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C. H. FETTER

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MULTIPLEX SYSTEM

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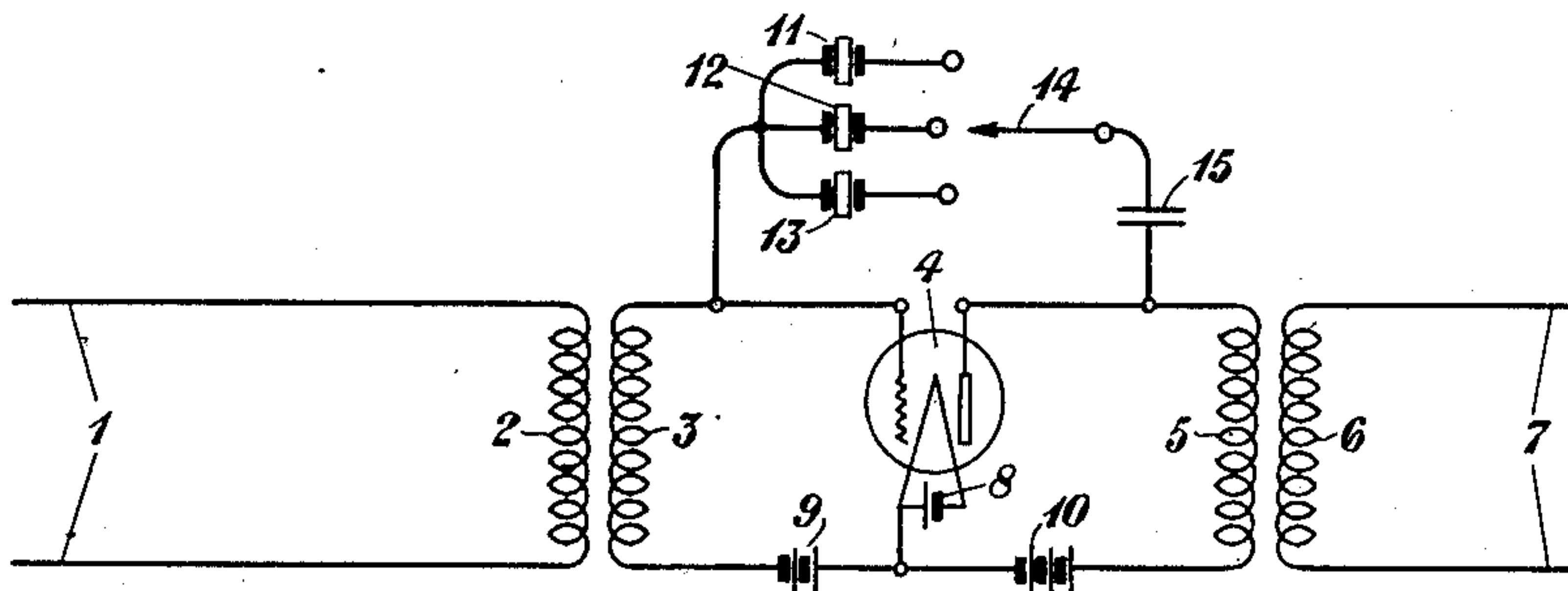


