

June 25, 1946.

T. C. POULTER ET AL

2,402,913

VACUUM CONTROL MEANS AND METHOD

Filed Jan. 11, 1943

2 Sheets-Sheet 1

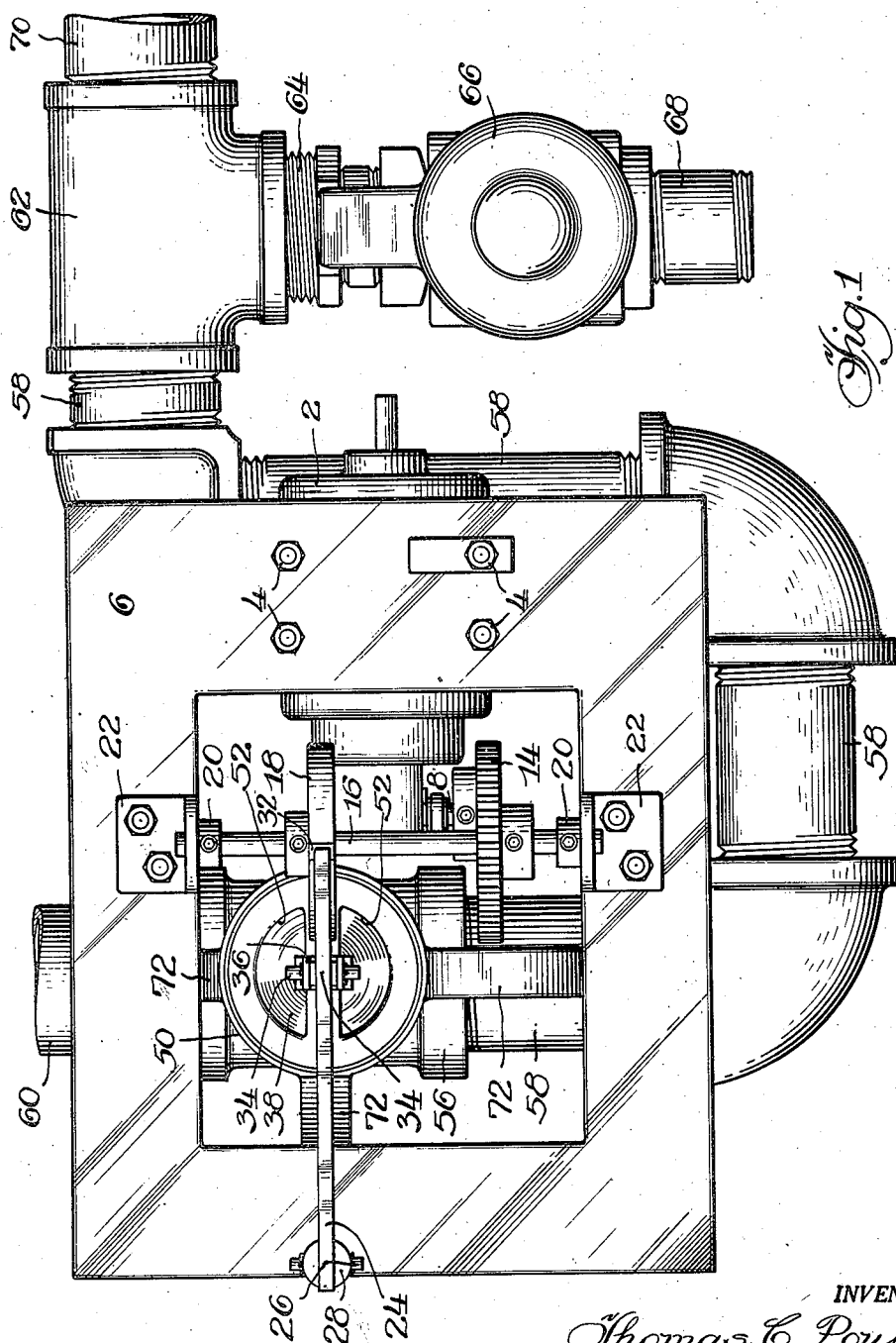


Fig. 1

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2 Sheets-Sheet 2

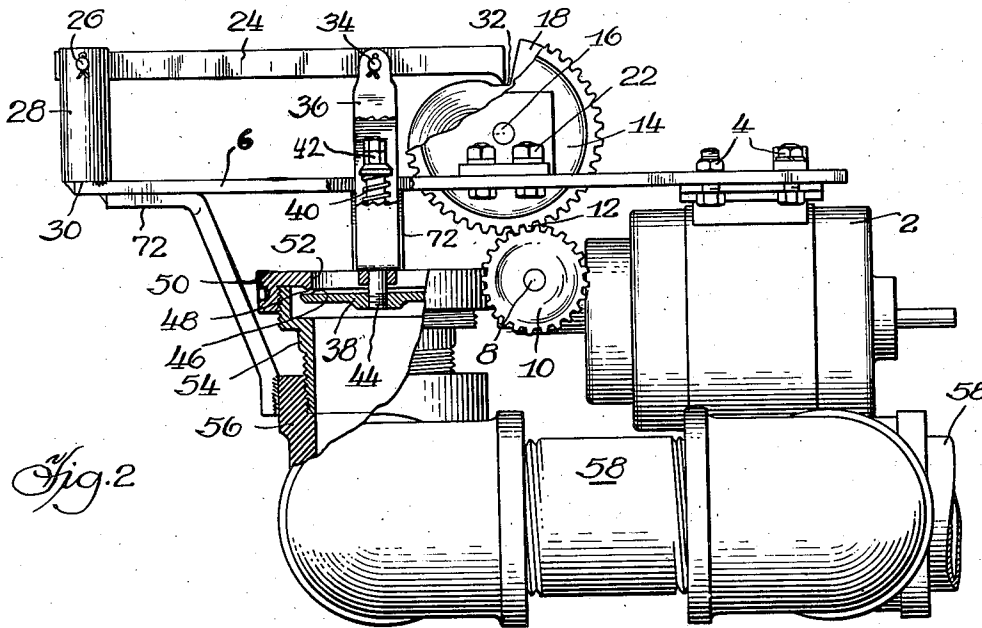


Fig. 2

