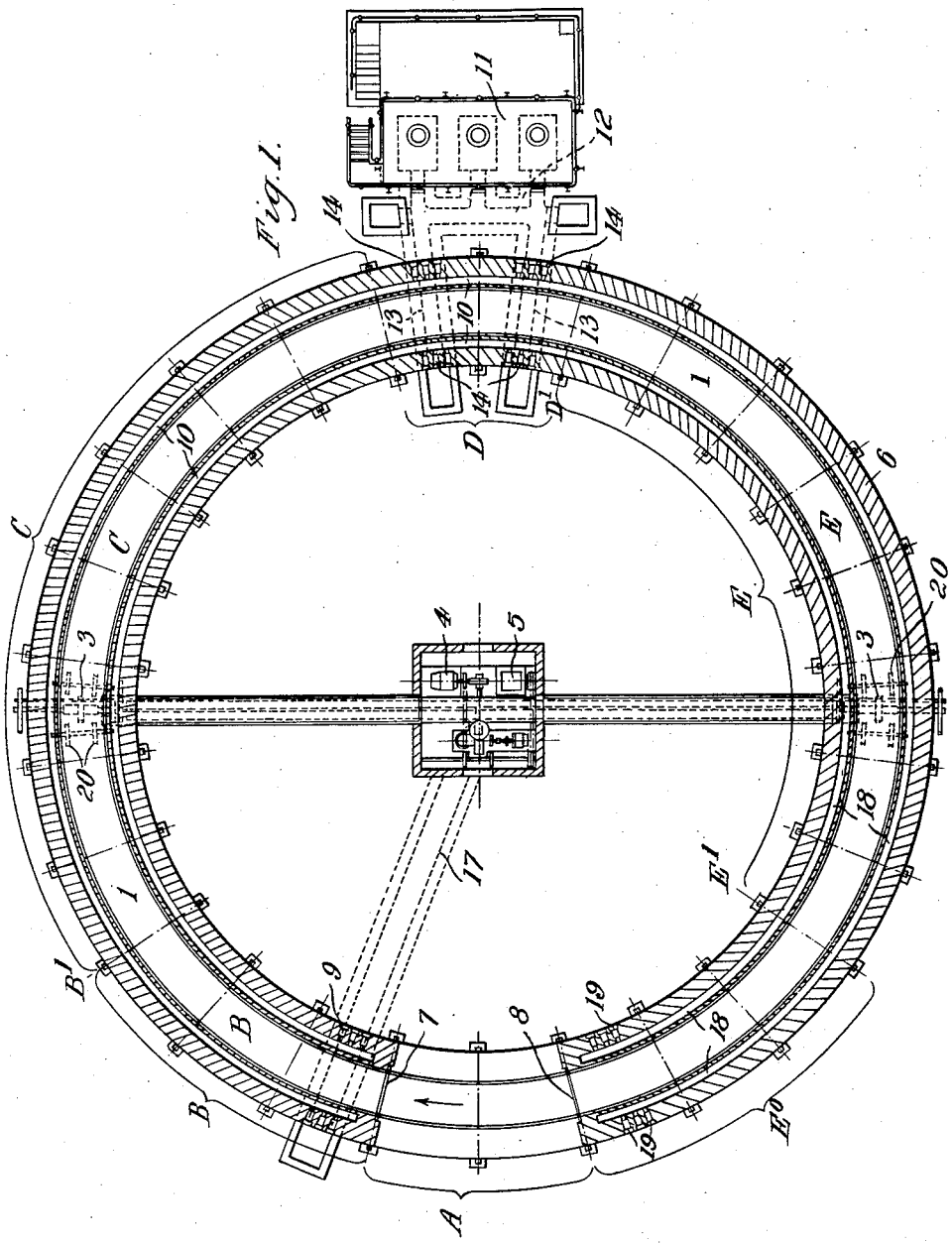
May 26, 1925. 1,539,653

A. McD. DUCKHAM

ANNULAR MUFFLE FURNACE OR OVEN

Filed July 24, 1923 7 Sheets-Sheet 1

Fig. 1.



