

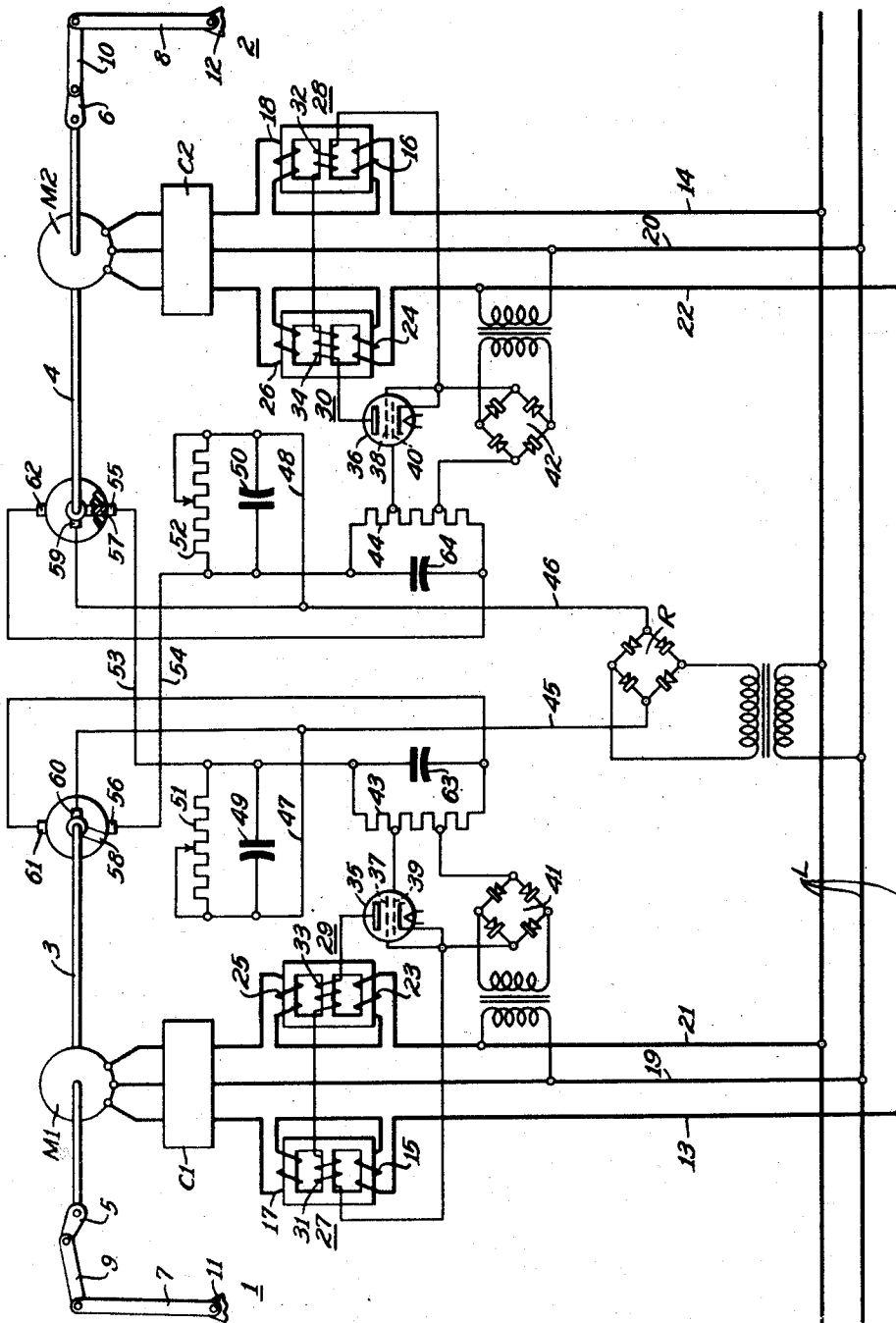
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E. B. ANKENMAN ET AL

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SPEED CONTROL SYSTEM FOR MOTORS

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WITNESSES:

Robert Chaired
Wm. G. Grouse

INVENTORS

Earl B. Ankenman and
Clare E. Center.

