Oct. 4, 1949. C. W. NICHOLS ET AL 2,483,592

FURNACE SHAFT CONSTRUCTION

Filed Jan. 6, 1948

2 Sheets-Sheet 1

Fig. 1.

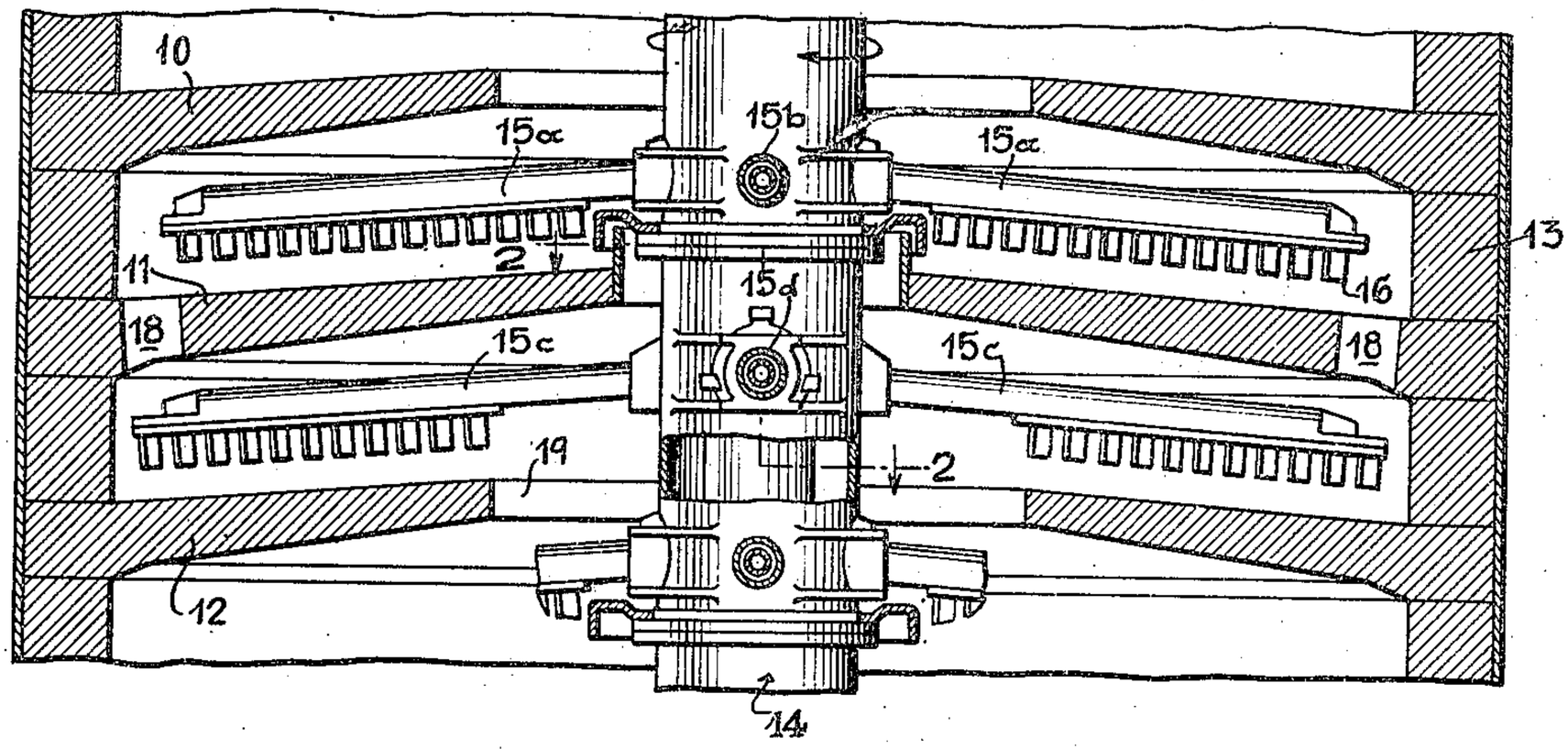
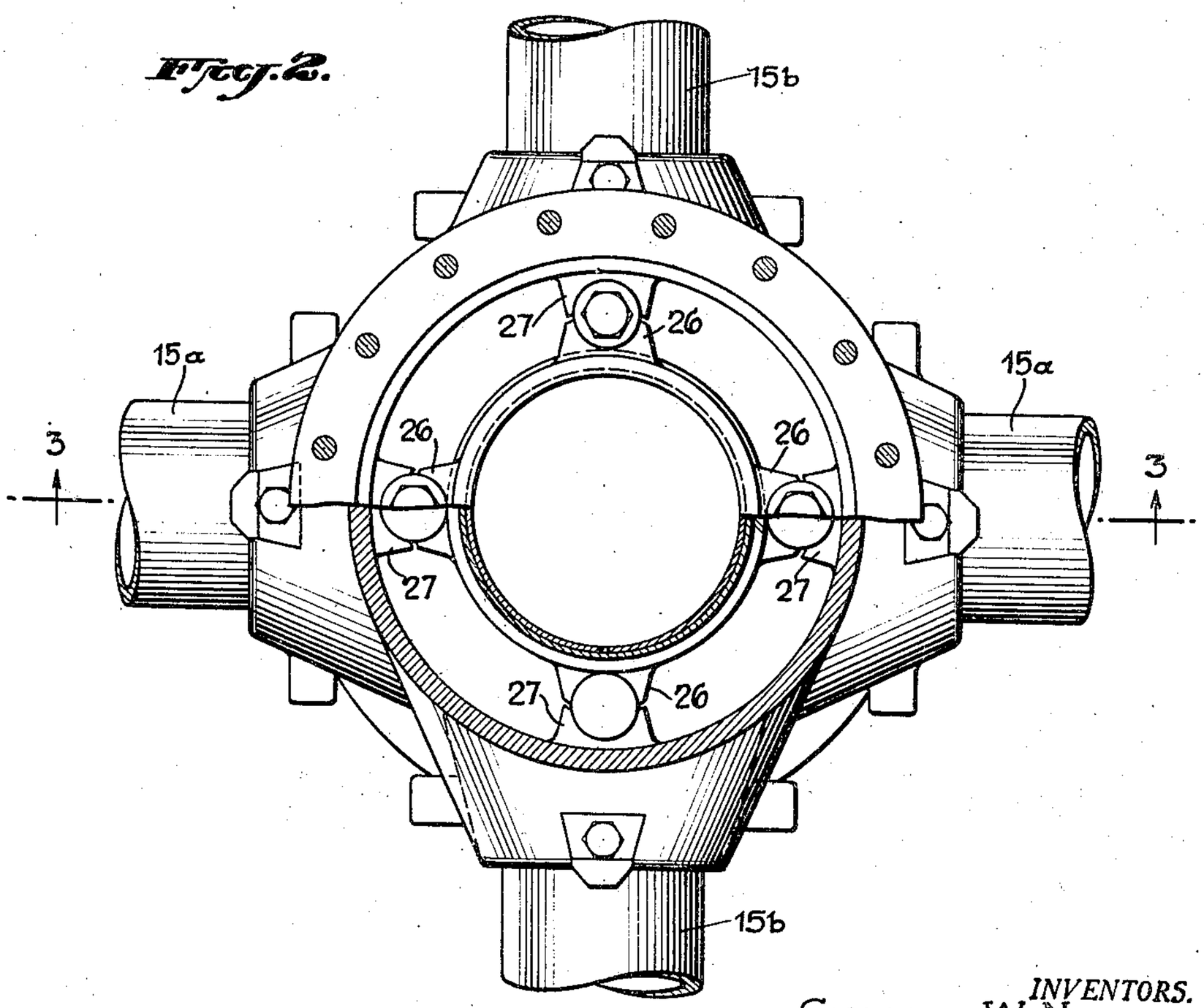


Fig. 2.



