

Jan. 21, 1969

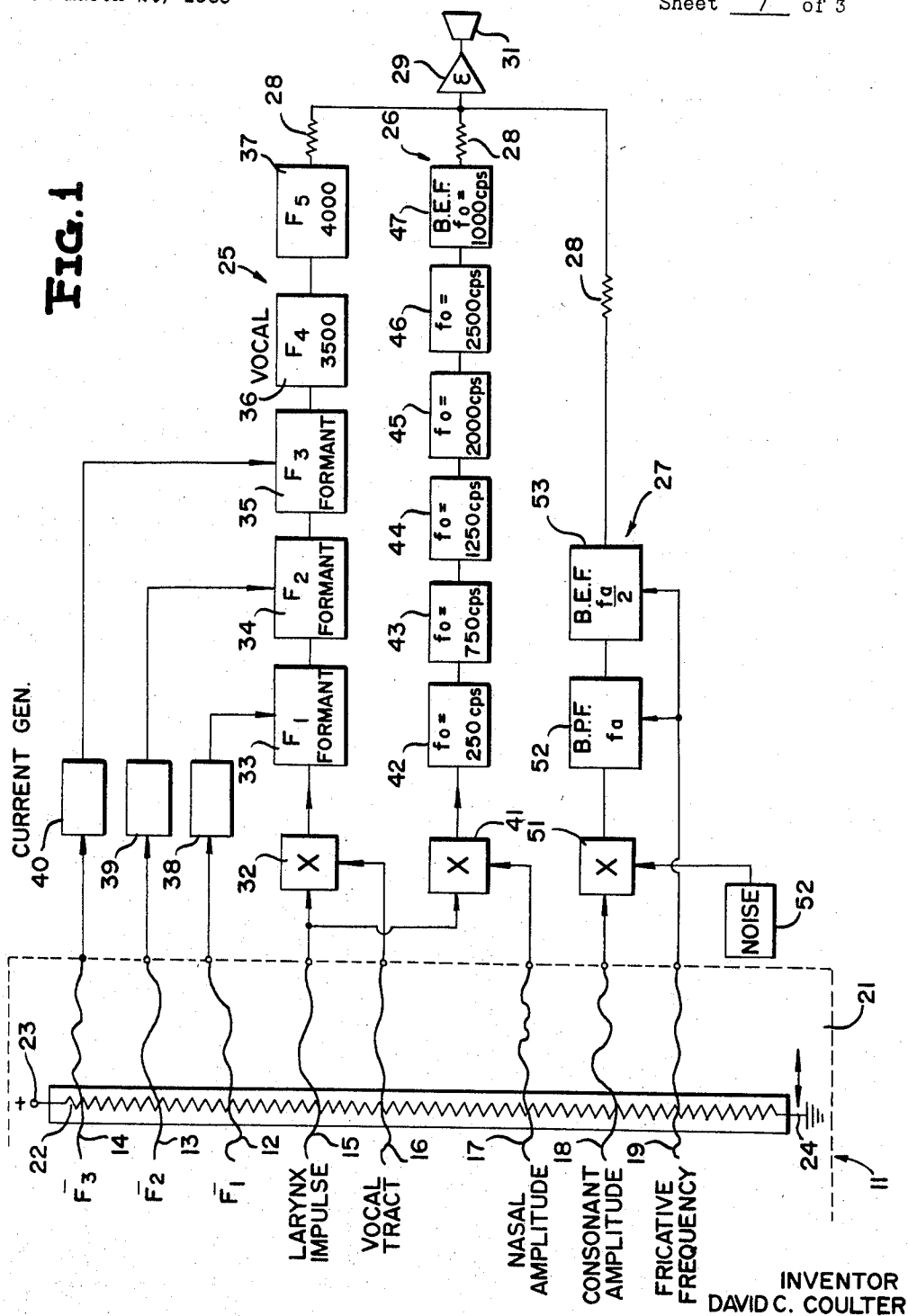
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3,423,530

