June 24, 1969 E. TAGLIASACCHI 3,452,261

TORQUE EQUALIZING CONTROL ARRANGEMENT FOR A SERIES OF DRIVEN UNITS

Filed Jan. 18, 1966

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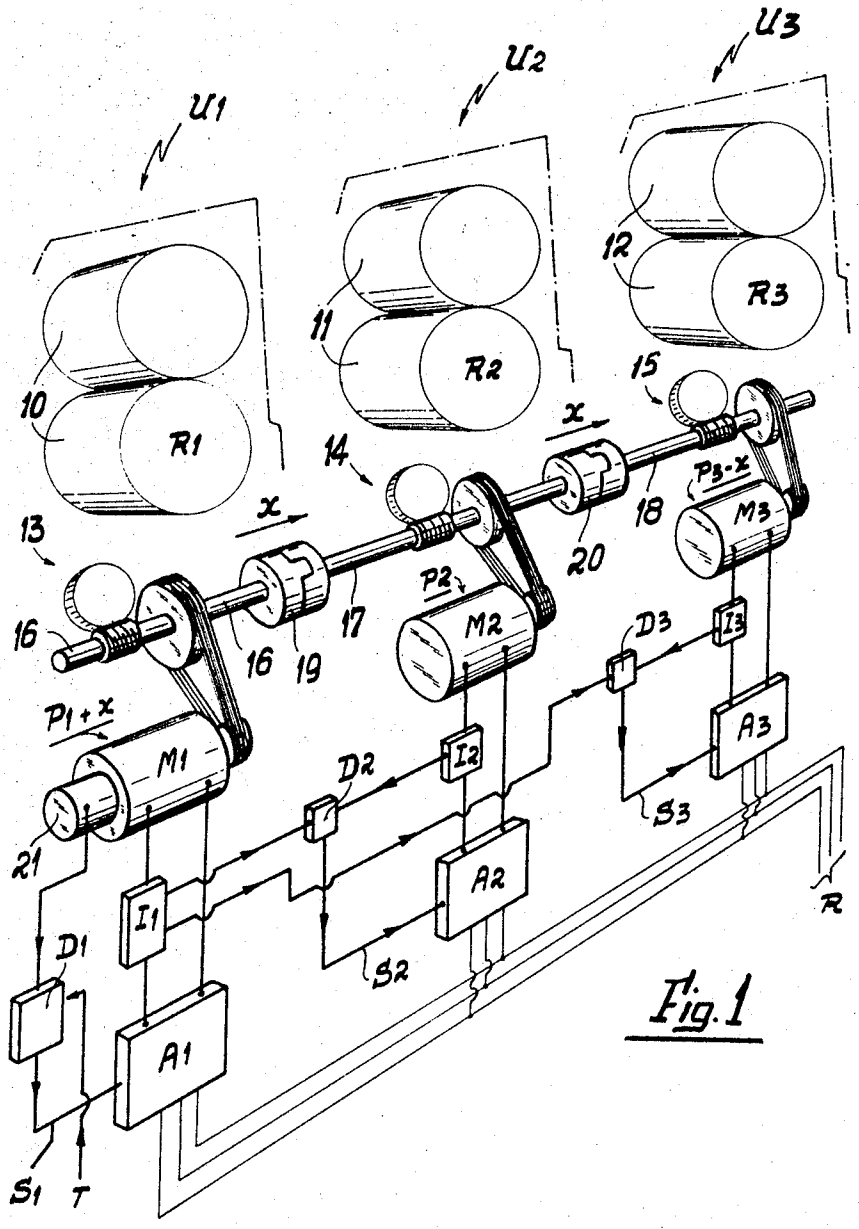


