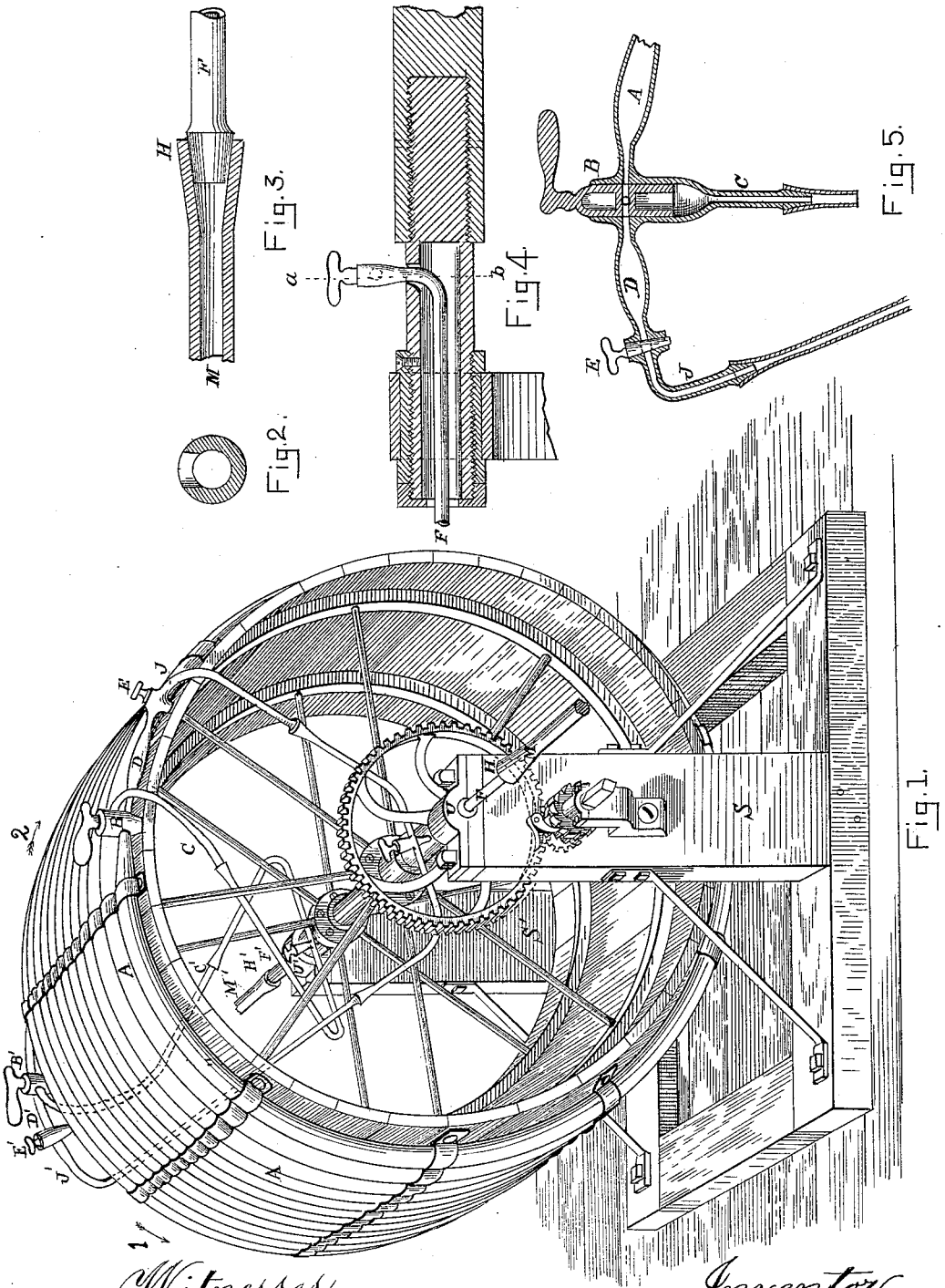
(No Model.) 3 Sheets—Sheet 1.

F. J. WILLS.

AIR PUMP.

No. 386,516. Patented July 24, 1888.



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(No Model.) 3 Sheets—Sheet 2.

