Nov. 19, 1935. J. B. DOW 2,021,649

SIGNALING SYSTEM

Filed June 21, 1932

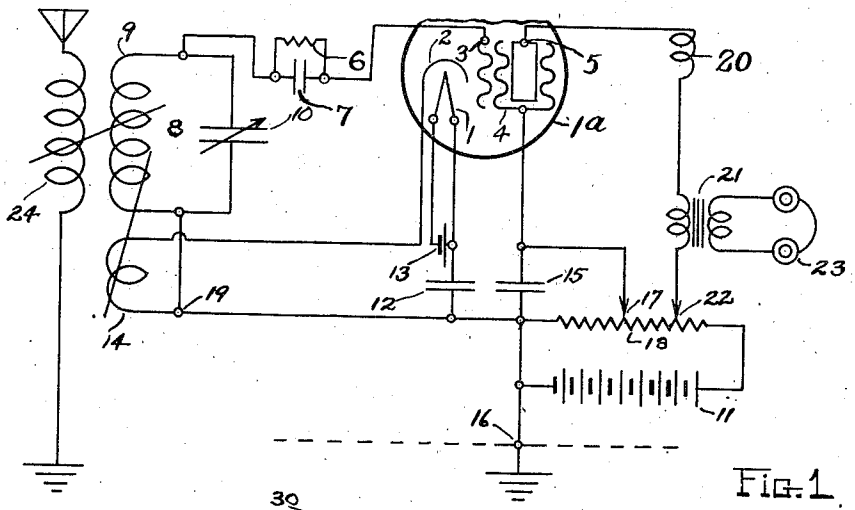


Fig. 1.

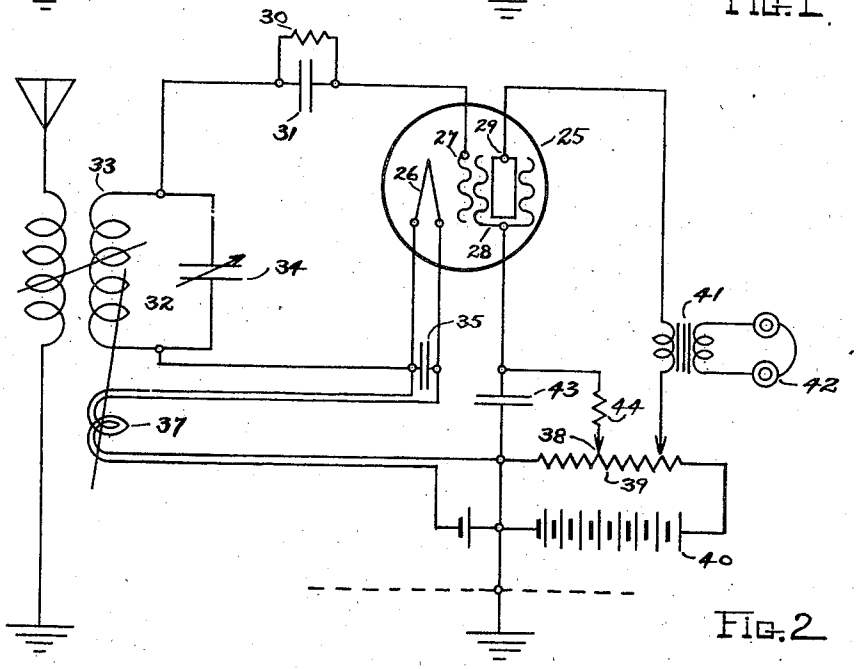


Fig. 2.

INVENTOR
Jennings B. Dow.
BY
Robert A Lavender
ATTORNEY

Patented Nov. 19, 1935 2,021,649

UNITED STATES PATENT OFFICE

2,021,649

SIGNALING SYSTEM

Jennings B. Dow, Washington, D. C.

Application June 21, 1932, Serial No. 618,485

16 Claims. (Cl. 250—20)

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

My invention relates broadly to signaling systems and more particularly to electron tube rectifiers and amplifiers of electric signals.

One of the objects of my invention is to provide a highly sensitive detector of electric oscillations.

Another object of my invention is to provide a detector or an amplifier circuit of the regenerative type having a final output circuit which is isolated by an electrostatic shield from that portion of the circuit involved in producing regeneration.

