

July 7, 1942.

J. A. FLINT

2,289,186

ELECTRICAL MIXING SYSTEM

Filed July 27, 1940

6 Sheets-Sheet 1

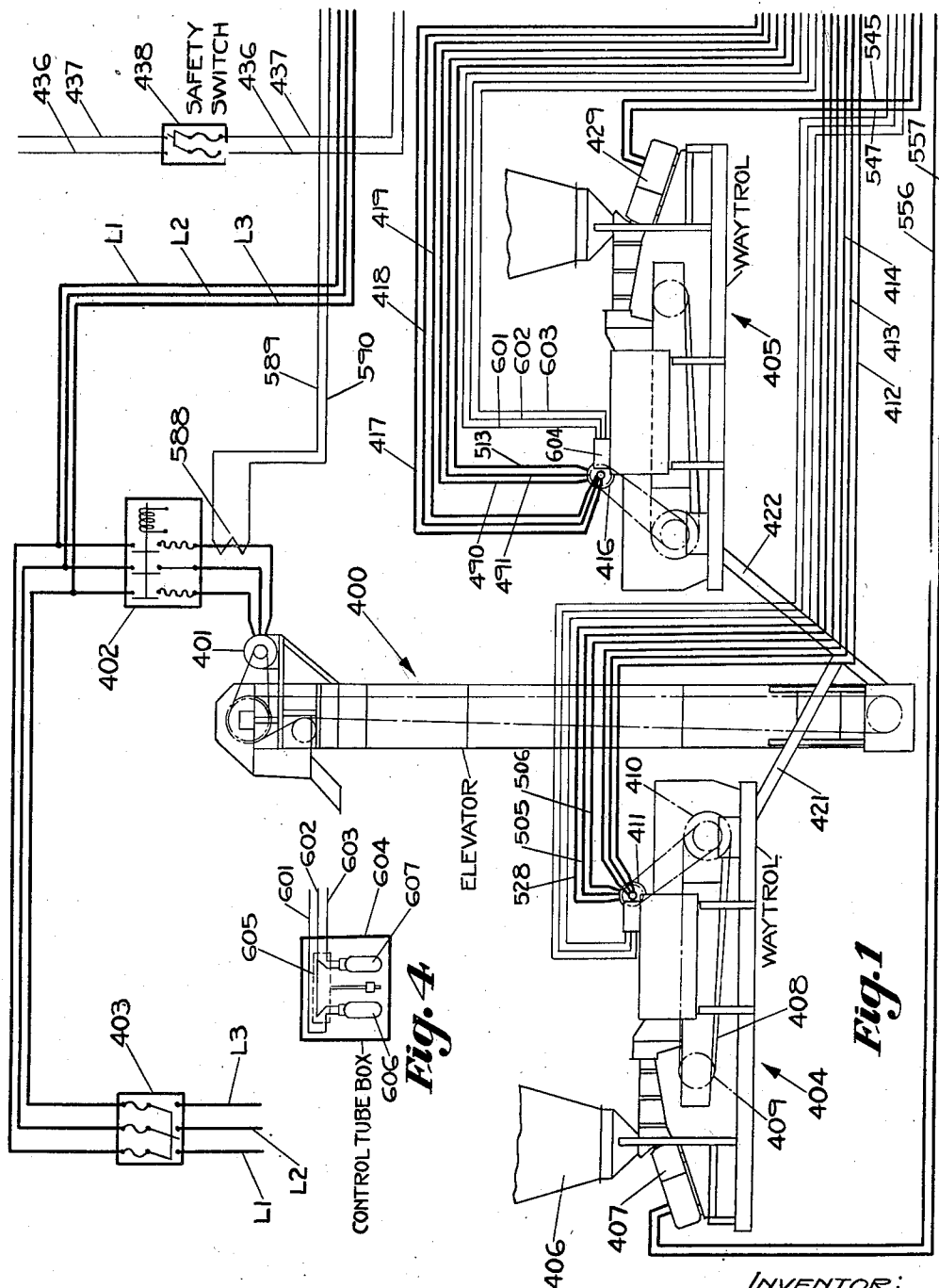


Fig. 1

Fig. 1

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July 7, 1942.

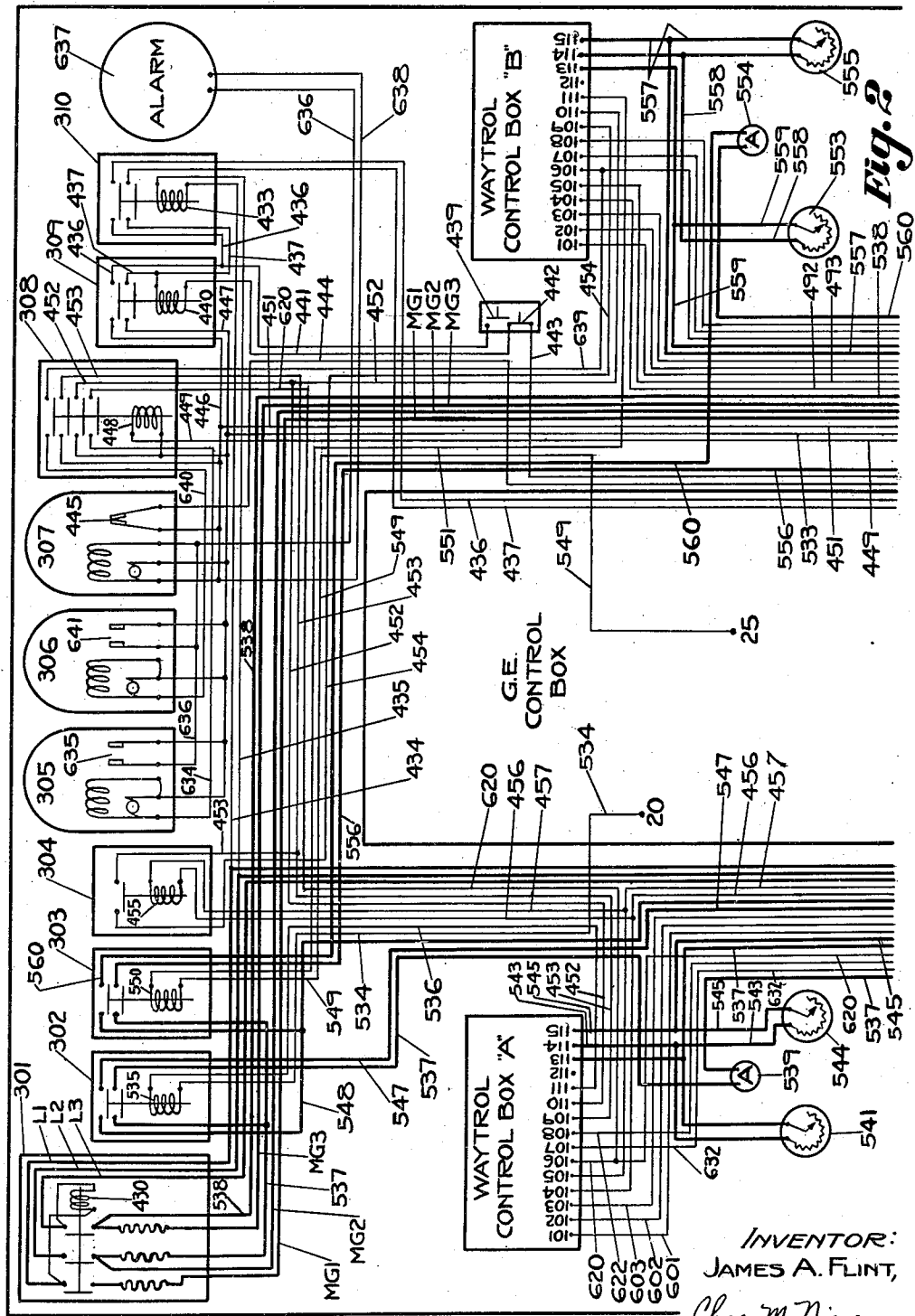
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6 Sheets-Sheet 2



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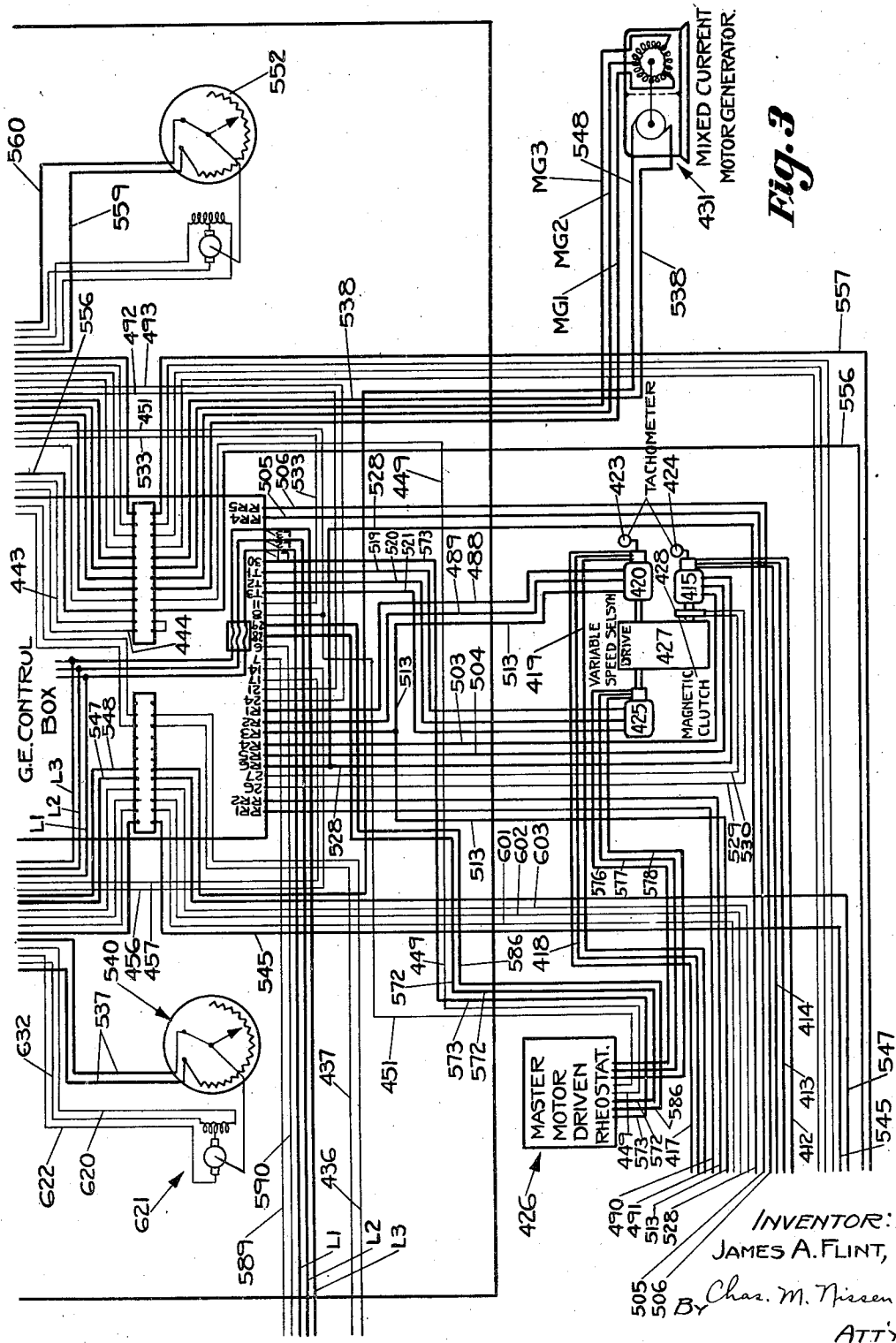
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6 Sheets-Sheet 4

