

[54] CONTINUOUS CASTING METHOD INCLUDING STRAND SUPPORT ADJUSTMENT

[72] Inventors: **Bernard Knell**, Thalwil, Switzerland; **Paul Desfossez**, Dillingen-Saar; **Walter Hess**; **Hans-Dieter Schulz**, both of Dusseldorf, all of Germany

[73] Assignees: **Concast Aktiengesellschaft**, Zurich; **Schloemann Aktiengesellschaft**, Dusseldorf, Germany

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[58] Field of Search164/282, 82

[56] References Cited

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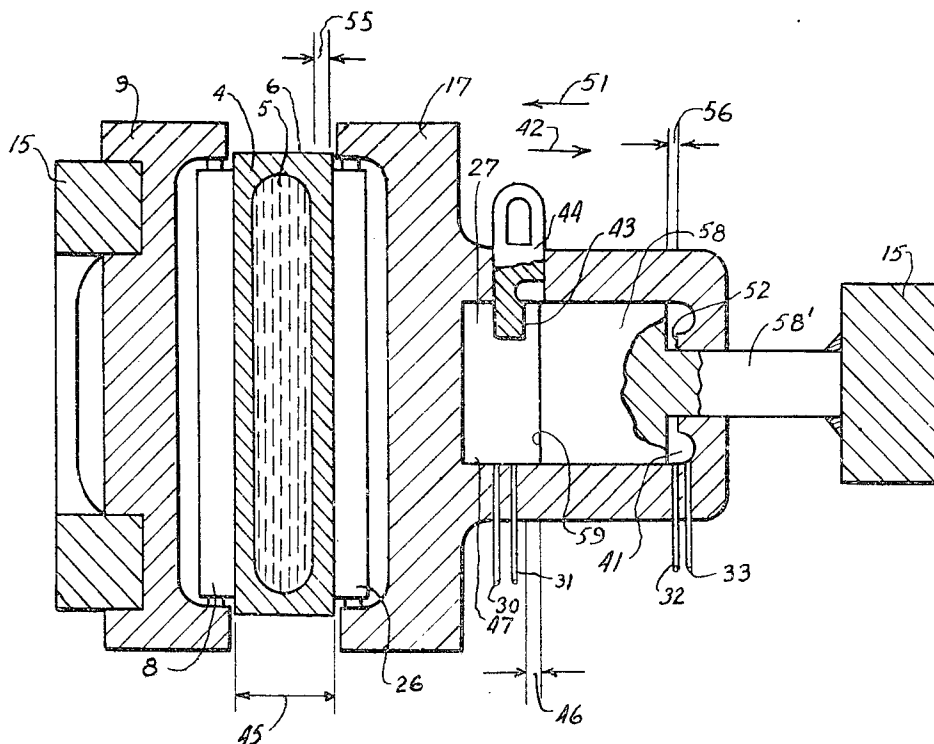
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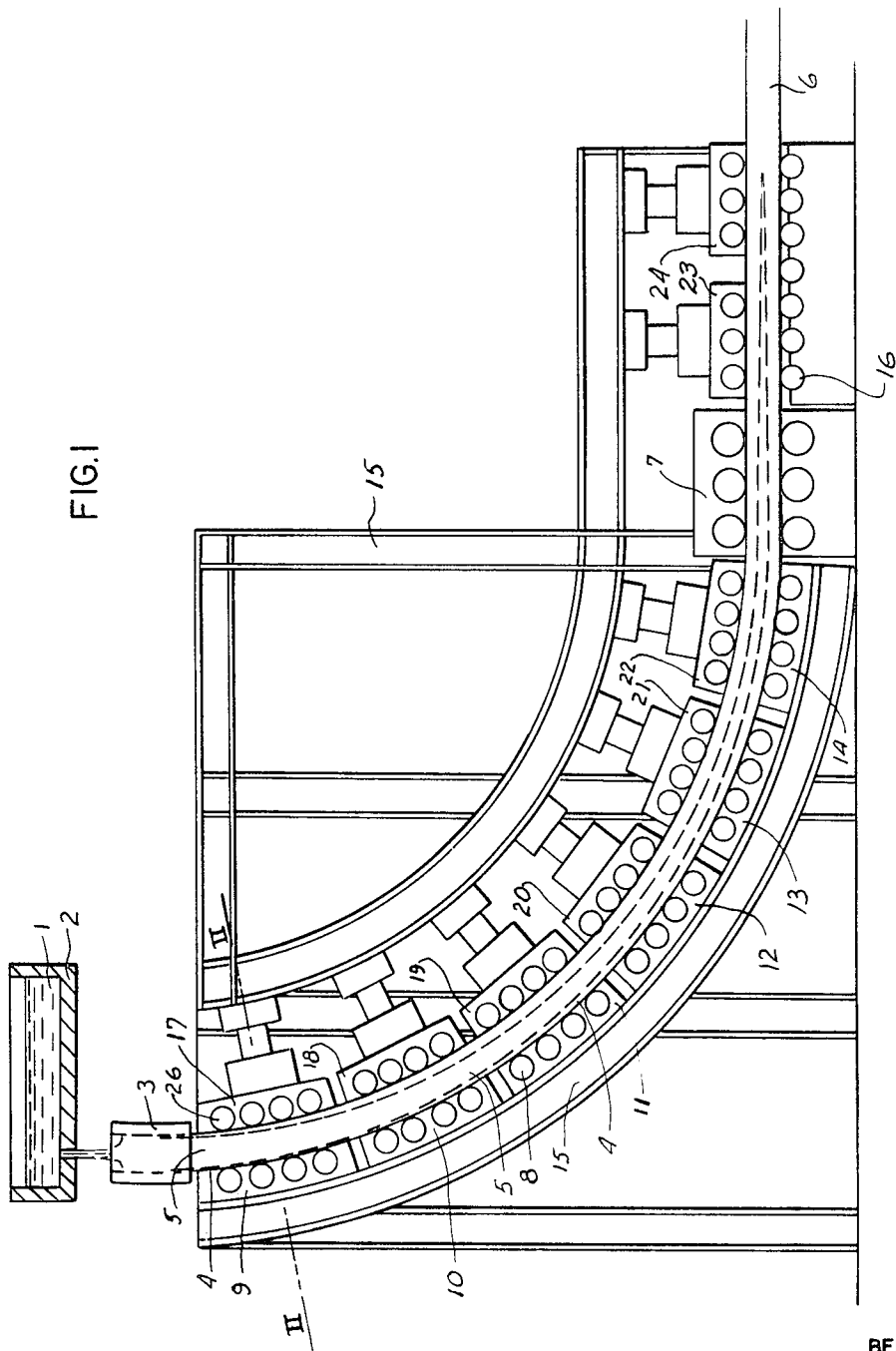
Primary Examiner—Robert D. Baldwin
Attorney—Sandoe, Hopgood & Calimafde

