Nov. 19, 1940. E. E. MAYER 2,221,982

ELECTROMECHANICAL DRIVING SYSTEM

Filed Nov. 24, 1937

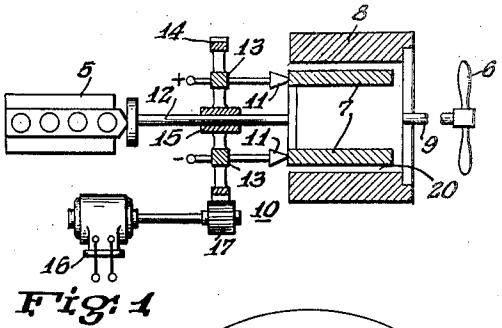


Fig. 1

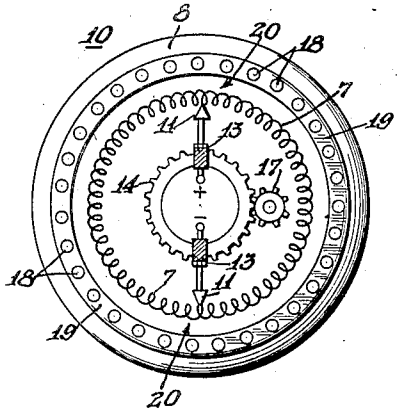


Fig. 2

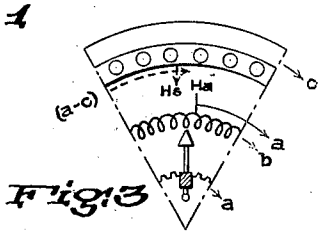


Fig. 3

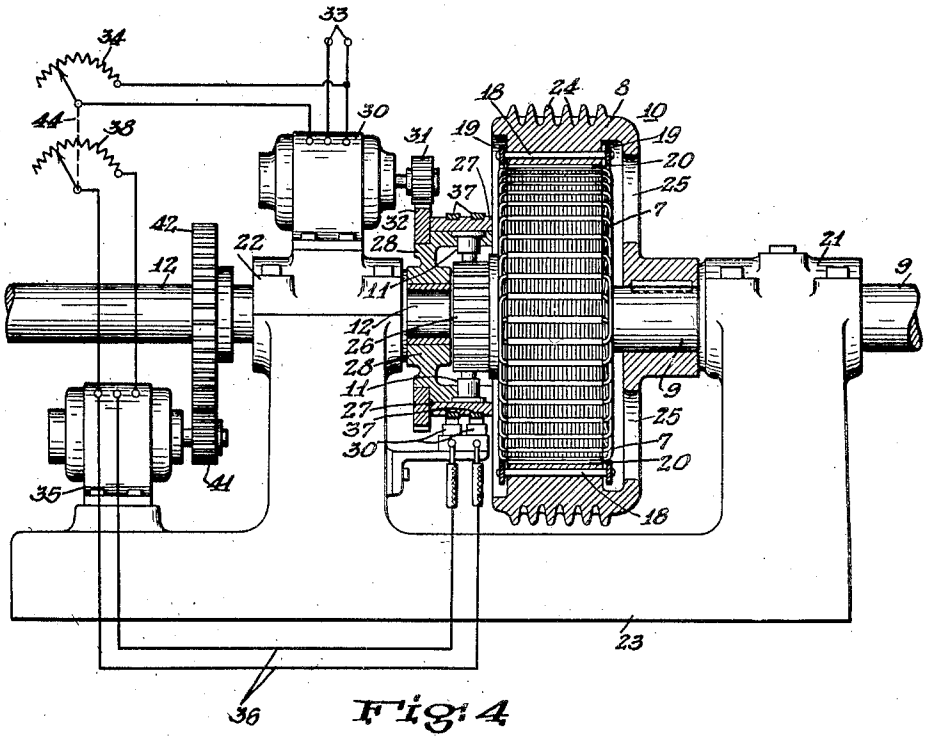


Fig. 4

INVENTOR.
Emil E. Mayer
BY Ostrolenk, Greener & Marsen
his ATTORNEYS

Patented Nov. 19, 1940 2,221,982

UNITED STATES PATENT OFFICE

2,221,982

ELECTROMECHANICAL DRIVING SYSTEM

Emil E. Mayer, New York, N. Y.

