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(54) **Method for transferring, by means of a radio relay system radiophonic signals for isofrequency broadcasting**

Verfahren zur Übertragung radiophoner Signale mittels Radiorelaisystem für das Isofrequenzsenden
Procédé pour transmettre les signaux radiophoniques à l'aide de système radio automatique tout
relais pour l'émission isofréquencielle

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EP-A- 0 291 676 **US-A- 4 475 243**
US-A- 5 089 815

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Description

The present invention relates to a method for transferring signals meant for "isofrequency" radio broadcasting by means of a video radio relay system. The term "radio relay system" will be used throughout hereinafter for the sake of brevity to refer to a video radio relay system.

It is known, for example from the European Patent No. 0 291 676 in the name of this same Applicant, to which reference is made for further details, how to broadcast radiophonic programs meant for listeners in moving vehicles, particularly in frequency modulation, by means of a series of stations with transmission antennas distributed for example along a motorway. The signal to be broadcast from each antenna is transferred to the stations by means of an optical fiber; delay devices are included therein, with a calibrated delay for each antenna, so that in the equal field region between adjacent transmission antennas the received signals are time-coherent, i.e. the signals in the region of confusion arrive at the same instant from the two adjacent antennas despite the differences in travel distance.

The above mentioned prior patent requires, in addition to antennas distributed along the road, the installation of a fiber-optics system for the transfer of the signal to the antennas. In many cases it would be convenient, for better coverage of the served area, to be able to broadcast from "isofrequency" stations located in a more favorable position, distant from the motorway, using existing stations as well.

For this purpose, the signal would have to be tapped from the optical fiber and transferred to the remote station, by means of a radio relay system, preserving its characteristics.

In order to perform this transfer by means of a radio relay system, it has been proposed to divide the frequency of the carrier, which is typically 103.3 MHz, frequency-modulated with a deviation of ± 75 kHz, by a fixed number such as 64, obtaining a signal at an intermediate frequency of approximately 1.61 MHz, which is thus modulated with a deviation of approximately ± 1.17 kHz, and to transmit this intermediate frequency over the radio relay system. At the receiving end of the radio relay system, the frequency of the received signal is multiplied by the same fixed number, so as to reconstruct the original signal.

However, despite being simple and effective, this process is highly sensitive to electrical noise introduced by the radio relay system. The noise affects the signal permanently and in inverse proportion to the divider number used; the smaller the resulting frequency deviation, the higher the noise. At the receiving station, multiplication acts both on the signal and on the noise, without affecting the damage already produced.

The aim of the invention is therefore to provide a method for transferring radiophonic signals by means of radio relay systems to an isofrequency broadcasting

station, with no appreciable deterioration of the quality of the final audio signal, particularly keeping to a minimum the sensitivity to the noise introduced by the transfer medium.

The invention achieves this aim, together with other objects and advantages which will become apparent from the continuation of the description, with a method for transferring, by means of a radio relay system, radiophonic signals for isofrequency broadcasting, characterized in that it includes the following steps:

a) generating, by means of a local oscillator, a fixed frequency which differs by a few MHz with respect to the carrier frequency of the radiophonic signal;

b) converting the modulated radiophonic signal by beating together with the fixed frequency in a first nonlinear mixer and by filtering in a band-pass filter, so as to obtain an intermediate carrier frequency signal equal to the difference between the carrier frequency of the radiophonic signal and the fixed frequency;

c) transmitting on the radio relay system the intermediate signal together with a reference frequency which is proportional to the fixed frequency according to a constant integer or fractional coefficient;

d) filtering the signal received from the radio relay system at the receiving station in two band-pass filters, so as to isolate the intermediate signal on one hand and the reference frequency on the other hand;

e) reconstructing the fixed frequency from the received reference frequency by multiplying by the constant integer or fractional coefficient; and

f) reconverting the intermediate signal by beating together with the fixed frequency in a second nonlinear mixer and by filtering in a band-pass filter, so as to obtain a modulated radiophonic signal with a carrier frequency equal to the sum of the carrier frequency of the intermediate signal and of the fixed frequency.

