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(54) **METHOD AND DEVICE FOR FORGING OF METAL IN SOLID-LIQUID STATE.**

(57) The invention allows to obtain high-quality forged mouldings for technological equipment: moulds and dies. The method provides for feeding the metal into a metal receiver, moving it from the metal receiver to a matrix and crystallizing it in the matrix under pressure. Before moving the metal to the matrix it is subjected to vacuum treatment. The metal is moved from the metal receiver to the matrix in the two-phase state: solid and liquid, whereas the metal is fed to the metal receiver in the solid state and melted directly inside the metal receiver. The metal is fed to the metal receiver in the form of

powder or as a powder with additions of chemical compounds. A device for implementing the method comprises a hydraulic press consisting of a frame (1) with stationary cross-pieces (2, 3, 4) and movable cross-pieces (5, 6, 7), with power drives consisting of cylinders (8, 11, 14, 17) and pipe lines (38, 39, 40, 41), and further comprises a mould consisting of a matrix (34) and a punch (37). A distinction of the device consists in that it is provided with an envelope (24), a pressure chamber (33) and a metal receiver with a support (22, 23) and a heating element (26-31).

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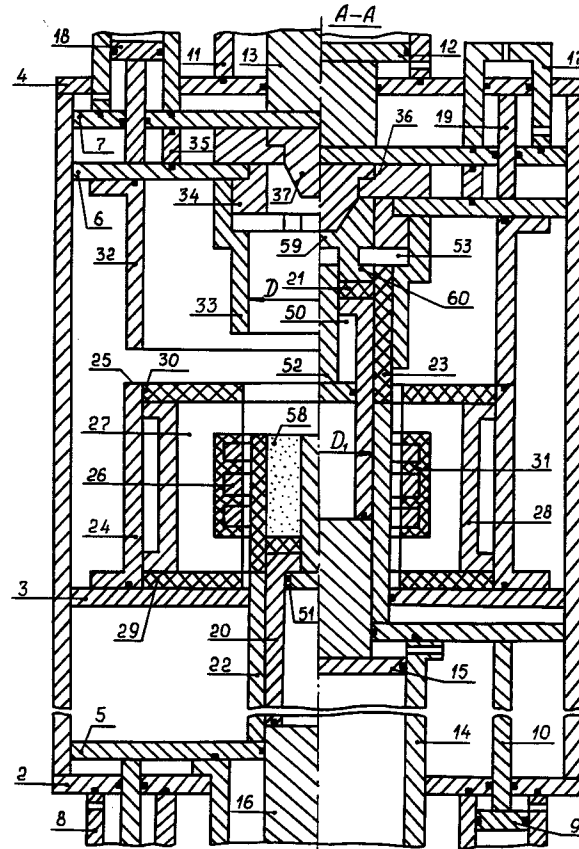


Fig. 2

Art of Engineering

The present invention relates to casting of metals, accompanied by moulding under pressure (stamping of molten metal), and is intended for the production of good-quality stamped castings having a predetermined composition usable primarily for the manufacture of machining attachments (such as moulds and dies) and cutting tools.

Review of the Prior Art

There is known in the prior art a process for the manufacture of the shaping components of moulds comprising the steps of producing a porous blank by compacting powder, and sintering the blank (Ref. a book by Paley M.M. Processes for Manufacturing Machining Attachments, Moulds and Dies, Moscow, Machinostroyeniye /Mechanical Engineering/Publishers, 1971, p. 139). The prior-art process is disadvantageous in that it does not permit to manufacture metal-shaping mould components which would feature a high plasticity (ductility) and an adequate impact strength (toughness). This limitation is accounted for by the fact that during the step of producing metal powder each powder particle gets coated by a film composed of chemical compounds of metal with gases (oxides, nitrides, carbides, etc.), and the presence of such films is conducive to the formation of brittle grain boundaries during sintering of powder. Furthermore, the methods of powder metallurgy are unable to produce pore-free blanks (since during compacting operation there is no close contact between powder particles, and the latter contact each other only at some points), and each pore or each brittle grain boundary becomes a stress concentrator, from which, under the effect of impact loads, cracks appear and develop.

Equally known in the prior art is an apparatus for hot, gas-assisted compacting of powder blanks, which apparatus comprises a water-cooled container, a heating furnace insertable into said container, and working gas admitted into said furnace to react with a powder-filled capsule placed into said furnace (Ref. a book by Kolikov A.P. et al. Processes and Equipment for Treatment of Refractory Powdery and Composite Materials, Moscow, Metallurgia Publishers, 1989, p. 103, Fig. 2.24). The prior-art apparatus is disadvantageous in that it does not permit to produce blanks of a high ductility and impact toughness, since this apparatus is unable to treat under vacuum the heated powder to clean its surface from chemical compounds formed as a result of reactions with gases (i.e. to remove gases from chemical compounds and to convert the latter to pure metals). Moreover, the prior-art apparatus necessitates that the bodies of capsules

be manufactured of metals having a higher melting point than that of the material of a powder contained therein. As a result, there is a great consumption of refractory metals for manufacturing capsules during the making of machining attachments from die steels and special alloys.

A study of the art-known processes has revealed that there exists a process that comes nearest to the instantly claimed technical solution both in its function and in the number of features in common (Ref. U.S.S.R. Inventor's Certificate No. 419,310; cl. B 22 D 27/12; publ. in 1974), the latter process being chosen as a prototype. The above-identified process is intended for stamping metal in solid-molten state and comprises the steps of delivering metal into a metal receiver, transferring the metal from the metal receiver into a die, and moulding the metal in the die under pressure.

A study of the art-known apparatuses has shown that there exists an apparatus that comes nearest to the instantly claimed apparatus both in its function and in the number of features in common (Ref. U.S.S.R. Inventor's Certificate No. 684,823; Cl. B 22 D 27/12; 1977), the latter apparatus being chosen as a prototype. The above-cited apparatus is intended for stamping metal in solid-molten state and comprises a hydraulic press formed by a support frame having stationary cross-pieces and movable cross-members, drives provided with cylinders and conduits, and a mould formed by a die and a punch.

