July 7, 1964 D. T. MUTH ETAL 3,140,335

LABORATORY FURNACE

Filed June 14, 1962

Fig. 1.

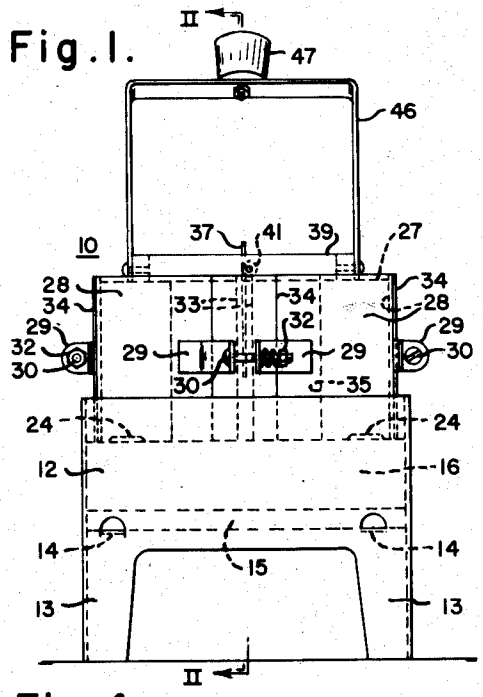


Fig. 2.

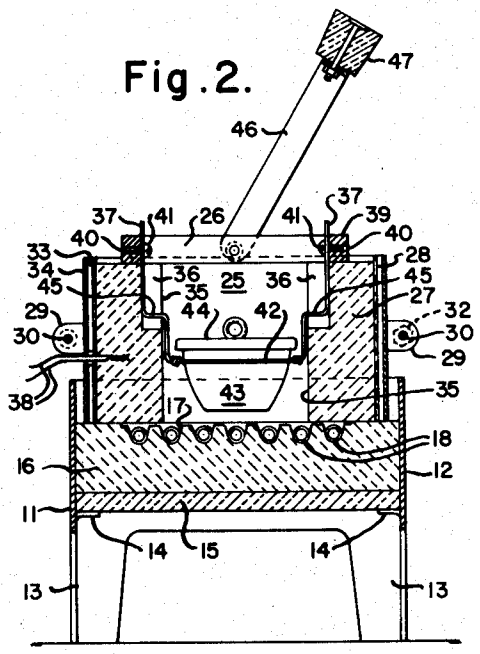


Fig. 4.

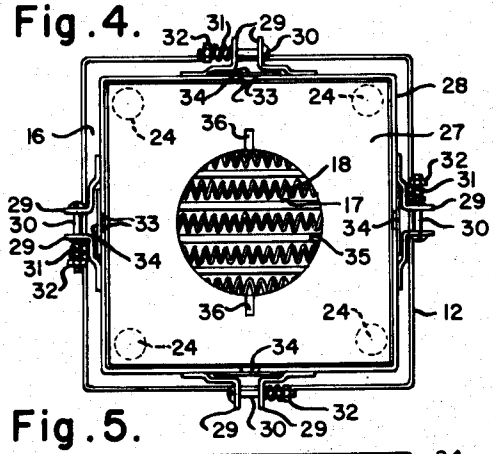


Fig. 3.

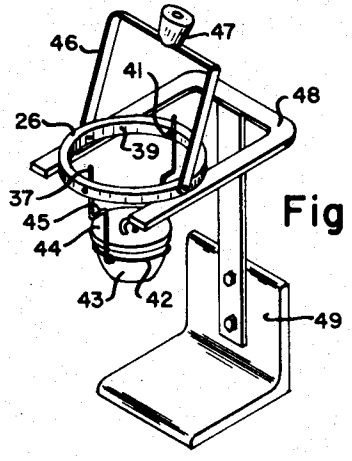
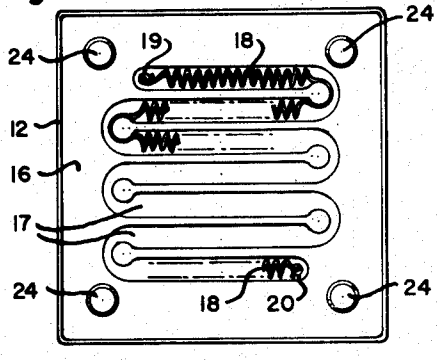


Fig. 5.