Application November 24, 1937, Serial No. 176,170

10 Claims. (Cl. 172—239)

My invention relates to electromechanical driving systems and more particularly relates to novel methods of and apparatus for electromagnetically driving a mechanical member at variable speeds upon direct actuation from a prime mover of substantially constant speed.

My present invention is particularly applicable as an efficient variable speed coupling between a Diesel engine and a load which is to be driven at different speeds. The commercial application of Diesel engines has been limited to substantially constant speed mechanism. Where variable speed driving was required an intermediate energy transformation generally was made. The Diesel engine was, for example, arranged to drive an electrical generator which in turn would operate an electrical motor at the proper speed required by the mechanical load. Such arrangement is obviously expensive in nature and adds to the weight and bulk of the installation. The electromechanical coupling system of my present invention makes possible wide variations in delivered speed with a minimum of auxiliary equipment.

Recent developments in Diesel engine design have brought forth high-speed Diesel engines which are very desirable for ship operation from power, low initial cost, weight and space considerations. However, in order to adapt such engines to operate the propeller, expensive gear-down mechanism is required and only one or two speeds of operation are feasible.

My invention is particularly adapted for coupling the propeller of a vessel with a Diesel engine to effect a wide range in speed control of the propeller, including reversed operation. The variable speed is performed by a simple control of the electromechanical coupling unit in a manner to be hereinafter described. The resultant speed of the driven member or load is independent of the speed of the prime mover. My invention is naturally applicable with any type of prime mover such as a steam engine, internal combustion engine and the like.

Besides the great flexibility of speed control made possible by my invention, other advantages result such as the practical elimination of vibrational shocks, the protection of the Diesel engine from excessive stresses and a simple operation for coupling and uncoupling of the engine and load.

The principle of my present invention depends upon the provision of a rotating magnetic field for driving an electrical member by induction motor action, together with means for variably controlling the speed of the rotating magnetic field independently of the speed of the prime mover.

In a preferred embodiment, a rotor constructed similar to the armature of a direct current dynamo is used having a comutator connected to the armature windings and brushes for coacting with the commutator. Direct current is impressed upon the armature windings through the commutator and brushes to generate a magnetic field about the armature having a predetermined spaced distribution with alternate north and south magnetic poles. The brushes are rotatably mounted with respect to the commutator and are driven at a speed independent of the commutator speed to rotate the magnetic field generated about the armature. The speed of rotation of the magnetic field with respect to the armature is directly determined by the speed of rotation of the brushes. In the preferred application the armature and commutator thereof is directly coupled to the prime mover, namely the Diesel engine.

A squirrel cage member is constructed concentric with and about the armature to intercept the rotating magnetic field. The squirrel cage structure is similar to that of an induction motor for effecting electromechanical coaction with the rotating magnetic field produced about the armature. The squirrel cage winding is driven at a speed substantially equal to the speed of rotation of the resultant magnetic field about the armature, differing therefrom by a slip, as in induction motor operation. A squirrel cage short-circuited winding is embedded in a structure similar to the rotor of an induction motor except that it is rotatably mounted concentric about the rotated armature. The squirrel cage or secondary winding of the electromechanical coupling unit of my invention is either mechanically connected to the driven load, such as the propeller of a vessel, or alternatively, may be directly driven; the coacting armature correspondingly being mechanically connected to the driver or load.

The speed of the prime mover, namely the Diesel engine, is maintained constant, or nearly so, for most efficient operation thereof, driving one of the coacting members of the electromechanical unit at the predetermined speed. The brushes for the armature are rotated at a variable speed by means of a separate small motor drive, creating a rotating magnetic field about the armature through which direct current is applied. The rotating magnetic field causes the squirrel cage or secondary winding to be driven

at a corresponding speed. The electrical interactions between the various components of the coupling unit of my invention will be hereinafter described in detail.

