

May 13, 1958

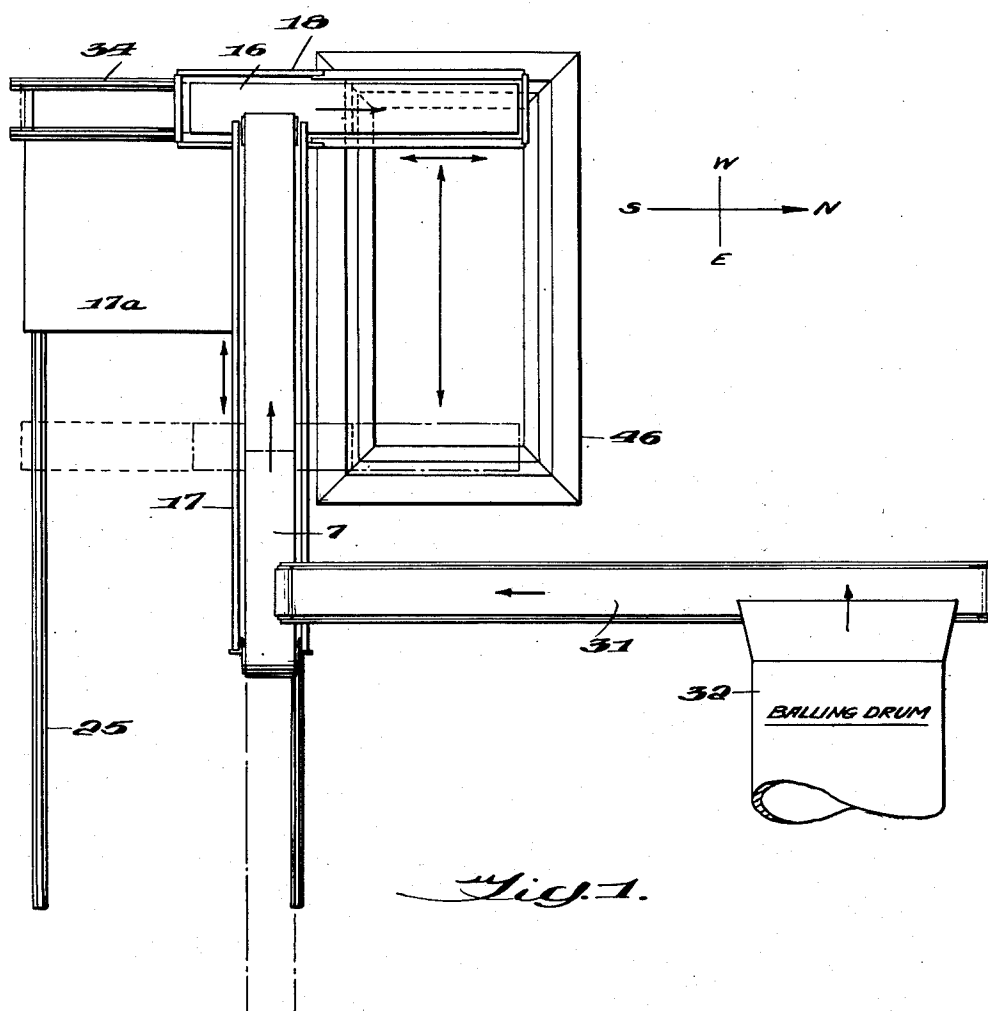
F. D. DE VANEY ET AL

2,834,484

APPARATUS FOR CHARGING FURNACE HAVING RECTANGULAR MOUTH

Filed June 21, 1954

7 Sheets-Sheet 1



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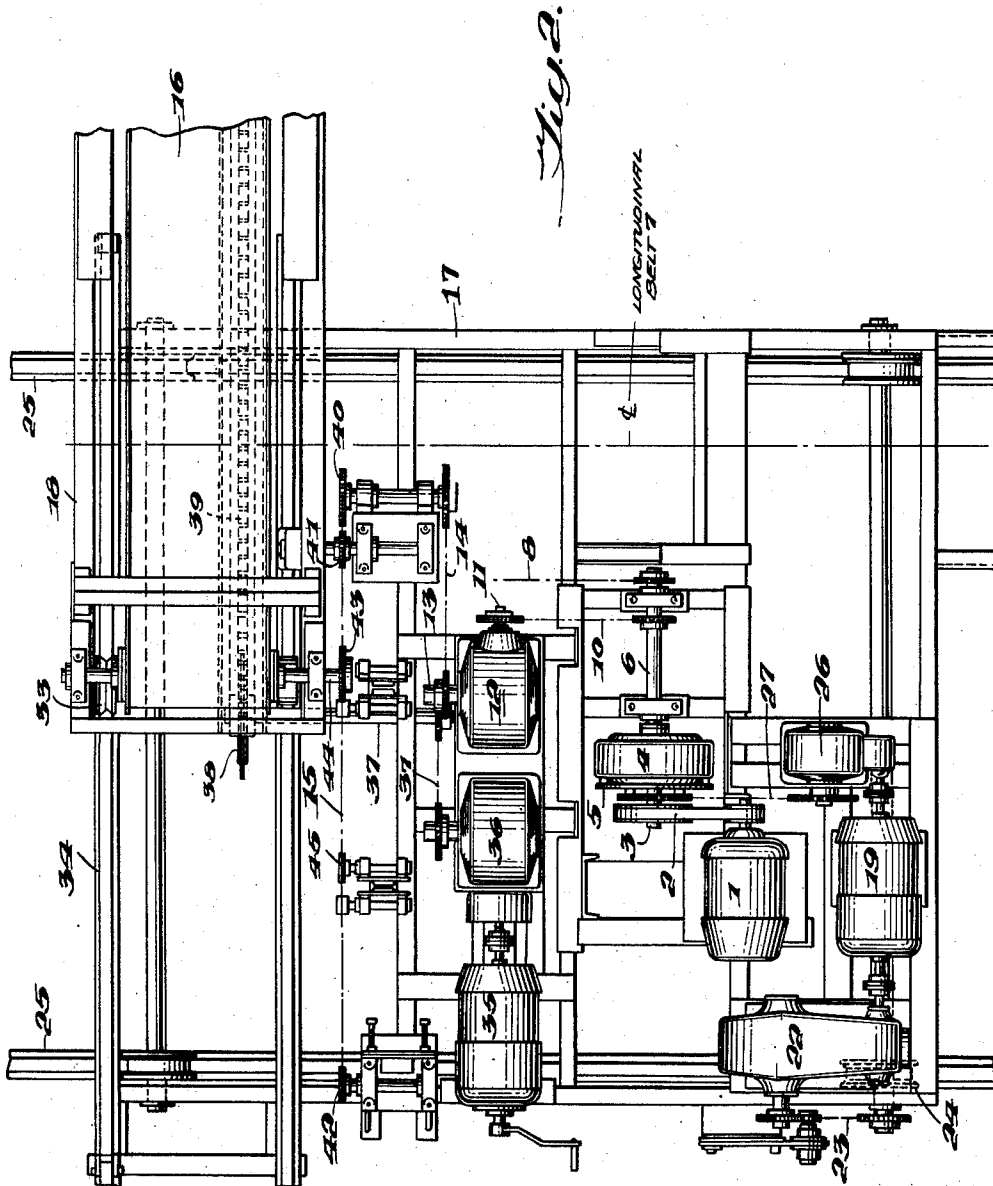
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Fig. 3.

