Aug. 22, 1961 F. BENEDITZ 2,996,876

DRIVE SYSTEM INCLUDING HELPER MOTOR

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FIG. 1.

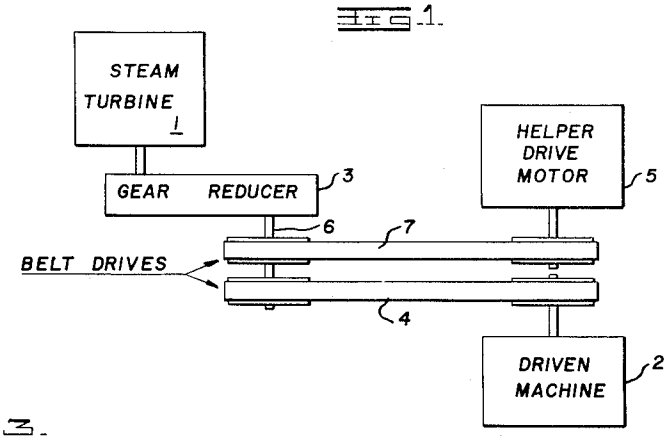
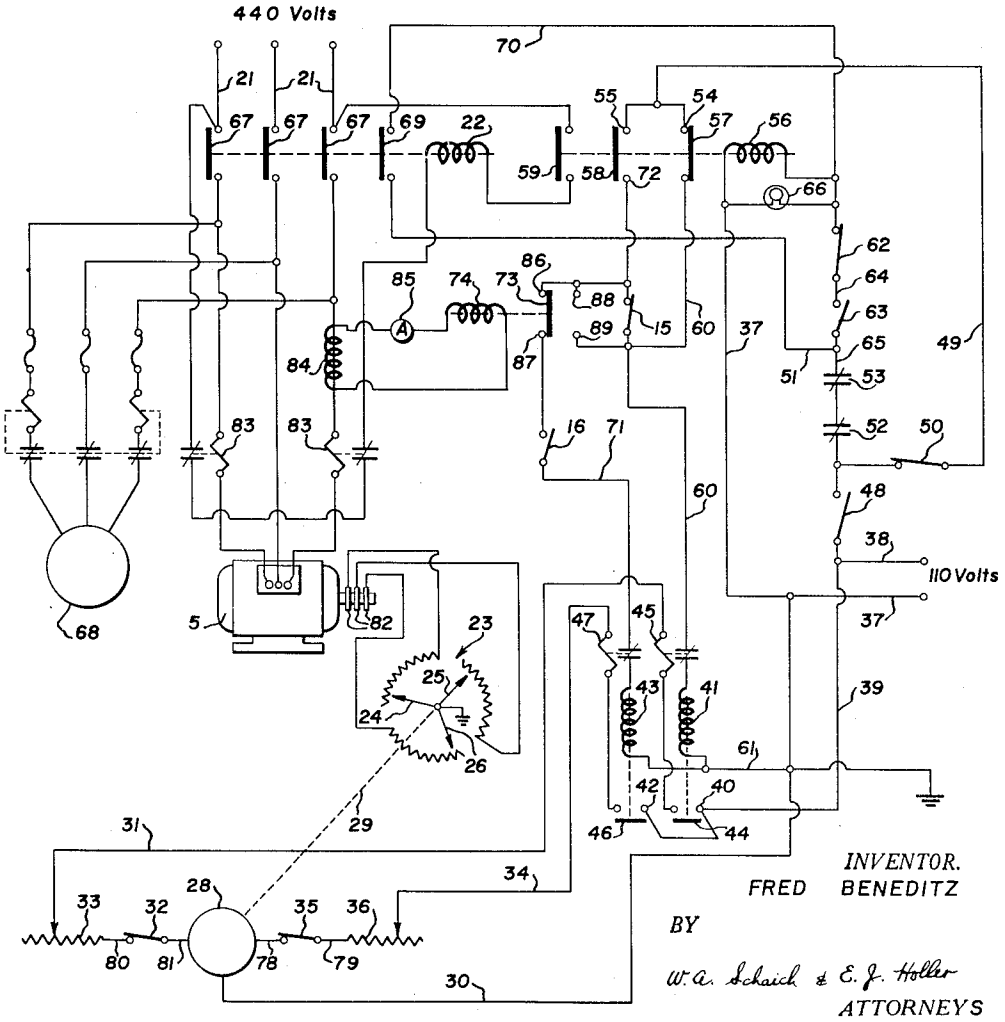


FIG. 3.

