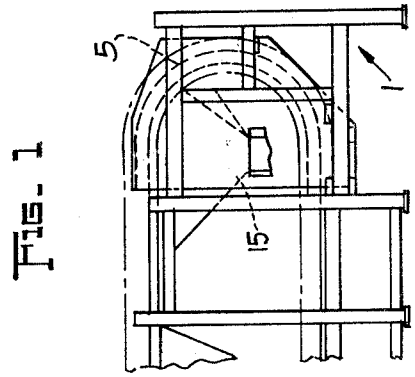
July 21, 1964 J. A. HANSEN 3,141,544

MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

Filed Jan. 12, 1962 5 Sheets-Sheet 1

FIG. 1



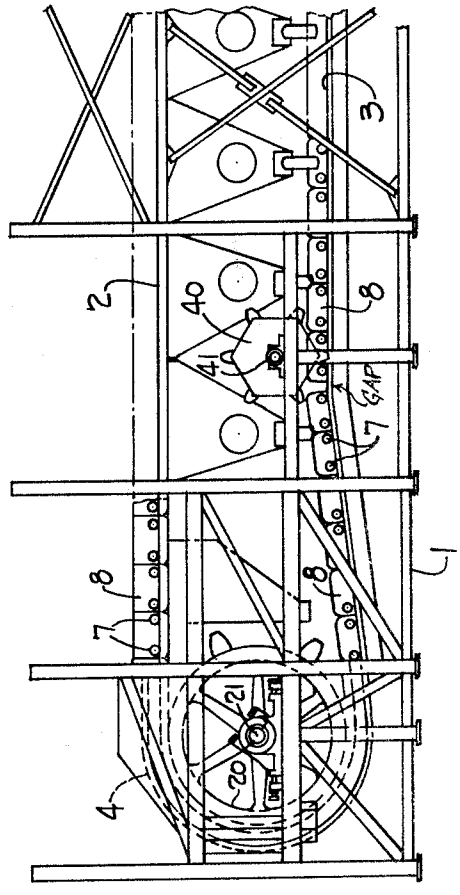
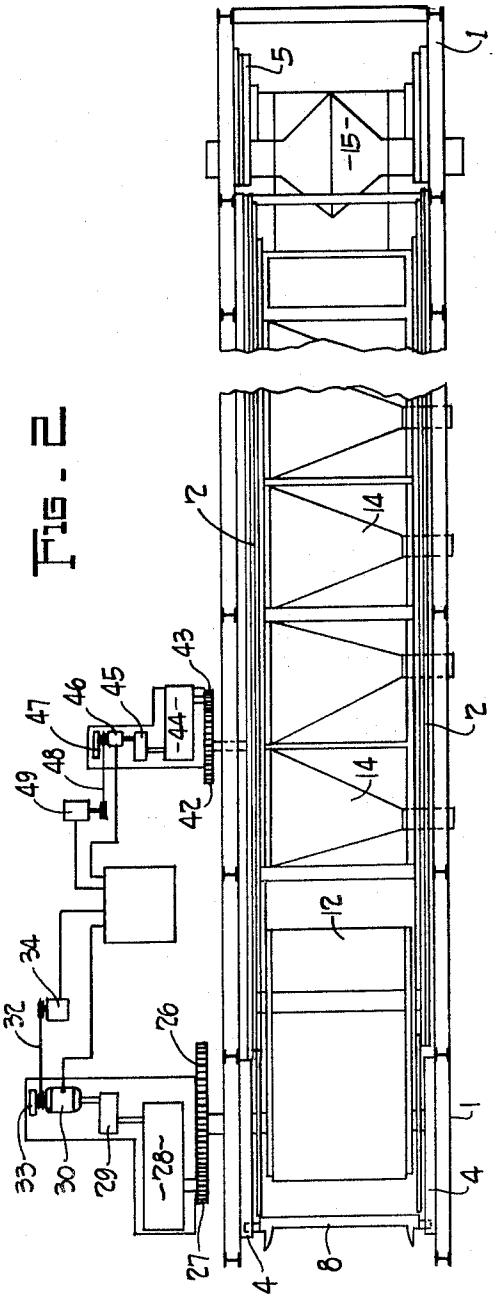


FIG. 2



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MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