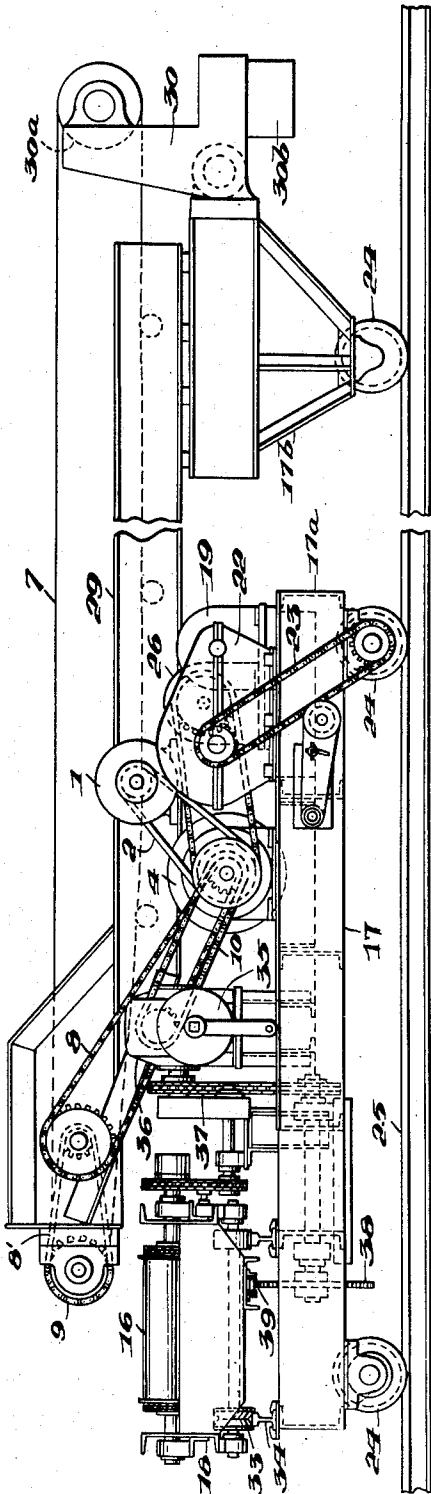
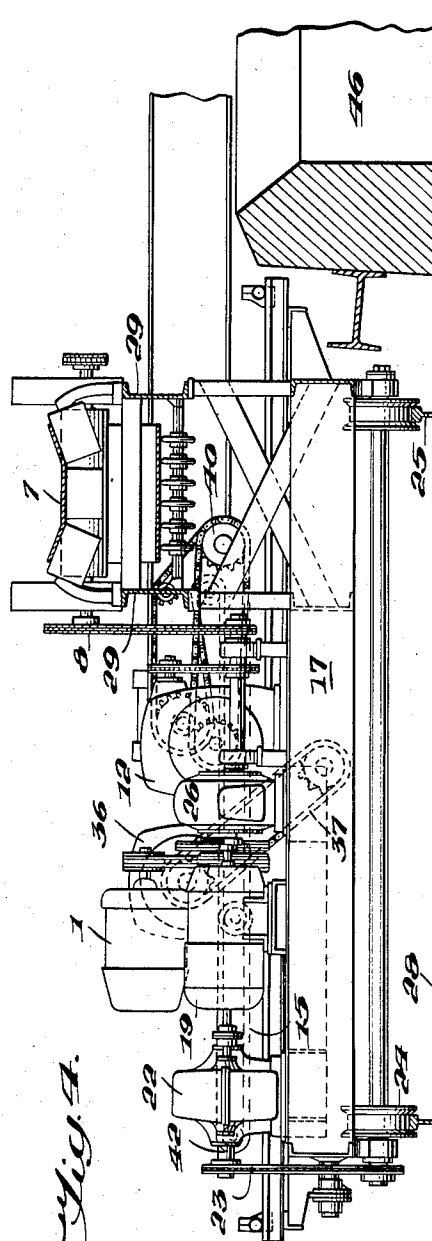


Fig. 4.



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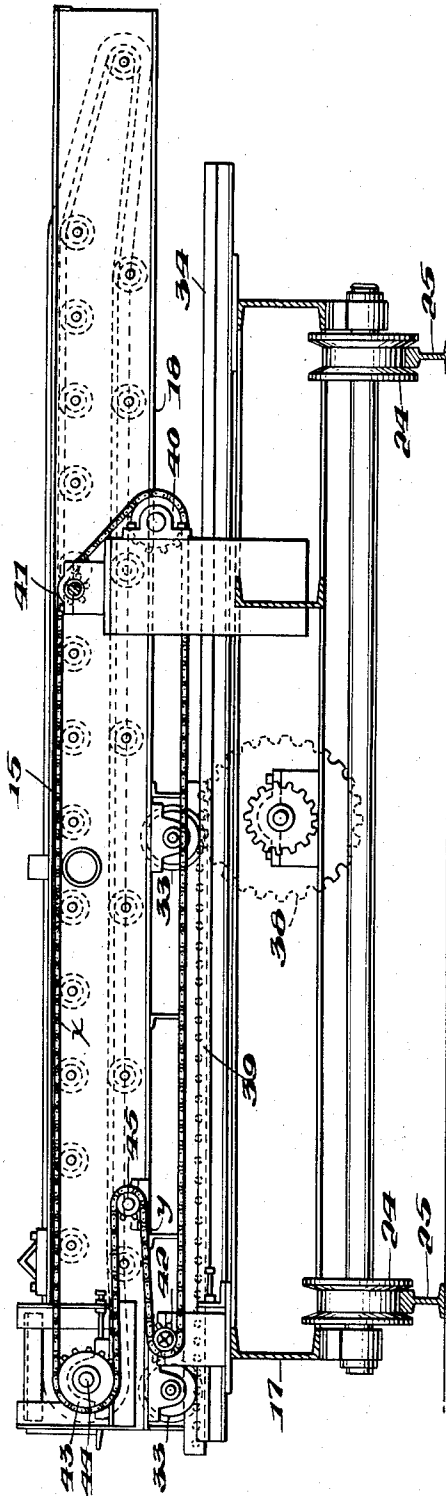


Fig. 5.

