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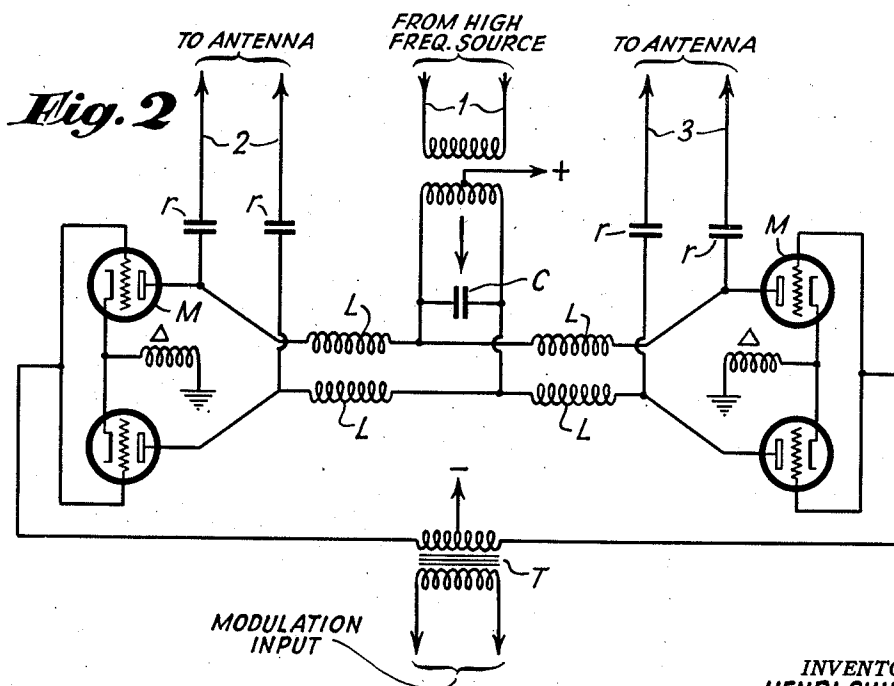
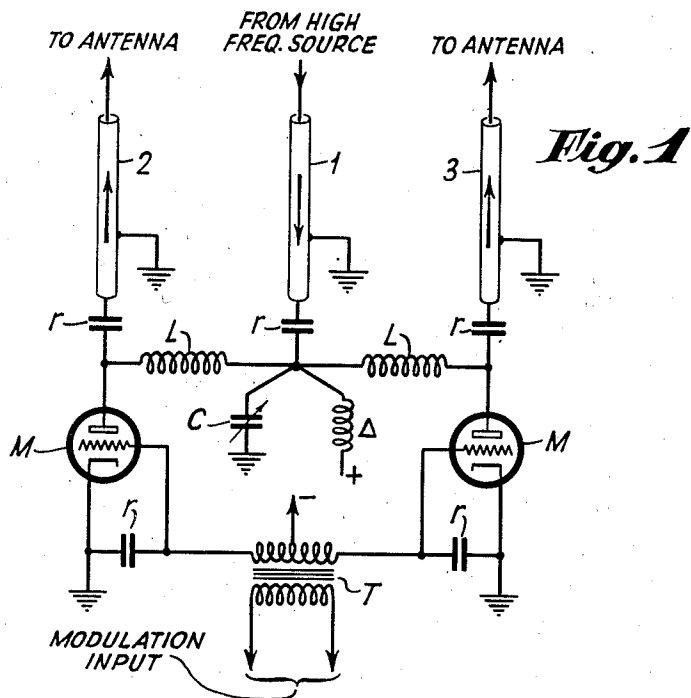
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COMMUNICATION SYSTEM USING MODULATED WAVES