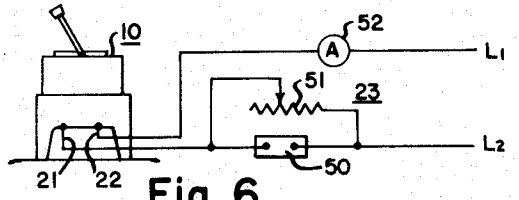


Fig. 6.

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3,140,335

LABORATORY FURNACE

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6 Claims. (Cl. 13—20)

This invention relates to an electrically heated laboratory furnace which produces precisely reproducible conditions of test. More particularly, this invention pertains to such a laboratory furnace for determining the free-swelling index of coal, and for other testing of coal samples and/or other materials.

In the determination of the free-swelling index of coal, for example, it has been routine to employ apparatus meeting the standard set forth in the American Society for Testing Materials Designation D720–57. Thereunder, at least four buttons have to be made very carefully in the case of each coal tested to attempt to reduce the variations in results which heretofore have occurred in prescribed heating apparatuses, including those using gas, or electricity, for heating. Thus, fuel gas heating apparatus is disclosed in the aforesaid ASTM designation and electric heating for such a determination was the subject of a discussion in an article by Messrs. Swartzman and Behnke in the October 1951 issue of "Mining Engineering," pages 871 et seq. Such variations affect the comparisons which can be made and appear to be inherent in apparatus heretofore used despite the care taken therewith and in the preparation and handling of the samples to be tested. As a consequence, consistently reproducible test conditions and results on a sample have not been obtainable with the assurance desired.

In a small-scale laboratory furnace of this invention, tests run therein are precisely reproducible for a given material like coal under all normal conditions and have enabled samples of different coals to be correctly evaluated even though but a single sample of each such coal is heated to produce a button from which the free-swelling index may be obtained. Hence, under this invention, testing costs can be markedly reduced, the over all test time may be lessened and excellent results obtained, which can readily be reproduced, if and when desired.

Other objects, features and advantages of this invention will be apparent from the following description and the accompanying drawing, which are illustrative of one embodiment only, in which

FIGURE 1 is a view in side elevation of a small scale laboratory furnace embodiment of this invention capable of being utilized in the testing of a coal sample to determine, e.g., the respective free-swelling index thereof;

FIGURE 2 is a view in section taken along line II—II of FIGURE 1;

FIGURE 3 is a view in perspective of a crucible holder which may be used in conjunction with the foregoing furnace embodiment;

FIGURE 4 is a plan view of the furnace embodiment of FIGURES 1 and 2 with the crucible holder removed therefrom;

FIGURE 5 is a plan view of the heater base of the furnace embodiment shown in FIGURES 1, 2 and 4 with the furnace heating chamber removed; and

FIGURE 6 schematically shows an automatic timer heating control which may be used with the furnace embodiment illustrated in the drawings.

Referring to the drawings, **10** indicates one laboratory furnace embodiment of this invention comprising a heater base **11**, a heating chamber **25** and a holder **26** for a specimen or sample of material to be tested. Base **11** comprises sheet metal stand **12** which is rectangular in

plan, has legs **13** and inwardly extending integral bracket ears **14**. The ears **14** support a rectangular plate of rigid electrical and thermal insulation **15** and a refractory heater block **16** thereon, which fit within the sides of stand **12**. Block **16** may be a rigid cast or molded refractory, which also is an electrical and thermal insulator, having a flat spiral or, as shown, a flat serpentine molded groove **17** in the top thereof for a corresponding length and flat configuration of heater coil element composed of electrical resistance heater wire **18** extending between terminals **19** and **20** respectively connected to conductive wires **21** and **22** leading to a furnace control **23** between the furnace and electric power source lines L_1 and L_2.