It is accordingly an object of my present invention to provide novel methods of and apparatus for variably driving a mechanical load from a substantially constant speed driving member.

Another object of my present invention is to provide a novel electromechanical coupling arrangement between a prime mover and a mechanical load.

Still another object of my present invention is to provide a novel electromechanical coupling between a constant speed prime mover and a variably driven load.

A further object of my present invention is to provide a novel electromechanical coupling unit operating by induction motor action together with means for independently controlling the speed of the rotating magnetic field thereof.

These and further objects of my present invention will become apparent in the following description taken in connection with the drawings, in which:

Figure 1 is a schematic illustration of the electromechanical coupling system of my present invention.

Figure 2 is a diagrammatic representation of the coupling unit thereof.

Figure 3 is a partial diagrammatic view used in presenting an analysis of the invention.

Figure 4 illustrates a preferred embodiment of my invention in elevation.

A schematic representation of a preferred form of my invention appears in Figure 1 wherein the electromechanical coupling unit 10 is connected between the prime mover 5, such as a Diesel engine, and propeller 6 of a vessel. It is to be understood that the application of my invention is not limited to either a Diesel engine prime mover or to a propeller load but is widely useful whereever a variable speed mechanical drive is required of a substantially constant speed driving member.

The coupling unit consists of a rotor 7 concentric with the secondary member 8 which is directly connected to the mechanical load or propeller 6 by shaft 9. The secondary member 8 is preferably a short-circuited squirrel cage winding well known to those skilled in the motor art, and coacts with the magnetic field generated by the armature or rotor member 7 in a manner to be described. The rotor 7, in a preferred construction, is similar to the armature of a direct current motor or generator, and is supplied with direct current through brushes as schematically indicated. The armature 7 is mechanically connected to the prime mover 5 by a shaft 12, or through mechanical gearing as desired. The brushes 11 conduct the externally generated direct current to the armature 7 through commutator segments associated with the armature 7 but not shown in the diagrammatic Figure 1.

The passage of direct current through the armature windings of the rotor 7 creates a magnetic field about the rotor having a distribution in space producing alternate north and south magnetic poles as will be understood by those skilled in the art. The number of poles produced is optional and depends upon the normal speed ratio required between the prime mover and the driven member.

In accordance with my invention, the brushes 11 are rotated at a speed independent of the armature 7 speed to directly control the speed of rotation of the resultant magnetic field about the rotor 7. As seen in Figure 1, the brushes 11 are insulatingly mounted upon gear 14 by insulation members 13. Hub 15 of gear 14 is rotatably mounted upon the drive shaft 12. A variable speed motor, preferably a direct current motor 16, is employed to drive the brush gear 14 through pinion 17 intermeshing therewith.

The speed of rotation of the magnetic field generated by the armature 7 depends solely upon the speed of rotation of brushes 11. Thus, for example, if the armature 7 were stationary and the brushes 11 were rotated, the space distribution of the magnetic field would change in correspondence with the movement of the brushes 11 over the commutator segments of the armature. Rotation of the armature 7 with respect to the brushes does not affect the space distribution of the resultant magnetic field about the armature 7 as will be evident to those skilled in the art. The rotating magnetic field distribution about the armature 7 intercepts the windings of the short-circuited secondary member 8, and induces secondary currents therein which react with the rotating magnetic field by induction motor action.

The rotating magnetic field about the armature 7 carries with it the secondary member 8 at a speed somewhat less than the speed of the rotating field, which speed difference is generally designated as a percentage and termed slip. The relation of the speed of the armature 7 (driven by the constant speed prime mover 5) to the electromagnetic interactions will be thoroughly analyzed hereinafter. The resultant speed of the secondary member 8 connected to the propeller 6 is thus seen to depend solely upon the speed of rotation of the brushes 11 and the slip of the secondary member 8.

Figure 2 is a diagrammatic representation of the electromagnetic unit comprising my invention. The short-circuited secondary member 8 contains conductors 18 set transverse to the member 8. A short-circuited ring 19 connects the outer end of the conductors 18 to form a short-circuited winding corresponding to the well-known squirrel cage winding used in ordinary induction motors. The design of the squirrel cage member 8 is in accordance with established principles in the motor art with provision for laminated iron construction about the inductance 18 to minimize hysteresis and current losses in the member 8.

