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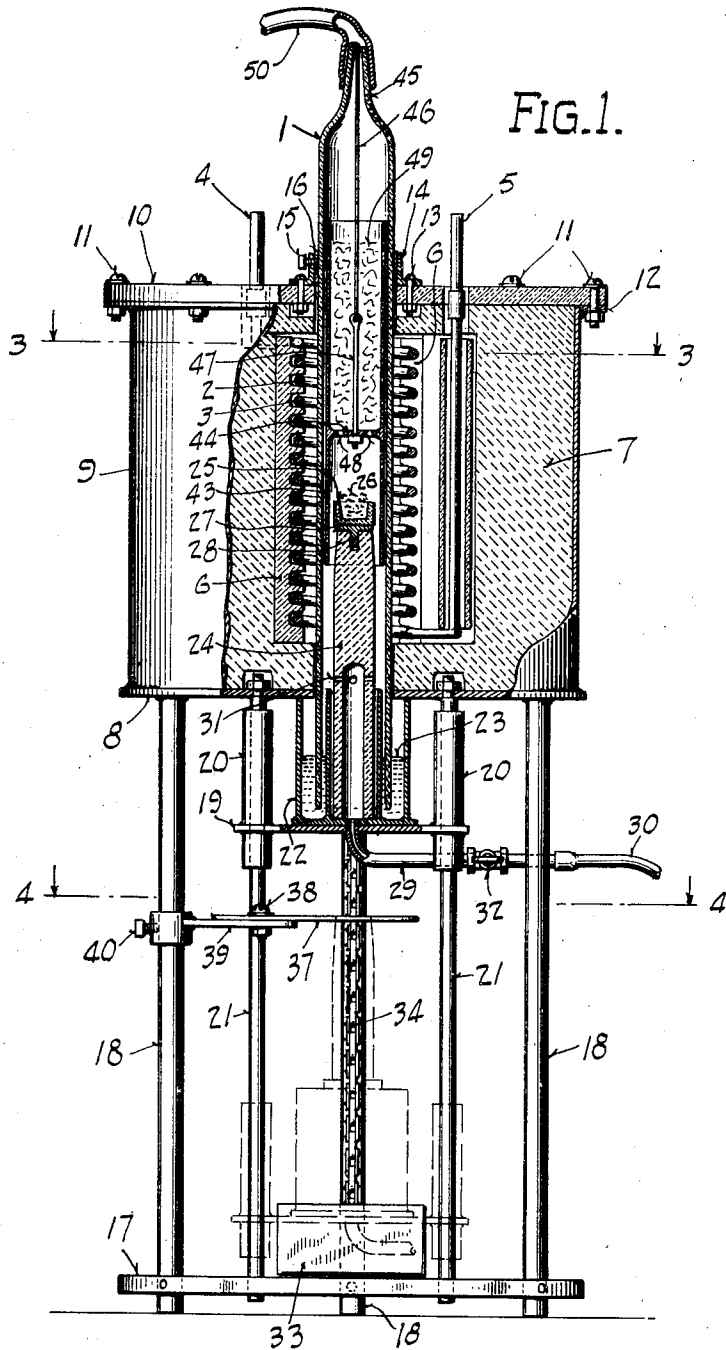
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CARBON COMBUSTION FURNACE

