United States Patent [19]
Meier et al.

[11] **3,926,244**
[45] **Dec. 16, 1975**

[54] **METHOD OF CONTROLLING THE COOLING RATE OF NARROW SIDE WALLS OF PLATE MOLDS AS A FUNCTION OF THE CASTING TAPER DURING CONTINUOUS CASTING**

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[22] Filed: **Mar. 25, 1974**

[21] Appl. No.: **454,682**

[30] **Foreign Application Priority Data**

Mar. 30, 1973 Switzerland 4599/73

[52] **U.S. Cl.** **164/4;** 164/82
[51] **Int. Cl.**^{2} **B22D 11/02**
[58] **Field of Search** .... 164/4, 82, 154, 273 R

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[57] **ABSTRACT**

A method of controlling the cooling rate of narrow side walls of plate molds during continuous casting, wherein the narrow side walls are fixedly clamped between the wide side walls, prior to start of the casting the hollow casting compartment between the narrow side walls is provided with a casting taper which converges in the direction of travel of the cast strand or casting and which is accommodated to the quality of the steel and the width of the strand. Prior to the start of the casting operation the casting taper is additionally adjusted to a reference value which corresponds to the contemplated casting speed and/or casting temperature, and upon deviation of the casting speed and/or casting temperature during the casting operation the casting taper is changed in accordance with reference values corresponding to such fluctuating or changing casting parameters.

15 Claims, 6 Drawing Figures

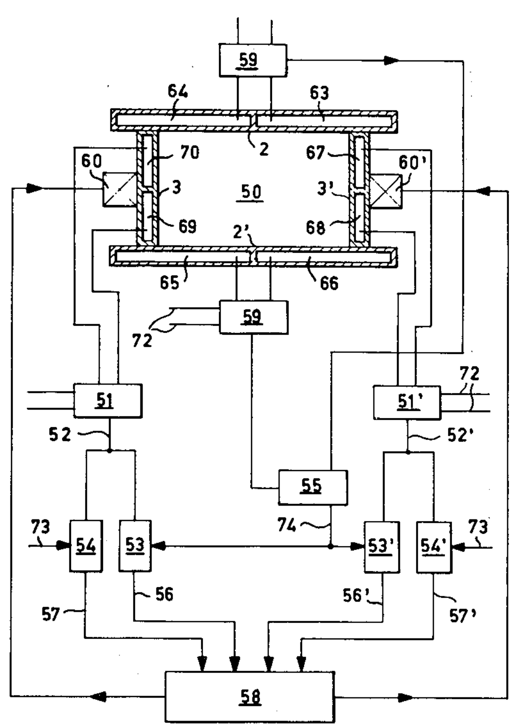
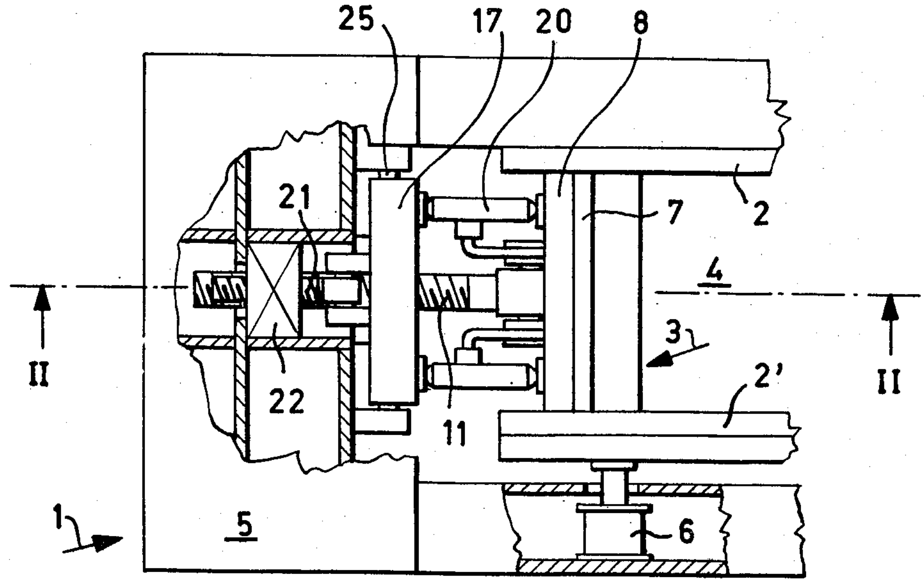


