United States Patent [19]

Hind

[11] **3,926,406**

[45] **Dec. 16, 1975**

[54] **CASTING OF METALS**

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[73] Assignee: **United States Steel Corporation,** Pittsburgh, Pa.

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Aug. 25, 1972 United Kingdom 39618/72

[52] **U.S. Cl.** **251/144;** 251/155; 251/176; 251/193

[51] **Int. Cl.²** **F16K 51/00**

[58] **Field of Search** 251/144, 155, 176, 193; 267/162

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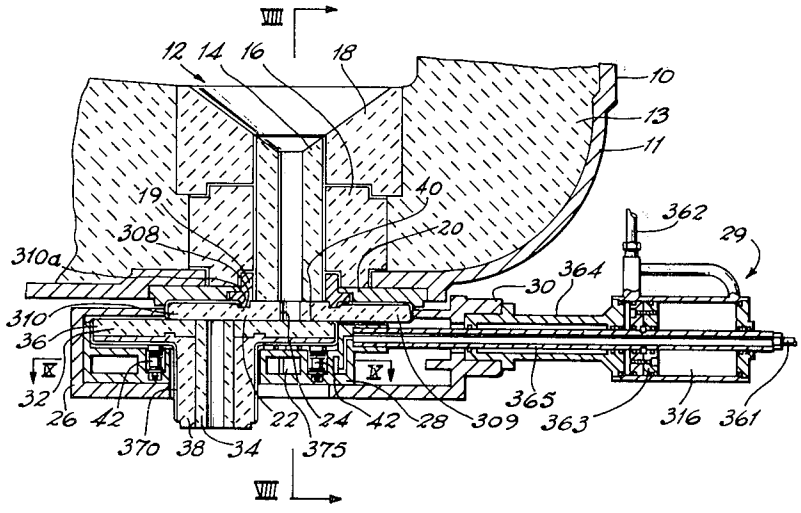
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[57] **ABSTRACT**

A sliding gate valve assembly for use in the casting of metals comprises a resilient device comprising two pad members resiliently urgeable relative to each other by spring means to urge a sliding gate member of the assembly into sealing engagement with a seating therefor and in the event of failure of the spring means, relative movement of said members is severely restricted to correspondingly restrict movement of the gate member away from the seating.