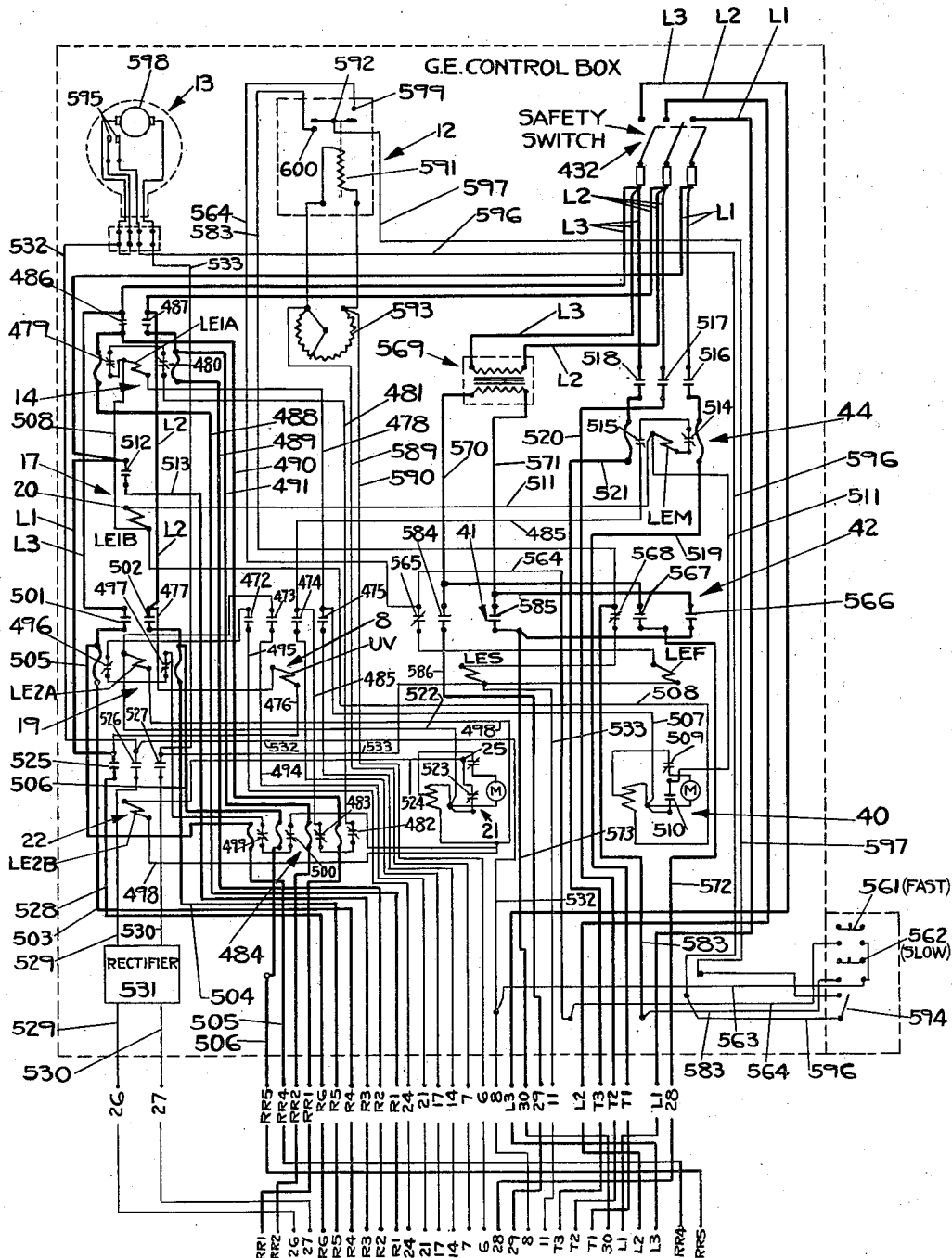


Fig. 5

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6 Sheets-Sheet 5

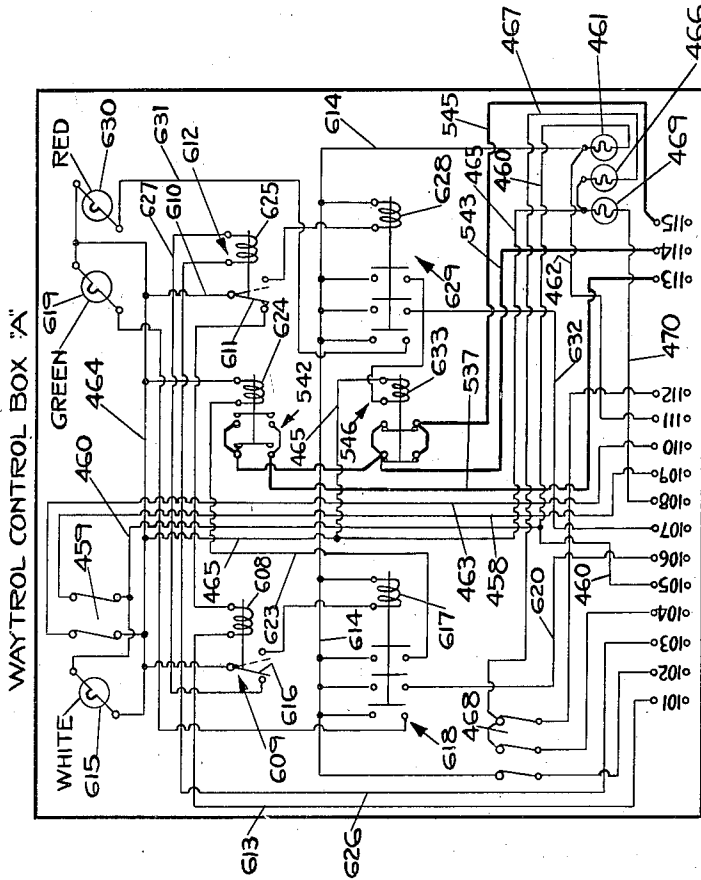


Fig. 6

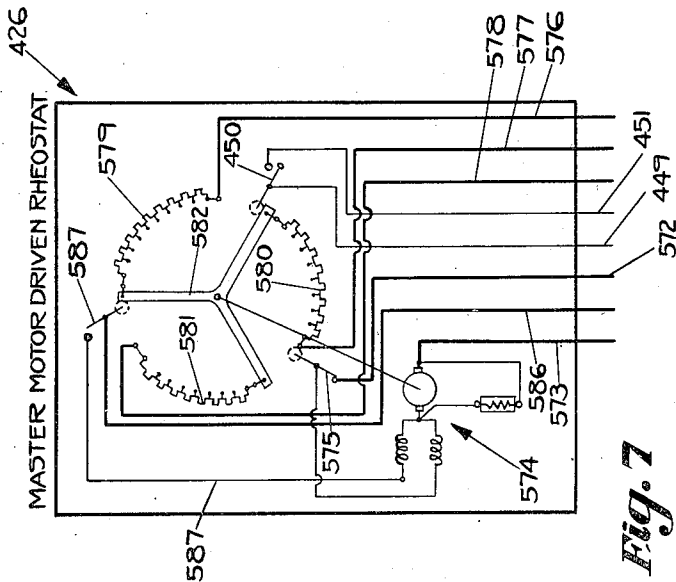


Fig. 7

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ELECTRICAL MIXING SYSTEM

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6 Sheets-Sheet 6

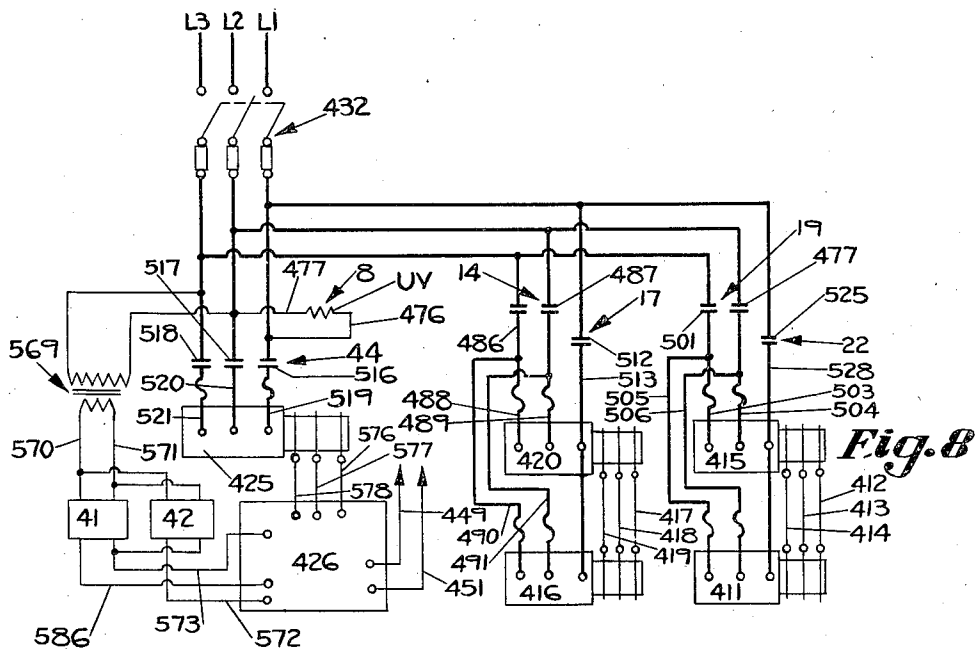


Fig. 8

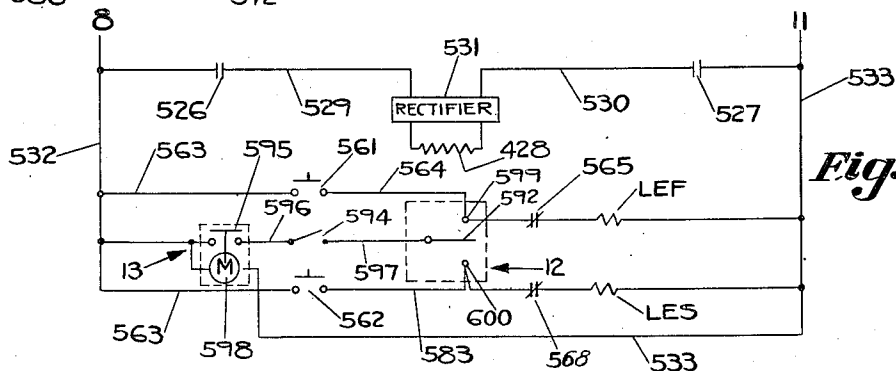


Fig. 9

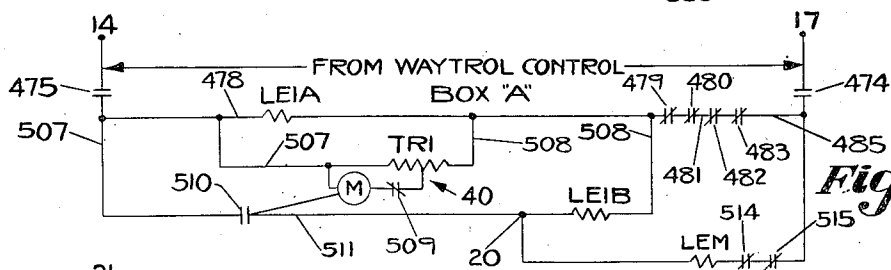


Fig. 10

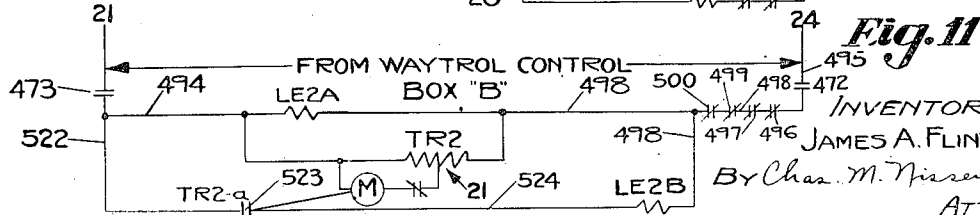


Fig. 11

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UNITED STATES PATENT OFFICE

2,289,186

ELECTRICAL MIXING SYSTEM

James A. Flint, Columbus, Ohio, assignor to The
Traylor Vibrator Company, a corporation of
Colorado

Application July 27, 1940, Serial No. 347,896

17 Claims. (Cl. 198—37)

This invention relates to a system for automatically and continuously feeding materials to a receiver, such as a crusher, conveyor or elevator, in which the materials delivered to said receiver are consistently maintained in a predetermined ratio.

An object of the invention is to provide a system of the above mentioned type in which the feed ratio of the various materials is maintained constant within extremely accurate limits, and limits which are much more accurate than any heretofore realized.

A further object of the invention is to provide a system of the remote control type in which an operator at a central station will be constantly informed of the feed ratio of a plurality of feeders.

A further object of the invention is to provide means for feeding material at a rate which is always directly proportional to the speed of a continuous weighing mechanism which is operated at a variable speed.

A further object of the invention is to provide an interlocked pair of constant weight feeders to require their operation in a certain sequence.

A further object of the invention is to provide an improved control and alarm system for a system of the above mentioned type.

Another object of the invention is to provide a feeder system in which the load on the receiving device, such as a conveyor, elevator or crusher, is automatically maintained substantially constant at all times.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings:

Figs. 1, 2 and 3 go together to make up the complete system with Fig. 1 positioned at the left of Fig. 3, and Fig. 2 placed above Fig. 3;

Fig. 4 is a detail of a control tube box;

Fig. 5 shows the apparatus and connections inside the C. E. control box illustrated on Fig. 2 of the drawings;

Fig. 6 shows the apparatus and connections inside the "Waytrol" control box A of Figs. 2 and 3 of the drawings which is the same construction as the "Waytrol" control box B of said Fig. 2 of the drawings;

Fig. 7 shows the internal construction of the master motor driven rheostat of Fig. 3 of the drawings; and

Figs. 8, 9, 10 and 11 are simplified cross the line diagrams of various parts of the system

which will be evident by comparison between these figures and other figures of the drawings.

There has been an ever increasing demand for an extremely accurate but highly flexible system for delivering a plurality of materials to a conveyor, elevator or crusher which are thereby or thereafter mixed to form some composite material. For example, in the manufacture of Portland cement, it is extremely desirable to mix limestone and shale prior to the forming of the clinker in a very accurate ratio, and it is desirable that this ratio be adjustable with ease and accuracy and the ratio be maintained throughout a wide range of adjustment.

It is furthermore desirable that the feed rate of the total material be manually or automatically adjustable while maintaining the ratio of the two materials intact.

Also, in the manufacture of Portland cement, after the clinker has been formed a similar mixing of clinker and gypsum is desired with the same flexibility and accuracy. This is of course only one illustration of which many might be given, such as the mixing of the ingredients to make glass, and the mixing of various ores.

Referring particularly to Figs. 1, 2 and 3 of the accompanying drawings, and first to Fig. 1 thereof, it will be seen that I have provided an elevator or elevating type of conveyor 400 having an electrical motor 401 adapted to be controlled by a solenoid operated switch 402 which controls the delivery of power from power mains L1, L2 and L3 through a disconnect switch 403. Purely as illustrative and by no means as restrictive, the power mains L1, L2 and L3 may have a voltage of 440 volts. Material is delivered to the boot of the elevator 400 by a pair of weighing feeder devices 404 and 405 which generally follow the construction of the constant capacity feeder disclosed in the application of Earle V. Francis, Serial No. 195,092, now Patent No. 2,276,382 dated March 17, 1942, except for the fact that the speed rate of the belt conveyor is made variable as hereinafter pointed out, or it may follow the structure of the constant capacity feeder as disclosed in the patent to E. V. Francis et al., No. 2,164,812, dated July 4, 1939.

