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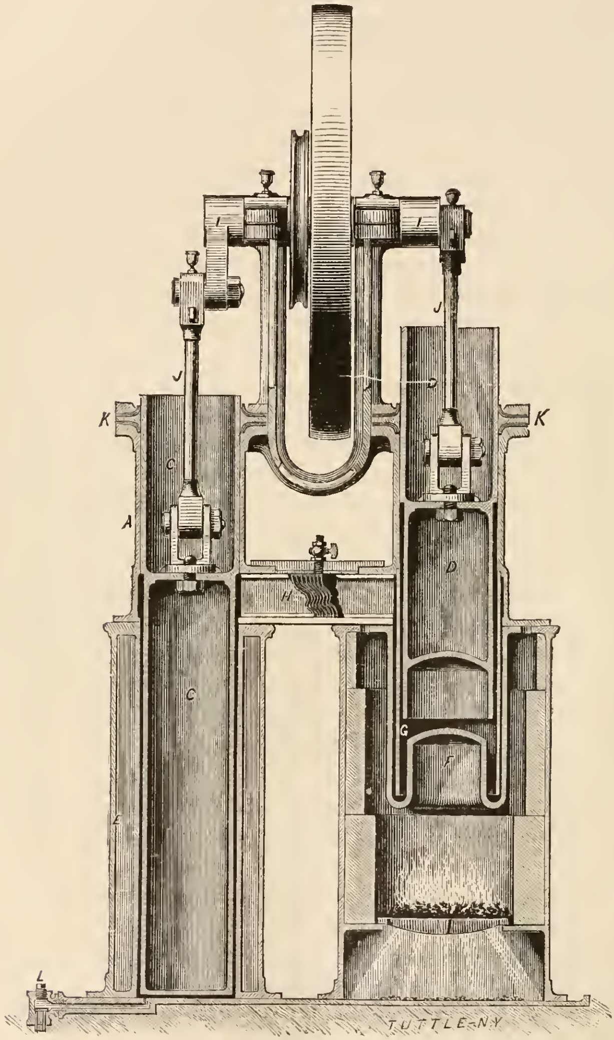
ton fitting the cylinder tightly, a plunger moving in it loosely, and the system of cranks and connecting-rods by which the motion of these parts is communicated. The upper portion of the cylinder, through which the tightly fitting piston alone moves, is water-jacketed, and consequently remains cool, while the part below this becomes more or less highly heated. In this heated portion the plunger moves, alternately displacing the air from above the fire. It is a long iron shell filled with wool or other non-conductor, and provided with studs on its sides which keep it from the walls of the cylinder. The machine is started by giving a few turns to the fly-wheel, when it begins running of itself, the action being as follows:

The plunger being raised, the air below it is heated and expands, forcing the piston upward. As it does this, the plunger is brought down with a quick motion, displacing the air, which passes through the annular space between the plunger and cylinder wall to the upper part of the cylinder. Here it comes in contact with the cool surface of the water-jacketed portion and contracts, forming a partial vacuum below the piston, which then descends by atmospheric pressure. By the upward movement of the plunger, the air is again brought in contact with the heated bottom and sides of the cylinder, and the same operation is repeated. The plunger-rod passes up through the piston, and by means of the simple system of connecting-rods and cranks shown in the figure the proper motion is given the plunger. The pump is placed at the side of the cylinder, and its rod connected directly to the beam of the engine. The water is drawn into the pump and discharged through the water-jacket, the slight heating of the water in its passage through the jacket being no disadvantage, while the continual passage of fresh water readily keeps the cylinder cool. The engines have so far only been made for pumping purposes, but they can readily be adapted to those of a small power, by using only a part of the power of the engine in pumping. Four sizes of the motor are made, three with single cylinders, six, eight, and twelve inches in diameter, and one with two cylinders of the latter size. The first lifts two hundred gallons of water fifty feet per hour, with an expenditure of fifteen feet of gas, the second three hundred and fifty, the third eight, and the fourth sixteen hundred gallons, the same height, with a proportional consumption of fuel. The prices vary from two hundred and ten dollars for the smaller to five hundred and fifty dollars for the largest size. Only the two smaller sizes are at present made to burn gas. They are perfectly safe, so simple that they can be used by the most inexperienced persons, and for their special purpose are probably as cheap and satisfactory machines as can be made.

