THE ISOCHRONAL WORTHINGTON PUMPING ENGINE.

By J. K. MAXWELL.

The steam pump is of recent origin, and has just now, by the expiration of the principal patents covering its essential parts, become an article of commerce, in the manufacture and sale of which the public may enter without let or hindrance. As the first steam engines were used for pumping, it is necessary to explain the difference between those and the "steam pump," which can be best understood by stating that the valves of early steam engines used for pumping were operated by bob weights, or springs, lifted or compressed as the engine approached the end of its stroke, and released at the proper time to reverse the steam valves.

The steam pump of the present day is provided with an auxiliary valve-moving engine, the valve of this auxiliary engine being moved by the main engine, and the valve of the main engine moved by the auxiliary engine without the assistance of the momentum of the main engine, the falling of weights, the compression of springs, or releasing of latches of any kind; all its motions being produced by steam direct from the boiler.

Some manufacturers use tappets, so arranged that at rapid speeds the momentum of the main piston assists in moving the main valve, while at slow speeds the auxiliary engine alone performs that office.

There is no record as to the origin of the idea of using one engine to move the valve of another. It was probably thought of soon after engines were made to move their own valves. The first record we have of such an arrangement was in a patent issued in England, to Dixon, in 1837, in which he mentioned two, three or four engines as being so placed that the valve of each could be operated by its neighbor. About 1830 Mr. Penn used a small pump piston and steam piston on the same rod, the valves of the engine being operated by a spring and latch. But little more was done in that direction until Worthington took up the subject, and after considerable labor produced what was called the "Baker & Worthington Jumper," which consisted of a steam piston and pump plunger on opposite ends of the same rod, and a tappet arm projecting from the middle upward, to engage with collars on the valve rod of the engine. The pump plunger worked through a central collar, and when it came near the end of

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Vertical Section of Duplex or Separate-acting Compound Condensing Engine.

Fig. 17. 5c

the stroke it passed out of the collar suddenly, equalizing the pressure on each end of the pump. So the main piston would jump forward enough to reverse the main valve.

In such a machine it was necessary to establish a resisting pressure in the pump before it could become self-operative. It was useful in its day, but was violent in action, suited only for moderate pressures and medium sizes. It was the principal steam pump in use until 1855, when C. A. Wilson, of Cincinnati, Ohio, and Hubbard & Conant, of New York, invented, and the latter took out a patent for, the first successful steam pump, with its valve operated by steam alone, and provided with cushion ports to prevent the valve-moving piston from striking the ends of its cylinder, which, though a small addition to what was already known, rendered the steam pump a comparatively safe and nearly noiseless machine. This was the first great step toward popularizing the modern steam pump. From 1855, for fourteen years, a great many patents were issued, out of which ten or twelve machines became the basis for considerable manufacturing establishments, and are still sold in the market.

In nearly all, the tappet arm of the Worthington was combined with the valve-moving device of Hubbard & Conant, so that if the latter failed the former would come to the rescue and carry the valve over the ports. A. S. Cameron produced the first successful steam pump without the tappet arm, using the main piston to push open small exhaust valves at the end of each stroke to reverse the main slide valve. In 1866 Cope & Maxwell patented the first successful steam pump operating its steam valve without tappets of any kind. It would work without noise at any speed. There were but two moving parts in it, namely, the main piston and the steam valve. Being without tappets and noiseless, the speed of the engine was limited only by the time required to seat the pump valves, so that very small machines were frequently forced to do more work than they should, and the pump valves were rapidly destroyed. In this type of machine rapidity of action reached its maximum.

About 1859 Worthington's "Jumper" had convinced him that rapid motion in reversing a steam pump was very destructive of its parts, so he doubled the machine and made one engine move the valve of the other, allowing one to rest at the end while the other is making the principal part of its stroke, which, though it seems a small step forward, yet in its practical appli-

cation its effect is almost marvelous. As an artificial means of producing an even flow of water through pipes it has no equal; its effect is superior to any number of pistons driven by cranks arranged on a rotating disk. It is commonly called the Duplex Engine, and is extensively used for waterworks and other heavy pumping. By an improvement adopted by Allison, and subsequently added to by Cope & Maxwell, the same quiet action is obtained in the single pumping engine. A piston attached to the main slide valve, working in a cylinder filled with fluid, with a stop cock in the channel leading from one end to the other, causes the slide valve to move slowly across its ports. The slide valve being provided with the proper lap, produces a pause at the end of the stroke, preventing a sudden reversal, giving quiet action. By arranging the water cushion cylinder on a lever operated by the main engine, and moving in a direction opposite to that of the main slide valve, which is forced along by the auxiliary engine with constant energy, and the resistance being increased through the cushion cylinder by the velocity of the main piston, the main slide valve opens until the main piston acquires sufficient velocity for the two forces to neutralize each other. Then it remains stationary while the piston velocity is constant. If the piston attempts to move quicker it will close the main valve, if slower it will open wider. It is a speed governor, controlling all parts of each stroke, independent of the load on the main engine. It is called the Isochronal Engine, as its piston moves through equal spaces in equal times. By combining the double engine of Worthington with the Isochronal feature of Cope & Maxwell the greatest safety and the most perfect action thus far attained in the direct-acting engine is secured. From the above-mentioned peculiarities it is named the "Isochronal Worthington Pumping Engine."

These engines are of the direct-acting, compound-condensing type, and are fitted with steam-moved valves, controlled by Cope & Maxwell's patent regulator or governor, whereby each machine is accurately controlled under any conditions of service, being in fact an ever watchful and never tiring engineer. The engines are combined and arranged so that each may be run singly if desired; or, in a moment's time they may be changed to work as duplex machines; engine No. 1 controlling its own main slide-valves through its governor, moves the auxiliary slide-valve of engine No. 2, to admit steam to move its main slide-valve; while engine No. 2 controls its own main slide-valves through

its governor, and moves the auxiliary slide-valve of engine No. 1 to admit steam to move its main slide-valve, thus keeping up a continuous plunger action and flow of water from the pumps. Each engine has an independent condenser and two air-pumps, the latter being operated from the rock shaft that gives motion to the governor or regulator cylinder.

The pumps are of the plunger variety, with packing-boxes in the middle, between the valve chambers, which admits of the packing being tightened up while the pumps are in motion. The pump-valves are easily accessible for inspection by the removal of a single cap at each end of the pump chambers. Ample air and vacuum vessels are provided, as are also shut-off valves for the suction and discharge pipes of each pump.

EXPLOSIVE AND DANGEROUS DUSTS.

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During the month of May last I was honored with an invitation to address the Kentucky Millers' Association on "Flour Explosions." Being a subject in which I had for many years been interested, I cheerfully undertook the preparation of a lecture, with illustrations. The experiments, although not new, for chemists well know the combustible nature of organic dust in a finely divided condition, yet so impressed my audience that I was more than repaid, on my part, in their interest and applause for the small amount of labor expended. In preparing that lecture there appeared to me certain conditions governing the combustible state of flour which hitherto had been passed by in investigating the appalling catastrophes that from time to time befall our national industries, in the form of mill fires and explosions. Many of my suggestions, the outgrowth of subsequent experiments, have been received with favor; and my theories, if such I may presume to term them, have had the endorsement of practical men before whom they have found their way. The desire to prosecute the