used for insulating the adjacent layers of wire from each other, but in the ½-inch coil it should come to within ⅛ inch of the circumference of the cheek, in the 1-inch coil to within 3-16 inch, and in the 2-inch coil to within ¼ inch. If there are not enough layers of wire and paper to give it the proper diameter, then it may be built up with additional sheets of paper.

The coil may be finished by bending a thin sheet of hard rubber, having a number of opposing holes drilled through near the ends and ¼ inch apart around it, and lacing it up with waxed black linen thread, or a cheaper way is to cover it with black pebbled book-binders' cloth and gluing the edges together.

The coil may then be taken out of the lathe and the cylindrical block removed from the aperture of the rear cheek and the shank of a turned button inserted in its stead to give it a finished appearance. The cheeks of the spool may then be screwed on the base of the instrument, which has previously been prepared to receive it, and which is provided with a condenser mounted in its interior, while a simple spring interrupter, reversing switch, and binding posts for connecting in the battery, are mounted on top.

When the terminals of the primary coil are properly connected with the foregoing devices, and each of the terminals of the secondary coil is connected with a brass plug end, to which it should be soldered, and then inserted in the radial hole, so that when the binding posts are screwed in they will make contact with them, the coil is complete and will present the aspect illustrated in Fig. 6.

PUMPING DEVICES FOR OPEN TANK SERVICE.*

By W. H. WAKEMAN.

IN thousands of buildings of various kinds and different heights it is necessary to maintain one or more tanks on the roof or in the upper story for the purpose of holding water to supplement the local department in case of fire, or for various uses in every-day service in and about the buildings. The expense of buying

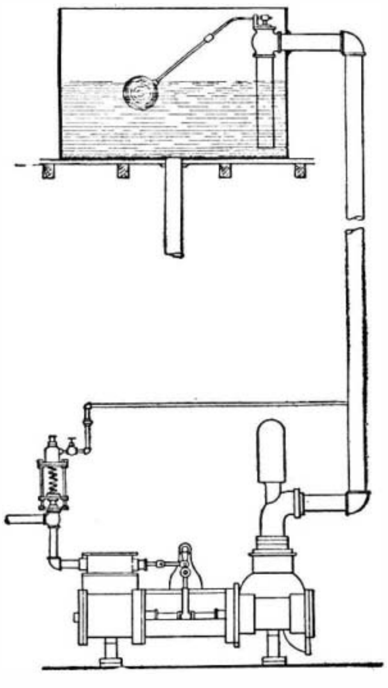


FIG. 1.

water from the water company, the lack of sufficient pressure in the mains to deliver this water where it is wanted in high buildings, or a combination of the two reasons given, makes it necessary in many cases to elevate it from wells, brooks, or street mains into these tanks by means of suitable pumps.

As the amount of water drawn out of these tanks from time to time varies greatly, and inasmuch as it is advisable to keep them nearly full without causing them to overflow, some kind of an automatic device is necessary to control the delivery of water that will be reliable in service and require little attention from the engineer in charge.

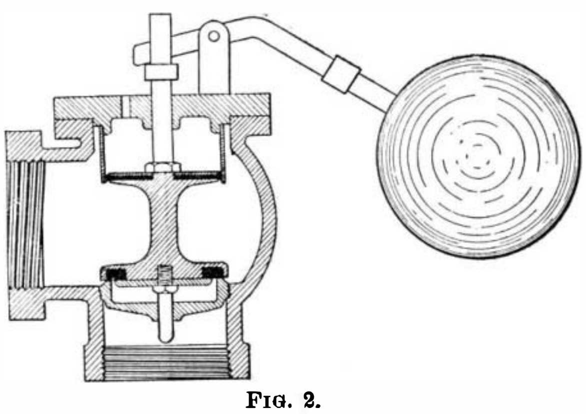


FIG. 2.

