

AMENDED SPECIFICATION

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(The Amendments are shown in erased and italic type)

PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in and relating to Thermally-actuated Motive Devices

We, CHARLES SCOTT-SNELL and EDWARD SCOTT-SNELL, both of Flat 4, 47, Linden Gardens, Bayswater, London, W.2, both British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to the production of pressure or velocity head in a fluid by means of heat and has for its object to provide improved methods and means therefor.

The invention is particularly applicable to the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel.

The invention consists in a thermally-actuated motive device wherein a continuously recurring intermittent local pressure reduction or vacuum is produced automatically by the sudden condensation of vapour previously generated by the application of heat to a part of the device, such condensation being controlled as desired.

The invention also consists in a thermally-actuated motive device wherein the control of condensation is effected by the natural, i.e. unaided, cooling of a free surface exposed to the vapour.

The invention also consists in a thermally-actuated motive device wherein the control of the condensation is effected by the upsetting of a hydrostatic balance.

The invention also consists in a thermally-actuated device for providing fluid pressure, comprising a vertical liquid reservoir, a connecting tube between two points thereon, said tube being so arranged or equipped that vapour generated by heat applied to part of the device is retained therein until a predetermined space is occupied thereby (the equivalent

volume of liquid being simultaneously ejected from the device).

The invention also consists in thermally-actuated apparatus including a vertical reservoir, a chamber connected to the top thereof, means for heating one end of said chamber, an enlargement in said vertical reservoir, a connection from said vertical reservoir to an air trap by way of a non-return valve and a connection to a source of fluid supply including a further non-return valve.

The invention also consists in a self-feeding pressure oil lamp having its feed supplied through heat derived from an incandescent mantle or the like, whereby on failure of the mantle or the like the oil feed automatically stops.

The invention also consists in thermally-actuated devices substantially as hereinafter described.

According to the present invention advantage is taken of the physical phenomenon that when two vessels containing a liquid having each of them a "free surface" in contact with its own vapour are connected the pressure in the whole system is that corresponding to the vapour pressure of the free surface which is subjected to the lowest envelope temperature. That is to say that however much heat is imparted to one of them the pressure in the combination is governed entirely by the temperature of the free surface in the cooler vessel. Now the pressure of a vapour above a free surface in contact with its own liquid is necessarily a definite and different one for each and every temperature of the liquid. For instance at the so-called "boiling point" of the liquid the vapour pressure is 14.7 lb. per square inch absolute, whereas at temperatures

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above and below this the vapour pressure is above and below atmospheric pressure respectively.

Thus, if one of the free surfaces can be so controlled automatically that its temperature alternates between two values corresponding to two pressures (above and below atmospheric pressure respectively) a ready means is provided for pumping oil against a pressure head in spite of the fact that heat is continuously applied to the other vessel.

One method of effecting this control may be explained with reference to a model constructed in glass and comprising a vertical tube near the upper end of which is a spherical enlargement, said upper end being integrally connected to the middle of an inclined cylindrical glass vessel closed at both ends.

In operation this apparatus is completely filled with kerosene oil and is supported with the lower end of the stem dipping into a vessel containing such oil. Heat is now applied to the lower end of the inclined vessel.

Vapour will form at the top of the inclined vessel displacing a corresponding quantity of liquid which passes out into the reservoir through the lower end of the vertical tube

This continues until a quantity of the liquid is vaporised, whereupon some of the vapour is driven out by expansion through the lower end of the vertical tube where it is immediately condensed. Consequently cool liquid enters the lower end of the vertical tube, which in turn condenses more of the vapour. As the cool liquid enters, however, the area of its free surface which is exposed to the vapour increases rapidly as the spherical enlargement is reached and thus the rate of condensation increases rapidly until a stage is reached in which the whole of the vapour is entirely condensed instantaneously, thus producing a powerful and sudden vacuum which causes the whole of the apparatus to be entirely filled with liquid drawn in from the reservoir.

The inlet pipe is of somewhat restricted internal area of cross section so that when the pressure within the apparatus drops this drop cannot fully be satisfied by the incoming liquid, consequently a very substantial and cumulative vacuum is formed in front of the liquid column; the volume of liquid entering the stem per unit of time as expressed by the velocity multiplied by the area of the pipe is very much greater than the volume of vapour which is capable of being generated (by the source of heat) in the same unit of time. Consequently the return of liquid does not cease at its entry into the inclined vessel,

but completely floods it as stated above, thus producing conditions analogous to those originally obtaining, viz. a system completely full of liquid, but at a temperature below that corresponding to atmospheric pressure.

This cycle of operations continues as long as heat is supplied to the inclined vessel, the outgoing stroke being found in practice to be comparatively slow but the recoil stroke, the moment the free surface spreads to the full area of the spherical enlargement, accelerating to such a speed that the remaining operation of completely filling the system takes a very small fraction of a second, and is certainly much too fast for the eye to follow when glass apparatus has been used in experimental investigation.

In utilising this intermittently produced vacuum to apply a positive pressure for any desired purpose, it is convenient to connect the stem to an auxiliary chamber embodying an inlet non-return valve, the entry to which is by way of a further stem dipping in the reservoir. This auxiliary chamber embodies also an outlet tube controlled by a further non-return valve communicating by way of an air vessel with the apparatus to which the positive pressure is to be applied.

The inlet opening is preferably somewhat bigger than the outlet opening.

The positive pressure is caused by the boiling of the liquid at the stage where only one free surface (this being then the governing one) exists. As soon as the other free surface which is not subjected to extraneous heat is developed the pressure is governed by this secondary temperature. This is of course subject to heating from the distillation effect and cooling of its envelope and when the cooling gains over the heating sufficiently to lower its vapour pressure below that corresponding to atmospheric pressure the reversal, or return flow, starts.

It has been found experimentally that it is possible to dispense with the outlet valve provided that the bore of the tube at the point where the outlet valve would normally be placed is a great deal less than the bore of the inlet valve opening.

