

can be returned with the next charge. The sound ones are to be ground coarse or fine, according to requirement, and the ground stuff is ready for use.

The material thus prepared I call "pyroconcentrates of fluxed clay." Its distinguishing characteristics, as compared with merely calcined clay substance, are as follows: The pyroconcentrates of fluxed clay consist, practically, of aggregates of aluminum silicate molecules that are bound together by vitrified remnants, mostly in the form of very thin films of the liquefied slag. When a comminuted mass of such concentrates is intensely heated, these vitrified particles resoften to some extent and then act as a mechanical bond without reacting, chemically, on the aluminum silicate. Granting that a lining which contains such remnants of the liquefied slag may be attacked by a bath of liquid melted monosilicate slag, it stands to reason that the ensuing corrosion cannot be very energetic, considering that the silicate constitution of the slag bath does not differ much from that of the slag remnants of the lining. Pure clay substance, on the other hand, contains nothing that could bind it under heat, and if a clay does frit together in calcining, this chemical action is evidence that the calcined mass contains sufficient soluble matter to become readily decomposed by a corrosive slag bath. The pyroconcentrates can be applied in the usual manner after mixing with tar, etc., for lining the inside of melting vessels and furnaces, as a top dressing for linings made of other material, and for the manufacture of tuyeres, crucibles, and other refractory products. Its proper application as a hearth lining allows, as already explained, of holding and manipulating a thin fluid slag, which is so corrosive that it readily destroys the acid, as well as the basic and so-called "neutral" linings that have been thus far devised. This feature may also give rise to an important improvement in the manufacture of steel, inasmuch as a decarbonized steel bath can be purified from remnants of sulphur and phosphorus by bringing it into intimate contact with thin fluid desulphurized blast furnace slag. That such slag readily absorbs ferrous sulphide bodily—i. e., holding it in intermolecular combination—and that it readily combines, chemically, with phosphoric oxide and phosphates is well known; but, in order to desulphurize the slag and in order to utilize the desulphurized slag for the indicated purpose, the suitable hearth lining material had first to be devised.

The mechanical portion of the herein described method of treating clay allows obviously of many modifications that are determined in actual practice—as, for instance, the most suitable shape and sizes of the pieces that are to constitute the charges and the manner of forming them, the most suitable devices for furthering the overflow of the slag from the fining charge and the arrangement of the hearth, which will be most advantageous for facilitating the separation of the slag from the fining charge—such modifications depending chiefly upon the capacity and construction of the furnace plant that is to be used and on the volume of the charges that are to be treated.

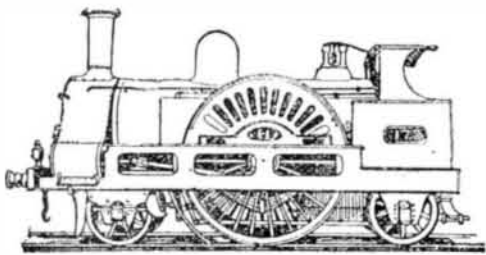
#### CLAIMS.

1. The herein described process of treating clay for the lining of metallurgical furnaces, etc., which consists in intermixing suitable clay with a flux which, if admixed in suitable proportions, combines with the fluxible accidental constituents of the clay to a thin fluid percolating slag when the mix is heated to about white heat; in preparing the mixes of clay and flux by forming and drying for the heating operation; in subjecting the prepared charges on the hearth of a suitable heating furnace first to a fritting heat and then to a melting heat; in furthering the outflow and removal of the slag from the melting and molten charges by suitable manipulation; in drawing and chilling the finished charges, and in preparing them for use by crushing, assorting, and grinding.

2. As a new article of manufacture, pyroconcentrates of fluxed clay, consisting of particles of dehydrated aluminum silicate holding remnants of a liquefied flux in mechanical combination, substantially as described.

#### A FAMOUS LOCOMOTIVE.

It is remarkable that one of the fastest, if not the fastest, engine now running was built forty-five years ago. She was designed when the great competition between the now vanished broad gauge and the narrow gauge was at its height. The Great Western on the broad gauge had beaten all records by upon several occasions obtaining a maximum speed of seventy-eight miles an hour, and it was necessary to beat her on the narrow gauge. The result was the building by Mr. F. Trevithick, superintendent of the northern division of the London and Northwestern Railway, of the Cornwall. Her driving wheel was made six inches larger than that of the Great Western, which



THE CORNWALL.

Built 45 years ago with the largest driving wheel in the world.

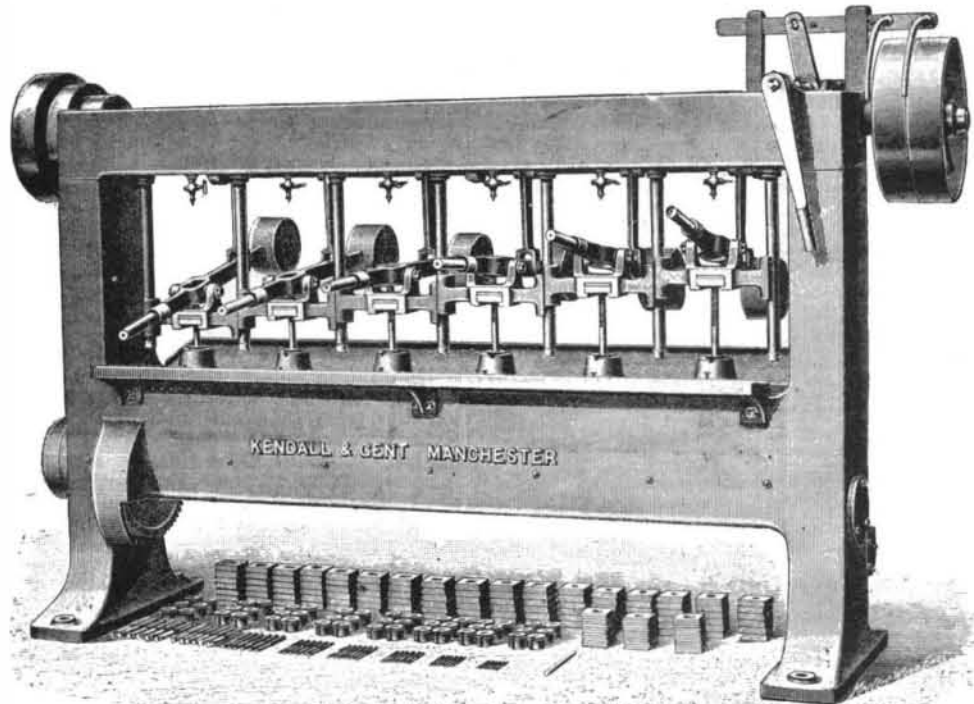
was 8 ft. in diameter. Mr. Trevithick, in order to obtain a large driving wheel and a low center of gravity, adopted the peculiar plan of placing the boiler under the driving axle. The driving wheel of 8 ft. 6 in. was the largest size which had then, or has since, been tried upon the ordinary 4 ft. 8½ in. gauge, the cylinders being 17½ in. diameter and 24 in. stroke. The engine appears to have fully answered the expectation of her designer, for upon the trial trip a speed of fully seventy-nine miles an hour was attained under favorable circumstances, thus beating the Great Western by one

mile an hour. She was shown at the exhibition of 1851, but the position of her boiler was not approved, and in 1863 a new boiler was put in her above the axle. We give a sketch taken from Mr. Stretton's "Locomotive Engine and its Development," and it is interesting to know that the engine is still working the forty-five minute expresses between Manchester and Liverpool, one of the fastest services in the kingdom, and it is stated that still, after her forty-five years' service, with

and the whole forms a light, powerful machine, and is capable of delivering water under high pressure, 360 gallons per minute.

