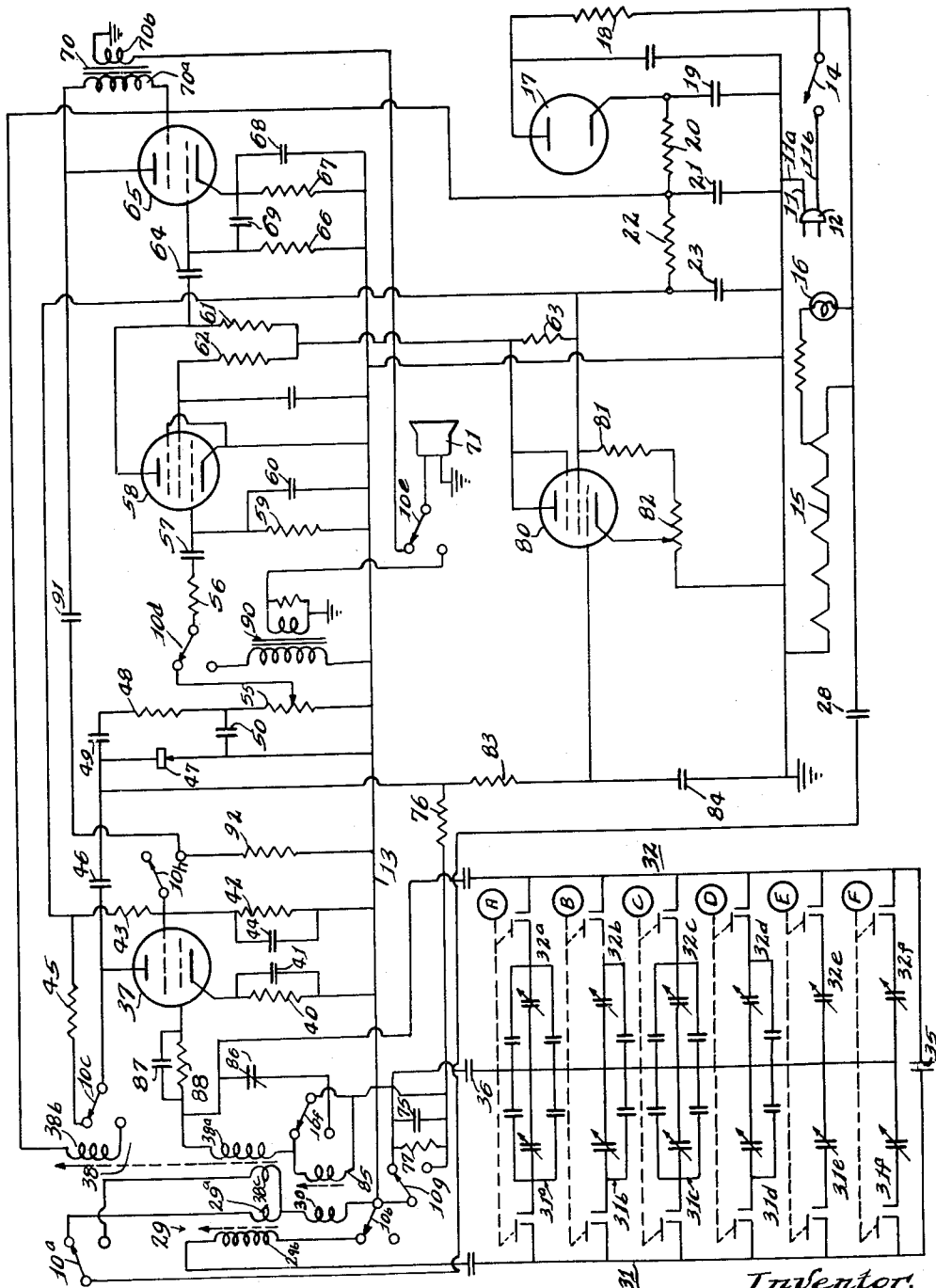


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CARRIER CURRENT INTERCOMMUNICATION SYSTEM
UTILIZING DUAL ACTION SQUELCH MEANS
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CARRIER CURRENT INTERCOMMUNICATION
SYSTEM UTILIZING DUAL ACTION SQUELCH
MEANS
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and this application July 18, 1960, Ser. No. 43,598
2 Claims. (Cl. 325-18)

This invention is concerned with a carrier wave intercommunication system which utilizes power lines for transmitting a modulated carrier wave between stations. This application is a division of my application Serial No. 512,206, filed May 31, 1955, now Patent No. 2,980,767.

