May 13, 1924. 1,493,968

R. W. DAVIS

SYSTEM OF DISTRIBUTION

Filed Nov. 15, 1920 2 Sheets-Sheet 1

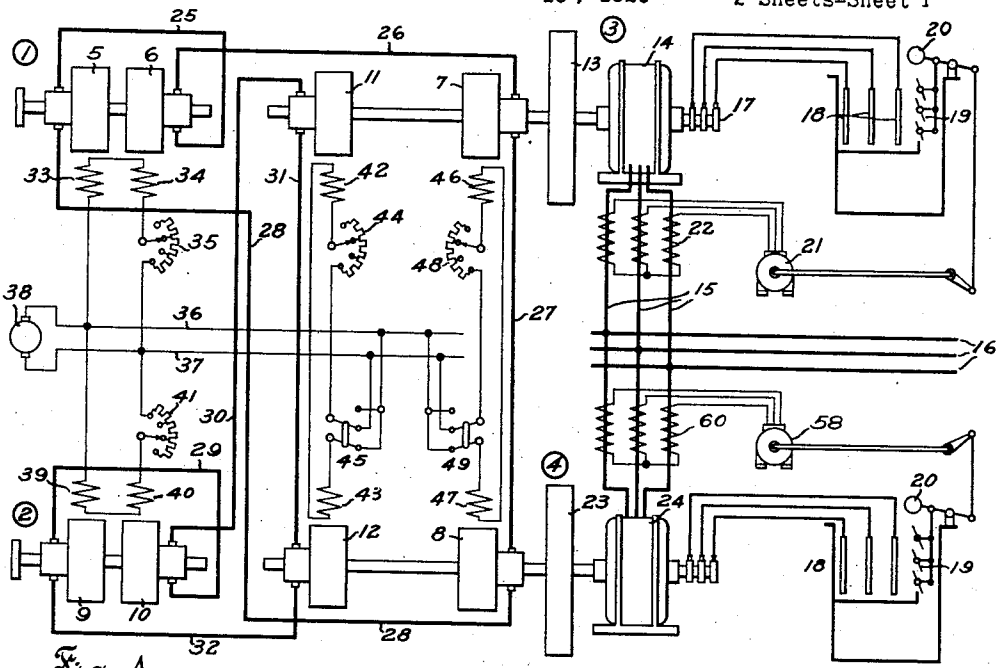


Fig. 1

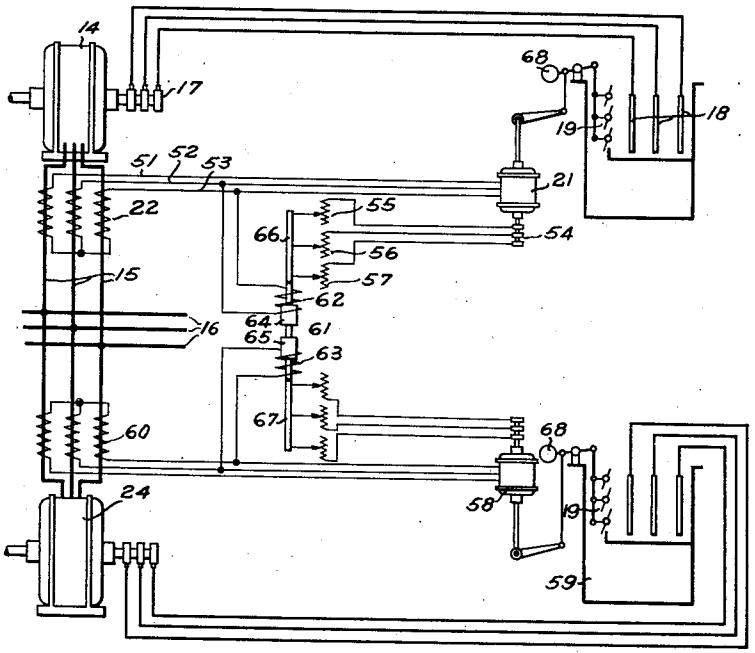


Fig. 2

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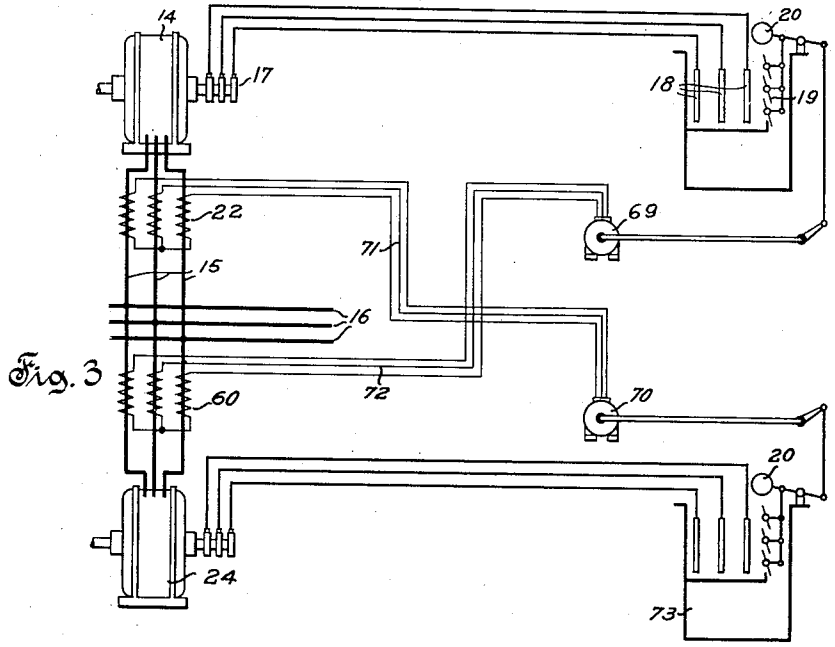


Fig. 3

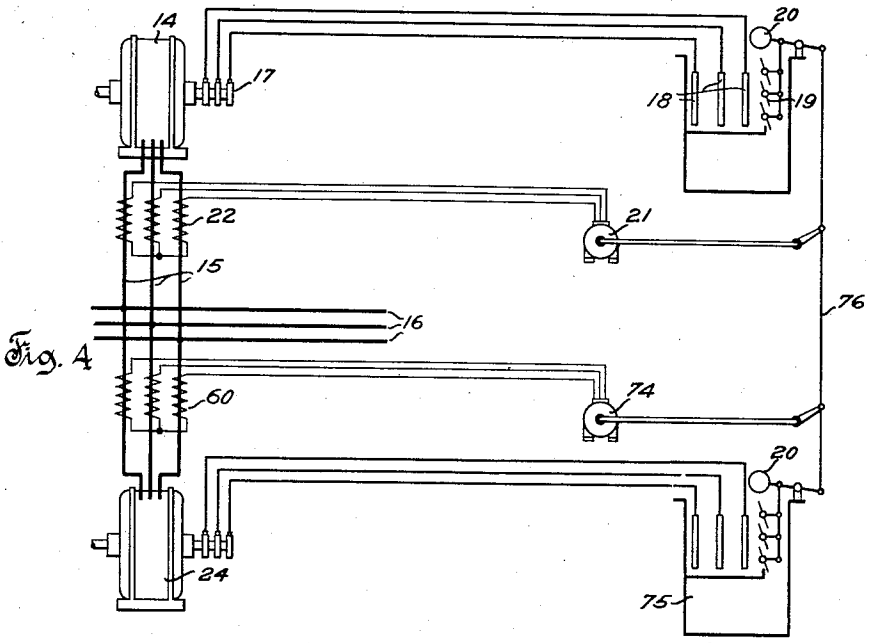


Fig. 4

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UNITED STATES PATENT OFFICE.

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SYSTEM OF DISTRIBUTION.

Application filed November 15, 1920. Serial No. 424,058.

To all whom it may concern:

Be it known that RAE W. DAVIS, a citizen of the United States, residing at West Allis, in the county of Milwaukee and State of Wisconsin, has invented a certain new and useful Improvement in Systems of Distribution, of which the following is a specification.

This invention relates to systems of distribution and more particularly to such systems involving the use of motors operating in conjunction with energy storing means such as flywheels. The invention is applicable in cases where the rolls of a mill, as in a steel mill, are driven by electric motors. In cases where the work driven by electric motors fluctuates widely and the load sometimes rises to excessive values it becomes desirable to provide a store of energy which may be drawn from to take care of such excessive loads. It is clearly desirable that the stored energy shall be of considerable amount to adequately take care of predetermined excesses. It is a rather difficult problem however, to economically design a flywheel unit which will take care of the load excesses frequently occurring in a steel mill. It is one of the objects of this invention to provide means whereby this problem is solved in an economical and efficient manner.

