Dec. 9, 1958 E. J. KAUFFMAN, SR 2,863,192

HOT TOP AND MOULD ASSEMBLY

Filed Dec. 30, 1954 2 Sheets-Sheet 1

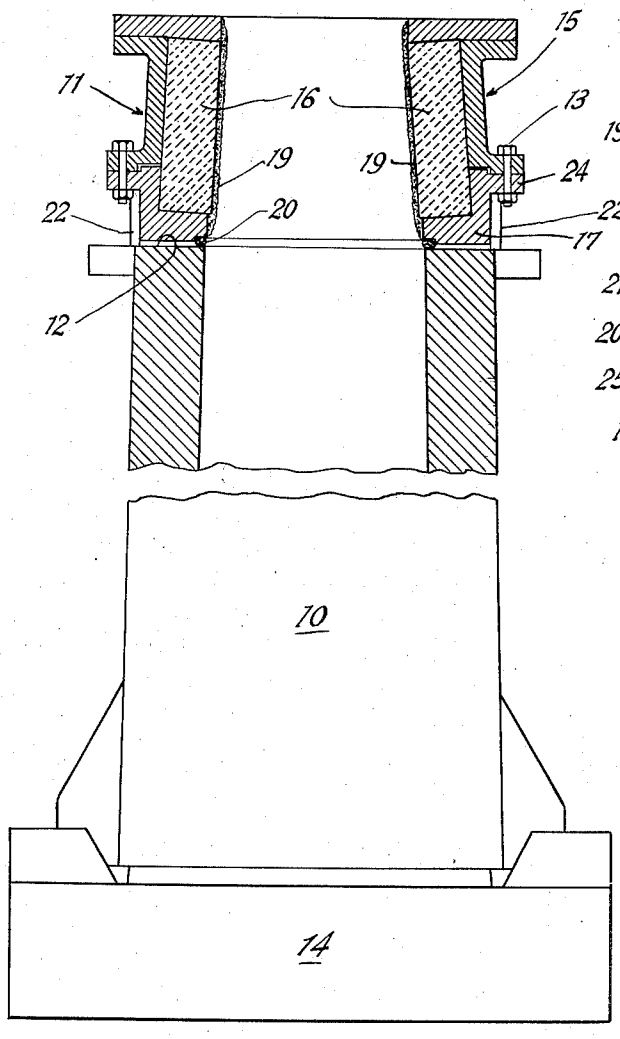

FIG. 1

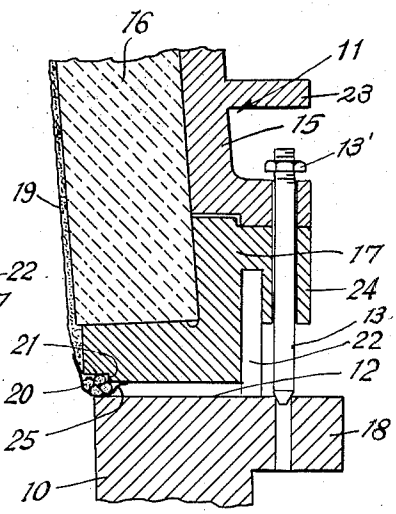

FIG. 2

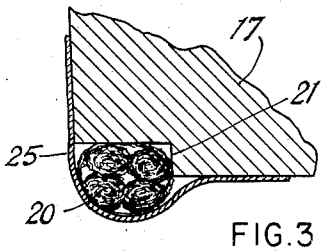

FIG. 3

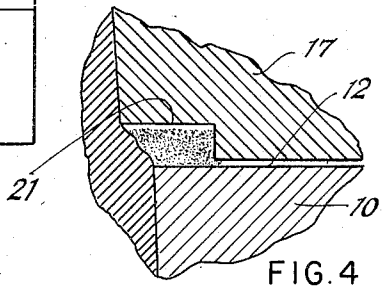

FIG. 4

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Dec. 9, 1958 E. J. KAUFFMAN, SR 2,863,192

