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[54] APPARATUS FOR THE HEATING AND COOLING
OF MOULDS FOR THE PRODUCTION OF PLASTIC
BODIES

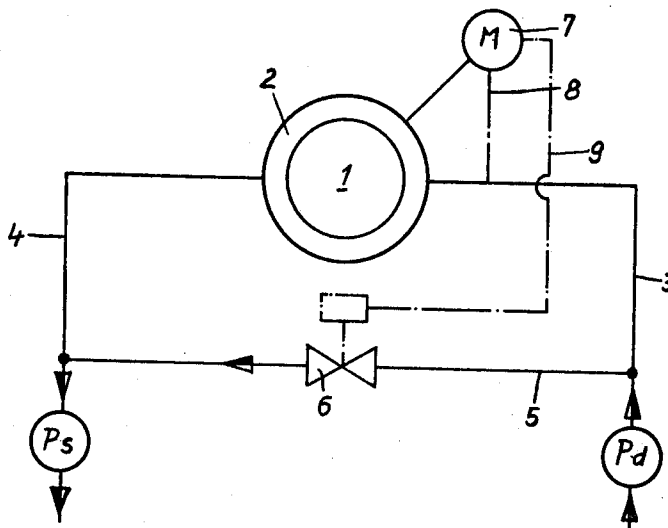
15 Claims, 3 Drawing Figs.

