

May 8, 1956

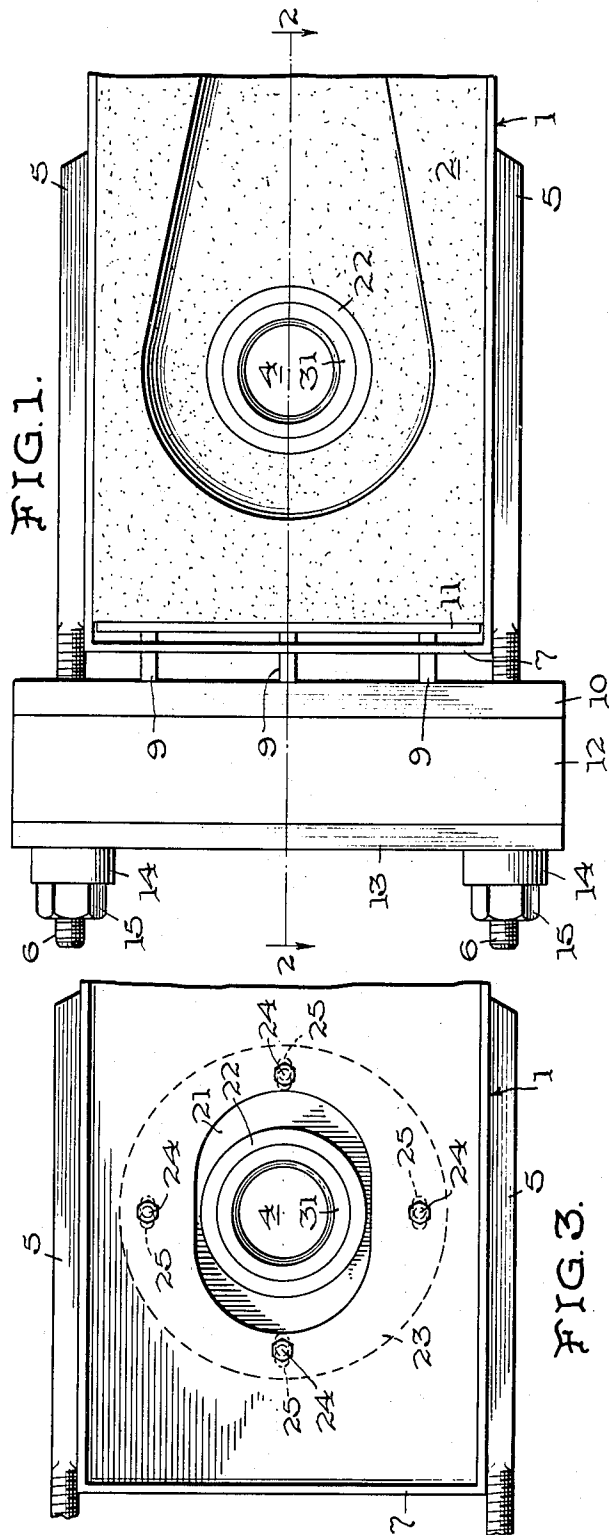
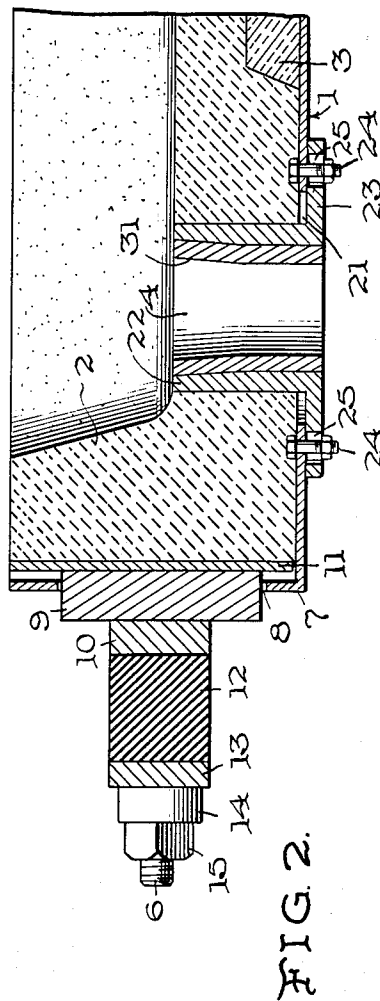
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2,744,303

