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J. A. FLEMING.

INSTRUMENT FOR MAKING ELECTRICAL MEASUREMENTS.

APPLICATION FILED FEB. 8, 1905.

Fig. 1.

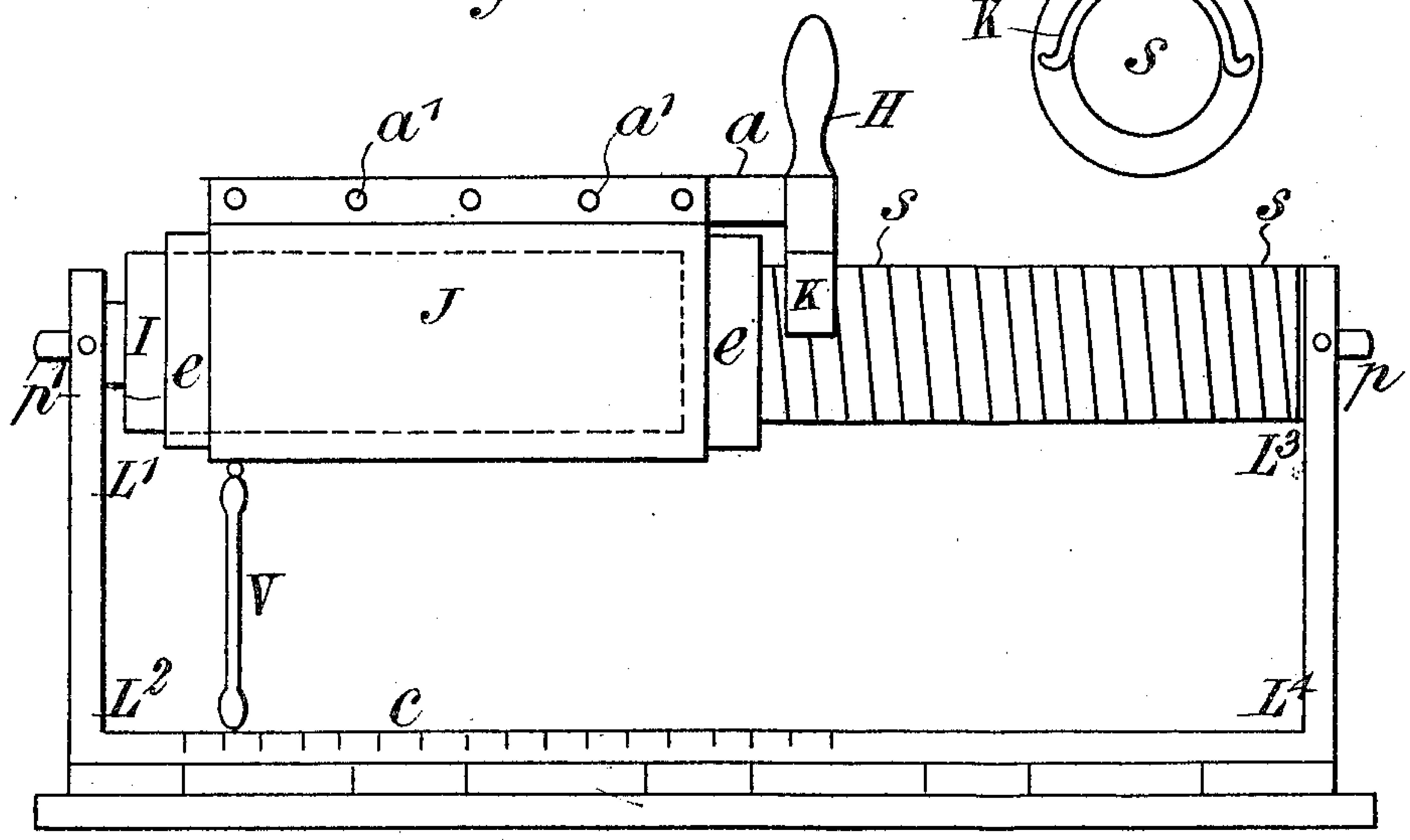


Fig. 2.