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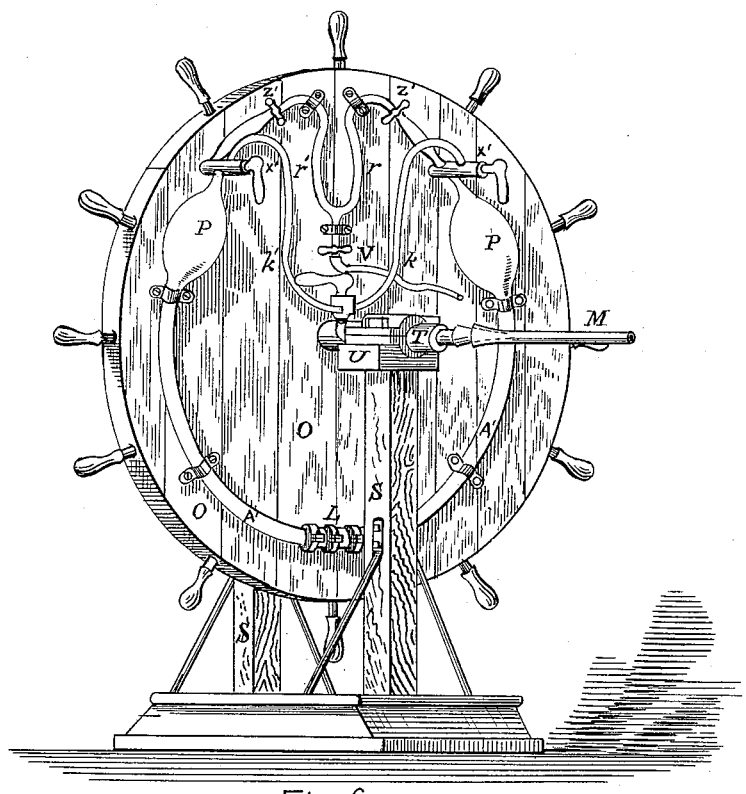

Fig. 6.

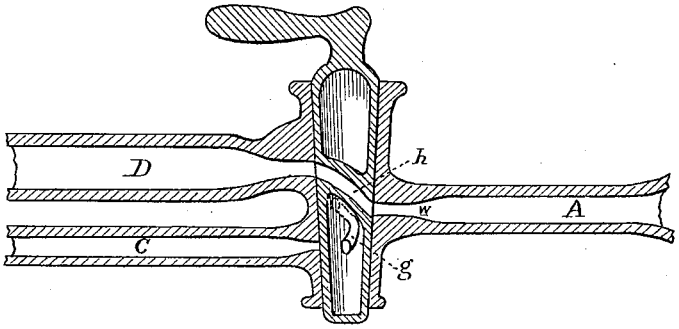

Fig. 7.

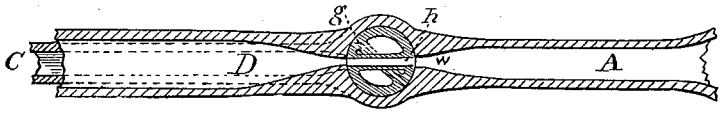

Fig. 8

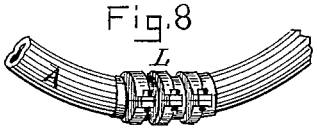

Fig. 9

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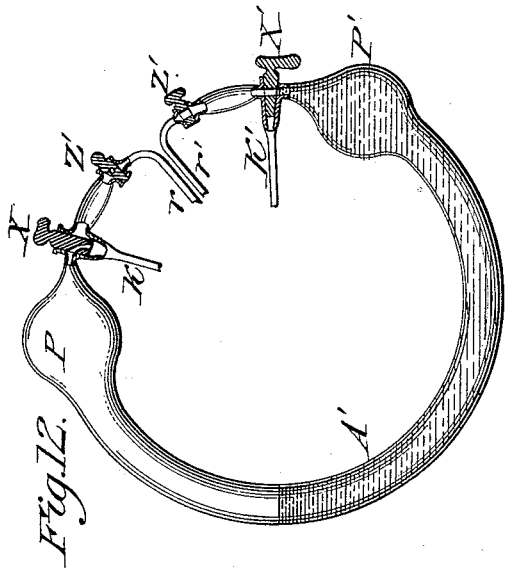

Fig. 12.

