July 28, 1936. G. A. MATHIEU 2,048,751

ULTRA SHORT WAVE CARRIER WAVE APPARATUS

Filed June 14, 1934

Fig. 1

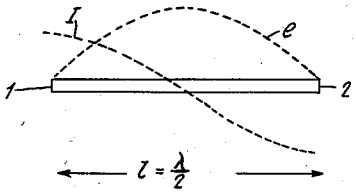


Fig. 2

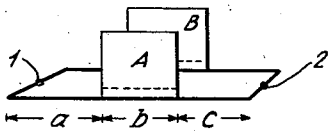


Fig. 3

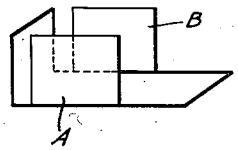


Fig. 4

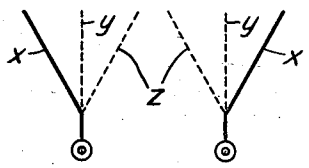


Fig. 5

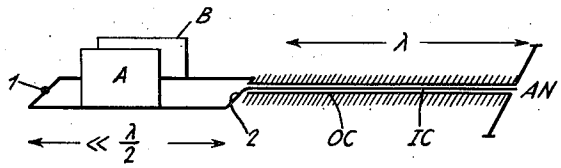


Fig. 6

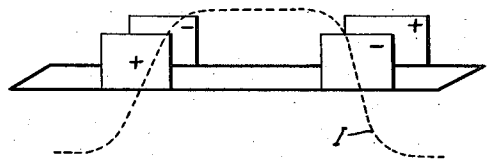


Fig. 7

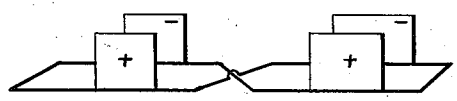


Fig. 8

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ULTRA SHORT WAVE CARRIER WAVE APPARATUS

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Application June 14, 1934, Serial No. 730,625
In Great Britain June 27, 1933

12 Claims. (Cl. 250—17)

This invention relates to ultra short wave carrier wave apparatus and more particularly to apparatus for use in wireless signaling on so-called micro or ultra short waves, by which expression is meant waves of a length below one meter, or thereabouts.

In ordinary wireless apparatus as at present in common use, it is customary to use tuned circuits consisting of lumped capacity and lumped inductance (i. e. ordinary condensers and inductance coils) generally connected in parallel but when wave lengths of below about one meter are in question the use of tuned circuits constituted by such lumped inductances and capacities becomes impracticable, in part because of the extremely small dimensions required for the said inductances and capacities, and in part because at such very short wave lengths the self-capacity of any ordinary form of coil and the self-inductance of any ordinary form of condenser become important factors.

Accordingly, in the art of wireless signaling with micro-waves distributed self-inductances and capacities have been made use of instead of lumped inductances and capacities for purposes of tuning. The well known Lecher wire arrangement illustrated in Fig. 1 of the drawing may be regarded as typical of the arrangements which have been used and proposed hitherto. In the said Fig. 1 the Lecher wire arrangement consists of two parallel wires joined together at their ends, the length of the circuit being one half the working wave length. This is represented conventionally in the said Fig. 1 by the dimension

$$l=\frac{\lambda}{2}$$

The nature of the distribution of the voltage and current along the Lecher wire circuit of Fig. 1 is well known and is represented in conventional fashion in the said Fig. 1 by the broken line curves, the curve *e* being the voltage distribution curve and the curve I being the current distribution curve. As will be seen the ends 1 and 2 are points of zero potential and maximum current.

Now, although a Lecher wire arrangement as is shown in Fig. 1 is quite a satisfactory device for the purpose for which it was originally intended, namely that of approximately measuring micro-waves, it is not so satisfactory for the purpose for which it has been more recently used, i. e. as a tuned circuit in a micro-wave transmitter, receiver or amplifier. The reason for this is that the rapid variation of the current and voltage along the length of the Lecher wires renders such a system difficult to couple satisfactorily to another circuit and unsatisfactory as a device for storing energy to be transferred to another circuit. Moreover, where it is required to accomplish variable, i. e. adjustable tuning, there is the difficulty that the length of the Lecher wires must be altered and this may involve practical difficulties and inconveniences.

According to this invention, an ordinary Lecher wire system for use as a tuned circuit in a carrier wave apparatus operating on wave lengths of the order of one meter or less is modified by providing conductive plates in conductive connection with the Lecher wires, said plates being in electrostatic association with one another and being positioned at and near points of maximum voltage or zero current. In this way the effective self-capacity of the whole arrangement is increased at and near the said points of maximum voltage and zero current.