11 Claims, 10 Drawing Figures



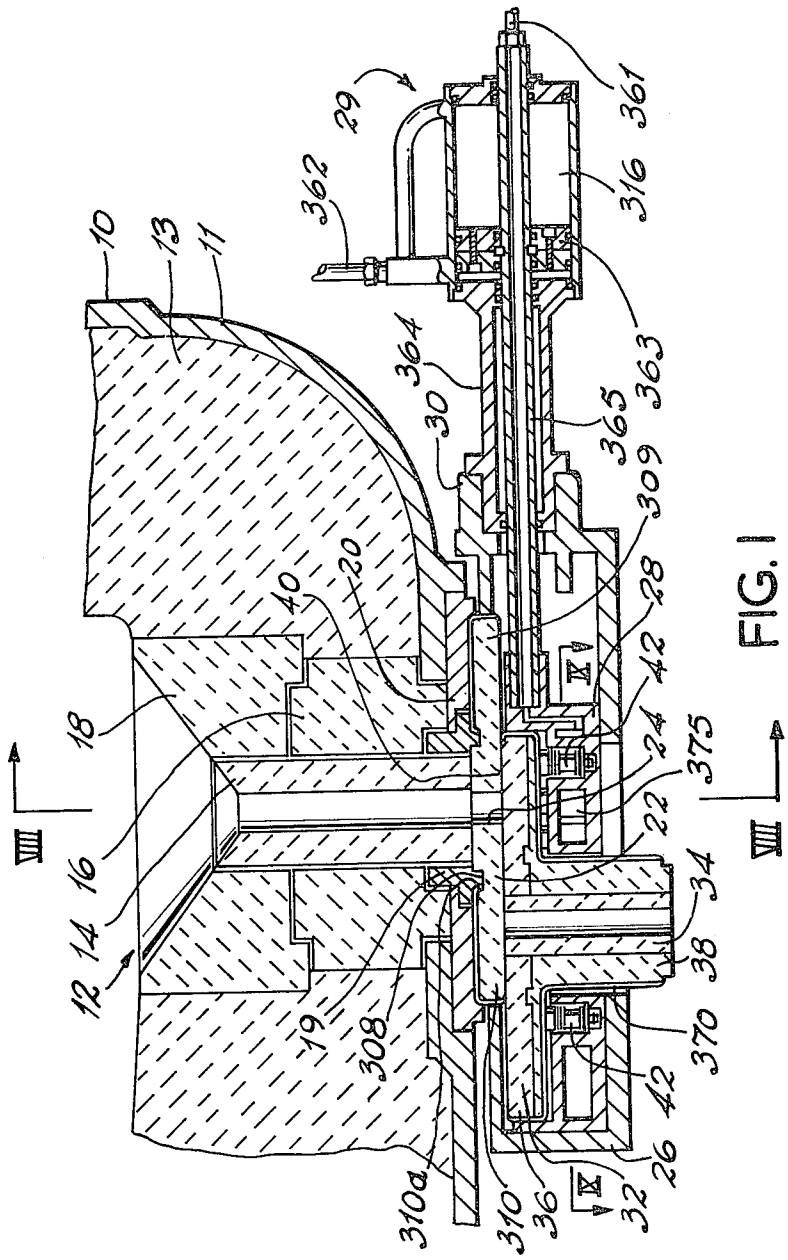

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FIG. 1

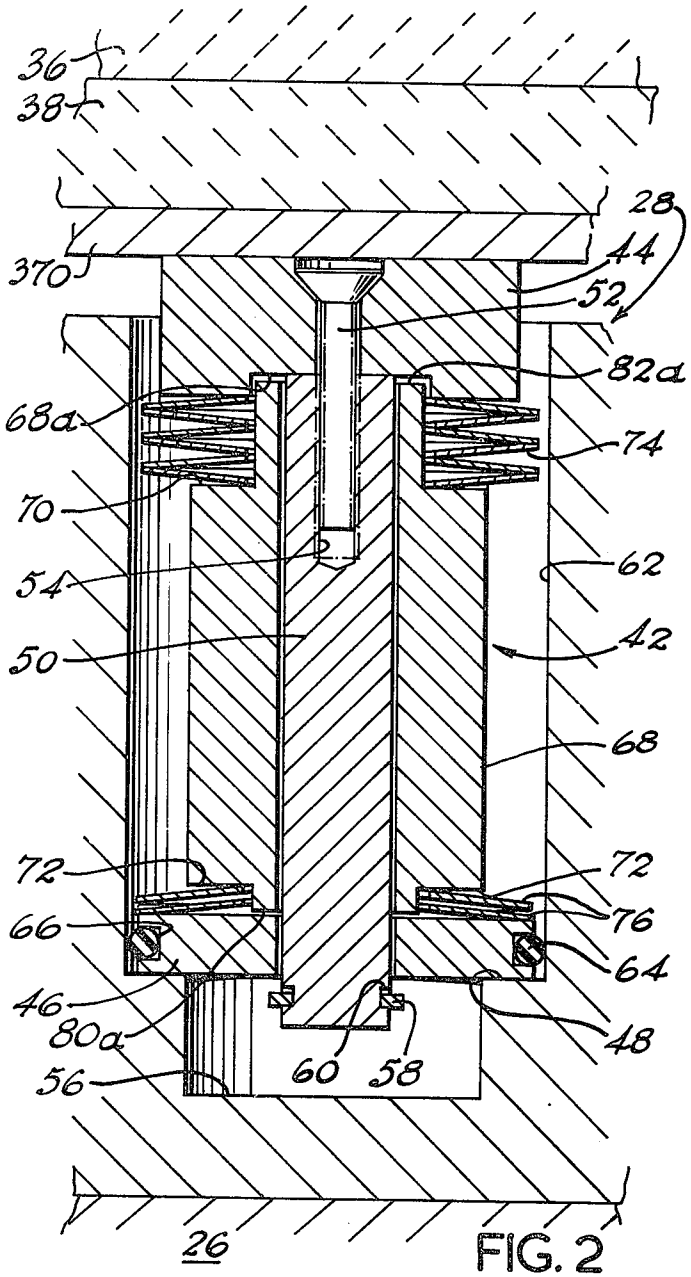

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FIG. 2

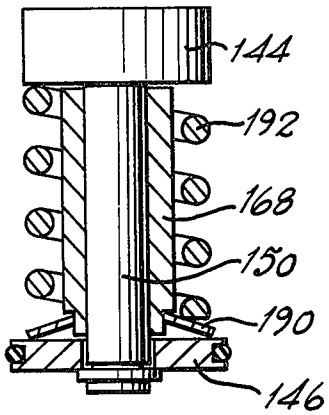


FIG.3

