PATENT SPECIFICATION

(11) 1 599 616

1 599 616

(21) Application No. 21292/78 (22) Filed 23 May 1978
(31) Convention Application No. 52/063710
(32) Filed 31 May 1977 in
(33) Japan (JP)
(44) Complete Specification published 7 Oct. 1981
(51) INT CL³ H04B 7/15
(52) Index at acceptance
H4L RSF

(19)

(54) A DEMODULATING SYSTEM FOR AN AUXILIARY CHANNEL IN A STRAIGHT-THROUGH RADIO FREQUENCY REPEATER

(71) We, FUJITSU LIMITED, a Company organized and existing under the laws of Japan of 1015, Kamikodanaka, Nakahara-ku, Kawasaki, Japan, do hereby declare the invention for which we pray that a Patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:

The present invention relates to a demodulating method for auxiliary channel signals in a straight through radio frequency repeater with a plurality of channels each of said channel including an auxiliary channel, and to a radio frequency repeater for use in such a method.

With the progress in microwave semiconductor technology, a type of multichannel microwave radio frequency repeater having a simple construction has come into practical use. This repeater receives frequency-modulated radio-frequency signals in the microwave frequency band and either transmitts the signals thus received after direct amplification thereof without converting them into intermediate frequencies, or transmits the received signals after slightly shifting the frequencies thereof to prevent any interference due to coupling of antennas.

In the above-mentioned type of microwave radio frequency repeater, almost all of its transmission characteristics depend upon the characteristics of the amplifier provided therein. At the present time good characteristics are available with this type of microwave radio frequency repeater by virtue of the microwave semiconductors used therein. However, a repeater station equipped with this type of microwave repeater still has a problem in respect of demodulating the signals of auxiliary channels. Usually the repeater station is not attended by any operator but is periodically visited by maintenance personnel for inspection. This situation necessitates the provision of an auxiliary channel in the microwave repeater, for use in emergencies, such as trouble with or an accident at the unattended repeater station, to give an alarm to the terminal station, to allow control of the repeater station by the terminal station or to permit maintenance personnel to communicate with the terminal station for necessary arrangements, etc. Such an auxiliary channel can find effective use in a conventional type, i.e., non-straight-through type, of repeater station since, in such a station, received signals can be demodulated by a demodulating circuit after their conversion into intermediate frequencies. However, in the case of a microwave radio frequency repeater using the straight-through system, the repeater is no longer one of a simple construction if equipped with an independent microwave local oscillator for conversion of the picked-up signals into intermediate frequencies. Furthermore, no satisfactory high-sensitivity microwave frequency discriminator is currently available, although such a discriminator is necessary for demodulating an auxiliary channel signal through direct FM detection of the microwave signal. Thus, with today's art an auxiliary channel is difficult to employ in a repeater station equipped with a microwave repeater using the straight-through system.

It is an object of the present invention to provide a demodulating method for auxiliary channels in a radio frequency repeater using the straight-through system, and a radio frequency repeater employing such a method which is capable of easily obtaining demodulated signals from the auxiliary channels without losing the feature of simple construction possessed by such a straight-through microwave radio frequency repeater.

According to the present invention there is provided a method for demodulating auxiliary channel signals in a straight-through radio frequency repeater which relays microwave signals frequency modulated by baseband signals comprised of main communication channel signals and auxiliary channel signals, the main communication channel signals and the auxiliary channel signals having different frequency bands, which comprise receiving at least two of said microwave signals, branching the or two of said microwave signals thus received, producing a difference frequency signal from the branched microwave signals and demodulating the difference frequency signal to regenerate said auxiliary channel signals.

According to a further aspect of the present invention there is provided a straight-through radio frequency repeater which relays microwave signals frequency modulated by baseband signals comprised of main communication channel signals and auxiliary channel signals, the main communication channel signals and the auxiliary channel signals having different frequency bands, comprising means for receiving at least two of said microwave signals, means for branching the or two of the microwave signals received, means for producing a difference frequency signal from the branched microwave signals, and means for demodulating the difference frequency signal to regenerate said auxiliary channel signals.

