

PATENT SPECIFICATION

252,263

Application Date : Dec. 3, 1924. No. 28,971 / 24.

Complete Left : Aug. 27, 1925.

Complete Accepted : June 3, 1926.



PROVISIONAL SPECIFICATION.

Improvements in and relating to Radio-telegraphic Direction Finding and other purposes.

I, ROBERT ALEXANDER WATSON WATT, a British subject, of the Radio Research Board Station, Ditton Park (North), Langley, Bucks, do hereby declare the nature of this invention to be as follows:—

This invention relates to an improved arrangement for the determination of the direction of arrival of electro-magnetic waves, and more particularly to an arrangement which will permit of obtaining a visible maximum effect in a particular direction, for instance, in the direction of a transmitting station, the invention being also and especially suitable for the location of atmospheric electric discharges.

Some of the arrangements for radio-telegraphic direction finding which have hitherto been proposed suffer from the limitations that their usefulness depends on the duration of the wave train to be observed, it being impossible to obtain a determination of direction of arrival unless the received wave train persists for or is repeated over a time comparable with or exceeding one second, and further that accurate determinations could not be obtained in the presence of interfering wave trains or impulses.

The main object of the present invention is to provide means for overcoming these limitations.

The invention consists in combining two or more directional aeri-als, with or without one or more non-directional aeri-als, directly, or by way of triode or other amplifiers, to an indicating instrument of the type commonly known as a cathode ray oscillograph, in such a manner that the indicating spot of the oscillograph shall be deflected in a direction which is simply related to the direction of arrival of the incident electro-magnetic wave train.

The directional aeri-als may, more particularly, be loop or frame aeri-als such as are well known in radio-telegraphic practice and they may be coupled directly or through amplifiers to the indicating device in such ways that the ionic beam is deflected either electromagnetically or electrostatically, or by a combination of these two methods.

In carrying the invention into effect, according to one mode, I employ two closed loop aeri-als arranged with their planes vertical at right angles to each other, the loops being brought into resonance with the incident wave train constituting the signal by means of added inductances and capacities according to known methods. Across the added tuning devices in each loop are connected the input terminals of two identical triode amplifiers, which may, for example, each contain one or two stages of resistance capacity coupled amplification, using triodes of large voltage factor. It is desirable that the amplifiers employed should be as nearly as possible free from distortion, both in amplitude and in phase, and they should preferably contain no rectifying circuits. The output terminals of the respective amplifiers are connected to two pairs of plates within a cathode ray oscillograph so arranged that the electromotive force from each amplifier produces a deflection of the ionic beam, and consequently of the indication spot, at right angles to the deflection produced by the electromotive force from the other amplifier.

When an electromagnetic wave train impinges on the aerial system the resultant electromotive forces applied to the deflecting plates produce a deflection of the indicating spot along a line which is a direct and visible measure of the direction of arrival of the incident wave train.

[Price

According to this mode of carrying the invention into effect the device will indicate the direction of arrival of the incident wave train with an ambiguity of two right angles, that is to say, it will determine the direction of the vector without discriminating its sense. According to a modification, this ambiguity may be removed by the introduction of a deflecting force from electromagnetic or electrostatic devices coupled to an amplifier which is connected to a non-directional aerial, which may, for example, be of the nature described in my British Patent No. 129,336.

Instead of being arranged for visual indication, the device may be arranged for photographic recording, or for the controlling of additional apparatus, as for example by the insertion in the oscillograph of electrodes on which the ionic beam impinges when deflected in selected directions.

I wish it to be understood that the device may be used for determining the direction of arrival of wave trains or impulses of very short duration, as for example, of durations less than one thousandth of a second, or when the apparent direction of arrival is varying rapidly, and that it may be used for the determination of the direction of arrival of two or more different wave trains arriving simultaneously from different sources, even when the frequencies of those wave trains are identical.

I also wish it to be understood that the arrangement hereinbefore described may be modified in various respects without in any way departing from the spirit of the invention, which is, briefly, that of a radiotelegraphic directional receiving device in which the moving portion is a self setting element of very slight inertia, consisting of an ionic beam.

Dated the 1st day of December, 1924.