TROUGH FOR TRANSFERRING MOLTEN METAL

Filed July 29, 1954

3 Sheets-Sheet 1



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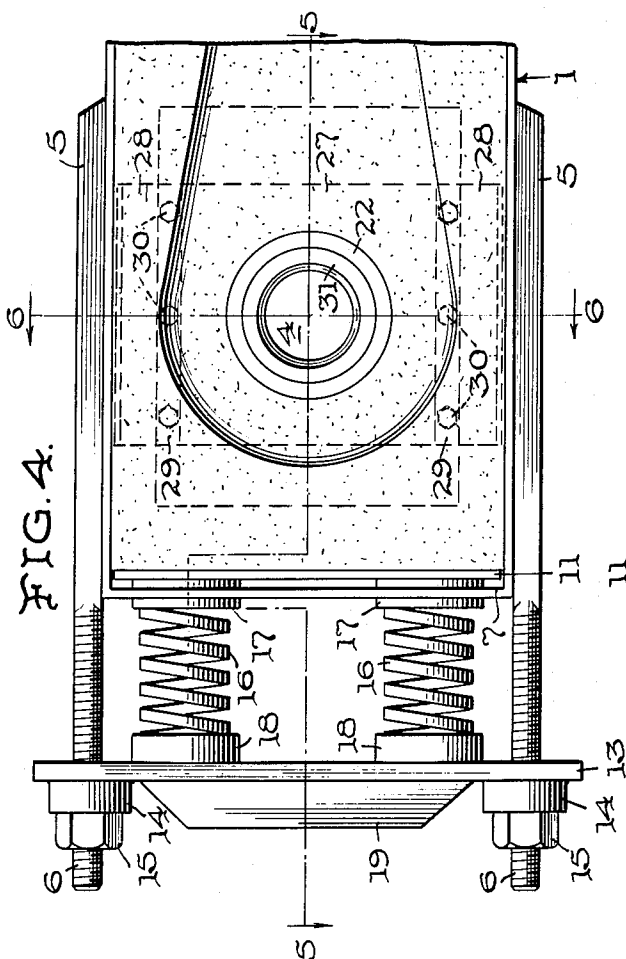
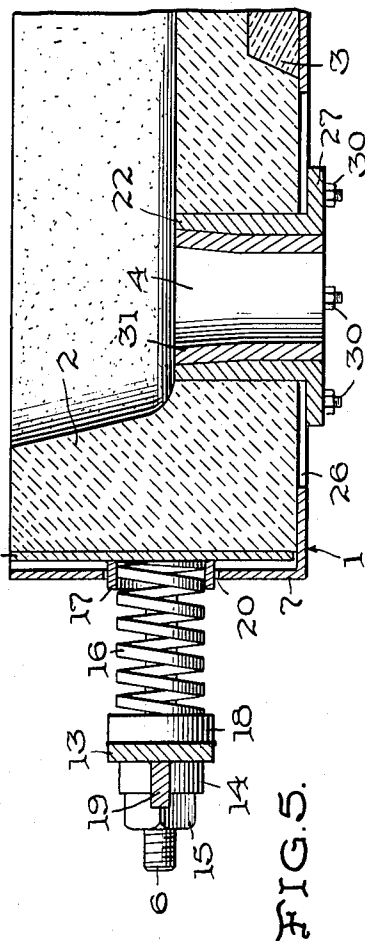
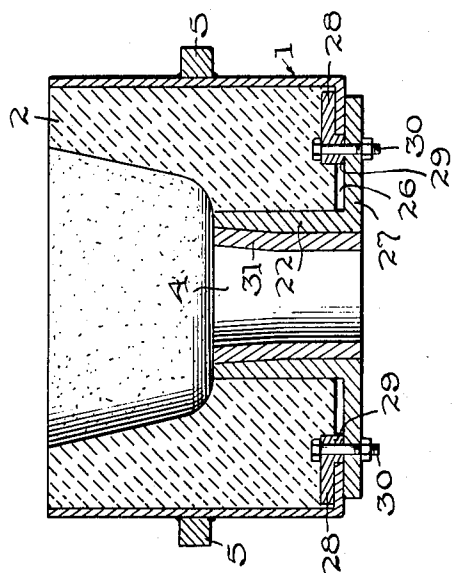
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TRough for Transferring Molten Metal

