March 12, 1957 A. C. LANE 2,785,364

CENTRIFUGAL DRIVES

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Fig. 1.

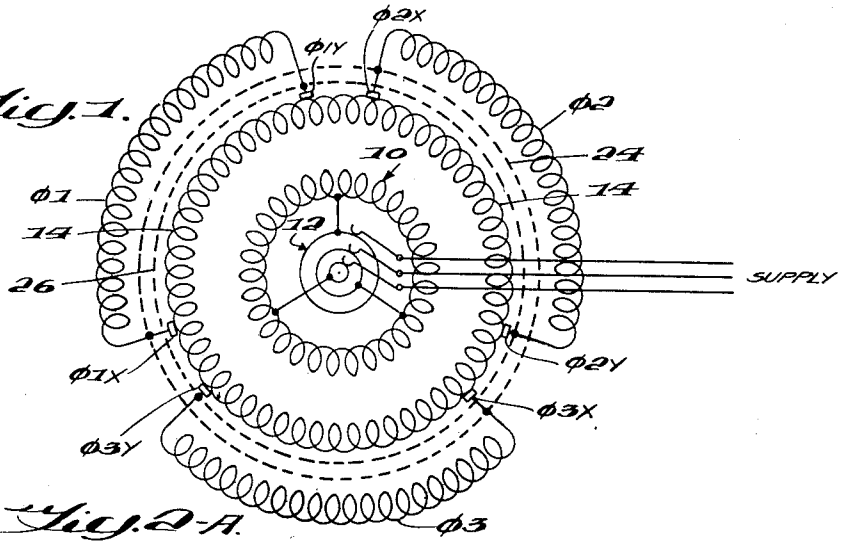


Fig. 2-A.

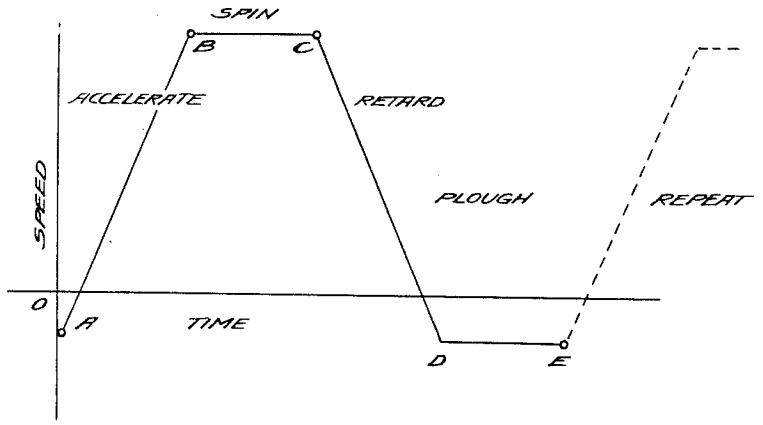
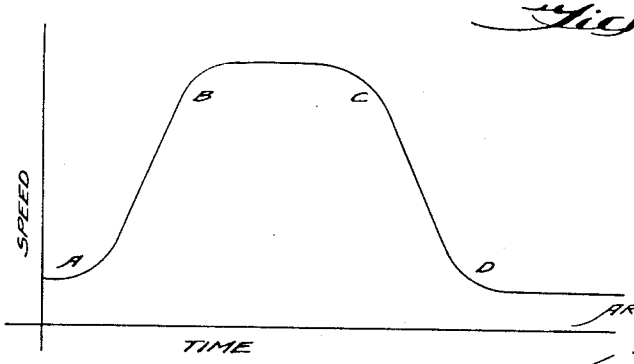


Fig. 2-B.