R. A. WATSON WATT.

COMPLETE SPECIFICATION.

Improvements in and relating to Radio-telegraphic Direction Finding and other purposes.

I, ROBERT ALEXANDER WATSON WATT, of The Radio Research Board Station of The Department of Scientific and Industrial Research, Ditton Park (North), Langley, in the County of Buckingham, a British subject, 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 an improved arrangement for the determination of the direction of arrival of electromagnetic waves, and more particularly to an arrangement which will permit of obtaining an observable maximum effect in a particular direction, for instance in the direction of a transmitting station, the invention being also and especially suitable for the location of atmospheric electric discharges.

Some of the arrangements for radio-telegraphic direction finding which have hitherto been proposed suffer from the limitations that their usefulness depends on the duration of the wave train to be observed, it being impossible to obtain a determination of the direction of arrival unless the received wave train persists for or is repeated over a time comparable with or exceeding one second, and further that accurate determinations cannot be obtained in the presence of interfering wave trains or impulses.

The main object of the present invention is to provide means for overcoming these limitations.

The invention consists in combining two or more directional aerials, with or without one or more non-directional aerials, directly or by way of triode or other amplifiers to an indicating instrument of the type commonly known as a cathode ray oscillograph, in such a manner that the indicating spot of the oscillograph shall be deflected in a direction which preferably has a simple linear relationship to the direction of arrival of the incident electromagnetic wave train, although more complex functional relationship may be employed and interpreted.

The directional aerials may more particularly be loop or frame aerials such as are well-known in radio-telegraphic practice and they may be coupled directly or through amplifiers to the indicating device in such ways that the ionic beam is deflected either electromagnetically or electrostatically, or by a combination of these two methods.

The invention is illustrated diagrammatically and by way of example in the accompanying drawings, in which:—

Figure 1 shows one mode of carrying the invention into effect, while

Figure 2 illustrates a modification thereof.

5 The invention also consists in the arrangements and combination of circuits hereinafter more particularly referred to.

10 Referring to the arrangement illustrated in Figure 1, two closed loop aerials N, S, and E, W, are arranged with their planes at right angles to each other, the base of each of the loops including respectively two inductive coils b, b (b^1, b^1) and condensers c, c (c^1, c^1) arranged between the two coils.

15 The loop aerials may be brought into resonance with each other and preferably into resonance with the incident wave train constituting the signal by means of these coils and condensers according to known methods. Across these added turning devices in each loop, for example across the points o, o (o^1, o^1), are connected the deflecting plates n, s, e, w , of a cathode ray oscillograph, the plates being so arranged in pairs that the electromotive force applied to one pair of plates, that is to say in the present instance the electromotive force developed across the tuning devices in one loop, produces a deflection of the ionic beam, and consequently of the indicating spot, approximately at right angles to the deflection produced by the electromotive force applied from the other loop to the other pairs of plates.

20 The mid-point M of the upper side of the loop and the mid-point M_1 of the added devices may conveniently and preferably be connected to the anode of the oscillograph and to earth for the reduction or elimination of spurious effects due to the action of the loops as partly non-directional aerials.

25 According to a modification which increases the sensitivity of the arrangement the loop aerials with their tuning devices are connected to the oscillograph not directly as in Figure 1 but by way of symmetrical and similar amplifiers as in Figure 2. These amplifiers may for example each contain one or two stages of resistance-capacity-coupled amplification and may employ triodes of large voltage amplification factor. It is desirable that the amplifiers used should be symmetrically disposed, and that they should be as nearly as possible free from distortion, both in amplitude and in phase, and they should preferably give no rectification effect, although my invention can be used with rectified currents.

30 Referring particularly to Figure 2, the loop circuits and the connections to earth are substantially as in Figure 1. The

points o, o, o^1, o^1 are now connected to the input grids G, G, G^1, G^1 , of similar triodes whose plate circuits contain resistances R, R, R^1, R^1 . The voltage released in the plate circuits by electromotive forces applied from the loops to the input grids may be applied by way of condensers F, F, F^1, F^1 , or by other known means, either directly to the deflecting plates of the oscillograph or, as in Figure 2, to the grid terminals of a second similar stage of amplification, which may be followed by still further stages. The amplifiers need not be of the type shown, which is typical and illustrative only, but may be of any type which satisfies the conditions already specified.