Groove **17** is deep enough so that the top of the heater element **18** is just below the level of the upper surface of heater block **16**, while bosses **24** extend above such surface at the respective corners of base **11** to center heating chamber **25**. Chamber **25** comprises a removable refractory block **27**, with thermal and electrical insulating properties, having a vertical heating well **35** and encased in an expansible sheet metal wall **28**. Wall **28** comprises four vertically extending angles one covering each corner quarter of block **27**, which is square in plan, the respective angles overlapping and being resiliently held together horizontally so that thermal expansion and contraction of block **27** and wall **28** may occur in the course of repeated use. Each angle of wall **28** has a bracket **29** on the outer side of its vertical edges **33** facing a corresponding and opposed bracket on an adjoining angle. The outstanding portions of each pair of opposed brackets **29** are drilled in registry for a screw **30** to go therethrough and through a spring **31** which is held in place by a nut **32** to resiliently urge each pair of adjacent brackets toward each other and keep wall **28** tightly against the vertical sides of heating block **27**. The vertical edges **33** of the angles of walls **28** do not meet but the gap between each adjacent pair of such edges is slidably covered by a flap **34** fastened to one of the angles only at each such location, thereby inhibiting refractory cracking and/or spalling, or disturbance of uniform temperature conditions obtaining within the vertical bore **35** extending entirely through the center of block **27**. The underside of block **27** is provided with corner recesses to fit over bosses **24** respectively so that body **27** is in firm, central seating engagement with and on heater block **16** as shown in FIGURE 2, wall **28** being inwardly spaced relative to the upper part of case **12** above block **16** to allow for the expansion and contraction which occurs in the course of use and to inhibit flow of air between the engaging surface portions of the blocks **16** and **27**, or into well bore **35**.

The upper part of the surface of well bore **35** is provided with two radially recessed slots **36** in diametrically opposed relation to accommodate the upper offset portions of legwires **37** in holder **26**. The diameter of bore **35** is smaller than the area covered by the groove **17** and is positioned in central relation to heater base **11** and heating element **18** so that when the electric current is on, the bore **35** and block **27** at least immediately around bore **35** will be heated. Leads **38** to a thermocouple are located in block **27** and provide a temperature indicating means which, if desired, may also be used for control of furnace temperature and thereby of the temperature of material being heated in bore **35**. Further, that portion of the heating coil directly within the perimeter of bore **35** will directly heat the test specimen, or container and test material heat placed within that bore, while the walls of the well bore **35** will radiate heat to such test specimen or container, for stable, relatively uniform heating after the furnace has been brought up to operating temperature. Moreover, the coil **18** when

heating relatively quickly brings furnace 10 up to whatever operating temperature is selected.

Holder 26 comprises a horizontal metal frame in the form of a ring 39 having drilled an tapped openings 40 at opposite diameters thereof for screws 41, the heads of which grip the upper ends of the respective sides of a holder wire support 37; at the bottom of which at the desired elevation there is a holder loop 42, for a crucible 43. The holder support may comprise a U-shaped wire or wires made of a material like platinum. Loop 42 is round in the illustrated embodiment to fit a silica crucible 43, which normally has a solid lid 44 with an eye projection thereon, useful in determining, e.g., the free-swelling index of coal, or for other purposes. In calibrating the furnace according to the ASTM procedure, the crucible is used with a pierced lid for passage of a calibrating thermocouple passed down through the top of bore 35 and the hole in such pierced lid. Holder wires 37 are provided with shouldered offset portions 45 so that they may slidably index with and fit easily into the respective slots 36 when frame 39 rests in a horizontal portion on the flat top of block 27 as shown in FIGURE 2. Thus, the adjustment of the height of support 37 relative to frame 39 will decide whether crucible 43 will rest directly on top of block 16 at the bottom of well 35, or will be positioned a predetermined distance thereabove. Moreover, although in testing the swelling characteristics of a coal, such a silica crucible is used, it is apparent that other tests may be carried out in the furnace, that other forms and types of test material containers may be utilized, and that the test specimen itself may be held by a support corresponding to a support 37 for heating in the well bore 35 without being in any container.

