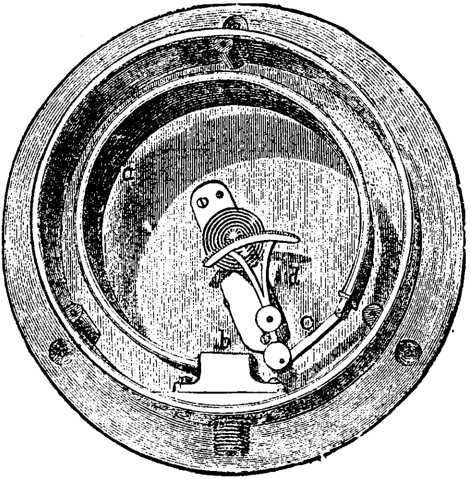
CHAPTER XI.

ON VARIOUS FORMS, APPLICATIONS, AND APPLIANCES OF THE STEAM ENGINE.

In the English edition of this work, the first part of this chapter is devoted to examples of Portable and fixed Agricultural engines, of different makers and styles of workmanship, but not in sufficient detail, nor illustrated on large enough scale to be of practical value as models, forming rather in fact an illustrated catalogue of the manufacturer, than a study for the mechanic. On this account, they have been entirely omitted, and their place supplied by a few illustrations from American workmanship, not only of Steam Engines, of various forms and applications, but also of various machines, or appliances, connected with the working of engines, as for the determination, or regulation of pressure, of the boilers; for the supply or feed of the boilers, the regulation of the speed of the engine, and the like.

The Gauges used in this country to show the pressures of steam in boilers are of various constructions, but perhaps the most common is the Bourdon, or, as it is known here, the Ashcroft gauge, from the party introducing it, and holding the patent. *Fig* 59 represents its interior construction. It consists of a thin metallic tube, *a*, bent into nearly a complete circle, closed at one end, the steam being introduced at the other, at *b*. The effect of the pressure of the steam on the interior of the tube is to expand the circle, more or less according

Fig. 59.



to the pressure, the elasticity of the metal returning the circle to its original position, when the pressure is removed. The free or closed end of the tube is connected by a link *c* with a lever *d*, at the opposite end of which is segmental gear, in gear with a pinion, on which is a hand, which marks the pressure on a dial. The dial and hand are not shown on the cut, but are on the exterior case removed to show the construction.

Fig. 60 is an elevation of a boiler with Clark's Patent Steam and Fire Regulator attached, for the control of the draft of the chimney by the pressure of steam in the boiler. It consists of a chamber, *a*, with a flexible diaphragm or cover on top, in communication with the boiler. On this diaphragm rests a plunger or piston, which is held down like a safety valve, by a lever and weight, *b*. The end of the lever is connected with a

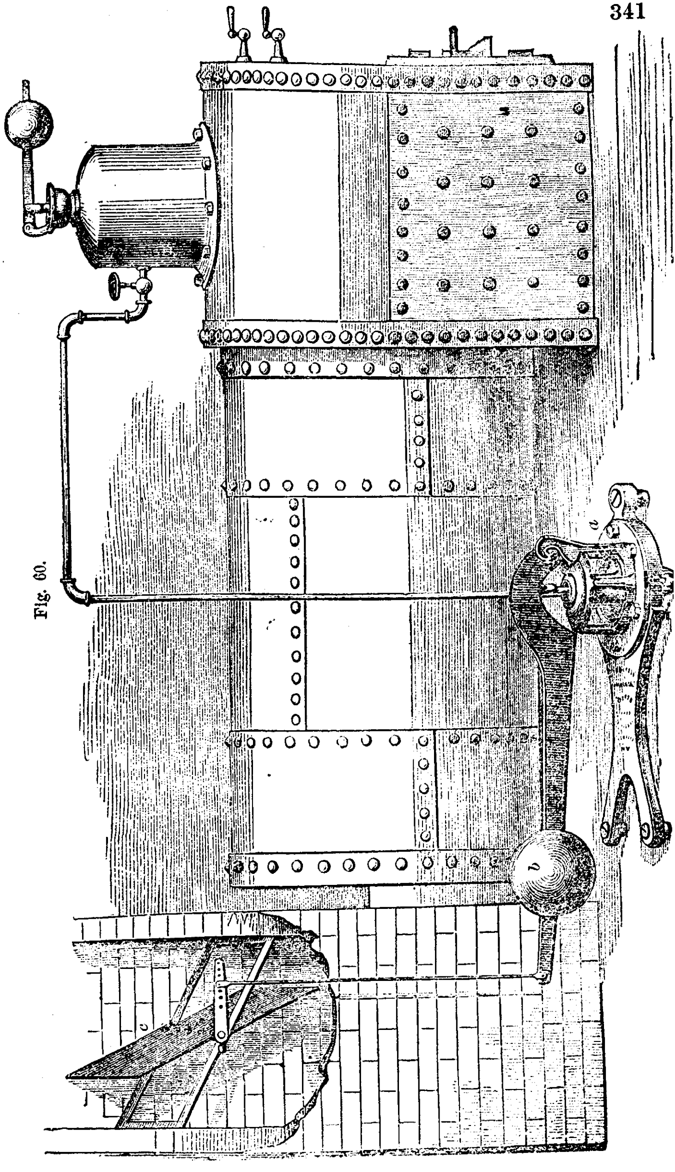


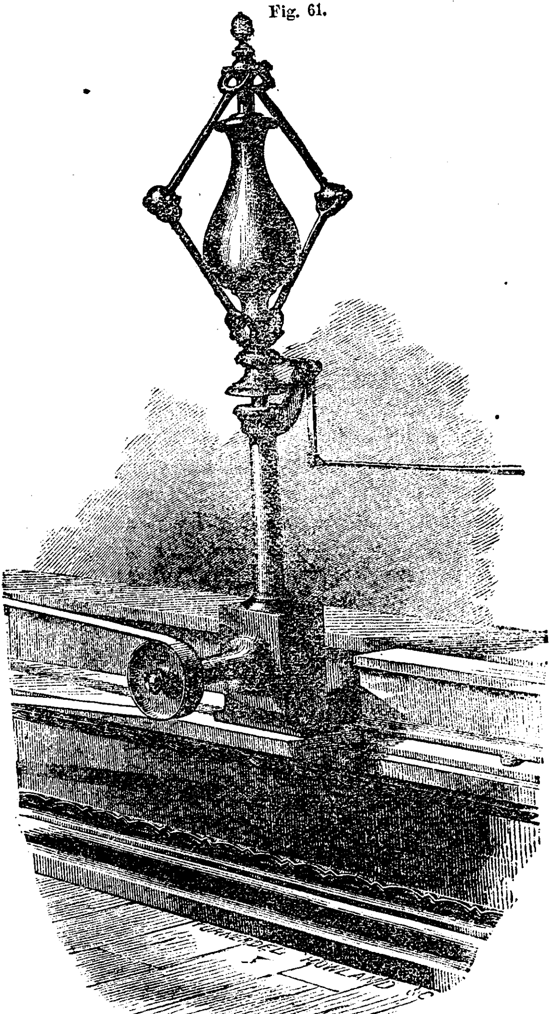
Fig. 60.

balanced damper, *c*, in the chimney. The weight, *b*, is placed at any required position on the lever, and when the pressure of steam in the boiler, exerted on the diaphragm, becomes sufficient to raise the weight, the lever rises, and the damper begins to close, and to check the draft in the chimney. When properly adjusted, the machine works on a variation of from one to two pounds between the extremes of motion. When the dampers are very large, say 3 feet or over, they should be set on rollers, like common grindstone rollers; the regulator should be attached directly to the damper, the length of the pipe connecting the regulator with the boiler being of no account.

Porter's Patent Governor, *fig.* 61, is a modification of the ordinary centrifugal governor. Very small balls are employed, from $2\frac{1}{4}$ to $2\frac{5}{8}$ inches in diameter. These swing from a single joint at the axis of the spindle, which is the most sensitive arrangement, and make from 300 to 350 revolutions per minute, at which speed their centrifugal force lifts the counterpoise. The lower arms are jointed to the upper ones at the centres of the balls, and connect with the slide by joints about two inches apart. The counterpoise may be attached to the slide in any manner; for the sake of elegance, it is put in the form of a vase rising between the arms, its stem forming the slide. The vase is hollow and filled with lead, and weighs from 60 lbs. to 175 lbs. It moves freely on the spindle, through nearly twice the vertical distances traversed by the balls, and is capable of rising from $2\frac{1}{2}$ to 3 inches, before its rim will touch the arms. It is represented in the figure as lifted through about one half of its range of action.

The standard is bored out of the solid, forming a long and perfect bearing for the spindle; the arms and balls are of gun metal, the joint pins of steel; every part of the governor is finished bright, except the bracket carrying the lever, and the square base of the standard, which are painted. The pulley is from 3 to 10 inches in diameter, and makes in the larger sizes about 125 revolutions, and in the smaller 230 revolutions per minute; the higher speed of the governor being got up by gearing.

Fig. 61.



