Oct. 18, 1966 W. WEHMEYER 3,279,005

METHOD OF EFFECTING THE SOLIDIFICATION OF METALS UNDER GASEOUS PRESSURE

Filed Sept. 2, 1964 5 Sheets-Sheet 1

Fig: 1

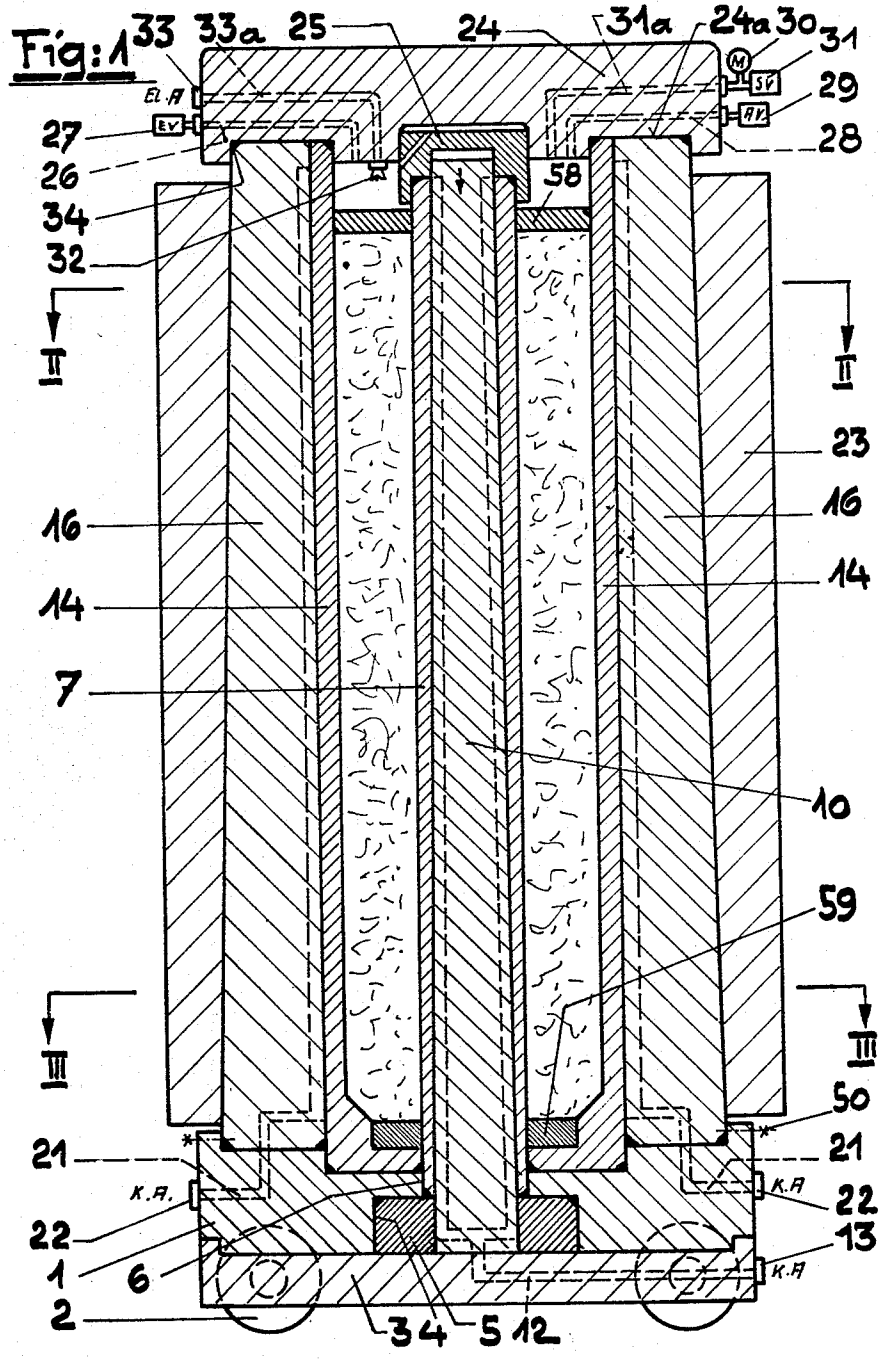
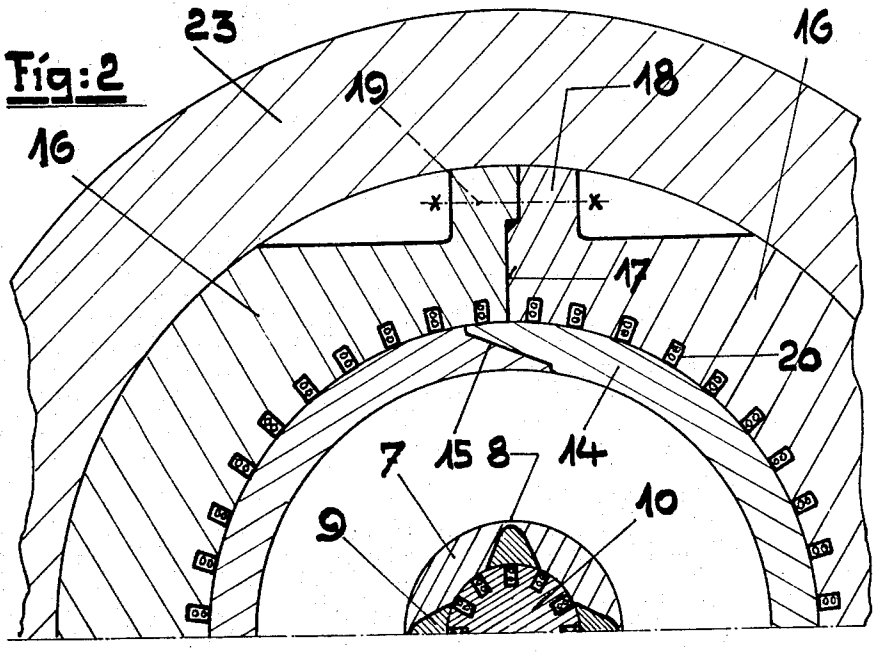


