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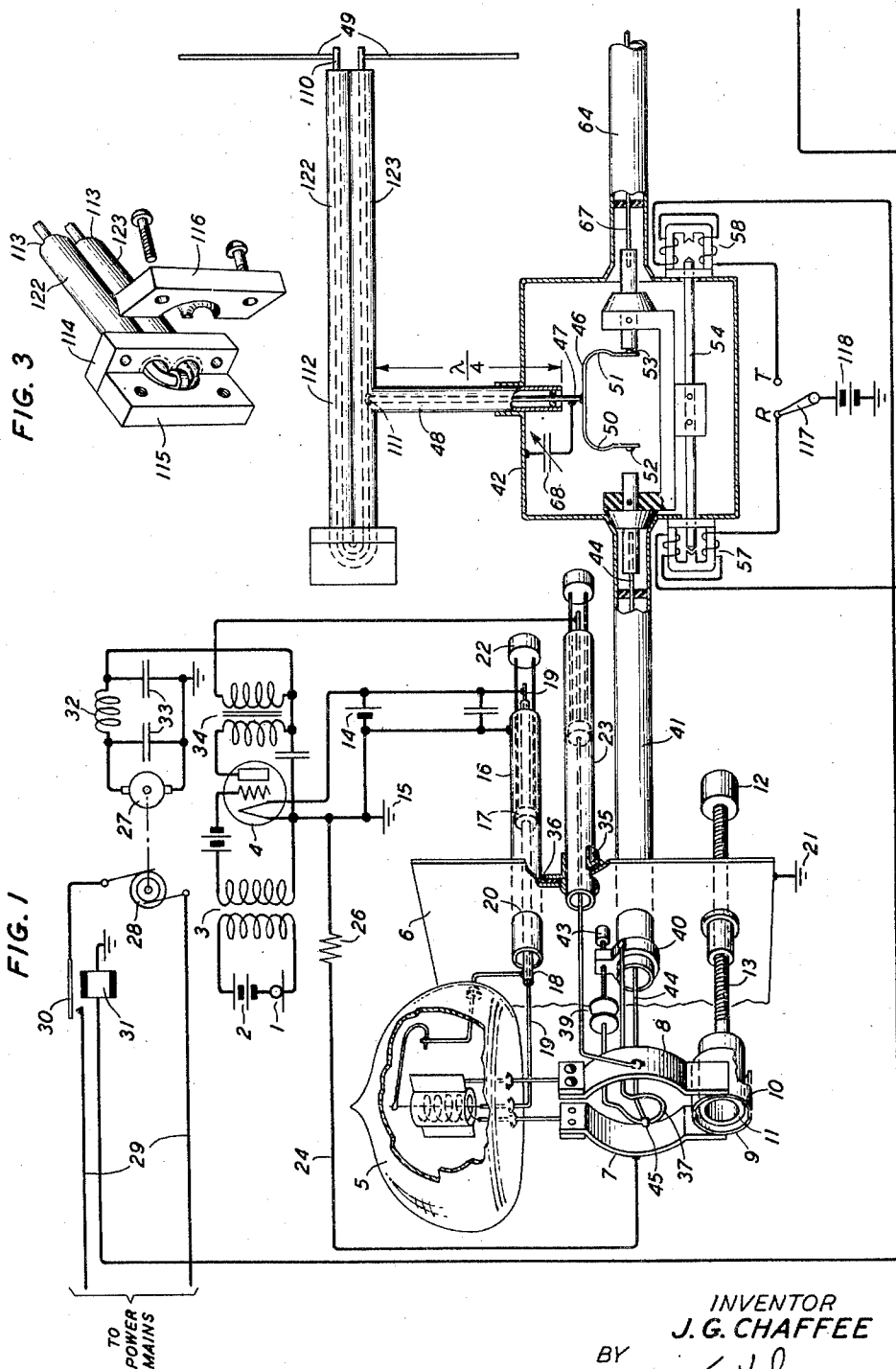
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ULTRA-SHORT WAVE TRANSMITTING AND RECEIVING SYSTEM

