

March 5, 1940.

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2,192,187

HIGH FREQUENCY TRANSMITTER

Filed July 20, 1937

2 Sheets-Sheet 1

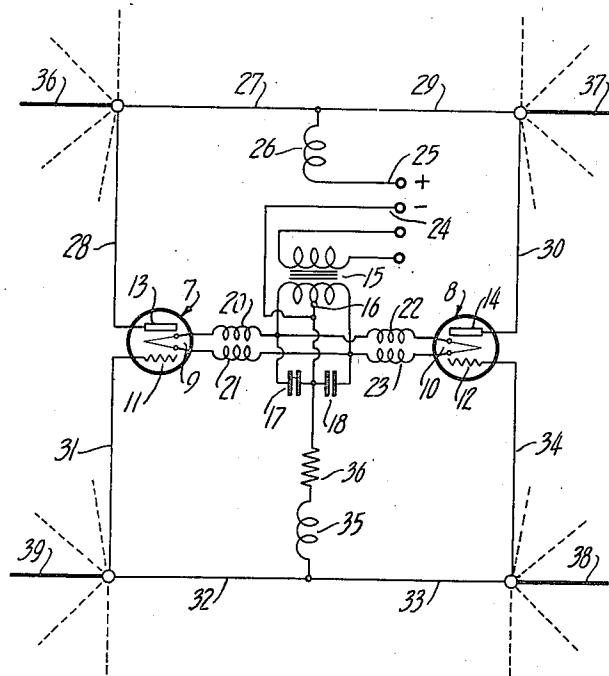


FIG. 1

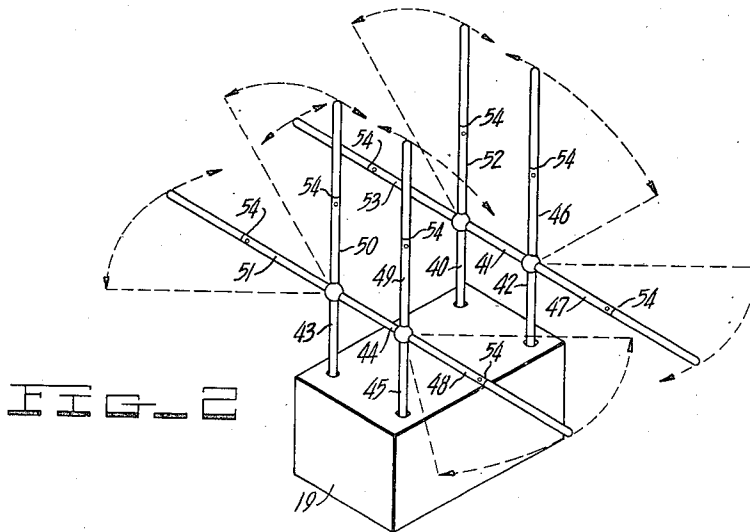


FIG. 2

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2 Sheets-Sheet 2

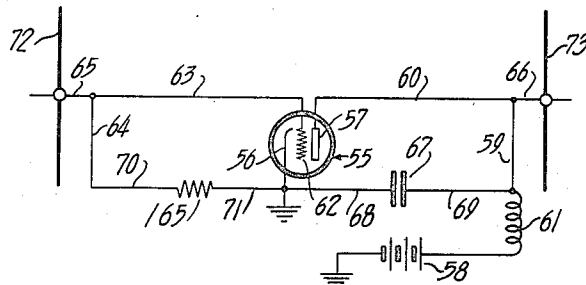


FIG. 3

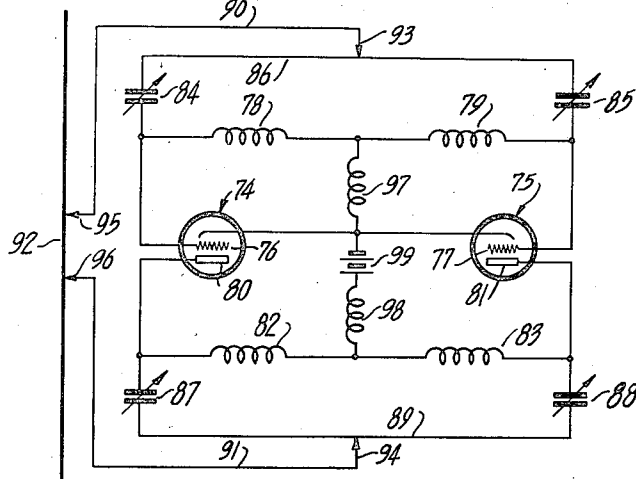


FIG. 4

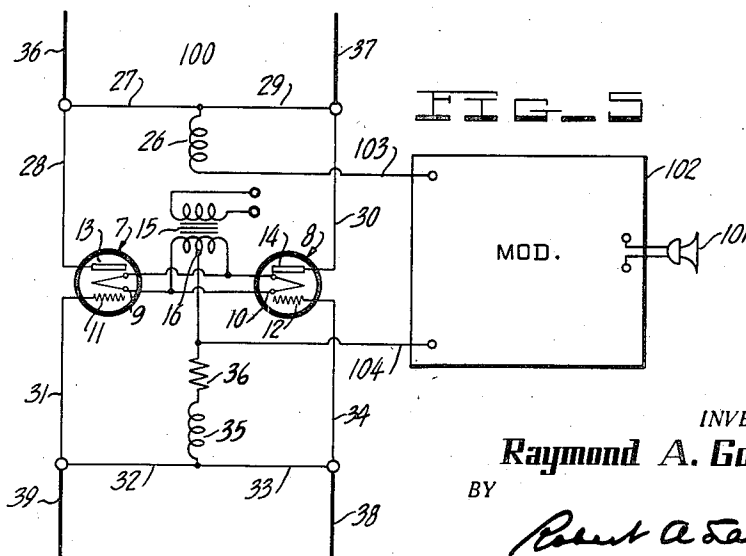


FIG. 5

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HIGH FREQUENCY TRANSMITTER

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Application July 20, 1937, Serial No. 154,613

5 Claims. (Cl. 250—11)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to radio transmission and more particularly to systems for controlling the spatial disposition of energy radiated at high frequencies.

5 Heretofore various means have been provided for radiating high frequency energy in accordance with predetermined space patterns, utilizing an antenna having known directional characteristics either alone or in combination with re-
10 flector elements, the latter serving to confine the field set up by the antenna within desired limits.

While antenna and reflector combinations have been used successfully to give space patterns of reliable characteristics, the systems heretofore
15 used have several disadvantages, among which are low efficiency due to loss of power in the antenna array, bulkiness, and inflexibility in use.

20 An object of the present invention is to provide a novel, compact, efficient and highly reliable transmitting unit that will overcome the disadvantages above mentioned.

Another object of the invention is to provide a radio transmitter having a novel form of antenna reflector array for controlling the directive
25 properties of high frequency radiant energy.

Another object of the present invention resides in the provision of a compact high frequency oscillator and transmitter unit coupled to antenna elements in a novel manner giving a maxi-
30 mum efficiency for a unit of its character.

Still another object of the invention is to provide a transmitter suitable for use at ultra-high frequencies which will have antenna and reflector elements arranged so as to be mutually adjust-
35 able with respect to each other and allow energy to be radiated according to a number of different space patterns depending upon the relation between the antenna and reflector elements.

40 Other objects of the invention are to provide a novel oscillator circuit connected to antenna elements so as to give several degrees of freedom in the selection of particular space-radiated patterns and to provide a novel oscillator circuit
45 having the optimum coupling between the oscillator circuit and the antenna elements.