BY

Paul E. Friedemann
ATTORNEY

UNITED STATES PATENT OFFICE

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SPEED CONTROL SYSTEM FOR MOTORS

Earl B. Ankenman, Olathe, Kans., and Clare E. Center, Reading, Mass., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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Our invention relates to motor control systems, and more particularly to systems of control for correlating the operation of two or more motors.

In many fields of industry electric motors operate loads that have the characteristic of a greatly unbalanced flywheel. This is especially true in the weaving industry. Usually a large number of looms are mounted on a single floor and each loom is operated by its own motor. If all the looms, or a great number of them, happen to get in step, as happens from time to time, then the sum of all the unbalanced flywheel type of loads is transmitted to the floor with the result that the building begins to vibrate. Usually buildings are not designed for such effects. Structural deterioration thus results.

One broad object of our invention is to so correlate the operation of a plurality of motors, operating loads of the unbalanced flywheel type, that large vibrating stresses are not transmitted to the building.

A more specific object of our invention is to correlate the operation of a plurality of motors disposed on a single floor of a building into pairs such that the two motors comprising each pair are operated sufficiently out-of-phase to effect the balancing of the respective unbalanced loads in twos.

A somewhat broader object of our invention is the provision of so operating two electric motors each driving an unbalanced load that the unbalanced load operated by one motor is always out-of-phase by a selected value with the unbalanced load operated by the other motor.

A somewhat specific object of our invention is the provision of electronic control means so interconnected with two motors, each operating an unbalanced load, that the relative speed of the motors is so controlled by said electronic control means that corresponding points on the motor shaft are maintained out-of-phase by a selected phase angle.

Other objects and advantages will become more apparent from a study of this specification and the accompanying drawing, in which the single figure is a diagrammatic showing of our invention.

In the figure two looms, 1 and 2, are illustrated graphically. Loom 1 has a crankshaft 3 and a crank arm 5. The crank arm 5 is connected to lever 7 of the lay by the link 9. The lever 7 of the lay is pivoted at 11. A motor M1 rotates the crankshaft 3 through a suitable reduction gear, not shown, so as to oscillate the lever 7 back and forth. At normal speeds, the operation is such that the lay makes anywhere from 120 to 55

200 complete cycles per minute, depending on the speed selected for the motor M1. Since the lay weighs a considerable amount, an appreciable vibratory force is set up in the floor supporting the loom. For various reasons it is not feasible to individually counterbalance this crankshaft and load.

In the figure, 2 represents a second loom. This second loom is similar to the first and has the crankshaft 4, crank arm 6, link 10, and the lay lever 8 pivoted at 12. The motor M2 operates this second loom. Normally the loom loads are about the same. The looms are driven by individual motors of the same frame size and capacity and are usually adjusted to operate at the same speed.

If a considerable number of looms or, as may sometimes happen, all of the looms on the same floor happen to get into step, the total force transmitted to the supports becomes great enough to set up harmful vibrations of the building. One of the purposes of our invention is thus to operate the looms in pairs, and to operate each pair such that the crankshaft of one loom is always out-of-phase with the crankshaft of the other. The out-of-phase relation may be such that the crankshaft of one loom is from 160° to 200° behind the crankshaft of the other. To break up the unbalance effects of the picker sticks, the extreme values are preferable. In this manner the forces of the two looms that operate as a pair neutralize each other. It thus makes little difference how the pairs operate with respect to each other since no concentrated force will be transmitted to the building floor. How we accomplish the correlated operation will become more apparent from the detailed description given hereinafter.

The starting and stopping of any two looms that are correlated, that is, combined during normal operation of our control, need not be inter-related. If loom 1 is to be started controller C1 is actuated whereupon motor M1 is energized from the leads L through conductor 13, alternating current coils 15 and 17 to controller C1, lead 19, and lead 21, alternating current coils 23 and 25 to controller C1.

If the loom 2 is to be started, the controller C2 is actuated whereupon circuits for the motor M2 are established from buses L through lead 14, alternating current coils 16 and 18, lead 20 and lead 22 and the alternating current coils 24 and 26.

In the absence of our system of control presently to be described, the operation of the two

motors M1 and M2 would be in accordance with the prior art.