Fig.1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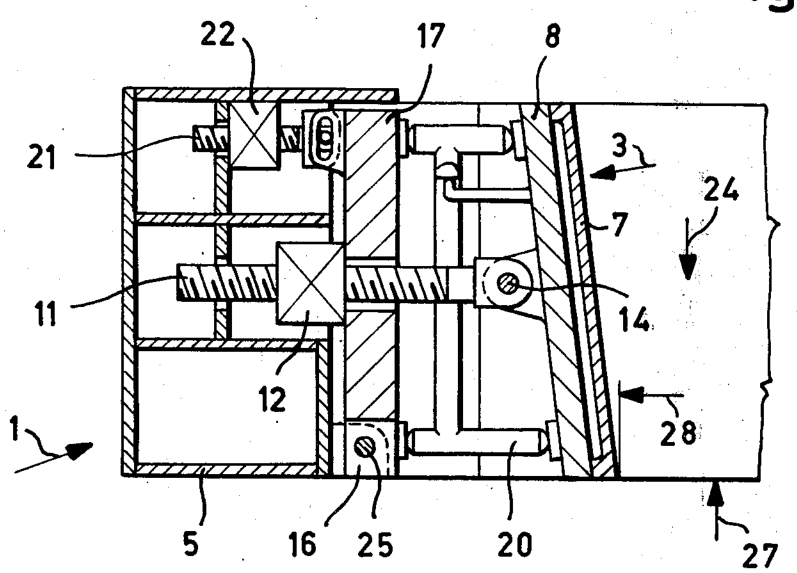
8
21
7
2
4
II
II
3
22
2'
11
1
5
6

Fig.2


22
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3
24
7
11
14
12
28
1
5
16
25
20
27