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3 Sheets-Sheet 2



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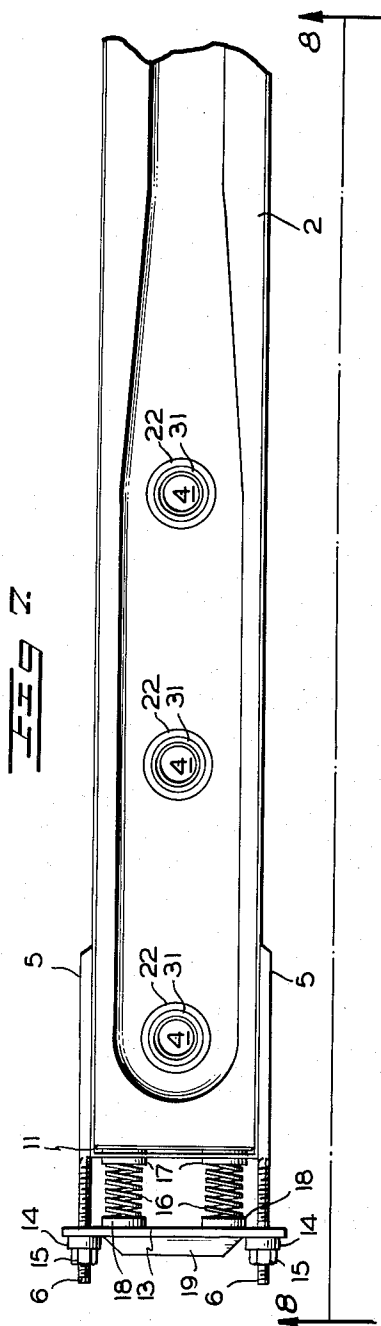
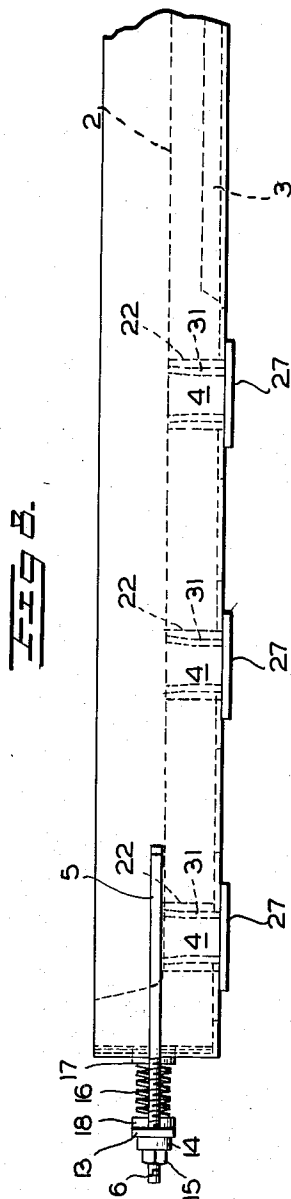
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TROUGH FOR TRANSFERRING MOLTEN METAL

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3 Sheets-Sheet 3



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2,744,303

TROUGH FOR TRANSFERRING MOLTEN METAL

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10 Claims. (Cl. 22—79)

This invention relates to improvements in pouring or transfer troughs for transferring molten metal. More particularly, this invention is concerned with apparatus and operation of said apparatus for transferring metal from one receptacle to another, e. g., from a remelt furnace to a continuous or semi-continuous casting station.