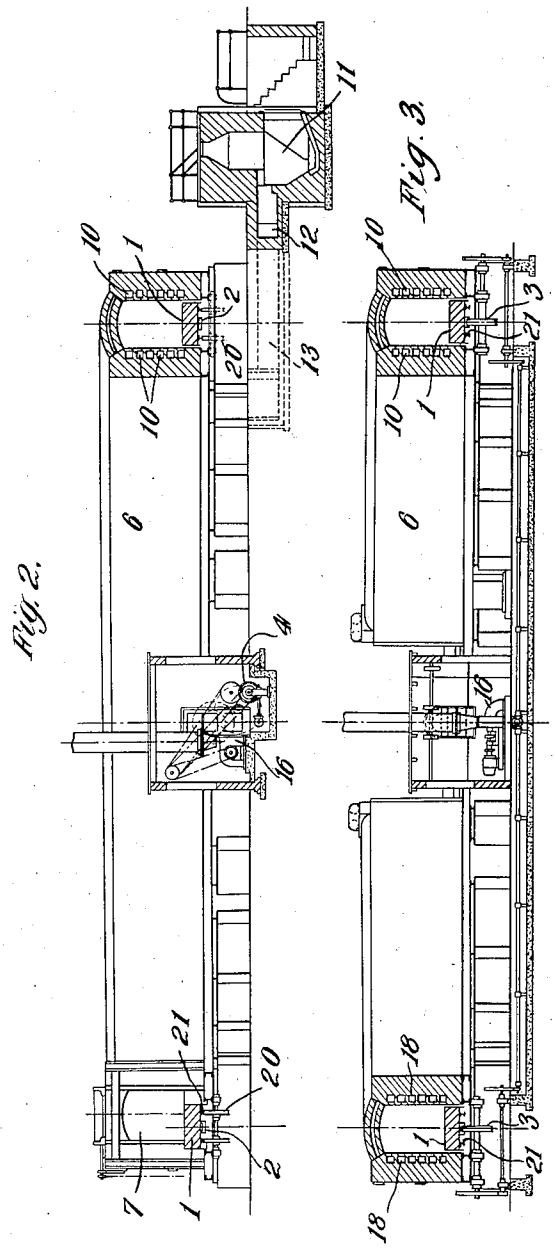
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Arthur McDougall Duckham
By James L. Norris
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ANNULAR MUFFLE FURNACE OR OVEN

Filed July 24, 1923 7 Sheets-Sheet 2



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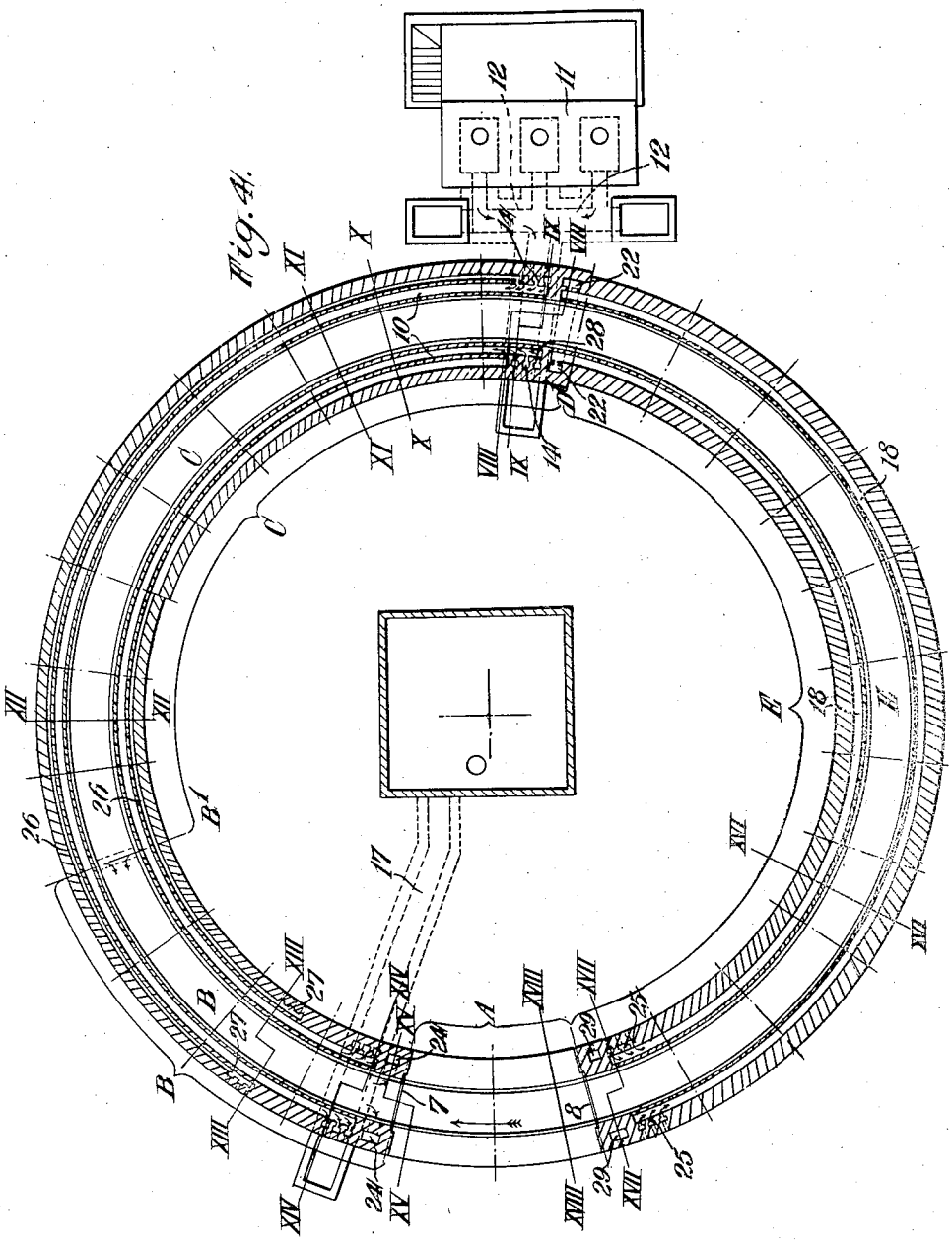
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ANNULAR MUFFLE FURNACE OR OVEN

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Fig. 4.