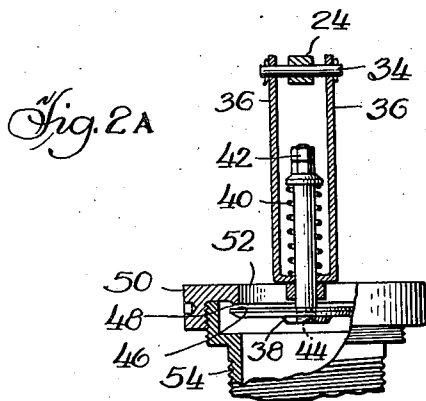


Fig. 2A

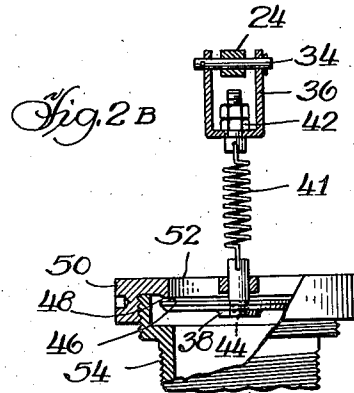


Fig. 2B

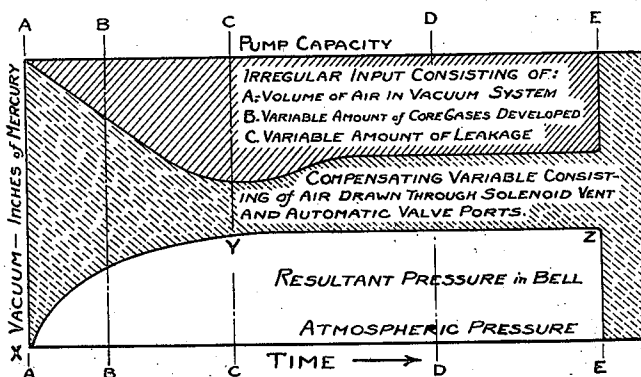


Fig. 3

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UNITED STATES PATENT OFFICE

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VACUUM CONTROL MEANS AND METHOD