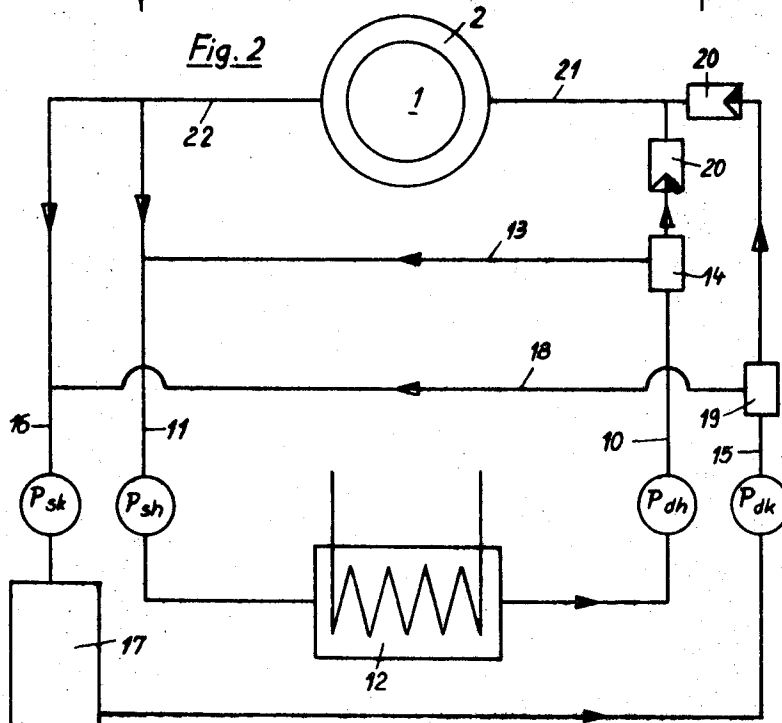
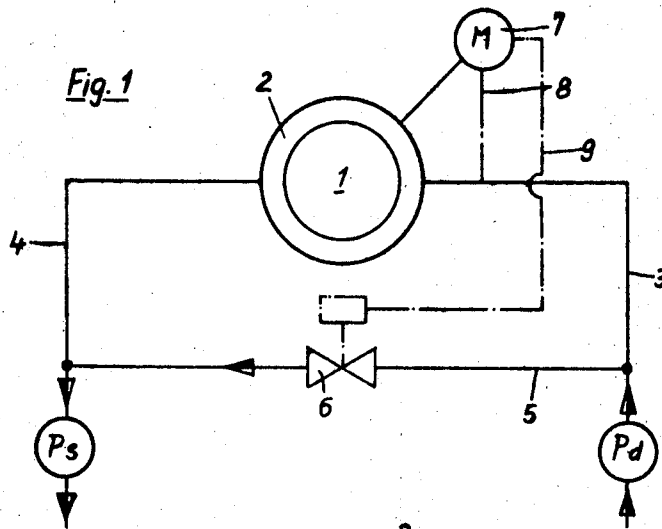
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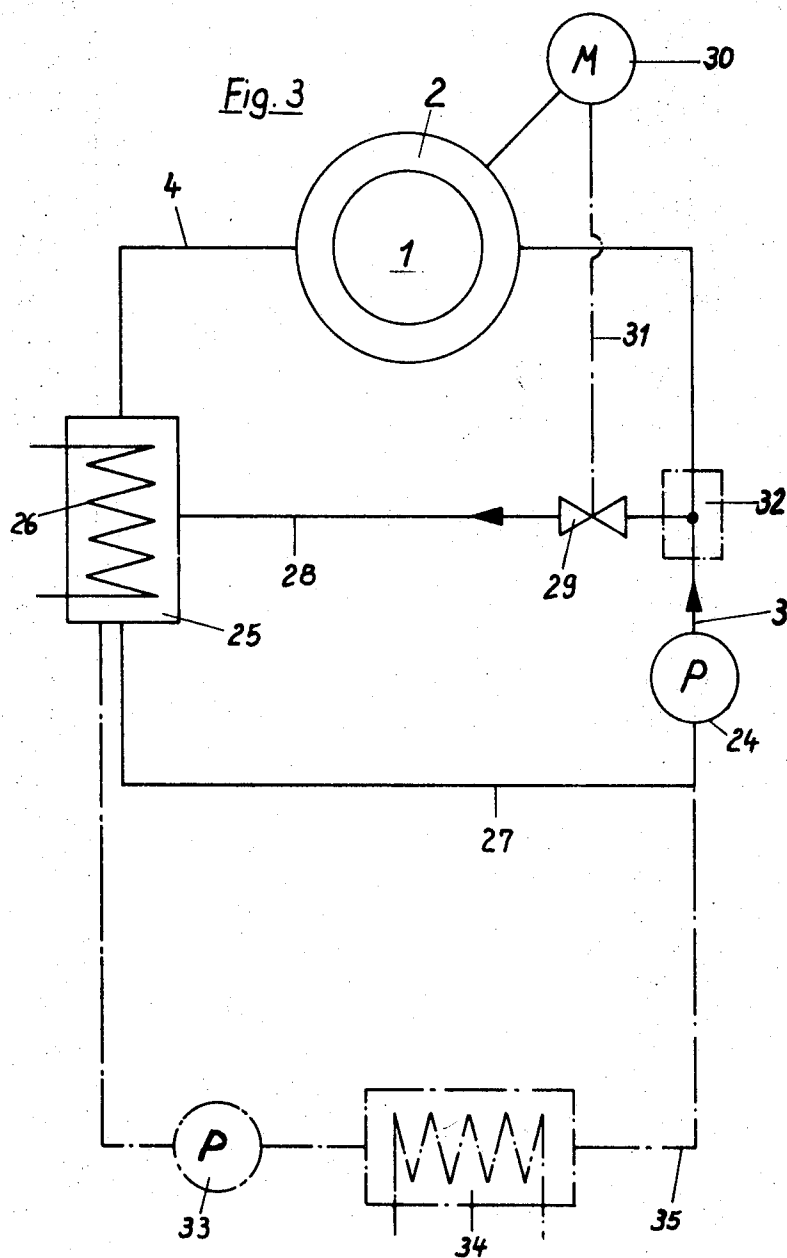
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ABSTRACT: In combination with a mould having an outer and an inner wall defining a space therebetween for the flow of cooling or heating fluid therethrough, fluid circuit means including a pressure pump for circulating fluid under pressure through the space and bypass means connected to the circuit means for bypassing part of the fluid pumped by the pump past the mould to avoid overpressure in the space and possible deformation of the mould walls.





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APPARATUS FOR THE HEATING AND COOLING OF MOULDS FOR THE PRODUCTION OF PLASTIC BODIES

The invention relates to an apparatus for the heating and cooling of moulds used for the production of plastic bodies, particularly by the rotary process, and having walls constructed for the conduction of a heating or cooling liquid, provided with at least one forward conduit, leading to the mould and having a pressure pump, and with at least one reverse conduit which leads from the mould and from which the liquid is conveyed back to the pressure pump via a heating or cooling device.

The walls of such moulds have to be as thin as possible, so that they can be rapidly heated and rapidly recooled. On the other hand, they have to be able to stand up to the pressure of the heating or cooling liquid pumped through the apparatus. This leads to difficulties, particularly in the case of large-size moulds. Furthermore, the moulds used in the rotary process have to be as light in weight and occupy as little space as possible.