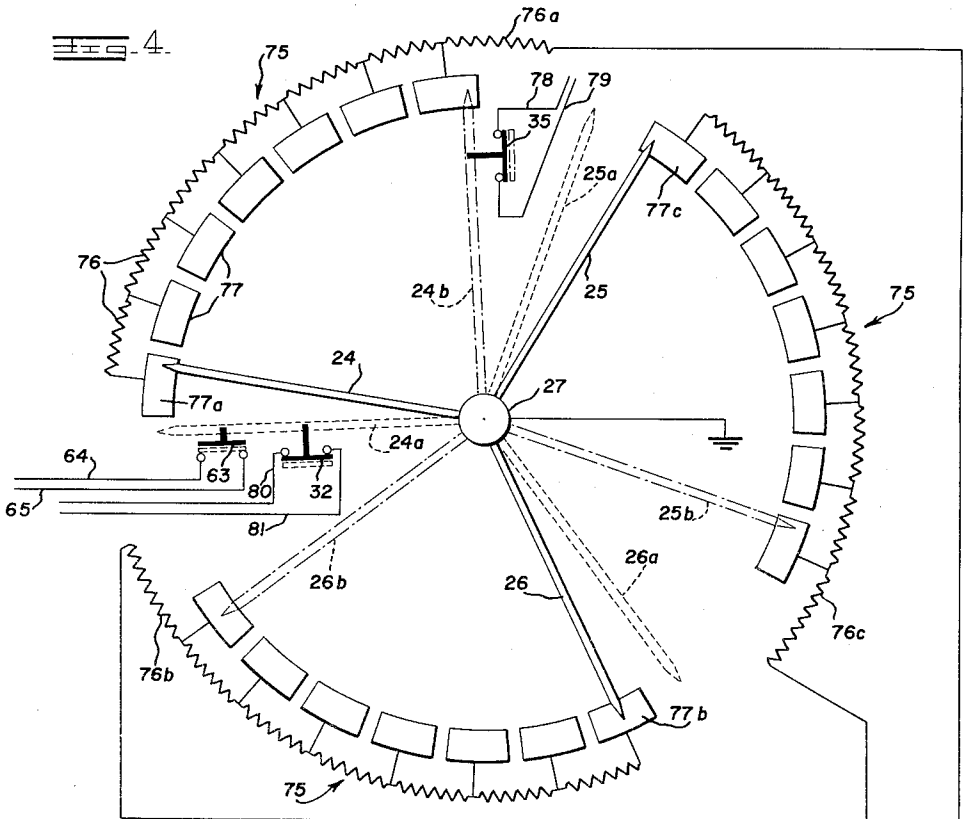


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DRIVE SYSTEM INCLUDING HELPER MOTOR

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Fig. 4.



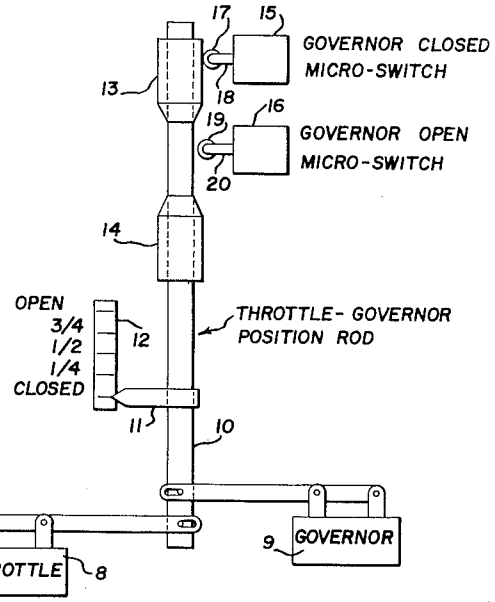


Fig. 2.

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DRIVE SYSTEM INCLUDING HELPER MOTOR

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9 Claims. (Cl. 60—6)

This invention relates to drive systems wherein a prime mover drives a load member, such as a machine having a rotary member which is to be driven by the prime mover. More particularly, this invention relates to such a drive system which includes a helper motor capable of assisting the prime mover to permit the latter to operate at less than maximum capacity and thereby have the ability to compensate for variations in the load to be driven.