HOT TOP AND MOULD ASSEMBLY

Filed Dec. 30, 1954 2 Sheets-Sheet 2

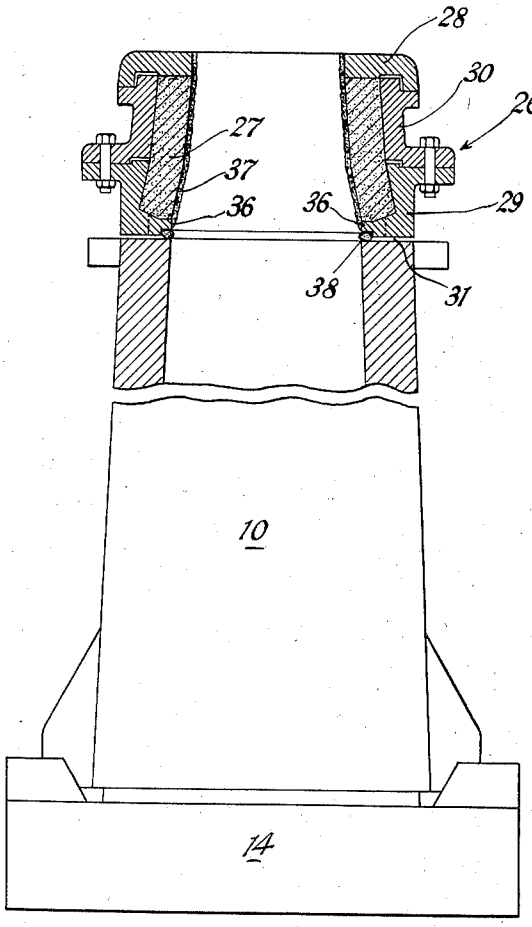

FIG.8

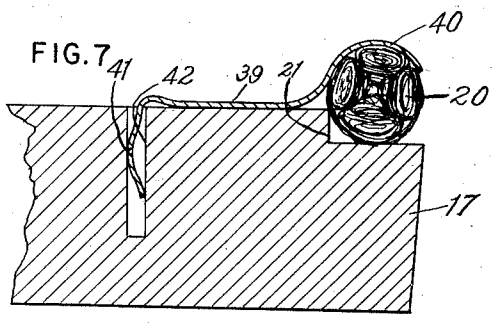

FIG.7

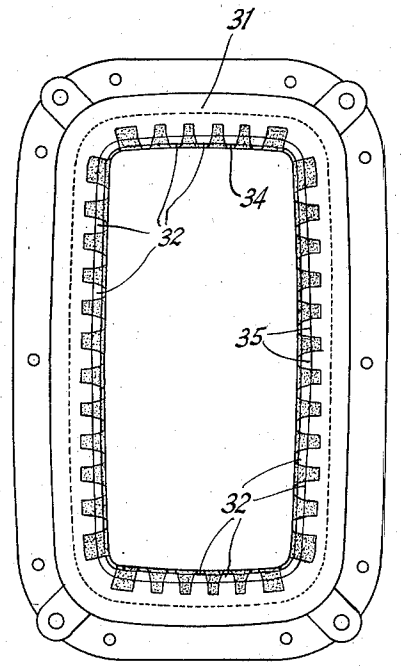

FIG.9

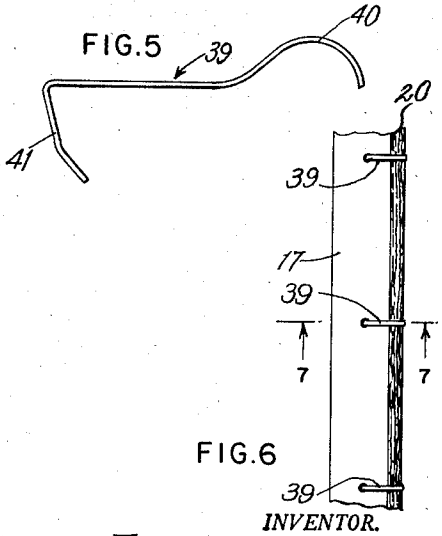

FIG.5

FIG.6

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2,863,192

HOT TOP AND MOULD ASSEMBLY

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Application December 30, 1954, Serial No. 478,848

13 Claims. (Cl. 22—147)

This invention relates to hot tops for ingot moulds. Hot tops are used in conjunction with ingot moulds for the production of certain types of high quality steel.

