

Nov. 15, 1966

E. S. SILVER

3,286,145

EDDY CURRENT APPARATUS

Filed Nov. 8, 1963

3 Sheets-Sheet 1

FIG. 1

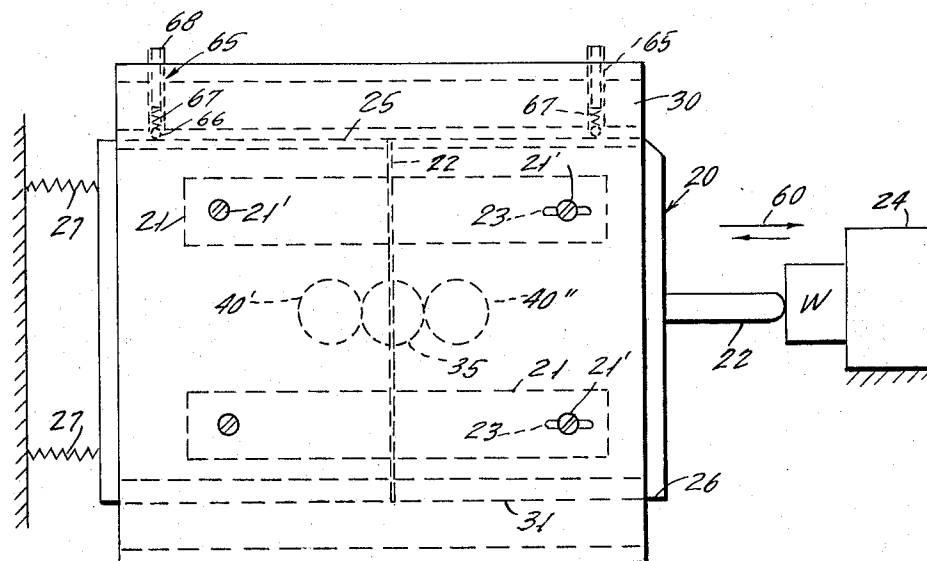
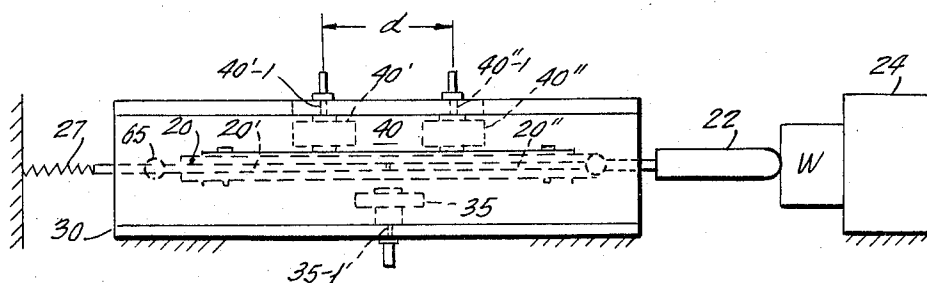


FIG. 2

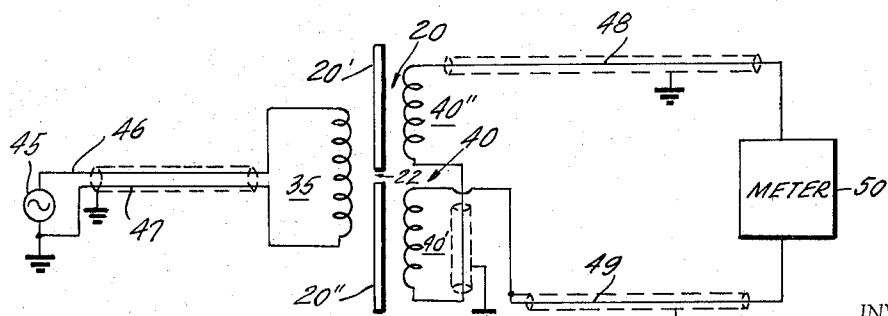


FIG. 3

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FIG. 5.

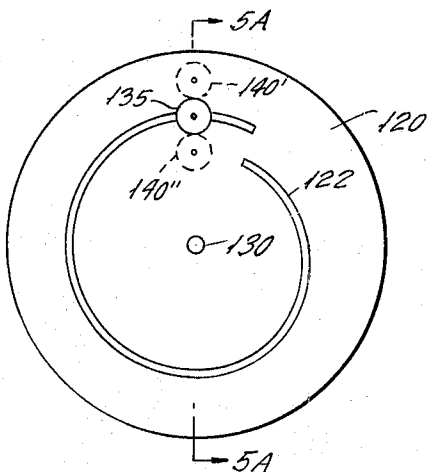


FIG. 5A.

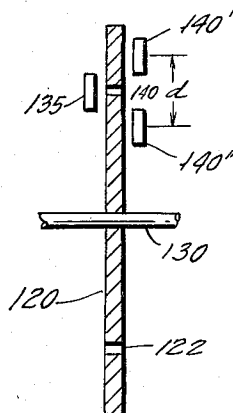


FIG. 6.

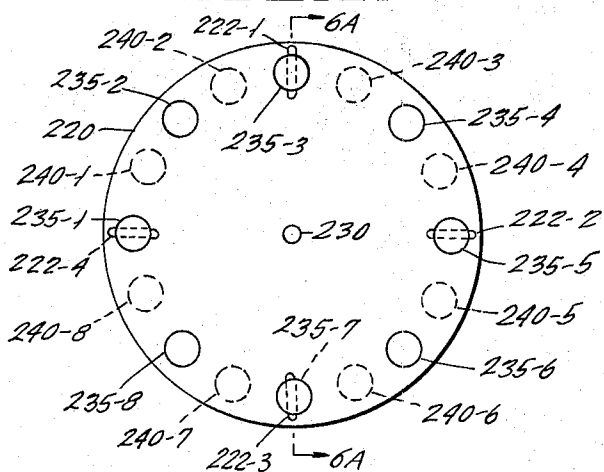


FIG. 6A.