Filed Sept. 16, 1939

2 Sheets-Sheet 1



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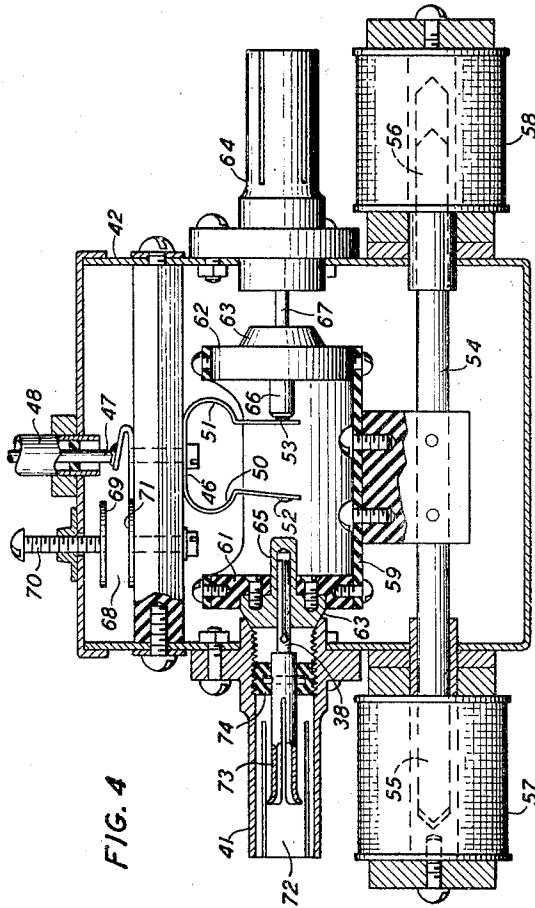
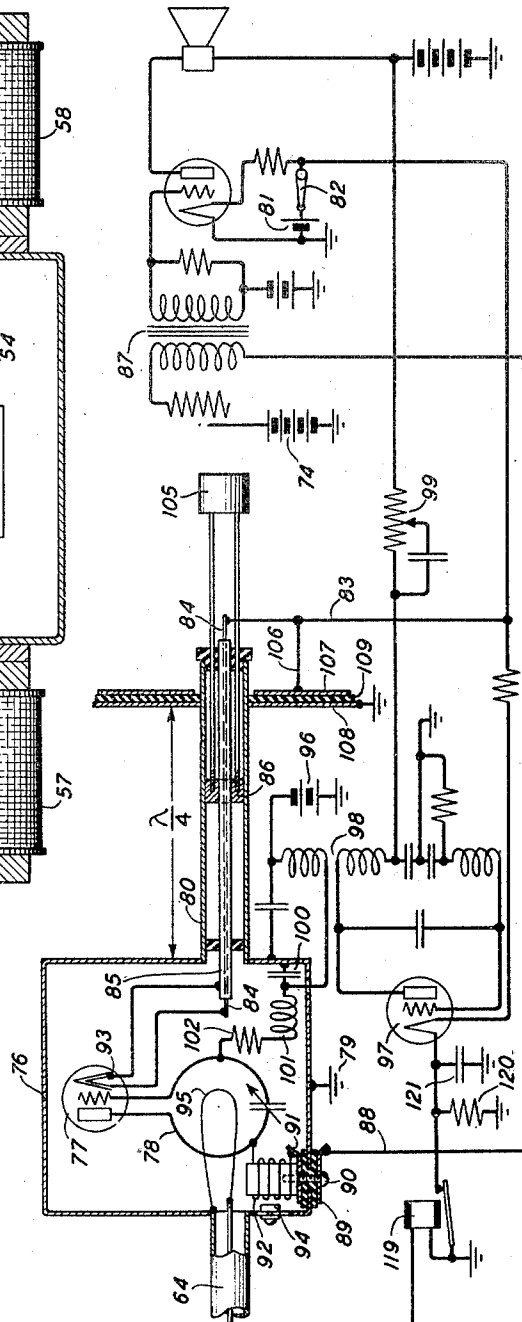


FIG. 4

FIG. 2



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ULTRA-SHORT WAVE TRANSMITTING AND RECEIVING SYSTEM

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This invention relates to ultra-short wave transmitting and receiving systems.

An object of the invention is to provide an efficient switching system for alternately connecting a transmitter and a receiver for very short waves to a common antenna.

Another object of the invention is to enable switching the antenna connections of ultra-short wave apparatus from the receiver to the transmitter while at the same time insuring against both clicks in the receiver and transmission of the high frequency relatively high power transmitter energy through the switching apparatus to the receiver.