Fig: 2



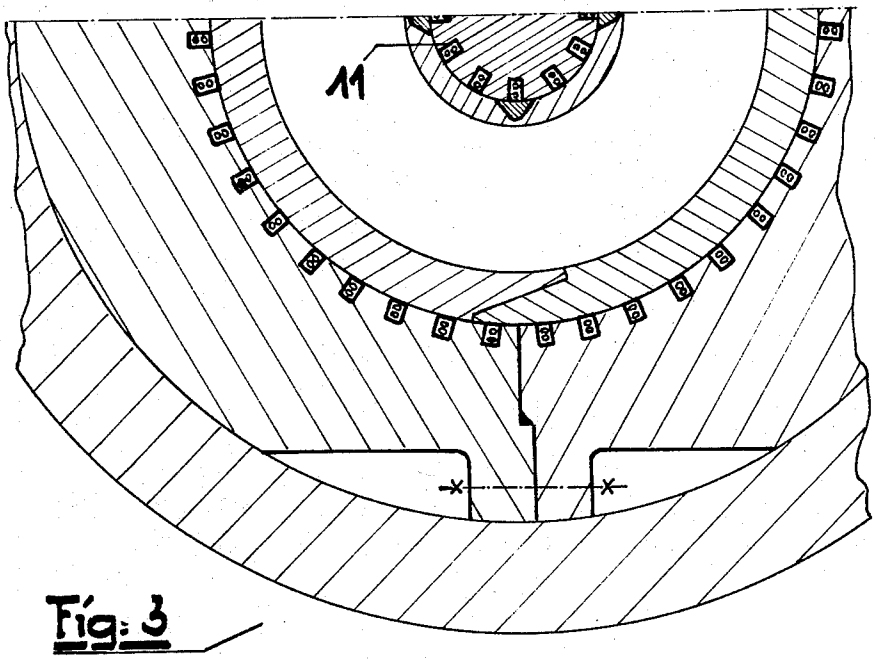
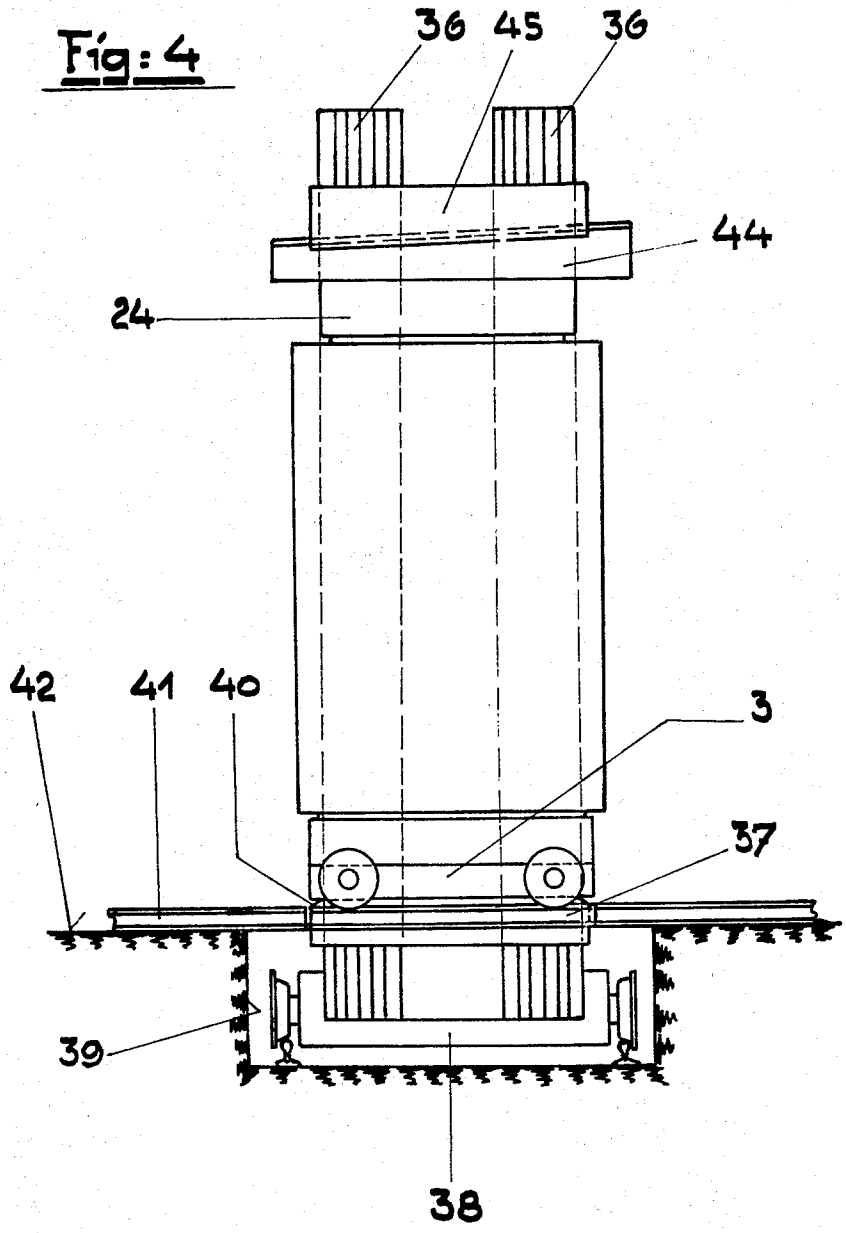


