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PROCESS FOR THE MANUFACTURE OF CONTINUOUS CASTINGS

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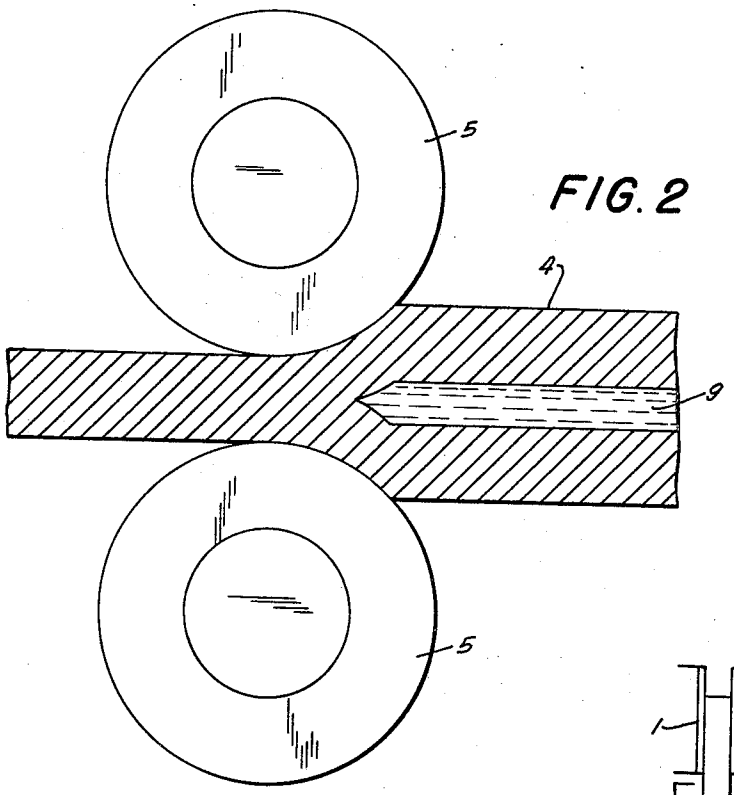

