United States Patent
Klein

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[54] **SINTERING FURNACE**

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[52] **U.S. Cl.** **263/3**

[51] **Int. Cl.** **F27b 9/28**

[58] **Field of Search** 263/3; 266/3

[56] **References Cited**

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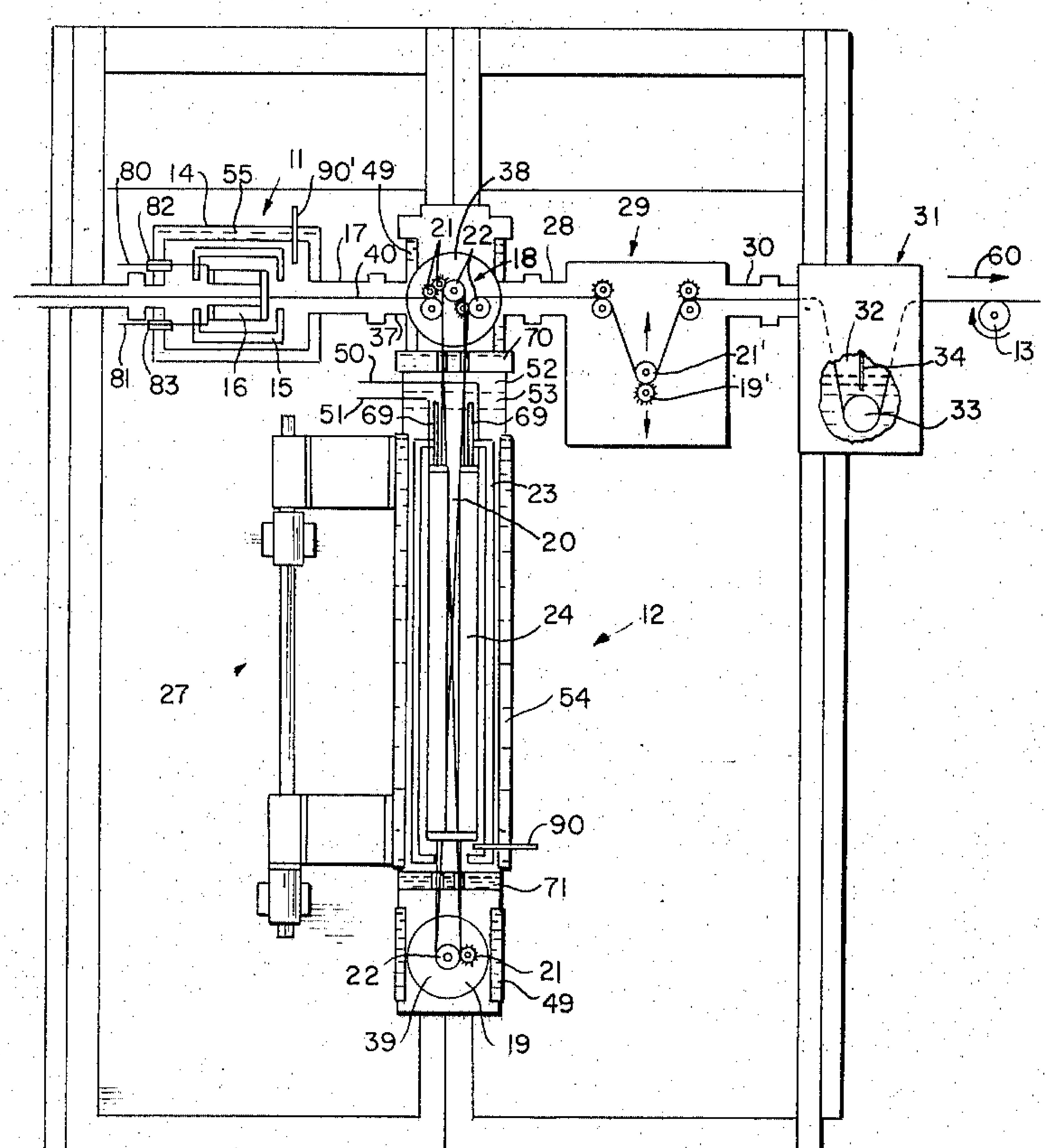
[57] **ABSTRACT**

A horizontal-vertical sintering furnace wherein a workpiece is presintered in the horizontal plane and sintered in the vertical plane. The workpiece makes multiple passes through a vertical sintering means.