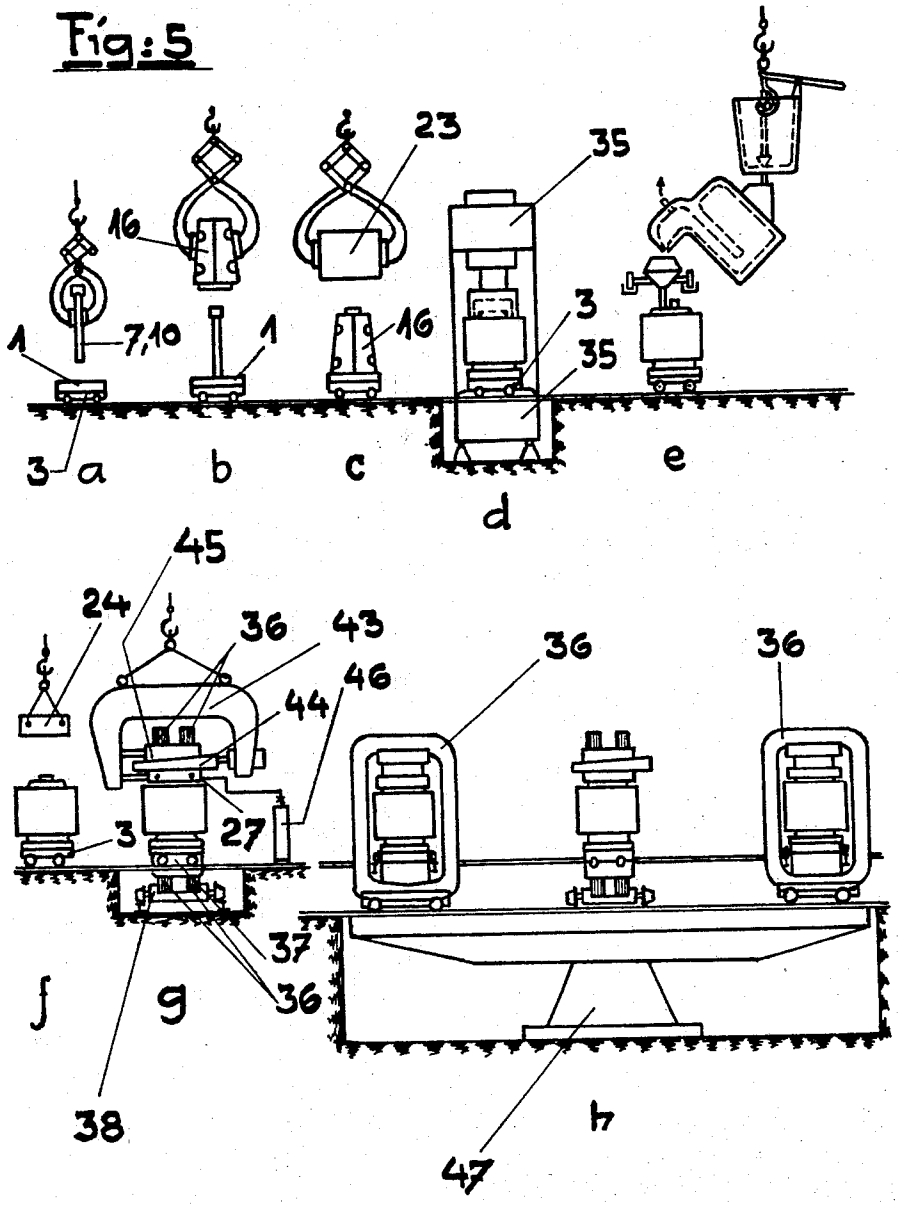
Fig: 3

Fig: 4



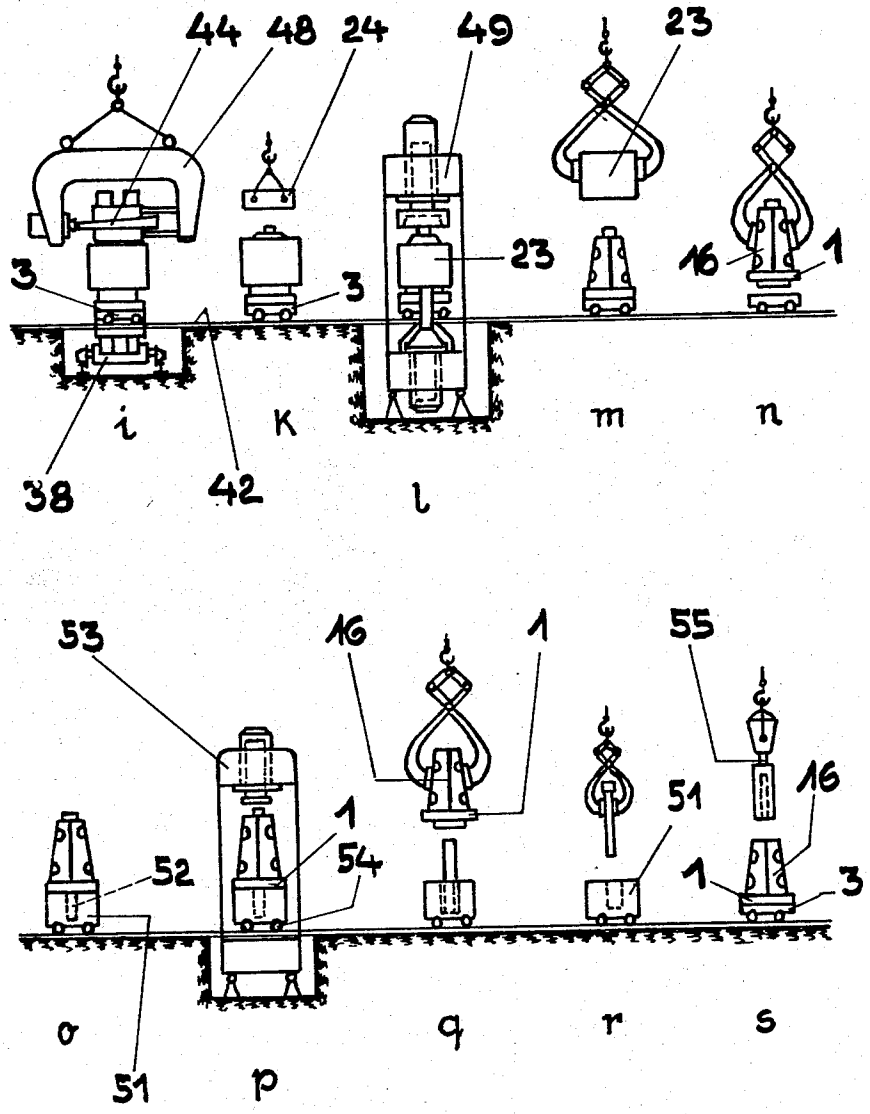
Oct. 18, 1966 W. WEHMEYER 3,279,005
METHOD OF EFFECTING THE SOLIDIFICATION OF METALS
UNDER GASEOUS PRESSURE
Filed Sept. 2, 1964 5 Sheets-Sheet 4

Fig: 5



Oct. 18, 1966 W. WEHMEYER 3,279,005
METHOD OF EFFECTING THE SOLIDIFICATION OF METALS
UNDER GASEOUS PRESSURE
Filed Sept. 2, 1964 5 Sheets-Sheet 5

Fig: 5



United States Patent Office 3,279,005 Patented Oct. 18, 1966

3,279,005

METHOD OF EFFECTING THE SOLIDIFICATION OF METALS UNDER GASEOUS PRESSURE

Werner Wehmeyer, Essen, Germany, assignor to Schloemann Aktiengesellschaft, Dusseldorf, Germany

Filed Sept. 2, 1964, Ser. No. 393,931
Claims priority, application Germany, Sept. 10, 1963, Sch 33,847
3 Claims. (Cl. 22—200)

It is known that metal, when it is cast and more or less rapidly solidified, acquires, owing to the shrinkage process upon cooling, cavities which can no longer be filled up by sucking in metal, kept as fluid as possible right to the end of the solidification process, from the rises or the lost heads.

It is likewise known that these contraction cavities, also known as shrink holes, can be obviated if the metal, in a liquid or semi-solidified condition, is subjected to pressure, and is kept under a constant pressure until the moment of complete solidification, as described in German patent specification No. 159,118, of February 18, 1903. In the process set forth in that specification, a constant low pressure is passed by way of a tube, from a pressure-gas storage, into the chill-mould filled with metal and closed, and this pressure connection is maintained during the solidification process.

Furthermore, by publication in "Stahl und Eisen," 81 (August 17, 1961), 17, page 1146/48, a process is known in which steel, in a semi-solidified condition, is kept in moulds, which are cooled with water, on hydraulic presses, by the upper part of the mould, under a constant pressure of from 6 to 10 kilogrammes per square millimetre, until the solidification of the steel is completed. The steel casting thus obtained is free from shrink holes and gas bubbles, has a very dense or compact texture, and higher tensile strength, elastic limit, extension and notch impact strength than rolled material of the same analysis. Whilst the first-mentioned process works only with a low pressure, which is too small to yield any improvement of texture, the pressures employed with this second process are sufficient to improve the texture.