The art-known process is disadvantageous in that it is unable to produce good-quality stamped castings. This limitation is conditioned by the fact that, when the metal passes from its molten state to the solid one, gases are not liberated from the metal. The metal of a stamped casting gets oversaturated with gases (the latter remaining in the metal in the form of a solution), thereby the ductility and the impact toughness of stamped castings is affected. The point is that the pressure applied to the metal in the process as its solidification diminishes the chemical nonuniformity of a casting, but still leaves this nonuniformity at a higher level as compared to the chemical nonuniformity of blanks prepared by powder metallurgy techniques. The art-known process is thus unable to produce stamped casting with predetermined properties, which is obtainable by the powder metallurgy techniques.

The prototype apparatus suffers from the same limitations as are inherent in the prototype process. What is more, the prototype apparatus requires a high metal input, since, to enable the cylinders secured to the movable cross-members to develop large efforts, it becomes necessary that such cylinders be made of large diameters, because such cylinders are supplied with working

fluid through flexible hoses in which the fluid cannot be supplied to the cylinders under high pressures. Thus, for instance, when a hose has an inner diameter of 50 mm, the maximum permissible dynamic pressure cannot exceed 35 kgf/cm² (Ref. a book by Anuriev V.I., Handbook for a Designer in Mechanical Engineering, vol. 3, Moscow, Mashinostroyeniye /Mechanical Engineering/ Publishers, 1980, p. 354, Table 46). Since working fluid is supplied under low pressure, cylinders can necessarily develop large efforts owing to the large diameters of their pistons, that is owing to a high metal input for manufacturing these cylinders.

Disclosure of the Invention

In the process in accordance with the present invention, prior to transferring the metal from a metal receiver to a die, the metal is subjected to vacuum treatment, and the metal is transferred to the die in the form of two phases, namely, as a solid and a liquid phases. The metal is fed to the metal receiver in solid state, in the form of a powder or a powder with chemical additives, to be melted directly in the metal receiver.

An apparatus for carrying out the above-described process comprises: a shell, a pressing chamber, a metal receiver with a support member and with a heating element. The support frame of the apparatus is formed by three interconnected cross-pieces, namely: a lower, a medium and an upper cross-pieces. Between the lower and medium cross-pieces there is provided a lower movable cross-member, whereas between the medium and upper cross-pieces there are provided a medium and an upper cross-members. In this arrangement, the lower cross-piece of the support frame carries cylinders responsible for actuating the lower movable cross-member, the upper cross-piece carries a cylinder for actuating the upper movable cross-member, the lower cross-member carries a cylinder for actuating the support of the metal receiver, the upper cross-member carries cylinders for actuating the medium cross-member. A die is secured to the medium cross-member, while the punch is secured to the upper cross-member. The conduits (pipelines) of the cylinders secured to the movable cross-members are provided with extension pieces having casings and movable piston rods with axial and radial openings. The casings of the extension pieces are mounted on the lower and upper cross-pieces of the support frame, while their piston rods are secured to the lower and upper movable cross-members. The apparatus shell consists of a lower, a medium and an upper parts, the lower part of the shell being attached to the medium cross-piece of the support frame, its medium part - to the medium cross-member, and its upper

part - to the upper cross-member. The pressing chamber is provided with a diaphragm which is disposed in the upper part of the chamber attached to the medium cross-member, the inner diameter of the pressing chamber being equal to the outer diameter of the metal receiver. The latter is formed by two sleeves, namely: a lower support sleeve and an upper, easily removable sleeve. The lower support sleeve is mounted on the lower movable cross-member, while the upper sleeve is mounted on the support sleeve. The support of the metal receiver is formed with a cavity which accommodates a piston with a rod, while the heating element is made in the form of an inductor arranged within the lower part of the shell.

Brief Description of the Drawings

The essence of the present invention will be better understood with the help of the accompanying drawings, wherein:

Fig. 1 shows a top view of the apparatus for carrying into effect the process for stamping metal in solid-molten state;

Fig. 2 shows an elevation view of the apparatus in accordance with the invention (a sectional view along A-A of Fig. 1); left-hand view shows the stage when a metal powder is charged into a metal receiver, while the right-hand view shows the stage when a pressed casting is prepared from a powder brought to its solid-molten state;

Fig. 3 shows an elevation view (along the axis B - B of Fig. 1) of the upper part of the apparatus;

Fig. 4 shows an elevation view (along the axis C - C of Fig. 1) of the lower part of the apparatus; and

Fig. 5 shows a horizontal sectional view of the diaphragm 53 shown in Fig. 2.

Embodiment of the Present Invention

The apparatus in accordance with the present invention comprises a press formed by a support frame 1 having three stationary cross-pieces, namely: a lower 2, a medium 3 and an upper 4 cross-pieces, and three movable cross-members, namely: a lower 5, a medium 6 and an upper 7 cross-members. The lower cross-piece 2 carries, attached thereto, cylinders 8 provided with pistons 9 and with rods 10, the latter being also attached to the cross-member 5. The upper cross-piece 4 carries a cylinder 11 provided with a piston 12 and a rod 13, the latter being attached to the cross-member 7. The lower cross-member 5 carries a cylinder 14 with a piston 15 and a rod 16, while the upper cross-member 7 carries cylinders 17 with pistons 18 and rods 19, the latter being connected