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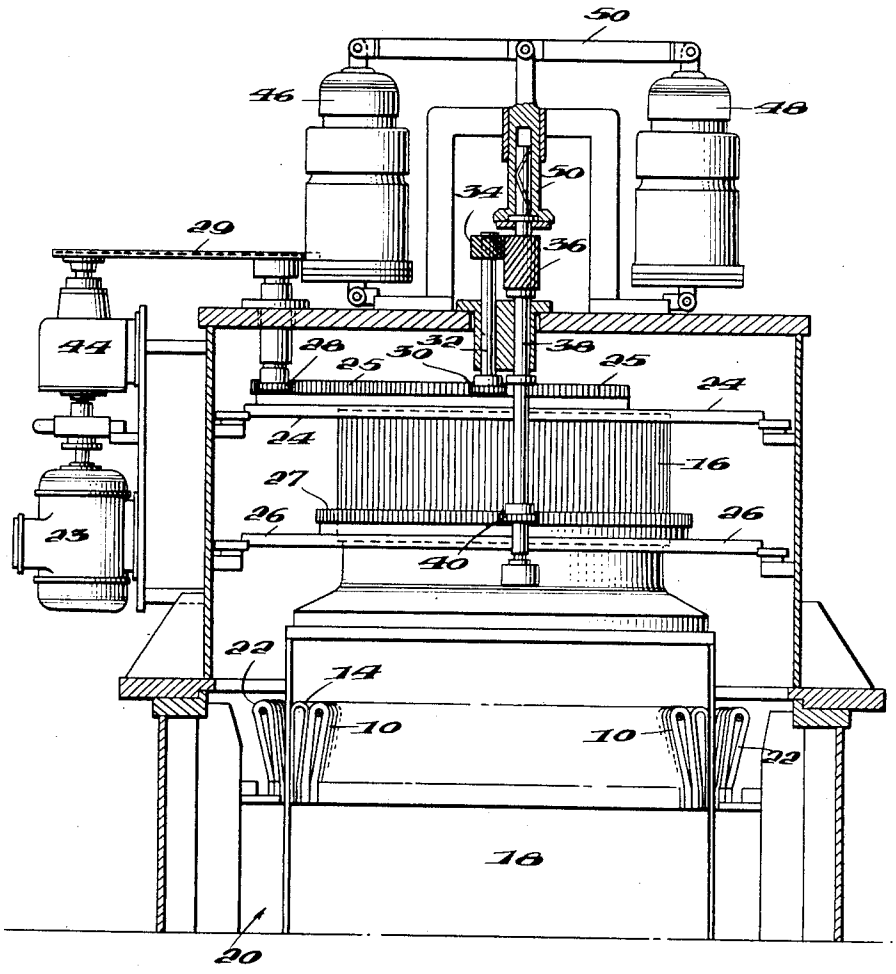
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Fig. 3.



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Fig. 7.

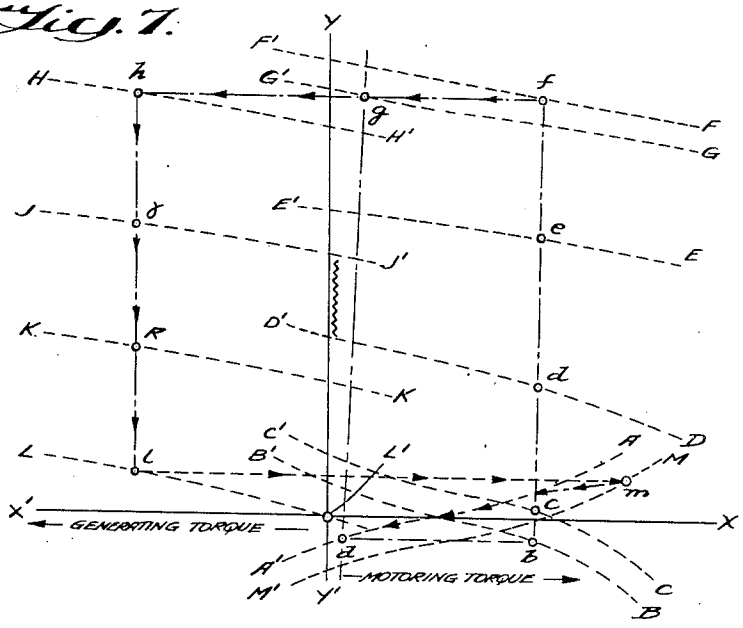
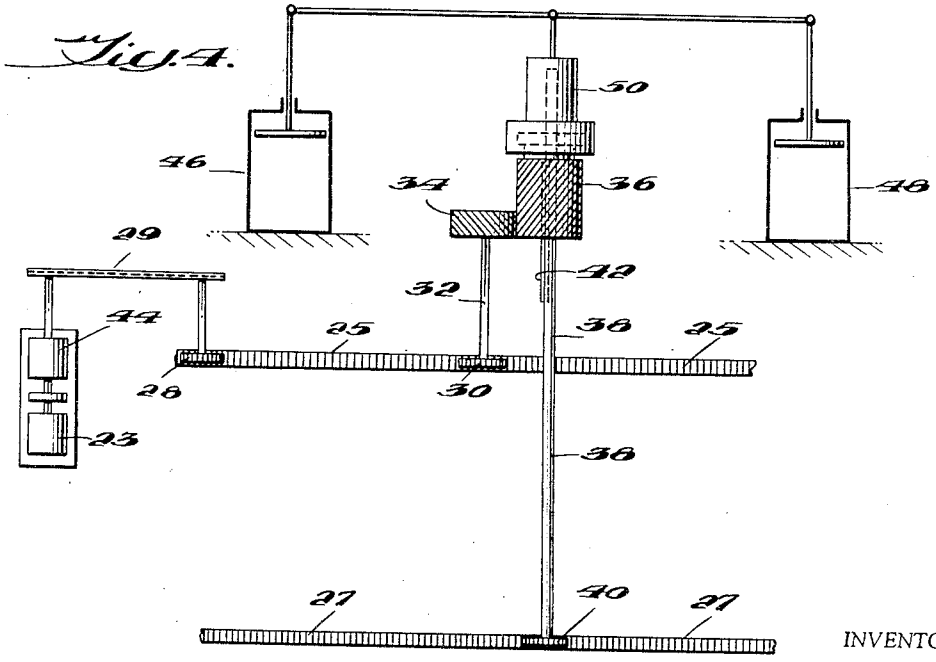