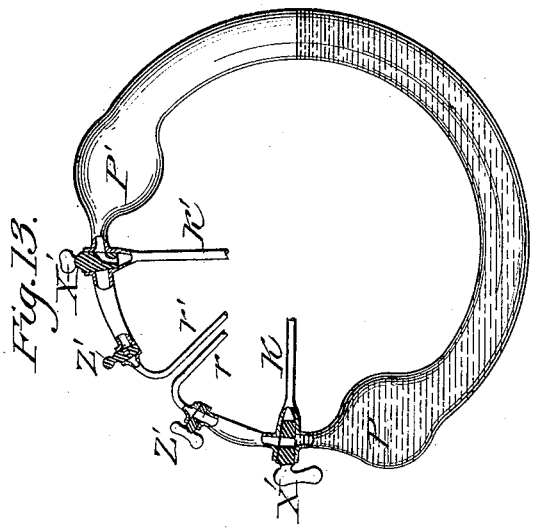

Fig. 13.

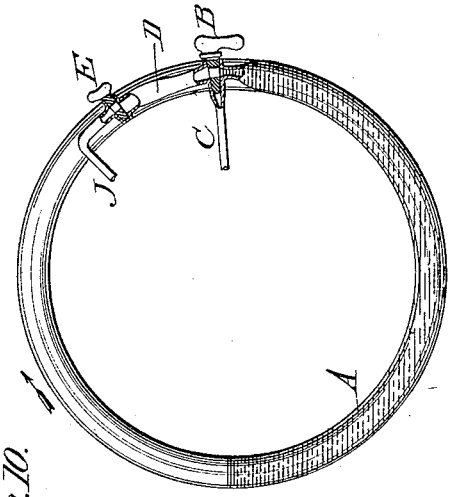

Fig. 10.

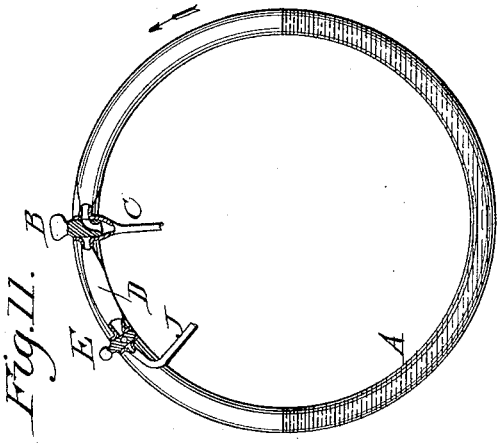

Fig. 11.

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UNITED STATES PATENT OFFICE.

FRANK J. WILLS, OF WINCHESTER, MASSACHUSETTS.

AIR-PUMP.

SPECIFICATION forming part of Letters Patent No. 386,516, dated July 24, 1888.

Application filed March 12, 1887. Serial No. 230,594. (No model.)

To all whom it may concern:

Be it known that I, FRANK J. WILLS, a citizen of the United States, residing at Winchester, in the county of Middlesex and State of Massachusetts, have invented a new and useful Air-Pump, of which the following is a specification.

My invention relates to improvements in air-pumps in which the flow of a body of mercury is the means of exhausting the air; and the objects of my improvements are, first, the production of an extremely high vacuum on a much larger scale than has hitherto been attempted by any known mercurial pump; second, to provide a machine that shall produce this vacuum easily, quickly, and cheaply, and, third, to provide a double-acting machine, which may be operated by hand or any other power. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is an oblique perspective view of the whole machine. Fig. 2 is a section of the extremity of the axle on line *a b*, Fig. 4. Fig. 3 is the ground-joint connection in sectional view G H, Fig. 1. Fig. 4 is a sectional view of one end of the axle, showing connection through the same by means of a bent tube. Fig. 5 shows one form of terminal cocks, &c., in which the old style of three-way cock is utilized. Fig. 6 shows in perspective the form of smaller pump constructed to be worked by hand. Fig. 7 shows the new form of three-way cock which is incorporated in the new pump. Fig. 8 shows a sectional view of new three-way cock on line through center of A, Fig. 7. Fig. 9 shows the method employed for joining the large pipe, whereby an air-tight joint is obtained. Fig. 10 shows one end of the pipe in the longer form of pump, with the mercury as it appears at the beginning of the operation. Fig. 11 shows one end of the pipe in the form of pump having the longer pipe, with the mercury as it appears after the pump has made a quarter of one revolution, provided an auxiliary pump is used in connection therewith. Fig. 12 shows the position of the mercury in the pump having a shorter and larger pipe, when the pump is turned completely to one side after having exhausted to its full capacity through the end P, and is ready after a change of stop-cocks to exhaust through the end P′ and expel the air through the pipe P. Fig. 13 shows this last operation completed by a reversal of the pump, the change of stop-cocks referred to above being indicated in this figure.