to the cross-member 6. The rod 16 carries a support 20 whose upper axial end supports a washer 21. The cross-member 5 carries a support sleeve 22 whose upper axial end upholds an easily detachable sleeve 23, both sleeves 22 and 23 forming a metal receiver. The medium cross-piece 3 upholds the lower part 24 of the shell with a packing ring 25, while the lower part 24 of the shell accommodates a heating element constituted by an induction coil 26, magnetic circuits 27, cantilevers 28, disks 29 and 30, and electroinsulating material 31. The medium cross-member 6 supports the medium part 32 of the shell, a pressing chamber 33, and the die 34 of a mould. The upper cross-member 7 carries the upper part 35 of the shell and a punch holder 36 with a punch 37. The cylinder 14 is communicated with the hydraulic system via conduits 38 and 39, while the cylinders 17 - via conduits 40 and 41. The conduits 38-41 are provided with extension pieces constituted by casings 42 and by movable rods 43 with nuts 44 and 45. The rods 43 are formed with axially 46 and radially extending 47 openings. The nuts 44 are formed with radial openings 48, and the casings 42 - with radial openings 49. Two casings 42 are secured to the lower cross-piece 2, and two casings - to the upper cross-piece 4. Two nuts 44 of the rods 43 are secured to the lower cross-member 5, while two more nuts 44 - to the upper cross-member 7. The support 20 is formed with a cavity 50 adapted to accommodate a piston 51 with a rod 52. The pressing chamber 32 houses a diaphragm 53 consisting of two parts or halves 54 and 55, at the junction of which openings 56 are formed. In one of these halves (e.g. in the half 55) a threaded opening 57 is formed screwing into it a puller or remover (not shown in the drawing). A metal powder 58 fills the cavity of the metal receiver, while the mould accommodates a pressed casting 59 with a butt-end 60. The components 6, 7, 20, 22, 24, 26, 32 and 35 are formed water-cooled (the water-cooling system is not shown in the drawings). The lower part 24 of the apparatus shell is provided with openings (not shown in the drawings) intended to remove the induction coil 26 and to pump out gases. The components 29 and 30 are made of an electrically insulating material (such as, e.g. of asbestos cement). The components 21 and 23 are made of ceramics (e.g. of a silica-based ceramics). The inner diameter D of the chamber 33 is equal to the outer diameter D_1 of the sleeve 23 of the metal receiver.

The apparatus in question is operated as follows:

Metal powder or feedstock materials such as lumps of metal scrap are charged into the metal receiver formed by the components 20-23, 51 and 52. The cross-member 7 is caused to sink until the

medium part 32 of the apparatus shell abuts against the packing ring 25 of the lower part 24 of the shell. The shell cavity is evacuated, voltage is supplied to the induction coil 26, and water is admitted to circulate through the induction coil. Unduction currents are used to heat the rod 52 and the powder 58 under vacuum. As the powder is heated, there takes place decomposition of chemical compounds (such as oxides, nitrides, etc.) and of surface films coating powder particles, and the gases thus liberated are pumped out by a vacuum pump (not shown in the drawing), while the surface of the powder becomes clean from chemical compounds. Once the material has been heated to a point where it becomes solid-molten (i.e. when the fraction of the molten phase has reached some 30 to 50%), the inductor coil 26 is de-energized, the cross-member 5 is lifted, whereby the sleeve 23 of the metal receiver comes to be lodged in the cavity of the chamber 33. Next, the piston 15 is lifted, which - via the rod 16, support 20 and washer 21 - causes semi-molten metal to flow from the cavity of the sleeve 23 towards the cavity of the die 34 through the openings 56 formed in the diaphragm 53, whereby the pressed casting 59 is formed under a mechanical pressure of 4 to 5 kgf/mm².

Once the pressed casting 59 has been formed, the cross-member 7 is lifted, whereas the cross-member 6 is lowered in relation to the cross-member 7, whereby the pressed casting 59 gets separated from the punch 37. The pressing chamber 33 gets detached from the cross-member 6, while the casting 59 with the diaphragm 53 are withdrawn from the die 34. First the halves 54 and 55 of the diaphragm 53, and next the butt-end 60 are removed from the casting 59. The diaphragm 53 is arranged into the cavity of the pressing chamber 33, the latter is attached to the cross-member 6, and the latter is lifted. The die 34 and the punch holder 36 are caused to join each other, while the cross-member 6 is caused to join the upper part 35 of the apparatus shell. A new washer 21 is placed onto the support 20, while a new sleeve 23 is placed onto the axial end of the sleeve 22 and a new portion of metal powder 58 is fed into the sleeve 23, whereupon the entire cycle of producing a pressed casting is repeated. Whenever, after producing a first casting, a need arises to prepare a new casting of some other geometric shape, then, after liberating the punch 37 from the casting 59, the punch holder 36 gets detached from the cross-member 7 and the punch 37 is replaced, whereby a pressed casting 59 of a different geometric shape is obtained.

The process in accordance with the present invention may be advantageously used, by way of example, for manufacturing the shape-forming components of machining attachments (such as

moulds and stamps), onto which severe requirements are imposed in terms of their quality (i.e. minimal chemical homogeneity, high ductility, impact toughness, strength and hardness). The process in question comprises the following operations:

- a coating or a lubricant is applied onto the surface of the components 34, 36, 37;
- a metal powder is charged into the metal receiver, vacuum-treated under depression of $5 \cdot 10^{-3}$ mm Hg, and heated by induction currents up to a temperature at which the powder assumes solid-molten state (the mass fraction of the molten phase is brought to some 30 to 50% of the total mass of the powder; grade Y10 steel powder is heated to a temperature of 1380 to 1430°C);
- a casting is formed by pressing from the powder in solid-molten state under a pressure of 4-5 kgf/mm²;
- once pressed, the casting is removed from the punch, extracted from the die, detached from the diaphragm, and cut off from the butt-end.

The fact that the prototype process has been supplemented with the step (operation) of metal vacuum treatment makes it possible to clean the metal from gases, which, in turn, leads to a higher ductility and impact toughness of pressed castings. Vacuum treatment of metal, followed by crystallization under pressure makes it possible to produce high-density castings free from stress concentrators in the form of interface boundaries originating from non-metallic inclusions (such as oxides, nitrides, etc.) and from oversaturated solutions of gases.

If the metal is transferred from the metal receiver into the die only in the form of a molten phase, then, it becomes difficult to avoid the formation of dendritic branches of the metal under crystallization and, consequently, it becomes impossible to obtain pressed castings with a minimal chemical inhomogeneity.

Conversely, if metal is transferred from the metal receiver into the die only in the form of a solid phase (such as, for instance, as steel powder heated up to a temperature of 800-900°C), then, it would be necessary to employ a higher pressure (and not $P = 4-5$ kgf/mm²) to obtain good-quality pressed castings. Consequently, the transfer of the metal from the metal receiver into the die in the form of two phases, viz. a solid and a liquid phases, makes it possible to produce castings featuring the minimal chemical inhomogeneity equal to that achievable by powder metallurgy methods. The advantage of this resides in the fact that high-density castings may be produced under a minimal pressure of 4-5 kgf/mm².

If the metal is fed into the metal receiver in molten state, then, it becomes difficult to avoid the formation of the dendrite-less structure of castings thus-produced. Conversely, if the metal is fed into the metal receiver in solid state and gets melted directly in the metal receiver, it becomes possible to obtain pressed castings featuring a minimal chemical inhomogeneity.