The armature 7 is indicated as a closed circuit winding concentric with the outer member 8. It is to be understood that the armature 7 is constructed similar to a direct current motor armature and is connected to commutator segments (shown in Figure 4), for coacting with the brushes 11 to produce a magnetic field distribution about the armature 7 having alternate north and south magnetic poles. A bipolar arrangement is shown with two brushes, one north and one south pole, but multi-polar and brush designs are used in practice for material speed reduction ratios. The brushes 11 are rotated by means of the gear 14 and its pinion 17 to generate the rotating magnetic field in the air gap 20 located between the armature 7 and the secondary member 8.

The following discussion relating to the theory of the electromagnetic interactions of component parts of electromagnetic coupling unit 10 of my invention will be helpful to a proper under-

standing thereof and for the actual design and construction of the unit.

Direct current is caused to flow through the windings of the armature 7 to produce a magnetic field distribution in the air gap 20 of unit 10. Rotation of brushes 11 by the gear 14 causes the distribution of magnetic flux in the air gap 20 to change in direct correspondence with the speed of movement of brushes 11. A magnetic field results from the direct current energization of the armature 7 and commutation thereof by brushes 11. This magnetic field rotates or moves in the air gap 20 at a speed and in direct correspondence to the movement of brushes 11.

Figure 3 is a partial schematic representation of my invention. A rotating magnetic field, which we shall term H_a is accordingly produced by armature 7, which intercepts the inductors 18 of the squirrel cage secondary member 8. A voltage is induced in the inductors 18 by the moving magnetic field H_a which causes a secondary current to flow through the squirrel cage winding 18. The secondary current in inductors 18 creates a counter-magnetic field H_s which interacts with the armature magnetic field H_a.

The interaction of the magnetic field H_a and H_s creates a torque which causes the secondary member 8 to be rotated. In order for current to be induced in inductors 18 there must exist a relative speed between the inductors 18, and the revolving field H_a. This is analagous to the operation of the squirrel cage of an induction motor. The frequency of the current induced in the inductors 18 is proportional to the difference in speed between the member 8 and the rotating field H_a.

For further analysis we shall assign the following letters to represent the relative speeds of the several components of the coupling unit 10. In this analysis the speeds referred to shall be understood to all be relative speeds, as reduced to a common basis. The actual speeds, of course, will depend on the number of poles used.

a=Relative speed of revolving brushes 11

b=Relative speed of armature 7 as driven by engine 5

c=Relative speed of squirrel cage or secondary member 8

The speed of the rotating magnetic field H_a is directly dependent upon the speed of the brushes 11. Therefore the relative speed of rotation of H_a equals a, and is in the same direction as the movement of the brushes 11. The relative speed c of the secondary member 8 is in the same direction as that of the rotating magnetic field H_a but somewhat less than the value a due to the requisite slip therebetween.

The frequency of the currents induced in the squirrel cage inductors 18 is proportional to the slip frequency, namely proportional to $(a-c)$. The secondary currents in the inductors 18 generate a rotating magnetic field H_s revolving, with respect to the secondary member 8, at a speed equal to $(a-c)$ in the same direction as member 8. However, the relative speed of the secondary magnetic field H_s in the air gap 20 is equal to the speed of the member 8 namely c, plus the speed of H_s with respect to member 8 namely $(a-c)$, resulting in a speed of a. The speed of the armature magnetic field, H_a is also a.

It is accordingly seen that the interacting magnetic fields H_a and H_s rotate at the same relative speed, a, which speed is directly determined by the speed of the rotating brushes 11 operated by the variable speed motor 16. In order to vary the speed of the secondary member 8 and therefore that of the mechanical load, the propeller 6 of Figure 1, it is only necessary to control the speed of the gear 14 by means of the variable speed motor 16. The brushes 11 are readily rotated by a small auxiliary motor 16 in either direction and at a speed within wide limits to effect the variable speed of operation upon the mechanical load, independently of the speed of operation of the prime mover 5.

