Aug. 20, 1940. H. R. MacMICHAEL 2,211,957

METHOD OF FURNACE CHARGING

Original Filed June 21, 1935 3 Sheets-Sheet 1

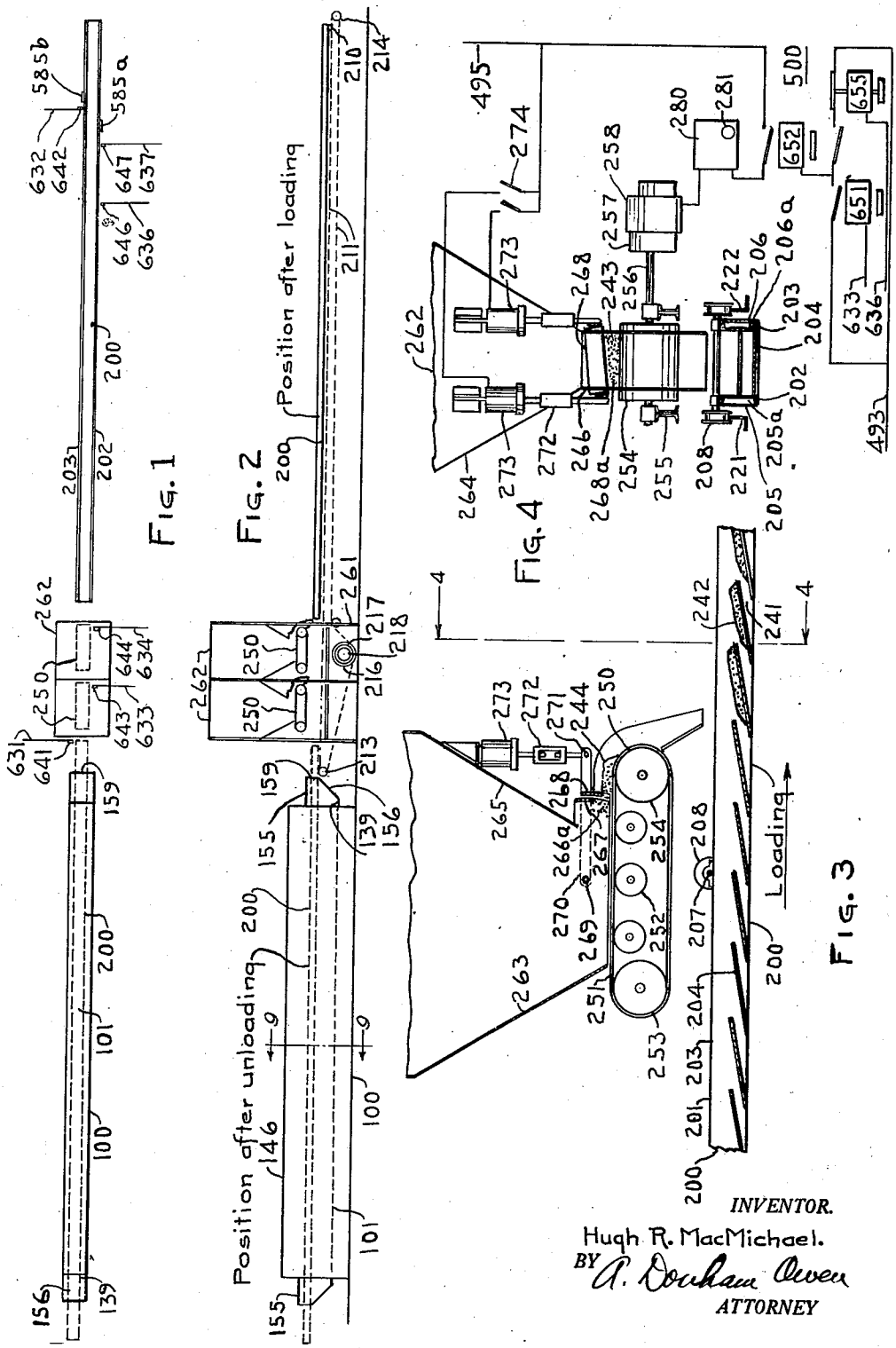


Fig. 1

Fig. 2