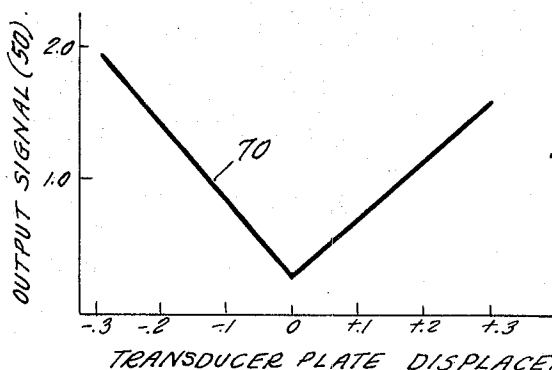
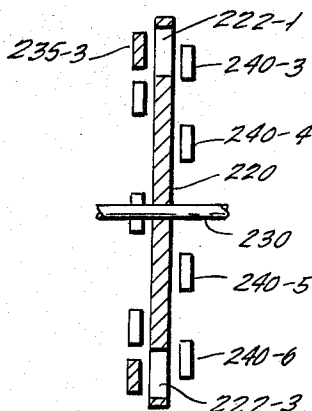


FIG. 4.

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FIG. 7.

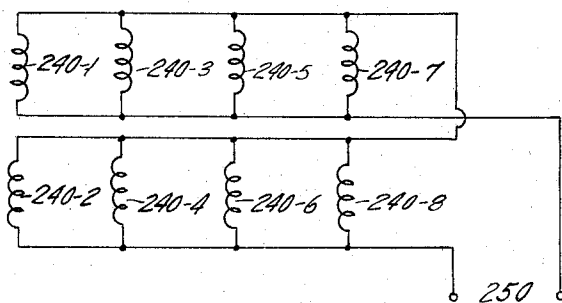


FIG. 8.

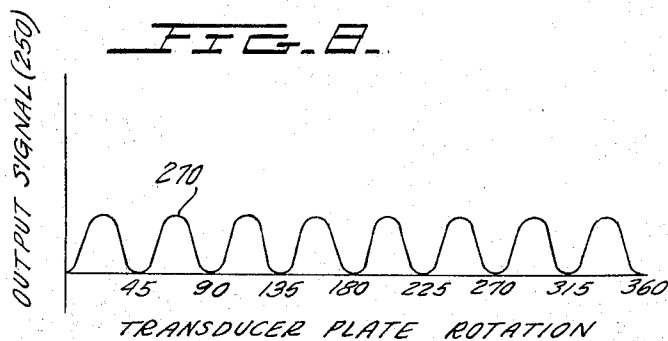


FIG. 9.

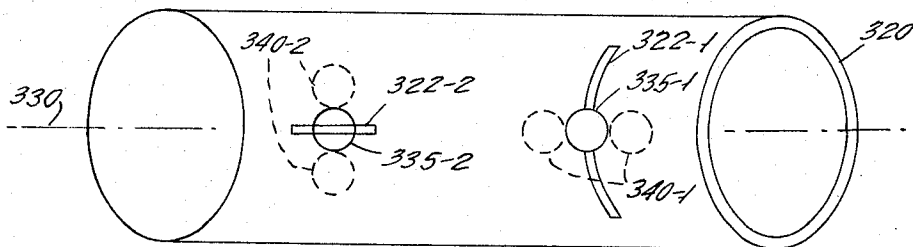
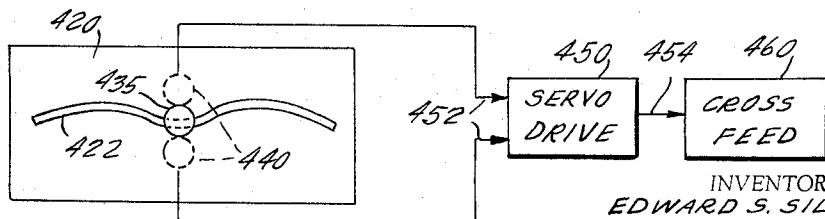


FIG. 10.



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EDDY CURRENT APPARATUS

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14 Claims. (Cl. 318—31)

My invention relates to an eddy current apparatus, and more particularly to such an apparatus employing the phenomenon of variation in eddy current field patterns about the vicinity of a predeterminedly positioned discontinuity to provide a transducer of improved simplicity, versatility and ease of operation.

A substantial variety of transducer types are presently known to convert physical movement into an electrical signal. As new applications have presented themselves, the transducer art has developed an increasingly greater variety of individual types of devices, each having increasingly specialized utility and necessitating various intricate arrangements of operating members. As, for example, the well known linear differential transformer is one such device which has shown favorable operation only when limited to certain definite application. The instant invention advantageously avoids the need for such a variety of limited utility transducer types, by providing a basic transducer mode of operation which may be easily adapted to satisfy a considerable variety of system requirements.

It is known that when a conductive member, such as a copper plate, is subjected to the action of an alternating magnetic field, eddy currents will be induced therein. If the conductive member is homogeneous, the eddy current distribution will establish uniform electromagnetic fields about the coupling regions. However, should the conductive member have a discontinuity, such as a slit or scratch, a distinctive variation in the electromagnetic field thereabout will be established. Various devices are presently known which utilize this phenomenon to locate flaws, cracks or other imperfections in an article by scanning the surface of an article with a device producing the eddy current pattern and detecting the abrupt variation of the eddy current distribution at the location of the flaw. I have, however, observed that in addition to providing such an abrupt variation, the electromagnetic field exhibits a regular variation about the coupling region, with the degree of such variation being directly related to the distance from the discontinuity.