Fig. 4.



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Fig. 5.

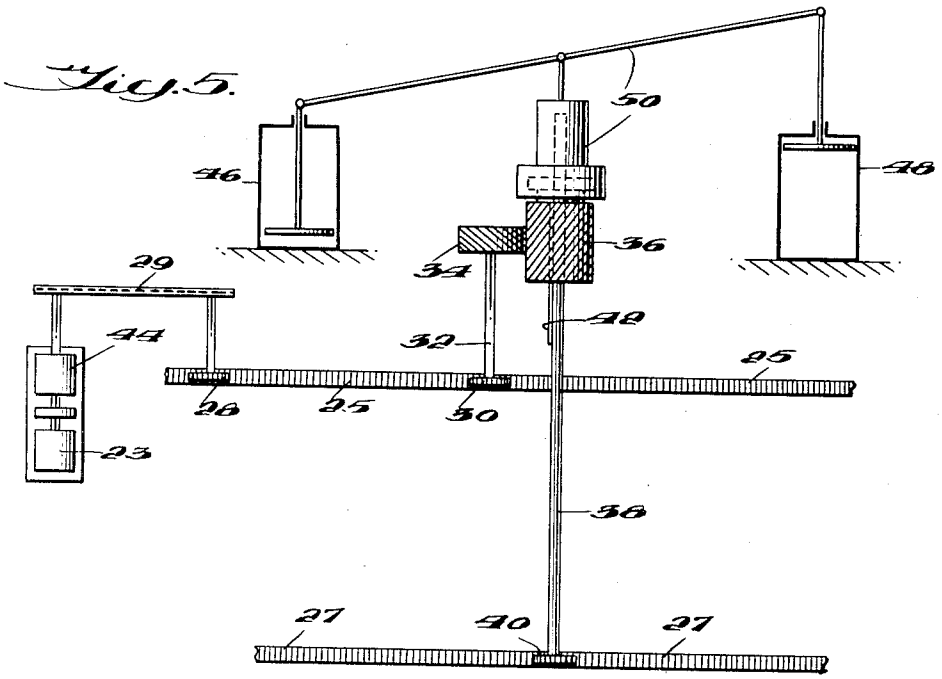
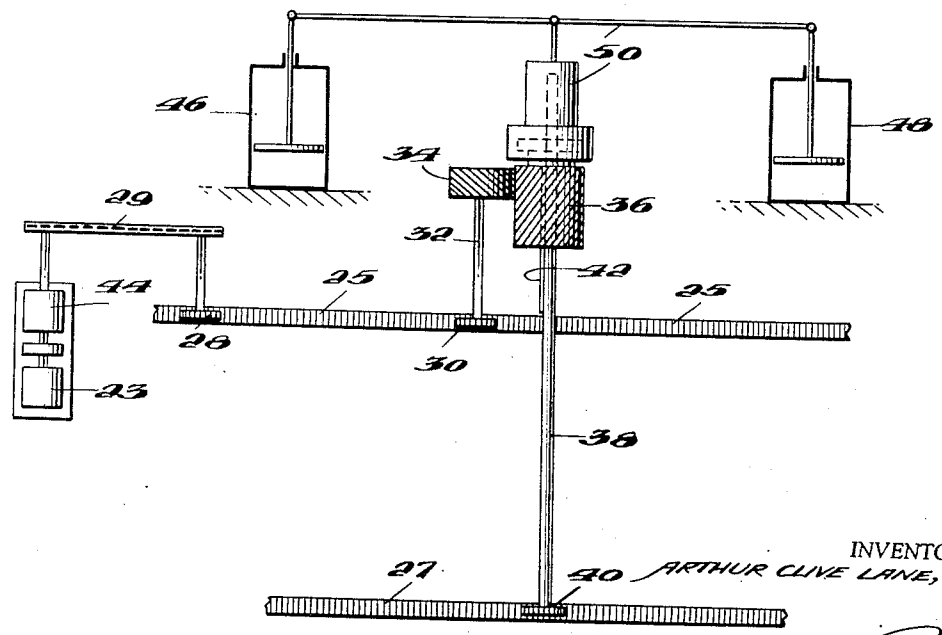


