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E. MENDENHALL ET AL

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CONSTRUCTION FOR SUBMERSIBLE MOTORS AND THE LIKE

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Fig. 1.

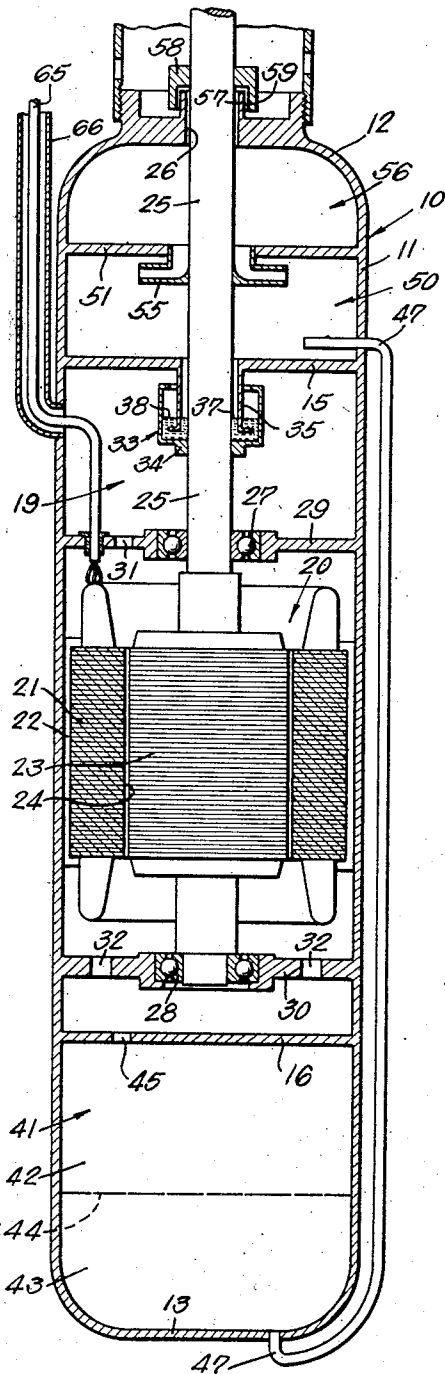
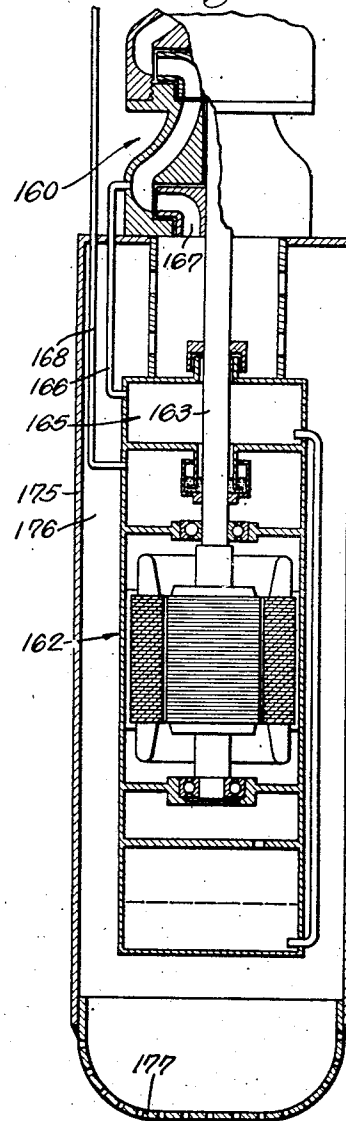


Fig. 2.



