

Oct. 7, 1941.

S. K. WELLMAN

2,258,431

HEAT TREATING FURNACE

Filed July 1, 1939

4 Sheets-Sheet 1

Fig.3

Fig.2

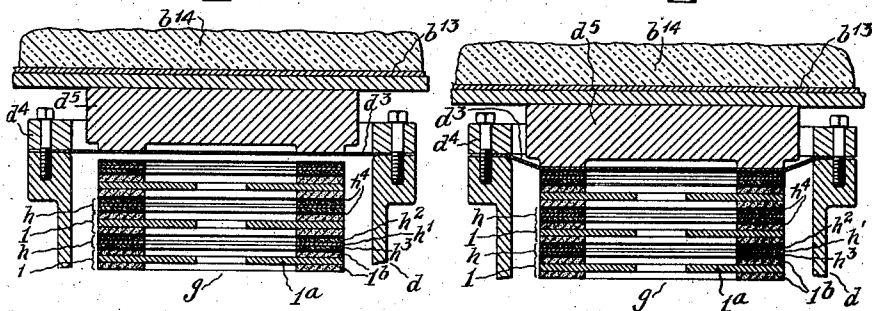
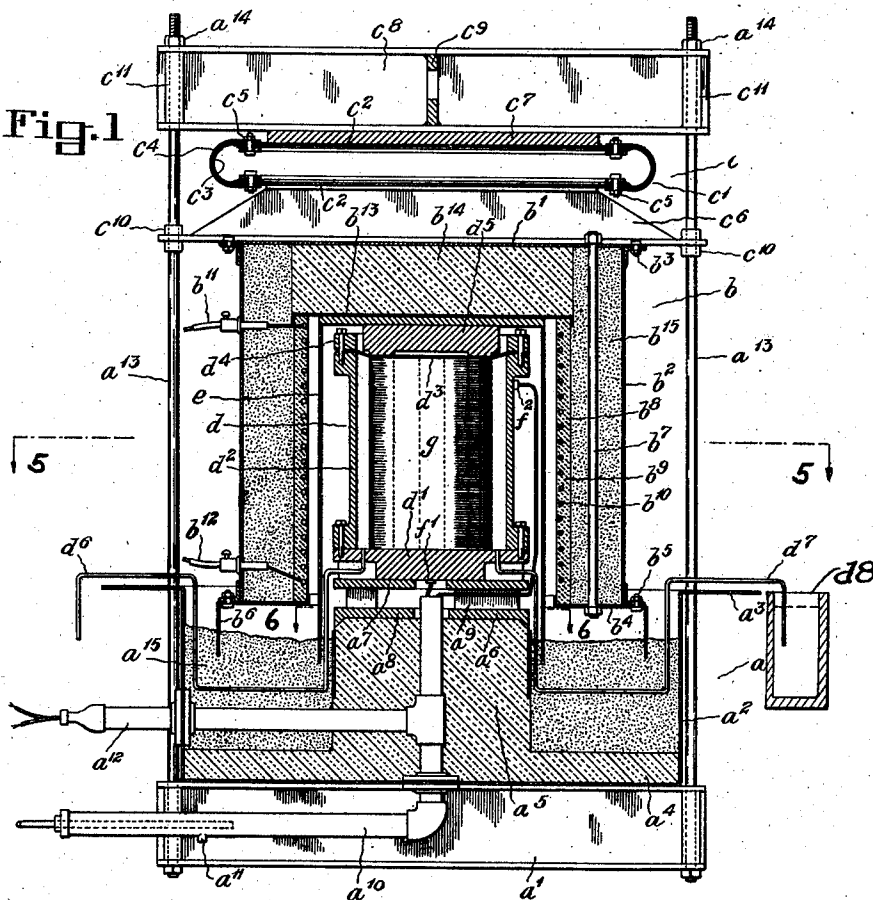


Fig. 1



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4 Sheets-Sheet 2

Fig. 4.

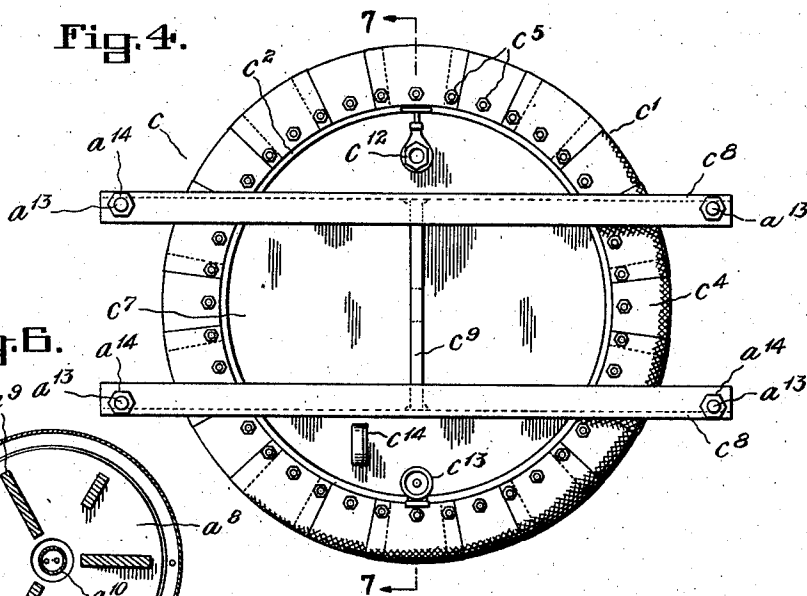


Fig. 6.