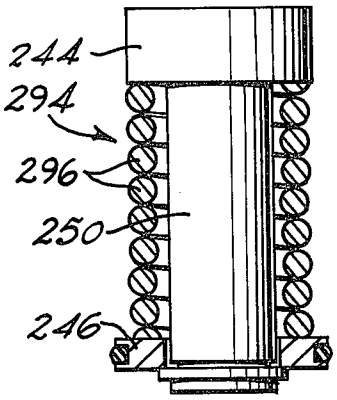


FIG.4

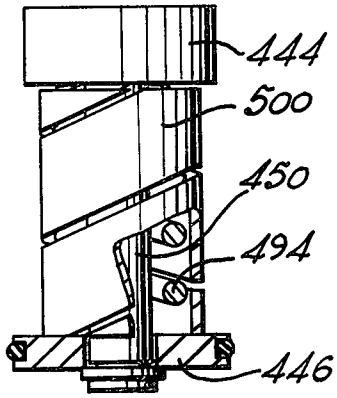


FIG.5

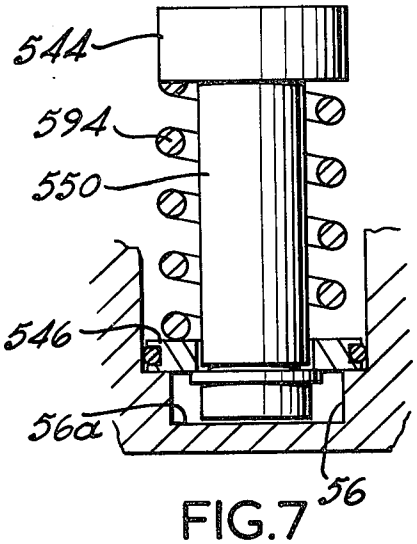


FIG.7

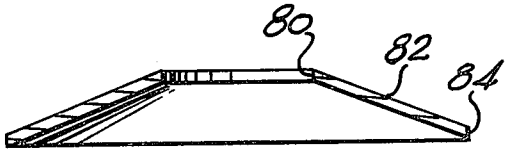


FIG.6

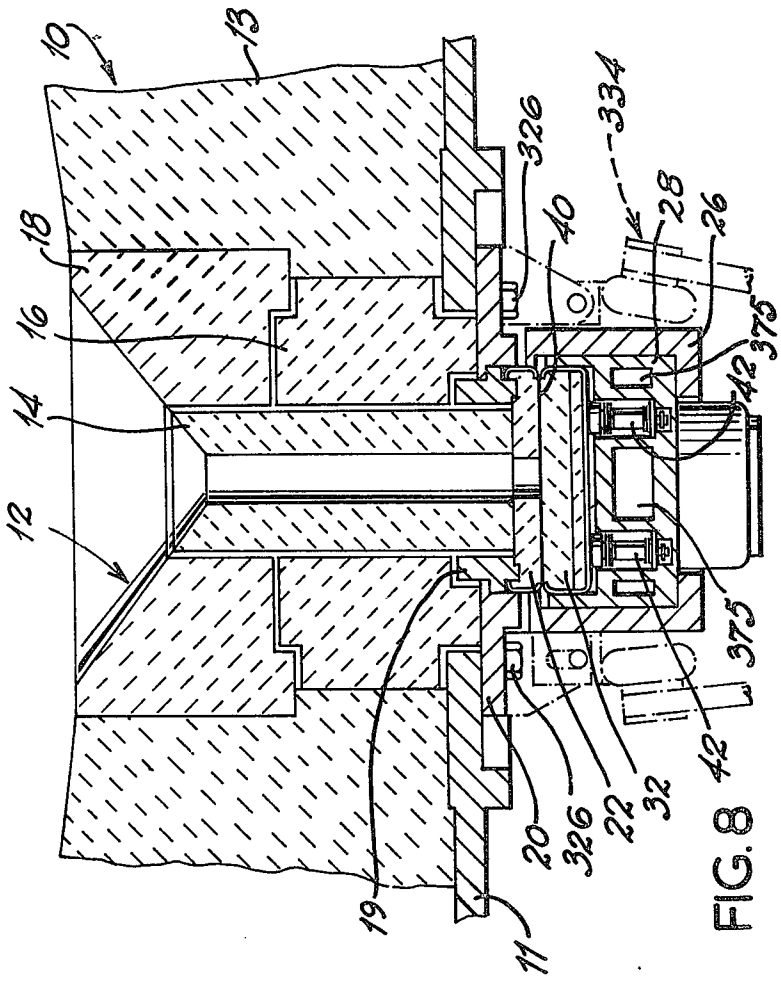
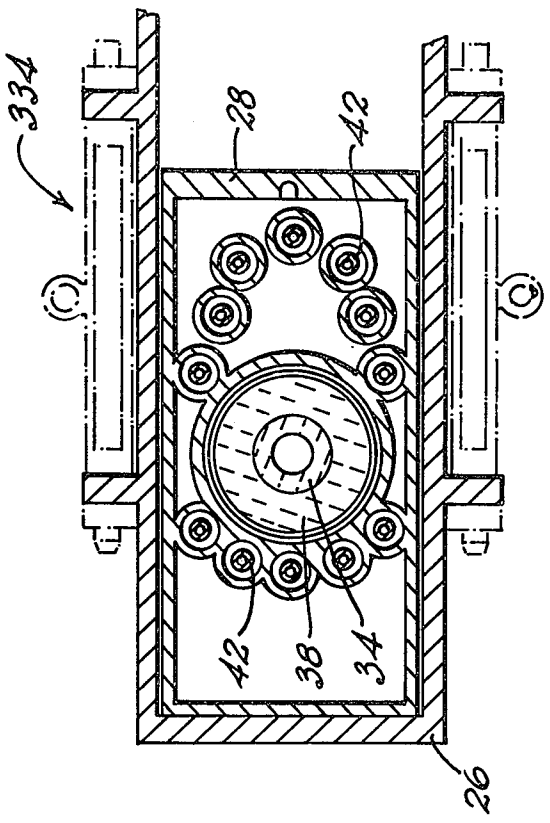