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ANNULAR MUFFLE FURNACE OR OVEN

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Fig. 5.

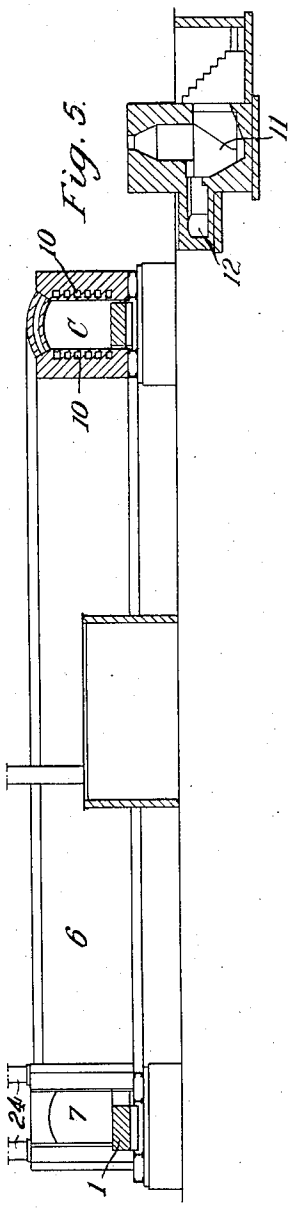
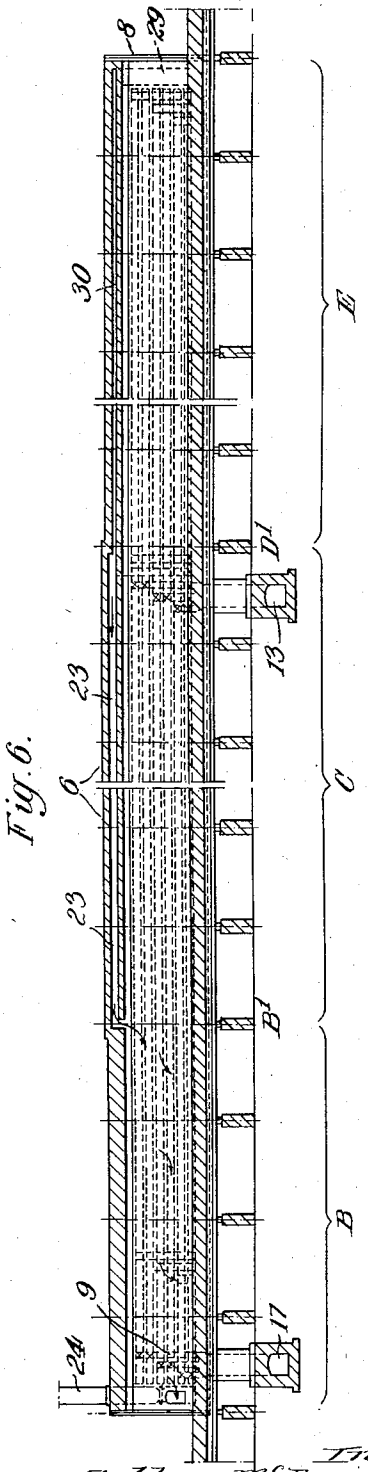


Fig. 6.



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ANNULAR MUFFLE FURNACE OR OVEN