Similar letters refer to like parts in all the drawings.

The machine is supported by a substantial frame-work, from which rise the two side supports, S S, on which rests the axle T, which fits into and revolves in the boxes U U′. The length of this axle may be varied to suit the needs of any particular machine. This axle should be of metal and of sufficient diameter to provide a firm support for the pump. About this axle is built a strong drum attached to the axle by radial supports. This drum should be about a yard in diameter to secure the best results. It should be strongly built, preferably of iron, in which case it may consist of a skeleton frame-work, properly braced and stiffened, and a cylindrical form is the best. Around the outside of this drum or frame-work is placed a pipe, A, Fig. 1, arranged in the form of a helix, said pipe to be preferably of glass; but it can be made of any suitable material and in one length or more, in which latter case it is to be joined by air-tight joints, as at Fig. 9, so as to make one continuous air-tight receptacle. It may be made of equal diameter throughout, or expanded or contracted at various points, if deemed necessary.

Two or more tubes, constructed as above, may be placed side by side or superimposed, if deemed advisable, and the whole tube may be of a total length less or more than one convolution.

If made of less than one convolution, the pump may assume the form shown in Fig. 6, in which a pipe of comparatively-large interior diameter, A′, (two or three inches, preferably,) is bent into a curve and securely fastened to a suitable frame-work, O. The ends of the pipe may be, and preferably should be, expanded into bulbs P′ P, for the purpose of obtaining greater efficiency. The arrangement of stop-cocks, connecting-tubes, &c., is in this case substantially as herein shown and described, except that the connection shown at V to the outside air or auxiliary pump may be made, as indicated, by a flexible tube, V, instead of through the axle, as the motion of the pump

in this case is less than one revolution upon its axle.

The pipe A′ may be made in one piece or in several, and joined in the latter case by air-tight joints, as at L, and shown in detail in Fig. 9, as necessity or convenience may require. In this form of pump the pipe A′ will of course approximate a curve in a plane rather than a helix.

In the large form of practical pump which I have found best a number of tubes of convenient length are united by air-tight joints around the drum in such a manner as to form one continuous passage of more than a hundred feet. This length can of course be increased or diminished at will. The ends of the tube thus made are drawn out, thereby reducing the diameter to an orifice about one-eighth of an inch in diameter, beyond which is a three-way cock, B B′, by which the pipe can be in turn closed, connected with C C′, and also with D D′, as shown in Figs. 7 and 8, and described elsewhere. Tube D D′ is widened into a chamber, as shown in the drawings, and provided with a stop-cock, E E′.

The supporting frame-work is connected rigidly with the axle by means of wheels or radial rods, and revolves with the same in proper boxes, which are supported by a suitable frame-work, of iron or other material.

Each end of the axle is hollowed for a short distance to receive one arm of the bent tube F F′, as shown in Fig. 4, which tube terminates at a point a short distance beyond the extremity of the axle in a ground joint, H H′, as shown in Fig. 3. The other end of the bent tube projects from the side of the axle through a suitable orifice and terminates in a stop-cock for isolating the pump from the outer connection on either side. The hollow of the axle above referred to as being made for the reception of the glass tube may be used as part of the air-connections in place of the glass tube by proper connections equivalent to those shown in the drawings.