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2 Sheets-Sheet 2

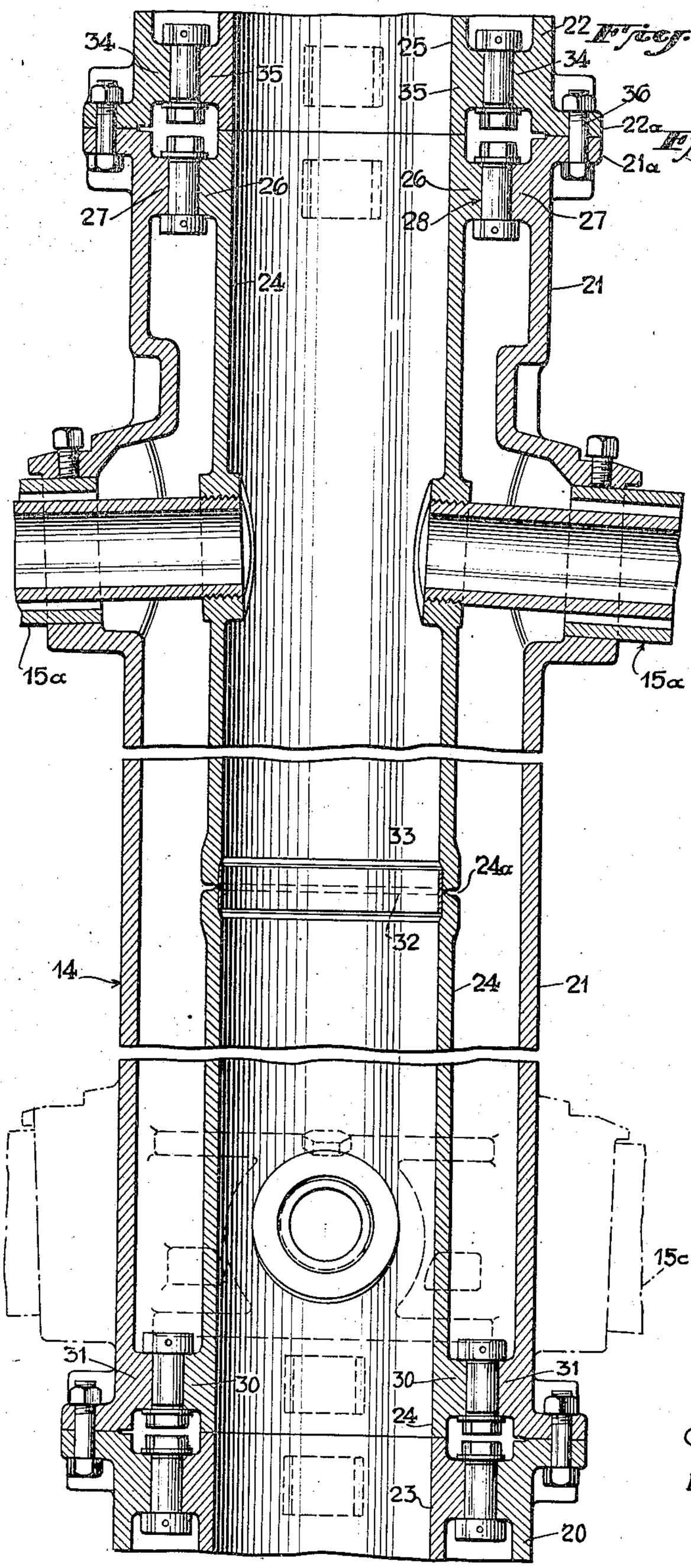


Fig. 3.

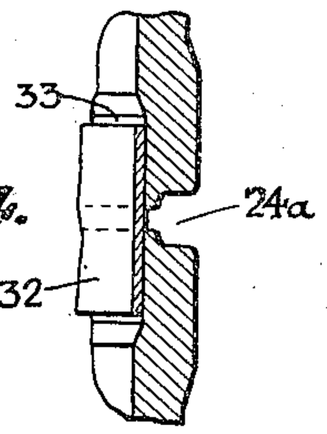


Fig. 4.