The rotation of the brushes 11 with respect to the armature 7 causes an alternating current to flow in the armature windings. The frequency of the alternating current of armature 7 depends upon the difference in speed between the armature and the brushes. If the brushes 11 and armature 7 rotate in synchronism, then the magnetic field H_a will rotate at that same speed and the inductors of the armature 7 would not be intercepted, thereby resulting in zero induced current in the armature 7. The current flowing through the windings of armature 7 is conducted thereto from the external source to generate the magnetic field H_a. In accordance with the principle of my invention the armature 7 is rotated at a speed independent of the speed of the brushes 11, resulting in a difference in speed equal to $(a-b)$. The speed of the magnetic field H_a is determined by the brush speed and equal to a. The windings of armature 7 will therefore be intercepted by the magnetic field H_a to produce alternating current at a frequency proportional to the relative speed thereof, namely $(a-b)$.

It will be recalled that the secondary member 8 generates a counter magnetic field H_s traveling in the air gap 20 at a speed a equal to the primary magnetic field H_a. The magnetic field H_s accordingly induces an alternating current in the armature winding 7 of the same frequency as that produced by the field H_a, namely a frequency corresponding to $(a-b)$. The magnetic field, H, in the air gap 20 may be viewed as the resultant of the magnetic fields H_a and H_s. The windings of armature 7 are intercepted by the resultant magnetic field at the relative speed $(a-b)$, to produce a resultant alternating current in the armature 7 of frequency proportional to $(a-b)$.

The magnitude of the alternating current I_a induced in the armature winding by the action of the magnetic field H intercepting the armature 7 accordingly, like the frequency, corresponds to the factor $(a-b)$. The voltage E_a induced in the armature winding 7 by the rotating magnetic field H in the air gap 20 has a frequency corresponding to the $(a-b)$ factor and is of a magnitude proportional to the relative speeds between the magnetic field H and the inductor speed of armature 7, namely $(a-b)$.

The alternating voltage produced by the magnetic field reacting on armature 7 has a frequency corresponding to $(a-b)$ and a magnitude also corresponding to $(a-b)$. However, $(a-b)$ is the relative speed between the rotating brushes 11 and the armature 7 produced by the prime mover 5. The counter voltage E_a produced in the armature 7 may be viewed as depending upon the differential speed between the armature 7 and the driven load 6 since the speed of the driven load is that of the secondary member 8 which has substantially the speed of the rotating magnetic field H (minus a nominal slip).

The commutation of the armature winding 7 by brushes 11 is at a frequency corresponding to

(a–b). Therefore the direct current input to the brushes 11 for the armature 7 will counteract the countervoltage E_a in the armature winding 7 which is of the same frequency of commutation. Accordingly, the direct current voltage impressed upon the brushes 11 need merely be increased in accordance with the difference in speed between the armature 7 and the brushes 11 namely (a–b) to counterbalance the countervoltage E_a impressed upon the armature 7. The countervoltage E_a tends to produce corresponding current I_a in the armature 7 which would demagnetize the original magnetic field H_a produced thereby. However, by the simple expedient of increasing the voltage impressed across the brushes 11, this counteraction or demagnetization effect is compensated for and the predetermined magnetic field intensity in the airgap 20 is maintained.

Figure 4 illustrates a preferred physical embodiment for carrying out the principles of my present invention. Electromagnetic coupling unit 10 is supported between bearings 21 and 22 extending from the base 23 of the structure. The driven shaft 9 is connected to the variable speed load such as the propeller 6 illustrated in Figure 1. The secondary member 8 is secured to shaft 9. The secondary member 8 is an iron structure overhanding and concentric with the armature 7. Member 8 contains the inductors 18 of the short-circuited squirrel cage winding. Copper rings 19 connect the ends of the bar inductors 18 to form the short-circuited squirrel cage which is embedded in the structure 8 in a manner well known in the electrical art. I prefer to employ cooling fins 24 projecting from the outer surface of the secondary member 8 to facilitate cooling the unit 10. Ventilating holes 25 in member 8 are employed to further assist in the ventilation of the unit 10.

