

Sept. 22, 1936.

G. RAMSEY

2,055,309

MULTIPLEX COMMUNICATION SYSTEM

Filed Feb. 19, 1931

3 Sheets-Sheet 1

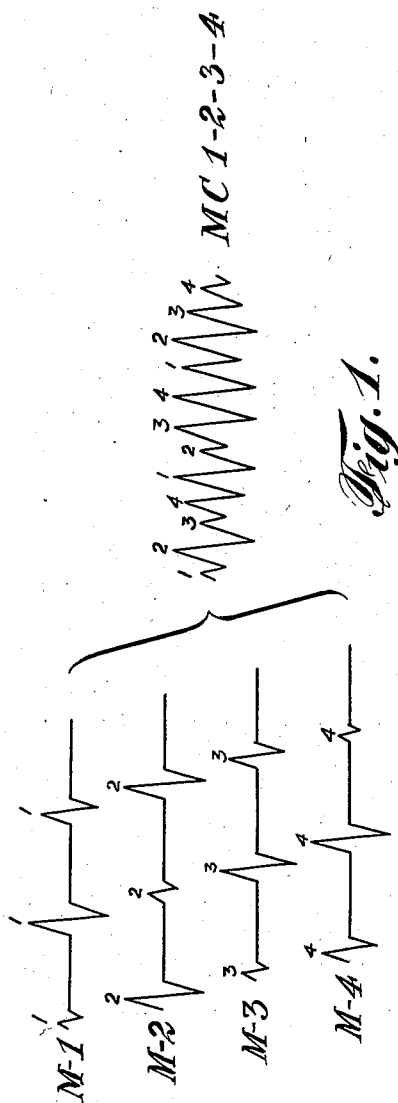


Fig. 1.

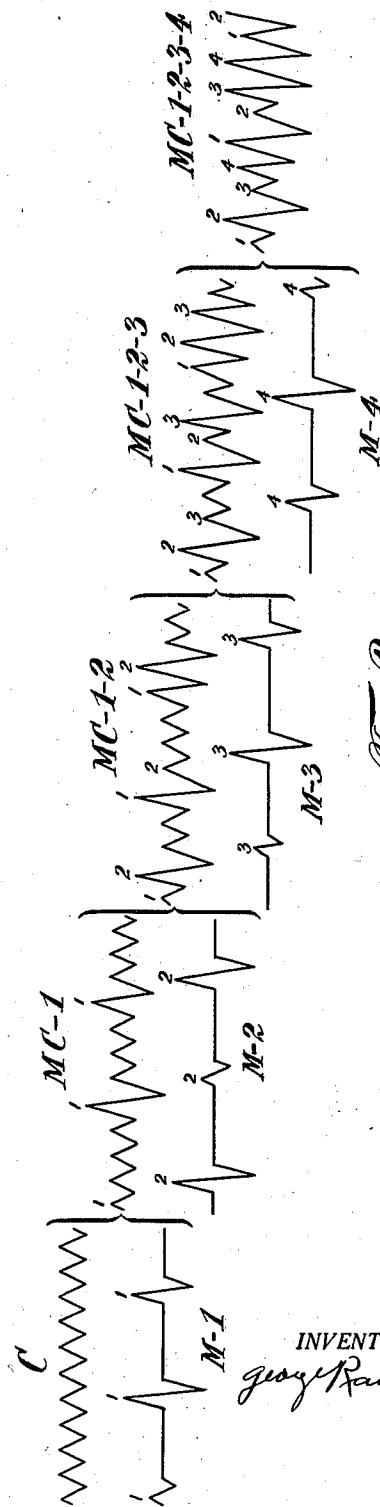


Fig. 2.

INVENTOR.
George Ramsey

Sept. 22, 1936.

