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MULTIFREQUENCY OSCILLATOR

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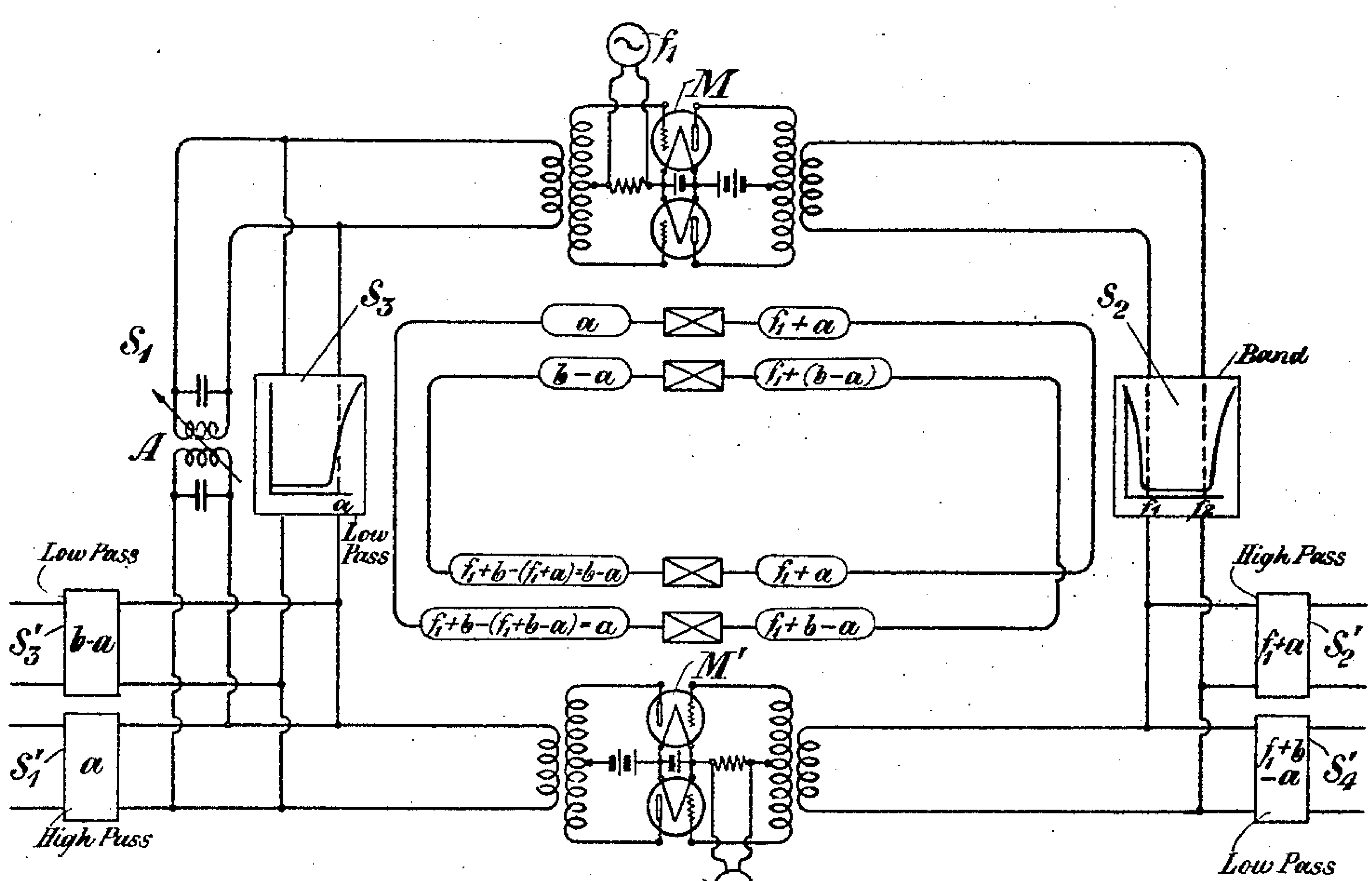