If the metal is fed into the metal receiver in the form of lumpy feed-stock materials, it becomes impossible to prepare castings having a minimal chemical inhomogeneity and, consequently, it becomes impossible to achieve the maximum wear resistance of machining attachments and tools. It is permissible to feed lumpy feedstock materials into the metal receiver in those cases when the shape-forming components to be cast have to meet milder requirements as to their wear resistance (e.g. in the production of machining attachments for pilot-scale, small-serial-scale and serial-scale fabrication cycles). The fact that the metal is fed into the metal receiver in the form of a powder makes it possible to produce the shape-forming components of machining attachments with a minimal chemical inhomogeneity and to achieve thereby the maximal wear resistance of machining attachments (which fact is of particular importance in making machining attachments for large-scale and mass-scale production of machine parts). The fact that the metal is fed into the metal receiver in the form of a metal powder and chemical compounds makes it also possible to manufacture the shape-forming components of machining attachments from carbides-, nitrides- and borides-based metal-loceramic materials. In this case, the metal powder is converted to a metal binder for refractory chemical compounds.

The expedient of providing the apparatus with a shell consisting of a lower, a medium and an upper parts makes it possible to conduct the process of manufacturing pressed castings under vacuum conditions. Similarly, the expedient of providing the apparatus in question with a pressing chamber and with a metal receiver equipped with a ceramic sleeve and a heating element in the form of an induction coil makes it possible to heat metal up to the desired temperature directly in the metal receiver and next, without any loss of sealing and still under vacuum conditions, to produce pressed castings. Furthermore, if the support frame of the press is formed only by a lower and an upper cross-pieces (without a medium cross-piece), it would be necessary to provide the apparatus with a telescopic shell consisting of three pipes insertable one into another. However, it is a known fact that it is technically difficult to manufacture a telescopic shell consisting of three large-diameter pipes. The expedient of providing the support frame of the

press with a medium cross-piece makes it possible to form a hermetically sealed chamber by the individual parts of the same shell. What is more, these shell parts need not be inserted one into another; they are merely joined together to each other and to the cross-pieces or cross-members only at their axial ends, whereby the manufacture of the shell parts is simplified. Moreover, this expedient makes it possible to fix a stationary induction coil in the lower shell part and to supply it with electric power and water through fixedly laid copper pipes.

If the lower cross-member of the press is not mounted between the lower and medium cross-pieces, and if a removable sleeve of the metal receiver is not placed on the lower cross-member, it would be impossible to ensure movement of the metal receiver filled with metal in relation to the induction coil and the pressing chamber. Similarly, the expedient of placing the lower cross-member of the press between the lower and medium cross-pieces and of placing onto it the removable sleeve of the metal receiver permits movement of the metal receiver filled with metal from the inductively heated heating zone towards the pressing chamber.

Were the cylinder 14 secured to the cross-piece 2, and not to the cross-member 5, then, it would be necessary at the initial moment of the formation of a casting 59 to ensure joint movement of the cross-member 5 and of the cylinder 14 piston 15 and, later on, after insertion of the sleeve 23 into the chamber 33, it would be necessary to lift only the piston 15. Such a sequence of operations would necessitate a sophisticated hydraulic system and would affect its reliability in operation. The expedient of securing the cylinder 14 to the cross-member 5 considerably simplifies the hydraulic system and enhances its reliability in operation. However, the fact of securing the cylinder 14 to the movable cross-member 5 makes impossible supply of the working fluid to the cylinder 14 through rigid stationary pipes. Were the working fluid supplied to the cylinder 14 through flexible pipes, then, it would be necessary to considerably reduce the pressure of the fluid supplied. To simplify the hydraulic system, while, at the same time, making it possible to supply a high-pressure working fluid to the cylinder 14 as the latter is secured to the movable cross-member 5, we have developed special-design extension pieces for conduits. When provided with extension pieces, the cylinder 14 is operated as follows:

In order to lift the piston 15, the fluid is supplied to the right-hand casing 42 (Fig. 4). Next the fluid flows from the casing 42 along the radially extending channel 47 to the axial channel 46 of the movable rod 43 and, from it, the fluid through the

channel 48 arrives into the piston compartment (i.e. under the piston 15) of the cylinder 14. The pressure exerted by the fluid lifts the piston 15 and forces the fluid from the compartment above the piston 15 of the cylinder 14 (into the axial opening 46 of the rod 43 of the of the left-hand extension piece of the conduit shown in Fig. 4), from which the fluid flows into the casing 42 and next to the drain of a sliding spool valve (the latter is not shown in the drawings).

Were the cylinders 17 fixed on the cross-piece 4, and not on the cross-member 7, then, as the cross-member 7 is lowered prior to releasing the pressed casting 59, it would be necessary to supply the working fluid not only to the cylinder 11, but also to the cylinders 17 and, for withdrawing the casting 59, it would be necessary to supply the fluid only to the cylinders 17, thus leaving the cross-member 7 in its upper position. This would lead to a complicated system of control of the cylinders 11 and 17. The expedient of fixing the cylinders 17 on the cross-member 7 instead of on the cross-piece 4 simplifies the hydraulic system for controlling the cylinders 11 and 17, while the expedient of providing this hydraulic system with conduit (pipe) extension pieces makes it possible to build up in the cylinders 17 secured to the moveable cross-member 7 high pressures (320 kgf/cm² and even more).

To lower the pistons 18, the working fluid is supplied to the casing 42 of the right-hand extension piece of the conduit (Fig. 3). From the casing 42 the fluid flows into the interior of the rod 43 and from the latter - into the piston compartments of the cylinders 17. At this, the fluid found under the pistons 18 is forced out into the rod 43 of the left-hand extension piece of the conduit, and from the rod 43 - into the casing 42, from which the fluid flows to the drain of a sliding spool valve (not shown in the drawing).

The expedient of fixing the casings 42 on stationary cross-pieces 2 and 4, and fixing the rods 43 on the movable cross-members 5 and 7 enables the rods 43 to travel beyond the limits of their working space, whereby the overall dimensions and the specific metal input of the apparatus may be reduced. It is true, instead of each conduit extension piece, it would be possible to use three hydraulically operated pivoting pins (hinges), but this technical solution would be necessarily more cumbersome and metal-consuming as compared to the conduit extension pieces employed by the present invention. In the claimed structural arrangement of the extension piece, the rod 43 can travel in a single direction, i.e. it has one degree of freedom and it is usable for supplying the fluid to a cylinder (s) also having only one degree of freedom, owing to which the technical solution in accordance with

the present invention achieves harmonization of the movements of the rods and the cylinders and minimizes the specific metal consumption.