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2 Sheets-Sheet 1



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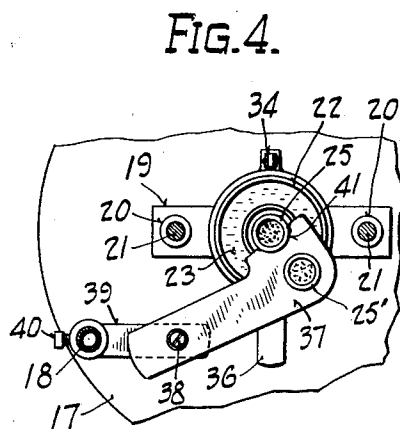
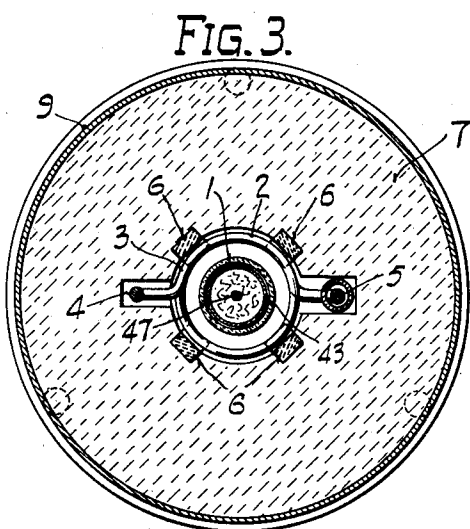
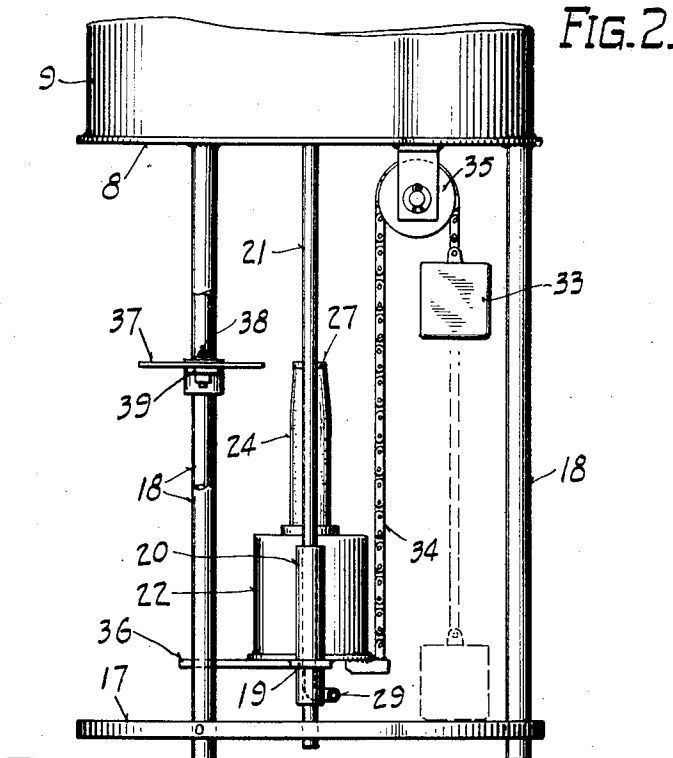
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CARBON COMBUSTION FURNACE

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CARBON COMBUSTION FURNACE

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6 Claims. (Cl. 23—253)

This invention relates to carbon combustion furnaces.

Horizontally disposed combustion tubes have been used in carbon combustion furnaces heretofore employed in analytical and metallurgical laboratories for determining the carbon content of iron, steel, or other substances containing carbon. While furnaces of this type have been widely and successfully employed, their use has not been free from difficulties and drawbacks. The sample was placed in a narrow boat which was shoved endwise from one end of the tube into the heated zone of the furnace. Any slight tipping of the boat as it was introduced might lead to spilling of some of the sample upon the combustion tube and cause a poor carbon determination or injury to the combustion tube, or both.

Furthermore, the tube being usually of small diameter it was close to the sample and exposed to spatters of iron oxide during the oxidizing or fusing of the samples of iron or steel. These spatters damage the tube and in the course of time necessitate its replacement. Attempts to provide shields to protect the tube from spatter led to unsatisfactory results since a shield introduced with each new sample increased the time required for the sample to heat up and tended to retard combustion. A shield permanently installed within the tube still further limited the rather restricted space available for the sample and made it difficult to insert the sample. Furthermore, the spatters were localized on the top part of the tube or on the permanently installed shield, and gradually formed a bead which directly interfered with introduction of the sample. Turning of the tube was of no avail since if the bead were turned to one side or the bottom, it would prevent insertion of the boat containing the sample.

The rubber stoppers commonly used at the ends of the combustion tube to connect with the oxygen supply and the carbon dioxide absorption train were also a constant source of trouble, particularly as one stopper had to be removed and replaced each time a sample was changed and leaks due to careless replacement might lead to unsatisfactory carbon determinations.

The horizontally disposed tube also necessitated a sample spread longitudinally along the boat in which it was introduced into the combustion tube. Particularly for iron and steel analyses, a more compact disposition of the sample is preferable. When all parts of the sample are close together the heat produced during oxidation of the iron and steel is concentrated

and is more effectively employed in rapidly oxidizing the carbon and fusing the metallic oxides produced.

