

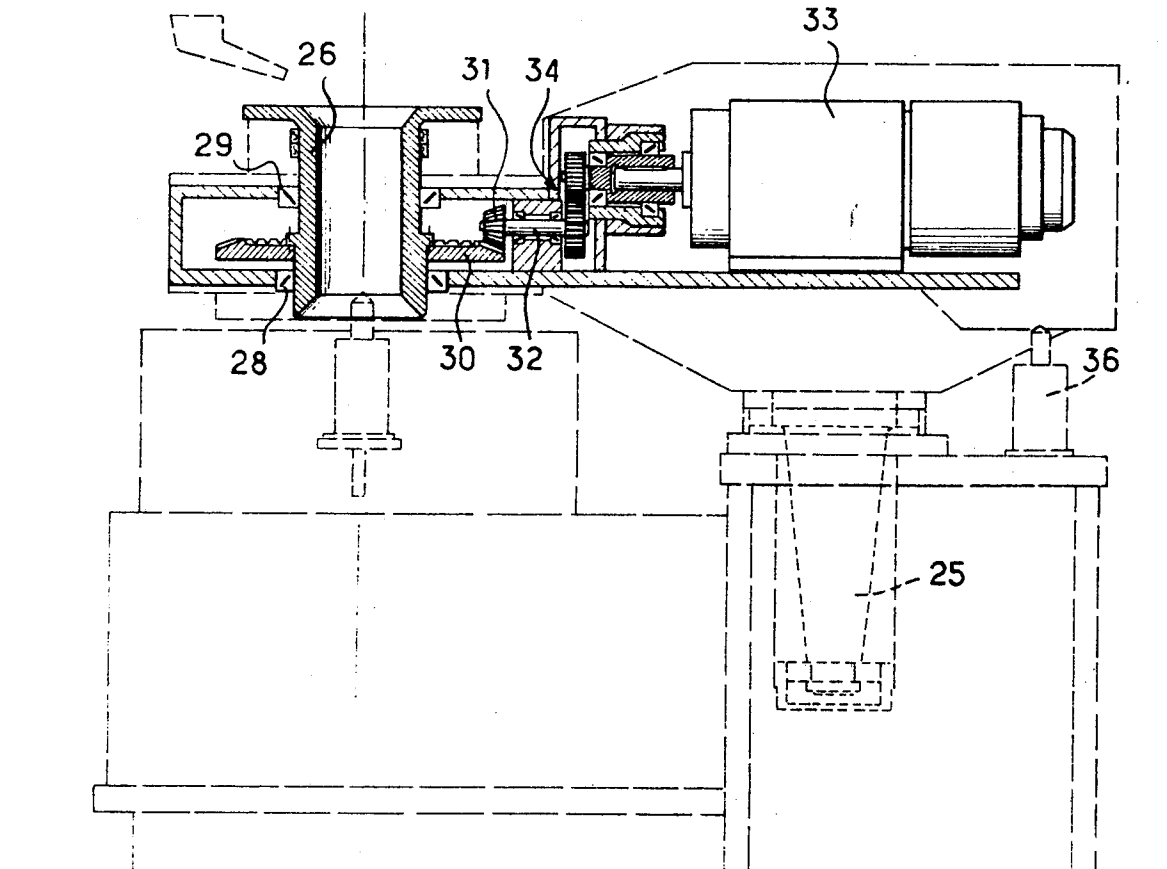
[72] Inventors **Pierre Peytavin**
Aulnoye-Aymeries;
Louis Babel, Sauvigny-Les-Bois, both of,
France
[21] Appl. No. **710,427**
[22] Filed **Feb. 14, 1968**
[45] Patented **June 8, 1971**
[73] Assignee **Societe civile dite: Societe Civile D'Etudes**
De Centrifugation
Paris, France
[32] Priority **Sept. 4, 1964, Mar. 3, 1965**
[33] **France**
[31] **PV 987,183 and PV 7,785**
Continuation-in-part of application Ser. No.
483,210, Aug. 27, 1965, now abandoned.

[56] **References Cited**
UNITED STATES PATENTS
2,752,648 7/1956 Robert 164/84 UX
FOREIGN PATENTS
1,181,997 1/1959 France 164/85
850,245 10/1960 Great Britain..... 164/281
984,053 2/1965 Great Britain..... 164/281
256,645 1/1928 Italy 164/82

Primary Examiner—J. Spencer Overholser
Assistant Examiner—R. Spencer Annear
Attorney—Holcombe, Wetherill & Brisebois

[54] **METHOD OF CONTINUOUSLY CASTING SOLID**
STEEL CYLINDERS
12 Claims, 8 Drawing Figs.
[52] U.S. Cl. **164/83,**
164/273, 164/281
[51] Int. Cl. **B22d 11/00**
[50] Field of Search..... **164/82-**
—85, 89, 260, 281, 273

ABSTRACT: Solid round castings suitable for direct drawing into tubes are continuously cast by pouring metal molten metal into a rotating bottomless mold at a point eccentric to the axis of the mold, and continuously withdrawing the casting from the bottom of the mold. The mold should be rotated at a number of rotations per minute equal to 6,000—18,000 divided by the diameter of the mold in millimeters. Improved results are obtained by vertically reciprocating the mold as it rotates.