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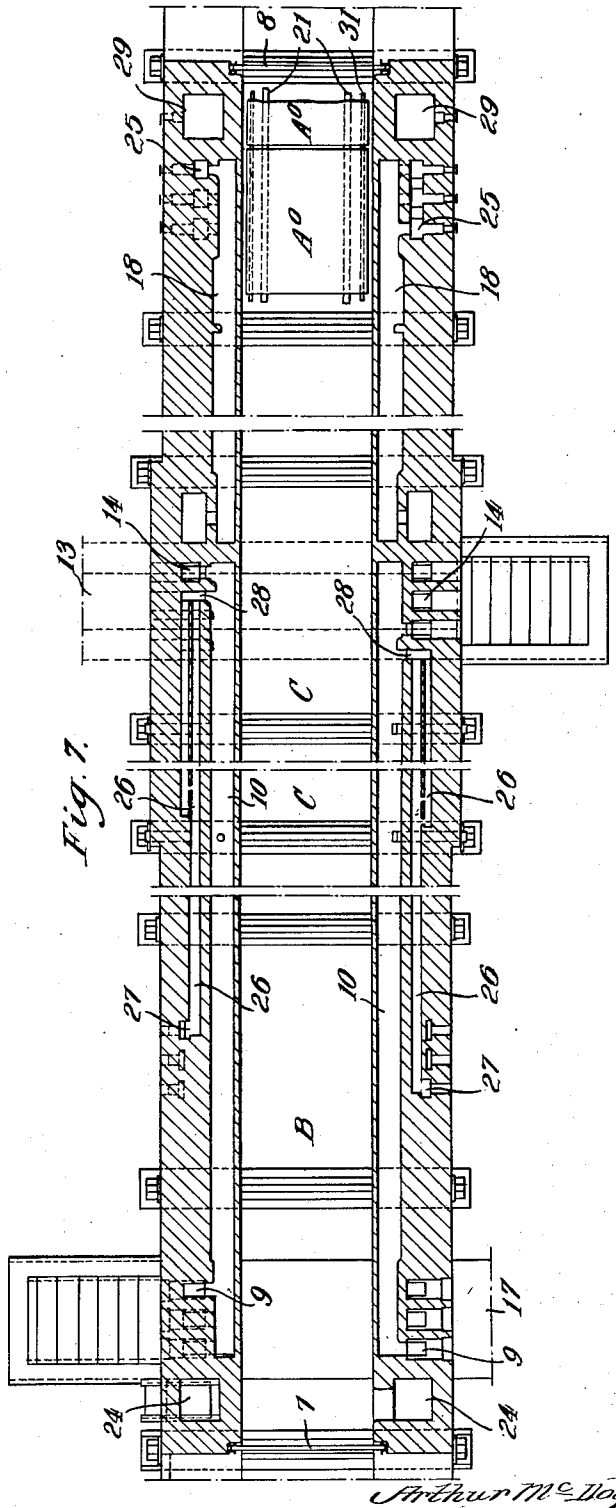


Fig. 7.

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ANNULAR MUFFLE FURNACE OR OVEN

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Fig. 13.

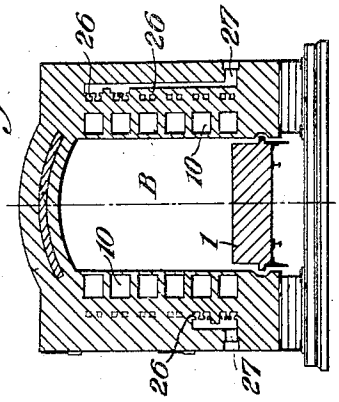


Fig. 15.

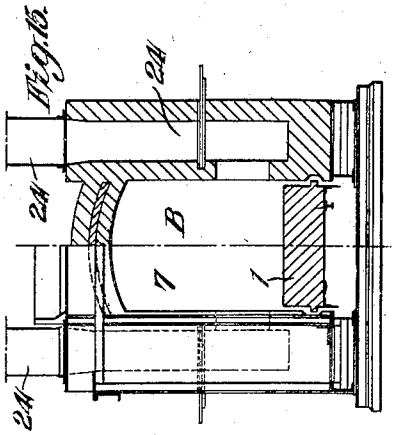


Fig. 11.

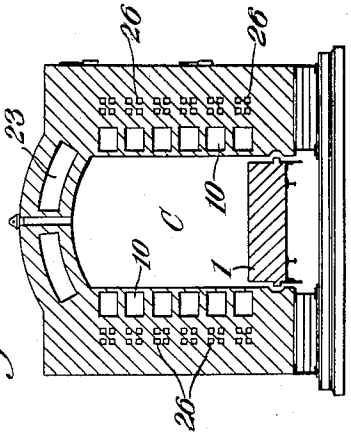


Fig. 12.

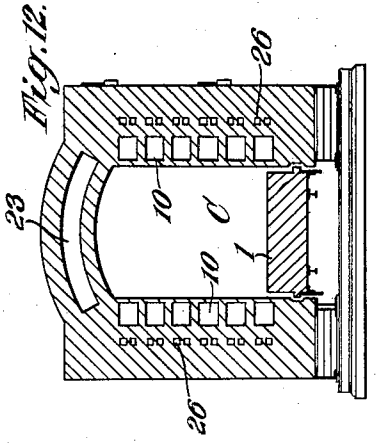


Fig. 8.

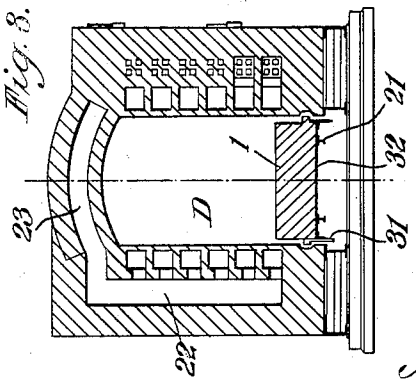
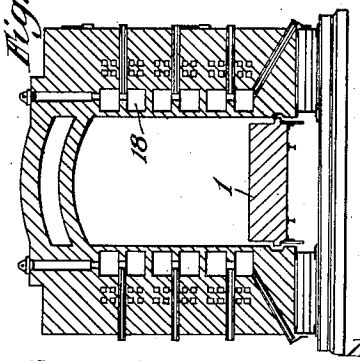


Fig. 10.



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ANNULAR MUFFLE FURNACE OR OVEN

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Fig. 16.