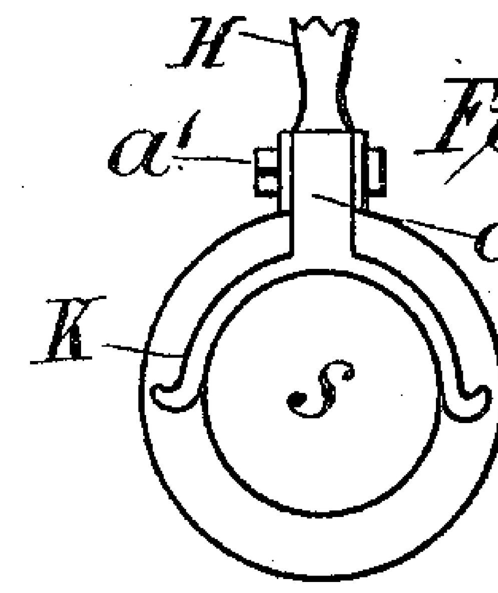


Fig. 4.

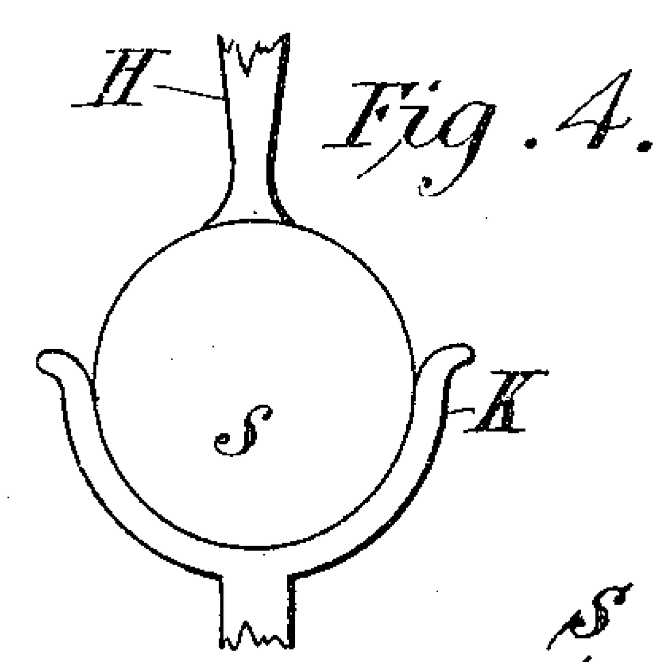
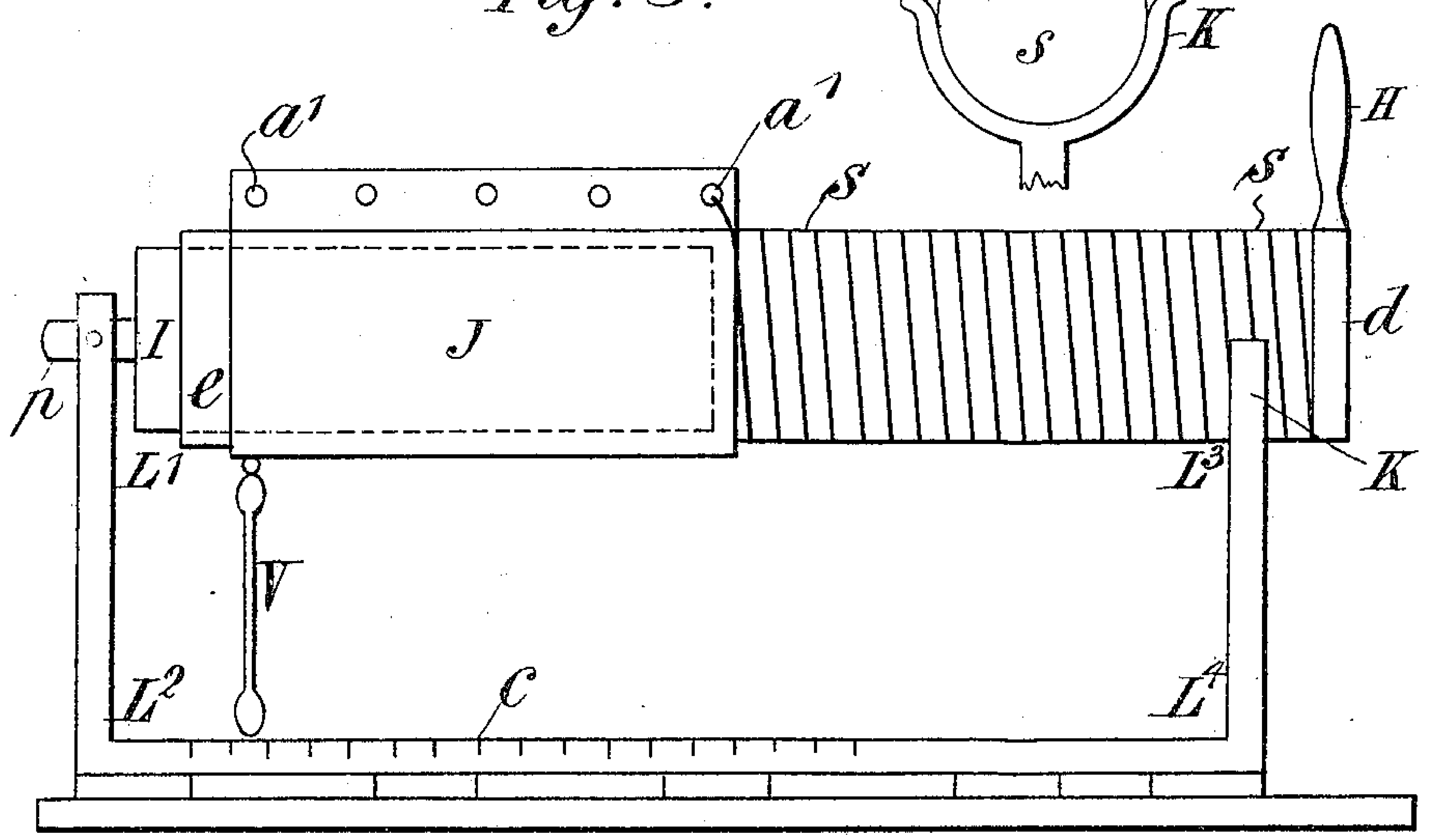