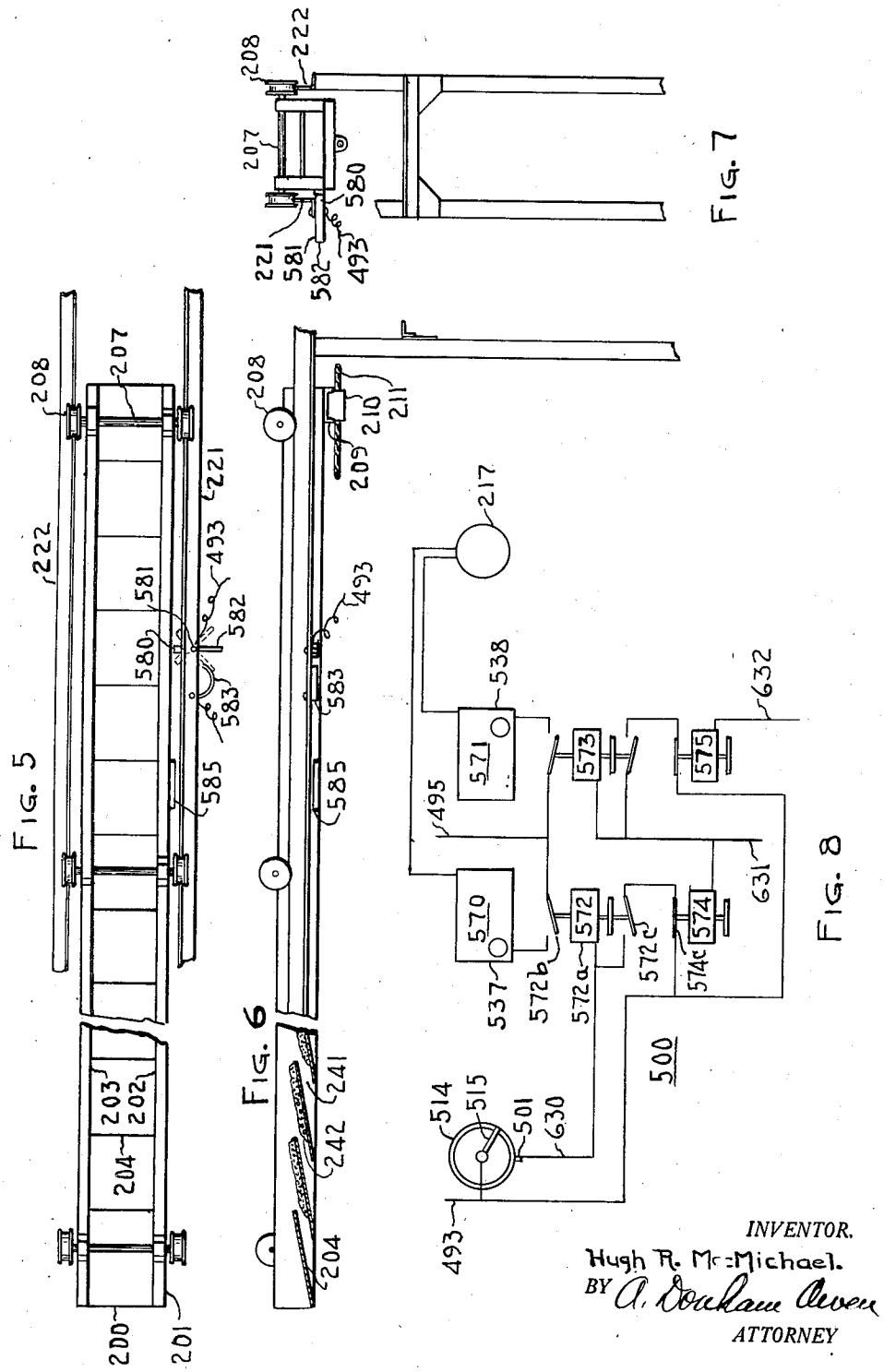
Fig. 4

Fig. 3

Aug. 20, 1940. H. R. MacMICHAEL 2,211,957

METHOD OF FURNACE CHARGING

Original Filed June 21, 1935 3 Sheets-Sheet 2



INVENTOR.