A bail 46 having an insulated knob 47 is fixed or pivotally connected to ring 39 on opposite sides thereof and rotated 90 angular degrees in plan away from the screws 41 respectively. In use at least, the handle 46 is tilted as shown so that the upper portion thereof and knob 47 are not directly above bore 35 and thus removed from the heating effect thereof. In general, the diameter of bore 35 is selected so that there will be a reasonably close fit between loop 42 and a crucibile or other container carried thereby within the sides of the bore. Thus, the block 27 of the illustrated embodiment may be made of suitable firebrick 4½ inches square, 2½ inches high and with a well bore 2¼ inches in diameter. Inasmuch as a silica low-form crucible specified in the ASTM procedure has an external diameter at the top of about 1.61 inches, such a crucible would be spaced about 0.32 of an inch from the surface of well 35. After a test is over, the holder 26 may be removed by means of bail 46 and knob 47 to carry the holder and container therewith and enable the holder to be set down on a forked rest 48 at the top of a weighted bottom 49, before using crucible tongs to remove the crucible lid and empty the coke button out of the crucible to enable it and the holder to be readied for a fresh sample. In use, the height of holder is adjusted above block 16 and heating element 18 so as to obtain the temperature at the base of the crucible in compliance with the prescribed American standard or other standard being utilized in the testing.

In operation, a furnace of this invention may be used to determine the free-swelling index of coal in lieu of the gas control procedure of ASTM Designation D720–57, or the procedures of the British or International Standards for making such a determination. In calibrating and using a furnace of this invention, a control 23 may be used having therein a timer 50, a rheostat 51 and an ammeter 52. Paralleling the ASTM and British procedures, the furnace heating curve is adjusted so that it will bring the inner surface of the bottom of the crucible up to 800° C.±10° C. in 1½ minutes and up to 820° C. ±5° C. in 2½ minutes after placing the crucible in position in the furnace, in order to calibrate the same. A

calibrating thermocouple, or the thermocouple connected to leads 38 if it is made slidably removable through a tap extending into the side of heating chamber block 27, is used in such calibration by being passed downwardly through the top of bore 35 and through the hole in the pierced lid of the empty crucible so that the unprotected junction of the thermocouple and a portion of each wire are in contact with the base of the crucible. The timer indicated is used in such calibration and subsequent test runs to increase resistance inrheostat 51 at the end of 1½ minutes to prevent overshooting of the prescribed final temperature of 820° C.±5° C. at the end of the additional minute. In a test run after calibration, a cold crucible with a coal sample therein, using the ASTM procedure specifications, is placed in holder 26 and then in heating chamber 27 as shown in FIGURE 2; the timer is started at the higher (lower resistance) heating value ascertained in the calibration until 1½ minutes have passed when the timer automatically reduces the heating current during the remaining minute of the test, or until the flame of the burning volatile matter dies out, whichever is the longer, after which the coke button is carefully removed and checked for its profile and swelling index number according to the chart in the ASTM designation. It has been found that after calibration of such a laboratory furnace embodiment of this invention and usage for a particular type of coal, the results of those tests relatively precisely reproduce one another. The calibration, selected timing arrangement and heating curve described would, of course, be different if other test standards and/or heating conditions are selected.

Although the small-scale laboratory furnace embodiment described above is square in plan, it will be evident that the respective heater base and heating chamber thereof, or either, may be made round if desired, or in other preferably regular shape, that the sheet metal case may be omitted relative to the refractory heating chamber block and that the holding of a container or test specimen may be performed by other means than as shown in the illustrated embodiment. Further, various other automatic or semi-automatic controls may be employed or there may be wholly manual operation of devices of this invention.

Various other changes may be made details of the illustrated embodiment and other embodiments provided without departing from the spirit of this invention or the scope of the appended claims.

