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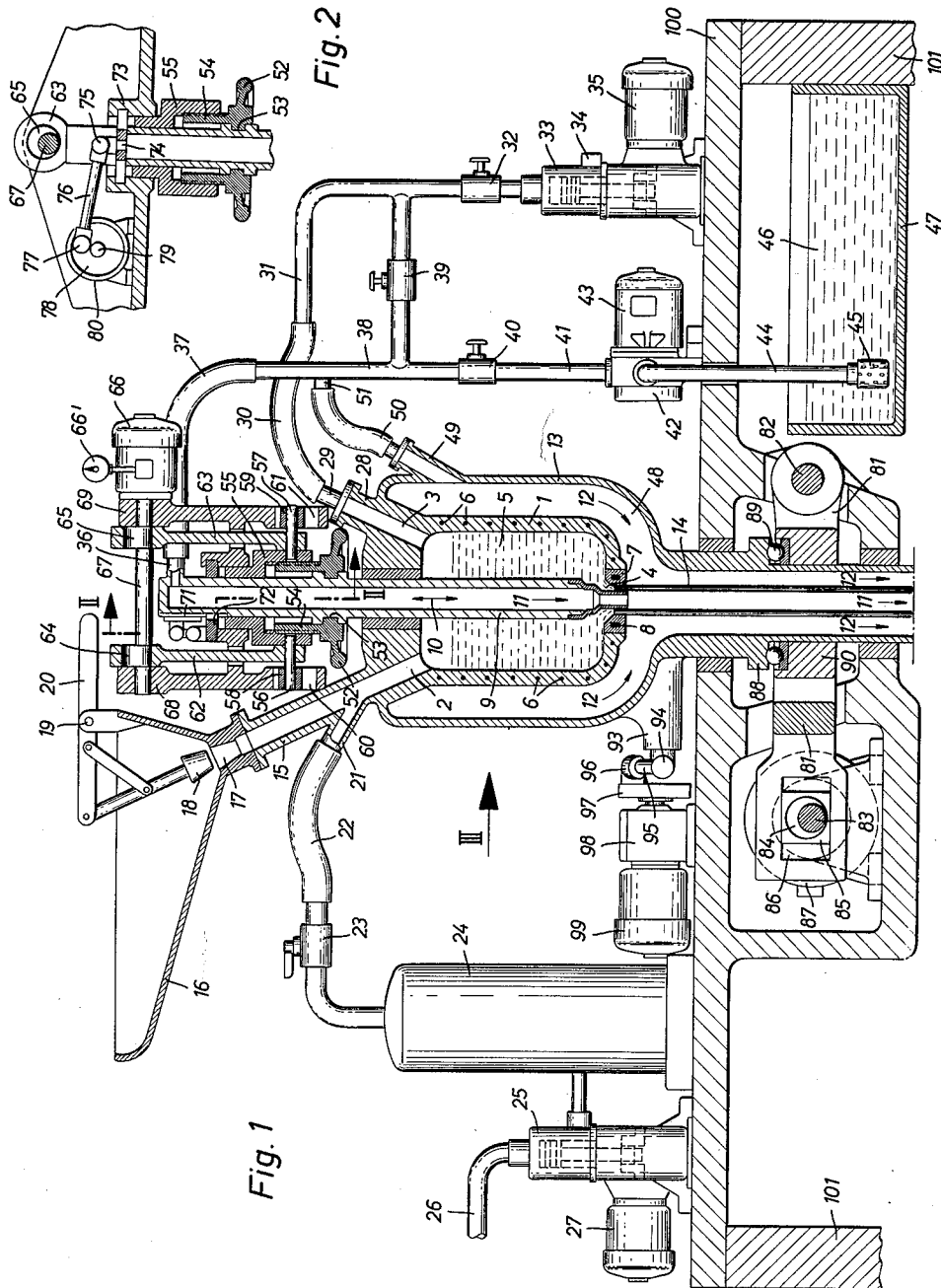
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3,103,718