When a prime mover, such as a steam turbine, is driving a load which requires the prime mover to operate at very nearly maximum capacity, it cannot compensate readily for fluctuations in the load which cause the prime mover to attempt to exceed its maximum capacity. Thus, if a machine is being driven by a steam turbine and the power transmission arrangement between the turbine and machine is such that to drive the machine at the desired speed requires the turbine to operate at very nearly full throttle, fluctuations in the load or in the steam pressure cannot be compensated for by the turbine governor since the throttle cannot be opened further. It is apparent that, under such an arrangement, the turbine may stall, with the result that the drive fails.

The present invention is directed toward the problem of providing a drive system wherein the prime mover, a steam turbine for example, is permitted to operate within a predetermined range which is well within its capacity. This is accomplished by providing a helper drive motor which supplies just enough power to permit the prime mover to operate within the predetermined range mentioned. The prime mover is used as the main source of power and power from the helper drive is used only when help is needed. Moreover, according to the present invention, the helper drive always remains a slave to the prime mover and its controls and, to this end, a drive system according to the present invention includes as an important feature thereof an automatic control system which makes the system versatile and guards the system against reasonably predictable malfunctions as will be more evident from the detailed description which follows.

It is therefore an object of the present invention to provide a new and improved system for driving a load member by means of a prime mover wherein the system includes a helper drive which permits the prime mover to operate in a range which is well within the capacity of the prime mover.

It is another object of the present invention to provide such a system wherein the helper drive always remains a slave to the prime mover and its controls.

It is a further object of the present invention to provide such a system which is versatile in that the amount of load carried by the helper drive is readily adjustable.

It is still another object of the present invention to provide such a system which includes automatic controls which not only insure that the helper drive is versatile and remains a slave to the prime mover and its controls, but also guard against reasonably predictable malfunctions of the system.

Briefly described, a preferred embodiment of a system according to the present invention comprises a steam turbine (as the prime mover) which, through a suitable gear reducer and belt drive power transmission arrangement, drives a load machine wherein the load imposed on the prime mover may fluctuate for any particular speed at which the load machine is driven and, of course, can vary according to the speed at which the load machine is

driven. A three-phase wound rotor slip ring induction motor has its output shaft belt coupled to the transmission arrangement so that the electric motor can assist the turbine to drive the load. This permits the turbine to operate at less than maximum capacity and thereby have the ability to compensate for variations in load.

The helper drive includes the drive motor itself, motor control grids, and an automatic control system to coordinate the electric drive with the steam turbine. Motor torque is varied with a motorized drum selector switch and a set of grid resistors. The automatic control system includes an overcurrent type of relay which prevents an overload trip of the helper drive should the control system demand more torque than the drive is capable of producing. When the maximum permissible line current is reached, the control will not respond to a demand for increase drive, and should excess current flow, the control will unload the helper drive to the point of maximum allowable current. Power interruption will cause the drive to fail but it will return to service automatically with the restoration of power. On its return, the helper drive will step up from zero torque to its normal load, removing the possibility of overdriving the turbine before the control has had time to correct for load changes which may have occurred.

A pair of control switches, operatively associated with the turbine, determine when the automatic control goes into action to either increase or decrease the amount of torque supplied by the electric helper drive motor. These switches are adjustable to permit the turbine to operate within a predetermined range below its maximum capacity. This means that the turbine can respond to fluctuations in the load, and the helper drive comes into action to either increase or decrease its output only when the load fluctuation, or turbine speed, causes either control switch to be actuated to bring the helper drive into play.

Other objects and advantages of the present invention will become more apparent from the following detailed description, taken in conjunction with the attached drawings, in which:

FIG. 1 is a diagram of a drive system according to an embodiment of the present invention;

FIG. 2 is an enlarged detail view showing control members for controlling increase and decrease of the amount of torque supplied by the helper drive;

FIG. 3 is an electrical circuit diagram of the automatic control circuit for he helper drive motor; and

FIG. 4 is an enlarged circuit diagram of the helper motor external rotor circuit shown in FIG. 3.

Referring to FIG. 1, the block designated by reference numeral **1** represents a prime mover which, according to a preferred embodiment of the invention, is a steam turbine. The block designated by reference numeral **2** represents a machine to be driven by turbine **1**. The drive is accomplished through a suitable power transmission arrangement including a gear reducer (designated by block **3**), and a belt drive **4**. Of course, gear reducer **3** and belt drive **4** are simply exemplary of a type of power transmission means which may be employed between turbine **1** and driven machine **2**.

A helper drive motor, designated by block **5**, has its output coupled to the output shaft **6** of gear reducer **3** by another belt drive **7**. By this arrangement, the helper drive motor can supply power to shaft **6** and thus assist turbine **1** in driving the load, or driven machine, **2**.