A further object of my invention is to provide a detector circuit of the autodyne type having a final output circuit which is isolated by an electrostatic shield from that portion of the circuit involved in oscillation generation.

A still further object of my invention is to provide a detector circuit so arranged that the low frequency pulses of anode current produced by detection are employed to produce secondary pulses of anode current in a second anode circuit associated with the same tube employed in the initial detection.

Other and further objects of my invention will be understood from the specification hereinafter following by reference to the accompanying drawing, in which:

Fig. 1 represents one form of the circuit of my invention in which an indirectly heated cathode type of four element electron tube is employed. Fig. 2 shows another form of the circuit of my invention wherein a directly heated cathode type of four element tube is employed together with certain other modifications of the circuit of Fig. 1.

Referring to Fig. 1 in greater detail, reference character 1a indicates an electron tube having a cathode heating element 1 suitably insulated from the cathode 2 by a ceramic or other insulating medium such as vacuum, a control grid element 3, a screen-like anode element 4 and a second anode element 5. Control grid 3 is connected as shown through a conventional grid leak 6 and grid condenser 7 to one end of a tunable resonant circuit 8 having an inductance 9 and a variable condenser 10 in parallel. The opposite end of the resonant circuit is connected through to the negative side of the anode energy source 11, and to the cathode heating element 1 through blocking condenser 12. Energy is supplied to cathode heating element 1 by battery 13. The cathode is connected through regeneration inductance 14 to the negative side of anode energy source 11. The screen-like anode element 4 is connected through blocking condenser 15 to the negative side of anode energy source 11 which point is connected to ground or to the usual metallic shielding at 16 as is common practice to reduce undesirable distributed capacity effects. Dotted line 16 represents a portion of the usual metallic shielding. Tap connection 17 on voltage divider 18 which divider is in parallel with the anode energy source 11, supplies the screen-like anode 4 at the desired positive potential with respect to the cathode 2. Tap connection 17 permits control of regeneration or oscillation. Regeneration inductance 14 is coupled to the inductance 9 of resonant circuit 8. Signaling energy is impressed upon the circuit by antenna coupling inductance 24 which is coupled to inductance 9 of the resonant circuit 8.

The circuit thus far described may be compared, except for certain details, to an ordinary three element tube regenerative circuit in that resonant circuit 8 between control grid 3 and cathode 2 constitutes the input circuit whereas regeneration inductance 14 between the cathode 2 and screen-like anode 4 which corresponds to the plate of an ordinary regenerative circuit, constitutes the output circuit. As the input and output circuits are coupled by virtue of inductances 14 and 9, regeneration can be made to result in a manner similar to that in the well known tuned-grid type of regenerative circuit. The only differences between the circuit thus far described and the ordinary regenerative circuit are: (a) Tube element 4, corresponding to the plate of the ordinary circuit, is at ground high frequency potential rather than the cathode as is customary; (b) the cathode is above ground high frequency potential by an amount corresponding to the reactance drop in inductance 14; neglecting the reactance drop in blocking condenser 12, a similar high frequency potential difference exists between cathode 2 and heater 1; (c) the lower side of resonant circuit 8 is connected to point 19 rather than to the cathode 2 as is customary in more conventional circuits. The connection shown permits one side of the condenser 10 to be grounded which is a convenience.

The remaining portion of the circuit comprises second anode 5 connected through high frequency choke coil 20 and the primary of telephone transformer 21 to tap connection 22 on voltage divider 18 for supplying the second anode 5 at the desired potential with respect to the cathode 2. It will be understood that the voltage divider 18 is shown merely as a convenient means for obtaining the proper anode voltages. Telephone receivers 23 are shown connected across the secondary of transformer 21 which transformer is employed because of the desirability of match-

ing the telephone impedance to that of the tube 1a.

Signaling energy is impressed upon the resonant circuit 8 by the action of coupling coil 24 and rectification takes place in the usual manner owing to the curvature of the grid-current grid-voltage characteristic of the tube. Since, as is customary when grid detection is employed, grid condenser 7 is so chosen as to have a high reactance to low frequencies, the low frequency pulses of rectified grid current flow through grid leak resistance 6 and in doing so, vary the grid potential. This controls the flow of electrons to the screen-like anode 4 and to second anode 5. Now, in the particular form of the invention disclosed in Fig. 1, that portion of the circuit included between tube elements 2, 3 and 4 is in a regenerative condition so that great amplification of the high frequency signaling energy takes place and correspondingly large rectified voltage pulses take place across grid leak resistance 6 as in ordinary regenerative circuits.