Hugh R. MacMichael.

BY A. Dunham Avery

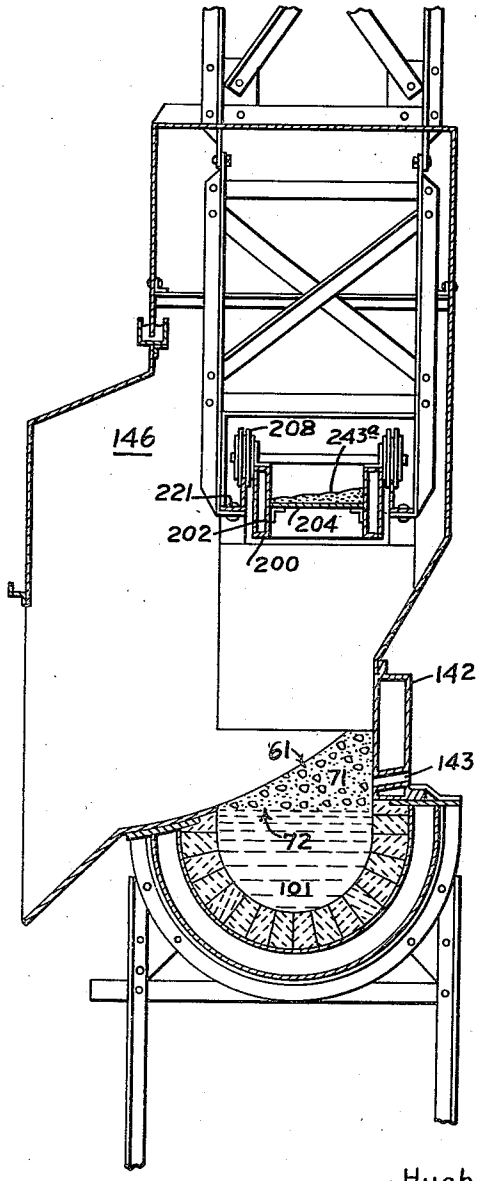
ATTORNEY

Aug. 20, 1940. H. R. MacMICHAEL 2,211,957

METHOD OF FURNACE CHARGING

Original Filed June 21, 1935 3 Sheets-Sheet 3

Fig. 9.



INVENTOR.
Hugh R. MacMichael.
BY A. Durham Owen
ATTORNEY.

Patented Aug. 20, 1940 2,211,957

UNITED STATES PATENT OFFICE

2,211,957

METHOD OF FURNACE CHARGING

Hugh R. MacMichael, Piedmont, Calif.

Original application June 21, 1935, Serial No. 27,697. Divided and this application August 1, 1939, Serial No. 287,785

2 Claims. (Cl. 214—152)

This invention relates to a method of furnace charging and more particularly for the charging of a lead-smelting Scotch-hearth type of elongated furnace. This application is a division of application Serial No. 27,697 of June 21, 1935. Reference is also made to application, Serial No. 124,834, for which this application is a substitute.

The Scotch-hearth type of lead-smelting furnace is commonly built with a crucible 20 inches wide having a continuous opening over its front side, and over its rear side having a water-cooled wall with longitudinally-spaced tuyère openings therethrough positioned just above the level of the front over-flow level of crucible. In operation, said crucible is full of molten lead whereon the smelting charge is floated with a charge depth of about a foot at the furnace back side adjacent the tuyères, tapering downwards across the furnace forming a wedge-like cross-section (see Fig. 9). As heretofore generally built and manually charged, the furnace is worked through said front side opening including the working operations of shoveling in of the fresh charge, of rabbling and of backing or reforming the entire smelting charge, and of the removal of the discardable lump-slag product from the furnace.