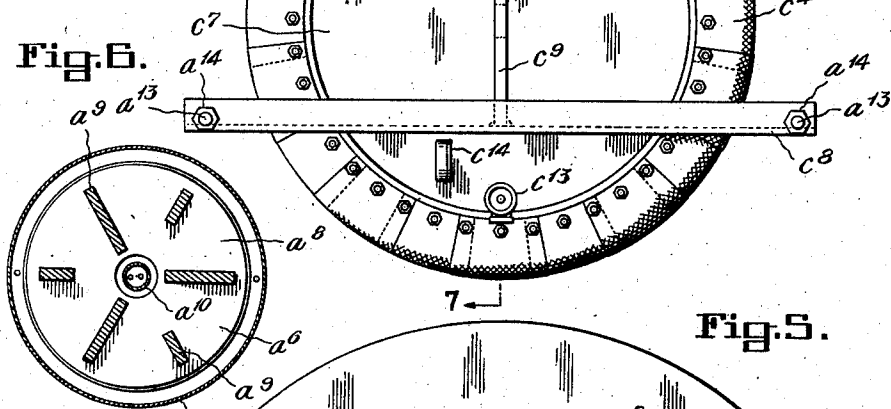
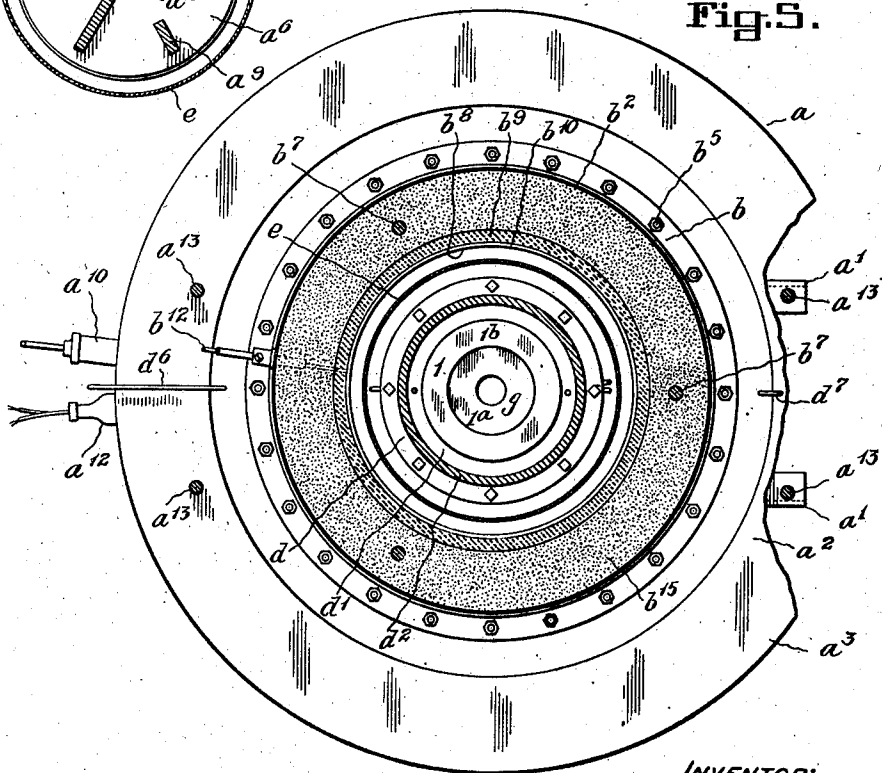


Fig.5.



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4 Sheets-Sheet 3

Fig 7.

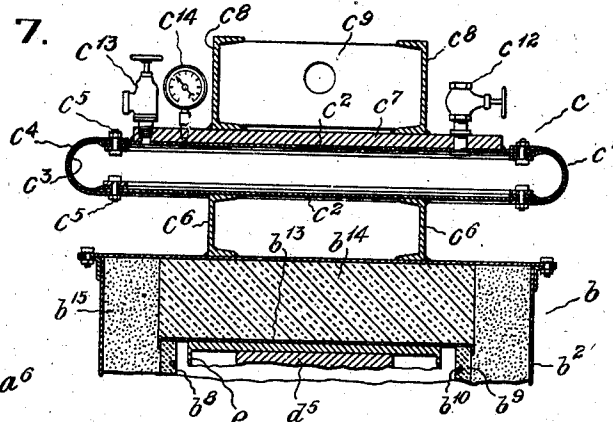


Fig 9.