Fig. 3.



Witnesses.

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INSTRUMENT FOR MAKING ELECTRICAL MEASUREMENTS.

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Application filed February 8, 1905. Serial No. 244,714.

To all whom it may concern:

Be it known that I, JOHN AMBROSE FLEMING, professor of electrical engineering, a subject of the King of Great Britain, residing at University College, Gower street, London, in the county of Middlesex, England, have invented certain new and useful Improvements in Instruments for Making Electrical Measurements, of which the following is a specification.

This invention relates to improvements in instruments called "cymometers," for the measurement of wave lengths and frequencies employed in Hertzian-wave wireless telegraphy, and for other electrical measurements such as small capacities and inductances. In space telegraphy of the above kind, the distance to which it is possible to propagate signals over land or sea depends very much upon the length of the electric wave used and it is necessary to be able to measure this wave length without disturbing the apparatus employed for sending. I do this by constructing a closed oscillating circuit consisting of a capacity in the form of a cylindrical sliding condenser and a helical variable inductance connected together so that one motion reduces or increases both the inductance and the capacity at the same time. Since the frequency in an oscillating circuit varies inversely as the square root of the product of capacity and inductance, this has the effect that the total alteration of the arrangement varies as the wave length. The condenser is formed of two concentric metal tubes. The dielectric of this condenser must be ebonite or some material which does not vary with the frequency and is a very good insulator.

Figure 1 is a side elevation and Fig. 2 an end elevation (some parts being omitted) of an instrument constructed according to this invention. Figs. 3 and 4 are similar views of a modification.