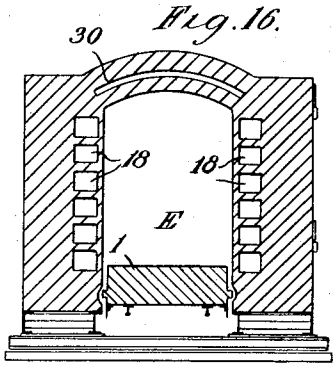


Fig. 9.

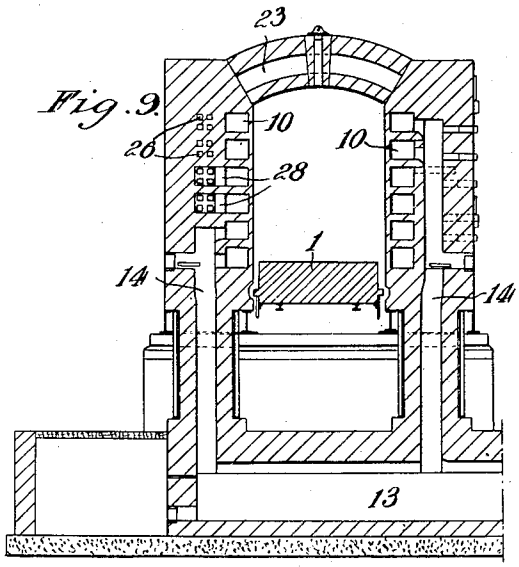


Fig. 17.

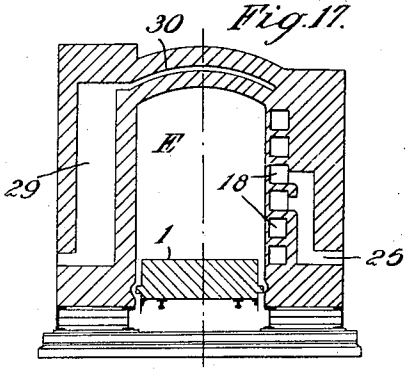


Fig. 18

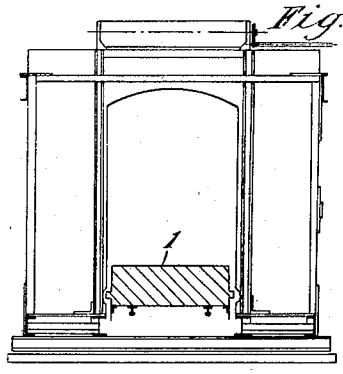
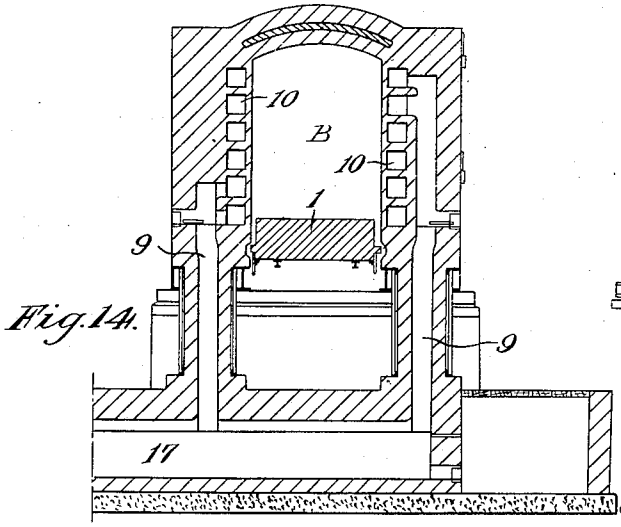


Fig. 14.



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UNITED STATES PATENT OFFICE.

ARTHUR McDOUGALL DUCKHAM, OF LONDON, ENGLAND, ASSIGNOR TO WOODALL, DUCKHAM & JONES (1920) LIMITED, OF LONDON, ENGLAND.

ANNULAR MUFFLE FURNACE OR OVEN.

Application filed July 24, 1923. Serial No. 653,575.

To all whom it may concern:

Be it known that I, Sir ARTHUR McDOUGALL DUCKHAM, a subject of the King of Great Britain, residing in London, England, have invented certain new and useful Improvements in Annular Muffle Furnaces or Ovens, of which the following is a specification.

This invention relates to annular muffle furnaces, ovens or kilns of the kind in which the goods to be burnt or treated are carried on a rotating annular support which forms the floor of the muffle oven or kiln and is rotated continuously or intermittently so as to bring the goods stacked upon any given part of the floor successively into different zones of the kiln, the arrangement being such that goods placed upon a portion of the floor while such portion is outside the apparatus enter the kiln at its cooler extremity, advance towards the point of ignition of the heating gases, and thence proceed into a portion of the kiln which is not heated, so that they may cool sufficiently and slowly enough to permit of their being withdrawn without danger when they reach the open discharging part of the apparatus, where they are replaced by fresh goods to be burned or treated.