Mr. Porter warrants the following action in this governor, operating any regulating valve or cut-off which is in reasonably good order. The engine should be run with the stop-valve wide open, and, except the usual oiling, will require no attention from the engineer, under any circumstances, after it is started, until it is to be stopped. No increase in the pressure of steam will affect its motion perceptibly. The extreme possible variation in the speed, between that at which the regulating valve will be held wide open, and that at which it will be closed, is from 3 to 5 per cent., being least in the largest governors. This is less than $\frac{1}{6}$ of the variation required by the average of ordinary governors, and is with difficulty detected by the senses. The entire load which the engine is capable of driving may be thrown on or off at once, and one watching the revolutions cannot tell when it is done. The governor will be sensibly affected by a variation in the motion of the engine of 1 revolution in 800. Notwithstanding this extreme sensitiveness, or rather by reason of it, it will not oscillate, but when the load is uniform will stand quite, or nearly, motionless.

For the supply of the water to the boiler, in many positions, it is very convenient to have a pump unconnected with the engine. On this account it is very usual in this country to have what are called donkey pumps or engines independent of the main engines, which can be used to feed the boilers, or for supplying water for many other purposes.

Fig. 62 is a longitudinal section of the Worthington Steam Pump, the first of its kind, and for many years in successful operation.

The general arrangement is that of a Steam Cylinder, the piston rod of which, carried through into the water cylinder and attached directly to the water plunger, works back and forth without rotary motion, and of course without using either crank or fly wheel.

In the figures, *a* is the Steam Cylinder—*b*, the Steam Chest—*d*, a handle for regulating the steam valve—*f*, the starting bar—*g*, *g*, tappets attached to the valve rod, which is moved by the contact of the arm *e*, on the piston rod with said tappets

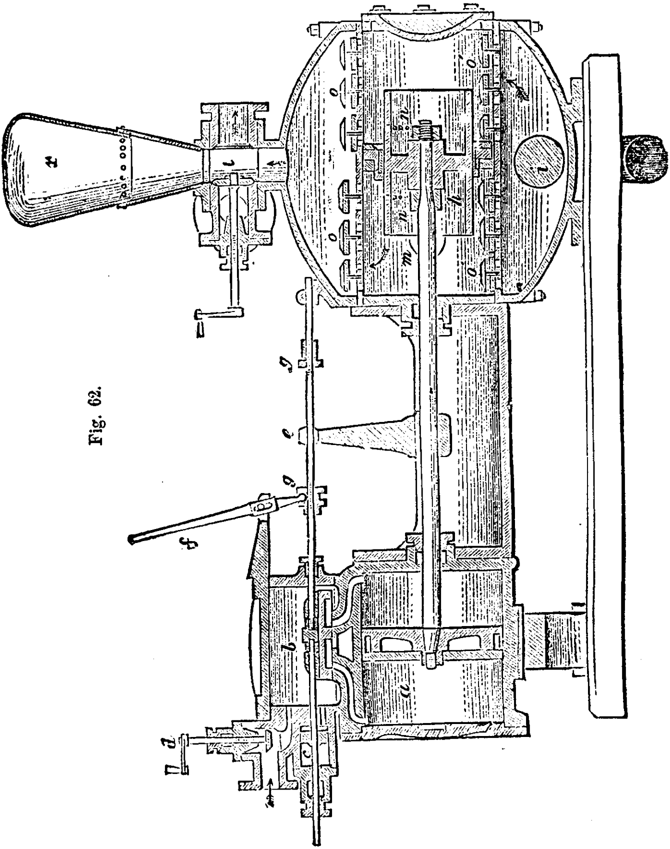
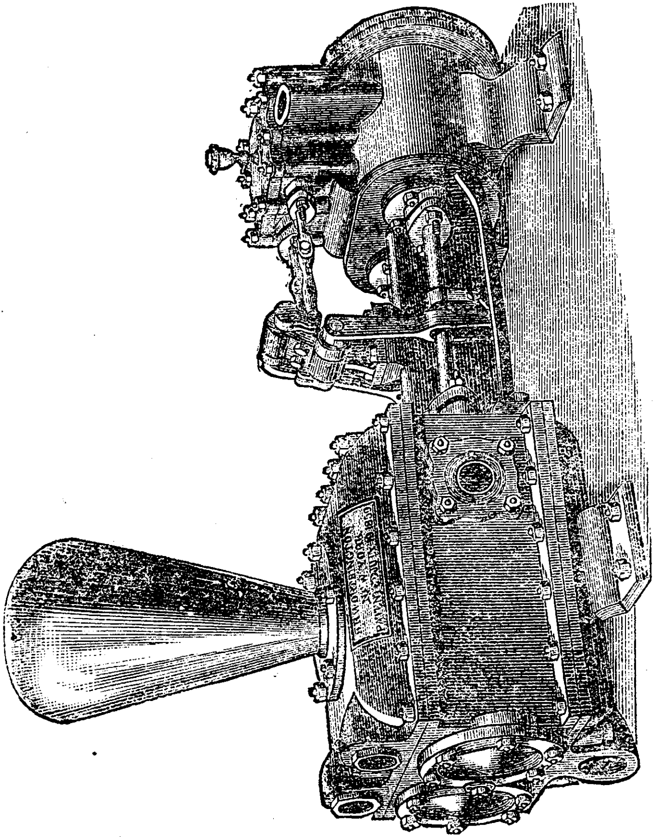


Fig. 62.

—*h*, the double-acting water plunger working through a packing ring—*o*, *o*, force valves—*ó*, *ó*, suction valves. The pump piston is represented as moving from right to left, the arrows indicating the course of the water through the passages. The suction valves *ó*, on the right side, and the force valves *o*, on the left side, are show open; *x*, is an air chamber made of copper; *s*, the suction pipe terminating in a vacuum chamber; made by prolonging the suction pipe, and closing it perfectly tight at the top, the connection being made to the pump by a branch as shown; *m*, *m*, are hand-hole plates, affording easy access to the water valves; *n*, *n*, small holes through the plunger,

Fig. 63.



which relieve the pressure near the end of the stroke, to give momentum to throw the valves when working at slow speed.

Fig. 63 is a perspective view of H. R. Worthington's Duplex Steam Pump. The prominent peculiarity of this pump is its valve motion. As seen in the cut, two steam pumps are placed side by side (or end to end, if desired). Each pump, by a rock shaft connected with its piston rod, gives a constant and easy motion to the steam valve of the other. Each pump therefore gives steam to and starts its neighbor, and then finishes its own stroke, pausing an instant till its own steam valve, being opened by the other pump, allows it to make the return stroke.

This combined action produces a perfectly positive valve motion without dead points, great regularity and ease of motion, and entire absence of noise or shock of any kind. Both kinds of pumps are made by Mr. Worthington, of various size according to the requirements, the duplex being used for boiler feed and for the supply of cities with water.

Fig. 64 is a side elevation of the Woodward Steam Pump. The pump is direct acting. The steam and water piston being on the same rod, but momentum is obtained to throw the valves by means of a fly wheel, placed beyond the pump, and connected with the piston rod by a cross head and a yoke. The machine is simple in its construction and action, and is extensively used.

Giffard's Injector, both in Europe and this country, is quite extensively used to supply the place of a pump, as independent feed for all classes of boilers. It is represented in elevation and section, *figs.* 65 and 66.

A, steam pipe leading from the boiler. *B*, a perforated tube or cylinder, through which the steam passes into the space *b*. *C*, screwed rod for regulating the passage of steam through the annular conical space *c*, and worked by the handle *d*. *E*, suction pipe, leading from the tank or hot well to small chamber *m*. *F*, annular conical opening or discharge pipe, the size of which is regulated by the movement of the tube or cylinder *B*. *G*, hand wheel for actuating the cylinder *B*. *H*, opening,

Fig. 64.

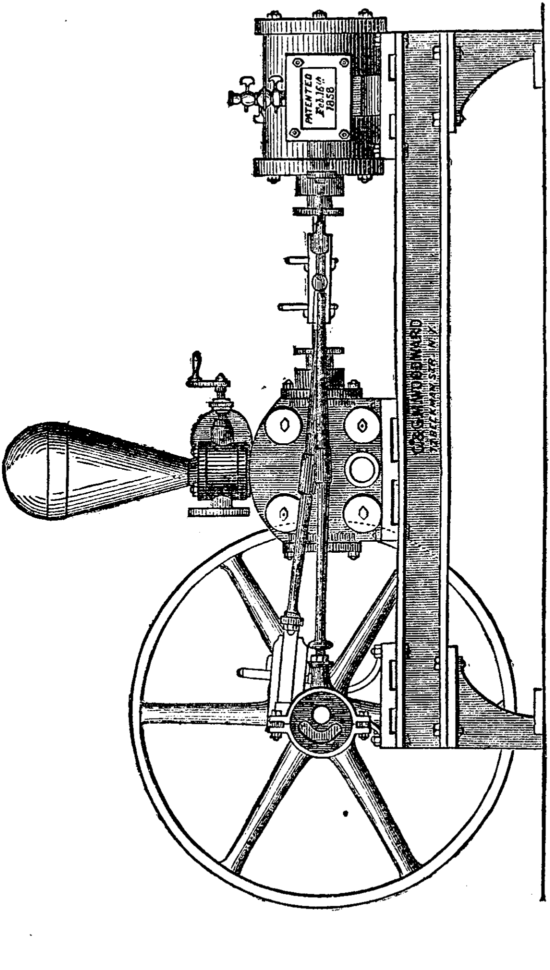


Fig. 65.

