APPARATUS THAT AUTOMATICALLY CONTROLS THE CORRELATION BETWEEN TIME AND AIR-PRESSURE

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This invention relates to the apparatus that automatically controls the correlation between time and air-pressure, and which is fit for an automatic controlling of the pressure to be charged especially at the time of low-pressure die casting.

As is well-known, in the case of low-pressure die casting, it is required that, in order to fill up the cavity with molten metal, air-pressure of 0.1 kg/cm² should be applied to the surface of the molten metal in the crucibles, and that the pressure should be kept at given height for a fixed period.

In such pressure-method, the pressure-valve is usually opened by hand, but, then, as it is difficult to control pressure, and, as the pressure tends to be given in too short time, the results are not always good, which is one of the great deficiencies of such method.

It is one of the objects of the present invention to provide a rising-curve of the pressure which is automatically controlled against time, and by which the uniformity of the quality and mass production are achieved.

FIG. 1 is a sectional view of an example of the automatic pressure controlling valve and the three-way change-over valve.

FIG. 2 is a block-diagram of a complete installation.

FIG. 3 is a diagram which shows the action of the automatic pressure controlling valve.

Explanations will be given hereafter about one embodiment of the invention referring to the attached figures.

FIG. 1 shows the automatic pressure controlling valve A hereafter to be called simply "controlling valve," and the three-way change-over valve B hereafter to be called simply "change-over valve," and the latter consists of a four-way electro-magnetic change-over valve for air C and the three-way stop-valve D.

The said controlling-valve A is provided with the upper oil-chamber 3 and the lower oil-chamber 4 between the upper air-chamber 1 and the lower air-chamber 2, and the upper air-chamber 1 and the upper oil-chamber 3, as well as the lower air-chamber 2 and the lower oil-chamber 4, are divided from each other by the plastic diaphragms 6 which are connected with the stem 5 that can move vertically.

The upper and the lower coil-chambers 3 and 4 are connected with each other, the opening of the passage between them being controlled by the controlling-needle 7. And both are connected with each other through the one-way check-valve 8.

The vertical motion of the said stem 5 is restricted by the lower stop 9 and the upper stop 10 which can be controlled freely, but the lower end of the stem 5 is connected with the spring holder 11 engaging one end of a spring 12 which forms a pressure means. The other end of the spring 12 is held by the plate 14 of the diaphragm 13 receiving the secondary pressure, and the said plate is raised by the bolt 15 when the stem 5 goes up. And with the said plate is connected the relief valve 16, and the needle 17 of the relief valve is pressed against the valve seat 16 by the spring 19 with the diaphragm 18 in between. The port E for the compressed air of the primary side is connected with the compressed-air chamber T (FIG. 2).

The said upper and lower air-chamber 1 and 2 are each connected with the two ports of the four-way electro-magnetic change-over valve C, while the other two ports of the electro-magnetic valve C are each connected with the upper cylinder-chamber 21 and the lower cylinder-chamber 22 which are divided by the piston 20 of the three-way change-over stop valve D.

One port a of the three-way change-over stop valve D is connected with the pressure chamber of secondary side F of the said controlling valve A, another port b with the controlled side G (FIG. 2) such as a furnace for example, and the remaining port c with the outside atmosphere.

The valve body 23 of the stop valve D, its upper valve seat 24 and lower valve seat 25 are shown at the lower right of FIG. 1.

The magnet 26 connects with spool 27 of the electromagnetic valve c which is pushed down by the movable core of the magnet 26 and is retracted by the retracting spring 28. The port 29 for the air on the primary side, the exhaust port 30, the push-button switch S of the magnet 26, the motor M, the compressor P, the filter Q, the reducing valve N, and the lubricator L are all indicated in FIG. 2.

The operation of an embodiment of the present invention is set forth below.

First, when the push-button switch S is closed, the magnet 26 of the change-over valve B is put into operation, and the movable core thereof lowers spool 27. When the spool 27 comes down to its lower position, the air-pressure from the port 29 is introduced into the upper air-chamber 1 of the controlling valve and the upper cylinder-chamber 21, and, at the same time, the air-pressure of the lower air-chamber 2 and the lower cylinder-chamber 22 is discharged into the atmosphere through the exhaust port 30.

The result is that the piston 20 is pushed down and the valve body 23 is set on the lower valve seat 25 and the secondary air-pressure from the controlling valve A is transmitted to the furnace, the controlled side G, through the valve B.

By the air-pressure, introduced into the upper air-room 1, a downward thrust is given on the stem 5 of the diaphragm-motor, and at the same time, the oil in the upper oil-chamber is given pressure, and the said pressed oil flows into the lower oil-chamber 4 through the orifice provided by the controlling needle 7 in the opening, and, accordingly, the stem 5 begins to lower at a constant speed.

The lowering speed of the stem 5 can be regulated minutely by controlling the opening of the orifice by the controlling needle 7 properly.

Now, when the stem 5 lowers, the spring holder 11 on its tip is pushed down and the spring 12 is gradually pressed and the additional pressure upon the diaphragm 13 receiving the secondary pressure increases in proportion with the distance the stem has lowered, and, therefore, the pressure on the controlled side increases in accordance with time. When this rising of the secondary pressure reaches the given highest degree, the lowering of the stem 5 is held by the stop 9, and, therefore, the pressure no longer rises and the fixed pressure can be kept on until the switch S is opened.