#### IMPROVED NUT TAPPING MACHINE.

We illustrate herewith an improved type of vertical nut tapping machine, possessing several novel features and constructed by Kendall & Gent, of Manchester.



#### IMPROVED NUT TAPPING MACHINE.

a load equal to her power, she is capable of running at the highest possible speed yet attained.—*Daily Graphic*.

#### STEAM FIRE ENGINE FOR BOMBAY.

The fire engine illustrated is one of a series of five recently made by Messrs. Merryweather & Sons for the Bombay municipality. In general design, says the *Engineer*, it is similar to those constructed by them for the Metropolitan Fire Brigade, but of greater capacity. In order to reduce unnecessary weight the usual gun metal distance piece between the pump and cylinder is replaced by three turned steel stays, the two upper ones carrying the crank shaft bearings. The bent crosshead, a specialty of the makers, is used, so that while the whole machinery is short and compact, a long connecting rod is admissible, which insures much freer running than could be obtained by a slotted crosshead or other arrangement usually used to shorten up the engine. A twenty foot length of suction, not shown, is carried on the engine, always attached to the pump, and the delivery outlets are fitted for improved instantaneous couplings.

A light fly wheel of large diameter is provided, in order that the engine may be worked at slow speed if required. The outside of the pump is triangular, and the two side covers are made removable in one piece with their respective valves. The pump is also fitted with a by-pass in case it is required to work from a limited water supply or through long lines of hose. A large hose box, forming seats for firemen, is fitted on the front of the engine, and the whole of the machinery is accessible from the back, so that the stoker can attend to the fire and the engine without moving from his post in the rear.

Our illustration shows the various points alluded to,

In vertical nut tapping machines, as hitherto made, the taps are driven from above, and after passing through the nuts they fall out of their holders into the trough with the lubricant, cuttings, nuts, etc., which very frequently results in damage to the taps and the very unpleasant necessity of the attendant having to "fish" out the taps from among the oil, cuttings, nuts, etc., in the trough, and reinsert them in the holder for each nut. In the machine illustrated above the operation is entirely reversed, so as to obviate all these defects, and also the great loss of time resulting from them. The taps, as will be seen from the engraving, are driven from below, and the nuts are passed on to them, until the shanks of the six taps, with which the machine is fitted, are full, so that the taps only require lifting out about once every six nuts, to allow them to fall off the shank.

This type of construction allows also of perfect lubrication, as the oil from the lower cistern is pumped by the machine into the upper one, and pipes being fixed over the center of each tap, a constant stream of oil is kept flowing down the grooves of the taps, insuring perfect lubrication.

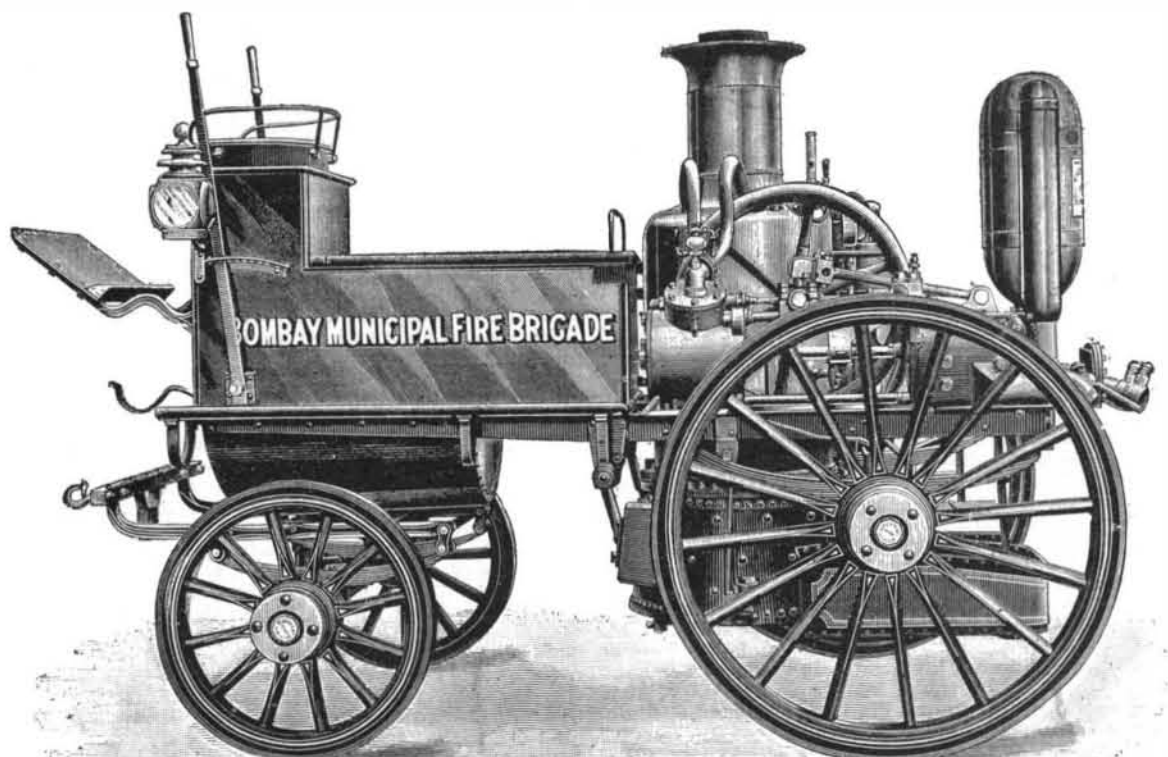
These machines, which are of very substantial construction, form very compact designs, the driving apparatus, stop motions, etc., being entirely self-contained.—*Practical Engineer*.

#### ON THE TRANSMISSION AND DISTRIBUTION OF POWER IN MODERN SHIPS.\*

By NABOR SOLIANI, of the Italian Admiralty.

IN modern ships steam power is used not only as a propelling agent, but also to execute a great variety

\* We are indebted to Messrs. Wigham, Richardson & Co., of Newcastle-on-Tyne, for the translation of this paper.