11 Claims, 5 Drawing Figures



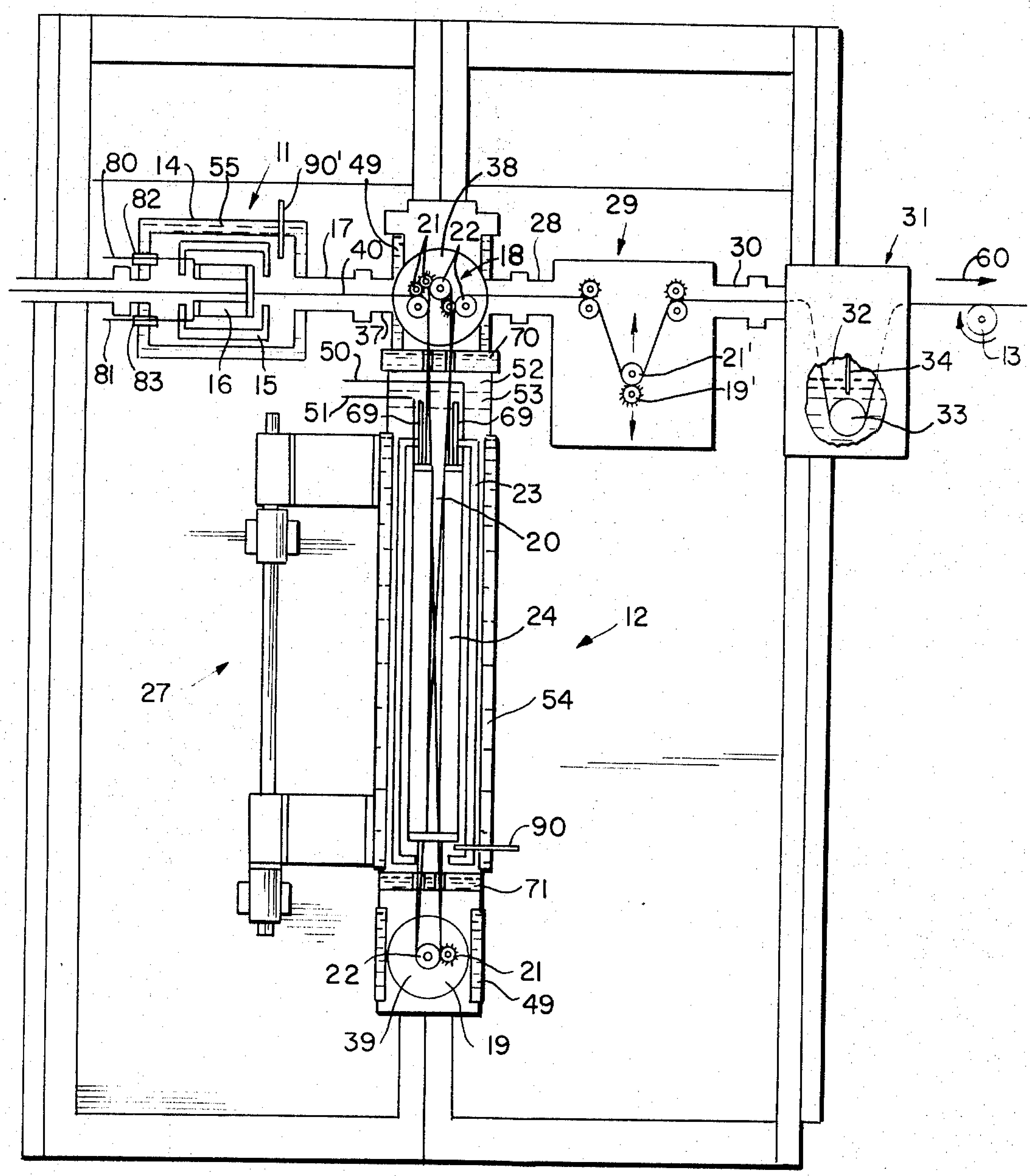


FIG. 1

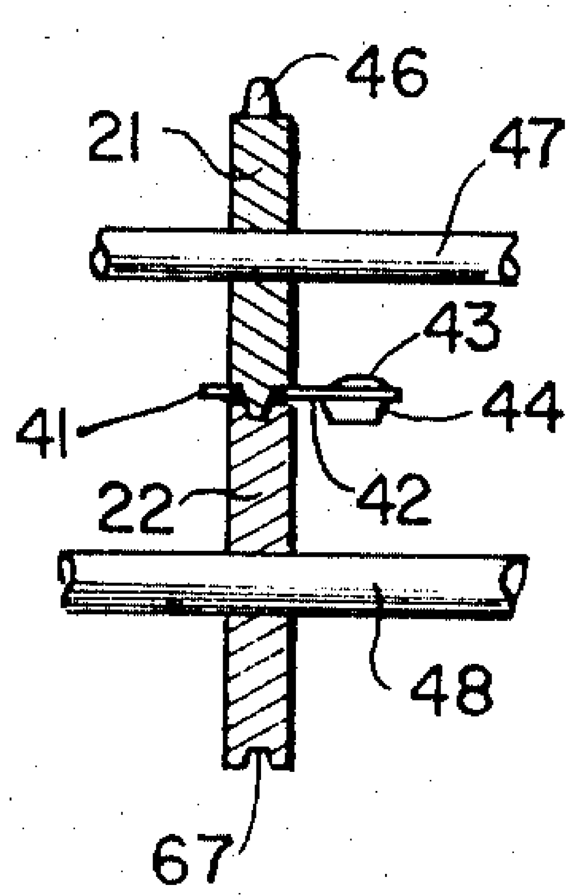