The invention is now described in greater detail with reference to a preferred embodiment, illustrated in the accompanying drawings, which are given only by way of non-limitative example and wherein:

Figure 1 is a block diagram of a first preferred embodiment of the process according to the invention; and

Figure 2 is a block diagram of a second preferred embodiment of the process according to the invention.

With reference to Figure 1, a radiophonic signal f_i has a carrier at 103.3 MHz and is frequency-modulated with a deviation $\Delta f = \pm 75$ kHz, with a monophonic or stereophonic program, according to standard rules of commercial radio broadcasting (as is known, the frequency of 103.3 MHz has been chosen in Italy for the isofrequency radio broadcasting service along motorways). The carrier frequency of the signal f_i is converted in a nonlinear mixer 10 by heating together with a fixed frequency f_X , preferably 101.3 MHz, generated by a synthesized-frequency local oscillator 12 controlled by a reference oscillator 14 which oscillates at a frequency f_C of 5 MHz. The output of the nonlinear mixer is filtered in a band-pass filter 16 which provides, on its output line, an intermediate signal at the frequency $F_P = f_i - f_X$, i.e. 2 MHz, the modulation deviation of which, Δf , is still ± 75 kHz.

The intermediate signal f_P and the reference frequency f_C are then combined in a linear adder circuit 18, and the resulting complex signal is transmitted over the radio relay system.

During reception, the complex signal is filtered in band-pass filters 20 and 22 to reobtain the intermediate signal at the frequency $f_P = f_i - f_X$ on one hand, and the reference frequency f_C of 5 MHz on the other hand. The latter is used to control a synthesized-frequency local oscillator 24 which is identical to the local oscillator 12 at the transmitting end of the radio relay system, in order to reconstruct the fixed frequency f_X . The central frequency of the intermediate signal f_P is then reconverted by beating together with the reconstructed fixed frequency f_X in a nonlinear mixer 26: this is followed by filtering in a band-pass filter 28 to obtain the frequency which is the result of the sum $f_X + f_P = f_X + (f_i - f_X) = f_i$.

The original radiophonic signal to be broadcast, with a carrier frequency f_i and with a deviation Δf again equal to ± 75 kHz, is thus reobtained.

It should be noted that the beat frequency f_X , at the transmitting end and at the receiving end, is constructed with the same procedure, starting from the same reference frequency f_C transmitted over the radio relay system together with the intermediate signal. Furthermore, the structure in transmission and in reception is complementary and compensatory. The person skilled in the art thus certainly understands that the inaccuracies or drifts of the reference frequency f_C are irrelevant; in other words, the precision of the frequency of the oscillation f_C at 5 MHz is neither relevant nor critical, since any imprecision is recovered by the symmetrical nature of the method.

Furthermore, it should be noted that the deviation of the modulation (normally ± 75 kHz) is not modified and in particular is not reduced during transmission over the radio relay system; accordingly, it is not unfavorably affected by the electrical noise of the radio relay system.

It should also be noted that the synthesized-frequency technique allows to obtain a fixed frequency f_X which is to a very large extent immune from the electrical

noise introduced by the radio relay system.

Preferably, the two frequencies f_C (typically 5 MHz) and $f_P = f_i - f_X$ (typically 2 MHz) are chosen so that they are low enough to be transmitted over a same channel of a standard radio relay system for video signals, the band whereof is approximately 10 MHz.

Transmission over the radio relay system is preferably performed with preemphasis and with no clamp.

Naturally, the reference frequency f_C and the intermediate frequency f_P can assume values different from the preferred ones indicated above, with the only caution, obvious to the skilled person, to avoid making one the multiple of the other.

By virtue of this fact it is possible to extend the above described method to the transmission of a plurality of isofrequency signals over a same link, choosing a different value of the intermediate frequency f_P for each signal to be transmitted, while maintaining a single reference frequency. Such an embodiment is shown in Figure 2, where the components identical to Figure 1 are designated by the same reference numerals.