This latter process has however the disadvantage that a large number of presses and cooled moulds have to be set up if a large number of castings, say from 60 to 120 castings per hour, are to be produced. The number of presses and chill-moulds increases moreover with the wall thickness, the cross-sectional area and the weight of the castings, because these factors determine the solidification time. The expenditure for so many presses influences the economy of the process.

It is the object of the present invention, with the same number of cooled moulds that is required for a high output, but with a set of only from two to five relatively small presses, to ensure the economy of a process which delivers finished castings that are solidified under a high and constant pressure.

For this purpose the invention starts from the process mentioned at the outset for obtaining the solidification of metals under gaseous pressure.

The process according to the invention consists in obtaining the desired gaseous pressure within the casting mould by the rise of pressure of an inert gas forced into the closed mould under a high pressure, owing to it being heated by the heat contained in the liquid or semi-liquid metal located in the casting mould, or by a supplementary supply of electrically generated heat.

To ensure the correct dimensions of the casting, and to obviate deformation of the casting moulds under the raised internal pressure, and to keep the moulds fluidtight, according to a further development of the invention the casting moulds employed for the process of the invention,

before the production of the internal pressure, are subjected to an external pre-stressing pressure exceeding the internal pressure. This is advantageously effected by wedging against correspondingly strong casings and frames. This appropriate apparatus must be so constructed that it can be very quickly actuated.

According to a still further development of the invention the gas employed is argon gas, since this does not enter into any combination with metals or any other substance. On account of the high price of the gas it is preferably employed repeatedly. It is circulated through storage reservoirs and compression plants.

It is frequently of interest to determine in advance the speed of solidification of the ingot, and it may also be of interest to let the solidification of the ingot proceed in a definite direction, for instance only from the cylindrical periphery and from the core. This can be attained, according to yet another development of the invention, by coating the casting mould, at individual surfaces of the mould, with pieces of cast metal or other fireproof material. If for example moulded pieces of fireproof material are placed on the bottom of the mould, and also, after the filling of the mould, upon the upper surface of the liquid, hardly any cooling at all takes place from the bottom and from the top.

For carrying out the process, therefore, a pressure container without any mechanical devices for producing or increasing the internal pressure is preferably employed. This distinguishes the mould according to the invention from the more expensive moulds that are described in detail in the abovementioned publication in "Stahl und Eisen."

Further details of the invention will be gathered from the following description, and from the accompanying drawings, in which:

FIGURE 1 shows a casting mould according to the invention in longitudinal sectional elevation;

FIGURE 2, a half section on the line II—II in FIGURE 1;

FIGURE 3, a half-section on the line III—III in FIGURE 1;

FIGURE 4, a view of the casting mould after it has been clamped in a frame shown in section; and

FIGURE 5 is subdivided into detail FIGURES *a* to *s* illustrating the various positions which the appliances necessary for carrying out the process assume in succession.

According to FIGURE 1, a bottom plate **1** is placed upon an under-plate **3** provided with wheels **2**. The bottom plate has an inner recess **4**, into which a filling-piece **5** is inserted. The bottom plate also has a cylindrical recess **6**, into which the copper inner jacket **7** of the casting mould is placed. From FIGURES 2 and 3 the shape of the copper inner jacket **7** can be recognized. It has four positions **8** of quite small wall thickness. The recesses hereby arising in the jacket **7** are filled up by wedges **9** of approximately triangular cross section. The inner jacket **7**, which forms the core of the mould, is supported upon a core-stud **10**, of steel. In it are inserted cooling elements **11**, with bores for cooling water, which have a connection to a cooling-water pipe **12** in the under-plate **3**, and open into the atmosphere at **13**. The core **7** is externally cylindrical, but internally frusto-conical, the core stud **10** having a correspondingly frusto-conical shape. The outer wall of the casting mould is formed by a two-part copper wall **14**, with butt joints **15**. The copper wall is internally and externally cylindrical, and is supported against a two-part steel jacket **16**, the parts of which meet one another at the butt joint **17**, the flanges **18** of which are held together by means of screw bolts **19**. The steel jacket **16** is bolted to the bottom plate **1** at **50**, and is provided with cooling elements **20**, with bores for the

cooling water, which find a continuation in the ducts **21** of the bottom plate **1**, and open into the atmosphere at **22**. Through them, cooling water or wet steam can be admitted and exhausted. The outer wall surface of the two-part steel jacket **16** is conical, and is surrounded by an internally conical initial stressing ring **23**, which, when it is pressed downwards, presses the steel mould parts **16** and the copper mould parts **14** together.