Fig. 1

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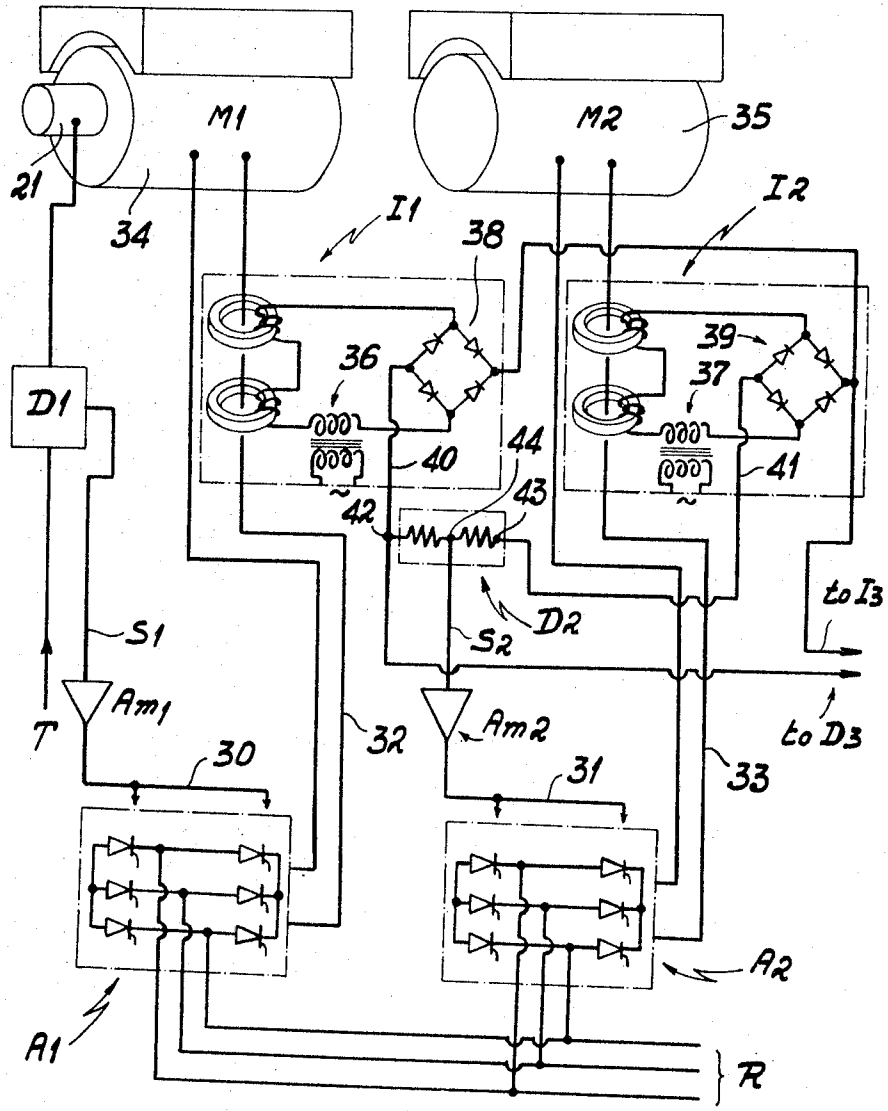


Fig. 2

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3,452,261

TORQUE EQUALIZING CONTROL ARRANGEMENT FOR A SERIES OF DRIVEN UNITS

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Int. Cl. H02p 5/46, 1/54, 7/74
U.S. Cl. 318—77 11 Claims

ABSTRACT OF THE DISCLOSURE

A series of printing units is driven from a series of motors through coupled sections of a synchronizing shaft. The electric energy supplied to each motor is controlled so that upon load variations, a constant equalizing torque is transmitted between the shaft sections in one direction.

The present invention generally relates to multiunit sheet-fed printing machines. More particularly, it is related to printing machines of the type including a sheet-feeding mechanism adapted to successively feed sheets to be printed, a plurality of rotary units each provided with inking means, transfer and/or direct impression cylinders adapted for one-color printing on the successively fed sheet, and a printed sheets piling-up mechanism, and wherein mechanically linking means are provided to interconnect the various printing units in proper registered relationship so that the various colors will successively print on each sheet as it successively passes through the various units. Said linking means are designed to ensure that the two or more printing units have to run at a predetermined angular position with each other to assure proper alignment of the colors which are respectively applied by the successive units to the sheets passing therethrough, and therefore to assure the desired angular relationship and simultaneous drive at synchronous speeds of said various units.

In the operation of said multiunit machines, in order to set up the individual printing units, it is however desired to run each printing unit independent of the other so that the set-up time can be reduced by setting up units more or less simultaneously. It is also desired that said units can be operated independently or in selected groups for particular runs of the press.

To meet the above and other conditions, there have been proposed and actually produced multiunit printing machines comprising a plurality of printing units, including a separate motor associated with and directly driving each printing unit individually, and speed equalizing means for mechanically connecting together the said units. Said means may advantageously consist of what is commonly referred to as a synchronising shaft connected to the gears of the various units thus ensuring a common speed and the desired angular relationship of the units. In order to allow individual or specially grouped run of the units, clutch means are provided along said synchronising shaft, which therefore comprises as many aligned shaft sections as many the various printing units are, each shaft section being connected to an individual unit and to the respective separate motor.