INVENTORS:
EARL MENDENHALL,
JUNIOR B. VAN HORN,

By *Fred W. Harris*
ATTORNEY

UNITED STATES PATENT OFFICE

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CONSTRUCTION FOR SUBMERSIBLE
MOTORS AND THE LIKE

Earl Mendenhall, Los Angeles, and Junius B. Van
Horn, Alhambra, Calif., assignors to Menhorn,
Inc., Los Angeles, Calif., a corporation of
California

Original application September 26, 1932, Serial
No. 634,911. Divided and this application Jan-
uary 12, 1935, Serial No. 1,520

12 Claims. (Cl. 172-36)

Our invention relates to submersible struc-
tures and more particularly to a submersible elec-
tric motor which can operate submerged in an
external liquid and which includes an enclosing
structure which effectively protects the elements
therein from contact with the external liquid in
which the enclosing structure is submerged. The
present application is a division of our co-pending
application entitled Submersible structure, Se-
rial No. 634,911, filed September 26, 1932.

It is often desirable to be able to maintain the
pressure inside a submerged structure at a value
somewhat different from the pressure of the sur-
rounding liquid, and it is an object of the present
invention to provide a novel structure for accom-
plishing this result. This result is especially de-
sirable in certain installations wherein segmen-
tal or sectional enclosing structures are utilized.
Any differential pressure on such a segmental en-
closing structure will tend to force liquid into or
from the structure depending upon whether the
pressure is greater outside or inside thereof. It
is sometimes difficult to maintain a fluid-tight
joint on such a segmental shell, especially after
the structure has been submerged for a long period
of time. So, also, it is sometimes difficult to ob-
tain castings which are entirely impervious. Any
minute pin holes in such castings might permit
the external liquid to enter the submerged struc-
ture with possible detrimental results. Thus, in
the preferred embodiment of the invention we
prefer to maintain the internal pressure some-
what greater than the external pressure, thus
insuring that no inward leakage will take place.

It is an object of the present invention to pro-
vide a system including a pump or other means
which changes the internal pressure relative to
the external pressure and which, at the same time,
is capable of substantially equalizing the pres-
sures on opposite sides of a sealing means used to
seal a shaft or other moving element extending
from the enclosing structure.

Our invention permits the use of a fluid-packed
seal in this connection, and it is a further object
of the present invention to provide a submersible
structure including such a fluid-packed seal in
which the pressures on opposite sides of the seal
are maintained substantially equalized at a value
greater than the pressure of the external liquid.

The pressure differential between the interior
and exterior of the enclosing structure can be
developed by any one of several means, but in
the preferred embodiment of the invention this
pressure differential is developed by use of a suit-

able pump, usually a pump of relatively small
character.

It is an object of the present invention to pro-
vide a novel submersible structure including a
pump for maintaining a pressure differential be-
tween the interior and exterior of the enclosing
structure.

It is a further object of the present invention
to provide a structure in which a restricted pas-
sage is utilized in conjunction with a pumping
means.

Another object of the invention is to provide
an improved submersible structure which is very
effectively sealed thereby permitting the use
therein of an electric motor or other moisture-
sensitive structure.

It is a further object of the invention to pro-
vide a novel system for compensating for ex-
pansion of the internal liquid, thus permitting the
use of an electric motor in the structure which
heats and expands this internal liquid.

Further objects of the invention lie in the novel
pressure-transfer or pressure-balance system
utilized.

Still a further object of the invention is to pro-
vide a submersible structure which may be uti-
lized for pumping purposes and which is surround-
ed by a suction pipe so that the level of the
pumped liquid can be drawn downward to a point
below the motor, if desired, without injury to the
motor.

Still further objects and advantages of the in-
vention will be made evident hereinafter to those
skilled in the art.

Referring to the drawing:

Fig. 1 is a sectional view of one embodiment of
the invention.

Fig. 2 is a sectional view of an alternative form
of the invention utilized in conjunction with a
turbine pump.

In Fig. 1 we have illustrated a submersible mo-
tor embodying the features of the invention, and
including a submerged enclosing structure 10 in-
cluding a shell 11 providing a dome or upper
wall 12 at the upper end thereof, and providing
a lower wall 13 at the lower end thereof. Inter-
mediate walls 15 and 16 extend inward from the
shell 11 and cooperate in defining a main cham-
ber which, in the embodiment of the invention
shown in Fig. 1, comprises a motor chamber 19.