The above and other objects and advantages of the invention will appear more fully upon consideration of the following specification, taken
50 in conjunction with the accompanying drawings wherein,

Fig. 1 is a schematic representation of one embodiment of the novel oscillator and transmitter according to the present invention,

55 Fig. 2 is a similar representation of another

embodiment of the invention showing the novel manner in which the antenna and reflector elements can be adjusted with relation to each other over a wide range,

Figs. 3 and 4 are schematic diagrams of other
5 embodiments of the present invention, and

Fig. 5 is a schematic diagram showing a means for modulating the novel oscillator represented in Fig. 1.

According to the present invention an oscillating circuit is provided wherein the capacity consists of the inter-electrode capacity of one or more thermionic discharge devices and the inductance consists of external conductors of such a value as to give oscillations without the use of external or additional condensers. The oscillations generated are maintained by means of suitable power supply means and radiated by means of one or more novelly arranged antenna elements according to a predetermined space pattern that may be varied considerably in characteristics by varying the space relation between several antenna elements. It is also contemplated that the novel oscillator of the present invention be coupled to a single antenna element
25 in a novel manner resulting in output efficiencies in excess of efficiencies obtained in transmitters of the prior art having similar power inputs.

Referring to Fig. 1, numerals 7 and 8 represent thermionic discharge devices such as triodes having cathode elements 9 and 10, grid electrodes 11 and 12, and plate or anode electrodes 13 and 14. Cathodes 9 and 10 are energized from a source of alternating current, not shown, by means of the transformer 15, the secondary of which is center-tapped as at 16 and has balancing condensers 17 and 18 connected thereto for purposes that will be readily understood. Radio frequency choke elements 20, 21, 22, and 23 are positioned as shown, in order to prevent high frequency energy from circulating through the cathode energizing system. High potential anode energy is supplied from some source, not shown, through conductors 24 and 25 and radio frequency choke 26.

Current from the anode source is fed to plate elements 13 and 14 through conductors 27, 28, 29, and 30, which conductors, when taken together, form also part of the inductance of the oscillating circuit. Conductors 31, 32, 33, and 34, when taken collectively, form the remainder of the inductance of the oscillating circuit, the capacitance of which is that capacity apparent across the grid and plate electrodes of discharge devices 7 and 8. An additional radio frequency choke 35 and a limiting resistor 36 are connected
55

as shown so that high frequency energy is excluded completely from the anode and cathode energy supplies. Antenna elements 36, 37, 38 and 39 are provided and are shown so connected to the high frequency circuit that antenna elements 36 and 37 form a dipole and antenna elements 38 and 39 form another dipole.

The above described oscillating system operates in conjunction with the antenna elements shown, to radiate energy in the following manner: when cathode elements 9 and 10 are energized and the anode energy supply is connected to the system, oscillations will be set up through the inductance 27, 28, 29, 30 and 31, 32, 33 and 34, and the inter-electrode capacitance of discharge devices 7 and 8. It will be readily apparent, therefore, that the frequency of oscillations set up will be extremely high, and depending upon the values of inductance and capacity, can be made to vary from what is known as the high frequency region up through the so-called super-frequency region. One hundred megacycles has been used, but higher or lower frequencies are readily attainable. Since the current in plates 13 and 14 will appear 180 degrees out of phase with the currents in grids 11 and 12, the antenna composed of elements 36 and 37 can be spaced from the antenna composed of elements 38 and 39 by 180 degrees setting up a condition whereby the two antennae act as mutual reflectors for each other and thereby constrain the high frequency energy radiated into two extremely sharp lobes. Elements 36, 37, 38, and 39 can be adjusted as indicated by the dashed lines in order to give a plurality of space patterns of widely different directional characteristics.