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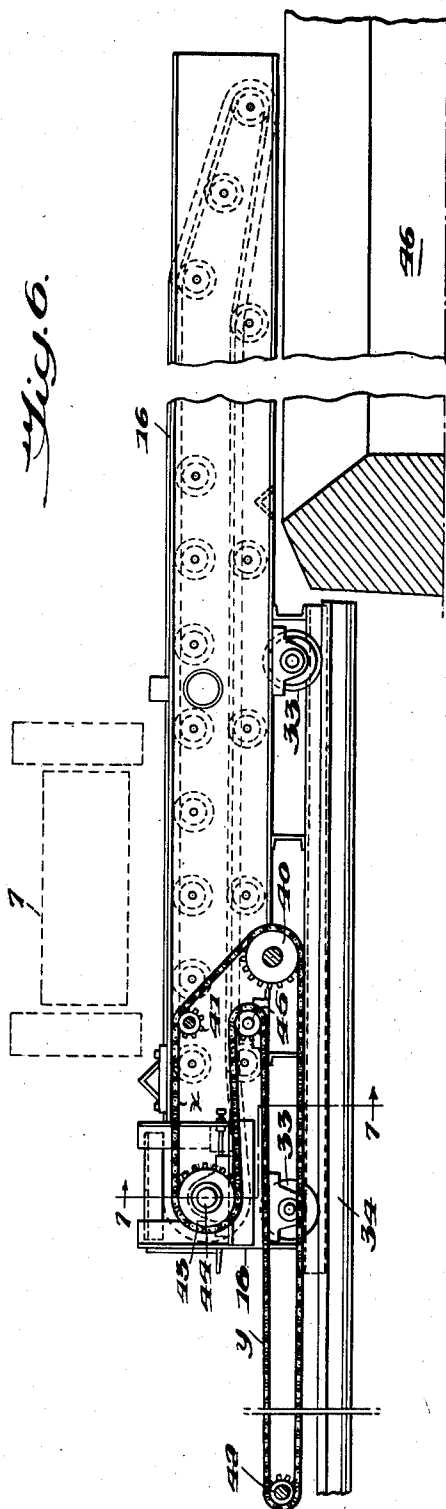
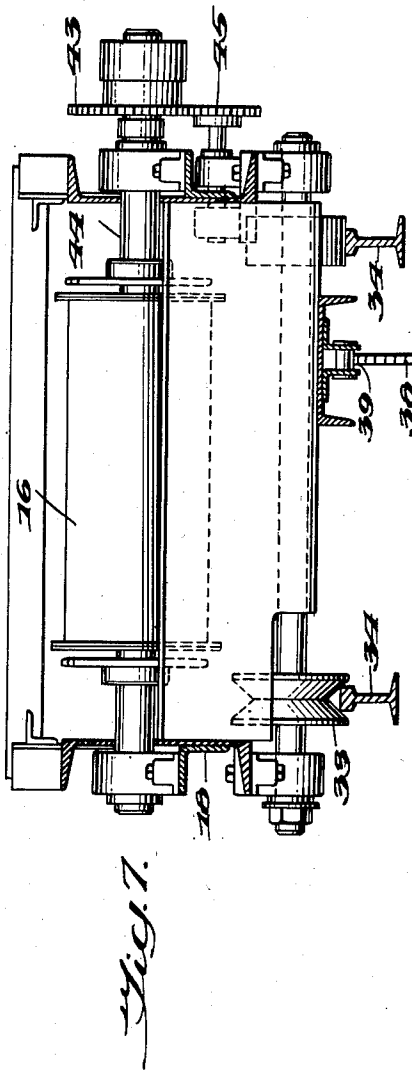
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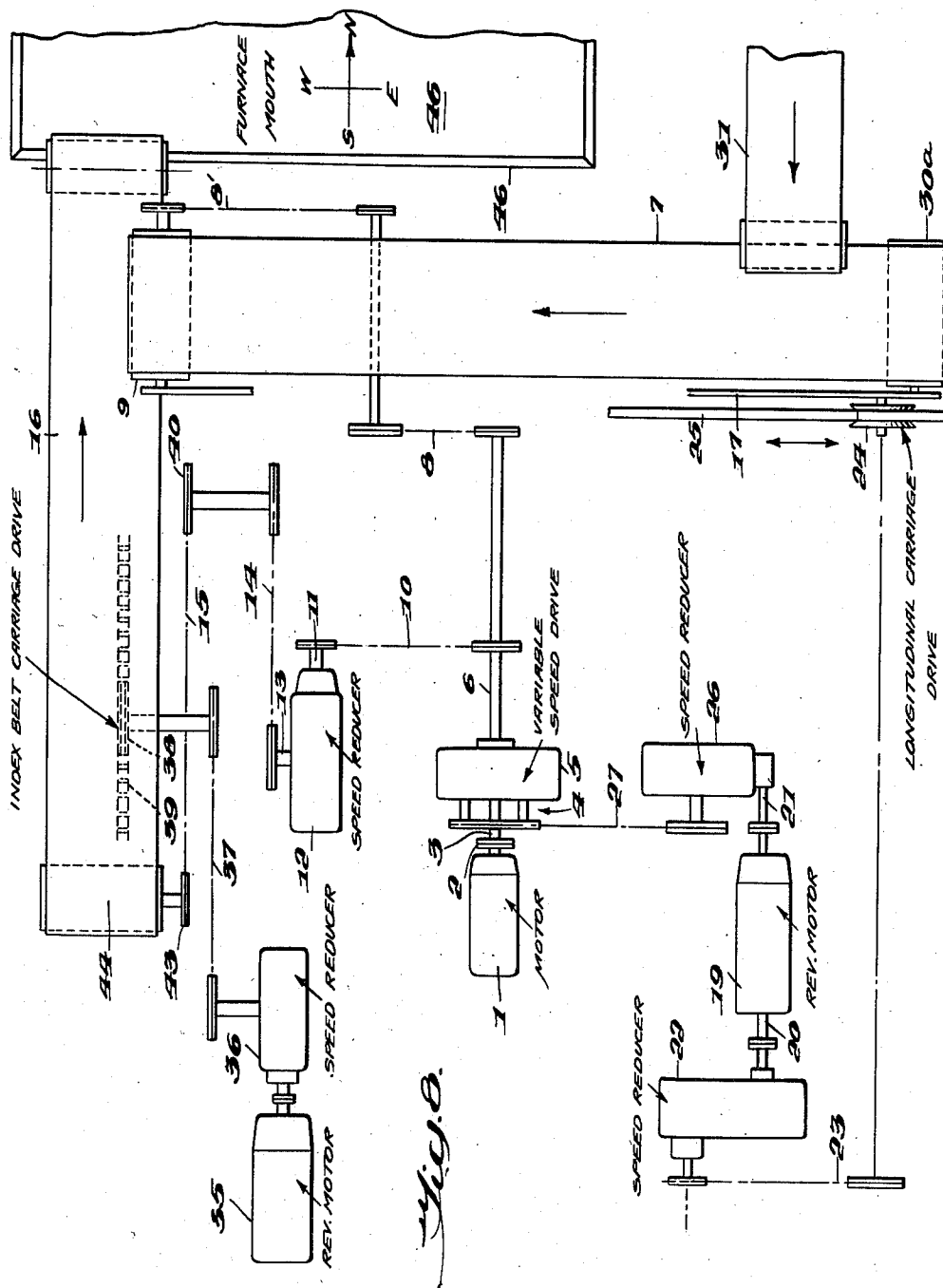
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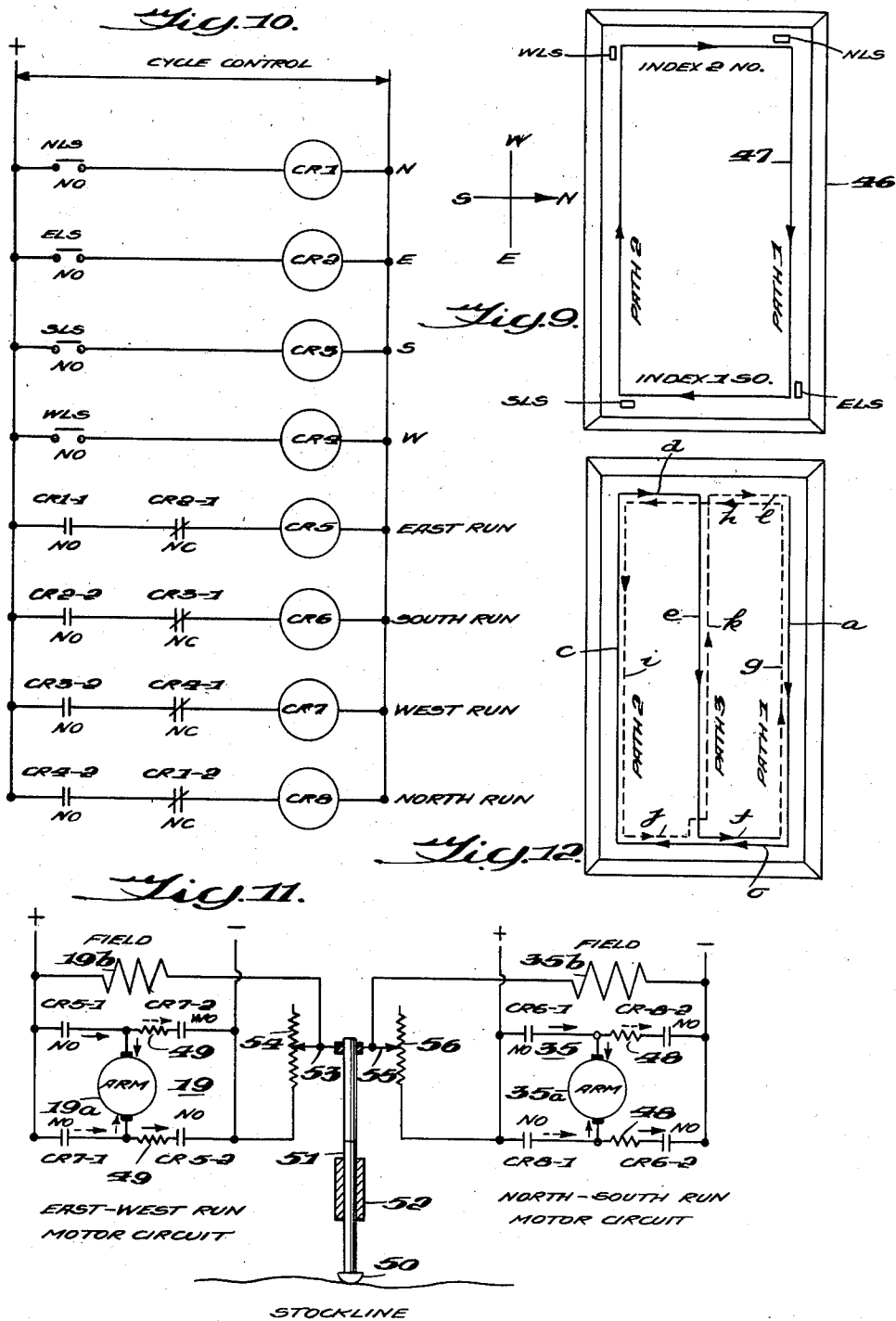
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2,834,484

APPARATUS FOR CHARGING FURNACE HAVING RECTANGULAR MOUTH

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bing, Minn., a corporation of Minnesota

Application June 21, 1954, Serial No. 437,948

10 Claims. (Cl. 214—18)

This invention relates to apparatus for laying down suc-
cessive layers of fluent particulate solid material on the
stockline of a column of particulate solid material gravi-
tationally descending through a generally vertical shaft-
type furnace having a substantially rectangular mouth.

An object of the present invention is to provide a
charging device which will deposit the material in layers
of substantially uniform thickness throughout the entire
area of furnace mouth. Another object is to provide
charging apparatus for laying down onto the stockline a
layer of fluent particulate solids by a combination of
longitudinal and transverse rectilinear movements of the
discharge point of the apparatus over the stockline.

The invention is particularly concerned with such an
apparatus adapted to deliver to such furnace and to dis-
tribute evenly over such stockline a layer of initially
fragile and moist pellets of balled-up masses of finely di-
vided mineral solids such as ore fines and concentrates
(e. g., iron ore concentrates), flue dust, and the like.
Consequently it is a particular object of the present inven-
tion to provide a furnace charging apparatus, of the type
above referred to, which is capable of laying down layers
of such fragile pellets with a minimum of mechanical
abuse, (i. e., deformation of pellets by the imposition of
crushing stresses).

A further inventive object is to provide such furnace
charging apparatus in which the pellets-carrying members
comprise a first conveyor belt arranged along one side
of and parallel with the furnace mouth and a second
conveyor belt arranged transversely to and at the dis-
charge end of said first belt for receiving material dis-
charged from said first belt, wherein each belt is re-
ciprocatable longitudinally of itself and wherein means
are provided for maintaining constant depths of loadings
on said belts irrespective of their reciprocations.

The principles of the invention are applicable to vari-
ous types of furnaces and for purposes of illustration will
be described herein as applied to the charging of the
pellet-indurating furnace with initially mechanically feeble
"raw" pellets of moist balled-up mineral solids such
as finely divided iron ore concentrates.

As is more fully explained in U. S. Patent No. 2,538,-
556 to De Coriolis and Campbell, the nature of such
initially fragile "raw" pellets and the characteristic of the
process of indurating the same in a vertical shaft-type
indurating furnace demand that the "raw" pellets be laid
down on the stockline in even, relatively thin layers and
with a minimum of mechanical abuse or rough handling.
These criteria apply to the operation not only of a fur-
nace of circular cross-section, as in Patent No. 2,538,556,
but also, and with equal force, of a furnace of substan-
tially rectangular cross-section as herein contemplated.