What is claimed is:

1. An electrically heated laboratory furnace comprising, in combination, a stand, a refractory heater block in said stand having a groove in the top thereof, a resistance heater coil element positioned in said groove in a planar manner, means for regulating the amount and length of respective portions of a heating cycle provided by said heater element, said stand having its wall extending above the top of said heater block, a refractory block comprising a heating chamber having a vertical well therein extending therethrough, said heating chamber having radial recesses communicating with said well diametrically opposite one another and extending from a position intermediate the top and bottom of said heating chamber upwardly through the top thereof, an expansible sheet metal case enclosing the outside of said heating chamber, said heating chamber being adapted to seat on said heater block in central relation thereto and to said heater element with the bottom of said well and the portion of the underside of said heating chamber around said well being directly above said heating element, a holder having a horizontal frame adapted to rest on top of said heating chamber, a generally U-shaped wire support depending from said frame having upper offset portions adapted to be lowered into and raised from said recesses respectively, said support further having a lower portion with a horizontal crucible loop, means for adjusting the distance between said wire support loop and

said frame, and a bail handle connected to said frame offset from a position directly above said well.

2. An electrically heated laboratory furance comprising, in combination, a refractory heater block having a groove in the top thereof, a flat resistance heater element positioned in said groove, means for regulating the amount and length of heating provided by said heater element, a refractory block comprising a heating chamber having a vertical well therein extending therethrough, said heating chamber having radial recesses communicating with said well extending from a position intermediate the top and bottom of said heating chamber upwardly through the top thereof, said heating chamber being adapted to seat on said heater block in central relation thereto and to said heater element with the bottom of said well and at least the portion of the underside of said heating chamber around said well being directly above said heating element, a holder having a horizontal frame adapted to rest on top of said heating chamber, a wire support depending from said frame having upper offset portions adapted to be lowered into and raised from said recesses respectively, said support further having a lower container holding portion and a handle on said holder to enable it to be carried.

3. An electrically heated laboratory furnace for a crucible and the like comprising, in combination, a refractory heater block, a substantially flat area resistance heater element carried by the top of said heater block, a refractory block comprising an open-topped heating chamber having an unobstructed cylindrical vertical well therein extending therethrough, said heating chamber being adapted to be carried by said heater block in central relation thereto and to said heater element with the bottom of said well and at least the portion of the underside of said heating chamber immediately around said well being directly above said heating element, a holder frame adapted to rest on the upper portion of said heating chamber spaced outwardly of the upper edge of said well, and a support depending from said frame for a crucible adapted to be lowered into and raised from said well.

4. An electrically heated laboratory furnace to determine the free-swelling index of coal, comprising, in combination, a refractory heater block having a horizontal winding groove in the top thereof, a resistance heater element positioned in said groove, means for regulating the amount and length of heating provided by said heater element, a refractory block comprising a heating chamber having a vertical well therein extending therethrough, said heating chamber having recesses extending outwardly from the upper portion of said well, said heating chamber being adapted to seat on said heater block in central relation thereto and to said heater element with the bottom of said well and the portion of the underside of said heating chamber around said well being directly above said heating element, a holder having a horizontal frame adapted to rest on top of said heating chamber around the top of said well, and a generally U-shaped wire support depending from said frame having offset portions adapted to extend into said recesses respectively, said support further having a horizontal crucible loop at the lower end thereof adjacent said heater element and the surface of said well.

5. An electrically heated laboratory furnace for a crucible and the like as set forth in claim 3, comprising, means for vertically adjusting said support to adjust the height of said crucible in said well relative to said top of said heater block, and a movable handle for said holder frame pivotally connected thereto and adapted to be swung away from a position directly over said well when said furnace is in use.

6. An electrically heated laboratory furnace comprising, in combination, a refractory heater block having a horizontal electrical heater means equidistant from the bottom of said block, means for positioning said heater means adjacent to put below the top of said heater block, means for regulating the amount of heating provided by said heater means, a refractory heating chamber having a vertical well therein, adapted to be placed on top of said heater block above said heater means, means for indexing the respective positions of said heater block and heating chamber one above another, removable depending means adapted to be supported by the top of said heating chamber and to support material to be heated in said well below the top thereof and adjacent said heater means and the surface of said well, means to index the position of said depending means relative to said heating chamber, and means to adjust the distance between said depending means and said heater means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,140,335 July 7, 1964

Daniel T. Muth et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 3, for "furance" read -- furnace --; column 6, line 23, for "pat" read -- but --.

Signed and sealed this 10th day of November 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE
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