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H. W. NICHOLS.
SELECTIVE RECEIVING SYSTEM.
APPLICATION FILED DEC. 18, 1920.

1,420,055. Patented June 20, 1922.

Fig. 1

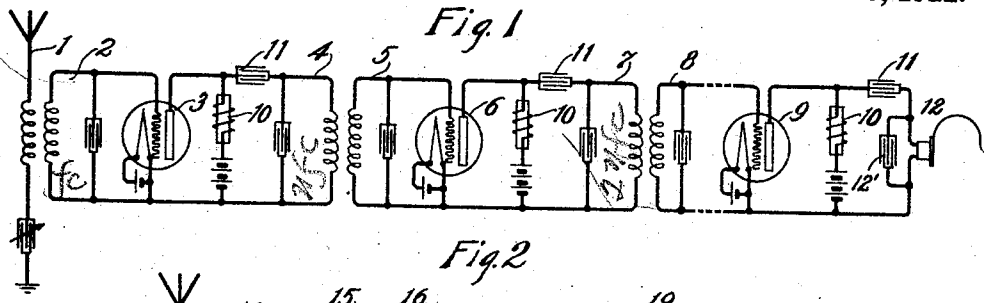


Fig. 2

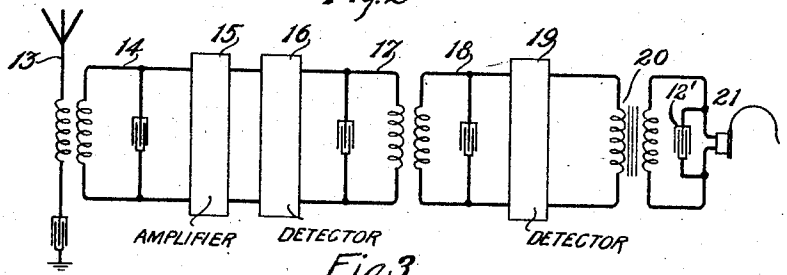
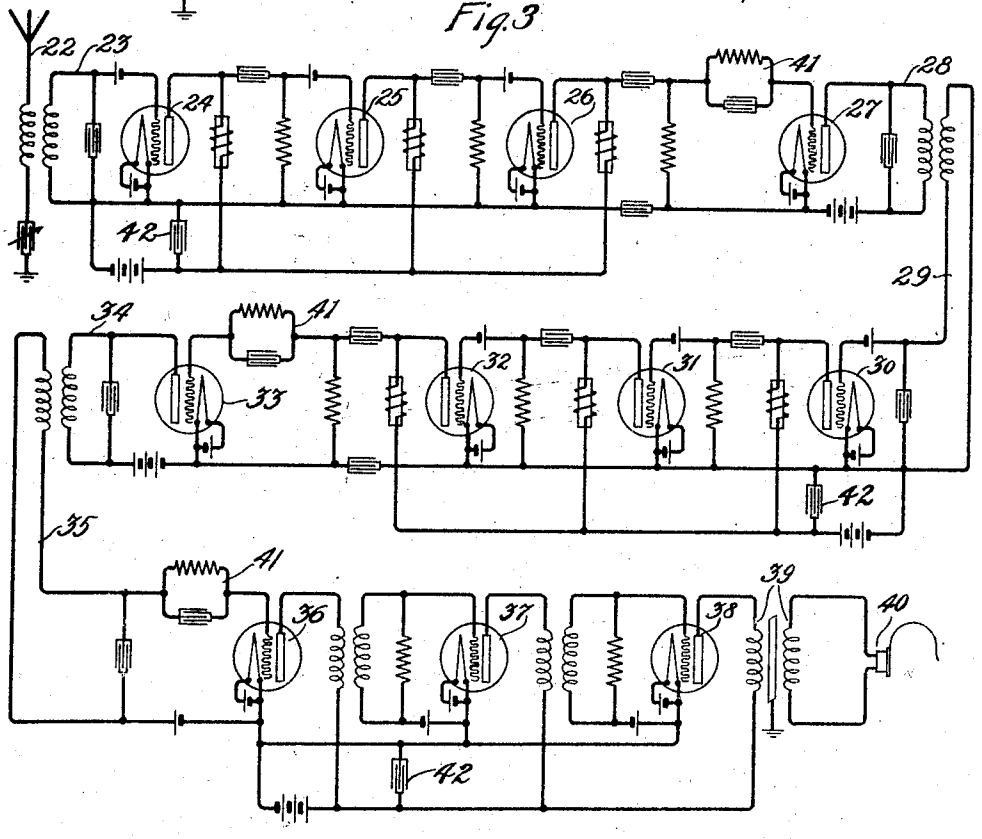