[57] ABSTRACT

A continuous casting method wherein a support and guide for a continuously cast metal strand that has a still-molten core within a solidified shell includes a plurality of members each mounted for movement toward and away from the strand at one side thereof. Each member carries a number of rolls or other contact elements adapted to engage the strand, and each has one stop adjustably positioned to stop movement of the member, and its contact elements, away from the strand at a specific predetermined point and thereby limit bulging of the strand (from ferrostatic pressure of the core) to an acceptable amount. Another stop is provided on each member to stop movement of each member toward the strand at a point at which the contact elements can engage the thinnest portion of the strand, or the dummy bar used for starting the casting. In the form illustrated the members are guided, and may be moved, by pistons and cylinders. Gravity, fluid pressure or spring pressure may be utilized to urge the contact elements into engagement with the strand.

2 Claims, 3 Drawing Figures





INVENTORS
BERNARD KNELL
PAUL DESFOSSEZ
WALTER HESS
HANS-DIETER SCHULZ

BY
Sandoe, Horgosel & Calinafde
ATTORNEYS

FIG.2

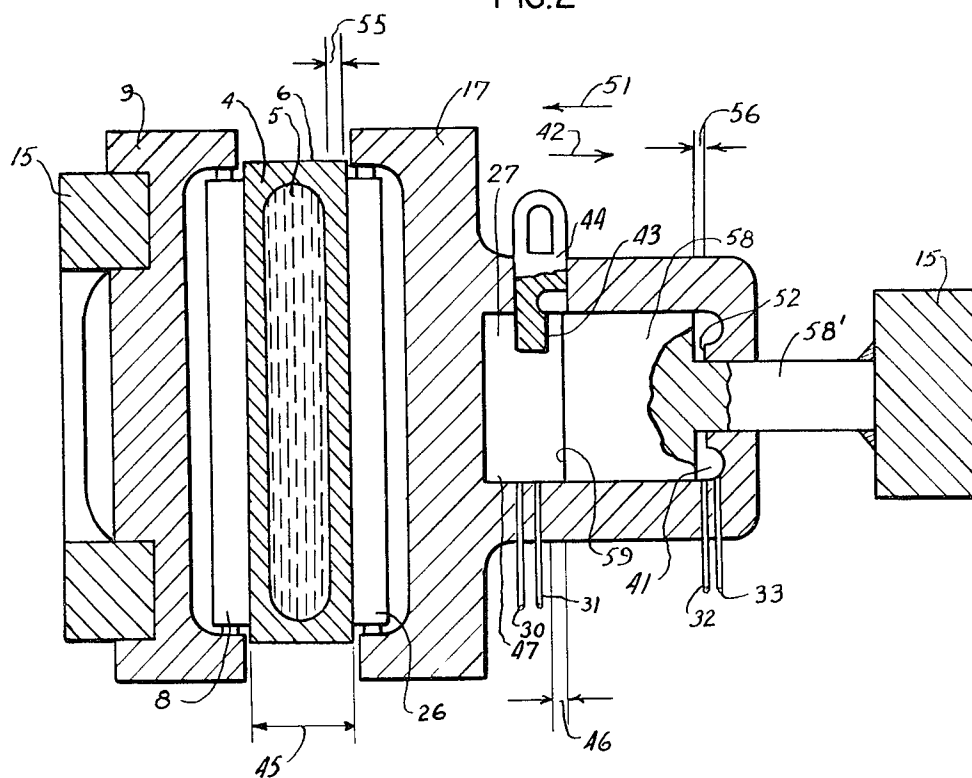
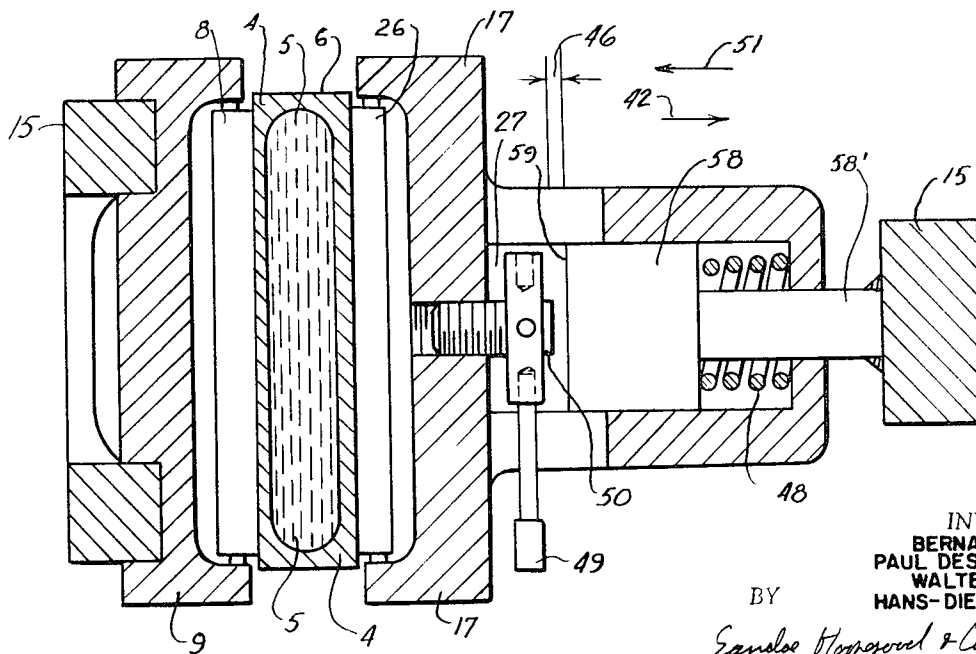


FIG.3



INVENTORS
BERNARD KNELL
PAUL DESFOSSEZ
WALTER HESS
HANS-DIETER SCHULZ

BY

Sandoe, Hopmann & Calimafale

ATTORNEYS

CONTINUOUS CASTING METHOD INCLUDING STRAND SUPPORT ADJUSTMENT

The present invention relates to the continuous casting of metal, particularly steel, and is an improved method for supporting and guiding a cast strand from the mold in a continuous casting machine.

