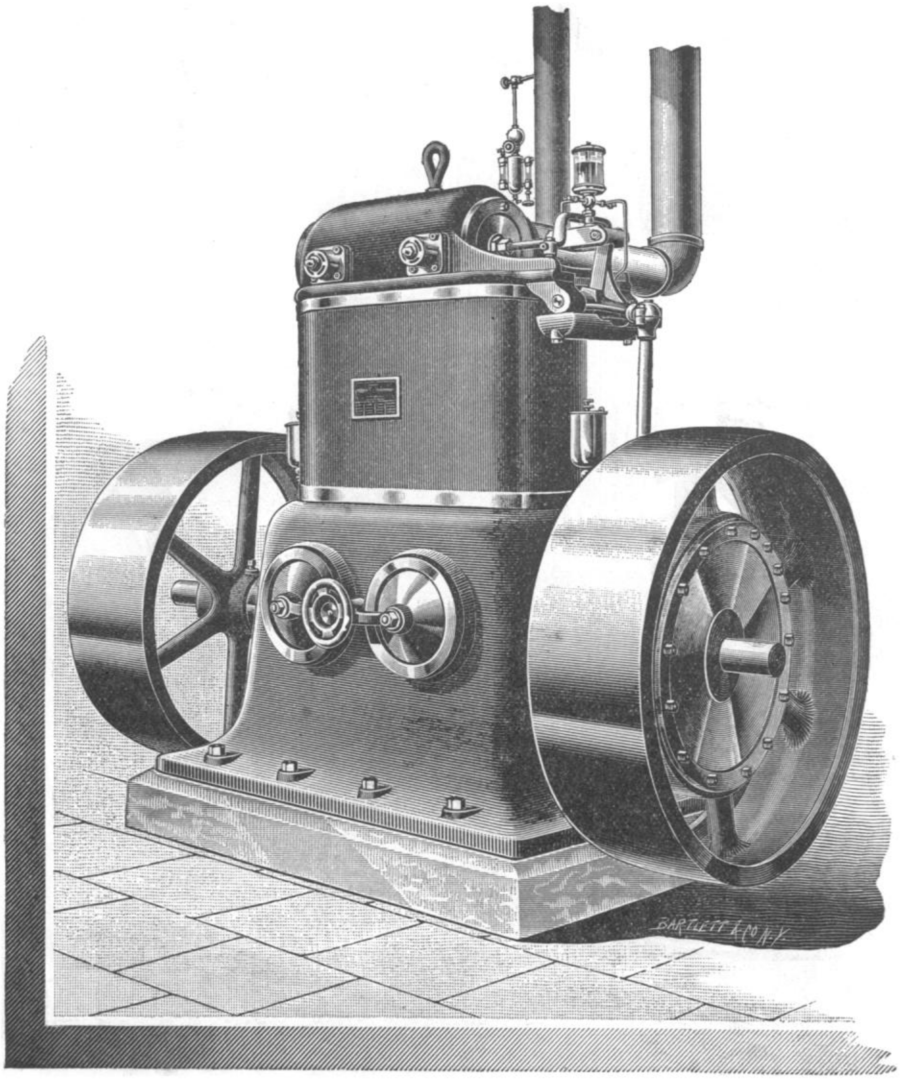
THE WESTINGHOUSE COMPOUND ENGINE.

THE American public is probably now fully prepared to accept compounding as the one and only road to the highest fuel economy in steam-engines. Compounding is almost universal among European manufacturers, extending down to engines of the smallest size, and has been forced upon them by the close margin of manufacturing profit there obtaining. The larger profits and freer methods which have ruled in this country, and particularly the great complication and prohibitive cost which follow the compounding of the ordinary automatic engine, have led to the almost universal adoption of the single cylinder.

It is not proposed to enter into a treatise upon compounding. Every one knows that to compound an engine a second cylinder of three or four times the piston area is added, called the low-pressure cylinder, into which the exhaust steam of the first or high-pressure cylinder, instead of being thrown away, is passed, and made to yield a further amount of work. The additional work thus obtained is roughly proportional to the mean effective pressure in the low-pressure cylinder, multiplied by the difference in area of the two pistons. By this means the power of the engine is increased, and the steam, when finally exhausted, is at a pressure so low that less unused work remains in it. The maximum possibilities of economy are thus secured. But why cannot the same result be reached by further expansion in a single cylinder? A single cylinder, in the performance of its work, must choose between the two horns of a dilemma.