It is a principal object of this invention to provide a new and improved intercommunication system, particularly adapted for use in multi-channel systems.

Another object of this invention is a provision of a carrier wave intercommunication system which utilizes power lines to couple stations together and means for disabling the receiving portions of the stations when no signal is being received, including a detector circuit and a squelch circuit in the receiving portions of the stations whereby said squelch circuit operates with a very small voltage change and includes a squelch tube having a control grid connected to the negative terminal of the detector, a screen grid connected directly to a source of high positive potential and an anode connected to a source of high positive potential through a large resistance, and an amplifier tube having an anode and a screen grid connected to the anode of the control tube, whereby the amplifier tube is disabled in the absence of a sufficient signal to cut off the control tube.

Further features and advantages will readily be apparent from the following specification and from the drawing which is a schematic representation of the circuit.

The present system is particularly designed for multi-channel use as contrasted with single channel systems, such as that shown in my copending application, Serial No. 430,956, filed May 19, 1954, now Patent No. 2,887,533. The general principles of operation of the present system are quite similar to those of the two station system shown in the copending application and reference may be had thereto for details of the external physical appearance of the station units and of the intercommunication and operation thereof. Preliminarily, one of the biggest differences between the two systems is the provision in a multi-channel system, of a plurality of selectable circuit components for tuning each station to one of a group of different frequencies.

While one specific circuit is shown in the drawing and values will be given herein for the components thereof, it is to be understood that this circuit is intended to be representative only and many modifications will be readily apparent to those skilled in the art.

The circuit which will be described is that of a "master" station and which can originate calls to and answer calls from any other station, as contrasted with a "staff" station which can only answer calls, or originate calls to other stations on its frequency. In the embodiment shown the station is provided with six sets of circuit components by virtue of which it may operate on any one of six different frequencies, the operating frequency being selected through manipulation of selector switches A, B, C, D, E and F. In contrast, a staff station for use in the same system operates on a single, fixed frequency. Many of the components of the circuit serve a dual function, operating in one manner during transmission and in another manner during reception and the interconnection

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of the various circuit elements, and thus the manner in which they operate, is determined by the position of an eight-pole double-throw switch 10, which will hereinafter sometimes be referred to as the "talk-listen" switch. This switch is shown in the listen position in the drawing and in practice, is generally spring biased to this position.

Turning now more specifically to the drawing, it will be seen that power cord 11 is provided with a male connector 12 which may be inserted into a suitable electrical outlet of a 110 volt A.C. or D.C. power system. The power line (not shown) then serves not only to supply power to the unit, but also to carry the modulated signals between the various units of the system. Conductor 11a of the power cord is connected to a common or ground line 13. Conductor 11b is broken by "On-Off" switch 14.

When switch 14 is closed, the series connected filaments 15 of the various tubes in the unit are connected across the power line as is an indicator light 16 which is lighted when the power is on. The power supply section of the unit comprises a single, half-wave rectifier 17, a 35W4, the anode of which is connected through resistor 18, 47 ohms, to one side 11b of the power line. A capacity input filter comprising capacitor 19, 40 μ f. (microfarads), resistor 20, 220 ohms, capacitor 21, 20 μ f., resistor 22, 2200 ohms and capacitor 23, 8 μ f., is connected between the cathode of rectifier 17 and the common line 13. The power supply has an output voltage of 80-95 volts depending on the current drawn. A high B+ of 100 volts is available across capacitor 21.

The signal input circuit for the unit is also connected, through blocking capacitor 28, .1 μ f., and section 10a of the talk-listen switch, across the power line. The input circuit includes primary winding 29a of antenna transformer 29 connected in series with a radio frequency choke 30. Antenna transformer secondary coil 29b is connected through section 10b of the talk-listen switch to ground and is tuned to resonance at the desired frequency by one of the variable capacitor sections 31a, 31b, 31c, 31d, 31e or 31f depending on which of the station selector switches A, B, C, D, E and F, is chosen, it being necessary that one of the selector switches be actuated for the unit to operate.