It is customary in connection with the electric drive of steel mills and the like to utilize two or more motor units. It is one of the objects of this invention to provide means whereby the flywheel capacity of both units is made available when a load is put upon either unit. Another object of the invention is the provision of a system whereby the size and weight of the flywheels necessary in such an installation will be reduced.

Another object is the provision of a system in which the power demands from an electric supply line for the units will be equalized.

Another object is the provision of a system in which the loads on the motor units will be equalized so that each unit will take an appropriate share of the load on the mill as a whole.

One of the more specific objects of the invention is the provision of means whereby the speed of the unit running at the higher speed will be reduced so as to permit the flywheel associated therewith to give up some of its energy. Other objects will appear hereinafter as the description of the invention proceeds.

The novel features of the invention will appear from this specification and the accompanying drawings forming a part thereof showing several embodiments of the invention, and all these novel features are intended to be pointed out in the claims.

In the drawings Fig. 1 is a diagrammatic showing of one embodiment of the invention. Figs. 2, 3 and 4 are modified forms of the controlling system for the main motors shown in Fig. 1. In Figs. 2, 3 and 4 only the main motors and the controlling means therefor have been shown, as the remainder of the system may, if desired, be the same as in Fig. 1.

Referring more particularly to Fig. 1, the invention is here shown as it may be applied in connection with two work motor units 1, 2 each of which may be connected in a suitable manner to drive rolls of a steel mill or the like. The system further comprises two flywheel motor-generator sets 3, 4. The motor unit 1 includes two motors 5, 6 connected in series by a conductor 25. This motor unit is connected in series with the generators 7, 8 of the motor generator sets 3, 4 respectively by means of the conductors 26, 27 and 28. The motor unit 2 comprises motors 9, 10 connected in series by conductor 29. This motor unit is connected in series with generators 11, 12 of the motor generator sets 3, 4 respectively by means of conductors 30, 31, 32.

The generators 7, 11 of set 3, along with a flywheel 13, are driven by a motor 14, here shown as of the wound rotor induction type. Power is supplied to motor 14 through leads 15 connected to the three phase supply line 16. The motor 14 is provided with slip rings 17 here shown as connected to the electrodes 18 of a liquid rheostat provided with a weir 19 of shutter type. The operation of rheostats of this type is well known and need not be herein described. It may be further stated that the rheostat in question is shown merely by way of example, it being understood that the resistance across the slip rings 17 may be varied through any other suitable means. The shutters of the weir have associated therewith a counter-weight 20 which is so positioned as to normally tend to close the shutters thereby permitting the electrode-containing receptacle to be filled with

electrolyte for the purpose of reducing the resistance across the slip rings of the motor. The weir is operatively connected to the torque motor 21 and the relation is such that when the torque of said motor increases the counter-weight 20 will be lifted so that the shutters of the weir are opened to a predetermined extent, thereby increasing the resistances of the rheostat. The torque motor 21 is here shown as supplied by means of the series transformers 22 associated with the leads 15, the torque produced being therefor in proportion to the current supplied to the motor 14.

The motor generator set 4 is provided with a flywheel 23 which, along with the generators 8, 12, is driven by a motor 24, here shown as of the same type as the motor 14. The motor 24 is shown as controlled in the same manner as motor 14 and no further description of this control is therefore necessary.

The field windings 33, 34 of the motors 5, 6 are preferably connected in series with each other and with a rheostat 35, the circuit thus formed being connected to and fed from the exciter buses 36, 37, in turn connected to the exciter 38. The field windings 39, 40 of the motors 9, 10 are in like manner connected in series with each other and with a rheostat 41 and also fed from the buses 36, 37.

The field windings 42, 43 of the generators 11, 12 respectively, are preferably connected in series with each other and with a rheostat 44 through a reversing switch 45 to the buses 36, 37. The field windings 46, 47 of the generators 7, 8 respectively are in like manner connected in series with each other and with the rheostat 48 through a reversing switch 49 to the buses 36, 37. It must be understood, however, that the control means for the field windings of the motors and generators may be elaborated and varied to satisfy the particular conditions confronted and the results desired to be obtained.

