

GENERAL DESCRIPTION OF DUTIES.

Station Duty.

A certain number of men are placed on duty at each station at 7 a.m. and at 7 p.m. respectively, and their names are entered in the occurrence book accordingly. Their duties are, to keep a proper watch, to receive and transmit all messages by telegraph or otherwise, and to make correct entries of the same in the occurrence book, with the exact time at which they are received and passed on. They must inform the engineer or senior at home of all calls to fires, and other matters of importance, and when ordered by him to turn out, they must ring down the coachman, call all hands, help to harness the horses, get ready the engine, and take all other measures in their power to ensure the engine starting as quickly as possible.

Men on duty are not permitted to leave the station, or go out of hearing of the bells, unless properly relieved, and an entry made to that effect in the occurrence book.

No man is considered relieved from station duty, until the man relieving him has booked himself on duty, or been booked on duty by the officer in charge, or the senior present.

These regulations are not intended to limit the discretion of an officer, or of the senior present, in sending a duty man out on urgent occasions for short distances—such as across a street, into the stable, up-stairs, or into other parts of the house or station, for periods not exceeding one or two minutes—but it is to be distinctly understood that the station is not to be left for a moment without a proper watch, except on occasions of fire requiring the attendance of all hands, or other great emergency; and that any officer sending out a duty man is bound to remain himself until the return of the latter, or to call some one else down to do so.

When several men are on duty together at a station, they are all responsible for carrying out the duties in the best possible manner, but the senior of them is principally responsible, and he is bound to satisfy himself that everything is in proper order and readiness for turning out, and so forth, and that the men of his watch are on the alert when required.

Escape Duty.

A man going on escape duty must be careful to leave his station in time to be at his post, and have the escape all ready for running at the appointed hour.

The hours of duty with the escapes are as follows, namely:—between the 1st of September and the 1st of May, from 8 p.m. to 7 a.m.; between the 1st of May and the 1st of September, from 9 p.m. to 6 a.m.

He will carefully inspect his escape, and in all matters proceed as explained in the detailed instructions; and before leaving in the morning he will lower or otherwise secure the escape in its appointed day station.

Upon receiving a call at his escape, and having a doubt as to whether it has also gone to the nearest station, he is to take such measures as are in his power to have it forwarded.

Steam Duties.

With regard to the steam duties on board the floating engines, and in charge of the land steamers, no detailed instructions are here given, as the work requires a large amount of special explanation, which is given by the responsible officers, and can only be understood after long practice and study; and no man receives a charge of this kind, until he has first proved his professional qualifications for it.

Each land steam-engine is thoroughly overhauled, and the boiler is forced at least once every six months in presence of the man in charge of it. This is done in the brigade workshops, and, if it turns out satisfactorily, the following certificates are signed, namely:—

"This is to certify that I have tested the boiler of No. engine to 180 lbs. on the square inch with cold water pressure.

"Signed, Officer in charge of the workshops."

"The above was done in my presence, and I consider the boiler quite safe to work with steam at a pressure of 120 lbs. on the square inch.

"Signed, Fireman in charge of the steamer."

"This boiler may be worked for a period not exceeding six months from the present date at a pressure not exceeding 120 lbs. on the square inch, and the safety valve may be screwed down to a pressure not exceeding 100 lbs.

"Signed, Chief Officer."

After these certificates have been completed, a card of general instructions, in the following form, is signed and handed to the man in charge.

Metropolitan Fire Brigade.

General instructions for working No. land steam fire-engine.

1. The boiler of this engine is to be worked at a pressure not exceeding 120 lbs. on the square inch.

2. The safety valve is not to be screwed down to more than 100 lbs., and the engineer must occasionally raise it, by hand or otherwise, both when getting up steam and when at work.

3. In order to keep this valve free, and to prevent it sticking, he is to ease up the spring, and to remove the whole pressure from it when not required, except sufficient to keep the lever and spring balance from shaking while the engine is travelling.

4. Whenever the work admits of it, the engineer is occasionally to fill his boiler with water as high as possible without allowing it to prime, and then blow off from all the cocks, including the gauge-cocks, and the cocks of the steam pockets, using only one at a time; this is the best precaution against scale or scum, and an intelligent engineer will find many opportunities of adopting it without interfering with the necessary work of his engine.

5. In addition to this, the boiler is to be altogether blown out and washed out occasionally.

6. The engineer must be careful to see that no soot is allowed to accumulate on the shell or tube plates of the boiler, as this would considerably reduce its steaming power.

7. The engineer is held responsible that the water in the boiler is always kept in sight in the gauge-glass whenever the fire is alight; and in case of any accident, such as the failure of the feeding apparatus, rendering this impossible, he is immediately to draw his fire.

8. A sufficient quantity of water should always be kept in the feed-vessel for supplying the boiler when the engine is not at work.

9. It being exceedingly dangerous to pour cold water on hot boiler-plates, the engineer is desired to be particularly cautious about putting cold water into the fire-box; and in case it becomes absolutely necessary to do so, he is to pour it on the fire-bars only, and not on the inner shell of the boiler or the tube plates.

10. After the suction-pipe has been taken out of the water, the engine should be run round for a few strokes, in order to blow the remaining water out of the pump.

11. On his return from a fire, the engineer is to enter in the book kept for that purpose the following particulars, as far as he is able, viz.—time at work; number of revolutions; quantity of water delivered, and any other circumstances which appear worthy of remark—such as the length of hose, number of deliveries, height of branch above engine, &c.

12. By *engineer* is meant the man in charge of the working of the engine, whoever he may be.

13. These instructions are not to be in force for a period longer than six months from this date.

Chief Station, Date 187

Signed, Chief Officer, Metropolitan Fire Brigade.

I have always found that if a boiler can stand a cold water pressure of any particular number of pounds on the square inch, it may be safely worked under steam to about two-thirds of that pressure, or, to put the same meaning conversely, that if a boiler is to be worked to any particular pressure, it should be forced with cold water to once and a half that pressure. Thus, if I wished to work a boiler to 150 lbs. on the square inch, I should force it with hydraulic pressure to 225 lbs.; or if I wished to work it to 120 lbs., I should force it to 180 lbs.

It will be observed, however, that I do not allow the safety valves to be screwed down to the full pressure, as I am of opinion that, with such small valves as are necessarily mounted on these machines, the pressure may frequently exceed that of the spring balance, especially when the boiler is blowing off steam.

Watching Duties at Theatres, Public Buildings, &c.

With regard to the watches in theatres, public buildings, &c., the general instructions are, for the men to make themselves acquainted with all parts of the premises, and with the means provided for extinguishing fire, to be vigilant in tracing out all causes of risk, to take active measures to obviate any danger that may arise, and, in case of fire, to use every available effort to extinguish it, and at the earliest convenient moment to send a message to the nearest station, stating the nature and extent of the fire, and whether further help is required, or not.

CLOTHING.

THE uniform of a fireman consists of the following articles, namely :— tunic, top-coat, cloth trousers, boots, belt, pouch, axe, and helmet; in addition to which a working dress is issued, consisting of duck jacket, duck trousers, cap, and for the steam men a similar suit of serge.

TUNIC.

The tunic is made of stout blue kersey, double breasted, with a stand-up collar about 1½ inches high. The ends of the collar are rounded off, and are mounted or faced on the outside with a piece of scarlet cloth of the same height as the collar, and about 2½ inches in length.

On each side of the tunic are sewn 6 brass buttons, about 3 inches apart, and the letters M.F.B. are marked on each button in old English characters. A corresponding number of button-holes are worked in the cloth, directly opposite each button, on the outer edges of the tunic.

The body and sleeves are lined with woollen plaid, and the skirt with black shallow.

The average length of the tunic is about 34 inches.

The superintendents' tunics are of somewhat finer cloth, and are single breasted.

The chief officer's tunic is, in most points, similar to those of the superintendents, but is distinguished from them by the buttons being of silver, and round instead of flat.

TOP-COAT.

The top or over-coats are also made of blue kersey, and are of a similar pattern to the tunics, with the exception of the collar being about 1½ inches higher, and made to turn over or stand up, as required, and without scarlet facings at the ends.

The average length of the top-coat is about 37 inches.

CLOTH TROUSERS.

The cloth trousers are made of blue kersey, and are lined on the inside with grey twilled cotton. They are made with whole falls or flaps in front, and are fastened in the usual way with stained bone buttons.

BOOTS.

The boots are made of the best grained leather, and are double fronted. The tops are made of sufficient length, so as to reach above the calf but below the knee, and they are fitted in the usual way with beckets for pulling the boots on.

Belt, Pouch, and Axe.

The belt is made of the best leather, about 2¼ inches wide and 48 inches long, and is mounted at one end with a strong brass buckle, 2¾ inches wide and 3½ inches long, and at the other end there are several holes pierced, of sufficient size to take the tongue of the buckle. The buckle is secured to the belt by means of three tinned rivets and washers.