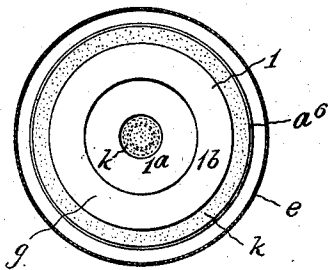
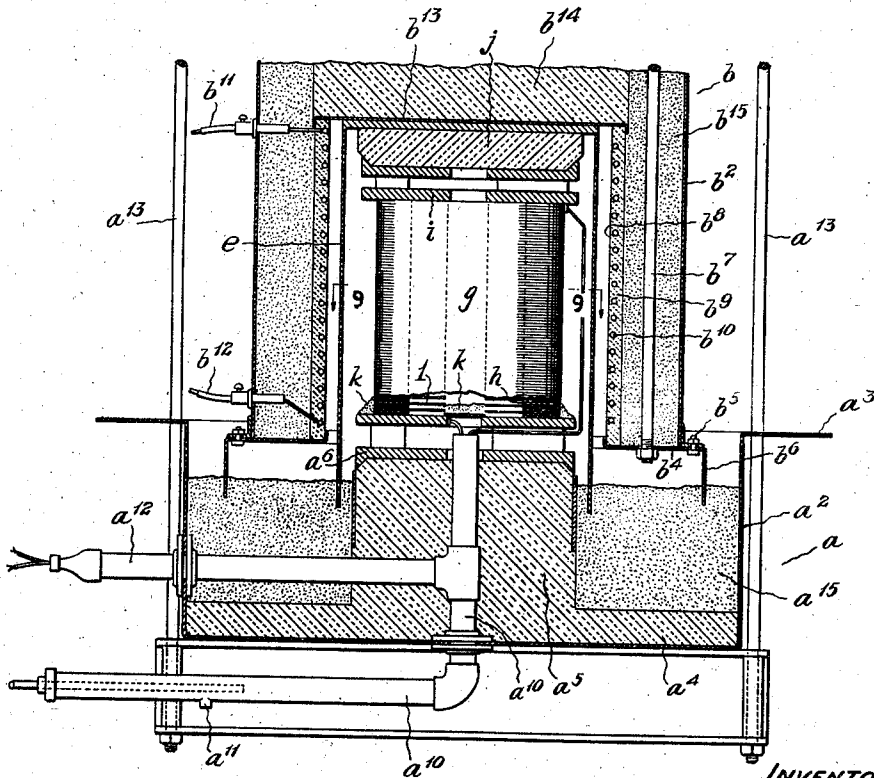


Fig 8.



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4 Sheets-Sheet 4

Fig. 11.

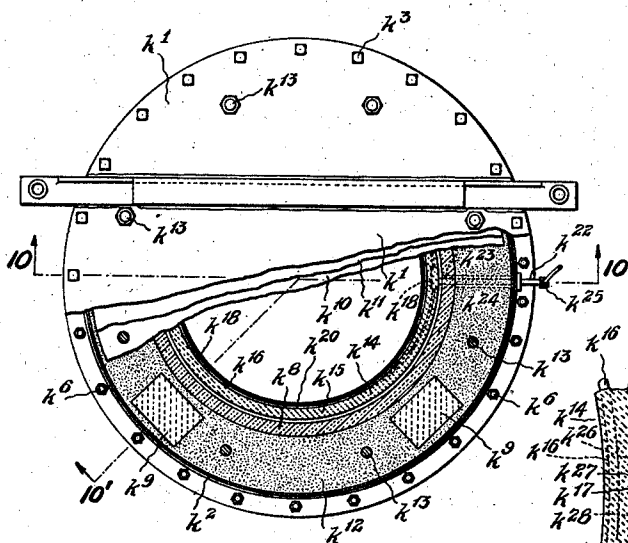


Fig. 14.

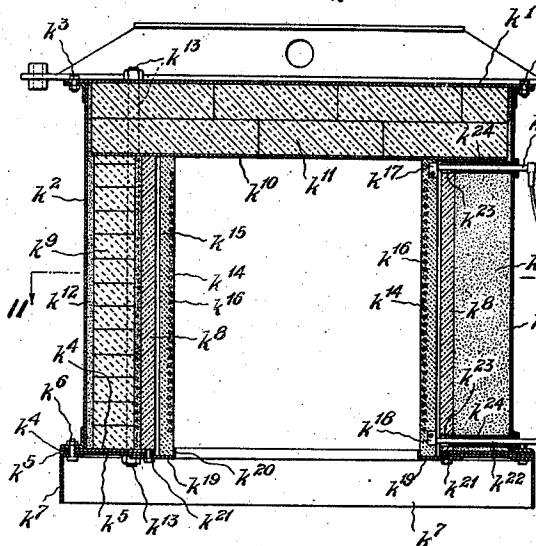
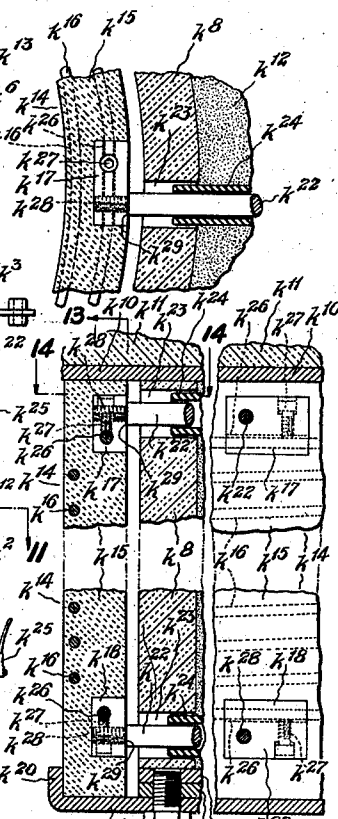


Fig. 10.

Fig. 12.

Fig. 13.

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UNITED STATES PATENT OFFICE

2,258,431

HEAT TREATING FURNACE

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Application July 1, 1939, Serial No. 282,344

12 Claims. (Cl. 266—5)

This invention relates to heat treating apparatus and particularly to furnace apparatus suitable for welding together the parts of composite metallic articles.

The present application constitutes a continuation in part of my earlier application Serial No. 210,651, filed May 28, 1938, upon which Patent No. 2,178,527 was granted October 31, 1939, and in which I have disclosed my improved apparatus as adapted for the heat treatment of composite machine elements for friction clutches, friction brakes, bearings and other devices in which one element slidably engages another element or body, the particular machine elements referred to each having a backing member of ferrous metal and welded thereto a facing member of compressed powdered material consisting predominantly of relatively high-melting-point metal such as copper or iron. Accordingly, in the present application my improved apparatus is described as applied to the production of such machine elements and specifically friction clutch disks or plates.