The operation of the system disclosed in Fig. 1 is as follows: Inasmuch as the motor unit 1 is supplied by a generator on each of the sets 3, 4, any load which is put upon said motor unit will necessarily be supplied by power from both sets. The same is true of motor unit 2. In case there should be a particularly heavy draft on motor unit 1, for example, the flywheel capacity of both sets will be available. By reason of the fact that one generator on each set supplies each given motor unit there will be an inherent tendency to equalization of the loads on the flywheel motor generator sets because if for any reason the speed of one set should become materially lower than that of the other the generator operating at the higher speed will take a greater part of the load than the one at the lower speed. This inherent regulation is augmented by the control system for the driving motors of the motor generator sets for when an additional current is supplied to either one of the driving motors the rheostat-controlling torque motor associated therewith will operate to reduce the speed of said driving motor thereby permitting the flywheel to give up some of its energy. It is also clear that with the disclosed system the electrical load on the common source of electricity will be equalized.

The modification illustrated in Fig. 2 may be considered to be a substitute for the control system associated with the driving motors 14, 24 of the motor generator sets 3, 4 of Fig. 1. It is assumed that the essential features and connections of the motor units 1, 2 and generators 7, 8, 11, 12 as shown in Fig. 1 will be substantially the same when the driving motors 14, 24 are controlled as shown in Fig. 2. Parts in Fig. 2 similar to those in Fig. 1 have been given the same reference numerals as far as advisable, for the sake of clearness. The weirs 19 of the rheostats controlling the motors 14 and 24 respectively are controlled by torque motors 21, 58 and fed by series transformers 22, 60 respectively. Each weir has a counter-weight 68 associated therewith and positioned so that the weight will normally tend to open the weir. The torque motors are so related to the weirs that upon an increase in torque the counter-weight will be lifted resulting in closure of the weirs to a predetermined extent. The torque motor 21, connected to transformers 22 by conductors 51, 52, 53, is provided with slip rings 54, said motor being here assumed to be of the wound-rotor induction type. These slip rings are connected to resistances 55, 56, 57. What has been stated in connection with torque motor 21 also applies to torque motor 58 the slip rings of which are in like manner connected to a set of three resistances. A differential relay 61 is provided and comprises opposed coils 62, 63. The coil 62 is here shown as connected across conductors 52, 53 and the current through coil 62 will therefore vary in the same sense as the current through leads 15 supplying motor 14. Coil 63 is connected to leads from the transformers 60 in a manner similar to the connection of coil 62. Coils 62 and 63 are here shown as provided with cores 64, 65 which may be mechanically connected. Associated with the core 64 is a member 66 provided with electrically connected contacts co-operable with the resistances 55, 56, 57. The core 65 is in like manner provided with a member 67 having contacts co-operable with the similar resistances associated with the torque motor 58.

The operation of the control system dis-

closed in Fig. 2 is as follows: Assuming the motor 24 to be loaded more heavily than motor 14, then coil 63 will overpower coil 62 and the members 66, 67 will be moved in a downward direction, as viewed in this figure. As a result of this motion resistance will be cut into the rotor circuit of the torque motor 21 and out of the rotor circuit of the torque motor 58. The loss of torque in the torque motor 21 will permit the counter-weight 68 to open the associated weir 19 to a predetermined extent thereby increasing the resistance across the slip rings 17 and reducing the speed of motor 14 so that the flywheel associated therewith will be permitted to give up a predetermined amount of energy. The reduction of resistance in the rotor circuit of torque motor 58, on the other hand, will cause an increase of torque which acting against the counter-weight 68 will cause a predetermined closure of the associated weir 19, thereby decreasing the resistance across the slip rings of motor 24 and increasing the speed of the latter so that it will take the increased load put upon it.

In the modification shown in Fig. 3 the motor 14 has its rheostat-weir controlled by means of torque motor 69 supplied through leads 72 connected to the series transformer 60 associated with the main leads of motor 24. The motor 24 on the other hand has the weir of its rheostat 73 controlled by means of a torque motor 70 connected through leads 71 to the series transformers 22.

