

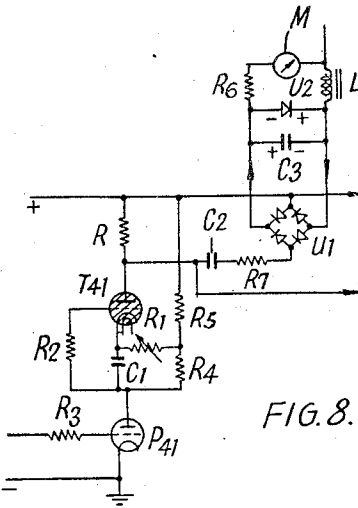
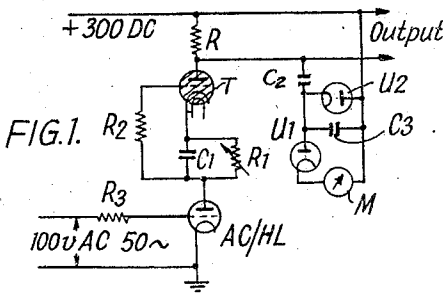
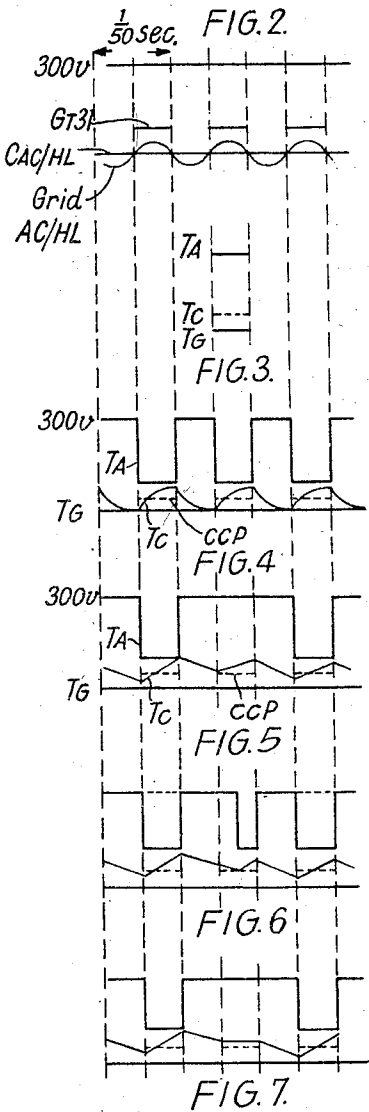
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SYNCHRONIZED PULSE PRODUCER

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## SYNCHRONIZED PULSE PRODUCER

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This invention relates to electrical frequency dividers of the kind comprising a grid-controlled discharge device or "Thyratron" (a registered trade-mark) having an anode load impedance with output terminals, a time constant cathode circuit of parallel resistance (which may be variable) and capacity of appropriate values, the grid of said tube being connected, preferably through a resistance, to the end of said time constant circuit remote from the cathode, and the aforesaid combination being subjected to a supply frequency voltage so that there may be obtained from said output terminals pulses having a frequency which is a sub-multiple of that of the input supply.

Heretofore the voltage of supply frequency has been applied across the whole combination above specified, and with this arrangement the output pulses of sub-multiple frequency are of sinusoidal wave form in nature, so that, if sub-multiple frequency pulses of rectangular wave form were required, the output pulses would be passed over a network of appropriate and per se known form.

The object of the present invention is to provide simple and effective means for deriving low power outputs of substantially rectangular wave form and at accurate sub-multiples of supply frequencies.

According to the present invention pulses of rectangular type and of supply frequency are applied to the "Thyratron" by means of a hard valve having its anode connected to the time constant circuit and having the sinusoidal supply voltage applied between the grid and cathode, the supply voltage being sufficiently high to cause this hard valve to saturate rapidly, whilst direct current anode supply is preferably used for the "Thyratron."

It has been found advantageous in some cases to divide the resistance of the time constant circuit into two portions, one of which is conveniently variable whilst the junction point of these resistances is connected through an appropriate relatively high resistance to the positive supply of the "Thyratron" whereby a backing-off current is passed at every half-cycle, thus preventing the discharge of the time constant circuit condenser until the cathode potential attains the required value. By this feature the operation of the frequency divider proceeds sharply and with certainty from one sub-multiple of the supply frequency to the next.