Fig. 1 represents an ordinary steam pump fitted with one of these devices. It is pumping water into an open tank, and near the end of the discharge-pipe there is a float-valve which shuts off the supply when the tank is full. Closing this valve causes pressure to rise in the discharge-pipe, and as there is a small pipe connected into it, this pressure is communicated to the regulator on the steam pipe, which is adjusted to close at a pressure slightly above normal conditions, thus shutting off steam and stopping the pump. When the water level in this tank is lowered a few inches, the float-valve opens, lowering the pressure,

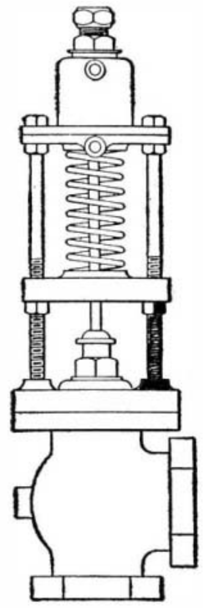


FIG. 3.

which permits the regulator-valve to open and admit steam to the pump again, thus securing water to maintain the desired quantity. These tanks should always be painted with Dixon's graphite paint to prevent rust and corrosion if made of iron, and to preserve the wood where tanks are made of this material.

An ordinary unbalanced float-valve will not answer

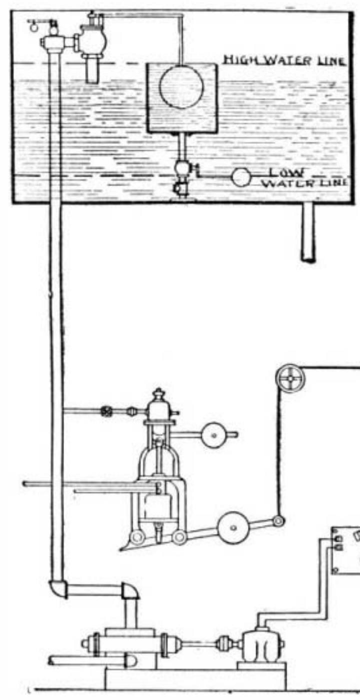


FIG. 4.

for this service, as it will work so hard that much force will be required to close it, and when the water level falls it will not open easily with full pressure acting on it. Fig. 2 illustrates a balanced valve that overcomes these objectionable features, as it is so nearly balanced that but little force is required to close it, and for the same reason it opens easily. It must be connected so that water will enter at the side and be discharged through the bottom.

Fig. 3 illustrates a reducing valve or regulator, which may be used in the steam pipe of a pump to control its speed. With ordinary pressure in the discharge water pipe, the helical spring (more commonly but incorrectly called a coil spring), keeps the steam valve open, but when closure of the float-valve causes pressure to rise in the discharge water pipe it acts on a diaphragm in the regulator, and overcoming the spring closes the valve.

In cases where the pump is to be shut down for a long time without attention from the engineer, a special fixture may be required, but the foregoing description explains the principle of operation.

Poor cylinder oil is sometimes used to lubricate the cylinders of pumps that are fitted with these economical and useful devices, and as this oil goes through the regulators also, they soon become so clogged with sediment from the oil that they are absolutely useless, which is certainly a great mistake. It would be much better to use Dixon's flake graphite and eliminate the objectionable oil entirely.

Fig. 4 illustrates a pump driven by an electric motor operated by a controller to maintain a water supply in an elevated tank. The illustration shows the tank just after it has been filled, and the motor is now at rest. Water is being drawn out for use in the building below, thus lowering the water line, but the pump is not started because the small auxiliary tank remains full, and this holds the float up, keeping the discharge valve closed.

When enough has been drawn out to bring it down to the low-water line, the lower float-valve will open and quickly empty the small tank, thus lowering the large float and opening the discharge valve. As this at once lowers the water pressure, the reduction is communicated to the controller, its position is reversed, causing the large round weight to descend, drawing the small wire cable over the two pulleys shown, which throws the switch in and starts the motor, thus filling the tank again.

The first effect of putting in more water is to close the lower float, but nothing else happens until the high-water line is reached, when water flows over into the small tank, raises the float, which closes the discharge or float-valve in the water pipe and stops the pump by causing the controller to throw out the switch, thus bringing it again into the position shown.

The object of this is to prevent the motor from being started and stopped often, as it would be if only one float-valve was used to control the pumping system. A small safety-valve is shown at the top of the discharge water pipe, so that if the motor fails to stop on account of derangement of the connecting devices, the safety-valve will open and prevent excessive pressure in the pipe. Attention is called to the fact that there are no wires connecting the float with the motor, as only those from the dynamo, or the street service wires, to the motor are used in connection with this ingenious device.