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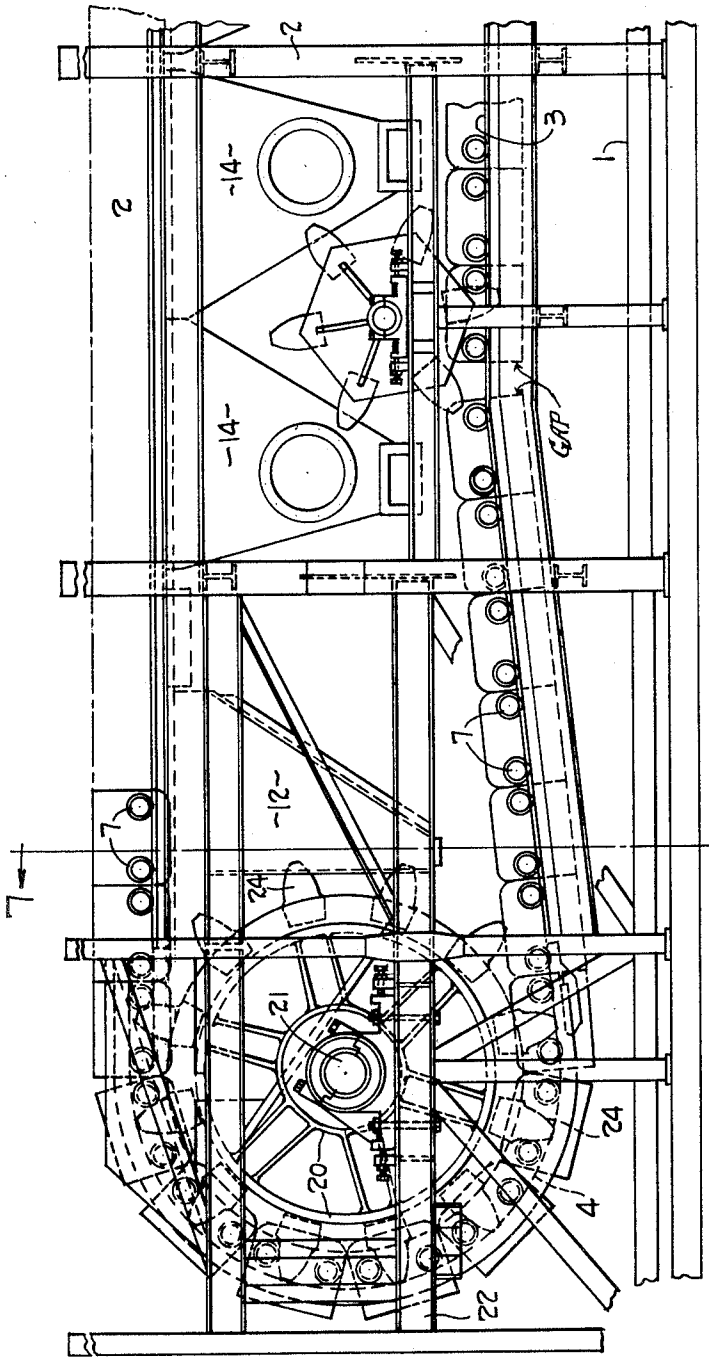

FIG. 5

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MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

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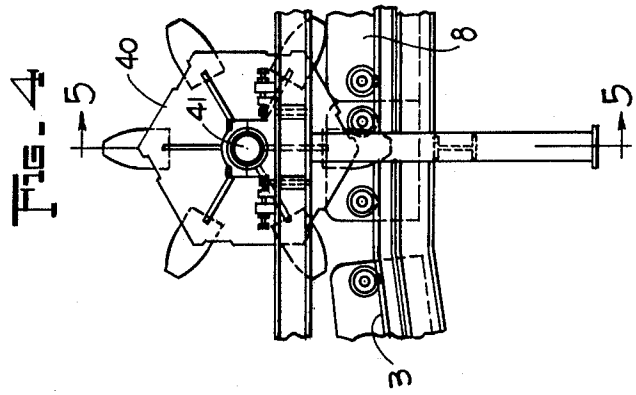
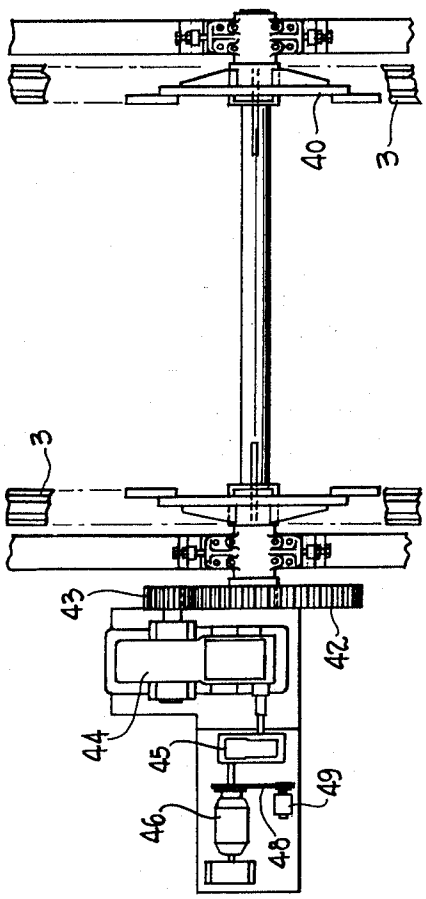


Fig. 4

Fig. 6



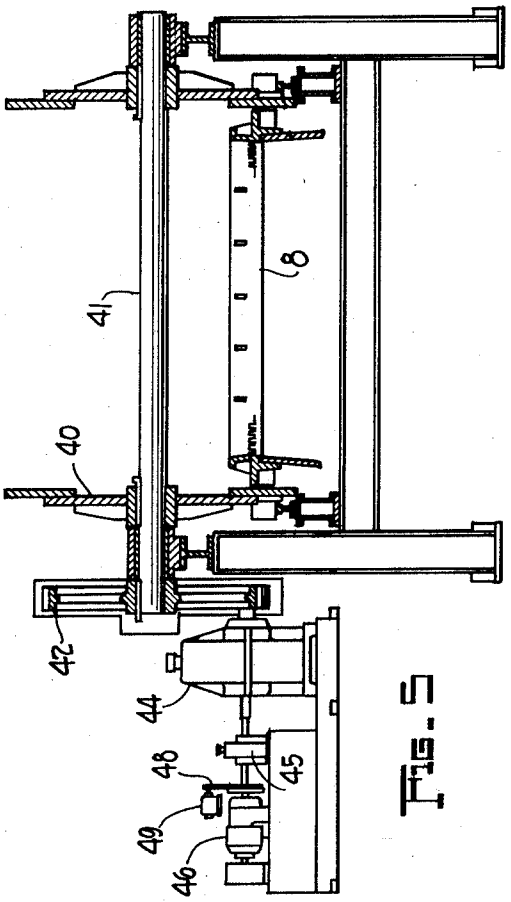


Fig. 5

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MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