In at least one known multiunit printing machine, described in U.S. Patent No. 3,221,651, assigned to the same assignee of this application, there is provided an arrangement for automatically coupling a plurality of units after they have been set up in a predetermined angular relationship with respect to each other so that the units can subsequently thereto be operated at the desired synchronous speed and angular relationship.

While it has been acknowledged that the above considered arrangement of a synchronising shaft to interconnect the various units, and the provision of clutch means for individually running same units, provides a simpler construction, particularly where the machine comprise two of few units, than the provision of electrical means for phasing individually motor driven units (such as the arrangement described in the U.S. Patent No. 3,073,997, assigned to the assignor of this application), said mechanical linking means are subject to certain objection as said synchronising shaft and the clutch means provided therealong cannot assure the most desirable precision in the angular relationship between the adjacent units, when the mechanical resistance is uncontrolledly subject to substantial variations and the magnitude and/or direction of the transmitted torque varies.

As a matter of fact, it has been found that a noticeably variation in said angular relationship may be induced by torsional deformation of the components of said synchronising shaft as the torque applied thereto varies as a consequence of an uncontrolled variation of the ratio between power output of any individual motor and the mechanical resistance of the respective directly driven unit, as the mechanical resistance to rotation, by any individual printing unit, is to be considered a variable which cannot be predicted and anyway controlled.

A more serious alteration from the predetermined angular relationship occurs when the direction of the torque transmitted through the synchronising shaft is reversed, for example by an unpredictable increase or decrease of the mechanical resistance of one unit above or respectively below the output power of the respective motor. Notwithstanding the most precise fit of the components of the clutch means, to the inversion of the torsional deformation in the shaft section or section a further variation results from the unavoidable clearance between the interfitted parts of the clutch means. Such clearance increases as the said parts are subject to wearing and other reasons depending from extensive and long service of the machine.

It is therefore the principal object of this invention to provide an improved multiunit machine of the type referred to above, which is not subject to the above and other objection, and wherein means are provide to minimize the effects of the above unpredictable and uncontrollable variations of the mechanical resistance offered by the individual printing units thereof.

More particulary, it is an object of this invention to provide means for controlledly feeding electric energy to the individual motors of the machine so that the torque transmitted through the synchronising shaft can not be reversed.

A further object of this invention is to provide means for controlledly feeding the individual motors with electrical energy substantially proportional to the energy fed to the adjacent motor so that a substantially uniform flow of power is mechanically transferred through the mechanical linking means interconnecteing the adjacent units, therefore assuring that the synchronising shaft components are subject to a torque of constant direction and substantially uniform magnitude.

According to the invention, each motor directly connected to a respective unit is fed through a controllable source of electrical energy, via a circuit including means responsive to the energy supplied to the motor and designed to give a signal indicative of the actual output power of the motor. The signals provided by said means are compared to provide a further signal indicative of the ratio between the output powers of paired motors, and said further signal is applied to the control means of at least one of said controllable source of electrical energy, whereby the electrical energy supplied to at least

two of said motors is adjusted to maintain said ratio within predetermined limits.

Other objects and advantages of the invention will be apparent as it is better understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

In the drawings:

FIGURE 1 purely diagrammatically shows a multiunit printing machine of the type disclosed in said prior U.S. Patent No. 3,221,651 provided with a control circuit according to the present invention, the various components of the synchronising shaft and clutch means thereof being generally illustrated, and

FIGURE 2 illustrated in diagrammatical form the essential wiring and circuitry of the means provided for controlledly feeding, according to the invention, two of the motors included in said machine.

Referring now to the drawings, wherein any structural detail and the particulars of the various electrical components have been omitted, as said machines and said components, as individually considered, are known and can be easily conceived by those skilled in the art to which this invention appertains:

The multiunit printing machine, an "offset" three-color press for example, in shown as comprising three printing units generally indicated at U_1 and respectively U_2 and U_3. Each unit comprises at least two coupled printing cylinders **10** and respectively **11** and **12**, driven by gear means **13**, **14** and **15** through transmissions (not shown) in a conventional manner. The various units are conventionally arranged in a row and mounted in a frame (not shown), and the synchronising shaft is supported for rotation along said row. The said shaft consists of three coaxial shaft sections **16** and respectively **17** and **18**, which are connected by clutch means **19** and respectively **20**. Each individual shaft section **16**, **17** and **18** is drivingly connected to said gear means **13** and respectively **14** and **15** of the respective printing unit U_1 and respectively U_2 and U_3, and drivedly connected, by conventional transmission means, to a motor M_1 and respectively M_2 and M_3. In the embodiment shown, said motors are assumed to be fed with D.C. by a suitable controllable source of D.C. A_1 and respectively A_2 and A_3.