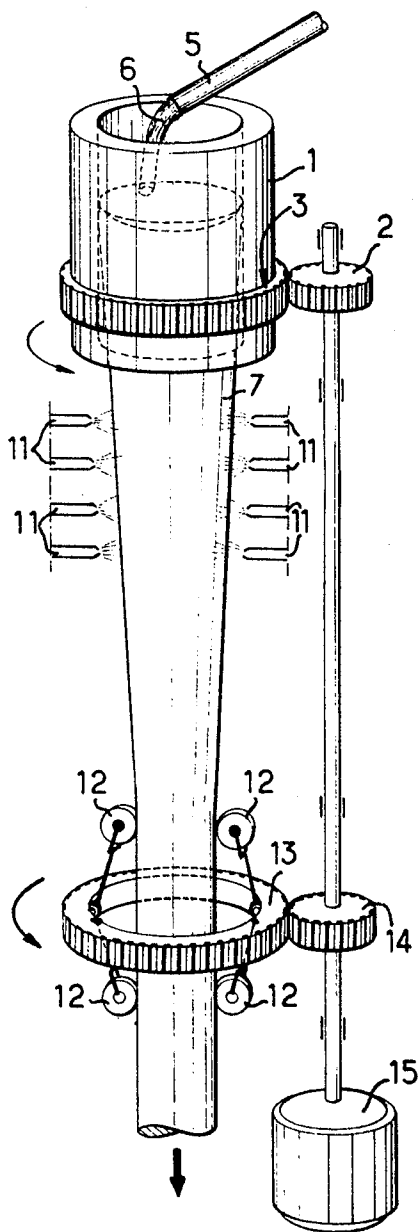


FIG. 1.

INVENTORS

Pierre Peytavin &

Louis Babel

BY

Harold Dyer

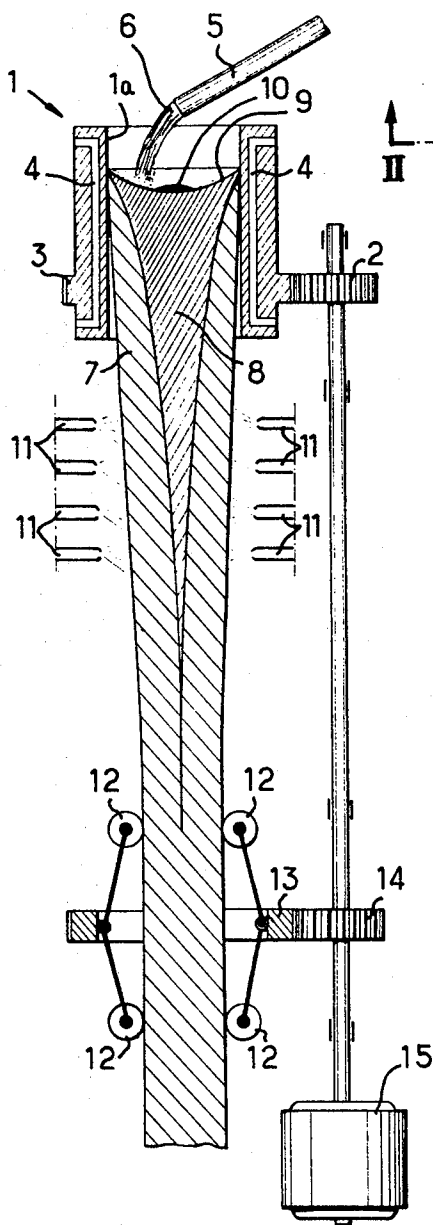


FIG. 2.

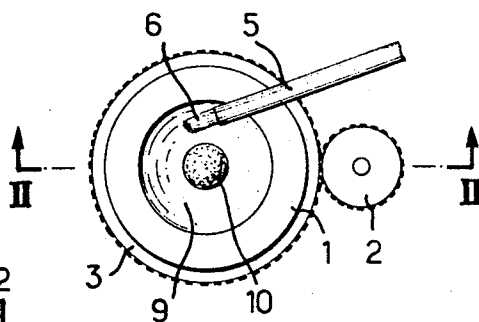


FIG. 3.