Filed July 23, 1938

2 Sheets-Sheet 1



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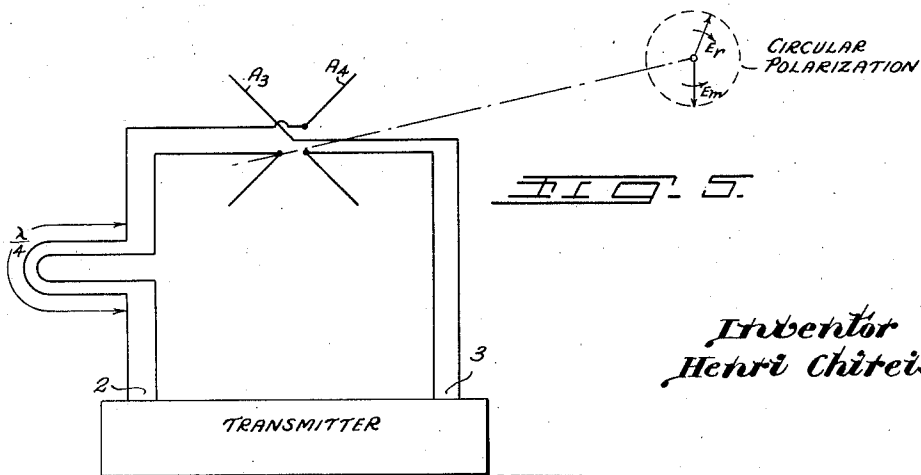
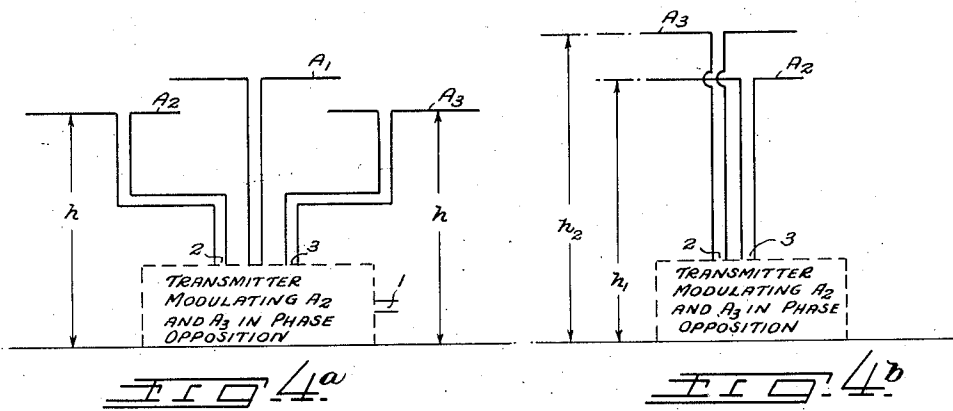
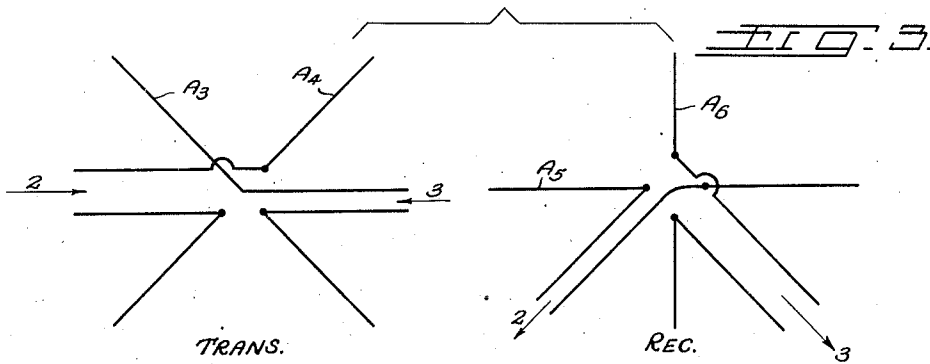
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COMMUNICATION SYSTEM USING MODULATED WAVES

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2 Sheets-Sheet 2



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COMMUNICATION SYSTEM USING
MODULATED WAVESHenri Chireix, Paris, France, assignor to Com-
pagnie Generale de Telegraphie Sans Fil, a cor-
poration of FranceApplication July 23, 1938, Serial No. 220,928
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6 Claims. (Cl. 250-17)

The new signaling methods hereinafter to be disclosed are particularly adapted to short or to ultra short waves. It is known in the art that waves of this kind may be generated under favorable conditions, both from the viewpoint of power and of output or efficiency, by the aid of magnetrons. It is also a well known fact that magnetrons are but poorly suited for modulation work.

Suppose that there is available a source of non-modulated high frequency energy and that this energy is not readily modulable, as furnished, for instance, by a magnetron. Suppose also that this very source is to be used for signaling on modulated waves, either for one-way or two-way communication with carrier currents.

Now, the principle of this invention is illustrated in Fig. 1, and in Fig. 2 which is a further development of the circuit of Fig. 1. Fig. 3 shows, by way of example only, how the antennae may be arranged in transmitting and receiving systems for use with the systems of Figs. 1 and 2. Figs. 4a and 4b and 5 show, by way of example, how aerials can be constructed and fed for use with the present invention.