Said sources A_1, A_2 and A_3 of D.C. are at their turn conventionally connected to a source R of A.C., such as a conventional three-phase network. Said sources A_1, A_2 and A_3 may consist of rotary or, preferably but not necessarily, stationary means, such as including controlled silicon diodes (as diagrammatically shown in FIG. 2), which can be controlled via leads S_1 and respectively S_2 and S_3. It is assumed that each printing unit will oppose a mechanical resistance or load torque R_1 and respectively R_2 and R_3 to be operated.

It will be evident that, assuming that the output torque of each motor M_1, M_2 and M_3 applied through a pulley and belt transmission to the respective shaft section would balance the mechanical resistance or load torque R_1, R_2 and R_3 of the printing unit connected thereto, the torque transmitted between the components or sections **16** to **20** of the synchronising shaft should be zero and no problem to be dealt with would exist. The purpose of said synchronising shaft is however to transfer between the units the balance of power required to equalize the speeds and assure the desired angular relationship between the units irrespective of the individual load torques and, therefore, a more or less significant flow of energy in the form of equalizing torques is actually transmitted through the components **16** to **20** of said synchronising shaft. Now, as the said mechanical resistance R_1, R_2 and R_3 are variables and cannot be predicted and kept under control, the said flow of energy is out of control and can be unpredicably reversed between the units and shaft sections.

Now, according to the invention, the D.C. fed to each motor is controlledly fed so that one motor will have an

output torque greater than the amount required for meeting the mechanical resistance or load torque of the respective printing unit, at least another motor will have an output torque smaller than the corresponding amount referred to its respective printing unit, and so that the sum of the output torques of all motors will balance the sum of the mechanical resistances of all units to drive said units at the desired speed.

As the above conditions are satisfied, a flow of energy is caused to flow in one predetermined direction, said flow of energy corresponding to the difference between the above-mentioned output torques and the load torques or mechanical resistances in the said paired one and other motors and their respective printing units, along the components **16** to **20** of the synchronising shaft. The said one motor having the greatest output torque could be the one connected to the first, or to the last, or even one intermediate unit of the row, provided that a given flow of energy, of a predetermined value, would be transmitted in one given and constant direction from said motor and the adjacent printing unit or units.

In the arrangement shown, the said energy or power is indicated by letter x and the first motor M_1 is assumed to act as the said "one motor." Such motor M_1 will therefore be fed by its source A_1 so that its output will have the value "P_1 plus x," wherein P_1 corresponds to the power balancing the mechanical resistance R_1 of the respectively driven unit U_1. The said "another motor" is the third motor M_3 and its source of D.C. is so adjusted that the output torque of motor M_3 will have the value "P_3 minus x," wherein P_3 indicates the power necessary to meet the mechanical resistance R_3 of the respective unit U_3. The feeding of intermediate motor or motors (if any) will be adjusted to have an output P_2 as required to meet the mechanical resistance R_2 of its respective unit U_2, and in any case the sum of powers will balance the sum of mechanical resistances, that is

$$(P_1+x)+P_2+(P_3-x)=P_1+P_2+P_3=R_1+R_2+R_3$$

The difference x (positive or negative) will therefore provide the flow of energy transmitted, anytime in the one direction indicated by the arrow, through the components **16** to **20** of the cynchronising shaft. The amount of the thus transmitted energy is not essential. It may be of the order of 20 percent of the mean power of the motors, for example, as the substantial uniformity of such energy and, in particular, its constant direction of flow, will subject the said components to a substantial uniform torque and therefore it will induce a substantially uniform and constant torsional deformation in the operation of the multiunit printing machine.

Various means can be made use of for providing the required control of the outputs of the feeding of the several motors. As shown in the drawings, in the circuits connecting the individual sources A_1, A_2 and A_3, of D.C. to the armatures of the respectively fed motors M_1 and respectively M_2 and M_3, individual transducers I_1 and respectively I_2 and I_3 are designed to provide signals indicative of the current fed to the respective motor. Such signals are therefore substantially linearly proportional to the output power of the respective motor. Such transducers may consist of resistors and the signal may consist of a difference of potential taken between the terminals of said resistors. Preferably, said transducers consist of saturable reactors adapted to provide a signal consisting of an A.C. potential which will be suitably rectified.