The diagram of Figure 2 is similar to that of Figure 1, but three local oscillators 12-1, 12-2 and 12-3 are used instead of a single local oscillator; these oscillators oscillate at three different fixed frequencies f_{X1} , f_{X2} , f_{X3} , but they are all controlled by a same reference oscillator 14 which oscillates at a frequency f_C . Respective nonlinear mixers 18-1, 18-2 and 18-3 are associated with the three local oscillators, and three isofrequency signals f_{i1} , f_{i2} and f_{i3} are applied to these mixers. The outputs of the nonlinear mixers are filtered in respective band-pass filters 16-1, 16-2 and 16-3 to obtain, similarly to the first embodiment, three intermediate signals f_{P1} , f_{P2} and f_{P3} at different frequency values, which are added in the linear adder 18 together with the reference frequency f_C .

Similarly, the receiving end uses three band-pass filters 20-1, 20-2 and 20-3 for the three intermediate frequencies (with functions similar to those of the band-pass filter 20 of Figure 1), in addition to the band-pass filter 22 for the reference frequency; three local oscillators 24-1, 24-2 and 24-3 (with functions similar to those of the local oscillator 24 of Figure 1); three nonlinear mixers 26-1, 26-2 and 26-3 (with functions similar to those of the mixer 26 of Figure 1); and three band-pass output filters 28-1, 28-2 and 28-3 (with functions similar to those of the band-pass filter 28 of Figure 1).

It is evident to a person skilled in the art that this second embodiment (which can be extended further to four or more frequencies), which provides a single reference frequency shared by a plurality of isofrequency signals, considerably increases the efficiency of the utilization of the frequency band of the radio relay system while preserving all of the advantages of the first embodiment.

Some preferred embodiments of the invention have been described; these embodiments are naturally susceptible to equivalent modifications which can be easily

devised by a person skilled in the art on the basis of the teachings given.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. Method for transferring, by means of a radio relay system, radiophonic signals for isofrequency broadcasting, characterized in that it comprises the following steps:

a) generating, by means of a local oscillator (12), a fixed frequency (f_X) which differs by a few MHz with respect to the carrier frequency of the radiophonic signal (f_I);

b) converting said modulated radiophonic signal (f_I) by beating together with said fixed frequency (f_X) in a first nonlinear mixer (10) and by filtering in a band-pass filter (16), so as to obtain an intermediate carrier frequency signal (f_P) equal to the difference between the carrier frequency of the radiophonic signal and said fixed frequency;

c) transmitting on the radio relay system said intermediate signal together with a reference frequency (f_C) which is proportional to said fixed frequency according to a constant integer or fractional coefficient;

d) filtering the signal received from the radio relay system at the receiving station in two band-pass filters (20, 22), so as to isolate the intermediate signal on one hand and the reference frequency on the other hand;

e) reconstructing said fixed frequency from the received reference frequency by multiplying by said constant integer or fractional coefficient; and

f) reconverting said intermediate signal by beating together with said fixed frequency in a second nonlinear mixer (26) and by filtering in a further band-pass filter (28), so as to obtain a modulated radiophonic signal with a carrier frequency equal to the sum of the carrier frequency of the intermediate signal and of said fixed frequency.

2. Method according to claim 1, characterized in that said fixed frequency is generated at the origin by means of a first local oscillator (12) which is controlled by a reference oscillator (14) which oscillates at said reference frequency.

3. Method according to claim 2, characterized in that said fixed frequency is generated, at the receiving end, by means of a second local oscillator (24) which is controlled by said received reference frequency.

4. Method according to claim 3, characterized in that said first and second local oscillators have identical characteristics.

5. Method according to claim 3, characterized in that said first and second local oscillators are of the synthesized frequency type.

6. Method according to one of claims 1 to 5, characterized in that transmission over the radio relay system is performed with preemphasis.

7. Method according to claim 6, characterized in that transmission over the radio relay system is performed with no clamp.

8. Method according to one of claims 1 to 7, characterized in that signal transfer is performed over a radio relay system for video transmissions.

9. Method according to one of claims 1 to 8, characterized in that the reference frequency is 5 MHz.

10. Method according to one of claims 1 to 9, characterized in that a plurality of isofrequency signals (f_{I1} , f_{I2} , f_{I3}) is converted at the transmitting end by beating together with respective fixed frequencies (f_{X1} , f_{X2} , f_{X3}) generated by respective local oscillators (12-1, 12-2, 12-3) controlled by a single reference oscillator (14) to obtain respective intermediate signals (f_{P1} , f_{P2} , f_{P3}) which are transmitted over the radio link together with the single reference frequency (f_C) generated by said reference oscillator, and in that at the receiving end the intermediate signals, isolated by means of respective band-pass filters (20-1, 20-2, 20-3), are converted by beating together with said fixed frequencies generated by respective local oscillators (24-1, 24-2, 24-3) which are all controlled by said single reference frequency, which is isolated by means of a band-pass filter (22).