The armature 7 is rotatably mounted within the secondary member 8 and is somewhat spaced therefrom to form the air gap 20. The armature 7 is constructed similar to the armature of the direct current motor containing a laminated structure having slotted portions at the periphery for insertion of the armature inductors forming the armature winding thereof. The commutator segments 26 connect with the armature winding in a well-known manner and rotate therewith. Armature 7 is secured directly to the driving shaft 12 which is connected to the prime mover 5 as shown in Figure 1. The brushes 11 are insulatingly mounted in a brush ring 27 concentric about the commutator 26. The hub 28 of the brush ring 27 is rotatably mounted upon shaft 12 and is arranged to be driven by motor 30 through the associated pinion 31 and the gear 32 intermeshing therewith. Gear 32 is secured to the brush ring 27.

The motor 30 is a variable speed motor designed to operate the brushes 11 at the speeds required to accomplish the variable driving of the system. A shunt-wound or compound-wound direct current motor is preferable as the motor 30, energized by a direct current source 33 which may be the vessel's lighting supply or any other suitable energy source. The variable resistance indicated at 34 connected to the motor 30 is used to control the speed of the motor 30. It is to be understood that a different type of drive may be employed in place of the motor 30 for driving the brush ring 27.

The direct current for energizing the armature winding 7 is preferably generated by a direct current generator 35 driven by the driving shaft 12 as shown in Figure 4. The gear 41 connected to generator 35 is driven by the gear 42 integral with or secured to the drive shaft 12. The speed of rotation of the driving shaft 12 is substantially constant according to the conditions of the invention and the output voltage of the generator 35 as found across the output leads 36 is controlled by the variable resistance 38 schematically shown in circuit with the generator 35. The direct current supply from leads 36 is connected to the appropriate brushes 11 through slip rings 37 insulatingly mounted about brush ring 27.

The operation of the electromechanical coupling arrangement of my invention is as follows:

The drive shaft 12, operating at a substantially constant speed, rotates the armature 7 which is energized by the direct current produced by generator 35 and supplied to the brushes 11 connected to the commutator 26 of the armature 7, through the slip rings 37. A magnetic field is produced in air gap 20 between the armature 7 and the secondary member 8 rotating in a direction and a speed determined by the operation of the motor 30 which rotates the brushes 11 independently about the commutator 26.

The secondary member 8 rotates in the direction of the magnetic field in the air gap 20 at a speed substantially equal thereto, which speed is determined by the actual rotation of the brushes 11 by motor 30. The speed and direction of motor 30 are controlled by the operator in a manner well-known in the electrical art and schematically indicated by the variable resistance or field rheostat 34. The rotation of the secondary member 8 carries the shaft 9 for driving the mechanical load such as the propeller of a vessel.

When the speed of rotation of the brushes 11 is made equal to the driven speed of the armature 7, negligible counter-voltage is induced in the armature 7. However, when the speed of rotation of the brushes 11 is faster or slower than the normal predetermined speed of the armature 7, a countervoltage E_a is induced therein in a manner hereinabove described having a frequency and magnitude proportional to (a–b). In order to compensate for the countervoltage E_a to maintain stability of operation, and sufficient magnetic strength in the air gap for proper torque characteristics of the coupling, the voltage output of the generator 35 is varied in accordance with the speed difference (a–b).

An important feature of my invention resides in the automatic compensation of the countervoltage E_a induced in the armature 7 as the variable speed between the armature 7 and the driven member 8 is effected. The resultant speed of the driven secondary member 8 is directly dependent upon the speed of the brushes 11 and therefore the speed and rotation of the motor 30. The operation of the motor 30 is manually controlled by the operator by means of the variable resistance 34 or equivalent electrical or electro-mechanical elements. The compensating voltage generated by 35 is controllable by the variable resistance 37.