The mass of the cold boat and of its contents was such that the time required to heat it to the required temperature for fusion and oxidation of the sample was considerable. Usually the boat was partly filled with a bed of 90 mesh alundum upon which the iron or steel chips were placed, the purpose of the alundum being to prevent contact between the boat and the oxide formed by fusion and oxidation of the chips so that the oxide could be readily removed and the boat used for another determination.

Another drawback to combustion furnaces with a horizontal tube arises from the length of the tube and the fairly considerable table space required for their mounting.

The present invention is based upon the discovery that these difficulties and drawbacks of the horizontal tube furnace can be substantially eliminated by providing a combustion furnace with a vertical combustion tube and a vertically movable plunger which makes a gas tight seal at the lower end of the tube and also supports the sample correctly centered in the heating zone of the furnace.

With the vertical tube the narrow boat is eliminated and a round crucible employed. The shape of the crucible and its placement in a fixed position on the plunger prevents any loss of sample by tipping. The spatters of oxide are well distributed throughout the circumference of the tube or shield and therefore have less interference with the sample than did the bead formed on the top of the old furnace tube.

The rubber stoppers are eliminated and preferably a liquid seal is made with the bottom end of the furnace tube. The seal is automatic and becomes effective when the sample is raised into the heating zone.

A more effective concentration of the sample is obtained and quicker oxidation results. The mass of the crucible and sample is not as great as that of the boat, alundum and chips, and therefore the furnace need not be at as high a temperature to assure complete oxidation and the time of heating up is considerably less.

Handling and calcining of the alundum is eliminated and the elimination of alundum by the use of cheap clay crucibles together with the shortening of time that the absorbing bulb is receiving a flow of oxygen aids in reducing corrections for blank. This provides more accurate determinations particularly as to low carbon

samples than was previously obtained in practice.

The construction of the present furnace with a vertical tube provides a more compact unit taking up less table space and shorter, less expensive, tubes can be employed. The tube therefore is less apt to be damaged from shock or jarring, and by properly supporting it, there is no tendency of warpage.

The principal object of the present invention is to provide an improved carbon combustion furnace which will eliminate or mitigate the drawbacks of the former type of furnace and which is more compact, more efficient, faster and less costly to operate than the furnaces heretofore used.

Another object of the invention is to provide a furnace which makes it possible to decrease the time and cost of a carbon determination.

These and further objects of the invention will be clear from the following detailed description and the accompanying drawings in which:

Figure 1 is a side elevation of the furnace with parts in section;

Fig. 2 is a side elevation of the furnace support, looking from the right in Fig. 1, and with the crucible support shown in lowered position;

Fig. 3 is a horizontal section on line 3—3 of Fig. 1; and

Fig. 4 is a horizontal section on line 4—4 of Fig. 1, showing the loading table.

Referring to the drawings, the furnace has a vertically disposed combustion tube 1 surrounded for a portion of its length by a heater 2. The tube 1 is of refractory material, either ceramic or metallic, and preferably has an open lower end and a partially closed upper end adapted to receive a rubber hose for connection to an absorption train.

While any suitable type of heater may be used, an electric resistance heating unit is preferred. This may consist of a coil 3 of any suitable resistance wire, "Alloy No. 10" being particularly adapted for use because of its exceptional ability to operate at high temperatures for an extended period of time. Terminals 4 and 5 are provided at the ends of the coil for connection to a source of power.

The turns of the coil are spaced apart by ceramic separators 6 seated in notches cut in the high temperature heat insulating bricks 7. The heat insulation around the coil may be of laminated structure, that is, consist of different materials at different distances from the coil 3 in view of the progressive decrease in temperature outward from the coil, but the detailed arrangement of the heat insulating material is not shown in the drawings as it forms no part of this invention.

The outer shell or casing provided to surround the heat insulating material has a bottom 8 of steel or other metal, a cylindrical shell section 9 welded thereto, and a top or cover 10 of high grade asbestos board or other suitable insulating material secured by bolts 11 to flange 12.

Bolts 13 fasten the flanged ring 14 to the cover around the hole cut for the passage of combustion tube 1. Set screws 15 in the ring 14 center the combustion tube in the heater and secure it against longitudinal movement despite the downward pull of gravity and the upward thrust that may be experienced when the lower end of the tube is immersed in the mercury seal as herein-after described. A wrapping of asbestos paper 16 around the tube is desirable to protect the combustion tube from direct contact with the

set screws and to intercept upward currents of heated air. Due to the vertical position of the tube and its suspension and shorter length, it is less likely to warp when exposed to high temperatures than a horizontal tube.