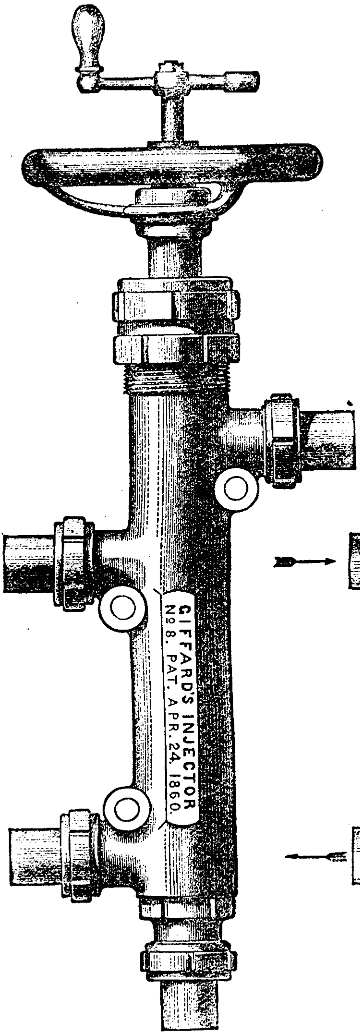
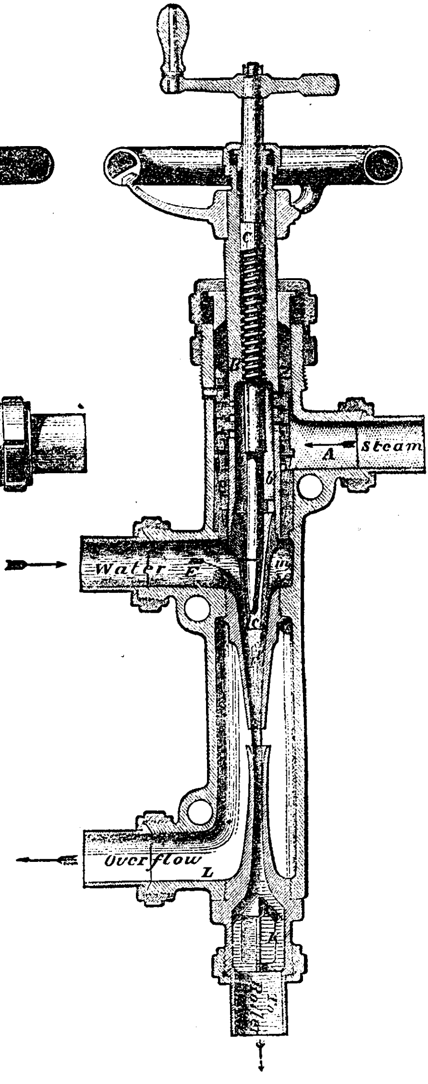

GIFFARD'S INJECTOR
Nº 8. PAT. APR. 24. 1860.

Fig. 66.


Steam
A
b
Water
E
m
Overflow
L

in connection with the atmosphere, intervening between discharge pipe *F* and the receiving pipe through which the water is forced. *I*, tube through which the water passes to the boiler. *K*, valve for preventing the return of the water from the boiler when the injector is not working. *L*, waste or overflow pipe. *M*, nut to tighten the packing rings *g* and upper packing *i* in cylinder *B*. *N*, lock nut to hold *M*.

The pipe *A* is connected with the steam space of the boiler at its highest part, to obtain as dry steam as possible. The passage of the steam into *A* is controlled by a cock, as is also the feed pipe to the boiler. In working, both are opened, the steam passes through *A* into the space *b*, and issuing through the nozzle *c* with the pressure due to its head, and a partial vacuum by its contact with the feed water, it drives this water in connection with the jet through the pipe *F* into the pipe *I* in connection with the water space of the boiler.

Method of Working.—Turn the wheel so as to permit a small quantity of water to flow to the instrument. Open the steam cock connecting the apparatus with the boiler. Turn slightly the handle, which will admit a small quantity of steam to the apparatus; a partial vacuum is thus produced, causing the water to enter through the supply pipe. As soon as this happens, which can be observed at the overflow pipe, the supply of steam or water may be increased as required, up to the capacity of the instrument, regulating either by means of the wheel and handle, so as to prevent any overflow. The quantity of water delivered into the boiler, may be varied by means of the stop cocks on the steam and water pipes, without altering the handles on the injector; a graduated cock on the water supply pipe is very convenient for this purpose.

The machines are manufactured by Wm. Sellers & Co. Philadelphia.

As an example of Portable Steam Engines, of which there are large numbers in this country of different manufacturers, we give the representation (*fig.* 67) of one made by J. C. Hoadley, of Lawrence, Mass.

In these machines, the rules and proportions of the loco-

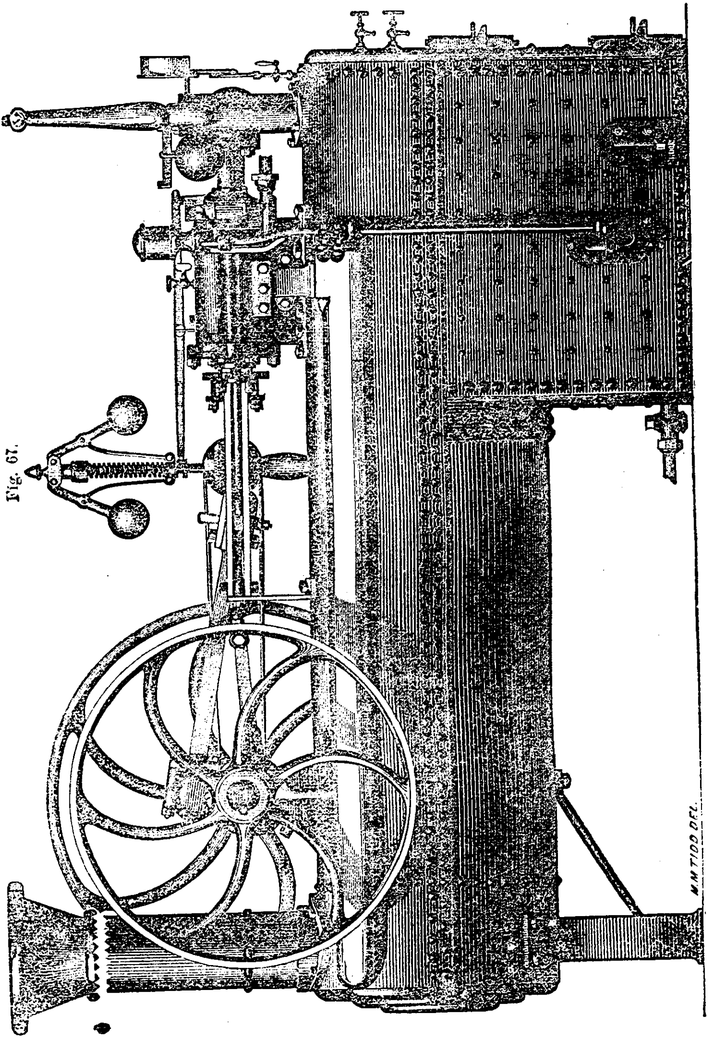


Fig. 67.

motive engine are adapted to the requirements of stationary power, for all purposes under forty horse power. The leading ideas are: high velocity, high pressure, good valve motion, large fire-box, numerous and short flues, and steam blast. The characteristic features are: great strength of boiler, fully adequate to bear with safety 200. lbs. pressure per sq. in., great compactness and simplicity, large and adjustable wearing surfaces, and the entire absence of all finish, or polish, for mere show.

The cylinder is placed over the centre of the boiler, at the fire-box end, so that the strain due to the engine is central to the boiler (which serves as bed plate); the starting valve is under the hand of the engineer when at the fire door; and both ends of the crank shaft are available for driving pulleys.

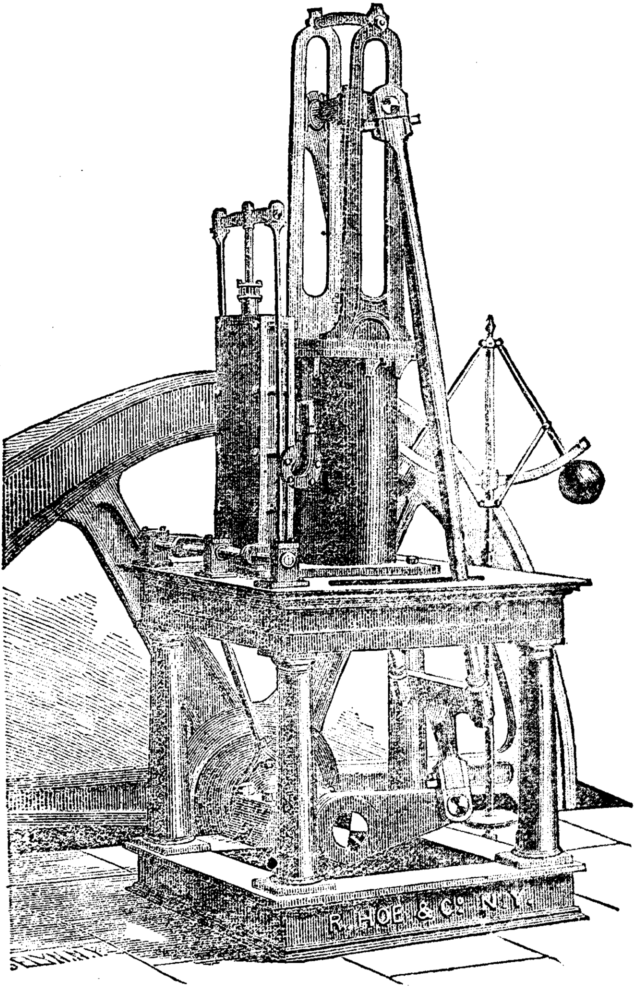
For the sake of compactness, the cylinders are set low, by means of a depression in the boiler between the stands of the crank shaft, to admit of the play of the crank and connecting rod. All the parts are attached to the boiler, which is made of sufficient strength to bear all extra strain due to the working of the engine.