The weighing feeder devices 404 and 405 are of similar construction, and so a brief description of one will suffice for both.

Said device 404 includes a hopper 406 which feeds a vibratory feeder 407 which in turn feeds a weighing mechanism comprising a continuous belt 408 carried between a pair of pulleys 409 and 410 mounted upon a tiltable frame provided

with appropriate counterbalancing scale mechanism which may be adjusted but during normal operation is maintained fixed with the weight at a definite position on the control poise. The pulley 410 is driven through a speed reducing mechanism from a receiving motor 411 of the Selsyn type, the 3-phase rotor of which is connected over lines 412, 413 and 414 to the 3-phase rotor of the driving Selsyn motor 415 (Fig. 3).

The stators of the two Selsyn motors 411 and 415 are energized as hereinafter pointed out, but as is well-known in a Selsyn system, the electrical connections between the receiving motor 411 and the driving motor 415 are such as to maintain them in synchronism once they are started in operation, thus providing what is in effect a positive electrical driving connection between the driving motor 415 and the receiving motor 411.

It may be stated that this specific type of driving connection, that is, the Selsyn type, has been found very satisfactory and is the preferred form to be employed in my invention, but other well known drives which accomplish an equivalent result may be employed in place of the Selsyn type.

Associated with the weighing feeder device 405 is a receiving Selsyn motor 416 which will be understood to be in relation to device 405 similar to that which motor 411 bears to device 404. The rotor of Selsyn motor 416 is connected over lines 417, 418 and 419 to the rotor of the driving Selsyn motor 420. The outputs from the two weighing feeder devices 404 and 405 are delivered to chutes 421 and 422, respectively, both of which feed into the boot of the elevator 400 as diagrammatically illustrated in Fig. 1 of the drawings. It may be stated that the apparatus disclosed in Fig. 1 of the drawings may or may not be located at a station which is removed from the control station at which control station all of the apparatus disclosed in Figs. 2 and 3 of the drawings will be concentrated. It is thus possible in the system of my invention to control the operation of a plurality of weighing feeder devices from a remote position and to know exactly the feed ratios of these two devices within very accurate limits. To know this ratio the counterpoise weights of the two weighing feeder devices 404 and 405 are preferably, but not necessarily, set at the same position so that both of the pivoted endless belt conveyors will carry the same constant amount of material at all times which is automatically controlled as hereinafter pointed out more completely. However, the counterpoise weights may have different settings on the two machines, in which case the feed ratio will be the ratio of the counterpoise reading times the speed of the two machines. The ratio of these feeds from the two weighing feeder devices 404 and 405 I have found to be controlled with extreme accuracy over a range from practically no load to maximum load by varying the speeds of travel of the two endless belts of said devices 404 and 405 (that of the former being seen at 408) and then comparing these two speeds. To this end the driving Selsyn motors 415 and 420 are provided with speed indicating and total travel recording tachometer odometers 423 and 424 which are of course visible at the operator's station, and by comparing the speeds of the two the feed ratio of the feed from weighing feeder devices 404 and 405 is very accurately indicated over the entire range of operation thereof.

The two driving Selsyn motors 415 and 420 are

driven from a variable speed induction motor 425 or any other type of variable speed motor, the speed of which is adjusted by a master motor driven rheostat 426 illustrated in detail as to the electrical circuits in Fig. 7 of the drawings which is hereinafter described completely.

As is well known, the speed of an induction motor may be adjusted by varying the amount of resistance in circuit with the wound rotor.