Attempts have already been made to overcome these difficulties by a system in which, in accordance with Pat. application Ser. No. 761,222 filed Sept. 20, 1968 and now Pat. Ser. No. 3,525,098 granted Aug. 18, 1970, by the same applicant, a suction pump of which the delivery is somewhat greater than the pressure pump is built into the reverse conduit. This makes it possible, when it is designed for a certain mould, i.e. for a certain flow resistance of the mould, and for liquid of a certain viscosity, to avoid the creation of an excess pressure, so that even very large moulds can be constructed with comparatively thin walls and thus satisfactorily heated or cooled. This system also renders it possible, owing to the fact that the liquid is pumped in and withdrawn by suction simultaneously, to circulate the said liquid at a high speed, so that the temperature gradient from the entry to the emergence of the heating or cooling liquid remains very limited, as a result of which even very large moulds can be kept to a certain constant temperature. This is of importance, since it is particularly with these large moulds that an even heating is often a decisive factor for the quality of the plastic bodies produced with them.

To provide a further improvement, the aforementioned apparatus comprises a heating liquid circuit and a cooling liquid circuit separate therefrom, each of these circuits having its own pressure pump and its own suction pump of the type described.

The effectiveness of the above measures in accordance with the older Patent Application Ser. No. 761,222 filed Sept. 20, 1968 and now Pat. No. 3,525,098 granted Aug. 18, 1970 nevertheless depends, as already mentioned, on the flow resistance of the mould and on the viscosity of the liquid pumped through it. In an apparatus of this kind, e.g. a rotation machine, however, a great variety of moulds have to be used, often of widely differing capacity and area and thus presenting different degrees of resistance to the through-flow. Furthermore, the viscosity of the heating or cooling liquid used depends to a great extent on the temperature, so that when the heating is carried out, at 220° C., for instance, it is far lower than when the cooling is effected, at 40° C. The heating and cooling temperature selected also depends on the conditions prevailing in the mould and the plastic body to be produced and above all on the nature of the plastics to be processed. It has been found that a mould through which heating liquid flows satisfactorily undergoes deformation when cooling liquid is passing through it, owing to the higher viscosity and the resulting lower rate of through-flow and higher pressure, and that it may burst open in consequence. The same thing can occur if the apparatus is designed for a particular mould with a particular resistance to flow and a different moulds with a greater internal resistance to flow is then employed. It is true that these dangers can be counteracted by designing stronger moulds, but this is at variance with the requirement that the moulds are to be as thin-walled as possible, so that they can be heated rapidly and also recooled rapidly.

In an apparatus with a supplementary suction pump in the return conduit, it has been found to be a still more serious

drawback that with the use of a mould in which a higher pressure is built up, either owing to the mould itself or owing to the higher viscosity of the liquid, the suction pump no longer receives enough liquid, so that the heating or cooling apparatus following it in the circuit is no longer subjected to a correct flow of liquid. The pressure pump then no longer receives heating or cooling liquid at the exact temperature required, so that the exact control or regulation of the heating or cooling of the mould breaks down.

The purpose of the invention is to provide an apparatus of the type described at the beginning which will ensure that the mould is kept free of undesirable excess pressures and also, if necessary, that the suction pump will always be fed sufficiently and that a sufficient quantity of liquid will at all times flow through the heating or cooling apparatus following it in the circuit, whatever the mould used, whatever its internal resistance to flow, whatever the heating or cooling liquid used and whatever the viscosity adopted, a further aim being comparative simplicity in the apparatus. The invention enables this object to be achieved by a system in which, between the pressure pump and the mould, a branch conduit is connected up to the forward conduit, leads into the reverse conduit and contains an overflow valve, or is connected up to a flow regulator of the forward conduit. When the pressure in the mould, either as a result of the internal flow resistance of the mould or in consequence of a higher viscosity of the liquid, e.g. as a result of the temperature of 40° C. in the cooling liquid, as compared with 220° C., which is that of the heating liquid, rises above a certain level, the overflow valve in the branch conduit opens to a greater or smaller extent, enabling a greater or a smaller quantity of liquid to flow direct into the return conduit. The mould is thus kept free of excess internal pressures. For this reason it is desirable for a pressure gauge for the liquid conveyed through the apparatus to be provided shortly before the mould is reached, or preferably on the mould itself. Furthermore, the overflow valve can with advantage consist of a pressure-controlled valve. The aforementioned pressure gauge can be operatively connected with this latter valve, thus ensuring automatic regulation. It may also be sufficient, however, for the overflow valve to be set by hand, when it is in particular the internal flow resistance of a mould that has to be considered, and not so much the change of the viscosity as between the heating and the cooling liquid. This is particularly the case when, as already suggested in the aforementioned older patent application, the operation is being carried out with a heating liquid circuit and with a cooling liquid circuit separate therefrom, in which case each of these circuits has its own pressure pump and its own return pump of the type mentioned. In accordance with the invention it is then desirable for a branch conduit of this kind to be provided in each circuit. By comparison with the object of the aforementioned older patent application, this provides the advantage that on the average a more satisfactory and reliable through-flow is obtained for a large number of different moulds with simpler means, i.e. dispensing with a suction pump mounted in the return conduit, so that these moulds can be made with very thin walls without any danger of bursting.