FIG. 8

FIG. 9



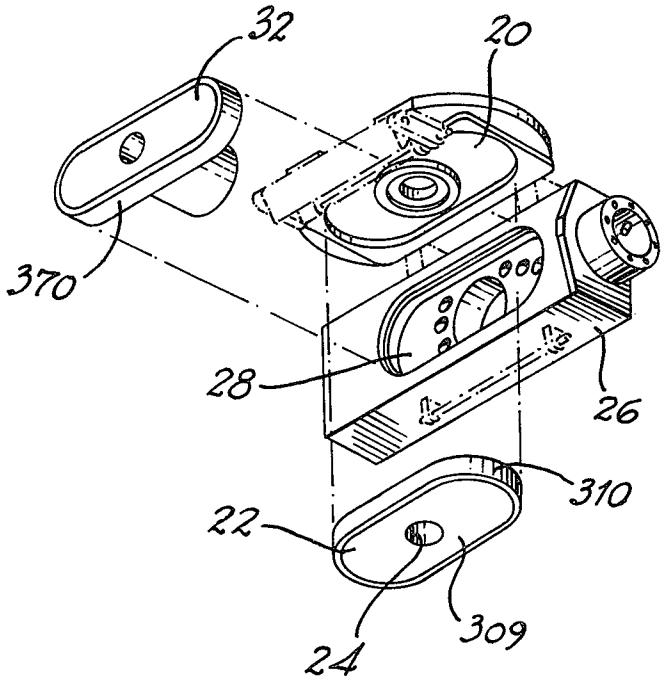


FIG. 10

CASTING OF METALS

This invention is concerned with improvements in or relating to the casting of metals including for example steel, aluminium and brass.

In for example one process for the continuous casting of steel, the flow of molten steel from a bottom pour ladle or tundish is controlled by a sliding gate valve assembly, in which a sliding gate member is arranged to slide in contact with a stationary orifice plate. Examples of such sliding gate valve assemblies are described in J. T. Shapland U.S. Pat. No. Re. 27,237 and U.S. Pat. No. 3,501,068, and in E. P. Shapland et al. application Ser. No. 377,385, all of common ownership. These patents and application describe arrangements in which the sliding gate member moves linearly; in an alternative arrangement the gate is rotary, and one example of this is described in Lyman U.S. Pat. No. 3,430,644, likewise of common ownership.

Advantageously the gate member is urged against the stationary orifice plate by springs to provide a yieldable seal between the sliding gate member and orifice plate; and advantageously the gate member and orifice plate each comprise a refractory body encased in a thin-walled metal casing to provide required mechanical and structural properties in combination with required refractory properties.

The springs are subject to considerable stresses in operation including at times severe heat stresses. Thus, there is a risk of spring relaxation and spring failure followed by movement of the gate member downwardly away from the stationary orifice plate and consequent leakage of molten steel.

It is an object of the present invention to provide an improved resilient device adapted for use in a sliding gate valve assembly in the casting of metals.

It is another object of the invention to provide a sliding gate valve assembly comprising such a resilient device.

It is another object of the invention to provide a metal casting plant comprising such a sliding gate valve assembly.

The invention provides a resilient device adapted for use in a sliding gate valve assembly in the casting of metals and comprising two pad members resiliently urgeable relative to each other to urge a sliding gate member of the assembly into sealing engagement with a seating therefor when the device is in use; the arrangement being such that in the event of resilient failure between the urgeable members, relative movement of said members is severely restricted to correspondingly restrict movement of the gate member away from the seating when the device is in use.

For example movement of the gate member away from the seating may be restricted to between five and thirty thousandths of an inch e.g. about twenty thousandths of an inch, as compared with prior art.

The invention also provides a self-contained resilient device adapted for use in a sliding gate valve assembly in the casting of metals and comprising (a) a core member, (b) opposed pad members mounted on the core member for relative movement of the pad members in directions longitudinal of the core member, and (c) spring means acting between the pad members to urge the pad members relative to each other, said spring means comprising a disc spring mounted around the core member.

The invention also provides a resilient device adapted for use in a sliding gate valve assembly in the casting of metals and comprising two pad members and spring means between the pad members, the pad members being resiliently urgeable apart by the spring means to urge a sliding gate member of the assembly into sealing engagement with a seating therefor when the device is in use, and the spring means comprising a first spring assembly which when the device is in use is normally resiliently operative to urge the pad members apart, and a second spring assembly which is relaxed when the first spring assembly is resiliently operative and becomes resiliently operative to urge the pad members apart in the event that the first spring assembly becomes inoperative.