APPARATUS FOR PRODUCING SEAMLESS PIPE

Filed April 27, 1959

3 Sheets-Sheet 1



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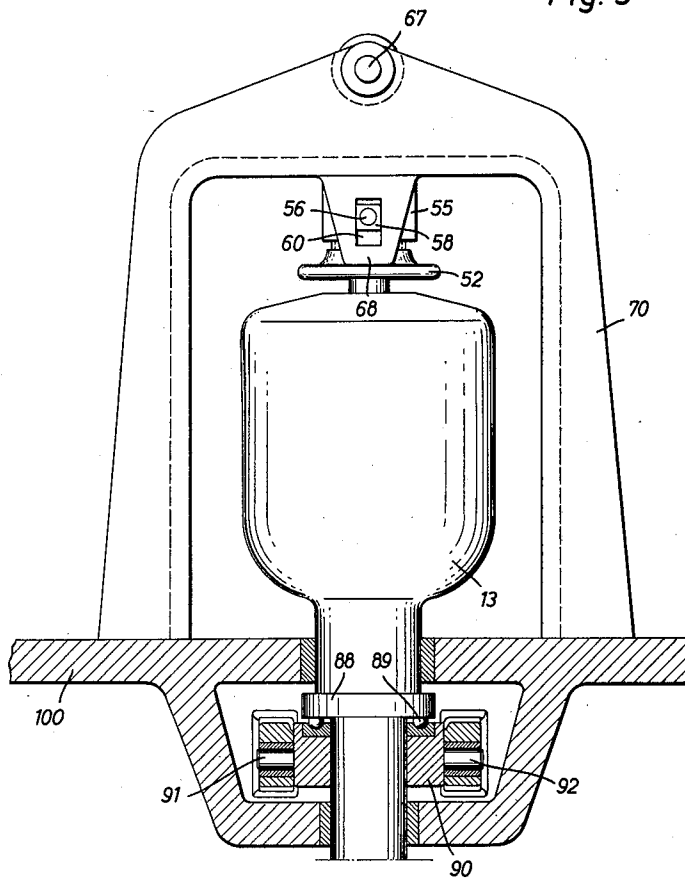
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Fig. 3



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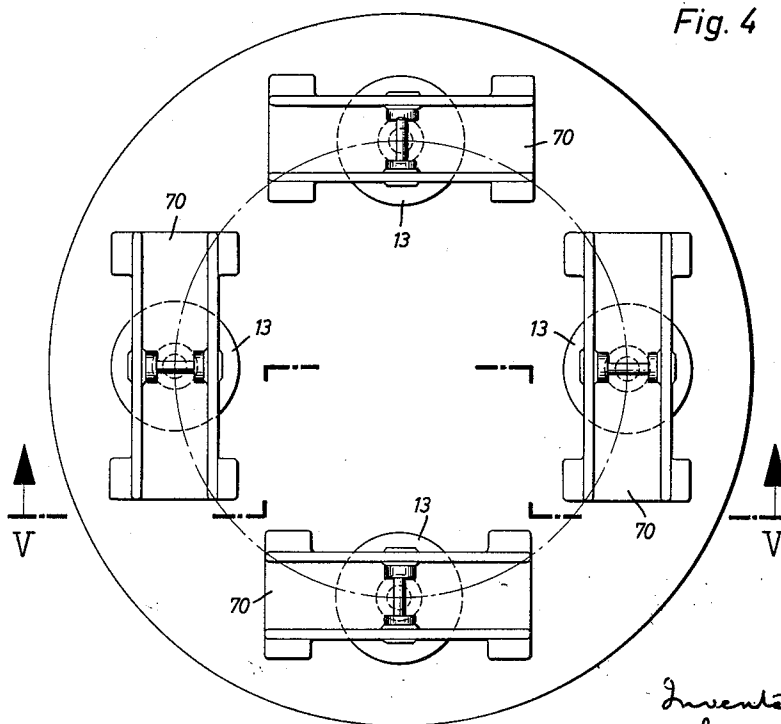
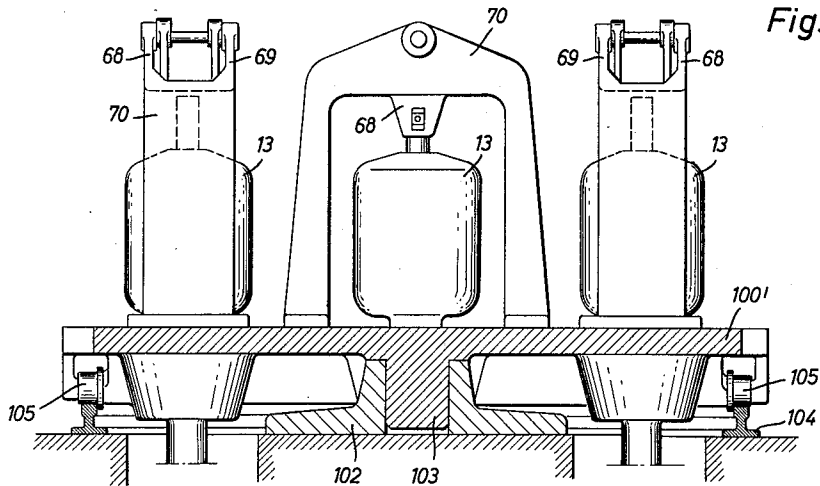
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APPARATUS FOR PRODUCING SEAMLESS PIPE