In accordance with the present invention, the "raw"
pellets are continuously supplied, from a fixed locus of
supply, e. g., from a non-reciprocable feeder belt com-
municating with a balling-up drum, to a first conveyor
belt which is disposed parallel to one side of the furnace

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mouth and which is reciprocatable longitudinally of said
side. Said first conveyor belt delivers the pellets to a
reciprocatable second conveyor belt which is disposed be-
neath the discharge end of the first conveyor belt and at
a right angle to and transversely reciprocable with re-
spect to the latter, the discharge end of the second con-
veyor belt extending over the mouth of the indurating
furnace so that pellets received on the second conveyor
belt, from said first belt, are delivered onto the top sur-
face or stockline of a charge column of similar pellets
occupying the furnace. The pellets are laid down in a
layer, as distinguished from being dumped into a pile,
onto the stockline of the charge column by appropriate
reciprocations of the first and second belts, as a unit,
longitudinally of said side of the mouth interspersed with
appropriate transverse reciprocations of said second belt
with respect to said first belt, whereby the discharge end
of the second belt is moved in longitudinal and trans-
verse paths over the mouth of the furnace.

Because of the above-mentioned fragility of the "raw"
pellets the permissible depth of loading of the pellets on
the conveyor belts is strictly limited, and it is highly
desirable—if not in fact absolutely necessary—that there
be a constant loading on both the aforesaid conveyor
belts at all times during operation of the furnace load-
ing apparatus. This criterion (i. e., substantially constant
loading of the conveyor belts at all times, regardless of
any and all reciprocatory movements of the belts) creates
three special, and actual, problems as regards the rates
of driving of the conveyor belts, as follows:

Let it be assumed that said first conveyor belt is po-
sitioned parallel to the south side of the furnace mouth,
that the same is reciprocable to the west and to the
east, and that said first conveyor belt is so positioned with
respect to a fixed supply source that its load-receiving
end is toward the east and beneath said supply source.

If said first conveyor belt were, as conventionally,
driven at a fixed speed, say, a speed of 90 feet per min-
ute, and if the same were moved longitudinally of the
side of the furnace mouth at, say, 30 feet per minute,
the result would be that in one direction of travel, namely
in the direction away from the supply locus, the effective
speed of said first conveyor belt with respect to said fixed
locus of supply would be 90 plus 30 or 120 feet per
minute, whereas in the reverse direction of travel the ef-
fective speed of said first conveyor belt with respect to
said supply locus would be 90 minus 30 or 60 feet per
minute. Thus, the depth of loading of pellets on said first
conveyor belt would vary by a ratio of 2 to 1. Such
variation is intolerable when handling objects of the
fragility of moist pellets of balled-up finely divided solids
such as iron ore concentrates. Consequently:

(1) It is necessary to counteract the variations in load-
ing of said first conveyor belt due to east-west reciproca-
tions of the latter with respect to the fixed supply locus.

Again, variations in loading of said first conveyor belt,
due to east-west reciprocations of the latter, would result
in similar variations in the loading of said second con-
veyor belt. Consequently:

(2) It is necessary to counteract the variations in load-
ing of said second conveyor belt due to variations arising
by reason of east-west reciprocations of said first con-
veyor belt.

A third problem arises from the fact that the loading
on said second conveyor belt tends to vary as (the latter
is reciprocated transversely (i. e., in north-south direc-
tions) with respect to said first conveyor belt. Thus, if
the second conveyor belt were, as conventionally, driven
at a fixed speed, say a rotational speed of 30 feet per
minute, and if said second conveyor belt were moved
transversely of said first conveyor belt at a rate of 10 feet

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per minute, the result would be that the effective speed of the second conveyor belt with respect to the discharge end of said first conveyor belt would vary between 30 plus 10 or 40 feet per minute, during the northerly movement, and 30 minus 10 or 20 feet per minute during the southerly movement. Thus, the depth of loading of said second conveyor belt would vary by an intolerable ratio of 2 to 1 solely by reason of the movement of said second conveyor belt with respect to the discharge end of said first conveyor belt. Consequently:

(3) It is necessary to counteract the variations in the loading of said second conveyor belt due to variations arising by reason of north-south reciprocations of the latter.

In order to maintain a constant depth of loading on said first conveyor belt, its effective speed with respect to its point of loading (i. e., with respect to said supply locus) must be maintained constant; in other words, the first conveyor belt must always move past said supply locus at some predetermined speed, say, 90 feet per minute. When said first conveyor belt is moved to the west, say at 30 feet per minute, its rotational speed must be slowed down to 60 feet per minute—60 feet/minute rotational speed plus 30 feet/minute translational speed equals 90 feet/minute effective speed as regards said supply locus. When said belt is moved to the east, its rotational speed must be increased to 120 feet per minute—120 feet/minute rotational speed minus 30 feet/minute translational speed equals 90 feet/minute effective speed as regards said supply locus.

Now there must be considered what happens at the transfer point from said first to said second conveyor belt. Assume the latter is not being moved in translation with respect to said first conveyor belt. When the first and second conveyor belts are being moved, as a unit, in the easterly direction—in which case the rotational speed of said first conveyor belt with respect to its point of loading has been increased to 120 feet/minute—the rate of discharge of feed from said first conveyor belt onto said second conveyor belt is

120

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90

times normal ("normal" being the rate of discharge when said first conveyor belt is not being moved in translation and said belt is being rotated at 90 feet/minute). Conversely, when the two belts as a unit are being moved to the west and the rotational speed of said first conveyor belt has been decreased to 60 feet/minute, the rate of discharge is

60

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90

times normal. In order to maintain a constant depth of loading on said second conveyor belt, the latter's rotational rate must be speeded up, or slowed down, by the same percentage change as the percentage change in rotational speed of said first conveyor belt. It is to be noted, in this connection, that the actual translational speed of said first conveyor belt must be superimposed in reverse upon the rotational speed of said belt, but the rotational speed of said second conveyor belt must only change by the same percentage as the change in rotational speed of said first conveyor belt; thus, said conveyor belt can be run at a different "normal" speed than that of said first conveyor belt.

Having solved problem "1" above, to solve problem "2" it is only necessary to apply the above percentage change to the rotational speed of said second conveyor belt.

In order to solve problem "3," i. e., to counteract variation in the depth of loading on said second conveyor belt due to north-south reciprocations of the latter with respect to its loading point, it is necessary to superimpose

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its speed in translation in reverse upon its rotational speed.

In the organization according to the present invention, the layer of "raw" pellets is laid down on the stockline by following a succession of east-west reciprocations of said first and second belts as a unit, and north-south reciprocations of said second conveyor belt, creating a pattern of rectilinear movement of the discharge end of said second conveyor belt. That is to say, a "ribbon" of "raw" pellets is laid down adjacent, say, the north wall of the furnace mouth by easterly movement of the first and second conveyor belts as a unit, the second conveyor belt not undergoing transverse movement with respect to said first conveyor belt: then a "ribbon" of pellets is held down adjacent say the east wall of the furnace mouth by moving said second conveyor belt (transversely of said first conveyor belt) to the south, the first and second conveyor belts not undergoing east-west reciprocation: then, a "ribbon" is laid down adjacent the south wall by westerly movement of the first and second conveyor belts as a unit, the second conveyor belt not undergoing transverse motion. Next, a further "ribbon" is laid down adjacent the west wall by movement of the second conveyor belt (transversely of the first conveyor belt) to the north, the first and second conveyor belts not undergoing east-west reciprocation. Consequently the pattern of pellet deposit will be a rectangular one and can be called a "two-path" pattern since there are two paths of pellet deposit in the east-west direction which constitutes the major dimension of the furnace mouth.

In laying down a layer of pellets on the stockline, some advantage may be derived—for a reason about to be explained—to follow a pattern having an odd number, more than one (e. g., three or five or seven), of east-west paths. The reason why this latter pattern may be advantageous is as follows:

Let it be assumed that the discharge end of said second conveyor belt overlies a locus adjacent the southwest corner of the rectangle, an east-to-west pass having been completed, and that said second conveyor belt is about to be reciprocated in a northerly direction along the west wall. Let it be assumed, further, that the "normal" speed of rotation of said second conveyor belt is 30 feet/minute, which rotational speed, it is to be assumed, is necessary for maintaining a constant depth of loading on the same. If said second conveyor belt is moved in a northerly direction at say 30 feet/minute its depth of loading remains constant but the discharge from the belt (during the interval of northerly movement) is meager because the influence of the rotational movement of the belt is largely cancelled out by the counter influence of its reciprocatory movement. On the other hand, during the interval of north-south movement of said second conveyor belt the feed is discharged from the belt at substantially twice its normal rate. Accordingly, a feeding pattern made up of two allochiral half cycles each having an odd number (3, 5, etc.) of east-west paths is a practical necessity in order that the inequalities in north-south feeding inherent in any one half-cycle can be cancelled out by the contrary inequalities of the next succeeding half-cycle, with resultant symmetry of feeding along the end walls and along paths at right angles to the end walls.