In buildings where an engine is run every day it is often advisable to utilize power from this source for pumping water, or in other words to run a power pump. In order to do this satisfactorily it is necessary to have a pump large enough and give it sufficient speed to supply the maximum quantity desired. An arrangement for shutting it down when the tank is full should form part of the outfit, as otherwise it would not be complete.

Fig. 5 shows a power-pump fitted with an automatic belt shifting attachment which operates as follows: When the pump has filled the tank, which action closes the discharge water-valve or float-valve, and commences to raise pressure in the discharge pipe, it

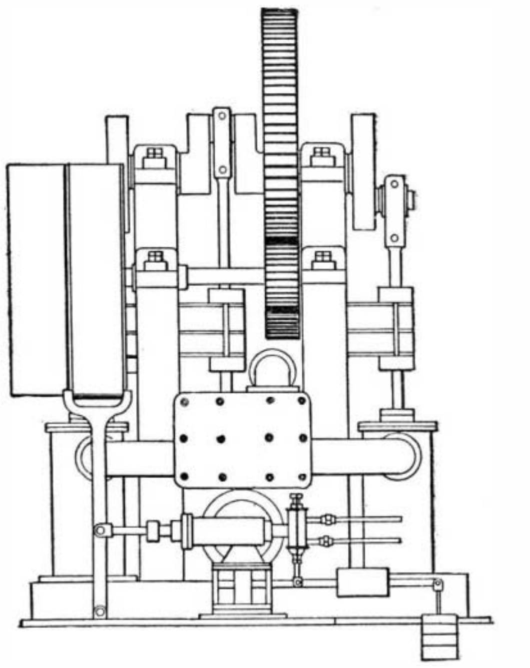


FIG 5.

is communicated to the small pilot-valve shown in front of the pump. This opens and allows water under high pressure to enter the horizontal cylinder near the valve where it operates on a piston, forcing it to the left hand, carrying the belt-shifter with it, running the belt onto the loose pulley and stopping the pump.

When water is drawn out of the tank, causing the float-valve to open, pressure is at once reduced in the discharge pipe. The weighted lever in front of the pump is lowered, shutting off water from one side of

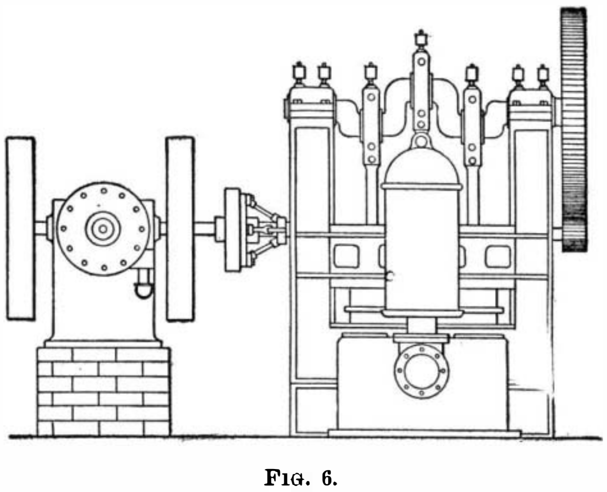


FIG. 6.

the piston and admitting it to the other, thus forcing it to the right hand again, running the belt back on to the tight pulley and starting the pump. This operation is repeated as often as the service requires, and there is no waste of power, as the pump is idle when water is not needed.

This is a triplex pump, and as the cranks are set at 120 degrees, one plunger delivers water after another at equal and short intervals, indefinitely, thus mak-

* Graphite.

ing an almost continuous stream delivered to the tank, which eliminates the shocks and jars due to intermittent action of pumps. This may seem a small matter to engineers who are employed in noisy mills and factories, but it is a large one to those who have charge of office buildings and schools where all noise is objectionable. Dixon's traction belt dressing should be used on these belts, as it will prevent slipping and squeaking, causing the pump to start promptly.

Of course it is possible to run a power pump without this controlling device, but it requires time and care to run the belt off when the tank is full, then to run it on again when more water is wanted. This plan almost always results in the loss of power by pumping water when it is not needed, flooding roofs, etc., also in lack of water due to an empty tank when it is wanted.