Fig. 5.

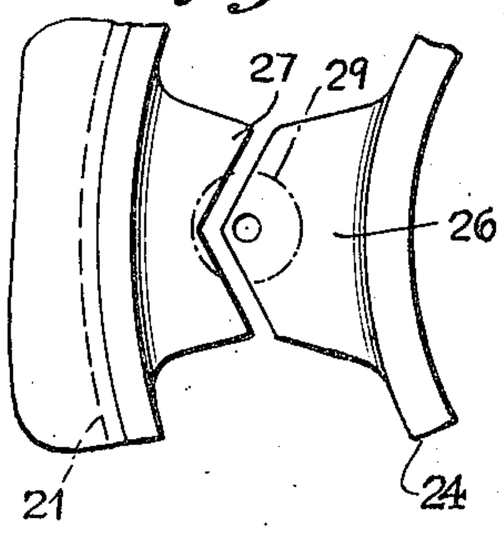


Fig. 6.

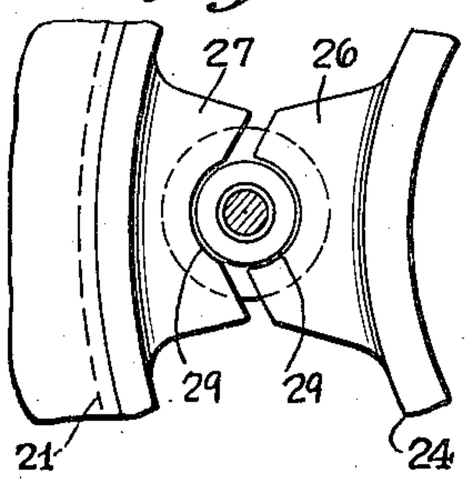
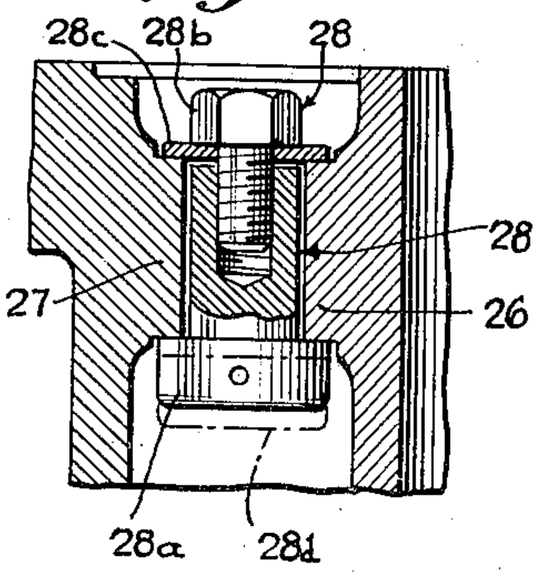


Fig. 7.



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FURNACE SHAFT CONSTRUCTION

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Application January 6, 1948, Serial No. 772

8 Claims. (Cl. 263—25)

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This invention relates to roasting furnaces, and more particularly to the construction of rotatable hollow shafts used in such furnaces.

Roasting furnaces of this character customarily are composed of a plurality of superposed roasting hearths which are contained within a cylindrical housing and which are normally provided with a central rotatable hollow shaft having hollow rabble arms attached radially thereto. The shaft has an inner passage through which cooling air is circulated to inner passages in the rabble arms, returning through outer passages in the rabble arms to an outer passage within the shaft. Shafts as used heretofore in such constructions have been made in sections, each of which has comprised a single casting, including integrally the inner and outer tubular members thereof. These members usually are interconnected by means of a plurality of integral webs. This integral construction has various disadvantages, as will be pointed out hereinafter.

