July 20, 1965 J. F. MUMMERT 3,195,875

STEEL-MAKING APPARATUS

Filed March 7, 1962 5 Sheets-Sheet 1

Fig. 1.

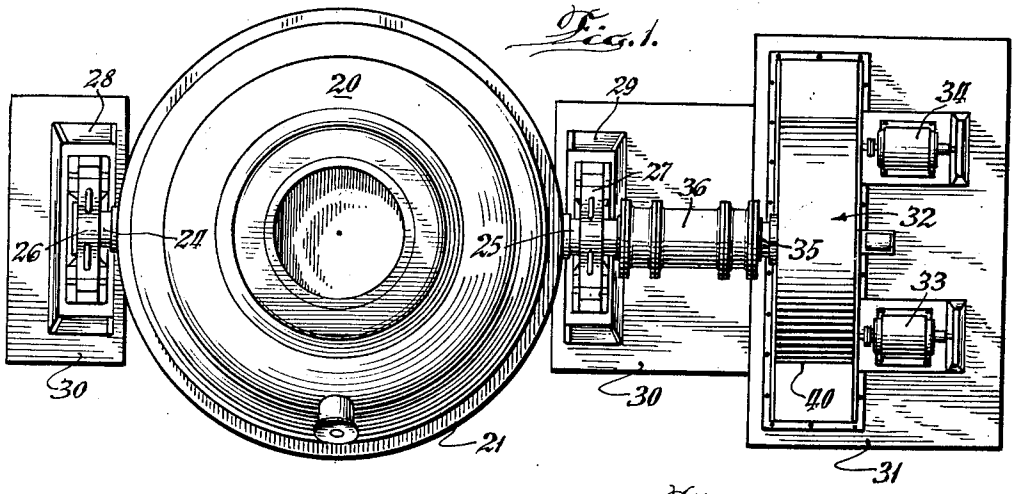



Fig. 2.

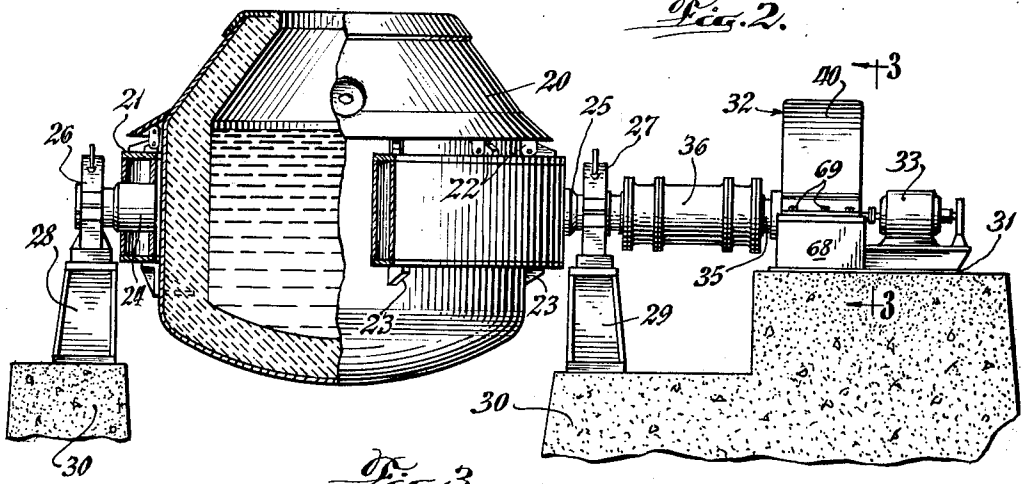
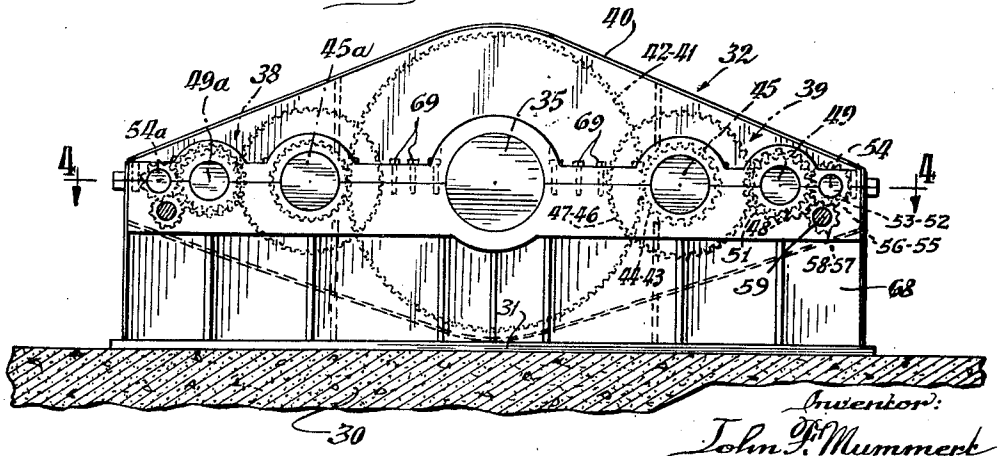



Fig. 3.




Inventor:
John F. Mummert
By Merriam, Smith & Haraldell
Attorneys.