Embodiments of the present invention will now be described, by way of example with reference to the accompanying drawings, in which:

Fig.1 is a block diagram of a conventional microwave radio frequency repeater using the straight through system provided in a repeater station;

Fig. 2 illustrates a frequency arrangement of the baseband signal and the carrier wave used in the repeater shown in Fig. 1;

Fig. 3 is a block diagram illustrating the structure of a first embodiment of the present invention;

Fig. 4 is a frequency arrangement of a baseband signal and the carrier wave used in the demodulating device of Fig. 3;

Fig. 5 is a block diagram illustrating the structure of a second embodiment of the present invention;

Fig. 6 is a block diagram illustrating the structure of a third embodiment of the present invention;

Fig. 7 is a block diagram illustrating the structure of a fourth embodiment of the present invention;

Fig. 8 is a block diagram illustrating the structure of a fifth embodiment of the present invention, and;

Fig. 9 is one example of the circuit diagram of the mixer and the demodulator used in the device according to the present invention.

Referring to Fig. 1, there is illustrated a block diagram of a conventional microwave radio frequency repeater in which a frequency-modulated microwave signal having a frequency F_1 (transmitted in an upline direction) is received by an antenna 1*a*, then directed by circulator 2*a* and amplified by an amplifier 3*a*. The amplifier 3*a*, as well as another amplifier 3*b*, may be provided with filter means for eliminating spurious radiation and/or with an AGC circuit and limiting circuit, if required. The signal thus amplified by amplifier 3*a* is applied to another circulator 2*b* to be transmitted through an antenna 1*b*. A microwave signal having a frequency F_2 (transmitted in a downline direction) is received by the antenna 1*b*, subjected to the circulator 2*b*, amplified by the amplifier 3*b* and transmitted by the antenna 1*a* after passing through the circulator 2*a*. This conventional type of repeater has almost all of its transmission characteristics dependent upon the characteristics of the amplifiers 3*a* and 3*b*, which nowadays are good owing to the use of microwave semiconductors of high quality as aforementioned. However, as noted hereinbefore, the repeater station in which the repeater is installed is unattended and must be periodically visited by maintenance personnel for inspection. Therefore, an auxiliary channel has to be provided at the expense of simplicity of construction in the repeater for use in an emergency, such as trouble with or an accident at the unattended repeater station, to give an alarm to the terminal station, to allow control of the repeater station by the terminal station, or to permit maintenance personnel to communicate with the terminal station for necessary arrangements, etc.

Referring to Fig. 2 illustrating the frequency arrangement of the repeater of Fig. 1, Fig. 2(a) illustrates the frequency arrangement of the baseband signal transmitted in the downline direction. It should be noted that 960 channels of main communication channel signals (designated C) are arranged in the range of from 60 KHz to 4 MHz, and two channels of signals respectiviely of from 0.3 to 4 KHz and from 4 to 8 KHz (designated A and B, respectively) are provided in the lower part of the baseband for the auxiliary channel. Illustrated in Fig. 2(b) are baseband signals transmitted in the upline direction. More specifically, two channels of signals, of respectively from 0.3 to 4 KHz and from 8 to 12 KHz (designated D and E, respectively), are provided for the auxiliary channel, and main communication channel signals are provided in the range of from 60 KHz to 4 MHz (designated F). These baseband signals in the upline and the downline directions are subjected to frequency modulation by means of microwave carriers of the 6 GHZ band (Frequencies F_1 and F_2), and separated from each other by 340 MHz, for use as transmitted-received waves for communication between terminal stations via repeater stations. Usually, terminal stations convert the received waves into intermediate frequencies and employ demodulating circuits, so that the auxiliary channel as aforementioned can be effectively utilized. However, in a repeater station employing a straight-through microwave radio frequency repeater, provision of an independent microwave local oscillator in the repeater for conversion of received waves into intermediate frequencies would deprive the repeater of its feature of simplicity of construction. In addition, no satisfactory high-sensitivity microwave frequency discriminator has yet been proposed, and such discriminators are required for demodulation of auxiliary channel signals through direct FM detection of microwaves.