Basically, my invention contemplates the utilization of a predeterminedly positioned discontinuity of known configuration, in conjunction with predeterminedly positionable primary and secondary coil means, such that relative movement of the known discontinuity about an established null coupling condition provides an indication accurately responsive to the extent of such relative movement. Substantial versatility of transducer movement may be provided simply by variation of the discontinuity configuration, coil placement and direction of transducer plate movement.

In the various embodiments to be henceforth described, I show a primary coil means positioned in inductive relationship with respect to a conductive transducer plate and a pair of series opposed secondary coil members spaced apart about the primary coil means and adjacent opposed surfaces of the transducer plate. Alternatively, the coil members may all be located along one side of the plate. For example, an E-core configuration may be utilized with the primary coil means forming the central leg and the secondary coil means forming the end legs. Should the voltages induced in each of the secondary coils be equal, they will cancel providing a net zero output voltage. This net zero output voltage, corresponding to a balanced condition of the transducer apparatus, is typically established when the discontinuity is symmetrically

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positioned intermediate the pair of secondary coil members and opposite the primary coil means. Should there be slight variations in the characteristics of the secondary coil means, or other factors upsetting the exact physical symmetrical arrangement such a balanced null condition may occur when the discontinuity is positioned other than exactly in between the pair of secondary coil members. Suitable adjustment of the discontinuity configuration or coil placement will, however, permit compensation for such variation, with the term symmetric as hereinafter used being inclusive of such an adjustment to obtain a symmetric electrical condition.

In one illustrative embodiment of my invention, the above described basic transducer movement is shown utilized to provide a linear transducer. The secondary coil members are spaced apart in a linear direction about the primary coil member. The transducer plate has an overall dimension considerably greater than the coil coupling region, and is positioned such that the primary and secondary coil members are located adjacent opposed surfaces thereof. The predetermined discontinuity longitudinally extends in a direction perpendicular to the spaced apart separation of the secondary coil members. The transducer plate is suitably restrained in the unit housing, such that its motion, and hence that of the discontinuity, is limited to the direction of the spaced apart separation of the secondary coil members. A balanced null condition is established when the longitudinal discontinuity is symmetrically positioned intermediate the spaced apart secondary coil members. Movement of the conductive plate to asymmetrically locate the discontinuity with respect to the pair of secondary coil members will increase the inductive coupling to one of said secondary coil members, while decreasing the inductive coupling to the other of said secondary coil members. Accordingly, the output signal provided by the sum voltage of the series opposed secondary coil members will experience a variation of amplitude and phase, which is operatively responsive to the extent of movement of the discontinuity within the coupling region. Movement of the transducer plate itself has been found to provide preferable linearity and simplicity of operation. However, my invention also contemplates providing such relative movement by movement of the coil members with the plate being stationary. Further, the basic linear transducer may be extended over greater operating ranges by providing a multiplicity of coupling coil and discontinuity groups, suitably circuit connected in successive or vernier arrangement.

In another embodiment of my invention, angular or rotary transducer movement is provided by rotating a somewhat modified transducer plate about a central axis. The primary and secondary coil members are inductively positioned adjacent the transducer plate, with the series opposed secondary coil members being spaced apart in a radial direction. The discontinuity slit extends in a generally spiral direction of gradually varying radius about the center of transducer plate rotation. Accordingly, rotation of the transducer plate will vary the location of the slit portion intermediate the primary and secondary coupling means, to individually vary the inductive coupling of each of the pair of series opposed coils, thereby yielding an output signal responsive to the extent of such angular variation.

In another rotary transducer embodiment of my invention, a plurality of primary and secondary coupling members are circularly disposed about respectively opposed regions of a rotatable transducer plate, with each of the primary coupling members being angularly intermediate a cooperating pair of secondary coupling members. The discontinuity means comprise a plurality of angularly separated radial slits. The primaries are electrically con-

nected in parallel adding with their individual field being in noninterfering relationship. The secondaries are in a series opposing relationship such that the symmetric location of the slits opposite predetermined ones of the primary coupling members, and intermediate the angular separation of its cooperating pair of secondary coupling members, will define a balanced coupling condition providing a null at the output of the secondary coupling members. Rotation of the plate will upset the null condition, providing a maximum signal responsive to the slits being positioned opposite predetermined ones of the secondary coil members. The output signal undergoes a series of cyclic variations, determined by the number of secondary, primary coil arrangements positioned thereabout, with the output signal providing an accurate indication of angular rotation. Further, such a cyclic output variation may be used in a manner synonymous to a gearing arrangement to effect rotation of a shaft proportionately responsive to the rotation of the transducer plate. Accordingly, by such an arrangement a step-up rotational arrangement may be effected in a manner avoiding the mechanical engagement problems, such as backlash, of individual gearing members.

As a further embodiment of my invention, a single transducer plate includes a plurality of discontinuity slits and coupling coil groups simultaneously responsive to components of motion in more than one direction. As, for example, the plate may be closed upon itself to have a cylindrical configuration, and include a first slit extending in the longitudinal axial direction of the cylinder and a second slit extending in a circumferential direction. This arrangement provides independent output signals responsive to rotation or axial movement of the cylindrical transducer plate. Further, the individual coupling groups of such a dual motion transducer may be designed to operate with and be sensitive to differing frequencies, so as to avoid interference coupling therebetween.

As another embodiment of my invention, the discontinuity slit may be of a pre-programmed configuration to provide an output signal along the length thereof directed to operate a servo-positioning arrangement. For example, the preprogrammed transducer plate may be attached to the carriage of a machine tool, such as a lathe. Longitudinal movement of the feed along the lathe bed effects relative movement of the secondary and primary coupling members along the length of the preprogrammed discontinuity slit. The instantaneous location of the slit portion intermediate the pair of series opposed secondary coil members will generate an electrical signal, which signal may be directed to the cross-feed to guide the cutting tool in accordance with the preprogrammed configuration of the longitudinal slit.