The expedient of realizing the support of the metal receiver with a cavity and the expedient of accomodating a piston with a rod into said cavity make it possible to fill up this cavity in the support with compressed gas (as an alternative, it would be possible to arrange a spring in the cavity instead of filling the latter with compressed gas; the purpose of both the gas and the spring is to retain the rod 52 in its upper position and to enable the rod to be retracted into said cavity as the metal is transferred from the metal receiver to the die of a mould). Provision for the rod 52 made of an electroconductive material (such as, e.g. graphite, or a chrome- or molybdenum-based alloys) enables the rod 52 to be heated with induction currents and to transfer the heat from the rod to the powder charged into the metal receiver. It means that this arrangement makes it possible to heat non-electroconductive powders. Whenever the metal receiver is filled steel powder or with steel scrap materials, the rod 52 becomes unnecessary.

Were the apparatus in accordance with the present invention provided with the rod 52, without being provided at the same time with the diaphragm 53, then, during the movement of the metal 58 from the metal receiver cavity into the die 34 cavity, the rod 52 would abut not against the diaphragm 53, but against the punch 37, i.e. the casting 59 will be formed with an additional cavity not specified by the drawing. The expedient of providing the pressing chamber 33 with the diaphragm 53 makes it possible to produce pressed castings having a predetermined height without unwanted cavities (the diaphragm constituting a support for the rod 52). If the apparatus in question does not comprise a rod 52 and if it not necessary to obtain castings of a predetermined height, the diaphragm 53 may be altogether dispensed with. The expedient of realizing the inner diameter of the pressing chamber equal to the outer diameter of the metal receiver makes it possible to heat metal powders by induction currents within the sleeve 23 and, once the powder has been thus heated, to employ the ceramic sleeve 23 as the lining of the pressing chamber thereby prolonging its service life.

Industrial Applicability

The process and apparatus in accordance with the present invention are intended for manufacturing machining attachments (dies, moulds and stamps) and cutting tooling in the tool-making industry. Use of the present invention will improve the quality of pressed castings by imparting to

them a minimal chemical inhomogeneity equal to that of starting powder, and superior mechanical properties over the blanks produced by traditional powder metallurgy methods, thereby rendering pressed castings advantageously distinguishable in terms of their ductility (plasticity) and impact toughness (the ductility and impact toughness of pressed castings will be superior over the same parameters of metal forgings by 10 to 15%, while their strength properties will be level with those of forged metal). Their minimal chemical inhomogeneity will provide a better wear resistance of the machining attachments manufactured from pressed castings. The apparatus in question is compact, its hydraulic system is simple and dependable.

The process of the invention cannot be carried out by conventional equipment and, therefore, the apparatus of the invention has no other use, but only in conjunction with the process of the invention. Therefore, the present Application is directed to a group of inventions interrelated so intimately as to constitute a single common inventive concept.

Claims

1. A process for stamping metal in solid-liquid state, comprising the steps of: feeding the metal into a metal receiver, transferring the metal from the metal receiver into a die, followed by crystallizing the metal in the die under pressure, **characterized** in that the step of transferring the metal into the die is preceded by vacuum treatment of the metal.
2. A process as claimed in Claim 1, **characterized** in that the metal is transferred from the metal receiver into the die in the form of two phases, namely, a solid and a liquid phases.
3. A process as claimed in Claim 1, **characterized** in that the metal is fed into the metal receiver in solid state to be melted down directly in the metal receiver.
4. A process as claimed in Claim 1, **characterized** in that the metal is fed into the metal receiver in the form of a powder or a powder with chemical compounds admixed as additives.
5. An apparatus for carrying into effect the process as claimed in Claims 1-4, comprising: a hydraulic press formed by a support frame with stationary cross-pieces and movable cross-members, by driving means in the form of cylinders and conduits, and a mould formed

by a die and a punch, **characterized** in that said apparatus also comprises a shell, a pressing chamber, and a metal receiver provided with a support and a heating element.

6. An apparatus as claimed in Claim 5, **characterized** in that its support frame is constituted by a lower, a medium and an upper cross-pieces attached to each other in such a manner that a lower movable cross-member is arranged between the lower and medium cross-pieces, and that a medium and an upper cross-members are arranged between the medium and upper cross-pieces; the lower cross-piece of the support frame carrying a cylinder for actuating the lower cross-member; the upper cross-piece carrying a cylinder for actuating the upper cross-member; the lower cross-member carrying a cylinder for actuating the support of the metal receiver; the upper cross-member carrying cylinders for actuating the medium cross-member; the die of the mould being secured to the medium cross-member, while punches being secured to the upper cross-member.
7. An apparatus as claimed in Claim 5, **characterized** in that the conduits (pipes) of the cylinders mounted on the movable cross-members are provided with extension pieces formed by casings and movable rods provided with axial and radial openings, the casings of the extension pieces being mounted on the lower and upper cross-pieces of the support frame, while their rods being attached to the lower and upper cross-members.
8. An apparatus as claimed in Claim 5, **characterized** in that said shell consists of a lower, a medium and an upper parts, the lower part of the shell being secured to the medium cross-piece of the support frame, its medium part - to the medium cross-member, and its upper part - to the upper cross-member.
9. An apparatus as claimed in Claim 5, **characterized** in that said pressing chamber is provided with a diaphragm arranged in its upper part secured to the medium cross-member, the inner diameter of the pressing chamber being equal to the outer diameter of the metal receiver.
10. An apparatus as claimed in Claim 5, **characterized** in that said metal receiver is formed by a lower support sleeve and an upper, easily detachable sleeve, said lower support sleeve being secured to the lower cross-member,

while said upper sleeve being secured to the support sleeve; and in that said support of the metal receiver is formed with a cavity which accommodates a piston with a rod, while said heating element is formed as an induction coil disposed within the lower part of the shell.