SPEECH SYNTHESIZER HAVING Q MULTIPLIER

Filed March 26, 1965

Sheet 1 of 3



By Hunzly & Rose
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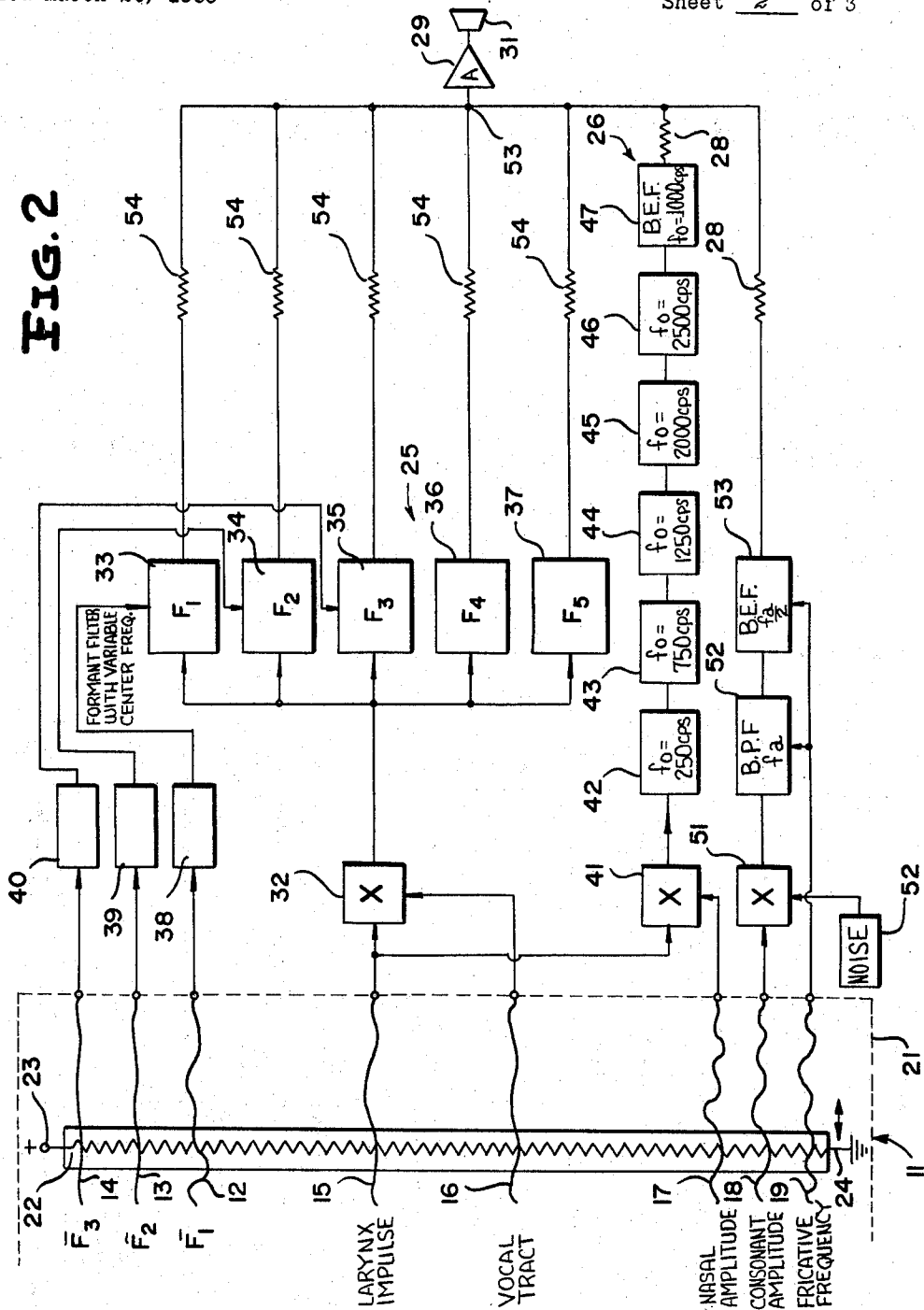
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FIG. 2



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SPEECH SYNTHESIZER HAVING Q MULTIPLIER