The pouch is also made of the best leather, 3¼ inches deep and 8½ inches wide in front, and 7½ inches deep and 8½ inches wide at the back. Between the front and back parts there is placed a piece of stiff leather, and the two parts are then securely sewn together. The back part is cut flap-shaped, and has a hole pierced in the end, which overlaps the front part, to take the stud fitted for the purpose, so that when the pouch is fastened the axe is secured firmly in its place. There are also sewn to the back part two beckets, of sufficient size to allow the belt to be rove through them.

Small Axe.

A small hatchet or axe is made somewhat in the shape of a tomahawk, and consists of two parts, called respectively the head and the handle.

The head is of faggotted wrought iron, 7½ inches long, steeled and tempered at the ends. One end is made with a blade and cutting edge, 2½ inches wide, slightly curved, and inclining towards the handle; the other end is also curved, and gradually brought to a flat point. At about the centre of the head there is a longitudinal hole or socket, to the sides of which there are welded on two clamps, 6 inches long and 1¼ inches wide, to receive the handle.

These clamps are drilled with two holes each to take ⅜-inch rivets.

The handle is of well-seasoned ash, 15 inches long, and of an average substance of about 1¼ inches square, with the angles rounded off; within a few inches of the bottom it is slightly reduced for the hand, which gives it the appearance of being shouldered at the lower end. It is fastened into the socket by the two rivets already mentioned, and is, when necessary, further steadied and secured at the upper end by a small cross wedge let in from the top, which prevents the head flying off when in use.

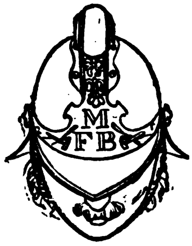
Its weight is—head and rivets 1 lb. 7 oz., handle 3 oz.; total 1 lb. 10 oz.

Helmet.

The pattern of helmet which I consider best adapted for the work of firemen, so far as shape is concerned, is shown on the accompanying woodcut.

The material of which it is made is of comparatively little consequence; I have chosen brass merely to distinguish our men from persons who come to render voluntary assistance, but leather helmets are found to answer very well.

The principal points in these helmets are that the front peak shades the eyes without much interfering with the sight, and the back peak protects the neck and ears from molten lead, &c., without preventing the men hearing—an object which has been found most difficult of attainment, and which has only been accomplished after much trouble and many experiments, by making the inner ends of the front and back peaks respectively meet at the point shown on the sketch, and covering the junction completely, but not closely, with the



wide upper end of the chin-strap. The length, breadth, and height of the upper or skull part keep the metal well clear of the temples, pole, and crown of the head, and the comb is so constructed as with a light weight to bear a very heavy blow. The projecting end of the comb, and that of the front peak, are so arranged that when a man falls forward they both strike the ground before any part of his face touches. The holes in the roof and the front of the comb are for ventilation, and the edge pieces round the peaks are for stiffening.

Several years ago, when I found it necessary to change this part of our uniform, I took some trouble on the subject, went to several countries for the purpose, and examined into the merits and defects of, I should think, nearly all the helmets in existence.

The result is the present pattern, which has now been some years in use, and which seems to me to combine the strength necessary for a fair amount of protection with lightness, and the absence of any projections which would prevent men passing through small apertures.

In America I have always been astonished at the shape of the helmets, which appeared to me to be so encumbered by the enormous back-flap, and so defective in point of protection, particularly about the eyes, that I should suppose it to be absolutely impossible for the men to go through such openings as we use—as, for instance, the panels of doors, &c.—or to approach strong flames, as we are in the habit of doing.

Our brass helmets are made in several parts, so that when accidents happen—as, of course, they do every day and night—an injured part can be taken out and replaced without much trouble or expense. All the parts are closed with either screws, rivets, or lap-joints, and there is no solder or other substance likely to melt in such temperatures as a man can stand.

All the helmets are made on a precisely similar pattern, but that of the chief officer is of silver, not brass.

Duck Jacket.

This jacket is made of duck, and is double breasted, with a turn-down collar 2½ inches wide.

On each side of the jacket six eyelet-holes are worked on the outer sides, at a distance of about 4 inches from the edge, and through these the shanks of a corresponding number of plain brass buttons, about ⅝ths of an inch in diameter, are passed, and the buttons are secured in their places by means of small split rings on the inner sides of the jacket.

On each side of the jacket, at the outer edges, six button-holes are worked, for the purpose of fastening it.

The average length of the jacket is about 1 foot 10 inches.

Duck Trousers.

These trousers are made of duck, and are of the same pattern as the cloth trousers, with the exception of the buttons, which are made of brass.

Caps.

The caps worn by the officers are made of blue cloth, and are about 8 inches in diameter at the top and about 3 inches deep at the side. A stout straight leather peak, 2 inches deep and 6 inches long, is sewn on to the front part of the cap. The caps are stiffened, and lined on the inside in the usual way. A chin-strap is fitted to the cap, and is made fast by two buttons, sewn on near the ends of the peak.

The caps worn by the men are made of blue cloth, and are about 10½ inches in diameter at the top; a bevel of about 2⅜ inches wide is sewn to the top, and to the bevel is sewn a band, 1½ inches wide, which is made to fit the head. A strip of scarlet piping is also sewn between the bevel and the band. Two eyelet-holes are made in the band, and through these a piece of black ribbon, 1¼ inches wide, is rove, and fastened with a bow or knot.

Badges.

The distinguishing badges are as follows:—

A fireman wears only his badge with a brass number on the left breast of his tunic.

An engineer wears a scale epaulette of brass on his right shoulder, and also a brass number on his left breast.

A superintendent wears a pair of scale epaulettes of brass, one on each shoulder.

The chief officer wears a pair of scale epaulettes precisely similar to those of the superintendents and other officers, except that they are, like his helmet and buttons, of silver.

The coachmen and pilots employed by the brigade receive also a somewhat similar distinguishing uniform, which enables them to be recognized by the police and to pass freely through the lines.

TELEGRAPHIC COMMUNICATION.

THE telegraphic system adopted is of the simplest possible kind, so that it can be thoroughly understood and worked by all hands.

Each station, with only a few exceptions, has a line of its own to the superintendent's station in the same district.

Each line of wire is independent of every other line, and has two dial instruments on it, one at each end, so that the breaking down of any one line—as of course frequently happens, from various causes, in a large city—does not in any way interfere with the working of the others.

By this system every message from a superior must of necessity pass through the hands not only of those who have to carry out what is ordered, but also of those who ought to be acquainted with what is done. Thus, for instance, the chief officer may wish an engine of a distant outlying station to be sent somewhere, and his message must necessarily pass through the superintendent of the district, who accordingly knows that one of his stations is temporarily weakened, and whose duty it is either to strengthen it himself at once, if necessary, or to ask for help to do so.

In addition to the general working lines from the ordinary stations to the superintendents' stations, and from the latter to the chief station, there are also a few auxiliary lines connecting the nearest stations of separate districts, so that in the event of a main line breaking down and causing, as it would, great inconvenience and delay, messages can, with one or two repetitions, be rapidly passed round by the auxiliary lines, and so reach the chief station through another district.

The following are the regulations hung up in every station close by the instruments :—

RULES TO BE OBSERVED FOR THE TRANSMISSION AND RECEIPT OF TELEGRAPHIC MESSAGES.

N.B.—It is usual during a message to silence the bells by means of the pegs placed on the instruments for that purpose.

1. Signs are transmitted from station to station by slightly raising the handle of the transmitter, and turning it from left to right at a speed of

about 120 revolutions per minute, resting the handle for a moment in the notches of the metal ring at the signs or letters to be indicated.

2. The words telegraphed will be indicated at the receiving station by the pointer of the indicator stopping at the same letters or signs as those indicated by the handle of the transmitter at the transmitting station.

3. To ensure safety in the communications, it is necessary to begin the motion of the handle of the transmitter with a sudden start, and to fall in at the notches of the letters to be telegraphed in a firm manner. This will require some few hours' practice.

4. The easiest way of acquiring the certainty to hit the notch of the letter to be telegraphed, is for the manipulator to keep his hand on the handle of his instrument, but not to lift or turn it round until his eye has caught on the dial of the transmitter (the large dial) the letter to be indicated; if he then look firmly at this letter, slightly raise the handle of his instrument, and turn it quickly, he can, without difficulty, drop it in at the notch of the letter on which his eye is fixed.

5. When the instruments are at rest, the handles and the indicators of all the instruments should point to the blank spaces on the dials.

6. Should the handle and the pointer in any of the instruments not point to the same letter or sign, the little knob near the dial of the indicator is to be pressed down, and the handle of the transmitter is to be turned once round, starting from and returning to the blank space on the dial; the pointer will then also be on the blank, and the little knob may be released.

7. "Attention" is called by turning the handle of the transmitter once or twice round, starting from and returning to the blank space; the receiving station repeats the sign, and then the transmitting station telegraphs the message.