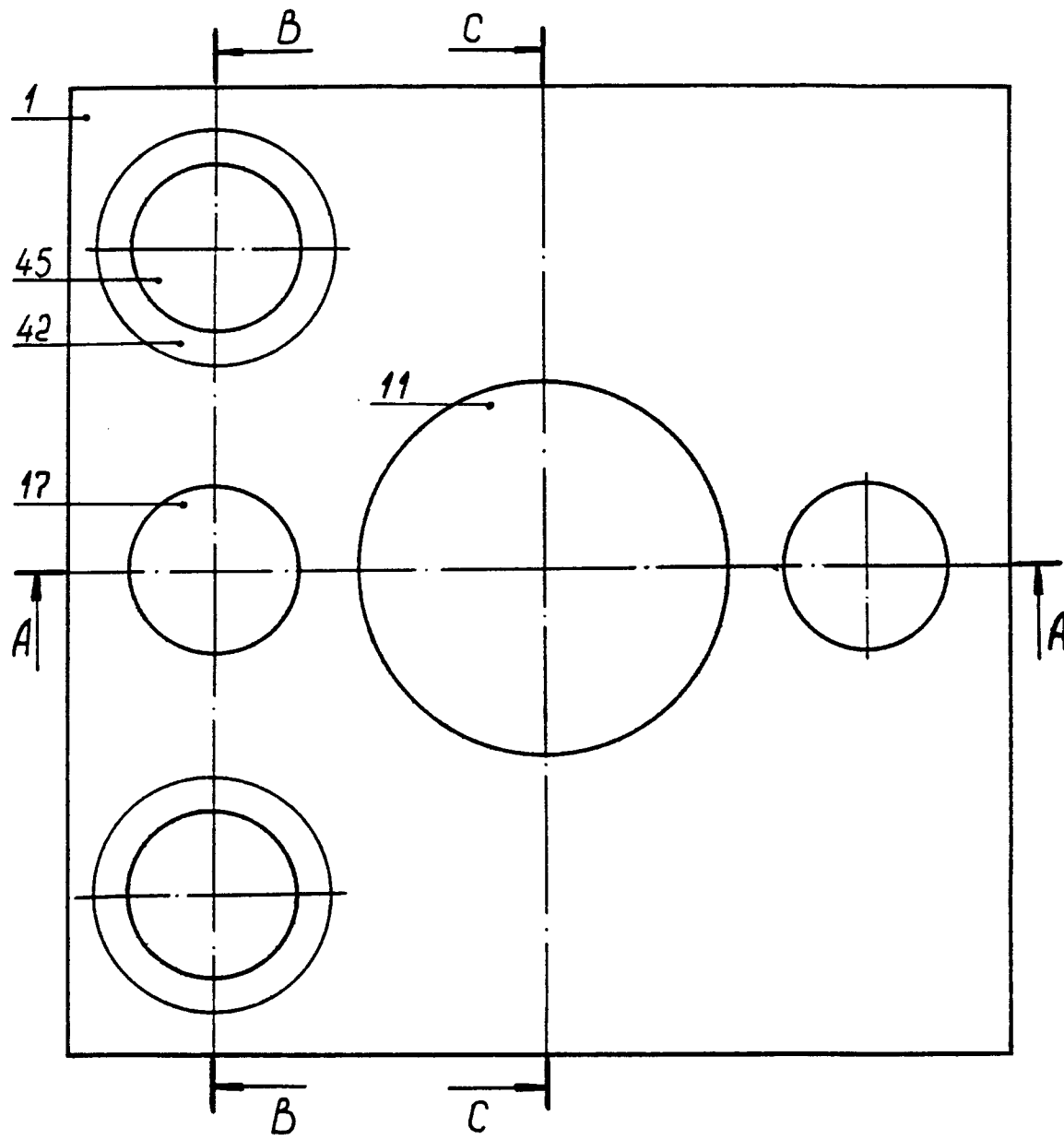


Fig. 1

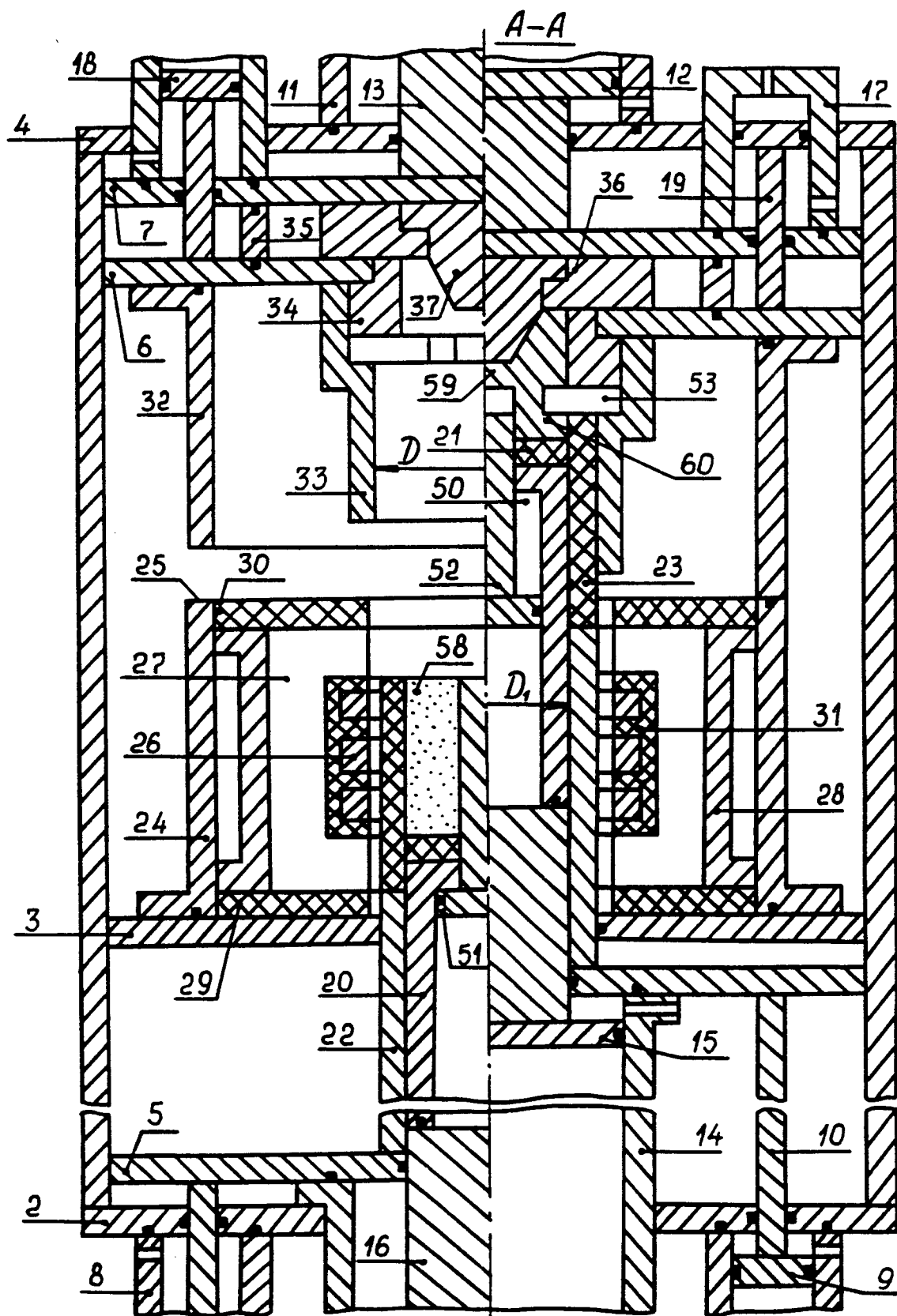