A hot top constitutes an upward extension of the mould cavity and is placed on top of the ingot mold before a steel ingot is poured, serving as a reservoir of molten metal to feed down into the ingot and prevent formation of "pipes" or voids in the ingot due to contraction as it solidifies and cools. The walls of the hot top are formed of refractory insulating material so as to avoid chilling and solidification of the metal within the hot top until after the metal within the mould itself has solidified.

The reuseable type of hot top is usually formed of a cast iron or cast steel body lined with refractory ceramic material. The body of the hot top is shaped to fit on the top edge of the mould as an upward continuation thereof, the hot top being somewhat tapered towards its upper end to facilitate the stripping of the hot top from the ingot.

Difficulty has been experienced in maintaining a tight seal between the base plate or bottom of the hot top and the top edge of the mould, so as to avoid metal flowing into any gap between the hot top and the mould and forming a projecting fin, which makes the ingot difficult to strip from the mould and may form a "lap" when the ingot is rolled, or cause the formation of transverse ingot cracks. This problem is more acute with some of the very fluid alloy steels such as certain of the silicon steels. Even when the confronting surfaces of the ingot mould and hot top are machined to an accurate finish, difficulty is still experienced due to warpage of the body of the hot top from the elevated temperature to which it is subjected in the pouring of ingots. The warpage appears to be due largely to the fact that the inner periphery of the base plate of the hot top, even when covered with a refractory slurry, is still subjected to a much higher temperature than the outer periphery of the base plate, and thus unequal growth of the metal of the inner periphery takes place, causing warpage and distortion of the base plate.

The present invention is directed to an improved hot top and assembly of mould and hot top, in which a ropelike, fibrous gasket extending along the inner periphery of the lower edge of the hot top seals the joint between the hot top and the mould despite warpage and surface irregularities. The ropelike gasket, which is compressed by the weight of the hot top, is preferably somewhat "combustible," first sealing the joint between the hot top and the mould until solidification of the steel in contact with the gasket has occurred, and then being more or less "burned away" or disintegrated at the continued elevated temperature occasioned by the molten metal, so as to permit the hot top to move downwardly slightly towards the mould as the ingot continues to solidify and cool. This slight downward movement of the hot top aids in reducing stressing of the skin of the ingot as it cools and prevents or reduces formation of transverse "hanger

cracks" caused by rupture of the newly formed ingot skin before the interior of the ingot has solidified.

A principal object of the present invention is to provide an improved hot top and mould assembly in which leakage of even the more molten steels between the hot top and mould is prevented and which provides for automatic descent of the hot top as the poured ingot shrinks. Another object is to provide an improved hot top specially formed for receiving a localized gasket for sealing between the hot top and the mould. A still further object of the invention is to provide an improved hot top construction in which warpage of the base plate is held to a minimum. Other objects and the nature and scope of the invention will be more apparent from the detailed description, read in conjunction with the drawings, in which:

Fig. 1 is a view, partly in elevation and partly in vertical section, of a mould, mould stool and hot top acocrding to one form of the present invention.

Fig. 2 is an enlarged, fragmentary vertical section of adjacent portions of the mould and hot top before the ingot is poured.

Fig. 3 is a somewhat diagrammatic, enlarged, fragmentary vertical section of the hot top illustrating how the gasket is held in place on the hot top prior to assembly of the hot top with the mould.

