

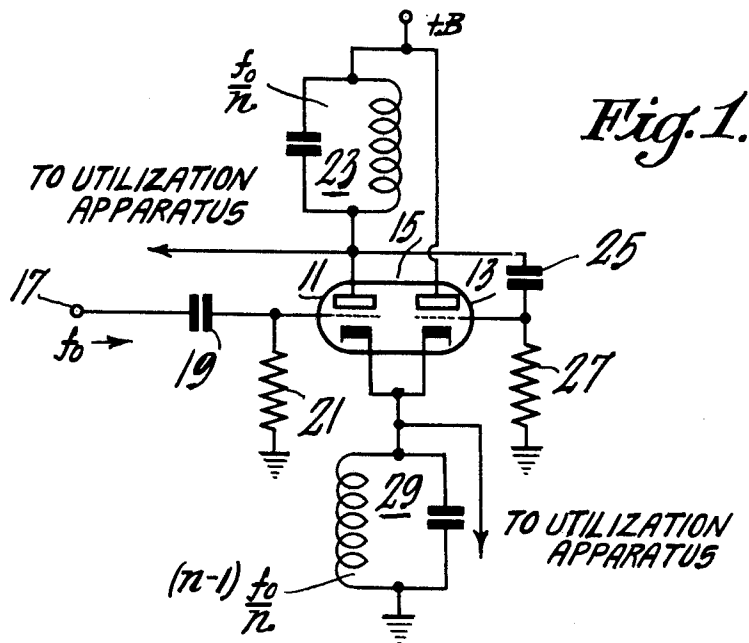
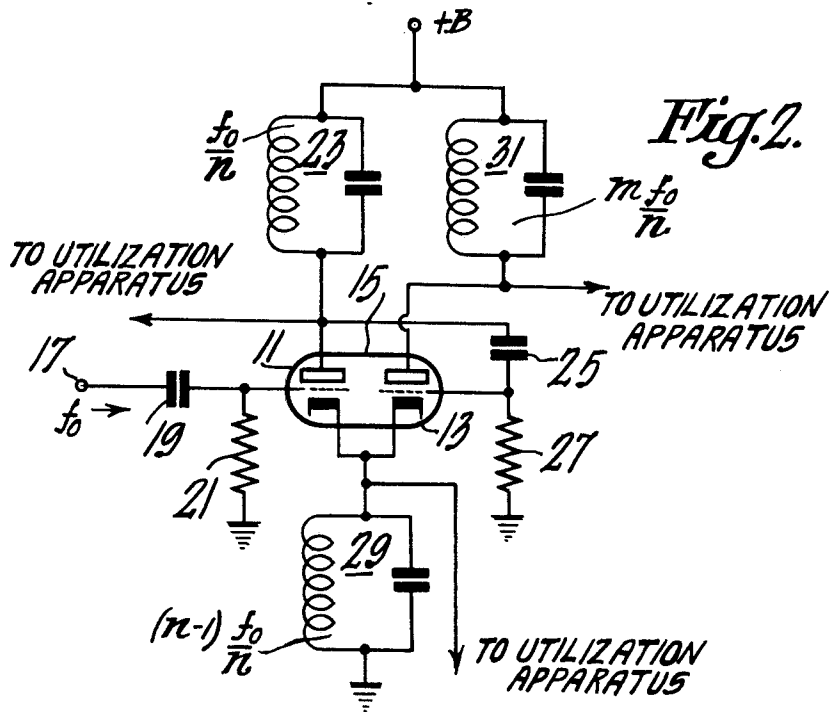
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G. C. SZIKLAI

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REGENERATIVE FREQUENCY DIVIDERS

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INVENTOR
George C. Sziklai
BY *John C. Mitchell*
ATTORNEY

1

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REGENERATIVE FREQUENCY DIVIDERS

George Clifford Sziklai, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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12 Claims. (Cl. 250—36)

This invention relates to frequency dividing apparatus and more particularly to cathode coupled regenerative frequency dividing circuits.

Frequency dividers are used in various types of apparatus but they are particularly useful in color television systems of the type described in RCA Review, December, 1949, volume 10, pages 504-524, in an article entitled "A Six Megacycle Compatible High-Definition Color Television System." In such systems frequency dividers may be used to divide the transmitter reference frequency, or color sampling frequency of, for example, 3.89 megacycles, by a predetermined factor which will provide a quotient frequency of 31.5 kc. The latter frequency is then applied to the transmitter sync signal generators where it is divided by a factor of two to produce the horizontal deflection frequency of 15,750 C. P. S. and by a factor of 525 to produce the vertical deflection frequency of 60 C. P. S. In this manner the sampling frequency is synchronized with the line and field frequencies.