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FIG. 3

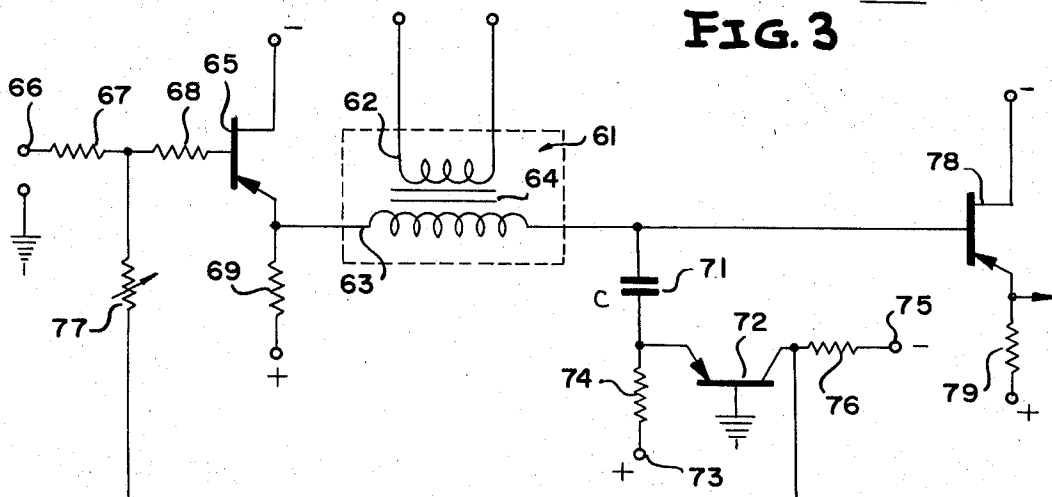


FIG. 4

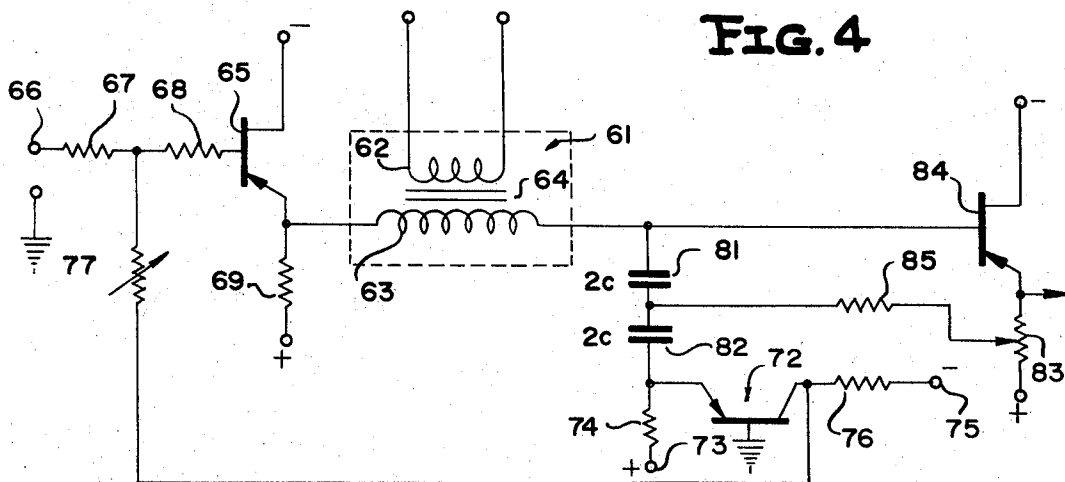
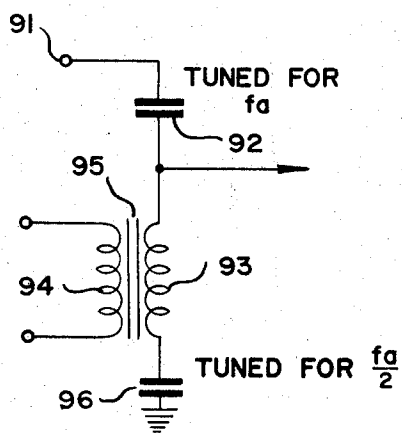


FIG. 5



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SPEECH SYNTHESIZER HAVING Q MULTIPLIER
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12 Claims

ABSTRACT OF THE DISCLOSURE

A speech synthesizing system includes sources of signal representing the frequency of the speech content of at least one formant and representing the speech amplitude, and has a formant filter responsive to and selectively passing the speech amplitude signal. The filter is essentially a series resonant circuit including an inductor coupled by a saturable core to a winding for receiving the formant frequency signal and thereby varying the inductance value of the inductor, and a capacitor connected in series circuit with the inductor to form a relatively low Q network. The current flowing through the capacitor is detected and utilized to develop a control signal which is applied back to the input terminal of the filter via a positive feedback network having a gain less than unity. The combination of the feedback control signal with the speech amplitude signal to which the filter is normally responsive is applied to the inductor to vary the Q of the filter as a direct function of the change in center frequency of the filter with change in the inductance value of the inductor.

The present invention relates generally to Q multipliers particularly adapted for use in speech synthesizers and more particularly to a Q multiplier in which band width remains substantially constant despite variations in the center or resonant frequency of a band pass filter in which the Q multiplier is employed.

It is known that an important aspect of synthesizing speech is to derive signals that accurately simulate the vocal tract excitation of a speaker. Simulation can be attained by deriving a vocal tract signal indicative of the product of a simulated larynx impulse and total vocal tract energy. The resulting product signal is then supplied to a plurality of formant filters, filters having band passes corresponding with different vocal cavities that simulate these cavities. Typically, the formant filters are divided into five different frequency spectra; namely 200 to 1000 cycles per second, 500 to 2500 cycles per second, 1500 to 3500 cycles per second, 3000 to 4000 cycles per second and 3500 to 5000 cycles per second.

It has been found that energy in the first three formants generally subsists in a relatively narrow spectra, the center frequency of which may vary anywhere between the extremes defined. In consequence, the most effective vocal tract simulation involves providing, for the first three formants, separate band pass filters having variable resonant or center frequencies. Because energy is concentrated in a relatively narrow band at any one time in each of the formants, it is also a requirement that each of the bandpass formant filters be of relatively high Q. Another important factor in accurate simulation of the vocal cavities constituting the first three formants is that the spectral content of speech is generally of a predetermined constant band width at any one time, for all frequencies over the formant. Thus, another requirement of vocal tract simulation networks is to provide filters having Q's that vary directly proportional to center frequency. By increasing or decreasing the Q of the filter proportionately with increases and decreases of the filter center frequency, the filter band width remains substan-

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tially constant. This is evident from the frequently employed expression for Q:

$$Q = \frac{F_0}{\Delta F} \text{ or } \Delta F = \frac{F_0}{Q}$$

where F_0 is the filter center frequency, and ΔF is the bandwidth of the filter between its three db points.