It is therefore seen that the basic concept of my invention resides in providing a basic transducer structure which permits a substantial versatility of individual transducer movements, thereby avoiding the myriad of devices heretofore necessary to provide such a variety of movements.

It is therefore a primary object of my invention to provide a transducer apparatus of improved simplicity of operation and increased versatility.

A further object of my invention is to provide a transducer apparatus employing the phenomenon of variation in eddy current coupling about the vicinity of a predeterminedly positioned discontinuity to provide a transducer of improved simplicity, versatility and ease of operation.

Another object of my invention is to provide an eddy current apparatus including primary and secondary coupling means inductively positioned about a transducer plate containing a predeterminedly positioned discontinuity means.

An additional object of my invention is to provide such an eddy current apparatus wherein the relative movement of the transducer plate with respect to the primary and

secondary coupling means provides an output electrical signal operatively responsive to the extent of such relative movement.

Still a further object of my invention is to provide such an eddy current apparatus wherein suitable variation of the discontinuity configuration or coil placement permits substantial versatility of transducer movements.

Still another object of my invention is to utilize such an eddy current transducer apparatus to provide pre-programmed follow-up servo movement of a positioning apparatus.

Still an additional object of my invention is to provide an eddy current apparatus which simultaneously yields output signals responsive to components of motion in more than one direction.

Yet a further object of my invention is to provide an improved transducer apparatus, accurately responsive to rotational movement.

Yet another object of my invention is to provide a transducer apparatus comprising a conductive plate having a predeterminedly positioned discontinuity of known configuration, primary and secondary coil means in cooperative coupling relationship about the discontinuity region of the plate, with the positioning of the discontinuity means effecting a variation in the electromagnetic field coupling between the primary and secondary coil means to provide an electrical signal responsive to the relative location of the discontinuity means thereabout.

These as well as other objects of my invention will readily become apparent after a consideration of the following drawings in which:

FIGURE 1 is a side elevation view of a linear transducer apparatus constructed in accordance with the basic teachings of my invention.

FIGURE 2 is a plan view of the apparatus shown in FIGURE 1.

FIGURE 3 is a simplified schematic representation showing the basic operation of the linear transducer of FIGURES 1 and 2.

FIGURE 4 is a graphical representation indicating the transducer movement provided by the embodiment of my invention shown in FIGURES 1 and 2.

FIGURES 5 and 5A diagrammatically show plan and cross-sectional end views of another embodiment of my invention to provide rotary transducer operation.

FIGURES 6 and 6A diagrammatically show plan and cross-sectional end views of still a further embodiment of my invention to provide rotational transducer information of improved accuracy.

FIGURE 7 illustrates the electrical connection of the secondary coil members shown in FIGURE 6.

FIGURE 8 illustrates the output signal provided by the embodiment of FIGURE 6, over a full revolution of transducer plate movement.

FIGURE 9 diagrammatically shows a still further embodiment of my invention to simultaneously provide two-degree of transducer movement information.

FIGURE 10 diagrammatically shows another embodiment of my invention as utilized to provide follow-up servo positioning responsive to the preprogrammed configuration of the discontinuity slit.

Reference is first made to FIGURES 1-4, which show the basic principles of my invention being employed to provide a linear transducer movement. Conducting transducer plate 20, typically formed of copper, contains a longitudinal slit 22. Transducer plate 20 is here shown constructed of two separate members 20', 20'', air-gap separated to form an adjustable slit 22. Plates 20', 20'' are joined by transverse member 21, connected thereto as by screws 21', with slits 23 in plate 20'' being preferably provided to permit an adjustment of slit width 22. Slit 22 may likewise be provided by forming conductive plate member 20 of a single member, containing a cut, scratch or other known discontinuity 22 therein to effect a suit-

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able variation of the eddy current field thereabout. Primary coil means 35 is mounted to housing 30 at a predetermined location, as by aperture 35-1. Similarly, secondary coil means 40, comprising series opposed coils 40', 40'', is mounted to housing 30 in spaced apart relationship about primary means 35, as by apertures 40'-1 and 40''-1. Secondary coil members 40', 40'' are spread apart in a direction perpendicular to the longitudinal extent of discontinuity slit 22. Plate 20 is maintained in this relationship by biasing means 65 bearing against edge surface 25 thereof, while the other edge surface 26 is guided along grooved housing 31. (The linear biasing means 65 may typically be formed of the biased arrangement of ball 66, spring 67 and adjusting screw 68.)

Primary coil means 35 is connected to a conventional type of A.C. generator 45 by a shielded leads 46, 47, and upon excitation thereof will establish an eddy current distribution within transducer plate 20. This eddy current distribution varies about the location of discontinuity 22 and will induce a voltage in the secondary coils 40', 40''. Coil members 40', 40'' are preferably identically constructed.

Accordingly, when the transducer plate member 20 is located as shown in FIGURES 1 and 2, with the longitudinal slot 22 symmetrically located intermediate the spaced apart separation of secondary coil means 40', 40'', the electromagnetic field generated by the eddy currents induced in conductive plate 20 will be so established as to generate equal voltages in each of the individual secondary coil members 40', 40''. Hence, their additive signal will cancel, presenting a null condition of voltage or phase to output meter 50, via shielded leads 48, 49. It is to be understood that although FIGURES 1 and 2 show an exactly symmetrical arrangement of the slit 22 intermediate the coil members to provide such a null or balanced condition, slight variations may be found in actual practice should there be minor deviations with respect to the characteristics or the placement of coil means 40', 40'' about primary coil means 35. Hence, the criteria for establishing such a null or balanced condition corresponds to there being equal voltages induced in coils 40', 40'' and is hence an electrically symmetric condition.