Fig. 4 is an enlarged, fragmentary vertical section of adjacent portions of the mould, hot top and ingot of Fig. 1 after pouring of the ingot.

Fig. 5 is an elevation of a spring clip which may be used for holding the hot top gasket in position.

Fig. 6 is a fragmentary bottom plan view of the peripheral portion of the hot top of Fig. 1, showing the use of spring clips for holding the gasket in position.

Fig. 7 is a fragmentary, vertical section taken along the line 7, 7 of Fig. 6.

Fig. 8 is a view similar to Fig. 1, showing a second form of hot top in accordance with the present invention.

Fig. 9 is a bottom plan view of the second form of the hot top.

Referring now to Fig. 1, the ingot mould assembly of the present invention includes a mould **10** and a superimposed hot top **11**. The mould, which preferably is formed of cast direct blast furnace metal, has suitably heavy wall sections and a top edge **12** which may or may not be machined although it must be fairly smooth. The mould may be either circular, square or rectangular in cross sections according to the shape of the ingot which it is desired to cast. Generally speaking, the hot top **11** conforms in cross section to the mould. Due to their shape, hot tops are more subject to warpage if rectangular and, therefore, the present invention has its greatest utility when rectangular hot tops are required.

The mould **10** is supported during teeming of the ingot by a stool **14**, generally indicated in the drawings, which supports the mould and may form the bottom of the mould cavity.

The hot top **11** of the present invention consists of a cast iron or steel shell **15** which is lined with preformed blocks of refractory ceramic material **16**, such as firebrick or a rammed ceramic refractory which is cast or rammed in place within the shell of the hot top. The lining **16** of ceramic material provides good heat insulation so so that in pouring the ingot, the steel within the hot top **11** is maintained liquid until solidification of the ingot within the mould itself is complete. The molten metal within the hot top serves as a reservoir to supply molten metal to that portion of the ingot below the hot top and thereby fill the voids caused by contraction of the metal upon cooling, so as to avoid a

"pipe" extending downwardly within that portion of the ingot received within the mould.

The hot top **11** is maintained centered on the mould **10** by a series of two or more downwardly projecting guide pins **13** (one shown) which are about ⅛" smaller in diameter than the hole provided for the pin in the peripheral two part lug **24**. Preferably, the pin **13** has a threaded upper end receiving a nut **13'**, and the lower end of the pin **13** is conical or otherwise tapered. A lug **23** on the hot top shell **15**, a short distance above the pin **13**, prevents the pin from falling out if the hot top is inverted.

When the hot top **11** is applied to the mould **10**, the tapered lower end of the pin **13** is received within a vertical bore in a projecting lug **18** of the mould. Since the bore within the lug **18** is of somewhat smaller diameter than the pin **13**, the pin will enter the lug **18** for only a portion of the length of its tapered lower end, the difference in diameter between the pin and the hole within the lug **24** providing for minor misalignment of the parts.

Since the guide pins **13** are a loose fit within the lugs **24**, and since the pins do not extend a substantial distance into the hole in the lug **18** of the mould, the guide pins will be free to move upwardly and will have little tendency to jam. Therefore, after the blocks **22** (referred to later), if any, are removed, or after the gasket **20** has burned away, the hot top **11** will be free to move downwardly towards the mould **10** as the ingot cools, the guide pins **13** merely rising (in effect) somewhat within the lugs **24**.