The antenna transformer has a primary winding of 80 turns of 7 strands No. 40 Litz wire with an inductance of 175 μ h. (microhenry) and a secondary winding of 335 turns of 7 strand No. 40 Litz wire, 2.8 mh. The values of the various capacitors depend on the frequencies used, which in the particular unit being described are as follows:

Channel	Frequency (Kc.)	Capacity 31 or 32 (μ f.)
A.....	98	1,300-1,350
B.....	116	800-850
C.....	139	500-550
D.....	161	400-450
E.....	212	300-350
F.....	250	300-350

The incoming signal is coupled through a circuit, including capacitors 35, 1.2 μ f. (micromicrofarads), and 36, 0.27 μ f., and which will be described more fully later, to the tuned grid circuit of the radio frequency amplifier stage 37, a 50C5. The tuned grid circuit includes winding 38a (a part of oscillator transformer 38) and the selected one of the variable capacitors 32a, 32b, 32c, 32d, 32e and 32f. The cathode of radio frequency amplifier 37 is returned to the common connection or ground 13 through a bias network including resistor 40, 330 ohms and capacitor 41, .1 μ f. The screen grid of the amplifier is connected at the junction point of two 47,000 ohm re-

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sistors 42 and 43 connected across the high voltage supply. Grounded resistor 42 is by-passed by capacitor 44, .01 μ f. The anode of amplifier 37 is connected through section 10c of the talk-listen switch and load resistor 45, 3600 ohms, to the power supply.

The amplified signal from tube 37 is coupled through capacitor 46, 500 μ f., to detector circuit including crystal diode 47, 1N48, and a load including resistor 48, 270,000 ohms and two shunt filter capacitors 49 and 50, 500 μ f. each. The audio signal is developed across volume control resistor 55, 500,000 ohms, and is coupled through section 10d of the talk-listen switch and the series combination of resistor 56, 470,000 ohms, and capacitor 57, .005 μ f., to the control grid of audio amplifier 58, a 12AU6, which is returned to ground through resistor 59, 10 megohms, shunted by carrier by-pass capacitor 60, 500 μ f. The anode and screen grid of tube 58 are connected, respectively, through resistors 61, 470,000 ohms, and 62, 1.5 megohms, and a common load resistor 63, .5 megohm, to the power supply. The purpose of resistor 63 will become apparent later in the discussion of the "squelch" circuit.

The output of tube 58 is developed across resistor 61 and is coupled through capacitor 64, .005 μ f., to the control grid of power amplifier 65, a 50C5. The control grid of amplifier 65 is returned to ground through resistor 66, 470,000 ohms, while the cathode thereof is connected to ground through bias resistor 67, 220 ohms, shunted by capacitor 68, 10 μ f.; the control grid and cathode are connected together by a capacitor 69, 100 μ f. The anode of audio output amplifier 65 is coupled through primary winding 70a of audio output transformer 70 to a high B+ (approximately 100 volts) at the junction of resistors 20 and 22; the screen grid being connected directly to this junction. Secondary winding 70b of the output transformer is connected through section 10e of the talk-listen switch to loudspeaker 71.

An automatic gain control voltage is developed across capacitor 75, .01 μ f., which is connected through resistor 76, 1.5 megohms, to the negative terminal of the detector circuit. The control grid of radio frequency amplifier 37 is returned through section 10f of the talk-listen switch to the juncture between capacitor 75 and resistor 76; the other terminal of capacitor 75 being grounded through section 10g of the talk-listen switch. Capacitor 75 is shunted by resistor 77, 4.7 megohms.

Inasmuch as the unit when in operation is normally left in "listen" condition, a squelch circuit is provided for preventing noise appearing on the power line from being amplified and reproduced when no signal is being received. The basic element of the squelch circuit is squelch tube 80, a 12AU6, connected for tetrode operation with the suppressor grid tied to the anode, which is in turn connected through resistor 63 to the power supply. The screen grid of squelch tube 80 is connected directly to the power supply and the cathode is returned to a variable positive voltage (0-4 volts) on a voltage divider made up of fixed resistor 81, 47,000 ohms and potentiometer 82, 2,000 ohms. The control grid of the squelch tube is connected to an integrating circuit made up of resistor 83, 1.5 megohms and capacitor 84, .01 μ f., connected to the negative terminal of the detector. With the "talk-listen" switch in the "listen" position, and with no signal being received, the control grid of the squelch tube will have a voltage of zero or just slightly negative applied thereto. Tube 80 will conduct heavily since the screen grid has a high positive voltage (80 volts), although the high plate current flowing through resistor 63 will reduce the anode voltage substantially to zero.