Linear translation of the plate 20 in either of the directions shown by arrows 60 will upset this null voltage relationship such that the voltages induced in one of the secondary coils will differ from the voltage induced in the other of the secondary coils, and accordingly present an output signal to output meter 50 operatively responsive to the extent of such relative movement. As an alternative to providing such relative movement by translating plate 20 relative to the stationary, primary and secondary means 35, 40, the coil means 35, 40 may be likewise moved. However, I have found that movement of the plate advantageously provides simplicity of construction and increased linearity of response. As a further alternative (not shown), a single primary coil may operate in conjunction with a single secondary coil, with the field coupling thereto being dependent upon the symmetric location of the slit with respect to the coil locations. Preferably, the secondary of this arrangement will be of a greater extent in the direction of transducer movement than is its cooperating primary coil means.

Linear translation of plate 20 may be provided in a variety of manners, depending upon the particular application desired; as, for example, FIGURES 1 and 2 show it being utilized as a comparator gage, wherein the work piece W to be measured is inserted in the region intermediate plate actuating projection 22 and stationary base support 24, with the tip of projection 22 being biased towards the work piece, as by spring 27. When a work piece of the desired size is placed within this region, the longitudinal slit 22 will be predeterminedly positioned (as, for example, symmetrically positioned as shown in FIGURES 1 and 2) to provide a known

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output signal. The placing of an oversized or undersized piece within this region will suitably translate plate 20 about its predetermined position to upset the eddy current coupling condition intermediate primary coil means 35 and secondary coil means 40, thereby yielding an output signal at 50 responsive to the extent of such size variation.

FIGURE 4 shows a typical transducer characteristic obtainable by the apparatus above discussed, utilizing a 10 millihenry air core primary energized by a 10.3 kilocycle source, in conjunction with identical 20 millihenry air core secondary coils. The coils were preferably operated near resonance for increased sensitivity, with it being understood that off-resonant operation may also be utilized. The slit width was adjusted to 0.008'', and the distance "d" between secondaries was $1\frac{15}{16}$ inches. Characteristic curve 70 shows a substantially linear response about both directions of the null position within approximately 0.5'', and having a sensitivity of about 0.179 millivolt output for each 0.001'' movement, per volt of primary excitation. The operating range may naturally be modified by suitable variation of the coil characteristics, placement, conducting plate and excitation frequency, as is dictated by the particular application, with it being understood that the above parameters are merely illustrative and in no way are intended to limit the scope of my invention.

FIGURES 5 and 5A diagrammatically show another embodiment of my invention, basically similar in operation to that above-discussed in conjunction with FIGURES 1-4, but utilizing a different slit configuration and coupling coil location to provide a rotary transducer movement. Plate 120 is suitably rotatably supported by a central axis member 130, and includes a spiral slit 122 having an angularly varying radius about the center of plate rotation. A primary excitation coil means 135 is located adjacent one side of plate 120 with a pair of series opposed secondary coil means 140 adjacent the other side being positioned along a radius of conducting plate 120, and spaced apart a distance d' about primary coil member 135. Accordingly, rotation of plate 120 will effect a repositioning of spiral slit 122 in the region intermediate the location of coupling members 135, 140 to vary the eddy current induced voltages generated within individual secondary coil members 140', 140''. The additive signal of series opposed coil members 140', 140'' may be presented to an output meter, in the manner analogous that shown in FIGURE 3 to provide an output variation operatively responsive to the extent of angular movement of transducer plate 120.

Reference is now made to FIGURES 6-8, which show a further embodiment of my invention for rotary transducer movement. A plurality of primary coil members 235-1 through 235-8 are shown circularly disposed in spaced angular relationship adjacent one side of circular conducting plate 220. A similar plurality of secondary coil members 240-1 through 240-8 are shown circularly disposed in spaced angular relationship about the opposite surface of conducting plate 220, with each of the primary coupling coils 235 being angularly intermediate a cooperating pair of secondary coupling coils 240. Conducting plate 220 is rotatively supported at central axis 230 and includes a plurality of radial slit members 222, illustratively shown equal to one-half the plurality of coupling coil groups, angularly separated about the coupling region of primary and secondary coil members 235, 240. The primary coil members 235 are connected to a suitable A.C. excitation source in parallel aiding relationship and induce noninterfering fields in plate 220. The secondary coil members 240-1 through 240-8 are connected in alternate parallel aiding relationship with the alternate parallel branches being connected in series opposition as schematically shown in FIGURE 7. The disposition of the radial discontinuity slits 222 opposite alternate primary coil means, as shown in FIGURES 5, 5A,

will establish a balanced coupling condition between the primary and secondary coil means, to provide a resultant null signal across output terminals 250. Rotation of plate 220 about axis 230 will periodically upset the null condition to provide a cyclic output signal variation 270 over a complete revolution, as shown in FIGURE 8. By presentation of the cyclic output signal to a suitable circuit, both the complete cycles and portions of the cycle may be registered to provide an accurate indication of the angular extent of rotation of plate 220 from a reference position. The use of several slits 232 and coil groups 235, 240 advantageously provides an averaging out of manufacturing inaccuracies. Further errors due to thermal or other physical changes will have only a secondary effect. That is, expansion of coupling coil diameters would not vary the effective centers of the coils; resistivity changes in the plate 220 would not affect the unbalance of a given asymmetric relationship; a size variation of plate 220 would merely cause relocation of the slits in the radial direction; and wobble of the plate will have a compensating effect in the additive output signal.