July 20, 1965 J. F. MUMMERT 3,195,875

STEEL-MAKING APPARATUS

Filed March 7, 1962 5 Sheets-Sheet 2

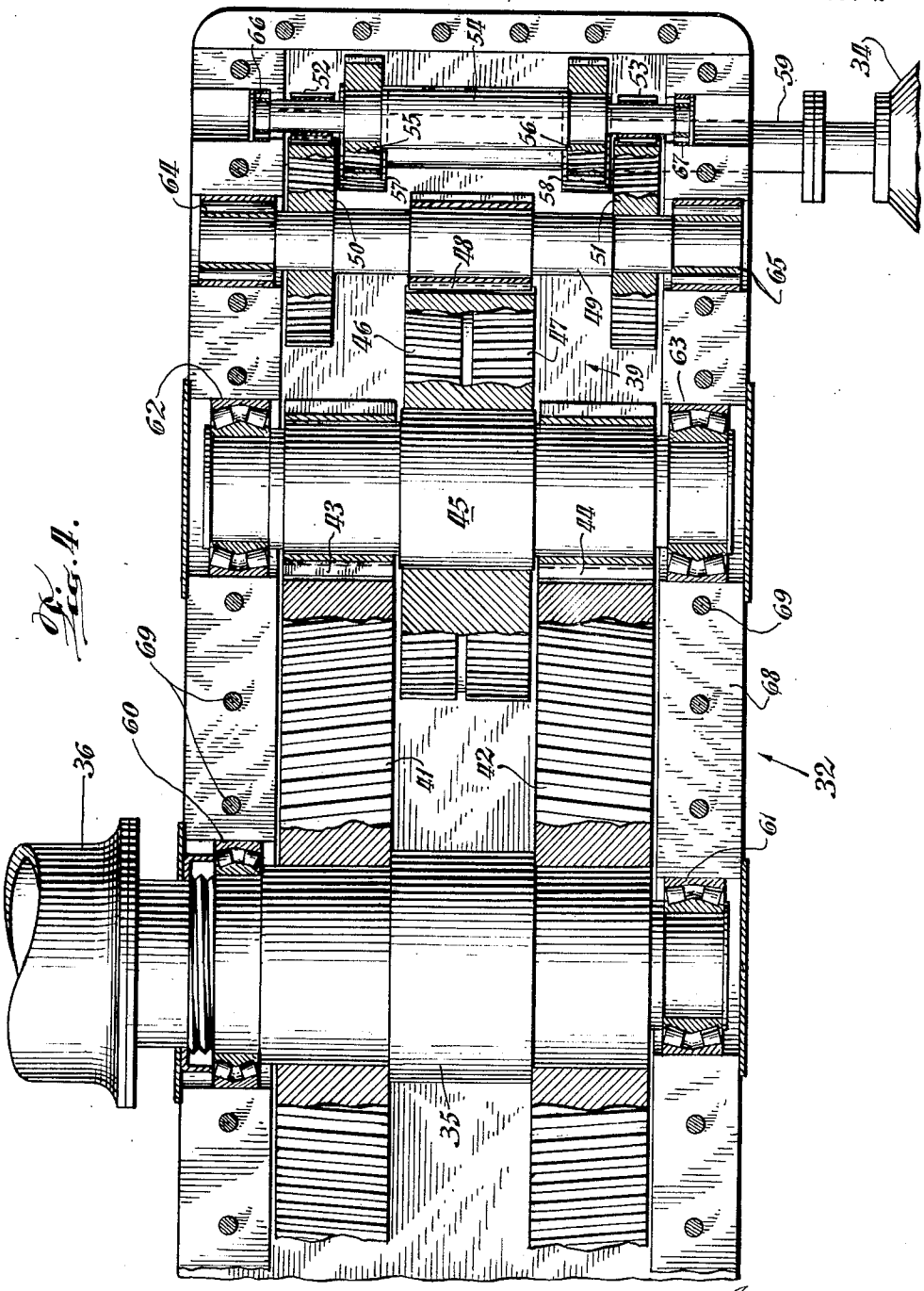



Fig. 4.

Inventor:
John F. Mummert
By Morrison, Smith & Davidson
Attorneys

July 20, 1965 J. F. MUMMERT 3,195,875

STEEL-MAKING APPARATUS

Filed March 7, 1962 5 Sheets-Sheet 3

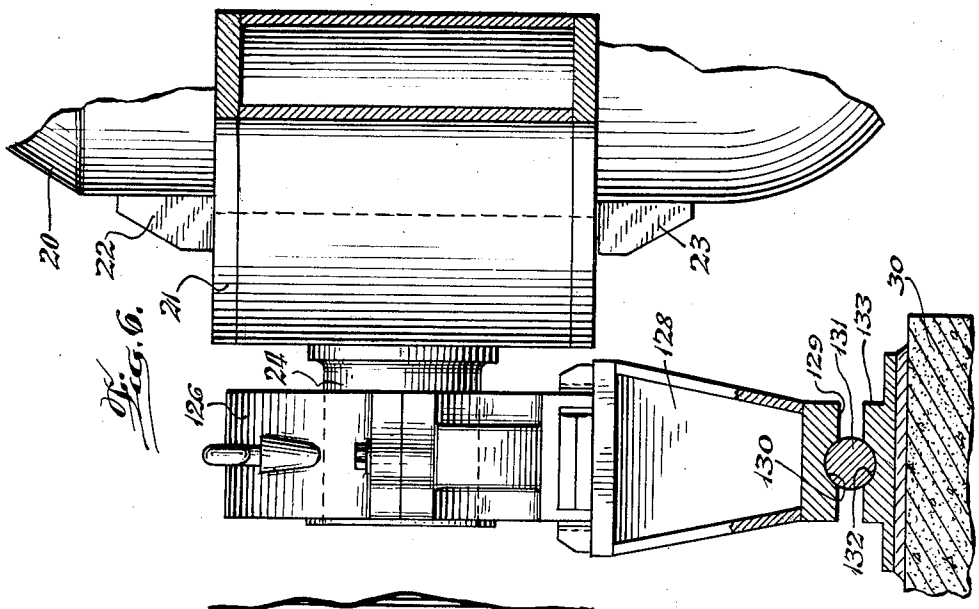



Fig. 6.