Preferably, said first conveyor belt is mounted on and extends longitudinally of a reciprocatable first carriage which latter is disposed parallel to one side of the furnace mouth. A reciprocatable second carriage is mounted on and disposed transversely to and movable with said first carriage, and provides the mounting for said second conveyor belt, the same extending longitudinally of said second carriage and being located at the discharge end of the first conveyor belt to receive fluent solid material discharged from the latter. The first and second conveyor belts are provided with means for rotating them. Said first carriage is provided with means for reciprocating it longitudinally, and said second carriage is provided with means for reciprocating it on and transversely with

respect to the first carriage whereby the discharge end of the second conveyor belt may be moved in longitudinal and transverse paths over the furnace mouth.

The belt-rotating means may and preferably does comprise a first motor mounted on the first carriage; a planetary speed reducer likewise mounted on the first carriage, said speed reducer having input and output shafts, the former of which is operatively associated with said first motor; and separate chain-and-sprocket power-transmitting means associated with said output shaft for imparting rotative movement to each of said belts. With this combination there is associated means for rotating the housing of the planetary speed reducer whereby to vary the speed of the output shaft. By selecting the proper drive ratios of the various components the speed of reciprocation of said first carriage may automatically be superimposed upon the rotational speed of said first conveyor belt and the same percentage speed change applied to said second conveyor belt.

Said first carriage is provided with suitable wheels running on rails disposed parallel to one side of the furnace mouth, and may be reciprocated on said rails by means of a second motor, mounted on said first carriage, and suitable means for transmitting power from said second motor to one or more of said wheels. Said second motor may, advantageously, be operatively coupled to the housing of said planetary speed reducer in such manner that when said second motor functions to reciprocate the first carriage, in one direction or the other, it also rotates the housing of the planetary speed reducer thereby effecting changes in the rotational speeds of said first and second conveyor belts.

Said second carriage preferably is caused to reciprocate as follows: Suitable rails are mounted on said first carriage transversely of the latter, upon which rails run suitable wheels attached to said second carriage. A length of roller chain is secured to either end of the second carriage to serve as a rack. A third motor is mounted on said first carriage, as are a chain-and-sprocket assembly including a sprocket engaging said rack, for transmitting power from said third motor to said rack. By actuation of the third motor the second carriage is caused to roll in one direction or another on the transversely mounted rails on the first carriage.

The rate of reciprocation of said second conveyor belt may be superimposed on its rotational rate, whereby to maintain a constant depth of loading on said second belt irrespective of reciprocation of said second belt transversely of said first belt, as follows:

On said first carriage there are rotationally mounted a motor-actuated driving sprocket and a first idler sprocket remote from said driving sprocket, while on said second carriage there is rotationally mounted a second idler sprocket. A driven sprocket is mounted at one end of the shaft of an end pulley of said second conveyor belt. All four sprockets are disposed in one plane. A drive chain has one end thereof looped about the driving sprocket and the other end looped about the driven sprocket, the intermediate parts of the drive chain respectively being looped about the first idler sprocket and the second idler sprocket, the disposition of the sprockets and associated drive chain thereon being such as, in effect, to "fold" the drive chain back on itself into a capital letter J: this disposition is such that movement of said second carriage relatively to said first carriage has the effect of rolling said driven sprocket and said second idler sprocket as a unit along said drive chain while maintaining a constant power-transmitting connection between the driving sprocket and the driven sprocket. This rolling of the driven sprocket along the drive chain, in one direction or another, effects a variation in the rate of rotation of said driven sprocket, and, hence, a corresponding variation in the rate of rotation of said second conveyor belt, by reason of the superimposition of the rate of translation of said driven sprocket on the rate at which said

driving sprocket tends to rotate said driven sprocket. When the movement of said second carriage is in a direction away from the driving sprocket, the rate of translation of the driven sprocket adds to the rotational speed imparted by the driving sprocket, whereas when the second carriage moves in a direction towards the driving sprocket the rotational speed imparted by the driving sprocket is diminished by the rate of translation of the driven sprocket.

A preferred embodiment of the invention will now be described and is illustrated in the accompanying drawings wherein:

Fig. 1 is a view in plan showing the general layout of the furnace charging apparatus for conveying the charging material from the balling drum to the mouth of the furnace;

Fig. 2 is also a plan view, more in detail showing the arrangement of the motors, speed reducers, etc. mounted on the longitudinal carriage and a portion of the transverse or index carriage and conveyor belt structure, the longitudinal belt and support therefor being omitted;

Fig. 3 is a side elevation of the charging apparatus showing the longitudinal carriage and conveyor belt, the index carriage and conveyor belt, and drive organizations therefor;

Fig. 4 is a vertical transverse section through the longitudinal carriage looking in the direction of the index carriage;

Fig. 5 is a side elevation of the index carriage showing the latter at that end of its reciprocatory path wherein the discharge point of the index belt is closed to the near or south wall of the furnace mouth;

Fig. 6 is also a side elevation of the index carriage showing the latter at the other end of its path of reciprocation wherein the discharge point of the index belt is close to the far or north wall of the furnace mouth;

Fig. 7 is a vertical transverse section through the index carriage and belt taken on line 7—7 of Fig. 6;

Fig. 8 is a diagrammatic view of the furnace charging apparatus showing the longitudinal and index belts, their directions of movement, and the drive motors and other operating components which drive the belts and their respective carriages in the interrelated manner necessary to charge the furnace mouth;

Fig. 9 is a diagrammatic view illustrating one form of charging patterns known as a "two pass" pattern;

Fig. 10 is a condensed circuit diagram showing an electrical control arrangement which will produce the "two pass" pattern of Fig. 9;

Fig. 11 is a circuit diagram for the drive motors for the longitudinal and index carriages, and which is related to the Fig. 10 circuit; and

Fig. 12 is a view similar to Fig. 9 but illustrating a different form of charging pattern which provides an odd number of paths for the longitudinal pass.

With reference now to the drawings and in particular to Fig. 8 which presents the principal operating components of the general organization in a diagrammatic form, item 1 is a conventional 3-phase alternating current motor. The shaft of motor 1 is coupled via a 2:1 reduction belt drive 2 to the input shaft 3 of a planetary type variable speed drive 4 of conventional construction, having a rotatable housing 5 which serves to change the ratio between the speed of its input shaft 3 and output shaft 6. Shaft 6 serves to drive the first or longitudinal conveyor belt 7 through chain and sprocket assemblies 8 and 8' which lead to the forward pulley 9 for the belt. Output shaft 6 is also coupled, through a chain and sprocket drive 10, to the input shaft 11 of a speed reducing unit 12. The output shaft 13 of the latter is connected through chain and sprocket assemblies 14, 15 in driving relation with the index conveyor belt 16. Thus motor 1 furnishes the power for driving both the so-called "first" belt 7 on the "first" or longitudinal carriage 17 and the "second" or index belt 16 on the "second" or index

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carriage 18, the motor 1 being mounted upon the carriage 17 as seen in Figs. 3 and 4.

The carriage 17 is reciprocated longitudinally of itself by means of a reversible, direct current motor 19 also on carriage 17 having output shaft 20, 21 extending from opposite ends thereof. Output shaft 20 drives the input to a speed reducer 22 and the output of this reducer is coupled via chain and sprocket drive assembly 23 to drive one of the wheels 24 on carriage 17, the wheels 24 being arranged to run on rails 25 secured to the supporting frame or floor structure 28 as shown in Figs. 3 and 4.

Also as is best seen in Fig. 3, carriage 17 is constituted by a forward truck component 17a which carries the various motors and other drive components which have been described, as well as the index belt 16 and index carriage 18 and the forward or discharge end of the longitudinal belt 7. The latter is supported by a structure including a pair of parallel spaced structural channel beams 29 extending longitudinally and rearwardly from the forward truck 17a to a single axled trailer truck 17b with wheels 24 running on rails 25. The trailer truck carries the pulley structure for the rear end of belt 7 and which includes an L-shaped member 30 pivotally mounted on truck 17b, a pulley 30a rotatably mounted on the upwardly extending vertical leg of the L-member 30 and a counterweight 30b depending from the rearwardly extending horizontal leg of such L-member. As is obvious from Fig. 3, the purpose of the pivotal support 30 for rear pulley 30a for belt 7 and the counterweight 30b is to maintain a suitable tension on the belt.

The opposite output shaft 21 of motor 19 is connected to drive the input of another speed reduction mechanism 26 mounted on truck 17a and the output of reducer 26 is connected via another chain and sprocket assembly 27 to the rotatable planetary housing 5 of the variable speed drive 4. Thus when motor 19 runs to thus drive the longitudinal carriage 17, it also rotates the planetary housing 5 to thereby cause a corresponding change in the speed of output shaft 6 which, as previously explained, serves to drive both the longitudinal belt 7 and index belt 16. Such an arrangement is essential to maintenance of a constant depth of loading on the main belt with respect to its point of loading by the discharge from the transfer belt 31. Fig. 1 shows the structural detail of the related components, the belt 31 serving to transfer pellets from the balling drum 32 to belt 7.