One of the objects of the present invention is the provision of a heat treating furnace adapted to subject the work during treatment to pressure which is controllable at will.

Another object of the invention is the provision of an electrically heated furnace of simple and rugged construction in which the work under treatment can be effectively subjected to selected atmospheres.

A further object of the invention is the provision of a heat treating furnace adapted to subject the work during treatment to pressure and having an effective air seal between the main walls of the furnace and the work under treatment.

Another object of the invention is the provision of a furnace having a chamber for the work to be treated, a second chamber surrounding the work chamber and means for introducing selected atmospheres into the respective chambers.

Still another object of the invention is the provision of improved work separators for the furnace whereby a plurality of composite elements to be treated can be stacked up with separators interposed between them and subjected to simultaneous pressure and heating without danger of the different elements being bonded together.

With the above and other more or less ancillary objects in view the invention consists in various novel combinations of parts and features of con-

struction which will be pointed out in the following description of specific furnaces shown in the accompanying drawings.

In the drawings,

Fig. 1 is a central vertical section of a sintering and welding furnace constructed in accordance with the present invention.

Fig. 2 is an enlarged fragmentary sectional view showing a portion of the structure shown in Fig. 1.

Fig. 3 is a view similar to Fig. 2 but showing the parts in their respective positions before pressure is applied to the work in the furnace.

Fig. 4 is a plan view of the upper part of the furnace shown in Fig. 1.

Fig. 5 is a horizontal sectional view on the line 5—5 of Fig. 1.

Fig. 6 is a horizontal section on the line 6—6 of Fig. 1.

Fig. 7 is a sectional view of the upper part of the furnace shown in Fig. 1, the section being taken on the line 7—7 of Fig. 4.

Fig. 8 is a central vertical sectional view of the furnace shown in Fig. 1 with some of its interior fittings modified to adapt the furnace for a modified form of heat treatment.

Fig. 9 is a horizontal sectional view taken on the line 9—9 of Fig. 8.

Fig. 10 is a vertical sectional view of a modified construction of the furnace cover or container shown in Figs. 1 to 9, inclusive, that portion of the figure above the metal plate *k*—1 being taken on the line 10—10 of Fig. 11 and the portion below plate *k*—1 being taken on the line 10'—10' of Fig. 11.

Fig. 11 is a plan view of the modified furnace cover construction shown in Fig. 10, with parts broken away to show a portion of the cover in section on the plane indicated by the line 11—11 of Fig. 10.

Fig. 12 is an enlarged fragmentary vertical sectional view of parts shown in Fig. 10.

Fig. 13 is a vertical sectional view on the line 13—13 of Fig. 12.

Fig. 14 is a horizontal sectional view taken on the line 14—14 of Fig. 12.

Referring in detail to the construction shown in Figs. 1 to 7, the furnace comprises a base structure designated as an entirety by the letter *a* and a cover or container structure designated as an entirety by the letter *b*. The base structure comprises a pair of underlying channel members *a*—1, *a*—1 upon which is mounted and secured (as by welding) a sheet steel tub or pan *a*—2 with the top of its side wall flanged outward at

a—3. The bottom of pan a—2 has a heat insulating lining a—4 which is formed with a central cylindrical upward extension a—5 designed to support the work in the furnace. Extension a—5 is covered by an iron casting a—6 which is cored out to form top and bottom plates a—7, a—8 connected by vertical webs a—9, thus providing passageways for the circulation of gases which may be introduced through pipe a—10. The horizontal branch of pipe a—10 is fitted with a downwardly opening nipple a—11, the purpose of which will later be explained. Branch pipe a—12 joined to the upright section of pipe a—10 serves as a conduit for thermocouple conductors, as will also later be explained.

The furnace cover structure b comprises an inverted cup-shape casing structure of sheet steel which consists of a circular top plate b—1, a cylindrical side wall b—2 attached to the top wall b—1 by bolts b—3, and annular bottom wall b—4 secured to side wall b—2 by bolts b—5 and having a depending flange or skirt b—6. This casing structure is strengthened by a plurality of tie rods or bolts b—7 joining top plate b—1 and bottom plate b—4. The cover structure b has its inner side wall formed by a tubular electric heating element b—8 which consists of a wall b—9 of refractory and heat insulating cement in which is embedded an electric helical heating coil b—10, the terminals of this coil being shown at b—11, b—12. The open top of heating element b—8 is closed by a sheet metal plate b—13 and the space between the latter and the top plate b—1 is filled with heat insulating material b—14. Also the space between side wall b—2 and heating element b—8 is filled with loose heat insulating material b—15.

For the purpose of applying downward pressure to the furnace cover, the latter is fitted with an air pressure device c which consists of an air chamber c—1 formed by top and bottom circular steel plates c—2, c—2 joined at their peripheries by a flexible rubber wall c—3 which may conveniently be formed from the inner tube of a pneumatic tire and which is reinforced by strips c—4 of heavy canvass, the edges of the circular plates c—2, the rubber wall c—3 and the canvass strips being hermetically joined as by bolts c—5. The air chamber c—1 rests upon and is secured, as by welding, to a pair of steel channels c—6, c—6 which are in turn welded to the top of the furnace cover (Fig. 7). To the top of the air chamber is welded a circular reinforcing plate c—7 on which in turn is welded a pair of channel members c—8. An apertured plate c—9 joins channels c—8 and a hoist may be attached to this plate c—9 to lift the furnace cover.