It will be noted that second anode 5 is shielded electrostatically by screen-like anode 4 from that portion of the electron stream between screen-like anode 4 and cathode 2. Screen-like anode 4 serves both as an anode for the regenerative portion of the circuit and as a screening element to isolate the final output circuit so that changes in the electrical constants of the load or high frequency variations in potential across the load, will have a minimum effect upon the regenerative portion of the circuit. With reference to the particular form of the invention shown in the drawing, the system of my invention differs from others of this class in that insofar as varying potentials of frequency comparable with the signaling frequency are concerned, the output circuit is isolated from the regenerative portion of the system by the use of a shield element and appropriate circuit connections. This isolation is accomplished by virtue of the fact that the external circuits between screening element 4 and cathode 2, and between screening element 4 and second anode 5, contain no common impedances at frequencies comparable with the signaling or oscillating frequencies. Other systems of this class have always been characterized by the presence of common impedances in these two circuits with the result that currents flowing in one of these circuits and varying at frequencies comparable with the signaling frequency, create corresponding potential variations across the common impedance and thereby influence the other circuit just as though the two circuits were coupled. Moreover, the circuit between screening element 4 and cathode 2 and the circuit between screening element 4 and second anode 5 are not coupled as it is desirable to maintain a substantially zero coefficient of coupling between these two circuits whereby no common impedances exist in these two circuits. Under these conditions the transfer of energy from the regenerative portion to the output circuit takes place only through the electron stream and the regenerative or oscillator portion is almost wholly independent of reaction from the output circuit such as that caused by changes in voltage due to the variable electrical constants of telephone receiver 23 during the movement of the diaphragm.

In the operation of that form of my invention described above, it is evident that the oscillation generator portion of the system varies the electron stream of the tube in accordance with the frequency of oscillation. The electron stream is also varied in accordance with the signaling frequency impressed upon grid 3. As the characteristics of all electron tubes are curved at one or more points detection through rectification is readily possible by appropriate selection of potentials for the elements of such tubes. Owing to rectification in the system, the current which flows in the circuit of the second anode 5 has a varying component having a frequency corresponding to the difference or combined effect between the signaling and oscillator frequencies.

The particular form of my invention thus far described is arranged as a detector. It will be understood that by substituting an appropriate fixed bias battery in place of grid leak 6 and grid condenser 7 and by substituting the primary of a suitable radio frequency transformer in place of choke coil 20 and audio transformer 21 that a regenerative type of radio frequency amplifier will result. I have found that such an amplifier arranged according to my invention is not only very selective according to the extent of regeneration employed but also results in an extremely high gain device which is very useful in radio signaling systems.

In Fig. 1, I show one form of my invention based upon a tuned-grid type of regenerative circuit. Obviously any other form of regenerative circuit might have been used to show the principles of my invention.

I have found that while under certain conditions of operation high frequency choke coil 20 is desirable, its use is not essential. I have found generally that blocking condenser 15 need be just large enough to present a low reactance path to the high frequencies but that it is sometimes desirable to make its capacity sufficiently large that it will offer a low reactance path to low frequencies as well.

Fig. 2 shows another form of the circuit of my invention in which an electron tube 25 of the directly heated cathode type is employed. Tube 25 contains a cathode 26, control grid 27, screen-like anode 28, and a second anode 29. Control grid 27 is connected through grid-leak 30 and grid condenser 31 to one side of resonant circuit 32 having inductance 33 and condenser 34 in parallel. The opposite side of resonant circuit 32 is connected to the cathode 26. Bypass condenser 35 serves to equalize the high frequency potentials of both terminals of cathode 26 which is supplied with heating energy from battery 36 through the double winding regeneration inductance 37. Regeneration inductance 37 is coupled to inductance 33, and regeneration or the strength of oscillations, according to which condition is desired, is controlled by varying tap connection 38 on voltage divider 39 which is connected across anode supply battery 40. Second anode 29 is connected to voltage divider 39 through output transformer 41 which matches the impedance of telephone receivers 42 to the tube impedance. A blocking condenser 43 is connected between screen-like anode 28 and the negative side of anode battery 40. In the circuit of Fig. 2, blocking condenser 43 is preferably chosen to have a low reactance to high frequencies and a high reactance to the low frequency pulses of current flowing to the screen-like anode through impedance 44. Impedance 44 is so chosen as to offer a relatively high impedance to the low frequency pulses of screen-like anode current. I prefer to make impedance 44 in the nature of a resistance, although it may be made inductive or may consist of a combination of re-