Referring now to FIG. 2, and still using a steam turbine as the prime mover **1**, it is seen that the turbine throttle **8** and turbine governor **9** are both operatively coupled to a throttle-governor position rod **10**. The arrangement is such, as will be appreciated by those skilled in the art, that rod **10** is moved in accordance with movements of the turbine throttle and governor whereby, as

seen in FIG. 2, the rod will rise as the throttle and governor open and will fall as they close. Rod **10** is shown as having a pointer **11** connected thereto which moves along a scale **12** to indicate the extent to which the throttle and governor are open.

Two collars **13** and **14** are positioned on rod **10** as shown in FIG. 2. Two switches **15** and **16** (microswitches, preferably) are supported with respect to rod **10** and collars **13** and **14** by suitable means, not shown, so that each switch is capable of being actuated by a collar. Thus, switch **15** has a roller **17** carried by an arm **18** projecting from the switch, and roller **17** is adapted to be engaged by collar **13** (as shown in FIG. 2) whereby the roller and arm are moved in a manner to actuate switch **15**. As described hereinafter, such actuation results in closing of switch **15**. Roller **19** and arm **20** are operatively associated with switch **16**. As shown in FIG. 2, roller **19** is not contacted by either collar **13** or **14**, with the result that switch **16** is not actuated when rod **10** is in the position shown in FIG. 2.

The spacing between collars **13** and **14**, and the spacing between switches **15** and **16**, both spacings being adjustable as desired, are chosen according to a preferred embodiment of the present invention so that neither switch **15** or **16** is actuated (closed) when the turbine is operating in the range from one-half to three-quarters capacity, i.e. when the turbine throttle is from one-half to three-quarters open. Thus, referring to FIG. 2, the spacing is such that when rod **10** rises to an extent such that pointer **11** reaches the one-half mark on scale **12**, roller **17** will roll off of collar **13** and open switch **15**. If rod **10** continues to rise, as when throttle **8** is opened further, collar **14** will contact roller **19** to close switch **16** when pointer **11** passes the three-quarter mark on scale **12**. As is explained in greater detail hereinafter, when switch **15** is closed the torque supplied by helper drive motor **5** is decreased, and when switch **16** is closed, the torque is increased. When neither switch is closed, the torque supplied by the helper motor remains substantially constant with turbine **1** compensating for fluctuations in the load. The helper drive motor thus remains a slave to the prime mover and its controls and the prime mover thus performs its intended function of being the prime source of power for the driven machine **2**.

Referring now to FIG. 3, helper drive motor **5** is shown as being a wound rotor slip ring induction motor having a stator energizable from three-phase power lines **21** when magnetic starter relay coil **22** is energized as described in greater detail hereinafter. The external rotor circuit of motor **5** includes a variable resistance grid assembly designated generally by the reference numeral **23** and whereby the total resistance of the rotor of motor **5** may be varied in order to vary the output torque of motor **5**. As will be appreciated by those skilled in the art, a wound rotor induction motor is capable of producing a relatively constant torque over a wide range of speed so that the output torque is substantially independent of the motor speed but is controllable by an external resistance in the rotor circuit. For a given resistance, the motor produces almost constant torque while following the speed of the turbine (or other prime mover) to which it is coupled. This is a desirable situation since the turbine is the prime mover and its throttle should determine the speed of the driven machine.

Resistance grid assembly **23** includes three electrically conductive contact arms **24**, **25** and **26** which, as shown in FIG. 4, project from a common hub **27** so that when the hub is turned each arm will be moved. Hub **27** is driven by a reversible control motor **28** through a suitable connection indicated generally by dotted line **29**. The arrangement is such that the output of motor **28** is stepped down appreciably whereby arms **24–26** will be turned slowly to add or subtract resistance smoothly and gradually in the rotor circuit of helper motor **5**.

Reversible control motor **28** has one side connected to lead **30**, and the other side selectively connectible to either lead **31**, through limit switch **32** and adjustable resistance **33**, or lead **34**, through limit switch **35** and adjustable resistance **36**. As is explained in greater detail hereinafter, control motor **28** is connected to lead **34** when it is desired to decrease the resistance in the rotor circuit of helper motor **5**, and control motor **28** is connected to lead **31** when it is desired to increase such resistance.