In accordance with the present invention, a construction is provided having a hollow rotatable shaft comprising separate inner and outer tubular members which, if desired, may be formed of dissimilar metals and which accomplish certain additional advantages, to appear more fully hereinafter.

Various other objects, features and advantages of our invention will be apparent from the detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the limits of the invention, reference for this latter purpose being had to the appended claims.

In the drawings:

Fig. 1 is a sectional front elevation of a typical portion of a roasting furnace of a type in which our invention can be used, the section being taken substantially along the vertical axis thereof;

Fig. 2 is a horizontal sectional view of a rotatable furnace shaft embodying our invention, the section being taken substantially on line 2—2 of Fig. 1;

Fig. 3 is an enlarged side elevation, in section with parts broken away, of the shaft shown in Fig. 2;

Fig. 4 is a fragmentary enlarged detailed view in section of two portions of an inner tubular section showing a severance of said portions and a seal therebetween;

Fig. 5 is an enlarged detailed top view of a pair of cooperating fingers and lugs upon the inner and outer shafts prior to forming same for the reception of a connecting member;

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Fig. 6 is a top view of the fingers shown in Fig. 5 with a connecting member shown in section therebetween; and

Fig. 7 is a side elevation, partly in section and with parts broken away, of the fingers and connecting member shown in Fig. 6.

In the furnace shown in Fig. 1, a plurality of vertically spaced and substantially circular hearths are provided as at 10, 11 and 12. These hearths are surrounded and supported in a conventional manner by a substantially cylindrical furnace wall 13. A rotatable shaft 14 is mounted vertically at the center of the hearths. To the shaft are attached a plurality of rabble arms 15*a*, 15*b*, 15*c* and 15*d* having attached thereto depending teeth 16 so mounted as gradually to move the charge radially of the hearths as the rabble arms slowly rotate.

Shaft 14 normally consists of a plurality of superposed tubular members, each having an outer tubular section and an inner tubular section, the latter conducting cooling air to the rabble arms as above mentioned. It is, of course, possible to employ only a single tubular member.

A charge to be roasted is introduced into the furnace at its top, passing successively downward under the influence of gravity and the pushing of the rabble arms through a central opening to hearth 11, thence through peripheral openings 18 to hearth 12 and then out the central opening 19 to similar lower hearths or to a final passage.

The structure and operation thus far described are old in the art, being shown, for example, in the patent to Dudley Baird No. 1,669,925, issued May 15, 1928.

In the operation of this type of furnace, it has been found that under high temperature conditions parts of the central shaft sometimes are fractured. This is due usually to unequal expansion of such parts. The region of the furnace about the outer surface of the shaft reaches high temperatures and the outer tubular sections expand both longitudinally and circumferentially. The inner tubular sections on the other hand are cooled more than said outer sections by the air circulating therein and do not reach the same high temperature. This temperature differential results in an expansion differential wherein the outer tubular sections lengthen relative to said inner sections. This places the connecting ribs or webs under high stress, sometimes to such an extent as to produce a fracture thereof or a frac-

ture of either the inner or outer tubular sections adjacent the juncture of the ribs therewith. Replacement of the shafts in prior construction has entailed considerable inconvenience and loss due to the shutting down of the furnace, and due to the fact that entire tubular members in many cases have to be replaced. Thus the fracture of a rib usually results in an item of substantial cost.

Moreover, the radially extending rabble arms are supported jointly by the inner and outer tubular sections. Thus a fracture of ribs results in a weakening of the support for the rabble arms and may cause them to twist relative to the supporting shaft due to loss of support of said inner members and due to the resistance of the material which is moved by said arms. Thus a twisting of the inner shaft may occur relative to the outer shaft. This twisting may be communicated to the unfractured ribs and damage them also.

Turning now to the novel features of our invention, Figs. 2 and 3 indicate that we have constructed the shaft **14** of separate parts which are associated in a novel manner. Outer tubular sections are shown as at **20, 21** and **22**. Corresponding inner tubular sections are shown as at **23, 24** and **25**.