The induction motor 425 drives the two driving Selsyn motors 415 and 420 through a variable speed Selsyn drive mechanism 427 which may take the form of any well known form of variable speed drive in which driving Selsyn motor 420 is driven directly from motor 425 and driving Selsyn motor 415 is driven through the variable speed Selsyn drive 427 and through a magnetic clutch 428 by which driving Selsyn motor 415 may be disconnected in case it is desired to operate only one of the weighing feeder mechanisms 404 and 405.

In this connection it may be pointed out that whenever induction motor 425 is operated, the weighing feeder device 405 is also operated but the weighing feeder device 404 may be shut down and this makes possible feeding of material from one of the weighing feeder devices 404 and 405, namely, device 405 independently of the operation of the other.

It is of course evident that the variable speed Selsyn drive 427 will determine the feed ratio of the two weighing feeder devices 404 and 405 and this ratio may be adjusted by adjusting said variable speed Selsyn drive 427. The total feed of the two weighing feeder devices 404 and 405 may be adjusted while maintaining the feed ratio absolutely constant by adjusting the speed of motor 425. In prior known devices where attempts have been made to accomplish this result, there has inherently been an introduction of errors because of the fact that the "Waytrols" being adjusted did not have exactly the same characteristics or where attempts were made to control two vibratory feeders by increasing the current in the two simultaneously their characteristics curves are such that the feed ratio of the two is not maintained over any appreciable range of operation. With my system, however, since the only thing that can possibly change the feed ratio of the two weight feeder devices 405 and 405 is the adjustment of the variable speed Selsyn drive 427, assuming of course that both devices 404 and 405 are in operation, there will be no possibility of a variation in said ratio due to any changes in the total feed rate of the devices 404 and 405 caused by increasing the speed of the motor 425, which may be called the master Selsyn driving motor.

Before describing in detail the control circuit, it may be pointed out that the weighing feeder device 404 is so constructed that it automatically adjusts the feed rate of the associated vibratory feeder 407 to maintain a constant amount of material on the belt conveyor 408 at all times, and the weighing feeder device 405 is of similar construction, it being provided with a similar vibratory feeder 429.

An understanding of the various control circuits can best be had by describing them in connection with the various steps of operation of the system which I shall now proceed to do. Upon the closing of the disconnect switch 403, it is of course evident that power is available on the lines L1, L2 and L3 beyond the switch 403, which lines extend into the bottom of the G. E. control

box as shown in Fig. 3 of the drawings. (The letters "G. E." are for identification only and do not signify any particular company.) As clearly shown in Fig. 3 of the drawings, lines L1, L2 and L3 extend into the G. E. control box and then out of it from which they extend to the magnetic contactor or switch 301 which is simply a magnetic switch having a closing coil 430 connected across two of the lines, namely, lines L1 and L3 which automatically close the switch whenever lines L1 and L3 are energized. Upon the closing of this switch 301 power is supplied to the alternating current motor of the mixed current motor generator 431 (Fig. 3) over lines MG1, MG2 and MG3, the D. C. generator side of which is connected in series with a single phase source of current supplied by lines L1 and L2 under the control of various automatic feed rate adjusting mechanism over a circuit which will hereinafter be traced.

In addition to starting rotation of the motor generator set 431, energy on the lines L1, L2 and L3 is supplied to the safety switch 432 in the G. E. control box (Fig. 5).

Energy from lines L2 and L3 extends to the energizing coil or solenoid 433 of interlock relay 310 (Fig. 2) by way of branch conductors 434 and 435 which closes the contacts of this interlock relay 310. As clearly shown in Fig. 1 of the drawings, there is a source of relatively low voltage, such as 110 volts, provided by lines 436 and 437 which are controlled by a safety switch 438, which lines 436 and 437 extend to the contacts of the interlock relay 310, and when said interlock relay 310 is closed this relatively low voltage on lines 436 and 437 is extended to and made available for the control circuit relay 309. The purpose of the interlock relay 310 is therefore to insure that the control voltage which is derived from the lines 436 and 437 will only be available in case the power circuit comprising lines L1, L2 and L3 is energized beyond the switch 403, and in case there is any failure of power on said lines L1, L2 and L3, interlock relay 310 will automatically drop out and remove the available low voltage supply from circuit control relay 309.

It is evident that the functions so far described take place immediately upon the closing of the master switch 403 which, in addition to preparing certain relays and circuits, has as its principal function the starting of the motor generator set 431.

To start the rest of the system into operation, the operator then pushes the push button "start" switch 439 (see Fig. 2) which energizes the solenoid 440 of control circuit relay 309 by connecting it across the two energized lines 436 and 437 over the following circuit:

One terminal of solenoid 440 is connected to line 437. The other terminal extends over conductor 441 to switch 439 which, when closed, completes the circuit to conductor 436. This closing is only momentary and thereafter a holding circuit is provided for solenoid 440 which may be traced from conductor 441 through normally closed "stop" switch 442, conductors 443 and 444 through the normally closed contacts 445 of timing relay 307, and thence by way of conductor 446 to conductor 436 through the upper contact of the now closed relay 309. The purpose of including the normally closed contacts 445 of timing relay 307 in this holding circuit is to provide a safety shutdown feature which will be described more completely hereinafter.

In the closing of the contacts of control circuit

relay 309, it effectively connects conductors 436 and 446 so as to energize the latter from the former and simultaneously connects conductor 437 to conductor 447 thereby energizing this conductor 447. The presence of power on these two conductors 446 and 447 as thus provided is effective to energize the solenoid or operating coil 448 of the 4-pole relay 308 through a circuit now to be described.

One terminal of solenoid 448 is connected directly to the energized conductor 447 as clearly illustrated. The other terminal of said solenoid 448 extends by way of a conductor 449 to the normally closed limit switch 450 (see Fig. 7) contained inside the master motor driven rheostat 426, which switch 450 is normally closed but which is open when all of the resistance of master motor driven rheostat 426 is put in circuit with the rotor of induction motor 425 and, as will be hereinafter evident, under such conditions the "Waytrol" control box A (see Fig. 2) is effectively disconnected. With the switch 450 closed, however, as it normally will be, this line extends from conductor 449 to conductor 451 which, as clearly shown in Fig. 2, is connected to conductor 446, thus completing the connection of the solenoid 448 across the energized lines 446 and 447. Solenoid 448, while being energized, of course closes the 4-pole switch of relay 308. Energized lines 447 and 446 are extended by the two center switches of relay 308 to conductors 452 and 453, respectively, to posts 110 and 109, respectively, on the "Waytrol" control box A so that these two posts 109 and 110 are thus energized.

It may be further pointed out that another branch of conductor 452 also extends to similar post 110 on "Waytrol" control box B, and post 109 of said "Waytrol" control box B is connected to conductor 453 by a branch thereof which extends up to the contacts of a control relay 304 and thence by way of conductor 454 which is connected to post 109 of "Waytrol" control box B.

As is hereinafter pointed out, relay 304 is under the control of "Waytrol" control box A, and therefore "Waytrol" control box B can only be energized after "Waytrol" control box A is energized.

Before proceeding with a further description of any of the circuits, it may be well pointed out at this time that "Waytrol" control box A controls the weighing feeder device 405 and "Waytrol" control box B controls the weighing feeder device 404; that is, "Waytrol" control boxes A and B are identical and so the description of only one is necessary. The mode of operation of "Waytrol" control box A will be described hereinafter, but at this time it may be stated that it operates automatically to maintain a predetermined weight of material on the conveyor belt associated with the balanced frame of weighing feeder device 405.

From the above description, it is evident that when relay 308 closes its contacts posts 109 and 110 on "Waytrol" control box A are energized and thus power is available at these posts. Referring particularly to Fig. 6 of the drawings which shows the internal circuits and apparatus of "Waytrol" control box A (which also applies to "Waytrol" control box B), it will be seen that the post 109 is connected to the post 105 and the post 110 is connected to the post 104 and since the two former are energized, the two latter are energized, and as clearly shown in Fig. 2 of the drawings energy on the posts 104 and 105 energizes the solenoid 455 of previously described

relay 304 by way of conductors 456 and 457 to close the contacts thereof, thus closing the circuit to supply power to the post 109 of "Waytrol" control box B over conductor 454, post 110 being previously directly connected to energized conductor 447 by way of conductor 452. This of course then energizes the "Waytrol" control box B.

Reverting to Fig. 6 it may be pointed out that the circuits which connect posts 109 and 110 to posts 105 and 104, respectively, may be traced as follows: Post 109 is connected to post 105 by way of conductor 458, the righthand blade of normally closed knife switch 459 and conductor 460, one branch of which leads directly to post 105, another branch of which leads by way of fuse 461 and conductor 462 to post 111 for a purpose hereinafter described.

Post 110 is connected to post 104 by way of conductor 463, lefthand blade of switch 459, busbar conductor 464, conductor 465, fuse 466, conductor 467 and the center blade of normally closed knife switch 468 which is connected directly to post 104 by a short conductor.

It may further be pointed out that a branch from conductor 465 leads to post 108 by way of fuse 469 and conductor 470 for a purpose hereinafter pointed out.

To summarize briefly some of the later operations which have taken place, it is evident that relays 304, 308, 309 and 310 have been energized in response to the closing of start switch 439 and as a result "Waytrol" control box A was first energized and thereafter "Waytrol" control box B was energized, thus placing these control boxes on an operative basis. The relay 304 is of course a "Waytrol" interlock relay, that is, it interlocks the "Waytrol" control box B under the control of "Waytrol" control box A.

As previously described, there are conditions under which only one of the "Waytrol" control boxes will be put into operation and that is the "Waytrol" or weighing feeder device 405 which is under the control of "Waytrol" control box A.

Attention is now directed particularly to Fig. 5 of the drawings and to the circuits and apparatus in the G. E. control box. When the main line switch 403 (Fig. 1) was closed energy was thus delivered to lines L1, L2 and L3 which extend to the G. E. control box and thence to normally closed safety switch 432 therein. The voltage on said lines L1, L2 and L3, such as 440 volts, is automatically applied to the operating coil or solenoid UV of an under voltage relay 8 having four normally opened contacts 472, 473, 474 and 475 associated therewith.

As clearly illustrated in Fig. 5 of the drawings, after the lines L1, L2 and L3 pass through switch 432, each has a number of branches, but since they are all connected together and are electrically the same they will retain the same designations L1, L2 and L3.