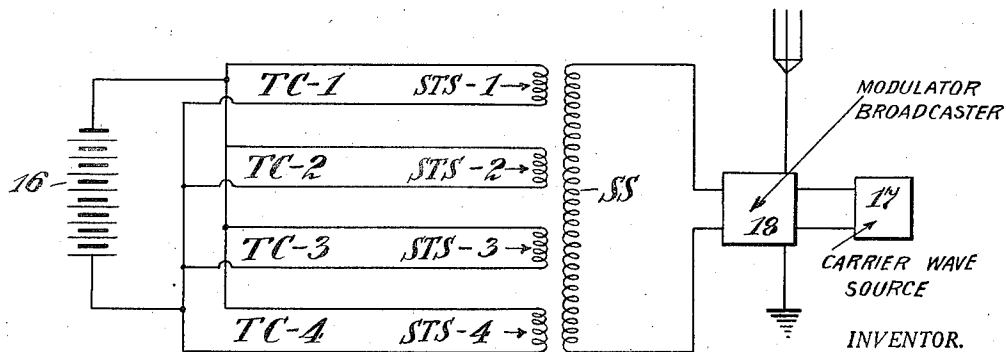
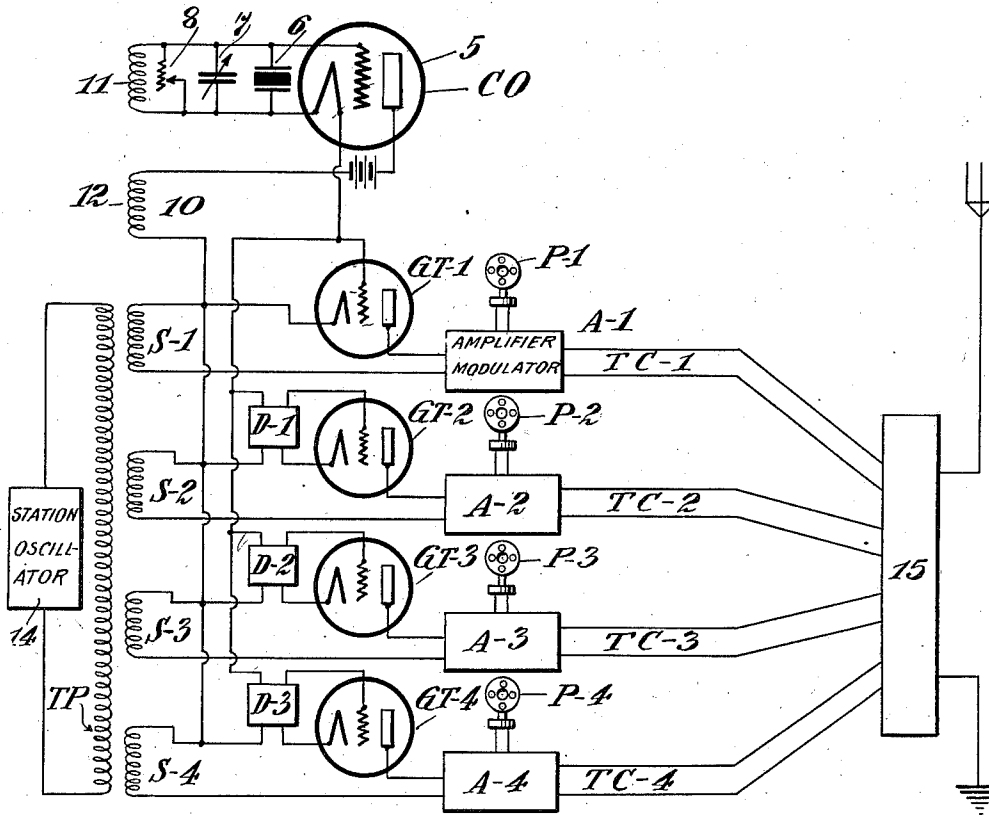
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MODULATOR
/BROADCASTER

CARRIER WAVE
SOURCE

INVENTOR.