Another object of the invention is to improve the control which the operator may exercise over the gain of a superregenerative radio receiver.

An additional object is to reduce reflections at a switching point for the coaxial conductors which lead from the transmitter and the receiver to the antenna.

A further object of the invention is to reduce undesired radiation from an ultra-high frequency transmitting oscillator.

A radio terminal system for ultra-high frequency waves embodying the invention may comprise a transmitter and receiver each suitably enclosed in a shielded container and connected by individual coaxial lines, as is also a dipole antenna, to a third shielded container enclosing a transmit-receive antenna switch. To enable tuning of the oscillator at the very short wavelengths involved the variable tuning capacity of the frequency determining circuit is connected in series with the internal grid-anode tube capacity and is provided with a movable element which is not conductively connected with either the anode or grid of the oscillator tube. The receiver may employ a superregenerative circuit which, contrary to the usual practice, is inactive in the absence of stimulating impulses. The receiver is provided with a coaxial line system for introducing cathode heating currents and which can be adjusted to secure optimum operation of the receiver. Energy loss in the circuits between the receiver and transmitter on the one hand and the antenna on the other is minimized by a design of the antenna switch housing to simulate a section of the coaxial connecting line and by a transmit-receive switch which electrically closes the contiguous end of one coaxial line whenever it connects the other to the antenna.

In the drawings:

Figs. 1 and 2, when placed end to end, illustrate schematically a complete radio terminal system in accordance with one embodiment of the invention, Fig. 1 showing the transmitter, antenna switch, and antenna, while Fig. 2 shows the receiver;

Fig. 3 shows a detail of the antenna; and

Fig. 4 is a partial section of the antenna switch and its housing and connecting lines.

Referring to Fig. 1, the radio transmitter comprises a microphone or other signal transmitter 1 with its associated current source 2, input transformer 3 and modulating amplifier 4 shown as of the simple triode type, and an electron discharge device 5 which, with its associated external circuits, constitutes an ultra-high frequency oscillator enclosed within a conductive shielding container 6, only a portion of one wall of which is shown. The device 5 is provided with a frequency determining circuit comprising the two semicylindrical inductance members 7 and 8 having openings or jacks into which the grid and anode plug terminals fit thus reducing to a minimum the electrical reactance of the external circuit connections. Members 7 and 8 terminate respectively in or are otherwise integrally connected to semicylindrical stator plates 9 and 10 which, together with the interposed conductive cylinder 11 separated by air-gaps from the plates, constitute a tuning condenser. The capacity of the condenser may be varied by rotating the knob 12 outside the shield thus causing the screw-threaded stem 13 to advance or retract the cylinder 11 within the space between stator plates 9 and 10.

Heating of the tuning circuit conductors 7 and 8 causes a poorly conducting oxide coating to form on their surfaces which finally increases the damping to such a point that the circuit oscillates much less readily. Accordingly, in order to stabilize and reduce damping of the circuit to a minimum it has been found desirable to gold-plate the entire surface of the members 7, 8, 9, 10 and 11 of the oscillatory circuit. The gold plating will withstand heating without oxidation.

The path of the current supply for the cathode of device 5 is as indicated from cathode heating source 14 by way of the ground 15, the tubular outer conductor 16 of a coaxial line, the short-circuit sliding tuning disc 17, the inner tubular member 18 of the coaxial line, the cathode, and insulated wire 19 passing through the inner tubular member back to the cathode heating source 14. The coaxial line passes

through and is metalically connected at 20 to the shield 6 which is connected to ground at 21. The tuning disc 17 is provided with a handle 22 to enable the short-circuited coaxial section 5 electrically facing the cathode to be so tuned that the amplitude of oscillations generated by the transmitter is a maximum.

The space current supply for device 5 is introduced through a coaxial line 23 passing through an opening in shield 6 so as not to contact therewith and which may be tuned by a similar short-circuiting device. An annular sleeve member 35 in contact with line 23 serves with the shield and the intervening dielectric 15 plate 36 to constitute a low impedance capacity path for high frequency current from the line 23 to ground. Grid bias electromotive force is provided by the rectifying action of the grid circuit over a path 24 through a resistance 26 having a suitable magnitude for this purpose. The connections of the grid bias lead and the space current supply lead to the conductors 7 and 8 respectively are made by slidable or fixed taps at points of minimum potential located by a probe which is applied to the various points of the conductors to ascertain at which the least variation of the current occurs upon contact of the probe.