Positioned in the motor chamber 19 is an elec-
tric motor 20 providing a stator 21 which is pre-
ferably spaced from the shell 11 to define one or
more passages 22. This motor also includes a
rotor 23 adapted to rotate in a rotor space 24

of the stator 21. A shaft 25 is operatively connected to the rotor 23, and, in the preferred embodiment of the invention, extends upward from the enclosing structure through a central opening in the upper wall 12 thereof, there being a clearance space 26 between the periphery of this shaft 25 and the upper wall 12. This shaft may be journaled by any suitable bearings such as those indicated by the numerals 27 and 28, these bearings being respectively supported in bearing plates 29 and 30 which provide suitable openings 31 and 32 therein.

It is usually preferable to fill the space around the motor 20 with an internal liquid, usually oil of relatively high dielectric strength. To seal this internal liquid from the external liquid, or from other surrounding media, a seal 33 is provided at the junction of the shaft 25 and the intermediate wall 15. Various types of seals may be utilized, but we have found that most satisfactory results accrue from the use of a fluid-packed seal. In the embodiment illustrated, this seal includes a rotatable cup 34 suitably secured to the shaft 25 and retaining a body of mercury or other sealing liquid. An apron 35 extends downward from the intermediate wall 15 beneath the surface of the sealing liquid, thus dividing this surface of the sealing liquid into two separated surfaces indicated respectively by the numerals 37 and 38. In the embodiment illustrated the surface 38 may be contacted by the internal liquid, while the surface 37 may be contacted by the liquid in the upper end of the enclosing structure, this seal being effective to separate these liquids at all times.

If certain types of seals are utilized such as the fluid-packed seal illustrated, we have found it desirable in most installations to transfer pressure between the ends or sides thereof usually substantially equalizing the pressures thereon. This may be accomplished in the embodiment shown in Fig. 1 by the use of a suitable pressure-transfer system shown as including a pressure-transfer or balance chamber 41 defined between the intermediate wall 16 and the lower wall 13. This pressure-transfer chamber 41 is shown as including contacting bodies of the internal and external liquids indicated respectively by the numerals 42 and 43, these bodies of liquid separating at a surface of contact 44. The internal liquid, being usually of lower density than the external liquid, assumes an upper position in the pressure-transfer chamber 41, and the body of this internal liquid 42 is shown as being in open communication with the internal liquid in the motor chamber 19 through one or more openings 45. The body of external liquid in the pressure-transfer chamber 41 is shown as being in open communication through a pipe 47 with an auxiliary or pumping chamber 50 bounded at its lower end by the intermediate wall 15 and bounded at its upper end by an intermediate wall 51. The pressure-transfer chamber 41 thus acts to substantially equalize the pressures exerted on opposite portions of the seal 33, thus preventing a disruptive displacement of the sealing liquid if a fluid-packed seal is utilized, thus preventing leakage through this sealing means.

It is usually desirable to maintain a pressure differential between the internal and external liquids. In most installations it is desirable to maintain the pressure on the internal liquid slightly greater than the pressure on the external liquid in which the enclosing structure 10 is submerged, i. e., to maintain the pressure on the internal

liquid greater than the pressure of the external liquid at the depth of submergence of the unit. In the form of the invention shown in Fig. 1 this is accomplished by the use of a pumping means illustrated as comprising an impeller 55 providing open passages discharging into the upper or pumping chamber 50, the impeller intaking from an intake chamber 56 defined between the intermediate wall 51 and the upper wall 12. However, other systems for maintaining a pressure differential may be utilized without departing from the spirit of the invention.