FIG. 4

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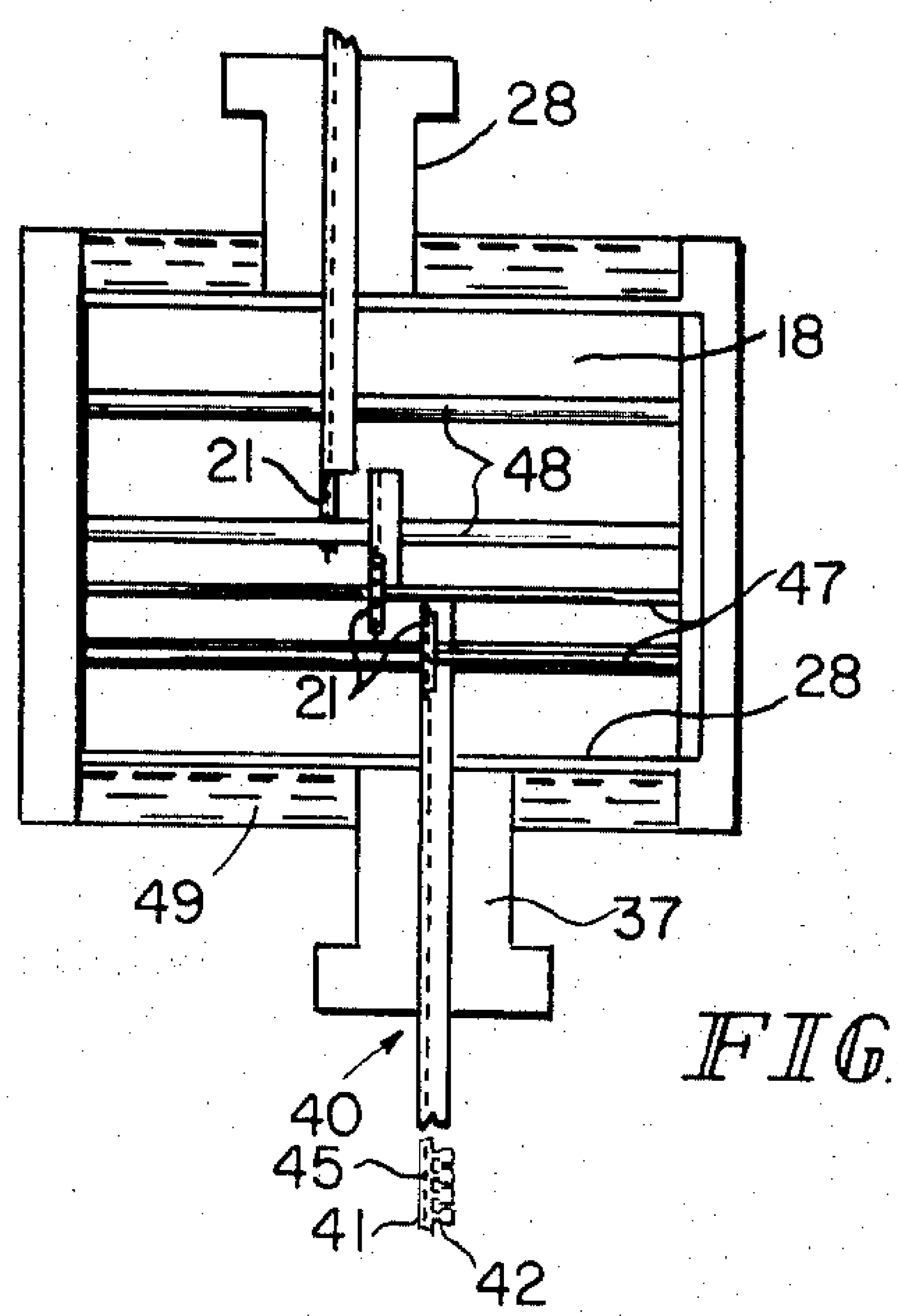