sistance and inductance. I have found that impedance 44 appears to improve the sensitivity of the circuit under certain conditions. This is probably due to the fact that the variations in current to the screen-like anode which flow through impedance 44 act to vary the potential of the screen-like anode with respect to the cathode. This variation in potential acts to regulate the flow of electrons from cathode 26 to second anode 29 in much the same way that grid element 27 regulates the flow of electrons.

I have found the circuit of my invention highly sensitive and relatively free from circuit noises which are so prevalent in ordinary detector circuits of corresponding sensitivity.

While I have described my invention in certain preferred embodiments, it will be understood that modifications may be made and that no limitations are intended other than those imposed by the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment of any royalty thereon.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a receiver of electric oscillations having an electron tube containing a cathode element, a control grid element, a screen-like anode element and a second anode element, an input circuit between said control grid and cathode elements, an output circuit between said screen-like anode element and said cathode element, the said circuits being coupled in such manner as to produce regeneration, means for controlling said regeneration, a second output circuit between said second anode and said screen-like anode elements and including an output device, the connections of said second output circuit comprising a circuit through said output device to said screen-like anode such that any reactance existing in the latter circuit which is common to said output circuit between the screen-like anode and cathode elements is negligible at the frequency for which regeneration exists in comparison with the internal impedance between cathode and screen-like anode of said electron tube.

2. In a receiver of electric oscillations having an electron tube containing a cathode element, a control grid element, a screen-like anode element and a second anode element, an input circuit between said control grid and cathode elements, an output circuit between said screen-like anode element and said cathode element, the said circuits being coupled in such manner as to produce oscillations, means for controlling the strength of said oscillations, a second output circuit between said second anode and said screen-like anode elements and including an output device, the connections of said second output circuit comprising a circuit through said output device to said screen-like anode such that any reactance existing in the latter circuit which is common to said output circuit between the screen-like anode and cathode elements is negligible at the frequency of said oscillations in comparison with the internal tube impedance between cathode and screen-like anode elements.

3. In a receiver of electric oscillations having an electron tube containing a cathode element, a control grid element, a screen-like anode element and a second anode element, an input circuit between said control grid and cathode elements, an output circuit between said screen-like anode element and said cathode element, the said circuits being coupled in such manner as to produce regeneration, means for controlling said regeneration, a second output circuit between said second anode and said screen-like anode elements, said second output circuit having in series connection the means for delivering the received energy to an output device, a metallic box at least partly surrounding said tube and circuits, a circuit having a relatively low impedance at the frequency of the received electric oscillations disposed between said screen-like anode and said shield box, and means including said screen-like anode for electrostatically shielding said cathode and control grid elements from the influence of high frequency potentials of signaling frequency existent across said second output circuit.

4. In a receiver of electric oscillations having an electron tube containing a cathode element, a control grid element, a screen-like anode element and a second anode element, an input circuit between said control grid and cathode elements, an output circuit between said screen-like anode element and said cathode element, the said circuits being coupled in such manner as to produce oscillations, means for controlling the strength of said oscillations, a second output circuit between said second anode and said screen-like anode elements, said second output circuit having in series connection the means for delivering the received energy to an output device, a metallic box at least partly surrounding said tube and circuits, a circuit having a relatively low impedance at the frequency of the received electric oscillations disposed between said screen-like anode and said shield box, and means including said screen-like anode for electrostatically shielding said cathode and control grid elements from the influence of high frequency potentials of signaling frequency existent across said second output circuit.

5. In a system responsive to electric oscillations having an electron tube containing a cathode element, a control grid element, a screen-like anode element, and a second anode element, an input circuit connecting said control grid and cathode, an output circuit connecting said cathode and screen-like anode, means for producing regeneration comprising the coupling between said circuits, a second output circuit connecting said second anode and said screen-like anode, said second output circuit containing in series connection the means for deriving energy from said system, a metallic shield box at least partly surrounding said system and a circuit of relatively low impedance at the frequency of said electric oscillations disposed between said screen-like anode and said metallic shield box.