#### IMPROVED STEAM FIRE ENGINE.

of other operations which in old ships were either not done at all or performed by hand. Thus, on board merchant ships, a portion of the disposable power in the boilers is now employed to control the rudder, to weigh the anchor, to ventilate the ship, and to light it, to load and unload cargo, to pump the water, etc., and on board men-of-war, in addition to this, its employment is still greater, viz., for the working of artillery and torpedoes, the service of ammunition, etc. For each of these services to be executed in different parts of the ship, there is one or more special apparatus to be furnished with the power supplied by the boilers on board in one way or in another. There are several means employed, or that could be employed, to attain this object, and the choice of a proper system of power distribution is of a great importance, both for the efficiency and regularity of the various services on board ships and the economy in the actual function of the same, which tells on the general economy of the ship.

To give an idea of the importance of these services it will be sufficient to notice the following table, in which are indicated the auxiliary machinery to be found on a large modern ironclad, as, for instance, the *Re Umberto*.

*Number and Power of Auxiliary Machinery in a First-Class Man-of-War.*

Machinery.	Number of Machinery on Board.	Power Indicated in Horsepower for each Machine. Full Force Used.	Total Power.
Main hydraulic pumps .....	2	160	320
Secondary pumps .....			80
Steering gear .....			200
Main capstan .....			160
Warping capstans .....			100
Dynamoes .....			100
Compressed air pumps .....	2		60
Fire engines .....	2		60
Circulating pumps .....	4		240
Main feed pumps .....	4		160
Auxiliary pumps .....	6		240
Bilge pumps .....	4		120
Exhaust pumps .....	2		140
Forced draught for boilers .....	12		240
Ventilating engines .....	8		80
Turning gear (for main engine) .....	2		50
Starting gear .....	2		40
Pumps for auxiliary condensers .....	6		30
Ash hoists .....	1		10
Workshop engine .....			
Total .....	69		2,480

Of course these machines do not all work at one and the same time, nor at full power, and it is doubtful if, even during a combat, the collective power in action of the secondary engines would reach the half of the total power before indicated; but being even reduced to so much it is always considerable. Power may be supplied to these apparatus:

1. Either by rigid or flexible mechanical transmissions, that is either by shafting or otherwise, by ropes and by belts, and so forth.
2. By steam; in such case each apparatus must have its own steam engine.
3. By pressure water; and then a central steam engine is required in order to pump the water, and also hydraulic engines at the points where the power has to be utilized.
4. By compressed air; and as in the preceding case, it will be necessary to have a central engine to produce compressed air, and each apparatus must have its own engines acting by compressed air.
5. Lastly, by electricity, with a central engine generating the electric current and electric motors at the operating points.

Now since the power comes from the steam in the boilers, steam is evidently the most direct and simple medium to convey and distribute it to where power is wanted.

We may have to change the form of this power, which in the boilers is in a thermic state, and so we shall the various kinds of apparatus necessary for the transformation we require to produce. Although the development of the power may by this transformation be made longer and more complicated, yet in many cases in the new form it is better adapted to the action it is intended to produce, or affords some other advantages which make it preferable.

In men-of-war, especially, power is already developed and utilized in different degrees, in several different forms, and this is the case because to light by electricity we require electric engines, and to cause torpedoes to move we require pumps to charge them with compressed air, and so on.

I propose, therefore, to examine the merits and defects of these several different forms, and the extent to which each may be applied, so that we may determine which is the best adapted to each individual case.

**Power Transmission and Distribution by Means of Shafts, Gearing, etc.**—This system of power transmission and distribution is not possible on board ships, except on a very limited scale, and in fact it is only used in the workshop for the few machine tools, and in the working of the rudder.

Did we wish to extend it further, even without taking account of the considerable weight of shafts and the great losses by friction, this system would entail a complication of gearing, blocks and belts such as to make it quite impracticable. Far more practicable, on the contrary, are the other systems to which I will now turn my attention.

**Power Transmission and Distribution by Means of Steam.**—The system of transmitting and distributing the power by means of steam is, as we have already stated, the simplest of all, as also the one most generally employed. In the mercantile navy especially, with the exception of a few ships, which use hydraulic apparatus to load and discharge cargo, all the rest use steam for the various machinery and secondary apparatus on board. Even in the Royal Navy steam machinery takes the lead, hydraulic machines being, as it were, confined to heavy artillery only. With steam no other intermediate medium is required between the source of power and the working machinery, and

therefore the action of these machines is completely independent of other apparatus. As long as the boilers are working and the circuit of the steam is in good order, all the working machinery can continue acting, and if any one part should get out of order, the work of the other machine will not be affected. We may also add that steam is a very pliable moving agent, that is to say it can generally be well adapted to any special conditions in which it has to act, especially when used, as is now general, at a high pressure. Against the above advantages must be set, however, some disadvantages; steam used on board ships is saturated, and, therefore, a very little cooling produces condensation. From this comes the necessity of applying drain cocks to the circuit of steam, and to the cylinders of working machinery; further, the flooding by water of a compartment of the ship through which the steam circuit passes might interrupt the action of many machines. For instance, if the flooding should be in the after hold of the ship, all the machinery placed in the after end of the flooded compartment, among which is the steering gear, would inevitably become inactive.

Steam circuit must be complete; that is to say, it must have two pipes—one for sending the steam to the cylinders of the working machinery, the other for discharging the steam from these machines into a surface condenser before passing again as water into the boilers. Herein is a greater difficulty and complication than in systems with one pipe only. Another disadvantage, moreover, is the quantity of lubricating substances which from the various auxiliary steam engines find their way to the condensers and thence to the boilers, considerably impairing both the good action of the latter and their durability. Finally, in a steam system there is this other drawback—that it heats the parts through which it passes or in which it acts.

As far as the actual power from the steam system is concerned, it is made up of two factors, namely, the power resulting from the boilers and the power resulting from the steam circuit, properly so called. And we may say at once that the net result of power is not very high, because for auxiliary engines simplicity and steadiness of action are aimed at rather than special economy of steam. However, some improvements have been made of late years, and in modern vessels with high pressure steam the auxiliary engines that have to be kept repeatedly and long in action are made of the compound type with considerable economy of steam. In the compound type of engines the consumption is reduced by nearly 30 percent. Further progress may be made in this direction. If steam for transmitting power is economical on board ships, where the distance to which power is required to reach is not very great, it is no longer so on land at greater distances, owing to the great condensation in the steam pipes.

On board ships, where the main engine is moved by steam, it finds a very suitable application, preferable to any other, for the auxiliary machinery in the engine and boiler rooms, more especially for the machines in which steadiness and continuity of action is indispensably required; and among these latter are the pumps and all machines that are an integral part of the moving apparatus of the vessel and necessary for its action. For such apparatus steam offers every advantage, and most of the objections noted above are avoided.

**Transmission and Distribution of Power by Water at High Pressure, commonly called the Hydraulic System.**—This is already in actual application on war ships for the working of large guns, and in some also for the steering gear, the winches, the capstans and the windlasses. In merchant ships hydraulic apparatus is not much used. Only comparatively few make use of it for loading and discharging cargo, notwithstanding that it is so well adapted for that service. This is probably owing to the greater first outlay. The chief merits of this system are its simplicity and steadiness, serious accidents rarely occur, its management is easy, and, above all, there is a perfect control over the working of the apparatus, which can be promptly regulated at will and with precision. This precision is of course due to the liquid being incompressible.