FIG. 3

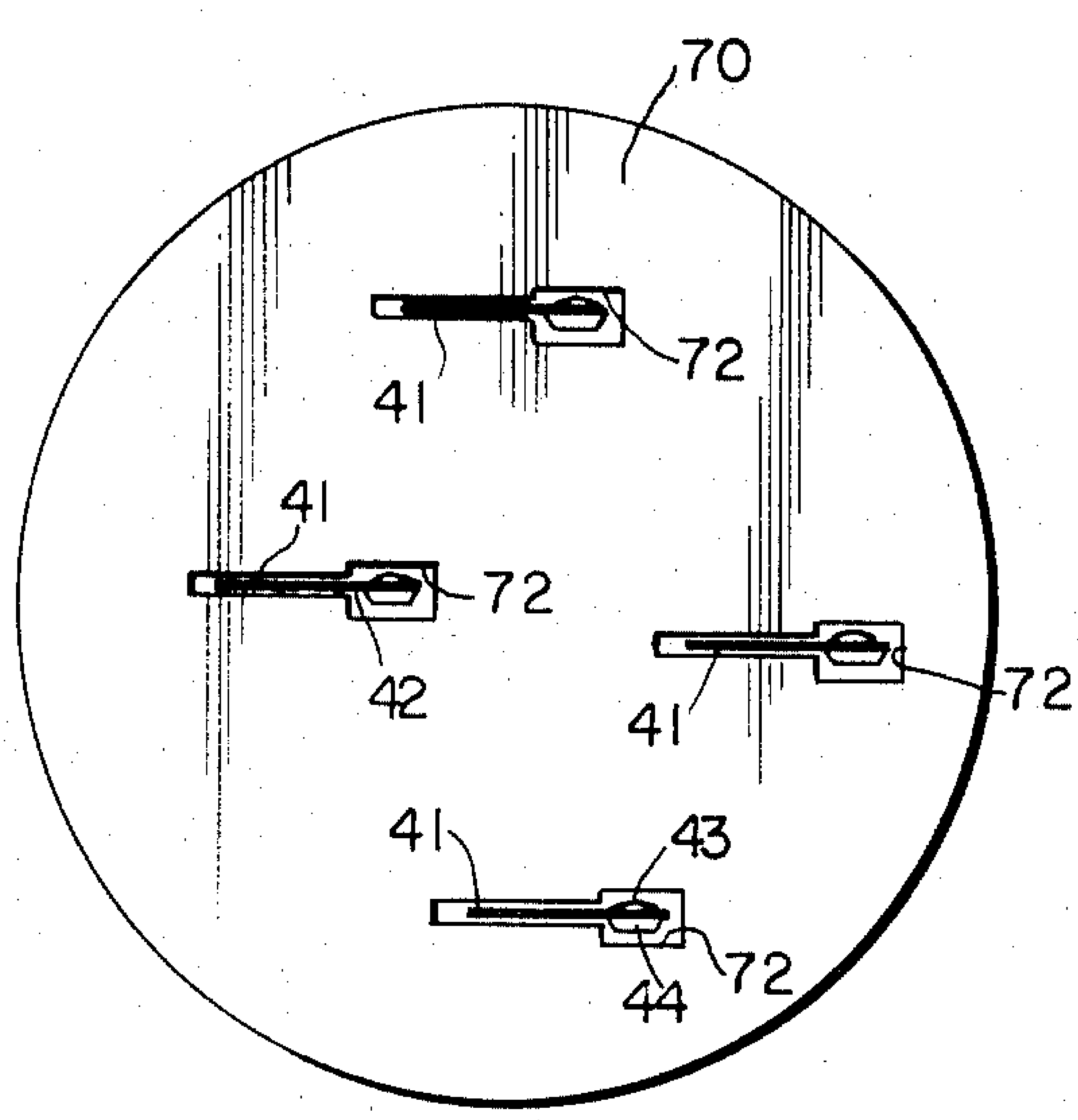

FIG 5

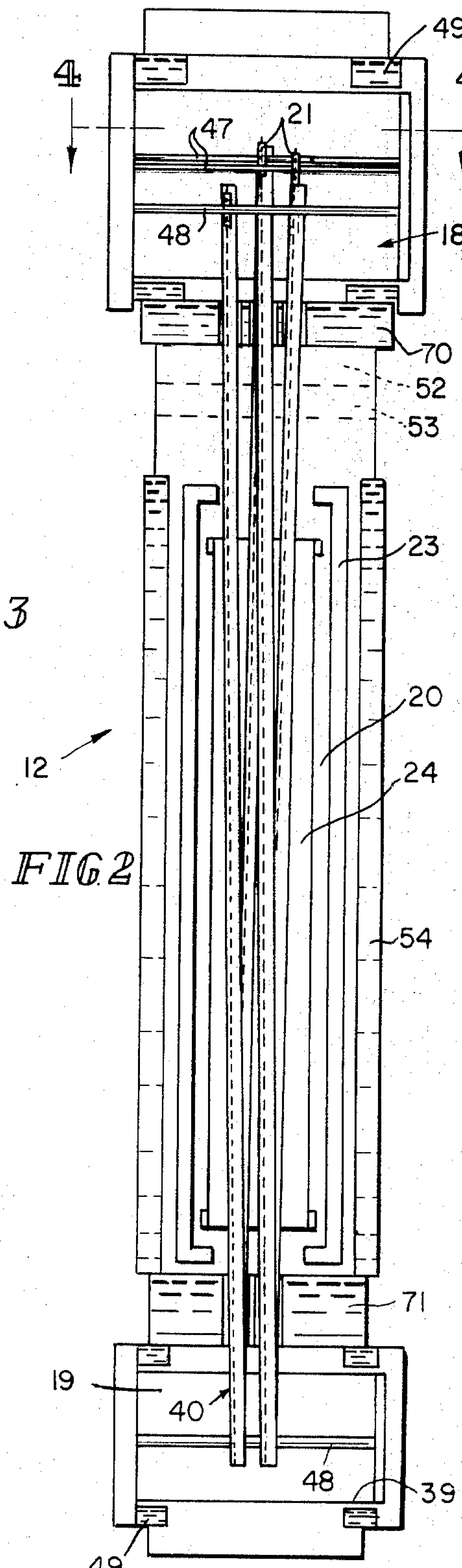

FIG 2

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SINTERING FURNACE

The present invention relates to a sintering furnace and process performed therein and more particularly, to a horizontal-vertical sintering furnace for sintering small, lightweight workpieces such as pellets suitable for use as capacitor anodes. The pellets are substantially continuously processed through the sintering furnace.

Generally, three different types of sintering furnaces are used to sinter workpieces fabricated from metal powders and the like in a substantially continuous and automated fashion. The three types of sintering furnaces are the mesh-belt conveyor furnace, the roller-hearth furnace and the pusher furnace. Each type of furnace has its specific application, depending on the production rate, the weight and size of the metal particles to be sintered, the type of metal to be sintered and the temperature required for sintering of the metal workpiece.

The mesh-belt conveyor sintering furnace is, perhaps, the most commonly used sintering furnace for continuous production of small lightweight workpieces. The furnace generally consists of a large table for loading the workpieces on the conveyor belt, a purge and burn-off chamber to distill off binders and/or lubricants, a sintering chamber, a cooling chamber and a discharge table. The workpieces are generally loaded on a continuously driven alloy mesh-belt at the front of the furnace and are discharged at the rear. A variable speed drive allows flexibility to meet the heating requirements of the workpieces to be sintered. Generally, the metal constituents used to fabricate the mesh-belt limits the furnace sintering temperature to about 1,150° C. Also, the use of the mesh-belt limits the furnace length because the stretch of the belt increases as the total load in the furnace increases resulting in undesirable sintering variations. This type of furnace is not satisfactory for the fabrication of several types of workpieces such as pellets suitable for the use as capacitor anodes because of the undesirably long horizontal length of the furnace needed to sinter the pellets, the contact of one side of the pellets with the mesh-belt which may result in conducting heat away from this portion of the pellet thereby resulting in variations of sintering temperature to which the pellet is subjected and the upper limit on the sintering temperature of about 1,150° C which is too low to achieve satisfactory sintering of the pellet in a reasonable length of time.

The roller-hearth continuous furnace transports trayloads of workpieces through a burn-off chamber, sintering chamber and cooling chamber by the use of driven rollers. The alloy metal used to fabricate the rollers of the furnace generally limits its temperature of operation to about 1,150° C. As with the mesh-belt conveyor sintering furnace, the roller-hearth continuous sintering furnace is disadvantageous for sintering pellets suitable for use as capacitor anodes because the sintering atmosphere does not sweep over all sides of the pellet, the sintering temperature is limited to 1,150° C and the unusual horizontal length of the furnace required to sinter the pellets as the pellets are substantially continuously processed there through.