The tubes leading from the pipe A at either extremity and marked C C′ are both connected, by small tubes and ground-joints or other devices, to the stop-cock at one end of the axle, while those marked J J′ are connected with the stop-cock at the other end of the axle. Mercury is introduced into one convolution of the pipe A until it about half fills the convolution.

Attachments by belting, gearing, &c., may be made to any convenient or suitable motor or power, or the pump may be revolved by hand, if desired.

The helix, revolving upon its horizontal axis, must be of a diameter sufficient to permit the mercury to rise to the height it would in case of a vacuum nearly perfect existing on one side and the full atmospheric pressure on the other. In practice it is found best to allow a few inches more than this, making the diameter of the convolutions of the pipe A about thirty-six inches.

The two forms of pumps are constructed substantially the same, the stop-cocks and general connecting parts being alike, and the flow of mercury being by gravitation in both forms. In one form the vacuum is produced by causing the mercury to pass by the action of the pump through a long pipe of comparatively small diameter. In the other form the vacuum is produced in a shorter and larger pipe by a partial revolution of the pump on its axis.

Operation: Referring to Fig. 1, if this machine be used without the aid of an auxiliary pump the operation is as follows: The objects to be exhausted having been connected with M′ in any suitable manner the pump is revolved until the mercury reaches one end. For convenience we will assume that the pump is turned, bringing stop-cock end B down to meet the mercury. This stop-cock B is turned so as to permit the air to flow out through B D E J H M and to allow the mercury to flow into and fill chamber D. When this is done, the cock E is closed and the pumps reversed. This has the effect of lifting end B away from the mercury; but the pressure of the air (which at this time has free access to the main body of the pipe through stop-cock B′ and D′ E′ J′ F H M) sustains the mercury until the motion of the pump, carrying the end B upward, brings it to a point where the upper level of the mercury in this end is about thirty inches above the level of the mercury on the other side. (It must be remembered that only sufficient mercury is introduced into the pipe to half fill one turn of the helical pipe, so that standing normally at about the level of the axle on each side, if the level rises on one side it will fall on the other, the length of the mercury in the pipe being four or five feet only, while the length of this helical pipe may be twenty or thirty times as much.) The motion of the pump being continued, the result is that the pressure of the air on the other side, not being sufficient to sustain it, the mercury on side B flows from chamber D, through stop-cock B, into the pipe below, producing a vacuum between its surface and stop-cock E. At this point the motion is arrested and stop cock B turned to open communication with the objects to be exhausted through C F′ H′ M′, when the air therein, expanding, enters the space in pipe where the vacuum has just been made, and the mercury then falls at this end more or less, depending on the capacity of the objects attached to M′. The motion of the pump is now continued as before, and the mercury is, as it were, screwed along the lower part of the helical pipe, drawing the air from the objects attached to M′ and forcing the air out before it through B′ D′ E′ J′ F H M. During this operation the level of the mercury will be constantly changing as the air becomes more and more attenuated on the exhaust side, and the mercury will rise higher and higher until the other end of the pipe is reached, when the level on the exhaust side will be within a comparatively short distance from the top of

the pump and on the other side correspondingly near the bottom. When stop-cock end B′ reaches this last level, the mercury which it meets is allowed to flow through cock B′, up and into D′, until it fills the same, when cock E′ is closed and the motion stopped. Cock B is now closed to cut off the air which has been drawn into the pipe from objects attached. The pump is now reversed and B′ allowed to rise. The mercury will flow out of chamber D′ soon after the cock E′ has reached the level of the axle, owing to the slight sustaining power of the rarefied air on the other side of the mercury. After the mercury has subsided well down into the pipe at end B′, the cock B′ is turned to allow communication with objects to be exhausted through B′ C′ F′ H′ M′, and then the motion is continued until the mercury is brought back to its original starting-place at end B. While on its way back and while exhausting through B′, the air previously drawn through end B is condensed until it reaches the normal density, which can be told by the mercury falling to within five or six inches of the bottom of the helix. Then cocks B and E are turned to open communication through B D E J F H M with the outer air, and the motion continued until the condensed air is driven out, and the mercury meeting cock B at last enters and fills chamber D. Then cock E is closed as before, and cock B′ closed to cut off the air withdrawn from lamps, &c. The pump is now reversed, allowing the mercury to drop from chamber D, cock B turned to communicate with objects attached, and the mercury sent back to stop-cock end B′, as at first. Thus the continued action of the pump, screwing the "mercurial piston" forward and backward from end to end, produces alternately a vacuum in one end and compression in the other, and vice versa, and by a proper change of stop-cocks connection is opened with the air and objects attached in turn, resulting in a gradual but rapid reduction of the density of the air in the lamps, &c., attached to M′. Toward the end of the operation the chambers D and D′ are sufficient to contain the residuum of condensed air and the cocks E and E′ are not opened. A little mercury is also then allowed to remain in D and D′ as a seal, through which the slight bubble of condensed air rises when the three-way cock is turned to permit its escape.