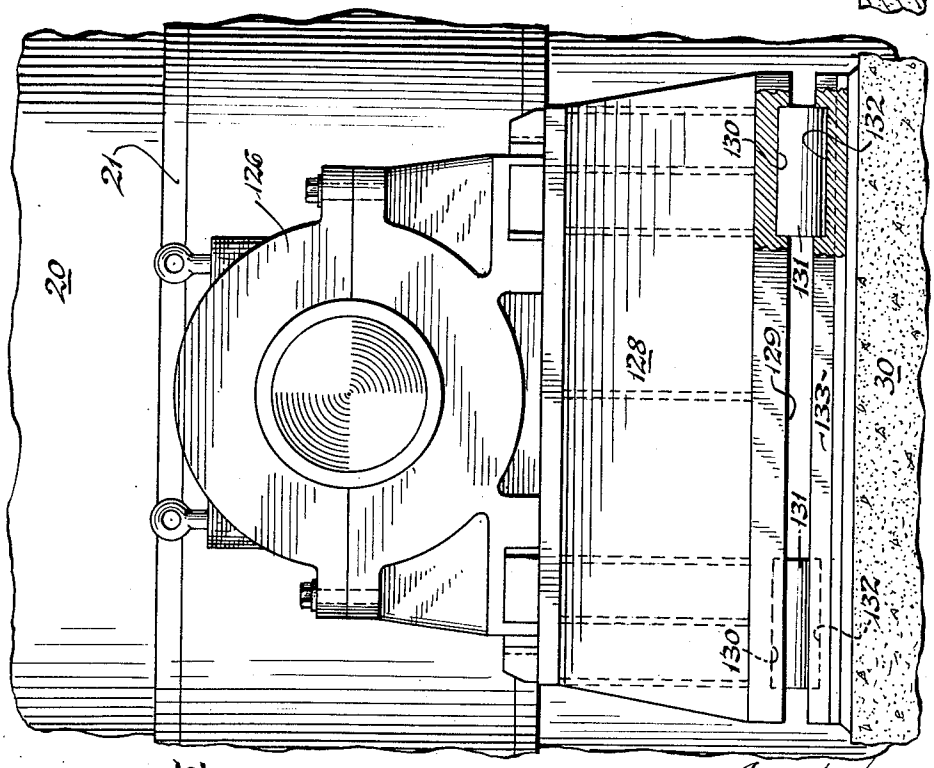



Fig. 5.

Inventor:
John F. Mummert
By Merriam, Smith & Marshall
Attorneys.

July 20, 1965 J. F. MUMMERT 3,195,875

STEEL-MAKING APPARATUS

Filed March 7, 1962 5 Sheets-Sheet 4

Fig. 7.

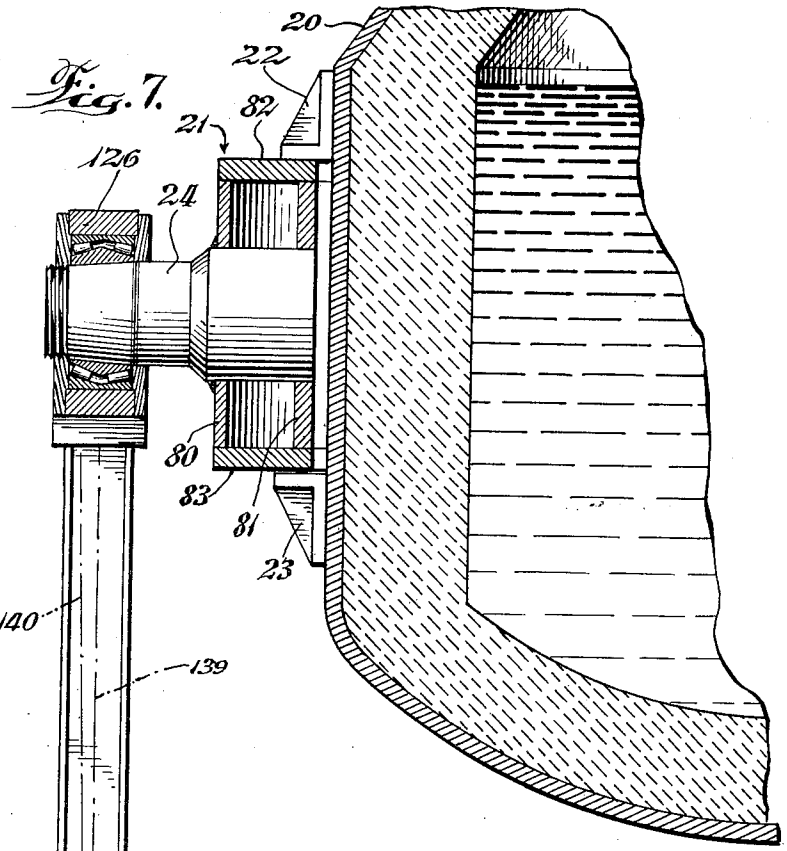



Fig. 8.