In continuous casting, molten metal is poured into a cooled open-ended mold to form a cast strand which is withdrawn from the mold along a strand guide and further cooled. As the strand emerges from the mold it has a thin solidified shell around a still-molten core. The ferrostatic pressure of the still-molten core tends to bulge the shell, and to prevent cracks or breaks in the shell due to bulging the strand emerging from the mold is supported and guided by support elements such as rolls, cooling plates, or guide rails.

In one known arrangement the strand is supported and guided by rolls mounted in sections at two opposite sides of the strand. The rolls are movably mounted in the respective sections and pressed against the strand by springs. The range of movement of each section toward the strand is limited by nuts that are adjustably positioned for the desired thickness of the strand. The sections are flexibly braced against movement away from the strand by springs which thus counteract the bulging with increasing force as the springs are compressed. For a given ferrostatic pressure at any point on the strand, the outward pressure exerted on the springs by bulging varies in accordance with the thickness of the skin at that point, since the skin is a constricting force. Thus, if the skin is too thin—because of too high a casting rate, insufficient cooling or too high a steel temperature in the tundish, etc.—the outward pressure may be too great for the bulging to be effectively limited by the springs, with the result that the skin cracks. Another problem with the arrangement is that the positions of the sections toward the strand are set for the thickness of the strand emerging from the mold. Thus, when the strand shrinks as it moves along the strand guide and it becomes almost completely solidified, the rolls in the sections are no longer in contact with the strand. Since the rolls are then no longer rotated by the strand, they are apt to be damaged by the high radiant heat from the strand.

In another known arrangement, the strand is supported and guided by rigidly mounted guide rails or guide rolls at one side. The opposite side is supported and guided by guide rails or guide rolls mounted in sections which are movably mounted and connected to be moved by hydraulic means. The range of movement of the sections toward the strand is limited by adjustable stops. The sections are moved away from the strand due to bulging of the strand, against the pressure of the hydraulic means, which are comparable in operation to the springs of the other known arrangement described above. The stops for the sections are adjusted for a particular strand thickness and are only readjusted when the apparatus is altered to cast a strand having a different thickness. This latter arrangement also has the disadvantages that the bulging is not effectively limited in the portions of the strand where the skin is relatively thin, and that the rolls are out of contact with the portions of the strand which have shrunk due to the cooling and solidification so that the rolls not being rotated are apt to be damaged by the radiated heat from the strand.

These disadvantages are overcome by support and guide means in accordance with the present invention in which members or sections that have support elements, such as rollers, carried thereon to engage the strand, are arranged along one side of the strand and are movably supported to move a predetermined adjustable amount in the direction away from the strand, thereby to limit the bulging of the strand to an acceptable amount. The range of movement toward the strand is also stopped at a predetermined point selected so that the support elements can engage the dummy bar, which is temporarily inserted in the bottom end of the mold to plug the mold at the start of casting and which is normally thinner than the cast strand that follows it out of the mold.

The members or sections in accordance with this invention are adapted to be urged toward the strand for maintaining their support elements in contact with the strand, by gravity, and/or by hydraulic or spring means. Thus, the members or sections are adapted to keep the bulging within acceptable limits in the portion of the strand where the skin is relatively thin, and to maintain support rolls on the sections in rolling engagement with the strand at all points—especially where the strand is substantially completely solidified and has thus shrunk—so that the heat radiating to the rolls from the strand is sufficiently dissipated by rotation of rolls to avoid damage.

In continuous casting apparatus embodying the strand support and guide of this invention, the opposite side of the strand from the side engaged by the above-described members or sections is suitably supported and guided by rigidly mounted guide rails, guide plates or rolls. And this strand support and guide is adapted for supporting and guiding strands along a curved, vertical, or a horizontal path.

Further objects, advantages and features of the invention will be apparent from the following detailed description of illustrative embodiments shown in the accompanying drawings in which:

FIG. 1 is a schematically represented side elevational view of continuous casting apparatus embodying the invention;

FIG. 2 is a section on the line II—II of FIG. 1; and

FIG. 3 is a view similar to the view of FIG. 2, but showing alternative structure.