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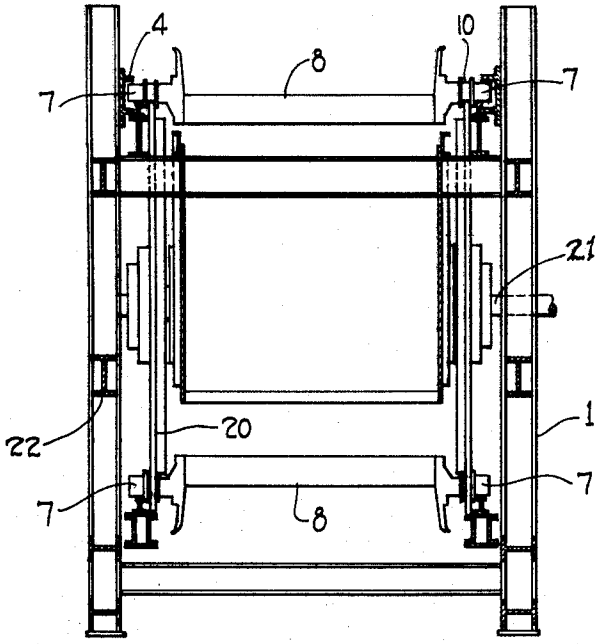
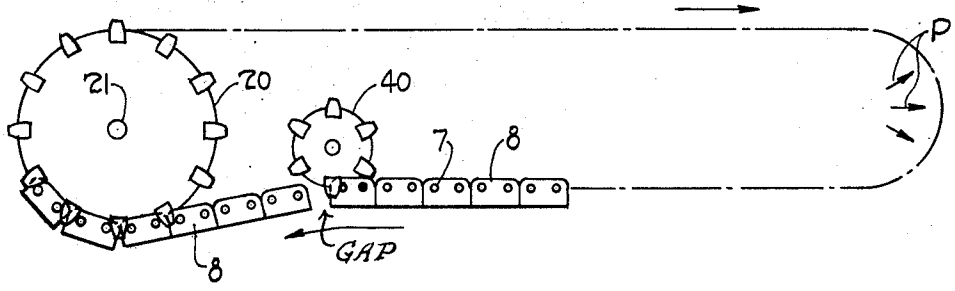


FIG. 7

FIG. 8



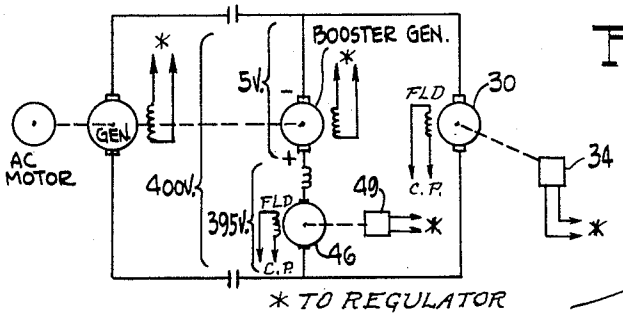


FIG. 10

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MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