Patentansprüche

1. Verfahren zur Übermittlung von Radiosignalen für eine gleichfrequente Rundfunkübertragung mittels

eines Zwischensendersystems,

dadurch gekennzeichnet,

daß es die folgenden Schritte beinhaltet:

a) Erzeugen einer Festfrequenz (f_X) mittels eines lokalen Frequenzgenerators (12), wobei sich die Festfrequenz von der Trägerfrequenz des Radiosignal (f_I) um einige MHz unterscheidet,

b) Umwandeln des modulierten Radiosignals (f_I) durch Überlagerung mit der Festfrequenz (f_X) in einem ersten nichtlinearen Mischungsverstärker (10) und durch anschließende Filterung in einem Bannpaßfilter (16), so daß sich ein Zwischenträgerfrequenzsignal (f_P) ergibt, das gleich der Differenz von der Trägerfrequenz des Radiosignals und der Festfrequenz ist,

c) Übermitteln des Zwischensignals über das Zwischensendersystem zusammen mit einer Bezugsfrequenz (f_C), die proportional zur Festfrequenz ist, wobei der Proportionalitätsfaktor konstant ganzzahlig oder gebrochen ist,

d) Filtern des von der Empfangsstation des Zwischensendersystems empfangenen Signals in zwei Bannpaßfiltern (20, 22), so daß das Zwischensignal und die Bezugsfrequenz voneinander getrennt werden,

e) Wiederherstellen der Festfrequenz aus der empfangenen Bezugsfrequenz durch Multiplikation mit dem konstanten ganzzahligen oder gebrochenen Proportionalitätsfaktor, und

f) Zurückwandeln des Zwischensignals durch die Überlagerung mit der Festfrequenz in einem zweiten nichtlinearen Mischverstärker (26) und durch anschließende Filterung in einem Bannpaßfilter (28), so daß sich ein moduliertes Radiosignal mit einer Trägerfrequenz ergibt, die gleich der Summe aus Trägerfrequenz des Zwischensignals und Festfrequenz ist.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Festfrequenz an der Quelle mittels eines lokalen Frequenzgenerators (12) erzeugt wird, der von einem Bezugsfrequenzgenerator (14) überwacht wird, der eine Bezugsfrequenz erzeugt.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Festfrequenz am Empfangsende mittels eines zweiten lokalen Frequenzgenerators (24) erzeugt wird, der durch die empfangene Bezugsfrequenz überwacht wird.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß der erste und der zweite lokale Frequenzgenerator eine identische Charakteristik aufweisen.

5. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß der erste und der zweite lokale Frequenzgenerator vom eine Frequenz künstlich erzeugenden Typ sind.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß das Senden über das Zwischensendersystem mit Vorverzerrung erfolgt.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß das Senden über das Zwischensendersystem ohne Erdungsschelle erfolgt.

8. Verfahren nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß die Signalübertragung über ein Zwischensendersystem für Fernsehübertragung erfolgt.

9. Verfahren nach einem der Ansprüche 1 bis 8, gekennzeichnet durch eine Bezugsfrequenz von 5 MHz.

10. Verfahren nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, daß eine Vielzahl von gleichfrequenten Signalen (f_{I1} , f_{I2} , f_{I3}) am Übertragungsende umgewandelt werden durch die Überlagerung mit jeweiligen Festfrequenzen (f_{X1} , f_{X2} , f_{X3}), die jeweils von einem der lokalen Frequenzgeneratoren (12-1, 12-2, 12-3) erzeugt werden und der von einem Bezugsgenerator (14) überwacht wird, um so jeweils unterschiedliche Zwischensignale (f_{P1} , f_{P2} , f_{P3}) zu erhalten, die zusammen mit der vom Bezugsgenerator erzeugten Bezugsfrequenz f_C über die Funkverbindung übermittelt werden und dadurch gekennzeichnet, daß am Empfangsende die mittels eines jeweiligen Bannpaßfilters (20-1, 20-2, 20-3) isolierten Zwischensignale umgewandelt werden durch die Überlagerung mit Festfrequenzen, die durch jeweilige lokale Frequenzgeneratoren (24-1, 24-2, 24-3) erzeugt werden, die alle von einer mittels eines Bannpaßfilters (22) isolierten Bezugsfrequenz überwacht werden.