6. In a system responsive to signaling energy having an electron tube containing a cathode element, a control grid element, a screen-like anode element and a second anode element, a circuit disposed between said control grid and cathode and means for impressing signaling energy upon said circuit, a circuit disposed between said cathode and screen-like anode, means for producing regeneration comprising coupling means common to said circuits, a circuit for deriving signaling energy from said system, said last mentioned circuit disposed between said second anode and said screen-like anode and including an output device, the connections of said system being such that any common portion of said last mentioned circuit and said circuit between the cathode and screen-like anode is substantially impedanceless at the frequency for which said re-

generation exists in comparison with the internal tube impedance between said cathode and screen-like anode elements.

7. In a system responsive to signaling energy having an electron tube containing a cathode element, a control element, a screen-like anode element and a second anode element, a circuit disposed between said control and cathode element and means for impressing signaling energy upon said circuit, a circuit disposed between said cathode and screen-like anode elements, means for producing oscillations comprising coupling means common to said circuits, a circuit for deriving signaling energy from said system, said last mentioned circuit disposed between said second anode and screen-like anode elements and including an output device, the connections of said system being such that any common portion of said last mentioned circuit and said circuit between the cathode and screen-like anode is substantially impedanceless at the frequency of said oscillations in comparison with the internal tube impedance existent between said cathode and screen-like anode elements.

8. In a system responsive to signaling energy having an electron tube containing a cathode element, a control element, a screen-like anode element and a second anode element, a circuit connecting said control and cathode elements and means for impressing signaling energy upon said circuit, a circuit connecting said cathode and screen-like anode elements, means for producing oscillations comprising coupling means common to said circuits, an output circuit connecting said second anode and screen-like anode elements, a metallic shield box at least partly surrounding said system and a circuit connection offering relatively low impedance at the frequency of said oscillations disposed between said screen-like anode and said metallic shield box.

9. A system responsive to electric oscillations comprising an electron tube having cathode, grid, anode and second anode elements, high frequency oscillation generating means disposed between said cathode, grid and first mentioned anode elements for modulating the electron stream of said tube at a frequency determined by said oscillation generating means, means for modulating the electron stream in accordance with the received electric oscillations, means for rectifying the resulting variations in the electron stream, and means responsive to said rectified variations disposed in series between said second anode and cathode elements, and means for substantially shielding that portion of the electron stream of said tube between said cathode and first mentioned anode elements from the influence of said second anode element for high frequency variations of potential upon said second anode, said shielding means comprising a shield element for said second anode and a circuit between said shield element and said means responsive to said rectified variations such that any portion of said last mentioned circuit which is common to the high frequency portion of said generating means is of negligible impedance at the frequency of the generated oscillations in comparison with the internal tube impedance between said cathode and first mentioned anode elements.

10. A system responsive to electric oscillations comprising an electron tube having cathode, grid, anode and second anode elements, high frequency oscillation generating means disposed between said cathode, grid and first mentioned anode elements for modulating the electron stream of said tube at a frequency determined by said oscillation generating means, means for modulating the electron stream in accordance with the received electric oscillations, means responsive to the resulting variations in said electron stream disposed in series between said second anode and cathode elements, and means for electrostatically shielding said grid element from the influence of said second anode element for high frequency variations of potential upon said second anode, said shielding means comprising a shield element for said second anode and a circuit between said shield element and said responsive means such that any portion of said last mentioned circuit which is common to the high frequency portion of said generating means is of negligible impedance at the frequency of the generated oscillations in comparison with the internal tube impedance existent between said cathode and first mentioned anode elements.

11. A system responsive to wave signaling energy comprising an electron tube having oscillation-generator-elements and at least one auxiliary element, means including said generator-elements for the self generation of oscillations by said tube and for varying the electron stream of said tube at a frequency determined by said oscillations, means for simultaneously varying said electron stream at a frequency determined by said signaling energy, means for utilizing the resulting variations in said electron stream to set up a flow of current at a third frequency in an auxiliary circuit disposed between said auxiliary element and one of said generator elements, and means comprising a shield element having a connection with said auxiliary circuit of low reactance at the frequency of said oscillations whereby the electron stream between said generator-elements is shielded electrostatically from the tube elements other than said generator elements.