The charge generally consists of lead sulphide (galena) ore concentrates in a pulverulent state with coke fines as fuel, and certain by-products. The continuously-operated furnace is worked on a cycle repeated at intervals of 1¼ to 2 minutes, the shorter time being preferable except hitherto as to the endurance of the operator. Following a mechanically quiescent period of a minute or so, the entire charge is rabbled and backed into its normal smelting wedge-like cross-section. Thereupon, fresh charge is added by the operator from a hand shovel as heretofore charged, which he does with a peculiar swinging motion whereby said charge is skillfully spread over the smelting surface in a thin, carefully distributed layer, thereby permitting an effective contact of the air blast (supplied through said tuyère opening and emerging through the surface of the smelting charge) with the fine particles of the freshly added charge causing an active oxidising or roasting action to take place thereon. In about a minute after charging said roasting effect is about completed and and the furnace is then to be started on another working cycle as above described. Unless the fresh charge is added at the proper time and properly distributed over the furnace, all or part of the smelting surface may become overheated and an excessive amount of lead will then be volatilized with resultant wasteful expense. So exacting is the operator's work in manual charging, that under otherwise identical conditions a stronger and more skillful operator will commonly get a one-third greater tonnage through a furnace than will a poorer operator, and the same skillful operator will do notably better work in cool favorable weather than when it is oppressively hot. Various efforts have been made to substitute mechanical methods and equipment for the charging of the furnace but all such efforts heretofore have been abandoned.

The general object of this invention is to provide methods of charging the lead Scotch-hearth furnace mechanically, thereby substantially reducing costs and increasing furnace capacity by maintaining the latter at its best operating rate and condition unhampered by the limitations of human skill and endurance.

Some of the specific objects of this invention are to provide methods for proportioning and assembling the materials making up the furnace charge, for controllably distributing the same on a charger to form thereon a unit charge in a thin layer of controllable variable thickness in its different parts and having generally the areal distribution currently required for the furnace, for depositing said unit charge in the furnace generally reproducing therein said predetermined thin layer distributional effect free from undesirable distributional irregularities or ridging effects.

Other objects are to provide methods whereby the separate proportioned elements of a unit charge may be placed controllably and respectively in superimposed thin layers on said charger and thence deposited in the furnace with a mixig effect thereby to obtain a thorough mixture of the charge elements as deposited in the furnace, while the areal distribution therein of each element is independently controllable by the preceding distribution thereof on said charger.

Another object of the invention is to provide methods whereby a mechanically-handled unit charge may be placed in the furnace, of manually-controllable variable thickness, enabling the operator to make charging corrections for irregularities in the running of the furnace after the manner now accomplished in manual charging by a skillful operator. For instance, if one part of the furnace is too cool, he may compensate by adding additional fuel in that part. Or if one part has smelted more rapidly so that the charge depth is too little, he may add additional ore and fuel thereto.

The foregoing and other objects of the furnace-charging methods of my invention may be better understood by a consideration of an arrangement adapted to the practice thereof, as set forth in the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a diagrammatic plan of the charging system and a furnace.

Fig. 2 is a diagrammatic side elevation of Fig. 1.

Fig. 3 is a longitudinal vertical section through a feeder with part of bin and charger.

Fig. 4 is an elevation on the line 4—4 of Fig. 3 and also an electrical control diagram.

Fig. 5 is a plan of the charger.

Fig. 6 is a side elevation partly in longitudinal cross section of Fig. 5.

Fig. 7 is an end elevation of Fig. 6.

Fig. 8 is an electrical control diagram for the charger movement.

Fig. 9 is a partial cross-section through the furnace and charger viewed on the line 9—9 of Fig. 1.

Like reference characters denote like parts in the several figures of the drawings.