Fig. 3

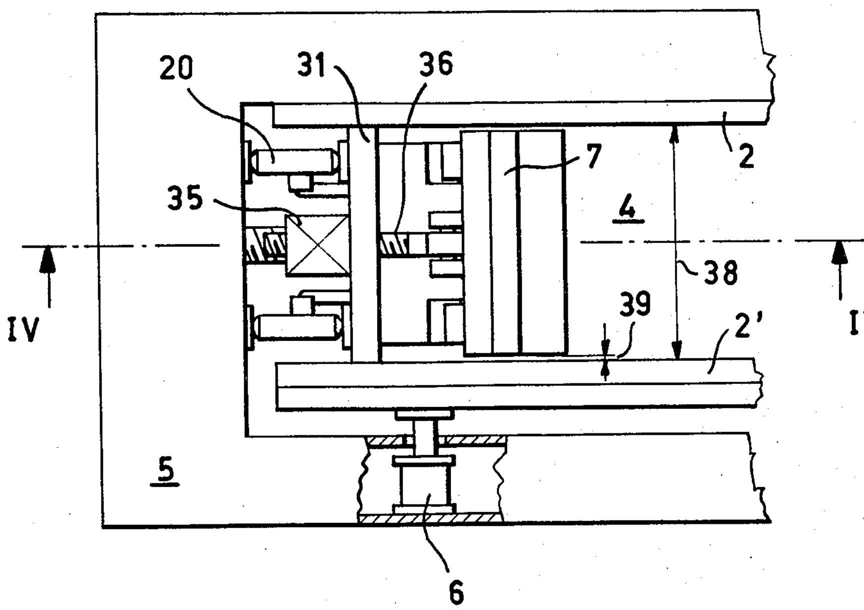


Fig. 4

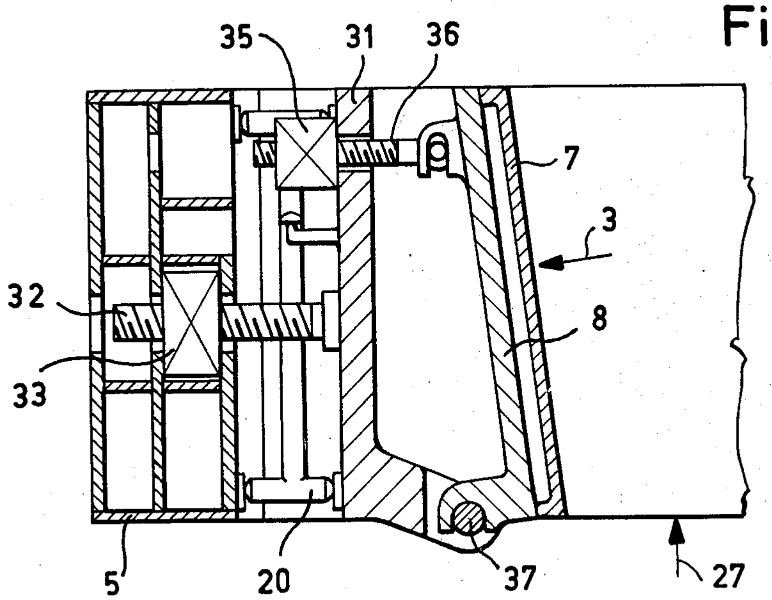


Fig. 5

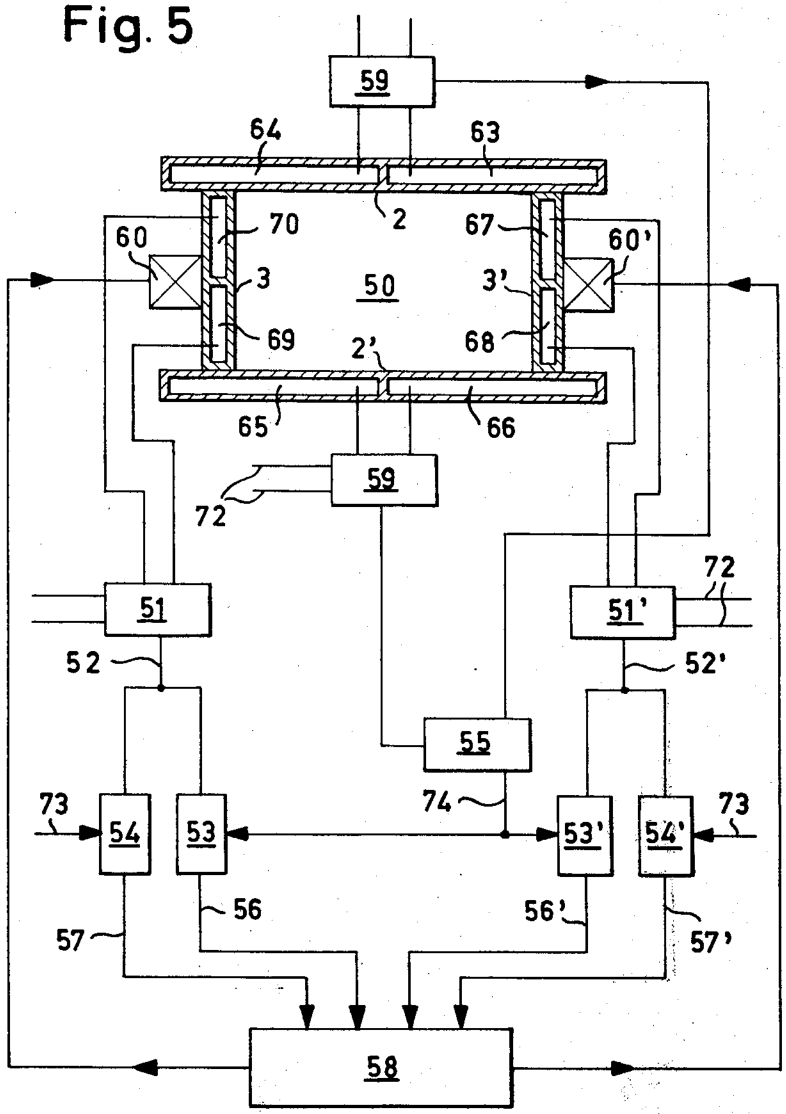
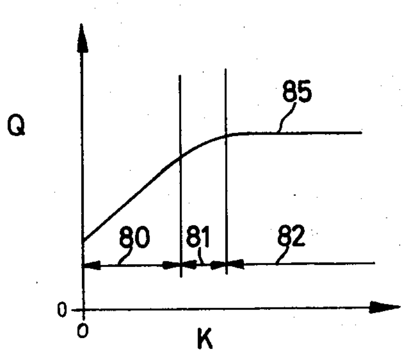

59
64
63
2
70
67
60
60'
3
50
3'
69
68
2'
65
66
59
72
72
51
51'
52
52'
55
73
74
73
54
53
53'
54'
56
56'
57
57'
58

Fig. 6


Q
85
80
81
82
0
0
K

METHOD OF CONTROLLING THE COOLING RATE OF NARROW SIDE WALLS OF PLATE MOLDS AS A FUNCTION OF THE CASTING TAPER DURING CONTINUOUS CASTING

BACKGROUND OF THE INVENTION

The present invention relates to a new and improved method of controlling the cooling rate of narrow side walls of plate molds during continuous casting, wherein the narrow side walls are fixedly clamped between wide side walls of the mold, prior to the start of the casting operation the hollow mold compartment between the narrow side walls is provided with a casting taper which converges in the direction of travel of the strand and which is accommodated to the quality of the cast metal, typically steel, and the width of the strand, and furthermore, the invention also pertains to a new and improved apparatus for the performance of the aforesaid method.

During the continuous casting of steel there is strived for as uniform as possible withdrawal of heat at all sides of the cast strand within the mold, in order that the strand, upon departure from the mold, possesses at all sides as uniform as possible thickness of the strand shell or skin.

Owing to differences in the contraction of the strand shell at the narrow and wide sides of the mold, governed by the shape or format of the casting or cast strand, it has been found during casting of slabs that the surface of the strand does not bear in the same manner against the narrow and wide side walls of the mold. Additionally, contact of the solidified shell of the strand against the walls of the mold can be influenced by the phenomenon of the mold bulging or bowing-out, particularly the wide sides of the mold. It is conventional practice to provide the narrow sides of the hollow mold compartment with a casting taper which converges in the direction of the outlet end of the mold and to design the wide sides of the hollow mold compartment so as to be parallel or to possess a casting taper which differs in relation to the narrow sides of the mold.

Additionally, this particular field of technology is aware of an adjustable plate mold construction which, along with the adjustment of the narrow sides of the mold to different widths of the strand, simultaneously alters the casting taper of the hollow mold compartment between such walls according to a value of the contraction of the strand which is predetermined as a function of the width of the strand. The adjusted casting taper or cone, however, is only optimum for a small range of the casting speed and the casting temperature, i.e., contact of the solidified strand shell and thus the withdrawn quantity of heat is only optimum at such values. Upon changing the casting speed and/or the casting temperature the shrinkage or contraction also alters, and consequently, there results non-uniform cooling and solidification of the shell or skin of the strand. These irregularities lead to fissures and ruptures and increase the breakout danger and wear of the mold.