Referring to the drawing, Fig. 1 shows a well known form of Lecher wire system;

Fig. 2 illustrates a simple form of Lecher wire arrangement in accordance with the principles of this invention;

Figs. 3, 5, 6 and 7 show various modifications of the invention;

Fig. 4 represents, schematically, the bending or hinging of the plates for tuning, as shown in Fig. 3; and—

Fig. 8 shows a circuit arrangement for an ultra short wave transmitter embodying the tuning arrangement of the invention.

One simple arrangement in accordance with this invention is shown in Fig. 2, which figure illustrates a Lecher wire arrangement as shown in Fig. 1, modified in accordance with this invention. Upon reference to said Fig. 2, it will be seen that there is upstanding from each of the Lecher wires a conductive plate A or B, these plates being mechanically in the form of plates such as are used in ordinary ultra short wave tuning condensers. The effect of providing the plates A and B is to increase the effective self-capacity with the result that, although the electrical length of the whole system is still one half wave length the physical length, i. e. the sum of the distances $a+b+c$ is less than one half wave length. The longer the distance b relative to the overall length of the whole system and the greater the dimension of the plates at right angles to the Lecher wires, the nearer must the physical length $a+b+c$ approach the half wave length and the more closely will the current and voltage distribution approach the distribution ob-

taining in an ordinary tuned circuit (such as is used on longer wave lengths) consisting of lumped capacity and inductance in parallel.

At first sight it would appear that an arrangement as shown in Fig. 2 could be regarded as consisting of one condenser with two loop inductances in parallel, but the said arrangement is not in fact equivalent to this because the points 1 and 2 retain the zero potential, maximum current conditions characteristic of a simple Lecher wire system. However, the sharpness of the zero potential points increases as the ratio of the length

$$\frac{b}{a+c}$$

increases.

The actual dimensions adopted for the plates A and B, i. e., their length and height, for a given working wave length, and also their distance apart (which is, of course, that of the Lecher wires) greatly affect the impedance of the whole circuit. So far the best dimensions for the plates have been determined in practice by trial and error in individual cases.

In practice it has been found of advantage in some cases to bend up one end of the Lecher wire system at right angles to the rest of the wires so as to be parallel to the upstanding plates, as illustrated in Fig. 3 of the drawing, which shows the arrangement of Fig. 2 modified by bending up the length *a*. The effect of bending up one end in this manner is to give a still further approach towards a quasi-constant distribution of current in the portion left unbent.

The tuning of an arrangement as shown in the Figs. 2 and 3 above described can be varied over a range of several centimetres by varying merely the relative positions of the plates A and B, e. g. by arranging the plates to be warped or hinged about axes such as are represented in the said Fig. 2 by broken lines. This bending or hinging of the plates for tuning is represented schematically in Fig. 4, which is a diagrammatic and sectional view of an arrangement as shown in Fig. 2 of the plates A and B being shown in three possible positions marked, respectively, *x*, *y* and *z*. As the plates are brought closer together the wave length to which the device is tuned is, of course, increased.

Fig. 5 shows an arrangement similar to that shown in Fig. 2 associated with an aerial, via a tubular concentric high frequency cable. The aerial is indicated at AN, the inner conductor of the high frequency cable being shown at IC and the outer conductor of this cable (which is earthed) being shown at OC. The high frequency cable, which is of form well known per se and may consist of two tubes arranged concentrically within one another and separated from one another mainly by air insulation, is of a length equal to the working wave length.

Fig. 6 shows a further modification in accordance with the invention. The arrangement of Fig. 6 may be regarded as consisting in effect of two arrangements as shown in Fig. 2 (above described) placed end to end and united in a single structure. The distribution of the current in Fig. 6 is indicated in conventional form by the broken line I and the individual plates are marked conventionally to indicate their instantaneous polarities at a particular time. An arrangement such as shown in Fig. 6 will, of course, act to some extent as a dipole aerial with end capacities and to avoid this the polarities of the plates may be reversed by crossing the Lecher wires between the pairs of plates as shown in Fig. 7. Furthermore, if desired, losses by radiation can be reduced to a minimum by placing the whole arrangement in a screening box made, for example, of solid copper sheet and having its sides running parallel to the plates at distances therefrom of one quarter the working wave length.