Referring to Fig. 1 in more detail, the energy of the emitter is fed by way of the feeder 1 through inductance coils L to two tubes M or groups of tubes of the variable conductance or μ type (say, triode tubes), these tubes or groups of tubes being mounted symmetrically and being grid modulated by the entire modulator currents by way of the transformer T. The plates of the triodes themselves are connected with the outgoing points of two feeders (2 and 3) brought to two distinct aerials, which aerials are disposed so that no appreciable reaction is exerted by one upon the other. Interaction between the two aerials, even though polarized identically, may be avoided by spacing the two aerials far apart from each other, or mounting one in the minimum point of the radiation diagram of the other. These antennae are preferably of the directional type and they point towards the correspondent or receiving station. The capacitors r here shown are blocking or stopping capacities insuring the impression of the requisite continuous potentials upon the tubes, while insuring effective short-circuiting in reference to the high frequency currents. Moreover, the blocking inductance Δ serves to furnish high potential direct current to the anodes of the tubes M. Finally, C is a variable condenser whose value shall be fixed hereinafter.

Now, the outstanding feature of this circuit organization is that the inductance coils L form conjointly with the capacitances of the tubes (that is, grid-plate and plate-filament capacitances) a circuit that is tuned to the high frequency source. The assumption shall here be

made that the feeders 2 and 3 are tuned, in other words, that they have no reactive power. If this is not so, this fact could be taken into consideration in the over-all tuning condition. It is known that if conditions are as stated, there results the so-called constant-intensity distribution system. In other words, the sum total of the current flowing through the tube M and the current feeding the corresponding aerial is constant. In such an arrangement the currents feeding the two antennae are then controlled in phase opposition or push-pull by means of the output of the transformer T. The total watt current taken from the feeder 1 itself is practically constant because of the fact that the two groups of tubes M operate in opposition; indeed it has no wattless component provided that the capacity of C is tuned to the inductance

$$\frac{L}{2}$$

For instance, if each of the tubes offers a resistance which varies from infinity to one-half the value of the resistance due to the corresponding feeder, with the conductance varying in accordance with a straight line law with the grid potential, it will be found that the total power that is absorbed will vary only at the ratio of 3 to 4 for a sinusoidal modulation. This fairly constant total power is due to the use of the symmetrical arrangement. However, if a constant current be supplied to the parallel combination of a single feeder 2 or 3, and a single tube M, the total power developed in the combination varies in the ratio of 1 to 3 as the resistance of M is varied between the aforesaid limits. Thus, by using the balanced arrangement, reaction of the modulation upon the source is approximately eliminated, it being understood that a variation thus effected in the conductance of the tubes M corresponds to a very high modulation percentage.

Fig. 2 of the appended drawings illustrates a further development of the circuit organization of Fig. 1, in a case where the transmission of energy or feed is effected by the aid of feeders of the kind comprising two wires being disposed symmetrically in relation to the ground. This illustration is sufficiently self-explanatory to require no additional comments. All that may be stated is that the plate blocking inductance coils have been eliminated, while blocking coils are inserted here in the filament circuits of the tubes, it being understood that these coils are dispensable as to the rest in cases where perfect symmetry exists.

It will thus be feasible to construct and feed the two aerials in various ways, to wit:

(1) Identical antennae presenting the same field polarization. (Note Figs. 4a and 4b.) If these antennae are fed in phase opposition from

the viewpoint of high frequency, then the field radiated in axial sense is only due to the modulation, and the same has practically a sinusoidal envelope. This is because the existence of compensation of the radio frequency currents due to carrier waves leaves nothing but the fields due to modulation, as known, in all symmetric push-pull circuit organizations. What is thus secured practically are the properties of a symmetric push-pull arrangement which are obtained by virtue of the aforementioned compensation of the carrier waves and because the components corresponding to the modulation become added to each other. Feeding a sinusoidal frequency at the input, the only harmonics which will remain in this envelope are odd harmonics of the modulation frequency, though under the conditions as hereinbefore described the third harmonic is only of an order of five percent.

Reception of such a wave may be insured by adding to the radiated energy the energy of a third antenna supplied directly by the generator (pilot wave). This is shown in Fig. 4a, wherein A_2 and A_3 are two identical antennas connected to feeder lines 2 and 3 of Figs. 1 and 2. The feeding of doublets A_2 and A_3 in phase opposition is insured by a convenient direction of the connections, the doublets being assumed to be identical or their lengths being assumed to differ by a whole number of $\lambda/2$. The antenna A_1 is in phase with A_2 or with A_3 in the absence of modulation. Antenna A_1 is the supplementary or auxiliary antenna fed by the line 1.