The foregoing describes the invention in general terms only. It is, however, obvious theoretically and has been proved in practice that the action depends primarily upon the change of area at the right moment of the free surface of the fluid piston, and that as far as the recoil stroke is concerned the smaller the entry to the bottom of the stem in relation to the cross-sectional area of the spherical enlargement the greater the vacuum induced in the apparatus until a limit is

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reached in which, although the velocity due to the vacuum is enormous, the volume passing is too small to overtake the rate of vapour generation and the vessel fails to become completely flooded, i.e. the recoil is incomplete. It is found that if the minimum effective heating surface, which is the chief controlling factor of its rate of evaporation at the critical moment when liquid enters, is made the same as the maximum cross-sectional area of the spherical enlargement, sure and certain completion of the recoil stroke is obtainable if the area controlling the rate of entry to the latter is about 1/60th this said cross-sectional area. However, since a wide variation in all these relations is permissible before failure to refill results, it is sufficient to arrange that the area controlling the entry of liquid into the stem is substantially less than the cross-sectional area of the enlargement itself. As regards the tube joining the enlargement to the inclined chamber, so long as its cross-sectional area is not less than that controlling the entry to the stem (when it would usurp the controlling function) its dimensions are dictated by considerations entirely subsidiary to the main principle.

The theory of the apparatus as so far set forth tacitly assumes the use in construction of material whose thermal characteristics in no way modify adversely the main principle, but since no material is completely devoid of thermal properties such as conductivity and thermal capacity means have to be employed to render the influence of these properties negligible. Ideally the condensing portion of the apparatus should be constructed of a material whose conductivity is negligible, that is to say that heat stored in the walls on the outward stroke should not influence in any degree the temperature of the surface on the recoil stroke, and heat should not be allowed to pass to it by the conductivity of its junction with the vapour generator portion which would augment this storage.

It will be understood that in the apparatus so far described the temperature of the free surface effecting condensation is controlled by a purely physical phenomenon, i.e. the dissipation of heat by natural means, but it is to be understood that other means of control may be employed. For example the upsetting of a hydrostatic balance may be employed to effect the necessary control.

In one manner of operating in accordance with this principle a vertical tube fitted with a non-return outlet valve at its upper end and a similar inlet valve at its lower end is provided.

A by-pass connection is provided which at its upper end is connected to the vertical tube near the outlet valve, while the lower end of the by-pass tube is connected to the vertical tube at a point near and above the inlet valve. The lower end of the vertical tube or an extension thereof dips into a reservoir of oil and the outlet valve communicates by way of an air vessel (to equalise pressure) with a fuel jet associated with an incandescent mantle.

As regards a by-pass tube this is formed of two tubes of different cross-sectional area, the upper portion being considerably smaller than the lower. Furthermore the lower portion of the by-pass tube embodies an inverted U bend, the limb of which remote from the vertical tube being shorter than the other limb and the connection of the upper portion of the by-pass tube to this shorter limb being made at a point at some little distance from the closed end thereof.

Means are provided for heating this closed end, for example by disposing this end adjacent the aforesaid incandescent mantle or by conducting heat from the latter by way of suitably conducting metal conducting pieces.

In operation, assuming the whole system is working correctly some heat from the mantle heats up the oil and the vapour collects at the bend of the inverted U tube gradually increasing in quantity until the level (which is the same in both limbs of the inverted U tube) falls to the level of the connection of the upper portion of the by-pass tube. Meanwhile fluid has been ejected through the outlet non-return valve owing to the increase in volume due to the vapour formation. Pressure is thus maintained upon the fluid feeding the burner jet, the air chamber serving to smooth off irregularities.

As soon as the level in the connection to the upper by-pass section is reached the vapour travels upwards therein and this upsets the hydrostatic balance between the main vertical tube and the by-pass section, so that the fluid from the former flows into and floods the latter, the vapour previously forming the contents of the latter becoming naturally displaced and assembling at the highest level in the system, i.e. that portion of the vertical tube in the vicinity of the junction of the upper by-pass tube and hence above a free surface of cold fluid created by the fall in level due to the rearrangement of level in accordance with a restored balance.

Contact between the vapour and the cold free surface produces condensation and a vacuum is created which can only be satisfied by an inflow of cold oil from the reservoir.

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This fluid entering in the vicinity of the free surface produces a cold layer which makes the vacuum cumulative and very powerful, and in fact admits of a considerable vertical distance between the fluid reservoir and the fuel jet.

It is to be understood that the vapour may be allowed to bubble up through the liquid in the upper portion of the vertical tube, the bubbles creating a number of free surfaces instead of a free surface in a horizontal plane.

Alternatively the incoming cold fluid may enter the vertical tube at other points, e.g. at a point above the level of the junction with the upper by-pass tube when it would fall through the space momentarily created by the fall in level which occurs as above explained when balancing operates.

One cycle of operations is now completed and in practice this cycle recurs automatically with regularity, the fluid fuel burner thus automatically causing the necessary fluid pressure for its own operation to result entirely automatically and without the necessity for any initial pressure to start the burner.

In order to commence operations it is only necessary to apply heat to the closed end of the lower by-pass portion.

According to a modification a vertical tube is provided as before and is furnished with a by-pass connection comprising a plain tube whose connection to the vertical tube is controlled by a gravity non-return valve. This by-pass tube is arranged to be heated near its lower end, the action being such that the generated vapour is caused to lift the non-return valve as soon as the hydrostatic balance is upset, whereupon cool liquid enters the lower by-pass connection and the sudden vacuum produced effects an induction of fresh liquid from a reservoir into which the lower end of the vertical tube (or a depending extension thereof) dips, whereas generation of vapour effects a discharge of liquid through the outlet non-return valve.

According to a further modification also operating upon the principle embodied in the last-described example a vertical tube, non-return valves and reservoir are pro-

vided as before and a by-pass tube connected to this pipe is arranged to be heated at about the middle of its length.

Near the lower end of the by-pass tube a closed vessel is interposed, the pipe connections to and from it being disposed near its lower end. This closed vessel is furnished with a partition extending nearly to the top of the vessel and a syphon tube serving to provide intermittent liquid communication between the two sides of the partition is provided.

The short limb of this syphon terminates on the side of the partition adjacent the lower connection of the by-pass tube to the vertical pipe, while the long syphon limb terminates on the other side of the partition.