e e is an ebonite tube which has within it and partially projecting from it a brass tube I. This brass tube has connected to it another ebonite tube S S on which is wound a spiral of thick copper wire which may conveniently be the size called "No. 14, standard wire-gage." The ebonite tube on which this spiral wire is wound is smaller in diameter than the ebonite tube *e e* and fits within it. The spiral of copper wire should be wound in rather open turns, the turns being about one-eighth inch to one-fourth inch apart and the outer end of the wire is attached to a metal pin *p* fixed in one end of the smaller ebonite cylinder, while the opposite end of the wire is insulated. On the ebonite tube *e e* slides an outer brass tube J which carries a bar *a a* terminating in a collar K, the said collar having an insulating-handle of ebonite H. This outer jacket must be of such a diameter that it can slide easily upon the ebonite tube *e e*, while at the same time, the collar K makes good electrical contact with spiral wire S S, the jacket and collar being moved by the handle H. The inner brass tube I has connected to it another pin *p'* and the two pins *p p'* are connected by a stout copper bar $L' L^2 L^3 L^4$. It will be seen that the arrangement constitutes a condenser in series with an inductance and that when the handle H is moved along the spiral this action at the same time reduces the inductance of the circuit and the capacity formed by the two metal cylinders I and J separated by the dielectric *e*. With regard to dimensions I have found it convenient in constructing an instrument to measure wave lengths up to two thousand feet, to adopt the following dimensions: The ebonite tube *e e* may conveniently be four inches in diameter, the thickness of the sides should not be less than one-tenth of an inch and the length of the tube about three feet. The outer brass jacket may be twenty-eight or thirty inches in length and the ebonite tube S S should also project for the same length beyond the ebonite tube *e*. The jacket *j* is conveniently made by bending round the outside ebonite tube a thin sheet of brass which is clamped by screws *a' a'* to a rectangular bar *a a* so that just the requisite degree of tightness may be given to this jacket enabling it to move smoothly and yet fit closely on the ebonite cylinder. The inner metal tube I should fit the inside of the ebonite tube *e* closely and project beyond it for the distance of an inch or so. The rod $L' L^2 L^3 L^4$ may consist of a strip of copper about an inch in width and about one-eighth of an inch in thickness.

In another form, shown in Figs. 3 and 4, I make the outer jacket J fixed and the inner jacket movable. The arrangement then consists of an ebonite tube *e* which may conveniently be about four feet or four feet six inches in length and four inches in diameter outside. This tube is embraced on its outside for about half its length with a metal jacket J formed of thin sheet metal bent round the tube and clamped together by screws a' a', the other half of the ebonite tube is wound with a bare copper wire put on in an open spiral, the turns being about one-eighth to one-fourth inch apart and in all cases it is best to cut upon the ebonite tube a groove in which this wire partially lies. In this arrangement one end of the copper wire is connected to the jacket J and the other to a metal collar d having an insulating-handle H. Inside this ebonite tube e is another brass tube I, which fits closely but it can slide in and out of the ebonite tube. The circuit is completed by a copper strip L' L^2 L^3 L^4 as above described, but in this case the copper strip ends in the collar K. One end of the brass cylinder I has a pin p attached to it and this is pivoted to one end of the copper strip. By taking hold of the handle H and moving the ebonite cylinder along, the ebonite tube e is drawn more or less off the inner metal tube I and at the same time the effective portion of the inductance-coil S S included in the circuit is shortened. In this manner the capacity and the inductance of the circuit are reduced together. The instrument is provided with a vacuum-tube V of the type employed in spectrum analysis consisting of two bulbs united by a narrow glass tube and this vacuum-tube is preferably constructed of uranium glass and filled with rarefied carbonic-acid gas, or, better still, the rare gas called "neon." This vacuum-tube is attached to the outer jacket J and moves with it. On the straight portion of the copper strip L^2 L^4 is engraved a scale c and one end of the vacuum-tube should nearly touch this scale.