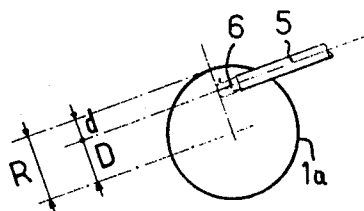
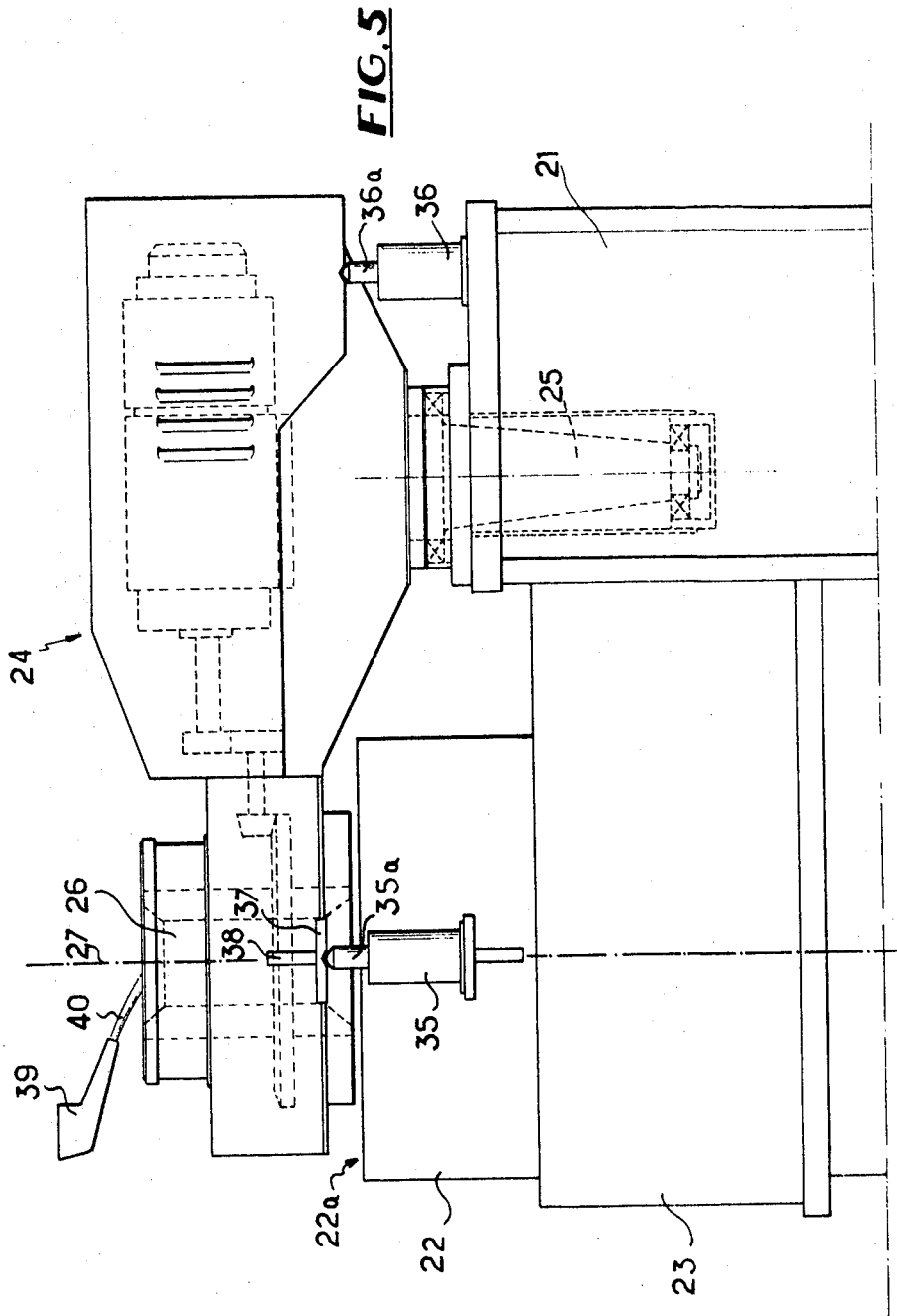


FIG. 4.