As above mentioned, each outer tubular section, such as **21**, will lengthen appreciably under the influence of heat by an amount greater than the lengthening of each cooler inner tubular section, such as **24**. The same is true concerning radial or diametric expansion. The latter is also sometimes referred to as circumferential expansion. This expansion differential, in structures having integral ribs, has affected not only the ribs interconnecting the inner and outer sections but also has affected the alignment of the rabble arms. Referring to Fig. 1, it will be seen that when an outer tubular section of the central shaft lengthens relative to an inner tubular section, the rabble arms, for example, **15***a* and **15***c*, will be misaligned as by spreading apart whereby the proper clearances relative to the hearths will be destroyed. Referring to Fig. 3, novel means are provided for compensating for the longitudinally greater expansion of each outer tubular section as compared to each inner tubular section. Consider, for example, the novel structure for associating one inner tubular section **24** with one corresponding outer tubular section **21**. The novel structure is constituted by a group of outwardly extending fingers **26** (Figs. 2 and 3) which are secured to the inner tubular section **24** and which protrude radially therefrom. The fingers or lugs **26** preferably are formed integral with said inner tubular section. Cooperating with the group of fingers **26** is a group of fingers **27** inwardly extending from the inner surface of the outer tubular section **21**. This group is equal in number to fingers **26**. The two co-acting fingers **26, 27**, comprising each pair, are held in radial alignment and clamped tightly together, for example, by means of a stud and bolt device **28** as shown in detail in Fig. 7. This device comprises a stud **28***a* having a head which is adapted jointly to engage surfaces of the fingers **26, 27**, and which cooperates with a bolt **28***b*. A suitable washer **28***c* can be used with bolt **28***b* to engage opposite surfaces of fingers **26, 27**. The bore through which the shank of the stud **28***a* extends is formed preferably as shown in Fig. 6. As indicated in Fig. 5, the finger **26** is originally formed with a pointed extremity which extends into a corresponding recess originally formed in the finger **27**. However, the adjacent faces of these fingers are in spaced relationship. A joint bore is formed as at **29** in the cooperating fingers.

It is preferable to form the joint bore **29** by a drilling operation. However, this bore can be formed in the casting. The shank of the stud **28***a* preferably is of slightly less diameter than the diameter of the joint bore **29** in order to permit, if necessary, diametric expansion of the inner tubular section.

The connecting member **28** for associating the cooperating fingers **26, 27**, of course, can be in any suitable form, the stud and bolt device being only one structure for this purpose. Each finger connecting member holds each cooperating pair of fingers against relative longitudinal and angular movement but not against relative radial movement caused by expansion.

It has been found desirable to locate the cooperating sets of lugs adjacent the extremities of the inner and outer tubular sections. One of the reasons for this is to provide easy accessibility thereto for purposes of machining castings and for ease of assembly and disassembly. Thus a second group of outwardly extending lugs **30** is formed at the opposite extremity of the inner tubular section **24**, which group cooperates with an equal number of inwardly extending lugs **31** upon the outer section.

In view of the fact that the cooperating fingers upon the tubular sections are locked against relative axial or longitudinal movement by virtue of their clamping or connecting members, it is desirable to sever the inner tubular section preferably at the mid-point thereof as at **24***a* (Figs. 3 and 4). The severance or weakening line **24***a* preferably is cast in each inner section to facilitate the subdivision thereof into two subsections. The fracture normally is made as by a hammer and chisel prior to assembly of the shaft. However, it is possible to allow the fracture to occur automatically when the shaft and furnace are in operation. Thus when the outer tubular section **21** becomes greater in length than the inner tubular section **24**, the two halves of the latter will separate. Thus after fracture at **24***a* there will be no resistance by the inner section to the expansion of the outer section. A seal is provided at the point of fracture of said inner section **24** by means of, for example, a metal ring member or collar **32** preferably of a resilient nature which tends to expand to seal the fracture as indicated in Fig. 4, whereby the air flowing through section **24** will not escape. The ring member **32** is sometimes referred to as the expansion ring and preferably fits within a suitable internal groove **33** formed upon the inner surface of the tubular section **24**. Such an expansion ring can be easily moved into position in a contracted condition. When released, it will expand into said groove and into a desired sealing position.