FIG. 1 of the drawings shows a curved installation for molding slabs wherein molten metal 1, such as steel, is poured from a tundish 2 into a cooled oscillating mold 3 having an open-ended mold cavity. At the start of casting the bottom end of the mold cavity is temporarily plugged by a dummy bar which—when the periphery of the first metal poured into the mold solidifies to form a shell—is drawn out of the mold cavity followed by the cast strand. To facilitate the introduction of the dummy bar into the mold cavity its cross section is smaller than the cross section of the mold cavity.

The cast strand 6 leaving the mold 3 has a solidified shell 4 and a still-molten core 5. It is withdrawn in a path defined by strand guides and is further cooled by devices (not shown), such as spray nozzles. The withdrawal is suitably accomplished by a combined withdrawal and straightening unit 7. As shown, the strand 6 follows a curved path to the unit 7 which straightens it horizontally. The molten core 5 of the strand may extend into the portion of the strand beyond the withdrawal and straightening unit 7, particularly at high casting rates.

On the outer face of its curvature the strand 6 is guided by rigidly mounted rolls 8. Instead of rolls, cooling plates may be used. In the model shown, the rolls 8 are, for manufacturing reasons, combined in units 9–14, which are mounted on a frame 15. In the horizontal region the lower face of the strand is guided by rigidly mounted lower support rolls 16. The side of the strand at the inside of its curvature, and its upward side along the horizontal portion is guided by rolls 26 which are crosswise to the longitudinal axis of the strand. The rolls 26 are mounted in members or sections 17–24 which are mounted for movement toward and away from the strand.

As shown in FIG. 2, each of the sections 17–24, illustrated by section 17, has a closed-end cylindrical bore 27 and a piston 58 slidable therein with a piston rod 58' extending out through the rear of the section and attached to the frame 15. Thus, the position of the piston 58 is fixed and the section 17 is movable relative to the piston, and the bore 27 and piston 58 are arranged to guide the movement of the section 17 respectively in opposite directions toward and away from the strand 6. The range of movement of the section 17 away from the strand, in the direction of arrow 42, is limited by the face 43 of a stop 44 engaged by the forward face 59 of the piston 58; the range of movement toward the strand, in the direction of arrow 51 is limited by a stop 52 at the rear of bore 27 engaged by the rearward end of piston 58. The position of the stop 52 is selected to enable the rolls 26 carried on the section 17 to

move far enough in the direction of arrow 51 to engage the surface of the dummy bar when the dummy bar, which is thinner than the strand being cast as already mentioned, is in the mold at the start of casting. The difference between the thickness of a dummy bar and the thickness 45 of a cast strand is illustrated by a dimension 55.

In FIG. 2 the section 17 is shown in an average position with its rolls 26 against the strand 6 (which is unbulged) and with its piston 58 spaced between the respective stops 44 and 52. The distance the section 17 is then free to move in the directions 42 and 51 away from and toward the strand 6, is indicated by dimensions 46 and 56, respectively, so that the total of dimensions 46 and 56 is the total range of movement of the section 17. The dimension 46 which is determined by the position of the face 43 of stop 44, which is adjusted by substituting a different stop 44, thus defines the limit of the bulging of the strand 6 that the section 17 will permit. And it will be apparent that the dimension 56 must be at least as great as the dimension 55 for the rolls 26 to engage the dummy bar at the start of casting.

In the embodiment illustrated in FIG. 2 the movement of the section toward or away from the strand 6, or a dummy bar may be externally controlled—for example, for facilitating insertion of a dummy bar into the mold cavity and then moving the rolls 26 into engagement with a dummy bar, or for adjusting the pressure of the rolls against a strand 6—by applying hydraulic pressure, or other fluid pressure, to one or the other of the cylinder zones 47 and 41 respectively at the front and back ends of the piston 58. For this purpose the section 17 is provided with an inlet tube 30 and outlet tube 31 connected into the forward cylinder zone 47 and an inlet tube 32 and an outlet tube 33 connected into the rearward cylinder zone 41.

The sections 17 are mounted so that gravity will normally urge them in the direction of the strand 6 to engage their rolls 26 with the strand. In operation the rolls 26 may be engaged with the strand by relying on gravity, or hydraulic pressure may be applied to the cylinder zone 47. As noted above, the range of movement of the rolls 26 in the direction away from the strand, when the strand bulges, is limited in accordance with the position of the face 43 of stop 44, which may be adjusted by substituting a different stop 44.