35 According to these modes of carrying the invention into effect the device will indicate the direction of arrival of the incident wave train with an ambiguity of two right angles, that is to say, it will determine the direction of the vector without discriminating its sense. According to a modification, this ambiguity may be resolved by the introduction of a deflecting force from electromagnetic or electrostatic devices coupled directly or by way of an amplifier with or without phase controlling devices, which is connected to a non-directional aerial which may for example be of the nature described in my British Patent No. 129,336, that is to say the necessary coupling devices may be inserted in and attached to the lead joining M, M, M^1, M^1 (Figures 1 and 2) to earth.

40 In all the modifications described the mode of action of the invention is such that when an electromagnetic wave train impinges on the aerial system the resultant electromotive forces applied to the deflecting plates produce a deflection of the indicating spot along a line which is a direct and visible measure of the direction of arrival of the incident wave train.

45 According to further modifications the device may be arranged for photographic recording in place of or in addition to visual observation and may be adapted by the provision of electrodes within the tube to any purpose in accordance with the invention.

50 For example, a plurality of radial conducting electrodes may be arranged within the oscillograph in such a manner that the deflection of the ionic beam in a specific direction completes a conduction circuit including part of the beam and one or more specific electrodes and thus actuates or controls auxiliary apparatus all or part of which is included within the said conducting circuit.

55 According to a further modification

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the electromotive forces or deflecting fields applied to the oscillograph may be of a low frequency derived from the wave frequency by known processes of heterodyning, rectification or detection.

I wish it to be understood that the device may be used for the determination of the direction of arrival of wave trains or impulses of very short duration, as for example of durations less than one-thousandth of a second, or when the apparent direction of arrival is varying rapidly, and that it may be used for the determination of the direction of arrival of two or more different wave trains arriving simultaneously from different sources, even when the frequencies of these wave trains are identical.

I also wish it to be understood that the arrangement hereinbefore described may be installed in or used for observing on fixed or movable stations.

I also wish it to be understood further that the arrangements hereinbefore described may be modified in various respects without in any way departing from the spirit of the invention, which is briefly that of a device for radio-telegraphic direction finding and similar purposes in which the moving portion is a self-setting element of very slight inertia, consisting of an ionic beam.

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. A method of employing directional aerials and cathode ray oscillographs in combination for radio-telegraphic direction finding and similar purposes.

2. A device for radio-telegraphic direction finding and similar purposes, in which the moving portion is an ionic beam.

3. Circuits comprising directional aerials in combination with means for applying to the ionic beam in the cathode ray oscillograph deflecting fields whose ratio and phase relations are controlled functions of the ratio of the electromotive forces in the directional aerials.

4. Circuits in which the functional relationship as claimed in Claim 3 is a linear one.

5. Circuits comprising directional aerials and oscillographs substantially as in Claims 3 and 4 in combination with non-directional aerials.

6. The method and circuits in accordance with Claims 1, 2, 3, 4 and 5, characterised in this that they are employed in the examination of sustained, interrupted, repeated or modulated wave trains.

7. The method and circuits in accordance with Claims 1, 2, 3, 4 and 5, characterised in this that they are employed in the examination of brief or rapidly varying wave trains or impulses from a fixed or apparently rapidly moving source.

8. The method and circuits according to Claims 1, 2, 3, 4 and 5, characterised in this that they are employed in the discrimination and separate determination of simultaneously arriving wave trains of the same or different frequencies.

9. Circuits as claimed in any of the preceding claims in which the electromotive forces in the aerial circuits are subjected to rectification or similar modification before the application of the deflecting fields to the ionic beam.

10. A combination of circuits as claimed in Claims 3, 4, 5 and 9, with apparatus for photographic or other methods of recording.

11. A combination of circuits for radio-telegraphic direction finding and similar purposes adapted to be used substantially as illustrated in and described with reference to Figures 1 and 2.

12. A combination of circuits as claimed in any of the preceding claims in which additional electrodes are provided within the oscillograph.

13. Methods of employing directional aerial systems in circuits substantially as described and as illustrated with reference to the accompanying drawings.