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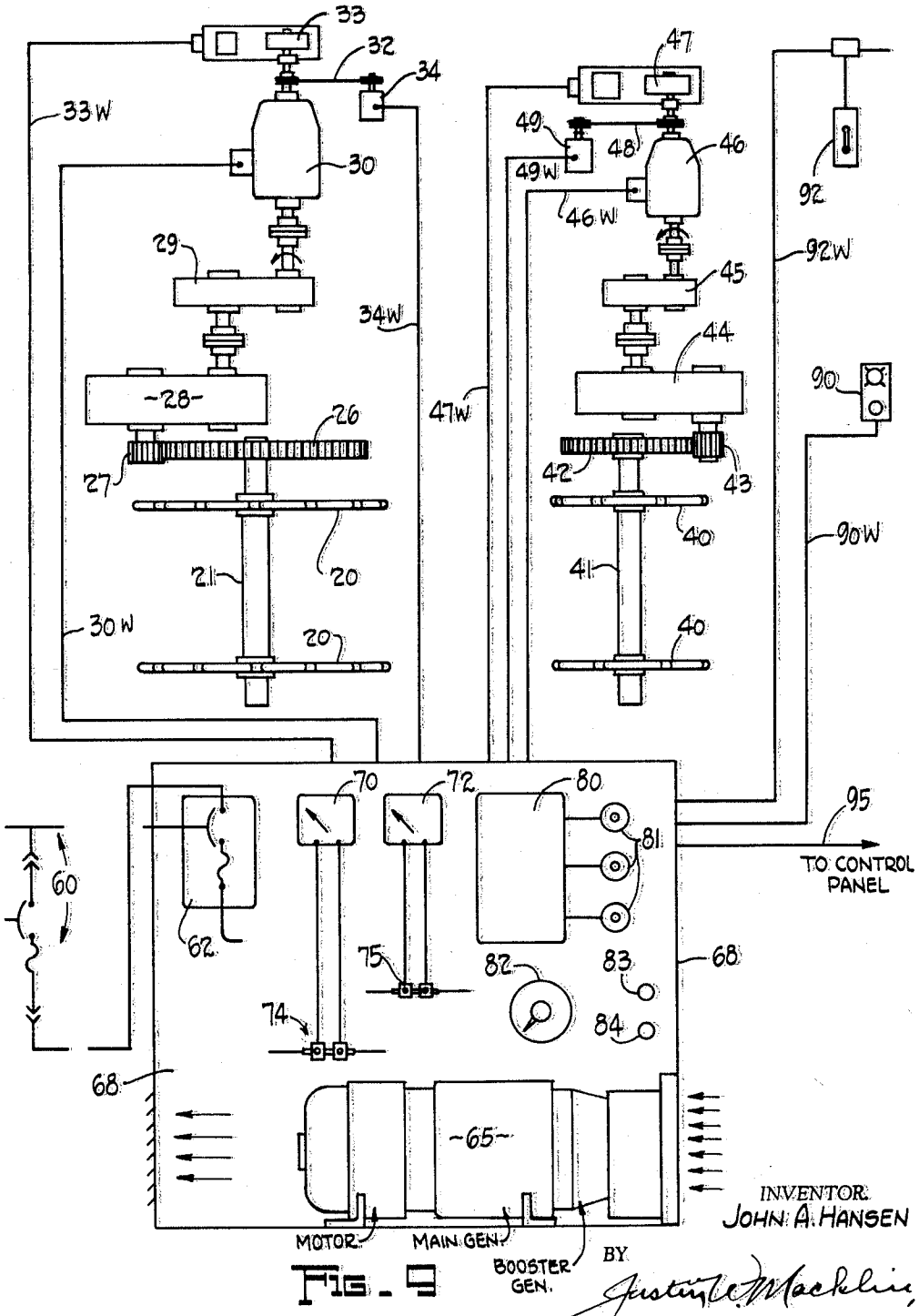

Fig. 9

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United States Patent Office 3,141,544 Patented July 21, 1964

3,141,544

MEANS FOR CONTROLLING THE MOVEMENT OF PALLETS ON A SINTERING MACHINE

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Filed Jan. 12, 1962, Ser. No. 165,838
7 Claims. (Cl. 198—203)

This invention relates to sintering machines of the general character known as the "Dwight-Lloyd" type of horizontal sintering machines in which a train of separate pallets are moved along a horizontal track in contact with each other. The movement is effected by sprocket wheels or equivalent means. The pallets pass from an upper horizontal reach around a curved raceway and onto a lower reach, along which they are moved to the feed end of the machine where they are lifted by the driving sprockets around a curved raceway to the feed end of the horizontal track portion.

The construction and operation of sintering machines of this general character are well understood. In the particular embodiment with which the present invention is concerned, the separate pallets are maintained in a continuous contacting train between the driving sprocket wheels and along the upper sintering reach or run and around the curved returning raceway where the dumping of the sintered material occurs. The continuous train from the driving sprocket and around the discharge return race may terminate between the return race and the drive means leaving a gap between the portion of the train of the discharged pallets and the pallets being lifted and moved upwardly to the upper reach, while remaining in contact and being moved by pushing the train. Thus, the train of contacting pallets is shorter than the total length of the closed circuit of the trackway, including the two curved race connecting portions of the trackway, namely, at the feed and driving end and at the dumping end.

If the train of contacting pallets is continuous in the closed circuit of the trackway, including the upper and lower reaches and connecting curved end races, thermal expansion of the pallets of the train and accumulation of material between the pallets. which is largely unavoidable particularly in continuous operation with certain materials, the forces exerted on the curved races at the ends of the trackways and the amount of expansion and elongation of the train of pallets may be damaging to the frame. Pressures on the wheels and axles of the pallets may create excessive binding action requiring additional power even if these forces are confined without damage.

Expansion gaps have sometimes been provided at the discharge or dumping end, allowing considerable free falling motion of successive pallets, each impinging against the pallet ahead with resulting destructive damage. The control of the amount of this gap requires a means for holding back the pallets moving downwardly around the discharge race, and obviously such means must be capable of being timed and synchronized with the driving means in order to maintain required registration of pallets with the driving sprockets.

Thus, an important object of the present invention is to control the continuous train of contacting pallets, maintaining them in contact, from the driving means along the upper sintering reach and around the curved return discharged race, in a manner to assure continuous effective operation while minimizing the difficulties and objectionable results heretofore encountered, and without adding appreciably to the power required for moving the pallets upwardly onto and along the sintering zone trackway.

Heretofore, a restraining means of some sort, such as

sprockets engaging the pallets and being controlled by mechanical brakes, have been employed to maintain a controlled small gap at the discharge end, that is, by holding a number of pallets in the end race against the tendency to fall freely around the same.

If the expansion gap is maintained in the lower reach, and the successful of the pallets is attained by merely passing the pallets around the discharge return raceway, this contact may be maintained by engaging the pallets below and beyond the return curved raceway. This, however, must be done in timed relation to the lifting and pushing sprockets at the other or feed end of the closed loop trackway.