In ships, the system in question has also the advantage, not to be found with steam, that no inconvenience arises in case any part or parts of the ship, containing hydraulic apparatus, or crossed by the hydraulic circuit, become flooded. All my readers must perceive the importance of this as regards the steering apparatus. Moreover, with the hydraulic system no radiation of heat, nor hot water leakage causing dampness or unwholesomeness, are possible; and an escape of the moving fluid, which, in the case of steam, might be attended with disastrous consequences, which would cause no mishap.

The hydraulic system requires, equally with the steam system, two sets of pipes, one to lead the water to the apparatus, the other to discharge it and lead it back to the pumps. With this difference, however, that hydraulic pipes are small in diameter, and for that reason they are easily fixed, nor have they the defects noted above which are inseparable from steam pipes.

Hydraulic apparatus is particularly adapted for great power, with slow rectilinear and limited movements, and still more suitable for those operations which it is necessary to regulate with facility, steadiness and precision, such as the working of guns and the fittings for loading them, the steering apparatus and the cargo cranes. For operations that do not require a slow movement, nor segmental or rectilinear movement, hydraulic apparatus is less suitable, the use of water being adapted to slow speeds only. In other cases it is evidently improper to use hydraulic power, because of the great loss that will ensue from the resistance in the pipes and valves and from the packing, and also because of the shocks to the apparatus at every changed direction of movement. Slow speeds require therefore high pressures. If we adopted hydraulic apparatus acting at low pressure and, consequently, with a large volume of water, large pipes would be needed to prevent an excessive loss of load. Both the apparatus and the connection would be heavy, bulky and unsuitable for ships, the working of the apparatus would by no means be easy, because of the difficulty in moderating the movement of large masses of water, and so we should only have the difficul-

ties without having the advantages of steam apparatus acting at an equal pressure. Finally, for the due efficiency of the hydraulic system it is necessary that the pressure in the pipes be kept high and constant, which would be difficult if in the circuit there were several working machines in quick motion. It is perhaps owing to this reason that the hydraulic system has not received on board the royal navies that development which in other respects it would deserve.

As we have already stated, with this system a form of power different from that supplied by the boilers is used, and it is necessary, therefore, to know how to produce it. A pump moved by steam and giving back in mechanical power through water under pressure form the thermic power of the steam is what is universally used. In hydraulic machinery on board ships, with the usual proportion for the diameters of pipes and for the main valves, the result is not under 90 per cent. That of the generatrix pump is not so high.

So far hydraulic pumps on warships have been made with single expansion engines, but on more modern ships compound engines, far more economical, have been introduced. Hydraulic pumps are among the most powerful auxiliary machinery of the ship, and it is, therefore, only reasonable to study economy of steam, more especially if we consider that their action must be developed in action just when it is necessary to have all the power which the boilers are capable of developing.

The actual economical result of hydraulic pumps is made up of two coefficients, namely, the power resulting from the steam engine and that from the pump. The former, supposing the engine is compound, we may take to be 60 per cent. The latter can be set down at 85 per cent., and therefore, the power resulting from the pump is about 51 per cent. I disregard the loss of power in the pipe leading the steam to the hydraulic pumps because it is insignificant, these pumps being, as a rule, placed near to the boilers. The total resulting power of the hydraulic system is, therefore, equal to  $0.90$  by  $0.51 = 46$  per cent. or nearly so. By the present system the action of every machine is dependent upon that of the steam hydraulic pumps; so that, if the latter get out of order and cease working, all the hydraulic working machinery must also come to a standstill. It is owing to this that in warships whenever hydraulic gear is applied there are always two independent hydraulic pumps in action, they are both kept going so that one may fill the place of the other in case of any accident. This requirement applies not only to the hydraulic system, but to all systems in which no direct use of steam is made.

As it has been stated before, the hydraulic system cannot universally be applied for the transmission and distribution of power on board ships, because it is not suitable to move machinery, so generally used on board, in which rapid motion is wanted.

**Transmission and Distribution of Power by Compressed Air.**—This system in many points bears an analogy to the hydraulic, but it differs essentially in respect to the nature of the moving agent. In the hydraulic system the moving agent is an incompressible and inextensible fluid, and, therefore, in the process of transferring the steam power to the water, the mechanical work of the plungers of the pumps (exclusive of the loss by the friction of the water in the pipes, in the passages, etc.) is integrally transmitted to the working machinery in the same form of mechanical power, without any further transformation.

In the compressed air system, on the contrary, the fluid being elastic, the thermic energy of steam acting in the engine of the pump which compresses the air is ceded to the compressed air, partly under the same form and partly under mechanical form. The first part, representing the work of compression of the air from atmospheric pressure to the pressure at which the air acts in the system, if not duly utilized, would cause a serious loss. By the same reason that the fluid is elastic, compressed air is very well adapted equally with the steam to the requirements of all kinds of machinery, viz., from slow to very quick motion; being only inferior to the hydraulic system in so far that it does not permit the regulation and control of these motions with that precision and steadiness which can be attained by the latter system. But as a compensation its merits are such as to bring it to the front for the transmission and distribution of power on board ships.

First of all the compressed air circuit is open, that is to say, it consists of the simple compressed air transmission pipe from the condensing pump to the working machinery, the air is discharged into the atmosphere after having done its work. Furthermore, the air which is thus discharged, being cold and pure, serves to ventilate and keep cool the compartments of the ship in which it is acting; these compartments under the steam system, unless they be provided with plenty of artificial ventilation, it is utterly impossible to live in, on account of the excessive heat. To this it may be added that this air, if discharged at a few pounds pressure into the foul air exhaust, will increase the fresh air circulation in the above compartments (up to 40 times) without having need of any special mechanism.

Those who are aware of the many difficulties which exist in ventilating the compartments in modern vessels will freely admit the importance of these advantages afforded by the compressed air system. This system, like the hydraulic system, presents the advantage of being a safe one in case of any damage happening in the circuit or in the working machinery, for a compressed air escape can neither injure anybody nor paralyze the whole ship, as is often the case with steam. Compressed air is also free from condensation, or at least it may be made so, and consequently there is no leakage or dropping of water to render the compartments of the ship damp, and for this reason there is no need of pipings to gather leakages. Besides, by compressed air the working machinery can continue working even though the compartment be flooded. This advantage, shared only with the hydraulic system, is especially important for the steering apparatus.

Another special advantage of the compressed air system is that by a simple arrangement of valves we can at once use steam instead of air to move the various auxiliary machines, if the compressors should fail in acting, and also in pressing cases of fire on board or of



springing a leak, when these compressors might either fail altogether or there may not be time to put them to rights. To do this it is sufficient that the discharge of air should take place into the foul air discharge pipes which are to be found in the compartments in which compressed air is acting, and in which pipes steam would produce, like compressed air, a strong current of discharged foul air.

In short, the system is simple; it does not require piping of a large diameter and it is easily put into actual practice. It could easily be applied even on board existing vessels on which all the working machinery is by steam, the work being equally well performed by compressed air. Consequently the thing in question is not that of introducing new and complicated machinery, which would require special knowledge, or be difficult and delicate to regulate, but only a different gas, more suitable than steam with the same machinery now existing on board and in the same manner.

