

C. G. ASHLEY.

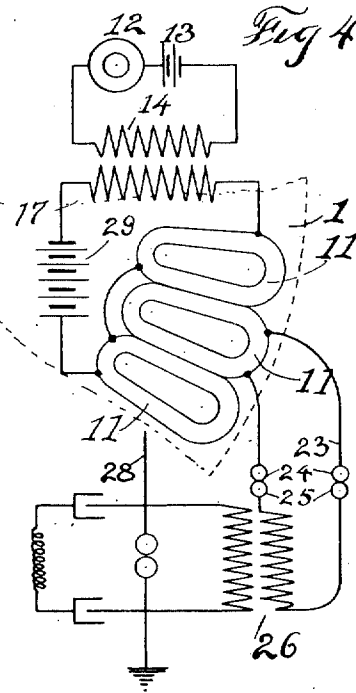
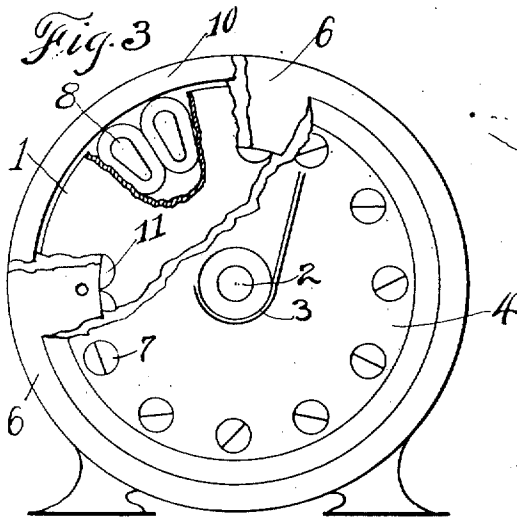
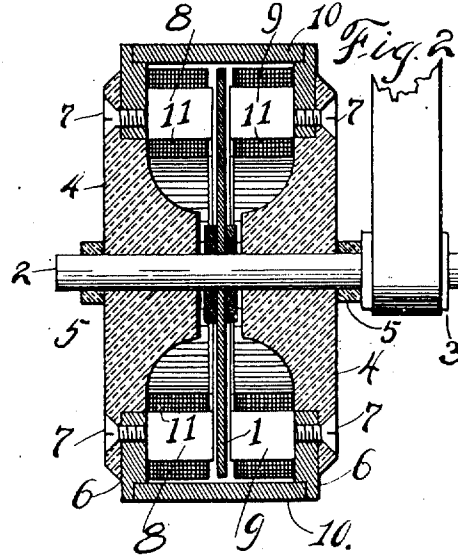
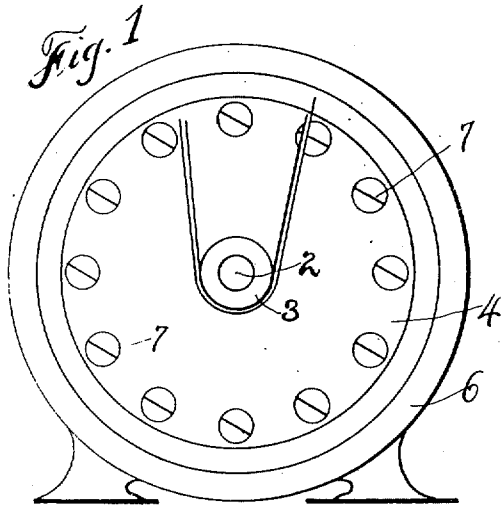
RELAY.

APPLICATION FILED NOV. 19, 1908.

Patented Apr. 18, 1911.

2 SHEETS-SHEET 1.

990,183.



Witnesses

L. J. Jennings.

David S. Hurlfish.

Inventor
Charles G. Ashley
By McMenamin
Attorneys.