A further proposal which has been advanced in the art concerns a plate mold which is subdivided into two components transversely with regard to the direction of travel of the strand. The upper portion does not possess any casting taper and the walls of the lower portion are resiliently urged against the strand surface. Gaps are provided between the walls arranged at the lower portion which neighbor one another, rendering possible free movement of the walls without mutual hindrance. The resilient or spring force which acts against such walls must be capable, on the one hand, of withstanding the force generated by the ferrostatic pressure and, on the other hand, the resilient force must not deform the strand shell which is still thin. This prior art equipment is unsuitable for casting operations where there prevail fluctuating casting parameters, such as casting speed and casting temperature and the like, because the resilient or spring force is not adjustable to different thicknesses or different strengths of the shell. Moreover, walls which are pressed against one another by such springs tend to wear rapidly. Additionally, such narrow side walls of the mold cannot be fixedly clamped between the wide side walls of the mold, so that at the region of the level of the molten bath there is precluded the use of such equipment.

Apart from the foregoing proposals there is also known in the art an apparatus for adjusting the format or shape of a plate mold when the casting operation is not in progress, wherein initially the narrow side walls of the mold are shifted without changing the casting taper and fixed in position in accordance with the desired shape or format of the strand to be cast, and subsequently the casting taper is adjusted to the desired extent. With this apparatus there is not present during the casting operation uniform cooling of the cast strand with changing casting parameters.

SUMMARY OF THE INVENTION

Hence, it will be recognized that in this particular field of technology there is still need for a method of, and apparatus for, controlling the cooling capacity of narrow side walls of plate molds during continuous casting in a manner not associated with the aforementioned drawbacks and limitations of the prior art proposals. Consequently, it is a primary object of the present invention to provide an improved method of controlling the cooling capacity or efficiency of narrow side walls of plate molds during continuous casting in a manner fulfilling the need existing in the art.

Another and more specific object of the invention aims at providing an improved method of carrying out continuous casting operations while providing optimum and uniform cooling within the mold during changes in the casting parameters, in particular the casting speed and the casting temperature.

Another object of the invention is directed at rendering possible continuous casting operations, particularly at high output continuous casting installations, with large differences in the casting speed and while providing improved quality in the cast strand and reducing the danger of metal breakout.

Now in order to implement these and still further objects of the invention, which will become more readily apparent as the description proceeds, the method aspects of this development are manifested by the features that prior to the start of the casting operation the casting taper is additionally adjusted to a reference value corresponding to the prescribed casting speed and/or casting temperature, and upon deviation of the casting speed and/or the casting temperature during the casting operation the casting taper is altered in accordance with predetermined reference values which produce a desired or optimum cooling effect corresponding to such fluctuating casting parameters.

When using this technique it is possible to provide optimum cooling conditions at the plate molds at the narrow sides of the strand, even in the presence of markedly varying casting speeds, casting temperatures and so forth. Consequently, in the case of continuous casting installations for slabs operating at high casting speeds, for instance in the order of about 2 meters per minute, there is present the possibility, during the same pour, to also work at a casting speed range beneath 1 meter per minute with a predetermined cooling rate and to cast strands possessing optimum quality and without increased risk of breakout. There are many reasons for casting with different casting speeds at such installations. By way of example it is mentioned: slow start of the casting operation, disturbances in the flow of metal between the tundish and the mold or between the ladle and tundish respectively, accommodation of the casting time to the operating cycle of the converter, reduced casting speed at the end of the casting operation, and so forth.

The accommodation of the casting taper during or shortly after the change of the casting speed, the casting temperature or other casting parameters which influence solidification of the strand, can be carried out according to different techniques. Thus, it is possible, for instance, to determine an optimum reference value of the taper or conicalness between the narrow sides of the mold walls as a function of the casting speed and/or the casting temperature by empirical tests. Such optimum reference value, as a general rule, is strived for in respect of uniform solidification of the shell of the strand. The casting taper can be accommodated to predetermined reference values corresponding to the altered casting speed and/or the altered casting temperature. Reference values for the casting taper "K" in the continuous casting art are normally expressed in terms of percent per meter (% per m).

It is further possible to use a desired reference cooling rate of the narrow side walls as the basic value for the adjustment of the taper. Both the casting temperature as well as also the casting speed are casting parameters which influence the cooling rate of the mold walls. According to a further aspect of the invention, the cooling rate of the narrow side walls of the mold can be continuously measured, such measurement values compared with those reference cooling rate values corresponding to the actual-casting speed and/or the actual-casting temperature and upon deviation between the reference- and actual- cooling rate values adjusting the casting taper until reaching the reference cooling rate. The cooling rate of the narrow side walls of the mold, not only is influenced by the casting speed and the casting temperature, but also by the flow at the liquid casting head, the nature and quantity of the casting powder slag and by bending moments produced by virtue of irregular cooling of the strand.