Fig. 6.



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2,785,364

CENTRIFUGAL DRIVES

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Application August 3, 1953, Serial No. 372,060

Claims priority, application Great Britain August 5, 1952

4 Claims. (Cl. 318—197)

This invention relates to the control of an alternating current motor of the Schrage type, particularly when used for driving centrifugals such as are used for sugar refining although applicable to other centrifugal devices. The object of this invention is to attain as closely as possible to the ideal speed-time cycle required for automatic operation with ploughing in the reverse direction for safety purposes and to achieve this type of cycle with minimum motor losses and without the necessity of employing a brake during normal operation.

This invention consists in the combined use of brush separation and brush adjustment of a Schrage motor controlled to effect a required cycle of operation efficiently. More particularly it consists in providing a pilot motor to move both brush rockers in opposite directions and actuators such as thrustors to move either brush rocker independently.

The invention will be better understood by reference to the accompanying drawings, in which:

Fig. 1 schematically illustrates the windings, brushes, brush rockers and slip rings of an alternating current motor of the Schrage type;

Fig. 2–A illustrates an ideal speed time cycle curve for a motor of the Schrage type used for driving centrifugal separating devices;

Fig. 2–B illustrates an operating cycle curve such as is obtained by conventional means for speed control of a Schrage type motor;

Fig. 3 is an elevational view, partly in cross section, disclosing my novel control means for adjusting the brush rockers of a Schrage type motor;

Figs. 4, 5 and 6 schematically disclose the brush rockers in different positions of adjustment resulting from the actuation of the control mechanism of Fig. 3, and

Fig. 7 illustrates the speed torque curves of a Schrage type motor employing the improved control means herein disclosed.

As is known in the art and diagrammatically indicated in Fig. 1, a Schrage motor is a polyphase alternating current commutator motor in which two sets or groups of movable brushes, i. e. $\phi 1X$, $\phi 2X$, $\phi 3X$, and $\phi 1Y$, $\phi 2Y$ and $\phi 3Y$ are provided for speed and power factor control. The brush groups are each connected to a separate rotatably mounted brush rocker as schematically represented in Fig. 1. These brush rockers 24 and 26 are shown in Fig. 3 and the racks 25 and 27 which cooperate with rockers 24 and 26 are shown in Figs. 4 to 6, inclusive, relative to the structural elements of the control mechanism.