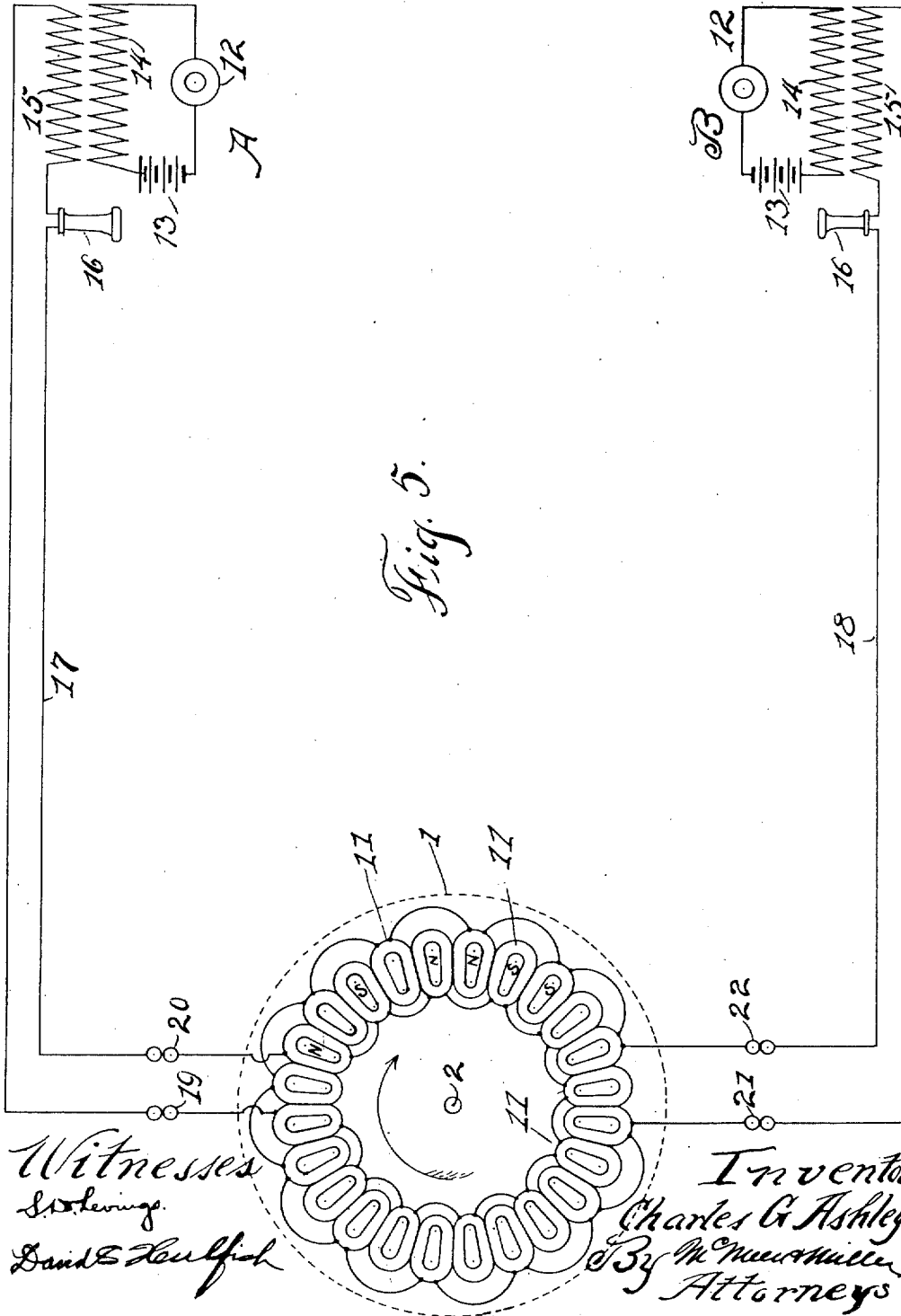
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2 SHEETS—SHEET 2.



Witnesses
S. H. Lewis
David S. Houlfish

Inventor
Charles G. Ashley
By M. M. Mullen
Attorneys

UNITED STATES PATENT OFFICE.

CHARLES G. ASHLEY, OF CHICAGO, ILLINOIS.

RELAY.

990,183.

Specification of Letters Patent.

Patented Apr. 18, 1911.

Continuation of application Serial No. 295,486, filed January 10, 1906. This application filed November 19, 1908. Serial No. 463,358.

To all whom it may concern:

Be it known that I, CHARLES G. ASHLEY, a citizen of the United States of America, and a resident of Chicago, county of Cook, and State of Illinois, have invented a new and useful Improvement in Relays, of which the following is a specification.