Space current for both the modulating amplifier 4 and the oscillator 5 is supplied by the unidirectional current generator unit 27 of a motor generator set, the motor 28 of which is operated by current from the power mains 29 to which it may be connected by armature 30 of relay 31. A series inductance 32 and shunt capacitances 33 serve in well-known manner to eliminate commutator ripples from the modulating circuit.

Modulation may be effected in well-known manner by using a signal frequency plate circuit transformer 34 to couple the plate current circuits of the amplifier 4 and the oscillator 5.

Oscillations produced by the oscillator 5 and modulated in accordance with signals impressed upon transmitter 1 may be picked up by the closed tuned loop comprising U-shaped conductor 37, the variable tuning capacity element 39 and the electrically conducting collar 40. The closed circuit 37, 39 together with at least an end section of the coaxial line 41 which conveys the modulated oscillations to the shielded container 42 of the antenna switch is rotatable about the longitudinal axis of the coaxial line to permit varying the coupling between the oscillation circuit 7, 8 and the closed loop 37, 39. The magnitude of the capacity element 39 may be varied by manipulation of the screw-head 43 to change the position of the movable plate of the capacity element. It is desirable also to terminate the coaxial line in an impedance of the proper magnitude. For that purpose the inner conductor 44 is connected to a selected point 45 in the tuned loop.

The antenna switch is shown diagrammatically within the container 42 of Fig. 1 and in more detail in Fig. 4. It comprises a fixed strip 46 of conducting material electrically connected to the end of the inner conductor 47 of the coaxial line 48 leading to a dipole antenna 49. The strip 46 supports at its ends two resilient members 50 and 51 which are provided with contact elements 52, 53, respectively. The movable element of the switch comprises a reciprocating rod 54 carrying at its ends magnetic armatures 55 and 56 of solenoids 57 and 58 respectively. The rod 54 also carries a frame 59 of dielectric material which

is provided at its ends with connectors 61 and 62 each having a tapered or conical portion 63 adapted to fit into the respectively adjacent inner open ends of the coaxial lines 41 and 64, and a sleeve 65 or 66 which snugly engages the split 5 terminal portion of the respectively adjacent inner conductor. As shown, the solenoid 57 is energized and the end of the sleeve 66 is in engagement with the contact 53. Accordingly the coaxial line 64 of the receiver is connected 10 through the switch to the coaxial line 48 of the antenna, the "go" circuit passing from inner conductor 67 by way of sleeve 66, contact 53 and strip 46 to the inner conductor 47 and the "return" circuit by way of outer conductor of coaxial line 64 and the shell 42 to the outer conductor of coaxial line 48. The connection between inner conductor 67 and sleeve 66 may be understood by reference to connector 61 which is shown in partial section and illustrates more clearly the sliding contact maintained between its sleeve portion 65 and the split terminal portion 38 of the inner conductor 44 of the coaxial line section 41.

It will also be observed at Fig. 4 that at the time solenoid 57 is energized and coaxial line 64 25 is connected to the antenna the coaxial line 41 is "stoppered" by the conical portion 63 of connector 61 and effectively short-circuited and shielded from the interior of the chamber 42.

Upon deenergization of the solenoid 57 and 20 energization of the solenoid 58 the rod 54 moves longitudinally to the right disconnecting the sleeve 66 from the contact 53 and carrying the tapering projection 63 into snug fit within the outer conductor of the coaxial line 64 which is 35 thus effectively "stoppered" to prevent any influx of energy from the region of the switch within the container 42 into the coaxial line 64, 67. At the same time the sleeve 65 comes into engagement with the contact 52 and its tapered portion 63 is withdrawn from the interior of the coaxial conductor 41 thus establishing connection between the transmitter and the antenna in a manner which will be obvious.

The switch is so designed that when either of 45 the solenoids is energized to close its respective circuits the spring portion 50 or 51 which is active at the time, is compressed. Accordingly, upon release of that particular connection the resiliency of the spring causes it to give an initial 50 throw to the reciprocating frame member 59 by reason of the pressure which the spring element exerts upon the associated cap member 61 or 62. This action assists the other solenoid in overcoming the inertia and friction of the reciprocating 55 element and facilitates the switching operation.