My invention provides a frequency divider which utilizes the cathode coupled oscillator principle disclosed in my U. S. Patent 2,509,280 granted May 30, 1950 and described in detail in the Proceedings of the IRE, volume 33, October, 1945, pages 701-709, in the article written by G. C. Sziklai and A. C. Schroeder entitled, "Cathode-Coupled Wide-Band Amplifier."

The present invention provides a submultiple frequency in constant relationship with a predetermined frequency by means of a stable and economical circuit. The present circuit employs a dual triode where heretofore at least a pentagrid mixer and a pentode were used. The predetermined frequency is applied to the control electrode of the first triode tube. A noise component of the predetermined frequency sets up a weak signal of a submultiple frequency in a tuned anode circuit of this triode. The submultiple frequency is then applied to the control electrode of the second triode tube. A tuned circuit in the cathode circuit of the second tube, which is also common to the cathode circuit of the first tube, selects and provides a frequency which is multiple of the submultiple frequency. When the latter frequency and the predetermined frequency are heterodyned in the first tube the desired submultiple frequency is produced.

The primary object of my invention is to provide an improved economical frequency dividing circuit.

Another object of my invention is to provide a frequency divider which operates at much higher frequencies than conventional multivibrators.

Another object of my invention is to provide an improved frequency divider which maintains a stable frequency.

A still further object of my invention is to provide a frequency divider which can produce odd fractions of a predetermined frequency.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention may best be understood with

2

reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 diagrammatically represents one form of a frequency dividing circuit embodying this invention; and

Fig. 2 is a modification of the frequency divider shown in Fig. 1.

Throughout the figures of the drawing, similar parts are represented by the same reference numerals.

Referring to Fig. 1, there is illustrated one embodiment of this invention in which there is shown a frequency dividing circuit including two electron discharge devices 11 and 13 in one envelope 15, each device having a cathode, an anode, and a control electrode. The terminal 17 represents a source of voltage of predetermined frequency which is coupled to the control electrode of the first electron discharge device 11 by means of a series condenser 19 and a shunt resistor 21. An oscillatory circuit 23 tuned to a subharmonic of the predetermined frequency is disposed in the anode circuit of the first device 11 and is coupled to the control electrode of the second device 13 by means of a series condenser 25 and a shunt resistor 27. The anodes of each device 11 and 13 are appropriately connected to a source of positive potential at +B. The cathodes of the electron discharge devices 11 and 13 are coupled by means of a common cathode-to-ground oscillatory circuit 29 tuned to a multiple of the subharmonic or submultiple of the predetermined frequency.

In the operation of the embodiment of the invention illustrated in Fig. 1, a predetermined frequency f_0 from the output terminal 17 of a source of voltage is applied to the control electrode of the first electron discharge device 11 by means of a series condenser 19 and a shunt resistor 21. The oscillatory circuit 23 in the anode circuit of the first device 11 is tuned to any desired submultiple frequency

$$\frac{f_0}{n}$$

of the predetermined frequency where n is any integer. This submultiple frequency

$$\frac{f_0}{n}$$

is then applied to the control electrode of the second electron discharge device 13 by means of a series condenser 25 and a shunt resistor 27. The common tuned cathode circuit 29 is tuned to a harmonic or multiple of the submultiple frequency

$$(n-1) \frac{f_0}{n}$$

The multiple of the submultiple frequency in the cathode circuit is heterodyned in the first electron discharge device 11 with the predetermined frequency which is applied to the control electrode of the first electron discharge device to produce the desired submultiple frequency in the anode circuit 23 of the first device. If the multiple of a submultiple frequency is desired, it may be obtained from the common cathode circuit of the devices.

The crank action necessary to start the operation of this divider is obtained from the noise component of the predetermined frequency, the particular noise component being determined by tuned plate circuit 23.

The following is an example of how the submultiple frequency of 2000 cycles per second is derived from an original frequency of 10,000 cycles per second. The original frequency of 10,000 cycles per second is applied to the control electrode of the first electron discharge device 11. The anode circuit 23 of the first device 11 is tuned to the desired submultiple frequency, 2000 cycles per second, which at this stage is merely a noise com-

ponent of the original frequency, 10,000 cycles per second. From the anode circuit 23 of the first device 11 the noise component is applied to the control electrode of the second electron discharge device 13. The second device due to the non-linear operation of the tube then multiplies the 2000 cycle noise component of the original frequency by four by properly tuning the cathode circuit 29. This latter frequency, 8000 cycles per second, beating in the first electron discharge device with the original frequency, 10,000 cycles per second, produces the desired frequency of 2000 cycles per second in the anode circuit 23 of the first electron discharge device 11. Although an original frequency of 10,000 cycles per second is used in the example, it should be understood that the operation of this frequency divider is not limited to any particular frequency. This circuit can function at much higher frequencies than the frequencies at which multivibrators operate. Another advantage of this circuit is its stability at high frequencies extending into hundreds of megacycles because the tuned circuits definitely determine the desired frequencies. Furthermore, odd fractions of a predetermined frequency, for example, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{5}{6}$ and $\frac{7}{6}$, can be easily obtained by using the circuits described in this invention.