The "one motor" M_1, which acts as "pilot" motor, is conventionally controlled to provide the required speed of run of the machine and the desired output. Such control is preferably provided by comprising, in a comparator circuit D_1, a reference potential T and speed signal provided by a tachometer dynamo **21** directly or gearedly connected to the shaft of said first motor M_1. The said comparator circuit D_1 provides an output difference signal which is applied, via a lead S_1, to the control means of

the controllable source A_1 of D.C. to the armature or to the field of said motor M_1, according to current knowledge. The said motor M_1 can therefore be controlled by adjustment of the reference potential T, according to the art, to provide the desired speed. The signal provided at the output of transducers I_1, I_2 and I_3 may be termed as "power signal" as it is indicative of the actual output power of the respective motor M_1 or respectively M_2 or M_3.

The power signal provided by transducer I_1 is separately compared with the power signals provided by transducers I_2 and I_3 in comparator circuits D_2 and respectively D_3, which therefore provide difference signals indicative of the relations existing between the actual outputs of motors M_1 and M_2, and respectively between the actual outputs of same motor M_1 and motor M_3. Said difference signals from D_2 and D_3 are applied, via leads S_2 and respectively S_3, to the control means of the respective controllable sources A_2 and A_3 of D.C. feeding the said motors M_2 and respectively M_3. It is evident that, upon suitable adjustment of parts, namely adjustment of the various circuits, the feeding of the various motors can be constantly kept under control so that the above discussed relations will be constantly satisfied, whilst the run of the entire printing machine will be adjusted and controlled upon adjustment of the reference potential T.

In FIG. 2 a part of the circuitry diagrammatically shown in FIG. 1 have been illustrated in a somewhat more detail. There are shown sources A_1 and A_2 of D.C. including controllable silicon diodes having control inputs at **30** and respectively **31**. Along leads **32** and **33** of the supply connections between said sources of D.C. and the armatures **34** and **35** of motors M_1 and respectively M_2 saturable reactors I_1 and I_2 are connected, said reactors being activated in A.C. at **36** and respectively **37** and provided with rectifiers **38** and respectively **39** so that a rectified power signal is provided at **40** and respectively at **41**, indicative of the actual power provided at the shafts of said motors M_1 and respectively M_2, as discussed above.

The power signals from **40** and **41** are applied to the inputs **42** and respectively **43** of the comparator circuit D_2 to provide at the center connection **44** thereof, the desired difference signal indicative of the actual relation of said actual powers provided by motors M_1 and M_2. Said difference signal is amplified in a suitable amplifier circuit Am_2 and then applied to the control input **31** of the source A_2 of D.C. supplying motor M_2.

The outputs of rectifier circuit **38** of transducer I_1 are further connected to the corresponding rectifier of transducer I_3 and to the comparator circuit D_3 of FIG. 1 to provide the difference signal to be applied to the source A_3 supplying the third motor M_3. The entire third circuitry related to said motor M_3 is similar to that related to motor M_2 and illustrated in FIG. 2 and, therefore, such third circuitry has not been illustrated in FIG. 2, for simplicity.

It is believed to be evident that the feeding of said motors M_2 and M_3 is controlled by difference signals, via leads S_2 and S_3 which correspond to the difference signal applied, via lead S_1, to the source of D.C. A_1 by the comparator circuit D_1 and provided by the comparison of the speed signal from tachometer dynamo **21** and the reference potential T, with respect to the first motor M_1. Such correspondence is advantageous in that the various electrical devices (comparator circuits, transducers, amplifiers and controllable sources of D.C. to supply the motors) related to the various units, can be similarly constructed and connected, and therefore a substantial saving in the manufacture, assembling and maintenance of the press may be attained.

It is further evident that the present invention includes various advantageous features, and it will be understood, too, that each of the new features described, and any combination thereof, may also find useful application

in other types of multiunit printing machines or apparatus differing from the one described.

Without further analysis the foregoing will so fully reveal the gist of this invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of this invention and, therefore, such adaptations should and are intended to be comprehended within the spirit and meaning of equivalents of the invention, as defined in and by the appended claims.