If the assumption is that the two motors M1 and M2 are running at the same speed and are out-of-phase the desired amount, as for example 180° out-of-phase and then one motor, as for example motor M1, begins to operate at a slightly higher speed than motor M2, the motor M1 will begin to lead motor M2 by slightly more than 180°. To provide means for varying the relative speeds of the motors and hence to introduce a control to keep the driven machines within the selected time phase, impedances may be used in the supply circuits of the two motors and the impedance values be so controlled that the leading motor is slowed down sufficiently to bring the driven loads back to the time phase selected.

In the figure, we show saturable reactors 27 and 29 in two of the phases of motor M1 and saturable reactors 28 and 30 in two of the phases of motor M2. The amount of regulation needed and the characteristics of the driven machines will dictate the kind, amount, and numbers of impedances required. Further, it is not essential that the impedances be saturable reactors. With suitable control modifications the impedances may be booster transformers, resistors, or capacitors.

Either motor M1 or motor M2 can be slowed down within the range of the regulating equipment depending on which motor tends to run ahead. By inserting more impedance in the supply circuit of the leading motor this motor is brought back to a speed that the desired phase relation of the motors is maintained.

The saturable reactors 27 and 29 are provided respectively, with the secondary windings 31 and 33 connected in series with the anode-cathode circuit of the gas-filled discharge tube 35. The grids 37 and 39 are connected to the source of direct current 41 through the resistor 43. The bias provided for each of the grids 37 and 39 in relation to the anode and cathode of the tube 35 is such that as long as the voltage across the connecting junctions on resistor 43 does not alter the tube 35 fires at each cycle and thus acts as a continually operating single-phase rectifier. The output of the tube 35 is so selected that coils 31 and 33 are fully energized to completely saturate the reactors 27 and 29. The impedance in series with the motor M1 is thus a minimum and motor M1 operates at full speed.

The saturable reactors 28 and 30 are provided respectively, with the secondary windings 32 and 34 connected in series with the anode-cathode circuit of the gas filled discharge tube 36. The grids 38 and 40 are connected to the source of direct current 42 through the resistor 44. The bias provided for each of the grids 38 and 40 in relation to the anode and cathode of the tube 36 is such that as long as the voltage across the connecting junctions on resistor 44 does not alter, the tube 36 fires at each cycle and thus acts as a continually operating single-phase rectifier. The output of tube 36 is so selected that coils 32 and 34 are fully energized to thus completely saturate the reactors 28 and 30. The impedance in series with motor M2 is thus a minimum and motor M2 operates at full speed.

Crankshaft 3 is provided with a disc of insulating material having a conducting segment 58 energized from a source of direct current R.

Crankshaft 4 is provided with a disc of insulating material having a conducting segment 57 also energized from the source of direct current, evidenced by the rectifier R.

One circuit may be traced from the positive terminal of the rectifier R (the source of direct current) through conductors 45 and 47, the capacitor 49 connected in parallel to the discharge resistor 51, conductor 53, brush 55, conducting segment 57, brush 59, and conductor 46 to the negative terminal of the rectifier R.

Another circuit may be traced from the positive terminal of the rectifier R through conductor 45, brush 60, segment 58, brush 56, conductor 54, capacitor 50 connected in parallel with discharge resistor 52, and conductors 48 and 46 to the negative terminal of the rectifier.

The two circuits above discussed are energized at the same instant when the two looms are operating at the exact out-of-phase relation selected.

Resistors 51 and 52 are so chosen and so adjusted that the capacitors become completely discharged exactly at the end of one-half revolution of the shafts 3 and 4.

If motor M1 is leading by more than the out-of-phase angle selected, then the impedance of the reactors 27 and 29 must be increased to decrease the supply voltage just enough to slow down motor M1 sufficiently to bring the two machines back in the desired out-of-phase relation. This condition is indicated in the figure.

Since the charging of capacitor 49 is governed by the disc on shaft 4 but its time of discharge by the position of the disc on shaft 3, it is apparent that we have a measure of the out-of-phase conditions of the shafts.

From the figure, it will be noted that segment 58, since it leads segment 57, need make less than a half revolution to make contact with brush 61.