The invention also provides a sliding gate valve assembly comprising a sliding gate member, a seating for said sliding gate member, and a self-contained resilient device adapted to urge the sliding gate member into sealing engagement with the seating, said device comprising spring means which comprises a disc spring.

The invention also provides a sliding gate valve assembly comprising a sliding gate member, a seating for said sliding gate member, and a resilient device comprising: (a) two pad members resiliently urgeable relative to each other to urge the sliding gate member into sealing engagement with the seating, one pad member being adjacent the sliding gate member, and the other remote therefrom, (b) a core member on which the pad members are mounted for relative movement of the pad members in directions longitudinal of the core member, the pad member which is adjacent the sliding gate member being fixed to the core member, and (c) spring means around the core member acting between the pad members to urge the pad members apart, the core member extending in a direction away from the sliding gate member towards stop means for severely restricting its movement in the event of failure of the spring means, whereby movement of the gate member away from the seating is correspondingly restricted.

The invention also comprehends in combination or as a kit of parts a resilient device according to the invention and a refractory body encased in a thin-walled metal casing, which may be provided by a sliding gate member or a stationary orifice plate.

The thin-walled metal casing is for example of steel having a wall thickness between 2.5 and 3.5 mm. e.g. about 3.0 mm.

It will be realised that either one or both of the sliding gate member and stationary orifice plate comprises a refractory body encased in a thin-walled metal casing.

The invention also comprehends method aspects.

There now follows a description, to be read with reference to the accompanying drawings, of a sliding gate valve assembly embodying the invention. This description, which is also illustrative of method aspects of the invention, is given by way of example of the invention only and not by way of limitation thereof.

In the accompanying drawings:

FIG. 1 shows a sectional side view of the sliding gate valve assembly embodying the invention;

FIG. 2 shows an enlarged sectional side view of a resilient device of the assembly;

FIG. 3 shows a first modified resilient device;

FIG. 4 shows a second modified resilient device;

FIG. 5 shows a third modified resilient device;

FIG. 6 shows a sectional view of a conical disc spring;

FIG. 7 shows a fourth modified resilient device;

FIG. 8 shows a section on the line VIII—VIII of FIG. 1;

FIG. 9 shows a section on the line IX—IX of FIG. 1; and

FIG. 10 shows an exploded perspective view of certain parts also shown in FIG. 1 with a toggle mechanism thereof in a released condition and a sliding gate carrier shown in a hingedly released vertical position.

The sliding gate valve assembly (FIGS. 1, 8, 9 and 10) embodying the invention is adapted for use in the casting of steel into an ingot mould (not shown) or a tundish of a continuous casting plant from a bottom pour ladle 10 which comprises an outer metal casing 11 and a refractory lining 13. A nozzle assembly 12 is mounted in the ladle 10 and comprises a refractory nozzle tube 14 supported within refractory blocks, 16, 18 and in a refractory outer nozzle member 19 mounted in a metal mounting plate 20 secured to the outer metal casing 11 of the ladle 10 by bolts 326 (FIG. 8). A stationary refractory orifice plate 22 is secured generally below the mounting plate 20 and comprises an orifice 24 in alignment with the nozzle tube 14.

The sliding gate valve assembly also comprises a framework 26 removably secured to the mounting plate 20 by a toggle mechanism 334 as described in more detail in said Shapland et al. Application; a sliding gate carrier 28 is mounted for horizontal sliding movement in the framework 26. The horizontal sliding movement of the carrier 28 is effected by a hydraulic cylinder and piston assembly 29 mounted in a bracket 30 of the framework 26. A refractory sliding gate 32 is supported in the carrier 28 and comprises a nozzle tube 34 extending downwardly from the region of the stationary plate 22. The nozzle tube 34 is supported in upper and lower refractory ring members 36, 38. A lower surface 40 of the stationary plate 22 provides an upstream seating for the sliding gate 32.

It will be realised that the sliding gate 32 is movable between a closed position as shown in FIG. 1 in which the tube 34 is not aligned with the orifice 24, and an open position (not shown) in which the tube 34 is aligned with the orifice 24 and molten steel is free to flow from the ladle 20 into the ingot mould or tundish through the tube 14, the orifice 24 and the tube 34.

The sliding gate 32 is urged against the stationary plate 22 into sealing engagement therewith by a plurality of spring devices 42 spaced around the tube 34; there are for example between 8 and 18 spring devices 42, 12 being shown in FIG. 9. Each spring device 42 acts between the carrier 28 and the sliding gate 32, being received in a bore 62 (FIG. 2) in the carrier 28. The spring devices 42 are arranged in a predetermined pattern around the nozzle tube 34 as shown in FIG. 9.