The invention consists in an improved construction of muffle furnaces or kilns of this type which, by reason of the novel features hereinafter described, is of greater efficiency in operation and has more extended application with regard to the goods which may be treated than is possible with previously proposed furnaces of this type. Amongst these features are novel arrangements for the supply and distribution of the heating gases, the recuperative heating of the secondary air supply for the combustion of these gases, the removal of moisture from the goods in the drying section of the kiln, the efficient and expeditious cooling of the treated goods, and the subsequent selective utilization of the heated air derived from the cooling zone of the furnace.

The annular travelling floor or tray of the furnace is rotated continuously or intermittently at the requisite time intervals by suitable means, as for example by means of a circular rack secured on the underside of a metal tray, which carries a refractory or insulating covering constituting the floor of the kiln, and gearing with one or more driving pinions actuated by suitable power means, the tray being otherwise supported upon rollers suitably spaced around the furnace. To obviate the tendency of the mass of material forming the insulating floor to jam owing to expansion and distortion, the insulating floor or covering of the metal tray is made in separate segments of comparatively short lengths, preferably with suitable expansion joints between adjacent sections.

The annular kiln may be regarded as arranged circumferentially in four main sections adapted to carry out the successive operations involved, namely loading and unloading, drying, heating, and cooling, the three last sections being, however, continuous and only the loading and unloading sections being separated from the remainder of the kiln by the inlet and outlet doors provided at the ends of the annular tunnel. The goods to be treated are loaded on the exposed part of the travelling floor in stacks of suitable lengths, so that the doors may pass readily between adjacent stacks when raised and lowered for loading and unloading purposes.

Provision is made for grading the temperature of the furnace from top to bottom or so distributing the heating gases that an even temperature is maintained at all levels in the kiln, such provision comprising a multiple arrangement of superposed horizontal flues which may be connected separately or in pairs or multiple with the source of heating gases at their inlet ends and with the waste gas flue at their outlets, but are otherwise isolated from each other.

The material or objects to be burnt or heat-treated are dried during an early part of their travel through the kiln by means of air. This air may be heated in a recuperator traversed by the waste gases from the kiln and admitted to the interior of the kiln at an intermediate point and discharged through ports near the entrance door. Alternatively the goods may be dried during

the early part of their travel through the kiln by taking air from the flues of the cooling zone at a point near the heating zone and conducting this heated air to the place where it is admitted to the interior of the kiln so as to dry and heat the goods, the moisture-laden air being exhausted by a chimney or fan at a point near the inlet end of the kiln.

The goods are cooled by air admitted to the flues surrounding the cooling section of the kiln, and the air so heated may be utilized either as secondary air for burning the producer gases in the combustion flues of the kiln or for drying the goods as hereinbefore set out or part of the air so heated may be devoted to one purpose and part to another.

The cooling of the goods may be expedited by introducing cold air directly into the interior of the kiln in contact with the goods at the latter part of the travel, and the air so heated may be led to the drying section of the kiln or applied to any other suitable purpose.

To obtain a high temperature of combustion the secondary air may be arranged to traverse the kiln, e. g. in flues in its side walls, in close proximity to the heating gases but following an opposite course. The air which has been used for cooling the goods, or some of it, may be further heated in this manner or an increased temperature may be imparted to such air by leading it around flues in proximity to the region of combustion of the heating gases before its discharge into the combustion flues.

In the accompanying drawings Fig. 1 is a sectional plan of an annular muffle furnace or kiln embodying the present invention, and Figs. 2 and 3 are transverse sections thereof taken on diametral planes at right angles to each other; Fig. 4 is a sectional plan showing a modified construction of furnace; Fig. 5 is a transverse section of same on a diametral plane; Fig. 6 is a developed partial vertical section of Fig. 4 along the central line of the muffle; Fig. 7 is a developed partial sectional plan view of Fig. 4 on an enlarged scale; Figs. 8–18 inclusive are transverse sections on the same scale as Fig. 7 taken on the lines VIII—VIII to XVIII—XVIII respectively of Fig. 4.

Referring first to Figs. 1, 2 and 3 the annular travelling floor or tray 1 of the muffle furnace or kiln is rotated at the appropriate time intervals by means of a circular rack 2 secured on the underside of the tray and engaging driving pinions 3 arranged at diametrically opposite points of the kiln and actuated by an electric motor 4, or alternatively through suitable countershafting by means of an auxiliary engine 5, both coupled through suitable gearing with the shaft of the driving pinions 3. As shown, the power-developing units may be grouped in a power house situated at the centre of the kiln.

The tray 1 includes a sufficient thickness of refractory or non-conducting material which forms the floor of the annular muffle or kiln 6, and the latter may be regarded as comprising four main sections, namely an open or loading and unloading section A in which the roof and side walls of the kiln are absent and which is separated from the muffle by a vertically sliding door 7 at the beginning or entering end of the kiln and a similar door 8 at the outlet end of the kiln. The drying section B starts at the entering door 7 and terminates at the line B′ where the heating section C begins, the latter terminating at the line D′, at which point the combustion of the heating gases, supplied through the arrangement of flues indicated at D, commences. The cooling section E extends from D′ to the line E, an auxiliary cooling section E° extending from this line to the outlet door 8. It will be understood that these sections are continuous, there being no separating partitions between the several sections, the subdivision of the kiln into such sections being entirely a matter of the most suitable arrangement in each specific case of drying, heating and cooling flues.