By arranging a uni-control element, schematically indicated at 44, for the manually controllable units 34 and 38, and by designing the control feature to properly compensate for the voltage in accordance with the variable speed ranges employed, automatic variable speed control of my invention is effected. The variation of the voltage output by generator 35 is controlled by the variable resistance 38. The resistance 38 is designed so that with the manual

movement of the speed control resistance **34** of the motor **30**, proper voltage output of the generator **35** is effected by corresponding motion produced on the variable resistance **38** through the uni-control feature **44**, as will now be evident to those skilled in the art.

Having described a preferred arrangement for carrying out my invention it will be evident that modifications are feasible which fall within the broader spirit and scope thereof. For example, the armature **7** with its associated commutator may be mechanically connected directly to the driven load such as propeller **9**, and the secondary member **8** correspondingly mechanically secured to the driven shaft **12**. It will thus be evident that the mechanical relation of the armature and secondary member with respect to the driving and driven shafts is interchangeable. Also, the relationship between the armature **7** and the outer secondary member **8** may be reversed whereby the squirrel cage **8** becomes the inner member, and the armature **7** becomes the outer member, overhanging and concentric about the squirrel cage winding.

It is to be understood that the independent rotation of the brushes **11** about the commutator **26** for the armature **7** may be effected by any conventional driving means and may be operated in either direction, faster or slower than the rotation of the driven armature **7** to effect a faster or slower speed of the driven shaft **9** and even effect a reversal of operation of the driven shaft **9** with respect to the driving shaft **12**. Compensation of the countervoltage in the armature may also be accomplished by various expediencies and in a manner preferably automatic in nature to insure the most efficient operation of the system.

I claim:

1. In combination, a driving member; a driven member; and a coupling for variably driving said driven member at variable speeds from said driving member comprising a rotatable armature driven by said driving member, means for energizing said armature for producing a magnetic field arranged with an alternate north and south magnetic pole distribution, means for superimposing a rotation of said magnetic field independent of the rotation of said armature, and a secondary member responsive to the magnetic field and continuously rotated thereby at a speed corresponding to the resultant speed of rotation of said magnetic field.

2. In combination, a substantially constant speed driving member; a driven member; and a coupling for variably driving said driven member at variable speeds from said driving member comprising a rotatable armature driven by said driving member, means for energizing said armature for producing a magnetic field circularly arranged with an alternate north and south magnetic pole distribution, means for superimposing a rotation of said magnetic field independent of the rotation of said armature, and a secondary member for reacting with the magnetic field and continuously rotated thereby at a speed corresponding to the resultant speed of rotation of said magnetic field.

3. In combination, a substantially constant speed driving member; a driven member; and a coupling for variably driving said driven member at variable speeds from said driving member comprising an armature driven by said driving member, means for energizing said armature for producing a magnetic field arranged with an alternate north and south magnetic pole distribution, means for superimposing a rotation of said magnetic field independent of the rotation of said armature; and a secondary member for reacting with the continuously rotated magnetic field and rotated at a speed corresponding to the resultant speed of rotation of said magnetic field comprising a rotor winding arranged concentric with said armature.

4. In combination, a driving member; a driven member; and a coupling for variably driving said driven member from said driving member operating at a substantially constant speed comprising an energized armature for producing a magnetic field with an alternate north and south magnetic pole distribution, said armature being mechanically connected to for rotation by said driving member at said speed; means for superimposing a rotation of said magnetic field independent of the rotation of said armature; and a secondary member mechanically connected to said driven member for reacting with the rotated magnetic field and rotated at a speed substantially equal to the resultant speed of rotation of said magnetic field comprising a short-circuited rotor winding arranged concentric about said armature.

5. In combination, a driving member; a driven member; and a coupling for variably driving said driven member from said driving member operable at a predetermined speed comprising electrically energized electromagnetic means for producing a magnetic field with an alternate north and south magnetic pole distribution including a direct current armature having a commutator, and brushes for impressing direct current on the armature; means for continuously rotating said magnetic field, independent of the rotation of said armature comprising mechanism for rotating said brushes over said commutator; and a secondary member for reacting with the magnetic field and continuously rotated at a speed corresponding to the resultant speed of rotation of said magnetic field, said armature being mechanically connected to for being driven by said driving member, and said secondary member being mechanically connected to for driving said driven member.