In this instance, it will be expedient to choose a slightly different dimension for the two aerials in so far as one thereof is made more directive than the other; or else they may be mounted at different heights above the ground. Putting it another way, it is advantageous to make arrangements so that a residual carrier wave remains by suppressing the symmetry of the sending arrangement, this being accomplished in any desired manner, as by having different dimensions for the two antennae, different directivities, and/or different heights above the ground. This is shown in Fig. 4b wherein antennas A_2 and A_3 are fed in phase opposition. The distances h_1 and h_2 are relatively unimportant insofar as the object of the invention is concerned. On the other hand, calculation shows that in the presence of conditions as hereinbefore defined, the energy which is put to work in the modulation amounts to one sixth the total energy furnished by the high-frequency source. This figure as a matter of fact is not disadvantageous when compared with the value of $1/6$, which, in the case of a wave subject to 100 percent amplitude modulation under sinusoidal conditions, represents the relationship of the useful energy operative in the modulation and the crest energy, the expression for which is

$$\frac{k^2}{2(1+K)^2}$$

where K is the modulation percentage, or with the value of $1/3$ if considered in the light of effective (R. M. S.) power of the ratio of effective modulating power to the modulated wave, the expression for which is

$$\frac{k^2}{2(1+\frac{k^2}{2})}$$

(2) Identical antennae with field polarization

of $\pi/2$ and feed in phase. In this instance, if one of the antennae, for instance, is subject to 45° left-hand polarization and the other one subject to right-hand polarization also at 45° (see Fig. 3 diagram at left), then the carrier wave (and the components corresponding to the even harmonics of the modulation) are transmitted in the form of vertical polarization, whereas the terms corresponding to the modulation and to the odd harmonics thereof are transmitted in the form of horizontal polarization (or vice versa). The expression "feed in phase" just employed in connection with the two antennae whose fields are polarized $\pi/2$ relative to each other, has no absolute physical sense since the two antennae are symmetric and since the two elements opposing each could be interchanged without any incidental alteration. In fact, this expression indicates and implies that the field currents are simultaneously zero in both antennae without in any way prejudicing the sense of the maxima or crests of the currents.

Mounting at the receiving end a system of two antennae polarized orthogonally, one being horizontal and other being vertical (Fig. 3, diagram at right), the carrier and the useful portion of the terms of modulation could therefore be treated separately to cause them later to interfere in the detector.

The transmitting aerial of Fig. 3 is constituted by two doublets A_3 and A_4 which are identical but which are inclined by $+45^\circ$ and -45° against the vertical in order to obtain consequently polarized fields. Feeder lines 2 and 3 are connected to feeder lines 2 and 3 of Figs. 1 and 2. The feeding may be effected in phase or in phase opposition. This depends on the direction of the connections, the feeders being supposed to be of equal length or to differ one from the other by an even number of $\lambda/2$.

More particularly speaking, the receiver handling the carrier could be of sufficient selectivity to eliminate the terms corresponding to the even harmonics of modulation, these terms being no longer suppressed as before (and this will be an easy matter especially in the case of transmission by means of carrier currents where the modulation frequencies are necessarily high).

This filtering method evidently presupposes that the plane of polarization of the incoming waves is the same at each instant as that of the transmitted waves or is shifted a fixed angle in reference thereto (case of ultra short waves inside the range of direct visibility), the system of aerial receiver antennae to be shifted a similar quantity. In the scheme shown in Fig. 3, the last mentioned angle is assumed to be zero (diagram Fig. 3 at right). The receiver arrangement adapted to the transmitter of Fig. 3 comprises two doublets A_5 and A_6 which are identical but disposed, one vertically, the other horizontally, when admitting that the wave polarization plane has not suffered any rotation between the transmitter and the receiver (note lines 12-18 of this page). If it would be otherwise, it would be necessary to turn receiving doublets A_5 and A_6 by a convenient angle, however preserving their orthogonal arrangement. The currents of the receiving doublets A_5 and A_6 pass convenient selector circuits and are combined in the receiver.

Contrasted with the case indicated in (1), the advantage here is that the whole energy of the carrier wave is utilized for the reception. Under the same assumption as regards the percentage

of modulation, the radiated high frequency energy compared with the amount of energy derived from the high frequency source will be raised to over fifty percent.