The instrument is used in the following manner: A determination must first be made of the electrical capacity formed by the two cylinders I and J separated by the ebonite tube when the cylinders are moved into different positions, and also of the inductance of of that part of the spiral included in the circuit corresponding to the same position of the cylinders. These measurements are made by well-known laboratory methods. Let C denote the capacity of the cylinders in any position and L the inductance of that part of the spiral included in the circuit for the same position or corresponding to the same capacity C. Then I call the quantity $\sqrt{CL}$ the oscillation constant of the instrument in that position. These oscillation constants can be measured and the numbers corresponding to them marked upon the scale. It is convenient to measure the capacity in microfarads and the inductance in centimeters. In the case of the instrument having the dimensions described, the oscillation constant in various positions would be a number varying from 0 to about 10. In any oscillatory electric circuit containing capacity and inductance, the frequency of the oscillations in that circuit is obtained by dividing the number five millions by the oscillation constant of the circuit, as above described. Again if oscillations are set up in an open electric circuit, such as an aerial wire, electric waves are radiated from this wire and these waves have a certain wave length. The velocity with which these waves travel away from the wire is very nearly one thousand million feet per second, and the relation between the wave length of the waves and the frequency of the oscillations in the wire, is given by the following rule. The wave length in feet multiplied by the frequency is equal to one thousand millions. Hence if we can determine the frequency of the oscillations in a vertical wire, such as an aerial wire used in wireless telegraphy, by any means, the wave length of the waves can be determined. Also since the frequency of the oscillations in any circuit is connected with the oscillation constant of that circuit, as above described we have the following simple rule connecting together the oscillation constant in an open electric circuit radiating electric waves and the wave length of the waves radiated, viz: Wave length in feet equals two hundred multiplied by oscillation constant. Either of the above forms of cymometer enables this oscillation constant to be measured at once. Thus supposing there is an aerial wire which forms the radiator of a wireless-telegraph transmitter and it is desired to find the wave length of the wave radiated, a part of this aerial wire is laid parallel to the copper bar L^2 L^4 of the cymometer and when the wireless-telegraph transmitter is in operation the handle H of the cymometer is moved to and fro until such a position is found that the vacuum-tube V glows most brightly. When this is the case, the oscillation constant of the cymometer agrees with that of the aerial radiator and the numerical value can be read off upon the scale of the cymometer, provided that the oscillation constant lies within the range of the cymometer used. In this manner by one single operation I measure at once the frequency of the oscillations and the wave length of the wave sent out from the transmitter.

What I claim is—

1. The combination of a condenser, a coil in series with the condenser and means for simultaneously varying the capacity of the condenser and the inductance of the coil, in the same proportion.

2. The combination of two conducting-surfaces, a dielectric between the surfaces, a coil having one end connected to one of the surfaces, a contact-maker resting on the coil and connected to the other surface and means for simultaneously moving the two surfaces and the coil and contact-maker relatively to each other respectively.

3. The combination of two conducting-surfaces, a dielectric between the surfaces, a coil having one end connected to one of the surfaces, a contact-maker resting on the coil and connected to the other surface, means for simultaneously moving the two surfaces and the coil and contact-maker relatively to each other respectively, and a vacuum-tube carried by one of the surfaces.

4. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them such cylinder being adapted to fit between the two metallic cylinders, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders and a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it.

5. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them such cylinder being adapted to fit between the two metallic cylinders, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders, a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it, and a metallic bar interposed in the circuit between the two metallic cylinders.

6. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed inside and projecting beyond the outer metallic cylinder, such cylinder being free to move outside the inner metallic cylinder, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to the outer metallic cylinder, a metallic bar connected to the inner metallic cylinder and a contact-maker fixed to the bar and resting on the coil.

7. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them such cylinder being adapted to fit between the two metallic cylinders, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders, a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it, and a glow vessel carried by the outer metallic cylinder.

8. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them such cylinder being adapted to fit between the two metallic cylinders, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders, a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it, a metallic bar interposed in the circuit between the two metallic cylinders, and a glow vessel carried by the outer metallic cylinder.

9. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed inside and projecting beyond the outer metallic cylinder, such cylinder being free to move outside the inner metallic cylinder, a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to the outer metallic cylinder, a metallic bar connected to the inner metallic cylinder, a contact-maker fixed to the bar and resting on the coil, and a glow vessel carried by the outer metallic cylinder.

10. An apparatus for measuring the lengths of electric waves, comprising a closed circuit containing inductance and capacity, the elements of the circuit being so constructed and arranged that the movement of a single part will simultaneously vary the inductance and capacity of the circuit.

11. An apparatus for measuring the lengths of electric waves, comprising a closed circuit containing inductance and capacity, the elements of the circuit being so constructed and arranged that the movement of a single part will simultaneously vary the inductance and capacity of the circuit, a pointer connected to the movable part, and a scale with which the pointer coöperates.

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Witnesses:

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