The shell **15** of the hot top includes a base plate **17** which serves to retain the lower portion of the refractory lining material **16** and to form a durable lower edge for the hot top that will not have a tendency to crack or spall. It is imperative that there be a tight joint between the base plate **17** of the hot top and the top edge **12** of the mould so that, upon pouring the ingot, the molten metal will not flow into any gaps between the mould and the hot top and form fins which make stripping of the ingot from the mould and hot top difficult and which would also, if not removed, form laps upon rolling the ingot, thus breaking the homogeneity of the metal and forming seams in the billet after rolling. This problem of a seal between the mould and the hot top is particularly acute with hot tops of the reuseable type, inasmuch as during the pouring of the ingot, the inner surface of the hot top is subjected to a much higher temperature than the outside surface of the hot top. This is particularly true of the base plate **17** which extends inwardly and is protected from direct contact with the molten steel of the ingot by only a relatively thin layer of refractory slurry **19** which is painted on the inner surface of the hot top before each pouring to protect the refractory lining **16** and fill small voids and imperfections on the inner surface of the hot top. In addition, the cast iron or steel from which the base plate **17** is formed actually tends to grow or increase in dimension under elevated temperatures. When subjected to the temperature of the ingot, the inner periphery of the base plate **17** actually increases slightly in length after repeated use of the hot top, while the outer periphery is not subjected to as high temperatures and consequently does not grow to the same extent as the inner periphery.

The result is that, even if the underside of the base plate **17** is initially machined to an accurate and smooth flat surface so as to make a tight seal with the top surface of the mould **10**, the base plate **17** will soon warp upon use so as to fail to maintain a tight seal between the hot top and the mould. The mould **10**, which is of much heavier section than the hot top **11**, is not warped by the heat of the pour. As previously mentioned, the problem of warpage of the base plate **17** of the hot top is much more acute with rectangular moulds than with circular or square moulds.

A compressible, porous, ropelike, fibrous gasket **20** is provided to seal the joint between the top edge **12** of the mould and the base plate **17** of the hot top, the gasket extending along the inner periphery of the lower edge of the hot top. Preferably, the gasket **20** is received within a rabbet **21** formed along the inner periphery of the lower edge of the base plate **17**. The gasket **20**, which preferably is about three-quarters of an inch to an inch in diameter, is compressed by the weight of the hot top so as to form a tight seal between the hot top and mould to prevent the molten metal flowing ino the joint between the mould and the hot top. Ordinary hot tops weigh from 500 to 20,000 pounds depending upon the size of the mould, 2500 pounds being an average weight for a hot top of the superimposed type. It has been found that the weight of the hot top alone will compress the gasket sufficiently to form a seal, even though the upper edge **12** of the mould and the confronting surface of the hot top have not been machined to true planar surfaces and even though warpage of the base plate **17** of the hot top has occurred.

If desired, a series of three or more hard wood spacer blocks **22** may be used to limit compression of the gasket **20** by weight of the hot top **11**, the compression of the gasket permitted by the blocks being only sufficient to seal between the hot top and mould. The spacer blocks are positioned between a peripheral flange **24** on the hot top supporting the guide pins **13** and the lugs **18** projecting from the mould.

The gasket **20** must, in its compressed state, be sufficiently resistant to the heat of the molten steel to maintain the seal between the hot top and the mould sufficiently long for the metal against the gasket to solidify, so as to prevent molten metal from flowing into the joint between the mould and hot top and forming fins. At the same time, the gasket **20** must be sufficiently compressed by the weight of the hot top alone to form a seal despite surface irragularities of the mould and hot top and warpage of the hot top. In addition, the gasket **20** must be sufficiently porous to pass gases released from the molten steel upon solidifying and to release gases formed by "burning" or disintegration of the gasket itself, so as to avoid forcing these gases upwardly through the molten metal within the hot top and causing "blow off" or "blow back" explosions or reactions in which the molten metal in extreme cases may actually be spattered from the hot top.

It has been found that braided rope or yarn formed of 80 percent asbestos and 20 percent cotton, and twisted or braided cotton rope formed entirely of cotton fibers, preferably impregnated with a fireproofing reagent such as ammonium phosphate to increase its fire resistance, make satisfactory gasket material. Four strand conventional twisted cotton rope of three-quarters of an inch to an inch diameter has proven particularly satisfactory from the standpoints of both service and cost.