8. After each word has been telegraphed, the handle of the transmitting instrument is to be brought to the blank space to signify the completion of the word.

9. The receiver, if he understands the word, will turn his handle once round, until it comes again to blank, to signify "Understood."

10. If he does not understand the word, he will turn his handle to R, to signify "Repeat," and then to blank, to signify that he is ready to have the word repeated.

11. The transmitter should never send a word until he has received "Understood" to the previous word.

12. Should it happen during the transmission of a message that, owing to inadvertence or any other cause, the handle of the transmitter and the pointer of the indicator, at either the transmitting or receiving stations, do not correspond, the little knob near the indicator of the instrument so observed is to be pressed down, and the handle of this instrument is to be turned once round, starting from and returning to the blank space, when it will be found that the handle and the pointer will correspond.

13. The receiver must, in all such cases, wait until he perceives that the sender has finished a word, and he must not attempt to adjust his instrument during the transmission of a message. As soon as he perceives that the word has been finished, he will first adjust his instrument, then give R, for repeat, and then turn his handle to blank.

14. At the end of a message requiring a reply, when the transmitter

has received after the last word the sign "Understood," he is to give the blank *once*, to signify that the message is concluded, and that he awaits an answer.—The receiver then, if he is prepared to give the answer, goes on immediately, and, when he has done, gives the blank *twice*, to signify he has no more to say. When the sender has received the information which he requires, he gives blank twice, and then the correspondence is closed. If, however, the receiver is not prepared to answer the message immediately, he will give the letter W twice, to signify "Wait," and then turn to blank.

15. When the transmitter, after having concluded his message, requires no reply, he gives blank twice, to signify that he has done; and, if the receiver wants no further explanation, he also gives blank twice, to signify "All right," and then the correspondence is closed, and the bells should be turned on again by withdrawing the pegs which silence them during the transmission of a message.

16. In no case will either the transmitter or receiver leave his instrument until after the conclusion of the correspondence has been notified in the manner above mentioned.

17. In case of wishing to use figures instead of letters, as in giving the number of a policy, the transmitter is at liberty to do so, but he must previously say in the ordinary manner, "see figures," and if there is time after the number has been communicated, the receiver should repeat the whole of the figures, in order to prove whether he has received them correctly.

18. The man on duty is answerable for the correct receipt and transmission of all messages, and he is under no circumstances to depute this responsibility to any one else, except to some one actually belonging to the brigade. He will do well at all times to make persons present stand back from the instruments, and keep silence during the transmission of messages; and he must be careful, before leaving the instruments, to see that the bells are turned on and the hands properly adjusted.

LIST OF ARTICLES

To be carried on Fire Engines of Various Kinds :—

Articles.	Large Steamer.	Small Steamer.	Seven-inch Manual.	Six-inch Manual.	Under Six-inch Manual.
Axes, large	1	1	1	1	1
Branch tallies ...	2	2	2	2	..
Branches	2	2	2	2	..
Breechings, delivery, 1 into 2, 2½ and 2½	1	1	1	1	..
Breechings, delivery, 1 into 2, 2½ and 1½	..	..	..	1	..
Breechings, delivery, 2 into 1, 2½ and 2½	1	1	1	1	..
Breechings, suction, 1 into 2, 3½ and 2½	1	1	6	..	..
Buckets, canvas ...	6	6	..	6	6
Chafing leathers ...	1	1	..	..	..
Chisels, cold ...	1	1	1	1	1
Cisterns, canvas ..	1	1	1	1	1
Crowbars	1	1	1	1	1
Double connecting screws	..	..	1	1	..
Double reduction screws	..	..	..	1	1
Elbows, delivery, 2½ and 2½	*According to circumstances and locality.*				
Elbows, delivery, 2½ and 1½					
Elbows, delivery, 2¼ and 1½					
Files	2	2	1	1	..
Gauge glasses, spare..	2	2	..	..	..
Hammers, iron ...	1	1	1	1	1
Hammers, tin ...	1	1	1	1	1
Hand loops	2	2	2	..	..
Hand pumps complete	1	1	1	1	1
Hose, 2½-in. 40-feet lengths of... ...	8	8	8	8	..
Hose, 1½-in. 40-feet lengths of... ...	..	..	..	..	6
Hose wrenches 2½-in.	2	2	2	2	..
Hose wrenches 1½-in.	..	..	..	2	2
Hydrants, ball ...	*According to circumstances and locality.*				
Hydrants, sluice ...					
Ladders	2	2	2	2	2
Lamps, carriage ...	2	2	2	2	2
Lamps, gauge ...	2	2	..	..	..
Leathers, lapping ...	6	6	6	6	6
Lines, lapping ...	6	6	6	6	6
Lines, long	1	1	1	1	1
Lines, short... ...	1	1	1	1	1
Mattocks	1	1	1	1	1
Nippers, small ...	1	1	..	..	..

Articles.	Large Steamer.	Small Steamer.	Seven-inch Manual.	Six-inch Manual.	Under Six-inch Manual.
Nozzles, 1⅜-inch ...	2	1	..	..	..
,, 1¼ ,, ...	2	1	..	..	..
,, 1⅛ ,, ...	2	1	..	..	..
,, 1 ,, ...	2	1	..	..	..
,, ⅞ ,, ...	2	2	1	..	..
,, ¾ ,, ...	2	2	1	1	..
,, ⅝ ,, ...	2	2	1	1	..
,, ½ ,, ...	2	2	1	1	1
,, ⅜ ,, ...	..	..	..	..	1
Oil cans, small ...	1	1	..	..	..
Oil feeders	1	1	..	..	..
Packing irons, sets of	1	1	..	..	..
Preventers	1	1	1	1	..
Saws...	1	1	1	1	1
Smoke caps complete	*According to circumstances.*				
Spades	1	1	1	1	1
Spanners, branch and nozzle	1	1	1	..	..
Spanners, shifting ...	1	1	1	1	1
Spanners, various ...	6	6	..	..	..
Standpipes	1	1	1	1	1
Stoking irons, sets of	1	1	..	..	..
Straps, bucket ...	1	1	1	1	1
,, ladder ...	2	2	2	2	2
,, lever ...	..	..	2	2	1
,, preventer ...	1	1	1	1	..
,, standpipe ...	1	1	..	..	1
,, stoking irons	2	2	..	..	..
,, suction pipe...	..	..	..	..	1
Suction pipe crutch...	1	1	..	..	..
Suction pipes, curricle	..	..	..	..	1
Suction pipes, manual	..	..	4	4	..
Suction pipes, steam.	2	2	..	..	..
Suction strainers, curricle	..	..	..	..	1
Suction strainers, manual	..	..	1	1	..
Suction strainers, steam	1	1	..	..	..
Suction pipe wrenches, 3½-in.	1	1	..	..	..
Sway-bars, spare ...	1	1	..	..	..
Tin cases, with working lists	..	..	1	1	1
Turncocks' tools, sets of	1	1	1	1	1
Valves, spare ...	6	6	..	..	..
Wedges, bundles of..	1	1	1	1	1
Wheel cloths ...	2	2	..	..	..

GENERAL MEMORANDA.

EVERY engine is marked on the outside with the number of the station to which it belongs in large plain brass figures, and is designated at fires by these numbers only.

Thus, if there be only one delivery on, the order would be given "Down with No. 60," "Avast No. 44;" or, if there be two deliveries on, "Knock off the near side delivery of No. 5," "Down with the off side of No. 10," and so forth.

The first length of either delivery-hose or suction-pipe is that next the engine, the second length is that next the first, the third next the second, and so on to the end length, which is usually called the last.

If an order be given to add a length, or to take off a length, the last length is the one to be dealt with; but if any particular place be meant for either adding or taking off, this must be specially mentioned, as, for instance, "Add a length between the second and third," or "Take off the second length."

When a length of hose is damaged, it is not always necessary that it should be removed at once. In such a case it is generally possible to keep the water running until a sound length, with the necessary wrenches or other tools, has been brought up and laid out alongside; and when all is ready for the change, the water is stopped for a moment, the old joints broken, the new joints made, and the water started again. With two men at each joint a change of the kind does not occupy more than 10 or 15 seconds.

The same principle holds good in all our business, the general rule being not to discontinue the work, whatever it may be, until everything is completely ready for the change. Thus, for instance, if an engine be at work in the front of a house, and it be desired to get a stream at the back instead, a line of hose may be commenced either the whole way from the engine or from the spot which the line already out can reach; a branch may be put on, and the whole got into proper position, and when everything is completely ready, and the necessary spanners or other tools have been brought to where the branch is at work, then the water may be stopped, the branch removed, the new joint made, and the engine instantly started again.

If this rule be not attended to, and the water be discontinued immediately on the order being given, considerable time may be lost, and the results in many cases might be most disastrous.

When a damaged length has been removed, it should be made up again as soon as convenient, with the female screw inside and the male screw outside. This is the mark of a damaged length, and it will readily catch the eye of a fireman who wants more hose.