Fig. 3



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UNITED STATES PATENT OFFICE.

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SELECTIVE RECEIVING SYSTEM.

1,420,055. Specification of Letters Patent. Patented June 20, 1922.

Application filed December 18, 1920. Serial No. 431,555.

To all whom it may concern:

Be it known that I, HAROLD W. NICHOLS, a citizen of the United States, residing at Maplewood, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Selective Receiving Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to a selective receiving system and more particularly to a radio receiving arrangement employing multiple detection.

When a receiving station adapted to cooperate with a low-power or "weak" transmitting station, receives energy from a high power or "strong" transmitting station, interference results, the measure of which is determined by the intensity of the signal current received from the "strong" station relative to that from the "weak" station and to some extent upon the relative frequencies of the waves radiated from the two transmitting stations. Hence, when two such stations employ frequencies which are close together on a percentage basis, i. e., the ratio of the frequency of the interfering to selected waves is large or that of the difference frequency relatively to that of the desired waves is small, selection at the receiving station of the signal currents radiated from the "weak" transmitting station is extremely difficult with the arrangements heretofore devised.

The primary object of this invention is to provide an arrangement which is selective of a current of low intensity compared to a strong interfering wave of frequency relatively close to that of the current to be selected.

Another object is to provide means for eliminating interference due to a current of large amplitude relative to that of the current which it is desired to receive.

A further object is to provide a selective arrangement of this type which employs multiple detection.

In this system advantage is taken of the fact that because of the curved characteristic of most detectors including the vacuum tube type, if a speech or other signal modulator carrier current is impressed on its input circuit there will be present in the output circuit the signal modulated first even harmonic of the carrier frequency and by tuning the output circuit of the detector and the coupled input circuit of the next detector to this first even harmonic considerable selectivity will be obtained.

According to the present invention the carrier wave received is impressed upon the tuned input circuit of a detector device from the output circuit of which the first even harmonic of the carrier frequency is selected and applied to the input circuit of a second detector device from the output circuit of which, in turn, the second even harmonic frequency of the carrier wave is selected. This process may be continued for any desired number of stages and the detected audio frequency signal current of the last stage is supplied to a telephone receiver or other indicator, The various stages may, if desired, be connected by amplifying devices.

Thus, an incoming signal modulated carrier frequency wave may be represented by the formula $A(1+k \cos. \varphi t) \sin. \omega t$ or by the three component sine frequencies A sin. ωt; $\frac{kA}{2}$ sin. $(\omega+\phi)t$; $\frac{kA}{2}$ sin. $(\omega-\phi)t$, in which A is an amplitude factor, sin. ωt is the instantaneous value of the carrier frequency current (wherein $\omega=2\pi f$, f being the frequency), sin. φt is the value of the current of signal frequency at any instant (where $\varphi=2\pi f'$, f' being the frequency and k is a constant. If this current is impressed on the grid circuit of a detector, the output current is given by the equation $i=B[E_B+\mu E_C+\mu A(1+k \cos \varphi t) \sin \omega t+K]^2$ or, taking $B=1$ and $E_B+\mu E_C+K=d$, then $i=[\mu A(1+k \cos \varphi t) \sin \omega t+d]^2$. In these two equations B is a constant, E_B is the plate battery potential μ is the amplifying factor of the tube, E_C is the polarizing potential applied to the grid, K is a constant and the other characters are the same as in the preceding formula.

Simplifying these expressions and neglecting co-efficients we get, in addition to the signal frequency and others, the following frequencies in the plate circuit: cos $2\omega t$ cos $(2\omega+2\varphi)t$ and cos $(2\omega+\varphi)t$ which are the signal modulated first even harmonic frequencies of the incoming carrier frequency. Impressing these frequencies through two coupled circuits tuned to 2ω on the grid of another detector as previously mentioned we get in its output circuit, in addition to the current of signal frequency and others the following frequencies (neglecting co-

efficients) $\cos 4\omega t$, $\cos 4\omega+\varphi)t$, $\cos (4\omega+2\varphi)t$, $\cos (4\omega+3\varphi)t$ and $\cos (4\omega+4\varphi)t$, which is a second even harmonic of the carrier frequency. Similarly, we can tune for the frequency 4ω and detect again and so on or we can get the signal frequency in this or any other output circuit and impress it across a signal indicating device.

It is to be noted that in the plate circuit of the first detector the amplitude of the signal frequency varies as A^2, in the plate circuit of the second detector as A^4, in the plate circuit of the third detector as A^8 and so on; A being the amplitude of the incoming modulated carrier wave.

Where a different harmonic frequency is selected the amplitude factor of the signal frequency will increase by a correspondingly different power.

The operation of a system involving this invention may be understood by reference to the following detailed description taken in conjunction with the attached drawing in which Fig. 1 diagrammatically illustrates a simple circuit arrangement embodying a multiplicity of stages of detection, Fig. 2 shows a two-stage detection arrangement and includes a high frequency amplifier, the amplifier and detectors being shown diagrammatically and Fig. 3 shows an arrangement involving three stages of detection, and a plurality of stages of amplification for both the high frequency and the audio frequency currents.

Referring to Fig. 1, an antenna 1 tuned to the frequency of the incoming waves is inductively coupled to a resonant circuit 2, also selective of the carrier frequency, which is connected to the input terminals of the detector 3. The detector herein shown, by way of example, as a three-element vacuum tube has included in its plate circuit a selective circuit 4 tuned to the first even harmonic of the frequency of the incoming carrier waves.

Inductively associated with the circuit 4 is a resonant circuit 5, tuned to the same frequency as circuit 4, which is connected to the input terminals of a detector 6, whose output circuit includes a circuit 7 selective of the second even harmonic of the carrier frequency. Current of the harmonic frequency selected by circuit 7 is transferred to a similarly tuned circuit 8 by the transformer interconnecting them and is impressed across the input circuit of a third detector.

As herein indicated this may be a detector 9, or other stages of detection may be introduced, in which event, the circuit 8 will be connected across the input of a succeeding detector and its output circuit will include a resonant circuit tuned to a harmonic of the frequency of circuit 8. Finally, a selective circuit tuned to the same frequency as that included in the output circuit of the detector which precedes the device 9 will be included in the input circuit of the last detector, the output current of which will be impressed across the signal indicating device herein shown by way of example as a telephone receiver.

Heating current for the filaments of the detecting tubes may be supplied from a single source or a separate battery for this purpose may be associated with each filament. In like manner plate current for the tubes may be provided from a single source or a separate battery may be associated with each tube output circuit as herein shown.

In either case, retard coils 10 and blocking condensers 11 should be inserted in the output circuits of the tubes to prevent short-circuiting of the source or sources of supply of plate current and the flow of direct current from said sources to the selective circuits associated with them. The blocking condensers are designed to permit the flow of the variable currents to said tuned circuits while preventing the flow of direct current thereto. In this, as well as in the following figures, a condenser 12′ may be used in shunt to the receiver 12 for the purpose of by-passing any high frequency current, that is, any current of carrier or like frequency which may be present in the receiver circuit.

Referring to Fig. 2, the antenna 13 and the circuit 14 inductively associated with it are tuned to the frequency of the incoming waves. Circuit 14 is connected across the input circuit of the amplifier 15 and the output circuit of the latter to the input circuit of a detector 16 whose output circuit includes the resonant circuit 17 tuned to the first even harmonic of the frequency of the signal waves. Inductively associated with this circuit 17 is a circuit 18 selective of the same frequency, which is adapted to impress the selected oscillations across the input circuit of the detector 19, whose output circuit is connected to the telephone receiver 21 by means of the transformer 20.

In Fig. 3, the antenna 22 is associated with a resonant circuit 23 tuned to the frequency of the incoming signal modulated waves. The high frequency current is amplified by a three-stage amplifying system including the amplifiers 24, 25 and 26 and detected by the detector 27 which includes in its output circuit the circuit 28 tuned to the first even harmonic frequency of the incoming waves. The latter circuit is inductively associated with the circuit 29 selective of the same frequency, whereby the se'ected oscillations are transmitted thereto and impressed across the input circuit of the amplifier 30. The variable current in the output circuit of the tube 30 is amplified by devices 31 and 32 and impressed across the input circuit of the de-

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tector 33, the output circuit of which includes the circuit 34 tuned to the first even harmonic of the current traversing its input circuit, i. e., the second even harmonic of the carrier frequency.

The current selected by the circuit 34 is transferred to the resonant circuit 35 tuned to the same frequency which is connected across the input circuit of the detector 36. After amplification by the amplifiers 37 and 38 this current is transmitted through the transformer or repeating coil 39 to the receiver 40.

In passing it is to be noted that the input circuit of each detector is provided with a leak-path 41 comprising a high resistance shunted by a condenser.

In the last two figures, no reference has been made to the sources of supply for the various thermionic devices or the retard coils and blocking condensers which are essential to their proper operation, but it is to be understood that these well-known features are employed in a manner which it is believed will be obvious from Fig. 3 in which they are shown. In this figure the condensers 42 are introduced to eliminate or suppress noises due to the operation of the supply source across which they are bridged, whether it be a battery or a direct current generator.

It may be stated that multiple detection is more selective than single detection and for large frequency differences between the current transmitted by the station whose waves it is desired to receive and the interfering station, a large number of stages of detection is more selective than a lesser number, or apparently than the heterodyne intermediate frequency method; but for a small frequency difference, which is usually desired, a large number of stages is less selective than a small number or apparently than the heterodyne intermediate frequency method.

The reason that for small frequency differences a large number of stages is less selective than a smaller number is that the amplitude of the signal current in the output of each stage varies as the square of the amplitude in the input of that stage, so that if A is the amplitude of the carrier frequency, for double detection the amplitude of the signal current will vary as A^4 and for triple detection as A^8. Thus, for a strong interfering transmitter the amplitude of the interfering current as compared with that of the signal current which it is desired to receive will be greater the greater the number of stages, for a given ratio of energy received from the interfering to that from the desired transmitter.

In the arrangement hereinbefore described several detectors are connected in cascade by means of the interconnecting selective circuits between them and the frequencies impressed upon the input circuits of the several detectors progressively increase from carrier frequency supplied to the first detector to the 1st, 2nd, 4th, 8th, etc., even power harmonic thereof supplied to the last of the series.

In another aspect, the detectors may be considered as relay devices which serve to initiate in their output circuits oscillations which are a harmonic frequency of that supplied to their input circuits.

In an arrangement of this kind the circuits may tend to "sing" or oscillate because of the harmonically tuned input and output circuits. This may be overcome by using short twisted leads, making the tuned circuits of small inductance and large capacity and using suitable choke coils in the plate circuits of the vacuum tube devices.

From the preceding description, it will be apparent that an arrangement has been devised employing multiple detection having a series of detectors connected by tuned circuits selective of a harmonic frequency of the preceding stage of detection and which is independent of the particular means employed to effect this condition.

It is therefore to be understood that this invention is not limited to the specific details herein shown and described but only by the scope of the attached claims.

What is claimed is:

1. A method of selective signal reception which comprises detecting incoming modulated signal waves selecting a harmonic frequency of said waves, detecting said waves of selected frequency and indicating the modulating waves.

2. A method of signal reception which involves multiple detection of modulated signal waves by selecting and detecting a progressively increasing harmonic frequency at each stage of detection and indicating the signal waves.

3. A method of selecting modulating current impressed upon a carrier of given frequency from an interfering signal current which modulates a carrier of different frequency, which comprises impressing both incoming waves upon a circuit selective of the desired frequency, controlling by means of the waves in said circuit an independent source of energy to initiate oscillations which are a harmonic of said selected frequency, selecting said harmonic frequency waves and controlling by means of the waves of harmonic frequency an independent source of energy to initiate oscillations which are a harmonic of the above-mentioned harmonic frequency.

4. A signal receiving system for a modulated carrier wave comprising a plurality of detectors and selective circuits interconnecting said detectors in cascade tuned to a harmonic of the frequency of the wave trav-

ersing the preceding interconnecting circuits and means to indicate the modulating current.

5. A radio receiving system for a modulated carrier current comprising means for selecting and impressing said carrier current upon the input circuit of a detector, means in the output circuit of said detector for selecting a harmonic of the carrier frequency, means for impressing said harmonic frequency on the input circuit of a second detector and means associated with the output circuit of said second detector to indicate the modulating current.

6. A radio receiving system comprising means to select a modulated carrier current and impress it upon the input circuit of the first of a plurality of detectors connected in cascade, means between each pair of detectors for selecting a harmonic frequency of the oscillations impressed across the input circuit of the preceding detector of the pair, means to impress said selected oscillations on the input circuit of the succeeding detector of said pair and means associated with the output circuit of the last detector of the series for indicating the modulating current.

7. A radio receiving system comprising means to select a modulated carrier current and impress it upon the input circuit of the first of a plurality of detectors connected in cascade, means between the detectors for selecting from the output circuit of the first and impressing upon the input circuit of the second detector a harmonic of the frequency of the current impressed upon the input circuit of the first detector and means associated with the second detector for indicating the signal current.

8. A selective radio system comprising a plurality of detectors, means connecting said detectors in cascade each adapted to select a progressively increasing harmonic of the incoming modulated waves and means connected to the last detector of the series for indicating the signal current.

9. A radio receiving system comprising a plurality of detectors connected in cascade, each having its output circuit selective of a harmonic frequency of the current supplied to its input circuit and signal indicating means associated with the last of said detectors.

10. A radio receiving system comprising a circuit selective of the incoming signal waves, a plurality of relay devices connected in cascade adapted to initiate oscillations of successively increasing harmonic frequencies in the circuits interconnecting them and a signal indicating means associated with the last relay.

11. A method of selective signal reception which comprises selectively receiving incoming carrier waves, and progressively increasing their frequency and selecting waves of increasing frequency in alternate steps.

12. A method of selective signal reception which comprises selectively receiving incoming carrier waves, increasing their frequency in steps and selecting waves of successively increased frequency.

13. A selective radio receiving system comprising means to selectively receive incoming carrier waves, means to increase progressively the frequency of said waves, and means to select waves of increased frequency alternating with said frequency increasing means.

14. A selective radio receiving system comprising means to selectively receive incoming waves, means to increase their frequency in steps having means to select waves of successively increasing frequency.

15. A selective radio receiving system comprising means to selectively receive incoming carrier waves, means to increase progressively the frequency of said waves including successive resonant circuits tuned to increased frequencies.

In witness whereof, I hereunto subscribe my name this 16th day of December, A. D., 1920.

HAROLD W. NICHOLS.