According to the present invention a synthesizer is provided having formant filters with these attributes by providing a variable, signal responsive inductance connected in a series resonant circuit with a tuning capacitor. High Q of the series resonant combination is achieved with a positive feedback network responsive to the current in the tuning capacitor. Because greater current flows in the tuning capacitor at higher frequencies, the amount of positive feedback increases for higher input frequencies, thereby satisfying the requirement of higher Q's for higher frequencies. That higher Q or narrower bandwidth is achieved with greater positive feedback, hence greater gain, can be appreciated when it is considered that the gain bandwidth product of any amplifier remains constant. Thus, as gain is increased, bandwidth must be decreased to satisfy the noted product relationship. The requirement for greater feedback at the higher frequencies is also necessary because of the particular variable inductances employed. The values of these inductances increase gradually and reach a maximum value at approximately 1250 cycles per second, thereafter, they become lossy and circuit is decreased. In consequence, it is doubly necessary to increase positive feedback at higher frequencies.

Another characteristic of the variable inductors employed in the present invention is that they become extremely lossy towards the low frequency end of the synthesized spectrum. They sometimes become so lossy that it is impossible to maintain circuit Q directly proportional to filter resonant frequency. To compensate for this lossiness and attain higher Q over the entire spectrum according to one embodiment of the present invention, an additional positive feedback network is provided and the capacitance is modified to include a pair of series capacitors having a total value, in series circuit, equal to the value of the tuning capacitor in the first described embodiment. The voltage across both capacitors is applied as one input to a positive feedback amplifier having gain of almost unity. The output of this positive feedback configuration is applied to the junction between the two series connected capacitors, thereby increasing the current in one of them. The increased current in said one capacitor is sensed to derive a greater positive feedback signal in the Q multiplication network and to achieve greater Q over the spectrum.

Another important aspect in synthesizing speech is to provide a fricative channel. Typically, such a channel includes a band pass filter and a band elimination filter responsive to a signal representing the amplitude of consonant utterances to be synthesized. This signal is multiplied by the output of a white noise source extending over the complete audio band of interest. The resonant or center frequencies of the band pass and band elimination filters are arranged so that they are octavely related, with the center frequency of the former being twice that of the latter. Most accurate synthesis is achieved when the center frequencies of these two filters are varied together in response to the fricative frequency of the source being synthesized.

According to the present invention, the center frequencies of the band pass and band elimination filters are varied so that they are octavely related by connecting capacitors to either side of a variable inductance, preferably of the same type employed in the formant filters.

The capacitor connected between one end of the variable inductance and the signal responsive input terminal is tuned with a quiescent value of the inductance for a predetermined center frequency of the band pass filter. The other capacitor, between the other end of the variable inductance and a reference potential, is tuned with the quiescent value of the variable inductor to a resonant frequency exactly one-half that of the other tuned circuit. By providing an output at the junction between the first capacitor and the variable inductance, it has been found that the combined effects of the band pass and band elimination filters are attained for all frequencies over the spectrum of interest as values of the inductance are varied.

It is, accordingly, an object of the present invention to provide a new and improved Q multiplication circuit particularly adapted for use in speech synthesizers.

It is another object of the present invention to provide a variable center frequency filter employing a variable reactance responsive to signal input current wherein filter band width remains substantially constant despite variations in the filter center frequency.

It is another object of the present invention to provide a new and improved high Q band pass filter having variable center frequency and fixed band width with variations of center frequency so that it is particularly adapted for use in vocal tract simulation of speech synthesizers.

Another object of the present invention is to provide a new and improved Q multiplier employing variable inductances connected in series circuit with a capacitor to form the filter configuration wherein the Q of the filter configuration is multiplied by positive feedback signals responsive to the current flow in the filter capacitor.

It is another object of the present invention to provide, in a variable center frequency band pass filter employing a variable inductance having Q's that become smaller for increasing filter center frequencies, a circuit to maintain the filter Q approximately proportionate with filter center frequency.

It is another object of the present invention to provide, in a variable center frequency band pass filter employing a variable inductance in series circuit with a capacitor, which inductance is extremely lossy and has low Q at low center frequencies, apparatus for maintaining the Q of said circuit substantially proportional to center frequency and at a relatively high value throughout the center frequency variations of said filter.

Another object of the present invention is to provide, a new and improved fricative speech synthesizer.

Another object of the present invention is to provide in a speech synthesizer, a fricative tract which includes a variable inductance that is shared with variable center frequency band pass and band elimination filters.

It is another object of the present invention to provide, in a speech synthesizer, a fricative tract employing cascaded band pass and band elimination filters having center frequencies that are octavely related and which are varied in response to changes of an inductance common to both of them.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a block diagram illustrating a speech synthesizer in which the present invention is designed to be utilized;

FIGURE 2 is a block diagram of a segment of the speech synthesis system according to a modification of the invention;

FIGURE 3 is a circuit diagram of one preferred embodiment of the variable center frequency band pass filter employed in the systems of FIGURE 1 or FIGURE 2;

FIGURE 4 is a modification of the circuit of FIGURE 3; and

FIGURE 5 is a circuit diagram illustrating the band pass and band elimination filter employed in the fricative track of the synthesizer.