It has been found in practice that there is a certain load which is the most economical in a single cylinder. If the load increases, the terminal pressure increases; which means, that, when the steam is finally thrown away, it still has in it, say, twenty pounds of available pressure above the atmosphere, or thirty-two pounds above effective vacuum, which is a dead waste that ought to be preserved, and converted into work. If, now, we seek to lower the terminal pressure in order to waste less exhaust pressure, we not only cut down the power of the engine enormously, but at once introduce the element of excessive internal condensation in the cylinder, — a most insidious and fatal enemy of economy. Internal condensation is due to the fact that the immediate internal surfaces of the cylinder, cylinder-heads, and piston, are subjected at each stroke to a wide fluctuation of temperature, ranging from, say 330°, the temperature of the steam admitted from the boiler, to 212°, the temperature of the exhaust. The earlier the cut-off, the lower the terminal pressure and corresponding temperature, and the greater the amount of steam required to re-heat the surfaces: hence the greater the condensation. Hence any considerable departure in either direction from the rated power of a single-cylinder engine means a sacrifice of economy, — waste of exhaust pressure if overload, and loss from condensation if under-load. The compound engine, therefore, economizes by getting additional work out of the exhaust steam, which would otherwise be wasted; and by dividing the fluctuations of temperature between two cylinders, compelling one-half the variation to take place in each cylinder, thereby reducing internal condensation in the ratio of the squares, namely, to one-quarter of that due to a single cylinder.



WESTINGHOUSE COMPOUND ENGINE, FRONT VIEW.

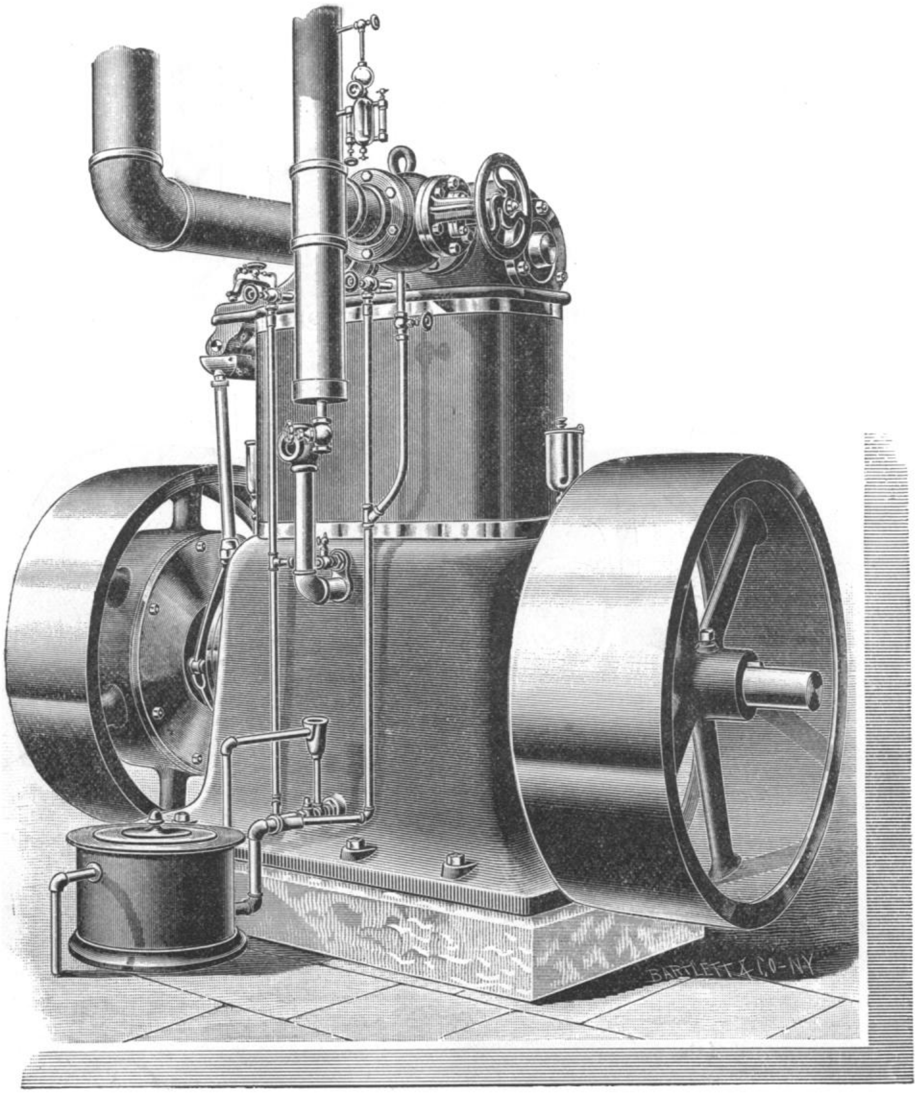
For the Westinghouse compound engine, figures of which illustrate this article, it is claimed that it not only exceeds the economical performance of any single-cylinder engine, but of any other compound engine, size for size, as well. In explanation of this, it is said that it is a high-speed compound engine, the high rotative speed tending to economy of steam by using it quick and using it hot, and to that extent reducing condensation.