INVENTORS
Pierre Peytavin &
Louis Babel

BY

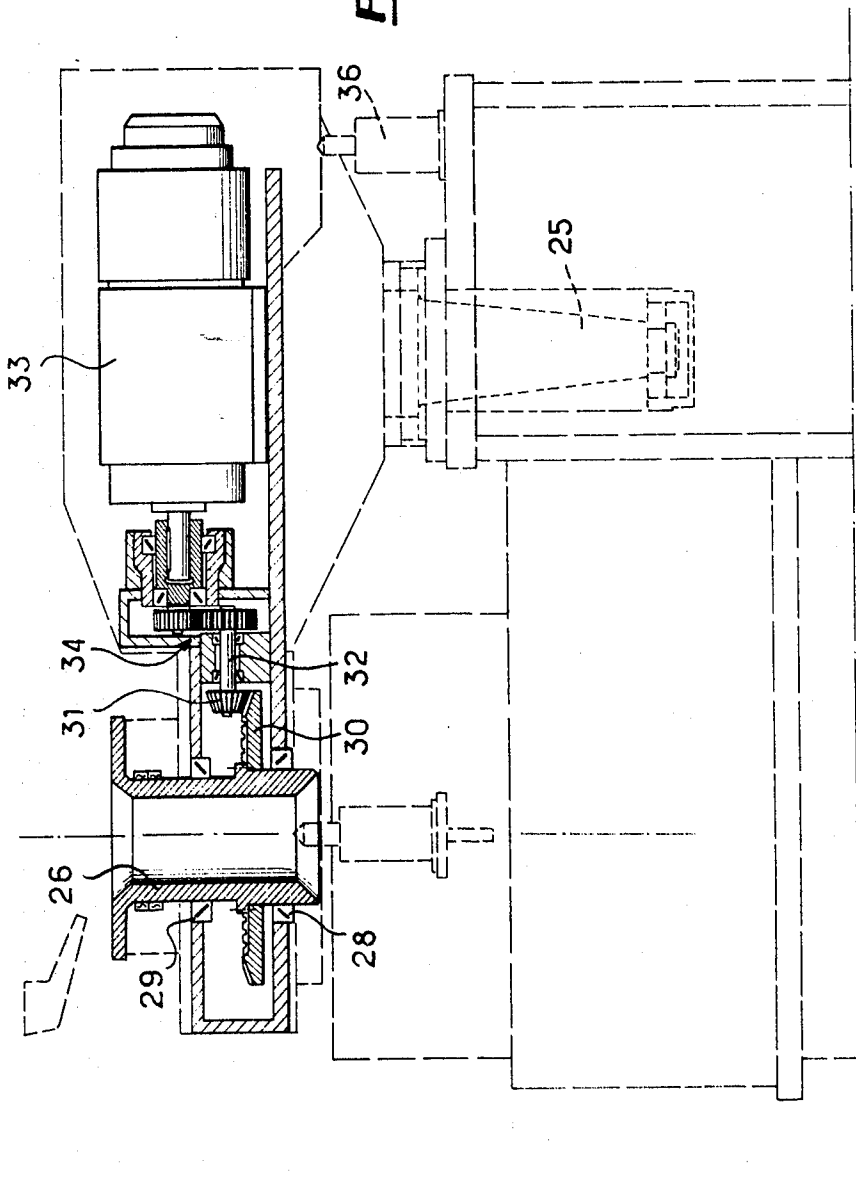
Harold Byers



Inventors
 PIERRE PEYTAYIN
 LOUIS BABEL

By
 Holcombe, Werkniell & Buisson
 Attorneys

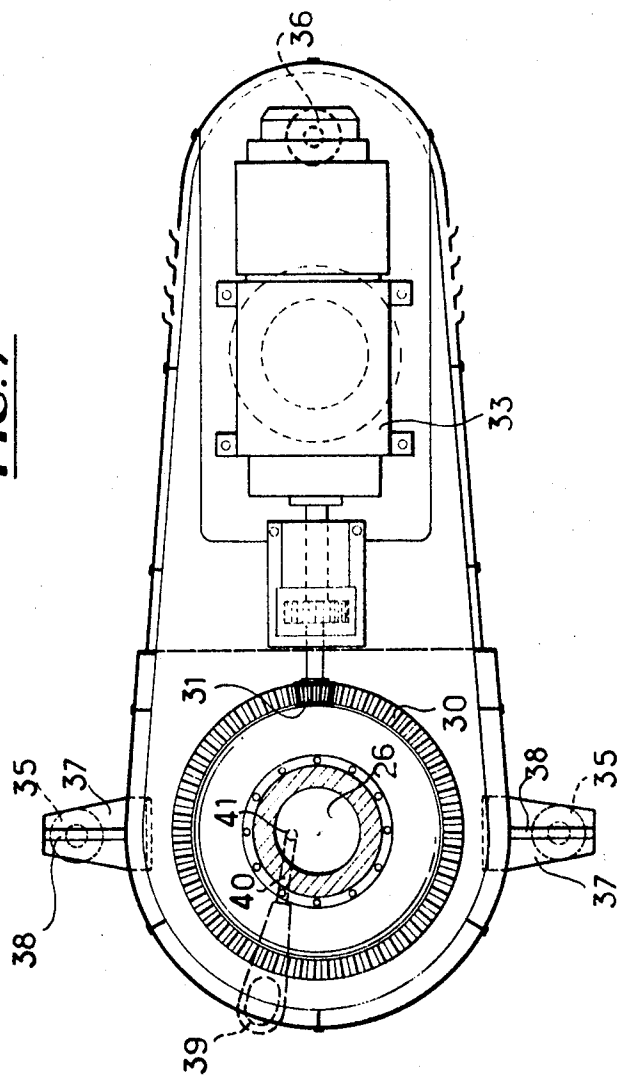
FIG. 6



Inventors
PIERRE PEYTAVIN
LOUIS BABEL

By
Holcombe, Warkentin & Buehler
Attorneys

FIG. 7



Inventors

PIERRE PEYTAVIN

LOUIS BABEL

By
HOLCOMBE, WATKINS & BRIDGES
Attorneys

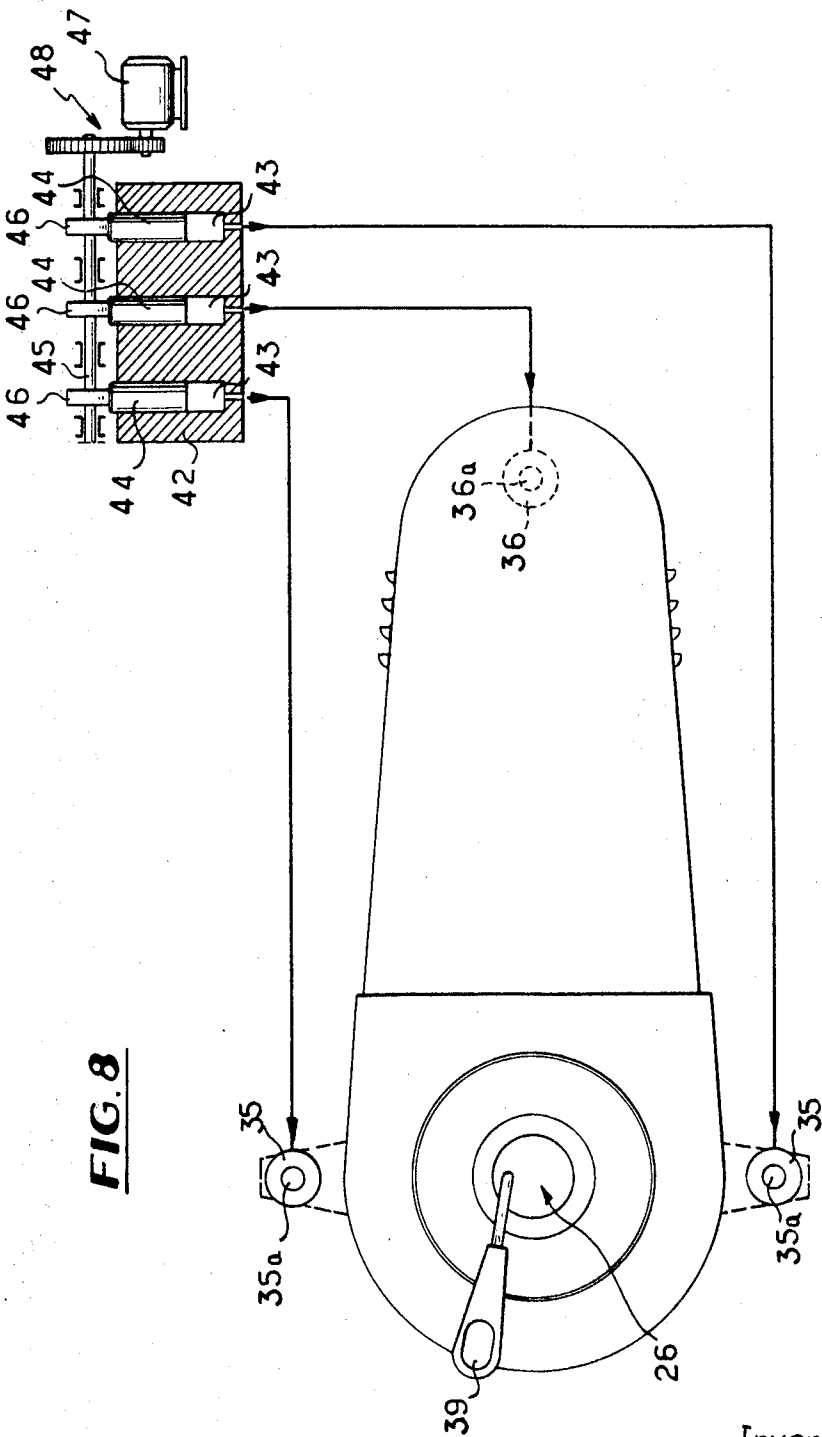


FIG. 8

Inventors
PIERRE PEYTAVIN
LOUIS BABEL
By
Holcombe, Verhaill & Buebois
Attorneys

METHOD OF CONTINUOUSLY CASTING SOLID STEEL CYLINDERS

This application is a continuation-in-part of our prior application, Ser. No. 483,210 filed Aug. 27, 1965, now abandoned.

Most processes which are in current use for manufacturing steel tubes begin by removing shavings from sections obtained by rolling ingots cast in a conventional manner.

It will be readily understood that the billets obtained in this manner are relatively expensive, and that this constitutes an increasing handicap in selling tubes manufactured according to said processes.

Processes are also known whereby bars or billets of polygonal section, and especially square section, are made by continuous static casting from molten steel.

Methods are also known, even though they involve some additional difficulties, which permit the production of steel bars by continuous nonrotating casting. Unfortunately, the round steel bars or billets heretofore obtained by the well-known process of continuous casting have not had the necessary qualities to permit them to be directly transformed into tubes, bars, beams or threads (filaments) by traditional methods.

In fact, the round bars obtained by continuous static casting have a tendency to develop two types of flaws which make them unsuitable for the manufacture of tubes.

On the one hand, their surfaces often have fissures, which in the case of the more serious ones, are productive of flaws in the outer surface of the tubes, and on the other hand, it frequently happens that round bars obtained by continuous casting have cavities in their central parts which lead to even more serious flaws in the tubes.