12. A system responsive to wave signaling energy comprising an electron tube having oscillation-generator-elements and at least one auxiliary element, means including said generator-elements for the self generation of oscillations by said tube and for varying the electron stream of said tube at a frequency determined by said oscillations, means for simultaneously varying said electron stream at a frequency determined by said signaling energy, means for utilizing the resulting variations in said electron stream to set up a flow of current at a third frequency in an auxiliary circuit disposed between said auxiliary element and one of said generator-elements, and shielding means within said tube having a connection to said auxiliary circuit comprising a path of relatively low reactance at the frequency of said oscillations and signaling energy.

13. A detector of wave signaling energy comprising an electron tube having oscillation-generator-elements and at least one auxiliary element, means disposed between said generator-elements for generating oscillations and for varying the electron stream of said tube at a frequency determined by said oscillations, means for simultaneously varying said electron stream at a frequency determined by said signaling energy, means for utilizing the resulting variations in said electron stream to set up a flow of current at a third frequency in an auxiliary circuit disposed between said auxiliary element and one of said generator-elements, and shielding means within said tube having a connection to said auxiliary circuit comprising a path of relatively low

impedance at the frequency of said oscillations and signaling energy, said shielding means having a connection to said auxiliary circuit comprising a path of relatively high impedance at said third frequency.

14. A system responsive to wave signaling energy comprising an electron tube including cathode, grid, anode and second anode elements positioned in the order named, circuits for the self-generation of oscillations disposed between said cathode, grid and first mentioned anode element for varying the electron stream of said tube at the frequency of said oscillations, means for varying the electron stream of said tube in accordance with the frequencies of said signaling energy, an auxiliary circuit disposed between said second anode and said cathode elements and including an output device, means for maintaining said second anode electropositive with respect to said cathode, means for setting up a flow of current in said output device which varies at frequencies equal to the difference between the frequency of said oscillations and the frequencies of said signaling energy whereby a potential across said output device is caused to vary in accordance with said flow of current, and means for substantially electrostatically shielding that portion of the electron stream of said tube between said cathode and first mentioned anode elements from the influence of said varying potential across said output device.

15. A system responsive to wave signaling energy comprising an electron tube including cathode, grid, anode and second anode elements, circuits for the self-generation of oscillations disposed between said cathode, grid and first mentioned anode element for varying the electron stream of said tube at the frequency of said oscillations, means for varying the electron stream of said tube in accordance with the frequencies of said wave signaling energy, a circuit disposed between said second anode and cathode elements and including an output device, means for maintaining said second anode electropositive with respect to said cathode, means for setting up a flow of current in said output device which varies at frequencies determined by the combined effect upon the electron stream of the frequency of said oscillations and the frequencies of said wave signaling energy whereby the potential across said output device is caused to vary in accordance with said flow of current, and means for substantially electrostatically shielding that portion of the electron stream between said cathode and anode elements from the influence of said varying potential across said output device.

16. A system responsive to wave signaling energy comprising an electron tube including cathode, grid, anode and second anode elements positioned in the order named, circuits for the self-generation of oscillations disposed between said cathode, grid and first mentioned anode element for varying the electron stream of said tube at the frequency of said oscillations, means for varying the electron stream of said tube in accordance with the frequencies of said signaling energy, a circuit disposed between said second anode and said cathode elements and including an output device having variable electrical constants, means for setting up a flow of current in said output device which varies at frequencies equal to the difference between the frequency of said oscillations and the frequencies of said signaling energy and means for substantially electrostatically shielding that portion of the electron stream of said tube between said cathode and first mentioned anode elements from the influence of said variable electrical constants of the output device.

JENNINGS B. DOW.

DISCLAIMER

2,021,649.—*Jennings B. Dow*, Washington, D. C. SIGNALING SYSTEM. Patent dated November 19, 1935. Disclaimer filed December 10, 1940, by the inventor; the assignee, *Radio Corporation of America*, consenting.

Hereby enters this claimer to claims 9, 10, 11, 12, 14, 15, and 16 in said specification.

[*Official Gazette January 7, 1941.*]