The novel antenna system of the present invention is not restricted to the form above disclosed but it may employ antenna elements adjustable in several different planes either separately or simultaneously. In Fig. 2, elements 40, 41, 42, 43, 44, and 45 which may be hollow tubes, represent the inductance of an oscillating system projecting from a cabinet 19, which may be of copper, aluminum, etc. and similar to that described in connection with Fig. 1, and elements 46, 47, 48, 49, 50, 51, 52 and 53 represent antennae of a slightly different embodiment from that shown in Fig. 1. As indicated by the arrows and the curved dashed lines, elements 47, 48, 51, and 53 are adjustable or pivotal in a horizontal plane, while elements 46, 49, 50 and 52 are adjustable or pivotal in vertical planes. No particular antenna pivoting means is shown but any conventional pivoting arrangement may be provided, or antenna elements 46, 47, 48, 49, 50, 51, 52 and 53 may be bent to the particular positions desired. By providing such an arrangement as this, space patterns of widely divergent directional characteristics are obtainable. As indicated at 54, each antenna element may be varied in length by forming the same telescopically whereby the maximum radiation may be obtained for a given oscillation frequency. Further, the horizontal component of the resultant space pattern obtainable from positioning members 47, 48, 51, and 53 as shown in Fig. 2 will be two sharp lobes and yet if elements 47 and 48 are pivoted toward each other so as to lie in the same line and elements 51 and 53 are likewise pivoted, yet telescoped so that no two elements are in contact, the resultant horizontal space pattern will be circular or non-directional. It will be seen, therefore, that the vertical members may be also related in various ways to give, in conjunction with the hori-

zontal members, widely divergent patterns to suit particular needs. Since the antenna elements and inductances may be constructed of hollow tubing, choke coils 26 and 35 may be connected to the center portions of inductances 41 and 44 by means of leads brought through the elements 40 or 42 and 43 or 45.

Another embodiment of the invention is shown in Fig. 3 wherein 55 represents a thermionic discharge device having a cathode element 56 which is connected to suitable energizing means, not shown, and an anode element 57 connected to a suitable source of energy, such as battery 58, by means of conductors 59 and 60 and the radio frequency choke coil 61. Control grid element 62 is shown connected in circuit with cathode 56 through conductors 63 and 64 and a suitable biasing resistance 165. Dipole antenna elements 72 and 73 are connected in the grid and anode circuits, respectively, and may be adjustably mounted on conductors 65 and 66, respectively. A radio frequency by-pass condenser 67 is provided so that the radio frequency energy may not go through battery 58. Additional conductors 68, 69, 70, and 71 are provided to form with conductors 59, 60, 63, 64, 65, and 66, inductances for the high frequency energy to be radiated by antennae 72 and 73. It will be seen, therefore, that this embodiment provides an oscillating circuit made up of external inductances in the grid-cathode and the cathode-anode circuits and the inter-electrode capacity of discharge device 50. The inductances can be made of any value suitable for resonating with the tube capacity at the desired frequency. Since conductors 65 and 66 act as inductances in grid and anode circuits, by varying the position of antenna elements 72 and 73, respectively, along these conductors, the frequency of oscillation may be changed at will. Antenna elements 72 and 73 may be positioned in any planes desired and thus a multiplicity of space patterns is available. Also, antenna elements 72 and 73 may be disposed in space 180 degrees apart so that they act as mutual reflectors in the manner above described.

In Fig. 4 there is shown another embodiment of the invention wherein thermionic discharge devices 74 and 75 are arranged in push-pull relation. Control grids 76 and 77 are connected together through inductances 78 and 79 while anodes 80 and 81 are also connected together through inductances 82 and 83 which, while shown in coil form, may be straight conductors as in the embodiments heretofore described, as the tube or thermionic discharge device capacities and the frequency desired will control the form which the inductances will take. Thus a high frequency oscillating circuit including these inductances and the inherent capacity between the electrodes of discharge device 74 and 75, will be formed. In order to obtain maximum current in the antenna, the grid elements 76 and 77 have been coupled by means of variable condensers 84 and 85 through the conductor 86. Likewise, the anodes 80 and 81 are coupled together through variable condensers 87 and 88 and conductor 89. It will be understood that since the oscillation frequency of this device will be rather high, radio frequency current will appear in conductors 86 and 89 in varying amounts along their length. Theoretically, the points of maximum current in these conductors will be the middle points thereof and there are provided additional conductor leads 90 and 91 for connecting the points of maximum current to antenna 92.