George Ramsey

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G. RAMSEY

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Fig. 5.

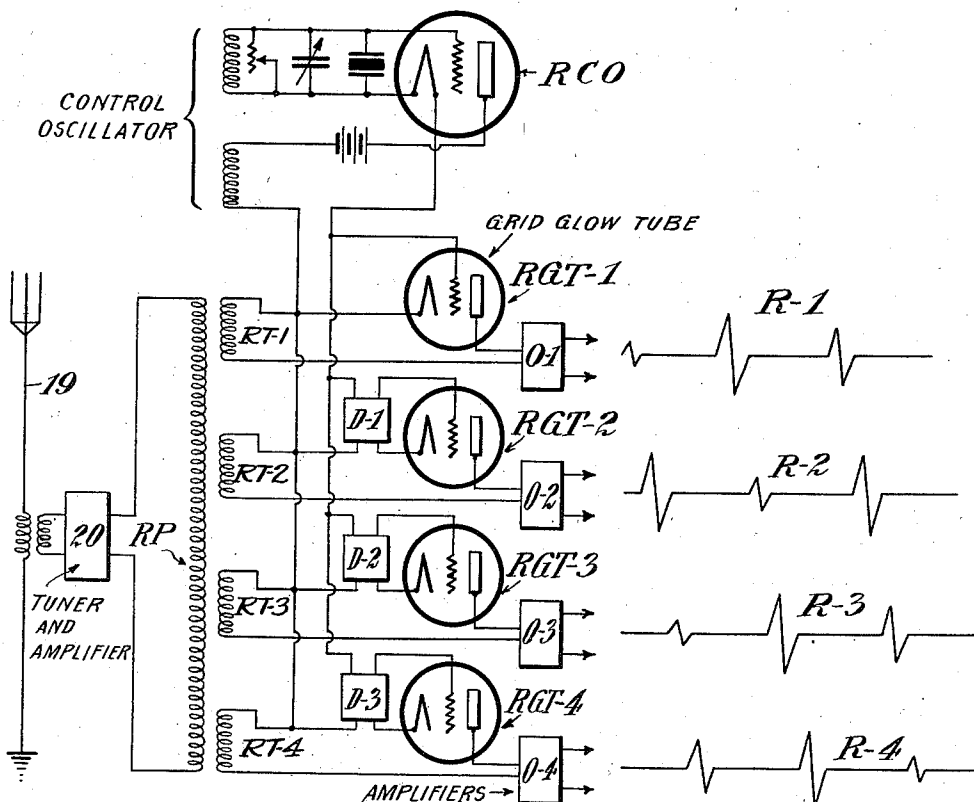
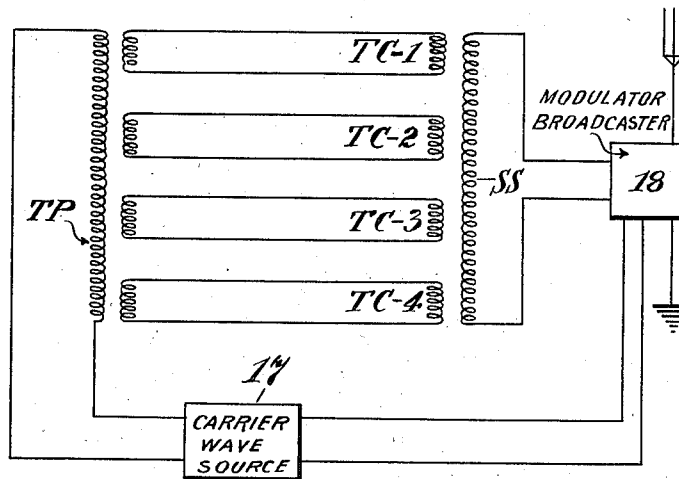


Fig. 6.