They have feed water heater, force pumps, Jackson's governor and valve, belt for governor, belt pulley, turned on the face, steam gauge; everything, in short, necessary to the convenient working of a steam engine. All engines are fired up and tried before they leave the shop, and they are warranted tight, safe, and complete.

A strong and convenient running gear, so arranged as to be easily attached and detached at pleasure, is furnished, if desired; forming, when separate, a useful wagon.

Fig. 68 is a compact vertical engine, as built by R. Hoe & Co., of this city. It is intended to drive printing presses, but is adapted to any kind of work, and is especially suited to such places as require economy of space.

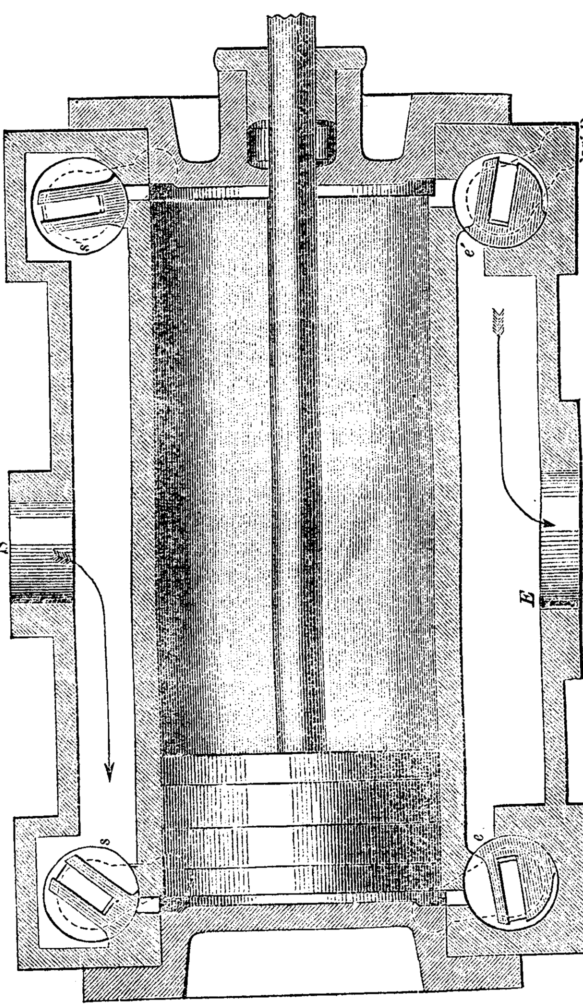
Fig. 68.



Although the value of expansion has been called in question by some of the engineers of the United States Navy, and under an appropriation from Congress is now to be made the subject of experimet; yet, in almost all the manufactories and workshops of the United States, no matter what the form of steam engine, or the purposes to which it is applied, whether stationary, locomotive, or marine, some form of cut-off, by which expansion of the steam can be availed of, is considered indispensable. Many varieties are in use, but those engines are most popular in which the cut-off is applied directly to the valves on the cylinder, opening them quickly and shutting off almost instantly, avoiding all wire drawing of the steam at the ports, and regulating the speed of the engine promptly. Of this class of engines, those manufactured by the Corliss Steam Engine Company, of Providence, R. I., are perhaps the widest known, not only for their extensive introduction, but also from having, by a long and successful litigation, established the claims of the patentee, Mr. George H. Corliss.

Fig. 70 is a section of the cylinder and valve chests of a horizontal Corliss engine. *S* is the steam connection, and *E* the exhaust; there are two distinct sets of valves, the steam *s*, *s'*, and the exhaust *e*, *e'*, operated independently of each other. In their construction the valves may be considered cylindrical plugs, of which portions near the ports are cut away to admit the steam and reduce the bearing surface; the valves are fitted on the lathe and the seats by boring. The motion given to the valves is rocking, but it will be observed that the valves are not firmly connected to the rocking shaft or cylinder; in the figure the valves are shown shade lined, and the shaft or stem plain; in this way the valves are not affected by the packing of the valve stem, but always rest upon the face of the ports. In the figure the piston is just about to commence its outstroke, the movement of the steam is supposed to be represented by the arrows; the inner steam valve *s*, and the outer exhaust *e'*, are just beginning to open. It will be observed that the outer steam *s'* is fully closed, whilst the inner exhaust valve *e* is but barely so, showing that there has been a cut-off on the steam

Fig. 70.



valve, but no lead to the exhaust, that it was left fully open till the completion of the stroke.

Fig. 71 is a side elevation of the cylinder, with the valve connections with the governor. *S* is the steam pipe; *s*, *s'* handles to the steam valves, and *c c'* to the exhaust valves, shown in dotted line in *fig.* 70. The handles to the exhaust valves are connected directly to a rocking plate *R*, to which motion is given by a connection *x*, with an eccentric on the engine shaft. When once set, therefore the movement of the exhaust valves is constant, and they will always be opened and closed at the same point of the stroke. Connected with the rocking plate R, and on opposite sides of its centre, the same as the exhaust valve connections, there are two levers, vibrating on a centre *c*, of which one only is shown, as it covers the other; to the upper ends of these levers pawls are attached, one end of which rests on the stems or rods connected with the handles *s*, *s'*, of the steam valves; on these stems there are notches against which the pawls strike, and as the levers vibrate inward they push back the stems and thereby open the valves, and this continues for the whole length of the inward motion of the levers, or till the outer extremities of the pawls come in contact with the end of the short lever *l*, which, pushing down the outer end of the pawls, relieves the stems at the other ends, and the valve stem returns to its place through the force of springs attached to the outer extremities of the valve stems. *a*, are cylindrical guides to the valve stems, at the inner extremities of which are air cushions. The lever *l* is connected directly with the governor. As the balls rise, they depress the extremity, which comes in contact with the pawls sooner, and thereby shut the valves earlier; and on the contrary when the balls are depressed, the valves remain open longer; as the pawls come in contact with the stems always at one point, the steam valves open constantly, but are closed at any point by the relief of the pawls, according to the speed of the governor.

Fig. 71.

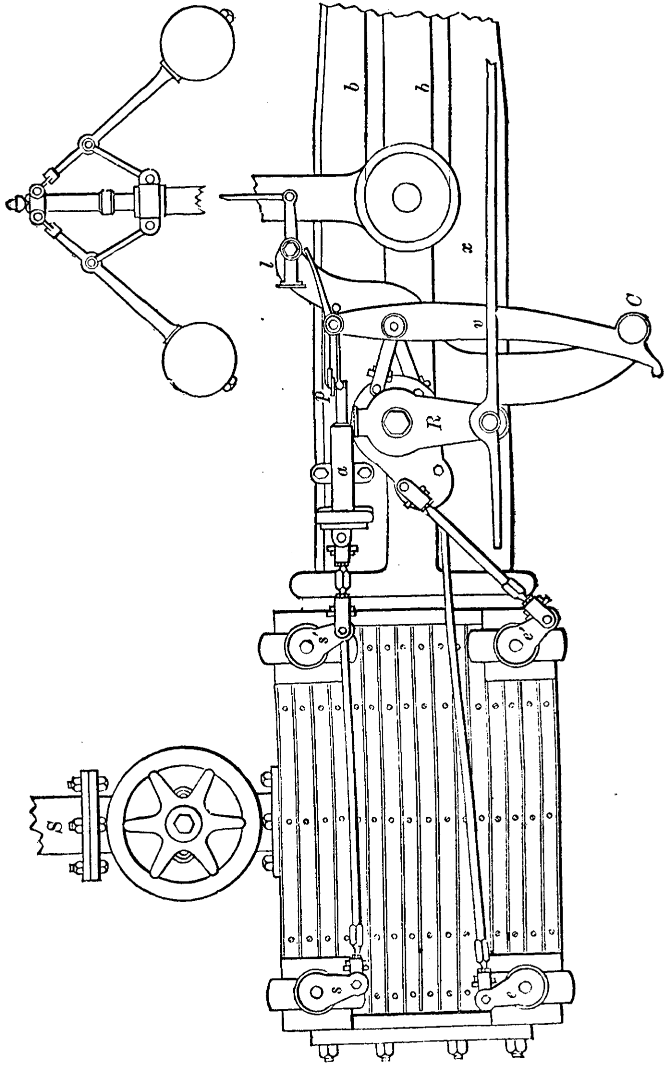


Fig. 71 represents, partly in section and partly in plan, the cylinder, steam chests, valves, &c., of one of the Woodruff & Beach high pressure Engines, Wright's patent.

