Nov. 26, 1946. P. F. G. HOLST ET AL 2,411,573

FREQUENCY COUNTER CIRCUIT

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Fig. 1.

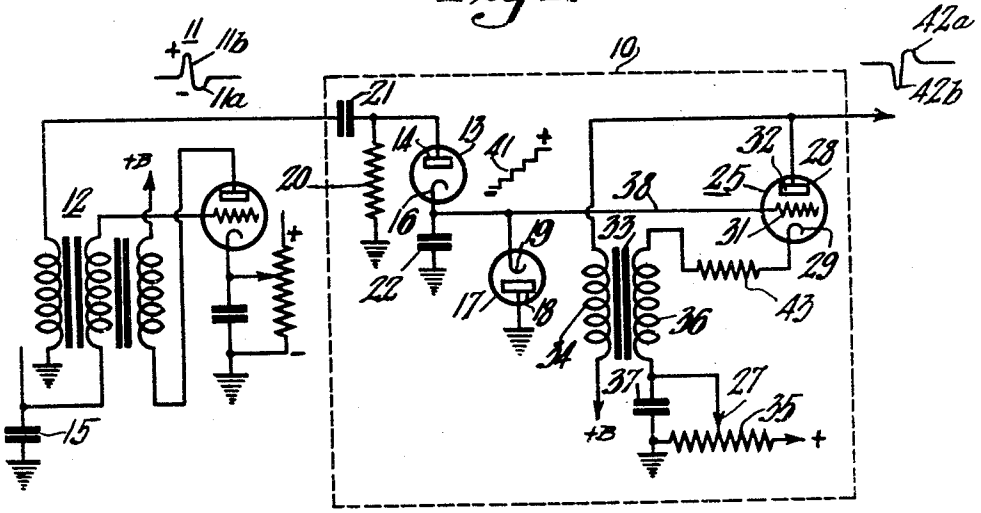


Fig. 2.

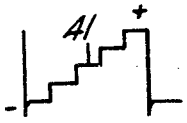
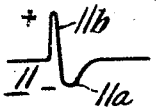


Fig. 3.



INVENTORS.
Paul F. G. Holst
& Loren R. Kirkwood
BY
C. O. Fuske
ATTORNEY

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FREQUENCY COUNTER CIRCUIT

Paul F. G. Holst and Loren R. Kirkwood, Oaklyn, N. J., assignors to Radio Corporation of America, a corporation of Delaware

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8 Claims. (Cl. 320—1)

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The invention covered herein may be manufactured and used by or for the Government of the United States for any governmental purpose without payment to us or assigns of any royalty thereon.

Our invention relates to frequency counter or frequency divider circuits of the type wherein pulses of current are applied through a diode or the like to a storage capacitor so that the voltage across the capacitor changes in steps.

An object of the present invention is to provide an improved counter circuit that is operated by voltage pulses comprising a positive voltage swing followed by a negative voltage swing.

A further object of the invention is to provide an improved frequency counter or divider circuit that is not affected by the negative part of the voltage pulses.

A further object of the invention is to provide an improved frequency counter or divider circuit in which each incoming pulse produces only one well defined step in the voltage across the storage capacitor.

A still further object of the invention is to provide an improved counter circuit that is always properly reset or returned to its original condition by its triggering of the blocking oscillator included in the counter circuit.

In a preferred embodiment of the invention the input or charging capacitor of the counter is provided with a resistor leak in place of the diode commonly used for discharging it at the end of an applied positive pulse. A diode is connected between the input capacitor and the storage capacitor so that current pulses flow into the storage capacitor only in response to applied positive pulses. Each applied positive pulse raises the storage capacitor potential one step until it is high enough to trigger the blocking oscillator. Each time said blocking oscillator is triggered, the storage capacitor is discharged by the grid current of the blocking oscillator tube. Preferably, a diode is connected across the storage capacitor with such a polarity that it will discharge the storage capacitor when the blocking oscillator has driven the voltage across it below ground potential.

Other objects, features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing in which

Figure 1 is a circuit diagram of one preferred embodiment of the invention and Figures 2 and 3 are graphs that are referred to in explaining the operation of the circuit shown in Fig. 1.

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Fig. 1 shows a frequency counter enclosed within the rectangle 10 embodying the present invention. The counter 10 in the example shown has pulses 11 applied to it from a blocking oscillator 12 that produces pulses having the positive portions 11*b* and preceding the negative portions 11*a* (Figs. 1 and 3). For the purpose of illustration, it is assumed that the blocking oscillator 12 is part of a conventional counter circuit that has a counter storage capacitor 15 included in the oscillator grid circuit.

Our improved counter circuit 10 comprises a diode 13 having an anode 14 and a cathode 16, a diode 17 having an anode 18 and a cathode 19, an input or charging capacitor 21, and a storage capacitor 22. The diode 13 is connected in series with the capacitors 21 and 22 in the polarity required for the positive pulses 11*b* to apply a charge to the capacitor 22. As in customary counter circuit design, the charging capacitor 21 is of small capacity compared with that of the storage capacitor 22.