My invention relates to a method of and apparatus for propagating electrical waves.

The device of my invention may be employed in space communication commonly known as wireless transmission and in telephony as commercially practiced.

My invention is serviceable in increasing the amplitude of electrical waves, when it is physically associated with the initial transmitting station, or where the invention is practiced at a point between stations.

The device of my invention may be said to constitute a relay, the initially produced electrical waves being amplified by means of the invention, whether the device of the invention is located at the transmitting station or at some point intermediate between stations.

In practicing my invention, I employ two circuits themselves out of inductive relation.

Where the apparatus is to be used purely as a transmitting relay device, or a one-way service is to be obtained, current impressed upon one of these circuits is, by means of the instrumentality hereinafter to be set forth, impressed upon the other circuit so as to produce in the latter circuit wave forms corresponding to the wave forms in the first circuit but with increased amplitude.

Where the device is to be used as a relay in a long distance telephone line such as are now commonly in use, either of the aforesaid circuits may, through the said agency hereinafter to be specified, have current initially impressed upon it to be reproduced in the companion circuit with wave forms corresponding to the wave forms in the impressing circuit, but of greater amplitude.

I have produced a successful repeater that may be used to amplify the currents emanating from either of two connected stations.

Each of the aforesaid circuits includes a winding and each of the windings is preferably subdivided into a number of coils, the coils of one circuit being alternately arranged with respect to the coils of the other

circuit, the coils being wound in directions to produce alternate polarity, the adjacent coils in each circuit being oppositely wound. These coils are so physically disposed with respect to each other that they will not effect inductive relation between the two circuits, a supplemental agency being required to effect telephonic or transmission union between the circuits, and it will thus be clear that the two circuits are not in direct inductive relation. A moving inductor common to all of the coils of both circuits is placed in close range of said coils, so that on the occasion of the magnetic fields at the coils, fields of eddy currents are set up in the inductor. If, for example, telephonic current is set up in one of the circuits, eddy currents result in the inductor corresponding to said telephonic currents, by reason of the coils in the circuit in which the telephonic currents are initially set up. The eddy currents thus set up or induced in the inductor underlie the coils in the circuit into which the telephonic current is to be relayed, and the current is induced from the inductor into these coils of this latter circuit. The value of the eddy currents induced in the inductor varies directly with the square of strength of the field through which the inductor is passing and the velocity of the inductor; the speed of the inductor, of course determines the rate of cutting of the lines of force. The inductor is desirably operated at a high and uniform peripheral velocity. It will thus be seen that the one of the two circuits that constitutes at the time being the transmitting circuit, induces eddy currents in the moving inductor, which eddy currents underlie the windings or coils in the circuit companion to the transmitting circuit upon which the wave form current is impressed at greater amplitude, the inductor, when moving, constituting the agency that causes the eddy currents in the inductor to act as inducing currents with respect to that circuit which is to receive the amplified wave form currents. As the coils of the two circuits are interleaved or alternated, in long distance telephony, either link in the telephone circuit thus united by the inductor and the coils may constitute the transmitting circuit, and the companion circuit the receiving circuit.

In one embodiment of my invention there

are normally no eddy currents in the inductor, these only being occasioned when a telephone circuit is subject to telephonic current.

5 In another embodiment of the invention the core of each coil may be permanently magnetized, either by an external battery or adheringly, these cores then producing eddy currents in the inductor which are modified
10 by the wave form current received by the device.

This application is a continuation of my application filed January 10, 1906, Serial No. 295,486, which was, on January 21,
15 1907, passed for issue and became forfeited for non-payment of the final fee.

I will explain my invention more fully by reference to the accompanying drawings, showing the preferred embodiment thereof,
20 in which—

Figure 1 is a side elevation of a device constructed in accordance with the invention. Fig. 2 is a vertical sectional view thereof. Fig. 3 is a view in elevation with several of the parts broken away to reveal certain internal characteristics of the apparatus. Fig. 4 illustrates the device of my invention located at a transmitting station, a portion only of the coils being shown for
25 the sake of illustration. Fig. 5 shows a telephone line with the device of my invention included at an intermediate point in the line.

Like parts are indicated by similar characters of reference throughout the different figures.