The rotor 18, best shown in Fig. 3, carries a primary polyphase winding 10. This winding may be a three-phase primary winding, for instance as indicated in Fig. 1, which is supplied from a power source through slip rings 12. A regulating winding 14 having predetermined points connected to the segments of the commutator 16 is mounted on the rotor of the machine.

The stator 20 also carries phase windings $\phi 1$, $\phi 2$ and $\phi 3$ which are indicated in Fig. 3 by reference numeral 22

and the ends of each of these phase windings are connected to brushes of the two afore-described sets, $\phi 1X$, $\phi 2X$, $\phi 3X$ and $\phi 1Y$, $\phi 2Y$ and $\phi 3Y$, respectively, so that the brushes of each corresponding pair are connected across one of the phase windings of the stator. The distance apart of the brushes of each pair can be varied by speed control as will hereinafter be more fully discussed. If it is assumed that these brushes are on the same commutator segment, the stator windings are short-circuited and the motor runs like an ordinary induction motor with the difference only that the stator windings are short-circuited instead of the rotor windings as is customary. If the brushes are separated a voltage appears across the stator windings which is aiding the voltage induced by the rotor windings if the separation is in one direction and is opposing if the separation is in the other direction.

The present invention provides a convenient and improved arrangement of the brush control means so as to combine the above speed control with an additional control, which is known as forward or backward shift of the brush axis, as may be required for acceleration and deceleration periods with a view to attaining the object first mentioned.

Referring to Fig. 2–B, owing to the inherent characteristics of the motor as determined by its speed, torque and brush position relationships, the changes from bottom speed to top speed and vice versa take place by a gradual change of slope as indicated at points A, B, C and D. This is essentially so for two reasons, firstly that the inherent change of speed with brush position of a Schrage motor obeys the sine law, being greatest in the middle of the range and least at top and bottom ends of the range and secondly because of the very great inertia of the centrifugal load which hinders any sudden change of slope of the speed-time curve. By conventional brush movement also the motor characteristics required for the acceleration, for the retardation and for the spin and plough periods, cannot be equally realised. Quite different conditions of brush-shift from neutral are required in order that these three main operations may be efficiently performed.

Fig. 3 shows a constructional embodiment of the invention, as presently preferred. However, it will be understood that the main object of the invention is to provide a suitable means for the joint operation of brush separation and brush shift to produce a required cycle of operation with maximum efficiency. Therefore although the above description has been based on what is considered to be the most convenient design it is intended to cover the operation using alternatives which are mechanically or electrically equivalent, such as actuators other than thrustors for operating the brush shift, or couplings other than sliding helical pinions enabling both control of brush separation and brush axis shift either separately or simultaneously as may be required.

The brushgear operated by a pilot motor and thrustors according to this invention is shown in Figs. 3, 4, 5 and 6. Pilot motor 23 drives through chain 29 one brush controlling rocker 24 direct through pinion 28 and rack 25 which is secured to rocker 24. It drives the other brush supporting rocker 26 through pinion 30, spindle 32, intermeshing helical pinions 34 and 36, spindle 38, pinion 40 and rack 27. Reference numerals 28, 30 and 40 designate pinions which engage with racks 25 and 27 fixed to the two brush rockers 24 and 26, respectively. Reference numerals 34 and 36 designate helical pinions, 34 being fixed directly on to the spindle 32 which carries 30, while 36 is free to slide along the spindle 38 which carries pinion 40, but is keyed at 42 to spindle 38 so that 36 and 38 must always rotate together. The drive 23–28–25–30–34 is irreversible by reason of a reduction gear 44 be-

tween 23 and 28. It cannot be driven in the direction 34–30–25–28–23.

The two thrustors 46 and 48 operate by a link mechanism 50 on to the helical pinion 36, so that this pinion is able to be held in any of three positions as shown in Figs. 4, 5 and 6, depending upon whether both the thrustors are excited, only one thrustor excited or neither thrustor excited. Intermediate positions between those shown in Figs. 4 and 5 or between Figs. 5 and 6 may, of course, be allowed for by simple mechanical means if desired.