The by-pass tube is formed with a small inverted U tube portion near its upper connection to the vertical tube, in which portion the generated vapour collects until the levels of liquid in contact therewith fall to such an extent as to permit access of the vapour to the cool free surface represented by the liquid in the vertical tube. As soon as this occurs condensation of vapour ensues with consequent disturbance of hydrostatic level between the liquid on the two sides of the partition in the closed vessel.

This action recurs until the balance is so far disturbed that the syphon is primed, whereupon cool liquid flows through the syphon and complete flooding of the by-pass tube takes place.

It will be appreciated that according to the present invention the continuous application of heat, which may be derived from flame contact, radiation from an incandescent body or other suitable means, causes intermittent action in contradistinction to circulation such as obtains under the application of heat to ordinary vaporising apparatus and the present invention comprehends means for generating pressure and ejecting part of the fluid contents of the apparatus and then automatically reducing pressure and recharging the generator with fluid, and these functions are carried out without pumps or pistons or like operative mechanism.

Dated this 9th day of November, 1926.

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COMPLETE SPECIFICATION (AMENDED)

Improvements in and relating to Thermally-actuated Motive Devices

We, CHARLES SCOTT-SNELL and EDWARD SCOTT-SNELL, both of Flat 4, 47, Linden Gardens, Bayswater, London, W.2, both British subjects, do hereby declare the nature of this invention and in

what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to the production

of pressure or velocity head in a fluid by means of heat and has for its object to provide improved methods and means for ~~therefor.~~

5 ~~The invention is particularly applicable~~ to the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel.

10 The invention consists in a thermally-actuated motive device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* comprising a liquid fuel containing tubular conduit continuously supplied with heat so disposed that the liquid continuity is broken by vaporisation of a portion of the liquid fuel until a sufficiency of vapour is produced to cause contact thereof with a section of the device cool enough to cause condensation, the resulting vacuum producing an influx of liquid fuel to replace that ejected by the vapour which was formed.

25 The invention also consists in a thermally-actuated motive device, *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* comprising a liquid fuel containing tubular conduit continuously supplied with heat so disposed that the liquid continuity is broken by vaporisation of a portion of the liquid until cooling of a free surface of the liquid exposed to the vapour occurs adequate to initiate condensation, the resulting vacuum producing an influx of liquid fuel which replaces that ejected by the vapour which was formed.

40 The invention also consists in a thermally-actuated motive device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* including a heat-receiving section so constituted that vapour generated therein is retained while liquid fuel is ejected until the level of liquid falls to a predetermined extent, which enables the vapour to be conveyed ~~escape~~ through a passage then uncovered, and ~~enter to flow into~~ a condenser, whereby ejection and influx of liquid fuel having access to the device is produced alternately without the need for positively operated parts.

55 The invention also consists in a thermally-actuated motive device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* including a heat-receiving section in which vapour is retained, while liquid fuel is ejected, until the hydrostatic balance of a liquid fuel container connected to the device is upset, whereupon a liquid flow is set up which 65 ejects the vapour to a condensing section

and replaces it with liquid fuel.

The invention also consists in a thermally-actuated device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel, for producing a recurring cycle of fluid pressure followed by a sudden pressure reduction*, comprising a vertical liquid fuel reservoir, a connecting tube between two points thereon said tube being so arranged or equipped that vapour generated by heat applied to part of the device is retained therein until a predetermined space is occupied thereby (the equivalent volume of liquid fuel being simultaneously ejected from the device), whereupon passage of vapour through said connecting tube and into contact with a cool free surface ensues and rapid condensation is initiated.

The invention also consists in a thermally-actuated motive device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* including a vertical reservoir connected by way of a non-return valve to a liquid fuel supply source, a chamber connected at a point between its ends through a small bore tube to a point on said reservoir, a connection including an inverted U bend between the upper end of said chamber and a further and lower point on said reservoir, means for continuously heating the lower end of said chamber, and a connection from the upper end of said vertical reservoir including a further non-return valve to the pump discharge outlet.

~~The invention also consists in a liquid fuel feeding device operating in the manner set forth above comprising a tubular element containing liquid fuel and having a heated zone and a cooled zone, said tubular element being adapted automatically to feed liquid fuel under pressure and to draw in further liquid fuel alternately.~~

The invention also consists in a thermally-actuated motive device *for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel* including means which cause a heated section to be charged intimately with liquid fuel and which cause fluid to be expelled therefrom, said means comprising automatic valves which mechanically arrest circulation with an adjacent liquid fuel container, until a predetermined change in hydrostatic head occurs.

The invention also consists in a self-feeding pressure liquid fuel lamp *operating in accordance with any of the preceding seven paragraphs* having its feed supplied through heat derived from an in-

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candescent mantle or the like, whereby on failure of the mantle or extinguishing of the light the liquid feed automatically ceases.

5 The invention also consists in thermally-actuated *fuel feeding* devices substantially as hereinafter described with reference to the accompanying drawings.

10 According to the present invention advantage is taken of the physical phenomenon that when two or more vessels containing a liquid having each of them a "free surface" in contact with its own vapour are connected the pressure in the whole system is that corresponding to the vapour pressure of the free surface which is subjected to the lowest temperature. That is to say, that however much heat is imparted to one of them the pressure in the combination is governed entirely by the temperature of the free surface in the cooler vessel. Now the pressure of a vapour above a free surface in contact with its own liquid is necessarily a definite and different one for each and every temperature of the liquid. For instance at the so-called "boiling point" of the liquid the vapour pressure is 14.7 lb. per square inch absolute, whereas at temperatures above and below this the vapour pressure is above and below atmospheric pressure respectively.

Thus, if one of the free surfaces can be so controlled automatically that its temperature alternates between two values corresponding to two pressures (above and below atmospheric pressure respectively) a ready means is provided for pumping oil against a pressure head in spite of the fact that heat is continuously applied to the other vessel.

Referring to the accompanying diagrammatic drawings:—

45 Figure 1 is an explanatory sketch illustrating the main principle underlying the present invention.

Figure 2 is a modification of Figure 1.

50 Figure 3 represents in sectional elevation a convenient practical construction of self-feeding pressure oil lamp.

Figure 4 is a sectional plan on the line I I of Figure 3.