Dated this 27th day of August, 1925.

MARKS & CLERK.

2nd Edition

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

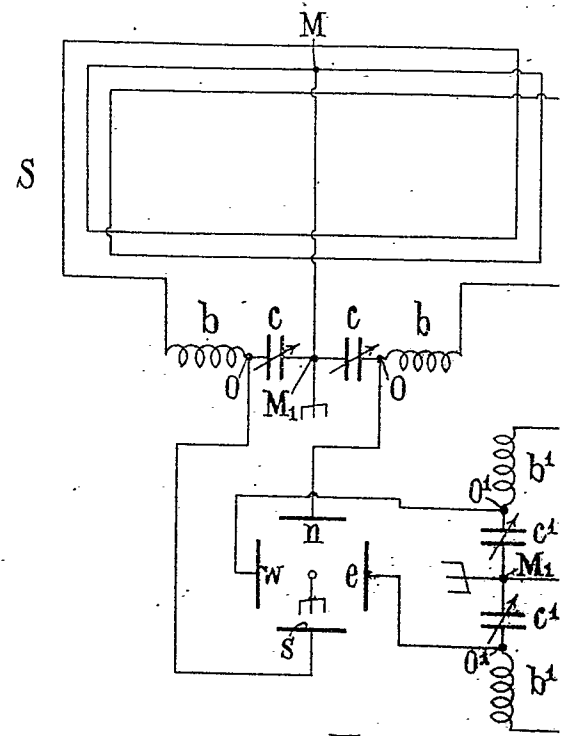


Fig. 1.

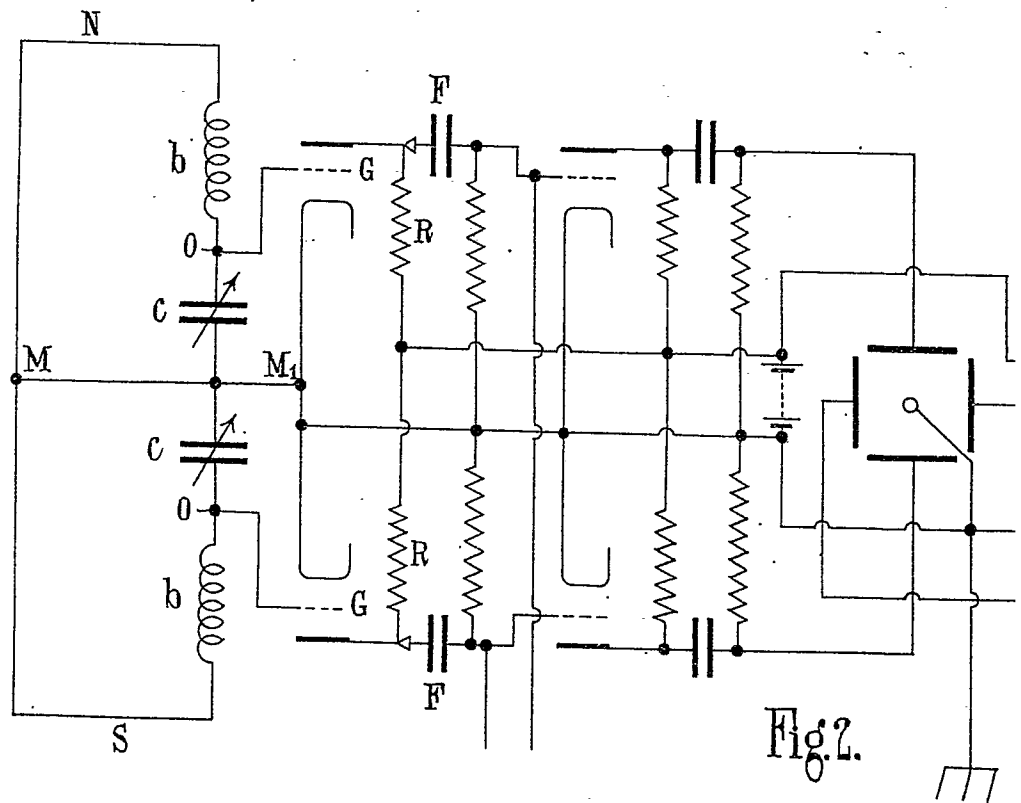


Fig. 2.