A further advantageous method for accommodating the casting taper during change of a casting parameter influencing the cooling rate of the narrow side walls of the mold can be realized according to the invention if the specific cooling rate of the narrow- and the wide side walls are continuously measured, the measurement values of the narrow- and wide side walls mutually compared and the specific actual-cooling rate ratio between such walls discriminated with the predetermined specific reference-cooling rate ratio and upon deviation between the specific reference- and actual-cooling rate ratio accommodating the casting taper until reaching the specific reference-cooling rate ratio. According to this technique the withdrawal of heat at the strand and the growth of the strand shell is controlled as a function of the sum of the casting parameters which are responsible therefor. At the same time all casting parameters and also all uncontrollable influencing factors, such as expansion within the mold or the bending moments at the strand generated by the secondary cooling and so forth, are taken into account.

The reference taper, for given casting parameters, can be advantageously ascertained during the casting operation if the cooling rate of the narrow side walls of the mold is continuously measured, during change of the casting taper K there is differentiated the deviation of the cooling rate ΔQ ($Kcal/cm^2 \cdot sec$) according to the deviation of the taper ΔK (%/m) and the reference taper associated with the reference cooling rate value determined from the curve characteristic. As a general rule, the reference cooling rate value and the reference taper is located at the transition region between the ascending and horizontal branch of the function curve ($\Delta Q/\Delta K$).

In order that there can be minimally selected the force for adjusting the casting taper of the hollow mold compartment between the narrow side walls during a continuous pour or casting and in order to be able to produce slabs according to desired dimension for different casting speeds as well as ensuring that at the same time there is not necessary any adjustment of the strand guide assembly which immediately follows the mold, it is possible, according to a further feature of the invention, during accommodation or adjustment of the casting taper, to maintain the size of the hollow mold compartment, corresponding to the rated size of the strand, at the output of the mold between the narrow mold walls. In this regard, as a general rule, the mold is designed such that the pivotable connection associated with the plates for the adjustment of the taper is formed by a shaft extending parallel to the narrow side walls of the mold, and which shaft is located near to a plane formed by the outlet of the mold.

The force for adjusting the casting taper during the casting operation can be maintained relatively small and there can be avoided scratching of the copper plates of the wide side walls of the mold if, according to an additional facet of the invention, the force for fixedly clamping the narrow side walls during the adjustment operation is reduced to about twice the value of the counter-force which acts by virtue of the ferrostatic pressure and after the adjustment again increased to the value which prevailed prior to the adjustment.

Not only is the invention concerned with the aforementioned method aspects, but as already heretofore mentioned, also deals with a new and improved construction of apparatus for the performance thereof, and specifically a plate mold wherein the narrow side walls of the mold which can be fixedly clamped between the wide side walls of the mold are equipped with devices for adjusting the hollow mold compartment to different strand dimensions and with devices for adjusting the casting taper. Between the support or carrier frame and the narrow side walls of the mold there is arranged a plate which is pivotably connected, and that alternately the one of both adjustment devices is attached to the support frame and to the plate and the other of the adjustment devices is connected to the plate and the narrow side wall.

The clamping force of the wide side walls can remain unchanged during the accommodation of the casting taper to the different casting parameters and at the same time there can be avoided wear of the copper plates at the wide side walls of the mold if, according to a further aspect of the invention, the taper adjustment device is attached to the plate and at the narrow side wall and the apparatus for adjusting the hollow mold compartment to different strand dimensions is attached to the plate and at the carrier or support frame, wherein the plate connected by the shaft with the narrow side wall can be clamped between the wide side walls, and if the size of the plate which determines the width of the hollow mold compartment is greater up to two millimeters in relation to the narrow side wall.

A further advantageous mold construction of the invention is manifested by the features that the taper adjustment device is secured to the plate and at the carrier frame, the device for adjusting the hollow mold compartment to different strand dimensions is secured to the plate and to the narrow side wall, and that the plate together with the narrow side wall is pivotable about the shaft arranged at the carrier frame.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above, will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

FIG. 1 is a plan view, partially in section, of part of a plate mold designed according to the teachings of the present invention;

FIG. 2 is a cross-sectional view of the arrangement depicted in FIG. 1, taken substantially along the line II—II thereof;

FIG. 3 is a plan view of a further embodiment of a partially illustrated plate mold designed according to the invention;

FIG. 4 is a cross-sectional view of the arrangement depicted in FIG. 3, taken substantially along the line IV—IV thereof;

FIG. 5 is a schematic illustration of a plate mold equipped with a control device; and

FIG. 6 is a diagram portraying the cooling rate as a function of the casting taper.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Describing now the drawings, in FIGS. 1 and 2 reference character **1** designates a plate mold for the continuous casting of metals, typically steel. A stationary wide side wall **2** and a movable wide side wall **2'** of the mold as well as the narrow side walls **3** (only one of which is visible in FIG. 1) delimit a hollow mold compartment or cavity **4.** Each narrow side wall **3** of the mold consists of a copper plate **7** confronting the hollow mold compartment **4** and a support plate **8.** The walls **2, 2', 3** are supported at a support or carrier frame **5** which extends about the mold **1.** Owing to the action of the force generated by a pistoncylinder unit **6** the narrow side walls **3** of the mold **1** are fixedly clamped between the wide side walls **2, 2'** thereof.