Referring to Fig. 3, there is shown a block diagram of a first embodiment of the present invention, in which: reference numerals 1*a*, 1*b* through 3*a*, 3*b* represent similar parts to those in Fig. 1; 4*a*, 4*b* denote branching directional couplers for extracting part of the signals transmitted through the up and down circuits; 5 represents a mixer for obtaining a difference frequency $F_1—F_2$ between the signals; 6 designates a demodulator, and; 7 denotes an output terminal for demodulated signals of the auxiliary channel. The demodulator 6 is comprised of a filter 6*a* for removing frequencies other than the difference frequency component $F_1—F_2$, an amplifier 6*b*, a frequency discriminator 6*c*, and a filter 6*d* for picking out signals for the auxiliary channel band.

Signals having frequencies F_1 and F_2, extracted by the directional couplers 4*a*, 4*b*, are mixed together by the mixer 5 to produce a frequency of the sum of F_1 and F_2 and a frequency of the difference between F_1 and F_2, respectively. Of these produced frequencies, the difference frequency $F_1—F_2$, which corresponds to an intermediate frequency, is picked out by the filter 6*a* of the demodulator 6, and is then demodulated by the frequency discriminator 6*c* which can be a conventional type. More specifically, in the frequency arrangement shown in Fig. 4, F_1 and F_2 are microwave signal carriers of the 6 GHz band (transmitted-received signals) illustrated in Fig. 2(c). If the difference between F_1 and F_2 is 340 MHz, the signal $F_1—F_2$ shown in Fig. 4(a) is a modulated signal with a frequency of 340 MHz as its own carrier. Therefore, the modulated signals can be demodulated by the demodulator 6 into demodulated signals as illustrated in Fig. 4(b). The signals in the range of from 60 KHz to 4 MHz, shown in Fig. 4(b), correspond to the sum of signals C and F of Figs. 2(a) and (b), and the signals in the range of from 0.3 KHz to 12 KHz correspond to signals A+D, B and E. Since these signals can be obtained separately through frequency separation filters, both of the signals in the upline and downline can be demodulated together at one time. Furthermore, the signal A+D is intended for use in an order wire channel of a so-called omnibus system, which is used when communication need not be carried out between particular repeater stations or between a particular terminal station and a particular repeater station. Also in this system, the order wire signals in both the upline and the downline can be demodulated together.

Still further, since an ordinary telecommunication system is provided with a spare channel intended for temporary use in the event of the occurrence of trouble with the system, even if a channel of either the upline or the downline becomes out of order, the demodulation operation is not interrupted immediately.

Fig. 5 is a block diagram illustrating a second embodiment of the invention. In this embodiment, in order to avoid the occurrence of interference due to coupling between the received frequencies and the transmitted frequencies, the received frequencies and the transmitted frequencies are frequency shifted so as to have a given difference, e.g., 340 MHz as in the preceding embodiment (two-freqency system). Reference numerals 1*a*, 1*b* through 7 denote similar elements or parts to those in Fig. 3. Reference numerals 8*a*, 8*b* are frequency shifting oscillators, and 9*a*, 9*b* frequency shifting mixers. These mixers may preferably be provided with a band pass filter function for removal of image frequencies. Frequency F_1 received by antenna 1*a* has its frequency shifted to frequency F_2 by means of the frequency shifting mixer 9*a*, and is applied to the mixer 5 after being extracted by the branching directional coupler 4*a*. Frequency F_1 received by antenna 1*b* is amplified by the amplifier 3*b*, extracted by the directional coupler 4*b*, and then applied to the mixer 5. Thus, a signal $F_1—F_2$ is available at the output terminal of the mixer 5, so that the signal $F_1—F_2$ can be demodulated by the demodulator 6 as in Fig. 2.