The rabble arms, such as **15***a*, **15***c*, are disposed near the extremities of the tubular sections **21, 24** and therefore near the cooperating groups of fingers or lugs **26, 27** and **30, 31**, respectively. Because of their proximity to their respective groups of cooperating fingers, no appreciable expansion differential can occur which will misalign said arms. That is, the distance between rabble arms **15***a* and the cooperating fingers **26, 27** is sufficiently small so that any expansion differential between tubular sections **21** and **24** will not disturb the alignment of said arms relative to arms **15***c* to an undesirable degree.

The association of the inner tubular sections

23 and 25 with their respective outer tubular sections 20 and 22 is effected by means identical to those described for tubular sections 21 and 24. For example, section 22, by means of fingers 34 thereon, is associated with section 25 upon which fingers 35 are formed. Each inner section is provided with a severance line analogous to 24*a*. The outer tubular sections are joined together as shown in Fig. 3 by means of external flange portions through which suitable fastening means extend. For example, outer tubular section 21 is secured to outer tubular section 22 by means of bolts 36 which extend through flanges 21*a* and 22*a*.

A satisfactory gas seal is obtained between abutting inner sections 24 and 25 by virtue of the fastened flanges 21*a*, 22*a* and by virtue of the proximity of fingers 26, 27 and 34, 35.

In operation, when the furnace shaft is heated within the furnace, the outer tubular sections will be heated to a greater extent than the inner tubular sections and hence will expand both radially and longitudinally to a greater extent than the inner tubular sections. The relatively greater radial expansion is accommodated by virtue of the fact that the fingers on the outer sections can move radially away from the fingers on the inner sections. And the relatively greater longitudinal expansion is accommodated by the axial separation of each inner tubular section into two subsections.

Instead of locking the opposite extremities of corresponding inner and outer tubular sections against relative longitudinal movement and splitting the inner tubular section as at 24*a*, it is desirable under some circumstances to clamp together only one extremity of corresponding inner and outer tubular sections and to employ at the opposite extremity a stud and shank arrangement as indicated in broken lines in Fig. 7 which will so associate the cooperating fingers that relative rotation will be prevented but some relative longitudinal motion can occur. Such a stud and bolt device is indicated at 28*d* and differs from the one originally described in that the shank or the stud is longer than that of stud 28*a*. If the inner and outer tubular sections are associated in this manner, it is desirable for each such section to have but one set of rabble arms thereupon and this set preferably should be mounted adjacent the tightly held extremities of said sections, namely, in proximity to the extremity which is locked against relative axial movement.

There are thus provided novel means for associating the inner and outer tubular sections of a rotatable furnace shaft. The means are very simple in construction and are inexpensive to manufacture and rugged in construction. The novel means eliminates almost entirely the possibility of furnace breakdown due to fracture of ribs or fingers which interconnect said inner and outer tubular sections. Moreover, it assures the maintenance of a proper alignment between rabble arms mounted on the shaft and enables the inner tubular sections to provide a driving torque to the rabble arms without the disadvantages which normally accompany an expansion differential between inner and outer tubular sections. The connecting members for holding in radial alignment cooperating fingers upon said sections insure the transmittal of a proper torque to the inner tubular sections whereby relative angular movement therebetween is prevented.

Although the invention has been described in

connection with certain preferred examples, it is to be expressly understood that the invention is not limited thereto. For example, instead of forming a severance line as at 24*a* upon each inner tubular section, it is possible originally to form each inner section in two separate subsections.

In the copending application of Charles W. Nichols Ser. No. 651,537, filed March 2, 1946, certain alternative constructions are disclosed and certain features of the present invention are claimed.