In the embodiment shown, the external liquid has access to the intake chamber 56 through the restricted passage 28. To prevent entry of sand or other foreign material into this intake chamber, and to suitably throttle the flow therein, we prefer to provide an upward extending neck 57 on the upper wall 12, there being an inverted cup 58 secured to the shaft 25 and depending around the neck 57, this cup being only slightly larger than the neck 57 to define a restricted or throttle passage 59 through which must pass any of the external liquid entering the intake chamber 56.

The pressure differential developed by the pumping means need not be large. A pumping means which develops a pressure differential of only a few pounds per square inch is adequate and will effectively prevent entry of the external liquid through any imperfection in the enclosing structure 10 such as might be formed by minute pin holes therein or by faulty joints if this enclosing structure is made of segmental character. The impeller 55 of Fig. 1 thus intakes at a pressure substantially equal to the pressure of the external liquid at the depth of submergence, and discharges into the pumping chamber 50 at a slightly greater pressure. This greater pressure is transmitted both to the surface 37 of the sealing liquid and to the surface 38 thereof, being transmitted to the latter surface through the pipe 47, the pressure-transfer chamber 41, and the internal liquid in the motor chamber 19.

Current may be supplied to the stator 21 through a cable 65 which is shown as extending upward to a point above the surface of the external liquid in which the structure is submerged, being there connected to the source of electric energy, not shown. If desired, this cable may extend downward in a pipe 66, this pipe being utilized for supplying additional internal liquid to the motor chamber if desired and acting as a surge means or compensating chamber receiving additional quantities of the internal liquid due to actuation of the pump means or due to expansion, or due to both. If this pipe is in open communication with the motor chamber, it will be clear that the pressure-transfer chamber 41 will act to force a column of the internal liquid upward in the pipe 66 until the pressure head developed is sufficient to substantially balance the pressure in the motor chamber 19 and in the pumping chamber 50. It will be noted that the pipe 66 is of relatively small diameter as compared to the diameter of the pressure-transfer chamber 41 so that a large change in the liquid level in the pipe 66 can be effected with only a minute movement of the surface of contact 44 of the internal and external liquids in the pressure-transfer chamber 41. Thus, when the motor is de-energized, the level of the internal liquid in the pipe 66 will be at or near the level of the external liquid in which the unit is submerged, in the event that the upper end of the pipe 66 is open

to the atmosphere. When the motor is energized, the pressure inside the structure will be slightly increased due to the action of the impeller 55 and due to expansion of the internal liquid when heated by the motor, and the pressure-transfer chamber 41 will cause an additional quantity of the internal liquid to move upward into the pipe 66 until the pressure head developed substantially equals the pressure head in the main chamber or in the pumping chamber 50. If the upper end of the pipe 66 is open to the atmosphere, the liquid level in this pipe will stand slightly above the level of the external liquid. If, however, the upper end of the pipe 66 is not open to the atmosphere but is suitably capped, the level of the internal liquid therein will depend upon the pressure of the medium in the pipe above this internal liquid.

It should not be understood, however, that we are limited to the use of a pipe 66, for in many instances it is unnecessary to add additional internal liquid to the motor chamber. If this pipe is dispensed with, the cable 65 may be secured in fluid-tight relationship with that portion of the shell around the motor. The internal liquid will then be entrapped in the shell and expansion thereof due to operation of the motor will be compensated for by a flow of the excess internal liquid into the pressure-transfer chamber, thus displacing a quantity of the external liquid therefrom which flows upward through the pipe 47 and thence through the passages of the impeller or other pumping means if utilized.