After the positive part 11*b* of each pulse 11 occurs, the resulting charge on the capacitor 21 is removed by a leak resistor 20 which is connected from the diode side of capacitor 21 to ground. In the usual counter circuit the function of the leak resistor 20 is performed by a discharge diode whose anode is connected to ground and whose cathode is connected to the anode of diode 13. The advantage in the use of a leak resistor 20 of the correct value will be explained hereinafter.

The oscillator portion of the counter circuit 10 is preferably a blocking oscillator 25 that comprises a triode tube 28 having a cathode 29, a grid 31 and an anode 32. A transformer 33 having a primary 34 and a secondary 36 is provided to couple the plate circuit to the cathode circuit. The low potential end of the secondary 36 is bypassed to ground through a filter capacitor 37; also it is connected through a variable tap 27 to a positive bias voltage on a potentiometer resistor 35. The high potential end of the secondary 36 is coupled to the cathode 29 through a relatively small resistor 43 (of 33 ohms resistance, for example) whose function will be discussed more fully later in this description.

The grid 31 of the blocking oscillator tube 28 is connected through a conductor 38 to one side of the storage capacitor 22. Thus, when this side of the capacitor 22 becomes sufficiently positive with respect to ground, the tube 28 will commence to conduct a current and the resulting oscillation will produce a pulse. It will be understood that the tube 28 is normally blocked by the

positive bias potential applied to the cathode 29 from the tap 27 on the potentiometer 35.

The diode 17 is connected across the storage capacitor 22 in the polarity required to discharge capacitor 22 in the event that it is charged to a negative potential with respect to ground when the oscillator 25 is triggered and goes through an oscillation. It may be noted that in counter circuits using a discharge diode in place of the discharge or leak resistor 20, the function of the diode 17 is performed by the discharge diode and the diode 13 in series.

The operation of the counter is as follows: The blocking oscillator 25 normally is blocked by the positive bias from the tap 27 on the resistor 35. That is, the oscillator tube 28 is biased beyond anode current cut-off by the positive voltage on its cathode 29.

Now when a series of positive pulses 11b is applied to the counter through the charging capacitor 21, the current pulse flow through the diode 13 into the capacitor 22 is in the direction to charge the storage capacitor 22 positive step by step with respect to ground potential. Each positive pulse 11b results in a current pulse and since the leak resistance 20 is high compared to the resistance of the diode 13, the effect of the leak resistance during the pulse period may be neglected. Under the above assumption, all current flowing to the storage capacitor 22 is obtained from the input capacitor 21, and both condensers will therefore become charged. Since the storage capacitor 22 has a far greater value than the input capacitor 21, the greatest voltage change will occur on the input capacitor 21. The total change in voltage across the two capacitors will equal the positive peak of the pulse. After the pulse 11 has reached its maximum positive voltage, and both condensers are fully charged, the current through the diode 13 will stop. The charge thus placed on the storage capacitor 22 cannot be conducted through the diodes 13 and 17, since this would require the diodes to conduct a current from their cathodes to their anodes. The storage capacitor 22 will therefore remain charged. On the other hand, the charge placed on the input capacitor will leak off through the resistor 20. The resistance value of the leak resistor 20 is made such that the charging condenser 21 will discharge during the time interval between successive applied pulses 11b, which interval is long compared with the duration of a pulse 11b.

The above described action produces across capacitor 22 the stepped voltage wave 41 (Figs. 1 and 2). The tap 27 is adjusted so that a predetermined number of pulses 11b will increase the voltage 41 to a value where the oscillator tube 28 begins to draw anode current. As a result, the oscillator 25 goes through one oscillation to produce the pulse 42a—42b, and the capacitor 22 is discharged by the grid current of the oscillator tube 28 during the time the oscillator grid is positive.

While it is desired to operate the blocking oscillator 25 with such an amplitude that a full discharge of the storage capacitor 22 is assured, it is not advisable to operate the oscillator at a much higher level on account of the large pulse currents which exist. If the resistor 43 is omitted, the pulse amplitude will be greatly in excess of the required amplitude. Resistor 43 is therefore added to limit the tube currents without injuring the performance of the counter circuit.

It will be apparent that by employing the leak resistor 20 in place of the usual discharge diode, each pulse will produce one well defined step in the voltage across the storage capacitor 22. Using a discharge diode, the charge on the input capacitor 21 will change during the voltage swing which follows the positive peak so that when the voltage swings in the positive direction after the maximum negative voltage another charge will be placed on the storage capacitor 22. Thus each pulse will place two charges on the storage capacitor 22, resulting in two steps instead of one well defined step. By employing our invention, this difficulty is avoided.

We claim as our invention:

1. In combination, a charging capacitor of comparatively small capacity, a unidirectional conducting device and a storage capacitor of comparatively large capacity connected in series in the order named, means for impressing a pulsating voltage across said series circuit, thereby causing said pulses to place charges on both capacitors, and a leakage resistor connected between the junction of the charging capacitor and said conducting device and the free plate of said storage capacitor, thereby substantially discharging the charging capacitor during the period between successive applied pulses.