Fig. 72 represents, in elevation, the cam shaft, to the upper end of which, not shown in the drawing, is attached the ordinary centrifugal governor. The cylinder, steam chests, valves, &c., being similar to those of other engines, need no special notice; but the cam for opening and closing the steam valves, *fig.* 72, requires particular attention, as it embodies a beautiful and simple device for cutting off the steam with certainty at any part of the stroke, the motion being produced automatically by the action of the governor on this cam, throwing it more or less out of centre with the spindle of the governor, as the rotation of the balls is less or more rapid, the eccentricity of the cam determining the amount of steam admitted to the working cylinder of the engine. To produce this effect the cam is made as follows:

C is a hollow cylinder or shell, with a part of one end formed into a cam proper. Throughout the whole length of this piece, upon the inside, there is a spiral groove cut to receive one end of a feather, by which its pitch or eccentricity is regulated. *C'* is also a hollow cylinder or shell, of the same length and diameter as *C*, with a similar spiral groove cut on the inside, the outside being perfectly smooth and plain, upon which the toe (*t*) for closing the valves is fastened. The inside piece consists of two hubs *D*, *D'*, eccentric with each other, and made in one piece, *D* being turned to exactly fit the inside of the shell *C*, and *D'* to fit the shell *C'*, the hub *D'* having a socket (*c*) into which the spindle (*s*) of the governor is screwed; the end (*d*) of the hub *D* forming a journal or bearing, with a bevel wheel on its extremity to convey motion from the crank-shaft gearing to the governor and cut-off. There is a hole throughout the length of the inside hubs *D* and *D'*, which is continued through the spindle of the governor, and contains the rod (*r*) that connects the cam with the governor. This hole is eccentric to the outside surface of the hub *D*, as well as to the shell *C*, and concentric with the hub *D'* and shell *C'*, and with the governor rod (*r*).

The shell *C* and hub *D*, and shell *C′* and hub *D′*, are connected together by feathers; one piece of each feather is of a spiral form, and the other a straight or rectangular piece, the two being connected together by a stub on the rectangular piece, which fits into a hole or bearing in the other or spiral piece, so that the latter can turn on the stub and accommodate itself to the groove in which it has to work. The spiral part of each feather works in the spiral groove on the inside of its corresponding shell *C* and *C′* respectively, and the rectangular pieces work in a straight groove cut in the hubs *D* and *D′*, the inner parts of the rectangular pieces being fastened to the governor rod (*r*), so that the feathers are permanently connected with the governor.

The shell *C′* revolves inside of two yokes (*y*) and (*y′*), one attached to each steam-valve toe, (*a*) and (*a′*) respectively.

On the inside of each yoke, and opposite to its valve-toe, is a raised piece, against which the closing piece (*t*) on the shell (*C′*) acts to close the valves.

This shell (*C′*), as before noticed, has a spiral groove on its inside, similar in all respects to that in the cam-shell (*C*); and being acted upon in the same manner and through the same rod by the governor, it is evident that the closing piece (*t*) on its outside will always hold the same relation to the opening toe on the lower or cam-shell (*C*); and whatever alteration is made in the one, a corresponding alteration takes place in the other, thereby insuring the closing of the valves at the proper time at every point of the variation of the cut-off.

When the several pieces above described are put together, the apparatus for opening and closing the valves and producing the cut-off is complete, as shown in *fig.* 72, and it operates as follows:

Motion is communicated by gearing from the crank-shaft to the bevel wheel on the piece (*d*) on the end of the hub *D*, and is communicated to the spindle of the governor, which is screwed into the socket on *D′*. As the balls rise or fall, through change of centrifugal force due to the variation in the speed of rotation, they raise or depress the governor-rod, which passes

Fig. 71.

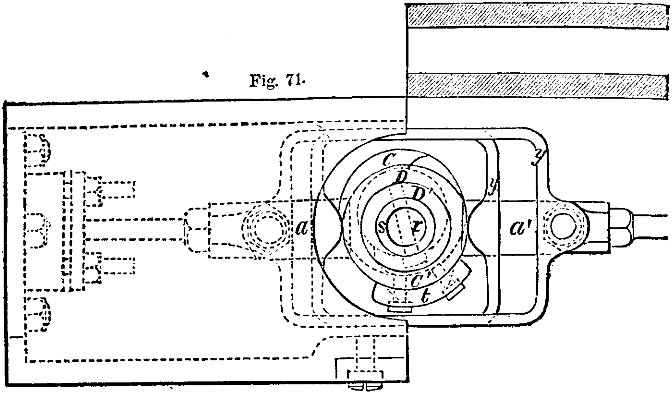
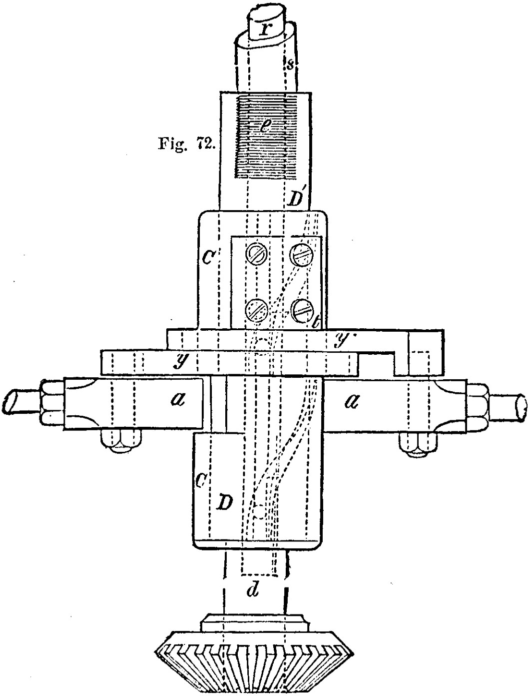


Fig. 72.



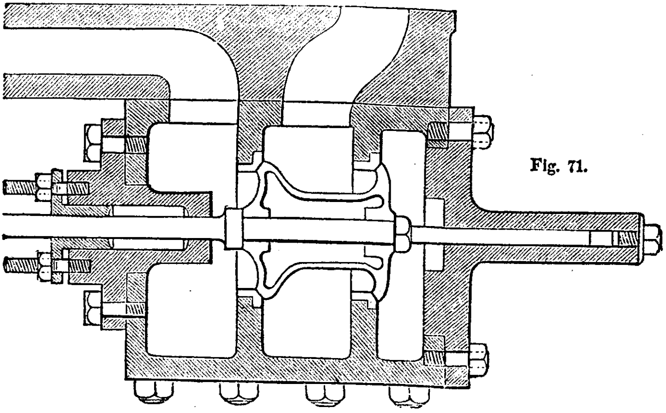


Fig. 71.

through the spindle and the hubs D' and D, and is attached to the feathers, thereby raising or depressing the feathers, which, acting on their respective spiral grooves, instantly alters the lift of the cam on the shell (C), and brings the closing toe (t) on the shell (C') into proper position for closing, and so regulates the amount of steam admitted to the cylinder.

Consequently, any speed may be selected at which the load of the engine is to move, and any variation from that will be instantly felt by the governor, and corrected by this simple and beautiful device. There is no jar in the working of the parts; the feathers move noiselessly in their grooves; the governor rod moves up and down through the spindle and the hubs D and D', and can be regulated by hand to give any required opening of the steam ports to suit the work to be done. Any change in the amount of work will then alter the speed of the engine, and so affect the governor and cam, as before said.

It is unnecessary to insist on the great economy attained by using steam with a well-regulated cut-off, for practical men know now that the essential points of excellence in the steam engine are a good boiler, which generates the greatest quantity of steam for the least consumption of fuel; and, secondly, a reliable cut-off, which uses the steam to the best advantage, by admitting the proper quantity for the work required.

STEAM FIRE ENGINES.—Portable engines for the extinguishment of fires, are an American invention, and to Messrs. A. B. & E. Latta, of Cincinnati, working on the right principles, is due the credit which they claim in their circular, as follows:

"We claim to be the *original* and first *projectors* of the *first successful steam fire engine* in the world's history. There have been many attempts at making a machine of such construction as would answer to extinguish fires; but none of them proved to be available in a sufficiently short space of time to warrant their use as a fire apparatus. We hold that a steam fire engine should be of such nature as to be brought into requisition in as short a space of time as is necessary to get the machine on the ground, and the hose laid and ready to work: that is, supposing the fire to be within one square of the place where the steamer is located. The object in locating a machine at any point is to protect that immediate vicinity; and it is therefore absolutely necessary to have it available in the shortest space of time, and that with unerring certainty. We think that reliability is of the greatest importance to the protection of a city from fire, as everything is dependent on the *working* of such apparatus in time; and for this reason no expense should be spared on this kind of machinery."

Fig. 73 is a representation of one of the Messrs. Latta's fire engines, of which there are many of different classes, according to the requirements; they say that they can furnish engines as low as $1,000, and have made some for $10,000.

The first peculiar feature of this engine is the boiler; it differs entirely from all boilers now in use.