In Fig. 2 we have illustrated another embodiment of the invention utilized in conjunction with a turbine pump 160, the submersible motor being indicated by the numeral 162 and being operatively connected to the turbine pump 160 by a shaft 163. The motor structure is quite similar to that shown in Fig. 1 except that the intake chamber 56 is eliminated, and no impeller is utilized in the upper end of the enclosing structure. Instead, the upper end of the enclosing structure includes a pressure chamber 165 which is in communication through a pipe 166 with one of the impellers of the turbine pump 160. In Fig. 2 we have illustrated the turbine pump 160 as being of the multi-stage type, and have shown the pipe 166 as communicating with the discharge of the lowermost impeller indicated by the numeral 167. This pipe may, however, communicate with certain other of the impellers of the turbine pump 160, it being clear that the pressure in the pressure chamber 165 can be increased by connecting the pipe 166 to one of the upper impellers of the pump unit. A pipe 168 is shown as communicating with the interior of the enclosing structure of the motor, this pipe serving the same function as the pipe 66 of Fig. 1. The pipe 168 may be open to the atmosphere at its upper end, or may be closed, or in some instances the pipe may be entirely dispensed with, the internal liquid being introduced into the motor prior to submergence.

In the event that a motor is positioned in the enclosing structure of the invention, this enclosing structure being below the pump unit as disclosed in Fig. 2, it is sometimes desirable to be able to lower the level of the external liquid to a position below the enclosing structure. One mode of accomplishing this result is disclosed in Fig. 2 wherein a suction pipe 175 extends downward from the lowermost pump bowl of the turbine pump 160. This suction pipe is spaced from the structure enclosing the motor to define an

annular suction space 176. The lower end of the suction pipe may be partially closed by a strainer element 177 which strains the incoming liquid. It will be clear that with this type of structure, the level of the external liquid can be lowered to a point below the motor. This is made possible only by the fact that a differential pressure is maintained on opposite sides of the enclosing structure, for it will be clear that a partial vacuum will be created in the upper end of the suction pipe in the event that the level of the external liquid is lowered to a point below the motor. If the pressure differential is sufficient to overcome this partial vacuum, it will be clear that there will be no tendency for the internal liquid to be drawn from the interior of the enclosing structure. Further, there will be no tendency for the level of the internal liquid in the pipe 168 to be drawn downward to admit air or gas into the upper end of the motor chamber, the pressure differential being maintained of sufficient value to prevent such an action. Such a suction pipe may be installed on the other form of the invention herein shown, if desired.

While we have herein shown the pressure-transfer means as comprising a chamber containing contacting bodies of the internal and external liquids, it should be understood that we are not limited to such a construction. If desired, other pressure-transfer means may be utilized.

It will be clear that our invention can be applied to various structures. Thus, the enclosing structure and its related elements can be used to enclose any suitable means which it is desired to keep from contact with the external medium in which the unit is submerged or positioned. Thus, the invention is not limited to use in conjunction with a submersible electric motor but finds utility in conjunction with various other structures such as bearings, other moisture-sensitive means, etc. It will be further clear that if our invention is embodied in conjunction with an electric motor to produce a submersible electric motor structure, this structure can be used for driving various means such as the pump shown in Fig. 2 or other driven means. Our structure may be installed in wells, pits, etc., or may be submerged beneath the surface of various bodies of liquid, such as being submerged in lakes or other bodies of water. Nor are we limited to the use of internal and external liquids comprising oil and water. Various other internal or external liquids may be utilized without departing from the spirit of the invention.

In conclusion, one of the important features of the invention is to utilize a pressure inside a submerged shell which is different from the pressure at the depth of submergence regardless of whether this pressure is developed by a pumping means or by other means. If the internal pressure is maintained greater than the external pressure, any tendency toward leakage will be outward rather than inward so that none of the external liquid will enter the shell either through the sealing means or through imperfection of joints therein.

Another important feature of the invention which is particularly desirable in certain installations is the maintenance of a differential pressure inside and outside the submerged shell, together with the maintenance of substantially equal pressures of the seal.