Fig. 8 shows diagrammatically the circuit arrangement of a powerful and efficient practical micro-wave transmitter. In this Fig. 8 AN is the aerial, which is connected through a tubular feeder IC—OC to a Lecher wire arrangement, in accordance with this invention, and consists in effect of two arrangements, as shown in Fig. 3 (above described), placed end to end and united in a single system. The transmitting valves which operate on the Barkhausen-Kurz principle as oscillators are shown at V_1 V_2 and V_1' and V_2' and the plate circuits, grid circuits, and cathode circuits of these valves are all tuned as shown so that from this point of view the arrangement of Fig. 8 is in accordance with the invention contained in the specification of United States application Serial No. 639,462, filed October 25, 1932, by Gaston A. Mathieu. The points at which high tension potential is applied for the grids of the valves are indicated at HT+ while the points at which negative potential is applied for the plates of the valves are indicated at HT—. With regard to the connections from the points HT— to the plates of the valves, it will be noted that these connections pass through the bent up ends of the Lecher wires, the zero points of potential of the Lecher wire arrangement being thus made use of for feeding the required plate potentials to the valves. The common negative connection for the cathodes is shown at CN, and R_1 R_2 R_3 R_4 are filament resistances. The connections to the plates are in practice made as short as possible but this is difficult to show in the drawing which is purely diagrammatic.

What is claimed is:

1. A tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each provided with an attached conductive plate in conductive connection therewith, said plates being in electrostatic association with one another and being positioned at points substantially of maximum voltage or zero current, whereby the effective self-capacity of the whole arrangement is increased at or near the said points, portions of said plates located on oppositely disposed Lecher wires being separated from one another along a line substantially at right angles to the wires by a distance at least equal to the separation of said Lecher wires.

2. A tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each in conductive connection with a conductive plate, said plates which are similar being opposite one another and being arranged at points of substantially maximum voltage or zero current, each Lecher wire passing substantially along one edge of the plate associated therewith.

3. An arrangement as defined in claim 1 and wherein the Lecher wires are bent up approximately through a right angle and connected together at one end, the arrangement being such that the connection between the Lecher wires is substantially at right angles to the general direction of said wires, said bent up portion lying

on the same side of said wires as do the plates.

4. An arrangement as defined in claim 2 and wherein the conductive plates are movably mounted with relation to one another in a direction substantially perpendicular to the axes of their surfaces.

5. A tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each provided with a conductive plate in conductive connection therewith, said plates being in electrostatic association with one another and being positioned at points substantially of maximum voltage or zero current, whereby the effective self-capacity of the whole arrangement is increased at or near the said points, portions of said plates located on oppositely disposed Lecher wires being separated from one another along a line substantially at right angles to the wires by a distance at least equal to the separation of said Lecher wires, said conductive plates being movably mounted with relation to one another and in effect hinged upon axes lying in or parallel to the general directions of the Lecher wires.

6. A tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each in conductive connection with a conductive plate, said plates which are similar being opposite one another and being arranged at points of substantially maximum voltage or zero current, each Lecher wire passing substantially along one edge of the plate associated therewith, and another similar tuned circuit whose Lecher wires are united with the Lecher wires of said first tuned circuit to form one prolonged Lecher wires system, the wires of which are joined together at both ends, there being two conductive plates associated with each wire.

7. A system as defined in claim 6, characterized in this that said Lecher wires are cross-connected at their points of juncture between the pairs of plates.

8. An ultra high frequency circuit comprising a pair of electron discharge devices each having cathode, anode and control electrodes, corresponding electrodes of said devices being coupled together, and another pair of electron discharge devices similarly arranged, and a tuned Lecher wire circuit for coupling the anodes of one pair of devices to the anodes of the other pair of devices, said Lecher wire circuit comprising a pair of wires each in conductive relation with at least one conductive plate, the plates on different wires of said pair having portions thereof separated from one another along a line substantially at right angles to the wires by a distance at least equal to the separation of said Lecher wires.

9. A transmitter circuit in accordance with claim 8 including means for maintaining the control electrodes of said devices at a high positive potential and their respective anodes at a much lower potential relative to their respective cathodes.

10. An ultra high frequency circuit comprising a pair of electron discharge devices each having cathode, anode and control electrodes, corresponding electrodes of said devices being coupled together, and another pair of electron discharge devices similarly arranged, and a tuned circuit for coupling the anodes of one pair of devices to the anodes of the other pair of devices, said tuned circuit comprising a pair of Lecher wires each in conductive connection with a conductive plate, said plates which are similar being opposite one another and being arranged at points of substantially maximum voltage or zero current, each Lecher wire passing substantially along one edge of the plate associated therewith.

11. A tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each in conductive connection with an attached conductive plate in the plane of the wire, said plates being similar and opposite one another and being arranged at points of substantially maximum voltage or zero current, each Lecher wire passing substantially along one edge of the plate associated therewith.

12. In combination, a tuned circuit arrangement for use on very high frequencies corresponding to wave lengths of the order of one meter and comprising a pair of Lecher wires each in conductive connection with a conductive plate, said plates which are similar being opposite one another and being arranged at points of substantially maximum voltage or zero current, each Lecher wire passing substantially along one edge of the plate associated therewith, said Lecher wires having an electrical length substantially equal to half the operating wave, an antenna, and a concentric line having inner and outer conductors coupling said antenna with said Lecher wires, said outer conductor of said line being grounded.

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