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Application January 11, 1943, Serial No. 471,984

7 Claims. (Cl. 230—2)

1

Our invention relates in general to automatic vacuum control means and is illustrated as applied to the control of a vacuum utilized in countergravity pouring of metal, as illustrated and described in co-pending application, Serial No. 439,186, filed in the United States Patent Office April 16, 1942, in the name of Thomas C. Poulter, entitled Method and apparatus for casting metal.

The general object of our invention is to devise automatic means for controlling the pressure in a vacuum system in accordance with a predetermined time-pressure curve.

A more specific object of our invention is to devise automatic means for controlling the vacuum in a closed chamber within a fixed maximum limit.

Another object of our invention is to provide such automatic control means as will enable the rate at which the vacuum is developed to be accurately controlled, thus making it possible to increase the vacuum at a predetermined fast rate or slow rate as may be desired. Such control is essential in order to duplicate results obtained from time to time as the equipment may be utilized.

Still another object of our invention is to provide such automatic control means as that above referred to wherein automatic compensating means will be afforded for any minor leaks which may occur in the system assuming, of course, that an adequate reserve pumping capacity or source of exhaustion is associated therewith.

Our invention also comprehends such an arrangement as will afford the free and unrestricted passage of any sudden surges of gas as may occur in casting equipment such as that above referred to due to evolution of core gases, and provides for the immediate dissipation of any such surge of gases developed within the system.

Our invention also contemplates such an arrangement as that described wherein the vacuum which is developed within the system may be automatically released after a predetermined period and in which, in fact, the entire cycle of operations is automatically controlled.

In casting ferrous metal, such as steel, by a countergravity pouring method such as that referred to in the above-mentioned copending application, the mold for the article to be cast is mounted within a vacuum chamber. It is necessary that the metal be drawn into the mold at a uniform rate which may be controlled in spite of leaks which may occur in the system and it is necessary to be able to repeat the process time after time with no significant variation in the vacuum control if successive, substantially identical castings are to be produced.

Our novel equipment is capable of accomplishing these results.

In the drawings:

2

Figure 1 is a top plan view of one embodiment of our invention.

Figure 2 is a side elevation of the structure shown in Figure 1, certain parts being omitted therefrom and a portion of the valve mechanism being cut away to show in section certain parts thereof.

Figure 2A is a fragmentary sectional view showing certain details of the structure shown in Figures 1 and 2, and Figure 2B is a fragmentary sectional view comparable to Figure 2A but showing a modification of the invention.

Figure 3 is a chart or graph illustrating the manner in which the vacuum is developed and controlled.

