[Second Edition.]

N° 27,683 A.D. 1904

Date of Application, 19th Dec., 1904
Complete Specification Left, 18th Sept., 1905—Accepted, 2nd Nov., 1905

PROVISIONAL SPECIFICATION.

Improvements in Instruments for the Measurement of Wave Lengths in Wireless Telegraphy.

JOHN AMBROSE FLEMING of University College Gower Street in the County of London, Doctor of Science. do hereby declare the nature of this invention to be as follows :—

My invention relates to improvements in instruments called kummeters for the measurement of the wave lengths and frequencies employed in Hertzian wave wireless telegraphy. In practical telegraphy of the above kind, the distance to which it is possible to propagate signals over land or sea depends very much upon the nature of the electric wave used and it is necessary to be able to measure the wave length quickly and directly 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 spiral variable inductance connected together so that one motion reduces or increases both the inductance and 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. My arrangement consists of a condenser formed of two concentric metal tubes, the dielectric of which must be ebonite, or some material the dielectric constant of which is independent of the frequency. On an extension of this ebonite, or on another ebonite tube attached to it, is wound an open spiral of non-magnetic wire. The outer cylinder of the condenser can slide over the dielectric tube easily, and this cylinder carries a metal rod ending in a crutch or collar, which rests upon or embraces the inductance spiral. The inner condenser cylinder and the far end of the inductance spiral are connected by a straight metal strap or rod so as to complete the electric circuit. Another wire or rod is attached to the end of the inner metal cylinder forming one coating of the condenser and is bent over to lie parallel with the outer condenser cylinder. To this rod is attached a vacuum tube which may contain air or other rarefied gas, preferably Neon or Argon. The lower end of this vacuum tube must just rest upon or nearly touch the outer condenser cylinder. A pointer moving over a fixed scale is attached to the outer cylinder. The process of measurement is as follows :—

The aerial wire in which the electric oscillations are created which transmits or creates the sending electric wave is placed for part of its course parallel with and closely touching, but insulated from, the rod or wire which connects the outer ends of the condenser and inductance coil of the kummeter. The capacity and inductance of this latter are then varied together by sliding along the outer cylinder by means of an insulating handle so that this electrical system comes to have a natural free time of oscillations equal to that of the oscillation in the telegraphic transmitter. When this is the case, resonance is established and the vacuum tube lights up or glows, owing to the electric field created round it being very strong. It is possible to so graduate the scale of the kummeter, that the length of the electric wave sent out by the aerial is indicated directly in feet or metres. The range of the instrument is decided by the capacity and inductance employed and it may be taken that the length of

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the longest wave measurable is equal to the square root of the product of the capacity in microfarads and the inductance in centimetres multiplied by a constant which is nearly 200 if the wave length is to be reckoned in feet and exactly 60 if it is to be measured in metres.

In the kummeter, made as above described, the indications are quite independent of the frequency of the groups of oscillations or upon the number of spark discharges per second of the telegraphic Hertzian transmitter. This is not the case when instruments are employed in which a hot wire ammeter or voltmeter of any kind is issued as an indicator.

Dated this 19 day of December 1904.

J. A. FLEMING.

COMPLETE SPECIFICATION.

Improvements in Instruments for the Measurement of Wave Lengths in Wireless Telegraphy.

I, John Ambrose Fleming, Professor of Electrical Engineering, of University College, Gower Street, London, in the County of Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

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 Figure 2 an end elevation (some parts being omitted) of an instrument constructed according to this invention. Figures 3 and 4 are similar views of a modification. Figures 5 and 6 a plan and side elevation of another 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, S.W.G. 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 $^1/_8$ inch to $^1/_4$ 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, whilst 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, whilst 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^1 and the two pins p p^1 are connected by a stout copper bar L^1 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 4 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 3 feet. The outer brass jacket may be 28 or 30 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^1 a^1 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^1 L^2 L^3 L^4 may consist of a strip of copper about an inch in width and about $^1/_8$ of an inch in thickness.

In another form, shown in Figures 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 4 feet or 4 feet 6 inches in length and 4 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^1 a^1, the outer half of the ebonite tube is wound with a bare copper wire put on in an open spiral, the turns being about $^1/_8$ to $^1/_4$ 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 upper 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^1 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 pivotted 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 rarified 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 and one end of the vacuum tube should nearly touch this scale.

In the arrangement shown at Figures 5 and 6 the inductance and capacity are parallel to each other instead of being co-axial but in other respects it is similar to the arrangement shown in Figures 1 and 2, the handle H being fixed to the outer tube J of the condenser and carrying the saddle K. The diameter of the tubes may be about half and their length double those in the case of the form shown in Figures 1 and 3.

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 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 centimetres. 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 5,000,000 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 = 200 × oscillation constant.

Either of the above forms of cymometer enable this oscillation form of 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.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An instrument for measuring the length of electric waves consisting of a closed circuit containing inductance and capacity such that one movement of the handle varies simultaneously and in the same proportion both the inductance and the capacity substantially as described.

2. Instruments for the measurement of wave lengths substantially as described and illustrated in the drawings.

Dated this 23rd day of June 1905.