Control motor lead **30** is connected to one side (the grounded side) **37** of a suitable power source which has lead **38** as its other side. The power across leads **37** and **38** may be, for example, 110 volt A.C. power. Lead **38** extends, via lead **39**, to a contact **40** of torque decrease relay **41**, and a contact **42** of torque increase relay **43**. When relay **41** is energized, it picks up contact arm **44** to complete a circuit from power lead **38** to control motor lead **31** via thermal overload device **45**. Similarly, when relay **43** is energized, it picks up contact arm **46** to complete a circuit from power lead **38** to control motor lead **34**, via thermal overload device **47**.

Power lead **38** goes to what can be described as a master control switch **48** shown in FIG. 3 as being in open position. When switch **48** is closed, power lead **38** is connected to a lead **49**, through torque adjust switch **50**, and is also connected to a lead **51**, through normally closed contact devices **52** and **53**. Device **52** may be, for example, an overspeed trip on turbine **1**, and device **53** may be a thermostat trip operatively associated with resistance grid assembly **23** so that if the grids should overheat device **53** will open to disconnect other components of the overall control circuit from power lead **38**.

Lead **49** goes to contacts **54** and **55** of control relay **56**. This control relay includes three contact arms **57**, **58** and **59**, one of which (**57**) is in closed position when the relay is deenergized, and the other two of which are in open position when the relay is deenergized. With contact arm **57** thus being in closed position, and with switch **50** closed, it is evident that when master switch **48** is closed power lead **38** is conected through to a lead **60** which goes, through thermal overload device **45**, to one side of torque decrease relay **41**. The other side of relay **41** (and also relay **43**) is connected to grounded lead **61**.

Referring now to the upper right hand portion of FIG. 3, two switches **62** and **63** are shown as connected in series between one side of normally closed contact device **53** and one side of control relay **56**. Switch **62** is a manually operable restart switch. Switch **63** is a switch located in the resistance grid assembly **23** (see FIG. 4) and is open except when the resistance grid assembly contact arms **24—26** are in the zero torque position as is explained more fully hereinafter.

Further detailed description of other components shown in FIGS. 3 and 4 is presented in connection with a description of operation of the cricuitry shown in FIGS. 3 and 4 which follows.

In starting this description of operation, it is assumed that turbine **1** is running with its throttle **8** less than one-half open, that the circuit of FIG. 3 is deenergized except that power is available at leads **21**, and **37**, **38**, and that the contact arms **24–26** of resistance grid assembly **23** are out of the zero torque position and in some other position between the permissible end limits of their movements. This is the situation as shown in FIG. 3.

Now, if master switch **48** is closed, power is supplied from lead **38** through switches **48**, **50**, lead **49**, relay contact arm **57**, and lead **60** to one side of decrease torque relay coil **41** to energize this coil. When energized, coil **41** picks up contact arm **44** to connect lead **31** of control motor **28** to power lead **38** via thermal overload device **45**, contact arm **44**, and lead **39**. Since the other side of control motor **28** is connected, via lead **30**, to the grounded lead **37** of the power source, control motor **28** is energized. When so energized, it actuates hub **27** to turn contact arms **24–26** in a counterclockwise direction as

viewed in FIGS. 3 and 4, until these contact arms reach the zero torque position represented by the dotted line showing of these arms (24*a*–26*a*) as seen in FIG. 4.

When sliding contact arms 24–26 are in this zero torque position, switch 63 is closed and, in the example shown, switch 63 is shown as being operatively associated with contact arm 24. Details of the mounting arrangement whereby switch 63 is adapted to be closed when arms 24–26 are in the zero torque position, and is adapted to open when these arms leave this position are omitted since it is believed evident to a person skilled in the art that any suitable mounting arrangement may be utilized to provide the action desired. In FIG. 4, reference numerals 64 and 65 are shown as applied to leads extending to switch 63, and these reference numerals are also applied in FIG. 3 to correlate FIGS. 3 and 4.

When switch 63 closes, power lead 38 is connected through to one side of control relay 56 which energizes this relay since the other side of the relay is connected to grounded power lead 37 as shown in FIG. 3. Indicator light 66 goes on to show that the control relay is energized. When energized, relay 56 opens contact arm 57 and closes contact arms 58 and 59. Contact arm 59 completes a circuit across one phase of the three-phase power leads 21 (as shown in FIG. 3) to energize magnetic starter relay 22. This closes magnetic starter contact arms 67 and thus energizes the stator of wound rotor induction motor 5. A fan motor 68 is also energized and this motor drives a fan for cooling the resistance grids of resistance grid assembly 23.