Such a restraining or holding means is referred to as a pallet retarding device or mechanism, and the principal problem and object here presented is to permit continued uniform movement with a minimum of restraining force, while timing the release of the return pallets at and through a gap near the end of the train of contacting pallets being picked up, lifted and pushed along the upper reach by the driving mechanism.

An important object of the present invention is to provide such a pallet restraining or retarding mechanism which shall be driven at precisely the desired speed to release the pallets in exact timed relation to the continued rotation of the sprockets of the driving mechanism.

Obviously, if such a restraining means exerts more holding power than necessary, or if it is attempted to be mechanically directly connected as by chains, gearing, or the like to the driving mechanism, serious mechanical difficulties are encountered in meeting the requirement to compensate for the longitudinal expansion of the train of pallets. This expansion occurs between the shorter cold starting condition and the thermally expanded and lengthened condition, in addition to which accumulations between the ends of the pallets may effect a very substantial alteration of the length of the pallet train. This variation in length changes with conditions, and an ideal control contemplated by the present invention is to provide a pair of sprockets or like restraining means engaging the pallets returning from the discharge end, and which means is so connected with a speed control means for the driving mechanism as to continuously maintain exact synchronized timing relationship of the pallets released from the retarder sprockets to the contacting continuous train portion moving to the driving sprockets.

A more specific object of the present invention is to provide electric power driving mechanism for both the sprocket driving means and for the retarding sprocket means, which shall be so interconnected that the current power supply, and corresponding speeds, of the two driving mechanisms will be inter-related, and any variation in the driving speed will be transmitted through controls governing the driving means rotating the retarder sprockets to effect immediate corresponding speed change of the retarder sprockets.

More specific objects include the provision of known components of electrical apparatus for such drive and control means, and which, when in operation, shall be effective, durable and trouble-free, and capable of continued operation through the varying conditions which occur in the continuous train of contacting pallets.

As will become more clearly apparent from the following description, the purpose of the control between the two drive means is to assure maintaining a continuous strand or train of contacting pallets from the drive sprocket means over the upper reach, down through the curved discharge race, and along the return track rails to the retarder sprocket means, while avoiding the inherent and obvious dangers of excessive torques and pressures in the curved discharge race.

The control of the present invention functions to hold

back the lower strand of empty pallets and the pallets in the dumping curve, and its operation is the direct function of the top strand speed. In other words, the control is essentially a "speed match" from the main drive motor for and to the retarder drive motor.

In carrying out my invention, the control means functions to effectively maintain the contiguously contacting series of pallets around the upper and lower reaches and around both curved end races, while providing for expansion or elongation of the train, and thus eliminating or minimizing the strains, pressures and many other factors causing difficulty at the discharge end. In operation, the control functions for this purpose adding no appreciable amount of power required for the driving means, because the automatic quick response of the timing control relationship of the input power and main driving means effectively control the sped of the retarder sprocket driving means.

For example, in a very large sintering machine, the present novel driving control has been so regulated as to effectively limit the amount of end thrust at the discharge curve to a relatively nominal amount of a ton or less, whereas many thousands of pounds of pressure would otherwise be exerted longitudinally of the frame and in the raceways and on the pallets, greatly adding to the power required. It has been demonstrated in practice that only a minute portion of the load on the main drive motor is added to what is required to move the pallets along the upper reach, and then permit them to fall freely into and around the discharge race.

It is understood that the pallets above mentioned are the type usually provided with axles and wheels minimizing the friction as they move along the rails and curved races. These and other details, objects and advantages will become apparent in the following description of an illustrative type of sintering machine to which the pallet movement control of the present invention may be applied. The operation of the control means will likewise become apparent in the description relating to the accompanying drawings, in which:

FIG. 1 is a somewhat diagrammatic side elevation of a sintering machine, some parts being omitted for clarity, and showing main driving and retarding sprockets acting upon the pallets;

FIG. 2 is a plan view of the frame of the machine omitting the pallets on the upper reach, while diagrammatically showing the main and retarder drive mechanisms and illustrating the timing interconnections;

FIG. 3 is a somewhat enlarged, more detailed view of the driving and feeding end of the sintering machine, showing the driving and retarding sprockets, pallets, and prefered location of the expansion gap;

FIG. 4 is a fragmentary detail of the retarder sprocket engaging a pallet and illustrating the gap and portions of the rails;

FIG. 5 is a sectional view taken on a plane indicated by the line 5—5 of FIG. 4, showing the sprockets, driving gear and one of the inverted pallets in section, and illustrating the drive and controlling connections;

FIG. 6 is a plan view of the parts shown in FIG. 4, omitting the pallets and portions of the rails for clarity;

FIG. 7 is a transverse section through the frame showing the drive sprockets engaging the wheels of pallets, the plane of the section passing through a windbox and the position of the plane being indicated by the line 7—7 on FIG. 3.

FIG. 8 is a diagrammatic view illustrating the closed circuit of the trackway or pathway for the pallets, and showing the contacting pallets moving to the retarder sprocket and passing from the gap to the drive sprocket at the left;

FIG. 9 is a view showing the drives and controlling tachometers for the pallet driving sprockets and retarding sprockets and very diagrammatically indicating the

controlling connections governing and synchronizing the driving and retarding means; and

FIG. 10 is a small diagram showing the principal connections and relationships between the motor generator and booster generator set and connections indicating the manner in which the main motor and retarder motor field voltages are controlled to synchronize the speed of the main motor and retarder motor responsive to the respectively connected tachometer generators.