Fig. 6 is a block diagram illustrating a third embodiment of the present invention. In this embodiment, all the received and transmitted frequencies in the upline and the downline have different frequencies from one another (four-frequency system). This embodiment prevents the occurrence of interference due to the coupling of the antennas. In Fig. 6 identical reference numerals to those in Fig. 5 designate identical parts or elements to those in Fig. 5. In Fig. 6, frequency F_1 received through the antenna 1*a* has its frequency converted to frequency F_2 by means of the frequency shifting mixer 9*a* for transmission. The frequency F_2 is extracted by the branching directional coupler 4*a* and applied to the mixer 5. The frequency F_2, received through the antenna 1*b*, has its frequency shifted to frequency F_4 for transmission, is, then extracted by the branching directional coupler 4*b* and, then, applied to the mixer 5. Thus, the mixer 5 produces an output signal having a frequency F_2—F_4 which can then be demodulated by the demodulator 6. Said branching directional couplers 4*a*, 4*b* may be located at the input sides of the respective frequency shifting mixers 9*a*, 9*b*, or at both of the input and output sides thereof. That is, branching and mixing may be performed at any place where the frequencies and signal strengths obtainable are easy to handle as intermediate frequencies by the demodulators and other devices. Since the characteristic feature of the present invention resides in the demodulation of the received auxillary channel signal the above-description is directed to a case where modulated auxiliary channel signals from the terminal stations are demodulated. To effect modulation of signals of the auxiliary channel in a microwave repeater using the straight-throught system, a frequency shifting oscillator with a frequency shifting mixer may be provided with a modulating function, if such a frequency shifting oscillator is provided in the repeater, or a microwave phase modulator may be used, if such a frequency mixer is not provided, to easily obtain modulated signals in either case.

Referring now to Fig. 7 a fourth embodiment of the present invention is illustrated. Multiplexed signals F_1, F_2, are received from two routes by a receiving antenna 11*a*, and are applied to a circulator 12*a* on the input end of the repeater. The circulator 12*a* delivers the received input signals F_1, F_2 to a band pass filter 13*a*. The band pass filter 13*a* allows only the signal F_1 to pass therethrough, while the input impedence of the filter takes a value of zero or infinity with respect to the other signal with frequency, F_2.

The received signal F_1 thus passes through the band pass filter 13*a*, is amplified up to a necessary level by an amplifier 14*a*, and is applied to a band pass filter 16*a*. The band pass filter 16*a* allows only the signals F_1 to pass therethrough, and the signal F_1, thus having passed through the filter, is then impressed into a circulator 12*b* on the output end. The circulator 12*b* transfers the input signal F_1 to a transmitting antenna 11*b*. Thus, the received signal F_1 is amplified and again transmitted under the straight-through system.

On the other hand, the received signal F_2 is reflected at the inlet of the band pass filter 13*a* to be returned to the circulator 12*a* and passes through the same into another band pass filter 13*b*. The band pass filter 13*b* allows only the signal F_2 to pass therethrough, so that the signal F_2 is applied to the amplifier 14*b*, which in turn amplifies the same signal up to a necessary level and feeds the amplified signal to the band pass filter 16*b*.

The band pass filter 16*b* allows only the signal F_2 to pass therethrough. The signal F_2, having passed through said filter, is fed to the band pass filter 16*a* after passing through the branching filter 12*b* on the output end. The output impedance of the band pass filter 16*a* takes a value of zero or infinity with respect to frequencies other than that of the signal F_1. Accordingly, the signal F_2 is reflected by the band pass filter 16*a* to be returned to the branching circulator 12*b*. The signal F_2 passes through the circulator 12*b* into the transmitting antenna 11*b*, through which the signal F_2 is radiated for transmission to the next repeater station or to the next terminal station. In this manner, the received signal F_2 is amplified and again transmitted under the straight-through system. A part of each of the received signals F_1, F_2 to be relayed is extracted from their respective transmission lines and applied to the mixer 5 for mixing thereof, and the difference frequency F_1—F_2 is produced by the band pass filter of the demodulator 6 and, then, subjected to demodulation through the frequency discriminator.

Illustrated in Fig. 8 is a fifth embodiment of the present invention. In this embodiment, multiplexed signals F_1, F_2, transmitted on two routes and received by the receiving antenna 11*a*, are applied to a band pass filter 17, which allows both of the signals F_1, F_2 to pass therethrough, and then, be amplified together by an amplifier 18 up to a necessary strength. They are further applied to band pass filter 19, which permits both of them to pass therethrough, and then, they are transmitted via a transmitting antenna 11*b* to the next repeater station or to the next terminal station. Thus, the signals F_1, F_2 are relayed in a straight-through manner.