The use of compressed air on board vessels is therefore, I believe, of very wide application, and with the exception of loading apparatus for guns, for which much simplicity and precision of movement is necessary, I hold it, in general, to be a very convenient form. I include among the latter also the turning gear for turrets or large gun training engines, in which precision of motion, owing to the great inertia of the parts in motion, cannot be obtained even by the hydraulic system. I am of opinion we ought only to exclude from this the auxiliary machinery of the main engines in which continuity of action is required.

Other less important secondary machinery may also be operated by steam, especially if they are in the engine or boiler space; but in many cases it will perhaps be better to have also these worked by compressed air. Compressed air is besides eminently well adapted to move the engines of dynamo-electric machines which are as a rule placed in closed compartments and require a cold temperature. It would also be convenient to apply compressed air to all machinery on deck where steam is liable to condensation. As in the hydraulic system, in order to insure the continued action of the machinery, it is necessary to have at least two compressing pumps, so that one of them may fill all the requirements of service in case the other one should fail. In action all the above pumps are expected to be at work. In ordinary circumstances one alone might be sufficient, owing to the fact that then only a few of the working machines are kept working at once.

Now we must say something of the economy of this system.

Until a few years ago the economic results of the existing appliances for power transmission and distribution by compressed air were little known, owing to the imperfect way in which this system was carried out. But now, thanks to Prof. Riedler's exertions, this system has been brought to such a degree of perfection as to allow of a very high economy, and which may be favorably compared with other systems. Applications, on an extensive scale, for the transmission and distribution of power by compressed air were first made in Italy by the Italian engineer, Sommeiller, for the perforation works of Mont Cenis. Then the same was again applied in Italy for piercing the St. Gothard tunnel, and in Paris and Manchester for distributing power to private houses according to Popp's system. In all these applications, in which the object is to send and to distribute power to a distance of some miles, the causes of their insufficiency lie:

1. In the imperfection of the compressors.
2. In the passive resistance in the piping which distributes the compressed air.
3. In the imperfection of the engines compressing the air.

The inefficiency of compressors was chiefly caused by the air compression being effected adiabatically, *i. e.*, without cooling the air, so that it gave out a heat which was then entirely lost in the pipe, at the end of which, where the air was to be utilized, the air was just as cold as when first entering the compressor. Thus all the difference of work between the necessary work to compress the air at a constant temperature and that necessary to compress it at a constant pressure was lost. In consequence of this, with an air pressure of six atmospheres used in those applications, the loss was about 30 per cent. Other reasons for this loss could be found in the imperfect type for the pumps; and in the first compressors Colladon used for the St. Gothard tunnel the lost power was such as to exceed the available power.

The power resulting from the compressors was first raised by cooling the pipes by cold water jackets; but a still greater success has been obtained by Professor Riedler by dividing the compression into two or more grades, and by cooling completely the air in refrigerators between the successive grades. In this manner he has succeeded in making the curve of compression nearly isothermal. Other improvements have been introduced in the pumps, and more especially in the inlet and discharge valves of compressed air, so that he has succeeded in reducing to say 24 per cent. the loss between the power indicated in the steam cylinders of the pump and the power available to be used as compressed air, cooled to the atmospheric temperature, at the beginning of the piping. Nearly 13 per cent. of this loss is due to the resistance of the machinery and 11 per cent. to the heating of the air. The power resulting from the most improved compressor is, therefore, for land appliances, 70 per cent. This result is for compressed air at six atmospheres pressure, which is more than sufficient for the wants on board. At a higher pressure the resulting power would be less favorable. But in appliances on board ships the distance to which the moving power is to be transmitted from the central station is very limited, the air has no time to get cold in the pipes, and, moreover, it is possible to prevent it from getting cold when it reaches the engines in which it must act. By doing so we utilize in the engines all the heat of compression left in the air, and the waste of available effect in the condenser is reduced to the waste of passive resistance, which is nearly 13 per cent., and to the slight loss due to leaks and so forth. To take the latter into consideration I will suppose that in compressors used on board the coefficient of power resulting from compressing pump be only 83 per cent. This would also be the power resulting from the entire compressor if it were actuated by an improved steam engine; but since, for want of space

and the necessity for simplicity in marine apparatus, it is not possible to have the most economical type of engine, we will admit, as it has been done for other systems of transmission, that the engine of the compressor, compared with a perfect engine, will give only 60 per cent. of resulting power. In the present case also we leave out the waste in the steam pipes. Thus the resulting power of the entire compressor becomes  $0.83 \times 0.60 = 49$  per cent.

The loss of available effect in the pipes of compressed air distribution due to air escapes and to resistance, using for the latter the same diameters as for steam pipes, is small and does not exceed 3 per cent., even in those portions of the pipes which are most distant from the compressor. In effect, in land appliances the loss of air pressure in the pipes, for a length of 400 ft., and at an air speed of 50 ft. per second, which is about equal to what is possible in the pipes of a ship, is not above 1 per cent., even taking into account the resistance of the waste for (discharge) trunks. Admitting that in the pipes on deck the total waste is 5 per cent., allowance is duly made for the loss due to the elbows, to radiation, etc. I will, therefore, suppose that the net economy of the piping of compressed air distribution is in the cases of ships, 0.95.

Now it remains to consider what is the economy of power of engines using compressed air. In order that a compressed air engine may give a good result of power, apart from other circumstances, it is necessary that the diagram of air expansion in its cylinders be, as much as possible, the inverted reproduction of the diagram of compression undergone by the air in the compressor cylinders. By this condition it is prescribed that the air in the engines should act expansively and with an approximate ratio of expansion little below that of the compression. But this is not enough. In appliances on land, even independently of load losses in the piping, it is not possible, without special contrivances, to reproduce in the engine the diagram of pressures obtained in the compressor. In fact the air comes into the engine as cold as if it had been compressed at perfectly constant temperature. Now, to compress the air at a constant temperature, it must be freed from heat, and then to expand it in the engine at constant temperature this heat must be restored to it, or else the air expanding adiabatically, *i. e.*, without transference of temperature, will get colder and its pressure will be less than it would be if the expansion were at constant temperature. Consequently the air in the engine will do less work than in the compressor. Besides the loss of available effect, there is also the inconvenience of the intense cold produced in the cylinders of the engine, by which the moisture of the air gets frozen and causes the passage to get obstructed by ice.

In order to prevent this serious disadvantage, in earlier compressed air engines the air was used at full pressure, without expansion, and the power resulting was indeed very low, about 40 per cent. But in modern engines expansion is used, and to increase the effect of it the air is heated before being admitted to the engine, and thus the evils due to freezing or to the condensing of dampness existing in the air are avoided. By the heating of the air combined with the injection of water, it is moreover possible to so increase the resulting power as to bring the work in the engine higher than the work in the compressor. In the Popp appliance in Paris, improved by Professor Riedler, the air is heated with small stoves, extremely simple, in which the heat is turned to such a great use that one one-fourth pound of coal per horse per hour is enough to double the result of power.