The base structure of the furnace carries a number of upstanding tie bolts or rods a—13 which slidably engage guides c—10 carried by channel members c—6 and guides c—11 carried by channels c—8. Thus, when the nuts a—14 of tie rods a—13 are screwed down on channels c—8 a top abutment is afforded for the air chamber c—1, enabling said chamber when inflated to subject the top of the furnace to downward pressure. The top plate of air chamber c—1 is provided with a valve-controlled air inlet c—12, also with an air relief valve c—13 and a pressure gauge c—14.

In the use of the furnace in carrying out the process or procedure last referred to, the work to be welded is enclosed within a tightly sealed metal chamber or container within the furnace. This inner sealed chamber is designated as an

entirety by the letter d and comprises a metal base d—1 (which in effect constitutes an upward extension of the central part of base a), a cylindrical side wall d—2 and a sheet metal top wall or diaphragm d—3. The side wall d—2 is tightly secured or sealed by bolts as shown to the base part d—1 and diaphragm d—3 is tightly secured to the side wall by a bolted ring d—4. A pressure block d—5 rests upon diaphragm d—3.

In order to provide for the maintenance of a current of suitable reducing gas through the sealed chamber d, the base plate d—1 is fitted with an inlet tube d—6 and an outlet tube d—7, said tubes being bent as shown in Fig. 1 to pass under the side wall of the furnace cover.

The sealed chamber d is provided with a protecting air seal in the form of an inverted cup-shape cover or container e of sheet metal, the top wall of this cover being interposed between the block d—5 and the top portion of the furnace cover b.

With the parts of the furnace assembled as shown in Fig. 1, the depending skirt b—6 of the furnace cover and the lower end of the air seal cover e are embedded in loose heat insulating material a—15 in the furnace base so as to prevent free access of air to the interior of the furnace chambers. In Fig. 1 thermocouples are shown at f—1 and f—2 in contact with the base and side wall, respectively, of the sealed chamber d, the conductors for these thermocouples being carried to the exterior of the furnace through pipes a—10 and a—12.

In Figs. 1, 2, 3 and 5 the work to be treated in the furnace is shown at g within the sealed chamber d and consists of a stack of composite clutch disks l, l together with suitably interposed separators h between the individual clutch disk assemblies, the separators serving to prevent the welding together of separate clutch disks or assemblies during the heat treatment.

Each of the clutch disks l, l comprises a disk proper 1a (Figs. 2 and 3) which is preferably formed of sheet steel, and two facing rings 1b, 1b which are formed of highly compressed and coherent powdered friction material of the character stated in the aforementioned application Serial No. 210,651 and consisting predominantly of high-melting-point metal such as copper or iron or mixtures of copper and iron and preferably also containing one or more additional metals with or without some solid, non-metallic material adapted to decrease or increase the coefficient of friction of the resulting mixture. For clutch and brake disks suitable for many uses a satisfactory composition is 73% copper, 14% lead, 7% tin, and 6% graphite. For friction clutches, there may also be used satisfactorily a composition consisting of 70.9% copper, 10.9% lead, 6.3% tin, 7.4% graphite and 4.5% air floated silica; also a composition consisting of 62% copper, 8% iron, 12% lead, 7% tin, 7% graphite and 4% silica.

Each of the separators h consists of a steel disk h—1 similar to the disks 1a, to which facings h—2 and h—3 of compressed and coherent powdered material which may be of the same character as the facings 1b of the clutch disks l, have previously been welded, together with a thin coating h—4 of graphite on the exposed face of each compressed powdered part, the graphite in practice being sprayed in colloidal state upon the separator to form, when dried, a thin even coating. These separators are remarkably strong and their faces formed by the porous facing

material, before they are coated with graphite, can be ground to accurate parallelism so that the parts of the individual clutch disk assemblies may be subjected to uniform pressure throughout their respective areas by the application of pressure to the top of the stack. Also, the porous character of the faces of the separators is adapted to give a very strong union between the facing material and the graphite coating, so that the separators as entireties are very durable.

The specific heat treatment to be carried out in the furnace in the case of the composite clutch disks is the welding of the porous facing members 1b of said disks to the steel disks or backing members 1a. As is explained in the aforesaid application Serial No. 210,651, the porous facing members tend to sorb gases and vapors capable of corroding ferrous metals and prior to my invention no one to my knowledge had succeeded in satisfactorily welding such facing members to ferrous metal backing members because the gases or vapors sorbed in the facing members were driven out during the welding operation against the ferrous metal of the backing member and oxidized or corroded the latter in a manner preventing the formation of a good weld or bond. The improved furnace, as shown in Figs. 1 to 7, is designed to overcome this difficulty by permitting the elimination of moisture or corrosive gases from the compressed powdered facing members in a manner preventing corrosion of the ferrous backing member, and thereafter effecting the welding together of the facing and backing members.

In the use of the furnace the facing members 1b, 1b, as assembled therein, may be either sintered or unsintered, but in the present description it is assumed that they have not previously been sintered. To carry out the procedure of eliminating moisture or gases from the porous facing members, the sintering of said members and the welding of said facing members to the steel backing members, the top of the cover or outer container of the furnace and the air seal structure e having first been lifted off the furnace base, the work to be treated is assembled in the chamber d and the latter closed by bolting on the top diaphragm d-3 thereof as shown in Fig. 3, a slight space preferably being left between the top of the stacked-up work and the diaphragm d-3. Alternatively the work can be stacked up on plate d-1 and the assembled side and top walls of chamber d can then be bolted to plate d-1. Next, the pressure block d-5 is applied, the air seal e is placed over the chamber d and the cover of the furnace is lowered into position over the furnace base so that the skirt b-6 is embedded in the loose insulation a-15 but with the furnace top or cover supported by the hoist. Under these conditions the stack of work is not subjected to pressure, except for the moderate weight of the work itself.