55 Figures 5 to 8 are explanatory sketches illustrating the method of free surface temperature control employed in Figures 3 and 4.

60 One method of effecting this control may be explained with reference to Figure 1 which illustrates a model constructed in glass and comprising a vertical tube *a* near the upper end of which is a spherical enlargement *b*, said upper end being integrally connected to the middle of an inclined cylindrical glass vessel *c* closed at both ends.

In operation this apparatus is completely filled with kerosene oil and is supported with the lower end of the stem dipping into a vessel containing such oil. Heat is now applied to the lower end of the inclined vessel *c*. 70

Vapour will form at the top of the inclined vessel *c* displacing a corresponding quantity of liquid which passes out into the reservoir *d* through the lower end of the vertical tube. 75

This continues until a quantity of the liquid is vaporised, whereupon some of the vapour is driven out by expansion through the lower end of the vertical tube where it is immediately condensed. Consequently cool liquid enters the lower end of the vertical tube *a*, which in turn condenses more of the vapour. As the cool liquid enters, however, the area of its free surface which is exposed to the vapour increases rapidly as the spherical enlargement *b* is reached and thus the rate of condensation increases rapidly until a stage is reached in which the whole of the vapour is entirely condensed instantaneously, thus producing a powerful and sudden vacuum which causes the whole of the apparatus to be entirely filled with kerosene drawn in from the reservoir. 85 90 95

The inlet pipe *a* is of somewhat restricted internal area of cross section so that when the pressure within the apparatus drops this drop cannot fully be satisfied by the incoming liquid, consequently a very substantial and cumulative vacuum is formed in front of the liquid column; the volume of liquid entering the stem *a* per unit of time as expressed by the velocity multiplied by the area of the pipe is very much greater than the volume of vapour which is capable of being generated (by the source of heat) in the same unit of time. Consequently the return of liquid does not cease at its entry into the inclined vessel, but completely floods it as stated above, thus producing conditions analogous to those originally obtaining, viz., a system completely full of liquid, but at a temperature below its normal boiling point. 100 105 110 115

This cycle of operations continues as long as heat is supplied to the inclined vessel *c*, the outgoing stroke being found in practice to be comparatively slow but the recoil stroke, the moment the free surface spreads to the full area of the spherical enlargement, accelerating to such a speed that the remaining operation of completely filling the system takes a very small fraction of a second, and is certainly much too fast for the eye to follow when glass apparatus has been used in experimental investigation. 120 125

In utilising this intermittently pro- 130

duced vacuum to apply a positive pressure ~~for any desired purpose~~ it is convenient as illustrated in Figure 2 to connect the stem to an auxiliary chamber *e* embodying an inlet non-return valve *f*, the entry to which chamber *e* is by way of a further stem *g* communicating with a reservoir (not shown). This auxiliary chamber *e* embodies also an outlet tube *i* controlled by a further non-return valve *j* communicating with the apparatus to which the positive pressure is to be applied, an air vessel being interposed if desired.

The inlet opening *g* is preferably somewhat bigger than the outlet opening *k*.

The positive pressure is caused by the boiling of the liquid at the stage where only one free surface (this being then the governing one) exists. As soon as the other free surface which is not subjected to extraneous heat is developed the pressure is governed by this secondary temperature. This is of course subject to some heating from the distillation effect and to some cooling of its envelope and when the cooling gains over the heating sufficiently to lower the vapour pressure below that corresponding to atmospheric pressure the reversal, or return flow in the stem *a* commences.

It has been found experimentally that it is possible to dispense with the outlet valve *j* provided that the bore of the tube π *i* at the point where the outlet valve would normally be placed is a great deal less than the bore of the inlet valve opening.

The foregoing describes the principle upon which the invention is based in general terms only. It is, however, obvious theoretically and has been proved in practice that the action depends primarily upon the change at the right moment of the area of the free surface of the fluid piston, and that as far as the recoil stroke is concerned the smaller the entry to the bottom of the stem in relation to the cross-sectional area of the spherical enlargement the greater the vacuum induced in the apparatus until a limit is reached in which, although the velocity due to the vacuum is enormous, the volume passing is too small to overtake the rate of vapour generation and the vessel fails to become completely flooded, i.e. the recoil is incomplete. It is found that if the minimum effective heating surface, which is the chief controlling factor of the rate of evaporation at the critical moment when liquid enters, is made the same as the maximum cross-sectional area of the spherical enlargement, sure and certain completion of the recoil stroke is obtainable if the area controlling the rate of

entry to the latter is about 1/60th of this said cross-sectional area. However, since a wide variation in all these relations is permissible before failure to refill results, it is sufficient to arrange that the area controlling the entry of liquid into the stem is substantially less than the cross-sectional area of the enlargement itself. As regards the tube joining the enlargement to the inclined chamber, so long as its cross-sectional area is not less than that controlling the entry to the stem (when it would usurp the controlling function) its dimensions are dictated by considerations entirely subsidiary to the main principle.

The theory of the action of the apparatus as so far set forth tacitly assumes the use in construction of material whose thermal characteristics in no way modify adversely the main principle, but since no material is completely devoid of thermal properties such as conductivity and thermal capacity means have to be employed to render the influence of these properties negligible. Ideally the condensing portion of the apparatus should be constructed of a material whose conductivity is negligible, that is to say that heat stored in the walls on the outward stroke should not influence in any degree the temperature of the surface on the recoil stroke, and heat should not be allowed to pass to it by the conductivity of its junction with the vapour generator portion which would augment this storage.

In the apparatus so far described the temperature of the free surface effecting condensation is controlled by a purely physical phenomenon, i.e. the dissipation of heat by natural means, but it is to be understood that other means of control may be employed, particularly when it is desired to construct the apparatus of metal possessing quite considerable heat conductivity. For example the upsetting of a hydrostatic balance may be employed to effect the necessary control.

In one manner of operating in accordance with this hydrostatic balance control principle, as illustrated in Figures 3 and 4, a system *m*, *n*, *o*, *p* is provided, the vertical portion *p* communicating through a non-return outlet valve *q* at its upper end with a chamber *r* by means of a pipe *s*.