The cyclically varying output signal 270 may also be utilized to drive an output shaft (not shown) at a rotational speed directly proportional to the speed of rotation of conducting transducer plate 220 and the number of primary-secondary coupling groups. Accordingly, this permits a variation of output shaft speeds, while avoiding the difficulties of mechanical gearing arrangements.

FIGURE 9 diagrammatically shows a still further embodiment of my invention, wherein the conducting transducer plate 320 is of cylindrical shape. Cylindrical transducer plate 320 is both longitudinally movable along axis 330, and rotatable about axis 330. The extent of the longitudinal movement is sensed by circumferential discontinuity slit 322-1 in coupling arrangement with primary coil means 335-1 and longitudinally spaced-separated series opposed secondary coil means 340-1. Similarly, rotational movement of cylindrical conductive plate about axis 330 is sensed by longitudinal slit 322-2 in coupling arrangement with primary coil member 335-2 and the space-separated secondary coil means 340-2. As a modification thereof, the extent of the motion sensing rotation may be extended by changing slit 322-2 to be of a spiral-like configuration axially varying along the length thereof, to operate in conjunction with axially spaced apart series opposed secondary coil members. Each of the sensing arrangements 322-1, 335-1, 340-1; and 322-2, 335-2, 340-2 independently operate in the same general manner as shown above in conjunction with the single motion transducers, such that their respective outputs provide the components of transducer movement in their respective sensing directions. Alternatively, various other arrangements may be constructed to provide a plurality of sensing arrangements within a single transducer plate, as for example to provide indications of respectively orthogonal movement within a common plane. Such combinations of transducers may be effected either with a completely separate arrangement of discontinuity means and coupling coil members as shown in FIGURE 9, or with a common primary means excited by a plurality of excitation frequencies with the separate secondaries being sensitive to individual components of the excitation frequency.

Reference is now made to diagrammatic FIGURE 10, which shows a system utilizing the basic eddy current transducer concepts of my invention to provide follow-up servo movement, responsive to a preprogrammed discontinuity configuration. Conducting plate 420 comprises a longitudinal discontinuity 422 varying in a predetermined manner along the length thereof intermediate the space separation of series opposed secondary coil members 440. Conducting plate 420 may typically be secured to the carriage of a lathe, such that the coupling coil arrangement 435, 440 is longitudinally translated along the length of discontinuity 422. The particular instantaneous location

of the portion of slit 422 within the coupling region provides an output signal 452 to conventional servo drive circuit 450, to provide drive signal 454 to the cross-feed, thereby positioning the cutting tool in accordance with the programmed information of longitudinal slit 422. It is likewise understood that such a servo drive arrangement may likewise be used in conjunction with various other machine tools, both for continuous control and point-to-point positioning control, with there being appropriate modification of the discontinuity slit configuration and the relative movement thereof with respect to the coupling means to provide the desired preprogrammed positioning. Further, such a basic arrangement may be utilized as a function generator to form a slit configuration representative of an electrical or mechanical input signal, thereby providing a transducer movement of said input signal.

It is therefore seen that my invention provides a basic transducer movement responsive to the variation in eddy current coupling between primary and secondary coil means, as effected by relative movement of a predetermined discontinuity means intermediate said primary and secondary coil means, to yield an electrical signal operatively related to the extent of such relative movement. In the foregoing my invention has been described in conjunction with preferred embodiments. However, many variations and modifications will now become apparent to those skilled in the art; as, for example, different coil and transducer plate configurations may be employed within the spirit and scope of my invention. I prefer, therefore, not to be limited to the specification contained herein but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows.

1. An eddy current apparatus for measuring the extent of displacement, comprising primary coupling means for establishing an alternating magnetic flux field; conducting means having at least one predeterminedly positioned discontinuity; said alternating magnetic flux field inducing eddy currents in said conducting means; secondary coupling means inductively positioned with respect to the electromagnetic fields generated by said eddy currents; said discontinuity effecting the distribution of said eddy currents, whereby the location of said discontinuity with respect to said primary and secondary coupling means effects a variation in the electromagnetic field coupling therebetween; at least one of said means being relatively movable; the extent of said relative movement being operatively related to the magnitude of said variation in electromagnetic field coupling; circuit means electrically interconnecting selected ones of said coupling means to provide an output signal responsive to said variation of electromagnetic field coupling; said output signal indicating the extent of said relative movement; said conducting means comprising a substantially solid plate coextensive about the location of said coupling means and of a greater dimensional extent than the region occupied by said coupling means; said discontinuity including at least one elongated slit of uniform width along its length; said slit symmetrically positionable with respect to cooperating coupling members of said first and second coupling means, said relative movement effecting a corresponding asymmetric relationship of said slit with respect to said cooperating coupling members.

2. An eddy current apparatus for measuring the extent of displacement, comprising primary coupling means for establishing an alternating magnetic flux field; conducting means having at least one predeterminedly positioned discontinuity; said alternating magnetic flux field inducing eddy currents in said conducting means; secondary coupling means inductively positioned with respect to the electromagnetic fields generated by said eddy currents; said discontinuity effecting the distribution of said eddy currents, whereby the location of said discontinuity with respect to said primary and secondary coupling means effects a variation in the electromagnetic field coupling

therebetween; at least one of said means being relatively movable; the extent of said relative movement being operatively related to the magnitude of said variation in electromagnetic field coupling; circuit means electrically interconnecting selected ones of said coupling means to provide an output signal responsive to said variation of electromagnetic field coupling; and said output signal indicating the extent of said relative movement; one of said coupling means including a pair of opposed coupling members space separated in a first direction about an individual coupling member of the other of said coupling means; the positioning of said discontinuity at a predetermined location intermediate said pair of opposed coupling members establishing a balanced coupling condition between said pair of opposed coupling members and said individual coupling member to provide a null condition of said output signal; relative movement of said discontinuity means in said first direction about said predetermined location upsetting said balanced coupling condition in a manner varying said output signal, responsive to the extent of said relative movement; said conducting means comprising a substantially solid plate coextensive about the location of said coupling means and of a greater dimensional extent than the region occupied by said coupling means; said discontinuity including at least one slit within said plate, extending in a second direction transverse to said first direction and of uniform width along its length; said slit symmetrically positionable with respect to cooperating coupling members of said first and second coupling means; said relative movement effecting a corresponding asymmetric relationship of said slit with respect to said cooperating coupling members.