The fire box or furnace is simply a square box or furnace of any required dimensions; it is nothing more than a water space surrounding the fire, stay-bolted as all water spaces are. It is made of boiler plate in the usual manner. The water space extends only ⅔ of the height, the balance being a single sheet. The bottom of this fire box is crossed by grate bars to support the fuel; in its rear side are fire doors, inserted for firing. The

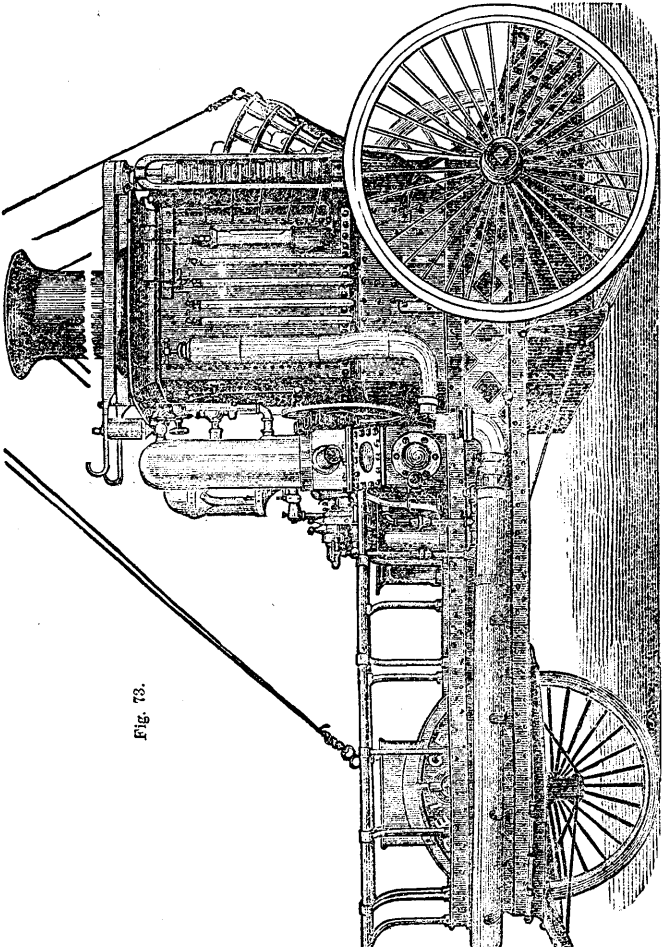


Fig. 73.

internal arrangements of the boiler are composed of a large number of tubes, lying across in a horizontal position, put together in sections with return bends resembling the coils for heating buildings. These coils are of small pipe (say one inch in diameter), and as numerous as may be necessary. They give the required amount of steam. They are secured to wrought-iron plates at each end by rivets. These plates lie close to the box, and are secured to it, top and bottom. These tubes are wrought iron, firmly screwed into the bends, so as to prevent any possible breaking.

The box has a hole through both sheets, in the same manner as a hollow stay-bolt, through which the coil pipe passes, having no connection with the box. After passing into the box it divides into two pipes, then subdivides into four, and so on, until its numbers equal the number of coils in the box, and to which each limb is attached. The upper ends of these coils are the same in number, and are carried through at the top or nearly the top of the box. They then run down outside to the steam chamber, or rather water space, as the box is both steam chamber and water space. These pipes empty their contents into the box, steam and water, as it may come, all together. It will be observed that these coils of tube are sufficiently separated to allow the fire to pass between them freely, and cover their whole surface.

The mode of operation of this boiler is this: The fire box is filled $\frac{2}{3}$ full of water. The coils are dry at starting; the space for fuel being filled with good wood, the fire is lighted, and in a few moments the engineer moves his hand pump, which takes its water from the box to which it is attached, and forces it through the coils. By this means steam is generated in from 3 to 5 minutes, so as to start the engine.

It will be seen that the water performs a complete circuit; it is taken from the box and passed through the coils; what is steam remains in the steam chamber, and what is not (if any) drops back into the box from where it started. Hence it will be seen that a large surface is exposed to a small quantity of water, and in a way that it is entirely controllable. All the engineer has to do to surcharge his steam, is to reduce the speed of the pump (which is independent of the main engine). By raising the heat and quantity of water, any degree of elasticity can be given to the steam, and that, too, with the least amount of waste heat in giving a natural draft. Hence the great economy of this boiler.

The next feature of this engine is, it has no wood work about it to perish with the heat and roughness of the streets. All the wheels are wrought iron; and, as yet, these are the only ones that have stood a steam fire engine. The frame is wrought iron; truck, on which the front wheel is hung, wrought iron. The axles are cast steel. The engine and pump is a double-acting piston pump direct, without any rotary motion; with a perfect balance valve, it is balanced at all times, and hence the engine remains quiet without blocking, when at work. The engine is mounted on three wheels, which enables it to be turned in a very short space.

Many engines have been constructed by the Messrs. Latta for the fire companies of different cities, and have been in successful competition with other engines; the farthest throw ever made by one of their first-class engines was 310 feet from a $1\frac{5}{8}$ inch nozzle; steaming time, starting from cold water, $3\frac{1}{2}$ minutes.

Fig. 74 is a representation of one class of steam fire engine, as built by the Amoskeag Manufacturing Company, at Manchester, N. H. The boiler is an upright tubular boiler, of a peculiar construction, the patent right to which is vested in the Amoskeag Manufacturing Company. This boiler is very simple in its combination, and for safety, strength, durability, and capacity for generating steam is unsurpassed. No fan or artificial blower is ever used or needed, the natural draft of the boiler being always sufficient. Starting with cold water in the boiler, a working head of steam can be generated in *less than five minutes* from the time of kindling the fire. The engine "Amoskeag," owned by the city of Manchester, has played two streams in *three minutes and forty seconds* after touching the match, at the same time drawing her own water. The boilers

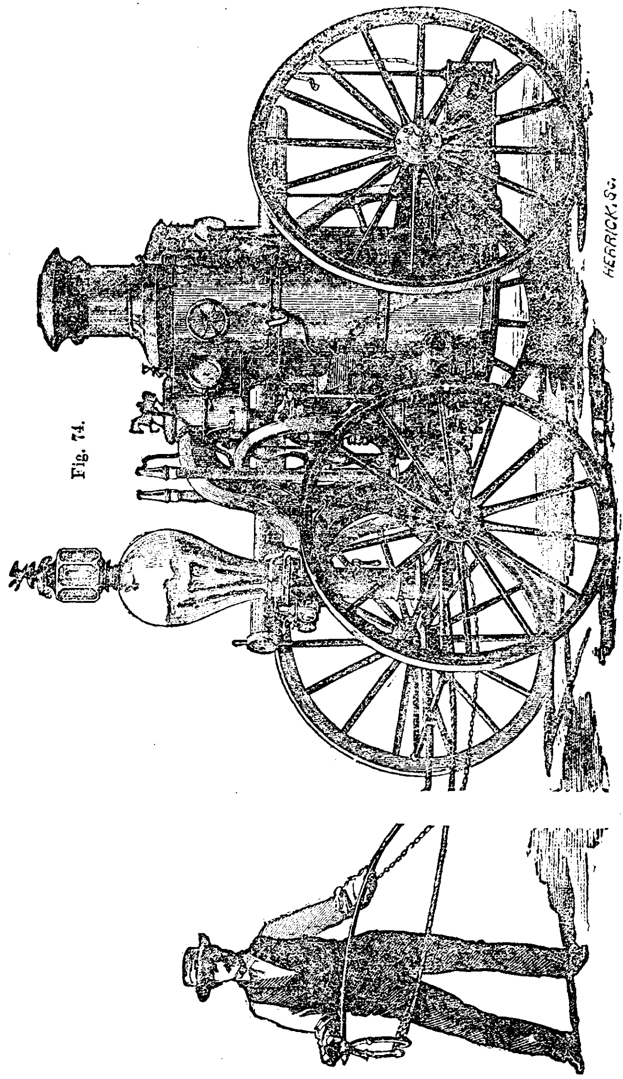


Fig. 74.

are made and proved so as to be safely run at a steam pressure of 140 to 150 lbs. to the square inch; but the engines are constructed so as to give the best streams at a pressure of about 100 lbs. to the square inch, and for service at fires a steam pressure of about 60 lbs. to the square inch is all that is required.

The various styles of engine are all *vertical* in their action, and in all the pumps and steam cylinders are firmly and directly fastened to the boiler, the steam cylinders being attached directly to the steam dome. This arrangement obviates the necessity of carrying steam to the cylinders through pipes of considerable length, and the machine has very little vibratory motion when in operation—so little that it is not necessary to block its wheels to keep it in its place, or to take the weight off the springs before commencing work.

The pumps are placed on the engines as near the ground as they can be with safety, and are arranged so as to attach the suction and leading hose to either or both sides of the machine, as may be most convenient or desirable, so that less difficulty will be found in placing an engine for work, and when required to draw its own water, it has only to draw it the shortest possible distance.

Each engine has two " feed pumps " for supplying the boiler, and also a connection between the main forcing pumps and the boiler, so that it can be supplied from that source if desirable. The tank which carries the water for supplying the boiler is so placed that the water in it is always above the " feed pumps," an advantage that insures the almost certain working of these pumps. These pumps are of brass, the best locomotive pattern, and one of them running with the engine, when at work, furnishes an ample supply of water to the boiler.

The engines are exceedingly portable; they can be turned about or placed for service in as contracted a space as any hand engine, and two good horses will draw a first-class engine with the greatest ease, carrying at the same time water for the boiler a supply of fuel sufficient to run the engine two hours, the driver, the engineer, and the fireman.