6. A coupling for variably driving a driven member from a driving member operable at a predetermined speed comprising electromagnetic means for producing a magnetic field with an alternate north and south magnetic pole distribution, said electromagnetic means being mechanically connected to for rotation by said driving member and including a direct current armature having a commutator, and brushes for impressing direct current on the armature; means for continuously rotating said magnetic field independently of the rotation of said armature comprising mechanism for rotating said brushes about said commutator; and a secondary member mechanically connected to said driven member for reacting with the magnetic field and rotated at a speed corresponding to the resultant speed of rotation of said magnetic field comprising a squirrel cage rotor winding arranged concentric with said armature.

7. A coupling for variably driving a driven member from a driving member operable at a predetermined speed comprising electromagnetic means for producing a magnetic field with an alternate north and south magnetic pole distribution including a direct current armature having a commutator, and brushes for impressing direct current on the armature; means for con-

tinuously rotating said magnetic field independently of the rotation of said armature comprising mechanism for rotating said brushes over said commutator; a secondary member for reacting with the magnetic field and rotated at a speed corresponding to the resultant speed of rotation of said magnetic field comprising a short-circuited rotor winding arranged concentric with said armature; a generator connected to said brushes for supplying said direct current to said armature; and means for controlling the voltage of said generator to counteract a counter-voltage produced in said armature dependent upon the relative speed of rotation between said armature and rotor.

8. A coupling for variably driving a driven member from a driving member operable at a predetermined speed comprising electromagnetic means for producing a magnetic field circularly arranged with an alternate north and south magnetic pole distribution, said electromagnetic means being mechanically connected to for rotation by said driving member at said speed and including a direct current armature having a commutator, and brushes for impressing direct current on the armature; means for continuously rotating said magnetic field independently of the rotation of said electromagnetic means comprising mechanism for rotating said brushes over said commutator including a variable speed motor having a variable resistance for controlling the speed thereof; a secondary member mechanically connected to said driven member for reacting with the rotated magnetic field and rotated thereby at a speed corresponding to the result speed of rotation of said magnetic field; a generator for supplying said direct current to said armature, having a variable resistance for controlling the generated voltage thereof; and uni-control means for inserting in said motor and generator variable amounts of said motor and generator variable resistances.

9. A coupling for variably driving a driven member from a driving member operating at a substantially constant speed comprising electromagnetic means for producing a magnetic field, comprising a direct current armature having a commutator and brushes for impressing direct current on the armature; means for rotating said magnetic field independently of the rotation of said armature comprising mechanism for rotating said brushes about said commutator including a variable speed motor; a secondary member for reacting with the magnetic field and rotated at a speed corresponding to the resultant speed of rotation of said magnetic field; a generator for supplying said direct current to said armature, having means for controlling the generated voltage thereof; and uni-control means for inserting variable amounts of resistance to vary said motor speed and generator voltage for controlling said generated voltage to counteract a counter-voltage produced in said armature dependent upon the relative speed of rotation between said armature and rotor.

10. A coupling for variably driving a driven member from a driving member operable at a predetermined speed comprising electromagnetic means for producing a magnetic field arranged with an alternate north and south magnetic pole distribution, mechanically connected for rotation by said driving member at said predetermined speed, comprising a direct current armature having a commutator and brushes for impressing direct current on the armature; means for rotating said magnetic field independently of the rotation of said armature comprising mechanism for rotating said brushes about said commutator including a variable speed motor having a variable resistance for controlling the speed thereof; a secondary member mechanically connected to said driven member for reacting with the rotated magnetic field and rotated at a speed corresponding to the resultant speed of rotation of said magnetic field comprising a squirrel cage rotor winding arranged concentric about said armature; a generator for supplying direct current to said armature, mechanically connected to said driving member, having a variable resistance for controlling the generated voltage thereof; and uni-control means for inserting in said motor and generator variable amounts of said motor and generator variable resistances for controlling said generated voltage to counteract a counter-voltage produced in said armature due to the relative speed of rotation between said armature and rotor as determined by the operation of said rotor.

EMIL E. MAYER.