J. A. FLEMING.

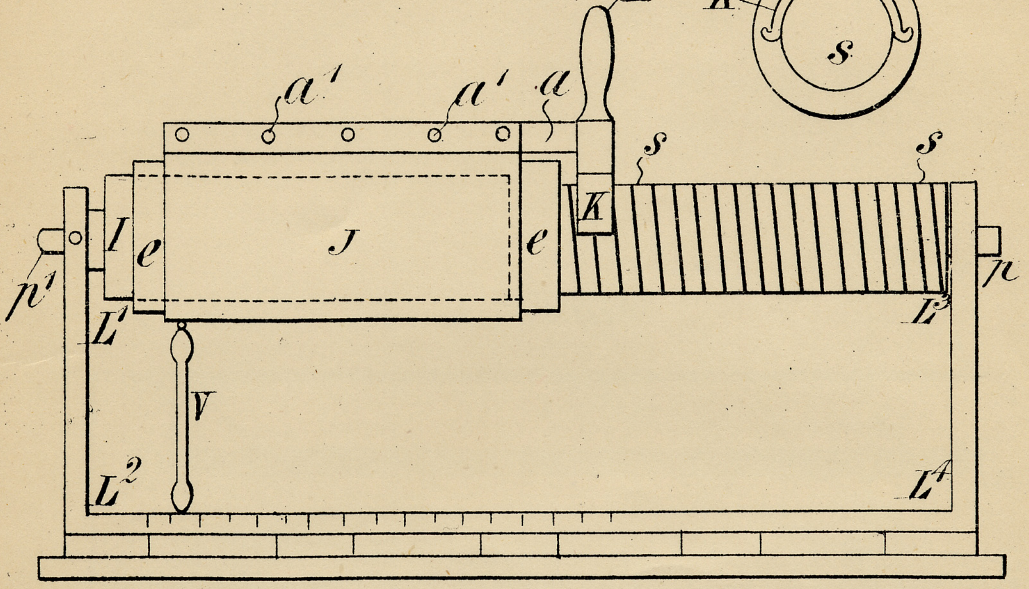
Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[G. 9235—125—4/1906]

(2nd Edition)

SHEET 1.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.



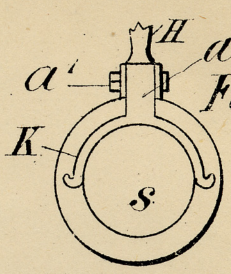


Fig. 2.

Fig. 3.

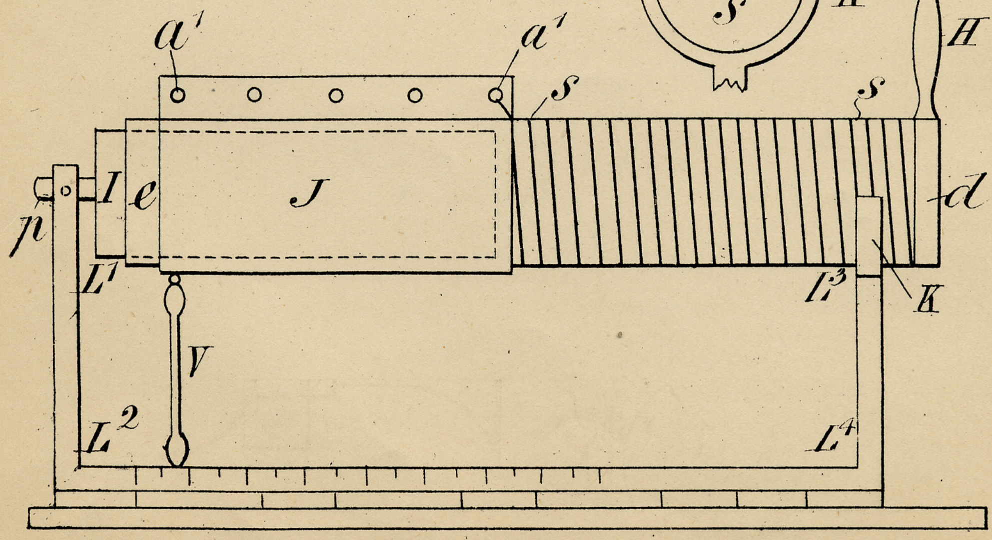


Fig. 4.

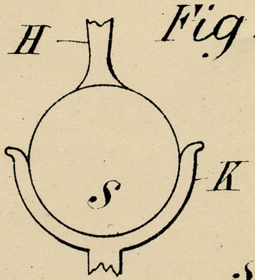


Fig. 5.

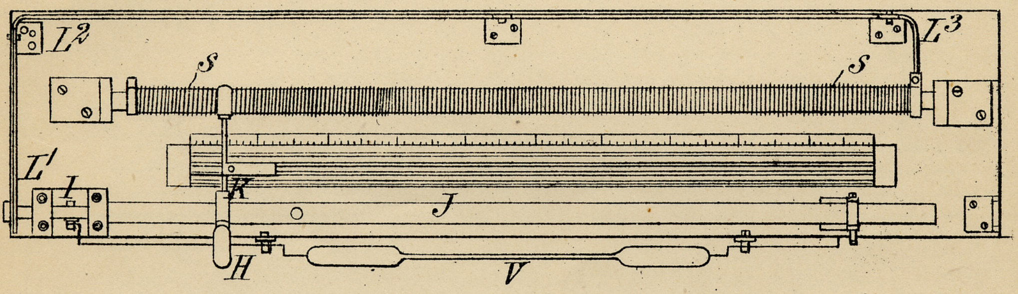
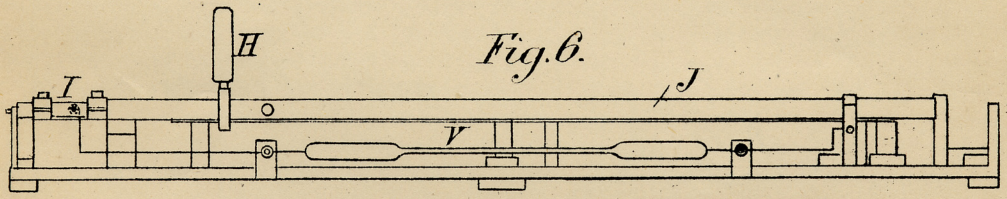


Fig. 6.



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