In the alternative embodiment illustrated in FIG. 3, instead of a replaceable stop 44, the range of movement of the section 17 in the direction away from the strand 6 in the direction 42 is limited and adjusted by means of a screw 50 threaded into the section 17 with a handle 49 for turning the screw relatively into or out from the back of the section. As shown, the movement of the section 17 in the direction 42 is stopped by the outward end of the screw 50 coming up against the forward face 59 of the piston 58. In this embodiment a spring 48 is arranged around the piston rod 58' for urging the section 17 away from the strand, in direction 42, but the spring tension is preferably selected so that the deadweight of the section 17 will cause the section to counteract the spring tension so that the rolls 26 rest on the strand with at least sufficient force for the rolls to be rotated by the movement of the strand.

In operation the distance 46, which is the permitted range of movement of the rolls 26 when the strand bulges, is set to restrict the bulging to an amount less than the amount at which the skin 4 might crack or break open. The range of permissible movement is therefore dependent upon the temperature of the skin, its thickness, the distance between the rolls 26 in the longitudinal direction of the strand, and the type of steel (or other metal) being cast. These factors in turn are dependent on, among others, the casting rate, the cooling intensity in the mold and along the path of the strand emerging from the mold, as well as the temperature of the steel (or other metal)

being cast.

For example, in casting a steel having the composition 0.10–0.20% C, 0.20–0.40% Si and 0.80–1.40% Mn in a slab shape strand 1,800×250 mm., in apparatus in which the distance between the rolls 26 was 75 mm. and in which the shell 4, at the portion of the strand emerging from the mold cavity, had a surface temperature of 1,400° C. and was 20 mm. thick, the distance 46 was set at 1 mm. which restrained the bulging a sufficient amount to avoid the occurrence of cracks or breaks in the shell. An increase of the shell thickness to 30 mm.—due to a lowering of the casting rate, for example—would enable the distance 46 to be increased to 1.5 mm. without danger, since the increase in shell thickness itself increases the resistance to cracking and breaking. Similarly, the distance 46 could be safely enlarged if the width of the supported shell surface or the distance between rolls 26 is reduced. Also, in the foregoing example if the shell temperature is 1,200° C. with a shell thickness of 50 mm., the other parameters being the same, the distance 46 could be increased to 2 mm. without risk of harmful effects.

In another example the casting of carbon steel in a slab shape strand 1,500×250 mm. was cast without harmful effects with a distance 46 of 1.5 mm. in each of the sections 17–24.

The distances 46 in the several sections 17–24 comprising the strand support may be the same in each section or they may be gradually increased in successive sections. For example, the bulging may be kept within safe limits by setting the distance 46 at the relatively small amount of 0.5 mm. in all the sections 17–24. The maintenance of such a relatively small distance 46 in all the sections, however, increases the production costs. Therefore, the distances 46 are advantageously increased in the sections further from the mold where the harmful effects of bulging are progressively less as the skin thickens and as the temperature of the skin lowers.

As mentioned above, the rolls 26 of the several sections 17–24 are in rolling contact with the strand 6, either by gravity or by fluid pressure applied in the cylinder zone 47. Of course, spring means (not shown) or other resilient pressure means could also be used instead of said fluid pressure to accomplish the same purpose.

What is claimed is:

1. A continuous coating method comprising the steps of (a) forming a continuously cast metal strand having a still-molten core within a solidified shell of predetermined controlled thickness, (b) supporting and guiding said strand by means including rigidly mounted support elements which extend along one side of the strand, and adjustable support elements which extend along the opposite side of the strand, said adjustable support elements being mounted at successive positions along the strand for movement toward and away from the strand during the casting operation, said adjustable support elements each being provided with an adjustable stop which is adjustable separately to permit separate movement during the casting period of each of said adjustable support elements over a predetermined distance in the direction away from the strand which is limited by the position of its stop, (c) adjusting said stops separately so that said predetermined distances are in accordance with changes in said predetermined controlled shell thickness, and (d) adjusting said stops separately so that said predetermined distances are less adjacent the portions of the strand at which the shell is relatively thin and are greater adjacent the portions at which the shell is relatively thicker.

2. The method of claim 1 in which said distances are about 0.5 mm. adjacent to the portions of the strand having a relatively thin shell and are from about 1.5 mm. to about 2 mm. adjacent to portions at which the shell is thicker.

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