It is manifest that solenoid UV is connected across one branch of lines L1 and L2 through short conductors 476 and 477 so that said solenoid UV is always energized as long as there is power on these two lines. The purpose of this under voltage relay 8 is of course to protect the system against under voltage, and the solenoid UV will release on a predetermined low voltage.

Most of the relays in the G. E. control box of Fig. 5 are operated from relatively low voltage, that is, 110 volts in the illustration given which is derived from the "Waytrol" control box A by virtue of a branch of conductors 456 and 457

which extend from posts 104 and 105 which are energized as previously described and thence to posts 14 and 17, respectively, of the G. E. control box, the circuit being clearly illustrated from "Waytrol" control box A, posts 104 and 105 to posts 14 and 17, respectively, by reference to Figs. 2 and 3 of the drawings over the downwardly extending branch of conductors 456 and 457. By virtue of this voltage on posts 14 and 17 the coil LE1A of relay 14 is energized over a circuit which may be traced in Fig. 5 but which is better shown in the simplified circuit of Fig. 10 which includes this relay and the posts 14 and 17. This circuit is from post 14, contacts 475 of relay 8, conductor 478 to one post of solenoid LE1A. The other post of said solenoid LE1A is connected through normally closed safety overload contacts 479 and 480 of relay 14, thence by way of conductor 481 through normally closed contacts 482 and 483 of safety overload switch 484, then by conductor 485 through contacts 474 of relay 8 to post 17. This energization of solenoid LE1A closes its contacts 486 and 487 thereby extending power lines L3 and L2, respectively, to conductors 488 and 489 to posts R1 and R2, respectively, from which said conductors 488 and 489 thence extend to the stator of the driving Selsyn motor 420. At the same time the closing of contacts 486 and 487 also extends power lines L3 and L2, respectively, to conductors 490 and 491 which extend to posts RR1 and RR2, respectively, through heater elements associated with overload switches 482 and 483, respectively, and thence beyond posts RR1 and RR2 to one phase winding of the stator of the receiving Selsyn motor 416 associated with the weighing feeder device 405.

As previously described, the 3-phase windings of the rotors of the Selsyn motors 420 and 416 are connected together over conductors 417, 418 and 419, and when switch 14 closes its contacts 486 and 487 single phase energy from lines L3 and L2 is delivered to energize one phase of the stators of these two Selsyn motors 420 and 416, and this causes the rotors of said motors 420 and 416 to lock into a predetermined position.

It may be pointed out that the safety switches 482 and 483 associated with the lines 490 and 491 are well known overload heater safety switches which open the circuit to coil LE1A of relay 14 in case of an overload in either of the conductors 490 or 491. Similarly, switches 479 and 480 drop out this relay 14 in case of an overload in conductors 488 or 489.

To summarize briefly, the operation of relay 14 has thus placed single phase voltage on the stators of the two Selsyn motors 416 and 420 and locked the rotors thereof into a predetermined position. As previously described posts 109 and 110 of the "Waytrol" control box B (Fig. 2) were energized over conductors 452 and 454, and these posts 109 and 110 are connected to the posts 104 and 105 of the "Waytrol" control box B in the same manner that the similarly designated posts are so connected in the "Waytrol" control box A.

From posts 104 and 105 of "Waytrol" control box B the low voltage (110 volts in the illustration given) is extended over conductors 492 and 493 to posts 21 and 24, respectively, on the G. E. control box.

Referring particularly to Figs. 5 and 11 of the drawings, it will be seen that placing power on posts 21 and 24 energizes the solenoid LE2A of relay 19. Post 21 is connected to one terminal

of solenoid LE2A through conductor 494 which includes the contact 473 of relay 8 in circuit therewith, and post 24 is connected through conductor 495 thence through contact 472, of relay 8, overload contacts 496 and 497 of switch 19 thence by conductor 498 through normally closed contacts 499 and 500 of overload switch 484 then by an upper branch of conductor 498 to the other terminal of solenoid LE2A. The energization of the solenoid LE2A of relay 19 closes its contacts at 501 and 502 to connect posts R4 and R5 to power lines L3 and L2, respectively, by way of conductors 503 and 504 which carry heating units associated with the safety contacts 496 and 497 of relay 19. Conductors 503 and 504 extend beyond posts R4 and R5, respectively, and to one winding of the 3-phase wound stator of the driving Selsyn motor 415 thus energizing a single phase of the stator thereof.

At the same time the closing of contacts 501 and 502 extends lines L3 and L2 to posts RR4 and RR5, respectively, by way of conductors 505 and 506 through heaters associated with safety overload switch contacts 499 and 500 of switch 484. Conductors 505 and 506 extend beyond the posts RR4 and RR5 to one phase winding of the stator of the receiving Selsyn motor 411 associated with the weighing feeder device 404. It is thus evident that the energization of the solenoid LE2A of relay 19 energizes one phase of the stator of the Selsyn transmitting motor 415 and one phase of the stator of the Selsyn receiving motors 411, and since their 3-phase rotors are connected together by conductors 412, 413 and 414 as previously described said rotors will be locked in step by this application of single phase current to the stators.

It is of course understood that to obtain synchronous operation of the Selsyn transmitters 415 and 420 and their associated receivers 411 and 416, respectively, it is necessary to energize the stators of both with 3-phase current instead of single phase current which alone has so far been applied by the described mechanism. It is desirable that the single phase connection between the stators be first made as previously described and thereafter connections be made to effect the 3-phase energization of said stators. To accomplish this feature I provide timing relays 21 and 40 which will now be described and which, it may be stated, are operated to control contactors 22 and 17, respectively.

As previously described, the low voltage, that is, 110 volts, was applied to the terminals of coil LE1A in response to certain previous conditions which were described in detail. This voltage is also applied to start the operation of the motor of the timing relay 40 over a circuit which extends from conductor 478 by way of conductor 507 to the motor of the timing relay 40 and thence through conductor 508 to a position on the other terminal of solenoid LE1A. This energization of the motor of relay 40 is through normally closed contacts 509 thereof, and after a predetermined time interval relay 40 closes contacts 510 by means of a cam which is operated by the motor M thereof which connects operating coil or solenoid LE1B of connector 17 directly across the energized lines 507 and 508, that is, conductor 508 extends directly from one terminal of solenoid LE1A to one terminal of solenoid LE1B.

Branch 507 which extends from conductor 478 is extended through switch 510 and thence to a continuing branch 511 which forms a continua-

tion of conductor 507 when switch 510 is closed. Conductor 511 extends to post 20 forming one terminal of solenoid LE1B. The energization of solenoid LE1B closes the contacts 512 of connector 17 and thereby extends line L1 to conductor 513 which leads to post R3 and extends beyond said post R3 by way of two branches leading to the third wire of the stator of driving Selsyn motor 420 and receiving Selsyn motor 416. This of course provides the application of 3-phase power from lines L1, L2 and L3 to the stators of the Selsyn motors 416 and 420, and thereafter any rotation of their rotors will be in synchronism, and consequently Selsyn motor 420 will drive Selsyn motor 416.

The closing of switch 510 of timing relay 40 with the consequent connection of line 511 to a source of power as previously described also energizes coil or solenoid LEM of transfer relay or contactor 44 by virtue of the fact that one post of the coil LEM is directly connected to conductor 511, the other post being connected through normally closed overload contactors 514 and 515 to a branch of conductor 485. In other words, switches 17 and 44 operate simultaneously after timing relay 40 has closed its contacts 510.

Solenoid LEM upon being energized closes the contacts 516, 517 and 518 of relay 44 which thus extend the lines L1, L2 and L3, respectively, to conductors 519, 520 and 521, the first and the last through heating elements associated with overload contacts 514 and 515, which conductors 519, 520 and 521 extend to posts T1, T2 and T3, respectively, and beyond said posts to the stators of the induction motor 425 which is the main drive motor for the Selsyn transmitter. This of course supplies 3-phase power to said induction motor 425 and starts it to rotate at an ultimate speed which will be determined by the master motor driven rheostat 426.

It is of course manifest that since the Selsyn transmitters 415 and 420 have previously been connected with their receivers 411 and 416, respectively, that the conveyor belts of the weighing feeder devices 404 and 405 will thus start to rotate at a speed determined by the speed of rotation of motor 425 and by the variable speed Selsyn drive 427, assuming of course that the magnetic clutch 428 is connected to couple the Selsyn transmitter motor 415 for driving.

When the solenoid LE2A of contactor 19 was energized, the timing relay 21 was simultaneously placed into operation, the circuit therefore being traced from the terminals of said solenoid LE2A by way of conductors 498 and 522. After a predetermined time interval for which this timing relay 21 is set, the cam thereof closes the contacts 523 thus connecting one post of solenoid LE2B of connector 22 to one energized post of solenoid LE2A over conductors 522 and 524, the other terminal of said solenoid LE2B being connected to conductor 498.

It is of course to be understood that this action took place simultaneously with the previously described action of relay 40, and thus when motor 425 started operation relay 22 had already performed its operation. When solenoid LE2B is thus energized, it closes its contacts 525, 526 and 527, the first of which extends line L1 to conductor 528 which leads to post R6 and beyond post R6 it has two branches, one of which extends to the third connection of the 3-phase stator of driving Selsyn motor 415 thus providing 3-phase power on the stator thereof, and the other branch of which extends to the

third connection of the 3-phase stator winding of receiving Selsyn motor 411 associated with weighing feeder device 404. In short, the contactor 22 has changed over the single phase application of power to the Selsyn motors 411 and 415 to 3-phase power, thus insuring their rotation in unison as previously described.

The contacts 526 and 527 operate to energize the magnetic clutch 428 associated with driving Selsyn motor 415 in a manner now to be described.

Two conductors 529 and 530 lead from magnetic clutch 428 (Fig. 3) to posts 26 and 27 on the G. E. control box which form the output circuit of a rectifier 531, the input circuit of which is provided by continuations of conductors 529 and 530 which extend to terminals of contacts 526 and 527. The other terminals of contacts 526 and 527 extend by conductors 532 and 533 to posts 8 and 11, respectively, and beyond said posts, the former connects to previously described conductor 451 which is supplied with power over a previously described circuit. Conductor 533 extends upwardly along side conductor 451 (see Fig. 3) until it connects with previously described conductor 447 which is connected to the other side of the source of power of low voltage. As a consequence, the magnetic clutch 428 is energized upon the actuation of contactor relay 22 thus insuring a drive connection for the sending Selsyn motor 415 when relay contactor 22 is energized.