A frame plate *t* forms part of the wall of the conduit *p* and also part of the wall of a further conduit *u*, the latter communicating with a vessel *v* containing a filter *w* by way of a non-return valve *x*. A communicating hole *y* and a fine air escape hole *z* as shown in Figure 3 are provided in the plate *t*.

The chamber *r* contains a tubular mem-

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ber 2 closed at its upper end to act as a pressure buffer air vessel and is connected freely at its upper end to a jet 3 whose nozzle is provided with a tapered needle 5 on a spindle 4 operable by a cam 6. This chamber, as well as the chamber *v* separately communicates with ducts 7 and 8 respectively in a casting 9. The former duct may be closed (as shown in Figure 3) or may be placed in communication with either duct 11 or duct 8 by means of a cock 16, while the latter duct is in constant communication with the inlet duct 10 which is connected to an oil supply source (not shown). The jet discharges into a mixing chamber 12 from which an inverted mantle 13 is suspended, air entering at 14.

Heat is conducted to the lower end of the tube *m* through an arm 15 formed conveniently of copper.

Any tendency for solid carbon to be deposited within the tube *m* after prolonged use may be prevented by ensuring that the tube *m* is periodically flushed out by the incoming oil from tube *n*. This may be arranged by suitably shaping the tube *m* or by providing a deflector therein.

Figures 5—8 illustrate diagrammatically the system *n, m, o, p* embodied in the construction according to Figures 3 and 4, the lower end of the pipe *p* being assumed to be in direct communication with an oil reservoir, while the non-return valves *q* and *x* and the inlet duct *u* are omitted for clearness.

Referring to Figures 5—8 the action may be explained as follows:

Heat is continuously applied to the lower end of the tube *m*, the whole system being assumed to be full of, say, kerosene oil. Oil vapour commences to form at 17 (Figure 5) and the conditions represented in Figure 6 are produced, oil having been discharged from the upper end of *p* corresponding to the volume of vapour so far generated in *m n*.

The hydrostatic head supported by the resistance to hydraulic flow in the smaller tube *o* vapour pressure of the oil is represented by *h*.

As heating proceeds vapour enters the tube *o* (of smaller cross-sectional area than *p, m* or *n*) and the bulk of this vapour is conveyed therethrough owing to the prevailing hydrostatic head which effects a clockwise circulation within the tubes *o, p* and *n*. This circulation continues until the cool kerosene in the tube *n* flows over the bent portion uniting the tube *n* with the tube *m*. This causes a very rapid condensation of the vapour such that the whole space within the tubes *m* and *n* is completely filled with cool

kerosene once more. Meanwhile the vapour in *o* is condensed substantially simultaneously by contact with the cool free surface of the oil within the pipe *p*. A rapidly increasing hydrostatic head is sustained until vapour passes out of the upper end of the tube *o* to be condensed by the new cool free surface of the oil within the pipe *p*. Immediately this condensing action commences there is an immediate reduction of pressure within the vapour filled space in the tubes *o, m*, and *n* which is accompanied by effects a rapid inflow of cool kerosene to the tube *n* from the supply source, this being sufficient in fact to flow over the bent portion uniting the tube *n* with the tube *m*. This in turn causes a still greater and very rapid condensation of the vapour such that the whole space within the tubes *m* and *n* is completely filled with cool kerosene once more.

The entry of cool kerosene to the tube *n* to satisfy the sudden reduction in vapour pressure is to the tube *n* and to any other space occupied by vapour in the process of condensation such as the tube *o* of such rapidity that the momentum of the column effects a flushing of the tubes *n, m* and *o*, thereby rendering extremely remote any chance of a stoppage due to foreign matter occurring in the tube *o*. This effect is facilitated by suitably shaping the inlet orifice *y* (Figure 3).

It will be noted that the fluid enters the tube *u* (Figure 3) in the vicinity of the said upper free surface which is produced and thus ensures that this region remains cool.

The vapour passing through the tube *o* may be allowed to bubble up through the liquid in the upper portion of the vertical tube *p*, the bubbles creating a number of free surfaces instead of a free surface in a horizontal plane.

One cycle of operations is now completed and in practice this cycle recurs automatically with regularity, the fluid fuel burner thus automatically causing the necessary fluid pressure for its own operation to result entirely automatically and without the necessity for any initial pressure to start the burner.

In order to commence operations it is only necessary to apply heat to the closed end of the lower by-pass portion, when, as soon as the pumping action commences, the mixture entering the mantle 13 may be ignited.

The heat of the latter then maintains the pump in operation without further attention.

In order to fill the apparatus with oil initially the cock 16 is turned through

half a revolution, thereby placing the ducts 7 and 11 in communication. A hand suction pump or other convenient device may now be applied to 11 and operated until filling is complete by means of fuel drawn in through the duct 10.

In order to extinguish the lamp it is merely necessary to turn the cock 16 so as to place the ducts 7 and 11 in communication with the atmosphere whereupon the small amount of fuel in the reservoir *r* flows out through 11 and the feed pressure is released.

It will be appreciated that the system will operate even with the fuel supply reservoir disposed at a level considerably below the lever of the fuel nozzle outlet and furthermore that since the pipe connecting the duct 10 with the fuel supply reservoir is always under reduced pressure (below atmospheric pressure) there is no escape of oil in the event of a breakage or leakage in this pipe.

In some cases we may provide some convenient means for adjusting the quantity of oil pumped in unit time, e.g. a bypass pipe connection between the reservoir *r* (Figure 3) and the duct 8, such connection including an adjustable spring-loaded valve.

It will be appreciated that according to the present invention the continuous application of heat, which may be derived from flame contact, radiation from an incandescent body or other suitable means causes intermittent action in contradistinction to circulation such as obtains under the application of heat to ordinary vaporising apparatus and the present invention comprehends means for generating pressure and ejecting part of the liquid fuel ~~fluid~~ contents of the apparatus and then automatically reducing pressure and recharging the generator with liquid fuel ~~fluid~~ and these functions are carried out without requiring positively operated parts.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A thermally-actuated motive device for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel comprising a liquid fuel containing tubular conduit continuously supplied with heat so disposed that the liquid continuity is broken by vaporisation of a portion of the liquid fuel until a sufficiency of vapour is produced to cause contact thereof with a section of the device cool enough to cause condensation, the resulting vacuum producing an influx of liquid fuel to replace

that ejected by the vapour which was formed.