A sintering machine embodying my invention is in general of known construction having a suitable main supporting rigid frame 1. An endless track is suitably mounted upon this frame and comprises upper and lower reaches 2 and 3, respectively connected by return bend races 4 and 5 at the feed end and delivery end respectively of the track. These return bend races constitute channels having inner and outer flanges suitably spaced and facing toward each other and engaging the supporting rollers or wheels 7 of the pallets 8.

The pallets may be of any suitable well known construction and need not be here described except that as shown they comprise a rigid cross frame grate portion and retaining side walls laterally extending axles 10 for the wheels 7. Each pallet may be relatively narrow with relation to its length transversely of the machine, and two wheels 7 are provided at each end.

The material to be sintered is fed to and loaded into the pallets at the left hand end of the upper reach, hereinafter referred to as the feed end of the machine. The pallets are pushed in contacting position in a continuous train along the upper reach to the right hand end where they are turned outwardly and downwardly, discharging the sintered material in the usual way as they pass around this return race to the return track 3, along which the empty pallets move in continuous contact and in inverted position.

Windboxes are disposed beneath the upper run of the trackway and have their open upper ends in substantially air tight contact with the bottoms of the pallets as they move along the upper reach, whereby the sintering draft may be effected in a well known manner. One of said windowboxes adjacent the loading position is indicated at 12, and successive windboxes 14 are positioned along the upper reach and are connected with draft creating means. A hopper 15 adjacent the discharge end may have a cleaning and cooling suction applied thereto. As is well known, hoods may also be provided above the pallets for suction and draft control for carrying out various processes.

An important characteristic of such an arrangement, with which the present invention is primarily concerned, is that it includes an endless trackway, and the pallets thereon are moved in close contacting relationship forming a train which is shorter than the path formed by the upper and lower reaches of the track and its connecting returned end raceways. A gap in the train of pallets is thus provided, constituting an expansion space.

As above indicated, the pallets are positively driven as by a pair of sprockets to raise them from the return lower trackway around the return race at the feed end of the machine, and the portion of the train on the upper reach 2 is pushed along by power applied to these sprockets to the discharge end. Such sprockets and driving means may be of well known design. As shown, a pair of sprocket wheels 20 are keyed to a shaft 21 suitably journaled on horizontal members 22 rigid with the frame. The sprocket teeth 24 are spaced to engage the hubs of the wheels 7, preferably at the forward side of each pallet.

Rigid with the shaft 21 is a large driving "bull" gear 26 (FIGS. 2 and 7) which in turn is driven by a pinion 27 to which power is delivered from a gear reduction unit 28. The ratio of reduction required being very high, a primary reduction unit 29 is connected to the

unit 28 and in turn is driven by a suitable motor 30. As will later appear, this main drive motor is a direct current motor capable of very accurate speed control and which rotates at a selected speed such that the sprockets are driven at a rate to move the pallets a few feet per minute, for example, four to six feet per minute. The slightest change in the continuous rate of drive of the sprockets will result in effecting a change in control of the secondary or retarder drive.

Positively driven from the shaft of the motor 30 through a suitable sprocket chain 32 is a tachometer generator 34. A suitable solenoid brake for stopping and holding the main motor 30 is indicated at 33. The tachometer and motor speeds are controlled to carry out the objects of the present invention, as will hereinafter appear.

The retarding sprocket drive comprises a pair of sprocket wheels 40 rigidly mounted on a shaft 41 journaled to the frame and rigidly carrying a gear 42 meshing with the driving pinion 43, in turn driven by a speed reducer unit 44, driven by a smaller speed reducer unit 45 directly connected thereto, and which, in turn is driven by a direct current motor 46, also provided with a solenoid brake 47. The shaft of the retarder driving motor 46 is connected by a sprocket chain 48 on suitable sprockets to a second tachometer generator 49.

Referring particularly to FIG. 9, a suitable power supply indicated at 60 may, for example, be 440 volts, three phase, sixty cycle, leading to a circuit breaker in a cabinet 62 and thence to a power unit 65 comprising a main generator, the motor and a booster generator. This unit is shown as mounted within a pressurized housing 68 through which air is caused to pass, as indicated by the arrows at the lower portion of the rectangle indicating the housing. Dials 70 and 72 of ammeters are suitably connected with shunts 74 and 75, in turn connected with the drive motor and retarder motor circuits respectively. A regulator 80 may include potentiometers with controls at 81. A retarding force rheostat is indicated at 82, while 83 and 84 indicate controls for starting and stopping the motor generator set.

Leading from this motor generator set to the main drive motor 30 is indicated a conducting cable 30W. Similarly, a cable 33W leads to the solenoid brake 33 on the main motor shaft, while the tachometer generator 34 is connected with controls within the cabinet by a cable 34W. Connections 46W, 47W and 49W lead from the controls within the housing to the retarder motor 46 and its brake 47 and to the tachometer generator 49, respectively.

An "inch ready" and "inch retarder" control 90 is connected through 90W, while a plurality of emergency stop and reset controls may be used, one of which is indicated at 92. These are connected through a cable 92W with the controls within the housing 68. An operator's control panel, not shown, is suitably connected by cables 95. The controls at the operator's panel may include manual controls, indicators, signal lights, etc., all of which apparatus and equipment are well known.