It has been found that both the asbestos-cotton gasket and the treated cotton rope gasket are sufficiently porous to pass gases liberated by the molten steel as well as gases formed by combustion of the gasket itself, these gases being passed outwardly between the hot top and the mould. The gasket **20**, when made of either of these materials and when compressed by the weight of the hot top **11**, is sufficiently refractory to contain the molten steel until a skin has formed against the gasket. However, the continued elevated temperature conditions to which the gasket is exposed during solidification of the ingot cause the gasket to be largely burned away, leaving only a crumbly ash. "Burning away" of the gasket **20**, i. e., disintegration that takes place in material in the gasket under the influence of the heat of the poured ingot, permits the hot top **11** to move towards the mould slightly, more or less closing the gap between the top edge **12** of

the mould and the base plate 17 of the hot top. This is a distinct advantage in producing sound ingots in that, shortly after pouring the ingot, a thin skin of solidified metal forms against the mould and against the hot top, the interior portion of the ingot being still molten. As the ingot continues to cool, the skin contracts somewhat and in places pulls away from the surface of the mould and of the hot top. However, if the skin is substantially stressed by binding against the matrix surfaces of the mould and hot top as it contracts, the skin is apt to be ruptured, forming so-called "hanger cracks." The disintegration which takes place in the gasket 20 under the influence of the heat of the poured ingot saps the hot-top-supporting strength of the gasket, thereby permitting the ingot as it solidifies to draw the hot top 11 down slightly towards the mould 10, and thus lessening stressing of the ingot and aiding in preventing hanger cracks.

The spacer blocks 22, which are inserted at the time the hot top is placed on the mould 10, are left in position until about five minutes after the ingot is poured, at which time the outer skin of the ingot has hardened. The blocks 22 are then knocked out so as to permit the hot top 11, when the gasket 20 burns away, to move downwardly towards the mould 10 with the skin of the ingot as it contracts in cooling.

As above mentioned, it is customary to coat the inner or matrix surface of the hot top 11 with a layer of refractory slurry 19 which may be one-sixteenth inch to one-quarter inch in thickness. The slurry, which is a mixture of ground-up clay or fire brick, a binder and water, is ordinarily painted on with a brush when preparing the hot tops for pouring a new heat of steel. The slurry is applied to the hot top 11 before the hot top is placed on the mould 10. After the slurry is applied, the hot top is heated somewhat to dry the slurry and set the binder. The coating of slurry ordinarily is brought downward to cover the inner periphery of the base plate 17 of the hot top to aid in protecting the base plate against the direct heat of the molten metal.

After the layer of refractory slurry 19 is applied to the hot top and baked, the gasket 20 is placed within the rabbet 21. The gasket, which extends along the rabbet 21, is cut to the correct length and the ends butted together to form a continuous seal when the hot top 11 is superimposed on the ingot 10. However, during handling of the hot top 11 and before it is placed on the mould 10, it is necessary to hold the gasket in position. Holding the gasket 20 within the rabbet of the hot top 11 is complicated somewhat due to the fact that the hot top may still be at a temperature of 300° F. or more, and there is apt to be some slurry within the rabbet 21 as well as along the inner periphery of the base plate 17. I have found that the gasket 20 may be secured within the rabbet 21 by pressure-sensitive industrial tape 25, such as glass cloth silicone coated tape No. X1001 P. S. L. No. 125079 L–5 of Minnesota Mining and Manufacturing Co. This tape is capable of adhering to the baked refractory slurry lining 19 and the bottom surface of the base plate 17, even under temperatures as high as 400° F. The gasket is secured by placing short strips of industrial tape 25 at right angles to the gasket, as indicated in Fig. 3. Instead of utilizing pressure-sensitive tape for securing the gasket 20 within the rabbet 21, a silicone adhesive such as Dow Corning Co. XC–269 may be brushed onto the rabbet of the base plate and the gasket 20 pressed into the rabbet, being retained by the adhesive. The gasket 20 may be applied to the base plate when it is at temperatures up to 480° F.