Fig. 1

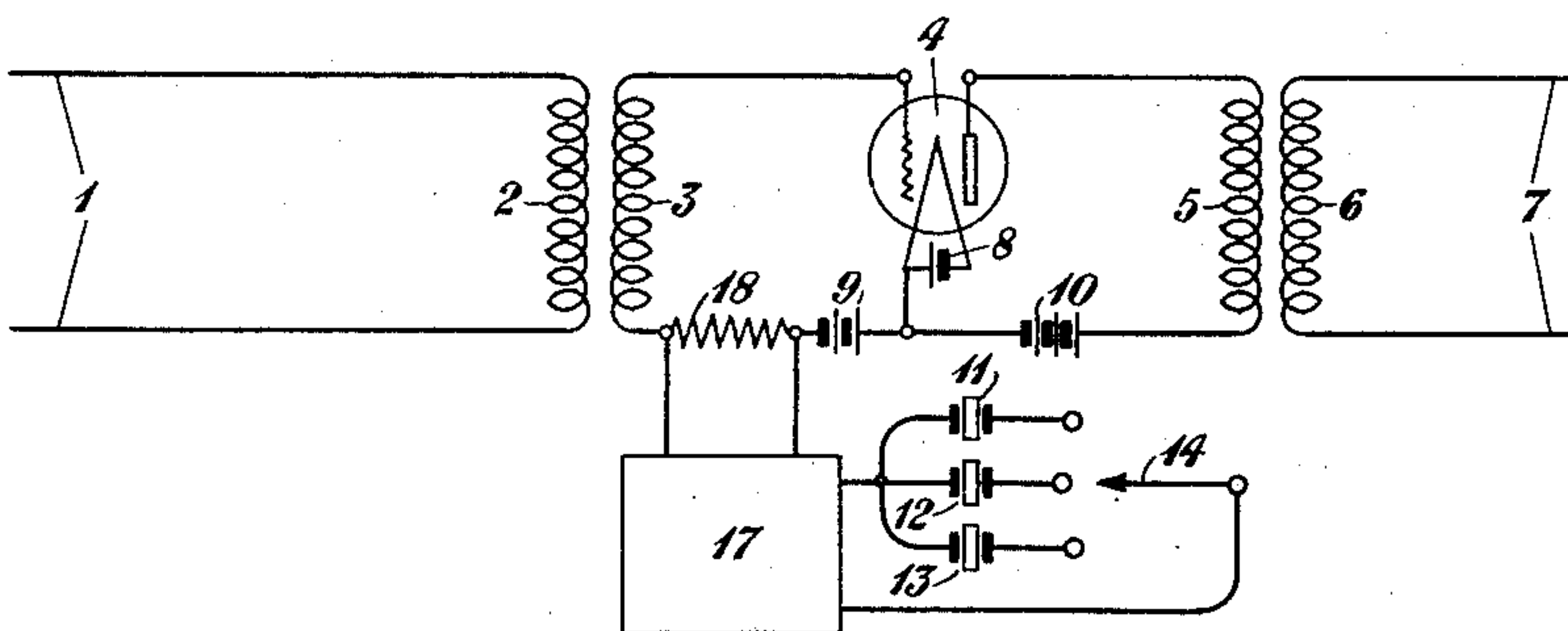


Fig. 2

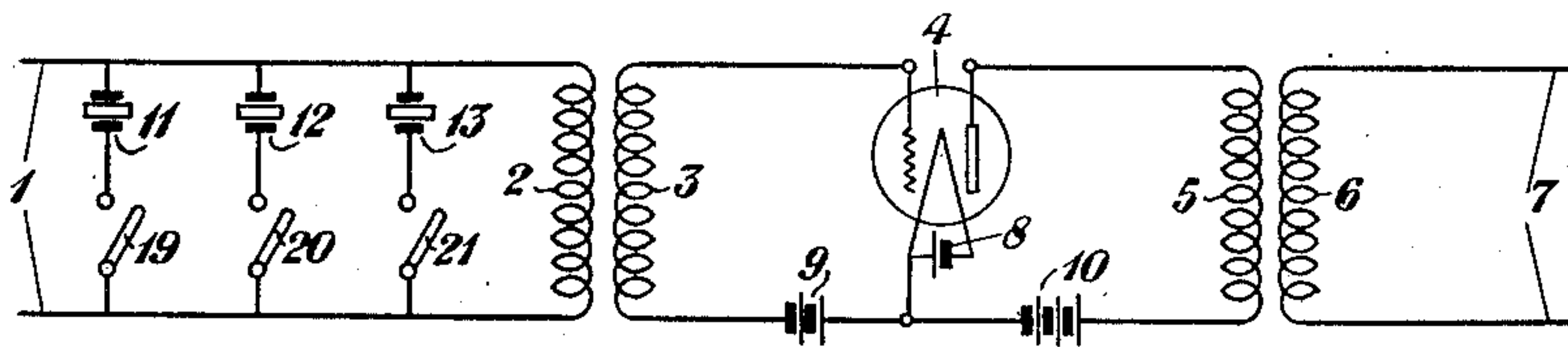


Fig. 3

INVENTOR
C. H. Fetter
BY *g v 4*
ATTORNEY

UNITED STATES PATENT OFFICE

CHARLES H. FETTER, OF MILLBURN, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

MULTIPLEX SYSTEM

Application filed December 3, 1924. Serial No. 753,729.

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

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

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

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

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

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

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

This invention, both as to its organization 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
75 following when read in connection with the accompanying drawings in which Figure 1 diagrammatically illustrates the use of piezo-electric crystals as frequency stabilizers; Fig. 2 illustrates a separate oscillator the
80 frequency of which is controlled by crystals; and 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
85 wherever they occur throughout the several views.

Referring to Fig. 1 of the drawings there is represented the incoming portion of a carrier suppression system upon which may be
90 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-
95 ing modulated upon separate carrier frequencies may be transmitted simultaneously over line 1 as side bands of the modulated carrier frequencies. Line 1 is shown as terminating
100 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 em-

ploying 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 pur-

poses. 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. The combination of an oscillator, a plurality of piezo-electric crystals having different vibratory frequencies, each piezo-electric crystal being capable of acting as a mechanical coupling element for said oscillator, a plurality of conductive plates two of which are placed on opposite sides of each piezo-electric crystal, a conductor connected between said oscillator and all of the conductive plates on one side of the various piezo-electric crystals, and a switch for connecting the conductive plate on the other side of any one of the various crystals to said oscillator, whereby there will be produced only current having the vibratory frequency of the selected crystal acting as a coupling element.

2. The combination of a vacuum tube having plate filament and grid electrodes, a plurality of piezo-electric crystals having different vibratory frequencies, and means for selectively connecting any one of said crystals between the grid and plate electrodes of said vacuum tube, the selected crystal being the essential coupling element for the vacuum tube so that oscillations of the frequency characteristic of the selected crystal will be sustained.

3. In an electrical oscillatory system, the combination of an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a plurality of piezo-electric crystals each having selected constant frequency oscillatory characteristics, and a switch for selectively connecting any one of said piezo-electric crystals between said input and output circuits for controlling

the generation of oscillations in accordance with the frequency of the selected piezo-electric crystal, the selected piezo-electric crystal being the only coupling device between said input and output circuits without which oscillations cannot be generated.

4. In an electrical oscillatory system, the combination of a vacuum tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a plurality of coupling elements of piezo-electric character all of which have different constant frequency oscillatory characteristics, and means for bridging any selected coupling element between said input and output circuits to form the sole coupling element between said circuits, in order that only oscillations of the frequency characteristic of the selected element may be sustained.

In testimony whereof, I have signed my name to this specification this 1st day of December, 1924.

CHARLES H. FETTER.

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