The presently used troughs for transferring molten metal generally comprise an elongated metal shell made of a suitable material, e. g. steel, and a refractory lining provided therein. It is common practice to use a castable refractory as the material of the lining and to ram the castable refractory material into the metal shell. As such, there is presented a relatively high coefficient of friction between the metal shell and the refractory lining. Such transfer troughs have not proven satisfactory in operation. Upon passage of molten metal along the trough, the metal shell and refractory lining are heated. Due to differences in thermal coefficient of expansion between the lining and the metal shell, the metal shell having a higher coefficient of thermal expansion, the shell tends to expand lengthwise at a faster rate than does the lining. This differential expansion, in combination with the high coefficient of friction existing between the shell and the lining, gives rise to excessive tensile stresses being set up in the lining thereby resulting in the formation of transverse cracks therein and failure thereof. As soon as a crack progresses through the lining, molten metal passes through the crack and causes heaving of the lining necessitating replacement thereof.

Additionally, molten metal transfer troughs generally employ underpour spouts for discharging the molten metal. Said underpour spouts are usually embedded in the refractory material and have flanges rigidly attached to the metal trough shell. The above-noted problem of lining failure due to differential expansion between the metal shell and the refractory lining is aggravated by the positive attachment of the spout to the metal shell. Moreover, in some instances troughs for transferring molten metal may be covered in order to ensure against contamination by oxide inclusions. Where the trough is relatively long the covers may be provided with suitable heating units to prevent excessive cooling of the molten metal being transferred. While the use of such heating units overcomes the disadvantage of molten metal cooling in the trough it further aggravates the problem of differential expansion causing an even greater difference in the amount of expansion between the metal shell and the refractory lining with a consequent greater tendency for the refractory lining material to crack.

Accordingly, it is an object of this invention to provide apparatus and method for prevention of cracking of the refractory lining in a molten metal transfer trough resulting from differential expansion between the metal trough shell and the refractory lining.

Another object of this invention is to prevent the

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refractory lining in a molten metal transfer trough from cracking due to tensile stresses set up as a result of greater expansion of the trough shell on heating than the refractory lining.

It is another object of this invention to prevent cracking of a refractory lining in a molten metal transfer trough due to tensile forces set up as a result of differential expansion between the refractory lining and the metal shell by pre-stressing said refractory lining.

It is a further object of this invention to prevent the occurrence of tensile stresses normally imparted to the refractory lining of a molten metal transfer trough as a result of differential expansion between the metal shell and the refractory lining by providing means for permitting said shell to expand independently of said lining.

Other objects and advantages of this invention will be apparent from the following detailed description in conjunction with the accompanying drawings.

This invention generally comprises at least one plate, loaded by suitable resilient means, bearing on at least one end of a molten metal transfer trough refractory lining. The amount of loading on said resiliently loaded plate is controlled by adjustment of compression nuts which when tightened cause the plate to exert a compressive force on the refractory trough lining. Under these conditions both the compressive load and the tensile strength of the refractory lining would have to be exceeded before cracking could occur. The compressive strength of refractory materials generally is many times greater than the tensile strength and by practice of the present invention a refractory lining with a resistance of many times the cracking resistance of conventional trough linings can be fabricated. In addition, the resilient loading means acting on the refractory trough lining through the compression plate has sufficient loading force to overcome the friction between said trough lining and said metal shell whereby the trough lining remains stationary while the steel shell expands relative to said lining through a sliding movement.

Where an under-pour spout which is embedded in the refractory material and attached to the metal shell is employed, it is within the scope of this invention to attach said spout to said shell by sliding means in such a manner as to permit said spout to remain stationary with the ramming material while the metal shell moves relative thereto.

For purposes of more satisfactory illustration, my invention will be more specifically described with reference to the following drawings. In the drawings:

Figure 1 is a fragmentary plan view of one end of a transfer trough embodying the principles of this invention.

Figure 2 is a sectional elevation of the end of said transfer trough taken along the line 2, 2 of Figure 1.