In many important buildings no steam is used during the summer and only a low pressure is available in winter. In such cases a gas engine may be used to pump the water, and while it is possible to run a power pump with a belt from an engine of this kind, the same as any other machine would be run, it would then be necessary to start the engine when water is wanted and shut it down when the tank is full, causing much unnecessary care and attention, especially if varying amounts of water are used from time to time.

Fig. 6 illustrates a triple-power pump driven by direct connection to a gas or gasoline engine. There is a clutch between them, however, which may be operated by hand or by means of a special device that stops the pump when the tank is full, and starts it again when more water is needed. If the pump is to be stopped for an hour or more, it is a good plan to stop the engine also, unless it is run to supply power for other purposes. If steady power is wanted, then the automatic clutch should be installed, and it will take care of the water supply without constant watching.

The principle on which this operates is similar to that already described in connection with the belt-shifting device. It is very economical in the use of power, as the pump runs when it is needed and at no other time.

This pump is fitted with seven grease cups in which Dixon's graphite grease may be used to good advantage. These are automatic cups, which feed this grease to keep bearings cool, rather than to wait until they heat enough to cause the grease to melt. This is an important difference that ought not to be overlooked.

HALLEY'S COMET.*

By F. W. Henkel, B.A., F.R.A.S., Late Director of Markree Observatory.

The shortly expected return of this well-known object, which was the first of these bodies known to move in closed paths round the sun, and the remarkable phenomena attending its last appearance (in 1835 and 1836) render Halley's comet a peculiar object of interest at the present time.

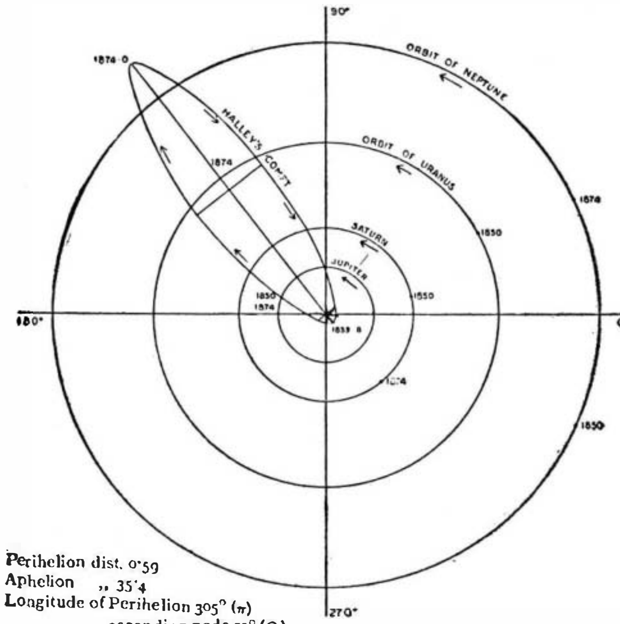
Newton, in the third section of the Principia, first showed that a body moving under the influence of a force varying inversely as the square of the distance from the center of force, will describe one or other of the curves known as the "conic sections," i.e., either an ellipse (or circle, as a special case), a parabola, or a hyperbola. These three curves may all be obtained by cutting a cone in different ways by a plane, but perhaps they may be more intelligibly defined to the non-mathematical reader as obtained by throwing the shadow of a circular disk upon a plane, such as the surface of a table. If, however, the disk is held parallel to the table, we shall get a circle; if it is held edgeways to the light, the shadow will be a straight line. If now we raise our disk so that its highest point is on a level with the source of light, we shall get a curve known as a parabola, which will be oval at one end, but the two sides will open out. If now we hold our disk still higher, we shall get another curve still, whose two sides will separate even farther from one another. This curve is known as the hyperbola.

While the planets move in ellipses, so little differing from circles that if represented on paper the deviation is not perceptible, on the other hand, most comets are found to move in orbits so nearly parabolic that only in a few cases are they known to be otherwise. A great comet which appeared in 1680, and approached very close to the sun, was the first whose path was calculated as a parabola, though there is some reason to believe that it was not truly so, but an enormously elongated ellipse.