During the progress of the material or objects to be burnt or heat treated through the section B they may be dried by means of air introduced into the interior of the kiln at or near the point B′, this air having been previously heated by suitable means as, for example, by means of a recuperator traversed by the waste gases, the drying air together with the moisture carried off by it being discharged through suitable outlet ports placed near the inlet door 7 of the kiln.

During the progress of the material through the heating section S it is heated by the combustion products of the fuel gases traversing the flues 10 which are arranged at different levels on either side of the kiln.

The heating gas, as shown in the drawings, is derived from a suitable producer 11 from which it passes along gas flues 12, 13 to gas inlets 14 where it meets the heated secondary air and combustion takes place along the flues 10 at either side of the kiln. A motor-driven fan 16 or equivalent device such as a suitable chimney connected by the waste gas flue 17 with the waste gas outlets 9 is preferably used to maintain a suitable flow of the heating gas and combustion products along the heating and combustion flues 10.

After traversing the sections C, D the material is cooled by air admitted to the flues 18 on either side of the cooling sections E°, E of the kiln through air inlets 19.

This air is heated continuously in its passage along the flues 18 and may have additional heat imparted to it by being led along flues immediately adjacent to the outside of the combustion flues 10, whence it passes as secondary air to the combustion flues, thus enabling a higher flame temperature to be obtained and simultaneously reducing radiation losses.

The cooling of the goods may be expedited by introducing cold air directly into the interior of the kiln at the latter part of the travel, say at the point E′, and the air so heated may be discharged through suitable outlets, e. g. in the roof of the kiln in section E° and thence to the drying section B for the purpose previously referred to, or applied to any other suitable purpose.

The rotating floor or tray 1 is supported by means of suitably disposed rollers or wheels such as 20 journalled in pairs in suitable members of the fixed support of the kiln, rails 21 fixed on the underside of the tray resting and running upon these rollers.

In the modified construction shown in general view in Figs. 4, 5 and 6 the driving gear of the rotating tray and the power-developing mechanism are omitted from the drawings, but it will be understood that the same general arrangement or any equivalent arrangement is applicable also to this construction.

The open section, that is the loading and unloading section, is as before indicated by A and extends between the inlet door 7 and outlet door 8 of the enclosed muffle. The air drying section B extends from the inlet door 7 to the line B′, at which point the drying air enters the interior of the kiln. The heating and burning section C extends from the line B′ to the line D′. The air cooling section E extends from the line D′ to the outlet door 8 of the kiln.

The goods are dried during the early part of their travel through the kiln from the inlet door 7 by taking air from the flues 18 of the cooling section E at a point near the end of the heating section C through uptakes 22 leading to a flue 23 extending along the top of the kiln and by-passing the heating section C to the point B′ where this heated air is admitted to the interior of the air drying section and, after traversing the same, is discharged through the waste air chimneys 24 near the inlet end of the kiln. This air enters the flues 18 through the inlets 25 near the outlet door of the kiln and after serving to cool the goods during their passage through the cooling section E, is utilized as above described for drying the goods at the initial part of their travel.

In addition to the drying air admitted through inlets 25 to the flues 18 in the side walls of the cooling section E, air inlet passages 29 in the side walls of the kiln near the outlet door 8 leading to an overhead flue 30 in the roof of the cooling section E may be provided, this flue 30 discharging into the overhead by-passing flue 23 of the heating section C.

To obtain high temperatures of the secondary air supplied for the combustion of the gaseous fuel delivered from the gas producer 11 through supply flues 12 to the gas inlets 14 leading to the flues 10 of the heating section, flues 26 may be built adjacent to the heating and combustion flues 10 of the kiln, the secondary air entering at inlets 27 and passing through the flues 26 in countercurrent to the heating gases, this heated secondary air entering the combustion and heating flues 10 at the ports 28 connecting the secondary air flues 26 with the said combustion flues 10 at points adjacent to the heating gas inlets 14.

This method of heating the secondary air provides a ready means of obtaining high combustion temperatures and has a certain cumulative heating effect, the temperatures of the secondary air and of the zone of intense combustion being mutually reactive.

The counter-flow method of heating the secondary air may be supplemented by the use of a recuperator heated by the waste gases as described in connection with Figs. 1 to 3, and in both constructions any suitable arrangement of dampers may be provided at appropriate points of the drying, heating and cooling flues to control the admission or discharge of the air and gases, and in particular to control the supply of fuel gas to the various flues of the multiple system of combustion flues, so that for example an even temperature or a definite gradation of temperature may be maintained from top to bottom of the kiln.

The arrangement of the air and gas flues in the several sections of the kiln is shown in more detail in the enlarged sectional views of Figs. 7 to 18, in which the various parts are designated by the same reference characters as the corresponding parts in Figs. 4 to 6.