It will be understood by those skilled in the art, after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and is desired to be secured by Letters Patent is:

1. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft comprising an inner shaft, a plurality of outwardly extending lugs secured to said inner shaft, an outer surrounding shaft having inner wall surfaces spaced from said inner shaft, a like plurality of inwardly extending lugs secured to the inner wall surfaces of said outer shaft, and a like plurality of members for connecting corresponding lugs upon said inner and outer shafts for holding same in radial alignment.

2. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner shaft, a plurality of outwardly extending fingers secured to said inner shaft adjacent each extremity thereof, an outer surrounding shaft having the inner wall surfaces thereof spaced from said inner shaft, a like plurality of inwardly extending fingers secured to the inner wall surfaces of said outer shaft adjacent the extremities thereof, and a like plurality of finger interconnecting members for holding in alignment corresponding fingers upon said inner and outer shafts, said inner shaft being formed into two subsections intermediate the extremities thereof.

3. In apparatus of the class described, an inner tubular member, a plurality of outwardly extending fingers secured to said member, an outer tubular member surrounding said inner member, a like plurality of inwardly extending fingers secured to the inner surface of said outer member, and mechanism for holding in alignment corresponding fingers upon said inner and outer members.

4. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner tubular member, a plurality of outwardly extending fingers secured to said member near each extremity thereof, an outer surrounding tubular member having inner wall surfaces spaced from said inner tubular member, a like plurality of inwardly extending fingers secured to said inner wall surfaces near the extremities of said outer tubular member, a like plurality of members for holding corresponding fingers upon said inner and outer tubular members in radial alignment, each of said inner tubular members being separated into two separate sub-sections intermediate the extremities thereof, said sub-sections being in abutting relation when there is no expansion differential between said inner and outer members but being subject to separation in response to a greater

expansion of said outer member relative to said inner member, and a ring member mounted between said sections for sealing the region of separation therebetween.

5. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner tubular section, a plurality of outwardly extending fingers secured to said section near each extremity thereof, an outer surrounding tubular section having inner wall surfaces spaced from said inner tubular section, a like plurality of inwardly extending fingers secured to said inner wall surfaces near the extremities of said outer tubular section, and a like plurality of members for holding corresponding fingers upon said inner and outer sections in radial alignment, said inner tubular member being separated into two separate sections intermediate the extremities thereof.

6. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner tubular section, a plurality of outwardly extending lugs secured to said section, an outer surrounding tubular section having the inner wall surfaces thereof spaced from the inner tubular section, a like plurality of inwardly extending lugs secured to the inner wall surfaces of said outer tubular section, and a like plurality of lug connecting members for holding each lug upon one section in cooperation with a corresponding lug upon the outer section, each connecting member being constructed and arranged to hold each pair of cooperating lugs against relative longitudinal and angular displacement.

7. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner shaft formed of tubular sections, a plurality of outwardly extending lugs secured to said sections near each extremity thereof, an outer surrounding shaft also formed of tubular sections having their inner wall surfaces spaced from said inner shaft sections, a like plurality of inwardly extending lugs secured to the inner wall surfaces of said outer surrounding tubular sections, a like plurality of clamp members for clamping in alignment corresponding lugs upon said inner and outer tubular sections, means for securing together adjacent ends of said outer tubular sections, each of said inner tubular sections having a frangible portion formed circumferentially and intermediate the extremities thereof, and an expansible sealing ring mounted internally of each inner tubular section in alignment with each frangible portion.

8. A combination of parts for use in a furnace of a type having rabble arms carried by a central shaft, comprising an inner shaft formed of tubular sections, a plurality of outwardly extending lugs secured to said sections near each extremity thereof, an outer surrounding shaft also formed of tubular sections having their inner wall surfaces spaced from said inner shaft sections, a like plurality of inwardly extending lugs secured to the inner wall surfaces of said outer surrounding tubular sections, a like plurality of lug interconnecting members for holding in alignment corresponding lugs upon said inner and outer tubular sections, and means for securing together adjacent ends of said outer tubular sections.

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