If the received signals F_1, F_2 being relayed are taken out of their common transmission line and applied to a non-linear element, such as diode, a signal having a frequency of the sum of F_1+F_2 and a signal having a frequency of the difference between F_1 and F_2 are produced. Out of these produced signals, the signal having the difference frequency of $F_1—F_2$ is extracted for demodulation by means of the frequency discriminator in the demodulator 6.

The signal having the difference frequency of $F_1—F_2$ contains frequency-modulated components possessed by the original signals F_1, F_2 and said components are available at the output terminal of the demodulator 6, so that they can be used as signals for the auxiliary channels on the two routes in a similar manner to that of the embodiments of Fig. 7.

In the embodiments of Fig. 7 and Fig. 8, it should be noted that the received signals are directly amplified for the relaying thereof. However, the demodulating method for the auxiliary channel according to the invention can, of course, include shifting the frequencies of the received signals into different frequencies for the relaying thereof. Also, in the case of a straight-through repeater having three or more routes, if the received signal on each route is subjected to amplification as in the embodiment of Fig. 7, first the sum of signals F_1, F_2 on two of the routes, or the difference $F_1—F_2$, is produced, and then, the sum of said sum F_1+F_2 and the signal F_3 on a third route or the difference therebetween is produced, and then, demodulated. Thus, the signals F_1, F_2, F_3 can be utilized as signals for the auxiliary channels of the three routes. A similar process to this can be applied in the case of using a four or more route straight-through repeater.

Fig. 9 illustrates in detail the circuits of the mixer 5 and the demodulator 6 used in the embodiments of the invention illustrated in Fig. 3, Fig. 5, Fig. 6 and Fig. 7. In Fig. 9, the directional couplers 4*a*, 4*b* can usually be coaxial directional couplers, such as Model 3004 manufactured by Narda Microwave Corporation. Isolators 21*a*, 21*b* are employed in connection with the directional couplers 4*a*, 4*b*, respectively, for the prevention of cross talk between the signal frequencies F_1, F_2. A suitable isolator which can satisfy this purpose is, for instance, M3E-7200 manufactured by microwave Associates, but the isolators 21*a* 21*b* can be omitted if desired. The mixer 5 can be a Doubly Balanced Mixer incorporating four diodes as illustrated in Fig. 9. A suitable model for the band pass filter 6*a* can be Model TBP-340-50-3, of Telonic Industries Inc. A suitable model type for the wide band amplifier 6*b* can be Model G.P.D.-401 or G.P.D.-403, of Avantec Inc. Model PLS-1 of Mini-Circuits Laboratory is suitable for use as the limiter 22. The frequency discriminator 6*c*, as illustrated, is constituted by a double-tuned discriminator incorporating transistors Q_1, Q_2, Q_3 and diodes D_5, D_6. The band pass filter 6*d* is a low frequency band pass filter constituted by inductance and capacitance elements, the output of which is amplified by a low frequency amplifier 23 and supplied to the terminal 7.

As described in the foregoing, according to the method of the present invention, no microwave oscillator is necessary for demodulating signals of the auxiliary channel. Furthermore, the demodulator does not require a microwave frequency discriminator, but need only include one intermediate frequency discriminator, thus being very simple in construction.

WHAT WE CLAIM IS:—

1. A method for demodulating auxiliary channel signals in a straight-through radio frequency repeater which relays microwave signals frequency modulated by baseband signals comprised of main communication channel signals and auxiliary channel signals, the main communication channel signals and the auxiliary channel signals having different frequency bands, which comprises receiving at least two of said microwave signals, branching the or two of said microwave signals thus received, producing a difference frequency signal from the branched microwave signals and demodulating the difference frequency signal to regenerate said auxiliary channel signals.

2. A method according to claim 1, wherein the said two microwave signals are of different frequencies and the difference frequency signal is obtained by subtracting one of said signals from the other.

3. A method according to claim 1, wherein the said two microwave signals are of the same frequency and the difference frequency signal is obtained by shifting the frequency of one of said signals and subtracting said shifted frequency signal from the other signal.

4. A method according to claims 1, 2 or 3, wherein said at least two microwave signals are comprised of microwave signals transmitted in an upline and microwave signals transmitted in a downline through the repeater.

5. A method according to claim 1, 2 or 3, wherein said at least two microwave signals are comprised of microwave signals

transmitted in one direction through the repeater.