We claim as our invention:—

1. In a submersible structure, the combination

of: an enclosing structure submerged in an external liquid and defining a main chamber containing an internal liquid; a rotatable shaft extending upward from said main chamber; a seal at the junction of said shaft and said enclosing structure; pump means above said main chamber and operated by said shaft and intaking from said external liquid in which said enclosing structure is submerged and discharging in communication with said seal; and walls forming a balance chamber communicating between said main chamber and the pressure developed by said pump means and containing pressure-transferring bodies of said internal and external liquids for building up the pressure in said main chamber to a value higher than the pressure of said external liquid at the depth of submergence of said structure and thereby substantially equalizing the pressures on opposite sides of said seal.

2. In a submergible structure adapted to be submerged in an external liquid, the combination of: walls forming a main chamber, a pumping chamber, and an intake chamber positioned in superposed relationship; a shaft extending from said main chamber and through both said pumping chamber and said intake chamber; sealing means around said shaft and separating said main chamber and said pumping chamber; pressure-transfer means communicating between said pumping chamber and said main chamber to substantially equalize the pressures acting on said sealing means; and pump means driven by said shaft and intaking from said intake chamber and discharging into said pumping chamber to raise the pressure in said pumping chamber and in said main chamber to a value above the pressure of said external liquid at the depth of submergence of said structure.

3. A combination as defined in claim 2 including restricted means communicating between said intake chamber and said external liquid to remove any foreign particles from said external liquid entering said intake chamber.

4. In a submersible structure adapted to be submerged in an external liquid, the combination of: walls adapted to be submerged in said external liquid and defining a main chamber containing an internal liquid and defining a pumping chamber thereabove; a shaft extending upward from said main chamber into said pumping chamber; pump means operatively connected to said shaft for increasing the pressure in said pumping chamber to a value above the pressure of said external liquid at the depth of submergence of said walls; a seal at the junction of said shaft and said walls and separating said main chamber and said pumping chamber and communicating with the discharge of said pump; and means for transmitting the discharge pressure of said pump to said main chamber whereby operation of said pump maintains the pressure in said main chamber at a value above the pressure of said external liquid at the depth of submergence of said walls and whereby the pressures on opposite sides of said seal are substantially equalized.

5. In a submersible electric motor structure, the combination of: a shell positioned in a surrounding medium and providing a main chamber filled with an internal liquid; a motor in said main chamber and acting when energized to heat said internal liquid to cause expansion thereof; a shaft on said motor extending upward from said shell; walls defining an auxiliary chamber above said main chamber and through which said

shaft extends, said auxiliary chamber communicating with said surrounding medium; a sealing means around said shaft and sealing said internal liquid in said main chamber from the medium in said auxiliary chamber; pump means for building up a pressure in said auxiliary chamber which is greater than the pressure of said surrounding medium; and a pressure-transfer means communicating with said auxiliary chamber and with said main chamber for building up a pressure in said main chamber substantially equal to the pressure in said auxiliary chamber.

6. In a submersible electric motor structure, the combination of: a shell positioned in a surrounding medium and defining a motor chamber; a motor in said chamber; walls defining a pumping chamber above said motor chamber, said walls including a central opening; a shaft on said motor and extending upward into said pumping chamber; means around said shaft for sealing said motor chamber from said pumping chamber and providing internal and external portions respectively communicating with said chambers; an impeller on said shaft and discharging into said pumping chamber and drawing said surrounding medium through said central opening and discharging same into said pumping chamber; and pressure-transfer means communicating between said pumping chamber and said motor chamber to substantially equalize the pressures on said internal and external portions of said sealing means.