FIG. 2

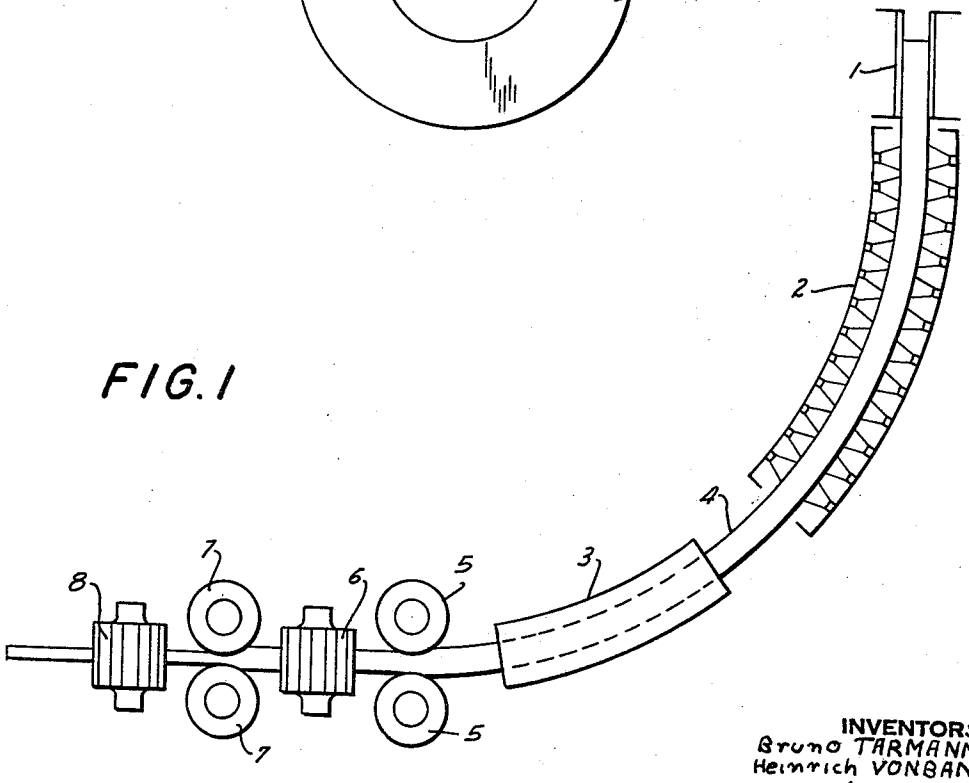

FIG. 1

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PROCESS FOR THE MANUFACTURE OF CONTINUOUS CASTINGS

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ABSTRACT OF THE DISCLOSURE

A process for the manufacture of strands of molten metal, in particular nonalloyed and alloyed steels, by continuous casting, in which the metal is worked while still in a partly molten condition, by means of a working installation arranged downstream from the casting mold. The improvement of the process resides in working that portion of the hardened strand in which there is situated a liquid core having a thickness of 5 to 30 mm., independent from the cross-sectional area thereof. The strand is worked in such a manner and to such an extent that the cross-section is reduced by at least 20% and the leading end of the liquid core is formed upstream from the plane in which said strand attains its final cross-sectional configuration due to the working thereof.

This invention relates generally to a method of continuous casting of molten metals, and in particular of nonalloyed and alloyed steels.

It is known that during the continuous casting of steel only the external peripheral zone of the strand is brought to a hardened condition in the ingot mold. The liquid interior, that is to say the so-called liquid pool or core, attains, with today's rapid continuous casting techniques, a depth i.e., length of about 5 to 15 meters. It is, furthermore, known that strong convection currents take place in the liquid core within initially prevent the formation of strong liquations and segregations. However, as soon as the diameter of the liquid core is decreased to a thickness of 5 to 30 mm., due to a concomitant increase of the external hardened zone, the convection currents lose their effectiveness, which manifests itself by the formation in the core of the strand of soft spots, shrinkages, cavities and liquations. These formed liquations and segregations cannot be removed by subsequent processing of the continuously cast strands. This limits, in some instances, the usability of the continuously cast strands.

In order to eliminate the afore-recited disadvantages, there has for example, been proposed in the prior art to press together the traveling strand by means of rollers at a point upstream from the natural terminating point of the liquid core until the interior wall surfaces of the already hardened external zone shell are welded to the adjacent boundary layers between the external shell and the liquid core. This is being accomplished without creating a change of the wall thickness or a stretching of the shell zone. In this manner, the formation of a slim liquid core can be avoided and the terminating point of the liquid core extends to the axial plane of the rollers of the roller press. It has been found that with this known process the aforerecited disadvantages can be eliminated but a new undesirable side effect takes place, namely cracks and fissures appear in the interior of the strand, which cannot be welded together during the further processing of the strand. (The aforedescribed known process is disclosed in Austrian Patent No. 187,251 and English Patent No. 766,584.)

It is therefore a general object of this invention to provide a novel process for continuous casting of molten metals in which all of the aforerecited disadvantages have been eliminated.

Experiments have indicated that during the working over of a strand which has not completely hardened, the formation of cracks and fissures cannot be absolutely avoided. It has, however, also been noted that these formed fissures and cracks are again subsequently welded together during this same working process, if the working takes place in a region of the strand, in which the liquid core thickness during hardening without working amounts to 5 to 30 mm., and if the working results in a substantial reduction in the cross-sectional area of the hardened portion of the strand. In other words, if the liquid core head terminates as a point which, due to the working of the strand, is positioned upstream from the plane in which the strand reaches its final cross-sectional configuration due to the working thereof.

The working process according to this invention can be carried out with the existing working installations for working strands, which are suitable for reduction of the cross-section of materials. It is preferred that the working is effected by means of rollers. The rollers of the driving installation in a continuous casting processing machine have been found suitable for carrying out the process step of this invention. The rollers of the driving installation may have the usual diameter that is prevalent in rolling mills of the described character. It has been found to be particularly advantageous to use grooved rollers in the fabrication of square and round strands.

It has also been found, in some instances, to be desirable not to permit the distance between the ingot mold and the working installation operating according to this invention, to become too large. It has, therefore, been proposed to provide a preworking installation which effects a preworking of the strand prior to the working process according to this invention. This preworking installation is arranged between the ingot mold and the working installation of this invention. Due to this preworking step there occurs a reduction of the cross-sectional area of the liquid core, and the strand, consequently, attains sooner the liquid core thickness of 5 to 30 mm. which is required for the working process of this invention.

The continuously cast strand which has been worked in accordance with the process of this invention has, after working, still a sufficiently high temperature so that, if necessary, it can by means of the usual known steps be further deformed into the desired shapes and dimensions.

The conditions which must prevail during the process of this invention can be maintained without difficulties.