6. A straight-through radio frequency repeater which relays microwave signals frequency modulated by baseband signals comprised of main communication channel signals and auxiliary channel signals, the main communication channel signals and the auxiliary channel signals having different frequency bands, comprising means for receiving at least two of said microwave signals, means for branching the or two of the microwave signals received, means for producing a difference frequency signal from the branched microwave signals, and means for demodulating the difference frequency signal to regenerate said auxiliary channel signals.

7. A straight-through radio frequency repeater according to claim 6, comprising means for receiving microwave signals in an upline of the repeater a first microwave amplifier connected to said upline receiving means, a first branching directional coupler connected to said first microwave amplifier to branch one of said microwave signals in the upline, means for receiving microwave signals in a downline of the repeater, a second microwave amplifier connected to said downline receiving means, a second branching directional coupler connected to said second microwave amplifier to branch one of the microwave signals in the down line, a frequency mixer connected to said first and second branching directional/couplers for producing a difference frequency signal from the branched signals in the upline and the downline and a demodulator connected to said frequency mixer for demodulating said difference frequency signal to regenerate said auxiliary channel signal.

8. A straight-through radio frequency repeater according to claim 7, comprising means for frequency shifting at least one of said received microwave signals applied to the branching means.

9. A straight-through radio frequency repeater according to claim 8, comprising frequency shifting means whereby a received microwave signal having a frequency F1 is frequency shifted into a microwave signal having a frequency F2 prior to being applied to said branching means, and frequency shifting means whereby a received microwave signal having a frequency F1 is frequency shifted into a microwave signal having a frequency F2 after being applied to said branching means, whereby a difference frequency signal is obtained from the output of said mixer.

10. A straight-through radio frequency repeater according to claim 8, comprising frequency shifting means whereby a received microwave signal to be branched having a frequency F1 is frequency shifted into a microwave signal having a frequency F2 and a received microwave signal to be branched having a frequency F3 is frequency shifted into a microwave signal having a frequency F4.

11. A straight-through radio frequency repeater according to claims 8, 9 or 10, wherein said frequency shifting means comprises a frequency shifting oscillator connected to a frequency shifting mixer connected in the received signals signal path and an amplifier.

12. A straight radio frequency repeater according to claim 11, wherein modulation of said auxiliary channel signals is effected by modulating an output from said frequency shifting oscillator.

13. A straight-through radio frequency repeater according to claim 6, comprising means for receiving multiplexed microwave signals, a first microwave amplifier connected to said receiving means for amplifying a first microwave signal of said received multiplexed microwave signals, a first branching directional coupler connected to said first microwave amplifier to branch said first microwave signal, a second microwave amplifier connected to said receiving means for amplifying a second microwave of said multiplexed microwaves, a second branching directional coupler connected to said second microwave amplifier to branch said second microwave signal, a frequency mixer connected to said first and second branching couplers for producing a difference frequency signal between the first and second microwave signals, and a demodulator connected to said frequency mixer for demodulating said difference frequency signal, whereby said auxiliary channel signals are regenerated.

14. A straight-through radio frequency repeater according to claim 6, comprising means for receiving multiplexed microwaves, a microwave amplifier connected to said receiving means for amplifying a first and second microwave of said multiplexed microwave signals, transmitting means connected to said microwave amplifier for transmitting an output of said microwave amplifier, branching means connected to said transmitting means for branching part of said transmitted output of said microwave amplifier, a signal producing means connected to said branching means for producing a difference frequency signal between said first and second microwaves, and a demodulator connected to said signal producing means for demodulating said difference frequency signal, whereby said auxiliary channel signals are regenerated.

15. A straight-through radio frequency repeater according to any of claims 6 to 14, wherein said demodulator provided at an output of said frequency mixer, comprises a first filter for removing signals other than said difference frequency signal, an amplifier connected to said first filter for amplifying said difference frequency signal, a frequency discriminator connected to said difference frequency signal amplifier for extracting said auxiliary channel signal from said difference frequency signal, and a second filter for picking up signals having a frequency band of said auxiliary channel signal.

16. A demodulating method for auxiliary channel signals in a straight-through radio freqeuncy repeater substantially as hereinbefore described with reference to Figs. 3 to 9 of the accompanying drawings.