The pusher type of sintering furnace is also a continuous processing furnace in which the workpieces to be sintered are positioned on trays which are pushed through the furnace by force being exerted thereagainst by the tray immediately behind. The trays are typically made of a heat-resistant alloy, ceramic, molybdenum, or graphite, depending upon the type of loading, the temperature, the atmosphere and the metals being sintered. The pusher type of sintering furnace is best suited for sintering metal parts which are too heavy for the mesh-belt type, where the production rate does not warrant the roller-hearth type of furnace, or where the temperature required for sintering is too high for either the mesh-belt or the roller-hearth furnace. The pusher type furnace, however, is not suited for sintering pellets suitable for use for electrolytic capacitors for the sintering atmosphere does not sweep over substantially all sides of the pellets and the horizontal length of the furnace required for substantially continuous processing is prohibitive to be suited for continuous processing.

Generally, a batch type sintering furnace is used to sinter pellets suitable for use as capacitor anodes. The pellets are placed in groups in the furnace and sintered without any substantial movement of any of the pellets in the furnace during sintering. The group of sintered pellets is removed from the furnace by the operator and a group of unsintered pellets replace the sintered pellets. Among several disadvantages of the batch processing furnace is that the temperature of the furnace may vary from area to area and corner to corner thereby subjecting the pellets to varying sintering conditions. As a result of the several different sintering conditions, the electrical and mechanical properties of the sintered pellets may vary.

Accordingly, an object of the present invention is to provide a horizontal-vertical sintering furnace for substantially continuously processing workpieces.

Another object of the present invention is to provide a horizontal-vertical sintering furnace which has its sintering atmosphere sweeping over all sides of the workpiece during substantially continuous processing of the workpiece through the furnace.

A further object of the present invention is to provide a horizontal-vertical sintering furnace for sintering pellets suitable for use in electrolytic capacitors.

A further object of the present invention is to provide a horizontal-vertical sintering furnace wherein the workpiece to be sintered makes multiple passes through the vertical sintering means of the furnace without deleteriously contaminating adjacent workpiece masses making passes through the same area of the furnace.

Another object of the present invention is to provide a horizontal-vertical sintering furnace including a horizontal presintering means positioned in advance of a vertical sintering means.

Yet another object of the present invention is to provide a horizontal-vertical sintering furnace which includes a vertical sintering means which maintains a temperature of about 2200° C.

Yet still another object of the present invention is to provide a horizontal-vertical sintering furnace which is capable of sintering powder masses suitable for use in an electrolytic capacitor wherein said powder masses are film-forming metal particles bonded to appendages integral with a substantially continuous tape or strip of film-forming metal, the tape substantially continuously moving through said furnace.

Another object of the present invention is to provide a horizontal-vertical sintering furnace including a presintering means, and sintering means wherein the sintering atmosphere may be an inert gas.

Yet another object of the present invention is to provide a horizontal-vertical sintering furnace wherein sintering is accomplished by the heat radiated by a heating means connected to a source of electrical energy.

Yet still another object of the present invention is to provide a horizontal-vertical sintering furnace for producing pellets suitable for use as anodes in electrolytic capacitors wherein the pellets are substantially continuously processed through the sintering furnace.

A further object of the present invention is too provide a horizontal-vertical sintering furnace wherein the workpiece to be sintered makes multiple passes through the vertical sintering means of the furnace.

Other objects of the invention and the nature thereof will become apparent from the following description considered in conjunction with the accompanying drawing.

In the drawings:

FIG. **1** is a schematic side elevation view of the horizontal-vertical sintering furnace;

FIG. **2** is a vertical section of the horizontal-vertical sintering furnace taken across the line **2—2** of FIG. **1**.

FIG. **3** is a vertical section illustrating the idler and sprocket means for guiding the workpiece to be sintered through the sintering furnace;

FIG. **4** is a horizontal section view taken across the lines **4—4** of FIG. **2**; and

FIG. **5** is a top view of a fluid cooled plate through which the workpieces pass and which separates the sintering chamber from the first and second chambers of the sintering means.

Generally speaking, the present invention relates to a sintering furnace for sintering workpieces such as those suitable for use as anodes in capacitors. The furnace includes a horizontal presintering means and a vertical sintering means. The workpieces substantially continuously move through the furnace. The workpieces may make more than one pass through the vertical sintering means.

Several of the prior art pellets suitable for use as anodes in electrolytic capacitors may be fabricated by sintering in vacuum a cylindrical admixture of a film-forming metal such as tantalum, zirconium, aluminum, niobium, titanium and the like and a volatile binder and/or lubricants which assist in compacting of the powder prior to sintering. The sintered pellet is anodized in an electrolytic bath to form an amorphous oxide layer on the surface of the pellet. The oxide layer serves as the dielectric of the anode. The pellet is impregnated with a concentrated solution of manganous nitrate which is pyrolytically converted in situ to manganese dioxide. The solid manganese dioxide is coated with collodial graphite, followed by a conductive layer of silver. The manganese dioxide layer, the graphite layer and the silver and the silver layer are the cathode of the capacitor. A suitable conductive wire such as nickel or the like is welded to the anode. The coated anode is suitably encapsulated in a metal or plastic container.

Porous bodies of film forming metal are obtained by sintering a mass of powder at temperatures below the melting point of the metal in an inert atmosphere or in vacuum. Generally, the properties of a sintered workpiece depend upon the type and mesh of the powder, the pressure used in compacting, the temperature, time and atmosphere of sintering. Generally speaking, the greater the compacting pressure the higher the sintering temperature and the longer the sintering time, the more dense the resultant metal structure is.