2. In combination, a storage capacitor, a charging capacitor, a unilaterally conducting device connected between one plate of each of said capacitors for admitting current from said charging capacitor to said storage capacitor to charge it in a certain polarity, a leakage resistor connected between the junction of the charging capacitor and said conducting device and the other plate of said storage capacitor for discharging said charging capacitor, means for impressing a pulsating current between said other plate of the storage capacitor and the other plate of the charging capacitor, a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor if it starts to acquire a charge in a polarity opposite to said certain polarity, and a loading impedance across the storage capacitor for discharging the storage capacitor following a predetermined charge of said certain polarity thereon.

3. In combination, a storage capacitor, a charging capacitor, a unilaterally conducting device connected between one plate of each of said capacitors for admitting current from said charging capacitor to said storage capacitor to charge it in a certain polarity, a leakage resistor connected between the junction of the charging capacitor and said conducting device and the other plate of said storage capacitor for discharging said charging capacitor, means for impressing periodic electrical pulses between said other plate of the storage capacitor and the other plate of the charging capacitor, a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor if it starts to acquire a charge in a polarity opposite to said certain polarity, and means comprising an oscillator connected across the storage capacitor for producing an electrical pulse and for discharging the storage capacitor in response to a predetermined charge of said certain polarity thereon.

4. In combination, a storage capacitor, a charging capacitor, a unilaterally conducting device connected between one plate of each of said capacitors for admitting current from said charging capacitor to said storage capacitor to charge

it in a certain polarity, a leakage resistor connected between the junction of the charging capacitor and said conducting device and the other plate of said storage capacitor for discharging said charging capacitor, means comprising a blocking oscillator for impressing periodic electrical pulses between said other plate of the storage capacitor and the other plate of the charging capacitor, said periodic pulses having positive and negative portions, a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor if it starts to acquire a charge in a polarity opposite to said certain polarity, and means comprising an oscillator connected across the storage capacitor for producing an electrical pulse and for discharging the storage capacitor in response to a predetermined charge of said certain polarity thereon.

5. A frequency counter comprising a charging capacitor, a unilateral conducting device and a storage capacitor connected in series with each other, said device being connected in the polarity required for an input pulse of a certain polarity to cause current flow into said storage capacitor to charge it at said certain polarity when it is applied to said charging capacitor, a leak resistor connected between ground and the junction point of said charging capacitor and said unilateral conducting device, said leak resistor having a resistance value such as to discharge said charging capacitor at the end of each applied pulse, and an oscillator comprising a vacuum tube having an electrode connected to the high potential side of said storage capacitor, said oscillator being normally blocked and being adjusted to oscillate to produce a pulse in response to said storage capacitor being charged to a predetermined potential of said certain polarity, and a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor in the event that it starts to charge at a polarity opposite to said certain polarity.

6. A frequency counter comprising a charging capacitor, a unilateral conducting device and a storage capacitor connected in series with each other, said device being connected in the polarity required for a positive input pulse to cause current flow into said storage capacitor when it is applied to said charging capacitor, a leak resistor connected between ground and the junction point of said charging capacitor and said unilateral conducting device, said leak resistor having a resistance value such as to discharge said charging capacitor at the end of each applied positive pulse, and an oscillator comprising a vacuum tube having a grid connected to the high potential side of said storage capacitor, said oscillator being normally blocked and being adjusted to oscillate to produce a pulse in response to said storage capacitor being charged to a predetermined positive potential, and a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor in the event that it starts to charge negatively with respect to ground.

7. In combination, a blocking oscillator comprising a vacuum tube having an anode, a control grid and a cathode, a storage capacitor to which said grid is connected, a charging capacitor and a unilateral conducting device connected in series with each other and said storage capacitor, said unilateral conducting device being connected in the polarity required to produce a positive charge on said storage capacitor in response to the application of a positive input pulse to said charging capacitor, and a second unilateral conducting device connected across said storage capacitor in the polarity required to prevent said storage capacitor from acquiring a negative charge, and a leak resistor connected between ground and the junction point of said charging capacitor and said unilateral conducting device to discharge said charging capacitor at the end of each positive input pulse.

8. A frequency counter comprising a charging capacitor, a unilateral conducting device and a storage capacitor connected in series with each other, said device being connected in the polarity required for a positive input pulse to cause current flow into said storage capacitor when it is applied to said charging capacitor, a leak resistor connected between ground and the junction point of said charging capacitor and said unilateral conducting device, said leak resistor having a resistance value such as to discharge said charging capacitor at the end of each applied positive pulse, and a blocking oscillator comprising a vacuum tube having a grid connected to the high potential side of said storage capacitor and having input and output circuits coupled through a transformer having a primary and a secondary, one end of said secondary being connected to the cathode of said tube, and the other end of said secondary being connected to a point of positive bias, and a second unilateral conducting device connected across said storage capacitor in the polarity required to discharge said storage capacitor in the event that it starts to charge negatively with respect to ground.

PAUL F. G. HOLST.
LOREN R. KIRKWOOD.