17. A straight-through radio frequency repeater substantially as hereinbefore described with reference to Figs. 3 to 9 of the accompanying drawings.

MARKS & CLERK
7th Floor
Scottish Life House
Bridge Street
Manchester M3 3DP
Agents for the Applicant

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1981
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

Fig. 1

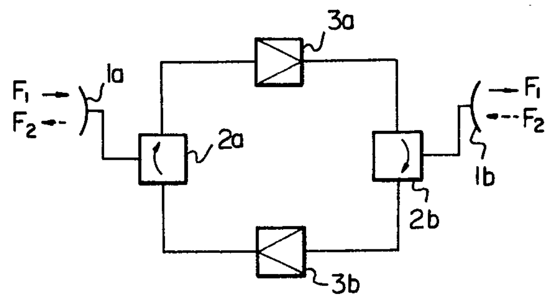

3a
F1
F2
1a
2a
F1
F2
1b
2b
3b

Fig. 2

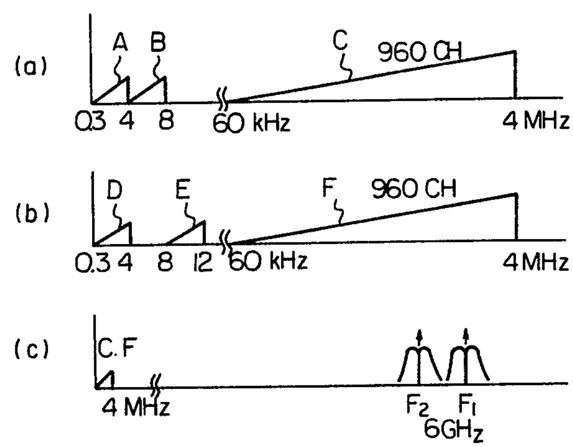

(a)
A
B
C
960 CH
0.3 4 8 60 kHz
4 MHz
(b)
D
E
F
960 CH
0.3 4 8 12 60 kHz
4 MHz
(c)
C.F
4 MHz
F2 F1
6GHz