The prevailing thickness of the strand shell, i.e., of the liquid core, can be easily calculated on the basis of known formulas as for example described in the article by J. Savage and M. D. Ashton, Iron and Steel 29 (1956), pages 229–235, so that the required distance between the ingot mold and the working installation for a certain strand cross-section can also be easily determined. Preferably, the working process according to this invention should be effected with steels having a large solidification period with a liquid core having a thickness near the upper limit of the thickness range, whereas with steels having a small solidification period the working process should be effected near the lower limit of the thickness range of 5 to 30 mm. of the liquid core.

In the event there are produced strands having different cross-sectional configurations and sizes, which generally would result in varying liquid core lengths, the correct liquid core length can always be obtained by ad-

justing the rate of pouring of the molten metal or by adjusting the cooling rate of the strand.

Furthermore, the determination of the required size of the worked over area of the hardened strand cross-section can be obtained without difficulty, because the cross-sectional portion of the liquid core can be calculated as well as the prevailing thickness of the liquid core. In order to shorten the liquid core length, in accordance with the process of this invention, to an extent that the liquid core point is positioned upstream from that plane in which the strand attains, due to the working thereof, its final cross-sectional configuration, it is only necessary to select such a large degree of deformation that it exceeds the cross-sectional portion of the liquid core. It has been found that strands of pronouncedly improved qualities can be obtained when the total cross-sectional area reduction during the working process of this invention is at least 20%.

The invention is illustrated by way of example in the accompanying drawings in which FIG. 1 is an elevated view of an installation for performing the process according to this invention and FIG. 2 is a view of the longitudinal section through the strand passing the pair of rollers **5** in FIG. 1.

Referring to FIG. 1 there is shown an open ended reciprocating mold **1** in which the partial solidified strand **4** is formed. The strand emerging from the mold passes the cooling device **2**, consisting of series of water sprays, and then runs through the insulated chamber **3**, designed to reduce the temperature gradient of the solidified portion of the strand. The insulated chamber is followed by 4 pairs of rollers **5**, **6**, **7** and **8**, which are employed for the reduction of the cross-section of the strand.

As a specific example, the following conditions are given for casting steel (0.35 percent C, 0.06 percent Mn, 0.20 percent Si, the rest substantially Fe):

Cross-section of mold	mm. square	140
Radius of curved path of the strand	m	6.5
Length of curved path of the strand	m	10.0
Length of cooling device	m	5.0
Length of insulated chamber	m	2.0
Diameter of all rollers	m	0.4

If the strand is withdrawn from the mold at a speed of 1.8 m. per minute, it enters the first pair of rollers with a liquid core of 22 mm. in thickness. Passing the four pairs of rollers the strand is reduced to cross-sections of 150 x 95 mm. in the first, to 100 x 107 mm. in the second, to 110 x 72 mm. in the third, and to 80 mm. square in the fourth pair of rollers. The process of the invention is performed by the first pair of rollers **5**, by means of which the cross-section area of the strand is reduced by about 32 percent, and whereby the reduction of the cross-section area of the solidified portion of the strand amounts to about 30 percent.

As it is seen from FIG. 2, the liquid core **9** ends far before the center plane of the two rollers **5**.

In the foregoing, the invention has been described in connection with a preferred arrangement of a process thereof. However, since many other variations and modifications will now become obvious to those skilled in the art, it is accordingly desired that the breadth of the claims not be limited to the specific disclosure herein contained.

What is claimed is:

1. In a process for the manufacture of strands of molten metal, in particular nonalloyed and alloyed steels, by continuous casting, where the metal is worked while still in a partly molten condition, by a working installation arranged downstream from the casting mold, the improvement comprising the step of working that portion of the hardened strand in which the liquid core thereof has a thickness of 5 to 30 mm., independent from the size of the cross-sectional area thereof, in such a way that the end of the core is formed upstream from the plane in which said strand attains its final cross-sectional configuration due to said working, the cross-section of said hardened strand being reduced by at least 20% by means of said working step thereby welding together the hardened strand shell so as to form a solid cross-section upstream from the transverse axis of said working installation.

2. The improvement as set forth in claim **1**, wherein said working is effected by a plurality of rollers.

3. The improvement as set forth in claim **2**, wherein said rollers are of standard diameter and are operatively mounted in a driving arrangement.

4. The improvement as set forth in claim **3**, including the step of pre-working said strand and thereby reducing its cross-sectional area prior to the step set forth in claim **1**.

5. The improvement as set forth in claim **4**, including further continuously working said strand after the step set forth in claim **1**.

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