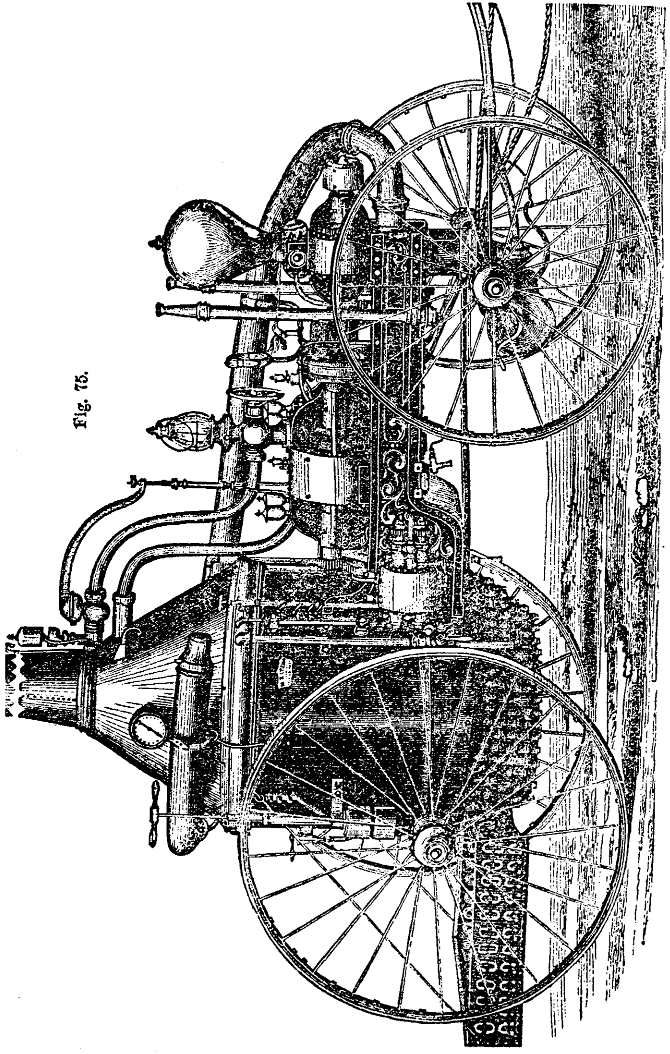


Fig. 75.

Fig. 75 is a representation of the class of steam fire engine built by Silsbee, Mynderse & Co., Seneca Falls, N. Y., under Holly's patent.

The boiler is vertical, with vertical water tubes passing directly through the fire. These tubes are closed at the bottom and open at the top, where they pass through a water-tight plate, and communicate with the water in the boiler. The arrangement of the tubes causes a constant current, the water rising on the outside of the tubes as they are heated, and its place being supplied by a current flowing downward through the tube to the boiler. The smoke and flame pass among the tubes up through flues.

Both engine and pump are rotary, and of the same type. They consist essentially of two elliptical rotary pistons, cogged and working into one another in an air-tight case. The pistons fit close to the inside of the case, and gear into each on the line of their conjugate diameters. The action is somewhat similar to the old-fashioned rotary pump, consisting of two cog wheels in gear with each other, the spaces at the side of the case being filled with water, which at the centre are occupied by the teeth in gear. In Holly's pump, instead of uniform teeth, and depending on the fit of the teeth with the side of the case and with each other for the packing, there are two large teeth in each piston opposite each other, which have slide pistons, and intermediate with these large teeth are small cogs, which continue the motion of the rotary pistons. The machine works very smoothly, and performs the work necessary, in ordinary service, under a pressure of 50 to 60 lbs.

There are many other makers of fire engines in this country; but sufficient examples are given to illustrate the class; so successful have they been, that they are fast superseding hand engines, even in the smaller cities.

Under a paid department, the following is, in the city of Boston, Mass., the comparative cost of running the two kinds of engines, viz.:

STEAM FIRE ENGINE.

1 engineer	$720 00
1 fireman	600 00
1 driver	600 00
1 foreman of hose	150 00
3 hosemen, at $125 each	375 00
7 men	$2,445 00
Keeping of 2 horses	315 00
Total	$2,760 00

HAND ENGINE.

1 foreman	$150 00
1 assistant foreman	125 00
1 clerk	125 00
1 steward	125 00
3 leading hosemen, at $125 each	375 00
33 men, at $100 each	3,300 00
40 men	$4,200 00

Here the engineer, fireman, and driver are constantly employed, the hosemen have other employment in the neighborhood, but all the company sleep in the engine house.

In the city of Manchester, N. H., a steam fire engine company is composed of fourteen men, all told, one of whom, acting as driver and steward, is constantly employed, remaining at the engine house with a pair of horses always ready to run out with the engine in case of an alarm of fire. The other members of the company have other employments, and turn out only on an alarm of fire.

STEAM FIRE ENGINES.

"Amoskeag,"	Expenditures	$864 32
"Fire King,"	"	855 78
"E. W. Harrington,"	"	496 09

The above expense includes pay of members, team expenses, cost of gas, wood, coal, and all necessities incident to service.

The "E. W. Harrington" is a second-class engine, stationed in the outskirts of the city, and was run cheaper from the fact that no horses were kept for it by the city.

A first-class hand-engine company is allowed to number, all told, fifty men, and the members of the company are paid as follows:

FIRST-CLASS HAND-ENGINE COMPANY.

1 foreman		$35 00
1 assistant foreman		28 00
1 clerk		28 00
1 steward		68 00
46 men, at $18 each		828 00
—		
50 men.	Total	$987 00

By this it will be seen that in a city like Manchester, with from twenty to twenty-five thousand inhabitants, a first-class steam fire engine can be run at an expense not to exceed that of a first-class hand engine, while in service it will do at least *four times* the work. The cost of repairs is found by experience to be no greater on the steam fire engines than on hand engines.

The Excavator, *fig.* 76, is the invention of the late Mr. Otis, an application of the spoon dredging machine of the docks to railway purposes, with very important modifications. The machine consists of a strong truck, *A*, *A*, mounted on railway wheels, on which is placed the boiler *C*, the crane *E*, and the requisite gearing. The excavator or shovel, *D*, is a box of wrought iron, with strong points in front to act as picks in loosening the earth, and its bottom hung by a hinge at *d*, so that, by detaching a catch, it may fly open and discharge the material raised. To operate the machine, suppose the shovel *D* to be in the position shown in the cut; it is lowered by the chains *o*, *o*, and thrown forward or backward, if necessary, by the drum *B*, and handle *S*, till the picks in the front of the shovel are brought in proper contact with the face of the cut; motion forward is now given to the shovel by the drum *B* and handle *S*, and at the same time it is raised by the chains *o*, *o*. These two motions can be so adjusted to each other, as to give movement to the shovel to enable it to loosen and scrape up a shovelful of earth. The handle *S* is now left free, and the shovel *D* is raised vertically by the chains *o*, *o*. The crane is now turned round, till the shovel comes over a rail car on a side track; the bottom of the shovel is opened, and the dirt deposited in the

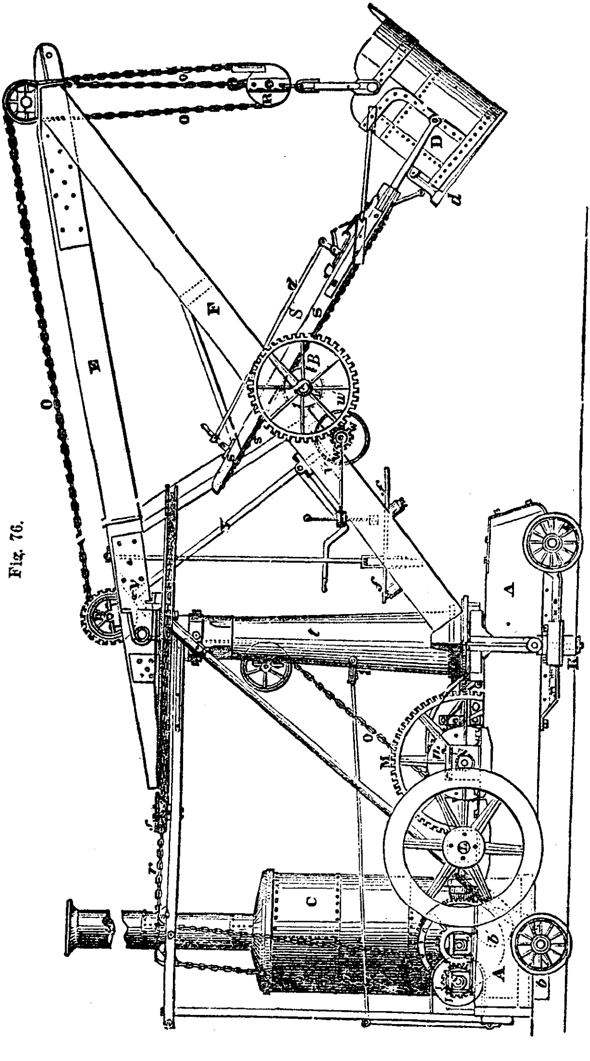


Fig. 76.

car. All these motions are performed by the aid of a steam engine, and are controlled by a man who stands on a platform at *f*.