(3) Similar aeriels mounted at right angles and fed with quadrature currents. In this case it is well known that the energy of the carrier wave and the energy of the even harmonics of modulation are transmitted in the form of a circularly polarized wave (say, left-hand), while that of the modulation and of the odd harmonics thereof are transmitted in the form of a wave subject to circular polarization, but turning in the opposite sense compared with the former, say to the right-hand side.

For reception there may then be used any desired sort of aerial, the modulation harmonics being suppressed by virtue of the selective properties of the circuits. The energy efficiency and output remains just as high as in the preceding instance.

Fig. 5 shows an embodiment of the invention with doublets A₃ and A₄ arranged as in Fig. 3. The feeding in quadrature is realized by known means, for instance, by inserting in one of the feeders (for instance 2) a loop of $\lambda/4$ length, so that the electric length of the two feeders differs by an odd multiple of $\lambda/4$. The feeder leads 2 and 3 of Fig. 5 connect with the feeder leads 2 and 3 of Fig. 2. The circular polarization is indicated by the carrier vector E_r and the modulation vector E_m. The receiving antenna has any desired form.

What I claim is:

1. A modulated wave transmitting system comprising a short wave generating source, means for feeding by the output of said source the midpoint of two symmetrically connected circuits which are tuned to said short wave frequency, each of said circuits comprising at least one inductance, and at least one mu-variable electronic tube the interelectrode capacity of which resonates with the said inductance, a modulation frequency source, means for push-pull exciting by said last source the grids of said electronic tubes of said two circuits, a pair of feeding lines respectively connected to the plates of said tubes in each of said circuits, and a pair of antennae respectively connected to said feeding lines.

2. A modulated wave transmitter system comprising two antennae without any appreciable reaction between each other, said two antennae being identically polarized and being of different efficiency, a short wave generating source, means comprising feeding lines for feeding by the output of said source the midpoint of two symmetrically connected circuits which are tuned to said short wave frequency, each of said circuits comprising at least one inductance and at least one variable-mu electronic tube, the interelectrode capacity of which resonates with said inductance, a modulation frequency source, means for push-pull exciting by said last source the grids of said electronic tubes of said two circuits, a pair of feeding lines respectively connected with the plates of said tubes in each of said circuits and said two antennae being respectively connected with said feeding lines.

3. A modulated wave transmitter system comprising two antennae without any appreciable reaction between each other, said two antennae being identically polarized and being of the same efficiency, an additional antenna of the same polarization as said first named antennae, a short wave generating source, means comprising feeding lines for feeding said two antennae in parallel relation by said source, a modulation frequency source, means for push-pull modulating by said source the currents in said two antennae, means in said feeding lines for feeding said two antennae in phase opposition, and means for feeding said additional antenna in phase with one of said antennae in the absence of modulation.

4. A modulated wave transmitting system comprising two identical antennae except for polarization, the two polarizations being at $\pi/2$ one to the other and without any appreciable reaction between each other, a short wave generating source, means comprising feeding lines, for feeding by the output of said source the midpoint of two symmetrically connected circuits which are tuned to said short wave frequency, each of said circuits comprising at least one inductance and at least one variable-mu electronic tube, the interelectrode capacity of which resonates with said inductance, a modulation frequency source, means for push-pull exciting by said last source the grids of said electronic tubes of said two circuits, means being provided in said feeding lines for feeding said antennae in phase.

5. A modulated wave transmitting system comprising two identical antennae except for polarization, the two polarizations being at $\pi/2$ one to the other and without any appreciable reaction between each other, a short wave generating source, means comprising feeding lines for feeding by the output of said source the midpoint of two symmetrically connected circuits which are tuned to said short wave frequency, each of said circuits comprising at least one inductance and at least one variable-mu electronic tube, the interelectrode capacity of which resonates with said inductance, a modulation frequency source, means for push-pull exciting by said last source the grids of said electronic tubes of said two circuits, means being provided in said feeding lines for feeding said antennae in phase opposition.

6. A modulated wave transmitting system comprising two identical antennae except for polarization, the two polarizations being at $\pi/2$ one to the other and without any appreciable reaction between each other, a short wave generating source, means comprising feeding lines for feeding by the output of said source the midpoint of two symmetrically connected circuits which are tuned to said short wave frequency, each of said circuits comprising at least one inductance and at least one variable-mu electronic tube, the interelectrode capacity of which resonates with said inductance, a modulation frequency source, means for push-pull exciting by said last source the grids of said electronic tubes of said two circuits, means being provided in said feeding lines for feeding said antennae in quadrature.

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