How the secondary pressure rises is shown on the diagram of FIG. 3.

If the switch S is opened, the magnet ceases to be in operation, and the movable core and the spool 27 are pushed up by the retracting spring 28, and then the air-pressure from the primary side flows into the lower cylinder-chamber 22 and the lower air-chamber 2 and the air-pressure of the upper cylinder-chamber 21 and the upper air-chamber 1 is discharged into the atmosphere through the exhaust ports.
Therefore the stem 5 is given an upward thrust and the oil in the lower oil-chamber 4 is given pressure and, pushing open the check-valve 8, flows fast into the upper oil-chamber 7, and so the stem 5 rises up rapidly until it collides against the upper stop 10.

At the final point of its rising, the stem 5 pulls up the diaphragm-plate 14, the relief valve seat 16 moves at the same time (as it is connected with the former), and the relief-valve 17 is opened and through it secondary air-pressure is charged into the atmosphere at once.

Here, one cycle of operation is finished, and the pressure on the controlled side becomes zero, and in this condition the new cycle is to be begun.

The highest pressure to be introduced into the controlled side C can be easily controlled by regulating the lower stop 9, changing the stroke of the stem, and adjusting the flange of the spring 12. And the time required to reach the highest pressure from zero can be regulated properly by adjusting the opening of the orifice between the upper and lower oil-chambers 3 and 4 with the controlling needle 7 (it is a matter of course that it can be adjusted by other means), and the duration of the highest pressure can be controlled by adjusting the opening time of the switch S, and so it is possible to control and automatically the correlation between time and pressure shown in FIG. 3.

In the case of the present invention, as distinct from reducing valves of the usual type, the secondary pressure is completely relieved of the influence of the pressure on the primary side, and, therefore, the secondary pressure cannot be made lower than a given degree, and, as the diameter of the diaphragm 13 receiving the secondary pressure can be made long, its sensibility is sharp and the error in the given pressure is very small and the proper quantity of the flow can be maintained.

Thus, it will be seen that the ports E and F as well as the ports a and b form together with the connections therebetween a delivery conduit means through which a fluid is delivered to a required delivery location, and the valve 23 forms a delivery valve means which connects with this conduit means to open and close the latter so as to initiate and terminate the flow of fluid therethrough. The diaphragm 13 is a pressure-responsive means which controls the pressure of the fluid in the delivery conduit means which includes the ports E, F, a and b, and this latter pressure-responsive means 13 communicates with the conduit means to act on the fluid thereof and is in turn actuated upon by pressure means formed by the spring 12 which acts to control the pressure transmitted to the fluid in the conduit means by way of the pressure-responsive means 13. The chamber 1 is a working chamber means which receives a working fluid, which is at suitable pressure, from the working fluid supply means B, and a pressure-responsive means is formed by the upper diaphragm 6 of FIG. 1 to respond to the introduction of working pressure fluid in the working chamber 1. The chamber 3, together with the adjustable valve 7 form a control means for controlling the rate of response of the pressure-responsive means formed by the upper diaphragm 6 of FIG. 1 to the introduction of fluid under pressure into the working chamber means 1, and the control means formed by the chamber means 3 and the valve means 7 will control the time it takes for the stem 5 to be displaced through a given increment of movement. This stem 5 forms a motion-transmitting means which transmits the motion of the upper diaphragm 6 of FIG. 1 to the pressure means 12 for increasing the pressure of the latter as the volume of the working chamber means 1 increases, so that as a result of the control means 3, 7 the rate of increase of the force exerted by the pressure means 12 on the pressure-responsive means 13 is regulated, and thus it is possible to regulate the rate at which the pressure increases in the fluid flowing along the conduit which includes the ports E, F.
said control means for receiving the oil therefrom, and a second air chamber adapted to be placed in communication with said supply means when the communication between the latter and said first-mentioned air chamber is terminated, a third diaphragm situated between and separating said second oil chamber and said second air chamber from each other so that as the volume of said second oil chamber increases the volume of said second air chamber decreases and air is discharged therefrom, said third diaphragm being operatively connected to said stem for movement therewith and moving in unison with said second diaphragm so that as oil flows from said first-mentioned oil chamber through said adjustable valve of said control means into said second oil chamber the volume of said second air chamber decreases while the volume of said first-mentioned air chamber increases and the pressure provided by said first diaphragm on the fluid in said delivery conduit means increases at a rate determined by the setting of said valve of said control means, and change-over means coating with said supply means for changing the latter over from an operative connection with said first-mentioned air chamber to an operative connection with said second air chamber, said change-over means coating with said delivery valve means for closing the latter when said supply conduit means is placed in communication with said second air chamber, and check-valve means for providing a communication between both of said oil chambers and for providing a rapid flow of oil from said second oil chamber to said first-mentioned oil chamber during an increase in the volume of said second air chamber when the latter is placed by said change-over means in communication with said supply means, said change-over means placing said first-mentioned air chamber in communication with a source of low pressure so that the air will be discharged therefrom as the oil flows rapidly through said check-valve means from said second to said first-mentioned oil chamber, whereby the increased pressure on said pressure means is relieved, said delivery valve means closes, and the pressure of the fluid in said delivery conduit means drops.

4. The combination of claim 3 and wherein a relief valve means connects with said first pressure-responsive means and with said delivery conduit means for placing the interior of the latter in communication with the outer atmosphere when said change-over means places said supply means in communication with said second air chamber.

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