Since, due to possible unbalance in the two thermionic discharge devices 74 and 75, the points of maximum current may not be at the middle of conductors 86 and 89, antenna 92 is adjustably connected thereto by means of various taps 93 and 94. Antenna element 92 is preferably a half wave doublet and in order to obtain the optimum distribution of current in the antenna, conductors 90 and 91 are adjustably connected at points 95 and 96.

In view of the provision of this novel means of coupling the oscillating circuit to the antenna, it is not necessary to introduce loss devices, such as variable condensers, into the output of the oscillating circuit. Variable condensers 84, 85, 87, 88 are not in the oscillating circuit proper, and are used to couple the circuit to antenna 92. These condensers have an added and important function since they can be varied to bring about phase equalization between the currents in corresponding grid and anode circuits, respectively. For example, the plate or anode currents in two thermionic devices arranged in push-pull are quite often out of phase by a small amount due to small inequalities in the capacities and/or inductances in the two tube circuits, and by altering the phase of one or both circuits without introducing loss factors into the oscillating circuit, there has been provided a novel means for controlling phase displacement. Radio frequency choke coils 97 and 98 are provided for keeping radio frequency current from the cathode energy source, not shown, and the anode or plate battery 99, in the same manner that similar choke coils have been described above in connection with Figs. 1 and 3.

Means for modulating the novel oscillator and transmitter of the invention is shown in Fig. 5, wherein the oscillating and radiating circuit shown generally at 100 is similar to that shown in Fig. 1; however, the cathode chokes 20, 21, 22, and 23 and the balancing condensers 17 and 18 have been omitted for purposes of clarity. A microphone 101 or any suitable signal pick-up device is connected to the modulating means 102 which may be any one of the types well known in the art today. The modulating means is connected in the power circuit of the oscillator by means of conductors 103 and 104 which will therefore deliver energy in varying amounts depending upon the amount of current passed by modulating means 102. As the current in the modulating circuit 102 varies, thus changing the energy in conductors 103 and 104, the amplitude of the oscillations being radiated will vary accordingly. Any of the well known types of modulating circuit may be employed in conjunction with the novel oscillator and transmitter unit of the present invention.

There is thus provided a high frequency transmitter capable of transmitting energy in a number of predetermined space patterns. Since the oscillating system is one wherein the main or solitary capacitance is that inherent in a tube or thermionic discharge device, it will be appreciated that the inductances designed to oscillate therewith will be of a very simple character since the resultant oscillation frequency will be in the ultra-high and superfrequencies. In actual construction it has been found that straight, short, tubular conductors offer sufficient inductance to resonate with the tube capacity in a system such as described herein, and the antenna elements, for example, 36, 37, 38, and 39 of Fig. 1, have a length on the order of a few feet. The whole

assembly, therefore, including oscillating circuit modulator and antenna system, can be incorporated into a small unit, as will be evident from the showing in Fig. 2.

The novel transmitter has many uses but it is particularly well adapted to directive transmission wherein an extremely narrow lobe of energy is desired. Due to the flexibility of the system, that is, the facility with which the space pattern can be controlled, it is possible for transmission to be received at several points at different angles to the transmitter and yet to completely eliminate transmission to points at some angles intermediate between any two of the desired receiving points. Such a transmitter is well adapted for use as a radio beacon or runway localizer for aircraft guidance, or it can be used advantageously on a naval vessel for communicating with other vessels of a fleet, selectively, or as a group. Further, although 100 megacycles has been indicated as a suitable frequency or oscillation, it is not intended to restrict the invention thereto, as much higher and lower frequencies may be radiated.