Another engine, and one of the most serviceable of this class of machines to be found in the market, is the Rider compression engine. Like the other hot-air engines, it is constructed chiefly with a view to pumping, but when desired for power in addition it may be obtained fitted with a governor and the necessary pulleys at a slight increase of cost. The pumping-engines have found their way into very general use on railroads, country seats, and in city buildings, and from their economy in the use of fuel and their little trouble they have in all these situations proved very satisfactory. They are made only with coal-burning furnaces, and are on this account more troublesome than they would be if using gas, but are still but little more so than an ordinary coal-stove. Replenishing of fires and oiling are the only duties to be performed, and these can be done by unskilled labor. The engine occupies about the same floor-space as a moderately large coal-stove, and is about the same height. Two sizes are made, one of six, and one of ten-inch cylinder. The former will pump five thousand gallons of water to a height of ten feet in an hour, or a smaller amount to a proportionally greater height, at an expenditure of four pounds of coal, and the latter will raise twelve thousand gallons to the same height, in the same time, with eight pounds of coal. These amounts of coal are those used when the engine is run consecutively for ten hours. If run for a shorter time, the coal consumed per hour will be somewhat greater, owing to the starting of the fire. The engines weigh considerable, the smaller size being some sixteen hundred pounds, and the larger about double. The prices do not differ materially from those of steam-engines of from one to three horse-power.

The internal construction of the engine and manner of working are shown in the sectional view in Fig. 10. It is also of the type which repeatedly uses a given body of air, but, unlike the motor of Ericsson, the alternate heating and cooling are done in separate cylinders. The air is heated in the cylinder B and cooled in the cylinder A. The plunger C fits the cylinder A in its upper portion, but is contracted in the lower part to allow of an annular space between it and the wall of the cylinder. The power-piston D also fits its cylinder B tightly in the upper portion, but loosely in the lower heated part. A leather packing, K K, in each cylinder secures as in other engines a perfect fit of these moving parts. Between the two cylinders is placed a regenerator, H, consisting of a number of perforated plates, through which the air passes in going from one cylinder to the other. Around the lower portion of the cylinder B is a water-jacket, E, and encircling the same part of the heating cylinder B is a metal shell, F, curved inward at the base. The extension G of the cylinder B down into this shell forms a narrow annular space, through which the air entering the heater has to pass in a thin sheet, and thus becomes thoroughly heated. In action, the plunger C descends and compresses the air below it to one third its previous bulk ; then by the further upward movement of the power-piston D and the completion of the down-stroke of the plunger, this air is transferred to the heater. This compressed air becoming heated expands and forces the power-piston to the end of its stroke, and entering the cylinder A carries the plunger nearly to its extreme upper position. The air in contact with the water-jacket becoming cooled contracts, and the pressure is reduced below the power-piston, which then descends by the force of the atmosphere. As it reaches the end of its downward stroke and begins

Fig. 10.



to ascend, the plunger comes down and the operation is repeated. When the air passes from the heater to the cool cylinder A, it heats the plates of the regenerator and this heat is given off to the cool air, when it is again forced into the heater. The utmost of the heat is thus utilized that is possible. The start in this as in all hot-air and gas engines must be made by hand, but after a few turns of the fly-wheel the motion acquired is maintained by the engine.

The engine is supplied with either a deep well-pump, or one for use when the water is not more than twenty or twenty-five feet below it. The former is a simple contrivance, tubular in form, so that it can readily be inserted in artesian wells. The pump for use with water at less depths is of special construction, provided with rolling valves. It is bolted to the cooling cylinder, and worked directly from the compression piston or plunger. With one or the other of these pumps the motors can be adapted to every variety of circumstance in which water is to be drawn from one point and conveyed to another. Houses in the country can have as complete a water-supply, and have it in as convenient a shape, as those in the city, and at but little greater cost.

One of the best of this class of motors made for power purposes is the Sherrill-Roper engine, shown in section in Fig. 11. The manner

Fig. 11.