Fig. 1

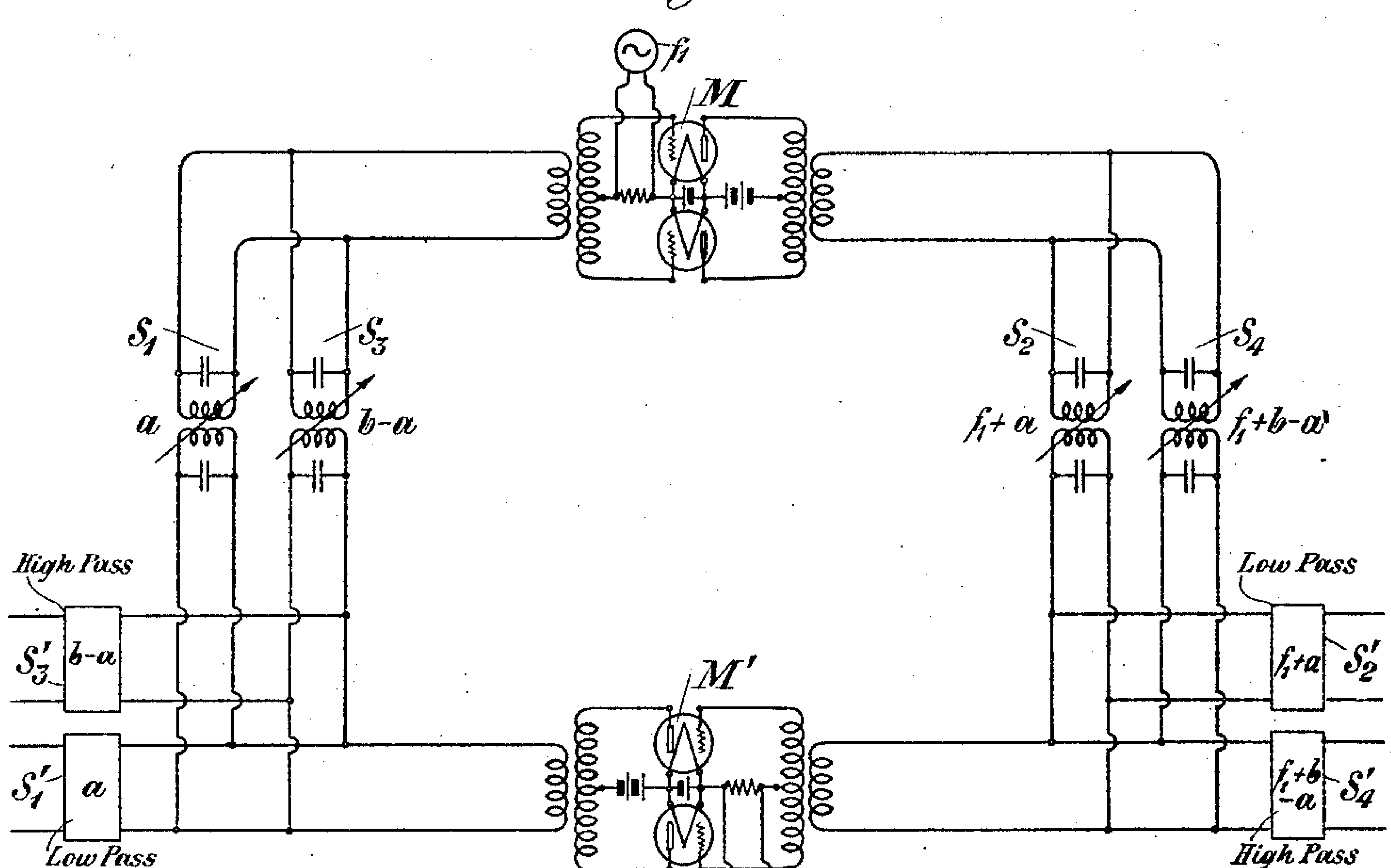

Fig. 2

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MULTIFREQUENCY OSCILLATOR.

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This invention relates to oscillation generators, and more particularly to an oscillation generator capable of producing a plurality of frequencies.

While multi-frequency generators have been produced heretofore, such generators have, for the most part, been of the type in which the various frequencies generated are related to each other as harmonics of a common fundamental. It is an object of the present invention to produce a multi-frequency generator in which the various frequencies produced may be related in a non-harmonic manner and yet may be definitely controlled by a principal frequency. Another object of the invention is to produce an oscillating circuit including a complete oscillating path in which the frequency changes from point to point in the path a plurality of times. Another object of the invention is to produce an oscillating circuit in which a high degree of stability is attained. Still another object of the invention is to produce an oscillating circuit in which, by the adjustment of a single tuning element, a plurality of different frequencies may all be simultaneously changed.

These objects and other objects of the invention are attained by the arrangements disclosed, which are fully set forth in the following description and illustrated in the accompanying drawing, Figures 1 and 2 of which are circuit diagrams showing two modifications of the invention.