Since both the screen grid and anode of audio amplifier 58 are connected to the anode of squelch tube 80, the audio amplifier itself will be cut off. Sensitivity control 82 may be adjusted so that this situation obtains regardless of the normal amount of noise encountered on the line. As soon as a signal is received by the station, the voltage

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applied to the control grid of the squelch tube will become increasingly negative, cutting this tube off and permitting the anode and screen grid voltage of audio amplifier 58 to rise to an operable value. Since the squelch tube operates on both the screen grid and anode of the amplifier, distortion of the incoming signal by partial cut-off of the squelch tube is minimized. The squelch circuit is extremely sensitive, and when properly adjusted may be triggered by a rectified signal as small as 0.10 volt on the grid of the squelch tube. The long time constant of the integrator circuit ($RC=.015$ sec.) connected to the grid of squelch tube 80 delays the build-up of negative voltage on the grid of the squelch and prevents cut-off of the squelch tube by bursts of high amplitude noise energy.

Turning back now to the input circuit of radio frequency amplifier 37, it will be recalled that primary coil 29a of tuned antenna transformer 29 is connected in series with coil 30 across the power line. Multi-channel carrier wave intercommunication systems which utilize the power lines for communicating messages between units must necessarily utilize carrier waves of different frequencies if more than one conversation is to be carried on at a time. This in turn requires the use of tuned, frequency-sensitive circuits in the input of the amplifier unit. This in itself is not a difficult problem, but it often happens that, after the system has been installed, additional reactive loads may be connected to the power line in such a manner that they affect the tuned input circuit, to the point of detuning it far enough so that it has little or no response at the desired frequency. An example of such a load which might be connected to the line is a small A.C.-D.C. radio receiver which normally has an .05 μ f. capacitor connected across the power supply input; a sufficient capacity to detune the input circuit of the intercommunication station system seriously. The radio frequency choke 30, which is connected in series with antenna transformer primary coil 29a across the line, comprises 80 turns of No. 28 wire and has an inductance of 38 μ h. It has been found that with this additional impedance in series with the amplifier input circuit the detuning effect of additional reactive loads connected to the power line is negligible.

It is desirable that the selectivity and sensitivity characteristics of the tuned input circuits of the station be approximately the same for all channels. Since the system operates on frequencies from 98 to 250 kilocycles, it was found necessary to provide a special coupling network in order to achieve this condition. As mentioned briefly previously, the secondary winding 29b of the antenna coil is tuned by one of a set, 31, of capacitors as determined by the band selector switch, while coil 38a is tuned by the selected one of group 32 of capacitors. The terminals of the two tuned circuits common to the inductance and capacity of each are coupled through capacitor 35 while the other terminals of the tuning capacitors 31 and 32 are connected to a common point and return through capacitor 36 and talk-listen switch section 10g to ground. Capacitor 35 together with the distributed capacity of the circuit components (a total of about 5.5 μ f.), provide adequate coupling of the signal at the higher frequencies while capacitor 36 insures adequate coupling on the low frequency bands, the circuits being slightly over-coupled on bands A and B to achieve the necessary band width.

When the talk-listen switch is pressed, moving it to "talk" position, the system is converted from a receiver to a transmitter, by changing the operation of some of the circuit elements. Amplifier tube 37 is utilized, in the talk position, as a modulated oscillator with a tuned grid circuit including coil 38a, compensating coil 85, compensating capacitor 86, variable up to 30 μ f., and the selected one of the tuning capacitors in group 32. Feedback is provided from the plate circuit to the grid circuit through coil 38b which is connected to the anode of the tube through section 10c of the talk-listen switch; the plate

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circuit of the oscillator being connected to the high B+ connection of the power supply. Self-bias of the oscillator is provided by a grid leak bias arrangement including resistor 88, 270,000 ohms, and capacitor 87, 100 μ f. The AGC system is shorted during transmission by section 10g of the talk-listen switch. The output of the modulated oscillator is inductively coupled from winding 38a of the oscillator coil to link winding 38c which is connected through section 10a of the talk-listen switch to the power line and returned to the common terminal through choke 30. Again, choke 30 minimizes the effect of reactive loads on the line, which during transmission would have the effect of detuning the oscillator. The oscillator coil windings are all of 7 strand, No. 40 Litz wire, winding 38a being 450 turns, 2.7 mh.; winding 38b, 144 turns, 2.0 mh. (slug tuned); and winding 38c, 80 turns, 150 μ h.