Again, the relative position of the two single-acting cylinders, with the cranks opposite instead of at right angles, gets rid at once of an intermediate receiver, and the consequent loss by free expansion due to exhausting from the high-pressure cylinder into the partially emptied receiver at each stroke, which is inseparable from other forms of construction.

But more important than any other factor of economy is the almost theoretical perfection of the steam-distribution. This is the more interesting from the fact that the first step in the design of the compound engine was the laying-out and perfecting of a theoretical diagram on the lines of maximum efficiency, upon which diagram the relative volumes and the valve functions were schemed. This is the reverse of the usual process; but the results, it is claimed, were most conspicuous in their success.

The governing idea in the design is a compound engine in which the functions of admission, cut-off, exhaust, and compression on both the high and low pressure cylinders shall be effected by a single valve, in which intermediate reduction of pressure without corresponding production of useful work shall be obviated, and in which substantially uniform compression to the full initial pressure shall be effected in the high-pressure cylinder, under all variations of load and boiler-pressure, and for all points of cut-off. Such a distribution of steam is theoretically perfect, and has been considered impossible in practice.

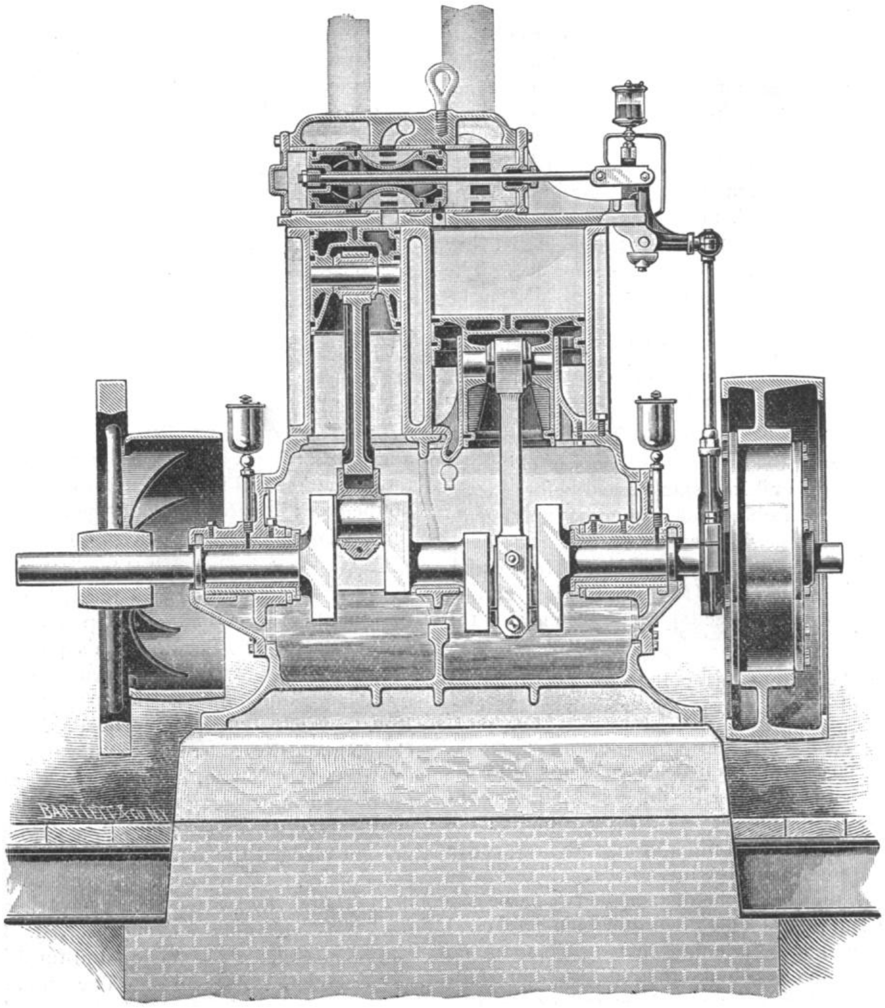
Both practice and theory have demonstrated as a necessity to secure the maximum economy of steam, not only that exhaust compression shall exist, but that it shall be raised exactly to the initial pressure of the incoming steam at the commencement of the stroke. We say exactly, since over-compression is equivalent to non-productive load in any other form; and, still more serious, under-compression fails to restore heat to the cylinder surfaces, besides leaving the clearance volume to be filled at the expense of live steam. This is true in general of any type of engine. It is therefore necessary not only that mechanism should be provided for effecting the full initial compression above indicated, but also that this mechanism, while still maintaining compression exactly to the initial, should at the same time possess the capacity of varying its effort, in order to meet each and every variation of load and pressure under which the engine may from moment to moment be operated. Such a capacity, or the attainment of such a result, constitutes the peculiar feature of the single-acting compound engine on which the Westinghouse Company rests its claims of superior economy.