In an apparatus in which the return conduit contains a suction pump, in accordance with the proposal made in the aforementioned older patent application, the delivery of the said suction pump being preferably somewhat greater than that of the pressure pump, the liquid being conveyed back to the pressure pump from the suction pump via the heating or cooling device, the invention provides that the branch conduit, as an additional supply conduit for the suction pump, is to lead into the return conduit before reaching the said suction pump. By this additional branch-flow supply conduit for the suction pump, this latter is at all times fed with sufficient heating or cooling liquid. The flow of liquid is not interrupted in the pump, and a correct flow continues through the subsequent heating and cooling devices. If the pressure in the mould, either owing to the internal flow resistance of the latter or as a result of a higher viscosity in the liquid, e.g. in consequence of

the temperature of 40° C. in the cooling liquid, as against the temperature of 220° C. in the heating liquid, rises above a certain level, the overflow valve in the branch-flow supply conduit opens to a greater or smaller extent and feeds a greater or smaller additional quantity to the suction pump. If the process is carried out with a heating liquid circuit and with a cooling liquid circuit separate therefrom, each such circuit having its own pressure pump and its own suction pump of this kind, then it is desirable, in accordance with the invention, for a branch-flow supply conduit of this kind, for the particular suction pump concerned, to be provided in each such circuit.

In another embodiment of the invention the branch-flow conduit is in each case connected up to a flow regulator of the particular forward conduit concerned. This suffices particularly in those cases in which it is especially the internal flow resistance of the mould that has to be taken into consideration and the change in the viscosity of the particular liquid flowing through the mould, owing to the provision of a cooling circuit separate from the heating circuit, can be taken into account in some other manner, e.g., by an appropriate preliminary setting of the flow regulator in each forward conduit. The capacity and internal area of each mould used, and thus its internal resistance to the flow, are known. Each mould can thus be allocated a certain characteristic number, in accordance with the internal resistance to flow, by which code number the flow regulator can be set, in addition to adjusting it in accordance with the viscosity of the liquid in question. It then diverts a certain quantity of the flowing liquid into the branch conduit, or into the supply conduit of the branch flow, for the suction pump concerned. No pressure is then required on the mould. Preferably, however, a pressure gauge, or at least a means of connecting up a pressure gauge, should nevertheless be provided, for control purposes.

The branch conduit concerned can also be provided on or in the mould itself. To this extent, a mould of this kind is then to be regarded as an integral part of the apparatus to which the invention relates.

Further details and advantages of the invention will emerge from the following description of examples illustrated schematically in the drawing. The diagrams are as follows:

FIG. 1 is a schematic diagram of a first version, with pressure pump and suction pump;

FIG. 2 is a schematic diagram of a second version, with pressure and suction pumps;

FIG. 3 is a schematic diagram of a third version, with pressure pump only.

The mould 1 shown in the drawing is of the double-walled type, with an internal chamber 2, for the through-flow of heating or cooling liquid. In the version shown in FIG. 1, a forward conduit 3 leads into this internal chamber 2, and a return conduit 4 leads out of it. The forward conduit 3 contains a pressure pump *Pd* and the return conduit 4 a suction pump *Ps*. The latter preferably has a higher rate of delivery than the pressure pump *Pd*. From the suction pump *Ps* the liquid is conveyed back to the pressure pump *Pd* via a heating or cooling device not shown in the drawing, appropriate control mechanisms being provided.