The furnace 100 has the crucible 101 (see Figs. 1 and 9) over the rear side of which is the wall 142 in the lower part whereof are the longitudinally spaced tuyère openings 143. Over the front side of said crucible 101 is a longitudinally continuous opening underneath the hood 146 generally enclosing the balance of said furnace. In said crucible the space up to the line 72 will be occupied in operation by molten lead, and floating thereon will be the smelting charge generally under-lying the line 61 occupying the wedge-like cross-sectional shaded area 71 having a depth of about a foot on the tuyère side and tapering down to almost nothing at the other side of said crucible. Longitudinally adjacent at each end of said crucible 101 are the dead plates 139 and the slope plates 156 adapted to receive charge deposited outside said furnace crucible length by the movable charger 200. Said hood 146 is provided with the end extensions 159 having the openings 159 wherethrough said charger 200 may pass.

The charger 200 has a longitudinal frame 201 composed of a left channel 202 and a right channel 203 between which are carried a plurality of spaced sloping flat plates 204, the bottom of one said plate overlapping the top of the next in louver fashion. The plates 204 have a slope somewhat less from that of the angle of repose of the charge as it is dropped from the feeders 250 to the charger 200, which slope may approximate a twenty percent grade, sloping downward in the direction in which the charger is moving as it decelerates for dropping its carried charge into the furnace 100. The closure plates 205 and 206 are welded to the channels 202 and 203 respectively thus making a water-tight space 205a and 206a respectively adapted to the circulation of water where this may be found advantageous.

The frame 201 is suspended from a plurality of spaced axles 207 carried by the wheels 208. The charger 200 is imparted longitudinal movement through its end beam 209 having a rope clamp 210 attached to a rope 211 operating over the left end sheave 213, the right end sheave 214, and is driven by the winch 216 through the motor 217, for travel on track rails 221 and 222 suitably supported.

The motor unit 217 is preferably a direct-current compound-wound, variable speed four-to-one ratio, reversible motor especially adapted for frequent quick starting and stopping, provided with a solenoid brake 218, and having the automatic control panel 570 actuated by the power contactor 572 (see Fig. 8) for movement to the left toward the furnace 100 and the panel 571 actuated by the power contactor 573 for movement to the right away from said furnace, each said automatic panel being electrically interlocked (not shown) with the other and equipped for push-button remote control, and having the shunt-field rheostats respectively 537 and 538 manually adjustable for controlling the speed separately in each direction of said motor 217. At its lowest speed the motor 217 will be adapted to impart movement to the charger 200 to the right at a speed of about four feet per second under the control of the panel 571 and the contactor 573, which movement is brought to a stop by the action of the solenoid brake 218 on said motor 217 when the current is cut off same. At its highest speed said motor 217 will impart movement to said charger 200 to the left at a controlled speed up to about sixteen feet per second under control of the panel 570 and the contactor 572, which movement will be controllably decelerated by the solenoid-brake 218 with said motor 217 said brake being rendered inoperative when current is supplied to said motor 217, and by means of adjustable spring or dead-weight pressure becoming operative instantly when the current is cut off therefrom.

When used in the charging of said Scotch hearth type of furnace, said plates 204 may be loaded longitudinally generally uniformly as viewed in longitudinal sectional area 242 (see Fig. 3) and with a laterally tapering load 243a (see Fig. 9) delivered through the feeder area 243 (see Fig. 4), thereby providing for heavier charging on the more active side of said furnace adjacent said tuyères 143, with generally uniform charging longitudinally.

The belt feeders 250 each have a conveyor belt 251 supported on the idlers 252, a tail pulley 253 and a head pulley 254 all carried on the frame 255, said head pulley 254 being driven by a shaft 256 connected with a geared speed reducer 257 driven from a motor unit 258 all suitably carried on a floor 260 carried by columns 261 supporting bins 262 each having a back plate 263, side plates 264 and the front plate 265 provided with an opening 266a extending between the cheek plates 266 connected by a baffle plate 267 through which opening the charge or material carried in said bin may pass out under the control of the sector gate 268 carried from the pivots 269 by the levers 270 each having front pivot 271 supported by a turnbuckle 272 suspended from the solenoid magnet 273 supported from the bin front plate 265. Each end of said gates 268 has its support as described and is thereby separately adjustable as to the height of the opening 268a left between it and the feeder belt 251, the turnbuckle 272 being adapted for ample manual adjustment and the solenoid 273 for a limited remote-control electrical adjustment by the manual operation of a switch 274 of which there is one conveniently located for each solenoid 273. Each of the bins 262 has a feeder 250, each arranged in like manner for delivering the charge in said bin by said feeder to the charger 200.