Figure 3 is a fragmentary plan view of the end of said trough shell of Figure 1 with the refractory lining removed showing the outlet spout and trough shell assembly.

Figure 4 is a fragmentary plan view of one end of a modification of the transfer trough of Figure 1.

Figure 5 is a sectional elevation of the end of said modified transfer trough taken along the line 5, 5 of Figure 4.

Figure 6 is a sectional elevation of said transfer trough taken along the line 6—6 of Figure 4.

Figure 7 is a fragmentary plan view of one end of a transfer trough applying the principles of this invention to a transfer trough having a plurality of outlet spouts.

Figure 8 is an elevational view of the transfer trough of Figure 7 taken along the line 8—8 of Figure 7.

With further reference to the drawings, the pouring trough of this invention generally comprises a metal shell 1 lined with a suitable castable refractory material 2 such

as "Kastolite," "Kaocast," and/or a plastic refractory such as "Korundal" ramming mixture. Along the bottom and sides of this metal shell 1 and between the shell 1 and lining 2 is preferably placed insulation 3 of a suitable material, e. g., magnesia. This insulation 3 is placed in contact with the bottom and sides of trough shell 1 except in the area near the outlet 4 of said trough. A layer of aluminum foil (not shown) may be placed over the insulation 3 to prevent the insulation from dewatering the refractory lining 2. While a rammed lining of castable refractory is preferred, the invention is applicable to any refractory lining including a lining of pre-fired brick. The surface of trough lining 2 can be provided with a coating of a refractory wash material such as "Vango" or "Pyrochrome" paint to prevent sticking of the molten metal to the trough and to simplify cleaning of the trough. Since the insulation 3 is not applied to the trough shell 1 in the area around the pouring spout 4 the thickness of the refractory lining 2 is thus increased in the area of the pouring spout. This aids in preventing localized overloading and cracking of the lining 2.

In order to prevent cracking of the refractory lining 2 due to a greater coefficient of expansion of the metal shell 1 on heating, the refractory lining 2 is put under a compressive load. One effect of such compressive load is to increase the magnitude of tensile stresses required to produce failure in the refractory lining 2. This loading is accomplished by a resilient means which also prevents the occurrence of tensile stresses normally imparted to said pouring trough lining 2 since said resilient means interposes a pressure or load between the pouring trough shell 1 and the refractory lining 2. This loading force is selected to be greater than the friction between refractory lining 2 and metal shell 1 such that the refractory lining 2 is compressed against the opposite end of the metal shell 1. Where the trough is employed to transfer molten metal from a remelt furnace to an ingot mold the lining may be compressed against the outlet of said remelt furnace. In either case expansion of the shell 1 merely causes a slight decrease in this compressive force. In this way, the resilient means takes up any differential expansion between the trough shell 1 and the refractory lining 2 while maintaining sufficient compressive loading on the refractory lining 2.

One means for applying such a loading force to the refractory material is shown in Figures 1 and 2 of the drawings. According to this embodiment of the invention a loading bolt 5 is welded to each side of metal shell 1 and extends a considerable distance beyond the outer end of metal shell 1. The loading bolts 5 are each provided with a threaded end 6. The end plate 7 of shell 1 has an opening 8 to permit projections 9 on a compression bar 10 to pass through said end plate 7 and contact a compression plate 11 which in turn contacts the end face of refractory lining 2. A relatively thick rubber-type resilient member 12 of a suitable material such as multi-ply rubber "Ankorite" gasketing material is placed in contact with compression bar 10 and held in place by a pressure bar 13. Pressure bar 13 is provided with openings at its two extremities, said openings being slightly larger than the diameter of loading bolts 5 to permit passage of loading bolts 5 through said openings. Member 12 and compression bar 10 are also provided with similar openings at the extremities thereof, said openings being in alignment. This permits loading bolts 5 to support pressure bar 13 in position against the resilient member 12. Washers 14 are then placed over bolts 5 and against pressure bar 13. Nuts 15 are provided on the end of loading bolts 5 and threaded up against washers 14 which in turn contact pressure bar 13. By tightening up on nuts 15 pressure may be brought to bear on refractory material 2 through resilient member 12 against compression bar 10 which has protruding portions 9 passing through opening 8, in the end plate 7. These protrud-

ing portions contact compression plate 11 in contact with refractory lining 2 thus placing a compressive force on the lining 2.