Reference is now made to FIGURE 1 of the drawings wherein there is illustrated a record 11 having eight information tracks thereon. The first three tracks 12-14 of record 11 contain information regarding the centroid frequency of the first, second and third formants of the speech to be synthesized. The remaining tracks 15-19 represent signals indicative of larynx impulse, vocal tract amplitude, nasal amplitude, consonant amplitude and fricative frequency, respectively, of the speech to be synthesized.

While record 11 may take any well known time varying readout means, it is preferably constructed as a potentiometric readout apparatus. In such an instance, each of tracks 12-19 comprises a very low resistance contact wire positioned on an insulating base 21. The amplitude positions of the contact wires correspond with time variations of the various parameters necessary to synthesize speech.

To read out the variations of the several tracks, resistance wire 22 is arranged to cover and contact each of them. One end of resistance wire 22 is connected to the DC source at terminal 23 while the other end is connected to ground terminal 24. To provide the eight different outputs, potentiometer 22 is moved longitudinally across record 11 so that the point at which the individual track is connected with potentiometer 22 is reflected as a voltage on the low resistance track wire for each track. Record 11 and potentiometer 22 are arranged so that the potentiometer generally moves from left to right relative to tracks 12-19 to produce the eight different time varying functions necessary to synthesize speech in accordance with the system disclosed herein.

Because each of tracks 12-19 has a quiescent zero signal amplitude different from ground potential, the readout device associated therewith is provided with a DC offset, not shown. Thereby, the signal supplied by each of tracks 12-19 to the synthesizer varies about zero rather than a predetermined offset voltage dependent upon the various positions of tracks 12-19.

Signals deriving from the eight output tracks of recorder 11 are combined in three separate channels of the synthesizer; namely vocal channel 25, nasal tract 26 and fricative tract 27. The output voltages deriving from tracks 25-27 are applied via separate resistors 28 to summing amplifier 29, the output of which feeds speaker 31 to provide speech sounds in accordance with the information contained on tracks 12-19.

To provide input for vocal tract 25, the output of larynx impulse track 15 and vocal track 16 are multiplied together in analog multiplier 32, the output of which is supplied to a vocal tract synthesizer including cascaded formant filters 33-37. Band pass formant filters 33-35 for the first, second and third formants, respectively, have variable center frequencies that are controlled by centroid frequency representing signals on tracks 12-14, respectively. The signal amplitudes on tracks 12-14 are translated into current amplitudes proportional to the voltage amplitudes of tracks 12-14 by current generators 38-40. The current amplitudes deriving from generators 38-40 are applied to formant filters 33-35, respectively, to vary the center frequencies of these band pass filters.

Filters 33-35 are characterized as having substantially constant bandwidths despite variations in their center frequencies. This implies that the Q's of the filters must increase as the filter center frequencies are increased. It has been found that if the bandwidth is not maintained constant (at approximately 50 c.p.s. for the lower formants, up to about 100 c.p.s. for the higher formants) as filter center frequencies vary, the sounds derived from speaker 31 do not approach an accurate synthesis of true human speech.

The output of the third formant filter 35 is coupled with the fourth formant filter 36, having a fixed center

frequency of approximately 3500 cycles per second and a bandwidth of two to three hundred cycles. The output of the fourth formant filter 36 is cascaded with the input of filter 37 for the fifth formant. Filter 37, also of the band pass type, has a fixed center frequency of approximately 4,000 cycles per second and substantially the same bandwidth as the fourth formant filter 36.

It has been found, through experimentation, that the signal deriving from the fifth formant filter 37 is to a very great extent an accurate synthesis of vocal tract excitation of a human when the center frequencies of formant filters 33-35 are varied by signals representing the centroids of the first, second and third formant centroid frequencies. While the output of filter 37 is a good simulation of vocal tract excitation, the vocal tract by itself is not adequate to provide a complete synthesis of the human voice. To provide complete synthesis, nasal tract 26 and fricative tract 27 must be employed.

The input to nasal tract 26 is derived by multiplying the larynx impulse response on track 15 with the nasal amplitude on track 17 in multiplier 41. The output of multiplier 41 is supplied to the first of five cascaded band pass filters 42-46. Each of filters 42-46 is a relatively low Q device, having a bandwidth between its three db points of two to four hundred cycles per second. The fixed center frequencies of filters 42-46 are approximately 250 cycles per second, 750 cycles per second, 1250 cycles per second, 2000 cycles per second and 2500 cycles per second. By cascading the output of the highest frequency filter 46 with band elimination filter 47, having a center frequency of approximately 1,000 cycles and a band width of two to four hundred cycles, there is applied as an input voltage to resistor 28, an accurate simulation of the human nasal tract excitation.