The casing for the heating unit is supported some distance above base plate 17 by three pillars 18 arranged at the corners of an equilateral triangle. A small platform 19 is secured to tubes 20 which are free to slide vertically on vertical guides 21. An annular trough 22, secured to platform 19, is partly filled with mercury or other suitable liquid 23 to make a liquid seal with the lower end of the combustion tube 1 when the platform is raised to its uppermost position with the outer wall of the trough resting against the bottom 8 of the casing around the heating unit.

Although mercury has been found to be suitable for sealing the bottom end of the combustion tube, other suitable heavy liquids of low volatility may be employed for sealing. The distance from the heating zone of the furnace to the seal should be sufficient to prevent undue vaporization of the liquid due to temperature. It is possible to employ other types of seal, such as gaskets, slip joints, magnetic, or powdered refractory materials which make no use of liquids. Where relatively short tubes are employed and the surfaces of the platform and seal parts are insufficient to keep the seal properly cooled, additional cooling means such as fins or a water cooling jacket may be provided.

A pedestal or plunger support 24 preferably of ceramic refractory material extends upwardly from inside the inner wall of the circumferential trough 22, and is adapted to support the crucible 25 with its charge 26 of material to be analyzed for carbon. A small metal plate 27 with a projecting pin 28 to keep it centered, rests on the upper end of the pedestal immediately below the crucible. The plate and pin are preferably made of a metal resistant to high temperature oxidation and are provided to prevent interruption of operation in case a crucible burns through during the course of a carbon determination. This, in the absence of the plate, would fuse the crucible to the upper end of the pedestal and necessitate a delay since time would be needed to remove the crucible from the hot pedestal, or to bring a new pedestal up to temperature if the old one is replaced. Loss of time is avoided by use of the plate since if the crucible fuses to this, both are removed together and can be quenched in water to free the plate for immediate return to the furnace.

A gas inlet pipe 29 passing through the bottom of platform 19 is connected to a small rubber tube 30 leading to a source of oxygen or other gas (not shown in the drawings). Oxygen introduced through the inlet rises in the hollow pedestal and then passes out through holes 31 into the annular space between the pedestal and combustion tube. A valve 32, to regulate or to shut off the flow of oxygen, may be provided in the inlet pipe, or placed elsewhere in the oxygen supply line.

The platform 19 may be counterbalanced by means of weight 33 and cable or chain 34 passing over pulley 35. With suitable adjustment of the counterweight, the platform is securely held by friction between the tubes 20 and guides 21, in any position at which it may be placed, particularly as the frictional engagement between these elements is enhanced by connecting the chain 34 to the platform at a point distant from the plane

defined by the guides. A small handle 36 is secured to the platform to provide a convenient means for moving it up or down. While a counterweight is shown and described, it is of course to be understood that a notched guide or other suitable means may be employed to hold the platform at any desired elevation, and the tubes 20 may have frictionless bearings on guide rods 21 to facilitate movement of the platform.

A loading table 37 is provided to expedite charging the furnace. This is pivotally connected at 38 to a supporting arm 39 carried by one of the pillars 18. A set screw 40 serves to lock the supporting arm 39 at a proper level to bring the loading table 37 flush with the upper surface of plate 27 when the platform 19 is moved to its lowest position. The loading table is swung out sideways to receive a crucible 25' with a charge for the next carbon determination.

At the conclusion of a determination being run, the supply of oxygen to the furnace is shut off; the platform 19 is moved to its lowermost position; and the loading table is swung around so that the notch 41 partially encircles the upper end of pedestal 24.

A momentary inspection suffices to show whether the charge in crucible 25, just removed from the furnace, has been properly fused down. Crucible 25 is removed by suitable tongs and crucible 25', with the charge for the next carbon determination, is then pushed from the loading table to the pedestal support. The loading table is then swung back out the way of the platform, and this is raised to its uppermost position in order to introduce crucible 25' into the combustion tube.

Contact between trough 22 and bottom 8 of the heater casing, arrests upward movement of the crucible and automatically positions it in the heated zone. The entrance of the lower end of the combustion tube into the mercury 23 simultaneously seals the combustion tube for its oxygen supply. The difficulties and loss of time previously experienced in removing and reinserting a rubber stopper each time a sample is charged or removed are entirely eliminated by the improved construction. Furthermore, the newly introduced cold crucible and charge at no time makes contact with the heated combustion tube, and there is, consequently, no thermal shock to the tube such as is experienced in horizontal furnaces each time a fresh sample is introduced by pushing a cold boat along the bottom of the hot combustion tube.