The travelling tray or platform of the kiln comprises a bed of firebrick or other refractory or non-conducting material of suitable proportion carried upon transverse plate 32 extending between two concentric beams 31, the rails 21 which run upon the rollers 20 being attached to the plates 32, and to obviate distortion of the bed consequent upon the repeated heating and cooling to which it is subjected, it is preferably made in segments A° (Fig. 7) of comparatively short lengths, say about 5 feet, with expansion joints of suitable character between adjacent segments, or the sectional bed may be in two or more layers with the joints of adjacent sections in one layer and staggered with respect to the joints of the adjacent

sections in the layers immediately above or below. Alternatively the tray may be trough-shaped and filled with granular refractory or non-conducting material.

Apertures may be provided for the inspection of the interior of the muffle chamber and its contents and for testing the progress of the treatment by means of sample test pieces, and provision may also be made for measuring the temperature at various points of the kiln by means of pyrometers.

The floor of the muffle may be sealed to prevent access of air from below by any known suitable means, as for example by a trough containing sand or even oil extending underneath the floor adjacent to its outer and inner peripheries, side plates carried by the floor dipping into the material contained in these fixed troughs.

It will be noted that by the arrangement of flues surrounding the muffle hereinbefore described the loss of heat by radiation is reduced to a minimum. The flues therefore, in addition to their other functions, act also as heat insulators for the muffle.

Further, it will be noted that the arrangement and disposition of the mechanism whereby the floor of the kiln is rotated and supported are such that these mechanisms are practically thermally isolated from the kiln, the driving mechanism and the roller path and roller wheels being situated in an annular passageway below and outside the kiln proper, and although so situated are nevertheless above ground and readily accessible for any necessary purpose, and preferably freely open to the atmosphere.

Having thus described the nature of the said invention and the best means I know of carrying the same into practical effect, I claim:—

1. An annular muffle furnace or kiln comprising a heating section having enclosing walls separating it from the heating gases, a multiple arrangement of heating flues in said walls traversed by the heating gases, a plurality of gas supply flues leading to said heating flues, and damper means adapted to connect the gas flues with the heating flues in alternative parallel arrangements, the heating flues being otherwise isolated from each other along their length.

2. An annular muffle furnace or kiln comprising four main sections, namely an open or loading and unloading section, a drying section in which the goods are in direct contact with a stream of heated air, a heating section having multiple heating-gas flues and a cooling section having multiple cooling-air flues.

3. An annular muffle furnace or kiln comprising four main sections, namely an open or loading and unloading section, a drying section having enclosing walls separating it from the heating gases, a heating section and a cooling section, a multiple arrangement of longitudinal flues in the walls of the heating section, a source of heating gases and means whereby the several longitudinal flues of the heating section may be connected at will with the source of heating gases, said flues being otherwise isolated from each other.

4. An annular muffle furnace or kiln comprising four main sections, namely an open or loading and unloading section, a drying section having enclosing walls separating it from the heating gases, a heating section and a cooling section, a multiple arrangement of longitudinal flues in the side walls of the heating section, means for supplying heating gases to said flues and longitudinal air flues in the side walls of the heating section external to the gas heating flues.

5. An annular muffle furnace or kiln comprising four main sections, namely an open or loading and unloading section, a drying section, a heating section and a cooling section, a multiple arrangement of longitudinal flues in the side walls of the heating section, means for supplying heating gases to said flues and longitudinal air flues in the roof of the heating section.

6. An annular muffle furnace according to claim 2, comprising combustion flues for the heating gases, air flues surrounding the cooling section of the kiln and leading to flues adjacent to the region of combustion of the fuel gas and connections between the said flues and the combustion flues.

7. An annular muffle furnace or kiln according to claim 2, comprising air flues surrounding the cooling section of the kiln, combustion flues in the heating section of the kiln, a connection between said air flues and said combustion flues and a by-pass connection from said air flues to the interior of the drying section of the kiln.

8. An annular muffle furnace according to claim 2, comprising heating flues in the walls of the heating and drying sections of the kiln, air flues in the walls of the kiln external to the said heating flues, and means operating to establish a flow of heating gases and of air through the respective flues in opposite directions.

9. An annular muffle furnace or kiln according to claim 2, having a travelling floor or tray constructed in separated sections of comparatively short lengths.

10. An annular muffle furnace or kiln according to claim 2, comprising an annular travelling floor or tray, mechanism for supporting and driving the said travelling floor, said mechanism being open to the atmosphere and entirely situated below and outside the kiln proper.

11. An annular muffle furnace or kiln comprising a heating section having enclosing walls separating it from the heating

gases, a multiple arrangement of heating flues in said walls, air flues located in the walls of a section of the kiln and leading to flues adjacent to the inlet ends of the heating flues, and connections between the said flues and the heating flues.

12. An annular muffle furnace or kiln comprising drying and heating sections having enclosing walls separating them from the heating gases, heating flues in the walls of the said heating and drying sections, air flues in the walls external to the said heating flues, and means operating to establish a flow of heating gases and of air through the respective flues in opposite directions.

In testimony whereof I have signed my name to this specification.

ARTHUR McDOUGALL DUCKHAM.