2. A thermally-actuated motive device for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel comprising a liquid fuel containing tubular conduit continuously supplied with heat so disposed that the liquid continuity is broken by vaporisation of a portion of the liquid until cooling of a free surface of the liquid exposed to the vapour occurs adequate to initiate condensation, the resulting vacuum producing an influx of liquid fuel which replaces that ejected by the vapour which was formed.

3. A thermally-actuated motive device, for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel including a heat-receiving section so constituted that vapour generated therein is retained while liquid fuel is ejected until the level of liquid falls to a predetermined extent, which enables the vapour to be conveyed ~~escape~~ through a passage then uncovered and ~~enter to flow into~~ a condenser, whereby ejection and influx of liquid fuel having access to the device are produced alternately without the need for positively operated parts.

4. A thermally-actuated motive device for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel including a heat-receiving section in which vapour is retained, while liquid fuel is ejected, until the hydrostatic balance of a liquid fuel container connected to the device is upset, whereupon a liquid flow is set up which ejects the vapour to a condensing section and replaces it with liquid fuel.

5. A thermally-actuated device for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel ~~for producing a recurring cycle of fluid pressure followed by a sudden pressure reduction.~~ comprising a vertical liquid reservoir, a connecting tube between two points thereon, said tube being so arranged or equipped that vapour generated by heat applied to part of the device is retained therein until a predetermined space is occupied thereby (the equivalent volume of liquid being simultaneously ejected from the device), whereupon passage of vapour through said connecting tube and into contact with a cool free surface ensues and rapid condensation is initiated.

6. A thermally-actuated motive for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel device including a vertical reservoir connected by way of

- a non-return valve to a liquid *fuel* supply source, a chamber connected at a point between its ends through a small bore tube to a point on said reservoir, a connection including an inverted **U**-bend between the upper end of said chamber and a further and lower point on said reservoir, means for continuously heating the lower end of said chamber, and a connection from the upper end of said vertical reservoir including a further non-return valve to the pump discharge outlet.
7. ~~A liquid fuel feeding device comprising a tubular element containing liquid fuel and having a continuously heated zone and a cooled zone, said tubular element being adapted automatically to feed liquid fuel under pressure and to draw in further liquid fuel alternately.~~
78. A thermally-actuated motive device for the delivery of oil under pressure to the vaporising jet of illuminating or heating apparatus using oil fuel including means which cause a heated section to be charged ~~intimately~~ *intermittently* with liquid *fuel*, and which cause fluid to be expelled therefrom, said means comprising automatic valves which mechanically arrest circulation with an adjacent liquid *fuel* container, until a predetermined change in hydrostatic head occurs.
89. A self-feeding pressure liquid fuel lamp operating in accordance with any of claims 1-8 having its feed supplied through heat derived from an incandescent mantle or the like, whereby on failure of the mantle or extinguishing of the light the liquid feed automatically ceases.
910. Thermally-actuated *fuel feeding* devices substantially as hereinbefore described with reference to the accompanying drawings.
- Dated this 21st day of May, 1927.
MARKS & CLERK.

[This Drawing is a reproduction of the Original on a reduced scale.]