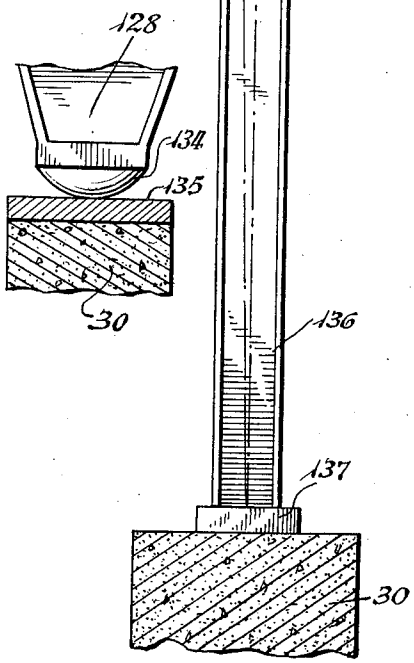
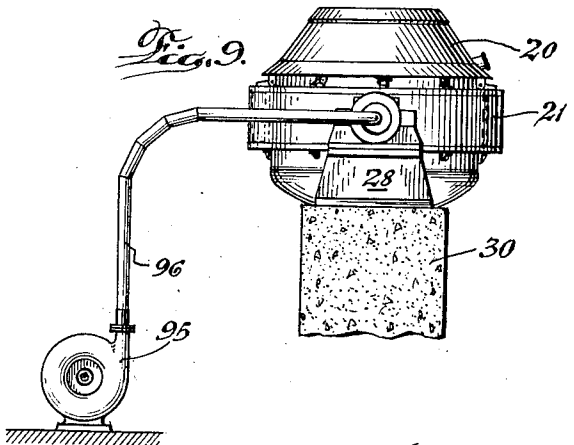



Fig. 9.




Inventor:
John F. Mummert
By Merriam, Smith & Marshall
Attorneys.

July 20, 1965 J. F. MUMMERT 3,195,875

STEEL-MAKING APPARATUS

Filed March 7, 1962 5 Sheets-Sheet 5

Fig. 10.

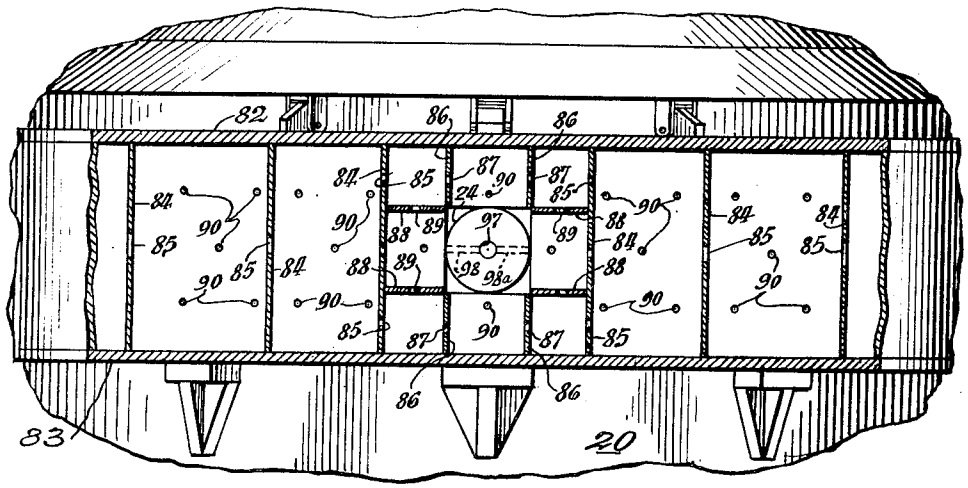
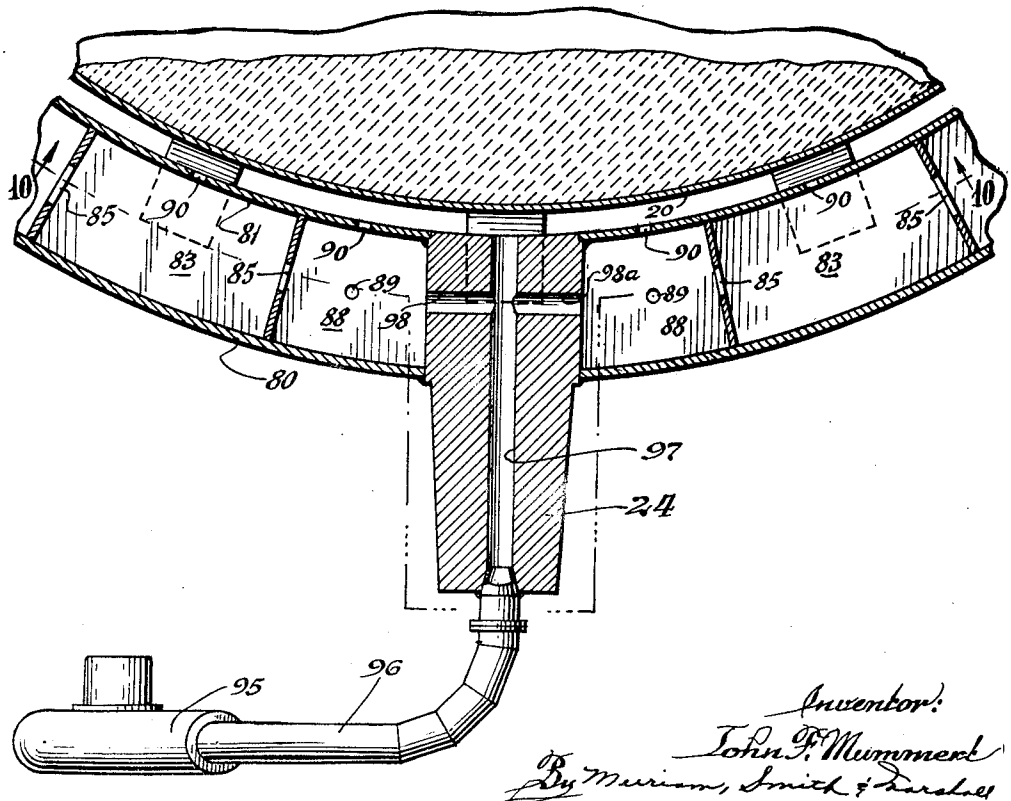



Fig. 11.