Fig. 7. INVENTOR.
G. Ramsey

UNITED STATES PATENT OFFICE

2,055,309

MULTIPLEX COMMUNICATION SYSTEM

George Ramsey, Brooklyn, N. Y.

Application February 19, 1931, Serial No. 516,955

4 Claims. (Cl. 250—9)

The present invention relates broadly to the transmission of communications by high frequency electrical currents and more especially to a method and apparatus for sending a large number of independent communications within a single wave band.

The present invention comprises broadly selecting linear spaced waves in a single wave band for transmitting independent communications. For example, assuming a five kilocycle wave band wherein five communications are to be sent. According to the present invention, the first, the sixth, the eleventh, and the sixteenth linear waves are modulated for the first communication; for the second communication, the second, seventh, twelfth and the seventeenth linear waves are modulated; for the third communication, the third, the eighth, the thirteenth and the eighteenth linear waves are modulated; for the fourth communication, the fourth, the ninth, the fourteenth and the nineteenth linear waves are modulated; and for the fifth communication, the fifth, the tenth, the fifteenth and the twentieth are modulated. The foregoing example illustrates the division of a single wave band of five hundred kilocycles into five linear channels, each channel of which comprises modulated waves oscillating at the rate of one hundred kilocycles. The foregoing example is merely illustrative and by the use of higher kilocycles more divisions may be provided and also the wave band may be divided longitudinally by utilizing groups of waves instead of single waves, for example, the first and second wave forms may be modulated for the first communication; the third and fourth waves modulated for the second communication; the fifth and sixth waves modulated for the third communication; the seventh and eighth waves modulated for the fourth communication and the ninth and tenth for the fifth communication. The longitudinal or linear division may be carried to the extent that the divisional oscillation is sufficiently rapid to provide the necessary carrier waves for communication purposes. It is preferable, though not necessary, that each divisional carrier wave according to the present invention shall be at least ten times as rapid in oscillation as the oscillations of the modulation wave which is being transmitted.

From the foregoing, it will be observed that the present method provides for multiplexing a single wave band and thereby conserving the other wave bands available while at the same time permitting a vast number of independent communications to be transmitted.

Different devices and apparatus may be utilized in carrying out the present invention. The preferred apparatus, however, comprises at the sending station a plurality of trigger circuits controlled by a control oscillator which operates

through predetermined step-back delay circuits arranged to delay in series the effect of the oscillator upon the trigger circuits except the first circuit. The trigger circuits may be energized through a carrier wave, but this wave only passes in a particular trigger circuit when this circuit is operative through the medium of the control oscillating circuit. By proper coordination between the control oscillating circuit and the carrier wave circuit, it will be observed that the trigger circuits may be made operative at predetermined wave intervals of the main carrier wave. The delay circuits between the oscillator and the trigger circuits are so arranged as to cause these trigger circuits to operate in echelon.

Each trigger circuit may be passed through a modulator amplifier connected with a communicating apparatus, which may comprise a microphone, so that the output of the trigger circuits is a modulated wave. These trigger circuits may be brought together so that the modulated waves therefrom are synthesized. There are several ways in which this may be done, the preferred way being to cause the trigger circuit modulated waves to modulate linear spaced wave forms in a carrier wave, whereby the modulated carrier wave in a single band goes out with each predetermined interval wave form carrying a separate communication.

The multi-modulated carrier wave may be transmitted over a wire, through the ether, or other circuits, and received at a receiving station. The receiving apparatus like the sending apparatus may assume different forms but preferably it comprises a plurality of trigger analyzer circuits. These trigger analyzer circuits are operated by a control oscillator corresponding to the control oscillator at the sending station. The oscillator at the receiving station is tuned to pick up communication No. 1 on receiving trigger circuit No. 1. A delay circuit is interposed between the oscillator and receiving trigger circuit No. 2 sufficient to delay the effective operation of receiving trigger circuit No. 2 so as to pick up communication No. 2 and the receiving trigger circuits 3 and 4 etc., are correspondingly delayed. These receiving trigger circuits have no current flowing therein except when the trigger circuit is made operative through the receiving control oscillator. In this way, the trigger receiving circuits operate in echelon and pick out the individual wave forms from the carrier wave which individual wave forms carry a single program or communication. After the individual wave forms have been analyzed from the composite carrier waves, these wave forms may be amplified in accordance with well known practice for any purposes desired.