A shield fitting closely inside the combustion tube is provided to protect it from spatters that may be thrown out by the oxidizing and fusing sample or charge 26. The shield may consist of a cylindrical sleeve 43 with a central partition 44 and may be constructed of ceramic material or metal resistant to high temperature oxidation. The shield is held from the contracted upper end 45 of the combustion tube 1 by means of a wire 46 with one end bent over the end of the tube and other end connected to a heavier wire 47 which is fastened to central partition 44.

The central partition is provided with a number of relatively large holes 48 to permit passage of gas upward into the upper end of the shield, this end being filled with loosely packed asbestos fibers or other insulating material 49. The function of the heat insulating material is to diminish transfer of heat upward and also to serve as a contact mass for catalyzing the oxidation of carbon monoxide to dioxide.

When a new shield is inserted it is positioned by means of the wire 46 so that the partition 44 is only slightly above the top of the charge 26. It is used in this position until spatters from the charge reduce its inside diameter sufficiently to interfere with the introduction of a crucible and its charge. The shield is then moved upward by means of the wire to bring an unspattered portion of the shield up to the crucible level. This operation can be repeated for a number of times before cleaning or replacement of the shield is necessary.

A rubber tube 50 slipped over the upper end 45 of tube 1 and the wire 46 is connected to an absorption train for collecting the carbon dioxide evolved in a carbon determination. As this may be of the kind commonly used and forms no part of this invention, the absorption train is not illustrated. No difficulty is experienced in making a tight joint with the upper end of tube 1 despite the presence of wire 46.

The crucibles 25 needed to hold the charge or sample have a number of advantages over the boats used in horizontal tube combustion furnaces. They can be readily molded by the analyst from fire clay admixed with about twenty percent of silica sand, and after drying are baked in a muffle furnace at a temperature of about 1800° F. The temperature may be varied with different materials and if a material containing combined carbon is employed it is best to use a temperature which will oxidize the carbon so that corrections for blank will be kept at a minimum. The cost of preparing them is small as compared to that of the boats which are usually purchased, and as each crucible can be used for a number of determinations, they contribute but little to the cost of a carbon determination.

A further advantage of these crucibles is that they are of such shape as to hold a large sample in a crucible having but little weight of its own. Consequently less time is required to bring the crucible and its contents up to temperature. The sample is held in a compact mass instead of being spread in a long line as in the boats used in horizontal combustion furnaces. This feature contributes to decrease the time required for a carbon determination, for when the sample is heated and oxygen is turned on, the heat evolved by oxidation of the sample is confined to a relatively small region instead of being dispersed and is more effective in rapidly fusing the iron oxide left as a residue in a carbon determination on iron and steel.

In carrying out a carbon determination with the improved furnace, a crucible with its charge is introduced into the furnace as described above in connection with the loading platform. It is allowed to preheat in the combustion tube for a short time with no oxygen flowing through the tube. During this preheating time, the carbon absorption tube is detached from the carbon absorption train, weighed and reconnected to the train. Oxygen is turned on and flushed through the combustion tube and absorption train for a period of time established by experiment as sufficient to complete the combustion. The oxygen flow is stopped, the crucible removed and replaced by another with a sample for the next carbon determination, and while this is preheating the carbon absorption tube is weighed again, the increase in weight over the first weighing giving the amount of carbon dioxide collected.

Due to the lesser time needed for changing samples, the shorter period needed for heating

the crucible and its charge, and the shorter time needed for the combustion itself, it is possible to make carbon determinations with the new furnace in about half the time needed with the old horizontal combustion furnaces. In carbon determinations on medium carbon steels, it is customary to use a sample of 1.3636 grams since, with a sample of this size, the percentage of carbon in the sample is twenty times the weight in grams of the carbon dioxide collected. Using a sample of this size, a combustion period with oxygen flowing for about six minutes is needed with the conventional types of carbon combustion furnaces. A period of three minutes is sufficient with the improved furnace of this invention. With one gram samples of gray iron or other high carbon samples with a small amount of lead oxide to assist the oxidation, the times for the old and the new furnaces are about ten minutes and three minutes respectively, and for half gram samples, about seven minutes and two minutes, respectively.