With the helical pinion 36 held in the neutral position as in Fig. 5 by reason of having only one thrustor excited, i. e. thrustor 48, it follows that the pitch circle diameters of the pinions 34 and 36 must be equal to one another and also that the pitch circle diameters of the pinions 28, 30 and 40 must be equal to one another, though not necessarily equal to that of 34 and 36. This ensures that any movement of the pilot motor 23 moves the two brush rockers 24 and 26 equally in opposite directions if it is required to maintain a neutral brush setting at any speed. However pinions 34 and 36 may be of different pitch circle diameters, and the pitch circles of 28, 30 and 40 may not be equal or again the racks 25 and 27 on brush rockers 24 and 26 may not be equal. Variations in these ratios may be altered at will if, for example, it is desired to give to the brushgear a progressive and uniform change of shift from neutral in relation to speed. This is very usual on Schrage motors where it is customary to set the brushgear more towards backward shift at low speeds and more towards forward shift at high speeds, for the modification of inherent neutral characteristics.

With the pilot motor 23 at rest and with the brushgear on neutral as in Fig. 5, if now both thrustors 46 and 48 are excited, the helical pinion 36 must rise as shown in Fig. 4. Since the train 34–30–25–28–23 is locked, the pinion 34 cannot rotate as 36 moves axially along spindle 32, so this axial sliding of 36 must be accompanied by a slight rotation of 36 relative to 34, i. e. a rotation of spindle 32 and also of pinion 40 and a corresponding movement of the racks 27 and rocker 26.

Similarly if both thrustors are switched off they must fall as shown in Fig. 6 and the pinion 36 must rotate a small amount in the opposite direction giving to rack 27 and also to rocker 26 a movement opposite to that caused by the thrustors rising.

The small movement of rocker 26 in one direction or the other about the neutral setting results in forward or backward shift of the brush axis, and its amount will depend upon the axial travel of 36 relative to 34 and to the angle of the helix of the meshing teeth of 34 and 36.

The pilot motor 23 and the thrustors 46 and 48 can be operated separately or together as required by the control scheme desired to be effected, so that at any time or at any point within the speed range the motor brushgear may be "on neutral," "with forward shift" or "with backward shift."

Thus it can be seen that the action of the thrustors can effect only the rack 27 and rocker 26 while the action of pilot motor 23 causes both rockers to rotate, since irrespective of the axial position of pinion 36 in relation to 34, if 34 rotates, 36 must also rotate.

Now referring to Fig. 2–A, the motor is required from B to C and from D to E to be on neutral brush setting. This is because the load is very light at these points, and neutral setting gives minimum losses under these conditions. From A to B the motor brushgear requires to have considerable backward shift in order to give minimum secondary current and maximum efficiency under conditions of heavy accelerating (motoring) torque. From C to D, the motor brushgear requires considerable forward shift in order to give minimum secondary current and maximum efficiency under conditions of heavy retarding (generating) torque.

The scheme of operations and the manner in which the desired cycle is obtained will be understood by reference to Fig. 7, which shows speed-torque curves of a Schrage motor. Speeds in the direction OY are forward speeds and those in direction OY′ reverse speeds. Torques in the direction OX are positive or motoring torques and those in direction OX′ negative or generating torques.

Curve AA′ is bottom speed neutral reverse
Curve BB′ is bottom speed neutral forward
Curves CC′, DD′, EE′, FF′ are four only of the infinite number of speed-torque curves with brushgear on backward shift, FF′ being that at maximum brush separation for high speed and CC′ that at maximum brush separation for bottom speed
Curve GG′ is the maximum speed on neutral
Curves HH′, JJ′, KK′, LL′ are four only of the infinite number of speed-torque curves with brushgear on forward shift, HH′ being that at maximum brush separation for top speed, and LL′ that at maximum brush separation for bottom speed
Curve MM′ is curve for maximum brush separation bottom speed in reverse with backward shift
(AA′ is a reflection of BB′ in the XCX′ axis; MM′ is a reflection of CC′ in the XCX′ axis)