The embodiment of the invention shown in Fig. 4 obviates the necessity of introducing loss circuits into the oscillation circuit, which is commonly done in the art today in order to equalize the output from two tubes in push-pull relation. By eliminating the use of conventional loss devices which are introduced into the output of one tube in order to lower its output power to that of a tube with lesser output and thereby equalize the tube outputs, there has been provided a transmitter of great efficiency since no power is dissipated in order to equalize tube outputs. Taking the energy from the oscillating circuit at the points of maximum current by means of adjustable conductors 90 and 91 assures that maximum power will be fed into the antenna. Additionally, the coupling condensers 84, 85, 87, and 88 provide an ingenious means for compensating for phase variation or displacement between the circuits of two tubes in push-pull.

Only doublet and dipole antennae have been shown in the drawings, but it is evident that loop antennae or any wave antennae may be employed. For example, antenna elements 36 and 37 might be connected together at their outer extremities by a conductor, thus forming them into a loop, and elements 38 and 39 might be likewise joined. Also, while the antenna elements have been shown directly connected to the inductances it is evident that they may be remotely placed and fed by transmission lines or concentric cables.

While the lengths of the antenna elements are not critical, it is desired that the antennae be half-wave. However, it is anticipated that these lengths may be made adjustable in order to equalize the grid and plate fields and in order to give vernier control of the frequencies radiated.

While several embodiments of the invention have been shown and described, it is understood that the invention is not to be restricted to these showings, as many changes will occur to those skilled in the art to which it pertains, and reference will accordingly be had to the appended claims for a definition of the limits of the invention.

The invention herein described and claimed may be used and/or manufactured by or for the

Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

- 5 1. A radio transmitter comprising a thermionic discharge device having anode, cathode, and control electrodes, means for energizing said anode and cathode, an inductance connected to said anode, a second inductance connected to said control electrode, said inductances forming the
10 tuned inductive elements in an oscillating circuit, a radiator element connected to said anode inductance, a second radiator element connected to said second inductance and laterally spaced
15 in parallel relation with respect to said first radiator element, whereby the mutual phase displacement of the energies radiated by said radiator elements is controlled by the phase relation between the energy flowing in said anode
20 inductance and the energy flowing in said second inductance.
2. A radio transmitter comprising a thermionic discharge device having anode, cathode, and control electrodes, means for energizing said
25 anode and cathode, an inductance connected to said anode, a second inductance connected to said control electrode, said inductances forming the tuned inductive elements in an oscillating circuit providing a phase displacement of substantially 180° between the respective energies
30 flowing in said inductances, a radiator element connected to said anode inductance, a second radiator element connected to said second inductance and laterally spaced in parallel relation

with respect to said first radiator element, whereby said elements are electrically excited 180° out of phase.

3. A high frequency transmitter comprising an oscillatory circuit including a thermionic discharge device having grid and plate electrodes, an inductance connected to said grid electrode, a second inductance connected to said plate electrode, said inductances forming the tuned inductive elements in an oscillating circuit, a dipole
10 antenna connected with said grid inductance and excited in substantially identical phase therewith, a second dipole antenna connected to said second inductance and excited in substantially identical phase therewith, said dipole antenna
15 having pivotally mounted arms whereby the angular position of said arms may be changed to alter the radiation pattern produced by said antenna.

4. A directive antenna system for radio apparatus comprising a plurality of spaced dipole antennae, each of said antennae having pivotally
20 mounted arms to allow the angular attitude of said arms to be varied, whereby the radiation pattern of said antenna system may be varied.

5. A directive antenna system for radio apparatus comprising a plurality of spaced dipole antennae, each of said antennae having pivotally
25 mounted arms to allow the angular attitude of said arms to be varied, and a pivotally attached
30 radiator element carried by each dipole intermediate its length, whereby the radiation pattern of said antenna system may be varied.

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