The piston and cylinder assembly 29 comprises a hydraulic cylinder 316 to which hydraulic fluid is supplied via hydraulic lines 362. A piston 363 is mounted in the cylinder 316 and is secured on a hollow ramrod 365. The ramrod 365 extends through a ramshield 364 to be secured to the gate carrier 28, the ramshield 364 being secured in the bracket 30. An air hose 361 is provided to continuously flow air through the hollow ramrod 365 not only for cooling the cylinder 316 but also the carrier 28 and the spring devices 42. The carrier 28 has for this purpose a plurality of connected air chambers 375 interiorly thereof, and the air hose 361 coupled to the hollow ramrod 317 delivers a constant stream of air to the air chambers 375 thereby cooling the carrier 28 and spring devices 42. The air may be dry or humid or alternatively carbon dioxide may be used.

The stationary plate 22 fits within a recess in the mounting plate 20 (FIGS. 1 and 10) and also the stationary plate 22 contains a central annular groove proportioned to receive an annular ring 308 of the outer nozzle member 19.

The plate 22 comprises two straight parallel sides joined by semi-circular end portions and comprises a refractory body 309 encased in a thin-walled steel casing 310. The refractory body 309 is secured in the casing 310 by means of a heat settable cement. A circular opening 310*a* (FIG. 1) is provided in the metal casing 310 adjacent the annular ring 308 to provide for a ceramic joint, and it will be realised that the casing 310 leaves the lower surface 40 exposed. A mastic refractory filler (for example as described in Cudby Application Ser. No. 380,808 of common ownership) is desirably inserted between the metal casing 310 and the plate 22 to accommodate irregularities. Thus the refractory body of the stationary plate 22 is encased so that in event of cracking, the same will be contained in position.

The sliding gate 32 similarly comprises a refractory body provided by the tube 34 and ring members 36, 38; this refractory body comprises an upper portion having straight parallel sides and semi-circular end portions corresponding to the stationary plate 22 and a lower circular cylindrical portion. Again, the refractory body is encased in a thin-walled steel casing 370, while leaving exposed an upper surface of the member 36 and a lower surface of the member 38 and nozzle tube 34. Again, the refractory body is secured in the casing 370 by a heat settable cement and the mastic refractory filler may be used.

The nozzle tube 34 of the sliding gate 32 consists of a highly erosion resistant refractory material and the lower ring member 38 surrounding the nozzle tube 34 is of low conductivity refractory material. The upper ring member 36 is of an abrasion resistant refractory material comparable to that of which the stationary plate 22 is formed.

The highly erosion resistant refractory material for example has a high content of alumina, normally in the range of 85 to 95% by weight. This material has a high density and is high temperature fired. The faces of such material often must be ground to exact shape. On the other hand the backup refractory, such as employed in the blocks 16, 18, and the ring member 38 may have for example a low alumina porous structure which may be castable; alternatively a fired material may be used. Also usable as to an alternaitve is a fused silica castable material.

The slidably engaging surfaces of the member 36 and the stationary orifice plate 22 are ground and polished to provide required sealing characteristics.

It will be noted from FIG. 10 that the orifice plate 22 is symmetrical in plan view about each of the two axes at right angles; and the sliding gate 32 is similarly symmetrical; this enables reversal of the orifice plate 22 and the sliding gate 32 to even the effects of erosion.

Each spring device 42 (FIG. 2) is self-contained and comprises opposed upper and lower pad members 44, 46 respectively. The upper pad member 44 is in engagement with the metal casing 370 of the sliding gate member 38 and the lower pad member 46 which is annular is remote from the gate member 38 being in engagement with a horizontal machined annular shoulder

48 provided in the appropriate bore 62 of the sliding gate carrier 28. The pad member 44 is fixed to a vertical core member 50 by a screw 52 which is screwed into a threaded bore 54 in the core member 50; alternatively the pad member 44 may be integral with the core member 50. The annular pad member 46 is mounted freely on the core member 50 which extends downwardly through the annular pad member 46 into a recess 56 which extends downwardly from the shoulder 48. A circlip 58 is fitted into an annular groove 60 in the core 50 to retain the annular pad member 46 prior to fitting of the spring device 42 into the carrier 28. It will be realised that the pad members 44, 46 are mounted in the core member 50 for relative movement of the pad members 44, 46 in the directions longitudinal of the core member 50.

A resilient O-ring 64 fitted into an annular groove 66 in the member 46 serves to locate the device 42 firmly in the bore 62.

A sleeve 68 is slidably mounted on the core member 50 between the pad members 44, 46. An upper end portion of the sleeve 68 is provided with an annular shoulder 70, and the lower end portion of the sleeve 68 is provided with an annular shoulder 72. The upper end portion of the sleeve 68 is received in a recess 68*a* in the pad member 44. A first spring assembly comprising six conical disc springs 74 are mounted around the sleeve 68 seated against the annular shoulder 70 and in engagement with the pad member 44, and similarly a second spring assembly comprising two conical disc springs 76 are mounted also around the sleeve 68 but seated against the shoulder 72 and in engagement with the pad member 46. The disc springs 74 act in series and the disc springs 76 act in parallel.