Furthermore, at the time solenoid LE1B was energized it is of course evident that the post 20 thereof was energized and there is a conductor 534 (see Fig. 2) which extends from post 20 to one terminal of the energizing coil or solenoid 535 of relay 302, the other terminal of which solenoid 535 is connected by conductor 536 to post 111 of "Waytrol" control box A which is connected to the other side of the source of low voltage as previously described. Consequently solenoid 535 is thus energized by timing relay 40, the result of which is to extend main lines L2 and L3 to conductors 537 and 538, the former of which leads through the lower pair of contacts of relay 302 and then extends through the ammeter 539 from which conductor 537 extends through the motor driven rheostat 540, and thence returns to a branch point, one branch of said conductor 537 leading to a manually adjustable rheostat 541 and another branch extending to post 113 of "Waytrol" control box A. From post 113 the one branch of conductor 537 extends to the normally opened contacts of magnetic switch or relay 542 (see Fig. 6), the function of which will be explained hereinafter. The other branch of conductor 537 after passing through rheostat 541 connects to a conductor 543 having two branches, one of which leads to post 114 of "Waytrol" control box A, the other one of which extends to hand operated rheostat 544 and through said rheostat 544 to a conductor 545, one branch of which extends to post 115 on "Waytrol" control box A.

By referring to Fig. 6 of the drawings, it will be seen that the conductors 543 and 545 are normally connected together by the normally closed contacts of a magnetic switch of relay 546, the function of which will be described hereinafter so that conductors 543 and 545 are normally connected together, and thus hand operated rheostat 544 is normally shunted. Thus from conductor 537 the normal circuit will extend from line L2 and switch 301 first through ammeter

539 and power driven rheostat 540 and thence normally through the hand operated rheostat 541 because of the normally open condition of relay 542, and then from conductor 543 directly to conductor 545 because of the normally closed contacts of relay 546, and then along conductor 545 to the energizing coil of feeder 429 associated with weighing feeder device 405 (see Fig. 1) from which a conductor 547 extends to and through the upper contacts of relay 302 which are now closed, thence to conductor 548 which leads directly to one brush of the D. C. motor of the motor generator set 431 (see Fig. 3). The other brush of said D. C. motor is connected directly by conductor 538 to the line L3 in switch 301. As a consequence of the closing of the contacts of this relay 302, mixed current, that is, alternating current from lines L2 and L3 in series with direct current from the generator of motor generator set 431, is thus fed to the energizing coil of the feeder 429 which is a mixed current type of feeder. In this circuit there is also normally included the power driven rheostat 540 and the hand operated rheostat 541. It is of course evident that the rate of feed of material by the feeder 429 from the hopper associated therewith will be governed by the amount of resistance in series therewith which will be the sum of the resistance of rheostats 540 and 541 under normal conditions. It may be stated at this time that control mechanism which I shall describe hereinafter is provided which is under the control of the balanced belt conveyer of the weighing feeder device 405 which will operate automatically to adjust the value of the effective resistance of rheostat 540, and under certain conditions will shunt the resistance of hand resistor 541 and under other conditions will place both rheostats 541 and 540 in series with the winding of feeder 429. In short, the feed rate of feeder 429 is automatically adjusted to maintain the weight of material on the weighing belt of weighing feeder device 405 substantially constant at all times.

In a similar manner when timing relay 21 (see Fig. 5) closed its contacts 523, it energized post 25 and as clearly seen by reference to Fig. 2 of the drawings, a conductor 549 extends from post 25 to one terminal of solenoid of the operating coil 550 of relay 303, the other terminal of which is connected by a conductor 551 to the post 111 of "Waytrol" control box B which is connected to the other line of the source of low voltage as previously described. As a consequence, when contacts 523 of timing relay 21 were closed, it also caused the energization of solenoid 550 of relay 303 thereby closing its contacts. Relay 303 in closing its contacts is effective to connect mixed current to the feeder 407 of weighing feeder device 404 in series with the motor driven rheostat 552, and the hand operated rheostat 553 as well as ammeter 554, a hand operated rheostat 555 being normally shunted by virtue of the normally closed contacts of the relay associated with posts 114 and 115 of "Waytrol" control box B which is of course a duplicate of "Waytrol" control box A as above described. This circuit may be traced from lines L2 and L3 of switch 301 as follows:

From line L2 the circuit leads by way of conductor 537 to the lower lefthand terminal of relay 303, and thence from the lower righthand terminal thereof by way of conductor 556 to the winding of feeder 407 of the weighing feeder device 404, thence by way of conductor 557 to

the post 115 of "Waytrol" control box B which, as previously mentioned, is normally directly connected to post 114, thence from post 114 by way of conductor 558 through hand rheostat 553, thence by way of conductor 559 through motor driven rheostat 552, thence by conductor 560 through ammeter 554 from which conductor 560 then extends through the upper contacts of relay 303 and connects to conductor 548 which, as previously described, is connected to one of the brushes of the direct current generator of the motor generator set 431, the other brush of which is directly connected by conductor 538 to the line L3 at switch 301.

It is thus evident that timing relay 21 has energized the feeder 407 associated with the weighing feeder device 404 with mixed current including power driven resistors 552 and 553 normally in series therewith, both of which are under the control of the "Waytrol" control box B.

The system may be operated either manually or automatically to adjust the speeds of the two conveyor belts associated with the weighing feeder devices 404 and 405 because, as previously described, this is the manner in which the total output of these two devices 404 and 405 is controlled, and this is done without any alteration whatever in their feed ratio. I shall now describe the manual operation of the system.

Referring to Fig. 5 of the drawings, it will be seen that I have provided a "fast" push-button switch 561 and a "slow" push-button switch 562. Upon closing the "fast" push-button 561, voltage on line 532 which is provided as previously described is extended over conductor 563 to conductor 564 through switch 561, which conductor 564 leads through the normally closed contact 565 and then to one terminal of the energizing coil or solenoid LEF of the connector switch 42 which is connected to conductor 533 which, as previously described, is connected to the other line of the source of low voltage. This energizes solenoid LEF and closes its normally opened contacts 566 and 567 and opens its normally closed contact 568. The closing of contacts 566 and 567 closes a circuit from the secondary of a transformer 569 by way of conductors 570 and 571, the primary of which transformer is connected to lines L2 and L3, which conductors 570 and 571 are thus connected to conductors 572 and 573, respectively, leading to and beyond posts 28 and 30, respectively, and extending to the master motor driven rheostat 426 (see Figs. 3 and 7).

As clearly shown in Fig. 7, conductor 573 extends to one brush of the armature of a reversible motor 574 which drives the motor driven rheostat 426 and is provided with a pair of separate field coils which, when selectively energized, cause the motor to rotate in reverse directions in a well-known manner.

As also clearly shown in Fig. 7, conductor 572 extends through a limit switch 575 which is normally closed but opens when all of the resistance of rheostat 426 is cut out through said switch 575 thence through one of the field windings of the motor 574 and to the other brush of the armature thereof. It is thus evident that so long as the "fast" switch 561 (Fig. 5) is held closed, relay or contactor 42 has its contacts closed, energizing motor 574 (Fig. 7) of the master motor driven rheostat 426 to adjust said rheostat to reduce the effective resistance which is connected in series with the wound rotor of the induction motor 425. In this connection it is obvious that three conductors 576, 577 and 578

extend from the rotor of induction motor 425 to resistors 579, 580 and 581, respectively, of the master motor driven rheostat 426 and thus are effectively connected in series therewith by the position of the adjustable 3-pole arm 582 of said master motor driven rheostat 426.

As previously mentioned, the speed of the motor 425 adjusts the total output of the two weighing feeder devices 404 and 405 without disturbing their feed ratio in any manner. In case the push-button 561 is released, relay 42 is immediately released and master motor driven rheostat 426 stays in any position to which it has been adjusted. In case it is desired to decrease the speed of the motor 425 and consequently decrease the total feed of the two weighing feeder devices 404 and 405, the "slow" switch 562 (Fig. 5) is closed thus extending energized line 532 over conductor 563 through switch 562 to conductor 583 through normally closed switch 568 of relay or connector 42 and thence to one terminal of the operating coil or solenoid LES of relay or connector 41. The other terminal of solenoid LES is connected to the other low voltage line by conductor 533 as previously described. Solenoid LES when energized closes its normally open contactors 584 and 585 and opens its normally closed contactor 586. Contactor 584 when closed extends previously described conductor 570 to conductor 586 which extends to and beyond post 29 and thence to master motor driven rheostat 426 (Figs. 3 and 7) which conductor 586 extends through normally closed limit switch 587 and thence to the other winding of the operating motor 574 which is connected to one brush of the armature thereof. Limit switch 587 is only opened when all of the resistance of rheostat 426 is in circuit and of course under these conditions it is impossible to insert more resistance or to reduce the speed of reduction motor 425 and the only way the rheostat 426 can thus be adjusted is to decrease the effective resistance thereof to increase the speed of motor 425.

Conversely, when all the resistance of rheostat 426 is effectively cut out and switch 575 is open, the only way the rheostat can be adjusted is to insert more resistance to decrease the speed of induction motor 425. The closing of contact 585 of relay 41 (Fig. 5) connects conductor 571 with previously described conductor 573 which, as previously described, leads to the other brush of the armature of motor 574. In other words, conductor 573 is common to the two relays or connectors 41 and 42 and when either is operated this conductor is connected to conductor 571. Conductors 572 and 586, however, are individual to the relays or connectors 42 and 41, respectively, and thus provide for the selective adjustment of the master motor driven rheostat 426 in reverse directions. It is to be noted that operating coil LES of connector 41 includes normally closed switch 568 of relay or connector 42 and conversely operating coil LEF of relay or connector 42 includes normally closed switch 565 of relay or connector 41. Consequently, when either relay or connector 41 or 42 is energized, it is impossible to energize the other because of the opening of the associated normally closed switch 565 or 568, as the case may be. It may be pointed out that a simplified circuit for controlling the solenoids LES and LEF is shown in Fig. 9 of the drawings.

To provide for the automatic control of the master motor driven rheostat 426 and thus to adjust automatically the feed rate of the mate-

rial received by the elevator 400, I provide a current transformer 588 (Fig. 1) in association with one of the lines, such as the line L3, after it has passed through switch 402 to the motor 401 of the elevator 400. As previously indicated, instead of the elevator 400, there may be a conveyor or crusher.