Referring to Fig. 1, M and M′ designate, respectively, two vacuum tube modulators of the balanced type having their input circuits connected to frequency sources f_1 and f_2, respectively. Owing to the balanced connections of the modulators, the frequencies f_1 and f_2 applied to the two modulators will be suppressed in the output circuit and will not be transmitted. The output circuit of the modulator M′ is connected to the input circuit of the modulator M through two parallel branches, one including the tuned selective circuit S_1 and the other including a low pass filter S_3. The output circuit of the modulator M is connected with the input circuit of the modulator M′ through a band filter S_2 having its cut-off point so located as to pass the frequencies f_1 and f_2.

The circuit arrangement above described constitutes a generator of oscillations and at different points in the circuit four different generated frequencies may be taken off. For this purpose, a high pass filter S_1' and a low pass filter S_3' are connected to the output circuit of the modulator M′, and a high pass filter S_2' and a low pass filter S_4' are connected to the output circuit of the modulator M.

The operation is as follows: The primary frequency generated by the system is determined by the adjustment of the tuned circuit S_1. Assuming that this selective circuit is tuned to a frequency a, and that oscillations of this frequency are set up in the tuned circuit, these oscillations will be impressed upon the modulator M to beat with the carrier frequency f_1, thereby producing sum and difference frequencies f_1+a and f_1-a, as well as a frequency corresponding to the unmodulated carrier f_1. The frequency f_1 is suppressed by reason of the balance of the modulator circuit and the difference frequency f_1-a is suppressed by the band filter S_2 as this frequency falls below its lower cut-off point. The frequency a is less than the difference between the frequencies f_1 and f_2, and consequently, the sum frequency f_1+a passes through the band filter S_2 and is impressed upon the modulator M′. The frequency f_1+a beats with the frequency f_2 to produce sum and difference frequencies. If b be taken as the difference between f_1 and f_2, the expression f_1+b may be substituted for the frequency f_2. The sum frequency will then be $2f_1+b+a$ and the difference frequency will be $b-a$. The unmodulated component corresponding to frequency f_2 is suppressed by the balanced circuit of the modulator. The low pass filter S_3 in the output circuit has its cut-off point below the frequency a, and if the frequencies f_1 and f_2 are so chosen that b is greater than a and $b-a$ is less than a, the difference frequency $b-a$ produced by the modulator M′ in its output circuit will be transmitted through the low pass filter S_3. The sum of the frequencies, however, $2f_1+b+a$, will be above the cut-off point of the filter S_3 and will also be too high to pass through the tuned circuit S_1, so that this frequency will be suppressed.

The difference frequency $b-a$ passes through the filter S_3 and is impressed upon the input of the modulator M. By beating with the carrier frequency f_1, a sum frequency $f_1+(b-a)$ and a difference frequency $f_1-(b-a)$ are produced. The difference frequency falls below the lower cut-off point of the band filter S_2 but the sum frequency $f_1+(b-a)$ falls between the cut-off points f_1 and f_2 of said filter, so that the sum frequency only is transmitted. The sum frequency in turn is impressed upon the modulator M′, thereby beating with the frequency f_2 to produce a sum frequency $2f_1+2b-a$ and a difference frequency a. The sum frequency is suppressed as it falls above the upper cut-off point of the filter S_3 and is too high to be passed to the tuned circuit S_1. The difference frequency a, however, passes through the tuned circuit S_1 and starts the cycle of operations above described anew.

It will be seen that in the complete oscillating circuit the frequency is changed four times and that the four frequencies thus produced need not bear a harmonic relation to each other. The primary frequency a is independent of the frequencies f_1 and f_2 supplied to the modulators and is determined only by the tuning of the selective circuit S_1. Consequently, the frequencies f_1 and f_2 may vary within limits from time to time without producing any change in the primary frequency a. The other three frequencies generated, namely, f_1+a, $b-a$ and $f_1+(b-a)$ are all functions of the primary frequency a but need not be harmonics thereof. In the assumed case, the generated frequency $b-a$ is less than a and the other two generated frequencies are greater. It will also be noted that the energy must be transmitted twice over the same path in order to complete one cycle of the action. The various frequencies transmitted during the different operations of the cycle are indicated by the schematic diagram shown in Fig. 1 in the interior of the main circuit layout.

Another characteristic of the arrangement disclosed is that all four of the frequencies generated may be changed (within limits) by merely adjusting the tuned circuit S_1. This follows from the fact that the frequencies f_1+a, $b-a$ and $f_1+(b-a)$ are all functions of the primary frequency a, and since the frequency a is independent of the frequencies f_1 and f_2 and is determined only by the tuning of the selective circuit S_1, it follows at once that all four of the frequencies generated will depend upon the tuning of the circuit S_1.