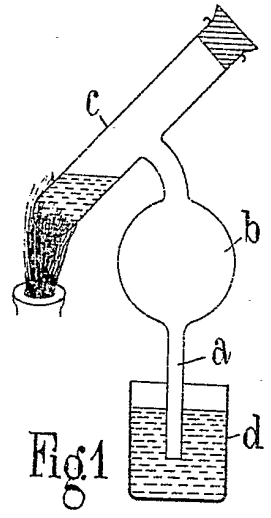


Fig. 1

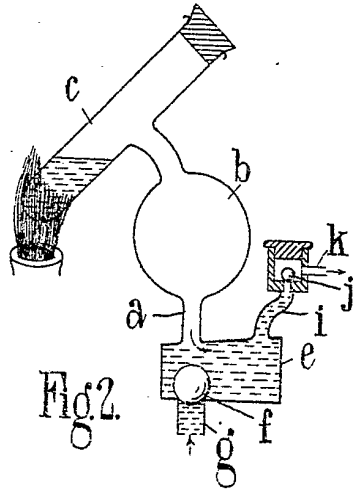


Fig. 2

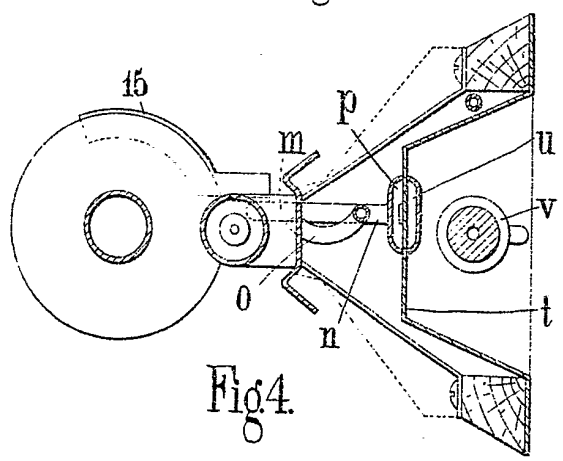


Fig. 4

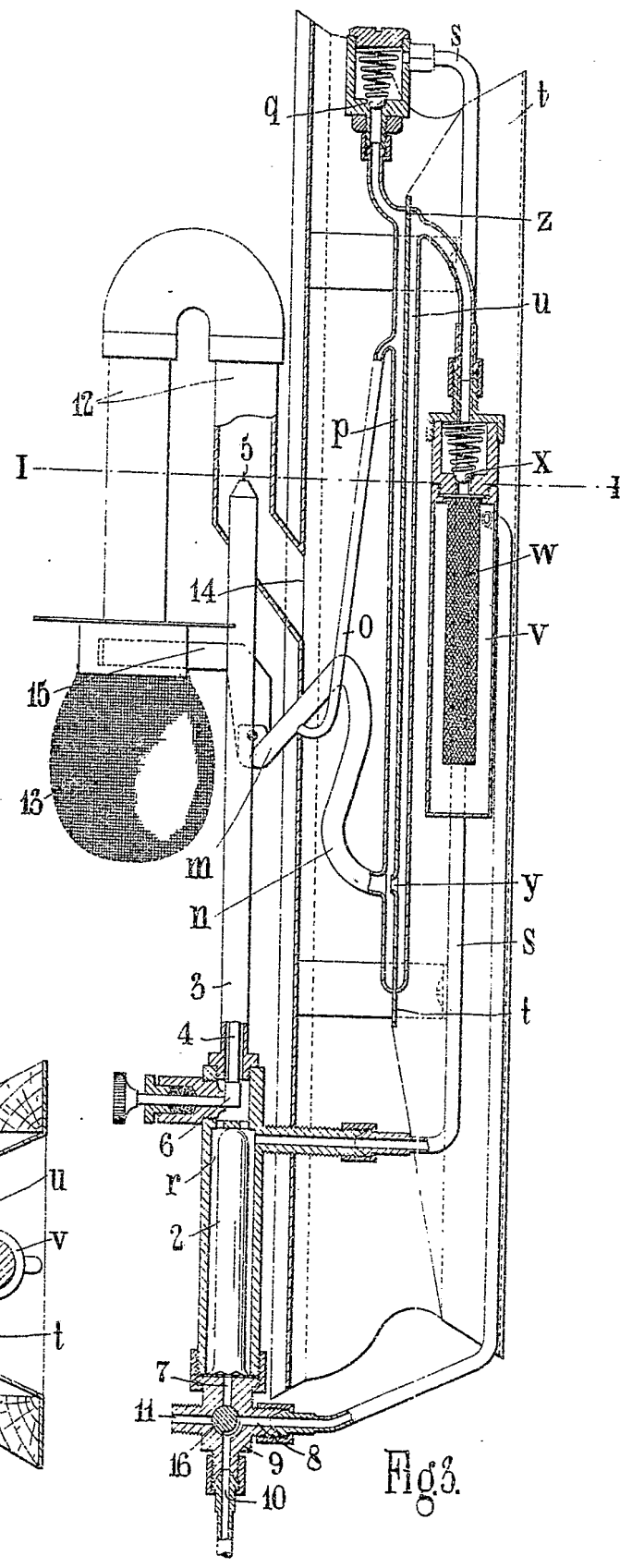


Fig. 3

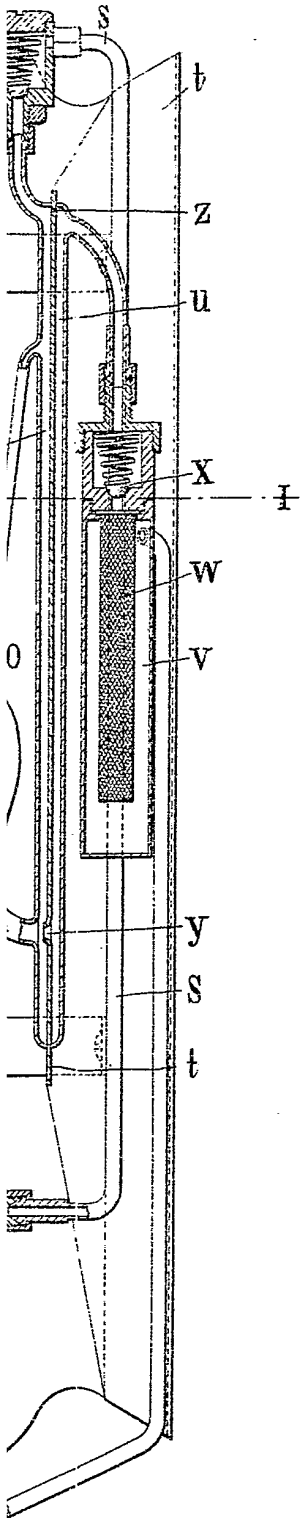


Fig. 5.

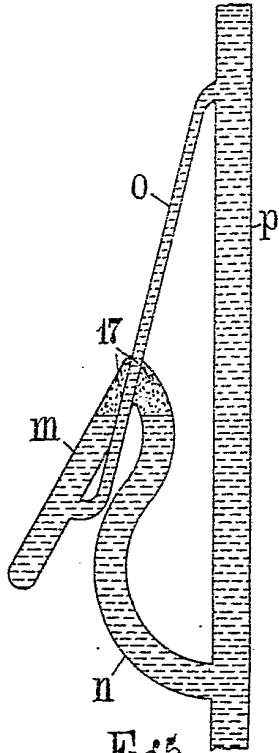


Fig. 6.

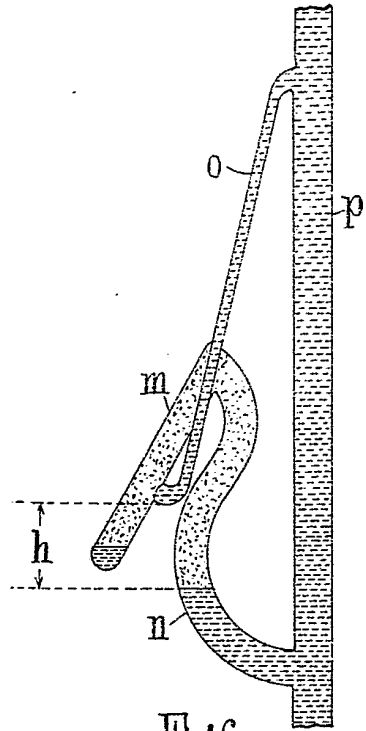


Fig. 7.

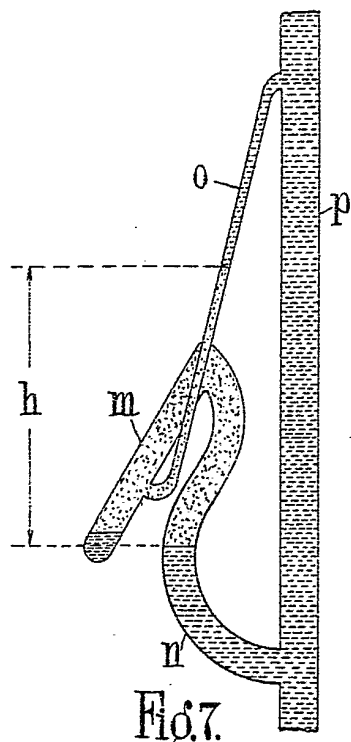


Fig. 8.