As heating of the work in the furnace is started a current of dry reducing gas, preferably hydrogen, is started flowing through inlet tube d-6 into the interior of the sealed chamber d and out from said chamber through tube d-7, outlet tube d-7 being controlled (by water seal d-8, for example) so as to regulate the flow and maintain a superatmospheric pressure in chamber d. At the same time that the flow of reducing gas is started through tube d-6, a supply of non-oxidizing gas, such as natural gas or the like, is admitted to pipe a-10, and a flame is

applied to ignite such gas as escapes through the nipple a-11 of the pipe, the flame at this point serving to indicate to the operator that the combustible gas is entering that part of the furnace chamber between the sealed chamber d and the air protecting seal e and maintaining a sufficient pressure to prevent infiltration of air. This is accomplished without subjecting the heating element b-8 of the furnace to the action of non-oxidizing or reducing gases.

The dry hydrogen introduced as aforesaid into chamber d diffuses therein, permeating the interstices between the assemblies of the stacked-up work, and serves, if its flow is sufficiently rapid, to absorb and carry out from the sealed chamber vapors and gases expelled from the pores of the facing material substantially as rapidly as they are expelled by the heat of the furnace. Accordingly, as the furnace is heated up to the welding temperature any moisture and gases driven out of the porous facing members is prevented from having corrosive action upon the surfaces of the ferrous backing members. As the temperature of the furnace is gradually increased and reaches a value of 1200° to 1300° F., sintering of the compressed powdered facings is effected. With further heating, the welding temperature lying in the range of 1350° to 1500° F. is reached, the hoist supporting the top of the furnace is eased off, nuts a-14 are applied to the tie rods a-13 and the pressure device c-1 is inflated to apply downward pressure to the furnace top b. This pressure causes the pressure block d-5 to force diaphragm d-3 downward, as shown in Figs. 1 and 2, against the stack of work and apply sufficient pressure thereto to insure firm contact between the compressed powdered facings and the clutch disks throughout the entire extent of their contiguous surfaces and thus effect the desired weld between the parts.

When the weld has been effected by the application of pressure as above described, the top of the furnace is lifted off and, with the protective air seal e remaining in position, the parts of the furnace, including the sealed chamber d, and the welded work are allowed to cool, the pressure of the hydrogen in the sealed chamber d and of the natural gas in the space surrounding the chamber d being meanwhile kept slightly above atmospheric pressure until the chamber d and the work therein have reached a sufficiently low temperature to prevent oxidation in contact with the air, whereupon the protective seal e can be removed and the chamber d further cooled to permit it to be opened for the removal of the work.

Usually the relatively thin steel disk or diaphragm d-3 is so distorted by the application of pressure to the furnace top that it is desirable to provide a fresh diaphragm for each operation of the furnace. Also, the protective seal e tends to deteriorate relatively rapidly because it is necessarily exposed to the air at high temperature. However, it is relatively inexpensive and its occasional renewal is not a serious matter.

Another way in which the ferrous backing member of the clutch disk can be effectively protected from corroding or oxidizing action of moisture or gases sorbed in the facing and successful welding of the porous facing directly to the backing member be attained consists in applying to the cleaned surface of the backing member a film of a suitable material capable of protecting the backing member from the corroding or oxidizing action without interfering with

the formation of a direct weld between the ferrous backing member and the predominant high-melting-point metal or metals of the facing member. Such a protecting film can be formed by the electric deposition of suitable metals on the backing member. A coating of copper is suitable where the predominant high-melting-point metal of the facing consists entirely of copper, while a coating of nickel is suitable where the predominant high-melting-point metal of the facing member includes a substantial percentage of iron powder. Such a coating of nickel is preferably applied over a thin plating of copper on the ferrous backing member, in accordance with usual nickel plating practice.

In the use of the protective metal coating, the assembled electroplated backing members and compressed facing members may be welded in a furnace of the type shown in Figs. 1 to 7, though with the use of the coated backing members the inner diaphragm chamber of the furnace becomes unnecessary. In Figs. 8 and 9 the modified furnace is shown with a charge therein of the assembled coated backing members and facing members, together with separators of the character already described.

With the omission of the sealed inner chamber *d* the stack of work to be welded is placed directly upon the base casting *a-6* while a similar cored out casting *i* is placed upon the top of the stack of work and on casting *i* in turn is placed a block *j* of heat insulating refractory material to be engaged by the top of the air sealing structure *e* of the furnace.

The welding operation, or combined sintering and welding operation, is carried out as follows. With the furnace top removed, the work to be welded is placed upon the base casting *a-6* of the furnace, charcoal is placed on the casting *a-6* around the work as indicated at *k*, the protective structure *e* is placed over the work, the furnace top is lowered into position and the air pressure device inflated to apply sufficient pressure to the elements to be welded to insure their firm mutual contact. Thereupon heating of the furnace is started and as its temperature rises air initially in the furnace oxidizes the charcoal at *k* to form carbon monoxide which fills the furnace chamber. Meanwhile pipe *a-10* can be opened to the supply of natural gas which, as in the last described procedure, prevents entrance of air into the furnace while it is cooling.

As the temperature of the furnace is raised any moisture or oxidizing or corroding gases sorbed in the compressed powdered facings will be driven out by the time the temperature has reached about 750° F. but the thin coating of copper or nickel on the ferrous backing members protects the latter from oxidizing or corroding action by these vapors or gases.