The mould is closed by a cover **24**, which is placed, with a filling piece **25**, upon the core jacket **7**, and furthermore accommodates, in an annular groove **24***a*, the upper rim of the outer mould wall **14**, **16**. A bore **26**, with a coupling means **27**, enables gas to be forced into the cavity of the mould. A bore **28**, with an outlet valve **29**, enables the most highly compressed gas to escape from the casting mould. By **30** is denoted a pressure gauge, and by **31** a safety valve, which opens the duct **31***a* as soon as the pressure in the casting mould exceeds a predetermined limit. An electrical heating means **32**, which may be designed for instance as a heating coil, a hot wire or an arc for condenser discharge, has an electrical lead by way of a duct **33***a* at **33**.

The corners **34**, each indicated black, denote packing rings or packing material. By **58** and **59** are denoted heat-checking plates, of ceramic material for instance.

The members **7** and **14** may consist of material other than copper, but it must be a good conductor of heat. To these parts is preferably applied a wear-proof film of fireproof metal oxides. The core of the casting mould, consisting of the copper member **7** and the steel core-stud **10**, is made so stout that it can take up the hydrostatic pressure of the liquid or solidifying metal, which corresponds to the rise of pressure of the high-pressure gas in the casting mould. Furthermore it must withstand the shrinkage pressure of the solidifying metal. The angles of the cones are in any case so selected that the parts that slip one upon another are self-checking.

The progress of the process according to the invention will now be described with reference to FIGURE 5, items *a* to *s*.

Upon the bottom plate **1**, which rests upon the travelling under-plate **3**, the core **7**, **10** is first mounted, with the aid of a crane, as shown in FIGURE *a*. Then the outer mould **14**, **16** is mounted upon the bottom plate **1**, as shown in FIGURE *b*. Next the conical prestressing ring **23** is slipped over the steel jacket **16**, FIGURE *c*. Then the under-plate **3** travels into a press **35**, FIGURE *d*, by which the pre-stressing ring **23** is pushed down. Next, according to FIGURE *e*, the filling of the casting mould with an accurately measured quantity of metal is effected. As promptly as possible after the completion of the pouring, the cover **24** is put on, FIGURE *f*. The travelling under-plate **3** now rolls into a frame **36**, the two frame members of which are held together below by a frame plate **37**. The frame **36** stands upon a frame carriage **38**, as shown in FIGURE 4 and in FIGURE *g* of FIGURE 5. The frame carriage **38** can travel so deeply in a recess **39** of the workshop floor **42** that rails **40** carried by it, on which the carriage **3** runs, are flush with rails **41** which lie on the workshop floor **42**, so that the travelling under-plate **3** can be pushed straight away into the frame **36**. In this position a press **43**, suspended from the crane, travels into a position above the frame **36**, and presses a wedge **44** between the cover **24** and a co-acting wedge **45**, which is fixedly connected with the frame **36**. The cover **24** is thereby firmly pressed on to the casting mould.

Argon gas from a bottle **46** is now passed through the inlet valve **27** into the cavity between the plate **58** and the cover **24**. After the closing of the inlet valve **27** the frame carriage **38** travels on to a turntable **47**, FIGURE *h*. Upon this turntable a number of frame carriages can be accommodated at the same time; for the frame carriages are to remain upon the turntable until the argon gas has reached the desired temperature and therefore the desired pressure, either by the transmission of heat from the melt or by the special electrical heating means mentioned above, and until the cast metal has solidified under this pressure. After the termination of this operation the argon gas is drawn off and collected. The frame carriage **38** travels on somewhat on the opposite side of the turntable **47** to a position underneath a further press **48**, FIGURE *i*, which drives the wedge **44** out again. Next the travelling under-plate **3** travels on to the floor **42** again, where, by means of a crane, the mould cover **24** is lifted off, as shown in FIGURE *k*. The frame carriage **38** goes back to the turn-table. Then the travelling bottom plate **3** travels underneath a press **49** (FIGURE *l*), which pushes up the press ring **23** from below, while the steel jacket **16**, with the copper jacket **14**, are held from above.