The motor unit 258 is preferably a direct-current compound-wound variable speed motor especially adapted for frequent quick starting and stopping and provided with its integral solenoid brake (not shown) and having an automatic con-

trol panel 280 adapted for operation manually and also from the control system 500, and having a shunt-field rheostat 281 manually adjustable for controlling the speed of said motor 258.

An operation control system generally designated as 500 is adapted for the timed control of the charger and the correlated control of the feeders. A clock-like timer 514 has the rotor 515 the speed of which is adjustable for the length of the operating cycle desired. Said rotor 515 receives electric current at its center from the relay bus 493, and at each revolution momentarily energizes contact 501 of line 630 energizing the solenoid coil 572a of the relay 572 thereby closing its power current contactor 572b and its relay current switch 572c through which relay current continues to flow until the stopping relay switch 574c is opened by the operation of the relay 574 energized by the line 631 from the terminal 641 (see Fig. 1) as the charger 200 is to be decelerated and stopped at the left-hand end of its travel into the furnace 100. Said power current contactor receives current from the power bus 495 supplying it to the panel 570 adapted to the control of the motor 217 for moving said charger to the left only, at a speed manually adjustable by the rheostat 537 on said panel 570.

When said motor 217 has stopped after cutting off power from said panel 570, the panel 571 electrically interlocked (not shown) therewith is actuated by said relay line 631 also connecting to the power relay 573 and remaining activated until stopped by the relay 575 energized by the line 632 from the terminal 642 (see Fig. 1) located near right hand end of the charger 200 travel.

In all wiring diagrams only one pole is shown (for simplicity) the other pole being assumed as grounded.

Near the right hand end and on one side of the charger 200 is a lug 585 (see Figs. 1 and 6) adapted to contact with an operating lever 580 of the switch 581 causing the blade 582 to move into contact with the terminal 583 thereby delivering current from the connected relay bus 493 to said terminal. As soon as the said lug 585 moves out of contact with said lever 580, the switch 581 returns to its neutral position by the tension of a spring not shown. The terminal 583 may be located to one side or the other of the switch 581 depending on the direction of travel of the charger 200 at the time when the desired contact is to be made. There are six switches 581 respectively connected with the terminals 641, 642, 643, 644, 646, and 647 (see Fig. 1) inclusive energizing the relay lines 631, 632, 634, 636, and 637, and each of said switches 581 are appropriately located on the charger track angles 221 and 222 (see Fig. 4) relative to the passage along same of the charger lug marked 585a on left channel 202 and 585b on the right channel 203 (see Fig. 1) so as to cause the related operating effect to take place at the predetermined point in the travel to the left or to the right of the charger 200.

The terminal 641 is adjustably located near the furnace 100 where deceleration of the charger 200 is to begin, said deceleration causing the carried charge to be discharged with a spreading effect into said furnace 100, said terminal 641 being connected through the line 631 to actuate the stopping relay 574 (see Fig. 8) for opening the relay contactor 572 as above referred to.

The terminal 643 (see Fig. 1) actuated by the charger lug 585a, connects by the line 633 to a starting relay 651 (see Fig. 4) for closing the power contactor 652 controlling the conventional automatic panel 280 for the operation of the motor 258 driving the feeder 250, the speed of which is controlled through a shunt-field rheostat 281 on said panel, said terminal 643 being positioned on the charger track 221 relative to the moving charger lug 585a so as to cause the feeders 250 to start delivering charge to the charger 200 at the proper point in its travel to the right away from the furnace 100. The terminal 646 through the line 636 operates the stopping relay 655 causing the feeder 250 to be stopped as the charge receiving length of the charger 200 passes to the right of said feeder 250 for which purpose said terminal 646 is appropriately positioned near the right end of the charge track 221 and is separated from the terminal 643 by a distance substantially equal to the length to be charged on the charger 200. In like manner the terminal 644 operates to start the second feeder 250 driven by its respective motor 258 not separately shown, and the terminal 647 serves to stop said feeder through means identical in principle with those for the first feeder 250.