When the temperature of the furnace rises into the range of 1200° to 1300° F. sintering of the compressed powdered facing is effected and with further rise of the temperature within the range of 1350°-1500° F. the facings become welded to the steel clutch plates. Thereupon the furnace top is removed, the air seal *e* being meanwhile left in position until the work has had time to cool and the supply of reducing gas also being maintained through the pipe *a-10* meanwhile to prevent infiltration of air to the work while it is cooling.

With respect to the welding procedures which have been described above it may be observed that if iron constitutes a large part of the high-

melting-point metal of the powdered facing material, higher temperatures than those given above may be required to effect sintering and welding, particularly where carbon monoxide is used as reducing gas in the furnace.

In Figs. 10 to 14, inclusive, is shown a modification of the outer cover or container structure of the furnace housing. In this modification the side wall of the cover or container has the tubular heating coil separably mounted so that it can readily be replaced without the necessity of dismantling or tearing down the entire furnace. According to this construction, the cover consists of a circular top plate *k-1*, a cylindrical metal side wall *k-2* attached to the top plate *k-1* by means of bolts *k-3*, an annular bottom wall composed of a pair of metal rings *k-4* and *k-5* secured to side wall *k-2* by bolts *k-6*, and having a depending flange or skirt *k-7*. Ring *k-4* may be composed of any convenient ferrous metal, while ring *k-5* should preferably be composed of heat resisting steel of the stainless type. A tubular retaining wall *k-8*, preferably of refractory material, is disposed concentrically on ring *k-4*, the retaining wall having about the same inner diameter as that of ring *k-4*. A plurality of brick columns *k-9*, *k-9* are disposed on ring *k-4* between retaining wall *k-8* and side wall *k-2* and are spaced approximately uniformly apart. These columns extend upwardly to the top of the retaining wall *k-8* and serve to support a heat resistant metal plate *k-10* which in turn supports rigid refractory heat insulating material *k-11* disposed thereon to fill the space between plate *k-10* and top plate *k-1*. Loose heat insulating material *k-12* fills the remaining space bounded by bottom wall *k-4*, side wall *k-2*, retaining wall *k-8*, and top plate *k-1*. A plurality of tie rods *k-13* extend between the top plate and bottom rings, each having nuts threadably engaged with opposite ends and adapted to be tightened against top plate *k-1* and bottom ring *k-5* so as to draw the whole structure tightly together, thereby making a rigid, self-sustaining unit yet not placing any substantial endwise pressure on retaining wall *k-8*. By avoiding such pressure on the retaining wall, bulging and distortion of the wall are also avoided when it is heated up to the high temperatures attained in the furnace.

The rigid unit thus produced acts as insulation and support for a replaceable inner wall and heating element *k-14*, which is formed in the shape of a tube having an outer diameter slightly smaller than the inner diameter of retaining wall *k-8*. The tubular member is thus adapted to be slipped inside the retaining wall. The tubular structure consists of a body *k-15* of rigid refractory heat insulating material in which is embedded an electric heating coil *k-16* terminating in connector blocks *k-17* and *k-18*. These latter blocks will be described more fully below. The tubular structure is supported by means of a ring *k-19* having an upturned flange *k-20* around its inner periphery, the flange being adapted to extend within the tube and hold it in concentric alignment with the retaining wall. The flanged ring *k-19* is secured to bottom rings *k-4* and *k-5* by means of screws *k-21*, *k-21*. Electrical connections are made with the heating coil by means of rods *k-22* which extend through insulating bushings *k-24*, *k-24*, which pass through side wall *k-2*, insulating material *k-12*, and holes *k-23* in retaining wall *k-8*. Rods *k-22* are reduced in diam-

eter and threaded at their inner ends and are adapted to be screwed into terminal blocks *k*-17 and *k*-18. Leads to an electric circuit may be connected to their outer ends by means of clips or clamps *k*-25.

The structure of blocks *k*-17 and *k*-18 will be understood more fully through reference to Figs. 12, 13 and 14. They consist of solid blocks of heat resisting metal, such as stainless steel, which are about half as thick as wall *k*-15, and are embedded in the wall adjacent opposite ends of a longitudinal element thereof with their outer faces approximately flush with the outer surface of wall *k*-15. Each block has a longitudinal hole *k*-26 extending therethrough near the bottom of top block *k*-17 and near the top of bottom block *k*-18, the hole being large enough to receive the resistance wire forming coil *k*-16. Set screws *k*-27 are threaded into the blocks so as to intersect holes *k*-26 and serve to clamp resistance wire *k*-16 therein. A threaded hole *k*-28 extends inwardly from the exposed face of each block and is adapted to receive the threaded end of rod *k*-22. It will be understood that in making electrical connections with the blocks, the rod *k*-22 is threaded into hole *k*-28 so as to bring the shoulder *k*-29 into contact with the face of the block. In this way a sound connection is made without depending entirely upon the threads to make a good electrical contact.

It will be seen that the furnace cover or container as constructed according to the foregoing modification permits the heating element to be removed and replaced whenever necessary with a minimum of delay, while also avoiding the expense involved in rebuilding the insulating structure each time that a new element is installed. For example, in the replacement it is merely necessary to unscrew rods *k*-22 and pull them backward out of blocks *k*-17 and *k*-18. Screws *k*-21 are then removed, whereupon flanged ring *k*-19 and the wall section *k*-14 may be lowered away from the rest of the cover. The new wall section and heating element may then be inserted and flanged ring *k*-19 replaced and fastened in with screws *k*-21, after which rods *k*-22 are reinserted and screwed down tight against the blocks *k*-17 and *k*-18.