The embodiment of this invention shown in Fig. 2 operates in substantially the same manner as the embodiment illustrated in Fig. 1. However, in Fig. 2, an oscillatory circuit 31 is included in the anode circuit of the second electron discharge device 13. The oscillatory circuit 29 in the cathode circuit of this invention must be tuned to the multiple of the submultiple frequency which will produce the submultiple frequency when heterodyned with the predetermined frequency, but the oscillatory circuit 31 disposed in the anode circuit of the second electron discharge device 13 may be tuned to any multiple of the submultiple frequency. This additional oscillatory circuit tuned to the submultiple frequency

$$m \frac{f_0}{n}$$

where m is an independent integer, provides an additional output frequency in the circuit of this invention.

Other amplifying devices, such as transistors, magnetic or dielectric amplifiers, etc. may be used in place of the vacuum tubes shown in Figs. 1 and 2 by connecting them in an analogous manner.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A cathode coupled regenerative frequency dividing circuit comprising a first triode electron discharge device having an anode, a cathode and a control electrode, means for applying a predetermined frequency to said control electrode, a circuit tuned to a submultiple of said frequency, means for applying a positive voltage to said anode through said circuit, a second triode electron discharge device having an anode, a cathode, and a control electrode, means coupling the anode of said first device to the control electrode of said second device, means for applying a positive voltage to the anode of said second device, means connecting the cathode of said first device to the cathode of said second device, a second circuit tuned to a multiple frequency of said submultiple of the predetermined frequency whereby said multiple frequency is equal to said predetermined frequency minus said submultiple frequency, and means for connecting said second circuit from the cathodes of said devices to ground, and means for providing an output at each of said tuned circuits.

2. A frequency divider comprising a twin triode discharge tube in which the anode of a first triode discharge path is capacitively coupled to the control electrode of a second triode discharge path and the cathode element is common to the two discharge paths, means for connecting the anodes of the triode discharge paths to a point of fixed reference potential, means for connecting the con-

trol electrode of said second triode discharge path to ground through a resistive element, means for connecting a voltage source of predetermined frequency to the control electrode of said first triode discharge path, a resonant circuit connected between the anode of said first triode discharge path and said point tuned to a submultiple frequency of said predetermined frequency, a common cathode-to-ground resonant circuit tuned to a multiple frequency of said submultiple whereby said multiple frequency heterodyned with said predetermined frequency produces said submultiple frequency, and means for providing an output at each of said tuned circuits.

3. A frequency divider comprising a pair of triode type electron control structures each having a first electrode, a control electrode and a second electrode, means for coupling a source of reference voltage of a predetermined frequency to the control electrode of one of said structures, means to apply direct operating potentials between a point of reference potential and the second electrode of each of said structures, a frequency determining circuit interposed between the second electrode of one of said structures and said point of substantially fixed reference potential tuned to a submultiple of said predetermined frequency, means coupling the second electrode of said one structure to the control electrode of said second structure with reference to alternating current variations, a common frequency determining circuit tuned to a multiple frequency of said submultiple frequency whereby the sum of said multiple and submultiple frequencies equals said predetermined frequency, said common circuit connected between said first electrodes and ground, and means for providing an output circuit at one of said frequency determining circuits.

4. A frequency divider comprising a pair of electron discharge structures each having an anode, a cathode, and a control electrode, means for coupling a voltage source of a predetermined frequency to the control electrode of the first of said structures, a frequency determining circuit tuned to a subharmonic frequency of said predetermined frequency coupled to the anode of said first structure, means for connecting a source of positive potential to the anodes of said structures, means coupling the anode of said first structure to the control electrode of the second of said structures, means intercoupling said cathodes, said means comprising a common frequency determining circuit connected from said cathodes to ground whereby said common circuit is tuned to a multiple of said subharmonic which produces said subharmonic when heterodyned with said predetermined frequency and by degenerative feedback injects said multiple of said subharmonic into said frequency determining circuit, and means for providing an output terminal at each of said frequency determining circuits.

5. A regenerative frequency divider comprising a first triode electron discharge device having a cathode, an anode and a control electrode, means for connecting said anode to the positive terminal of a source of voltage, means for impressing a wave of predetermined frequency on said control electrode, an oscillatory circuit tuned to the subharmonic of said frequency and disposed in said connecting means, a second triode electron discharge device having a cathode, an anode and a control electrode, means for connecting the anode of said second device to said positive terminal, means for coupling the anode of said first device to the control electrode of said second device, a common cathode connection between the cathode of said first electron discharge device and the cathode of said second electron discharge device, a second oscillatory circuit tuned to a multiple of said subharmonic coupled between said common cathode connection and ground reference potential, said multiple frequency being equal to the difference between said predetermined frequency and said subharmonic, and means for providing an output terminal at each of said oscillatory circuits.