As has been explained the shield container 42 constitutes the electrical connecting link between the outer conductors of coaxial lines 41 and 64 60 and the outer conductor of coaxial line 48. The sudden change in spacing and dimensions as the circuit proceeds from the coaxial line through the container 42, may tend to occasion reflections and undesirable energy losses. In order, therefore, to make the container 42 and the internal 65 switching mechanism so simulate a section of coaxial conductor as to give smooth transmission from one coaxial line to another, a supplementary variable capacitance 68 is provided in shunt between the switch and the shield container 42. 70 As shown in detail in Fig. 4, this comprises a capacity plate 69, the position of which is controlled by an external screw 70, the plate 69 being associated with a plate 71 electrically connected to the strip 46. 75

Connection of the container 42 and its internal switching mechanism to the coaxial line is facilitated by the telescoping sleeve connection such as 12 and 13 of Fig. 4. The split sleeves engage the ends of the coaxial members to insure good electrical continuity in the circuit and the inner sleeve 73 is carried by the screw-threaded insulator 74 which is adjustable to secure the best possible operation of the switch.

The receiving apparatus is illustrated in Fig. 2 in which a shielding container 76 encloses an electron discharge device 77 and its associated high frequency circuits. Connected between the grid and the anode of the device 77 is a tuned loop circuit 78 which may structurally be somewhat similar to that of the transmitter of Fig. 1.

The cathode of device 77 is provided with a heater of filamentary type. In order to introduce cathode heating current and space current within the container 76, a coaxial line impedance 80 is provided somewhat similar in function to the lines 16 and 23 of Fig. 1. Cathode heating current is supplied from an external source 81 by way of switch 82, conductor 83, insulated internal conductor 84, the cathode heater, the inner conductor 85, conductive short-circuiting disc 86, the shield 76 and ground 79. Space current for the device 77 is supplied from a source 74 through the primary winding of an output transformer 87, conductor 88, plate 89, screw 90, plate 91, the high frequency choke 92 and tuned circuit 78. The return path is by way of the cathode, its connection to the heater at point 93 over the path to ground which has been previously traced. Plates 89 and 91 separated from shield 76 by dielectric sheets by their capacity to the shield aid in draining high frequency oscillations from the space current path. A metallic slider 94 positioned closely adjacent the coil 92 provides means for varying the capacity of choke coil 92 to ground, thus enabling the high frequency impedance of the coil 92 as viewed from the tuned circuit to be adjusted to a point at which maximum efficiency of the circuit is attained. The coupling loop 95 by which the coaxial line 64 is connected to the tuned circuit may be similar to the corresponding loops 37 of Fig. 1, if desired.

The discharge device 77 is very similar in its operation to the well-known superregenerative amplifier in which a receiving circuit adjusted for incipient oscillations is triggered off by incoming oscillations and by its self-oscillating action rapidly builds up local oscillations which are checked periodically by a quenching voltage or negative impulse impressed from a local source. In the present instance, however, instead of setting the device 77 in a strongly oscillating condition, a negative grid bias is applied by the source 96 of such magnitude as to prevent the flow of plate current in the absence of local stimulating impulses. A local stimulating oscillator 97 operating at a frequency in excess of audibility as, for example, several hundred kilocycles or even higher, depending upon the frequency to be received, is coupled by means of the transformer 98 to the terminals of a capacity element 100 in the path leading to the grid. It follows that during operation of the stimulating oscillator 97 there will be impressed during each second several hundred thousand positive impulses which will traverse the path by way of choke coil 101 and resistance 102 to the grid of the device 77. Choke coil 101 readily passes these stimulating pulses while discriminating strongly against the much higher frequency oscillations which tube 93 tends to generate. These positive impulses

are preferably of such magnitude as to set the device 77 momentarily into a condition suitable for sustaining oscillations. It will, therefore, function in the manner of the well-known superregenerative receiver. The resulting signal 5 modulation frequency currents to which the superregenerative detecting action gives rise will pass by way of coil 92 to the primary winding of transformer 87 and after amplification by the amplifier 103 are impressed upon telephone line 10 or loud-speaker 104. Coil 92 readily passes the relatively low frequency detected signal modulations.