That is to say, the longitudinal belt 7 must always move past the transfer belt 31 at a constant rate, for example the 90 feet per minute rate previously referred to, regardless of the direction in which carriage 17 is traveling. This is accomplished, in principle, by superimposing the actual linear speed of carriage 17, in reverse, upon the linear speed of belt 7.

When reversible motor 19 is rotating in such direction as to drive carriage 17 from east to west at a rate of 30 feet per minute, the speed of belt 7 must be slowed down from its normal absolute speed of 90 feet per minute to a lower speed of 60 feet per minute with respect to carriage 17. This result is obtained automatically through rotation of housing 5 of the variable speed drive in such direction as will reduce the speed of shaft 6 that drives belt 7.

In a similar manner, when motor 19 reverses and carriage 17 thus travels from west to east, at the rate of 30 feet per minute, the speed of belt 7 must be increased from its normal absolute speed of 90 feet per minute to a higher speed of 120 feet per minute with respect to carriage 17. This result is also obtained automatically because, with a reversed direction of rotation of motor 19, housing 5 of the variable speed drive 4 also rotates in the opposite direction to thereby increase the speed of shaft 6 driving the belt 7.

When carriage 17 reaches the east and west extremes of its path of longitudinal movement, motor 19 is stopped

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by means of limit switches (to be later described). This of course also stops rotation of housing 5 of the variable speed drive 4 so that shaft 6 will rotate at its "normal" speed to drive belt 7 at its "normal" linear speed of 90 feet per minute.

The index carriage 18, as shown more clearly in Figs. 5 and 6 is mounted on wheels 33 which run on a set of rails 34 arranged on the longitudinal carriage 17 at right angles to the rails 25 on which carriage 17 runs. To reciprocate the index carriage 18, a reversible motor 35 (see Figs. 2 and 8) is used. Motor 35 drives through a speed reduction unit 36 and a chain and sprocket assembly 37 to a pinion gear 38 which meshes with a gear rack 39 secured longitudinally of the carriage 18 at the lower side thereof. Motor 35 is likewise controlled by limit switches (to be later explained) in such manner that it runs to shift carriage 18 and hence shift belt 16 from south to north, or vice versa, when the longitudinal carriage 17 is stopped; motor 35 stops to thus stop carriage 18 when the longitudinal carriage 17 is being shifted from east to west or vice versa.

Motors 1, 19, and 35, speed reducers 12, 22, 26 and 36, and the variable speed drive 5 are all mounted on the longitudinal carriage 17 as is clear from Fig. 2. Since the motor furnishing the driving power for the index belt 16 is mounted on carriage 17, a special "wrap-around" arrangement is required in the driving chain and sprocket assembly 15 to compensate for the indexing of the belt 16. This "wrap around" arrangement, shown most clearly in Figs. 5 and 6, includes a sprocket 40 rotatably mounted on carriage 17 and driven by the chain and sprocket drive 14, Fig. 2. Sprockets 41 and 42 are idler sprockets also mounted on carriage 17. Another sprocket 43 is rotatably mounted on the index belt drive pulley shaft 44 and serves to transmit power from the chain 15 to index belt 16. Sprocket 45 is an idler mounted on the index belt carriage 18. Thus sprockets 40, 41 and 42 are rotatably mounted on the longitudinal carriage 17 and sprockets 43, 44 are mounted on and thus move with the index carriage 18.

With this arrangement, when the carriage 18 and belt 16 indexes "south" as indicated in Fig. 5, that section of the chain 15 designated X becomes longer by the same amount that section Y thereof becomes shorter. All other sections of the chain 15 remain the same in length. Thus the drive for the index belt 16 will operate satisfactorily regardless of the position of index carriage 18 with respect to carriage 17. Sprockets 40 and 41 being mounted on carriage 17, their peripheral speed is not influenced by any motion of the index carriage 18. This being so, the section of chain 15 between sprockets 41 and 43 will run at a linear speed which is not influenced by any motion of the indexing carriage 18. Since sprocket 43 is fixed upon the drive shaft 44 of index belt 16, the linear speed of the latter is fixed with respect to the linear speed of the section of chain 15 between sprockets 41 and 43. Thus the speed of index belt 16 with respect to carriage 17 is not affected by any motion of the indexing carriage 18.

As explained in the introductory portion of the specification, in accordance with the present invention, the "raw" pellets are continuously supplied, from a fixed locus of supply, e. g., from a non-reciprocable feeder belt 31 communicating with a balling-up drum 32, to a first conveyor belt 7 which is disposed parallel to one side of the furnace mouth and which is reciprocable longitudinally of said side by means of carriage 17. The first conveyor belt 7 delivers the pellets to a reciprocable second conveyor belt 16 which is disposed beneath the discharge end of the first conveyor belt 7 and at a right angle to and transversely reciprocable with respect to the latter by means of an index carriage 18, the discharge end of the second conveyor belt 16 extending over the mouth 46 of the indurating furnace so that pellets received on the second conveyor belt (from said first belt)

are delivered onto the top surface or stockline of a charge column of similar pellets occupying the furnace. The pellets are laid down in a layer (as distinguished from being dumped into a pile) onto the stockline of the charge column by appropriate reciprocations of the first and second belts, as a unit, longitudinally of said side of the mouth interspersed with appropriate transverse reciprocations of said second belt with respect to said first belt, whereby the discharge end of the second belt is moved in longitudinal and transverse paths over the mouth of the furnace and is thus able to reach any part of the furnace mouth.

It is important that the deposit of pellets onto the stockline be such as will maintain the column of pellets in the furnace at a uniform height throughout the area of the column, i. e. throughout the area of the furnace mouth 46. Since the latter is rectangular, the desired result may be achieved by rectilinear movement of the discharge end of the index belt 16 extending parallel with the side and end walls of the furnace mouth.

One pattern of pellet deposit found satisfactory can be called a "two path" cycle shown diagrammatically in Fig. 9. Here as indicated by the line 47, the discharge end of the index belt 16 describes a rectangular path in a clockwise direction. Assuming for purposes of illustration, the cycle to begin at the northwest corner of the furnace mouth, path 1 moves the feeder east to the northeast corner of the furnace mouth 46, index 1 moves the feeder south to the southeast corner of the furnace mouth; path 2 moves the feeder west to the southwest corner of the furnace mouth; and index 2 moves the feeder north to the northwest corner of the furnace mouth, i. e. to the starting point; the cycle then repeats.

For this arrangement, four limit switches are employed, these being indicated in Fig. 9 by letter groups NLS, ELS, SLS and WLS. As shown in the condensed circuit diagram of Fig. 10, each of these limit switches functions, when closed, to energize a control relay. As indicated in the diagram, limit switch NLS controls relay CR1, limit switch ELS controls relay CR2, limit switch SLS controls relay CR3, and limit switch WLS controls relay CR4.

With the feeder at the northwest corner of the furnace mouth 46, the arrangement is such that limit switches WLS and NLS are closed and limit switches ELS and SLS are open. With limit switch NLS closed, relay CR1 becomes energized to thereby close its front contacts CR1-1 in the energizing circuit of the east run relay CR5. Limit switch ELS being open, control relay CR2 remains unenergized and its back contacts CR2-1 are closed. Thus the east run motor control relay CR5 is energized and closes its front contacts CR5-1 and CR5-2 shown in the armature circuit of the east-west run motor 19 in Fig. 11. Current now passes through the armature 19a of motor 19 from the direct current power supply line in the direction indicated by the solid arrows and the armature of motor 19 begins to run in such direction as will cause the longitudinal carriage 17 to move in the eastward direction. Motion in no other direction is possible because limit switches ELS and SLS are open. Hence control relay CR2 remains unenergized and thereby also the south run relay CR6 since the contacts of relay CR2 are in the energizing circuit of relay CR6. Although limit switch WLS is closed and hence relay CR4 is energized, in which condition its front contacts CR4-1 are closed, the front contacts CR3-2 of relay CR3 are open since the latter is unenergized because limit switch SLS is open. Consequently the west run relay CR7 remains unenergized. Limit switch NLS is closed thus energizing relay CR1, which opens the back contacts CR1-2 of the latter in the energizing circuit of the north run relay CR8 and hence the latter remains unenergized.

As carriage 17 begins its eastward run, limit switch

WLS opens, and when the carriage reaches the end of its eastward travel, limit switch ELS closes and thereby energizes relay CR2. Back contacts CR2-1 of relay CR2 are thereby caused to open and thus open the circuit to relay CR5, opening its contacts CR5-1 and CR5-2 and causing motor 19 and hence carriage 18 to stop. At the same time, the energizing circuit to the south run relay CR6 will close as front contacts CR2-2 of relay CR2 close, and back contacts CR3-1 of relay CR3 are already closed because relay CR3 is unenergized. Energization of relay CR6 effects closure of its contacts CR6-1 and CR6-2 in the armature circuit 35a of the north-south run motor 35 in Fig. 11. Current now passes through the armature 35a of motor 35 from the direct current power supply line in the direction indicated by the solid arrows, and the armature of motor 35 begins to run in such direction as will cause the indexing carriage 18 to index in the southward direction.