Inventor:
John F. Mummert
By Muriam, Smith & Marshall
Attorneys.

United States Patent Office 3,195,875 Patented July 20, 1965



3,195,875

# STEEL-MAKING APPARATUS

John F. Mummert, Birmingham, Ala., assignor to Chicago Bridge & Iron Company, Chicago, Ill., a corporation of Illinois

Filed Mar. 7, 1962, Ser. No. 178,043
16 Claims. (Cl. 266—36)

The present invention relates generally to large processing apparatus operating at high temperatures, and more particularly to apparatus such as a steel-making converter able to process tens or hundreds of tons of steel at temperatures above that of molten steel.

A steel-making converter may typically include a vessel, a hollow annular ring around the vessel and spaced radially therefrom, means mounting the vessel on the annular ring, a pair of trunnions extending from within the ring and in diametrically opposed directions, a pair of stanchion means each for supporting a respective trunnion, and means drivingly connected to one of the trunnions for rotating the vessel between an upright steel-making position and an inverted position.

The temperature due to the heat generated within the vessel during the steel-making operation exceeds the allowable operating temperature for material, such as steel, of which the converter is constructed. Therefore, in accordance with the present invention, means are provided for circulating cooling air through the hollow annular ring around the vessel, and for directing the cooling air from the annular ring into the space between the ring and the vessel. Before passing into the atmosphere, the cooling air absorbs a substantial amount of heat which would otherwise overheat the converter.

A manifestation of the heat generated during the steel-making operation is axial expansion of the trunnions. The two trunnions are mounted on respective stanchion-supported bearings which, in ordinary converters, are usually mounted for movement in an axial direction with the trunnions so as to accommodate the axial expansion or thrust. However, because of the relatively dirty environment normally existing around steel-making operations, the movable mountings for the bearings have been subject to contamination by dust, dirt, slag particles, etc. As a result, it has been necessary to provide complicated dust-proof housings for the bearing mountings to prevent the contaminants from interfering with bearing axial movement.

In the steel-making converter of the present invention, part of the axial expansion normally present in ordinary converters is eliminated by lowering the temperature of the converter with cooling air circulated through the annular ring. The remainder of the axial expansion is offset by thrust-accommodating means. More specifically, one of the bearings is fixedly mounted on its stanchion to prevent movement of that bearing in any direction. The other bearing constitutes conventional self-aligning bearing means fixedly mounted atop stanchion means the lower end of which is constructed to permit a slight angular movement of the entire stanchion member in response to axial expansion by the trunnion. The stanchion member is relatively long compared to the reduced distance the bearing means would have to move in an axial direction to accommodate the thrust. Therefore, the angular change is so slight that it can be readily accommodated by the self-aligning bearing means, and only minute sliding action occurs within the bearing means.

To enable such angular movement, the lower part of the stanchion means is provided with rocker means, or a pivotal mounting, or the entire stanchion means is constructed as a slender resilient member which will



deflect through the required angle in response to axial thrust.

In order to process large batches of steel (e. g. 350 tons) the subject converter is built to a size too large to be preassembled in a shop, and the converter must be assembled in the field. Because the trunnions cannot be machined to the desired tolerances when the converter is field assembled, there will be a substantial misalignment of the trunnions, which misalignment is further aggravated by trunnion deflections normally occurring on such large asesmblies. Connecting a misaligned trunnion directly to driving means is undesirable.

In the subject converter, trunnion misalignment is accommodated by providing a coupling having one end connected to the trunnion and another end connected to a driving shaft. Because of the very heavy weight of the huge assembly and the load within the converter vessel, the driving shaft is normally subjected to high torque loads which, in the absence of a proper driving gear arrangement for the shaft, could result in shaft bending and substantial loads on the driving shaft bearings. These defects are eliminated in the subject converter by providing a gear drive arrangement which imparts a balanced drive to the shaft and eliminates bearing loads and shaft bending, said gear drive arrangement constituting a single self-contained unit which simplifies foundation construction and installation procedures. It provides a drive with one positive lubrication system, thus reducing maintenance and repairs. It includes a dirt-proof housing having a minimum number of housing portions completely enclosing the gears so as to minimize the contamination of the gear drive by dirt, slag particles, etc. normally found around a steel-making operation, and entering the housing through seams or openings in the housing portions.

Other features and advantages are inherent in the structure claimed and disclosed, or will become apparent to those skilled in the art from the following detailed description in conjunction with the accompanying diagrammatic drawings, wherein:

FIGURE 1 is a top plan view of an embodiment of a steel-making converter constructed in accordance with the present invention;

FIGURE 2 is a side elevational view, partially in section, of the converter of FIGURE 1;

FIGURE 3 is an end view of a gear drive arrangement for the subject converter, taken along line 3—3 in FIGURE 2;

FIGURE 4 is an enlarged fragmentary sectional view of the gear drive arrangement, taken along line 4—4 in FIGURE 3;

FIGURE 5 is an enlarged end view of stanchion means together with an embodiment of axial-thrust-accommodating means for a trunnion;

FIGURE 6 is a side elevational view of the structure illustrated in FIGURE 5;

FIGURE 7 is a side elevational view, partially in section, illustrating another embodiment of structure for accommodating trunnion axial thrust;

FIGURE 8 is a fragmentary side elevational view, partially in section, illustrating still another embodiment for accommodating trunnion axial thrust;

FIGURE 9 is an elevational view illustrating a portion of apparatus for circulating cooling air through a hollow annular ring surrounding the converter vessel;

FIGURE 10 is an enlarged end view, partially in section, illustrating the construction of that portion of the hollow annular ring adjacent one of the trunnions; and

FIGURE 11 is a plan view, partially in section, of the portion of the hollow annular ring illustrated in FIGURE 10.