In order to adjust the hollow mold compartment **4** to different strand dimensions there is secured to each narrow side wall **3** and to a plate **17** a device consisting of a spindle **11** and an adjustment drive or gearing **12** which cooperates with such spindle **11.** The spindle **11** is hingedly connected with the associated narrow side wall **3** by means of a bolt **14** or equivalent. The adjustment drive **12** is secured to the plate **17** which, in turn, is connected by means of a hinge or pivot means **16** with the carrier or support frame **5.** Between the pivotal plate **17** and the narrow side wall **3** there are suspended insertable format-dependent support gauges **20.**

Now in order to be able to adjust the casting taper or cone during casting a taper adjustment device is arranged at the plate **17** and at the carrier or support frame **5.** A spindle **21** cooperates with an adjustment drive or gearing **22** which is secured to the support frame **5.** During movement of the spindle **21,** the plate **17** together with the narrow side wall **3** is rocked about a shaft or axle **25** which extends transverse to the direction of travel **24** of the casting or strand and parallel to the narrow side walls **3.** The shaft **25** is arranged near the plane **27** formed by the outlet or discharge end of the mold **1,** and the adjustment drive or gearing **22,** viewed in the direction of travel **24** of the strand, is arranged in front of or forwardly of such shaft **25.** By virtue of this arrangement of the shaft **25** there can be achieved the beneficial result that, during adjustment of the casting taper during the casting operation by means of the adjustment drive **22,** there can be practically maintained the dimensions or size **28,** associated with the rated size or dimensions of the strand, of the hollow mold compartment **4** at the outlet end of the mold between the narrow sides or side walls **3.** The adjustment drives **12** and **22** are equipped, for instance, with not particularly illustrated electrical devices. Other adjustment devices, for instance hydraulic adjustment devices, could be equally used.

In FIGS. **3** and **4** there is illustrated a different solution. The construction of the mold with regard to the support or carrier frame **5,** the therein supported wide side walls **2, 2'** and the piston-cylinder unit **6** are the same as considered above with regard to the description of FIGS. **1** and **2.**

In order to adjust the hollow mold compartment **4** with regard to the width of the casting or strand there is connected, on the one hand, a spindle **32** with a plate **31** and, on the other hand, with the carrier or support frame **5.** This spindle **32** can be driven by means of an adjustment drive or gearing **33.** The adjustment drive **33** is secured to the support frame **5.** Between the plate **31** and the support frame **5** there are suspended the format-dependent adjustment- and support gauges **20.** An adjustment drive or gearing **35** is connected with the plate **31,** and which adjustment drive cooperates with a spindle **36** and serves for adjusting the taper of the hollow mold compartment **4** between the narrow side walls **3** of the mold. In so doing, the associated narrow side wall **3** is rocked or pivoted about a shaft or axle **37.** The center line of the shaft **37** is located at the mold outlet plane **27.** The shaft **37** hingedly connects the narrow side wall **3** with the plate **31** arranged between the narrow side wall **3** and the support frame **5.** The dimension **38** of the clamping wall **31** and which dimension determines the width of the hollow mold compartment is larger, in contrast to the narrow side wall **3,** by as much as up to two millimeters.

The clamping force generated by the piston-cylinder unit **6** is thus completely taken-up by the plate **31** in the cold condition of the mold. Due to heating of the copper plate **7** during the casting operation there is closed gap **39,** especially at the region of the molten metal bath, which is present in the cold state of the mold. In order to prevent penetration of steel spatters or the like into the gap **39** during the start of the casting operation, the joints can be covered by means of adhesive tapes or bands. With this solution rocking or pivoting of the narrow side walls **3** during the casting operation can be accomplished with slight force and without changing the contact force of the piston-cylinder units **6.**