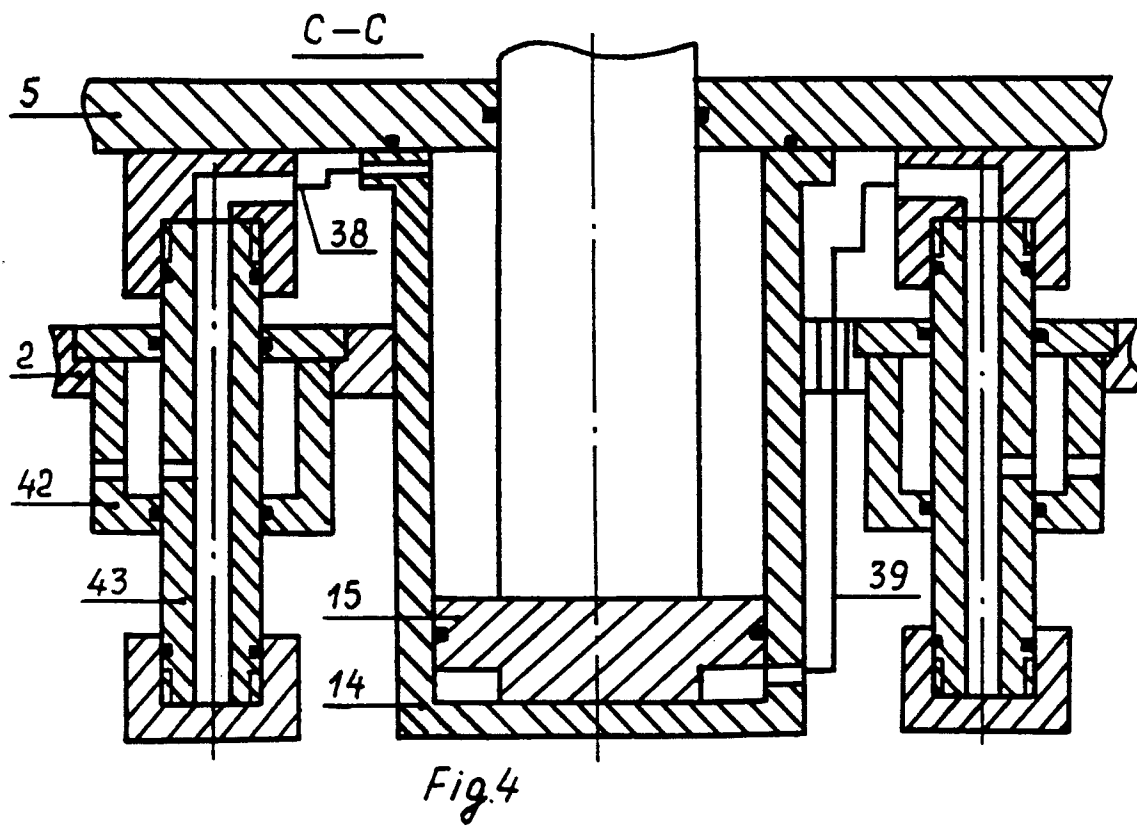
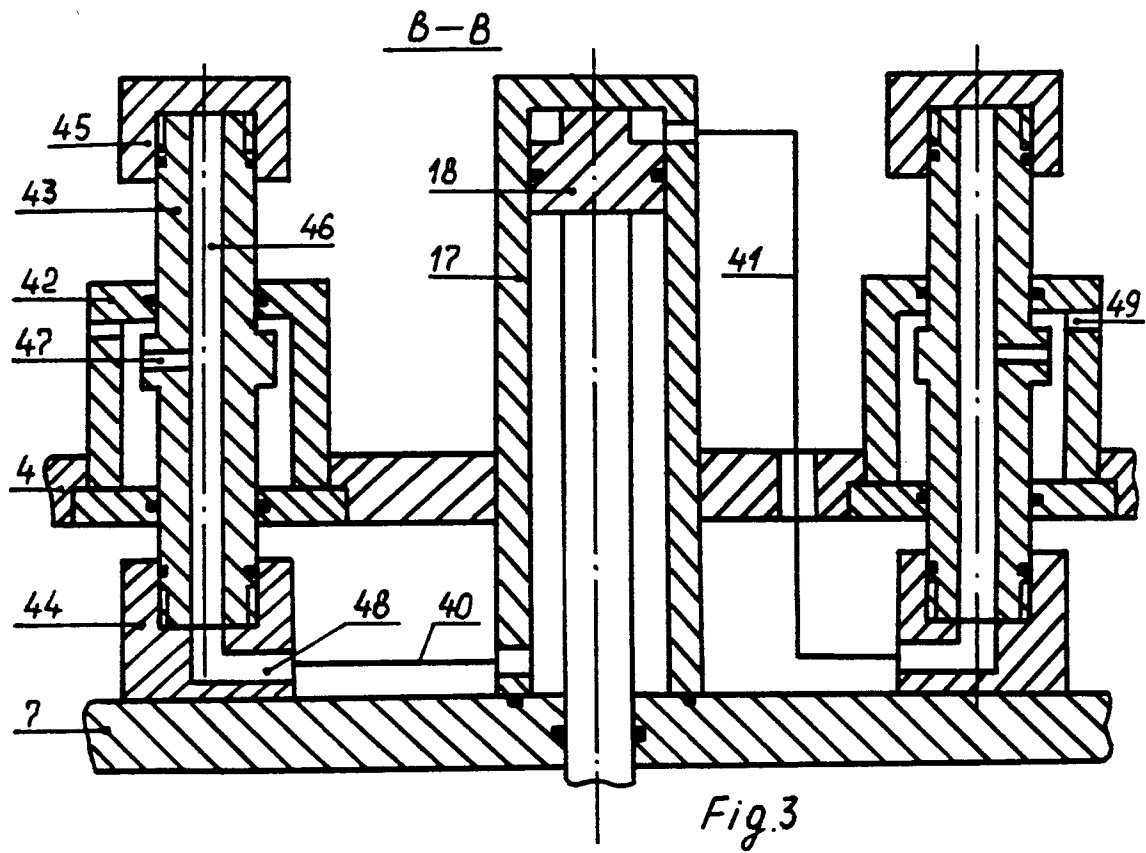