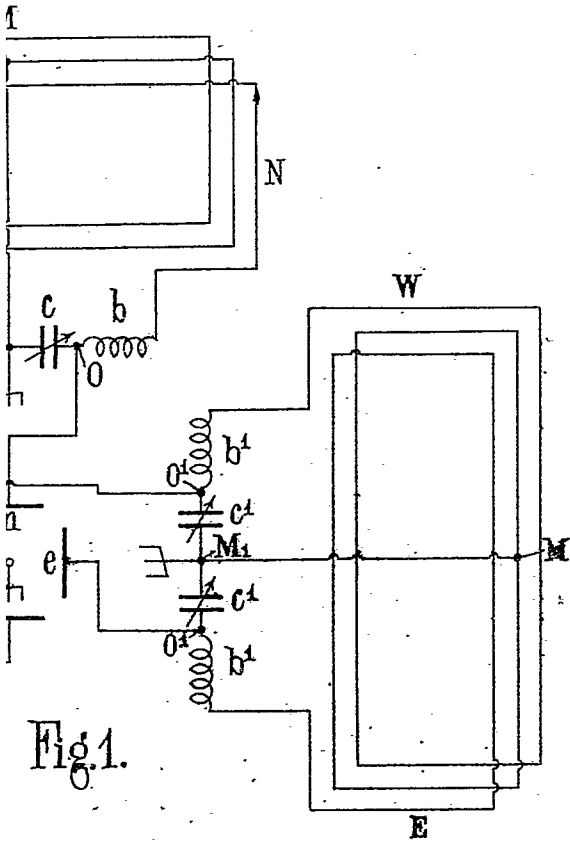


Fig. 1.

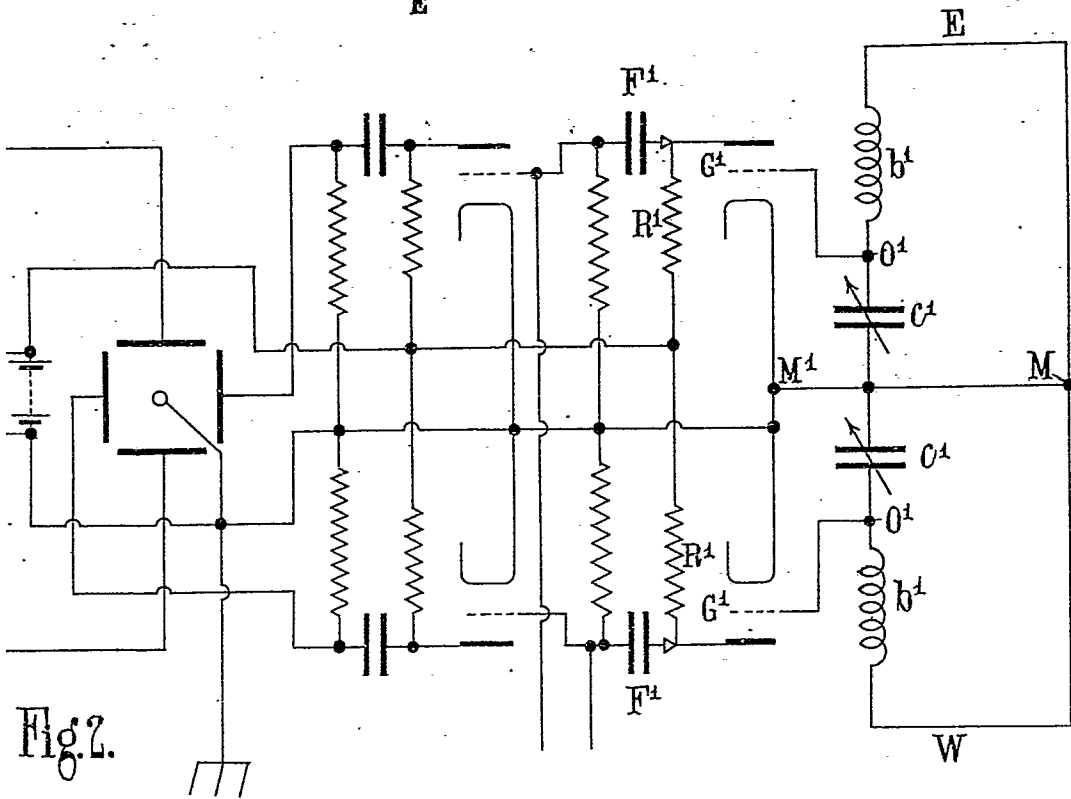


Fig. 2.