Turning attention now to FIG. **5** reference numeral **50** designates a plate mold for slabs which, as already described, essentially comprises both of the wide side walls **2, 2'** and both of the narrow side walls **3, 3'**. The mold walls possess cooling chambers or compartments **63–70** which encompass given cooling regions. In order to simplify the showing of the drawings the cooling chambers have not been subdivided in the direction of travel of the strand. If desired the cooling rate can be differentially measured and evaluated by subdividing the cooling chambers transversely with respect to the direction of travel of the strand. Each cooling chamber **63–70** is equipped with water infeed- and outfeed lines or conduits **72.** Measuring elements **59** are connected with the water infeed- and outfeed lines **72** of the wide sides **2, 2'** of the mold for determining the quantity of withdrawn heat and the cooling rate. At each of the measuring elements **59** there is simultaneously formed an average or mean value of the cooling rate of the cooling chambers **63, 64,** and **65, 66** respectively, which are delivered to an average value forming device **55.** The cooling rate of both cooling chambers **67, 68** and **69, 70** of the narrow side walls **3, 3'** are measured at the measuring or measurement elements **51** and **51'** respectively, and delivered as average or mean values **52** and **52'** to the difference or differential value forming devices **53, 54** and **53', 54'** respectively. The differential value forming devices **53, 53'** furthermore have delivered thereto an output signal **74** emanating from the average or mean value forming device **55.** The differential value forming devices **53, 53'** generate differential value signals **56, 56'** respectively, which correspond to the difference between the cooling rate of the corresponding narrow sides and wide sides of the mold. These signals **56, 56'** are delivered to a computer **58.** The differential value forming devices **54, 54'** generate differential value signals **57, 57'** resulting from the actual-cooling rates of the narrow sides and a signal **73** for the predetermined reference-cooling rate of the narrow sides and which reference-cooling rate is correlated to or associated with the actual-casting speed and/or the actual-casting temperature. The computer **58** can selectively control mechanical adjustment or setting elements **60, 60'** for the adjustment of the taper of the narrow sides of the mold either as a function of the signals **56, 56'** or the signals **57, 57'**. If the adjustment elements **60, 60'** are controlled as a function of the signals **56, 56'**, then by changing the casting taper the cooling rate of the narrow side walls is continuously adjusted to a predetermined cooling rate ratio between the narrow and wide side walls of the mold. Consequently, there is attainable a uniform cooling rate ratio or relationship between the narrow- and wide sides of the mold. With this method it is possible that there prevails a differential value **57, 57'** in relation to a predetermined reference-cooling rate value of the narrow sides of the mold and which is accommodated to the casting speed, etc. If the adjustment elements **60, 60'** are controlled in accordance with the signals **57, 57'**, then independent of the cooling rate of the wide sides of the mold there is continuously measured the cooling rate of the narrow side walls of the mold and there is adjusted the casting taper in accordance with a predetermined reference-cooling rate value. The cooling surfaces of the narrow- and wide sides of the mold and which are associated with each format or shape are introduced into the computer **58,** so that the specific cooling rate can be continously calculated in Kcal per cm^2 sec.

The computer **58** can also control the mechanical adjustment elements **60** and **60'** in accordance with random combinable programs of both differential value signals **56, 57** and **56', 57'**.

The described apparatuses for the accommodation of the casting taper of the narrow side walls, during the casting operation, to different casting parameters functions as follows: With a high output continuous casting installation there should be cast, for instance, a sequence of a number of pours. The strand format or shape amounts to 2,000 × 250 mm, the reference-casting speed 2 m/min and the maximum strand casting speed 2.5 m/min. Prior to the start of casting there is adjusted to 0.9 percent per meter the casting taper, converging in the direction of casting, of the hollow mold compartment between the narrow side walls in accordance with the starting speed of 1 m/min, the strand width and the steel quality. The aforementioned casting taper "K" in percent per meter (% per m) is calculated according to the following equation:

$$\%\ K \text{ per m} = \frac{\Delta B}{Bu} \cdot \frac{100}{L}.$$

It is to be appreciated that the symbol ΔB constitutes the difference in millimeters of the upper and the lower width of the conical hollow mold compartment **4,** the symbol Bu the size in millimeters of the smaller width of the hollow mold compartment and the symbol L the height in meters of the hollow mold compartment **4.** After uncoupling the starter bar, during the continuous pour or casting the casting taper should be adjusted to a size which is associated with the reference strand casting speed of **2** meters/min. For this purpose, prior to the adjustment operation, the clamping force which acts upon the wide side wall **2'** is reduced to about twice the value of the counterforce which acts upon the wide side walls by means of the ferrostatic pressure. The taper of the narrow side walls is now simultaneously changed during the increase of the casting speed to 2 meters/min so as to have a casting taper or cone of 0.5 percent per meter. After such adjustment the clamping force is again increased to at least a five fold value of the counterforce acting upon the wide side walls of the mold.

When using a mold according to the showing of FIGS. **3** and **4** there is not necessary a reduction of the clamping force during the adjustment of the casting taper.

In the case of molds which are equipped with devices for measuring the cooling rate at the narrow side walls, after accommodation of the casting taper to the changed casting speed the actual-cooling rate value of both narrow sides can be compared with the reference cooling rate value which has been predetermined to the altered casting speed. If the actual and reference values do not coincide, then by means of the obtained error or deviation signal it is possible to adjust the casting taper at one or both narrow sides of the mold.

Further adjustments of the casting taper are for example necessary if for some reason, for instance owing to a leaky stopper, there must be cast during a certain time with the maximum casting speed of 2.5 m/min. Prior to termination of the casting operation the casting speed is reduced in stages or steps to about 0.8–1 m/min while accommodating the casting taper to a value of 0.8–0.9 % per meter.

If the casting taper is accommodated to a changed casting temperature, then such occurs in the same manner as for a change in the casting speed. A higher casting temperature delays the solidification of the strand shell in the mold similar to the situation where there is present a higher casting speed. The cooling rate of the narrow side walls is thus increased. The accommodation of the casting taper therefore requires, during increase of the casting temperature, a reduction in the taper and during reduction of the casting temperature an increase of the taper respectively.