This is owing to the fact that the heat supplied to the air is nearly five times more efficaciously used than if it were employed in producing steam.

Water existing in or injected into the air while passing through the stove causes the air to be saturated with steam, which, getting condensed during expansion, transfers latent heat to the air. But the expediency of using injected water is more than anything else of a practical nature as forming a very efficient lubricant for the pistons. By applying air heating at 150° Centigrade temperature (302° Fahrenheit) to an old Farcot engine of 80 horse power, used as a compressed air engine and which was worked at first by steam, an efficiency of 90 per cent. was obtained; that is to say, in the Farcot engine compressed air gave out 90 per cent. of the theoretical power.

Better results might be obtained by modern compressed air engines of the compound system, in which the heating of the air is effected in two stages; but the above example may be sufficient to show that even with imperfect steam engines, with single cylinders, used as compressed air engines, a good result of power can be got.

It may be argued against the foregoing that although on land the economy is increased by artificially heating the air before being admitted into the engine, this cannot be done on board vessels except in a way which would deprive the system of all its merits. On board ships, however, it is possible to produce hot air in the compressors, and to transmit it equally hot into the engines; thus the loss of heat in the compressors used on land and the necessary heating of the same before using it in the engines are prevented. By regulating the compression so that the compressed air temperature is say 150° Centigrade (302° Fahrenheit), it is possible, as it has previously been observed, to get from marine engines a net result of compressed air power of 90 per cent. With this temperature in the admission, the air may be discharged from the engines cold, a few degrees above the freezing point, provided it acts with sufficient expansion. In many auxiliary marine engines this is impossible, but this is no inconvenience, because, as I have already stated for auxiliary engines, in the compartments of a ship the air must be discharged from the engines into the foul air discharge pumps, so that these engines might be worked by steam when compressed air fails. Therefore the net result from the compressed air system of transmission and distribution will be  $0.498 \times 0.95 \times 0.90 = 0.424$ , say 42 per cent., which (result) is not much below the result of power from the hydraulic system.

**Transmission of Power by Electricity.**—This is a very valuable system, on account of its adaptability for transmitting power to a great distance, for which other means would be unfitted, and also on account of the simplicity and facility with which power can be distributed to the various machines, whatever be their

number, and wherever they may be placed or disposed. Besides, so important are the discoveries continually being made in electricity, and so rapid is the progress in its application, that we may think that, in the not distant future, electricity will be the main agent in the service of human activity. But it is not now my task to bring forward this train of thoughts, nor even to deal with the transmission and distribution of power in all its aspects, but only to treat of it in respect to the limited and special case of ships, and in the actual and present state of our knowledge. Even in the present state of development of electric appliances it is possible to execute by electricity the greater part of the functions on board ship which are now performed by steam, by compressed water, etc. In truth, by compound dynamo machines well regulated to supply variable electric currents with a constant potential, and employing also a compound motor placed derivatively on the main circuit, the working machinery can even now be moved at a constant velocity, whatever be the resistance to be overcome, and at the will of the manipulator, without the action of these motors influencing that of the others or changing the movement of the generator. And this essential condition becomes so much easier of attainment on board ships, where, the circuits being short, they can be arranged with very little resistance. With proper contrivances the velocity of the working machinery can be also varied, although not so very extensively as by other systems of transmission. In altering the normal velocity of the motors there is a loss of available effect, but this loss is not of great importance, since the motors, which are to be kept continually moving for a length of time, act generally at their normal velocity, which it is rarely necessary to alter, so much the more in the present case in which the motors preserve automatically this velocity, even if the resistance to be overcome should change. The fixing of the power transmission circuits offers but little difficulty with electric wires, which can be easily bent as desired. They are easily passed through anywhere, and easily joined again in case they should break. By electric motors there are no radiations of heat, nor the hot water leakage to make the compartments either too hot or too damp, and the very simple working of a commutator is sufficient to set up, to accelerate, to slacken, or stop the movement of the motor at will.

Electricity, therefore, in its present conditions of development, fulfills the principal requirements necessary for a system of power transmission and distribution; it may, moreover, be said that it exhibits certain advantages which other forms of power cannot afford, and for which in many cases it is preferable. But, on the other side, it has features of its own which limit the application on board ships. A special condition in dynamo-electric machinery and electric motors requires that the peripheral velocity of the armature should be high; consequently, in the case of machines and motors whose dimensions are to be comparatively small, their revolutions must be very great, and all machinery on board ships is made as small as possible for the saving of space and weight. This does not create any difficulty for dynamos, but for motors it makes it absolutely necessary to interpose gearing, or other means for reducing the speed between them and the working machinery, if the latter works at a lower speed. It follows that electro-motors are more particularly adapted for the apparatus requiring rapid motion and are, perhaps, unsuitable for those with slow movement, when the intervening gearing required for transforming the movement becomes out of place or embarrassing; because gearing, besides complicating the apparatus, causes also, as a rule, a loss of power and sometimes a considerable loss to power. Electric apparatus is besides distinguished by delicacy of construction and the subtle nature of the electricity itself. How greatly improved soever electric apparatus may now be, yet it cannot be contradicted that there is still uncertainty as to the steadiness of action. Variations may arise from the slightest causes, not always easy to detect at once nor easy to remove.

As an instance, a contact between the two branches of the main circuit may paralyze all the machinery, and besides produce irreparable damages in the generators. It is not easy, as a rule, to find out either the cause or the cure of even slight mishaps. This observation will be readily admitted by those who have had some experience in the electric lighting service on board vessels, where not unfrequently considerable time is needed to find out the cause of inaction of circuits or of the dynamo generator. If a steam pipe breaks, if an ordinary machine gets out of order, it is not difficult to spot the place, even for those who have but a slight experience, and to see at once the best way to repair it; but when any disarrangement happens in the interior of an electric apparatus or in any point of circuits' system, it needs the experienced mind of a skilled electrician to inquire into the causes, and all his ability to set things in order again. These defects impair, at least for the present, the advisableness of applying electricity to move apparatus in which steadiness and continuity of action is necessary, or that cannot be readily functioned by other means when electricity fails. This applies especially to the auxiliary machines which are integral parts of the main engines of the ships, and also to the steering gear.

In France electric motors have very successfully been applied for elevating and working guns, but only small guns which could have been moved by hand, and it is still doubtful whether electricity is suitable for larger guns. On the French ironclad *Jaureguiberry*, now in course of construction, in the yards of the *Société des Forges et Chantiers de la Méditerranée*, the turrets for guns 15, 27, and 30 centimeters each, which can also be worked by hand, will be supplied with electric motors. It is said, however, that electricity will be used on board this war ship for other services as well. But electro-motors are very well adapted for ventilating engines which revolve rapidly, and no serious harm will ensue if they cease to act.

As in the case of the transmission of power by water or by compressed air, so in that by electricity, it is necessary, in order to secure as much as possible the continuance of action of the working machinery, to have at least two dynamo generators, and both kept moving together when the ship is in action.