Thus, as is apparent, the several functions and operations of such a sintering machine may be governed by suitable control apparatus, and these may include safety limit switches, emergency stops, push button stations and related components required for effective and safe operation of such a machine. However, the parts primarily here concerned are essentially the novel means for attaining the speed match between the main drive motor and the retarder drive, while moving the pallets in a contiguously contacting train along the upper and lower reaches and around both of the curved races, and while maintaining a safe gap in the train of pallets between the retarder sprockets and the main drive sprockets.

As may be apparent from FIG. 9, the motor and the main and booster generators have a common drive shaft. This is also indicated by the broken line on FIG. 10, leading from the A.C. motor to the generator and to the booster generator.

The wiring connections of FIG. 10 show the main power lines to the main drive motor 30. Connected across these lines and in parallel with the main motor are both the booster generator and the retarder motor connected in series, and, thus taken together, are in parallel with the main motor.

The fields of the generators and motors may be connected to the regulator and control circuitry in such a manner that any error signals from the tachometer generators will cause the retarder motor to respond to and follow any speed change of the main drive motor, however slight, and almost instantaneously.

Assuming, for example, 400 volts across the generator and main drive motor under a given condition of load, obviously while the main drive speed is being maintained, there would be no voltage on the booster generator, and the retarder motor would likewise be responding to 400 volts and normally would be running at the same pallet driving speed.

Now, if a friction change or load change slows down the main motor, the retarder motor would tend to continue at its same speed, which accordingly must be corrected by slowing it down correspondingly. The regulator circuitry would then produce a polarity on the field of the booster generator opposite that of the 400 volts applied across the retarder and booster generator. This would reduce the voltage across the retarder motor and slow it down. The brackets of FIG. 10 marked 5 v. and 395 v. indicate the normal maximum of such a change, that is, a reduction of five volts to the booster generator would reduce the 400 volts across the lines to 395 volts on the retarder motor 46.

The asterisks (*) appearing at the field indications of the main generator, booster generator and the two tachometers 34 and 49 of FIG. 10 are noted below the figure by the words "to regulator" to lead to the regulator circuitry. The field indications "FLD C. P." at the motors 30 and 46 lead to the control panel where the potential on them may be governed.

The tachometer generators 34 and 49 being directly driven from the shafts of the respective motors 30 and 46 will through the regulator circuitry immediately effect a corresponding change in the potential of the generator field, which, in turn, effects the output voltage of the generator plus the input voltage to the motors. If it is assumed that the main motor is slowed down as by an increase of friction on the chain of pallets, the retarder motor would tend to continue at the same speed unless this is corrected by correspondingly slowing it down. Now the regulator will produce a polarity on the field of the booster generator opposite or negative to the 400 volts applied across the booster generator and retarder motor. This reduction in voltage across the retarder motor results in slowing it down to a driving speed synchronized with that of the main drive motor.

Thus, assuming that the drive and movement of the pallets is normally steady and uniform, any forces effecting a variation of the speed of the retarder motor will be instantly corrected by the automatic regulator, and indeed so quickly that before the variation or error signal from the tachometer generator connected to the retarder motor has changed an amount of one-half of one percent relative to the speed of the tachometer generator on the main drive motor, correction starts and continues quickly until the speeds of the main drive motor and the retarder motor match exactly.

From the description, and having in mind the connections indicated in FIGS. 9 and 10, it will be apparent that the slightest variation in the speed of the tachometer generator of the retarder motor relative to the speed of the tachometer generator driven by the main motor will cause a signal current to transistors in the retarder regulator. This signal is greatly amplified by the transistors

and causes a change in the input voltage to the retarder motor to cause its speed to match that of the main drive motor exactly, and to maintain the predetermined and pre-set retarding torque desired.

The input voltage to the retarder motor, being varied relative to the main drive motor by its regulator and by the relatively small generator (FIGS. 9 and 10), adds or subtracts voltage, as required, to the armature terminals of the retarder motor. The armature of the booster generator is in series with the armature of the main generator, and, as indicated by the illustration above, the voltage at the retarder motor armature terminals is at all times the algebraic sum (i.e., plus or minus totals) of the voltage outputs of the main drive generator and the booster generator.

Illustrative speeds which have been used in practice are 1750 r.p.m. for the drive motor which effects five feet per minute pallet speed. The retarder motor preferably is so geared that 1750 r.p.m. corresponds to 4.9 feet per minute pallet speed. The controls are such that the one half of one percent differential in the r.p.m. of the drive motor and retarder motor may produce a full zero to one hundred percent change in torque of the retarder motor. The corrective action, however, occurs in but a small fraction of a second in time, and the resulting compression is but a small fraction of an inch. For example, a correction of error may so synchronize the motors that there would be but a few thousandths of an inch of shortening of the entire train of pallets.

Referring further to the illustration of the drawings, during normal operation the complete train of pallets, partly shown in FIG. 8, would be being pushed solidly and pressing against the sprockets of the retarder motor. Thus, the retarder motor cannot rotate slower than the main drive motor, because the moving pallets are forcing it to rotate at a matching speed. The regulator functions to prevent the retarder motor from ever quite "catching up" with or overtaking the main drive motor, and thus it acts to retard the pallets just the right amount to maintain the proper amount of pressure margin between the pallets at the discharge curve.