An example of a conical disc spring (sometimes known as a Belleville washer) is shown in FIG. 6; the disc spring shown in FIG. 6 comprises a disc of suitable metal with a central hole 80 to which a frusto-conical side wall 82 converges. The outer periphery 84 of the disc is circular cylindrical, being coaxial with the hole 80. If a plurality of such disc springs are mounted coaxially together in series, i.e. with adjacent discs inverted with respect to each other, the load deflection characteristic of the series is the same as for a single disc. If on the other hand, a plurality of disc springs are mounted coaxially together in parallel, i.e. with all discs converging in the same direction, the load required to give a particular deflection is multiplied by the number of disc springs in parallel. Thus, then, assembly of springs 76 in parallel is more preferred than the assembly of springs 74 in series.

In normal operation of the spring device 42, the springs 76 in parallel have a higher load deflection characteristic than the spring series 74. The sleeve 68 extends longitudinally of the core member 50 towards the pad member 46 to leave a small gap 80*a* between a lower end face of the sleeve 68 and the pad member 46. Thus, the springs 74 are resiliently operative and act between the sleeve 68 and the pad member 44 to urge the pad member 44 upwardly against the sliding gate member 38; again, there is a small gap 82*a* left between an upper end face of the sleeve 68 and the pad member 44. The actual width of the gap 82*a* varies in accordance with the accuracy of manufacture of the sliding gate and associated parts, but does not exceed about ten thousandths of an inch.

Disc springs are generally less likely to fail under heat and other stresses than coil springs, but in the event of failure of the spring series 74, the pad member 44 moves downwardly to close the gap 82*a* and it will be realised that its downward movement is severely restricted, being defined by the width of the gap 82*a*, and that movement of the sliding gate 32 away from the stationary orifice plate 22 is correspondingly severely restricted.

In the event that excessive manufacturing tolerances cause closure of the gap 82*a* against action of the spring series 74 (without failure thereof) rendering the springs 74 inoperative, the springs 76 become resiliently operative to act with twice the load deflection characteristic of the series 74 to maintain resilient urging of the sliding gate against the stationary plate 22.

It is rather unlikely that the springs 76 will be subject to failure, but in that event the resultant downward movement of the sleeve 68 is defined by the width of the gap 80*a* which is for example no more than twenty thousandths of an inch. Thus, in the event of failure of the spring series 74 and the springs 76, the total downward movement would be limited to thirty thousandths of an inch. With movement of the sliding gate 32 away from the stationary orifice plate 22 of only ten or at the most thirty thousandths of an inch, the risk of large scale leakage of molten metal is minimised.

It will be realised that in any case failure of the series 74 will not necessarily always involve failure of the entire complement of the springs 74; it is perfectly possible for one spring to fail and the others to remain effective; similarly in the case of the springs 76.

In a modification the springs 76 are omitted, in which case the sleeve 68 is at all times in engagement with the pad member 46; in this case filure of the spring series 74 is still catered for, but excessive manufacturing tolerances are not so well covered.

In another modification thin washers are located between the pad member 46 and the springs 76 to limit further the possible downward movement of the sleeve 68 in the event of failure of the springs 76.

The first modified spring device (FIG. 3) resembles that shown in FIG. 2 in many respects and is described in so far as it differs therefrom. The device shown in FIG. 3 comprises upper and lower pad members 144, 146 and a core member 150. A sleeve 168 is mounted on the core member 150. A single disc spring 190 acts between and is in engagement with the sleeve 168 and the pad member 146, and fulfils the same function as the springs 76 of FIG. 2. A coil spring 192 surrounds the sleeve 168 and acts between and is in engagement with the disc spring 190 and the pad 144, fulfilling the same function as the spring series 74 of FIG. 2.

The second modified spring device (FIG. 4) again resembles that shown in FIG. 2 in many respects and is described in so far as it differs therefrom. The device shown in FIG. 4 comprises pad members 244, 246, and a core member 250. A coil spring 294 acts between and is in engagement with the pad members 244, 246. This coil spring has closely spaced loops 296 and in the event of failure of the spring, downward movement of the pad 244 is severely restricted by the spacing of the loops.

The third modified device (FIG. 5) resembles that shown in FIG. 4 in many respects and is described in so far as it differs therefrom. The third modified device comprises upper and lower pad members 444, 446, a core member 450 and a coil spring 494 as in FIG. 4, but the coil spring 494 has normal loop spacing. The coil spring 494 is surrounded by a relatively powerful band

spring **500** which comprises a spiral band; this is located between the pad members **444, 446** so that it comes into operation only in the event of abnormal downward movement of the upper pad member, there normally being a gap between the band spring and the pad member **444.** In a sliding gate valve assembly incorporating such band springs, it may be necessary only to use the devices with band springs in some of the positions around the nozzle tube of the sliding gate, prior art spring devices being used in the remaining positions; e.g. three or four devices incorporating band springs may be used out of a total of eight to 16.