In the example of the invention shown in FIG. 1, a branch supply conduit 5 for the suction pump *Ps* is connected to the forward conduit 3, between the pressure pump *Pd* and the mould 1, and leads into the return conduit 4, before reaching the suction pump, and contains an overflow valve 6. A pressure gauge 7 for the liquid conveyed through the apparatus is provided on the mould 1. The overflow valve 6 is adjusted by hand, according to the said pressure gauge. As shown at 8, the pressure gauge 7 can also be connected up shortly before the mould 1. A control connection 9 is also shown, in dot-and-dash lines, between the pressure gauge 7 and the overflow valve 6, the overflow valve 6 being automatically controlled via the said control line.

In the version shown in FIG. 2, a heating liquid circuit is provided, with a forward conduit 10, a pressure pump *Pdh*, a return conduit 11 and a suction pump *Psh*. From the latter the

heating liquid is conveyed via a heating device 12 back to the pressure pump *Pdh*. In a similar manner to that shown in FIG. 1, a branch supply conduit 13 is connected up to the forward conduit 10 of the heating circuit and leads into the return conduit 11 before reaching the suction pump *Psh*, the said branch leading from a flow regulator 14 of the forward conduit 10. The said regulator is set to the viscosity of the heating liquid used and also adjusted in accordance with the internal flow resistance of the particular mould 1 used. Furthermore, a cooling liquid circuit is provided, with a forward conduit 15, a pressure pump *Pdk*, a return conduit 16 and a suction pump *Psk*. From this latter the heating liquid is conveyed back to the pressure pump *Pdk* concerned, via a storage container 17 and/or a cooling device not shown in the drawing. Between the forward conduit 15 and the return conduit 16, and in a similar manner to the version with the heating circuit, is a branch-flow supply conduit 18 for the suction pump *Psk* concerned. This branch supply conduit 18 starts from a flow regulator 19 built into the forward conduit 15. Before the mould is reached, the forward conduit 10 of the heating circuit and the forward conduit 15 of the cooling circuit lead into one common supply conduit 21, to the mould 1, a nonreturn valve 20 of the customary kind being interrelated in the case of each of the said forward conduits. In similar fashion, one common discharge conduit 22 leads from the mould and then branches off into the two return conduits 11 and 16. In this version shown in FIG. 2, likewise, a pressure gauge can be mounted shortly before the mould 1 is reached, or on this latter. The flow regulators 14 and 19 are set either according to the said pressure gauge or according to the characteristic numbers allocated to the mould in question. They ensure that the suction pump *Psh* or *Psk*, as the case may be, is at all times fed with an adequate quantity of liquid, so that the correct flow takes place through the heating and cooling devices. Furthermore, this system keeps the mould free of excessive internal pressures.

It is naturally also possible, in the case of heating and cooling circuits separate from each other, for an overflow valve 6, in accordance with the version shown in FIG. 1, to be mounted in the branch-flow supply conduit, 13 or 18, as the case may be.

The mould 1 shown in FIG. 3 is likewise of the double-walled type, with an internal chamber 2 for the through-flow of heating or cooling liquid. A forward conduit 3 leads into this internal chamber 2, and a return conduit 4 starts from the latter. To this extent, this version coincides with these shown in FIGS. 1 and 2 and described in the foregoing. In the forward conduit 3 a pressure pump 24 is provided. The return conduit 4 leads to a storage container 25, which may contain a heating or cooling device 26. From there the liquid is conveyed via a conduit 27 back to the pressure pump 24, appropriate control mechanisms being provided.

The invention provides that between the pressure pump 24 and the mould 1 a branch-flow supply conduit 28 is to be connected up to the forward conduit 3, lead direct into the storage container 25 and contain an overflow valve 29. The branch conduit 28, however, can also lead into the return conduit 4 before the storage container 25 is reached. The mould 1 bears a pressure gauge 30 for the liquid caused to pass through the apparatus. The overflow valve 29 is set by hand in accordance with the said gauge. The pressure gauge 30 can also be connected up to the forward conduit 3 shortly before the mould 1 is reached. Furthermore, a control line 31, shown in dot-and-dash lines, is mounted between the pressure gauge 30 and the overflow valve 29, via which said line the overflow valve 29 can be automatically controlled.

A further component shown in dot-and-dash lines is a flow regulator 32 in the forward conduit 3, and this can be provided in place of the overflow valve 29, and the branch conduit 28 is then connected to it. This flow regulator 32 is set in accordance with the internal flow resistance of the particular mould 1 employed, either in accordance with the pressure gauge 30 or in accordance with the characteristic numbers al-

located to the mould concerned. This keeps the mould free of excessive internal pressures.