Referring initially in FIGURES 1 and 2, there is illustrated an embodiment of a steel-making converter constructed in accordance with the present invention and comprising a processing or steel-making converter vessel **20**, a hollow annular ring **21** located around the vessel **20** and spaced radially therefrom, upper and lower means **22, 23** respectively, for mounting vessel **20** on ring **21**, and trunnions **24, 25** extending outwardly from within ring **21** and in diametrically opposed directions. Mounting means **22** may be of the type shown in the application of Paul R. Johnson, Serial No. 151,021, filed November 8, 1961 now U.S. Patent No. 3,146,983.

The outer ends of trunnions **24, 25** are rotatably mounted on bearings **26, 27** respectively, each supported by a respective stanchion means **28, 29** both resting on a foundation **30** having an elevated portion **31** supporting a gear drive arrangement indicated generally at **32**. Gear drive arrangement **32** is driven by motor means **33, 34**, and drives a shaft **35** connected by a coupling **36** to trunnion **25**. Coupling **36** accommodates whatever misalignment or deflections there are in trunnion **25** which, because of the extremely large size of the converter, was assembled on site, without previously having been machined in an assembled condition.

Gear arrangement **32** is enclosed within a dust-proof housing including an upper portion **40** and a lower portion **68** connected together by bolts **69**. The housing completely encloses the gear arrangement and prevents the gear arrangement and the lubricant therein from becoming contaminated by the dust, slag particles, etc. usually found in the dirty environment normally existing around steel-making operations.

Referring to FIGURES 3 and 4, gear arrangement **32** is shown to comprise a pair of bull gears or first gear means **41, 42** fixedly mounted on drive shaft **35**. Bull gears **41, 42** are driven by gear trains or second and third gear means **38, 39** each located on an opposite side of the bull gears and each mounted so as to impart balanced driving forces to the bull gears. Each gear train **38, 39** is constructed substantially identically, and FIGURE 4 illustrates in detail the construction of gear train **39**. Drivingly engaging bull gears **41, 42** are a pair of driving gears **43, 44** fixedly mounted on a shaft **45**, in turn mounting a pair of driven gears **46, 47** drivingly engaged by a gear **48** fixedly mounted on a shaft **49**. Mounted at opposite ends of shaft **49** are a pair of driven gears **50, 51** drivingly engaged by gears **52, 53** respectively, each fixedly mounted on a shaft **54** also mounting a pair of driven gears **55, 56** each driven by a respective gear **57, 58** mounted on a shaft **59** driven by motor means **34**. Shaft **35** is journalled on bearings **60, 61**; shaft **45** is journalled on bearings **62, 63**; shaft **49** is journalled on bearings **64, 65**; and shaft **54** is journalled on bearings **66, 67**. Bearing means for shaft **59** are not shown.

It should be noted from FIGURE 3 that the axis of all the shafts in the gear trains (shafts **45, 49** and **54** in gear train **38**, and shafts **45*a*, 49*a*** and **54*a*** in gear train **39**) lie in the same horizontal plane as the axis for shaft **35** mounting the bull gears. Each of the gears on shaft **45** and each of the gears on shaft **45*a*** exerts a compressive force against a respective bull gear **41, 42** as well as a force extending in a tangential direction, The compressive force exerted by a gear on shaft **45** extends in a radial direction toward the axis of drive shaft **35** and the compressive force exerted by the opposing gear on shaft **45*a*** extends in an opposite radial direction toward the axis of shaft **35**. Accordingly, the equal and opposite compressive forces exerted by the gears on shafts **45, 45*a*** balance out and avoid a bending torque on shaft **35** and unbalanced loads on bearings **60, 61** which would otherwise arise if the compressive forces were not so balanced.

The gears on shaft **45** and the gears on shaft **45*a*** rotate in the same senses to drive the ball gears on shaft **35**. For example, assuming the driving gears on shaft **45** are rotating in a clockwise sense, as viewed in FIGURE 3, the driving gears on shaft **45*a*** would also rotate in a clockwise sense in order to drive the bull gears on shaft **35** in the same direction as they are being driven by the driving gears on shaft **45**. Because the shafts **45, 35** and **45*a*** have axes lying in a common horizontal plane, the tangential force exerted against the bull gears on shaft **35** by the gears on shaft **45** is in an upward vertical direction, as viewed in FIGURE 3. At the same time, the tangential force exerted by the driving gears on shaft **45*a*** against the bull gears on shaft **35** extends in a downward direction, as viewed in FIGURE 3. The magnitude of each of these tangential forces is substantially equal, and since they are in opposite directions, they effectively balance each other, thereby avoiding bending or deflection of the shaft **35**, and unbalanced loads on bearings **60, 61**.

FIGURES 5 through 8 illustrate means for accommodating the outward axial thrust of a trunnion resulting from axial expansion caused by heat arising during normal processing operations in the vessel **20**, i.e., heat generated during the steel-making operation. One embodiment of thrust-accommodating means is illustrated in FIGURES 5 and 6, wherein the numeral **126** represents conventional self-aligning bearing means for trunnion **24**. The bearing means on opposite trunnion **25** is fixedly mounted in a manner which prevents movement of the bearing means and trunion **25** in any direction. Therefore, axial expansion is manifest by an outward axial thrust of trunnion **24**. Bearing means **126** is mounted on a stanchion member **128** including a lower surface **129** having a pair of spaced segmental cylindrical indentations **130** therein for receiving and confining the upper portions of cylindrical members **131**, the lower portions of which are received and confined within a pair of spaced segmental cylindrical depressions **132** in a base member **133** supported by foundation **30**. The axes of cylindrical members **131** extend transversely to the axis of trunnion **24**.