As index carriage 18 begins its southward run, limit switch NLS opens and when it reaches the end of that run, limit switch SLS closes to thus energize relay CR3 and open the back contacts CR3-1 of the latter thereupon causing relay CR6 to become deenergized and opening its contacts CR6-1 and CR6-2 and stopping motor 35. At the same time, the energizing circuit to the west run relay CR7 will be completed through the then closed front contacts CR3-2 of relay CR3 and back contacts CR4-1 which are also closed since the west limit switch WLS is at such time unenergized, thus closing contacts CR7-1 and CR7-2 of relay CR7 in the armature circuit of the east-west run motor 19. Current then flows through motor armature 19a in the direction indicated by the broken arrows, and armature 19a will run in such direction as will cause the longitudinal carriage 17 to move in the westward direction. Limit switch ELS then opens.

As carriage 17 reaches the end of its westward travel, limit switch WLS closes thereby energizing relay CR4 and causing the back contacts CR4-1 of the latter to open and thereby open the circuit to motor control relay CR7. The contacts CR7-1 and CR7-2 of the latter open and thus cause motor 19 to stop. At the same time the energizing circuit to the north run relay CR8 will be completed through front contacts CR4-2 of relay CR4 now closed and the closed, back contacts CR1-2 of unenergized relay CR1. Energization of relay CR8 effects closure of its contacts CR8-1 and CR8-2 in the armature circuit of the north-south run motor 35. Current now passes through the armature 35a of motor 35 from the direct current power supply line in the direction indicated by the broken arrows, and the armature of motor 35 begins to run in such direction as will cause the indexing carriage 18 to index in the northward direction. Limit switch SLS now opens.

As index carriage 18 reaches the end of its northward travel, limit switch NLS is closed to thus energize relay CR1 and open the back contacts CR1-2 of the latter thereupon causing relay CR8 to become deenergized and opening its contacts CR8-1 and CR8-2 to thereby stop motor 35. This completes the "two path" cycle (path 1 to the east and path 2 to the west) for the feeder coupled with indexing of the feeder in the north-south directions at the ends of the east and west paths and the cycle then repeats itself.

In the event the cycle is stopped for any reason such as a power failure, the feeder will re-start in the same direction it was traveling, if it stopped with only one limit switch in the closed position, as for example in the middle of path 1 (to the east). In such event, when power is again applied only limit switch NLS is energized and hence only relay CR1 will be energized which in turn will effect energization of the east run motor 19. Should the cycle be stopped at the northwest corner of the furnace mouth 46, again the feeder will move east

because limit switch NLS being closed will energize relay CR1 thus opening the back contacts CR1-2 and hence opening the circuit to the north run relay CR8; and by closing front contacts CR1-1 the circuit is closed for energizing the east run relay CR5. If the feeder is stopped and then moved manually so that none of the limit switches are closed, it is only necessary to move the feeder to the limit of its movement in any one direction to start the cycle.

The limit switches ELS and WLS are preferably located on the longitudinal carriage 17 and are arranged to be actuated respectively by cams (not shown) on the main frame as the carriage reaches the east and west ends of its travel. Limit switches NLS and SLS may be located on carriage 17 at opposite ends of the north-south travel of the index carriage 18 so as to be also actuated by other cams (not shown) on the latter as the carriage reaches the opposite ends of its travel.

The following tables of longitudinal and index carriage speeds, absolute and relative speeds of the longitudinal and index conveyor belts, times of travel and units of material deposited have been found satisfactory for application to a furnace, the mouth 46 of which measures 6 feet in the north-south direction and 14 feet in the east-west direction.

The feeder path 47 i. e. the line of discharge of the pellets from the index belt 16, in such case is located one foot from the east and west walls and six inches from the north and south walls.

A. Motion of index carriage versus feed to furnace mouth

	Speed of index carriage 18, ft./min.	Discharge speed of index belt 16, ft./min.	Time required for 5' travel of index carriage 18, secs.	Units of pellets deposited for travel of index carriage 18
Stationary-----	0	30	-----	-----
No. to So.-----	30	60	10	600
So. to No.-----	10	20	30	600

As is evident from Fig. 1, index belt 16 always travels in a northward direction with respect to its carriage 18 and hence in order to deposit about the same number of units of pellets onto the stockline for the northward as well as the southward travel of index carriage 18, it is necessary to move carriage 18 at a higher speed when movement of the carriage is southward than when movement of the carriage is northward. This can be achieved through use of appropriately sized resistors 48 in the two armature circuits of motor 35.

With the discharge point of the index belt located one foot from the east and west walls of the furnace mouth, it will distribute the pellets over a two foot wide path and which path is five feet in length. The area of the furnace mouth supplied will thus be ten square feet. The rate of pellet feed will thus be

$$\frac{600}{10}$$

or 60 units per square foot of stockline.

B. Motion of longitudinal carriage versus feed to furnace

	Speed of Long. Carriage 17	Discharge Speed of Long. Belt 7, ft./min.	Discharge Speed of Index Belt 16, ft./min.	Time required for 12' Travel of Long. Carriage 17	Units of pellets deposited for travel of Long. Carriage 17
Stationary-----	0	90	30	-----	-----
West to East....	11	101	33.6	65	12,200
East to West....	9	81	27	80	12,160

¹ These are approximately the same.

As is also evident from Fig. 1, the longitudinal carriage belt 7 always travels in a westward direction with respect to its carriage 17 and hence in order to deposit about the same number of units of pellets onto the stockline for the westward as well as the eastward travel of carriage 17, it is necessary to move carriage 17 at a higher speed when its movement is eastward than when movement of the carriage is westward. This can be achieved through use of appropriately sized resistors 49 in the two armature circuits of motor 19.

When making an east or west pass, the discharge from the index belt 16 must feed three feet of width, i. e., half the width of the furnace. With twelve feet of travel, the area fed per pass is thirty-six square feet. The rate of pellet feed for an east or west pass will thus be approximately

$$\frac{2200}{36}$$

or 61 units per square foot of stockline which is just about the same as the 60 unit feed rate for a north or south index. Thus the rate of deposit of pellets will be approximately uniform for the complete path of travel of the feeder around the stockline in the furnace. The total time required for the feeder to complete one cycle is 185 seconds, or about 3 minutes.

While the feeder control which has been described assures a substantially uniform rate of deposit of pellets onto the stockline, the latter may not always be uniform in height throughout its area. Low or high spots may appear and hence it is desirable to modify the rate of travel of the feeder in an automatic manner so as to slow it down when over a low spot and speed it up when over a high spot. The desired result is obtained through use of the principles disclosed and claimed in the co-pending application Serial No. 237,209, filed July 17, 1951, in the names DeVaney and Beggs and assigned to the same assignee to which this application is assigned. As shown clearly in Fig. 11, the embodiment thereof as applied to the present application comprises a feeler element 50 at the lower end of a rod 51 slidably mounted in a guide 52 secured to the main frame of the feeder. Feeler element 50 rides in surface contact with the stockline, feeling out the high and low spots and travels along a path around the stockline substantially the same as the feeder path 47 indicated on Fig. 9. Rod 51 has attached thereto and insulated therefrom an adjustable contact 53 which slides along a variable resistor 54 connected in series with the field winding 19b of motor 19. In a similar manner, another adjustable contact 55 secured to and insulated from rod 51 is arranged to slide along a variable resistor 56 connected in series with the field winding 35b of motor 35.

Any high spots encountered by the feeler 50 will cause the rod 51 to raise and move contacts 53 and 55 along their respectively associated resistors 54 and 56 in such direction as to increase the in-circuit resistance of the latter two resistors thus increasing the resistance of the field circuits of motors 19 and 35 and decreasing the field current and causing whichever one of the two motors is then running to increase its speed and thereby correspondingly decrease the rate of pellet discharge from the feeder over the high area.

Conversely, any low spot encountered by the feeler 50 is effective to decrease the in-circuit resistance of resistors 54 and 56 thus decreasing the resistance of the field circuit of motors 19 and 35 and hence increasing the field current of these motors and causing the one of them that is then running to decrease its speed and thereby correspondingly increase the rate of pellet discharge from the feeder over the low area.

In accordance with the invention, other patterns may be employed for laying down the charging material on the stockline. For example, it may be desirable to follow a pattern somewhat more complex than that shown

in Fig. 9 having an odd number, more than one (e. g., three or five or seven), of east-west paths. The advantages of such arrangement stem from the following considerations:

Let it be assumed that the discharge end of the index conveyor belt 16 overlies a locus adjacent the southwest corner of the furnace mouth, an east-to-west path having been completed, and that the index conveyor belt is about to be reciprocated in a northerly direction along the west wall. Let it be assumed, further, that the "normal" speed of rotation of the index conveyor belt is 30 feet/minute, which rotational speed, it is to be assumed, is necessary for maintaining a constant depth of loading on the same. If the index conveyor belt is reciprocated in a northerly direction at say 30 feet/minute, its depth of loading remains constant but the discharge from the belt (during the interval of northerly reciprocation) is meager because the influence of the rotational movement of the belt is largely cancelled out by the counter influence of its reciprocatory movement. On the other hand, during the interval of north-south reciprocation of the index conveyor belt, the feed is discharged from the belt at substantially twice its normal rate. Accordingly, a feeding pattern made up of two allochiral half cycles each having an odd number (3, 5, etc.) of east-west paths has the advantage in that the inequalities in north-south feeding inherent in any one half-cycle can be cancelled out by the contrary inequalities of the next succeeding half-cycle, with resultant symmetry of feeding along the end walls and along paths at right angles to the end walls.