Although attempts have been made to produce round bars having superior qualities by traditional methods of continuous casting, it has not been possible heretofore to use them in industry because the relatively high cost of transforming a round bar into a tube involves a problem in that even an apparently small increase in the percentage of tubes rejected is enough to absorb and even exceed the savings realized by the manufacture of round bars by continuous casting, if these round bars are less perfect than the bars produced according to the traditional process.

The present application relates to a new process permitting the continuous casting of round bars, particularly of steel, from which it is possible to form tubes, bars, beams or filaments having characteristics as good as those obtained from the round bars produced by processes now in use.

The present invention has for an object a new process for continuously casting round metal bars, this process being essentially characterized by the fact that the continuous casting is accomplished in a cooled mold turning at a speed within a predetermined range about a practically vertical axis, shaping being effected by a jet of molten metal entering at a point eccentric with respect to the axis of the mold.

According to the invention, the jet of molten metal may strike the mold at a point located in the outer third of the radius of the casting.

In addition, it may be advantageous to impart to the jet of molten metal supplied to the mold a component of horizontal speed perpendicular to the radius of the mold passing through the impact point.

According to one preferred method of carrying out the invention there may be imparted to the jet of liquid metal a horizontal component of speed different from the tangential speed of the mold, at the point of impact of the jet, so as to mold the part of the metal that is still liquid to rotate relative to the mold.

In accordance with the invention, the casting is preferably cooled after leaving the mold by a spray of water from fixed jets, which has the advantage of an excellent distribution of the cooling action about the periphery of the rough casting.