In the great haste with which our work has to be done, particularly at the commencement of a fire, when we are necessarily short-handed, there is very rarely time to make up the hose in this way; but as great inconvenience, and in some cases serious danger, might result from bringing a damaged length into use, the fireman should, as soon as the joints have been made and the water is running again, put up an overhand knot on the damaged length, so that any of his mates coming for more hose would know that it was damaged, and would pass it by accordingly.

In giving an order concerning the starting or stopping of the water, whether from an engine or a stand-pipe, great care must be taken that the message is correctly delivered, as otherwise very great inconvenience, and, in certain cases, most serious difficulty and danger, may result, particularly at large fires, when there are several jets at work. The only really safe course to pursue is to send a message the whole way to the man in charge of the engine or stand-pipe, saying exactly what is wanted, and, in case of more than one delivery being on, mentioning particularly which delivery the message refers to; as, for instance, "Start the off-side delivery of No. 20;" or "Knock off the near-side delivery of No. 45."

The shouting of orders from a distance is in general a proceeding to be greatly avoided. When it is successful, which of course may sometimes be the case, it causes at least an appearance of great confusion and unsteadiness; but as a matter of fact it is very rarely successful—on the contrary, it almost invariably tends to mistakes and consequent danger, when more than one engine or more than one delivery is at work.

There may be cases in which it may not be advisable to send a man all the way with a message—such as, for instance, when the branch is high up in a house, and the engine working directly under the window, and within speaking distance; there may also be cases in which it is impossible to spare a man to go, or impossible for him to go even if he could be spared—such as, when the stairs or other passages are crowded with goods, and men at work on them.

For these reasons I have never issued any positive instructions on this subject, and I give none now; but I am nevertheless strongly of opinion that the transmission of orders by shouting from a distance is a practice which should, as far as possible, be avoided.

Thus it will be seen, notwithstanding the absence of precise directions, that I consider it the business of the senior present, whenever he hears orders shouted in this way, to ascertain for himself whether there is or is not sufficient reason for doing so, and, if necessary, to censure those guilty of the irregularity.

AN

APPENDIX

OF

Manufacturers' and other Advertisements,

HAVING REFERENCE TO

FIRE PROTECTION

FOR

LIFE AND PROPERTY.

FIRE INSURANCE COMPANIES.

MAKERS OF FIRE ENGINES TO THE

METROPOLITAN (LONDON),

MANCHESTER, LIVERPOOL, & OTHER FIRE BRIGADES;

Sole Makers of Steam Fire Engines to Her Britannic Majesty's War Department;

Makers of Fire Engines to Her Britannic Majesty's Board of Admiralty; Council for India; Agents for the Crown Colonies; and Board of Trade; to the French, Prussian, Russian, Italian, Turkish, Spanish, Belgian, Dutch, Chinese, and Brazilian Governments; to the Dean and Chapters of Canterbury, Lincoln, and other Cathedrals;

HER MAJESTY THE QUEEN,

H.R.H. The Prince of Wales, The Duke of Westminster, Duke of Sutherland, Earl Derby, and the principal members of the Aristocracy; for the chief Public Institutions, Insurance Companies, Theatres, Hotels, and Factories in the United Kingdom.

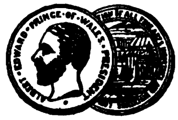
[London Brigade Manual Fire Engine.]

MERRYWEATHER & SONS have received the following Prizes and Awards for their Steam and Hand-worked Fire Engines:—

- First Prize Medal—Great Exhibition, London 1851
- First Prize Medal—Great Exhibition, Paris 1855
- First Prize Medal—International Exhibition, London 1862
- First Prize Medal—International Exhibition, Calcutta 1862
- First Grand Prize, £250—International Competition, Crystal Palace (Highest Award) 1863
- First Prize Medal—St. Petersburgh .. 1863
- Do. Netherlands 1864
- Money Prize—Holland 1864
- First Grand Prize—Rotterdam Competition 1864
- First Prize Medal—Calcutta 1864
- Special First Grand Prize (500 thalers) Cologne International Exhibition .. 1865
- First Prize Medal—Exhibition, Dublin .. 1865
- First Grand Prize and only Gold Medal—Paris International Exhibition .. 1867
- First Grand Prize—Newcastle-on-Tyne Competition 1868
- First Award—Wigan 1868
- Do. Nottingham 1868
- First Prize—St. Petersburgh 1870
- First Award—Stockton-on-Tees 1872
- Do. Coventry 1872
- Do. Barrow-in-Furness 1872
- Great Gold Medal—International Exhibition, Moscow 1872
- First Award—Manchester .. .. 1865 & 1872
- Grand Medal for Progress—International Exhibition, Vienna (Highest Award) 1873
- First Award—Liverpool .. .. 1863 & 1874
- Prize Medal—International Exhibition, London 1875
- First Award—Stockholm 1875
- Highly Commended—Sydney, Australia .. 1876

COMPLETE ILLUSTRATED CATALOGUES FORWARDED ON APPLICATION.



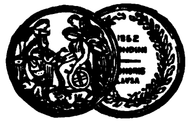
MEDALS, PRIZES, AND AWARDS

OBTAINED BY

SHAND, MASON & CO.,

FOR THE BEST

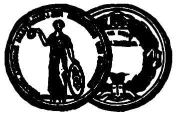
STEAM AND MANUAL

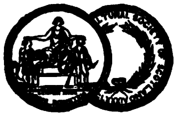


FIRE ENGINES,

Steam Pumping Engines, &c.

PRIZE MEDAL, Great Exhibition, London . . .	1851
,, ,, International Exhibition	1862
FIRST PRIZE of £250, Crystal Palace, London . .	1863
SECOND ,, £100 ,, ,, . .	1863
THE ONLY GOLD MEDAL, Middleburg, Holland .	1864
FIRST MONEY PRIZE ,, ,, .	1864
SPECIAL ,, ,, ,, ,, .	1864
GREAT GOLD MEDAL, Cologne	1865
PRIZE MEDAL, Dublin Exhibition	1865
PRIZE MEDAL, Paris Exhibition	1867
FIRST AWARD, Bradford Competition	1867
GOLD MEDAL, Akola Exhibition, India	1868
SILVER ,, ,, ,, ...	1868
SPECIAL MONEY PRIZE ,, ...	1868
GOLD MEDAL, Altona, Germany	1869
SILVER MEDAL, Edinburgh	1869
FIRST AWARD, Glasgow Competition	1870
FIRST AWARD, Preston Competition	1871
GOLD MEDAL, Moscow Exhibition	1872
GRAND MEDAL, Vienna Exhibition	1873
,, ,, London International Exhibition .	1874
GOLD MEDAL, Norrkoping, Sweden	1876
HIGHLY COMMENDED, Queensland Exhibition, Australia	1876




JAMES QUIN & COMPANY, LIMITED,

GOLDEN HILL RUBBER WORKS,

LEYLAND, *near* PRESTON,

MANUFACTURERS OF

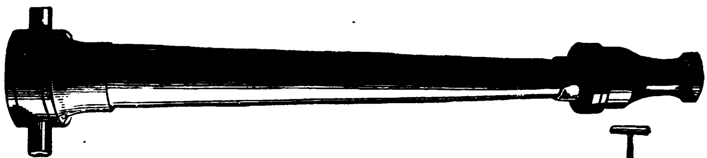
Vulcanized India Rubber Articles of every description; also India Rubber Air and Waterproof Fabrics; Water Beds, Pillows, Cushions, &c.; Waterproof Coats, Capes, and Overalls, made of Single and Double Texture Cloth, Steam Vulcanized, warranted for Hot Climates; Bed Sheets for Hospital purposes, &c., &c.

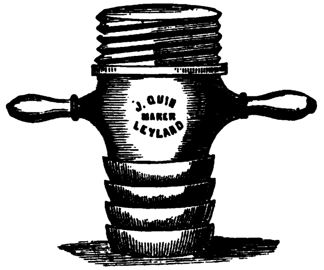
To MERCHANTS, SHIPPERS, WHOLESALE BUYERS, &c.

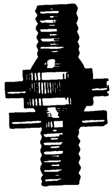
JAMES QUIN & CO., LIMITED, have great pleasure in calling the attention of buyers of India Rubber and Cotton Delivery Hose, in all sizes, to their Patent Machine for making the Hose by Power,—this being the only Machine ever invented for making India Rubber Hose by Power,—they are in a position to offer buyers a great advantage.

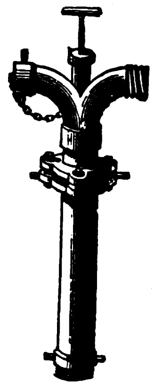
A 60-ft. length of 2-in. 4-ply Delivery Hose is, by the use of this Machine, made in less than one minute, and larger orders can be executed in a very short space of time. By the Machine process, the Rubber and Cloth are firmly pressed together, making the Hose cylindrical, pliable, and very durable.