In addition, the gasket 20 may be retained within the rabbet 21 by mechanical means, such as the spring 39 of Fig. 5, which may be formed of round or flat wire. The spring 39 has an arcuate end portion 40 adapted to overlie the gasket 20 and hold it in the rabbet 21, and an angularly extending opposite end portion 41 for insertion within a small hole 42 in the underside of the base plate 17 of the hot top.

Referring to Figs. 5 and 7, the portion 41 of the spring 39 extends from the body of the spring at an angle slightly less than 90° so as to bias the intermediate portion of the spring against the hot top, and is given an intermediate bend so as to wedge the portion 41 within the hole 42 and hold the spring against displacement. As indicated in Fig. 6, the springs 39 are located at intervals along the inner periphery of the underside of the base plate 17 of the hot top.

In the second form of my invention, shown in Figs. 8 and 9, I have disclosed a hot top 26 which is provided with a rammed refractory lining 27. The hot top 26 serves a funtion similar to the hot top 11 previously described. The hot top 26 is formed of a cast iron or steel base 29, body 30 and a cover 28, the base, body and cover being secured together by bolts to form the hot top casing.

The undersurface 31 of the hot top base 29 is made up in part of a continuous surface and in part of series of spaced, inwardly projecting lugs or prickers 32, the undersurfaces of the prickers being flush with the smooth, planar surface 31 of the hot top base. The inwardly projecting ends of the prickers may be cut away at 34 to form a step or rabbet extending across the end of each pricker, the rabbets of the various prickers being aligned so as to form a continuous rabbet 35, extending about the inner periphery of the bottom of the hot top after the ceramic lining 27 is moulded flush with the surface established by the undersides and inwardly projecting ends of the prickers. The rabbet 35 is generally similar to the rabbet 21 previously described and serves a similar purpose.

The hot top casing 30 and cover 28 are likewise formed of cast iron or steel and are provided with the contours generally indicated in the drawing, the base, casing and cover together providing a continuous, upwardly tapering shell for receiving the rammed refractory. The hot top body may be provided with the usual trunnions (not shown) for rotatively supporting the hot top when it is not positioned on the ingot mould.

The rammed refractory 27 is moulded within the hot top 26 in the usual manner to completely line the inside of the hot top body with the exception of the inwardly projecting end surfaces 36 of the prickers 32. The inner surface of the rammed refractory is upwardly tapering and aligned with the end surfaces of the prickers 32, the refractory lining extending between the prickers 32 along the undersurface 31 of the base 29 and being struck along the line of the underside of the prickers. In this construction the prickers retain the rammed refractory within the hot top body and serve to reinforce the lower edge of the rammed refractory against breakage. The hot top 26 is then heated to dry and harden the refractory lining 27. The rammed refractory 27 is preferably of the type initially containing wood flour, the wood flour subsequently being burned out so as to provide a refractory that is highly porous and has good heat-insulating value, the refractory having considerable permeability in order to permit the passage of gases through the refractory, so as to aid in preventing "blow back."

The hot top 26 is used in exactly the same manner as the hot top 11 previously described. Before being used, it is likewise coated with a refractory slurry 37 to protect the rammed refractory 27 and inner ends 36 of the prickers 32 against the heat of the pour. After the refractory slurry lining is baked, the gasket 38, similar in all respects to the gasket 20, is positioned within the rabbet 35 formed in part by the surfaces 34 of the prickers and in part within the refractory lining 27, the gasket 38 also preferably being held within the rabbet by industrial tape, as previously described. The hot top 26 is then placed on a mould 10 in the same manner as the hot top 11 previously described, the gasket serving to form a tight seal between the undersurface of the hot top and the top surface of the mould. The hot top 26 may be retained in position on the mould 10 by a series of pins (not shown) having a tapered lower

end and similar to the pins 34 previously described in connection with the hot top 11.