It is to be understood that the present invention is applicable to any type of communication comprising music, conversation, pictures, television,

telegraphy, or any other intelligence which it is desired to communicate from one point to another. It is to be understood that various types of communication may be carried on in the same wave band, for example, speech, music, and television.

It is realized that the present invention may be practiced by variations from the present disclosure and may be embodied in apparatus specifically different from that herewith described, and, therefore, it is to be understood that the disclosure herewith is to be considered as illustrative and not in the limiting sense.

Fig. 1 illustrates the modulating of four waves which are synthesized into a carrier wave containing the four individual modulated waves representing four communications.

Fig. 2 illustrates a carrier wave upon which is imposed in echelon four modulated waves representing four individual communications so that the carrier wave as transmitted is a composite modulated wave carrying four separate communications.

Fig. 3 illustrates diagrammatically one form of sending apparatus.

Fig. 4 illustrates diagrammatically a modification of a sending apparatus shown in Fig. 3.

Fig. 5 illustrates diagrammatically a further modification of the sending apparatus shown in Fig. 3.

Fig. 6 illustrates diagrammatically one form of receiving apparatus.

Fig. 7 illustrates diagrammatically the analysis of a received wave at the receiving station.

Referring now to the drawings and more especially to Fig. 1 which diagrammatically illustrates one method of carrying out this invention comprising providing a plurality of modulated spaced apart wave forms arranged in echelon and then synthesized into a carrier wave. For convenience in analyzing the waves and structure hereinafter referred to, initials have been utilized as well as numerals.

In Fig. 1, the first modulated communication wave is indicated as M-1; the second modulated communication wave as M-2; the third modulated wave as M-3; and the fourth modulated communication wave as M-4. These modulations are spaced apart in echelon with three carrier wave form cycles between each wave form in a single communication wave so that when the four communication waves are superimposed one upon another, the final wave is a modulated carrier wave designated as MC-1-2-3-4 which is a continuous wave.

Fig. 2 illustrates another method of producing a modulated carrier wave by modulating a constant amplitude carrier wave C by superimposing thereon the modulated communication waves. For example, the carrier wave C when imposed upon modulated communication wave M-1, produces modulated carrier wave MC-1, which is modulated as to each fourth wave form. When modulated communication wave M-2 is superimposed upon modulated carrier wave MC-1, modulated carrier wave MC-1-2 is produced. When modulated communication wave M-3 is superimposed upon the wave MC-1-2, modulated carrier wave MC-1-2-3 is produced. When communication wave M-4 is superimposed upon carrier wave MC-1-2-3, the final carrier wave MC-1-2-3-4 is produced. This carrier wave is identical with the carrier wave MC-1-2-3-4 illustrated in Fig. 1.