BRASS FITTINGS, of every description, for Extinguishing Fires, also supplied.





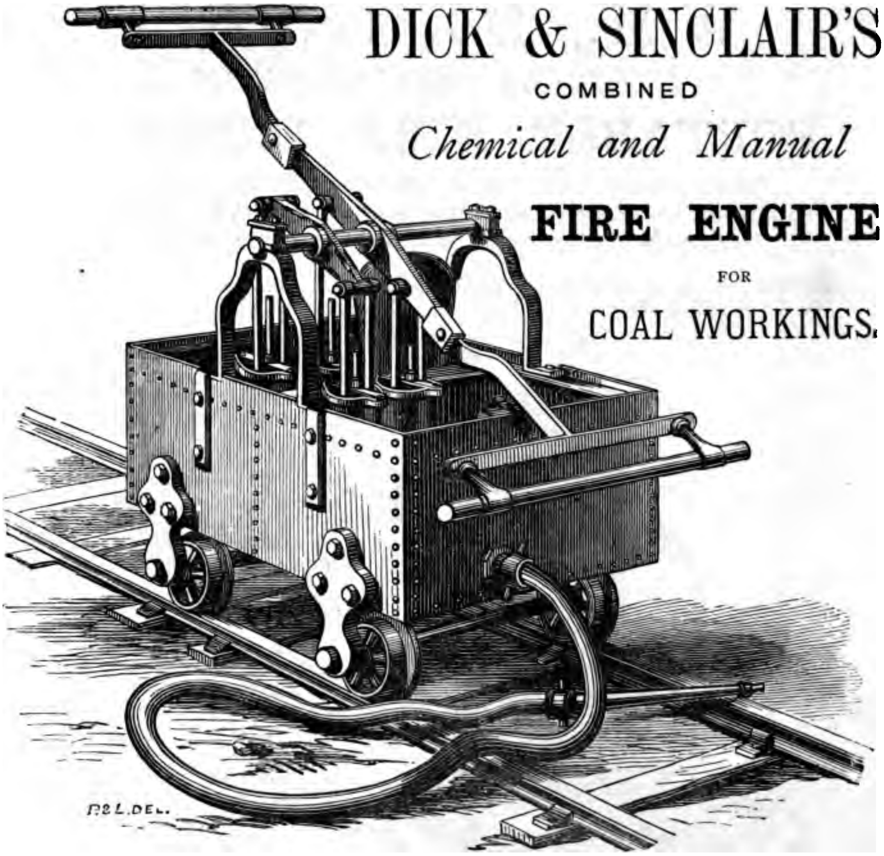




WAREHOUSES—

13, SISE LANE, and 5, SKINNER'S PLACE, QUEEN VICTORIA STREET, LONDON, E.C.

23, YORK STREET, MANCHESTER; and 31, AVENHAM STREET, PRESTON.



This powerful Engine is divided into two compartments, with four 4-inch Pumps, two of which are connected with the suction and two with the delivery.

The Chemicalized Water from the Cisterns meet in the Air-Chamber, and produce carbonic acid gas under heavy pressure. The Water, thus densely charged with gas, is thrown on the fire, with marvellous effect.

Full Particulars on application.

PRICE.

Engine, including necessary Fittings and one Length of Hose 25 Yards long £76

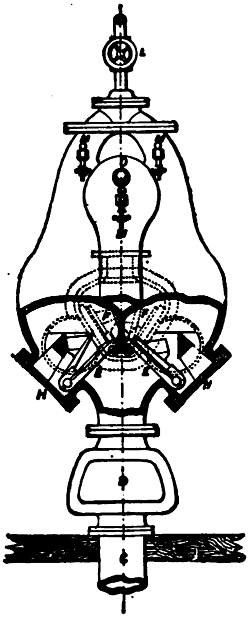
Chemicals for Ditto, 30/ per Cwt.

JAMES SINCLAIR,

48 & 50, BLACKFRIARS STREET, MANCHESTER;
104, LEADENHALL STREET, LONDON.

THE SIMPLEST, CHEAPEST, & MOST RELIABLE

FIRE PUMP.



FRONT ELEVATION.

GOVERNMENT

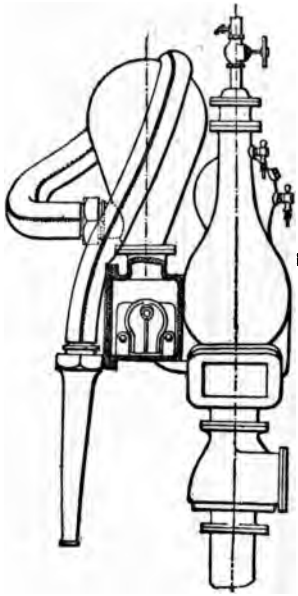
GOLD MEDAL,

Breda, Holland, 1876.

SILVER MEDAL,

Manchester, 1875.

The size which throws 100 Tons of Water per Hour costs only £100.



SIDE ELEVATION.

The Pulsometer.

A STEAM-PUMP WITHOUT A STEAM ENGINE.

THE ONLY PUMP that can be left WITHOUT ATTENTION for Months, and then, by merely turning the Steam Valve, be immediately brought into full action. This point cannot be too strongly borne in mind, as unless a Fire Pump is ALWAYS READY, it is practically useless.

The same Fire Pumps can also be used for distributing a supply of Water for other purposes to any part of the Building where it is fixed.

CAN NEVER BE WORN OUT.
WILL PUMP ALMOST ANYTHING.
REQUIRES NO FIXING.
NEEDS NO SKILLED ATTENDANCE.

NEVER REQUIRES OIL, TALLOW, OR PACKING.
IS CHEAPER THAN ANY OTHER PUMP.
OCCUPIES LESS SPACE THAN ANY OTHER PUMP.

SOLE MANUFACTURERS AND OWNERS OF THE PATENTS,

HODGKIN, NEUHAUS & CO.,

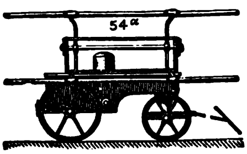
WELLINGTON ROAD, BATTERSEA, LONDON, ENGLAND.

Show-room, 61, Queen Victoria Street, London, where the Pulsometer and other Steam-Pumps are always to be seen in action.

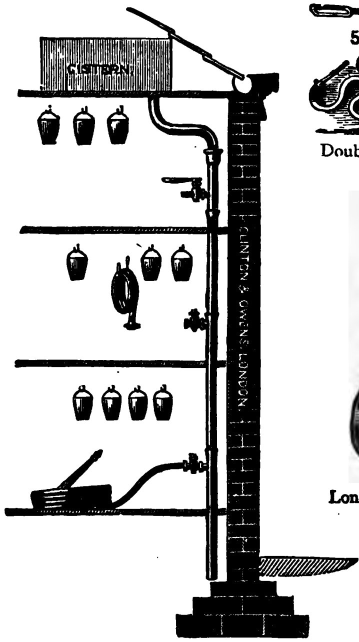
S. OWENS & CO.,

HYDRAULIC ENGINEERS,

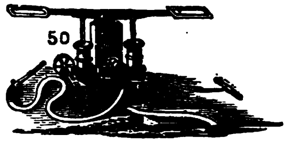
WHITEFRIARS STREET, LONDON, E.C.



Mansion Fire Engine.



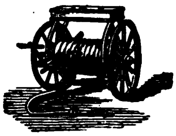
Arrangement of Pipes, Fire Cocks, and Hose for the Interior of Mansions and other Buildings.



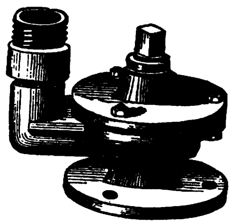
Double-barrel Farm Fire Engine.

The Cassiobury Fire Extinguisher.

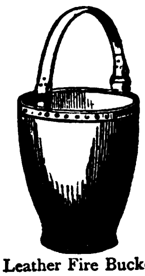
London Pattern Sluice Valve



Improved Hose Reel.

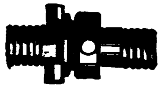


Improved Diaphragm Hydrant



Leather Fire Bucket.

Blake's Patent Direct-acting Steam Fire Engine.



Hose Union.

S. OWENS & CO. Manufacture and Erect every description of Hydraulic and General Engineers' Work for Mansions, Farms, &c., comprising Pumps, Turbines, Water Wheels, Warming Apparatus, Baths, Drying Closets, Gas Works, Apparatus for Liquid Manure Distribution, Fire Mains, Hydrants, Hose Pipes, &c.

Particulars taken in any part of the Country. Plans and Estimates furnished.