The remaining channel of the synthesizer, fricative tract 27 includes analog multiplier 51 having one of its inputs responsive to track 18 that provides voltages representing amplitudes of consonants spoken by the source being synthesized. The other input to multiplier 51 is a white noise source 52 that extends between approximately 1000 and 5000 cycles per second. The output of multiplier 51 is connected with cascaded bandpass filter 52 and band elimination filter 53.

The center frequencies of filters 52 and 53 are controlled by the signal amplitude of fricative frequency track 19 so that the center frequencies of both filters remain separated by an octave, with the band pass filter center frequency being twice that of the band elimination filter center frequency. The Q of filters 52 and 53 are relatively low so that the three db points are generally 200 to 400 cycles apart. It has been found that varying filters 52 and 53 so that their center frequencies are separated by substantially an octave in response to the amplitude of the fricative frequency track 19 results in the derivation of a very accurate fricative simulation.

As indicated supra, the outputs of channels 25-27 are combined in amplifier 29 to produce a synthesized speech signal that very closely represents the human voice.

While FIGURE 1 specifically discloses the various band pass and band elimination filters as being cascaded, it is to be understood that these filters may also be connected in parallel with each other and to their common source, as illustrated in the partial system diagram FIGURE 2. In FIGURE 2, each of formant filters 33-37 for formants F1-F5 is arranged to have its inputs driven in parallel by the output of multiplier 32. The outputs of filters 33-37 are summed at node 53 with which they are coupled via isolating resistors 54. Node 53 is also responsive to the outputs of channels 26 and 27 for the nasal and fricative tracts, respectively. The arrangement of FIGURE 1 is generally considered to be preferred over that of FIGURE 2 since fewer components are required and the possibility of saturating amplifier 29 with a large number of inputs is not as probable as it is with the modification. The system of FIGURE 2, in some cases, is advantageously employed because the characteristics of one filter network

do not affect the response solicited from another filter network.

Reference is now made to FIGURE 3 of the drawings, a circuit diagram of a preferred embodiment for the variable center frequency, band pass filters employed in each of formant filters 33-35. The central component in the formant filter is a variable, saturable inductance 61 having a control winding 62 responsive to the output of one of current generators 38-40. Winding 62 is coupled with secondary winding 63 via core 64. The flux level in core 64 controls the inductance of secondary winding 63 in accordance with DC current flowing in control winding 62. Variable inductance 61 is preferably of the type made available by the Vari-L Company, Inc. of Stamford, Conn. The response of a typical one of these variable inductances is given in Table 1.

TABLE 1

I MA	Center frequency (c.p.s.)	Q	C. mfd.
0	200	7	.0672
1	305	10	.0672
3	555	16	.0672
5	890	20	.0672
7	1,250	20	.0672
10	1,895	16	.0672
20	3,800	11	.0672
30	4,500	10	.0672
50	5,100	9	.0672

An inspection of Table 1 reveals that the Q of the coil, with a capacitance of .067 microfarad in series therewith is relatively small and increases only for center frequencies up to 1250 cycles per second. For higher center frequencies of a filter formed by the series combination of the Vari-L variable inductance and a fixed capacitor, the Q of the circuit decreases. Since the Q of the filter circuit decreases for increasing frequencies, the requirement for fixed bandwidth with varying center frequencies cannot be achieved at the higher frequencies.

Actually, for the lower frequencies, less than 500 cycles, the Q of the Vari-L variable inductances, in combination with a series tuning capacitance, decreases so rapidly that bandwidth again does not remain constant. Thus, in adapting the Vari-L variable inductance to the circuit employed in the synthesizer, it is necessary to compensate in some manner for the Q roll-off at the low and high ends of the spectrum. Another criteria for formant filters 33-35 is that they be of relatively narrow bandwidth, 50 to 100 c.p.s. is the maximum bandwidth generally tolerated. Hence, the formant filters must be of relative high Q elements in which Q is increased to maintain substantially constant bandwidth over each particular formant. I have found that the positive feedback arrangement of FIGURE 3 admirably suits these requirements.

The circuit of FIGURE 3 comprises a PNP transistor 65 in common collector or emitter follower configuration with signal input terminal 66 through series connected resistors 67 and 68. In the case of the first formant filter 33, terminal 66 is connected directly to the output terminal of multiplier 32 while in formant filters 34 and 35, terminal 66 is connected to the output terminal of formant filters 33 and 34, respectively. The low source impedance output voltage across resistor 69 in the emitter circuit of transistor 65 is connected to the input of a series resonant circuit comprising inductance 63 and capacitance 71. Capacitance 71 is selected to have a value to tune inductance 63 so that a resonant circuit in the audio band is formed. As indicated by Table 1, a suitable value of capacitor 71 is frequently 0.0672 microfarad for the variable inductances employed.