The fourth modified spring device (FIG. 7) again resembles that shown in FIG. **4** in many respects and is described in so far as it differs therefrom. The fourth modified device comprised upper and lower pad members **544, 546,** a core member **550** and a coil spring **594,** but again the coil spring **594** has normal loop spacing. However, the core member **550** extends in a direction away from the sliding gate member **32** into the recess **56** in the carrier **28** towards stop means provided by a base wall **56***a* of the recess **56** so that a lower end face of the core member **550** is closely adjacent the base wall **56***a* of the recess **56;** downward movement of the core member **550** and thus of the pad member **544** is severely restricted by the width of the gap between the lower end face of the core member **550** and the base wall **56***a;* the width of this gap is for example no more than twenty five or thirty thousandths of an inch.

The steel used in the casings for the refractory bodies is very ductile, for example a hot rolled pickled and oiled grade for drawing; in some cases deep drawing or extra deep drawing quality may be specified.

Suitable spring manterials for disc coil or band springs operating at high temperatures include the following according to the maximum operating temperature; 18/8 Stainless Steel; nickel/chromium alloys; and titanium/vanadium alloys.

For example, 18/8 Stainless Steel can be used up to about 450°C; and nickel/chromium alloys up to about 600°C.

Disc springs are available for example from Messrs. S.A.M. Equipment Limited of Sheffield, England, in sizes ranging from 1 inch to 24 inches in diameter and thicknesses ranging from 26 SWG to more than ⅝ inch.

Disc springs are produced with various load deflection characteristics which are not necessarily rectilinear but may be for example progressive, regressive or inverted; this may be of particular importance in regard to the springs **76.**

It will be realised that spring devices embodying the invention and the metal encased refractory parts which have been described hereinbefore may be incorporated in sliding gate valve assemblies for tundishes or other metal holding vessels or furnaces, as well as for ladles in the continuous casting of steel.

Again, it will be realised that spring devices embodying the invention are readily adapted to sliding gate valve assemblies as described in the aforementioned J. T. Shapland and Lyman patents.

Although the above description has been given with reference to a bottom pour vessel it will be realised that sliding gate assemblies embodying the invention may also be incorporated in for example side pour vessels.

In a modification the sliding movement of the carrier **28** is effected by a piston and cylinder device mounted on a side wall of the ladle **10** as described in U.S. patent application Ser. No. 300,957 of J. J. Klaus and E. P. Shapland with particular but not exclusive reference to FIG. 7 thereof.

In another modification the refractory ring member **36** of the orifice plate **22** is of identical shape and dimensions to the refractory body **309** of the sliding gate **32,** and in this case an upper end portion of the nozzle tube **34** terminates just below the ring member **36** rather than extending through the ring member **36.**

I claim:

1. In a sliding gate valve assembly for controlling flow of molten metal, which assembly comprises a sliding gate member, a seating for said gate member, and resilient devices urging said gate member into sealing engagement with said seating, the improvement in which each of said devices comprises:

a core member;

two spaced-apart pad members mounted on said core member for relative movement in directions longitudinal of said core member;

a sleeve member slidably mounted on said core member intermediate said pad members and extending longitudinally of said core member;

spring means around said core member acting to urge said pad members apart; and

means including said sleeve member acting to restrict severely relative movement of said pad members toward each other to restrict correspondingly movement of said gate member away from said seating in the event of failure of said spring means.

2. The improvement according to claim **1,** wherein a small gap is normally left between each pad member and an adjacent end face of the sleeve member, said gaps defining said restricted relative movement of the pad members.

3. The improvement according to claim **2,** wherein end portions of the sleeve member are each provided with an annular shoulder, and the spring means comprises a first spring assembly seated against the annular shoulder and in engagement with one pad member and a second spring assembly seated against the other annular shoulder and in engagement with the other pad member, the second spring assembly being more powerful than the first spring assembly.

4. The improvement according to claim **3,** wherein each spring assembly comprises a plurality of disc springs.

5. The improvement according to claim **3,** wherein the first spring assembly comprises a plurality of disc springs acting in series, and the second spring assembly comprises a plurality of disc springs acting in parallel.

6. The improvement according to claim **1,** wherein the spring means comprises a disc spring acting between and in engagement with the sleeve member and one of the pad members.

7. The improvement according to claim **6,** wherein the spring means also comprises a coil spring acting between and in engagement with the disc spring and the other pad member.

8. A sliding gate valve assembly according to claim **1,** wherein the sliding gate member comprises a refractory body and a thin-walled metal casing encasing said refractory body.

9. A sliding gate valve assembly according to claim **1,** comprising a stationary orifice plate providing the seating for the sliding gate member and comprising a refractory body and a thin-walled metal casing encasing said refractory body.

10. An assembly according to claim **9,** wherein the sliding gate member also comprises a refractory body and a thin-walled metal casing encasing the refractory body.

11. An assembly according to claim **10,** wherein each

of the orifice plate and sliding gate comprises in plan view two straight sides, two semi-circular end portions joining the sides, and a central circular orifice, and is symmetrical about each of two axes at right angles.

* * * * *