Fig. 3 illustrates one form of sending station in which are arranged four trigger circuits TC-1, TC-2, TC-3 and TC-4. Each trigger circuit TC comprises the secondaries of a transformer, designated in the respective circuits as S-1, S-2, S-3 and S-4, in circuit with a trigger tube which may comprise a gas filled tube. One form of such tube is known in the art as the grid glow tube. These types of tubes are filled with different gases, some with neon gas, others with argon gas, and others with mercury vapor. The characteristic of this type of tube is that the operation of the tube, from zero to full current, may be controlled entirely by the grid, so that no current flows through the tube unless the grid is properly energized, in which case the tube glows and the current passes through the tube. Each of the trigger circuits is provided with one of these grid glow tubes, as for example, GT-1, GT-2, GT-3, and GT-4. The grids of each of these grid glow GT tubes are connected with a control oscillator CO. The control oscillator circuit may comprise a three element tube 5 connected in a circuit including a piezo crystal 6, an adjustable condenser 7 and an adjustable resistance 8 with an oscillating circuit 10 between the plate and filament of the tube 5 coupled by the coupling coils 11 and 12 with the circuit including the crystal 6. This oscillating circuit is tuned to the interval by which the main carrier wave is to be divided. One side of the circuit 10 is connected with the grids of the GT tubes and the other side of the oscillating circuit 10 is connected with the filaments of the GT tubes. Delay circuits D-1, D-2 and D-3 are provided between the oscillating circuit 10 and certain of the filaments of the GT tubes respectively. Suppose the TC circuits are to produce the M-1, M-2, M-3, and M-4 modulated waves of Fig. 7 and Fig. 2, then the delay circuit D-1 delays one phase, delay circuit D-2 delays two phases while delay circuit D-3 delays three phases or cycles, thus producing the modulated waves, with their respective spaced wave forms in echelon in the relation of one wave to another. Amplifier modulators A-1, A-2, A-3 and A-4 are connected in the TC circuits. Microphones P-1, P-2, P-3 and P-4 are connected respectively with the modulator amplifiers. This microphone modulator amplifier unit in each of the TC circuits permits the individual modulation of the waves in the separate TC circuits. TC circuits may be energized in various ways, one of which, as shown in Fig. 3, is a station oscillator 14 connected through a transformer primary TP which is coupled with the secondaries S. This oscillator 14 produces the oscillation of the carrier wave for the station and tends to energize each of the TC circuits. In view of the blocking effect of the GT tubes, no energy flows in the TC circuits except when the control oscillator CO energizes the grids of the GT tubes. This oscillation occurs in synchronism with spaced apart wave forms of the carrier wave and, since the delay circuits D cause the action in the TC circuits to occur in echelon, the TC circuits produce the modulated communication wave indicated as M-1, M-2, M-3 and M-4 waves illustrated in Figs. 1 and 2. These modulated waves are brought into a synthesizer and broadcasting apparatus 15 where the carrier wave MC-1-2-3-4 is transmitted.

Fig. 4 is a construction identical with that shown in Fig. 2 as to the TC circuits and the

control oscillator, the only difference being the manner in which these circuits are energized and the manner in which the carrier wave is produced.

5 In Fig. 4, each TC circuit is energized through a battery 16 and the terminals of the TC circuits comprise primaries of sending transformers ST-1, ST-2, ST-3, and ST-4, which are coupled with a sending secondary SS. The sending secondary has imposed upon it the main carrier wave from the carrier wave source 17. The individual modulated waves are imposed on the main carrier wave through a modulator broadcaster 18 which is connected with the antenna. 10 This type of sending station produces the modulated carrier wave MC-1-2-3-4 by the method indicated in Fig. 2.

Fig. 5 is a modification of a sending station comprising a combination of the construction shown in Figs. 3 and 4, wherein the battery 16 of Fig. 4 is replaced by the transformer TP of the type shown in Fig. 3 and both the transformer TP in Fig. 5 and the sending secondary SS in Fig. 5 are energized from a common carrier wave source 17. 20

In the foregoing figures for the purpose of simplification, balancing resistances such as are usually used with the grid glow tubes and other well known apparatus have been omitted, the purpose of the present disclosure being to simplify the disclosure of the present invention by omitting undue complications relating to features and elements which are well known in the art and which are obvious to one skilled in the art. It is also to be understood that sources of electrical energy are to be supplied where necessary as will be obvious to those skilled in the art. 30