With regard to freedom from mischief done by an inflow of water, electricity is worse than either compressed air or water, for the reason that all electric

motors in the flooded compartments would necessarily cease from acting. By the same reason electro-motors are not very suitable for deck apparatus which are exposed to rain or to heavy seas. Finally, electro-motors are not very well adapted for machinery designed to execute the working, for instance, of the rudder, of the anchors, etc., in which the resistance to be overcome might suddenly change and be beyond the power of the motor, since in such cases the current might increase too much and cause mischief. I am inclined, therefore, to think that, upon the whole, the area of electric application on board vessels is not so extensive as it might at first sight appear, and that great improvements must be made before electricity supercedes those other means which are now used for the transmission and distribution of power. I do not mean to say that these improvements will never be attained. On the contrary, in all probability, if not certainly, this will be done, and perhaps the day will come when even the main marine engines will become electro-motors. I mean when we shall be able to store up on board ships electric power in the same way we do now store up coals, or rather, when we shall succeed in transforming directly into electricity the power contained in coal.

All authors agree that for short distances the result of power of this system is very high. If we suppose the actual efficiency of the dynamo engine is 0.60, the entire efficiency of the electric system of power transmission and distribution is  $0.60 \times 0.75 = 0.45$ , say 45 per cent., which little differs from the result given by the other indirect systems, viz., by compressed air or by hydraulic apparatus.

**Comparison of Weight, Cost, Volume, and Working Expenses of Auxiliary Machinery by the Various Systems of Transmission and Distribution on Board Vessels.**—Before summing up the examination of the different systems for the transmission and distribution of power, before forming a final judgment as to their relative efficiency for the service of auxiliary machinery on board ships, we must make a comparison between these systems from the point of view of the weight, cost, and volume of the apparatus and of the working cost of the same, in case one of them were applied in general to the exclusion of others. To look closely into this subject I will direct the attention in particular to the instance of a first-class man-of-war, of which I have already indicated the number and power of its various machines, and taking the maximum collective power of the auxiliary machinery when in motion and when in action to be 1,200 horses. I will further suppose that the circuits of transmission and distribution have the same development in every case, and that their weight is in proportion to the unit of weight per foot of the principal branches by which they are composed; and, finally, to establish approximate figures of comparison, I will suppose in each case the weight of the entire circuit, branch lines included, to be equal to that of its main branches over a length of 650 ft., and with the size carried to the end equal to the size at the origin or beginning of the circuit.

**Direct Steam System.**—In this system we have only to consider the steam circuit and the steam engines of the different working machinery. To lead the necessary steam for a power of 1,200 horses, from 75 lb. to 90 lb. pressure, such as is generally used on board modern ships, steam pipes are required of about 7 in. in diameter, with an average weight of about 20 lb. per foot, and thus the total weight of the steam circuit will be  $2 \times 650 \times 20$  lb. = 26,000 lb. or 11½ tons. The weight of auxiliary engines in modern ships varies from 44 lb. to 110 lb. per indicated horse power, according to the type, to their revolutions, and to the manner in which they are applied to the apparatus they have set in motion. Taking the intermediate figure of 88 lb., in the instance of the ship we have undertaken to examine of nearly 2,400 horse power in its auxiliary apparatus, its engines will be 96 tons total weight. Calculating the pipes at £200 per ton, and the engines at £120 per ton, including the fitting, the cost for steam system will amount to £2,300 for the former and to £11,500 for the latter. With regard to the space taken by the pipes and engines, I will fix the estimate on the basis of average density (weight divided per cubic foot volume). It may be admitted that in marine apparatus the average density of tubes is 0.8 and that of engines is 1.2.

This being so, we have for steam system :

Steam.	Circuits.	Machinery to Transform Power.	Motors of the Apparatus.	Total.
Weight.....	12 tons.	.....	96 tons.	108 tons.
Cost.....	2,300.	.....	11,500.	13,800.
Volume in cubic meters of 35 cubic feet each.....	15	.....	80	95

**Hydraulic System.**—In this case there ought to be, for the main branches of the circuit, pipes of about 4¼ in. internal diameter, the weight being on an average between the admission and discharge pipes about 20 lb. per foot, and, consequently, according to the hypothesis previously made, the weight of hydraulic circuits will be 11½ tons. But hydraulic engines are much heavier than steam, their weight varying from 220 lb. to 660 lb. per horse power, according as their action is rather slow or very slow. Adopting the lesser figure, which is, perhaps, the nearer approximation, we have, for hydraulic motors, a weight of 240 tons. It is necessary to add to this weight that of the hydraulic pumps which supply the water. I will suppose there are on board five pumps, four being sufficient for the service, and the fifth one should be kept as a subsidiary pump in case any of the former should fail. Each one of these pumps must have an indicated power of say 400 horses, and weigh nearly 30 tons. Therefore, the weight of the five pumps would be 150 tons. To this we must finally add the weight of the water and the weight of suction tanks. The total weight of both together would be about 40 tons. The density or weight of hydraulic circuits and machinery, without water, is greater than that of circuits and machinery by steam, and we may admit on an average the following figures: Density of circuits = 2.5, density of machin-

ery = 2, density of the tanks with the water = 1. This being so, we have :

Hydraulic.	Water and Tanks.	Circuits.	Machinery Transforming the Power.	Motors of Apparatus.	Total.
Weight.....	40 tons.	12 tons.	150 tons.	240 tons.	442 tons.
Cost.....	400.	2,400.	18,000.	28,000.	49,800.
Volume in cubic meters of 35 cubic feet each.....	40	4.8	125	120	289.8

**Compressed Air System.**—In this system the circuit is open, that is to say, it is formed by the single branch which leads compressed air to the working machinery, and, consequently, neither discharge pipes nor return pipes are needed, as in other systems. For admitting the air the same pipes can be used as those required for steam, because the air can be used at the same pressure as that of steam. The weight of the pipes would be about 29 lb. per foot, and, since its development is the half of that in the preceding cases, the weight of compressed circuit will be  $29 \times 650 = 18,850$  lb., or say 8 tons.

The engines remain the same as in the system by steam, and of which we know already the weight. To the weight just now indicated it is necessary to add the weight of the air compressors. Equally in this case I will take five compressors of 400 horse power each. Their weight is nearly 220 lb. kilogrammes per horse, or rather, their total weight is 200 tons. We shall, therefore, have for the compressed air system, adopting also the same coefficients :

Compressed Air.	Circuits.	Machinery Transforming Power.	Apparatus Engines.	Total.
Weight.....	8 tons.	200 tons.	96 tons.	204 tons.
Cost.....	16,000.	24,000.	11,520.	51,520.
Volume in cubic meters of 35 cubic feet each.....	10	166	80	256

**Electric System.**—In the actual applications on board ships a very low potential of only 65 volts is used, which, for electric lighting service on ships, seems suitable, but I think this would no longer be adequate in the present case of a general system of transmission and distribution, on account of the enormous current which it would be necessary to transmit into the circuit. In effect, admitting an efficiency of 90 per cent. resulting from the dynamo-electric generators and the electric motors, the electric power at the origin of the circuit should be of  $\frac{1,200}{0.9} = 1,300$  electric horses, to form

which, with a potential of 65 volts, would require a current of 15,000 amperes. And since the circuits would be covered and could not admit a current above 2 amperes per square millimeter of section, it follows that the two branches of the circuit at their origin must be composed each one of a bundle of 75 copper wires of a square centimeter section each (38 in. each). The weight of the entire circuit would be nearly double that for steam or hydraulic circuits. But there is also this to be said, it would not answer, owing to the difficulties coming in the way, to apply on board ships dynamo-electric engines acting with more than 1,000 amperes, and, for the same reason, wishing to get all the necessary power with an engine of 1,000 amperes, it would require a battery of 15 dynamo-electric machines. With so many machines at work, the probability of their getting easily out of order would be great indeed; and, besides, that regularity of action which is so much needed could hardly be expected from them.