Revendications

1. Procédé pour transférer, par l'intermédiaire d'une liaison par faisceau hertzien multi-relais, des signaux radiophoniques destinés à une diffusion en isofréquence, caractérisé en ce qu'il comporte les étapes consistant à :

a) générer, par l'intermédiaire d'un oscillateur local (12), une fréquence fixe (f_X) qui diffère de

la fréquence porteuse du signal radiophonique (f_1) de quelques MHz,

b) convertir ledit signal radiophonique modulé (f_1), par battement avec ladite fréquence fixe (f_x) dans un premier mélangeur non-linéaire (10) et par filtrage dans un filtre passe-bande (16), de manière à obtenir un signal d'une fréquence porteuse intermédiaire (f_p) égale à la différence entre la fréquence porteuse du signal radiophonique et ladite fréquence fixe,

c) transmettre via la liaison par faisceau hertzien multi-relais ledit signal intermédiaire en association avec une fréquence de référence (f_c) qui est proportionnelle à ladite fréquence fixe selon un coefficient entier ou fractionnel constant,

d) filtrer le signal reçu en provenance de la liaison par faisceau hertzien multi-relais au niveau de la station réceptrice dans deux filtres passe-bande (20, 22), de manière à isoler le signal intermédiaire, d'une part, et la fréquence de référence, d'autre part,

e) reconstruire ladite fréquence fixe à partir de la fréquence de référence reçue en la multipliant par ledit coefficient entier ou fractionnel constant, et

f) reconvertir ledit signal intermédiaire, par battement avec ladite fréquence fixe dans un second mélangeur non-linéaire (26) et par filtrage dans un autre filtre passe-bande (28), de manière à obtenir un signal radiophonique modulé avec une fréquence porteuse égale à la somme de la fréquence porteuse du signal intermédiaire et de ladite fréquence fixe.

2. Procédé selon la revendication 1, caractérisé en ce que ladite fréquence fixe est générée à l'origine par l'intermédiaire d'un premier oscillateur local (12) qui est commandé par un oscillateur de référence (14) qui oscille à ladite fréquence de référence.

3. Procédé selon la revendication 2, caractérisé en ce que ladite fréquence fixe est générée, au niveau de l'extrémité réceptrice, par l'intermédiaire d'un second oscillateur local (24) qui est commandé par ladite fréquence de référence reçue.

4. Procédé selon la revendication 3, caractérisé en ce que lesdits premier et second oscillateurs locaux ont des caractéristiques identiques.

5. Procédé selon la revendication 3, caractérisé en ce que lesdits premier et second oscillateurs locaux sont du type à fréquence synthétisée.

6. Procédé selon l'une quelconque des revendications 1 à 5, caractérisé en ce que la transmission via la liaison par faisceau hertzien multi-relais est effec-

tuée avec une pré-accentuation.

7. Procédé selon la revendication 6, caractérisé en ce que la transmission via la liaison par faisceau hertzien multi-relais est effectuée sans verrouillage.

8. Procédé selon l'une quelconque des revendications 1 à 7, caractérisé en ce que le transfert de signaux est effectué via une liaison par faisceau hertzien multi-relais pour les transmissions vidéo.

9. Procédé selon l'une quelconque des revendications 1 à 8, caractérisé en ce que la fréquence de référence est de 5 MHz.