Referring first more particularly to Figs. 1, 2 and 3, the rotor or inductor 1 is composed of suitable metal, copper being preferred. This rotor or inductor presents to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor due to the structure and arrangement of the inductor, and is desirably in the form of a disk, in practice, about three and one-fourth inches in diameter, though I do not wish to be limited to the proportions
35 illustrated. The inductor is rigidly mounted upon a shaft 2, to which shaft is secured a pulley 3 that drives the shaft. The shaft finds bearings in the non-magnetic caps 4, desirably formed of brass, collars 5 being provided upon the shaft 2 to confine the inductor 1 to a uniform plane of rotation. The brass caps 4 are recessed on their interiors at their rims to receive rings 6 of suitable magnetic material, as very soft iron,
40 these rings being secured to the caps 4 by screws 7. These rings 6 are provided with inseting polar projections 8—9, that are desirably integrally formed with the rings. The inductor is interposed between the poles
45 8 belonging to one ring 6 and the poles 9

belonging to the companion ring 6. The outer peripheral portions of the rings 6 are grooved on their inner faces to receive a yoke ring 10, also desirably composed of very soft iron. The poles 8 directly face
50 the poles 9, each pole 8 and its companion pole 9 being co-axial; the inductor 1 is thus enveloped by a source of magnetizable systems, each comprising a pole 8, the pole 9, companion to the pole 8, the rings 6, and
55 the ring 10, the elements 6—10 being common to all of the magnetic systems, while each pair of elements 8—9 is individual to the magnetic system. The polar portions 8—9 receive a single section of the magnetizing winding, this section constituting a
60 coil 11, that is subdivided into two parts—one placed around the pole piece 8 and the other about the pole piece 9, though I do not wish to be limited to the particular disposition of this coil. The faces of the polar
65 portions 8—9 opposed to the disk 1, are of unlike polarity when current is passing through the coil surrounding or associated with a set of polar portions 8—9.

Referring now more particularly to Fig. 5, the relative arrangement of the coils 11 will be explained. A telephone line unites two substations, A—B, that may be associated with the line in any suitable way well understood by those skilled in the art, the illustration chosen being simply taken to make the operation of the invention clearly understood. Said stations A—B may be equipped with telephonic apparatus of any well known or suitable construction and arrangement. Assuming telephonic apparatus to be at said stations A—B, the telephonic transmitter 12 at each station may be included in circuit with a source of energizing current 13 and the primary 14 of an induction coil, the secondary 15 of which coil is included directly in the line and in circuit with a telephone receiver 16. The telephone line includes two circuits 17—18 that are not directly inductively associated at the relay but which depend for their telephonic relation upon the moving inductor. The circuit 17 includes one set of coils 11 and the circuit 18 includes another set of coils 11, the coils of one circuit being interposed between the coils of the other circuit, each coil of one circuit being followed immediately by the coil of the other circuit, whereby these coils are alternated. The contiguous coils 11 in the same circuit are wound in opposite directions, whereby the interposed coils of the companion circuit are subject to equal and opposing induced pressures, whereby these latter coils have no current induced in them, so that, as I have hitherto stated, the two circuits 17—18 are not in direct inductive relation, the coils of one circuit having current induced in them by reason of current flowing
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through the coils of the other circuit by way of the inductor 1, in which eddy currents are generated, that constitute the inducing currents that cause the occurrence of wave

5 form currents in the circuit companion to the circuit that receives the initial wave form currents. Thus, the coils 11 that are in the initiating circuit have differential effect upon the coils that are in the companion circuit, whereby there is no induction from one circuit directly to the other, the element 1 constituting the vehicle for causing the currents in one circuit to occasion currents in the other circuit, this result being only effected when said vehicle 1 is in operation. It will thus be seen that I have provided in each of the circuits 17—18 a winding including a plurality of coils, the coils of the different circuits being so inter-related that the tendency for induction between a coil of one circuit and an adjacent coil of the other circuit is neutralized by the opposing effect of an adjacent coil of the first circuit upon said coil of the second circuit, the latter coil being interposed between the former two. It will also be observed that the coils connected with the initiating circuit cooperate with a moving inductor to set up in the inductor eddy currents, and that these eddy currents are in inductive relation to the coils of the circuit into which the wave form currents are to be relayed, these eddy currents acting, so to speak, as primary inducing currents.