Cooling of the rough casting at its departure from the mold may also be effected by means of jets turning, with respect to the axis of the casting, at a speed different from that of the casting.

The mold may advantageously be made from a good heat conducting metal such as copper, and may be cooled by a strong circulation of water.

According to the invention, the mold may have a slightly tapered shape, the smaller end of the frustoconical mold being situated at the bottom.

The mold should be rotated at a speed high enough to produce the desired rounding and smoothing effect on the casting surface, but low enough to avoid the creation of excessive centrifugal forces. In practice this speed depends in part on the diameter of the casting and it has been found that the minimum speed of rotation, in revolutions per minute, is equal to 6,000, divided by the diameter of the casting in millimeters, and that the maximum speed for any casting is 3 times the minimum. Thus in the case of casting having a diameter of 120 mm. the minimum speed of rotation is $6,000/120=50$ r.p.m. and the maximum is 150 r.p.m.

The speed of extraction from the mold is naturally a function of its diameter. By way of example, the applicant has obtained excellent results with extraction speeds of 60 to 80 centimeters per minute for castings having a diameter of 140 mm. However, extraction speeds above this may be utilized in carrying out the invention.

An examination of round bars produced in accordance with the process of the present invention reveals scarcely any flaws on the surface, and inspection of macrographic sections thereof fails to show the existence of any significant defect or appreciable porosity in the axial portion of the casting.

These remarkably good results are due to the combination of the rotation of the mold and the feeding of molten metal through a spout so positioned that the impact point of the molten metal is eccentric with respect to the axis of the mold.

In fact, the elimination of one or the other of these two features leads to results quite markedly inferior in quality as compared with the castings produced according to the present invention.

It is believed that the improved quality of the results obtained over and above that of the round bars produced in accordance with prior methods of continuous casting, can be explained by a very great uniformity in the formation of the solidified wall of the casting which thickens during cooling.

This great regularity in the formation of the wall of the casting seems to be due, in the process according to the invention, to the fact that the jet of liquid metal flowing from the spout falls on a constantly changing point on the casting, at which point its temperature decreases rapidly, which avoids the abrasive effects of the jet of liquid metal on already solidified parts of the shape.

In fact, it is known that one of the prevailing problems in conventional processes of nonrotating continuous casting, is that of irregularities in the formation of the walls of the casting, which irregularities result in large part from the fact that the jet of metal entering the mold flows along a very unstable path which leads it to irregularly lap the walls of the casting and to cause at certain spots a refusion of the metal which is just beginning to solidify.

It has also been shown that during the process according to the present invention the slag and other impurities carried along by the jet of molten metal collect spontaneously in the central cavity of the paraboloid of revolution formed by the free surface of the metal. The impurities consequently cannot cause defects on the external surface of the casting as is the case in those of continuous castings in which the mold is not rotated. Moreover, these impurities can easily be withdrawn by reason of the fact that they are concentrated at a very accessible point.

The feature of imparting to the jet of molten metal supplied to the casting, in accordance with a preferred embodiment of the invention, a horizontal speed component which is different from the tangential speed of the mold at the impact point, makes it possible to impart to the liquid metal contained in the casting during solidification, a differential rotating movement with respect to the solidified portion of the casting which is, of

course, carried along by the speed of rotation of the mold. This rotational movement of the solidified part of the casting with respect to the liquid metal which it supports also contributes very efficiently to an extremely regular formation of the walls of the casting.

The difference in speed of rotation between the solid and liquid parts of the casting is significant inasmuch as it is found that the dendrites of the casting are not radially disposed, but are disposed at a certain angle with respect to the radial direction of the casting. This angular alignment has a very favorable influence on the structure at the center of the latter.

Another object of the present invention is to provide a new article of manufacture consisting of a casting produced by the continuous casting process just described, one of the advantageous characteristics of which is that its dendrites are inclined with respect to the radii of its sections.

By way of example, the applicant has produced by continuous casting, round steel rods or sections directly utilizable for the manufacture of tubes by a process having the following characteristics: The round rods were manufactured in a mold having a diameter of 140 mm. The speed of rotation of the mold was 70 r.p.m. The jet of liquid metal struck the casting at a point located about 10 mm. from the wall of the mold. The speed of extraction of the casting was about 70/80 centimeters per minute.

In another example of operation of the invention, a mold having a diameter of 90 mm. and a height of 220 mm. turning at a speed of 100 r.p.m. was utilized. The casting was made of grade B steel.

The casting was extracted at a speed of 110 centimeters per minute, and cooled on leaving the mold by being sprinkled from stationary jets at a rate of flow of 6 to 8 cubic meters of water per hour.

The impact point of the jet of molten metal was centered at about 15 mm. from the wall of the mold.

In another example of the process according to the invention, grade C steel was run through the same ingot mold having a 90 mm. diameter and 220 mm. in height, rotating at 90 r.p.m. The speed of extraction was about 1 meter per minute. The casting was not cooled on leaving the mold and the impact point of the jet of molten metal was at about 5 mm. from the edge of the mold.

The castings of circular section obtained according to the invention, by reason of their particular structure resulting from their process of formation, have marked advantages when they are utilized for certain applications other than the conventional manufacture of tubes, in which they permit finished products of particularly good quality to be obtained.