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APPARATUS FOR PRODUCING SEAMLESS PIPE
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The present invention relates to a new method and apparatus for producing rod-shaped and tubular stock and, more particularly seamless pipes, especially of iron or steel.

Prior to this invention, the production of seamless pipe has been a very complicated, protracted, and expensive process. It generally consisted of first inserting an ingot, usually in a white-hot condition, into a press and forming a bore in the ingot by means of a ram, and then passing the ingot through a drawing die to form a pipe. An economic production of seamless pipes according to this method requires them to be made of a relatively short length of about 10 to 15 m. Such a pipe is then reduced in diameter and extended in a rolling mill, cooled, then subjected to a pressure test, straightened, and then further treated in accordance with its particular purpose.

It is an object of the present invention to simplify the production of rod-shaped and tubular stock and especially of seamless pipe, and to reduce the cost of such production considerably.

A further object of the invention is to provide a new method of extruding rod-shaped and tubular stock and especially seamless pipe so as to permit a complete production of such materials within a very short time and of practically any desired length.

For attaining these objects, the new method generally consists in subjecting a liquid material, preferably iron or steel, to a very high pressure by means of a gas, preferably an inert gas, in then heating or cooling the material to attain a viscous condition, and in then extruding such viscous material to form rod-shaped or tubular stock and especially seamless pipe.

The apparatus for carrying out the method according to the invention preferably consists of a cylindrical container with at least one inlet and one outlet, wherein the latter consists of an exchangeable extrusion nozzle which may be equipped with a movable mandrel which is adapted to be passed into the nozzle and to be moved therein, and which is provided with cooling means.

The proper execution of the new method further requires suitable means for cooling the inner wall of the container as well as the extrusion nozzle, and means for heating the contents of the container, as well as means for determining and measuring the viscosity of the material used for producing the rod-shaped or tubular stock.

According to the invention, the material is inserted in a liquid condition into a pressure-resistant container, which is provided with means for heating and cooling the same; it is then degassed in the container and thereafter subjected to a high pressure by means of an inert gas, whereupon, as soon as the material has attained the proper degree of viscosity, it is extruded by such pressure from the container through the extrusion nozzle which is provided centrally thereof with a hollow mandrel. It is thus possible to produce seamless pipe of many times the length which was previously attainable, and to attain them im-

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mediately in a finished condition, bright-drawn and of the desired inner and outer diameters. Such pipes may now be attained at a rate of production of, for example, 200 to 500 m./min.