Our novel apparatus, in the embodiment illustrated, comprises the power means 2 here illustrated as an electric motor mounted as at 4, 4 on the base or bed plate 6, said motor incorporating a speed control mechanism and serving as actuating means for the apparatus. The motor 2 may actuate the shaft 8 on which may be mounted the small gear 10 meshing as at 12 (Figure 2) with the large gear wheel 14 mounted on the shaft 16 for actuation thereof. Also mounted on the shaft 16 may be the cam wheel 18, and the shaft 16 may be suitably supported adjacent opposite ends by bearings as at 20, 20 and mountings therefor at 22, 22. Associated with the cam 18 may be a cam follower 24 in the form of a lever arm fulcrumed at one end as at 26 from the support 28 mounted as at 30 on the bed plate 6. The cam follower 24 may engage the cam 18 as at 32 (Figure 2) and may have pivotal connection at an intermediate point as at 34 to the link 36 which is connected to the valve 38 through the compression spring 40. The maximum strain of the spring 40 may be controlled by the adjusting nuts 42 mounted on the end of the valve stem 44. The valve 38 is illustrated at rest in its non-operating position where it may be slightly spaced as at 46 from the seat 48 afforded on the cap 50 within which may be formed a plurality of ports 52, 52 open to the atmosphere. The cap 50 may have threaded connection with the short nipple 54, and the opposite end of said nipple may have threaded connection to the standard pipe T 56 in the line 58. In Figure 2A we have shown in somewhat greater detail the parts enumerated above, and in Figure 2B we have shown a slight modification therefrom, similar in all respects, except that the connecting spring between the link 36 and the valve stem 44 is in the form of a tension spring 41 instead of a compression spring.

One end of the line 58 may lead as at 60 to a source of exhaustion or vacuum supply, such as a pump (not shown). In the line 58 may be mounted the T 62 having a connection as at 64 to the solenoid vent valve assembly 66 af-

fording automatic control means for opening or closing the vent at 68 in the line 58, said vent being open to the atmosphere. The other end of the line 58 may afford connection as at 70 to a vacuum bell or system to be evacuated, such as that illustrated and described in the said depending application. The pipe line 58 and associated parts may be held in assembled relationship with the base or bed plate 6 by means of the brackets 72, 72 afforded for that purpose.

With the power means or motor 2 at rest, the vacuum pump or exhaust means (not shown) may be set in operation while the cam follower 24 is seated as at 32 at the point of minimum radius on the cam wheel 18, and as the air is drawn towards the pump at 60, it may enter the line 58 through the solenoid controlled vent at 68 and through the ports 52, 52 of the automatic valve. Thus atmospheric pressure will be maintained in the vacuum bell connected as at 70 at one end of the line 58, the opposite end of said line being connected as at 60 to the vacuum pump, as already described. This condition of atmospheric pressure in the line and in the vacuum chamber is illustrated at the left of the graph of Figure 3 as at A—A, and at the right of said figure as at E—E. When the mold and ladle of molten metal (not shown) are in position for pouring, the electric motor 2 may be started as by a switch which may at the same time actuate the solenoid valve 66 to close the vent at 68. As the motor 2 operates, the cam wheel 18 is rotated and the cam follower 24 is gradually elevated, bringing the valve 38 into engagement with the seat 48 and closing the ports 52, 52. The stress of the spring 40 connected between the valve stem 44 and the link 36 varies from a minimum when the cam follower rests as at 32 at the minimum radius of the cam, to whatever maximum tension is required to obtain the desired maximum vacuum, which is reached when the cam follower has moved to the point of maximum radius on the circumference of the cam. The maximum strain thus afforded on the spring 40 may be varied as desired, as already described, by the adjusting nuts at 42. Also, the rate at which the vacuum is developed may be controlled by modifying the speed of the cam 18 and the character of the curve joining the point of minimum radius to that of maximum radius thereon. This may conveniently be done by substituting cams of various form as desired.

It will be understood that as the cam follower moves about the cam from the point of minimum radius to that of maximum radius, the valve 38 is forced against the valve seat at 48 with progressively greater pressure until the predetermined maximum is reached. This progressive increase of pressure is illustrated in the graph of Figure 3. The line B—B illustrates the condition that would prevail if the cam follower were stopped at a point intermediate the minimum and maximum radii thereof. The area at the top of the graph, cross-hatched in solid lines, represents the volume of gases being pumped away from the bell or system. These gases consist of the air in the system at the time of starting, a variable amount of core gas developed by the contact of the molten metal in the mold with the cores which may form parts of said mold, and any air that may be drawn into the system through leaks as, for example, at the juncture of the bell with the plate upon which it may be seated, or elsewhere.