According to a subsidiary feature of the invention the frequency divider is provided with an output frequency meter in the form of a milliamme-

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ter or the like connected to the output terminals of the frequency divider in association with a rectifier system.

To enable the invention to be clearly understood it will now be described with reference to the accompanying drawings, in which:

Fig. 1 is an electrical diagram illustrating the simplest form of frequency divider in accordance with the invention and including also a simple arrangement of output frequency meter.

Figs. 2 to 7 inclusive are graphs illustrating the operation of the arrangements illustrated in Figs. 1 and 8, and

Fig. 8 is an electrical diagram illustrating the preferred arrangement in accordance with the invention, including the preferred output frequency meter system.

Referring first to Fig. 1 of the accompanying drawings, at T is shown the "Thyratron" having the anode load resistance R, the time constant cathode circuit comprising the condenser C1 and resistance R1, the latter being preferably variable, and the grid current limiting resistance R2. If the "Thyratron" T is a "Mazda" T.31 ("Mazda" being a registered trade-mark) suitable values for C1 and R1 are 4 microfarads and 10,000 ohms respectively whilst the resistance R2 may be 500,000 ohms.

The "Thyratron" T is controlled by a supply frequency sine wave voltage which is applied to a hard triode AC/HL, the grid of which has the sinusoidal supply voltage applied to it, the "Thyratron" receiving its operating power from the direct current source. As shown the hard triode AC/HL has its anode connected to the time constant circuit C1, R1 and has the supply voltage applied to its grid, preferably through a resistance R3 which may be of 5000,000 ohms. This hard valve may be a "Mazda" valve type AC/HL and the supply voltage may be 110 volts, so that during every positive half-cycle the hard valve will be caused to saturate rapidly, thus impressing voltages of sufficiently rectangular type form upon this "Thyratron" combination to cause it to generate substantially rectangular pulses of sub-multiple frequency.

Referring to Figs. 2, 3 and 4, it may be assumed that the circuit shown in Fig. 1 has its parameters chosen for any particular value of the division factor  $n$ ; then the hard valve AC/HL only conducts when the "Thyratron" conducts, although it becomes conducting for a period of half-a-cycle during each cycle. The application of the 110 volts alternating supply to the grid of the hard valve through the resistance R3 ensures that

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when the hard valve does conduct it saturates rapidly, thus ensuring the application of a substantially square wave form to the "Thyratron" which in turn produces a substantially square wave form output across the load resistance R.

If the "Thyratron" T.31 does not conduct the wave forms at various points are as shown in Fig. 2 wherein the sinusoidal wave is that applied to the grid of the hard valve AC/HL, the cathode potential CAC/HL of which is the horizontal base line. The anode supply voltage on the "Thyratron" is assumed to be 300 volts direct current and the periodic grid potential of the "Thyratron" is represented by the three lines GT31. Thus, under these conditions the voltages applied to the "Thyratron" are as shown in Fig. 3 wherein TA is the anode voltage, TC the cathode voltage and TG the grid voltage of the "Thyratron" during each inadequate positive half-cycle of the voltage applied to the grid of the hard valve AC/HL. There is a critical "Thyratron" cathode potential TC (Fig. 3) such that if the cathode potential is higher than this the grid biasing of the "Thyratron" is too high for the "Thyratron" to fire.

Assume now that the circuit of Fig. 1 is set to operate with  $n=1$ , then during each cycle of the supply frequency the "Thyratron" conducts for a period of  $1/100$  second and its anode potential falls. During each conduction period of the "Thyratron" the condenser C1 becomes charged causing the "Thyratron" cathode to become positive with respect to the "Thyratron" grid. During each non-conducting half-cycle of the "Thyratron" the condenser C1 discharges through the resistance R1 and the "Thyratron" cathode potential falls to such a value during the half-cycle that the "Thyratron" is not too strongly biased to fire on the next half-cycle. These conditions are shown by Fig. 4 wherein TA represents the "Thyratron" anode voltage, TG the "Thyratron" grid voltage, CCP the critical cathode potential of the "Thyratron" and TC the pulsating potential of the "Thyratron" cathode.

If now the value of the time constant resistance R1 is increased the discharge rate of the condenser C1 is reduced until at the beginning of the next half-cycle the bias of the "Thyratron" is too great for firing, so that for the purpose of illustration it may be assumed that  $n=2$ , as indicated by Fig. 5. By further increasing R, a succession of values 2, 3, 4, 5 . . . for  $n$  may be obtained.