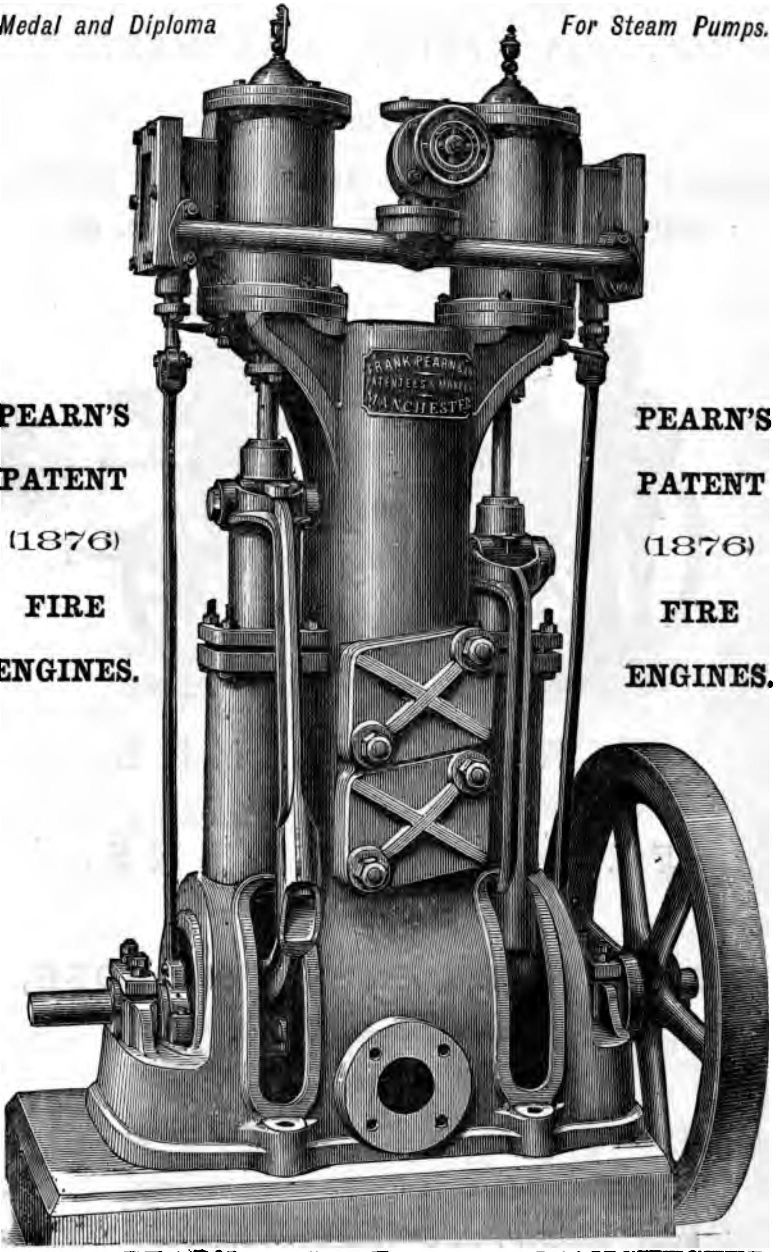
Illustrated Catalogues can be had on application.

THE MANCHESTER PUMPING ENGINE.

PHILADELPHIA EXHIBITION.

Medal and Diploma *For Steam Pumps.*

PEARN'S PATENT (1876) FIRE ENGINES.

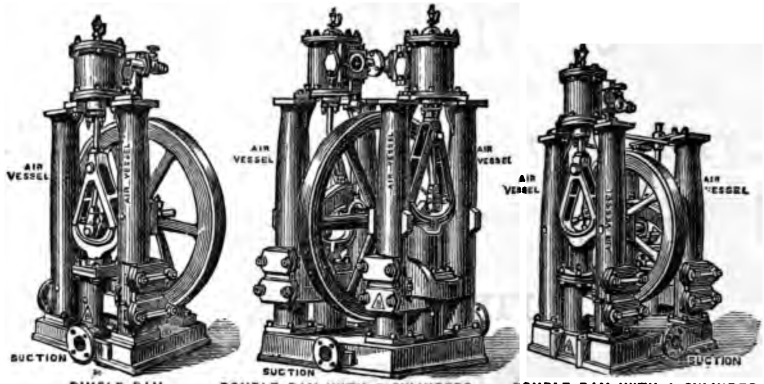


PEARN'S PATENT (1876) FIRE ENGINES.

FRANK PEARN & CO., Patentees, MANCHESTER.

STEAM PUMPS,

For Feeding Boilers, Raising Water, and Forming an excellent Steam Fire Engine.



SINGLE RAM. DOUBLE RAM WITH 2 CYLINDERS. DOUBLE RAM WITH 1 CYLINDER.

DESCRIPTION.

JOHN CAMERON invented the above design of Steam Pump in 1853, and has since made about 5,000. They are now well known, and extensively used for various purposes, viz.:—To feed boilers, to force water and chemical liquids. The larger sizes are an excellent Steam Fire Engine. They are now much used in deep Mines, and can be specially made to force water any height. The exhaust Steam can be condensed and utilized in heating water, or in adding vacuum power to the Pump.

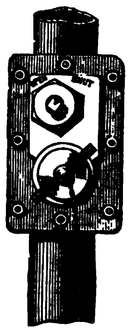
JOHN CAMERON, Oldfield Road Ironworks, Salford, MANCHESTER.

NO EXTRA INSURANCE NECESSARY WITH

PATENT

ECONOMIC

STEAM ENGINE.



If fitted with Gas Fire it has also all the advantages of a Gas Engine,

Without any Noise or Smell, and expense of a Special Foundation.

K. W. HEDGES & CO.,

HYDRAULIC ENGINEERS,

AND

CONTRACTORS FOR EVERY DESCRIPTION OF WATER SUPPLY, AND FOR ERECTION OF IMPROVED FULL-WAY FIRE-COCKS AND HYDRANTS.

36, KING WILLIAM STREET, LONDON, E.C.

GUEST & CHRIMES,

FOUNDRY & BRASS WORKS, ROTHERHAM,

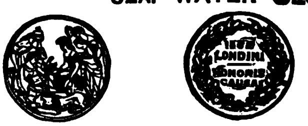
AND

85, SOUTHWARK STREET, LONDON, S.E.

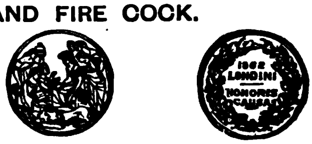
PRIZE MEDALS.

1851.

52A.—WATER CLOSET AND FIRE COCK.



1862.—AWARDED.
CLASS 8.—FOR WATER METER, &c., SIEMENS'
"PRACTICAL SUCCESS OF WATER METERS &C.; ORIGINALITY OF THE WHOLE."



1862.—AWARDED.
CLASS 31.—FOR WATER WORKS ARTICLES.
"PROGRESS IN FABRICATION OF USEFUL ARTICLES FOR THE DISTRIBUTION OF WATER IN TOWNS."

BATEMAN & MOORE'S & CHRIMES' PATENT HYDRANTS OR FIRE COCKS;
IMPROVED SLUICE COCKS AND GAS VALVES;
CATHELS' & TERRACE'S PATENT FOUR WAY DISC GAS VALVES;
CATHELS' PATENT DISTRICT DRY GAS GOVERNOR;
CHRIMES' PATENT HIGH-PRESSURE SINGLE AND DOUBLE LOOSE VALVE AND SCREW-DOWN COCK;
SIEMENS' PATENT WATER METER;
Eskholme's Patent Pneumatic Regulator and Valve Closet;
BELL & CHRIMES' PATENT SERVICE BOX VALVES;
WASTE PREVENTING SINGLE AND DOUBLE VALVE SERVICE BOXES;
IMPROVED SELF-ACTING & PULL WATER CLOSET;
LOWE'S PATENT EFFLUVIA TRAPS, BEGGS' IMPROVED;
NEWTON'S PATENT STREET GULLEY;
GAS CHANDELIERS, BRACKETS, AND FITTINGS;
GLASS CHANDELIERS AND BRACKETS;
CROSLEY AND GOLDSMITH'S PATENT WET GAS METER;
WET AND DRY GAS METERS.

FIRE EXTINGUISHING APPARATUS

Of every description, as HAND or DELIVERY PIPES, JETS, JET and SPREADER to distribute Water in imitation of Rain; HOSE COUPLINGS, LEATHER, INDIA RUBBER, GUTTA PERCHA, and CANVAS HOSE; COUPLING WRENCHES, &c., or any other Article made to order or size.

PLUMBERS' AND GAS FITTERS' BRASS WORK OF EVERY DESCRIPTION.
Drawings, Descriptions, Prices, and Testimonials, will be forwarded per Post, on application as above.

ALL THE ABOVE ARTICLES MAY BE SEEN ON APPLICATION TO

GUEST & CHRIMES, BRASS WORKS, ROTHERHAM;

OR TO

THOMAS BEGGS & SON, 85, SOUTHWARK ST., LONDON, S.E.

TRADE MARK. G B B REGISTERED.

FIRE! FIRE!!