Fig. 3

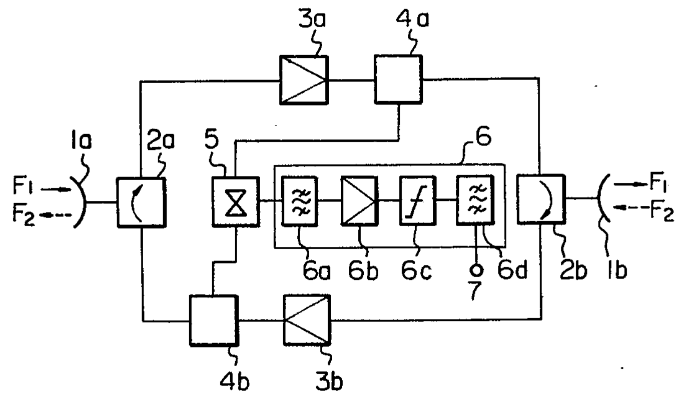

3a
4a
1a
2a
5
6
F1
F2
6a
6b
6c
7
6d
2b
1b
4b
3b

Fig. 4

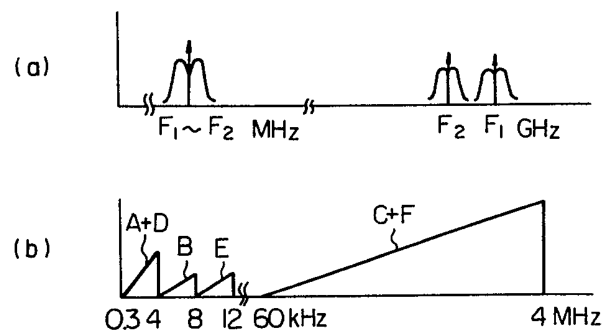

(a)
F1~F2 MHz
F2 F1 GHz
(b)
A+D
B
E
C+F
0.3 4 8 12 60 kHz
4 MHz

Fig. 5

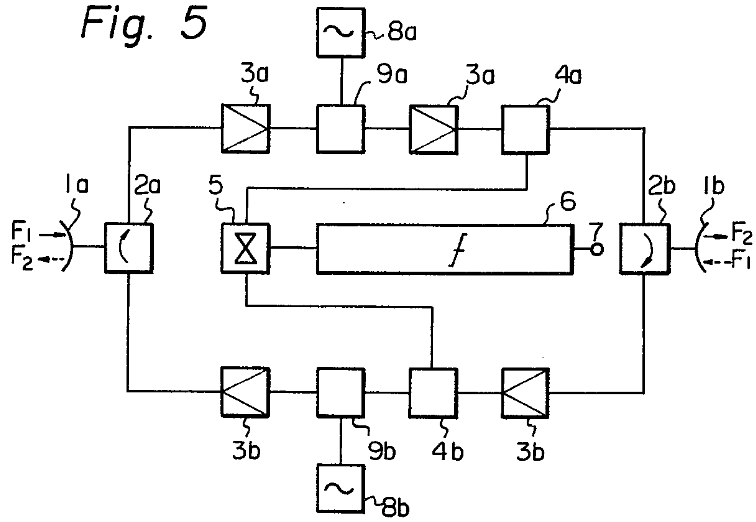

8a
3a
9a
3a
4a
1a
2a
5
6
2b
1b
F1
F2
f
7
F2
F1
3b
9b
4b
3b
8b

Fig. 6

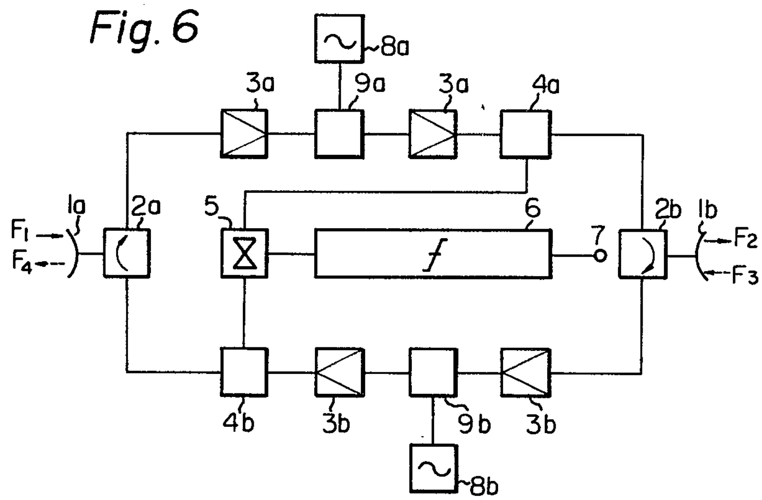

8a
3a
9a
3a
4a
1a
2a
5
6
2b
1b
F1
F4
f
7
F2
F3
4b
3b
9b
3b
8b

Fig. 7

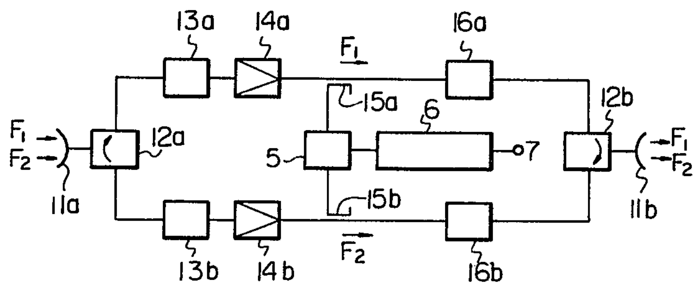
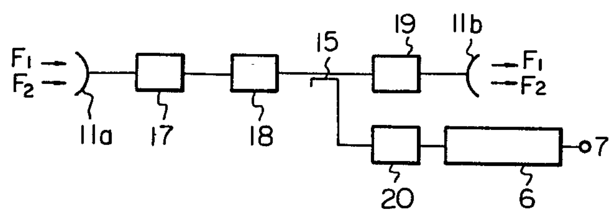

13a
14a
F1
16a
15a
6
12b
F1
F2
12a
5
7
F1
F2
11a
15b
11b
13b
14b
F2
16b

Fig. 8


15
19
11b
F1
F2
F1
F2
11a
17
18
7
20
6

1599616 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

Fig. 9