Magnetic starter relay 22 includes a fourth contact arm 69 which is also closed when the relay is energized to provide a circuit via lead 51, contact arm 69, and lead 70 to one side of control relay 56. As can be seen from FIG. 3 this seal or holding circuit bypasses switches 62 and 63 so that control relay 56 can remain energized even though either switch is opened as occurs when the movable contact arms 24–26 leave the zero torque position. However, while the seal or holding circuit is thus set up as described, switch 63 is not opened until control motor 28 is energized to cause switch 63 to be opened and, therefore, even though three-phase power is applied to the stator of helper motor 5, this motor does not deliver any output torque because its rotor circuit is open at this time.

On the assumption that turbine 1 is operating at less than half throttle, micro-switch 15 will be closed and micro-switch 16 will be open as has been described above. This condition is shown in FIG. 3 where the closed micro-switch 15 is shown as being located between relay 41 and contact 72 of control relay 56 whereby, when control relay contact arm 58 closes and arm 57 opens, power can still be supplied to one side of torque decrease relay 41. Micro-switch 16 is shown as being located in a line 71 which comes from control relay contact 72, goes through a normally closed contact arm 73 of a modified overcurrent relay 74 (described in greater detail hereinafter) and goes through micro-switch 16 (when the switch is closed) to one side of torque increase relay 43.

When the turbine throttle 8 goes past half-open position, and before it reaches three-quarters-open position, micro-switch 15 opens, and micro-switch 16 remains open, as has been described above. The opening of micro-switch 15 makes no difference at this stage of the operation being described since contact arms 24–26 of resistance grid assembly 23 have previously been moved to the above-described zero torque position and are still located in this position. However, should turbine throttle 8 go past three-quarter-open position then, as has been described above, micro-switch 16 is closed by collar 14 on the throttle-governor position rod 10.

Closing of micro-switch 16 connects one side of torque increase relay 43 to power lead 38 through switches 48 and 50, lead 49, and contact arms 58 and 73. When relay 43 is energized, its contact arm 46 is closed to connect lead 34 of control motor 28 to power lead 38 via lead 39, contact arm 46, and thermal overload device 47. The internal circuit of control motor 28 is such that when this motor is energized as just described, it turns movable contact arms 24–26 in a clockwise direction as viewed in FIGS. 3 and 4 to first open switch 63, then connect the maximum resistance into each phase of the helper motor rotor circuit, and then reduce the resistance in each phase as movement of the contact arms continues. As will be appreciated by those skilled in the art, reduction in the resistance of the external rotor circuit of helper motor 5 results in an increase in the output torque of the helper motor whereby the helper motor assumes a share of the load being driven by the turbine and thus assists the turbine in driving the load. It is to be noted furthermore that, by having the helper motor start from zero torque, i.e., with its rotor circuit open, and then going from full resistance in the rotor circuit to a decreased resistance in the rotor circuit, the helper motor gradually assumes a share of the load and therefore does not come into action with an output torque which might provide too much of a jolt on the system.

As the helper motor increases its share of the load, turbine throttle 8 will ultimately drop back below three-quarter-open position. When it does so drop back, throttle-governor position rod will likewise move until collar 14 no longer engages roller 19 on actuating arm 20 of micro-switch 16, whereupon the micro-switch will open to deenergize control motor 28. This stabilizes the system with both the turbine and the helper motor sharing the load. If the turbine throttle closes to less than half-open, micro-switch 15 will again be closed and energize torque decrease relay 41 to put more resistance in the rotor circuit of the helper drive motor.

Referring more specifically to FIG. 4, it is noted that each of the resistance elements 75 which is adapted to be connected in a phase of the helper motor rotor circuit is actually made up of a plurality of series-connected resistance elements 76 to which contact segments 77 are connected so that, as the movable contact arms 24–26 travel over the contact segments, resistance will be removed from or added to the helper motor rotor circuit in predetermined increments. It is to be noted furthermore that the positioning of contact arm 24 relative to contact segment 77*a*, the positioning of contact arm 26 relative to contact segment 77*b*, and the positioning of contact arm 25 relative to contact segment 77*c*, are such that, as the contact arms move slowly in a clockwise direction as viewed in FIG. 4, contact arm 24 will contact segment 77*a* first, then contact arm 26 will contact segment 77*b*, and finally contact arm 25 will contact segment 77*c*. When arms 24 and 26 contact segments 77*a* and 77*b*, this completes a single-phase connection of the helper drive motor rotor circuit. When contact arm 25 contacts segment 77*c*, this completes a three-phase connection of the rotor circuit and, as movement of the contact arms 24–26 continues, a resistance element 76 is removed one phase at a time so that output torque changes are quite smooth.