10. Procédé selon l'une quelconque des revendications 1 à 9, caractérisé en ce qu'une pluralité de signaux isofréquences (f_{11} , f_{12} , f_{13}) sont convertis au niveau de l'extrémité émettrice, par battement avec des fréquences fixes (f_{x1} , f_{x2} , f_{x3}) respectives générées par des oscillateurs locaux (12-1, 12-2, 12-3) respectifs commandés par un oscillateur de référence (14) unique, de manière à obtenir des signaux intermédiaires (f_{p1} , f_{p2} , f_{p3}) respectifs qui sont transmis via la liaison hertzienne en association avec la fréquence de référence unique (f_c) générée par ledit oscillateur de référence, et en ce que, au niveau de l'extrémité réceptrice, les signaux intermédiaires, isolés par l'intermédiaire de filtres passe-bande (20-1, 20-2, 20-3) respectifs sont convertis par battement avec lesdites fréquences fixes générées par des oscillateurs locaux (24-1, 24-2, 24-3) respectifs qui sont tous commandés par ladite fréquence de référence unique, qui est isolée par l'intermédiaire d'un filtre passe-bande (22).

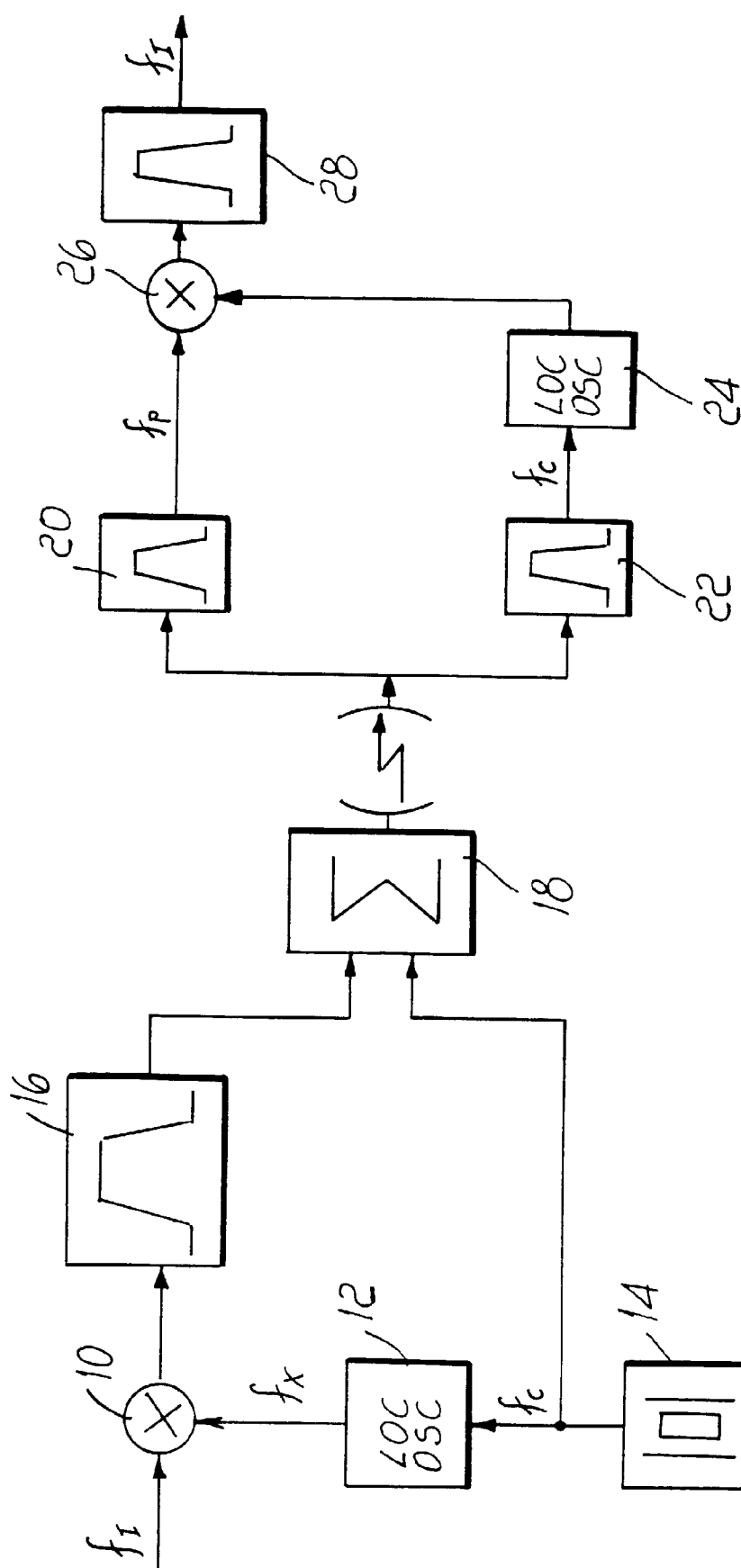


Fig. 1

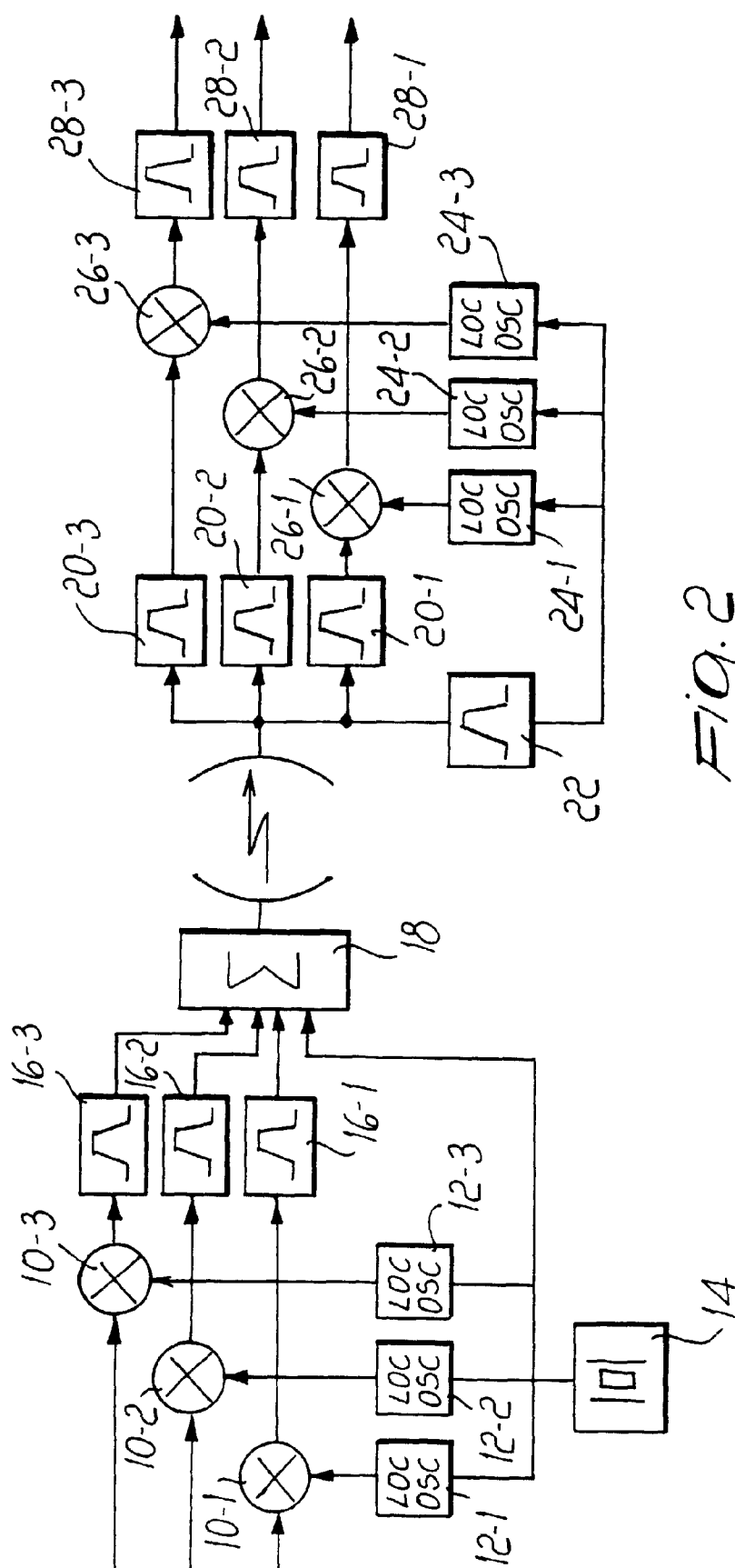


Fig. 2