FIG. 3 shows, in dot-and-dash lines, a further variant, in which, with the container 25 constructed as a simple storage container, i.e. without cooling or heating device 26, a pump 33 is provided behind it, by which the liquid is pumped out of the storage container 25 into a special heating or cooling device 34, from which it is conveyed to the pressure pump 24 via a conduit 35.

In the drawing, only one heating or cooling device 26, 34, is shown in each case. An appropriate cooling device is to be connected in parallel with a heating device, suitable control mechanism being provided in order to ensure that the heating circuit is closed, via the heating device, and that the cooling circuit is closed, via the cooling device, and that in either case the branch-flow conduit 28 takes effect. This is why the heating circuit and the cooling circuit have a section of forward conduit and a section of return conduit in common. The branch conduit 28 then leads, in each case, into the conduit which the said circuits have in common.

It is also possible to provide, in a manner not shown in the drawing, a heating liquid circuit and a cooling liquid circuit separate therefrom, a pressure pump 24 and a storage container 25 and, in accordance with the invention, a branch conduit 28 with an overflow valve 29 or flow regulator 32, then being associated with each circuit.

In practice the entire apparatus forms part of a machine, particularly a rotary machine, for the production of plastic bodies. The apparatus to which the invention relates is then mounted in or on the body of the machine.

I claim:

1. In a moulding apparatus, a combination comprising at least one mould having an outer and an inner wall spaced from each other and defining between said walls a space for the passage of a heat transfer fluid therethrough, at least said inner wall being a thin wall to assure quick heat transfer from said fluid to moulding material in a cavity defined by said inner wall and vice versa; fluid circuit means for circulating the fluid through said space and including a feed conduit communicating with said space for feeding fluid thereinto, a return conduit for discharging the fluid from said space and a pressure pump for pumping the fluid under pressure through said circuit means and said space; means in said fluid circuit means for changing the temperature of the fluid passing therethrough; a bypass conduit between said feed conduit and said return conduit; and regulating means cooperating with said bypass conduit for regulating the amount of fluid flowing therethrough so that only part of the fluid pumped by said pump will flow through said space to thereby avoid excessive pressure in said space which could lead to a deformation of at least said inner wall.

2. A combination as defined in claim 1, wherein said regu-

lating means comprise an overflow valve in said bypass conduit.

3. A combination as defined in claim 1, wherein said regulating means comprise a flow regulator at the junction of said feed conduit and said bypass conduit.

4. A combination as defined in claim 1, and including a storage container in said return conduit, said bypass conduit communicating at one end with said storage container.

5. A combination as defined in claim 1, wherein said means for changing the temperature of said fluid comprise heating means in said circuit means upstream of said pressure pump for heating the fluid.

6. A combination as defined in claim 1, wherein said means for changing the temperature of said fluid comprise cooling means in said circuit means upstream of said pressure pump for cooling the fluid.

7. A combination as defined in claim 1, and including pressure sensing means communicating with said space for sensing the fluid pressure in said space.

8. A combination as defined in claim 7, and including means cooperating with said pressure sensing means and said regulating means for automatically adjusting the latter in accordance with the fluid pressure in said space to maintain the fluid pressure below a critical value which would cause deformation of at least said inner wall.

9. A combination as defined in claim 1, and including a suction pump in said fluid circuit means downstream of the junction of said bypass conduit with said return conduit.

10. A combination as defined in claim 9, wherein the delivery of said suction pump is greater than that of said pressure pump.

11. A combination as defined in claim 1, wherein two of said fluid circuit means are provided, each provided with a bypass conduit and regulating means cooperating with said bypass conduit, and wherein said means for changing the temperature of said fluid comprises heating means in one of said circuit means upstream of the pressure pump thereof for heating the fluid and cooling means in the other circuit means upstream of the pressure pump thereof for cooling the fluid.

12. A combination as defined in claim 11, and including a one-way valve in the feed conduit of each circuit means downstream of the junction of the bypass conduit and the feed conduit of the respective circuit means.

13. A combination as defined in claim 11, and including a suction pump in each fluid circuit downstream of the junction of the bypass conduit and the return conduit of the respective circuit means.

14. A combination as defined in claim 11, wherein at least a portion of said bypass conduit is mounted on said mould.

15. A combination as defined in claim 1, wherein at least a portion of said bypass conduit is mounted in said mould.

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