Dot-dash lines 24*b*–26*b* represent the upper limits of movement of movable contact arms 24–26. When the contact arms reach their upper limit of movement, they open a limit switch 35 which, as can be seen from FIG. 3, deenergizes control motor 28. Lead designations 78 and 79 are shown in FIGS. 3 and 4 in order to correlate the position of limit switch 34 in these two figures. When contact arms 24–26 reach their lower limit of movement (represented by dotted lines 24*a*–26*a*), they open limit switch 32 to deenergize control motor 28 and prevent a further attempted decrease of the torque supplied by helper drive motor 5. Reference numbers 80 and 81 have been applied to leads shown in FIG. 4 in order to correlate this figure with FIG. 3 insofar as limit switch 32 is concerned. It is to be noted that even when the contact arms 24–26 are at their upper limit of movement, the resistance elements 76*a*–76*c* are still left in the rotor cir-

cuit so that there is not a complete short circuit across the rings insofar as the resistance grid assembly **23** is concerned.

The movable contact arms **24–26** and contact segments **77** may be made of any suitable conductive material sufficiently strong for the purpose intended. Also, as shown in FIGS. 3 and 4, the common conductive hub **27** to which contact arms are attached is grounded, and each of the three resistances **75** is connected to a helper drive motor rotor slip ring **82**. Of course, the number of resistance elements **76** shown in FIG. 4 is simply exemplary, it being understood that any suitable arrangement of resistances can be provided depending upon the desired smoothness of the torque increase or decrease.

A further feature of the control circuit shown in FIG. 3 is overcurrent relay **74** which functions to prevent the helper drive motor **5** from being overloaded and kicking out the thermal overloads **83** which, as shown in FIG. 3, are located in the power lines leading to the helper motor stator circuit. Relay **74** is connected to a current transformer **84** through an ammeter **85**, said current transformer being coupled to one of the stator input lines of the helper motor as shown in FIG. 3. When the helper drive motor **5** is drawing almost full load current, relay **74** operates to move contact arm **73** away from contacts **86** and **87** but not far enough to bridge contacts **88** and **89**. This breaks the circuit from power lead **38** to increase torque relay **43**, even though micro-switch **16** is still closed, thus deenergizing control motor **28** and preventing the control motor from taking any more resistance out of the rotor circuit of helper motor **5**.

Should the current drawn by the helper drive motor continue to rise, relay **74** causes contact arm **73** to bridge relay contacts **88** and **89**. This completes a circuit from power lead **38** through to decrease torque relay **41**, and energizes relay **41** to, in turn, energize control motor **28** to add resistance to the rotor circuit of helper drive motor **5**. Contact arm **73** will bridge relay contacts **88** and **89** if the load imposed by driven machine **2** becomes too great with both turbine **1** and helper drive motor **5** delivering maximum power. If the load thus does become too great, the speed at which the load is driven will start to decrease. Moreover, when the output torque of the helper drive motor **5** is reduced as a consequence of contact arm **73** bridging relay contacts **88** and **89**, the speed will continue to drop more rapidly, resulting in a stall which will cause the usual turbine protective system to go into action to protect the turbine. Meanwhile, overcurrent relay **74** has effectively prevented the helper drive motor from being overloaded and it is apparent that the action of overcurrent relay **74** is predetermined so that contact arm **73** does bridge contacts **88** and **89** before the stator current becomes sufficient to trip the thermal overloads **83**.

From the foregoing detailed description, it is seen that a drive system according to the present invention does not simply include a helper drive motor which assists a prime mover to drive a load but, instead, includes a helper drive motor in such a way that the helper drive always remains a slave to the prime mover and its controls, and the control switches (**15** and **16**) for the helper drive are completely adjustable as to when the helper drive will come in and what percentage of the load it will assume. The system is thus versatile and, additionally, it guards against any reasonably predictable malfunction.

Any type of turbine failure will remove the helper drive from the line, as will any failure of the helper drive itself. Power interruption will naturally cause the helper drive to fail but it will return to service automatically with the restoration of power. On its return, the helper drive will step up from zero torque to its normal load, removing the possibility of overdriving the turbine before the control has had time to correct for load changes which may have occurred. In the event of a turbine overspeed trip, the helper drive will drop out instantly. When the turbine is returned to service, the drive will again start automatically.