3. An eddy current apparatus as set forth in claim 1, said cooperating coupling members including a plurality of secondary coil means spaced separated in a first direction about a primary coil means; said slit longitudinally extending in a second direction, transverse to said first direction; means for moving said plate in said first direction; said movement effecting repositioning of said slit along said first direction intermediate individual ones of said secondary coil means; said movement varying the relative electromagnetic field coupling between said primary coil means and individual ones of said plurality of secondary coil means; selected ones of said secondary coil means being in series opposition whereby balanced coupling to said series opposed coils effects an output null condition; the symmetric location of said slit intermediate said space separated, series opposed secondary coil means providing said balanced condition; the movement of said plate in said first direction asymmetrically repositioning said slit to upset said balanced coupling condition in a manner varying said output signal variation responsive to the extent of said relative movement.

4. An eddy current apparatus for measuring the extent of displacement, comprising primary coupling means for establishing an alternating magnetic flux field; conducting means having at least one predeterminedly positioned discontinuity; said alternating magnetic flux field inducing eddy currents in said conducting means; secondary coupling means inductively positioned with respect to the electromagnetic fields generated by said eddy currents; said discontinuity effecting the distribution of said eddy currents, whereby the location of said discontinuity with respect to said primary and secondary coupling means effects a variation in the electromagnetic field coupling therebetween; at least one of said means being relatively movable; the extent of said relative movement being operatively related to the magnitude of said variation in electromagnetic field coupling; circuit means electrically interconnecting selected ones of said coupling means to provide an output signal responsive to said variation of electromagnetic field coupling; said output signal indicating the extent of said relative movement; said conducting means comprising a plate coextensive about the location of said

coupling means and of a greater dimensional extent than the region occupied by said coupling means; said discontinuity including at least one slit symmetrically positionable with respect to cooperating coupling members of said first and second coupling means; said relative movement effecting a corresponding asymmetric relationship of said slit with respect to said cooperating coupling members; said cooperating coupling members including a plurality of secondary coil means space separated in a first direction about a primary coil means; said slit extending in a second direction; means for rotating said plate about an axis; one of said directions being along an arc in the direction of said rotation; and the other direction being radial to said arc; said relative movement effecting repositioning of said slit along said first direction intermediate individual ones of said secondary coil means; said movement varying the relative electromagnetic field coupling between said primary coil means and individual ones of said plurality of secondary coil means; selected ones of said secondary coil means being in series opposition whereby balanced coupling to said series opposed coils effects an output null condition; the symmetric location of said slit intermediate said space separated, series opposed secondary coil means providing said balanced condition; rotation of said plate asymmetrically repositioning said slit to upset said balanced coupling condition in a manner varying said output signal variation responsive to the angular extent of said rotation.

5. An eddy current apparatus comprising primary coupling means for establishing an alternating magnetic flux field; conducting means having at least one predeterminedly positioned discontinuity; said alternating magnetic flux field including eddy currents in said conducting means; secondary coupling means inductively positioned with respect to the electromagnetic fields generated by said eddy currents; said discontinuity effecting the distribution of said eddy currents, whereby the location of said discontinuity with respect to said primary and secondary coupling means effects a variation in the electromagnetic field coupling therebetween; at least one of said means being relatively movable; the extent of said relative movement being operatively related to the magnitude of said variation in electromagnetic field coupling; circuit means electrically interconnecting selected ones of said coupling means to provide an output signal responsive to said variation of electromagnetic field coupling; said output signal indicating the extent of said relative movement; said conducting means comprising a plate rotatable about an axis; each of said primary and secondary coupling means including a plurality of individual coupling members circularly disposed in predetermined angular relationship about an intermediate region of said plate; each of said primary coupling members being angularly intermediate cooperating secondary coupling members; said discontinuity means comprising a plurality of individual slits; said slits being circularly disposed in predetermined angularly relationship about said intermediate region; each of said slits extending in a generally radial direction; selected ones of said coupling members being in series opposition; the symmetric location of each of said slits opposite predetermined ones of said primary coupling members effecting balanced coupling to said cooperating secondary coupling means; said balanced coupling providing a null condition of said output signal; rotation of said plate asymmetrically repositioning said slits to upset said balanced coupling condition in a manner varying said output signal variation responsive to the angular extent of said rotation.

6. An eddy current apparatus as set forth in claim 5, said output signal cyclically varying responsive to said rotation, and having a maximum value responsive to said slits being positioned opposite predetermined ones of said secondary coil members; a complete revolution of said plate providing a predetermined plurality of said cyclic variations.

7. An eddy current apparatus as set forth in claim 3, said first direction being perpendicular to said second direction; said plate being linearly movable in said first direction, whereby said output signal is proportionally responsive to said linear movement.