The optimum casting taper or cone K (reference value) of the casting taper during the casting operation can be determined as a function of all of the effective casting parameters, such as casting speed, casting tmperature, strand format or shape, steel quality, nature of the casting powder slag and so forth, in the following manner: If at a graph, such as depicted in FIG. 6, there is plotted along the ordinate the cooling rate Q (Kcal/cm^2 . sec) and along the abscissa the taper K (in % per m), then at the region **80**, with increasing taper K, there increases the cooling rate curve **85** from a taper which equals null to the higher cooling rate values, and then at the region **81** transforms into an approximately horizontal curve. The optimum taper K (good cooling rate and relatively little wear) as a general rule is located at the transition curve at the region **81** from the ascending to the horizontal curve branch at the region or section **82**. The illustrated curve **85** is only valid for one example, because depending upon the nature of the mold and the casting parameters the illustrated curve can deviate. By differentiating the deviations ($\Delta Q/\Delta K$) there can be rapidly determined the sought for curve region during the casting operation. By means of a computer connected with the continuous casting installation it is possible to also automatically determine the optimum cooling rate as a function of the taper while taking into account all casting parameters which act upon or influence the cooling rate.

Of course, it is to be mentioned that the invention is in no way to be considered as limited to the exemplary embodiments and examples. The method of this invention cannot only be carried out with the described exemplary embodiments of apparatus but, it is for instance possible to use such method aspects also with molds which are not equipped with the described plates **17, 31.**

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

Accordingly, what is claimed is:

1. A method of controlling the cooling rate of the narrow side walls of a plate mold during continuous casting, said plate mold further possessing wide side walls, wherein the narrow side walls of the mold are fixedly clamped between the wide side walls of the mold, prior to the start of the casting operation the hollow mold compartment is provided between the narrow side walls with a casting taper which converges in the direction of travel of the cast strand and which is accommodated to the quality of the steel and the width of the strand, the improvement comprising the steps of prior to starting the casting operation additionally adjusting the casting taper to a reference value corresponding to at least one prescribed casting parameter, and upon deviation of the casting parameter during the casting operation altering the casting taper according to predetermined reference values which produce a desired cooling effect and corresponding to such changing casting parameter.

2. The method as defined in claim **1**, including the step of using as the casting parameter at least the casting speed.

3. The method as defined in claim **1**, including the step of using as the casting parameter at least the casting temperature.

4. The method as defined in claim **1**, including the step of using as the casting parameter both the casting speed and the casting temperature.

5. The method as defined in claim **1**, including the step of continuously measuring the cooling rate of the narrow side walls of the mold to obtain measurement values, comparing such measurement values with a reference cooling rate value corresponding to an actual casting parameter, and upon the presence of a deviation between the reference cooling rate value and the actual cooling rate value altering the casting taper until reaching the reference cooling rate value.

6. The method as defined in claim **5**, wherein said actual casting parameter constitutes at least the actual casting speed.

7. The method as defined in claim **5**, wherein said actual casting parameter constitutes at least the actual casting temperature.

8. The method as defined in claim **5**, wherein said actual casting parameter constitutes at least both the actual casting speed and the actual casting temperature.

9. The method as defined in claim **1**, including the step of continuously measuring the specific cooling rate of the narrow and wide side walls of the mold to obtain measurement values, comparing such measurement values regarding the narrow and wide side walls of the mold, discriminating the specific actual cooling rate ratio between such walls from a predetermined specific reference cooling rate ratio, and upon deviation between the specific reference cooling rate ratio and the actual cooling rate ratio altering the casting taper until reaching the specific reference cooling rate ratio.

10. The method as defined in claim **1**, including the step of continuously measuring the cooling rate of the narrow side walls of the mold, upon change of the casting taper differentiating the deviation of the cooling rate after the deviation of the casting taper and determining a reference taper which is associated with a reference cooling rate value from the characteristics of a function curve, wherein the cooling rate is plotted as a function of the casting taper.

11. The method as defined in claim **10**, including the step of selecting the reference cooling rate value and the reference taper at a transition region between an ascending and horizontal branch of said function curve.

12. The method as defined in claim **1**, including the step of maintaining the size of the hollow mold compartment at the outlet end of the mold between the narrow side walls of the mold during accommodation of the casting taper.

13. The method as defined in claim **1**, including the step of reducing the force required for fixedly clamping the narrow side walls of the mold during the adjustment of the casting taper to about twice the value of a counterforce which is effective owing to the ferrostatic pressure of the cast steel, and after such adjustment again increasing such clamping force to the value which prevailed prior to the adjustment.

14. The method as defined in claim **1**, wherein said predetermined reference values which produce a de-

sired cooling effect comprise selectively at least one of the following values: the casting taper in percent per meter or a specific cooling rate of the strand.

15. The method as defined in claim **1**, wherein said predetermined reference values which produce a desired cooling effect comprise the casting taper in percent per meter and a specific cooling rate of the strand.

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