Generally speaking, the sintering temperature necessary to achieve the desired sintering of the compact is about ⅔ the melting point temperature of the film-forming metal powder. However a higher temperature is frequently used which may be just slightly below the melting point temperature of the metal particles to be sintered if a dense structure is desired. The sintering temperature used in the present invention varies from between about 60 to about 75 percent of the melting point temperature of the metal workpiece to be sintered with a sintering temperature about 70 percent of the melting point temperature of the metal of the workpiece preferred.

A departure from several prior art processes is realized by depositing a moistened mass of film-forming metal powder on appendages formed from a substantially continuous tape of film-forming metal foil. The moistened mass is deposited on the appendages by a suitable means such as by a dropper (not shown). The moistened powder may essentially consist of an admixture of film-forming metal particles such as tantalum, niobium, zirconium, titanium, aluminum and a suitable liquid carrier such as water, benzene, toluene and the like. No mechanical pressure is applied to the moistened powder after it is deposited on the cooperatively associated appendage. The use of the carrier with the powder appears to significantly reduce frictional forces between adjacent film-forming metal particles thereby assisting in compacting the metal particles to the required density prior to sintering of the green compact.

Usually, sintered film-forming metal pellets such as tantalum pellets are characterized by a myriad of intercommunicating voids which makes the pellets suitable for use as anodes in electrolytic capacitors. Generally the film-forming metal pellets are sintered in a vacuum atmosphere. A vacuum atmosphere is generally used because volatile binders are normally used to bind or retain the particles together until sintered. The vacuum atmosphere affords a convenient means by which the binders may be removed from the powder thereby significantly reducing the possibility of contamination of the pellets by the binder. Among other things, contamination sites on the powder of the pellet may produce defects in the oxide dielectric film later formed over the pellet. By eliminating the binder from the green compact, one eliminates a source of contamination and the necessity of sintering in a vacuum environment.

Referring now to the drawing, FIG. **1** illustrates a sintering furnace **10**. The sintering furnace components include a first sintering means or section such as presintering means **11** providing a presintering zone which is positioned in the horizontal plane and a second sintering means or section such as sintering means **12** providing a sintering zone which is positioned in the vertical plane. A workpiece **40** such as a substantially continuous tape of film-forming metal or the like is advanced through the presinter means **11** and the sintering means **12** by a suitable tape drive means **13**. The movement of the tape through the sintering furnace may be accomplished by suitable gearing (not shown) driven by a suitable drive motor (not shown) or the like. The drive means may be a variable speed drive means so that the speed of the tape through the furnace may be varied as the circumstances warrant.

The workpiece **40** may take any one of several different configurations. One of the several possible configurations which may be processed through the furnace is illustrated in FIGS. **2** and **3**, and more particularly in FIG. **3** as being a tape **41** having a plurality of integral appendages **42**. The tape is a film-forming metal. Each of the appendages carry a deposit of film-forming metal powder **43**. The film-forming metal of the tape and the deposit may be any of tantalum, niobium, titanium, aluminum, zirconium. The tape and the deposit are preferably the same film-forming metal. The tape includes a plurality of substantially equally spaced apertures **45**. Each of the appendages may include a depression **44** formed therein for retaining film-forming metal deposit within a confined area during the presintering of the powder. The powder is connected to the appendage by bonding, more particularly, by fusing, presintering, the powder to the appendage in the horizontal plane and thereafter sintering the powder and appendage in the vertical plane to provide, for example, a mass of sintered powder bonded to the appendage, the powder having a myriad of intercommunicating voids. Each of the sintered appendages may be separated from the tape by any suitable means such as a metal cutting apparatus (not shown) and used as, for example, after further processing as an anode for an electrolytic capacitor.

The sintering furnace **10** includes two main components, that is, horizontal presintering means **11**, and vertical sintering means **12**. The presintering means is positioned in advance of but in close proximity to the vertical sintering means. Positioning the horizontal presintering means before the vertical sintering means provides several functions, among which is that the initially loose film-forming metal particles are fused in the horizontal plane so that the film-forming metal particles do not become separated from each other and from their cooperatively associated appendage during passage of the appendages and powder through the vertical sintering means **12**.

After fusing of the film-forming powder to its cooperatively associated appendage, the powder and appendage may then be sintered in the vertical plane thereby significantly reducing the overall length of the sintering furnace. As an example of the length of the furnace necessary to sinter tantalum powder to a tantalum appendage carried by a tantalum tape moving at a rate of about **6** inches per minute so as to provide a pellet suitable for use in an electrolytic capacitor, the furnace probably will require a heat zone length of about 92 inches if the sintering temperature is about 60 to about 75 percent of the melting point temperature of tantalum, that is, about 1800°C to about 2200° C with about 2100° C being the preferred sintering temperature for tantalum.

The presinter means **11** has a heat zone length of about 6 inches and a presintering temperature of about 50 to about 60 percent of the melting point temperature of the metal of the workpiece. If the workpiece metal is tantalum, the presintering temperature is about 1500° C to about 18° C. The presinter means fuses the powder to its cooperatively associated appendage. The powder and cooperatively associated appendages may be processed in the vertical plane significantly reducing the length of the furnace resulting in a significant savings of physical space. The presinter means also serves to heat the compact rather gradually causing moisture which may be carried by the powder to be vaporized and driven from the powder. The presintering means includes a substantially cylindrical housing **14** fabricated from any suitable material such as stainless steel and the like, cooling jacket means **55** provided at the inside periphery of the housing for circulating a cooling fluid such as water, heat shield and heat reflector means **15** positioned the inner wall of the cooling jacket and a tubular-like heating element **16** connected to a suitable source of electrical energy such as an alternating current source or a direct current source (not shown) through leads **80** and **81** suitably sealed in the housing by insulative means **82** and **83** respectively. For illustrative purposes only, the length of the heating element **16** is about 6 inches. The heating element serves to preheat the film-forming metal particles and fuse adjacent particles to each other and to the cooperatively associated appendage. Due to the relatively high temperatures present within the presintering means, the heat shields and reflector means and the heating means are fabricated from a suitable high temperature metal such as molybdenum, tantalum, tungsten and the like. Of the several high temperature metals, molybdenum and tantalum are preferred, with tantalum being the most preferred metal.