When segment 58 makes contact with brush 61 the capacitor 49 is still partially charged and thus completes its discharge from the left-hand capacitor terminal through conductors 47 and 45, brush 60, segment 58, brush 61, capacitor 63 connected in parallel with resistor 43 to the right-hand terminal of the capacitor 49. The bias of grid 39 is thus so changed that tube 35 goes out. The direct current in coils 31 and 33 ceases with the result that the reactance in the supply circuit for motor M1 is increased.

Motor M1 thus decreases in speed and such decrease is a function of the angle of lead in excess of the adjusted angle of lead or out-of-phase relation of motor M1 with respect to motor M2.

When motor M2 is leading by more than the desired lead angle, the capacitor 50 discharges through the circuit from the left-hand terminal of the capacitor 50 through conductor 54, capacitor 64 connected in parallel with resistor 44, brush 62, segment 57, brush 59, and conductors 46 and 48 to the other terminal of capacitor 50. The tube 36 thus becomes non-conducting and motor M2 is slowed down.

In either case, regardless of which motor is ahead, the length of time the respective tubes 35 and 36 are made non-conducting is always a function of the angular amount of lead of the leading motor.

While we have described but one embodiment, we do not wish to be limited to the single embodiment but wish to be limited only by the scope of the claims hereto appended.

We claim as our invention:

1. In a system of control, in combination, control circuits, a motor operating an unbalanced load, a second motor operating a similar unbalanced load, switching means operatively related with the output shaft of one motor for clos-

ing and opening contacts as a function of the angular position of the shaft, switching means operatively related with the output shaft of the other motor for closing and opening contacts as a function of the angular position of the second shaft, said switching means being so related to their respective output shafts that said control circuits are energized when the shafts are in a selected out-of-phase relation, a saturable reactor in each of the supply circuits for the motors, said reactors being normally saturated by the energization of said control circuits, and means responsive to the operation of said switching means for deenergizing a portion of said control circuits in response to a departure of the desired out-of-phase relation of the shafts for unsaturating the reactor in the supply circuit of the motor driving its load in advance of the desired out-of-phase relation.

2. In a system of control, in combination, a motor operating an unbalanced load, a saturable reactor in the supply circuit of the motor, electronic means interconnected with the supply circuit and said saturable reactor to normally energize said reactor to saturation, a second motor operating an unbalanced load, a saturable reactor in the supply circuit of the second motor, electronic means interconnected with the supply circuit and said saturable reactor to normally energize said saturable reactor to saturation, and means for momentarily effecting the deenergization of the electronic means interconnected with the saturable reactor in the supply circuit of the motor operating its load in advance of the selected relative position of the loads operated by the motors.

3. In a system of control for a pair of electric motors, in combination, an electric motor, a supply circuit for the motor, a saturable reactor in the supply circuit, electronic means for maintaining said reactor saturated, a second electric motor, a supply circuit for the second motor, a saturable reactor in the supply circuit of the second motor, second electronic means for maintaining said second reactor saturated, two switching means one operable by each of said motors, and means responsive to the asynchronous operation of said two switching means for effecting the deenergization of the electronic means controlling the saturable reactor in the supply circuit of the motor with the higher speed.

4. In a system of control for a pair of electric motors, in combination, an electric motor, a supply circuit for the motor, a variable impedance in circuit relation with the motor and the supply circuit, means for altering the impedance value of the variable impedance, a second electric motor, a supply circuit for the second electric motor, a variable impedance in circuit relation with the second motor and supply circuit, second means for altering the impedance value of the second variable impedance, two switching means one operable by each of said motors, means operable by the asynchronous operation of said switching means for selectively affecting the operation of the particular means for altering the impedance value of the variable impedance of the motor with the higher speed.

5. In a system of control for a pair of electric motors, in combination, an electric motor, a second electric motor, supply terminals including circuit connections and a variable impedance in circuit relation with each of said motors for effecting speed changes of each of said motors, electronic means for normally maintaining the impedance value of one variable impedance at a constant value to cause the motor, with which the impedance is connected, to operate at substantially constant speed, second electronic means for normally maintaining the impedance value of the other variable impedance at a constant value to thus maintain the second motor at substantially constant speed, two switching means one operable by each of said motors, and means responsive to the asynchronous operation of said two switching means for effecting the deenergization of the electronic means controlling the impedance in the circuit with the motor having the higher speed.

EARL B. ANKENMAN.
CLARE E. CENTER.

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