A first application of these castings consists in cutting them in order to obtain lengths directly utilizable in the manufacture of any profiles whatever by hot drawing, and especially by hot drawing processes utilizing glass as a lubricant.

Another application of the castings of circular section according to the invention consists in utilizing them to obtain for example, through forging or rolling, rods or filaments of reduced diameter.

The invention also includes suitable apparatus for carrying out the above-described process, characterized by the fact that it comprises in combination: a cooled mold section rotating about a substantially vertical axis, means for directing a jet of liquid metal to an eccentric point located at the upper part of the mold, and means to extract vertically toward the bottom the castings which is thereby formed.

A further object of the present invention is to provide a process of the foregoing type in which the mold is vertically reciprocated during the casting process.

The amplitude of the reciprocation may be of the order of from 5 to 30 mm. During this reciprocation the downward speed of the mold may be equal to or greater than the speed at which the casting is extracted, for example about 1.15 times that speed.

The upward speed of the mold may differ from its downward speed, and may be, for example from 1 to 3 times as great.

The amplitude and speed of reciprocation of the mold are dependent on other casting conditions and particularly on the speed at which the casting passes through the mold.

The combination of rotation and vertical reciprocation of the mold causes the solidified skin of the casting to be more easily and surely formed, because the vertical movement of the casting relative to the surface of the mold cooperates with the centrifugal force resulting from rotation of the mold to prevent the adhesion of areas of the skin to the mold in a manner which would cause tearing of the skin.

As a consequence of the combination of these two characteristics, any point of adhesion which may develop are immediately separated by the relative vertical displacement between the mold and casting, while the liquid which is urged toward the mold wall by centrifugal force immediately reforms the skin covering the very small area over which it has been torn loose or ruptured by such adhesion.

This leads to better quality control and permits higher casting speeds.

The present invention also comprises a new device for carrying out the process which has just been described, which device is essentially characterized by the fact that the rotating mold is mounted so that it may be vertically reciprocated along the casting axis and is provided with means for causing such reciprocation.

It will of course be understood that the particular methods of using the round rods indicated above in no way limit the scope of the invention, which relates a particular means and method of manufacture of round rods by continuous casting and the round rods produced by said method, whatever use is later made thereof.

Likewise, it is equally true that the invention is not limited to castings made of steel, but that it concerns all cylindrical casting which may be manufactured by the process involved, from steel or from alloys whose fusion temperatures are on the order of those of conventional or special steels.

In order that the invention may be better understood, two preferred embodiments of the apparatus comprised by the invention will now be described, purely by way of illustration and example, with reference to the accompanying drawings in which:

FIG. 1 is a perspective view showing schematically a first apparatus for carrying out the process according to the invention;

FIG. 2 is a vertical cross section through the device shown in FIG. 1 taken along line II-II of FIG. 3;

FIG. 3 is a schematic plan view corresponding to FIG. 2;

FIG. 4 is a schematic top view showing the position of the impact point of the jet of molten metal with respect to the mold;

FIG. 5 is a schematic vertical elevation showing a second apparatus for carrying out the invention;

FIG. 6 is a schematic vertical section taken through the axis of the mold shown in FIG. 5;

FIG. 7 is a top plan view of the apparatus shown in FIG. 5; and

FIG. 8 is a schematic view showing the control system for the hydraulic cylinders used in connection with the apparatus of FIG. 5.

Like reference numerals denote like parts throughout the several views.

In FIG. 1 there is shown a mold 1 which is mounted on means not shown so as to be able to turn about its vertical axis.

This mold 1 is driven by pinion 2 which meshes with ring gear 3 fixed on the mold.

As can be seen in FIG. 2, mold 1 is cooled by water circulating in cavities 4 appropriately positioned inside the mold walls.

A small spout 5 delivers a jet of liquid metal 6 which is cooled by the mold and forms a casting 7 the central part 8 of which is still liquid, as can be seen in FIG. 2.

It will be noted that by reason of the rotation of the mold, the free surface 9 of the liquid metal 8 has the shape of a paraboloid, at the center of which slag 10 collects and from which it can be easily eliminated.

The drawing also shows jets 11 which spray water into cooling contact with that portion of the casting 7 which has left the lower part of the mold.

It is noteworthy that because of the rotation of the casting according to the invention, it is possible to spray a very large quantity of cooling water which may, for example, be from 2 to 3 cubic meters of water per ton of cast metal.

FIG. 2 also shows how the casting is extracted toward the bottom by means of a device consisting, for example, of two pairs of power actuated rollers 12, resiliently urged against the casting and mounted on a toothed support 13 which is driven by a pinion 14 with the same speed of rotation as that which is communicated to the casting by mold 1.

FIG. 2 also shows how pinions 2 and 14, which are mounted on a single shaft, can be driven by motor 15.

In order to illustrate the eccentric position of the stream 6 of liquid metal with respect to the mold, there is shown schematically in FIG. 4 the inner surface 1a of the walls of the mold, and the supply conduit 5, as well as the liquid metal jet or stream 6.

FIG. 4 also shows the radius R of the mold as well as distances D and d which are the distances of the impact point of the jet 6 on the casting from the center of the mold on the one hand, and from its wall 1a on the other hand.

As has been previously indicated, the axis of the spout 6 can be advantageously located in the outer third of the radius of the mold, which signifies that d is not more than $R/3$.

