and connecting-rod attached to the engine. In the working cylinder was a close-fitting piston, the top of this cylinder being in communication with one heating vessel, and the bottom with the other end. As the displacers moved up and down the air in the heating vessels was displaced and sent alternately to the top, or cool part, and to the bottom, or heated part, of the vessels. The air being heated or cooled as the plungers were respectively at the top or bottom of their stroke, a difference of pressure ensued in the spaces above and below the working piston. Two engines of this kind were constructed, one of 45 horse power, working for upwards of three years in driving the works of the Dundee foundry. It was, however, ultimately laid aside, owing to the failure of the heating vessels under the exposure to the great heat.

This was in 1845, and some time afterwards Captain Ericsson came forward with his so-called caloric engine, which was carried out on a large scale in the form of a pair of marine engines of 600-horse power. To all these engines was applied the Stirling regenerator consisting of a passage chamber filled either with thin metallic grating, with copper wire gauze or with thin metallic tubes. The spent heated air exhausted through them, left behind a portion of its heat, which was picked up by the incoming cold air on its passage in the opposite direction. Using as much as 4900 square feet of heating surface, Ericsson seems to have expected to get back with the incoming air all the heat expended in working the engine. Mr. Cook showed a large diagram of Ericsson's form of air engine—too well known and too much resembling in principle Stirlings' to need recapitulating its points.

Mr. Wenham's hot-air engine belongs to the class in which the fire is enclosed and fed by air pumped in beneath the grate to maintain the combustion, the larger portion of the air entering above the fire to be heated, the whole—together with the products of combustion—being made to act on the piston. Sir George Cayley, as stated, first brought an engine of this kind to work. The air pumped in could be conveyed above or below the fire at will. It first passed round a casing surrounding the furnace to keep it cool, and the cylinder was surrounded by a water belt. Such an engine was at work for months, but its joints gave great trouble, and the cylinder and piston packing were quickly destroyed by the dust and grit from the fuel. An attempt to filter the air by passing it through sheets of wire gauze failed through their choking up.

The next step forward with this kind of engine was the invention of the protecting drum—first brought out in America—for a single-acting vertical cylinder, in which the working pressure acts on the under side only. The drum is a prolongation of the piston, and, its length slightly exceeding the stroke, its diameter being slightly less than that of the cylinder, and the packing ring being near the top, the working portions are thus very ingeniously protected.

The engraving gives a sectional view of Wenham's engine of 1-horse power. A special feature is the furnace shown at A, in which perfect combustion is obtained from ordinary bituminous coal, which is generally preferred for this engine. The space under the grate is separated from the upper part by a moderately air-tight diaphragm, and above the grate is an annulus of segmental fire-bricks (as shown) with semi-cylindrical grooves at their joints, so that when placed together the centre forms a cylindrical hopper containing a store of fuel sufficient for several hours' work, and the grooves at the joints form a series of vertical flues through the bricks. The column of coal descends as it is consumed on the furnace bars, and the air, coming into contact with nothing but coal in a state of incandescent ignition, all the products of combustion must pass through the ignited portion. The channels in the fire-bricks that serve as flues being also white-hot, no unconsumed fire gases can pass through.

The furnace has a cover by which it can be hermetically closed in front of the ashpit, shown at Z, and there is a similar cover for filling the coal hopper at Y. The products of combustion after leaving the channels of the bricks are met by a baffle-plate W, lined with fire-clay, which prevents the cover of the furnace from getting unduly hot. The fire-bricks are separated from the outside shell of the stove by a ring of powdered brick or ashes. There are two cold air supply inlets to the fire, the one below the fire at T, and the other above the fire at S, and there is a swing valve, by which more or less of the air supply is directed below or above the fire. If all the air be directed *below* the fire the combustion becomes very intense, and the heat, and consequent expansion of the air, correspondingly great, and the engine will gain in power and speed. If, on the other hand, all the air be directed *above* the fire through the passage S, a very dull fire will be the result; the air will be comparatively cool with less increase of volume, and there will be a diminution in the power of the engine. This difference of power serves as a very effective means of regulating the speed of the engine, and the governor was consequently attached to the lever of the swing valve at S. No other regulation for speed is required, giving this advantage that the combustion of the coal is exactly proportioned to the amount of work performed.

The engine is of the "steeple" form, having two piston rods placed diagonally, with the main or crank shaft running between them; and in order to make the cylinder as compact as possible the cylinder cover is provided with a segmental chase or depression, in which the crank passes. The engine is single-acting, the air pressure acting on the underside of the piston only, the air is admitted from the heater by means of a "poppet" valve E, moved by a cam at G on the main shaft. There is a similar valve, also moved by a cam, which opens from the cylinder to the exhaust. This valve is shown at F.

The chief peculiarity in this engine is the method by which the top of the cylinder serves as the air pump, and is made to convey into the heater for expansion the reduced bulk of air required for the due performance of the engine. The top of the piston does not reach the cylinder cover, but there is a clearance space left between them. The result is that the pressure in the heater should never exceed 15 lb. on the square inch, the extent of this pressure is obtained entirely by the amount of clearance space above the piston the action of which may be thus explained. The piston rises until it compresses the air contained in the air pump to half its volume, or to a pressure of 15 lb. per square inch, and not till then does there exist equilibrium between the air in the air-pump and that in the heater. The pump valve Q then opens, and during the remainder of the stroke air is pumped into the furnace. At the end of the stroke the valve Q closes, leaving still 15 lb. pressure in the space above the piston. As there is no further escape for this, it acts upon the piston during part of the down stroke and equalises the action of the engine, a small fly-wheel only is therefore required.

This, is of course, not any advantage in power, for whatever power is required in order to obtain this pressure of 15 lb. above the piston, must be deducted from the force of the up-stroke, it is only transferred from the lower side of the piston to be utilised above by the subsequent expansion of the compressed air. After this expansion has ceased the inlet air-pump valve below Q opens, and admits the quantity of cold air required for the next stroke of the engine.

KASTENBEIN'S TYPE COMPOSING AND DISTRIBUTING MACHINES.—(See page 73.)

Machines for composing and distributing type have occupied the minds of inventors for many years and there does not seem to be any reason why a satisfactory solution of the question should not some day be arrived at. The probability is that like many other similar things the machines will improve gradually by the independent labor of different minds. The machines which we illustrate, from *The Engineer*, on page 73, have been adopted by the proprietors of the *Times* and are now used in several printing establishments. Many improvements yet remain to be made but the machines are certainly useful and extremely ingenious.

Considering that nearly a hundred different characters, ninety-six in fact, have to be composed and distributed with speed, the parts of the machines are necessarily complicated in number if not in form, but we hope that with the aid of the accompanying engravings all the main parts will be made intelligible to our readers.

Figs. 1 and 2 represent front and side elevations of the composing machine. Each letter, or other character, has its own receptacle, or type box, in which the characters lie on their sides and one upon the other; these type boxes, which are generally about 15in. in length, are mounted on the top of the machine, and are marked *a* in the engravings. The boxes are without bottoms, which are replaced by a plate in the machine, from which the lowest of the types is pushed when wanted by means of a slide, when this slide recedes, the type falls in a vertical position, face upwards, into a