While I have described and illustrated a preferred embodiment of my invention, I wish it to be understood that I do not intend to be restricted solely thereto but that I do intend to cover all modifications thereof which will be apparent to one skilled in the art and which come within the spirit and scope of my invention.

What is claimed is:

1. A drive system comprising a prime mover having an adjustable power output, a load member, power transmitting means connecting said load member in driven relation to said prime mover, a helper drive motor having an adjustable power output, means connecting said helper motor to said power transmitting means so that said helper motor can help said prime mover to drive said load member, a first control member, a second control member, means connecting both said first and second control members to said prime mover, said connecting means being operable to actuate said first control member in response to one predetermined value of power output from said prime mover and being operable to actuate said second control member in response to another predetermined value of power output from said prime mover, and said connecting means being inoperable to actuate either control member throughout a range of power outputs from said prime mover lying between said predetermined values of said power output, said range being a substantial fraction of the entire range of power outputs from said prime mover, helper motor control means operable when actuated to vary the power output of said helper motor, and means connecting both said first control member and said second control member to said helper motor control means, said helper motor control means being operable in response to actuation of said first control member to increase the power output of said helper motor, and being operable in response to actuation of said second control member to decrease the power output of said helper motor.

2. A drive system according to claim 1, wherein said means connecting said control members to said helper motor control means includes means operable in response to actuation of said first control member to operate said helper motor control means to first decrease and then increase the power output of said helper motor.

3. A drive system comprising a prime mover having an adjustable power output, a load member, power transmitting means connecting said load member in driven relation to said prime mover, an electrical helper drive motor having an adjustable power output, means connecting said helper motor to said power transmitting means so that said helper motor can help said prime mover to drive said load member, a first control switch, a second control switch, means on said prime mover engageable with both of said switches, said prime mover means being operable to actuate said first control switch in response to one predetermined value of power output from said prime mover and being operable to actuate said second control switch in response to another predetermined value of power output from said prime mover, a helper motor control operable when energized to vary the power output of said helper motor, means connecting said control motor to said helper motor to vary the power output of said helper motor when said control motor is energized, and electrical circuit means electrically connecting both of said control switches to said helper motor control motor, said electrical circuit means including means operable in response to actuation of said first control switch to energize said control motor to increase the power output of said helper motor, and also including means operable in response to actuation of said second control switch to energize said control motor to decrease the power output of said helper motor.

4. A drive system comprising a prime mover having an adjustable power output, a load member, power

transmitting means connecting said load member in driven relation to said prime mover, an electrical helper drive motor having a stator circuit and a rotor circuit, said rotor circuit including an adjustable impedance, means connecting said helper motor to said power transmitting means so that said helper motor can help said prime mover to drive said load member, a pair of control switches, means on said prime mover engageable with each control switch to actuate each control switch, said prime mover means being operable to actuate one of said control switches in response to one adjustably predetermined value of power output from said prime mover and being operable to actuate the other control switch in response to another adjustably predetermined value of power output from said prime mover, a reversible electrical control motor, means connecting said control motor to the variable impedance in the rotor circuit of said helper motor, said control motor being operable, when energized, to either increase or decrease said impedance, and electrical circuit means connecting both control switches to said reversible control motor, said circuit means including means operable in response to actuation of said first control switch to energize said control motor to decrease said rotor impedance and thereby increase the output torque of said helper motor, and also including means operable in response to actuation of said second control switch to energize said control motor to increase said rotor impedance and thereby decrease the output torque of said helper motor.

5. A drive system according to claim 4, wherein said helper motor is a three-phase wound rotor induction motor, and said adjustable impedance includes an adjustable resistance located in each phase of said rotor circuit.

6. A drive system according to claim 4, wherein said adjustable impedance in the rotor circuit of said helper drive motor includes means operable, when actuated, to open said rotor circuit.

7. A drive system according to claim 4, wherein said electrical circuit means includes means operable, when actuated, to prevent any further decrease of the impedance in the rotor circuit of said helper motor when the stator circuit of said helper motor is drawing substantially full load current.

8. A drive system according to claim 7, wherein said electrical circuit means includes means operable, when actuated, to energize said control motor to increase the impedance in the rotor circuit of the helper motor in the event that the stator circuit of the helper motor continues to draw substantially full load current and the driven load ultimately becomes too great for both the prime mover and the helper motor.

9. A drive system according to claim 6, including means for energizing the stator circuit of said helper motor prior to closing the rotor circuit of said helper motor.

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