Turning now to the second embodiment of the invention, FIG. 5 shows the upper part of a continuous casting machine in which the mold is vertically reciprocated.

Reference numeral 21 indicates the frame which carries the first cooling means and the first guide rolls to contact the workpiece. These are enclosed in the housings 22 and 23 and are not illustrated since they are of a conventional type and the details thereof form no part of the invention.

The support for the rotary mold, which support carries reference numeral 24, swings about a pivot 25 so as to clear the top 22a of the housing 22, which gives access to the line along which the casting formed by the mold 26 is extracted. The axis 27 of the mold is, when in operating position, aligned with this line of extraction.

FIG. 6 shows how the rotating mold 26 is supported by two thrust bearings 28 and 29, (which are schematically illustrated) and driven through a beveled ring gear 30 by a bevel gear 31 fixed to the shaft 32 driven from the motor 33 through gears 34.

For the sake of simplicity the rotary joints which make it possible to cool the mold 32 have not been illustrated, since these joints are not in themselves novel.

FIG. 7 shows the ring gear 30 as well as the pinion 31, driven by the motor 33.

FIG. 7 also shows the two hydraulic cylinders 35 positioned on opposite sides of the rotating mold, as well as the hydraulic cylinder 36 positioned.

The movable pistons 35a of the hydraulic cylinders 35 act on the brackets 37 fixed to the frame of the support 24 of the rotating mold, which brackets are reinforced by the vertical webs 38 welded thereto.

The movable piston 36a of the hydraulic cylinder 36 rests directly on the supporting frame 24.

As has been schematically shown, the upper ends of the movable pistons 35a and 36a of the hydraulic cylinders have a slightly conical shape so as to insure the exact positioning of the mold 26, when they engage in correspondingly shaped recesses in the brackets 37, in the case of the cylinders 35 and the support 24, in the case of the cylinder 36.

The pivot 25, which has been schematically shown, has the characteristic of permitting the vertical displacement of the mold support 24 when the latter is acted upon by the cylinders 35 and 36.

On the other hand, when the movable pistons of the cylinders 35 and 36 are completely lowered, the pivot 25 carries stops which keep the lower part of the mold 26 a certain

distance above the surface 22a, so that the mold 26 can be swung to uncover the upper of the housing 22.

FIGS. 5 and 7 also, schematically show the shoe 39 from which the jet of molten metal 40 is ejected to strike the casting at the eccentrically positioned point 41.

FIG. 8 schematically shows how the hydraulic cylinders 35 and 36 are controlled from a single pump having three cylinders 43, the pistons 44 of which are simultaneously displaced by a shaft 45 provided with three identical cams 46, said shaft being driven by a motor 47 through suitable reduction gearing 48.

Conventional means are provided to compensate for any leaks which may occur in any of the circuits.

It will thus be seen that rotation of the motor 47 causes the periodic raising and lowering of the mold support 24, by means of the hydraulic cylinders 35 and 36.

Of course, the mold support 24 might be reciprocated by other means, such for example as mechanically controlled cams. However, the hydraulic device which has just been described affords great flexibility in adjusting the speed and amplitude of reciprocation of the mold 26.

We claim:

1. A process for continuously molding a solid metal casting comprising the steps of rotating a bottomless cylindrical mold about its main axis at a speed between 50 and 200 r.p.m. while maintaining said mold in a vertical position, cooling said rotating mold, and introducing a jet of molten metal into said cooled rotating mold at a point eccentric to the axis thereof, while continuously withdrawing said casting from the lower end of said mold.

2. Process according to claim 1 wherein the point of introduction of said jet into said rotating mold is located within the outer third of the radius of said casting but spaced inwardly from said mold.

3. Process according to claim 1 wherein said jet of molten metal has a component of horizontal speed perpendicular to the radius of the mold passing through the point of impact of said jet of molten metal on said casting.

4. Process according to claim 1 wherein said jet of molten metal has a component of horizontal speed different from the speed of rotation of said casting at the point of impact of said jet with said casting.

5. Process according to claim 1 wherein said mold is rotated at a speed ranging from 70 to 100 r.p.m.

6. Process according to claim 1 wherein said casting upon withdrawal is subjected to a cooling water spray after passing the point of exit.

7. Process according to claim 1 wherein said casting upon withdrawal is subjected to a cooling water spray after passing the point of exit, said spray being directed from spray means rotating about said casting.

8. A process for continuously molding a solid metal casting comprising the steps of rotating a bottomless cylindrical mold about its main axis at a number of revolutions per minute equal to from 6,000 to 18,000 divided by the number of millimeters in the mold diameter while maintaining said mold in a vertical position, cooling said rotating mold, and introducing a jet of molten metal from which said casting is to be formed into said rotating mold at a point eccentric to the axis thereof while continuously withdrawing said casting from the lower end of said mold.

9. The method claimed in claim 8 in which said mold is vertically reciprocated while being rotated.

10. The method claimed in claim 9 in which said mold, during reciprocation is moved downwardly more rapidly than said casting is withdrawn therefrom.

11. The method of manufacturing an article of manufacture which comprises the steps of producing a casting by the method claimed in claim 8, and hot drawing said casting.

12. The method claimed in claim 11 in which glass is used as a lubricant during said drawing.