From current transformer 588, conductors 589 and 590 extend to posts 7 and 8, respectively, on the G. E. control box (Figs. 3 and 5) and from said posts to the terminals of a solenoid 591 having associated therewith a normally balanced armature 592, which solenoid and armature form a part of relay 12. Shunted across the terminals of solenoid 591 is a variable rheostat 593 which may be adjusted by hand to adjust the effective value of the shunt so as to adjust the balanced condition of armature 592 to correspond to any predetermined current flow in the line L3 through transformer 588. To make the automatic control of the master motor driven rheostat 426 effective, the automatic control switch 594 (Figs. 5 and 9) is closed and this effectively connects the energized conductor 532 through a periodically closing contact 595 of timer 13, then by conductor 596 through switch 594 to conductor 597 which is connected to the armature 592 of the normally balanced relay 12. It may be pointed out that the timer 13 has a motor 598 which is directly connected across the energized lines 532 and 533 to run continuously whenever these lines are energized and which periodically opens and closes the contacts 595 so that armature 592 is connected to conductor 532 when automatic switch 594 is closed only for predetermined recurring intervals. This of course produces a step by step adjustment of the master motor driven rheostat 426 whenever relay 12 becomes unbalanced thus effecting a time delay which prevents hunting and allows the load on the elevator 400 to reach a condition of equilibrium.

As clearly seen by reference to Fig. 5 of the drawings, the relay 12 is provided with an upper contact 599 which is connected to a branch of the previously described conductor 564. It is also provided with a lower contact 600 which is connected to a branch of the previously described conductor 583. Thus, in case the current in the transformer 588 is reduced to a predetermined value, armature 592 will move upwardly to make connection with upper contact 599 which will energize solenoid LEF with the results previously described in connection with the energization of said solenoid, namely, to increase the speed of induction motor 425 by adjusting master motor driven rheostat 426. This of course will continue so long as the contacts 595 of timer 13 are closed unless the current flowing through transformer 588 is increased to reestablish the armature 592 of balanced relay 12. An overload on the line L3 will of course increase the current in transformer 588 to pull the armature 592 against a biasing spring to make connection with contact 600 which energizes solenoid LES to reduce the speed of induction motor 425 in a manner which is obvious from previous description.

Attention is now directed to the structure in the "Waytrol" control box A and the associated mechanism which is operative to maintain at all times a constant amount of material on the belt conveyor associated with the constant weight feeder device 405. Referring first to Figs. 1, 2 and 3 of the drawings, it will be seen that posts 101, 102 and 103 of "Waytrol" control box A are

connected by conductors 601, 602 and 603, respectively, to a control tube box 604 which is shown in detail in Fig. 4 of the drawings. Within said box 604 is a pivoted frame 605 which carries a pair of mercury tube switches 606 and 607. Conductor 602 is common to these two switches and conductor 601 is individual to switch 606, while conductor 603 is individual to switch 607. The frame 605 is controlled by the frame of the continuous weighing belt conveyor, and when said weighing conveyor is in a balanced condition, both the switches 606 and 607 are in open circuit condition. In case the material on the belt conveyor is too light, frame 605 tilts to close the contacts on switch 606 thus connecting conductors 601 and 602 which connects posts 101 and 102 of "Waytrol" control box A. This causes a solenoid 608 of a relay 609 to be energized (see Fig. 6) over the following circuit.

From bus-bar conductor 464 which was energized as previously described, through conductor 610, normally closed contacts 611 of relay 612, and thence directly to one terminal of solenoid 608, the other terminal of solenoid 608 is connected over conductor 613 to post 101 which, as just previously stated, is connected to post 102 by switch 606, conductors 601 and 602, and thence from post 102 through the lefthand contact of switch 468 to a bus-bar conductor 614 which is connected to the conductor 462 and post 111 which is energized from the other line of the low voltage source as previously described; that is, bus-bars 464 and 614 are connected to the two lines of the low voltage source of supply over circuits previously described.

It may be pointed out that when energy was supplied to the "Waytrol" control box A from the low voltage source, a white signal light 615 was energized because one terminal of it is connected to bus-bar conductor 464, and the other terminal of it is connected to conductor 460 which is connected directly to the other bus-bar conductor 614 through fuse 481. When solenoid 608 is thus energized, it pulls its armature 616 into contact with a lower terminal which connects bus-bar 464 with one terminal of the operating coil or solenoid 617 of a multiple pole relay, the other terminal of which solenoid 617 is connected directly to bus-bar 614. The solenoid 617 when thus energized closes a plurality of circuits. The lefthand contact connects a green signal light 619 directly across the bus-bars 614 and 464 over obvious circuits.

The second contact from the left connects the bus-bar 614 to a conductor 620 which extends to post 106 and beyond post 106 to form two branches (see Figs. 2 and 3), the lower one of which extends to the terminal of one field coil of reversible motor 621, the center tap of which field coil is connected to one brush of the armature, the other brush of which is connected by a conductor 622 to and through the post 108 which, as previously described, is connected by conductor 470, fuse 469 and conductor 465 to bus-bar 464. This of course starts rotation of the motor 621 to drive the motor driven rheostat 540 in a direction to reduce the effective resistance thereof of which of course increases the feed rate of the vibratory feeder 429 associated with the weighing feeder device 405. At the same time the third set of contacts of relay 618 closes the circuit from bus-bar conductor 614 by way of conductor 623 to one terminal of solenoid 624 of normally open relay 542, the other terminal of which is

connected directly to bus-bar 464 over an obvious conductor.

The energization of solenoid 624 closes the contacts thereof which connect conductors 537 and 543 which are connected to posts 113 and 114, respectively, thus shunting out the resistance of rheostat 541. This shunting of rheostat 541 is of course automatic and immediately increases the feed rate of vibratory feeder 429 of weighing feeder device 405 to increase the feed rate of the material from the hopper associated therewith to the weighing conveyor. It is obvious that rheostat 541 will be shunted and rheostat 540 will move to decrease its effective resistance simultaneously, and both actions will continue until the normal load is again present on the belt conveyor of the weighing device 405 whereupon mercury switch 606 (Fig. 4) will open its contacts and the relays which have been operated in the "Waytrol" control box A will immediately drop out.

The rheostat 541 is adjustable so that the amount of the immediate increase in feed rate in feeder 429 may be adjustably determined. Should an overload condition develop on the weighing conveyor of the device 405 frame 605 will tilt in an opposite direction from that above described and close the contacts of mercury switch 607 which by way of conductors 602 and 603 interconnects posts 102 and 103, thus connecting bus-bar 614 to one terminal of the solenoid 625 of relay 612.

The circuit from bus-bar 614 extends through the lefthand terminal of knife switch 468 to post 102, thence to post 103 which is connected thereto over wires 602 and 603 and switch 607 as just described. From post 103 conductor 626 leads to one terminal of the solenoid 625. The other terminal of solenoid 625 extends to bus-bar 464 by way of conductor 627, normally closed armature 616 of relay 609 and thence to bus-bar 464 by an obvious conductor. It is to be noted that solenoid 625 can only be energized when solenoid 608 is de-energized, and vice versa. This of course provides an interlock between the two relays 609 and 612 so that only one can be energized at a time. When solenoid 625 is energized, its armature 611 opens the normally closed circuit and connects conductor 610 leading from bus-bar 464 to one terminal of a solenoid 628 of a relay 629. The other terminal of solenoid 628 is connected directly to bus-bar 614 over an obvious conductor.

Solenoid 628 when energized closes three different circuits now to be described. The first circuit is to signal lamp 630, one terminal of which is connected to bus-bar 464, the other of which is connected to conductor 631 to the lefthand contacts of relay 629 to bus-bar 614. The second pair of contacts from the left of relay 629 extend the circuit from bus-bar 614 to conductor 632 which leads to post 107 and beyond post 107 to one end of the field coil of motor 621 (see Fig. 3) associated with the motor driven rheostat 540 which of course causes this motor 621 to operate in a reverse direction than that previously described in response to an overweight on the weighing belt of weighing device 405. The return circuit for this motor 621 is of course by way of conductor 622 as previously described.

The third pair of contacts on relay 629 when closed extend bus-bar 614 to one terminal of the solenoid 633 of the normally closed relay 546 over an obvious circuit, the other terminal of said solenoid 633 being connected to bus-bar 464 by

way of conductor 465. When solenoid 633 is thus energized, it opens its contacts and thus removes the shunt connection normally existing between conductors 543 and 545 which of course removes the previously described normal short circuit of hand operated rheostat 544. This of course inserts the effective resistance of rheostat 544 in series with the vibratory feeder 429 associated with weighing device 405 and instantly reduces its feed rate. The motor driven rheostat 540 also starts to act to increase the resistance in series with said motor 429 and the reduced feeding rate of said feeder 429 is thus maintained until the weighing conveyor of weighing feeder device 405 is again restored to its normal condition of equilibrium, whereupon switch 607 opens and restores the relays in the "Waytrol" control box A to their normal condition.

The "Waytrol" control box B and the associated apparatus including the hand operated rheostats 553 and 555 and the motor driven rheostat 552 operate in a manner which is the same as that just described for equivalent apparatus controlled by "Waytrol" control box A; that is, rheostat 541 corresponds to rheostat 553, rheostat 544 corresponds to rheostat 555, and motor driven rheostat 540 corresponds to motor driven rheostat 552. The "Waytrol" control box B of course controls the feeder 407 associated with the weighing feeder device 404, and there is a control switch associated with the belt conveyor thereof similar to the switch shown in Fig. 4 of the drawings. Except for a particular situation which is hereinafter described, the circuits leading to and from "Waytrol" control box B are believed so obvious as not to justify individual description.

There are certain alarm and protective devices associated with the system which shall now be described. In the case where the weighing conveyor associated with the weighing feeder device 405 was light and thus required more material on it to produce a stabilized condition, the relay 618 (Fig. 6) of the "Waytrol" control box was energized and connected with the bus-bar 614 through the second contact from the left to the post 108 from which extends conductor 620. This conductor 620 has two branches, one of which leads to the motor 621 of motor driven rheostat 540, the other one of which extends upwardly (see Fig. 2 of the drawings) and through the lower pair of contacts of relay 308 and then by way of a conductor 634 to one post of a motor driven timing relay 305, the other post of which is directly connected to the conductor 447 so that the low voltage previously mentioned is applied directly to the terminals of the timing relay 305.