Having thus described the invention and the mode of making use thereof, what is claimed as new and desired to be protected by Letters Patent is:

1. An improved multiunit machine comprising a purality of driven units, a separate motor associated with and directly driving each printing unit indivdually, and a synchronising shaft having connected unit sections to mechanically connect said units to each other to equalize the speed thereof and maintain a predetermined angular relationship therebetween, characterized in that the multiunit machine includes as many controllable sources of electrical energy as there are separate motors are comprised in the machine, to individually and controllably feed said motors, transducer means sensitive to the energy individually supplied to said motors to provide power signals indicative of said energy and thereby of the mechanical resistance encountered by the individual motors and of the power output of the same, comparator circuits connected to pairs of said transducer means to provide difference signals indicative of the relation existing between the actual power output of motors driving adjacent printing units, said relation determining the magnitude and direction of torque transmitted between said unit sections, and circuitries connecting said comparator circuits to said controllable sources of electrical energy to apply to the controls of said source said difference signals for controlling the power outputs of said motor so as to maintain within predetermined limits said angular relationship of said unit sections—whereby in the said synchronising shaft a torque of predetermined constant magnitude is mechanically transmitted in a given direction between adjacent printing units.

2. The improved printing machine defined in claim **1**, wherein the said controllable sources of electrical energy consist of means providing a D.C. output and wherein said transducer means are connected in the circuits individually connecting each one of said sources to the armature of the respectively fed motor.

3. The improved printing machine defined in claim **2**, wherein the said controllable sources of D.C. consist of rectifier means including controllable silicon diodes, and wherein the outputs of said comparator circuits are selectively connected to the control inputs of said rectifier means.

4. The improved printing machine defined in claim **1**, wherein the said transducer means consist of saturable reactors.

5. The improved printing machine defined in claim **1**, and comprising a pilot printing unit and at least one further printing unit, a tachometer dynamo drivedly connected to the motor drivingly connected to said pilot unit and providing an output signal indicative of the actual speed of said pilot unit, a source of a reference potential, a first comparator circuit having inputs connected to said dynamo and to said source of reference potential and providing a first difference signal, means to apply said first difference signal to the control means of a first source of electrical energy feedingly connected to said motor of pilot unit, a first transducer means connected between said first source of energy and said motor and having an output providing a first power signal indicative of the electric energy supplied thereto and thereby of the actual power output of said motor, a further source of electrical energy feedingly connected to the further motor drivingly

connected to said further printing unit, a further transducer means connected between said further source of energy and said further motor and having an output providing a further power signal indicative of the actual power output of said further motor, a further comparator circuit having inputs connected to the outputs of said first and further transducer means and providing a further difference signal indicative of the actual relationship between the power outputs of said motors, and means to apply said further difference signal to the control means of said further source of energy to maintain within given limits the said relationship as the actual speed of the printing units is controlled and maintained upon adjustment of said reference potential.

6. In an apparatus in which a pair of rotary units are connected by a synchronising shaft in a preselected angular relationship for simultaneous rotation with each other and a first and an other electric motor is drivingly connected to the first and respectively the other of said units for individually meeting the respective mechanical resistances thereof, in combination, a first and an other controllable source of current having control input terminals and connected to said first and respectively to said other unit for individually feeding said motors, means responsive to said current to detect the actual power output of each motor and to provide power signals individually indicative of each power output, signal comparating means connected to provide a comparison of said power signals and a difference signal indicative of the relationship between the actual power outputs of said motors, and means to apply the said difference signal to the control input terminals of said other source of current to maintain within given limits said relationship and assure constant direction and magnitude of torque mechanically transferred through said synchronizing shaft.

7. In an apparatus as set forth in claim **6**, in which said combination comprises a tachometer dynamo connected to said first motor for rotation therewith and providing a speed signal indicative of the rotational speed

thereof, a reference potential, a comparator circuit connected to said dynamo and to said reference potential to provide a first difference signal, and means to apply said first difference signal to the control input terminals of said first controllable source of current to maintain at a given value the rotational speed of said units as a function of said reference potential.

8. In an apparatus as set forth in claim **6**, in which said synchronising shaft comprises shaft sections individually connected to each unit and clutch means to detachably connect said shaft sections to each other.

9. In an apparatus as set forth in claim **6**, in which said sources of current include controllable silicon diodes to supply rectified current to said motors, and wherein said difference signals are applied to the controls of said diodes.

10. In an apparatus as set forth in claim **9**, in which said means responsive to said current consist of transducer means connected in the circuits connecting said sources of current to the armature of the respectively supplied motor.

11. In an apparatus as set forth in claim **10**, in which said transducer means consist of saturable reactors.

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