The modulation information is coupled from transducer 71 (the loudspeaker is used also as a microphone) through section 10e of the talk-listen switch to an audio input transformer 90, the secondary of which is connected through section 10d of the talk-listen switch to the control grid of audio amplifier 58. (The continuous oscillation produced by tube 37 is rectified in detector 47 using a sufficient negative voltage on the grid of the squelch tube 80 to cut this tube off to permit operation of audio tube 58 during transmission.) The audio signal is coupled from audio amplifier 58 to modulator tube 65 where it is further amplified and coupled through capacitor 91, .05 μ f., and section 10h of the talk-listen switch to the screen grid of oscillator 37. Section 10h of the talk-listen switch also connects resistor 92, 15,000 ohms, in parallel with resistor 42 of the screen grid voltage divider during transmission. Thus, a relatively low voltage, of the order of 15 volts, is applied to the oscillator screen grid during transmission. This low voltage keeps the stage in oscillation but at a low amplitude except during the positive swing of the modulating signal. This circuit and its noise reducing operation are fully described in my aforementioned copending application and reference may be had thereto for further details thereof.

It will be recalled that the selected capacitors of group 32 are utilized both during reception and transmission of resonate with winding 38a, tuning the grid circuit of tube 37 to the same frequency. However, as the input impedance of tube 37 (which is in shunt with the tuned circuit) varies between the two conditions of the tube, the tuned circuit made up of winding 38a and the selected one of the capacitors 32, will not resonate at the same frequency during both reception and transmission. In order to correct this condition and to insure that the unit will operate at substantially the same frequency during both transmission and reception, on each band, a compensating circuit including compensating coil 85 and compensating capacitor 86 are added to the circuit. As shown in the drawing, coil 85 is placed in series with winding 38a of the oscillator transformer while capacitor 86 is placed in parallel with the series combination thereof, through operation of section 10f of the talk-listen switch. In the embodiment which is discussed herein, compensating coil 85, 250 μ h., has 150 turns of 7 strand No. 40 Litz wire and is slug tuned, while capacitor 86 is variable with a maximum capacity of 30 μ f.

In adjusting the tuned circuits, capacitors 31 and 32 are first adjusted to the proper frequencies with the unit operating as a receiver. At the same time the antenna and oscillator coils are properly adjusted on the lowest frequency band. The unit is then operated as a trans-

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mitter and compensating coil 85 is adjusted on band A to cause operation at the proper frequency; the compensating capacitor 86 is similarly adjusted on band F. The above steps or part of them may then be repeated one or more times to eliminate any detuning due to interaction between the various circuits.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. In an intercommunication system including a plurality of stations and a power line interconnecting such stations, means in each station for preventing noise which appears on the power line from being received and reproduced in the receiver portions of said stations, comprising: a signal channel including a detector circuit connected with the power line and having a negative terminal; an amplifier tube in said signal channel having a screen grid and an anode; an integrator circuit including a resistor and a capacitor, connected with the negative terminal of said detector circuit; a source of positive potential; a control tube having a control grid connected with the capacitor of said integrator circuit, a screen grid connected with said source of positive potential, an anode connected with said source of positive potential through a high resistance, and a cathode connected to said source of positive potential through a variable resistance; a high resistance connecting the anode of said control tube to the screen grid of said amplifier tube; and a second high resistance connecting the anode of said control tube to the anode of said amplifier tube, whereby with no signal being received, said control tube conducts heavily and provides a low voltage to the anode and screen grid of said amplifier disabling said amplifier, and with a signal being received, a negative voltage is applied to the control grid of said control tube and the control tube is cut off, said long time constant circuit acting to prevent bursts of high amplitude noise from cutting off said control tube.

2. In a carrier wave intercommunication system which utilizes power lines to couple stations, said stations each having a detector circuit with a load having a negative terminal, means in each station for disabling the station in the absence of a signal, comprising: a control tube having a control grid connected with the negative terminal of said detector, and an anode connected with a source of positive potential through a large resistance; and an amplifier tube connected with said detector for amplifying the signal therefrom and having an anode and a screen grid, resistors connecting both the anode and the screen grid of the amplifier with the anode of said control tube and through said large resistance with said source of positive potential, whereby with no signal being received, the control tube conducts heavily applying a low voltage to the anode and screen grid of the amplifier and with a signal being received, conduction through the control tube is reduced permitting said amplifier to operate.

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