When shell 1 expands to a greater degree than refractory lining 2 it merely causes nuts 15 to move a short distance away from compression plate 11 thereby decreasing the pressure on compression plate 11 and in turn decreasing the pressure against refractory lining 2. Although the pressure is reduced the refractory lining 2 is still maintained in a sufficient state of compression. Any reduction in compressive load on the lining 2 due to expansion of the shell is readily compensated for by increasing the original compressive load on the lining 2 prior to expansion of the shell to a satisfactory value, it being understood that the refractory lining 2 possesses relatively high compressive strength. Contraction of pouring trough shell 1 on cooling merely increases the pressure on refractory lining 2.

While the rubber-type resilient member 12 above described has been found satisfactory, spring-type resilient members have been found to be a more preferred loading medium for pre-stressing the refractory lining 2 with a compressive load. An example of such loading member is shown in Figures 4 and 5 wherein parts similar to those shown in Figures 1 and 2 are designated by the same numbers. As illustrated in Figures 4 and 5, spring type resilient members 16 are employed. As in the previous embodiment, loading bolts 5 are welded to the side of shell 1, said loading bolts 5 having threaded portions 6 at the ends thereof. A compression plate 11 one face of which contacts the end face of refractory lining 2 has two short pieces of pipe 17 welded to the face opposite that which contacts the refractory lining 2. Two spring members 16 are employed as resilient means, the ends of these spring members 16 being squared and ground. A pressure bar 13 has two pieces of pipe 18 welded to one face and has openings at each end of a size large enough to permit easy passage therethrough of loading bolts 5 for supporting bar 13. One extremity of each of spring members 16 is inserted in a short pipe section 17 and bears against compression plate 11. The opposite extremity fits within pipe 18 and bears against the surface of pressure bar 13. To give added rigidity to pressure bar 13 a plate 19 may be welded to the face of the bar 13 opposite the face to which pipe sections 18 are welded. In this embodiment end plate 7 has holes 20 of a sufficient diameter to permit short pipe sections 17 to pass through with ease.

With the two springs 16 properly positioned between plate 11 and pressure bar 13 a load may be applied to the end of refractory lining 2 by moving pressure bar 13 toward the end of refractory lining 2. Pressure bar 13 is held against spring member 16 by nuts 15 with a washer 14 between each of the nuts 15 and pressure bar 13. By tightening up on nuts 15 the compression of spring member 16 is increased thereby exerting a greater load against the end of refractory lining 2. When trough shell 1 expands to a greater extent than refractory lining 2 the pressure exerted by springs 16 against the end of refractory lining 2 is decreased. However, the amount of actual movement between trough shell 1 and refractory lining 2 is relatively small and the amount of decrease in the pressure exerted on lining 2 by spring members 16 is negligible.

From either embodiment it can be seen that the refractory lining 2 is constantly maintained in compression through said resilient means, thereby preventing the occurrence of tensile stresses in refractory lining 2 normally set up by differential expansion between the metal shell 1 and the refractory lining 2.

In the past, it has been customary to have a fixed outlet spout in pouring troughs. Such outlet spouts added to the problems with regard to cracking since the

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outlet spout was generally embedded in the refractory material and also rigidly supported by the shell. As a result, the differential expansion between the pouring trough shell 1 and the refractory lining 2 imparted stresses to the refractory material surrounding said outlet spout. Therefore, in accordance with this invention, the outlet spout 22 is made free floating. This means that the outlet spout 22 may move with the refractory lining 2 relative to the trough shell 1. This may be accomplished in one instance by providing an elongated hole 21 as shown in Figures 2 and 3 in trough shell 1 with the flange 23 of the outlet spout 22 attached by means of bolts 24 to the bottom of shell 1 through elongated bolt holes 25. The flange 23 of the outlet spout 22 is bolted by means of bolts 24 to shell 1 with a sufficiently low pressure to permit sliding movement of the outlet spout 22 relative to metal shell 1. This permits the metal shell 1 to expand or contract a greater amount than refractory lining 2 without having stresses imparted to lining 2 by shell 1 through outlet spout 22.