Fig. 2



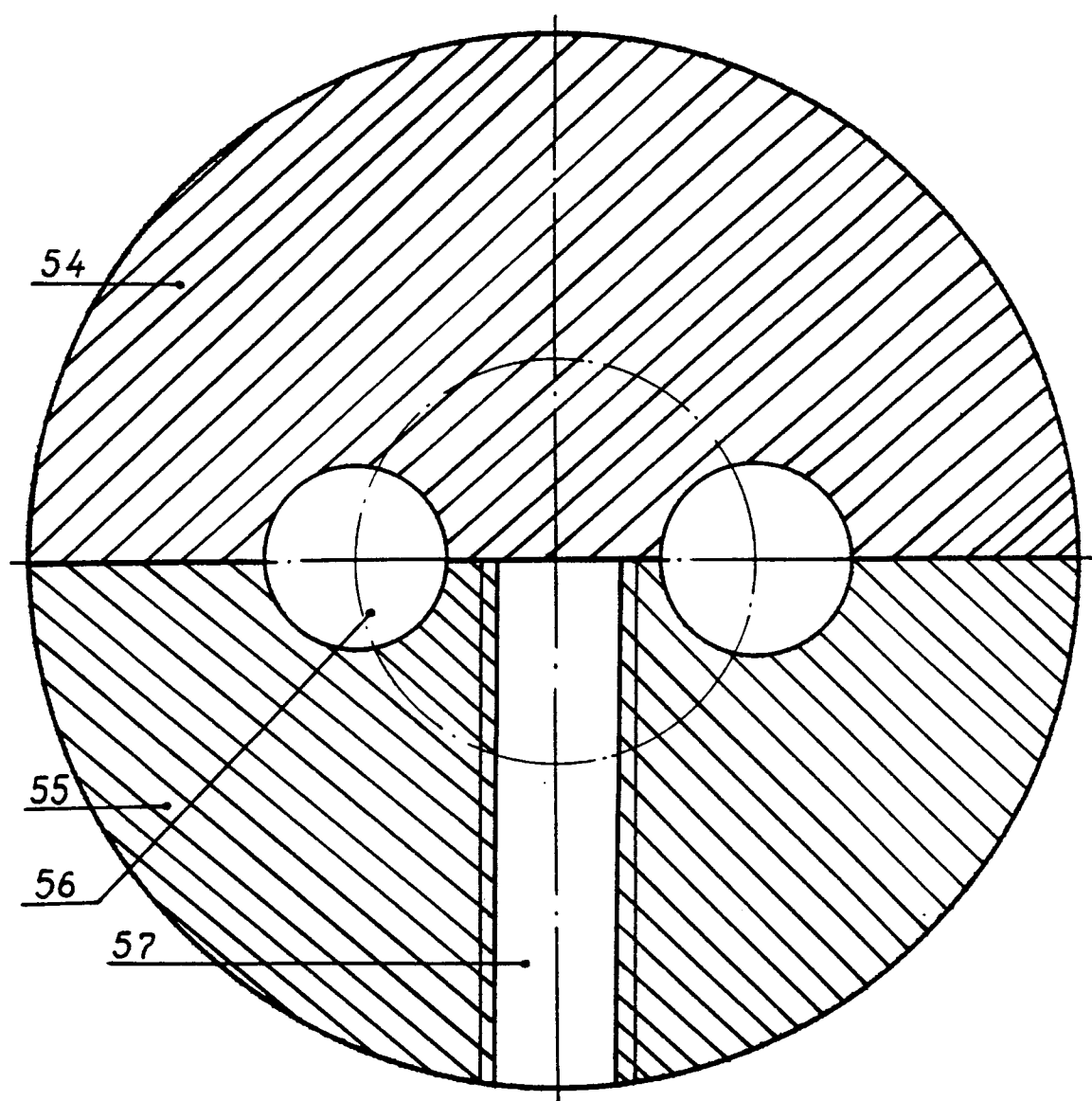


Fig.5

INTERNATIONAL SEARCH REPORT

International Application No PCT/SU 91/00116

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : B 22 D 18/02		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵ :	B 22 D 18/00, 18/02; 27/11; 17/04	
Documentation Searched other than Minimum Documentation to the extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	SU, A1, 789232 (Gorkovsky politekhnicheskyy institut im. A.A. Zhdanova) 23 December 1980, column 3, lines 5-24	1-4
A	US, A, 3815663 (JOHN L. CONNOR et al.) 11 June 1974, the abstract	5-10
A	SU, A1, 161100 (Ju. F. Cherny et al.) 9 March 1964	1,5,9
A	SU, A1, 623644 (Permsky gosudarstvennyy universitet im. A.M. Gorkogo), 4 August 1978	5
* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
8 October 1991 (08.10.91)	5 December 1991 (05.12.91)	
International Searching Authority ISA/SU	Signature of Authorized Officer	