After a predetermined time, the normally open contacts 635 of timing relay 305 will be closed in case this voltage is maintained on said relay 305 in which case conductor 447 is extended by way of conductor 636 to an alarm 637, one terminal of which is connected directly to conductor 446 by way of conductor 638. In other words, if the "Waytrol" control box A has its relay 618 energized for a predetermined length of time, alarm 637 will be sounded. More generally, this means if the weighing conveyor of the weighing feeder device 405 does not receive sufficient material to be brought into equilibrium for an extended period which might occur, for example, as the hopper associated with the feeder 429 became empty, the alarm 637 will sound calling the attendant's attention to the fact that something is wrong

and material is not being received properly by the weighing feeder device 405.

In a similar manner, underweight on the weighing conveyor of the weighing feeder device 404 will apply potential of post 106 of "Waytrol" control box B, which potential is extended by conductor 639 through the upper pair of contacts of relay 308 and thence by conductor 640 to one post of the timing relay 306, the other post of which is connected directly to the other energized conductor 447. Timing relay 306 is thus thrown in operation whenever the weighing belt associated with weighing device 404 is light, and if this condition maintains for a predetermined time as determined by the timing of relay 306, its normally open contacts 641 are closed, and since these contacts are in parallel with contacts 635 of relay 305 this will also cause the sounding of alarm 637.

As previously described at the outset of this description, the holding circuit for the control circuit 309 which controls the starting and stopping of substantially the entire system, included the normally closed contacts 445 of timing relay 307. The function of this timing relay 307 is to shut down the entire system in case the alarm 637 is allowed to operate for a prolonged predetermined length of time. This is effected by virtue of the fact that the clutch coil of the timing motor of relay 307 is connected directly across the conductors 636 and 638 which supply energy to the alarm 637. The armature of this relay is directly connected across the energized conductors 446 and 447. Consequently, whenever alarm 637 is energized timing relay 307 starts to count time and unless the faulty condition is rectified to shut off the alarm 637 in a predetermined length of time, timing relay 307 automatically opens its contacts 445 at the end of the time period and this breaks the holding circuit for solenoid 440 of relay 309 which automatically shuts down the entire system insofar as it is controlled by relay 309 as previously described which includes substantially everything except the rotation of the motor generator set 431.

As previously stated, it is possible to operate the weighing feeder device 405 alone, but it is not possible to operate the weighing feeder device 404 alone, and in case it is desired to operate the weighing feeder device 405 alone it is only necessary to open the switch 468 and the "Waytrol" control box B to disable the weighing feeder 404 and its control devices. In the operation of the device under conditions in which both of the weighing feeder devices 404 and 405 are operated, it is of course evident that each will maintain a predetermined amount of material on its weighing conveyor at all times. These amounts are preferably exactly the same and in any event they are not changed while the system is in operation, because it has been found in practice that if an attempt is made to adjust the weights of material on two weighing devices while running the conveyors at the same speed, extreme accuracy is not realized, but I have discovered that if the weights of material on the two or more weighing feeder devices are maintained constant, a definite ratio which may be widely adjusted can be maintained between the outputs thereof by adjusting the speeds of the weighing conveyors.

The material from the two weighing devices 404 and 405 is delivered by chutes 421 and 422 to the elevator, conveyor or crusher, and ele-

vator 400 being illustrated in the drawings, thus producing a mixture of materials having a desired ratio. This ratio is indicated at all times at the operator's station, which may be either adjacent to or remote from the weighing devices 404 and 405, by the tachometers 423 and 424. The total amount of material delivered to the elevator 400 may be adjusted without in any way affecting the ratio and entirely independent of any characteristics of any feeders or weighing conveyors by adjusting the speed of the master drive motor 425. The feed ratio of the two weighing feeder devices 404 and 405 may be readily adjusted by the variable speed Selsyn drive 427. The total out-put of the weighing feeder devices 404 and 405 may be adjusted either manually or automatically. When adjusted automatically the load on the elevator 400 or conveyor or crusher which replaces it will be automatically maintained substantially constant within limits as determined by the operator. The system is provided with numerous interlocks as previously described and an alarm which indicates an abnormal condition, such as lack of proper material on the weighing conveyors of one of the weighing feeder devices 404 and 405, and unless the undesirable condition is corrected within a predetermined time the entire system is shut down automatically requiring it to be started again manually by an operator.

The total travel recorded by odometers 423, 424 gives the total feet of belt travel for each belt of devices 404 and 405. This multiplied by the counter-poise setting of the associated weighing device gives the total poundage feed by each machine. This is an important feature of my invention.

It is of course evident that many features of the invention, while realizing their greatest efficiency in the complete system which I have disclosed, may be independently employed. For example, the automatic means for maintaining a constant load on the elevator 400 might well be provided entirely independently of the extremely elaborate and weighing devices 404 and 405 and might be controlled in connection with one or more feeders, such as the feeders 407 and 429, feeding directly into the elevator 400 or the crusher or conveyor substituted therefore.

Other legitimate sub-combinations will be suggested to those skilled in the art which may have utility separate from the complete system.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. In a feeding system the combination with a power driven material receiver, of an electric motor for driving said receiver, feeder mechanism for feeding material to said receiver, and means responsive to the current flow to said motor to adjust the feed rate of said feeder mechanism to maintain a fairly constant current flow to said motor.

2. In a feeding system the combination with a power driven material receiver, of an electric motor for driving said receiver, feeder mechanism for feeding material to said receiver, and means controlled by the current flow to said

motor to adjust the feed rate of said feeder mechanism to maintain a fairly constant current flow to said motor.

3. A variable rate accurate weighing apparatus comprising a balanced conveyor, means for keeping a constant weight of material thereon, a variable speed motor for driving said balanced conveyor, remote means for adjusting the speed of said motor, and means for accurately measuring and indicating the speed of said motor at said remote means, said remote means including a rotating electrical machine which rotates continuously with the motor of said balanced conveyor.

4. Mixing feeder apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources comprising a constant weight feeding device associated with each source, each of said constant weight feeding devices comprising a variable speed conveyor mounted on weighing apparatus, a feeder, and mechanism controlled by the balanced or unbalanced condition of said weighing apparatus to control said feeder thereby to maintain a substantially constant weight of material on said conveyor independently of the speed thereof, and means for varying the speed ratio of the conveyors of said constant weight feeding devices including an independent rotary driving device for each conveyor and mechanism for driving said rotary driving devices from a common rotary motor at least one such drive including a variable ratio drive means.

5. Mixing feeder apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources comprising a constant weight feeding device associated with each source, each of said constant weight feeding devices comprising a variable speed conveyor mounted on weighing apparatus, a feeder, and mechanism controlled by the balanced or unbalanced condition of said weighing apparatus to control said feeder thereby to maintain a substantially constant weight of material on said conveyor independently of the speed thereof, and means for varying the speed ratio of the conveyors of said constant weight feeding devices including independent electrical driving connections comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, and mechanism for driving said driver motors from a common variable speed rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied.

6. Mixing feeder apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources comprising a constant weight feeding device associated with each source, each of said constant weight feeding devices comprising a variable speed conveyor mounted on weighing apparatus, a feeder, and mechanism controlled by the balanced or unbalanced condition of said weighing apparatus to control said feeder thereby to maintain a substantially constant weight of material on said conveyor independently of the speed thereof, and means for varying the speed ratio of the conveyors of said constant weight feeding devices including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, and mechanism for driving said driver motors from a common rotary motor through

variable gearing whereby the speed ratio of said driver motors may be varied.

7. Mixing feeder apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources comprising a constant weight feeding device associated with each source, each of said constant weight feeding devices comprising a variable speed conveyor mounted on weighing apparatus, a feeder, and mechanism controlled by the balanced or unbalanced condition of said weighing apparatus to control said feeder thereby to maintain a substantially constant weight of material on said conveyor independently of the speed thereof, and means for varying the speed ratio of the conveyors of said constant weight feeding devices including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, mechanism for driving said driver motors from a common variable speed rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied, and means adjacent said last named mechanism for measuring the speeds of said driver motors.

8. Mixing feeder apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources comprising a constant weight feeding device associated with each source, each of said constant weight feeding devices comprising a variable speed conveyor mounted on weighing apparatus, a feeder, and mechanism controlled by the balanced or unbalanced condition of said weighing apparatus to control said feeder thereby to maintain a substantially constant weight of material on said conveyor independently of the speed thereof, and means for varying the speed ratio of the conveyors of said constant weight feeding devices including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, mechanism for driving said driver motors from a common rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied, and means adjacent said last named mechanism for measuring the speeds of said driver motors.

9. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including an independent rotary driving device for each conveyor and mechanism for driving said rotary driving devices from a common rotary motor, at least one such drive including a variable ratio drive means.

10. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, and mechanism for driving said driver motors from a common variable speed rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied.

11. Mixing apparatus comprising a material receiver, means for feeding material thereto from

a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, and mechanism for driving said driver motors from a common rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied.

12. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, mechanism for driving said driver motors from a common variable speed rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied, and means adjacent said last named mechanism for measuring the speeds of said driver motors.

13. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including independent electrical driving connections for each, each such driving connection comprising a rotary receiver motor on the conveyor and an interconnected remote rotary driver motor, mechanism for driving said driver motors from a common rotary motor through variable gearing whereby the speed ratio of said driver motors may be varied, and means adjacent said last named mechanism for measuring the speeds of said driver motors.

14. Mixing apparatus comprising a material receiver, means for feeding material thereto from

a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including means for driving said conveyors at a variable ratio and variable speeds with a fixed ratio including a rotary motor common to said conveyors and at least one variable ratio drive between said motor and one of said conveyors.

15. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including means for driving said conveyors at a variable ratio including a rotary motor common to said conveyors and at least one variable ratio drive between said motor and one of said conveyors.

16. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including means for driving said conveyors at a variable ratio including a rotary motor common to said conveyors and at least one variable ratio drive between said motor and one of said conveyors, and means for determining said speed ratio and the speed of at least one of said conveyors.

17. Mixing apparatus comprising a material receiver, means for feeding material thereto from a plurality of sources including a variable speed conveyor associated with each source, and means for varying the speed ratio of the conveyors including means for driving said conveyors at a variable ratio including a rotary motor common to said conveyors and at least one variable ratio drive between said motor and one of said conveyors, and means for determining said speed ratio.

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