In 1682 a comet was observed by Newton, Halley, and others, and on examining the circumstances of its motion, Edmund Halley computed its orbit on the supposition that this was a parabola. Comparing his results with observations of previous comets, for which purpose it was necessary for him to compute their orbits from the necessarily imperfect observations of earlier times, he found that in 1531 and 1607 comets had appeared which followed so nearly the same path as this one that he ventured to assert its identity with them, and to predict its return in a period of about seventy-five years. It was afterward ascertained that comets had been seen in 1066, 1378, and 1456 whose paths were the same as that of the comet of 1682, and it is now known that all these were apparitions of one and the same body. In 1066 its appearance was figured on the Bayeux tapestry, and it was regarded (after the event) as an omen of the Norman conquest. In 1456 the comet is said to have been of extraordinary splendor, its tail 60 degrees long, and it is stated that a papal bull was fulminated against the Turks and the comet, and it was ordained that the bells of all churches should be rung at mid-day. Although Halley had predicted its reappearance, he did not live to observe this himself, dying in 1742, at the age of 83, after having been Astronomer Royal for twenty-three years. He pointed out that the comet must have passed very near the planet Jupiter in the interval between 1607 and 1682, and its velocity increased, thereby resulting in a shortening of its period of revolution. Thus he concluded that, while the interval between 1607 and 1682 was only seventy-five years, the following revolution would probably take a longer time; but the then state of mathematics did not enable him to make the necessary calculations to determine this with accuracy. Were the sun and comet alone existing in space, the latter's path would be an exact ellipse, and the period of its revolution always the same. This is, however, not the case. Besides the sun there are also the planets, and these, by the law of gravitation, attract, and are attracted by, one another, and other bodies. Their masses, however, being very small, in comparison with that of the sun, the general nature of the paths pursued by planets and comets is not changed by this action; but deviations nevertheless arise, which are the more perceptible as their masses are greater and their approaches more close.

Thus Jupiter, the giant planet of our system, whose mass is about 1-1,000 that of the sun, has at times a greater effect on comets when near to him than the sun itself. Lexell's comet of 1770 must have been at one time fifty-eight times less distant from Jupiter than from the sun, and so the planet's attraction ($58^2/1000$ that of the sun) must have been three times greater.

The celebrated Clairaut, who so greatly advanced the science of astronomy by his work on the moon, as well as by his researches in pure mathematics, undertook the great labor of calculating the effect of the action of the planets upon Halley's comet for a period of about 150 years, and in a memoir presented to the Académie des Sciences, at Paris, he predicted the date of perihelion as April 18, 1759, subject to an uncertainty of about a month. As the result of his calculations he estimated that the period of revolution of the comet was increased by 100 days on account of the action of Saturn, and 518 days by Jupiter. It was first seen by Palitsch, a Saxon peasant, about the end of 1758, and came to perihelion on March 12, 1759, just a month earlier than the time assigned by Clairaut. Before its next return the orbit was calculated by no less than four mathematicians, Damoiseau, Pontécoulant, Rosenberger, and Lehmann, and they all agreed in giving a day in the month of November, 1835, as the time of its perihelion passage. It was first seen at Rome early in August of that year, and was visible up to the 16th of November in the northern hemisphere.



After this, passing its perihelion on that day, it was seen at the Cape and at Melbourne up to the early part of May, 1836, when it finally disappeared from view. Very careful observations and elaborate drawings of its appearance were made by Sir John Herschel, who was then in South Africa. At first it presented the appearance of an almost round nebula, having a bright nucleus not quite at its center. By the beginning of October, 1835, a small tail appeared, and this reached a length of about 20 deg. by the middle of the month. After this the tail diminished, so that before the time of perihelion (November 16) it had again disappeared. On the 2d of October, the day when the tail was first seen, an emission of light was seen coming from the nucleus, on the side presented toward the sun. This emission ceased for a time and then recommenced on the 8th of that month. At this time one observer perceived what he called a "second tail," in a direction opposite to the original tail, thus presented toward the sun. The shape and brightness of the emanations continually varied from the 5th to the 22d of October. At one time two or three emanations were seen to issue in different directions, these having forms sometimes like that of a gas flame coming from a flattened opening, at other times only slightly divergent, and again occasionally only one jet was seen. When more than one such jet or emanation was visible, the principal jet of light oscillated in direction to and fro on either side of the line directed toward the sun, "like a compass needle thrown into vibration and oscillating about a mean position." Sir J. Herschel concluded, from his own observations and those of others, that the matter of the nucleus is largely converted into vapor by the sun's heat, and escapes in jets and streams from the parts turned toward the sun. This matter is, however, prevented from proceeding in this direction by some force directed from the sun, much more powerful than gravitation (and repulsive). Being thus repelled from the sun with considerable velocity, it must leave the nucleus altogether, and, consequently, at each approach the comet must lose a portion of its substance, for the feeble attractive power of the nucleus will prevent this matter being retained within the comet's sphere of attraction, and it will be too far away to be re-absorbed afterward. Thus it is probable that at each apparition the comet will be less conspicuous. After passing its perihelion, the comet was not seen again till near the end of January, when it had no longer a tail, but was seen as a small, round disk, surrounded by a "coma" or nebulous envelope. As the comet gradually receded from the sun this coma disappeared as though absorbed into the disk, and this latter increased greatly in size, so that during one week (from January 25 to February 1) it increased in volume forty times. This increase of size continued, so that mainly from this cause it became invisible, its illumination becoming fainter and fainter as its size increased. The shape of the disk changed gradually from a nearly circular form to that of a paraboloid. The nucleus meanwhile remained nearly unchanged, but the ray or jet proceeding from it increased in length and brightness, its direction being along the axis of the paraboloid. "If," says Herschel, "the office of the jets was to feed the tail, the office of the ray would seem to have been to conduct back its successively condensing matter to the nucleus."