The main use of an auxiliary pump is to exhaust the objects partially before the mercurial pump is started and during its use to reduce the atmospheric pressure in the pump. Extreme variations of level are prevented by its use and the proper degree of exhaustion arrived at sooner. The connection to the auxiliary pump is made through M.

The following description will apply to the shorter pump, the action of which is shown in Figs. 12 and 13.

The bulb on one side being lowered to meet the mercury, all the air and gases on that side are expelled through the stop-cock and passages, as indicated. When the mercury completely fills this globe, the stop-cock is closed and machine turned so as to raise this bulb. In doing so a vacuum is formed in this side. The stop-cock is turned, opening communication through the proper passages to the lamps, &c., and the air within the same, expanding, fills the bulb. Meanwhile a similar operation has been going on in the other bulb, only in reverse order. When the machine is creating a vacuum in one side, it is expelling the air from the other. Thus a continual double action is produced, resulting in a high degree of exhaustion.

Both pumps can be made single acting by using only the communication to the lamps on one side and to the air or auxiliary pump on the other. This may be desirable in the event of a leak in a stop-cock at either end.

The great commercial advantage of this pump may be seen when we consider that the air and gas can be exhausted from about one hundred and fifty lamps of the usual size for domestic incandescent lighting (sixteen-candle power) at one operation on a pump such as is described above, whereas the capacity of the Geissler pumps as now used ranges from five to fourteen.

I know that prior to my invention machines for exhausting air have been used, in which a body of mercury has been made to pass by its own weight through a helical pipe as a piston. I therefore do not claim such use of mercury in a tube, broadly.

What I do claim, and desire to secure by Letters Patent, is—

1. In a vacuum-pump, the combination of a curved pipe containing a body of mercury, and smaller tubes provided with suitable stop-cocks running from each end of the pipe to and through the ends of the axle of the machine, substantially as shown and described.

2. In a vacuum-pump, the combination of a pipe having a piston of mercury curved around a supporting-frame, tubes leading from each end of the pipe provided with suitable stop-cocks, and an axle made hollow at each end to allow the flow of air, one end of the axle being connected to a stationary pipe leading to the vessels to be exhausted, the other end similarly connected leading to the outer air or to auxiliary pumps, the whole system of pipes, tubes, and hollow axle being connected by air-tight joints, substantially as herein shown and described.

3. In a vacuum-pump, the combination of an axle made hollow at each end, either with or without an inclosed tube, a stationary tube connected to one end of the axle and leading to the globes or other articles to be exhausted, (the connections to be all air-tight,) and the system of pipes, stop-cocks, and tubes, whereby the air is exhausted by the action of mercury flowing through a pipe, substantially as herein shown and described.

4. In a vacuum-pump, the combination of

the curved pipe A′, Fig. 6, containing a body of mercury, and the tubes K K′ R R′, provided with suitable stop-cocks, *x x′ z z′*, with a supporting-frame, O, made to vibrate upon an axle, T, so that the mercury in the tube may by its own weight be made to pass by the motion of the frame from one end of the tube to the other and back again, substantially as described and shown.

5. In a vacuum-pump, the combination of the curved pipe A′, Fig. 6, containing a body of mercury, the pipes provided with suitable stop-cocks, *x x′ z z′*, the supporting-frame and the axle having a hollow end, the tube, pipes, and axle forming a continuous air-tight passage from the mercury to and through one end of the axle to the stationary pipe leading to the globes to be exhausted, substantially as shown and described.

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