The four frequencies generated may be readily taken off from the oscillating system by means of combinations of high pass and low pass filters as indicated in the diagram. Since only the frequencies a and $b-a$ appear in the output circuit of the modulator M′, these two frequencies may be taken off through high pass filter S_1', and low pass filter S_a', respectively, these filters being connected in branches leading from the output circuit of the modulator M′. The lower cut-off point of the high pass filter and the upper cut-off point of the low pass filter should be brought as close to each other as is consistent with selectivity and the two frequencies representing these cut-off points should be intermediate between the normal values of frequencies a and $b-a$, so as to allow for any change in the frequencies due to adjustments of the tuned circuit S_1. The frequencies f_1+a and $f_1+(b-a)$ appear only in the output circuit of the modulator M and can be taken off through the high pass filter S_2' and low pass filter S_4, respectively, these filters being connected in branches associated with the output circuit of the modulator M. Here again the lower cut-off frequency of the filter S_2' and the upper cut-off frequency of the filter S_4' should be as close together as is consistent with the proper selectivity and the two cut-off frequencies should also be located intermediate between the normal values of f_1+a and $f_1+(b-a)$ to permit of a desired amount of change in the frequencies by changing the tuning of the circuit S_1.

A modified arrangement is shown in Fig. 2, in which a tuned circuit selective of the frequency $b-a$ is substituted for the low pass filter S_3. Also, instead of the band filter S_2 of Fig. 1, a pair of branches including tuned circuits S_2 and S_4, selective of frequencies f_1+a and $f_1+(b-a)$, respectively, are used.

The operation will be similar to that described in connection with Fig. 1 but it will be noted that in this arrangement, if the selective circuits S_2, S_3 and S_4 are sharply tuned, the generator will tend to be more stable. This follows from the fact that each one of the four frequencies generated depends upon the setting of four different tuned circuits selective of four different frequencies. For example, the primary frequency a depends not only upon the setting of the selective circuit S_1 but upon the setting of the other three selective circuits S_2, S_3 and S_4 as well. Similarly, the other three frequencies likewise mutually depend upon all four tuned circuits.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a multi-frequency oscillation generator, a closed path in which the oscillations flow, means to determine a primary frequency in said path, and means to produce a plurality of changes in frequency as the energy flows over said path, the frequencies resulting from such frequency changes not being related to the primary frequency as harmonics thereof.

2. In a multi-frequency generator, a closed path through which the generated frequencies flow, means in said path to determine a primary frequency, and means in said path to produce successive changes in the frequency, the final change being a change to the primary frequency, and a complete cycle of changes involving a transmission of energy more than once about said path.

3. In a multi-frequency generator, a closed path over which the frequencies generated flow, means in said path to determine a primary frequency, means in said path to step up the frequency, and means in said path to step down the frequency, the successive frequency changes thus produced being so related that the energy will flow a plurality of times about said path in order to complete a cycle.

4. In a multi-frequency generator, a closed path over which the frequencies generated flow, means in said path to determine a primary frequency, means in said path to combine said primary frequency with an auxiliary frequency to produce a sum frequency, and means in said path to combine said sum frequency with another auxiliary frequency to produce a difference frequency, whereby a plurality of said frequency changes occur as the energy traverses said path.

5. In a multi-frequency generator, a closed path over which the frequencies generated flow, means in said path to determine a primary frequency, means in said path to combine said primary frequency with an auxiliary frequency to produce a sum frequency, and means in said path to combine said sum frequency with another auxiliary frequency to produce a difference frequency, whereby a plurality of said frequency changes occur as the energy traverses said path, the last frequency change being a change to the primary frequency, said auxiliary frequencies being so related to each other that the energy will flow over said path a plurality of times in order to complete a cycle.

6. In a multi-frequency oscillator, a closed path over which the oscillations generated flow, a pair of frequency changing and translating devices in said path, a plurality of selective branches in each portion of the path connecting the output of one translating device to the input of the successive translating device, one of the selective devices in one of the branches of one of said portions of said path determining one of the frequencies generated independently of the selective devices in other branches.

7. In a multi-frequency oscillator, a closed path over which the oscillations generated flow, a pair of frequency changing and translating devices in said path, a plurality of selective branches in each portion of the path connecting the output of one translating device to the input of the successive translating device, one of the selective devices in one of the branches of one of said portions of said path determining one of the frequencies generated independently of the selective devices in other branches, said selective device determining all the other frequencies circulating in said path.

In testimony whereof, I have signed my name to this specification this 18th day of September, 1924.

HERMAN A. AFFEL.