The carbon combustion furnace of this invention has been found to be as accurate in making carbon determinations as was the former type of horizontal tube furnace. Repeated checks on Bureau of Standard samples show results comparable with those obtained by the Bureau of Standards with the former furnace and using combustion periods of longer time.

Since the new furnace decreases not only the time required for the combustion but also the time required for preheating the sample before combustion and that needed for the manipulation involved in changing a sample, it materially increases the number of carbon determinations which can be turned out per furnace per day, and correspondingly diminishes the heating energy cost and amount of oxygen chargeable to each determination. A further and perhaps even more important advantage is gained when the furnace is operated in a laboratory run in conjunction with a foundry. Due to the decreased time required for making a carbon determination, the laboratory can follow the carbon content of a heat up to a period more immediately preceding its tapping and fewer heats are lost by failure to meet the carbon specification.

While the improved carbon combustion furnace and its use have been described particularly in connection with carbon determinations on ferrous metal samples and it is anticipated that the furnace may find its most extensive application in this field, it is to be understood that it is by no means limited thereto and may also be employed in determining the carbon content of organic and other materials and for other uses.

I claim:

1. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for entering the lower end of the tube and supporting a sample to be analyzed centrally of the coil and radially spaced from the wall of the tube, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, a conduit for supplying oxygen to the lower end of said tube, and a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, the heated tube being free from thermal shock and warpage of the kind present in horizontal tubes heretofore

employed, and the radial space between the sample and the tube providing for more rapid and uniform contact between the vertically rising oxygen and the sample to obtain a more complete and rapid combustion of the carbon in the sample than possible with horizontal furnace tubes.

2. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for entering the lower end of the tube and supporting a sample to be analyzed centrally of the coil and radially spaced from the wall of the tube, a crucible for holding the sample, a removable plate laterally interlocked with the top of the pedestal for supporting the crucible and protecting the pedestal from fusion of the sample therewith in the event of rupture of the crucible bottom, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, and a conduit for supplying oxygen to the lower end of said tube, a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, the heated tube being free from thermal shock and warpage of the kind present in horizontal tubes heretofore employed, and the radial space between the sample and the tube providing for more rapid and uniform contact between the vertically rising oxygen and the sample to obtain a more complete and rapid combustion of the carbon in the sample than possible with horizontal furnace tubes.

3. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for entering the lower end of the tube and supporting a sample to be analyzed centrally of the coil, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, a conduit for supplying oxygen to the lower end of said tube, a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, and a movable sleeve lining the inside of the tube in the heating zone to protect the tube from spatter from the sample.

4. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for entering the lower end of the tube and supporting a sample to be analyzed centrally of the coil, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, a conduit for supplying oxygen to the lower end of said tube, a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, and a tubular sleeve suspended from the upper end of the tube and lining the same in the heating zone to provide a combustion chamber for the sample.

5. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for enter-

ing the lower end of the tube and supporting a sample to be analyzed centrally of the coil, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, a conduit for supplying oxygen to the lower end of said tube, a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, and a tubular sleeve suspended from the upper end of the tube and lining the same in the heating zone to provide a combustion chamber for the sample, said sleeve having a central apertured partition above the sample and porous heat insulation supported on the partition, the products of combustion passing upwardly through the holes in the partition and through said insulation.

6. In a furnace for making carbon determinations in the analysis of steel and the like, a vertical heating coil disposed in a refractory insulated housing, a refractory furnace tube extending axially through said coil and housing, an elevator having a central pedestal for entering the lower end of the tube and supporting a

sample to be analyzed centrally of the coil and radially spaced from the wall of the tube, means operable by said elevator for sealing the lower end of said tube closed when the furnace is loaded, a conduit for supplying oxygen to the lower end of said tube, a conduit connected with the upper end of said tube for removing products of combustion therefrom to be analyzed, the heated tube being free from thermal shock and warpage of the kind present in horizontal tubes heretofore employed, the radial space between the sample and the tube providing for more rapid and uniform contact between the vertically rising oxygen and the sample to obtain a more complete and rapid combustion of the carbon in the sample than possible with horizontal furnace tubes, and a tubular sleeve suspended from the upper end of the tube at adjustable position to protect the tube from spatter from the sample, said sleeve being adapted to be raised to successive positions to present fresh walls adjacent the level of the sample for receiving spatter.

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