When trunnion outward axial thrust occurs, self-aligning bearing means **126** and stanchion member **128** pivot in a counter-clockwise sense about the axis of cylinders **131**. Because the length of stanchion member **128** is relatively great compared to the distance bearing means **126** will be moved in an axial direction, the angular movement of bearing means **126** is relatively slight. The direction of movement of the bearing means includes components in both an outward direction (in the direction of axial thrust) and a downward direction. The axial directional component is accommodated by movement of the stanchion member. The downward directional component is accommodated by the self-aligning bearing means which adjusts itself.

FIGURE 8 illustrates another embodiment of thrust-accommodating means, this embodiment being similar to that illustrated in FIGURES 5 and 6, the difference being that the lower portion of stanchion member **128** is provided with rocker means **134** for rocking on a planar base plate or member **135** in response to an outward axial thrust of the trunnion. This, in turn, causes a slight angular movement of stanchion member **128** and the self-aligning bearing means, similar to that undergone by these elements in the embodiment of FIGURES 5 and 6.

A third embodiment of thrust-accommodating means is illustrated in FIGURE 7. In this embodiment, the stanchion means comprises a long, slender, resilient member **136** fixedly esecured at **137** to foundation **30**. Because member **136** is constructed from resilient material and has a relatively slender, elongated configuration, it is capable of bending or deflecting outwardly, in response to an outward thrust of the trunnion, through an angle defined by the vertical dash-dot line **139** and the angularly extending dash-dot line **140**. This angle of deflection is

within the limits of misalignment for which self-aligning bearing means 126 will adjust itself.

FIGURES 9 through 11 illustrate means for introducing cooling air into the ring at a predetermined location (at one trunnion), for circulating cooling air through the hollow annular ring and for directing the air from the ring into the space between the ring and the converter vessel. Cooling air is forced by blower means 95 through a conduit 96 into a longitudinally extending air conducting first channel 97 in a trunnion (e.g. 24). At that portion of the trunnion located inside the hollow annular ring, there are a pair of transversely extending or second and third air conducting channels 98, 98*a* each having one end communicating with longitudinal channel 97 and another end communicating with the hollow interior of the annular ring.

Each ring has a substantially rectangular cross-section and comprises an inner wall 81, an outer wall 80, an upper wall 82, and a lower wall 83 (FIGURE 7). Located within the hollow annular ring, at spaced intervals therearound, are vertically extending diaphragms or bracing members 84 having openings 85 and dividing the ring into a plurality of chambers.

Referring to FIGURE 10, that portion of trunnion 24 extending within the hollow annular ring is braced by vertically extending members 86 having openings 87 therein, and by horizontally extending members 88 having openings 89 therein. Air passes from trunnion channels 98 through openings 89 in brace members 88, and then through openings 85 and 87 in vertically extending members 84, 86 respectively.

The size of an opening in a member 84 increases as the distance between the respective member 84 and the air-conducting channels in trunnion 24 increases. This provides those portions of the annular ring remote from the trunnion with substantially the same amounts of air as are provided to those portions of the annular ring close to the trunnion.

The inner wall 81 of the annular ring includes openings 90 through which air is directed into the space between the annular ring and the vessel 20 so as to cool the vessel. The air passing through openings 90 eventually passes out of the space between the ring and the vessel, either above or below the ring, and into the atmosphere. As a result of the heat absorbed by the cooling air, the material from which the converter is constructed is maintained at allowable operating temperatures, and the amount of axial expansion undergone by the trunnions is reduced.

Although the illustrated embodiment relates to a steelmaking converter, it should be noted that the subject invention may be utilized in conjunction with other processing equipment utilizing rotatable vessels for processing heavy loads at extremely high temperature conditions and in a relatively dirty environment.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. In combination:
a processing vessel;
a hollow annular ring around said vessel and spaced radially therefrom;
means mounting said vessel on said ring;
a pair of trunnions extending outwardly from within the ring and in diametrically opposed directions;
stanchion means for supporting each trunnion;
means, located adjacent a first of said stranchion means, drivingly connected to one of said trunnions for rotating the latter about its axis;
self-aligning bearing means on the other of the trunnions and supported atop the second of said stanchion means;
said second stranchion means comprising means mounting the top of the second stanchion means for angular movement relative to the bottom of the stanchion means, in response to axial thrust of the trunnions resulting from expansion caused by heat arising during normal processing operations in said vessel, and in a direction having a component extending in the direction of said axial thrust;
the length of said second stanchion means being sufficiently great, compared to the length of said axial thrust to confine the angle of said angular movement within the limits for which said self-aligning bearing means will adjust itself;
means for circulating cooling air through said hollow annular ring;
and means on said annular ring for directing air circulated therethrough into the space between the ring and the vessel.

2. In the combination of claim 1 wherein said means for rotating said one trunnion comprises:
first gear means connected to said one trunnion;
second and third gear means each drivingly engaging said first gear means on a respective side thereof diametrically opposed from the side engaged by the other of the second and third gear means;
the axes of the first, second, and third gear means lying in the same plane;
and a pair of motor means each drivingly connected to a respective one of said second and third gear means.

3. In the combination of claim 1 wherein said second stanchion mounting means comprises:
a rocker located at the bottom of the second stanchion means;
and a planar surface on which said rocker rests.

4. In the combination of claim 1 wherein said second stanchion mounting means comprises:
a substantially horizontal cylindrical member located at the bottom of the second stanchion means and having an axis transverse to the axis of the trunnions;
a stanchion bottom surface having a segmental cylindrical indentation for receiving and confining the upper portion of said cylindrical member;
and a base member having a segmental cylindrical depression for receiving and confining the lower portion of said cylindrical member.