692. *Q.*—Having now described the most usual and approved forms of engines applicable to numerous miscellaneous purposes for which a moderate amount of steam power is required, will you briefly recapitulate what amount of work of different kinds an engine of a given power will perform, so that any one desiring to employ an engine to perform a given amount of work, will be able to tell what the power of such engine should be?

A.—It will of course be impossible to recapitulate all the purposes to which engines are applicable, or to specify for every case the amount of power necessary for the accomplishment of a given amount of work; but some examples may be given which will be applicable to the bulk of the cases occurring in practice.

693. *Q.*—Beginning, then, with the power necessary for threshing,—a 4 horse power engine, with cylinder 6 inches diameter, pressure of steam 45 lbs., per square inch, and making 140 revolutions per minute, will thresh out 40 quarters of wheat in 10 hours with a consumption of 3 cwt. of coals.

A.—Although this may be done, it is probably too much to say that it can be done on an average, and about three fourths of a quarter of wheat per horse power would probably be a nearer average. The amount of power consumed varies with the yield.

Messrs. Barrett, Exall, and Andrewes give the following table as illustrative of the work done, and the fuel consumed by their portable engines; but this must be regarded as a maximum performance:—

Number of Horse Power.	Weight of Engine.		Quarters of Corn thrashed in 10 Hours.	Quantity of Coals consumed in 10 Hours.	Quantity of Water required for 10 Hours in Gallons.
	Tons.	Cwts.		Cwts.	
4	2	0	40	8	300
5	2	5	50	4	380
6	2	10	60	5	460
7	2	15	70	6	540
8	3	0	80	7	620
10	8	10	100	9	780

694. *Q.*—In speaking of horses power, I suppose you mean indicator horse power?

A.—Yes; or rather the dynamometer horse power, which is the same, barring the friction of the engine. At the shows of the Royal Agricultural Society, the power actually exerted by the different engines is ascertained by the application of a friction wheel or dynamometer.

695. *Q.*—Can you give any other examples of the power necessary for grinding corn?

A.—An engine exerting 23½ horses power by the indicator works two pairs of flour stones of 4 feet 8 inches diameter, two pairs of stones grinding oatmeal of 4 feet 8 inches diameter, one dressing machine, one pair of fanners, one dust screen, and one sifting machine. One of the flour stones makes 85, and the other 90 revolutions in the minute. One of the oatmeal stones makes 120, and the other 140 revolutions in the minute. To take another case:—An engine exerting 26½ indicator horses power works two pairs of flour stones, one dressing machine, two pairs of stones grinding oatmeal, and one pair of shelling stones. The flour stones, one pair of the oatmeal stones, and shelling stones, are 4 feet 8 inches diameter. The diameter of the other pair of oatmeal stones is 3 feet 8 inches. The length of the cylinder of the dressing machine is 7 feet 6 inches. The flour stones make 87 revolutions in the minute, and the larger oatmeal stone 111 revolutions, but the smaller oatmeal stone and the shelling stone revolve faster than this. At the time the indicator diagram was taken, each pair of flour stones was grinding at the rate of 5 bushels an hour; each pair of oatmeal stones about 24 bushels an hour; and the shelling stones were shelling at the rate of about 54 bushels an hour. The fanners and screen were also in operation.

696. *Q.*—Have you any other case to enumerate?

A.—I may mention one in which the power of the same engine was increased by giving it a larger supply of steam. The engine when working with 8.65 horses power, gives motion to one pair of oatmeal stones of 4 feet 6 inches diameter, and one pair of flour stones 4 feet 8 inches diameter. The oatmeal stone makes 100 revolutions in the minute, and the flour stone 89. The oatmeal stones grind about 36 bushels in the hour, and the flour stones 5 bushels in the hour. The engine when working to 12 horses power drives one pair of flour stones, 4 feet 8 inches diameter, at 89 revolutions per minute and one pair of stones of the same diameter at 105 revolutions, grinding beans for cattle. The flour mill stones with this proportion of power, being more largely fed, ground 6 bushels per hour, and the other stones also ground 6 bushels per hour. When the power was increased to 18 horses, and the engine was burdened in addition with a dressing machine having a cylinder of 19 inches diameter, the speed of the flour stone fell to 85, and of the beans stone to 100 revolutions per minute, and the yield was also reduced. The dressing machine dressed 24 bushels per hour.

697. *Q.*—What is the power necessary to work a sugar mill such as is used to press the juice from canes in the West Indies?

A.—Twenty horses power will work a sugar mill having rollers about 5 feet long and 28 inches diameter; the rollers making $2\frac{1}{3}$ turns in a minute. If the rollers be 26 inches diameter and $4\frac{1}{2}$ feet long, 18 horses power will suffice to work them at the same speed, and 16 horses power if the length be reduced to 3 feet 8 inches. 12 horses power will be required to work a sugar mill with rollers 24 inches diameter and 4 feet 2 inches long; and 10 horses power will suffice if the rollers be 3 feet 10 inches long and 23 inches diameter. The speed of the surface of sugar mill rollers should not be greater than 16 feet per minute, to allow time for the canes to part with their juice. In the old mills the speed was invariably too great. The quantity of juice expressed will not be increased by increasing the speed of the rollers, but more of the juice will pass away in the begass or woody refuse of the cane.

698. *Q.*—What is the amount of power necessary to drive cotton mills?

A.—An indicator or actual horse power will drive 305 hand mule spindles, with proportion of preparing machinery for the same; or 230 self-acting mule spindles with preparation; or 104 throstle spindles with preparation; or $10\frac{1}{2}$ power looms with common sizing. The throstles referred to are the common throstles spinning 34's twist for power loom weaving, and the spindles make 4000 turns per minute. The self-acting mules are Robert's, about one half spinning 36's weft, and spindles revolving 4800 turns per minute; and the other half spinning 36's twist, with the spindles revolving 5200 times per minute. Half the hand mules were spinning 36's weft, at 4700 revolutions, and the other half 36's twist at 5000 revolutions per minute. The average breadth of the looms was 37 inches, weaving 37 inch cloth, making 123 picks per minute,—all common calicoes about 60 reed, Stockport count, and 68 picks to the inch. To take another example in the case of a mill for twisting cotton yarn into thread:—In this mill there are 27 frames with 96 common throstle spindles in each, making in all 2592 spindles. The spindles turn 2200 times in a minute; the bobbins are $1\frac{7}{8}$ inches diameter, and the part which holds the thread is $2\frac{3}{16}$ inches long. In addition to the twisting frames the steam engine works 4 turning lathes, 3 polishing lathes, 2 American machines for turning small bobbins, two circular saws, one of 22 and the other of 14 inches diameter, and 24 bobbin heads or machines for filling the bobbins with finished thread. The power required to drive the whole of this machinery is $28\frac{1}{2}$ horses. When all the machinery except the spindles is thrown off, the power required is 21 horses, so that 2592, the total number of spindles, divided by 21, the total power, is the number of twisting spindles worked by each actual horse power. The number is 122.84.

699. *Q.*—What work will be done by a given engine in sawing timber, pressing cotton, blowing furnaces, driving piles, and dredging earth out of rivers?

A.—A high pressure cylinder 10 inches diameter, 4 feet stroke, making 35 revolutions with steam of 90 to 100 lbs. on the square inch, supplied by three cylindrical boilers 30 inches diameter and 20 feet long, works two vertical saws of 34 inches stroke, which are capable of cutting 30 feet of yellow pine, 18 inches deep, in the minute. A high pressure cylinder 14 inches diameter and 4 feet stroke, making 60 strokes per minute with steam of 40 lbs. on the square inch, supplied by three cylindrical boilers without flues, 30 inches diameter and 26 feet long, with 32 square feet of grate surface, works four cotton presses geared 6 to 1, with two screws in each of $7\frac{1}{2}$ inches diameter and $1\frac{5}{8}$ pitch, which presses will screw 1000 bales of cotton in the twelve hours. Also one high pressure cylinder of 10 inches diameter and 3 feet stroke, making 45 to 60 revolutions per minute, with steam of 45 to 50 lbs. per square inch, with two hydraulic presses having 12 inch rams of $4\frac{1}{2}$ feet stroke, and force pumps 2 inches diameter and 6 inches stroke, presses 30 bales of cotton per hour. One condensing engine with cylinder 56 inches diameter, 10 feet stroke, and making 15 strokes per minute with steam of 60 lbs. pressure per square inch, cut off at $\frac{1}{4}$th of the stroke, supplied by six boilers, each 5 feet diameter, and 24 feet long, with a 22-inch double-return flue in each, and 198 square feet of fire grate, works a blast cylinder of 126 inches diameter, and 10 feet stroke, at 15 strokes per minute. The pressure of the blast is 4 to 5 lbs. per square inch; the area of pipes 2300 square inches, and the engine blows four furnaces of 14 feet diameter, each making 100 tons of pig iron per week. Two high pressure cylinders, each of 6 inches diameter and 18 inches stroke, making 60 to 80 strokes per minute, with steam of 60 lbs. per square inch, lift two rams, each weighing 1000 lbs., five times in a minute, the leaders for the lift being 24 feet long. One high pressure cylinder of 12 inches diameter and 5 feet stroke, making 20 strokes per minute, with steam of 60 to 70 lbs. pressure per square inch, lifts 6 buckets full of dredging per minute from a depth of 30 feet below the water, or lifts 10 buckets full of mud per minute from a depth of 18 feet below the water.