VOSES' PATENT HYDROPULT,

A PORTABLE FIRE ANNIHILATOR,

Weighs but Eight Pounds, and will throw Water Fifty Feet. It is also the Best Article ever invented for

Watering Gardens, Sprinkling Plants, Washing Carriages, and Draining Boats.

It will throw Eight Gallons of Water per Minute. It is invaluable for Extinguishing Fires, or Protecting Roofs near a Fire.

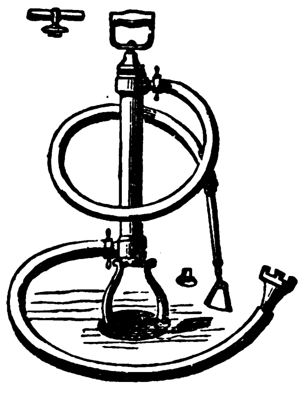
Upwards of Thirty Thousand now in use.

MANUFACTURERS—

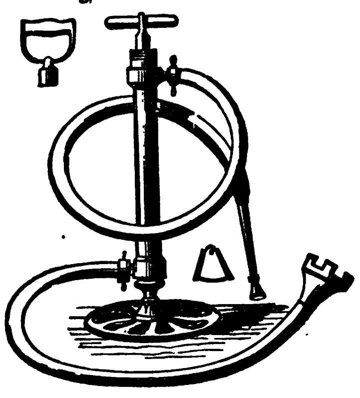
GRIFFITHS & BROWETT, BIRMINGHAM; 21, MOORGATE STREET, LONDON; AND 25, BOULEVARD MAGENTA, PARIS.

THE IMPROVED HYDROPULT.

No. 6.—With Patent Stirrup Crutch or Cross Handle, Rose and Spreader. —29/6 each.



No. 7.—With Round Stand Crutch, or Cross Handle, Rose and Spreader. —25/6 each.



The advantages of this form of Hydropult consist in the ease with which it can be worked, and the continuous stream of Water which it throws.

JOHN WARNER & SONS,

HYDRAULIC AND SANITARY ENGINEERS,

BRAZIERS AND COPPERSMITHS,

THE CRESCENT FOUNDRY, CRIPPLEGATE, LONDON, E.C.,

AND THE FOUNDRY AND WORKS, WALTON-ON-THE-NAZE, ESSEX.

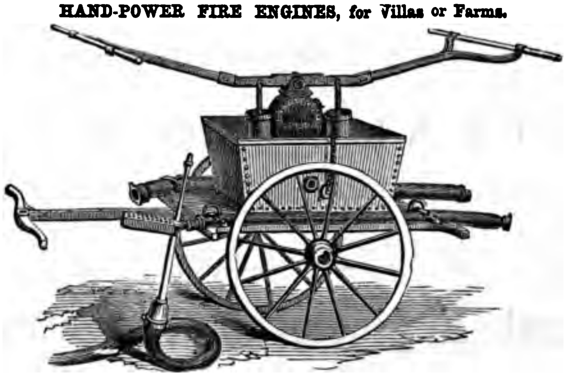
Manufacturers of Hydraulic Machinery of every description, Wind Engines, Fire Engines, Garden Engines, Water Wheels, Rams, Deep Well Pumps, Centrifugal Pumps, Horse Gear Frames, Engine Frames, &c., Cocks and Valves for Water at High or Low Pressure, Plumbers' Cocks and Fittings, Closets, Baths, Lavatories, Steam Valves and Engine Fittings, Beer Engines and Fittings, Bells, Tea Urns, and General Braziery.

Bell and Brass Founders To Her Majesty,
By Special Appointment.

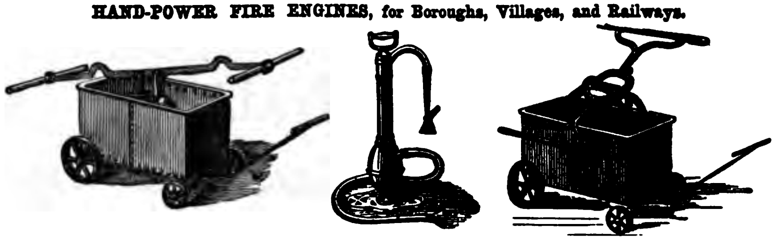
ESTABLISHED 1768.

WARNER'S FIRE ENGINES.

HAND-POWER FIRE ENGINES, for Villas or Farms.



HAND-POWER FIRE ENGINES, for Boroughs, Villages, and Railways.



HAND-POWER FIRE ENGINES, for Mansions, Warehouses, Factories, and Dwellings.

HOSE, BRANCH PIPES, UNIONS, BUCKETS, HELMETS, &c.

Full Priced Catalogues upon application.

BINNEY & SON,

LONDON & GLASGOW.

BINNEY'S
IMPROVED SPREADING NOZZLE

Is the best for Extinguishing Fires. The water passing through it like a shower of rain, is readily converted into Steam, occupying a large space, and absorbing the supply of air from the fire. A slight turn of the wrist enables the fireman to convert the stream of water into a shower, and thus drive the smoke and heat before him.

PRICES—½-in. ⅝-in. and ¾-in. Bore, 40/-; ⅞-in. and 1-in. Bore, 50/-; 1⅛-in. and 1¼-in. Bore, 60/-.

Large Discount allowed to Dealers and Fire Brigades.

HOSE, BRANCH PIPES, UNIONS, AND EVERY DESCRIPTION OF FIRE FITTINGS.

PATENT SELF-LUBRICATING
STEAM & HYDRAULIC ENGINE PACKING.

It supersedes anything of the kind ever invented. It keeps the rods cool, bright, and clean, and works without Oil or Grease, saving largely in cost and labour.

All the Lubricative Packing Company's Packing has their Trade Mark, a BLUE THREAD, in the Cover, and their Label.

Leather, India-Rubber, Lubricating Oils, Gauge Glasses, Boiler Composition, &c.

BINNEY & SON,

SOLE LICENCEES FOR THE LUBRICATIVE PACKING CO., & MILL FURNISHERS GENERALLY,

9, OSWALD STREET, GLASGOW; 63, BROAD STREET, BIRMINGHAM;

AND

CATHERINE STREET, CITY ROAD, LONDON, E.C.

DAVIS & HENWOOD,

India Rubber and Gutta Percha Manufacturers,

IRWELL RUBBER WORKS,

SALFORD, MANCHESTER.

(Successors to H. STATHAM & Co.,—*Established 1847.)*

FIRE ENGINE HOSE, both Delivery and Suction, in India Rubber and Canvas

PATENT CANVAS HOSE.

PATENT CANVAS HOSE, lined with India Rubber, to order.

INDIA RUBBER, in Sheet, Washers, Valves, Buffers, Rings, &c.

PACKING, both with and without India Rubber Core.

HOSE PIPING, Delivery and Suction.

INDIA RUBBER BELTING (best make only).

PIECE GOODS, both Single and Double Textures.

INFLATED IN 1 MINUTE.

SOLE MANUFACTURERS

OF THE

SCHÖNROCK

PATENT LIFE JACKET,

(Worn as a Waistcoat),

Water-proof Tweed, and other Garments for Hot and Cold Climates, in Single and Double Textures.

TEXTURE PIECE GOODS.

INFLATED IN 1 MINUTE.

PRICE LISTS ON APPLICATION.

And 110, CANNON STREET, LONDON, E.C.

The Committee now direct their attention to promoting, by the supply of Escapes, efficient and well-organised means for saving life in the suburban and provincial districts; and their labours, in this respect, have resulted in **Forty-seven** of the Society's Fire Escapes being placed at various provincial towns in the United Kingdom, at the following places:—

Beckenham.	**High Wycombe.**	**Saint Albans.**
Bournemouth.	**Hitchin.**	**Salisbury.**
Brentford.	**Ipswich.**	**Sevenoaks.**
Canterbury.	**Kingston-upon-Thames.**	**Southampton.**
Chatham.	**Lichfield.**	**Staines.**
Chippenham.	**Lowestoft.**	**Sudbury.**
Colchester.	**Luton.**	**Tenby.**
Crewe.	**Maidstone.**	**Twickenham.**
Dartford.	**Maidenhead.**	**Uxbridge.**
Deal.	**Maldon (Essex).**	**Ventnor.**
Devizes.	**Marlborough.**	**Warwick.**
Epsom.	**Newbury.**	**Watford.**
Eton.	**Norwich.**	**Wimbledon.**
Gravesend.	**Reading.**	**Winchester.**
Henley-on-Thames.	**Rugby.**	**Windsor.**
Highgate.		**Worthing.**

The Fire Escapes are intrusted to the Executive of the localities to which they have been sent, upon their entering into an Agreement with the Society to provide suitable Stations, maintain them in working order, and ready for instant service in case of fire.

The Machines being the property of the Society, it is a condition of each Agreement that, if they are not kept in a sound and efficient state, the Committee have the power, at one month's notice, to require the Local Authorities to return the Escapes to the Society.