The hot top 26 utilizing a rammed refractory lining does not require the preformed, specially cut refractory lining blocks of the hot top 11. In addition, since the inner peripheral zone of the base 29 is formed in part of the projections or prickers 32 and in part of the refractory ceramic lining 27, warpage of the base is minimized due to the fact that (1) the ceramic has no tendency to grow as does the cast iron, (2) the ceramic has a lower coefficient of expansion than cast iron, and (3) expansion of the prickers compresses the ceramic slightly instead of causing distortion of the base.

I claim:

1. In a superimposed-type hot top for ingot moulds, in which the hot top has a hollow metal shell provided at the bottom with an inwardly-extending annular flange, the shell being lined with refractory above the flange; the improvement which comprises: an annular rabbet at the inner lower corner of the inwardly-extending flange, and an annular gasket positioned in the rabbet and composed at least in part of material which disintegrates when subjected to the heat of the poured ingot, the gasket extending below the bottom surface of the flange and initially having sufficient compressive strength to support the hot top on an ingot mould with the bottom surface of said flange in spaced relation to the mould, and the durability of the gasket under the influence of the heat of the poured ingot being coordinated with the rate of skin formation on the ingot whereby, upon formation of the skin on the ingot, the heat of the ingot saps the hot-top-supporting strength of the gasket, thereby allowing the hot top to descend towards the mould as the ingot solidifies.

2. A hot top as in claim 1 in which the metal shell is provided with captive slidable guide pins which engage holes in the top of the ingot mould and align the hot top with the mould cavity and maintain the alignment during descent of the hot top.

3. A hot top as in claim 1 in which the inner portion of the inwardly-extending annular flange is provided at intervals with transverse slots, and the lining of the shell is a rammed refractory lining which extends into and fills the slots.

4. A hot top as in claim 1 in which the gasket is ropelike and means are provided to positively hold the gasket in the rabbet.

5. A hot top as in claim 1 in which the gasket is ropelike and is made of asbestos and cotton.

6. A hot top as in claim 5 in which the gasket is impregnated with a fire retardant.

7. A hot top as in claim 1 in which the gasket is a cotton rope.

8. A hot top as in claim 7 in which the cotton rope is impregnated with a fire retardant.

9. In an assembly of ingot mould and hot top, the ingot mould having a generally flat top surface and the hot top being of the superimposed type as distinguished from the inserted type in which a portion of the hot top nests within the mould cavity, the improvement which comprises: the bottom of the hot top being in spaced relation to the top of the mould and being free to move towards the top of the mould; and an annular gasket in a localized zone adjacent to the mould cavity and composed at least in part of material which disintegrates when subjected to the heat of the poured ingot, the gasket initially having sufficient compressive strength to support the hot top in its spaced relation to the mould, and the durability of the gasket under the influence of the heat of the poured ingot being coordinated with the rate of skin formation on the ingot whereby, upon formation of the skin on the ingot, the heat of the ingot saps the hot-top-supporting strength of the gasket, thereby allowing the hot top to descend towards the mould as the ingot solidifies.

10. The improvement as in claim 9 in which there is means to maintain the alignment of the hot top with the mould cavity during the descent of the hot top.

11. The improvement as in claim 9 in which the gasket is impregnated with a fire retardant.

12. The improvement as in claim 9 in which the gasket is made of asbestos and cotton.

13. The improvement as in claim 9 in which the gasket is made of cotton.

References Cited in the file of this patent

UNITED STATES PATENTS

1,398,874	McNally et al.	Nov. 29, 1921
1,665,515	Trembour	Apr. 10, 1928
1,668,567	Messler	May 8, 1928
1,689,174	Perry	Oct. 23, 1928
1,893,207	Messler et al.	Jan. 3, 1933
2,668,336	Jones	Feb. 9, 1954

FOREIGN PATENTS

228,016	Great Britain	Jan. 29, 1925
550,295	Great Britain	Jan. 1, 1943

OTHER REFERENCES

The Ingot Phase of Steel Production, Emil Gathmann, 1942, pages 102 and 106 pertinent.