35 In telephone exchange practice the relay may be associated with the telephone line in any suitable way, there being indicated in Fig. 5 terminals 19—20—21—22 of the relay, adapted for association with the telephone circuit in any preferred way. It is not thought necessary to illustrate the locations of the eddy currents in the disk 1, as such location will be manifest to one skilled in the art.

45 It is obvious that the geographical location of the relay with respect to the stations at the ends of the circuit does not modify the law of operation of the relay. This fact is illustrated in Fig. 4, where the relay is located at the same place with substation equipment.

In Fig. 4 I have illustrated diagrammatically a substation equipment including, for example, a telephone transmitter 12 in local circuit with a battery 13 and the primary 14 of an induction coil. A circuit for the relay corresponding to either of the circuits 17—18, say circuit 17, includes a number of coils 11, while the interposed coil of the companion circuit 23 is connected with the terminals 24, that are adapted for connection with the terminals 25 that complete the circuit 23. The terminals 25 may include any suitable form of propagating instrumentality, such as the winding 26 of an induction coil. This

winding 26 may constitute the primary of an induction coil, the secondary 27 of which is connected in any suitable form of circuit for the propagation of telephone currents.

I have illustrated a "wireless" apparatus 70 in association with the coil 27, but, obviously, my invention is not limited to this association. In the wireless apparatus illustrated, I have shown the well-known aerial conductor 28 and associate parts that are well understood by those skilled in the art and need not be further described.

In Fig. 4 I have illustrated only a fraction of the coils 11. It is understood that these coils are preferably arranged in a complete circle, as illustrated in Fig. 5, and that there is supplied thereto the inductor 1 and the associate parts, as described in connection with Figs. 1, 2, 3 and 5. Inasmuch as the equipment shown in Fig. 4 is, as there illustrated, adapted for the propagation of wave form current in one direction at increased amplitude, the number of coils 11 in the circuit 23 might be reduced to one, and the number of coils 11 in the circuit 17 might be reduced to two, one on each side of the former coil, though, as stated, I prefer the arrangements illustrated in Figs. 1 to 3, inclusive.

In Fig. 4 I include a battery or other 95 source of direct current 29 which causes a permanent magnetization of the cores surrounded by the coils 11. Wave form current caused by the transmitter 12 is superimposed upon the current furnished by the source 29 so as to modify the flux of the cores of said coils to produce the action that has hitherto been described.

I have illustrated the coils 11 of each set as being connected in series to produce an accumulative effect, but I do not wish to be limited to this precise way of connecting the coils. I prefer, even in the form shown in Fig. 4, to make the resistance, the wire of the coils 11, and the number of turns of said wire the same, but this condition can be varied according to engineering practice as desired. The number of turns of wire in each coil of the same circuit should preferably be the same, in order to prevent the direct inductive relation of the circuits.

While I have shown particular apparatus for furnishing the initial impression of wave form currents upon the relay, I do not wish to be limited to the particular means for accomplishing this effect illustrated.

The inductor 1 is the element of the relay that is desirably actuated or rotated while the coils 11 are maintained stationary, but I do not wish to be limited to this characteristic because all that is desired is relative movement between said coils and inductor.

While the pole pieces 8—9 belonging to each coil 11 are illustrated as being united by a yoke ring of magnetic material common

to all of the pole pieces, I do not wish to be limited to this arrangement.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. An instrument for increasing the amplitude of wave form current, including two windings directly out of inductive relation, for connection in different circuits, and an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

2. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, and an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

3. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, and an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

4. An instrument for increasing the amplitude of wave form current, including two windings directly out of inductive relation for connection in different circuits, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

5. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in

the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

6. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

7. An instrument for increasing the amplitude of wave form current, including two windings directly out of inductive relation for connection in different circuits; an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

8. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

9. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

10. An instrument for increasing the amplitude of wave form current, including two

windings directly out of inductive relation for connection in different circuits, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

11. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

12. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

13. An instrument for increasing the amplitude of wave form current, including two windings directly out of inductive relation for connection in different circuits, and an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy cur-

rents in the inductor, due to the structure and arrangement of the inductor.

14. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, and an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

15. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, and an inductor movable with respect to said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

16. An instrument for increasing the amplitude of wave form current, including two windings directly out of inductive relation, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

17. An instrument for increasing the amplitude of wave form current, including two windings for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect

to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

18. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

19. An instrument for increasing the amplitude of wave form current, including two windings, directly out of inductive relation, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

20. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the

inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

21. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

22. An instrument for increasing the amplitude of wave form current, including two windings, directly out of inductive relation, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

23. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with

with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

24. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

25. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, and an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

26. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

27. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive

relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions between which the inductor is disposed.

28. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

29. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, and an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor due to the structure and arrangement of the inductor.

30. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

31. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is dis-

posed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

32. An instrument for increasing the amplitude of wave form current, including two windings, for connection in different circuits, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

33. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

34. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

35. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding.

36. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in co-

operation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation to the other winding, and magnetizable core portions for said coils.

37. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

38. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils.

39. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

40. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

41. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of said windings in-

cluding a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed.

42. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

43. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

44. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of the said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material.

45. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting

eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

46. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the face of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

47. An instrument for increasing the amplitude of wave form current, including two windings, and an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

48. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

49. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings be-

ing divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy current in the inductor, due to the structure and arrangement of the inductor.

50. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

51. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

52. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents

are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

53. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

54. An instrument for increasing the amplitude of wave form current, including two windings, an inductor for and movable with respect to said windings, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

55. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, each of said windings being divided into a plurality of coils, the coils of one winding being alternated with respect to the coils of the other winding, the coils of one winding acting oppositely to each other upon the adjacent coils of the companion winding, one winding in coöperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive rela-

tion with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

56. An instrument for increasing the amplitude of wave form current, including two windings, an inductor movable with respect to said windings, one of said windings including a number of coils, said coils acting oppositely with respect to each other upon the remaining winding, one winding in cooperation with the inductor effecting eddy currents in the inductor, which eddy currents are caused to be in primary inductive relation with the other winding, and magnetizable core portions for said coils, each coil having two such magnetizable core portions, between which the inductor is disposed, the said two core portions for each coil being directly united by magnetic material, said inductor presenting to each of the poles at all times a uniform mass of metal which is at a uniform distance from the faces of the poles, so that there will be no fluctuation of the eddy currents in the inductor, due to the structure and arrangement of the inductor.

57. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conducting disk rotating near said coils, said coils and disk thus producing eddy currents in said disk in response to current values in said coils; and a second set of coils related to the eddy currents in the disk as the secondary winding of an induction coil is related to the currents of the primary winding of the induction coil.

58. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conducting disk rotating near said coils, said coils and disk thus producing eddy currents in said disk in response to current value in said coils; and a second set of coils related to the eddy currents in the disk as the secondary coil of an induction coil is related to the currents of the primary coil of the induction coil, said first set of coils and said second set of coils being similar.

59. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conducting disk rotating near said coils, said coils and disk thus producing eddy currents in said disk in response to current value in said coils; and a second set of

coils related to the eddy currents in the disk as the secondary coil of an induction coil is related to the currents of the primary coil of the induction coil, said first set of coils and said second set of coils being similar, and being arranged non-inductively each upon the other.

60. In an instrument for increasing the amplitude of wave form current, a set of field coils; an armature, and a second set of coils positioned to have inductive relation to currents in said armature.

61. In an instrument for increasing the amplitude of wave form current, means for producing corresponding currents of amplified value in a moving conductor; and means for transferring the energy of said currents electro-magnetically to a stationary conductor.

62. In an instrument for increasing the amplitude of wave form current, field coils; an armature; and inductive coils related inductively to currents in said armature produced by currents in said field coils.

63. In an instrument for increasing the amplitude of wave form current, a set of field coils; an armature; and a second set of coils positioned to have inductive relation to currents in said armature, said two sets of coils being mechanically similar and electrically interchangeable.

64. In an instrument for increasing the amplitude of wave form current, means for producing corresponding currents of amplified value in a moving conductor; and means for transferring the energy of said currents electro-magnetically to a stationary conductor, said two sets of coils being mechanically similar and electrically interchangeable.

65. In an instrument for increasing the amplitude of wave form current, field coils; an armature; and inductive coils related inductively to currents in said armature produced by currents in said field coils, said two sets of coils being mechanically similar and electrically interchangeable.

66. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conductor moving near said coils, said coils and conductor thus producing eddy currents in said conductor in response to current values in said coils; and a second set of coils related to the eddy currents in the conductor as the secondary winding of an induction coil is related to the currents of the primary winding of the induction coil.

67. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conductor moving near said coils, said coils and conductor thus producing eddy currents in said conductor in response to current value in said coils; and a second

set of coils related to the eddy currents in the conductor as the secondary coil of an induction coil is related to the currents of the primary coil of the induction coil, said first set of coils and said second set of coils being similar.

68. In an instrument for increasing the amplitude of wave form current, a set of coils adapted to carry the current to be amplified; a conductor moving near said coils, said coils and conductor thus producing eddy currents in said conductor in response to current value in said coils; and a second set of coils related to the eddy currents in the conductor as the secondary coil of an induction coil is related to the currents of the primary coil of the induction coil, said first set of coils and said second set of coils being similar, and being arranged non-inductively each upon the other.

69. In an electrodynamic relay, a uniform mass of metal maintaining relative motion with a field coil; and another coil in inductive relation to the current in the uniform mass of metal; said two coils electrically interchangeable and non-inductively associated in regard to each other.

70. In an electrodynamic relay, a mass of metal maintaining relative motion with a field coil; and another coil in inductive relation to the current in the mass of metal, said two coils electrically interchangeable and non-inductively associated in regard to each other.

71. In an electrodynamic relay, means for maintaining continuously eddy currents in a mass of metal by relative motion between such metal and a field coil; a second coil out of direct inductive relation with said field coil but in inductive relation with an eddy current in said mass of metal.

72. In an electrodynamic relay, a field coil producing eddy currents in a uniform inductor maintaining relative motion with regard to such field coil; and a second coil out of direct inductive relation with said field coil but in inductive relation with the eddy currents in the inductor.

73. In an electrodynamic relay, means for producing a plurality of eddy currents in an armature of uniform mass maintaining relative motion with regard to a plurality of field coils; an equal number of similar coils out of direct inductive relation with the first

named coils but in direct inductive relation with the eddy currents in said armature.

74. In an electrodynamic relay, means for establishing an electromagnetically inductive couple in regard to an electrodynamically induced current in a uniform inductor or armature maintaining constant relative motion with reference to a field coil.

75. In an electrodynamic relay, means for electrodynamic induction to be maintained by relative motion between a uniform inductor and a field; an electromagnetic couple maintained between electrodynamically induced current and a second coil which does not form a direct electromagnetic couple with the field coil.

76. In an electrodynamic device for increasing the amplitude of wave form current, means for maintaining eddy currents in a mass of metal by relative motion between such metal, and a plurality of field coils wound alternately clockwise and counterclockwise; a second set of similarly wound coils, each disposed in direct effective inductive relation with the eddy current in the aforesaid mass of metal.

77. In an electrodynamic device for increasing the amplitude of wave form current, means for establishing a series of eddy currents of alternate direction in a mass of metal maintaining relative motion with a plurality of field coils of alternate polarity; a second set of similarly wound and connected coils each disposed in effective inductive relation with an eddy current in the aforesaid mass of metal.

78. In an electrodynamic device for increasing the amplitude of wave form current, a conductive mass, a field coil; and coils for establishing an electromagnetically inductive couple with an electrodynamically induced current in said conductive mass when said mass is maintaining relative motion with reference to said field coil, said field coil not forming an electromagnetically inductive couple with the aforesaid coils.

Signed by me at Chicago, county of Cook and State of Illinois in the presence of two witnesses.

CHARLES G. ASHLEY.

Witnesses:

DAVID S. HULFISH,
HARRIET L. SMITH.

Corrections in Letters Patent No. 990,183.

It is hereby certified that in Letters Patent No. 990,183, granted April 18, 1911, upon the application of Charles G. Ashley, of Chicago, Illinois, for an improvement in "Relays," errors appear in the printed specification requiring correction as follows: Page 11, line 8, after the word "uniform," the words *mass of metal which is at a uniform* should be inserted, and same page, line 14, after the word "amplitude," the word *of* should be inserted; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of June, A. D., 1911.

[SEAL.]

C. C. BILLINGS,
Acting Commissioner of Patents.