Mode of operation

The Scotch-hearth type of lead-smelting furnace requires a thin layer of fresh charge accurately distributed areally over the furnace, generally uniform in thickness longitudinally but tapering off laterally from the tuyère side of the furnace (see Fig. 9) towards the open side where little of the air-blast comes through. Properly to control the operation and to compensate for preceding irregularities in furnace working conditions, it is essential that the operator be always enabled to control manually the distribution and quantity respectively both of the ore and the fuel of each unit charge, although with a mechanically uniformly charged furnace, many successive charges may be formed and deposited without the necessity for the continuous changes of distribution inherently required in manually-charged furnaces.

The quantity of charge from a bin 262 is adjustable by the average height of the gate opening 268a over the belt 251, and by the relative speeds of the feeder 250 adjustable by the motor rheostat 281 on the panel 280, and the speed of the charger 200 on its loading travel to the right adjustable by rheostat 538 on the panel 571. The charge distribution laterally on the charger 200 is manually adjustable by the turnbuckles 272 independently adjustable on each side of the gate 268. For adding extra charge along one side of the charger 200 over some special length thereof and without disturbing the turnbuckle adjustment, one of the switches 274 may be manually operated raising the gate end thereunder, said gate returning to normal position by gravity as soon as said switch 274 is opened. Said switches may be conveniently located to suit operator.

The terminals 643, 646 and the like are located relative to the charger lug 585a so as to distribute charge over the desired length of the charger, which length will approximate the charge receiving length of the furnace plus a length to allow for charge falling outside the furnace on account of the spreading effect as deposited in said furnace, and so that irregularities in forming and depositing the end portions of the charger may not result in corresponding irregularities in furnace smelting operations.

The charger speed to the furnace will be suitably adjusted in a range generally of ten to sixteen feet per second, and the deceleration of said speeding charger will be adjusted by means of its adjustable brake 218 so that a rapid deceleration causes the carried charge to move ahead relative to the slowing charger thereby causing said charge to pass through the louver spaces 241 (see Fig. 3) and to be deposited below. By suitably regulating said rate of deceleration, the charge from a fifteen-inch length of plate might be spread over approximately a thirty-inch length of furnace, while conversely said thirty-inch length of furnace would then receive one-half the charge from each of two successive said fifteen-inch lengths of charger, thereby effecting a very complete uniform mixture of the layers of materials of which said charge may be composed. More or less spreading effect may be caused dependent on charger velocity in feet per second when brake is first applied and on the resultant rate of deceleration in feet per second, both of which are to be adjusted for the desired effect in relation to the handling characteristics of the charge and the result desired in the furnace.

Having made the aforesaid adjustments determining the quantity of each material per unit charge and its distribution on the charger and thereafter as it is deposited in the furnace, the timer 514 is set for the time cycle desired, and the charging operation then becomes automatic subject to ready adjustment manually at any time.

Dumping by acceleration would permit of less impact due to less horizontal velocity in the charge particles as they are deposited in the furnace, which, for some ores, may be advantageous as to furnace operation. A spreading effect may be secured by either of these methods such that the charge on one lineal inch of the charger may slide off the supporting plate 204 while the charger as a whole is moving more than a lineal inch, and consequently the said lineal inch of charge may be systematically spread over more than a lineal inch of the furnace, and one lineal inch of the furnace receives part of the charge carried by more than a lineal inch of the charger, it being understood that "inch" or "inches" as used here and in the related claims relates to a conveniently referable unit of distance rather than to a precise unit of measurement.