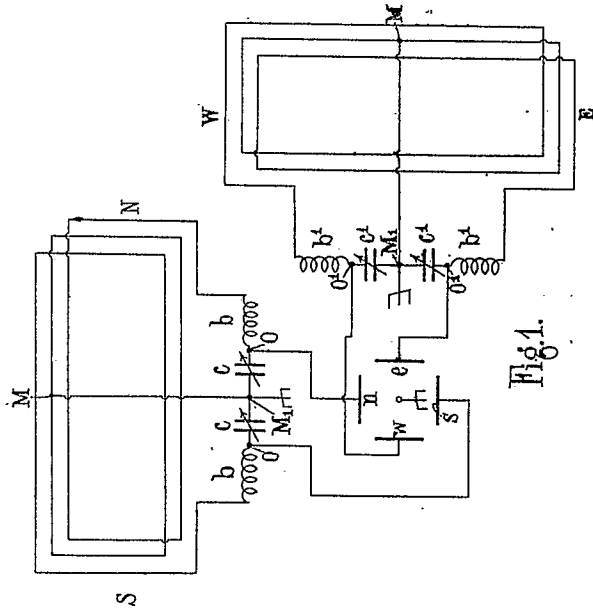


Fig. 1.

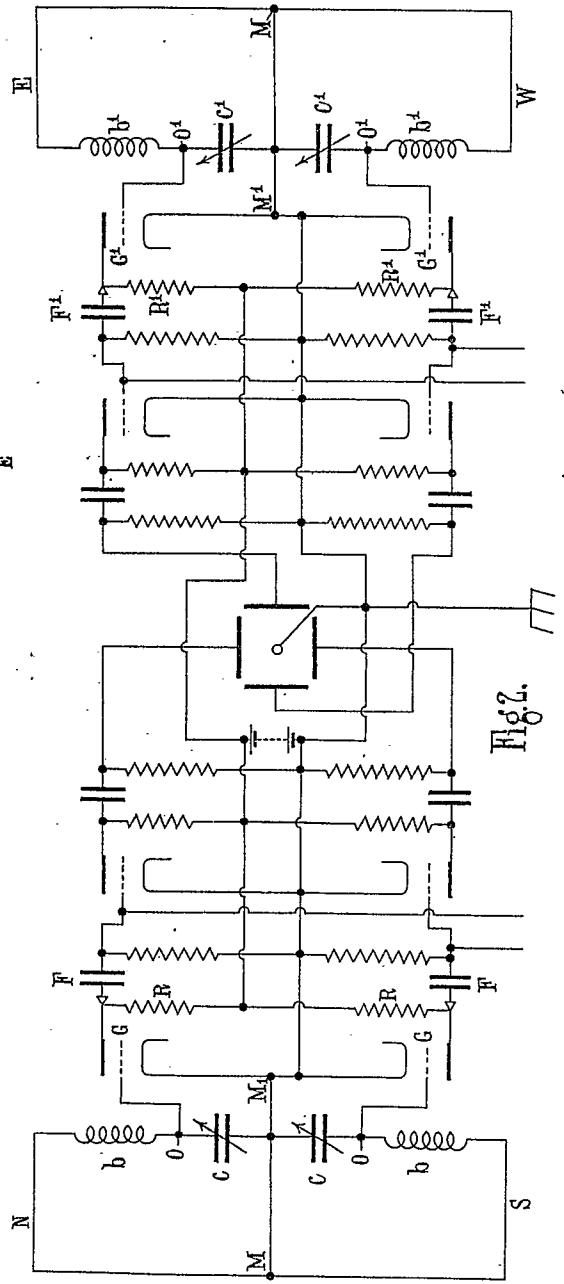


Fig. 2.

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