It has been found advisable to suspend the container, and preferably also the mandrel therein, so as to be movable backwards and forwards in its axial direction and also to be rotatable about its axis. The mandrel which extends through the extrusion nozzle is preferably made of a tubular shape so as to be cooled from the inside by a cooling agent which is discharged therefrom in the direction of and through the pipe to be formed. This also applies to the cooling agent for cooling the container, and the pipe as it is being extruded from the extrusion nozzle will thus be surrounded at the inside and outside by a cooling agent which preferably consists of an inert gas to prevent scaling of the pipe. For ascertaining the degree of viscosity of the material within the container, it is advisable to determine the frictional resistance prevailing between the material and a wall surface which is movable relative thereto. This wall surface may consist, for example, of the hollow mandrel which is associated with the extrusion nozzle. However, it is also possible to measure and indicate the oscillatory movements of the container and to determine therefrom the degree of viscosity of the material. In order to render the pipe production still more economical, it is advisable to combine several containers, for example, on a turntable, and to extrude a pipe from one container, while in the meantime the liquid metal is filled into and prepared in the other containers.

Further objects, features, and advantages of the present invention will be apparent from the following detailed description thereof, particularly when read with reference to the accompanying diagrammatic drawings, in which—

FIGURE 1 shows a side view, partly in cross section, of an apparatus for producing seamless pipes according to the new invention;

FIGURE 2 shows a partial cross section taken along line II—II of FIGURE 1;

FIGURE 3 shows a view, partly in section, of a part of the apparatus according to FIGURE 1, as seen in the direction of the arrow III therein;

FIGURE 4 shows a plan view of a turntable on which four apparatus according to FIGURE 1 are mounted; while

FIGURE 5 shows a side view of FIGURE 4, partly in a cross section taken along line V—V of FIGURE 4.

Referring to the drawings, the particular embodiment of the invention as shown therein consists of a container 1 for receiving and preparing the material for the extrusion process. This container 1 has three openings 2, 3, and 4. The opening 2 serves as an inlet for supplying the liquid metal 5, as well as the inert gas under pressure into the container 1. The upper opening 3 serves as an outlet through which the container is evacuated and oxidizing gases contained in the liquid metal are extracted. The bottom opening 4 finally serves as an outlet through which the molten material 5 is extruded to form a seamless pipe. Inlet opening 2 is connected by one or more suitable valves to the container 1 in which the metal is heated to maintain it in a liquid condition, while opening 3 is similarly connected by valves to the suction pump for evacuating the gases from the metal in container 1.

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The container is preferably provided with an electric inductive-heating system as indicated by a coil 6, and the extrusion nozzle 7 which surrounds the outlet opening 4 is provided with a separate heating coil 8 and mounted in container 1 so as to be exchangeable. For opening and closing the outlet 4, various means may be used. In the embodiment of the invention as illustrated, outlet 4 may be closed by moving a hollow tubular shaft or mandrel 9 which has a plug portion thereon in the downward direction as indicated by the arrow 10. This tubular mandrel 9 and the container 1 are cooled either by water or by an inert gas which flows in the direction indicated by the arrows 11 and 12. The cooling water or gas which is passed through the hollow mandrel 9, as well as the gas flowing between container 1 and the outer wall 13 emerge in the same direction in which the seamless pipe 14 is extruded from the container when the annular aperture between the hollow mandrel 9 and extrusion nozzle 7 is opened.