The motor is now assumed to be running at point *a* on curve AA′, i. e., it is running at minimum speed in reverse or neutral, which is the desired condition for ploughing. When ploughing is finished and the next cycle of operations is to begin, the motor is plugged (reversal of primary switch). Curve BB′ therefore applies (forward, bottom speed, neutral). Motor is therefore running at *b* with a large motoring torque. There is then a large accelerating torque trying to reverse the motor up towards the direction B′. At the same time the thrustors are operated to put the brushgear on to backward shift at bottom speed (curve CC′), so motor accelerates through zero speed up the line *bc*. The pilot motor is set into operation to move both brush rockers and run up through the speed range with brushgear still on backward shift along line *cdef*. When brushgear reaches its maximum speed setting (curve FF′) the thrustors return brushgear to neutral (curve GG′), the speed maintaining itself at value determined by *fg*. The large accelerating torque has now disappeared and motor will run at *g* for the spinning operation as long as desired. At the end of the spinning period the thrustors operate to put the brushgear on to forward shift (curve HH′) so that the motor is now running at *h* with a large generating or retarding torque. The pilot motor now comes into operation to reduce the speed along the line *h, j, k, l*, until low speed brush position LL′ is reached (kinetic energy of the centrifugal being transformed into electrical power returned to the supply during this operation). When point *l* is reached the motor is plugged to curve MM′ so that a large motoring torque, represented by point *m* is applied, tending to accelerate the motor in a reverse direction towards M′. At the same time the thrustors restore the brushgear to neutral reverse (curve AA′) and motor runs through zero at point X up to point *a* where ploughing can now take place. This completes the cycle and it can be seen that the whole operation takes place under complete control, without the need for any mechanical brake, the essential principle being that reversing, accelerating and retarding torques are applied precisely when required and of a desirable value, by the joint operation of brush separation and brush shift.

The operation during the acceleration period known as "charging," i. e. filling the basket with massecuite, may take place while the motor is actually undergoing acceleration, or it may be desired to halt the acceleration temporarily at some such speed as 300 R. P. M. so that the charging takes place at a constant speed. As soon as the charging is complete the acceleration is resumed and the cycle completed as described.

Such a halt in the acceleration would be achieved by

simultaneously stopping the pilot motor and putting the brushgear into neutral by means of the thrustors at the instant that the desired charging speed were reached. The resumption of the cycle would be achieved by restarting the pilot motor and putting the brushgear into backward shift by the thrustors. In this way a sharp transition between acceleration and steady speed and between steady speed and further acceleration can be obtained.

The invention is not concerned only with centrifugals for sugar refining as it can be applied to other centrifugals, nor is it confined to the precise cycle of operation described. For instance, some sugar centrifugals do not need to go into reverse for ploughing, and the general scheme applies equally well in this case.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a brush shifting induction dynamoelectric machine of the Schrage type provided with a stator and a rotor, a primary winding on said rotor energized through slip rings, a commutator connected to a regulating winding positioned on the rotor of said machine and having the ends of each one of a plurality of independent secondary phase windings on said stator connected to a pair of brushes which coact with said commutator, a first rotatably mounted brush rocker carrying a first brush group comprising one brush of each pair, a second rotatably mounted brush rocker carrying a second brush group comprising the other brush of each pair, the combination, comprising, an interconnecting drive mechanism for said first and second brush rockers for angularly adjusting the

position of said brush groups about said commutator, said interconnecting drive mechanism comprising two intermeshing helical gears mounted for relative axial displacement on separate shafts which are connected to rotate in unison with said first and second brush rockers respectively, a separate drive independently connected to one of said brush rockers by which said one rocker is directly rotatably driven and said other rocker is indirectly rotatably driven through said interconnecting drive mechanism, and separate power means connected to one of said intermeshing helical gears for axially moving said gear relative to the other to effect angular displacement of said shafts upon which said gears are mounted and of the respective brush groups of said first and second rockers.

2. The dynamoelectric machine as defined in claim 1 wherein the separate drive comprises an electric motor.

3. A dynamoelectric machine as defined in claim 1 wherein the separate power means for axially moving said helical gear comprises hydraulic mechanism.

4. A dynamoelectric machine as defined in claim 1 wherein the separate power means for axially moving said helical gear comprises two thrustors connected by linkage means to the axially movable helical gear.

References Cited in the file of this patent

UNITED STATES PATENTS

1,590,030 Hull ---------- June 27, 1926