WESTINGHOUSE COMPOUND ENGINE, REAR VIEW.

In general form, the compound engine more nearly resembles their Junior engine. The mechanical characteristics of the single-acting engine are retained in every particular. One cylinder is enlarged to practically three and a half times the area of the other. The valve-chest is across the top of the cylinders, being the construction which admits of the least possible clearance in the low-pressure cylinder. The valve-chest is in one piece, the various steam-passages being chambered in it. The valve-seat is in the form of a bush, in which the ports are cut, not cast, to an exact register. This bushing is reamed out, and forced steam-tight into its bored seat. This form of construction has many advantages. The casting is greatly simplified, avoiding all chances of porousness, sand-holes, and other defects which are liable to cause concealed leaks. The valve-seat can be made perfect, and the parts registered exactly, on which latter fact depends the perfection of the steam-distribution, and the consequent economy of the engine; and, lastly, the valve-seat can be easily and cheaply renewed when worn.

The valve-chest also contains a small by-pass valve controlling a cored passage, by which live steam can be admitted to the low-pressure cylinder, to turn the engine over its centre when starting. The steam and exhaust connections are on the side of the valve-chest towards the back of the engine, bringing the throttle-valve into convenient position, and admitting of the ready removal of the valve-chest when desired.



WESTINGHOUSE COMPOUND ENGINE, LONGITUDINAL SECTION.

NOTES AND NEWS.

F. M. WEBSTER, Purdue University, La Fayette, Ind., in a letter to the United States Entomological Bureau, Dec. 23, 1887, states that some two or three years previous samples of various substances used for insecticides were placed in the Agricultural Museum of Purdue University, at La Fayette, Ind. As the object was merely to display the substances, they were placed in glass flasks, such as are used for similar displays of seeds, the mouth being in the base when the flask is in an upright position. One of these flasks contained several ounces of powdered white hellebore, which, as it was never disturbed, had settled into a somewhat compact body. On removing this flask a few days later, the cork stopper was found to have been burrowed through, evidently from without, and the mass of powder was literally full of burrows and channels passing through it in all directions. On turning the powder out upon a table, and examining it carefully, two adult beetles of *Tenebrioides mauritanica* were found dead in the burrows in the powder. How long these beetles had remained in the powder alive, it is obviously impossible to state; but it would be safe to say that they entered it from motives of choice, and either subsisted upon it, or else did an incredible amount of tunnelling without sustenance. While at the time the beetles were removed from the powder the latter was not fresh, and did not retain its full strength, there still remained enough to impart a tingling, burning sensation to the nostrils when any of the powder was inhaled through the nose, yet not enough to set one to sneezing.

— In Germany, for some years past, according to the *Journal of the Society of Arts*, London, efforts have been made, and with considerable success, to acclimatize the oak silkworms of China and Japan (*Attacus Pernyi* and *Attacus Yama-mai*). They have been raised in the open air, protected from the attacks of birds by nets of gauze or wire, changed from place to place as the oak-leaves are consumed. Late frosts and excessively dry weather have been injurious in depriving the worms of food. In California a new wild silk-moth, before unknown, has been found thriving on the poisonous species of *Rhamnus Californicus* or *R. Purshianus*. It produces a silk as good as that of the domesticated *Bombyx*. Owing to the favorable nature of the climate, without the frosts or rains of China and Japan, great hopes are obtained of propagating this species. In Yucatan a wild moth has also been met with, somewhat allied to the mulberry-worm, which produces silk of a bluish tint; but the gum which envelops it is difficult to remove. Mr. John MacIntyre, a recent traveller in Manchuria, records having met with several new species of silkworm, which he describes in the *Chinese Times*. One wild worm feeds on the *Pinus chinensis*. It forms handsome cocoons, which yield a strong silk; but they are so mixed up with the needle-like leaves of the pine, that the