A suitable apertured conduit means **17** fabricated from any suitable material such as stainless steel or the like is used to connect the presintering means **11** to the sintering means **12**. The aperture of the conduit has suitable dimensions to assure that the tape and its associated appendages are afforded sufficient clearance on all sides thereof from the inner walls of the conduit means.

The sintering means **12** is located in the vertical plane and includes an inlet port **37** connected to the presintering means **11** through the conduit means **17**. The conduit means and the inlet port of the sintering means are fixedly retained in abutting relationship by fastening means (not shown) such as bolts or the like. The sintering means includes a first chamber **18** positioned at the upper extremity of main sintering chamber **20** and separated therefrom by fluid cooled, apertured plate **70** and a second chamber **19** positioned at the lower extremity of the main sintering chamber and separated therefrom by a fluid cooled, apertured plate **71**. The plates **70** and **71** are similar and each includes a sufficient number of apertures **72** respectively to allow passage of said workpiece through the plates. The first and second chambers may be connected to the main sintering chamber by any suitable fastening means such as bolts and the like.

The first and second chambers each include a detachable or movable spool means **38** and **39**. The spool means include a plurality of sprocket means **21** and idler means **22** for guiding the travel of the tape through the main sintering chamber. FIG. **4** illustrates sprocket means having a plurality of spaced apart peripheral teeth **46** which mate with peripheral groove **67** of the idler means. As shown in FIG. **4**, the teeth of the sprocket means engage with and project through the apertures **45** of the tape **41**. The sprocket means and the idler means cooperate to guide the tape along a selected path through the sintering means. The sprocket means and the idler means are journalled to the side walls by shafts **47** and **48** respectively. The sprocket means and the idler means in each chamber are journalled independent of one another using bearing means (not shown) of low friction. Another desirable feature of the low temperature present in the first and second chambers is that the effect of the expansion of the shafts, the idler means and the sprocket means is minimized. It should be noted that all of the idler means or all of the sprocket means may be carried by the same shaft. The first and second chambers are substantially surrounded by a cooling jacket **49** which maintains the temperature of the first and second chambers at less than about 500° C, preferably less than about 200° C providing a zone of reduced temperature. The cooling medium circulated in the jacket may be fluid such as water or the like. The shafts **47** and **48** may be apertured to carry a cooling fluid to thereby assist in maintaining the desired temperature in the first and second chambers.

The first and second chambers **18** and **19** are maintained at about less than 500° C for, among other things, it is difficult to retain proper lubrication on the sprocket means **21** and idler means **22** of the first and second chambers. In addition, at temperatures higher than about 500° C the lubricants used on the sprocket means and the idler means may tend to contaminate the film-forming metal tape and fused powder.

The sintering chamber **20** includes heat shield and reflector means **23** immediately adjacent cooling jacket **54** and heating means **24** adjacent the heat shield and reflector means. For illustrative purposes only, the length of heating means **24** is about **24** inches. The heating means is connected to a suitable source of electrical energy such as an alternating current source or a direct current source (not shown) by leads **50** and **51**. The leads **50** and **51** are extended through the wall of the sintering chamber and through sealed insulators **52** and **53** respectively suitably seated in the wall of the chamber. The heating means **24** is suitably suspended in the sintering chamber by suspension means such as by elongated means **69** may be suspension rods suitably attached to the housing **23** of the sintering chamber. The heat shield and reflector means and the heating means are fabricated from any suitable high temperature metal such as molybdenum, tantalum, tungsten and the like. Of the several high temperature heating metals, molybdenum and tantalum are preferred with tantalum being the most preferred material used as the heating means. The housing of the sintering chamber and the first and second chambers may be fabricated from any suitable material such as stainless steel or the like.

The sintering **12** may further include vertical support bracket means **27** which permits the sintering means to be displaced with respect to the presinter means **14**. The support bracket means **27** permits the furnace to be displaced outwardly from the mounting panel **28** providing accessibility to all sections of the furnace by the operator thereby facilitating cleaning and/or repairing of the furnace, if necessary.

The tape **41** carrying the film-forming metal powder **43** makes four passes through the sintering chamber of the furnace as illustrated in FIG. **2**. It is recognized that a greater number or a fewer number of passes of an individual appendage through the sintering chamber of the furnace may be accomplished by simply adding to or subtracting from the number of sprocket means and idler means in the first and the second chambers.

In the embodiment illustrated in the drawing, sintered porous pellet of film-forming metal powder and cooperatively associated appendage exits the sintering means through conduit means **28** which is similar to conduit means **17**. The tape is then processed through tape tension means **29** connected to the conduit means **28** by any suitable fastener means (not shown) such as bolts or the like. The tape tension means **29** includes a plurality of sprocket means **19'** and idler means **21'** similar to those illustrated in FIG. **4** for maintaining the tape under substantially constant tension as the tape is processed through the sintering furnace. The tape tension means substantially eliminates subjection of the tape to sudden movements which may cause the tape to endure shear stresses and/or to deformation which may effect the sintering of the tape and the powder. The tape tension means may be positioned either at the exit of the sintering means **12** as shown in the drawing or positioned intermediate the presinter means **14** and the sintering means **12**. The tape tension means assures that substantially constant tension is maintained on the tape throughout processing thereof through the sintering furnace.