7. In a submersible electric motor structure, the combination of: a shell defining a main chamber and an auxiliary chamber above said main chamber, said main chamber entrapping a body of internal liquid and said auxiliary chamber communicating with an external liquid in which said shell is submerged; an electric motor in said main chamber and acting when energized to heat said internal liquid to cause expansion thereof, said internal liquid substantially filling said main chamber around said motor; a pressure-transfer means below said main chamber and communicating with said internal and external liquids and receiving any excess internal liquid due to said expansion and correspondingly displacing a portion of said external liquid; walls forming a passage communicating between said pressure-transfer means and said auxiliary chamber to conduct to said auxiliary chamber the displaced external liquid; a shaft operatively connected to said motor and extending from said main chamber into said auxiliary chamber; and a sealing means around said shaft and separating said internal liquid in said main chamber from said external liquid in said auxiliary chamber, said pressure-transfer means transferring pressure between those portions of said seal respectively communicating with said main chamber and said auxiliary chamber.

8. In a submersible electric motor structure, the combination of: a shell containing an internal liquid and adapted to be submerged in an external liquid, said shell providing a motor chamber; a motor in said motor chamber; walls defining a compensating chamber communicating with said internal liquid and adapted to receive any excess internal liquid when the operation of said motor causes expansion of said internal liquid; a seal around said shaft for sealing said internal liquid from said external liquid; pressure means for building up a pressure inside said shell which pressure is greater than the pressure of said external liquid at the depth of

submergence of said shell, said pressure forcing a portion of said internal liquid upward in said compensating chamber to raise the level of said internal liquid therein; and means for substantially equalizing the pressures on opposite sides of said seal at said increased pressure developed by said pressure means whereby the pressures on said seal are substantially equalized at a value greater than the pressure of said external liquid at the depth of submergence of said shell.

9. In a submersible electric motor structure, the combination of: a shell defining a main chamber completely filled with an internal liquid and adapted to be submerged in an external liquid; an electric motor in said shell and heating said internal liquid when energized, thereby causing expansion thereof; a shaft operatively connected to said motor; a seal around said shaft and sealing said external liquid from said internal liquid and providing internal and external portions respectively communicating therewith; a pumping means operatively connected to said shaft for building up on one portion of said seal a pressure greater than the pressure of said external liquid at the depth of submergence of said shell; and a pressure-transfer means for transmitting the increased pressure to the other portion of said seal to substantially equalize the pressures on said internal and external portions of said seal at a value greater than the pressure of said external liquid at the depth of submergence of said shell, said pressure-transfer means receiving any excess of said internal liquid due to expansion thereof, said pumping means providing passage means through which the pumped liquid may flow during such expansion of said internal liquid to compensate for said expansion and maintain a substantially constant pressure differential between said internal and external liquids.

10. A combination as defined in claim 5 in which said pump means is above and spaced from said auxiliary chamber, and including passage

means communicating between the discharge of said pump means and said auxiliary chamber.

11. In a submersible motor structure the combination of: a shell adapted to be submerged in an external liquid and providing a motor chamber and an auxiliary chamber; a motor in said motor chamber; a shaft driven by said motor and extending from said motor chamber through said auxiliary chamber, there being a restricted passage at the junction of said shaft and said shell and through which said external liquid has access to said auxiliary chamber, said motor chamber containing a body of an internal liquid; a seal means around said shaft and separating said motor chamber and said auxiliary chamber; a pipe communicating with one of said chambers and extending upward from said shell and containing a body of liquid exerting a pressure at the point of communication of said pipe and said one of said chambers which pressure is greater than the pressure of said external liquid at the depth of submergence of said shell; and pressure-transfer means communicating with each of said chambers and transferring pressure variations in one of said chambers to the other of said chambers to substantially equalize the pressures on opposite sides of said seal means at a value greater than the pressure of said external liquid at the depth of submergence of said shell.

12. In a submersible structure, the combination of: a shell positioned in an external liquid and defining a chamber and a balance chamber in communication with each other, said chamber containing a body of neutral liquid; a shaft extending from said shell; walls defining an auxiliary chamber around said shaft; sealing means sealing said auxiliary chamber from said chamber; and pipe means communicating between said balance chamber and said auxiliary chamber and extending therebetween at a position outside said shell.

EARL MENDENHALL.
JUNIOUS B. VAN HORN.