The ordinary quenching type superregenerative receiver is controllable only with considerable difficulty. A great advantage of the circuit just described is that by gradual increase of the amplitude of the stimulating oscillations, or by controlling the plate or grid bias potentials of the superregenerating oscillator, any desired gain 20 may be obtained with an excellent degree of control. Any of the many available devices for controlling the stimulating impulses may be employed. One such device which is illustrated herein is the plate circuit variable resistor 99.

A feature of the receiving circuit is the provision for preventing the building up of oscillations on the external surface of the coaxial conductor 80 used as a high frequency impedance for the cathode heating energy supply circuit. The short-circuiting disc 86 connected to knob 105 by which it may be manipulated enables the coaxial section facing the device 77 to be tuned for best operation of the receiver. However, there is a certain aperture provided by the inner conductor 84. In order to by-pass to earth any high frequency potentials appearing at the outer terminal of conductor 84, a connection 106 is provided to the outer plate 107 of a condenser the inner plate 108 of which is connected directly to outer conductor 80 while the outer plate 107 insulated from the inner plate by the dielectric sheet 109 is also insulated from the outer conductor 80. Plate 108 is also grounded as shown. The capacity between plates 107 and 108 is sufficient to very greatly reduce any stray oscillation potential at that point. In order to free the external heater lead and the outer surface of the concentric system from the last traces of radio frequency potentials the condenser plate 108 is positioned at a distance of one-quarter wavelength from the adjacent wall of the shield 76 as is indicated in Fig. 2.

The coaxial line system 47, 48 in Fig. 1 leading from the casing 42 to the antenna is of the unbalanced type in which the outer conductor 48 is at ground potential, the inner conductor 47 at a high oscillation potential. In order to connect such a line to the symmetrical dipole antenna a U-shaped antenna feed line is provided with an internal conductor 110 into the tapped ends of which the threaded straight conductors constituting the dipole may be screwed. The inner conductor 47 of the coaxial line is connected to the U-shaped internal conductor 110 at a point 111 so selected that the electrical distance along the U-shaped structure to the correspondingly located point 112 on the other leg of the U is exactly a half wave-length. The potentials at points 111 and 112 will, therefore, be 180 degrees apart as will the potentials at the end points of conductor 110.

A convenient way of constructing the U-shaped antenna feed line is to provide outer sleeves 113 with a small block 114 bored to receive their inner ends in a snug fit as shown in Fig. 3. Blocks

115 and 116 which may be identical in their size and shape are provided with recesses such that when the blocks are fitted together the recesses will provide a smooth continuation of the outer coaxial conductor.

The impedance of each antenna of the dipole as viewed from the feed line is about 35 ohms. The feed line sections 122 and 123 are preferably so designed as to give each a characteristic impedance of 35 ohms. Since at the point 111, the lines 122 and 123 constitute two parallel branches as viewed from the line 43, their joint parallel impedance is 17.5 ohms.

Coaxial lines 41 and 43, in accordance with current practice, are preferably made to have a characteristic impedance of about 70 ohms. These lines are to be connected alternately to a point 111 at which an impedance of 17.5 ohms is presented. Accordingly the line 43 is so designed as to provide an impedance transforming section in a manner well known to the art. To this end the length of line 43 is made equal to one-quarter wave-length, and it is so designed that its characteristic impedance is equal to the square root of the product of the impedances which it connects. In other words it is given a magnitude equal to the square root of the product of 70 and 17.5, or 35 ohms. It can, therefore, be of the same dimensions as lines 117 and 118.

If it is desirable to locate the antenna switch at a considerable distance from the antenna it is possible to do so by interposing any desired length of 70 ohm concentric line between the lower end of quarter wave line 43 and strip 46, thus moving the antenna switch to any desired distance from the antenna.

In operation the transmit-receive system is controlled by a switch 117 which, although shown adjacent the switch casing 72, is in practice preferably located at the position of the transmitter 1. During receiving the switch is thrown to the left as shown in the figure thus completing a circuit by way of ground, source 118, switch 117, solenoid 57 and receiver control relay 119. Energization of relay 57 connects the receiver to the antenna and disconnects and short-circuits the transmitter coaxial line 41 as previously explained and as shown in the drawings. Energization of relay 119 causes resistance 120 to be short-circuited thus permitting the current through the cathode of device 97 to rise with a consequent activation of the cathode from its dull and hence non-emitting state, and energization of the oscillator 97 to produce stimulating impulses. Tube 97 is preferably of a type having a very thin filamentary cathode so that the thermal lag will be small. The resistance 120 is shunted by a click absorbing capacity element 121. Thus the receiver may be quickly energized and deenergized under control of relay 119.