The comet's envelope and ray gradually faded, and as last seen it had the same form as in the previous August, viz., that of a small, round nebula, with a bright point near the center. In all, it was visible from the 5th of August, 1835, to the 5th of May, 1836, a period of nine months.

The period of revolution of this comet is given in Herschel's "Outlines of Astronomy" as 27,865.74 days, so that, since it passed its perihelion on the 15th of November, 1835, it should again return to this position on March 2, 1912; but on account of the considerable disturbing action of the planets Jupiter, Saturn, and Uranus, the actual date may differ considerably from this. So eccentric is the position of the sun in its orbit, that while at perihelion the comet's distance from the sun is about 0.586 of the earth's distance, or about 55 millions of miles, it recedes to a distance of 35.4 times that of our earth, or about 3,300 millions of miles, considerably greater than that of Neptune. While the planets all move in orbits lying nearly in the same plane, the comet's orbit makes an angle of 17 deg. with the ecliptic (plane of the earth's orbit), and its motion therein is in a direction contrary to that of the planets (and of most of the other short period comets), or is retrograde. While the planets move in a direction opposite to the hands of a clock, as seen from our northern latitudes, the comet of Halley moves in the "clockwise" direction (as shown in the accompanying diagram). This comet, as also five others, viz., Pons's comet, seen in 1812 and 1884; Olbers's comet, seen in 1815 and 1887; De Vico's comet of 1846; Brorsen's comet of 1847, and Westphal's comet of 1852, passes near Neptune's orbit at its aphelion, and these comets are sometimes known as Neptune's family of comets. If at any time a comet enters our system from an infinite distance, moving in a parabola under the sun's attraction, it will have its motion either accelerated or retarded when it comes near any of the planets. The smallest increase of velocity will change the parabolic orbit into a hyperbolic one, the smallest decrease will convert it into an ellipse. In the latter case the comet will become a permanent member of our system. This it is possible is what has actually happened, and the converse case of a loss seems also to have occurred. A comet was discovered in 1770, and was shown by Lexell to move in an elliptic orbit, with a short period of about five and one-half years. It was, however, never seen again, nor were any former records of its appearance to be found. Lexell, however, showed that in 1767, when at its aphelion, or farthest from the sun, the comet must have been fifty-eight times nearer to the planet Jupiter than to the sun, and that then the planet's attraction on it was three times that of the sun; that in all probability it had been moving in a parabola, which orbit was converted into an ellipse by the planet's action. He further showed that since the aphelion was close to Jupiter's orbit and the comet's period five and one-half years, that of Jupiter being eleven years, at the end of two revolutions of the comet and one of the planet they would again be close together, 500 times less than their distance from the sun, so that in all probability the comet's orbit would become again parabolic or hyperbolic. Thus he anticipated its eventual disappearance, and, in fact, it was never again seen. Laplace and Leverrier later showed, however, that Lexell's results were liable to considerable uncertainty.

Although, as we have stated, the motion of a comet is greatly affected by the proximity of a planet, the

* Knowledge and Scientific News.