It was found under certain circumstances in practice that conditions indicated by Fig. 6 were sometimes obtained, that is, the operation of the circuit during increase of resistance R1 did not proceed sharply from one sub-multiple of frequency to the next. To avoid this possibility it was arranged that if the "Thyratron" did not fire immediately at the beginning of the half-cycle of positive voltage on the grid of the hard valve, the "Thyratron" would be prevented from firing at all during that half-cycle, and this was achieved by dividing the resistance R1 into two portions, R1 and R4, as shown in Fig. 8, and connecting the junction point of the resistance parts R1 and R4 to the positive supply to the "Thyratron." In this way a "backing-off" current was caused to flow at every such half-cycle in question, to prevent the discharge of the time constant condenser C1. This current is that of the circuit of the resistances R5 and R4 and thence through the hard valve. The resultant

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wave forms are indicated by Fig. 7. It will be appreciated that this modification may in some cases prevent operation of the circuit for values of  $n=1$  and possibly 2, necessitating reduction of the capacity of the time constant condenser C1 such as from 4 to 2 microfarads, thus reducing the voltage developed across it and requiring a reduction in the value of the resistance R4 in order to prevent the voltage developed across this resistance by the backing-off current from becoming so small as not to prevent the discharge of the condenser C1 during those conducting half-cycles of the hard valve for which the "Thyratron" was non-conducting. It was found that with C1=2 microfarads, R4=3,000 ohms and R5=50,000 ohms, the circuit covered the frequency division range of  $n=1$  to 14.

The simple output frequency meter shown in Fig. 1 may be a small milliammeter M supplied from the output leads through a condenser C2 and rectifier or rectifier system U1 so that the meter measures the rectified current. The meter may be calibrated and its scale chosen to give readings of full supply frequency and sub-multiples thereof. The rectifier U2 is added to render the law of the meter scale more nearly linear by by-passing current as the voltage across a smoothing condenser C3 increases with the higher frequencies of operation.

In Fig. 8 is also shown the preferred form of frequency meter comprising the milliammeter M supplied from the output circuit of the "Thyratron" with unidirectional current through the condenser C2, resistance R7 and rectifier bridge U1 with smoothing condenser C3, smoothing choke L, resistance R6 and bridging rectifier U2, the latter being provided to render the law of the scale of the meter M more nearly linear by by-passing current as the voltage across the condenser C3 increases with the higher frequencies of operation. The resistance R7 serves to limit the current through the rectifiers on the initial charging of the condenser C2 when the high tension supply is switched on.

In the final arrangement adopted as the result of experiments the "Mazda" "Thyratron" T.31 was replaced by a "Mazda" "Thyratron" type T.41 and the hard valve "Mazda" AC/HL was replaced by a "Mazda" type P.41.

We claim:

1. An electrical frequency divider, comprising a thermionic discharge device having an anode provided with a load impedance and output terminals, a cathode having a time constant circuit connected thereto, and a controlling grid connected to said circuit remote from the cathode, a source of sinusoidal supply frequency, and means connected to receive said sinusoidal supply frequency and connected to said time constant circuit for subjecting said discharge device to voltages of said supply frequency and of substantially rectangular form whereby substantially rectangular pulses of sub-multiple frequency are generated.

2. An electrical frequency divider, comprising a thermionic discharge device having an anode provided with a load impedance and output terminals, a cathode having a time constant circuit connected thereto, and a controlling grid connected to said circuit remote from the cathode, a source of sinusoidal supply frequency, and a valve having a cathode and grid connected to said sinusoidal supply frequency, and an anode connected to said time constant circuit.

3. An electrical frequency divider according to

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claim 2, wherein said valve is a hard valve, and the anode thereof is connected to said time constant circuit at a point remote from its connection to the cathode of said discharge device.

4. An electrical frequency divider according to claim 2, including a source of direct current for exciting the anode of said thermionic discharge device. 5

5. An electrical frequency divider according to claim 2, wherein said time constant circuit comprises resistance and capacity in parallel. 10

6. An electrical frequency divider according to claim 2, including means for connecting the positive side of a source of direct current supply to the anode of said thermionic discharge device, and wherein said time constant circuit comprises resistance and capacity in parallel, said resistance being divided into two portions and having the junction point of said portions connected to said positive supply for said thermionic discharge device. 15

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