A liquid gas seal **31** is connected to the tape tension means through a suitable conduit means **30** similar to conduit means **17** and **21**. The liquid containing gas seal includes a chamber partially filled with mercury or the like. The chamber is separated into at least two sections by a baffle **34** which extends at least into the liquid. The sintered appendages pass from a first section of the chamber to a second section of the chamber by being immersed in the liquid. The baffle and the liquid cooperate to provide a gas seal between the sintering furnace and the tape drive means substantially surrounded by ambient air. The gas seal efficiently and effectively prevents the sintering environment or atmosphere of the sintering furnace from flowing beyond the gas seal under normal conditions. If the atmosphere of the furnace is to flow in any direction, it will flow toward the opening of the presinter means thereby substantially preventing the ambient from entering the sintering means through the presinter means.

Generally, the sintering of pellets suitable for use as anodes for capacitors is usually done in a vacuum at a pressure considerably lower than 1 mm Hg. in order to reduce the possibility of contaminating the pellets. The vacuum equipment normally used is bulky and expensive. By depositing moistened powder on the appendages, the vacuum sintering environment may have substituted therefor an inert gas at about atmospheric pressure. The invert gas may be any of the high thermal conductivity inert gases as argon, helium and the like.

The inert gas may be introduced into the furnace through any suitable means such as atmosphere inlets **90** and 90' located in both of the horizontal and vertical chambers or through atmosphere inlet **80** located in the vertical chamber.

Having thus described the physical relationship of the various components of the present invention, the functional cooperation thereof will be described hereinafter.

The workpiece is pulled through the sintering means by tape drive means **13**. The tape drive means includes a sprocket wheel which has teeth that engage with and displace the apertures **45** in the direction of arrow **60**.

The workpiece such as the film-forming metal power tantalum and cooperatively associated film-forming metal appendage such as tantalum are presintered in presintering means **14** in an inert gas atmosphere such as argon at about atmospheric pressure at a temperature of about 1500° C to about 1800° C for about 5 minutes. The presintered powder and appendages are guided through the first and second chambers and the sintering chamber by sprocket means **21** and idler means **22**. The presintered powder and appendages are sintered in an inert gas atmosphere such as argon at about atmospheric pressure at a temperature of about 18002 C to about 2200° C for about 15 minutes. The individual appendages and cooperatively associated film-forming powder masses are guided by the cooperatively associated sprocket means **19** and idler means **21** so as to make four passes through the area of the sintering means substantially surrounded by the two point suspended heating means **24**. The multiple passage of the substantially continuous tape through the sintering section of the furnace significantly reduces the length of the furnace thereby resulting in a savings of material and space. However, more importantly, the metal powder and the associated appendage are substantially uniformly heated on four sides thereby insuring that each of the pellets experience substantially the same sintering temperature as does every other pellet sintered in the furnace.

The sintered workpiece exists the sintering means through the conduit **21** and proceeds through the tension means **26**. The sintered workpiece exits the tension means through conduit **30** and travels through the gas seal means **31**. The gas seal **31** channels the flow of the inert gas in such manner that the major flow of the gas exits the furnace through the horizontal presintering means.

While the invention is illustrated and described in an embodiment, it will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of this invention and as set forth in the appended claims.

Having thus described my invention, I claim:

1. In an apparatus for sintering a substantially continuously moving workpiece, a substantially horizontal presintering means including means for presintering said workpiece as said workpiece moves through said presintering means, a substantially vertical sintering means connected to said presintering means, said sintering means including first and second chambers separated by a sintering chamber, said first and second chambers including means for guiding said workpiece through said sintering chamber a multiplicity of times, said sintering means including means for sintering said presintered workpiece as said workpiece moves through said sintering means, and means substantially enclosing said presintering means and said sintering means for reducing the temperature of the outer periphery of said presintering means and said sintering means.

2. The apparatus of claim **1**, wherein said guide means includes sprocket means and idler means for guiding said workpiece during multiple passes through said sintering chamber.

3. The apparatus of claim **2**, wherein said sintering chamber includes heating means and means for allowing a sintering atmosphere to sweep over all exposed sides of said workpiece as said workpiece passes in close proximity to said heating means.

4. The apparatus of claim **3**, wherein said heating means is tubular-like, said workpiece making multiple passes through said heating means.

5. The apparatus of claim **1**, wherein said means for sintering includes vertical heat means suspended in said vertical sintering means by suspension means.

6. The apparatus of claim **5**, wherein said suspension means are at least two rod-like means coupled to the side wall of said vertical sintering means.

7. The apparatus of claim **3**, wherein said heating means is fabricated from a metal selected from the group consisting of tantalum, molybdenum and tungsten.

8. The apparatus of claim **23**, further including workpiece tension means connected to said sintering means for maintaining said workpiece under substantially constant tension.

9. The apparatus of claim **8**, wherein said workpiece, prior to presintering, includes substantially continuous tape of film-forming metal including a plurality of appendages and substantially unbonded film-forming metal powder carried by said appendages.

10. The apparatus of claim **3**, further including means influencing the directional flow of said atmosphere toward said presintering means.

11. The apparatus of claim **10**, wherein said means influencing the direction of flow of said atmosphere is a liquid seal.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3704872 Dated December 5, 1972

Inventor(s) Gerhart P. Klein

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 6, line 6, change "18° C." to ---1800° C.---.

Col. 8, line 42, after "chamber" insert ---32---.

Col. 8, line 67, change "invert" to ---inert---.

Col. 8, line 68, after "gases" insert ---such---.

Col. 9, line 26, change "18002" to ---1800°---.

Col. 10., line 40, change "23" to ---1---.

Signed and sealed this 1st day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents