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MULTIPLEX SYSTEM

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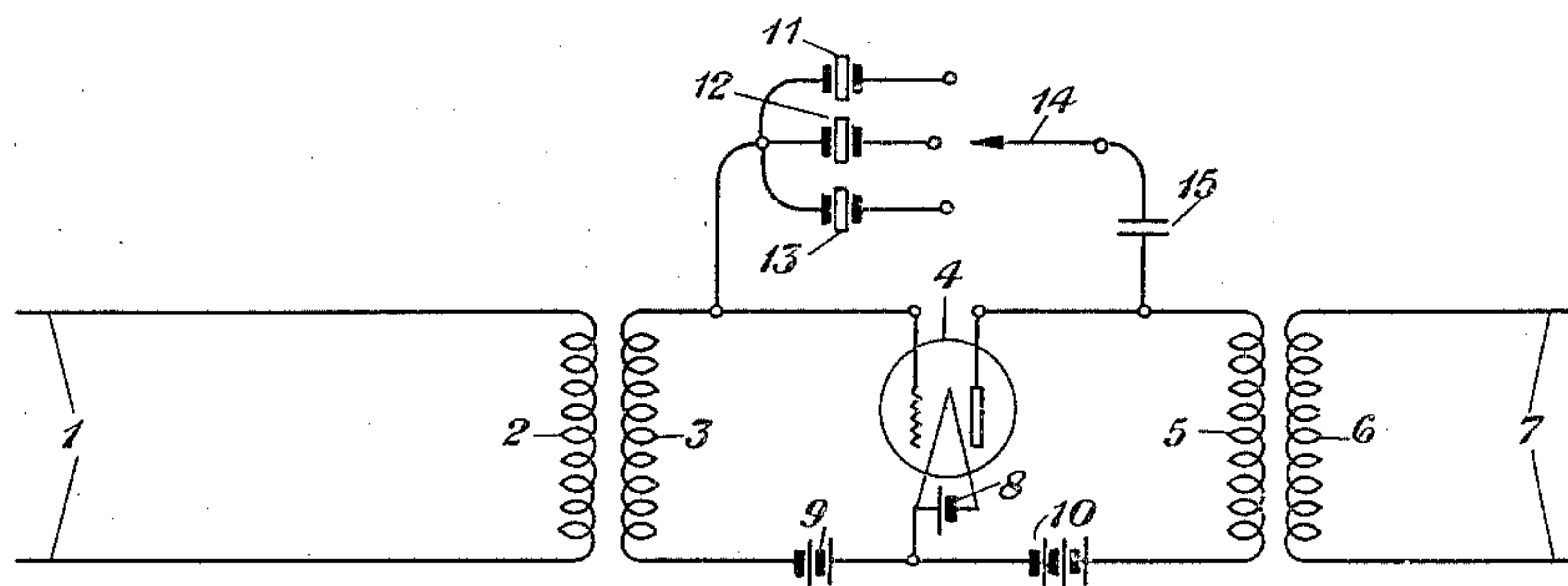


Fig. 1

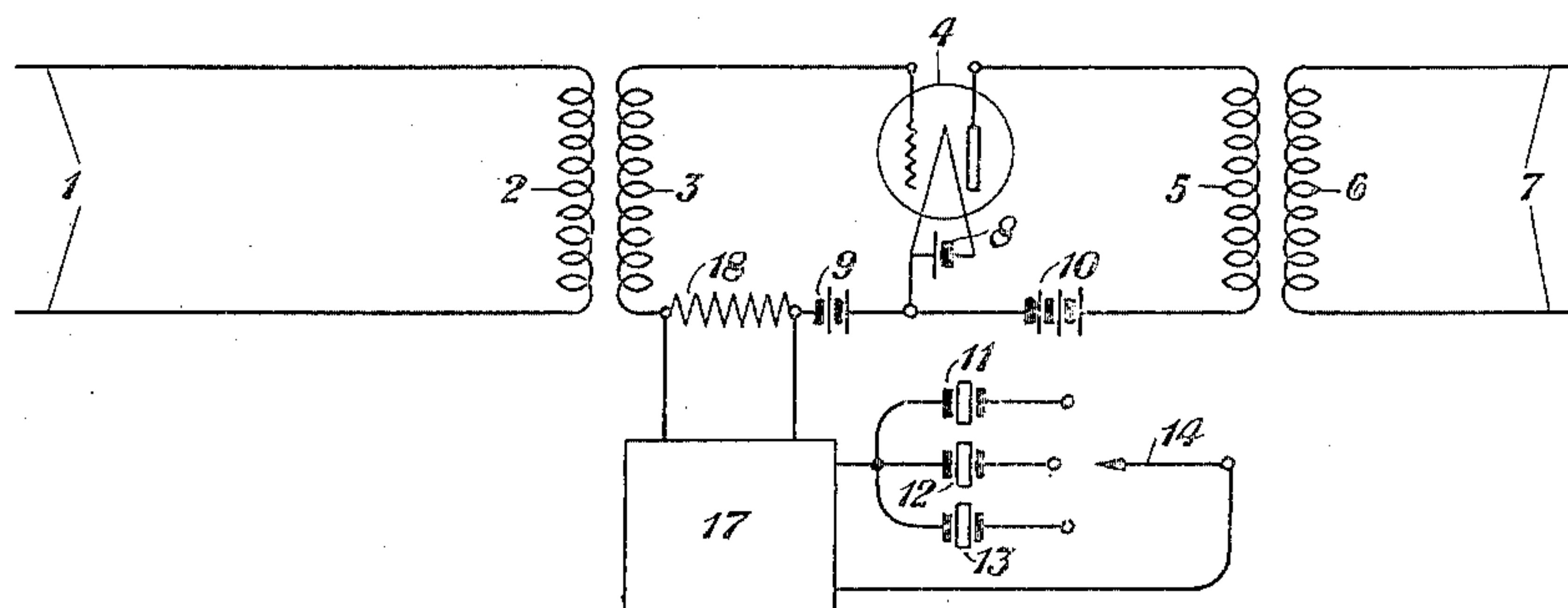


Fig. 2

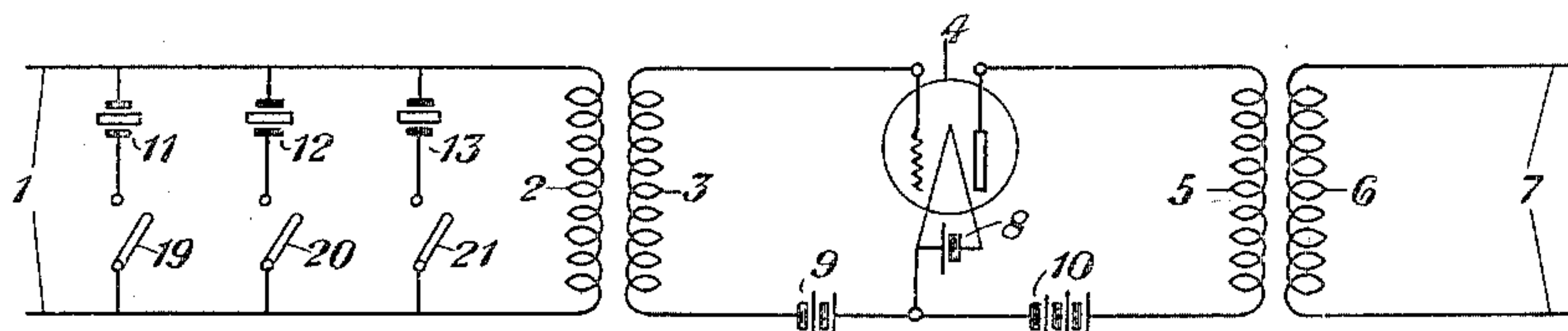


Fig. 3

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MULTIPLEX SYSTEM

Original application filed December 3, 1924, Serial No. 753,729. Divided and this application filed June 21, 1927. Serial No. 200,419.

This invention relates to multiplex systems, and more particularly, to multiplex systems employing piezo-electric crystals for selecting the channels of transmission.

5 This is a division of applicant's copending application, filed December 3, 1924, Serial Number 753,729.

Where multiplex transmission is attained by the use of carrier currents a plurality of
10 carrier frequencies are transmitted over a common transmission circuit, the carrier frequencies being separated sufficiently to prevent interference and each frequency being assigned for use as a separate channel of com-
15 munication so that signals may be transmitted by impressing them upon the carrier frequencies.

It has long been known that certain crystals have electric properties when under
20 mechanical stress, and these crystals are known as piezo-electric crystals. Those that are the most strongly piezo-electric are the crystals of quartz and Rochelle salts. A rod cut from such a crystal, having its sides con-
25 nected to a source of alternating current of the proper frequency, vibrates and reacts upon the alternating current circuit. It has also been discovered that these crystals may be made to act as transmitters (the direct
30 piezo-electric effect) as well as receivers (the converse effect).

Piezo-electric crystals have been developed which, when employed in connection with os-
35 cillators, act as frequency stabilizers, thereby rendering the oscillating circuit practically free from disturbing capacity effects, battery voltage variations, etc. One way in which this can be accomplished is by inserting a crystal serially in the plate circuit of
40 an oscillator. When the crystal is connected in this manner it offers very little resistance to a frequency which is a function of its physical dimensions, and a comparatively high impedance to other frequencies. There-
45 fore, when the electrical circuit is tuned to the natural frequency of the crystal, maximum energy is obtained from the oscillator, and when the frequency of the electrical circuit is not the same as the natural crystal fre-
50 quency, the frequency of the oscillator will

remain the same, being governed by the frequency of the crystal, but the output will be considerably reduced.

Crystals having piezo-electric properties also display characteristics which make them
55 useful as resonators, behaving very much like an electric circuit having series inductance, capacity and resistance. The impedance characteristic of the crystal is such that the resonance curve for the crystal is very much
60 sharper than a corresponding curve for an electrical circuit of the type that is widely in use at the present time.

One of the objects of this invention is to obtain the selection of a particular fre-
65 quency band in a multiplex system by transmitting the frequencies of all of the channels and then suppressing the undesired channels by means of resonators of the piezo-electric
70 type.

Another object of this invention is to provide a system in which a plurality of frequency channels may be employed in a small range of the frequency spectrum.

This invention, both as to its organization
75 and method of operation, as well as the further objects, features and advantages thereof, will be more fully understood by reference to the detailed description hereinafter following when read in connection with the accom-
80 panying drawing in which Figure 1 diagrammatically illustrates the use of piezo-electric crystals as frequency stabilizers; Fig. 2 illustrates a separate oscillator the frequency of which is controlled by crystals; and
85 Fig. 3 illustrates the use of crystals as absorbers in obtaining selectivity between a plurality of channels. The same parts are designated by the same reference characters wherever they occur throughout the several
90 views.

Referring to Fig. 1 of the drawing there is represented the incoming portion of a carrier suppression system upon which may be
95 superposed a plurality of channels of different frequency bands. In practice a number of programs are superposed upon the separate carrier frequencies in a manner well understood in the art. All of the programs be-
100 ing modulated upon separate carrier fre-

quencies may be transmitted simultaneously over line 1 as side bands of the modulated carrier frequencies. Line 1 is shown as terminating in inductance 2. Signals coming in over line 1 are impressed upon the inductance 2 and are also impressed upon inductance 3 in a manner well understood in the art. Batteries 8, 9 and 10 are filament, grid and plate batteries respectively. For the purpose of illustration it has been assumed that only three carrier channels, each representing a side band of the carrier frequency, are superposed upon the line 1. Each of the crystals 11, 12 and 13 has a natural vibration at the frequencies of the carriers of the separate channels. A capacity 15 is interposed serially in the circuit of the crystal in order to keep the plate potential off the grid of the tube. By moving the switch 14 to connect the crystal corresponding to the carrier frequency of the desired channel, there will thus be impressed on the input circuit of the oscillator-detector tube 4 two frequencies, one, the side band superposed on line 1, and two, the frequency corresponding to the crystal vibration. The two frequencies beat in the input circuit, and as a result thereof the original signaling frequency appears in the output circuit of the oscillator-detector tube 4, among other much higher frequencies. By means of the coupled inductances 5 and 6 the products of the beating reaction are impressed on line 7, which leads to a low frequency receiving set. However, to eliminate the high frequencies a low frequency filter may be interposed in the circuit connecting inductance 6 and the low frequency receiving set.

Fig. 2 represents a modification of Fig. 1 showing another arrangement in which the same results are obtainable in a carrier suppression system. In this figure there is a separate oscillator 17 and the frequency thereof is determined by the crystals 11, 12 or 13, depending upon which crystal is connected by switch 14. Thus in the input circuit of the oscillator-detector tube 4 there are found the side bands of line 1 and the carrier frequency of the particular program desired as determined by the crystal connected by switch 14. As these frequencies beat in the input circuit of the oscillator-detector tube 4 there appears in the output circuit the original signaling frequency and other much higher frequencies. Again, by using a low pass filter these high frequency components are attenuated and eliminated, and the low frequency or voice frequency currents are impressed on line 7 from which they are led to an appropriate receiving set.

Thus for both Figs. 1 and 2 above the incoming signals consist of the plurality of side bands, and the particular program desired is obtained by beating any one of these incoming side bands with the proper frequency locally supplied to the oscillator-detector tube.

It is important in the operation of such a system that the local oscillator be very constant in frequency and free from harmonics. These requirements are met by employing the crystal as a stabilizer. Another advantage which is particularly noteworthy is that there is no tuning necessary for the operation of crystals.

In Fig. 3 there is illustrated the means for employing crystals to suppress all undesired channels. The crystals are arranged for suppressing programs impressed on line 1 which are present in the form of a carrier and a side band. Thus one crystal is provided at the receiving end corresponding to each channel impressed on line 1, and adapted so as to be bridged across the line 1 by means of switches 19, 20 and 21 in any desired combination. The three programs, as assumed merely for the purpose of illustration, modulated individually upon three different carrier frequencies, have bridged circuits each including the crystals 11, 12 and 13, tuned to the carrier frequencies transmitted. By closing switches 19 and 21 line 1 will be short-circuited at the frequencies corresponding to crystals 11 and 13, and the frequency corresponding to crystal 12 will be transmitted to the input circuit of the demodulator 4 without distortion. Similarly by closing switches 20 and 21 the frequency corresponding to crystal 11 will be transmitted to the input circuit of the demodulator 4, and the frequencies corresponding to the crystals 12 and 13 will be effectively suppressed, and by closing switches 19 and 20 the frequency of crystal 13 will be transmitted and the frequencies of 11 and 12 will be effectively suppressed.

It is to be noted that by bridging a crystal across line 1 as above described the frequency of that carrier to which the crystal corresponds will be greatly attenuated. The attenuation resulting from bridging each of the crystals across line 1 is sufficient to effectively suppress the carrier frequency corresponding to the crystal thus interposed. By this arrangement all frequencies near the crystal frequency are attenuated very distinctly while frequencies further away from the crystal frequency are practically unaffected thereby. However, Fig. 3, the illustration under discussion, represents a carrier transmission system of the type well understood in the art. In such a system, although one side band corresponding to the original voice current is also transmitted along with the carrier, yet by bridging across line 1 the crystal having the frequency of the carrier, the carrier frequency will be suppressed to a very marked degree, but the side band will not be effected to any great extent. Nevertheless, the side band will be ineffective unless it beats with the carrier frequency upon which it is modulated. It may therefore be concluded that by

suppressing the carrier frequency the side band will remain ineffective, and the program corresponding to the frequency will be nullified to all intents and purposes. And if two of the carrier frequencies are suppressed by bridging the corresponding crystals across the transmission line, the third carrier frequency will be transmitted to the demodulator 4 along with its side band and there properly demodulated, while the side bands of the suppressed carriers will remain ineffective.

It is possible, with the arrangements of this invention, to use many more channels in a given frequency range than in former arrangements of multiplex systems using tuned electrical circuits, because of the fact that crystals are much more selective than the corresponding tuned electrical circuits. And the method of selection herein described may be applied to all kinds of circuits employing carrier currents, although it is particularly applicable to systems for music distribution over line wires to a plurality of subscribers.

It will be obvious that while the invention has been illustrated in certain particular arrangements, it is capable of embodiment in many and widely different arrangements without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In a program transmission system, a line upon which a plurality of different carrier frequency combinations may be impressed, each carrier frequency combination including a carrier wave and a band of signals superimposed thereon, a three-element vacuum tube the input circuit of which is coupled to said line, and a plurality of piezo-electric crystals shunting said line and vibrating at natural periods corresponding to the carrier waves of undesired carrier frequency combinations, each piezo-electric crystal being in mechanical vibration for the carrier wave of each undesired carrier frequency combination and suppressing the effect of said carrier wave, said piezo-electric crystals being mutually independent in their mechanical vibrations and non-reactive, desired frequency combinations and the bands of signals of undesired carrier frequency combinations being impressed on the input circuit of said vacuum tube, said vacuum tube demodulating the desired carrier frequency combinations so that the products of demodulation may appear in the output circuit of said vacuum tube, the bands of signals of undesired carrier frequency combinations being rendered ineffective.

2. In a multiplex program transmission system, a line upon which are impressed a plurality of different modulated carrier frequency combinations, each carrier frequency combination including a carrier wave and a band of signals superimposed thereon, selecting means consisting of independent and

mutually non-reactive piezo-electric devices associated with said line to suppress the carrier waves of undesired modulated carrier frequency combinations and to pass freely the carrier waves of desired modulated carrier frequency combinations, a demodulator for demodulating the desired carrier frequency combinations, the bands of signals of undesired carrier frequency combinations being impressed upon said demodulator and being rendered ineffective thereby, and means associated with said demodulator for observing the desired signals.

3. In a multiplex program transmission system in which a plurality of carrier current frequencies are each modulated by signals and impressed on a transmission circuit, selective means consisting of a plurality of piezo-electric devices associated with the said transmission circuit to suppress the carrier current frequencies of undesired carrier current combinations and to transmit freely all components of desired carrier current combinations and the signals previously modulated on the carrier current frequencies of undesired carrier frequency combinations, each piezo-electric device suppressing the carrier current frequency of each undesired carrier frequency combination so that the signals modulated thereon may be rendered ineffective and unsuitable for demodulation, and a demodulator in which only the desired carrier current combinations are dissociated to reproduce the original signals.

4. In a program transmission system, a circuit upon which are impressed a plurality of closely spaced carrier currents each of which is modulated by signals, a selective arrangement associated with said transmission circuit to transmit only one of the carrier components of said modulated carrier currents to the exclusion of the others, said selective arrangement consisting of a plurality of mutually independent and non-reactive mechanical or crystal resonators which vibrate at frequencies corresponding to the carrier frequencies of the signals impressed upon said transmission circuit, and a demodulator upon which are impressed the signals corresponding to the various carrier currents untransmitted by said selective arrangement and in which the desired carrier current and the signals modulated thereon are demodulated to reproduce only the desired signals.

5. In a program transmission system in which a plurality of carrier currents are each modulated by signals and impressed on a transmission circuit, a selecting arrangement to suppress the carrier components of the undesired modulated carrier currents to the exclusion of the others, said selecting arrangement consisting of a plurality of piezo-electric resonators which are independent and mutually non-reactive each of which vibrates at a frequency corresponding to a carrier

component impressed upon the transmission circuit, means associated with said selecting arrangement to connect in parallel relationship across the transmission circuit piezo-electric resonators corresponding to the signals which are to be suppressed, and a vacuum tube device for demodulating the desired carrier current signal, to thus reproduce the desired signals.

6. In a program transmission system, a transmission circuit in which a plurality of channels of communication are transmitted, each channel consisting of a carrier frequency and one side band, selecting means associated with said transmission circuit to suppress the carrier frequencies of all undesired communication channels to the exclusion of the others, said selecting means comprising a plurality of piezo-electric devices each of which mechanically vibrates independently at a frequency corresponding to a carrier frequency of a communication channel, means to connect said piezo-electric devices corresponding to the communication channels to be suppressed in parallel arrangement in said transmission circuit, and means consisting of a demodulator to dissociate the desired communication channel in order to reproduce the original signals of said desired communication channel.

7. In a signaling system for program transmission in which a plurality of channels of communication are transmitted and impressed upon a transmission circuit, each of said channels having a carrier frequency and one side band as a result of modulation, a selecting arrangement associated with said transmission circuit consisting of a plurality of independent and mutually non-reactive piezo-electric resonators arranged to suppress the carrier frequencies of all undesired channels and to transmit freely all components of desired channels, each piezo-electric resonator suppressing the carrier frequency of one of said undesired channels and not affecting its side band, and means consisting of a three-element vacuum tube device for demodulating a desired channel, in order to separate desired signals from the carrier frequency of the channel, the side bands of undesired channels being rendered substantially ineffective.

8. In a signaling system for program transmission in which a plurality of carrier frequencies are each modulated by signals and impressed upon a transmission circuit, means for selecting certain carrier frequencies to the exclusion of the others, said selecting means comprising a plurality of piezo-electric resonators which are in independent mechanical vibration and mutually non-reactive, each piezo-electric resonator vibrating at the frequency of the carrier of a particular modulated carrier current, and means for connecting said piezo-electric resonators

in parallel relationship across the transmission circuit to suppress the carrier frequencies of the various undesired carrier current combinations, the signals previously modulated upon each carrier wave being unaffected and freely transmitted.

9. In a signaling system for program transmission in which a plurality of carrier frequencies are each modulated by signals and impressed upon a transmission circuit, means for selecting certain carrier frequencies to the exclusion of the others, said selecting means comprising a plurality of piezo-electric resonators which are in mechanical vibration and are mutually independent and non-reactive, each piezo-electric resonator vibrating at the frequency of the carrier of a modulated carrier current, means for connecting said piezo-electric resonators in parallel relationship across the transmission circuit to suppress all but one of the carrier frequencies of the various carrier current combinations, the signals previously modulated on each suppressed carrier frequency being freely transmitted, and means consisting of a demodulator associated with said transmission circuit for demodulating the signals corresponding to the side bands of the unsuppressed carrier to obtain the desired signals originally modulated thereon.

10. In a signaling system for program transmission, a pair of intercommunicating stations, a plurality of signaling channels at one station, a plurality of corresponding receiving channels at the other station, a demodulator at said second mentioned station, means whereby carrier currents modulated in accordance with signals are transmitted from each of said first mentioned channels to each of said second mentioned channels and applied to the demodulator thereat, and selective means consisting of a plurality of piezo-electric devices whereby only the carrier currents of undesired modulated carrier currents will be suppressed, the demodulator separating the signals from the unsuppressed carrier current upon which they are modulated.

11. A signaling system including a circuit for transmitting a plurality of carrier frequencies each modulated by a band of signals, means for suppressing all of the carrier frequencies but one, a circuit upon which are impressed the unsuppressed carrier frequency and the band of signals modulated thereon as well as the bands of signals corresponding to the suppressed carrier frequencies, and means to derive the signals modulated on the unsuppressed carrier frequency.

12. A signaling system comprising a circuit for transmitting a plurality of carrier waves each modulated by a band of signals, means for suppressing all of the carrier waves but one without affecting any of the bands of

signals modulated on said carrier waves, and a detector for deriving the signals modulated on the unsuppressed carrier wave.

13. A signaling system comprising means for transmitting a plurality of carrier frequencies each modulated by bands of signals, means for suppressing all of the carrier frequencies but one without affecting the bands of signals modulated on any of said carrier frequencies, and means to beat the unsuppressed carrier frequency and all of the bands of signals in order to derive the signals corresponding to the unsuppressed carrier frequency.

14. A signaling system comprising means for transmitting a plurality of carrier waves each modulated by a band of signals, means for suppressing all of the carrier waves but one while freely transmitting the bands of signals previously modulated on all of said suppressed carrier waves, and a demodulator to which are transmitted the unsuppressed carrier wave and the bands of signals previously modulated on all of the carrier waves, said demodulator deriving the original signals corresponding to the unsuppressed carrier wave, said demodulator rendering the remaining bands of signals substantially ineffective

15. The combination of a vacuum tube system coupled to a transmission circuit transmitting a carrier frequency and a side band corresponding to signals, and a piezo-electric device the natural period of vibration of which coincides with the oscillations of carrier frequency, said piezo-electric device suppressing the oscillations of carrier frequency.

16. The combination of a circuit transmitting a band of signals and current of a particular frequency which is not desired, and a piezo-electric device connected in shunt across said circuit, said device having a natural period of vibration which coincides with the particular undesired frequency.

17. The combination of a circuit transmitting current representing a band of signals and current of a particular frequency, and a shunt-connected piezo-electric device having a frequency of vibration substantially the same as the particular frequency of the latter current, said piezo-electric device by-passing said latter current and exhibiting high attenuation to the former current representing said band of signals.

18. An electrical filtering arrangement for discriminating against a plurality of different frequencies transmitted between an input circuit and an output circuit, comprising a plurality of piezo-electric crystals of different frequency characteristics connected in parallel relationship.

19. A filtering system for discriminating between currents of particular frequencies and all other currents, comprising a plurality of piezo-electric crystals of vibratory fre-

quencies corresponding to the particular frequencies to be discriminated against.

20. A filtering arrangement for separating a plurality of carrier frequencies from the corresponding bands of signals transmitted therewith, comprising a plurality of parallel connected piezo-electric crystals of vibratory frequencies corresponding respectively to the various carrier frequencies.

21. A transmission circuit transmitting a plurality of carrier waves and a plurality of side bands of signals corresponding to the various carrier waves, including a filtering arrangement for discriminating against the carrier waves, said arrangement consisting of a plurality of piezo-electric crystals of different vibratory frequencies, said vibratory frequencies respectively equaling the frequencies of said carrier waves.

In testimony whereof, I have signed my name to this specification this 17th day of June, 1927.

CHARLES H. FETTER.