The mis-match of the normal driving speeds of the main drive and the retarder drive is important in assuring maintaining contiguity of the pallets in the train. It is particularly important in assuring closing any gap in the train of pallets behind the retarder, such as may be present around the curve when the sintering machine is being started up from cold condition, at which time a gap or gaps may be present in the train. By reason of the normally slower retarder driving speed, any undesirable gaps will be closed in the first few moments of operation.

As heretofore indicated, increase of pressure due to expansion or excessive retarding force would exert pressures on the discharge guide rails in directions indicated by the arrows P of the FIG. 8.

The control by inhibiting action of the potentiometer will tend to cause the retarder motor to run a little slower than the main drive motor. Thus, the push of the pallets forcing the retarder motor to rotate at the same speed as the main drive pallet speed causes the retarder motor to regenerate power back into the drive generator and produce retarding effect.

It will be seen that while the retarder acts to exert a constant retarding torque, this control is primarily a speed matching action.

Having thus described my invention, what I claim is:

1. A pallet moving and retarding means for a Dwight-Lloyd type of horizontal sintering machine in which a train of material carrying pallets are moved along a horizontal trackway in contact with each other and the pallets constitute a continuous train around a curved raceway and onto a lower reach of trackway and are then moved upwardly around a curved raceway to the feed end of the horizontal portion; and including

(*a*) main drive sprocket wheel means for raising the pallets while in contact upwardly around the curved raceway and for pushing the train along the upper horizontal raceway;

(*b*) the length of the train of contacting pallets being less than the length of the trackway whereby an expansion gap may be left between successive pallets as they pass a given point;

(*c*) a retarder sprocket adapted to engage successive pallets and resist movement of the pallets approaching the gap;

(*d*) electric driving and retarder motors for respectively driving the main drive sprocket wheel means and the retarder sprocket at predetermined speeds, the retarder sprocket being normally driven at a slightly slower speed by its motor, but at the same time being normally forced by movement of the pallets to maintain the speed corresponding to the movement of the main drive sprocket wheel means whereby a resisting hold-back pressure of a small fraction of the driving power of the main drive sprocket wheel means is maintained up to a controlled limit;

(*e*) tachometer generators positively driven with each of said driving and retarder motors; and

(*f*) means to control the voltage and, therefore, the speed of said retarder motor as a function of the speed of the main drive sprocket wheel means, said control means comprising a booster generator having a voltage output varying as a function of any speed differential between said tachometer generators, said retarder motor being responsive to the voltage output of said booster generator to cause immediate synchronizing of the retarder sprocket with the speed of the main drive sprocket wheel means consequent upon a change of speed of the main drive sprocket wheel means sensed by said tachometer generators.

2. The structure defined in claim 1 in which means are provided for causing pallets to move on the lower reach of the trackway from the expansion gap to the means for raising and pushing the pallets set forth in clause (*a*).

3. The apparatus and retarding means defined in claim 1 in which the lower reach of the trackway is sloped from the gap toward the main drive sprockets.

4. Means for driving and retarding a train of contacting material carrying pallets on a closed circuit trackway of a Dwight-Lloyd type of sintering machine; including

(*a*) means for mechanically engaging successive pallets and for pushing the train along an upper horizontal raceway;

(*b*) means for positively engaging successive pallets to retard the movement thereof to provide a gap in the train of pallets while maintaining contact of them at desired portions of the trackway;

(*c*) a tachometer generator connected with each of said pallet driving means;

(*d*) means responsive to any speed differential between said tachometer generators to supply sufficient power to one of the means set forth in clause (*a*) and (*b*) to cause said one means to attain a speed equal to that of the other means.

5. An apparatus for controlling the movement of pallets in a sintering machine in which a train of material carrying pallets are moved along a trackway in contact with each other and in which the contact is maintained by a retarding means, said apparatus including;

(*a*) a main drive sprocket wheel means for engaging successive pallets and for pushing the train;

(*b*) retarding sprocket wheel means for engaging the pallets;

(*c*) a motor driving the main sprocket wheel means;

(*d*) a motor driving the retarding sprocket wheel means;

(*e*) a main generator for supplying sufficient voltages to each of the motors to match the driving speeds of said motors;

(*f*) a booster generator unit for supplying voltage only to the motor driving the retarding sprocket wheel means, the total voltage supplied to the motor driving the retarding sprocket wheel means being the algebraic sum of the voltage output of the main generator and the booster generator;

(*g*) a tachometer generator driven by each of said motors; and

(*h*) means responsive to any speed differential between said tachometer generators to alternately add to and subtract from the voltage output of the booster generator to thereby vary its voltage output and correspondingly vary the voltage input of the retarder motor to cause a speed match between said motors as a function of voltage differentials between said tachometer generators.

6. A speed matching apparatus for a pallet driving means and pallet retarding means acting to move a train of contacting pallets of a sintering machine, said means including;

(*a*) tachometer generators each positively driven by one of said means and having equal voltage outputs for matched speeds of said driving means and said retarding means;

(*b*) a motor generator for supplying voltage to said pallet driving means and pallet retarding means to match their speeds; and

(*c*) means responsive to any voltage output differentials between said tachometer generators to add to and subtract from the voltage supplied to one of said pallet driving means and pallet retarding means to match the speeds of said driving and retarding means in response to speed differentials sensed by said tachometer generators.

7. The speed matching apparatus defined in claim 6 in which the pallet retarding means is positively driven while resisting to the amount of a small portion of the force exerted by the pallet driving means.

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