8. An eddy current apparatus for measuring the extent of displacement, comprising primary coupling means for establishing an alternating magnetic flux field; conducting means having at least one predeterminedly positioned discontinuity; said alternating magnetic flux field inducing eddy currents in said conducting means; secondary coupling means inductively positioned with respect to the electromagnetic fields generated by said eddy currents; said discontinuity effecting the distribution of said eddy currents, whereby the location of said discontinuity with respect to said primary and secondary coupling means effects a variation in the electromagnetic field coupling therebetween; at least one of said means being relatively movable; the extent of said relative movement being operatively related to the magnitude of said variation in electromagnetic field coupling; circuit means electrically interconnecting selected ones of said coupling means to provide an output signal responsive to said variation of electromagnetic field coupling; said output signal indicating the extent of said relative movement; said conducting means comprising a plate coextensive about the location of said coupling means and of a greater dimensional extent than the region occupied by said coupling means; said discontinuity including at least one slit symmetrically positionable with respect to cooperating coupling members of said first and second coupling means; said relative movement effecting a corresponding asymmetric relationship of said slit with respect to said cooperating coupling members; said cooperating coupling members comprising a first and second group; said first group including a plurality of secondary coil means space separated in a first direction about cooperating primary coil means; a first of said slits longitudinally extending in a second direction, transverse to said first direction; said second group including a plurality of secondary coil means space separated in a third direction about cooperating primary coil means; a second of said slits longitudinally extending in a fourth direction, transverse to said third direction; movement of said plate in a direction having a component in said first or third directions providing said asymmetric relationship with respect to said first or second group respectively; said movement varying the relative electromagnetic field coupling between said primary coil means and individual ones of said plurality of secondary coil means of said groups; selected ones of said secondary coil means being in series opposition whereby balanced coupling to said series opposed coils effects an output null condition of the respective one of said groups; the individual symmetric location of each of said slits intermediate its associated space separated series opposed secondary coil means independently providing said balanced condition of its associated group, whereby said first and second groups provide independent output signals responsive to the components of plate movement in said first and third directions.

9. An eddy current apparatus as set forth in claim 8, said first direction being rotational about an axis; said third direction being linear in the direction of said axis.

10. A transducer apparatus comprising a substantially solid conductive plate; said conductive plate including at least one predeterminedly positioned discontinuity; primary and secondary coil means in cooperative coupling relationship, located adjacent said plate; said discontinuity effecting the electromagnetic field coupling intermediate said primary and secondary coil means, whereby the symmetric location of said discontinuity relative to said primary and secondary coil means establishes a balanced coupling condition therebetween; the asymmetric location of said discontinuity relative to said primary and secondary

coil means providing an unbalanced coupling condition operatively responsive thereto; said plate being movable in a first direction relative to said coil means; the extent of said plate movement about said symmetric location providing an output signal responsive to said unbalanced condition; a plurality of secondary coil means being space separated in said first direction about a primary coil means; said discontinuity comprising a slit longitudinally extending in a second direction transverse to said first direction; said relative movement effecting repositioning of said slit along said first direction intermediate individual ones of said secondary coil means; said movement varying the relative electromagnetic field coupling between said primary coil means and individual ones of said plurality of secondary coil means; selected ones of said secondary coil means being in series opposition whereby balanced coupling to said series opposed coils effects an output null condition; the symmetric location of said slit intermediate said space separated, series opposed secondary coil means providing said balanced condition; relative movement of said plate in said first direction asymmetrically repositioning said slit to upset said balanced coupling condition in a manner varying said output signal variation responsive to the extent of said relative movement.

11. A transducer apparatus as set forth in claim 10, wherein said first direction is perpendicular to said second direction; said plate being linearly movable in said first direction, whereby said output signal is proportionally responsive to said linear movement.

12. A transducer apparatus comprising a conductive plate; said conductive plate including at least one predeterminedly positioned discontinuity; primary and secondary coil means in cooperative coupling relationship, located adjacent said plate; said discontinuity effecting the electromagnetic field coupling intermediate said primary and secondary coil means, whereby the symmetric location of said discontinuity relative to said primary and secondary coil means establishes a balanced coupling condition therebetween; the asymmetric location of said discontinuity relative to said primary and secondary coil means providing an unbalanced coupling condition operatively responsive thereto; said plate being movable relative to said coil means; the extent of said plate movement about said symmetric location providing an output signal responsive to said unbalanced condition; a plurality of secondary coil means being space separated in a first direction about a primary coil means; said discontinuity comprising a slit longitudinally extending in a second direction transverse to said first direction; means for rotating said plate about an axis; one of said directions being along an arc in the direction of said rotation; and the other direction being radial to said arc; said relative movement effecting repositioning of said slit along said first direction, intermediate individual ones of said secondary coil means; said movement varying the relative electromagnetic field coupling between said primary coil means and individual ones of said plurality of secondary coil means; selected ones of said secondary coil means being in series opposition whereby balanced coupling to said series opposed coils effects an output null condition; the symmetric location of said slit intermediate said space separated, series opposed secondary coil means providing said balanced condition; rotation of said plate asymmetrically repositioning said slit to upset said balanced coupling condition in a manner varying said output signal variation responsive to the angular extent of said rotation.

13. A follow-up positioning system comprising in combination: article positioning means responsive to a servo drive signal; preprogrammed storage means for generating said servo drive signal; said storage means comprising a conductive plate; said conductive plate having a longitudinal discontinuity of a predetermined configuration; primary and secondary coil means in cooperative

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coupling relationship located adjacent said plate; one of said coil means including individual coil members extending transverse to said discontinuity; said predetermined configuration varying in said transverse direction along the length of said discontinuity; the instantaneous location of said discontinuity along said transverse direction varying the coupling condition between individual ones of the coil members of said one of said coil means and the other of said coil means; said variation of coupling condition generating said servo drive signal; said longitudinal discontinuity relatively movable along said longitudinal direction, with respect to said coil means; the instantaneous transverse location of said discontinuity with respect to said individual coil members generating said drive signal in accordance with said predetermined discontinuity configuration.

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14. An eddy current apparatus as set forth in claim 1, further including means for adjusting said slit width.

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