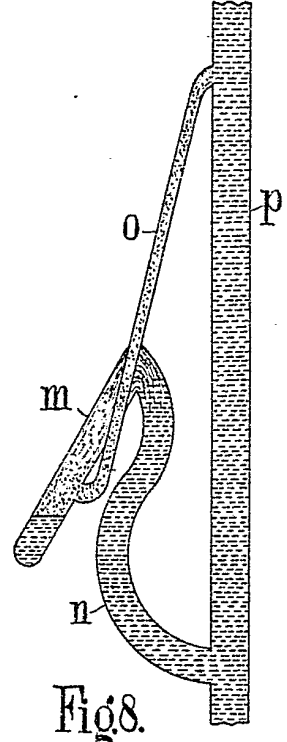


Fig. 9.

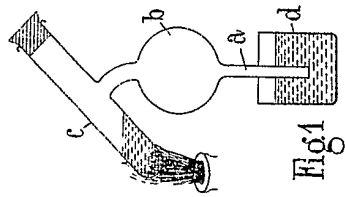


Fig. 1

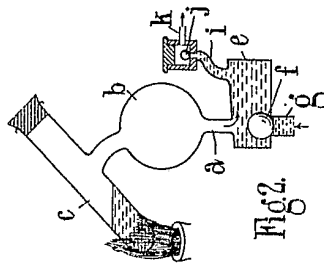


Fig. 2

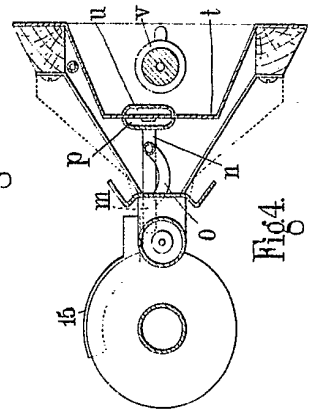


Fig. 4

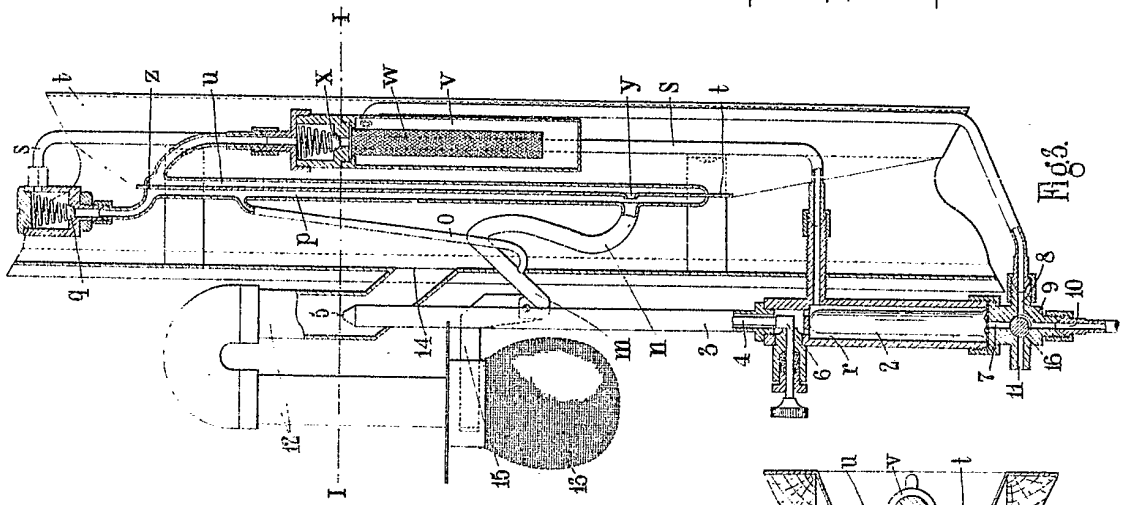


Fig. 3

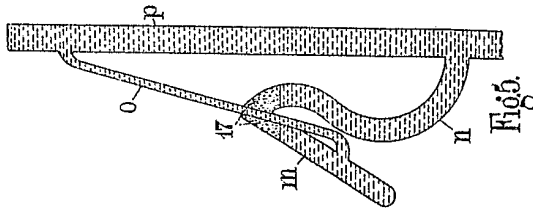


Fig. 5

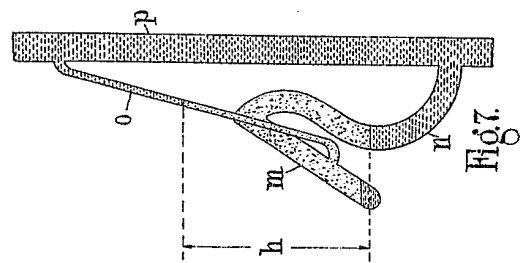


Fig. 7

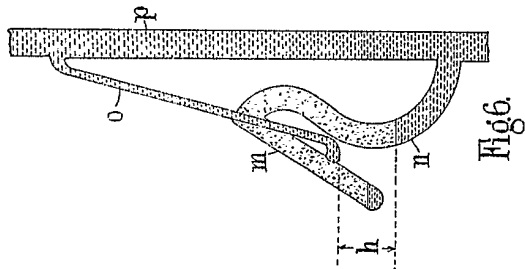


Fig. 6

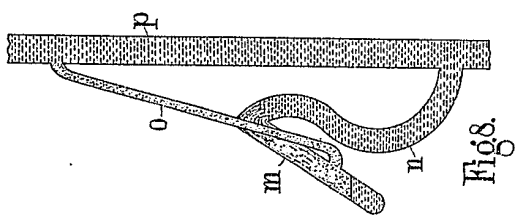


Fig. 8

[This Drawing is a reproduction of the Original on a reduced scale.]