It is, therefore, necessary to have the dynamo generators reduced to a much smaller number, which could be done by duly raising their potential. Thus, by bringing the potential to 200 volts, the necessary dynamos would be reduced to five, a figure which may be admitted. It would also be necessary to have a spare dynamo in case any of those in actual service might get out of order.

For the electric lighting service requiring a lower potential, it would, perhaps, be convenient to leave on board the special engines and special circuits which exist at present. I do not, however, consider this now, but simply suppose that the electric lighting service is performed by the large dynamos for power transmission. Adopting this solution, the weight of the circuit would be reduced to a third of the preceding, and be, therefore, nearly two-thirds of the weight required for the steam or hydraulic system. The six dynamos ought to be worked by steam engines, each of 320 indicated horse power. Calculating the entire weight of the dynamos and engines at the rate of 2 cwt. per horse, a rather low figure, the total weight will be 192 tons.

The weight of electric motors varies from 1 cwt. to 2 cwt. per horse power, according to their type, the speed of their acting, etc. Supposing it may be possible to adopt the lightest motors, the weight of the motors which are necessary to move all the auxiliary machines on board requiring the complete power of 2,400 horses will be of 120 tons. Applying the coefficients previously established in the case of steam system with regard to the cost of these apparatus and the volume of same, which are pretty well adapted to the present case also, we have :

Electricity.	Circuits.	Machines Transforming Power.	Motors of Apparatus.	Total.
Weight.....	9.6 tons.	192 tons.	120 tons.	321.6 tons.
Cost.....	1,920.	23,040.	14,400.	39,360.
Volume in cubic meters of 35 cubic feet each.....	12	160	100	272

Comparing the results of the above tables, we observe that whether for the weight, the cost, or the space taken, direct transmission by steam stands first.

The electric system and the compressed air system come next; while the hydraulic system, which requires greater weight and cost, comes last. Even in so far as actual working costs are concerned, the direct system by steam must necessarily be the first. After that, admitting that the sinking fund expenditure is in proportion to the cost, and the result of the three indirect systems being nearly the same, the most suitable system would be the electric one; but it is also well to notice that the cost of the latter is nearly the same as that of the compressed air system, and because electric apparatus is much more delicate than compressed air, it may well be that, owing to the heavier outlay for the management of the former, the compressed air system is the more advantageous.

**Conclusion.**—From the above statements I think we may draw the following conclusions :

1. The direct steam system is, because of its efficiency, regularity, and steadiness of action, economy in weight, space, and cost, the most suitable.

Consequently, in the majority of cases it is the more preferable of systems, and it is, in fact, preferred. But, admitting that for special reasons it may be found expedient, for the moving of auxiliary machinery, to make use of one of the indirect systems of transmission, steam being the first source of power, and the efficiency of the same being truly reliable, steam power may still be the proper one to use for all machinery forming an integral part of the apparatus of the ship and necessary for its action. This machinery consists of the circulating, the feed, and the air pumps, the starting gear, and, generally speaking, all machinery in the engine and boiler rooms.

2. The water pressure system is not suitable for general use, but it is very well adapted for the working of large guns. If it should be used for the latter, it may also be successfully applied to the steering apparatus.

3. The compressed air system may be very advantageously applied to all the auxiliary machinery of the ship, excepting only those machines, which are an integral part of the main engines, owing to the reasons hereinbefore stated, and excepting the working of large guns, for which the hydraulic system is preferable. But for ammunition lifts and turning gears of turrets and platforms compressed air could successfully be used.

4. The electric system is not the proper one to use generally for the transmission and distribution of power, but it might answer for the working of middle size and smaller guns, and for moving machinery which revolves rapidly, such as for instance the ventilators.

But in case compressed air should be used on board ships as a general means of power transmission and distribution, it would be better to use it, even for the ventilators (especially if they are exposed to coal dust), rather than to use electricity.

Applying the above reflections to the case already mentioned of a first-class man-of-war, the proportions given in the annexed table would be suitable for the different systems of auxiliary machinery.

According to this distribution, the total collective power of machinery worked by compressed air would amount to nearly 1,500 horses, but, taking into account only the machines which in action must work at the same time, it would be sufficient to have a disposable compressed air power of 800 horses, which would be given by four main compressed air pumps of 250 horses each. In addition to this there should be an auxiliary

*Apportionment of the Various Systems on Board a First-Class Man-of-War.*

	Main Engines.	Auxiliary Engines.	Hydraulic Motors.	Air Motors.	Electric Machinery.
Main engines.....	19,500	19,500			
Circulating pumps.....	240	240			
Main feed pumps.....	160	160			
Auxiliary pumps.....	240	240			
Auxiliary condensing pumps.....	40	40			
Bilge pumps.....	120	120			
Turning gear for main engines.....	50	50			
Starting gear.....	50	50			
Fire engines.....	60				60
Exhaust pumps.....	140				140
Compressed air pumps for torpedo service.....	60				60
Hydraulic pumps.....	160				160
Steering gear.....	200				200
Capstan.....	160				160
Warping capstans.....	100				100
Dynamo engines.....	130				130
Forced draught engines.....	240				240
Ventilating engines.....					
Ash hoists.....	30				30
Workshop engine.....	10				10
Gun training engines.....	160				160
Ammunition lifts.....	100				100
Compressed air pumps for power.....	1,250	1,250			
Hydraulic gear for large guns.....			120		
Electric light.....					100
Electric power for working rapid-firing guns.....					20
Total.....	—	21,650	120	1,550	120

compressed air pump, also of 250 horses, in case one of the main pumps should get out of order. Thus the weight of machinery on board, owing to the addition of compressed air pumps, would be augmented by say 125 tons.

#### H. M. CRUISERS PIQUE, RAINBOW, AND RETRIBUTION.

MESSRS. PALMER'S Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne, have delivered to the Admiralty the three cruisers which they were intrusted to build under the Naval Defense Act. The vessels are second-class cruisers of the following leading dimensions and particulars :

Length between perpendiculars.....	300 ft.
Breadth, extreme.....	43 ft. 8 in.
Depth moulded.....	22 " 9 "
Displacement on a mean draught of 17 ft. 6 in.....	3,600 tons.
Indicated horse power.....	9,000 tons.
Speed.....	19½ knots.