To multiply the Q of the band pass filter comprising the series resonant circuit including inductance 63 and capacitor 71, a positive feedback signal is derived indicative of the current flowing through the capacitor. The positive feedback network includes a grounded base transistor 72 having its emitter connected to be responsive to the AC current in capacitor 71 and DC biased by the positive voltage at terminal 73. The bias connection between ter-

minial 73 and the emitter of transistor 72 is established through isolating resistor 74. Because transistor 72 is connected in its grounded base configuration, the impedance between its emitter and ground is quite small, on the order of 30 ohms. Thereby, the Q of the resonant filter circuit comprising inductance 63 and capacitor 71 is not adversely affected by the grounded base configuration. However, because transistor 72 is connected in grounded base configuration, the voltage at its collector is directly proportional to the current in capacitor 71. To establish collector electrode bias for PNP transistor 72, its collector is connected to the negative DC potential at terminal 75 via resistor 76, across which is developed a voltage indicative of the current through tuning capacitor 71.

The voltage developed across load resistor 76 is coupled via the positive feedback path, including variable resistor 77, to the junction between current limiting resistors 67 and 68 in the base input circuit of transistor 65. Resistor 77 is adjusted so that the positive feedback to the base of transistor 65 is less than unity for all frequencies in the audio band between 100 and 5,000 cycles. By maintaining the positive feedback less than unity, any possibility of uncontrolled oscillation is obviated.

To isolate the filter output voltage, at the junction between inductor 63 and capacitor 71, and prevent possible loading by succeeding stages, the junction between the reactances of the bandpass filter is connected to the base of emitter follower transistor 78. The low impedance output across emitter resistance 79 of transistor 78 is connected to the following stage. In the case of formant filters 33 and 34, the voltage developed across resistor 79 is connected to variable center frequency formant filters 34, 35 respectively. The output of the third formant filter 35 is connected to the input of passive, frequency filter 36 for the fourth formant.

In operation, the positive feedback loop formed from capacitor 71 to the base of transistor 65 through grounded base transistor 72 and resistor 77 increases the Q of the band pass filter by approximately a factor of 4. In addition, Q is greater for the higher frequencies than the lower frequencies. This is because the current through capacitor 71 is greater for the high frequencies because of the decreased capacitive impedance at these frequencies. In response to the increased current through capacitor 71, a greater voltage is developed at the collector of grounded base transistor 75 for the higher frequencies than for the lower frequencies and more positive feedback is attained at the higher frequencies. Increasing the positive feedback at the higher frequencies results in a network having a greater Q.

I have found that the circuit described enables Q to be increased proportionately with increased filter center frequency. Since the circuit Q and resonant frequency increase at the same rate, the bandwidth between the three db points of the filter remains substantially constant despite variations in center frequency. As indicated supra, the constant bandwidth feature, as a function of filter resonant or center frequency, is desired in formant filter networks to provide the most authentic speech synthesis.

Reference is now made to FIGURE 4 of the drawings wherein there is disclosed another embodiment of the present invention. The embodiment of FIGURE 4 is substantially like that shown in FIGURE 3 except that capacitor 71, having a value of C, is replaced with the series combination of capacitors 81 and 82, each of which has a value of 2C. Since capacitors 81 and 82 each have a value of 2C, their total series capacitance is C, identical with the capacitance of capacitor 71.

The junction between capacitors 81 and 82 is connected in a positive network to potentiometer 83 in the emitter circuit of PNP transistor 84. The base of PNP common collector transistor 84 is connected to the junction between capacitor 81 and inductance 63. To connect the output of transistor 84 in the positive feedback network, potentiometer 83 is provided with a slider that is connected through fixed resistance 85 to the junction of ca-

pacitors 81 and 82. By adjusting the position of potentiometer slider 83, the feedback voltage is varied to the degree desired.

Because of the increased gain introduced by the bootstrap network, circuit Q is increased over the entire audio range. For each formant bootstrap, circuit Q is set at different levels because of the properties of coil 63. This is accomplished by controlling the setting of the tap of potentiometer 83.

Reference is now made to FIGURE 5 of the drawings, a circuit diagram of a preferred configuration of bandpass filter 52 and band elimination filter 53. As indicated supra, the center frequencies of filters 52 and 53 are varied so that they are octavely related, with the center frequency of the former twice that of the latter. I have found that this configuration is attained with the circuit of FIGURE 5 wherein input terminal 91 is connected to be responsive to the output of analog multiplier 51. Terminal 91 is connected through tuning capacitor 92 to variable inductor 93, of the type previously described, having control winding 94 and core 95. The end of inductor 93 opposite to capacitor 92 is connected to ground through second capacitor 96. The output of the entire configuration, at the junction between capacitor 92 and inductor 93, is supplied directly to resistance 28 at the output of fricative channel 27.