It will be seen that in each of the illustrated forms of the improved heat treating furnace the apparatus comprises a base structure adapted to support the work to be treated and a housing structure to enclose the stacked-up work, the housing means in each instance comprising one or more covers or containers having an upper end wall to be disposed above the top of the work and adapted to transmit downward pressure thereto and a side wall connected to and extending downward from the end wall to surround the work. In the form of furnace shown in Figs. 1 to 7 the furnace includes two such containers, namely, the inner container *d* and the outer bell or inverted cup-shape container, while in the construction shown in Fig. 8 only the outer bell-shaped container is provided. In each form of construction, however, I prefer to provide also the inverted cup-shape air seal which also can be considered as such a container.

While in most instances the furnace is provided with special means for forcing the outer container downward to exert pressure upon the stack of articles being treated, the weight of the furnace container or containers, with or without the placing of additional weights on top of the furnace

cover, may exert sufficient pressure on the work. This, of course, is more likely to be the case when the innermost container *d* is not used.

While the forms of construction which have been shown and described are such as are preferred, it should be understood that various modifications of the constructions disclosed may be made within the bounds of the invention as defined in the appended claims.

What I claim is:

1. In a heat treating furnace, the combination of means for supporting an upright stack of plate-like articles to be treated; housing means comprising a base structure and a rigid, unitary, bell-like cover having a top wall and a side wall depending therefrom, the said top and side walls in the operation of the furnace being respectively disposed above and laterally around the stack of articles under treatment; sealing means cooperating with the cover side wall and the base structure to prevent free escape of gas from the interior of the housing, said sealing means being constructed and arranged to permit the said cover to be raised away from the base structure; means carried by the said cover for heating the chamber enclosed by the cover; and fluid pressure means operable at will for compressing the stack of articles under treatment between the support thereof and the top wall of the said cover with a variable pressure in excess of the weight of the said cover and parts sustained by it.

2. A furnace as claimed in claim 1 in which the base structure of the housing has a central elevated table constituting the support for the plate-like articles.

3. A furnace as claimed in claim 1 in which a portion of the base structure of the housing constitutes the support for the plate-like articles and the fluid pressure means is constructed and arranged to apply downward pressure to the top wall of the housing cover to effect the compression of the plate-like articles.

4. A furnace as claimed in claim 1 in which a portion of the base structure of the housing constitutes the support for the plate-like articles and the fluid pressure means is constructed and arranged to apply downward pressure to the top wall of the housing cover and comprises a frame structure attached to the base structure of the housing to form an abutment overlying the top wall of the housing cover to take the reaction of the pressure means.

5. A furnace as claimed in claim 1 in which the housing cover comprises a top wall section of refractory material and a side wall section of refractory material and the heating means of the furnace comprises an electrical conductor embedded in the refractory material of the said side wall.

6. A furnace as claimed in claim 1 in which the top wall of the housing cover is substantially rigid under pressure transmitted between its outer surface and its inner surface and comprises outer and inner metal sections and an intermediate section of refractory material, the side wall of the said cover has a tubular inner section of rigid refractory material, a tubular outer section of metal, an annular bottom metal section and loose refractory material between the said inner and outer sections, and the heating means of the furnace comprises a helical electrical conductor embedded in the inner side wall section of rigid refractory material.

7. A furnace as claimed in claim 1 in which the side wall of the housing cover comprises a tubu-

lar inner section of rigid refractory material and means for disengageably securing said inner section to the cover structure so it can be removed as a unit without tearing down the cover structure, and the heating means of the furnace comprises an electrical conductor embedded in the said inner section and terminal conductors supported by the cover and disengageably secured to the embedded conductor to facilitate removal of said tubular inner section.

8. A furnace as claimed in claim 1 in which the housing cover has a substantially rigid top wall and a tubular side wall having a tubular inner section of rigid refractory material, a tubular outer section of metal, an annular bottom section of metal, a plurality of pillars of refractory material extending between the top wall and the bottom section of the side wall, and a plurality of tie rods disposed between the inner and outer sections of the side wall and connecting the top wall and the bottom section of the side wall to bind the parts of the cover together.

9. A furnace as claimed in claim 1 in which the housing means includes in addition to the cover an air seal of bell-like shape having the upper side of its end wall shaped to conform to and engage the under side of the cover end wall and the lower part of its side wall engaging the sealing means so that the air seal encloses the stack of articles to be treated and serves following heat treatment when the cover is raised off the base to prevent access of air to said articles while the latter are cooling.

10. A furnace as claimed in claim 1 in which the housing means includes a container disposed

within the bell-like cover and having a side wall supported on the base structure and a top end wall with a part thereof supporting the cover and movable downward with said cover to apply pressure to the stack of articles to be treated.

11. A furnace as claimed in claim 1 in which the bell-like cover is the outer of three housing-means containers having in each case a top wall and a side wall, namely, an inner container, an air seal container surrounding the inner container and the outer container surrounding the air seal container, the inner container having its side wall supported on the base structure and its top wall deformable under downward pressure to exert downward pressure on the stack of articles and the air seal container and outer container having their side walls supported from their top walls which in turn are supported by the top wall of the inner container, and in which there is provided means for introducing a selected gaseous atmosphere into the inner container and means for introducing a selected gaseous atmosphere into the space between the inner container and the air seal container.

12. In heat treating apparatus, a separator adapted to engage units of work during heat treatment thereof, said separator consisting of a body of strong metal having parallel opposite sides, a porous facing welded on each of said parallel sides, said facing being formed of condensed powdered material composed at least predominantly of high-melting-point metal, and a thin coating of graphite on the exposed surface of each of said facings.

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