At the beginning of the operation, the outlet 4 is tightly closed and the inside of container 1 is completely evacuated. The liquid material, for example, steel, is then filled through a valve into the container and the oxidizing gases are extracted therefrom. Thereupon the inert gas is fed under a high pressure into the container. The container is then cooled to such an extent that the material therein, for example, the steel, has the desired temperature and a certain degree of viscosity. The hollow mandrel 9 and container 1 may be subjected to longitudinal and rotary vibrations in order to agitate the liquid steel and effect a thorough mixture thereof. After the steel has attained the desired degree of viscosity, mandrel 9 will be shifted to a position in which the material would start to flow out between the shaft and the container 1 if the steel was not too viscous. The container is then heated until the steel has become sufficiently fluid to emerge from the extrusion nozzle, and such heating is carried out automatically so that the extrusion speed will remain constant. Since the steel in container 1 is subjected to pressure, it will liquefy at a lower temperature in accordance with the amount of pressure applied, for example, at a temperature which is 10° C. lower than the normal melting point if the pressure applied amounts to 1000 atm. Consequently, when the steel emerges from the extrusion nozzle, it will solidify sooner than if it was not subjected to such pressure. If the seamless pipe to be produced is for any reason to be made shorter than the amount of material in container 1 would allow, the extrusion nozzle only has to be quickly and strongly heated so that the material will fully melt at that point and the pipe formed will tear off at the nozzle. It is then only necessary to close the extrusion nozzle to prevent the liquid material from flowing out of the container. Naturally, the extrusion of the metal from the container may also be interrupted solely by closing the extrusion nozzle.

If several containers 1 of a type as shown in FIGURE 1 are mounted on a turntable, as illustrated in FIGURES 4 and 5, the continuous production of the pipes does not need to be interrupted because one extrusion nozzle or the mandrel which is associated therewith has been damaged and has to be exchanged. Such exchange may be easily carried out while the extrusion process continues on another container.

Although the means for supplying the molten metal or the cooling agent, that is, the cooling fluid or the inert gas, or the means for reciprocating the container and the mandrel and the specific manner of arranging the various containers relative to each other may be in accordance with many different designs, a few suitable embodiments of the invention will now be described with respect to those elements illustrated in the drawings which have as yet not been particularly mentioned.

The inlet 2 of container 1 is connected to an inlet pipe 15 which carries an open funnel-like container 16 into which the liquid metal is poured. The opening 17

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of container 16 may be closed by a plug 18 which may be operated by a lever 20 which is pivotally mounted at 19. Inlet pipe 15 branches off into a pipe 21 which is connected by a flexible hose 22 and a control valve 23 to a surge tank 24 which is supplied by a reciprocating pump 25 driven by a motor 27 with an inert gas which is drawn from a suitable source of supply through a pipe 26.

The outlet 3 is connected by a pipe flange 28 to a hose connection 29 on which a flexible hose 30 is secured which is connected through a pipe 31 and a control valve 32 to a reciprocating pump 33 which is driven by a motor 35 and operates as a suction pump to evacuate the container 1 and then also the oxidizing gases of the molten metal therein.

The inside of the hollow mandrel 9 communicates through a hose coupling 36 and a flexible hose 37 with a pipe 38 which may be connected, on the one hand, by a control valve 39 to pipe 31 and, on the other hand, by a control valve 40 to a pipe 41 which is connected to the pressure side of a rotary pump 42 which is driven by a motor 43. The suction side of pump 42 is connected to a pipe 44 with a suction strainer 45 thereon which is immersed in a cooling fluid 46 in a container 47. The annular chamber 48 formed between the container 1 and the outer wall 13 is likewise connected to pipe 38 through a pipe flange 49, a flexible hose 50, and a hose connection 51.