With a quiescent DC current level applied to control winding 94, capacitor 92 is set at a value to provide series tuning for the lowest frequency of band pass filter 52. The value of capacitor 96 is set to provide a resonant circuit with inductor 93 for the lowest frequency of band elimination filter 53. As the value of inductance 93 decreases in response to increasing currents in control winding 94, the center frequency of band pass filter increases proportionately with the center frequency of the band elimination filter. Thus, if it is assumed that the frequency variations of bandpass filter 52 are between 2500 and 3000 cycles per second, the resonant or center frequency of band elimination filter 53 extends between 1250 and 4000 cycles per second. The variation between these two extremes of filters 52 and 53 are always proportional so that the center frequency of the former is always twice that of the latter.

While I have described and illustrated several specific embodiments of my invention, it will be clear that variation of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a speech synthesizing system having sources of input signal representing the frequency of speech content of at least one formant and the speech amplitude, a formant filter responsive to and selectively passing said speech amplitude signal, said filter including an inductor having a variable inductance value, means responsive to said formant frequency signal for varying the inductance value of said inductor to change the center frequency of said filter, and means responsive to the level of the speech amplitude signal over the range of frequency passed by the filter for supplying a positive feedback control signal to the input of said filter to maintain the bandwidth thereof substantially constant despite changes in the filter center frequency.

2. The system of claim 1, wherein said means for supplying positive feedback control signal comprises means for varying the Q of said filter directly as a function of the center frequency thereof.

3. The system according to claim 2 wherein said filter includes a capacitor connected in series circuit with said inductor, wherein said means for supplying positive feedback control signal includes a positive feedback network having gain less than unity, said feedback network deriving a signal in response to the current through said capacitor.

4. The system of claim 3 wherein said capacitor in-

cludes a pair of series connected capacitors, and wherein is further included a positive feedback loop having gain less than unity responsive to the voltage across said pair of series connected capacitors and feeding back a voltage to the junction between said pair of series connected capacitors to increase the current through at least one of said pair of series connected capacitors for low frequency signals.

5. A band pass filter circuit responsive to an input signal, said filter comprising an amplifying element having a first electrode for emitting charge carriers, a second electrode for collecting said charge carriers and a third electrode for controlling the flow of said charge carriers between said first and second electrodes; means for feeding said signal to said third electrode; a series resonant circuit including inductance and capacitance connected in series circuit to said first electrode; means responsive to the current flow in said capacitance for deriving a control signal proportional thereto; and means forming a positive feedback loop having a gain less than unity for coupling said control signal back to said third electrode.

6. A band pass filter responsive to an input signal, said filter comprising an amplifying device having an input terminal and an output terminal, means for supplying said signal to said input terminal, a series resonant circuit including an inductance and a capacitance connected to said output circuit, means for deriving a control signal having an amplitude proportional to the current flowing in said capacitance, and means for coupling said control signal in a positive feedback loop having a gain less than unity to said input terminal.

7. A band pass filter comprising an emitter follower transistor having a base electrode for receiving an input signal, a series resonant circuit including an inductor and a capacitor connected to the emitter electrode of said emitter follower transistor, a grounded base transistor having an emitter electrode connected to said capacitor and responsive to the current flowing in said capacitor for developing an output signal at the collector electrode thereof proportional to the current in said capacitor, and a positive feedback loop having gain less than unity connecting said collector electrode of said grounded base transistor to said base electrode of said emitter follower transistor.

8. The filter of claim 7 wherein said capacitor comprises a pair of series connected capacitors, said pair of capacitors having a tap between them, a second emitter follower transistor having a base electrode connected to said pair of capacitors for sensing the voltage thereacross, and means for feeding the voltage appearing at the emitter electrode of said second emitter follower to said tap to form a positive feedback loop having gain less than unity.

9. A signal responsive filter having substantially constant bandwidth irrespective of variation in center fre-

quency thereof in response to a signal, said filter comprising an inductance, the value of which is varied in response to input signal, a tuning capacitance connected in series circuit with said inductance, means for deriving a signal proportional to the current flow through said capacitance, positive feedback means having gain less than unity for linearly combining said last named signal with said input signal, and means for feeding said combined signal to said inductance.

10. The filter of claim 9 wherein said capacitance comprises a pair of series connected capacitors having a tap between them, and further positive feedback means having gain less than unity responsive to the voltage across said capacitance for feeding signal developed therefrom to said tap.

11. In a speech synthesizing system having sources of input signal representing the frequency of the speech content in at least one formant and the speech amplitude, a formant filter responsive to and selectively passing said speech amplitude signal, said filter including an inductor, means for varying the inductance value of said inductor in response to said formant frequency signal applied thereto, said inductor connected in series circuit with a capacitor to form a relatively low Q series resonant circuit, the output of said filter developed across one of said inductor and said capacitor and positive feedback means having gain less than unity responsive to the amplitude of signal current in said filter for application of a control signal representative of said current amplitude to said inductor to vary the tap Q of said filter as a direct function of the change in center frequency of said filter with change in said inductance value of said inductor.

12. The synthesizer of claim 11 wherein said filter further includes a second positive feedback network having gain less than unity, said capacitor including a pair of series connected capacitors, said second feedback network having an input responsive to the voltage across said series connected capacitors for deriving therefrom an output voltage for application to the junction between said series connected capacitors.

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