According to FIGURE *m* the press ring **23** is lifted off the steel jacket **16**, and is returned to the position shown in FIGURE *c* in readiness to be used again. Next it is important that the removal of the mould core **7**, **10** is quickly effected, since this core should be subject to the steadily increasing shrinkage stress of the cooling hollow cast material. In order to enable the core stud **10** to be removed, the outer jacket **16**, with the bottom plate **1**, which is bolted to it at **50** (FIGURE 1), is lifted (see FIGURE *n*) by a crane, and placed upon a discharge carriage **51**, FIGURE *o*. The latter supports the bottom plate **1**, and has an inner cavity **52**, into which the core stud **10**, by a press **53**, (FIGURE *p*), beneath which the discharge carriage **51** is slid, is ejected in a downward direction. Here, of course, a supplementary supporting of the body of the discharge carriage **51** is necessary, to avoid crushing its wheels **54**.

After the core-stud **10**, according to FIGURE *p*, has been expelled downwards from the copper jacket **7**, the latter no longer has a firm seat in the ingot, since it comprises the thin, flexible parts **8** (compare FIGURE 2); and the wedges **9**, after the withdrawal of the core-stud **10**, immediately drop out of themselves. If the jacket **7**, with the aid of the press **53**, has been expelled downwards into the cavity **52** along with the core stud **10**, the outer jacket **16** can be lifted by means of a crane, as shown in FIGURE *q*, in which case the ingot, together with the bottom plate, follows it. According to FIGURE *r*, the mould core **10**, **7** is then lifted out of the expulsion carriage **51**. The outer jacket **14**, **16**, with the bottom plate **1**, is now placed upon the under-plate **3** again. By means of a spreader clamp **55**, which engages in the internal cavity of the ingot, the ingot is drawn out of the mould **14**, **16**, as shown in FIGURE *s*. This is possible without difficulty, because meanwhile the casting has shrunk. All the parts are now ready for a fresh charge.

The time required for heating up the argon gas amounts in general to only a few seconds. The duration of the solidification of an ingot of a length of 850 mm., an external diameter of 250 mm. and an internal diameter of 150 mm., with a fall of temperature from 1350° to about 1250° C., amounts however to from 60 to 80 seconds for example. By the abovementioned provision of cool lining members **58** of metal or ceramic material, the time for the development of pressure, that is, for the heating of the argon gas, can be increased from 2 seconds, for example, to about 50 seconds.

The cooling of the mould members is continued, preferably steadily, during the entire operation according to FIGURE 5, items *e* to *s*, so that the mould members are soon ready for fresh employment. The cooling is continued at least until the solidified but still very hot casting metal is removed from the mould. For uniform working it is obviously desirable that the argon gas according to FIGURE 5, item *g*, should always be supplied at the same pressure. If the argon gas is stored in a battery of bottles, this aim is attained by interposing an ordinary pressure-reducing valve between the battery of bottles and the casting mold.

I claim:

1. A method for the solidification of metal under gaseous pressure in a casting mold, comprising the steps of: pouring the molten metal to be solidified into the casting mold, covering the molten metal in the casting mold with a thermally insulating layer, closing the mold, forcing inert gas under high pressure into the casting mold above the thermally insulating layer, and heating the inert gas in the casting mold by means of an electrically generated source of heat.

2. A method for the solidification of metal under gaseous pressure as claimed in claim 1, the electrically generated source of heat being an arc for condenser discharge.

3. A method for the solidification of metal under gaseous pressure as claimed in claim 1, the inert gas employed being argon.

References Cited by the Examiner

UNITED STATES PATENTS

1,772,490	8/1930	Kelley	22—200 X
2,406,333	8/1946	Jensen	22—72
2,561,062	7/1951	Ling	22—72
2,881,489	4/1959	Mullaney et al.	22—214 X
2,960,736	11/1960	Poudevigne	22—72 X
3,010,167	11/1961	Kozinski	22—200
3,200,455	7/1965	Operhall et al.	22—200

J. SPENCER OVERHOLSER, *Primary Examiner.*

R. S. ANNEAR, *Assistant Examiner.*