The intermediate area of the graph, shown in

broken-line cross-hatching, represents the amount of air which may be drawn into the system through the air ports at 52, 52 in order to compensate for the variable amount of gases existing in the bell, and in order to produce the resultant desired pressure, as illustrated by the smooth curve X—Y of said graph illustrating the gradual increase of vacuum in the system. The time-pressure curve shown at X—Z is controlled by the pressure the cam follower 24 exerts on the spring 40.

If, at any time during the cycle, a greater vacuum tends to be produced in the bell than has been predetermined, atmospheric pressure will force the valve 38 away from the seat at 48, thus allowing air to be drawn into the system through the ports 52, 52. In other words, the system including the vacuum chamber is being exhausted at a predetermined rate as the strain of the spring 40 is gradually increased due to the changing position of the cam follower 24.

It will be understood that there is an ununiform input into the vacuum chamber and the system because of leakages, the amount of which can not be foreseen, and because of the development of a variable amount of core gases within the molds. The purpose of the automatic valve is to superimpose on this ununiform input another input which is ununiform, but such that the total input combined with the output through the pump, will adjust the pressure in the system in accordance with the predetermined time-pressure scale and to a predetermined final value. The length of the cycle is also predetermined by the circumference of the cam 18 and when the said cam has rotated through a complete revolution, the cam follower 24 will again drop to the point of minimum radius at which point the motor may be stopped and the solenoid again energized to open the vent at 68 to the atmosphere. The condition then obtaining will be that shown at E—E on the graph of Figure 3. If it is desired, the maximum vacuum may be maintained for a longer period by stopping the motor for a given length of time while the cam follower is on the maximum radius of the cam, otherwise the total time cycle or the slope of the time-pressure curve may be varied by substituting a different cam, as already described. The line C—C on the graph of Figure 3 illustrates the condition which prevails when the maximum quantity of gases is being withdrawn from the bell and the minimum quantity of air is being drawn into the system through the ports 52, 52. Shortly thereafter, a condition of substantial stability occurs, as illustrated by the line D—D, where the gases being withdrawn from the bell are substantially constant as are also those being drawn through the ports, and the straight line Y—Z represents the maximum vacuum steadily maintained as a result. The system is restored to its starting condition with atmospheric pressure being maintained in the line and in the bell when the cam follower has travelled the circumference of the cam 18 and reaches again the starting point illustrated in Figure 2 when the motor may be automatically cut off and the solenoid valve assembly reenergized. The vacuum bell may then be dismantled, the mold removed, a new one inserted, the bell replaced, and the cycle repeated.

To those skilled in the art, it will be understood that in a system such as this it is necessary to evacuate at a uniform rate the vacuum or bell within which the casting is to be poured. It will also be understood that there is an un-

5

uniform input into this vacuum bell due to leak-
ages which are irregular and to the evolution
of gases from the cores forming a part of the
mold. The mechanism herein described superim-
poses on the above-mentioned ununiform input
another input which is also ununiform but is
such that the total of the two inputs, combined
with the output to the pump or source of the
vacuum, so adjusts the pressure in the dome or
vacuum bell that it corresponds with a predeter-
mined time-pressure cycle and reaches a prede-
termined final maximum value, as clearly set
forth in the accompanying graph.

It will be understood that our automatic valve
arrangement readily allows the free passage of
any sudden surges of gas within the vacuum
bell, such as may be caused by the admission of
core gases to the vacuum pump, because the pas-
sage between the pump and the bell is free and
unrestricted. Any such surge is immediately dis-
sipated because an increase in pressure in the
system allows the spring 40 immediately to close
the automatic valve 33, thus greatly reducing the
compensating values normally being drawn into
the system.