In lieu of elongated bolt holes 25 and an elongated opening 21 in the bottom of pouring trough shell 1 there may be a rectangular opening 26 in the bottom of said pouring trough as shown in Figures 4, 5, and 6. Outlet spout 22 has a rectangular flange 27 of a length slightly less than the width of the trough shell 1 and a width substantially less than the length of rectangular opening 26. Outlet spout 22 is positioned within the trough shell 1 with the longitudinal dimension of the flange 27 transverse to the longitudinal dimension of the trough shell 1. In this position the end portions of flange 27 extend beyond the sides of opening 26 and the upper faces of said end portions are placed in contact with the lower faces of the marginal portions of the bottom of trough shell 1 on either side of rectangular opening 26. To hold outlet spout 22 in position and yet permit longitudinal motion relative to the pouring trough shell 1, runner plates 28 are employed. Each runner plate 28 has a downwardly projecting flange 29 along one edge of said plate 28. The difference between the thickness of the flanges 29 and the thickness of the remainder or horizontal portions of runner plate 28 should be equal to or preferably greater than the thickness of the bottom of trough shell 1. Each runner plate 28 is then attached by means of bolts 30 to one end portion of the flange 27 through aligned holes provided in the flanges 29 of the runner plates 28 and the respective end portions of flange 27 with the lower edge of the flanges 29 of each runner plate 28 contacting the upper face of its respective end portion of flange 27. The runner plates 28 are bolted to flange 27 in such a position that the flanges 29 fit within opening 26 with remaining or horizontal portions of runner plates 28 extending in a direction away from the center line of said trough across the upper faces of the marginal portions of the bottom of trough shell 1 on either side of opening 26. Thus a slot is effectively formed between the horizontal portions of runner plates 28 and the upper faces of the end portions of flange 27 with portions of the bottom of trough shell 1 on either side of opening 26 fitting within said slot. This effectively positions outlet spout 22 within trough shell 1, permitting movement only in the longitudinal direction with respect to trough shell 1.

For best operation of the outlet spout 22 a replaceable ceramic orifice 31 may be used. Such an orifice 31 may be fabricated from suitable material, e. g., stabilized zirconia, with good resistance to attack by molten aluminum. The orifice 31 will remain in place in the refractory lining and need not be removed after each pour. This eliminates damage to refractory trough linings caused by insertion and removal of the pouring spout as is done in conventional practice.

While the above have been considered the preferred embodiments of the invention, it will be understood by those skilled in the art that various changes and modi-

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fications may be made without departing from the spirit and scope of the invention. It is to be noted that although transfer troughs having loading means at the outlet end only have been shown and specifically described, similar loading means may be applied to either or both ends of a transfer trough.

While only one outlet spout has been specifically described, this invention would be applicable to a transfer trough employing several outlet spouts as shown in Figures 7 and 8. In Figures 7 and 8 the resilient means effectively interposed between the ends of said metal shell and the corresponding ends of said refractory lining are identical to those shown in Figures 4 and 5 and like numerals for corresponding parts have been applied thereto. Similarly, each of the plurality of outlet spouts 22 of Figures 7 and 8 and the means for making said outlet spouts 22 free floating are identical to the means specifically described in connection with Figures 4, 5 and 6. However, it is to be distinctly understood that the resilient means and the means for making outlet spouts 22 free floating specifically described in connection with Figures 1, 2 and 3 could be employed in lieu of those specifically described in connection with Figures 4, 5 and 6.

What is claimed is:

1. In a molten metal transfer trough having a metal shell and a lining of refractory material, means for applying compressive pressure to at least one end of said refractory lining in a direction longitudinally with respect to the trough.