The receiving apparatus may be a substantial duplicate of the sending apparatus and an example is shown in Fig. 6, in which the incoming composite carrier wave is received on the antenna 19 and is amplified through the amplifier 20 where the wave is transmitted to the primary of the receiving transformer RP, from which it goes to the receiving trigger circuits RT-1, RT-2, RT-3 and RT-4. These receiving trigger circuits are substantially identical with the circuits described as to the sending station in Fig. 3 and include the receiving grid glow tubes RGT-1, RGT-2, RGT-3 and RGT-4, which are controlled by the receiving control oscillator RCO, identical in circuit with that described as to Fig. 3. The RT circuits include receiving amplifiers O-1, O-2, O-3 and O-4. 40

Fig. 7 illustrates the analysis of the received carrier wave as it is analyzed by the apparatus shown in Fig. 6. This received carrier wave is analyzed through the receiving trigger circuits RT in the individual modulated waves received in echelon as modulated waves R-1, R-2, R-3, and R-4. Each of these modulated waves corresponds exactly with the modulation communication waves M-1, M-2, M-3, and M-4 originated at the sending station. 50

The foregoing disclosure is largely diagrammatic and illustrates the method of dividing the carrier wave linearly in a single band in such manner as to comprise four independent communication channels. It is to be understood that the invention is in no way limited to four channels but that the carrier wave may be divided into many channels. In each case, the channels are superimposed on the carrier wave in echelon and the carrier wave is analyzed linearly in echelon at the receiving station to separate the 65

several communicating channels so that a plurality of individual communications may be simultaneously received in a single wave band.

The main carrier wave is preferably divided linearly as to equal wave length divisions and therefore each communication occurs at regularly spaced apart intervals on the main carrier wave. These equal spaced apart intervals may be considered as sub-harmonic points in the main carrier wave. Thus where four communications are transmitted, the frequency at which succeeding waves of a single communication occur is at one-fourth the rate of the main carrier wave. Hence, the communications may be considered as occurring on a fourth sub-harmonic of the main carrier wave. These fourth sub-harmonics are transmitted and received in echelon, thereby completing the full wave train for the main carrier wave. 10

What I claim is:— 20

1. An apparatus for sending a plurality of separate communications in a single high frequency wave band comprising means to produce a high frequency carrier wave, a plurality of parallel circuits, distortionless grid glow tubes in each of said circuits, control means to render said tubes operative at predetermined intervals in arithmetical timed relation to the carrier wave to pass predetermined portions of said carrier wave through said circuits, and delay devices between said control means and certain of said tubes whereby each circuit passes a distinct selected portion of said carrier wave. 25

2. An apparatus for sending a plurality of communications in a single high frequency wave band comprising a plurality of circuits, a grid glow tube in each of said circuits, means to operate said tubes in timed relation at a single sub-harmonic of the high frequency band, delay devices to delay the operation of certain of said tubes a time interval equal to one wave in said band, means to impose a communication on the waves in each of said circuits, and means to transmit said communications as distinctive portions of said high frequency band. 35

3. In the art of radio communications, a plurality of individual channels, a grid glow tube in each of said channels, a control oscillator comprising an electronic tube circuit controlled by a piezo crystal to produce a predetermined oscillatory current, the output from said control oscillator being connected on one side with the filaments of the grid glow tubes and on the other side with the grids of said grid glow tubes, one of the grids of the grid glow tubes being connected directly in circuit with said control oscillator, and delay circuits between the grids of the remaining grid glow tubes and the oscillator, said delay circuits being of progressive values to cause the control oscillator to progressively affect said tubes, and means to transmit an oscillating current to each of said channels. 40

4. An apparatus in the art of communications comprising in combination means to produce a carrier wave, a plurality of channels, a grid glow tube in each channel, a distortionless control oscillator operating at a sub-harmonic of said carrier wave, progressive delay circuits from said control oscillator being connected on one side with the filament of said grid glow tubes and on the other side with the grids of said grid glow tubes, and means to combine the output of said channels. 65

GEORGE RAMSEY. 75