6. In a frequency division network a triode tube pro-

5

vided with an electron emission element, an anode, and an input electrode, means for coupling a voltage source of a predetermined frequency f_0 to the input electrode of said tube, an output circuit coupled to said anode, said output circuit being tuned to a subharmonic frequency

$$\frac{f_0}{n}$$

where n is an integer, a second triode tube provided with an electron emission element, an anode and an input electrode, means for transferring said subharmonic frequency from said output circuit to the input electrode of said second tube, a second output circuit connected between the electron emission elements of both tubes and ground thereby producing degenerative feedback, said second output circuit being tuned to a frequency

$$(n-1) \frac{f_0}{n}$$

and means for connecting the anodes of both tubes to a source of a positive potential.

7. A frequency divider having a plurality of output terminals comprising a first triode electron discharge tube having an anode, a cathode and a control electrode, means for coupling a voltage source of a predetermined frequency to the control electrode of said tube, a first frequency responsive means coupled to the anode of said tube and a second frequency responsive means disposed between the cathode of said tube and ground, whereby said second frequency responsive means is tuned to a multiple of the frequency to which said first frequency responsive means is tuned and whereby the sum of these two frequencies is equal to said predetermined frequency, a second triode electron discharge tube having an anode, a cathode and a control electrode, means for coupling the anode of said first tube to the control electrode of said second tube, means for connecting the anodes of said tubes to a positive terminal of a source of potential, means for connecting together the cathodes of each of said tubes whereby degenerative feedback from said first triode electron discharge tube to said second triode electron discharge tube is produced, and means for providing an output terminal at each of said frequency responsive means.

8. A frequency divider having a plurality of output terminals comprising a tube provided with an anode, a cathode and a control electrode, means for coupling a voltage source of predetermined frequency f_0 to the control electrode of said tube, an output circuit coupled to said anode, said output circuit being tuned to a subharmonic frequency

$$\frac{f_0}{n}$$

where n is an integer, a second tube provided with an anode, a cathode, and a control electrode, means coupling said output circuit to the control electrode of said second tube, means for connecting the anodes of said tubes to a positive terminal of a source of potential, and a second output circuit connected between the cathodes of each of said tubes and ground whereby degenerative feedback from said second tube to said first tube is produced, said second output circuit being tuned to a frequency

$$(n-1) \frac{f_0}{n}$$

9. A frequency divider as in claim 8 having a plurality

6

of output terminals including a third output circuit coupled to the anode of said second tube, said third output circuit being tuned to a frequency

$$m \frac{f_0}{n}$$

where m is an independent integer.

10. A frequency divider comprising a first and a second triode electron discharge device each having an anode, cathode, and a control electrode, means for coupling a voltage source of a predetermined frequency to said control electrode of said first device, means for coupling the anode of said first device to the control electrode of said second device, a first oscillatory circuit coupled to the anode of said first device, means for coupling the cathodes of said first and second devices including a second oscillatory circuit, whereby said first oscillatory circuit produces a submultiple frequency of said predetermined frequency, said second oscillatory circuit produces a multiple frequency of said submultiple, and the sum of said submultiple frequencies is equal to said predetermined frequency, means for connecting the plates of said devices to a positive terminal of a source of potential, and means for providing an output terminal at one of said oscillatory circuits.

11. A regenerative frequency dividing circuit comprising a first non-linear amplifying device having an electron emissive element, a control electrode, and an electron collecting element, means for applying a predetermined frequency to the control electrode of said non-linear amplifying device, a circuit tuned to a submultiple of said frequency connected to the electron collecting element of said first device, a second non-linear amplifying device having an electron emissive element, a control electrode, and an electron collecting element, means for coupling the electron collecting element of said first device to the control electrode of said second device, means for connecting the electron emissive electrodes of said first and said second devices by means of a second circuit tuned to a multiple of said submultiple of the predetermined frequency whereby degenerative feedback from said first non-linear amplifying device to said second non-linear amplifying device is produced and whereby said multiple frequency is equal to said predetermined frequency minus said submultiple frequency, and means for providing an output from at least one of said tuned circuits.

12. A regenerative frequency dividing circuit as in claim 11 including a third circuit connected to the electron collecting element of said second device, said third circuit being tuned to a frequency

$$m \frac{f_0}{n}$$

where f_0 is the predetermined frequency and m and n are independent integers.

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