To those skilled in the art it will be apparent
that the function of the solenoid valve is merely
auxiliary to the opening afforded by the auto-
matic valve 33. The system is equally operable
whether or not the solenoid valve is used, but by
utilizing it, it is easier to make a fine adjustment
at the valve 33 than would otherwise be possible.
In other words, if the solenoid valve were omit-
ted, there would be a tendency for a slight vacu-
um to be created within the system before the
valve 33 were entirely closed by the cam follower,
and this slight vacuum might be developed in
such manner as to interfere with the uniform
degree of pressure within the system which is
desired in order to flow the metal smoothly into
the mold. By providing the vent 63 with the
solenoid control therefor, it is possible to provide
a large opening to the atmosphere which may
be instantly closed when it is desired to begin
reducing the pressure in the bell. The valve 33
will automatically control the rate at which this
pressure is reduced.

It is to be understood that we do not wish to
be limited by the exact embodiments of the de-
vice shown which are merely by way of illustra-
tion and not limitation as various and other
forms of the device will, of course, be apparent
to those skilled in the art without departing
from the spirit of the invention or the scope of
the claims.

We claim:

1. In a vacuum system having an ununiform
gas input and exhaustion means therefor, auto-
matic means for controlling a second ununiform
input such that the total input combined with
the output due to exhaustion thereof automati-
cally adjusts the pressure therein at a predeter-
mined rate of change, said automatic means
comprising a valve in said system having an
opening to the atmosphere, and means auto-
matically responsive to the pressure in said sys-
tem for controlling the input at said opening,
said responsive means comprising yielding means
under stress for maintaining said valve normally
closed, and means for modifying said stress.

2. In a vacuum system having an ununiform

6

gas input and exhaustion means therefor, throt-
tling means for controlling a second ununiform
input such that the total input combined with
the output due to exhaustion thereof automati-
cally adjusts the pressure therein at a predeter-
mined changing rate, said throttling means com-
prising a valve in said system having an opening
to the atmosphere, and means automatically re-
sponsive to the pressure in said system for con-
trolling the input at said opening, said responsive
means including yielding means under stress as-
sociated with said valve for maintaining said
valve normally closed, and means for varying
said stress at said predetermined changing rate.

3. Control means for a vacuum system having
a vacuum source such as a pump, a chamber to
be evacuated, and a connecting line therebe-
tween, comprising a valve in said line, and auto-
matic control means for said valve responsive to
the pressure within said line to adjust the open-
ing of said valve to atmospheric pressure, said
means comprising resilient means connected to
said valve and under stress to maintain said
valve normally closed, and means for modifying
said stress at a rate commensurate with the de-
sired change of pressure in said system.

4. Control means for a vacuum system having
an exhaust source such as a pump, a chamber to
be evacuated, and a connecting line therebe-
tween comprising a valve in said line, and auto-
matic control means for said valve including
yielding means responsive to pressure within said
line to adjust the opening of said valve to at-
mospheric pressure, and means for varying the
stress of said yielding means.

5. In a vacuum system having a source devel-
oping said vacuum, control means having a cycle
operable to increase said vacuum in said system
at a predetermined rate, said means comprising
a valve in said system having an opening nor-
mally closed to the atmosphere at the begin-
ning of said cycle, yielding means under stress
at the beginning of said cycle to maintain said
valve in said closed position, and means for vary-
ing said stress at a rate commensurate with said
predetermined rate.

6. In a pressure regulating system for vacuum
casting, a chamber to be evacuated, an exhaust-
ing pump, a connection between said pump and
chamber, a differential valve in said connection
having one side exposed to pump pressure and
the other side to atmospheric pressure through
a restricted opening, yielding means supporting
said valve substantially closed, and control means
connected to said yielding means and operable
to modify the stress thereof at a rate commen-
surate with the desired rate of change of pres-
sure within said system.

7. In a vacuum system having a source devel-
oping said vacuum, control means operable to
increase said vacuum in said system at a prede-
termined rate, said means comprising a valve in
said system having an opening normally closed
to the atmosphere, yielding means operable to
maintain said valve in said closed position, and
means for varying the stress of said yielding
means at a rate commensurate with the desired
rate of change of pressure in said system.

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