This Society is the only systematic organization in England for rewarding brave exertions in saving Life from Fire; for which silver medals, testimonials, and donations of money have been awarded in **Nine Hundred and Twenty-seven** cases.

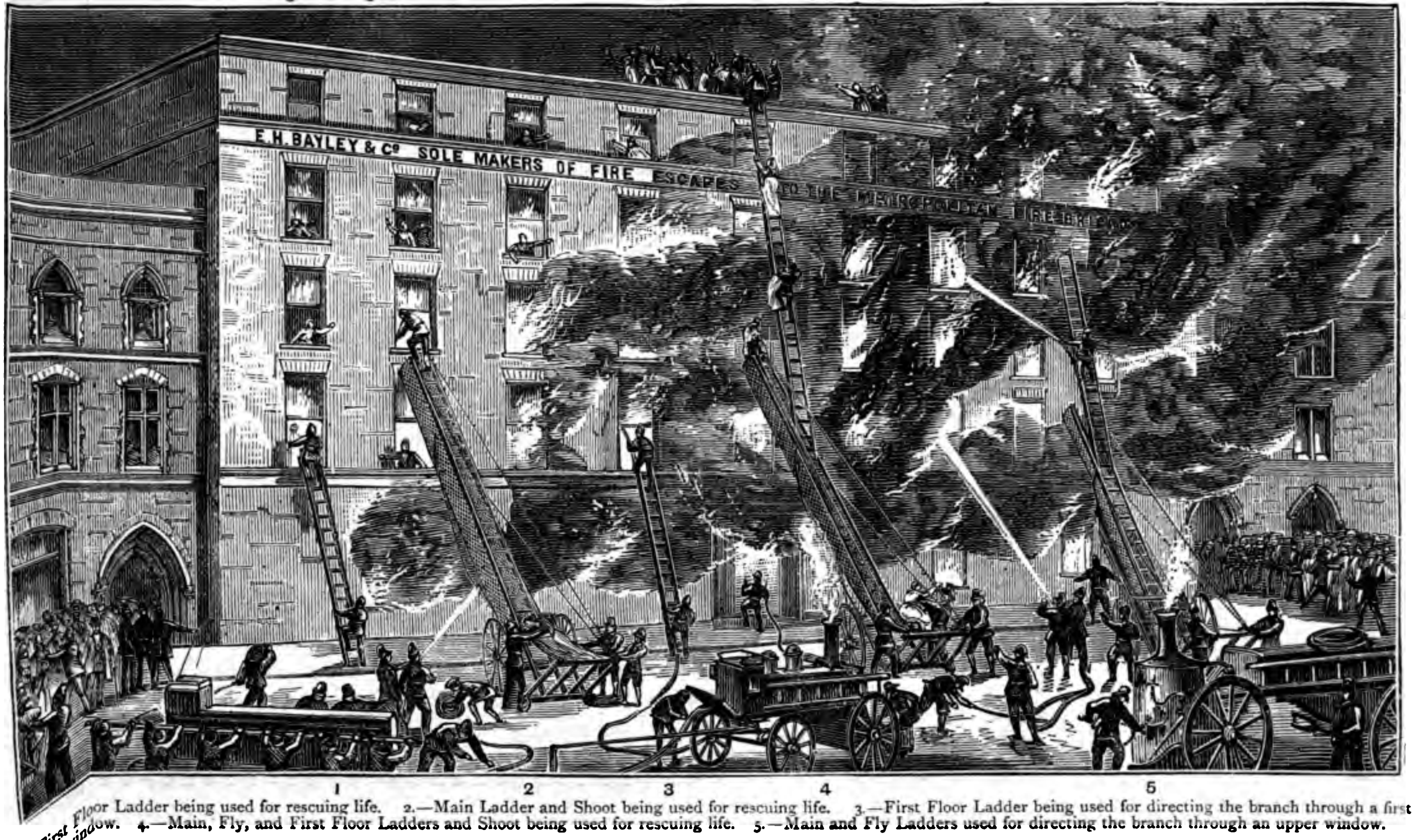
The Committee issue gratis a broadsheet of practical Rules, showing what is best to be done upon an alarm of fire, and how to treat injuries from fire.

Copies of the Annual Report can be obtained upon application to MR. CHARLES WRIGHT, *Secretary to the Society,—Office, 66, Ludgate Hill, E.C.*

DONATIONS *and* ANNUAL SUBSCRIPTIONS *will be received at the* BANK OF ENGLAND, *to the account of the Society's Treasurer and Trustees; by the Treasurer,* ALDERMAN THOMAS QUESTED FINNIS; *by any Member of the Committee; or by the Secretary, at the Society's Office, 66, Ludgate Hill, E.C.*

Form of a Bequest.—I give unto the Treasurer of the ROYAL SOCIETY FOR THE PROTECTION OF LIFE FROM FIRE the sum of £ , to be paid out of such part of my personal Estate as by Law may be applied for such purpose, the Receipt of the Treasurer for the time being of the said Society to be an effectual discharge for such Legacy.

This Engraving illustrates the various methods of using an Escape at a Fire.



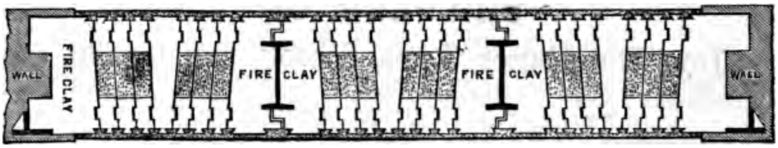
1 2 3 4 5

1.—First Floor Ladder being used for rescuing life. 2.—Main Ladder and Shoot being used for rescuing life. 3.—First Floor Ladder being used for directing the branch through a first floor window. 4.—Main, Fly, and First Floor Ladders and Shoot being used for rescuing life. 5.—Main and Fly Ladders used for directing the branch through an upper window.

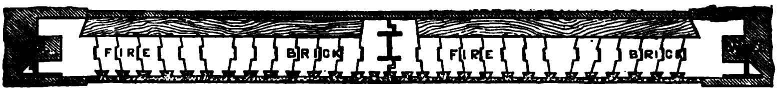
FIRE-RESISTING

COMPOUND ARCHED FLOORS AND ROOFS.

Patented in Great Britain, France, Belgium and other Countries.



Section of Warehouse and Mill. Floor finished with Portland Cement and Ceiled.



Section of Floor for Public Buildings, Mansions, &c. Joists and Boarded Floor on Patent Floor.

Inventor & Patentee—GEORGE NORTHCROFT,

ARCHITECT & SURVEYOR,

5, CASTLE STREET, LIVERPOOL.

These Fire-resisting Compound Arched Floors and Roofs have been designed by the patentee with the view of enabling architects to erect buildings of equally durable materials throughout, and to avoid the necessity of using timber for floors and roofs in the erection of public buildings and institutions, mansions, warehouses, mills, or other buildings designed to contain costly works of art, articles of virtu, merchandise, and machinery.

By the adoption of Northcroft's Patent, not only the walls, but floors and roofs, can be constructed of brickwork, bonded together with iron, embedded in the work, so that in the event of fire occurring in any particular part, it is prevented burning its way through into other rooms adjoining the one in which the fire originated, thus securing as perfect an immunity from fire to the goods in other parts of the building as it is possible to obtain.

It is most undesirable for the architect to have recourse to concrete in the construction of Fire-proof Buildings, which, although a good building material when skilfully handled, is exceedingly treacherous when not so, or under severe fire tests, and it is not at all necessary, for by the aid of machinery, clays can now be moulded into any required form; and daily experience teaches, for strength and durability, in positions where the material is constantly exposed to the action of fire, none so reliable can be obtained as the fire-brick.

The patentee, therefore, having determined that, under all circumstances, implicit confidence may be placed in his floors and roofs, will only use the best known and approved fire-clays in the manufacture of his goods.

The design of the floors and roofs is simple, and intended to facilitate building operations by employing in their erection the bricklayers engaged carrying up the walls. No delay necessarily need occur. When the walls are brought up to the floor level, the flat centres are set, and the cast-iron wall-plates bedded on the walls, the rolled iron joists placed on their bearings, and the skewbacks bedded to them in a composite of asphalte, which renders expansion easy, and avoids disturbing the adjacent parts. The various arches are then filled in, and when the floor is completed, the walls can be at once proceeded with up to the next floor level. The distance between the girders, and their depth, is determined by the load to carry and the width of the rooms. In any event perfect security can be guaranteed, the strength regulated to meet the requirements of the occupants or owners of the building, and the depth according to the bulk of goods to be warehoused upon each floor, so as to prevent the heat passing through.

These Fire-resisting Compound Arched Floors and Roofs are patented in Great Britain, France, Belgium, and other countries.

Information given and designs furnished for rendering buildings fire-resisting, and their erection superintended, by the patentee, GEORGE NORTHCROFT, 5, Castle Street, Liverpool.