5. In the combination of claim 1 wherein:
said second stanchion means comprises a relatively slender member constructed of resilient material capable of bending resiliently in response to said thrust;
and said second stanchion mounting means includes a base located below said member;
and means for fixing the bottom of said member to the base.

6. In the combination of claim 1 wherein said air circulating means comprises:
an air-conducting first channel extending longitudinally through one of said trunnions;
blower means;
conduit means connecting said blower means to an end of first channel at the outer portion of said one trunnion;
air-conducting second and third channels each having one end communicating with said first channel and another end communicating with the interior of the hollow annular ring.

7. In a combination as recited in claim 6 wherein:
said hollow annular ring has openings therein facing the vessel for directing air thereagainst;
a plurality of vertically extending bracing plates in said annular ring dividing the latter into a plurality of chambers;
an air passage opening in each bracing plate;
the size of said air passage openings increasing from plate to plate as the distance between the opening and the air-conducting channels increases.

8. In combination:
a processing vessel;

a hollow ring around said vessel;
means mounting said vessel on said ring;
a pair of trunnions extending outwardly from the ring and in diametrically opposed directions;
stanchion means for supporting each trunnion;
and self-aligning bearing means on one of the trunnions and supported atop one of said stanchion means;
said one stanchion means comprising means mounting the top of the one stanchion means for angular movement relative to the bottom of the one stanchion means, in response to axial thrust of the trunnions resulting from expansion caused by heat arising during normal processing operations in said vessel, and in a direction having a component extending in the direction of said axial thrust;
the length of said one stanchion means being sufficiently great, compared to the length of said axial thrust, to confine the angle of said angular movement within the limits for which said self-aligning bearing means will adjust itself.

**9.** In the combination of claim **8** wherein said second stanchion mounting means comprises:
a rocker located at the bottom of the second stanchion means;
and a planar surface on which said rocker rests.

**10.** In the combination of claim **8** wherein said stanchion mounting means comprises:
a substantially horizontal cylindrical member located at the bottom of the second stanchion means and having an axis transverse to the axis of the trunnions;
a stanchion bottom surface having a segmental cylindrical indentation for receiving and confining the upper portion of said cylindrical member;
and a base member having a segmental cylindrical depression for receiving and confining the lower portion of said cylindrical member.

**11.** In the combination of claim **8** wherein:
said second stanchion means comprising a relatively slender member constructed of resilient material capable of bending resiliently in response to said thrust;
and said second stanchion mounting means includes a base located below said member;
and means for fixing the bottom of said member to the base.

**12.** In the combination of claim **8**:
said ring comprising a hollow annular ring around said vessel and spaced radially therefrom;
means for circulating cooling air circumferentially through said hollow annular ring;
and means on said annular ring for directing air circulated therethrough into the space between the ring and the vessel.

**13.** In the combination of claim **12** wherein said hollow annular ring has openings therein facing the vessel for directing air thereagainst;
a plurality of vertically extending bracing plates in said annular ring dividing the latter into a plurality of chambers;
an air passage opening in each bracing plate;
means for introducing cooling air into said hollow ring at a predetermined location;
the size of said air passage openings increasing from plate to plate as the distance between the opening and said air-introducing location increases.

**14.** In combination:
a processing vessel;
a ring around said vessel;
means mounting said vessel on said ring;
a pair of trunnions extending outwardly from within the ring and in diametrically opposed directions;



stanchion means for supporting each trunnion;
first gear means connected to one of said trunnions;
second and third gear means each drivingly engaging said first gear means on a respective side thereof diametrically opposed from the side engaged by the other of the second and third gear means;
the axes of the first, second and third gear means lying in the same plane;
a pair of motor means each drivingly connected to a respective one of said second and third gear means;
and self-aligning bearing means on the other of the trunnions and supported atop one of said stanchion means;
said one stanchion means comprising means mounting the top of the one stanchion means for angular movement relative to the bottom of the one stanchion means, in response to axial thrust of the trunnions resulting from expansion caused by heat arising during normal processing operations in said vessel, and in a direction having a component extending in the direction of said axial thrust;
the length of said one stanchion means being sufficiently great, compared to the length of said axial thrust, to confine the angle of said angular movement within the limits for which said self-aligning bearing means will adjust itself.

**15.** In combination:
a processing vessel;
a hollow annular ring around said vessel and spaced radially therefrom;
means mounting said vessel on said ring;
a pair of trunnions extending outwardly from within the ring and in diametrically opposed directions;
stanchion means for supporting each trunnion;
means for introducing cooling air into said hollow annular ring at a predetermined location;
said hollow annular ring having openings therein facing the vessel for directing air thereagainst;
a plurality of vertically extending bracing plates in said annular ring dividing the latter into a plurality of chambers;
and an air passage opening in each bracing plate;
the size of said air passage openings increasing from plate to plate as the distance between the openings and said air-introducing location increases.

**16.** In the combination of claim **15** wherein said air-introducing means comprises:
an air-conducting first channel extending longitudinally through said one of said trunnions;
blower means;
conduit means connecting said blower means to an end of said first channel at the outer portion of said one trunnion;
air-conducting second and third channels each having one end communicating with said first channel and another end communicating with the interior of the hollow annular ring.


**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,891,607 | 12/32 | Rainey | 165—82 |
| 2,143,557 | 1/39 | Howat | 266—39 |
| 2,817,249 | 12/57 | Hindmarch | 74—665 |
| 2,976,090 | 3/61 | McFeaters | 266—36 X |

FOREIGN PATENTS

| | | |
|---|---|---|
| 250,890 | 9/11 | Germany. |


MORRIS O. WOLK, *Primary Examiner.*

JAMES H. TAYMAN, JR., *Examiner.*