If the cooling fluid is to be passed through the hollow mandrel 9, control valve 39 is closed and control valve 40 is opened, whereupon motor 43 is switched on. Since chamber 48 around container 1 communicates with pipe 38 through the flexible hose 50, the cooling fluid, for example, water, also flows through chamber 48. If chamber 48 and the inside of mandrel 9 should be supplied with an inert gas in order to protect the extruded pipe from scaling, both control valves 32 and 40 should be closed. After the liquid metal in container 1 has been degassed while control valve 32 is still open and control valve 39 should then be regulated so that the tainer 1 through the opening 3, hose 30, pipe 31 and the opened control valve 39 and hose 37 to the inside of mandrel 9 and also through hose 50 into chamber 48. The pressure of the gas in surge tank 24 and the control valve 39 should then be regulated so that the pressure in container 1 will still be of a sufficient strength to force the viscous material 5 through the extrusion nozzle 7. Of course, if it is desired that the flow of inert gas along the walls of container 1 and nozzle 7 and along the extruded pipe 14, as well as through mandrel 9 and through the extruded pipe should exert a more effective cooling action, the gas after emerging from outlet 3 of the container may first be passed through a suitable cooling system, not shown, or it may be supplied to chamber 48 and mandrel 9 from a separate source.

Above the container 1, the hollow shaft of mandrel 9 carries a handwheel 52 which engages into an annular groove 53 in the outer surface of this shaft so as to be rotatable thereon, but nonslidable in its axial direction. This handwheel 52 has a threaded portion 54 thereon which engages into a threaded bushing 55. This bushing 55 is slidably mounted on the mandrel shaft 9 to guide the same and is, in turn, guided within a bushing 73 which is integrally secured to and connects a pair of brackets 68 and 69 on the upper part of a frame 70. Bushing 55 carries a pair of trunnions 56 and 57, each of which carries a slide member 58 or 59, respectively. As illustrated in FIGURE 3, slide members 58 and 59 are slidable in elongated apertures 60 and 61 in brackets 68 and 69. Between brackets 68 and 69 and bushing 55, trunnions 56 and 57 are rotatably mounted on the lower ends of a pair of connecting rods 62 and 63, the upper ends of which are rotatably connected to a pair of eccentrics 64 and 65 which are rigidly secured

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to a shaft 67. This shaft 67 is rotatably mounted within frame 70 and driven by a motor 66 which is also mounted on frame 70. Since the speed of rotation of shaft 67 is dependent upon the viscosity of the material 5 in container 1 and the friction encountered by mandrel 9 therein, the readings on a speedometer 66' provided on motor 66 will serve as an indication of the degree of the viscosity or fluidity of the material.

When shaft 67 is not being driven by motor 66, mandrel 9 may be raised or lowered by turning of the handwheel 52 for the purpose of opening or closing the extrusion nozzle 7. In the embodiment of the invention according to FIGURE 1, handwheel 52 is shown as being turned to a position in which mandrel 9 is raised from the extrusion nozzle 7 so that the liquid material 5 can be extruded through nozzle 7 in the downward direction. If shaft 67 is then rotated by motor 66, mandrel 9 will be reciprocated in a vertical direction.

It is advisable to move the mandrel 9 not only upwardly and downwardly, but also to give it torsional vibrations. This may be effected by reciprocating the mandrel about its longitudinal axis. The upper end of mandrel 9 is for this purpose provided with a groove 71 which extends parallel to the axis of the mandrel. An annular disk 72 which is mounted within the bushing 73 on brackets 68 and 69 engages with an inner tooth into groove 71 and is, in turn, connected by a trunnion 74 and a ball-and-socket joint 75 to a connecting rod 76 which is eccentrically mounted by another ball-and-socket joint 77 on a disk 78 which is secured to the shaft 79 of a motor 80. Thus, mandrel 9 may be reciprocated in the vertical direction by motor 66 and in a rotary direction about its longitudinal axis by motor 80.

In a similar manner it is also possible to reciprocate the container 1 and the outer wall 13 with the various parts thereon both in the vertical and rotary directions. In the particular embodiment of the invention as illustrated in the drawings, the vertical reciprocation of these parts is effected by a bifurcated rocker arm 81 which is pivotable upwardly and downwardly about a trunnion 82 by means of an eccentric 84 on a shaft 83. The eccentric 84 is rotatably mounted in a slide member 85 which is slidable laterally in an elongated aperture 86 in rocker arm 81. Shaft 83 may be driven by a motor 87. On its lower tubular part, the outer wall of chamber 48 is provided with a flange 88 which rests on a thrust bearing 89 for supporting the entire container 1 including chamber 48. This thrust bearing 89 is, in turn, supported by an annular part 90 which, as shown in FIGURE 3, is pivotably mounted on trunnions 91 and 92 between the two arms of the bifurcated rocker arm 81.