The distributional effect is readily understood by analogy to manual shoveling. As examples, assume that an evenly distributed load of fluent material is placed on a shovel pallet; a skilled shoveler may then swing the shovel along a path so as (*a*) to discharge said material into a heap, or (*b*) to spread it along and generally reproduce the distributional effect which prevailed on the shovel pallet, or (*c*) he may cause it to be spread over a much longer length than the length of the shovel pallet. Or an effect intermediate to the foregoing typical examples may be produced. The charging apparatus of this invention is devised generally to duplicate any of the foregoing described depositing distributional effects from the appropriately loaded charger.

The charge as deposited in the furnace by aforesaid methods tends to be irregularly spread at each end. Therefore, said irregular end charge is to be deposited outside the active smelting length of furnace on the dead-plates 139 and the slope plates 156 to be discarded therefrom.

The term "charge" throughout the specification and the claims is to be understood as meaning one or more of the elements whether separately or as a mixture which enter into the charging operation, such as ore or concentrate of same, slag, dust, fume, drosses or scrap metallic material, whether primary from outside source or secondary as a by-product of the furnace operation, flux and coke breeze or other fuel.

Some differing charge elements can be mixed and suitably handled as a mixture while other elements such as ore concentrates and fine coke breeze (fine coke) will not remain uniformly disseminated in a mixture after handling through fires. I prefer therefore, to handle each such diverse or heterogeneous element through a separate charge bin and feeder. I provide as many feeder and charge bin units as thus necessary, dependent on the number of elements entering the charge, and whether they can most conveniently and efficiently be handled in certain mixtures or separately, the elements in any one charge bin being preferably of a homogeneous nature as to handling. The more or less heterogeneous elements from the plurality of bins may then each be laid in a suitable layer on the charger by the individual feeders, and followed by the unique spreading and mixing action as the charger load is deposited in the furnace, the results thus obtained are uniform and ideal beyond any possibility of the prior art.

The charging methods and system as described are advantageous where a unit charge is to be accurately measured and accurately distributed and deposited in a furnace with a controlled layer representing a well-mixed proportionate part of each of the elements going into the charge. It is well adapted to the charging of a very long relatively narrow furnace such as a long Scotch hearth for smelting lead ores. The charger may be made in relatively shorter wider units for other types of furnaces or for other uses of forming, transporting and depositing unit charges or mixtures of materials.

While I refer to a furnace as the place in which the charge is to be deposited, the method described is applicable irrespective of the place in or on which the charge is next to be deposited, and the word "furnace" used in the specification and claims will be understood as applying to any charge-receiving means with which my charging system may be advantageously used.

This application being a substituted application for my previously filed application, Serial No. 124,834, which is a division from my original application Ser. No. 27,697 filed June 21, 1935, carries much of the original description for details of apparatus adapted particularly to the practice of the methods herein described and claimed. However, other apparatus may be adapted to the purpose. Moreover, other modifications will occur to those skilled in the related arts.

Although certain novel features of my invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the several steps in the process and in its operation, as well as in the forms and details of the apparatus illustrated may be made by those skilled in the art without departing from the spirit of my invention.

What is claimed is:

1. The method of charging a furnace of the Scotch-hearth type which includes loading a charger having a supporting surface co-extensive with the area to be charged, said charger having

discharge openings; inserting said charger into the furnace in such manner as not to disturb the supported charge; and changing the velocity of the charger so as to cause relative movement between the charge and charger so as to cause said charge to pass through the discharge openings in a projected manner.

2. The method of charging a furnace of the Scotch-hearth type which comprises loading a charger in such manner as to form a plurality of substantially unit volumes of charge distributed over an area substantially co-extensive with the area of the furnace to be charged, moving said charger into said furnace in such manner as to impart momentum to said volumes in the direction of movement of said charger, then decelerating the charger whereby to cause the momentum thus imparted to said volumes to project said volumes simultaneously on to said furnace to form a thin even layer of charge thereon over substantially its entire area.

HUGH R. MACMICHAEL.