2. A trough for the transfer of molten metal comprising an elongated metal shell, a refractory lining provided in said shell, and resilient compressive means provided at at least one end of said metal shell and the corresponding end of said refractory lining whereby pressure is applied to said refractory lining to compress the refractory material in a longitudinal direction with regard to said trough.

3. The transfer trough according to claim 2 having at least one outlet spout embedded in, and extending through, said refractory lining.

4. The transfer trough according to claim 3 wherein said outlet spout is movably supported by said metal shell such that said outlet spout may move longitudinally relative to said metal shell.

5. The transfer trough according to claim 4 wherein the resilient means comprises a non-metallic material, an outwardly projecting flange is provided at the bottom of said spout, and the means supporting the outlet spout comprises an elongated hole in the bottom of said trough shell, through which all but the flange of said outlet spout passes into the trough shell, the upper face of said flange contacting the lower face of the bottom of said metal shell, elongated holes in said flange, and bolt means passing through said elongated holes and threaded into the bottom portion of said metal shell, said bolt means being sufficiently loose to permit sliding motion of said spout relative to said shell.

6. The transfer trough according to claim 3 wherein the resilient means employed are spring means.

7. A transfer trough for the transfer of molten metal comprising an elongated metal shell, a refractory lining provided therein, resilient means effectively interposed between the outlet end of said metal shell and the corresponding end of said refractory lining whereby compressive pressure is applied to said refractory lining in a longitudinal direction with regard to said trough, and an outlet spout provided in said refractory lining and supported by said metal shell such that said outlet spout may move longitudinally relative to said metal shell.

8. A transfer trough for the transfer of molten metal comprising an elongated metal shell, a refractory lining provided therein, resilient means effectively interposed between the ends of said metal shell and the corresponding ends of said refractory lining whereby compressive

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pressure is applied to said refractory lining in a longitudinal direction with regard to said trough, and a plurality of outlet spouts provided in said refractory lining and supported by said metal shell such that said outlet spouts may move longitudinally relative to said metal shell.

9. A transfer trough for transferring molten metal having an underpour outlet spout at the end of said trough furthest removed from the inlet end of said trough comprising an elongated steel shell open at the top and having a rammed refractory lining within said shell, a movable plate bearing on the end of said refractory lining nearest the outlet end thereof, spring means pressing said movable plate against the end of said refractory lining, said spring means passing through openings in the outlet end of said trough shell, means for exerting pressure against the extremity of said spring means furthest removed from said movable plate, said means comprising a pressure bar having openings in the extremities thereof, a pair of threaded rods, one of said rods being attached to each side of said trough shell, said rods being of a size slightly less than the size of the openings in the extremities of said pressure bar and passing therethrough, and nut means threaded upon the threaded end portions of said rods whereby compressive pressure is applied to said refractory lining by moving said nuts on the threaded portions of said rods in such direction as to force the pressure bar toward the end of said lining thereby compressing said spring means.

10. The transfer trough of claim 9 wherein said outlet spout is embedded in the refractory and extends there-

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through and wherein said shell has a substantially rectangular opening in the bottom near the outlet end of said shell, the width of said opening being less than the width of said shell, said outlet spout having an outwardly projecting rectangular flange of a width less than the length of said rectangular opening and a length less than the width of the trough shell but greater than the width of said rectangular opening such that all but said flange of said outlet spout may pass into the trough shell through said rectangular opening with the upper faces of the end portions of said flange contacting the lower faces of the marginal portion of the opening in said shell on two opposite sides thereof, said outlet spout being held in position by runner plates bolted to either end portion of said flange through downwardly projecting flanges of said runner plates fitting within said rectangular opening, said runner plates having horizontal portions extending away from said bolts and from the centerline of said trough across the upper faces of the portion of the bottom of said trough shell on either side of said rectangular opening.

References Cited in the file of this patent

UNITED STATES PATENTS

1,896,669 Frisch et al. Feb. 7, 1933

FOREIGN PATENTS

33,754 Netherlands Oct. 15, 1934
176,311 Austria Oct. 10, 1953