For reciprocating the container 1 including the chamber 48 about its vertical axis, the outer wall 13 of the latter may be provided with a lateral extension 93 which is connected by a ball-and-socket joint 94 on one end of a rod 95 and another ball-and-socket joint 96 on the other end to an eccentric on a disk 97 which is rotatably mounted in a bearing 98 and driven by a motor 99.

All of the elements as above described are supported by a frame 100 which is mounted on a suitable foundation 101.

In order to render the production of seamless pipes still more economical, it is also possible, instead of applying a single apparatus as shown in FIGURE 1 and mounting the same on a stationary frame 100, to provide a plurality of such apparatus on a turntable 100'. The necessary preliminary operations preceding the actual extrusion of the pipe or pipes, for example, the evacuation of the container 1, the filling of the molten metal therein, the degassing of the metal, the application of the gas pressure, etc., may then be carried out successively in each apparatus at the different stops of the turntable 100' so that very little time will be lost between the actual extrusion operations. Since the in-

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dividual elements of one complete apparatus have already been adequately described with reference to FIGURES 1 and 2, a diagrammatic illustration of the arrangement of several apparatus on a turntable 100', as shown in FIGURES 4 and 5, will be sufficient to explain this feature of the invention. The turntable 100' is rotatably mounted on a central trunnion 103 in a base 102 and its weight is supported near its outer periphery by rollers 105 which are movable on a circular rail 104.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. A casting and extruding apparatus, comprising, in combination, a container having inlet means for introducing a metal into said container, and an outlet nozzle; first closure means for closing said inlet means; an elongated member extending into said container and having a projecting portion projecting out of the same; second closure means for closing said outlet nozzle; means on said container for varying the temperature of a metal therein; means for introducing a gas under high pressure into the container so that the metal assumes a selected viscous condition at a selected temperature and pressure; a motor operatively connected to said projecting portion of said elongated member for reciprocating the same so that the resistance encountered by said elongated member in the metal increases as the metal assumes a viscous condition; measuring means connected to said motor for measuring the speed of said motor so that the reduction of the motor speed due to the greater resistance of the viscous metal is a measure of the viscosity of the metal; and means for opening said second closure means when said measuring means indicate said selected viscous condition whereby the metal is extruded through said outlet nozzle and assumes a solid state under atmospheric pressure.

2. An apparatus as set forth in claim 1, wherein said elongated member is tubular and said second closure means is a tubular closure portion of said elongated member and forms with said outlet nozzle an annular extrusion opening; and means for introducing a coolant into said projecting portion so that the coolant flows through said elongated member, said closure portion, and in extrusion direction through a tubular body extruded through said annular extrusion opening.

3. A casting and extruding apparatus, comprising, in combination, a container having inlet means for introducing a metal into said container, and an outlet nozzle; first closure means for closing said inlet means; second closure means for closing said outlet nozzle; means on said container for varying the temperature of a metal therein; means for introducing a gas under high pressure into the container while said first closure means is closed so that the pressure in said container is raised to said high pressure while the metal assumes a selected viscous condition at a selected temperature and pressure; means for measuring and indicating the viscous condition of the metal to determine said selected viscous condition, and including a movable member located in said container, moving means outside of said container for moving said movable member so that the same encounters resistance in the metal, and measuring means connected to said moving means for moving and indicating resistance overcome by said movable member; and means for opening said second closure means when said measuring means indicate said selected viscous condition whereby the metal is extruded through said outlet nozzle and assumes a solid state under atmospheric pressure.

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