A pattern or cycle having such an odd number of east-west paths, i. e. three, is illustrated in Fig. 12. As seen in this view, the first half of the cycle is made up of six legs (a-f) shown in solid lines, and the second half of the cycle is also made up of six legs (g-l) shown in broken lines.

The first leg *a* (path 1) of the first half of the cycle begins with the discharge point of the index belt 16 at the northwest corner of the furnace mouth 46 and runs eastward along the north wall by eastward movement of the longitudinal carriage 17 to the east wall. Carriage 17 now stops, and carriage 18 indexes south (leg *b*) to the south wall. Carriage 18 now stops and carriage 17 runs west (leg *c*) which is path 2 to the west wall. Carriage 17 stops and carriage 18 indexes north (leg *d*) to about midway between the north and south walls. Carriage 18 stops and carriage 17 runs east (leg *e*) which is path 3 to the east wall. Carriage 17 stops and carriage 18 indexes north (leg *f*) to the north wall and stops. This completes the first half of the cycle.

In the second half of the cycle, the first leg *g*, retracing path 1 in the opposite direction, is made by longitudinal movement of carriage 17 along the north wall to the west wall. Carriage 18 then indexes south (leg *h*) to the south wall and stops. Carriage 17 then moves east (leg *i*), retracing path 2 in the opposite direction, to the east wall and stops. Carriage 18 then indexes north (leg *j*) to about midway between the north and south walls and stops. Carriage 17 then moves west (leg *k*), retracing path 3 in the opposite direction, to the west wall and stops. Carriage 18 then indexes north (leg *l*) to the north wall and stops at the northwest corner, i. e. the starting point of the first half of the cycle.

The control circuit for the motors 19 and 35 to effect the three path pattern shown in Fig. 12 has not been included. However, the basic arrangements for such control would be essentially the same as with the two path pattern featuring limit switches and relays controlled thereby which will function to establish the necessary east-west and north-south movements of the feeder.

In conclusion, it will be evident that the present invention as described and illustrated provides a charging or feeder device for a furnace which will deposit the material in layers of substantially uniform thickness

through the entire area of the furnace mouth. The specific embodiment of the invention described and illustrated is however to be viewed as representative rather than limitative of the inventive concepts disclosed and hence various changes in the construction and arrangement of the various operating components may be effected without however departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. In combination with a vertical shaft furnace having a substantially rectangular mouth, of means for charging fluent material into the mouth of said furnace, said furnace charging means comprising, a first conveyor belt disposed parallel to one side of the furnace mouth, a second conveyor belt disposed at the discharge end of said first belt and transversely of the latter for receiving material discharged from said first belt, means for rotating said first and second belts, means for reciprocating said first and second belts as a unit longitudinally of said side of said furnace mouth whereby to move said first belt in translation with respect to a point of loading therefor, means for transversely reciprocating said second belt relative to said first belt whereby to move said second belt in translation with respect to the point of loading from said first belt and thereby enabling the discharge end of said second belt to be moved in longitudinal and transverse paths over the furnace mouth, means superimposing the actual translational speeds of said belts in reverse upon their respective rotational speeds and means changing the rotational speed of said second belt by the same percentage as the change in rotational speed of said first belt thereby to maintain constant the effective speeds of said belts relative to their respective points of loading irrespective of the translatory movements of said belts thereby to maintain constant the material loading on said belts.

2. In combination with a vertical shaft furnace having a substantially rectangular mouth, of means for charging fluent material into the mouth of said furnace, said furnace charging means comprising a first conveyor belt disposed parallel to one side of the furnace mouth, a second conveyor belt disposed at the discharge end of said first belt and transversely to said first belt for receiving fluent material discharged from said first belt, means for rotating said first and second belts, said first and second belts being movable as a unit when said first belt is moved longitudinally of said side of said furnace mouth, and said second belt being movable longitudinally of itself independent of longitudinal movement of said first belt, means for moving said first and second belts as a unit only when said second belt is not moving longitudinally of itself, and means for moving said second belt only when said first and second belts are not moving as a unit, whereby the discharge end of said second belt may be moved in longitudinal or transverse paths over the furnace mouth in dependence upon whichever one of said belts is being moved longitudinally of itself.

3. The combination defined in claim 2 wherein said first and second belts are each mounted on carriages so as to enable the said longitudinal movements of said belts, said carriage for said second belt being carried by the carriage for said first belt, the means for moving said belts are constituted by reversible electric motor means individual to and driving said carriages, and means including limit switches actuated by said carriages for controlling said motors to run in alternation.

4. Apparatus for depositing successive layers of fluent particulate solid material on to the stockline of a column of material in a shaft-type furnace having a rectangular mouth at the top, comprising a first endless conveyor disposed parallel to one side of the furnace mouth, a second endless conveyor disposed transversely of the first endless conveyor to receive material discharged therefrom, means for driving said first and second endless con-

veyors, means for shifting said first and second endless conveyors as a unit longitudinally of said first endless conveyor and means for shifting said second endless conveyor longitudinally of itself in relation to said first endless conveyor whereby the discharge end of said second endless conveyor is movable in longitudinal and transverse paths over the furnace mouth to deposit the material in layers of substantially uniform thickness throughout the entire area of the furnace mouth, and means for maintaining substantially constant the effective driving speeds of the first and second endless conveyors relative to their respective points of loading irrespective of the longitudinal shifting movements of said conveyors so as to maintain a substantially constant rate of loading on said conveyors.

5. Apparatus according to claim 4, wherein the means for maintaining the effective speeds of the endless conveyors substantially constant comprises means for superimposing the speed of the longitudinal shifting movement of said conveyors in reverse upon their respective speeds of feed and means for changing the speed of said second conveyor by the same percentage as the first conveyor.

6. Apparatus according to claim 5, wherein said first and second conveyors are driven from a common motor through variable speed drive means controlled in dependence upon the direction of shifting movement of said first conveyor for superimposing the actual shifting speed of said first conveyor in reverse upon its speed of drive, and for simultaneously changing the driven speed of said second conveyor by the same percentage as the change in driven speed of the first conveyor, and means for superimposing the shifting speed of said second conveyor in reverse upon the driven speed thereof.

7. Apparatus according to claim 6, wherein the variable speed drive means comprises a planetary gear having an input shaft connected to the conveyor driving motor, an output shaft connected for transmitting drive to said first and second conveyors, and a rotatable housing carrying elements of the planetary gear system, said housing being driven in one direction or the other in dependence on shifting movement of the conveyor system longitudinally of the first conveyor so as to superimpose the shifting speed of said first conveyor in reverse on the driving speed thereof.

8. Apparatus according to claim 7, wherein the conveyor driving motor and variable speed drive means are mounted on a carriage carrying the first conveyor and movable to shift said first conveyor longitudinally of itself, and said second conveyor is mounted on a carriage displaceable transversely of said first carriage, said second conveyor being driven from the output shaft of said vari-

able speed drive means through chain and sprocket drive means arranged so that the effective speed of said second conveyor in relation to the point of delivery from the first conveyor is maintained substantially constant irrespective of shifting movements of said second conveyor transversely with respect to said first conveyor.

9. Apparatus according to claim 8, wherein said chain and sprocket drive means comprises a driving sprocket mounted on said first carriage, a first idler sprocket also mounted on said first carriage, a driven sprocket mounted on said second carriage in driving relation with said second conveyor, and a second idler sprocket also mounted on said second carriage, the first and second idler sprockets being disposed so that intermediate parts of a driving chain cooperating with the driving and driven sprockets and looped around the first and second idler sprockets maintain a constant power transmitting connection between the driving and driven sprockets while effecting a variation in speed of drive of said second conveyor dependent on the speed and direction of shifting movements of said second carriage so as to maintain the effective speed of the second conveyor substantially constant.

10. The combination with a substantially vertical shaft furnace for heat-treating fluent mineral solid particles descending therethrough in a substantially continuous column, said shaft having a substantially rectangular mouth, of a feeder belt positioned with its discharge end above the furnace mouth and adapted continuously to discharge a layer of such particulate material onto the stockline of a column of particulate material in said shaft furnace, a carriage adapted to advance and retract the feeder belt longitudinally of the furnace mouth, an indexing mechanism supported on the carriage and adapted to shift the feeder belt longitudinally of itself and laterally with respect to the carriage only when said carriage is stationary, a conveyor belt adapted continuously to convey particulate material to and to discharge same onto the feeder belt irrespective of shifting movement of the latter, said conveyor belt being supported on and movable with said carriage, and means for reciprocating the carriage along one side of said furnace mouth only when said feeder belt is not being shifted, whereby the discharge end of said feeder belt may be moved in longitudinal and transverse paths alternately over the furnace mouth.

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