The operation of the system discloesd in Fig. 3 is as follows: Assuming that the motor 24 is taking a heavy load the current in series transformer 60 will cause an increase of torque in torque motor 69 thereby causing the latter to lift the counter-weight 20 to open the weir to a predetermined extent thereby acting to slow down the speed of motor 14. The resulting reduction in current in the leads 15 will cause reduction in the torque of motor 70 permitting the counter-weight 20 of rheostat 73 to close the weir a predetermined extent whereby the torque and speed of motor 24 are increased to enable it to carry its load.

In the modification shown in Fig. 4 the motor 14 has its rheostat controlled by means of a torque motor 21 connected to the series transformers 22. The rheostat 75 of motor 24 is controlled by means of torque motor 74 connected to series transformers 60. In each instance the counter-weight 20 of the rheostat is so positioned as to normally tend to close the weir. Each torque motor is so related to its associated weir than an increase of torque will tend to lift the counter-weight thereby opening the weir in question to a predetermined extent. In this modification the torque motors are mechanically connected by any suitable means as by a rod 76. As a result of this construction the weirs of both rheostats must always be opened or closed the same amount. It is clear that if either motor 14, or 24 is loaded to a greater extent than the other the associated torque motor will increase its torque, but as the torque motors are mechanically connected a load on one of the main motors will result in an opening of the weir associated with the unloaded main motor to an extent equal to that of the weir of the loaded main motor, whereby each flywheel is caused to assist in the carrying of the load.

It should be understood that it is not desired that the invention claimed be limited to the exact details of construction shown and described herein, for obvious modifications will occur to a person skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In combination, a work motor, two induction motor-driven flywheel generator sets, said generators being connected in series to supply said motor, and a slip regulator for each of said induction motors.

2. In combination, a work motor, two generators connected in series for supplying said motor, each of said generators having a flywheel associated therewith, and means whereby the flywheel operating at the higher speed is caused to give up energy.

3. In combination, a work motor, a plurality of flywheel generator sets for supplying said motor, and means whereby the flywheel capacity of all sets is made available when said motor takes a load.

4. In combination, two flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means whereby the flywheel capacity of both sets is made available when either when either of said motors takes a load.

5. In combination, a work motor, two motor-driven flywheel generator sets connected in series for supplying said work motor, and means for regulating the speed of one of said driving motors in accordance with the load on said work motor.

6. In combination, a work motor, two motor-driven flywheel generator sets connected in series for supplying said work motor, and means for causing the speed of the driving motor running at the higher speed to drop a predetermined amount.

7. In combination, a work motor, two motor-driven flywheel generator sets connected in series for supplying said work motor, and means effective to maintain said driving motors at substantially the same relative speed.

8. In combination, a work motor, two motor-driven flywheel generator sets con-

nected in series for supplying said work motor, and means effective to cause said driving motors to each take a share of the load substantially in proportion to their capacities.

9. In combination, two motor-driven flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means for regulating the speed of one of said driving motors in accordance with the load on said work motor.

10. In combination, two motor-driven flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means for causing the speed of the driving motor running at the higher speed to drop a predetermined amount.

11. In combination, two motor-driven flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means effective to maintain said driving motors at substantially the same relative speed.

12. In combination, two motor-driven flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means effective to cause said driving motors to each take a share of the load substantially in proportion to their capacities.

13. In combination, two motor-driven flywheel generator sets, each set comprising two generators, a work motor supplied by a generator on each set, another work motor supplied by the remaining generators on said sets, and means controlling the speed of one of said driving motors in response to the load on the other.

14. In combination, a pair of motors, means for equalizing the speed of said motors comprising means for reducing the speed of the motor running at the higher speed in response to the load on the other motor.

15. In combination, a pair of motors, fed from the same source of electricity, means for equalizing the speed of said motors comprising means for reducing the speed of the motor running at the higher speed in response to the load on the other motor.

16. In combination, a work motor, two induction motor-driven flywheel generator sets, said generators being connected in series to supply said motor, and means including a slip regulator for each of said induction motors for reducing the speed of the induction motor running at the higher speed.

17. In combination, a plurality of work motors, a plurality of fly-wheel generator sets for supplying said work motors, and means whereby the fly-wheel capacity of all of said fly-wheel generator sets is made available when any one or all of said work motors takes or take a load.

In testimony whereof, the signature of the inventor is affixed hereto.

RAE W. DAVIS.