When the control switch 117 is thrown to the right, the solenoid 57 and relay 119 are deenergized and solenoid 58 is energized to connect the transmitter to the antenna. Deenergization of relay 119 stops the production of stimulating impulses at the receiver. Operation of solenoid 58 disconnects the receiver from the antenna and short-circuits the coaxial line 64 by the conical plug 63 within the antenna switch casing 42. At the same time switch 31 is energized to close its armature contact and apply power from the power mains 29 to motor 28 thus permitting the transmitter to be energized.

It will be appreciated that the apparatus which has been described provides a highly compact

and efficient radio terminal system for oscillations of the order of 500 to 1000 megacycles frequency.

What is claimed is:

1. A radio terminal system comprising an antenna, a radio transmitter and a radio receiver, individual coaxial lines leading from the antenna, the transmitter and the receiver to a shielded container and having their outer conductors electrically connected to the container, a switch within the container connected to the inner conductor of the antenna coaxial line, and remotely controlled means for causing the switch to connect the antenna to the inner conductor of one or the other coaxial lines and at the same time to completely close the end of the third coaxial line whereby either the transmitter or the receiver may be electrically connected to the antenna as desired, the other being electrically isolated therefrom.

2. A combined transmitting and receiving system comprising a transmitter, a receiver, an antenna, an electrically shielded enclosure, individual coaxial lines extending from the transmitter, receiver and antenna respectively to the shielded enclosure, the outer conductors of the coaxial lines being each electrically connected to the enclosure and the inner members of the coaxial lines extending to points therewithin, a switch within the enclosure electrically connected to the inner member of the antenna line and remotely controlled means for causing said switch to connect the antenna line to the transmitter line or to the receiver line, and means associated with the switch for causing the section of circuit including the shielded enclosure and the switch to electrically simulate a coaxial line section in order to minimize reflections.

3. A system comprising an oscillation transmitter, an oscillation receiver normally unresponsive except to conjoint incidence of incoming oscillations and locally produced oscillations, a local oscillator connected to said receiver, an antenna, a transmit-receive switch connected to the antenna and movable to connect either the transmitter or the receiver to the antenna, and means for controlling movement of the switch so as to disconnect the receiver and connect the transmitter to the antenna and for simultaneously disabling the oscillator thus rendering the receiver non-responsive during intervals of activity of the transmitter.

4. A system comprising a transmitter, a receiver having thermionic apparatus including cathode-heating means, an antenna, a transmit-receive switch connected to the antenna and movable to connect either the transmitter or the receiver to the antenna and means for controlling the movement of the switch, terminals for the transmitter and receiver adjacent the switch, one of the terminals comprising a coaxial conductor, said switch comprising a sliding contact member which, in all positions, remains in contact with the inner conductor of the coaxial terminal to enable connection to be made between the inner conductor and the antenna, and an enlarged portion carried by the sliding contact member and of such size and shape as to completely close one end of the outer conductor of the coaxial conductor to short circuit the coaxial terminal when the sliding member is moved to such a position as to bring the enlarged portion into contact with the end of the outer conductor.

5. A radio terminal system comprising an antenna, a radio transmitter and a radio receiver,

individual coaxial lines leading from the antenna, the transmitter and the receiver to a shielded container, a switch in the container connected to the antenna line and remote controlled means
5 for causing the switch to connect the antenna to one of the other coaxial lines and at the same time to completely close the end of the third whereby either the transmitter or the receiver may be electrically connected to the antenna as
10 desired, the other being electrically isolated therefrom.

6. A combined transmitting and receiving system comprising a transmitter, a receiver, an antenna, an electrically shielded enclosure, individual
15 coaxial lines extending from the transmitter,

receiver and antenna, respectively, to the shielded enclosure, the outer conductors of the coaxial lines being each electrically connected to the enclosure and the inner members extending to points therewithin, a switch within the enclosure
5 electrically connected to the inner member of the antenna line and adapted to be remotely controlled to connect the antenna line to the transmitter line or to the receiver line, and means
10 associated with the switch for causing the circuit section by way of the shielded enclosure and switch to electrically simulate the coaxial lines which they connect in order to minimize reflections at the switching point.

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