Laboratory and Shop Notes

A Linear Current Regulator

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CONVENTIONAL vacuum-tube current regulators are effective in maintaining a current at a predetermined value, accounting for their widespread use in the familiar electronically regulated power supplies. In some applications, however, it is desirable to have the controlled current respond linearly (or in some other specified fashion) to changes in some mechanical controlling device; and the ordinary circuits do not satisfy this condition, since their linearity depends upon that of an associated dc amplifier. To be sure, any desired approximation to linearity can be obtained by increasing the gain of this amplifier, but for many purposes a sufficiently linear regulator of adequate stability becomes unnecessarily complex. The simple circuit described here is novel in that its linearity depends upon that of no element except a single helical potentiometer, which is inexpensively available to linearity tolerances of 0.1 percent or better.

The circuit appears in Fig. 1. In its over-all geometry it is similar to the conventional circuits mentioned above, but differs in the use of an ac supplied thyratron followed by a diode and an integrating circuit in place of the usual dc amplifier. By virtue of the "all or nothing" character of the thyratron plate current characteristic, the "operating point" of this element does not change over the controlling range; and this may be regarded as accounting for the linearity of the circuit.

In the absence of any thyratron pulses, the load current I gradually increases toward its zero bias value as the grid potential of the 6L6's decays through the integrating network. Eventually in this process, however, a point is reached beyond which the thyratron is allowed to fire on each peak of its alternating plate voltage. The train of negative pulses which thus appear on the plate of the diode recharges the 6L6 grid leak capacitance until the thyratron grid returns to the cut-off region and I again begins to drift toward saturation. If the helipot is now rotated slowly, the controlled current follows in a linear manner. The amplitude and frequency of the hunting are determined by the circuit constants, and the conditions imposed will depend on the application to which the circuit is to be put. The original model of the regulator was designed to provide a linear time variation of magnetic field in a nuclear magnetic resonance spectrometer, so that useful absorption line profiles could be plotted automatically on a chart recorder. The circuit values of Fig. 1 were used, with R_4 a magnet winding of several thousand henries inductance, and the helipot was driven by a gear train attached to a 1-rpm synchronous motor. Records of current as a function of time were made with a Brown recording potentiometer, and no observable deviations from linearity occurred even when a purely resistive load was substituted for the magnet winding. The maximum controlled current with three triode-connected 6L6's in parallel is about 160 ma.

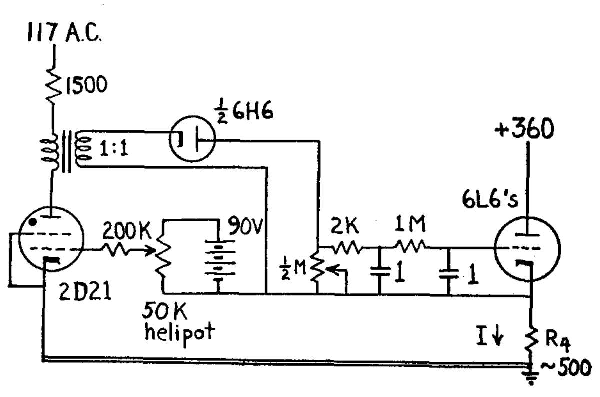

FIG. 1. The helipot is provided with a synchronous motor drive, which changes the battery contribution to the thyratron bias in a linear way with time.

A possible difficulty lies in the well-known tendency for the firing point of a thyratron to drift occasionally. Modern gas tetrodes such as the 2D21 are less subject to this instability, and no change of the controlled current from this source has been observed.

By replacing the 60-cycle plate supply of the 2D21 with an oscillator of higher frequency and reducing the time constants of the integrating network, it should be possible to adapt this circuit to the production of more rapid current changes. In this way it should be possible to speed up the response to the point at which conventional sawtooth generators become useful.

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A Hodoscope Unit with the Neon Lamps Normally Off

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IN many cosmic-ray experiments it is desirable to obtain the data with a hodoscope unit. These units can be operated in either of two ways:

A. The neon lamps are normally off. When the event that is to be recorded occurs, the corresponding lamps ignite for a time long enough to photograph adequately. The camera shutter is kept open and therefore the only camera mechanism needed is the one to change the frame after it has been exposed.

B. The neon lamps are normally on. When the event to be recorded occurs, the corresponding lamps are extinguished for a short time. The camera shutter is normally closed and when the event happens it is triggered by the master pulse of the hodoscope unit.

It has been our experience and that of many investigators[1,2] that method *A* is very unrealiable because of a curious phenomenon shown by neon lamps. After being kept in the dark for a time exceeding 10 or 15 min neon lamps do not strike readily even when a voltage twice as large as the normal striking voltage is applied. With a continuous voltage, the lamp might take even two seconds before it strikes. In our hodoscope unit, the voltage applied to the lamps is obtained from a univibrator with a pulse width of 0.16 sec. If the lamps do not ignite every time they receive a pulse from the univibrator, the data obtained from the hodoscope unit can be very misleading.

In method B, since the lamps are normally on, they can not possibly remain ignited when the potential across the electrodes disappears. Nevertheless, in this method, the timing of the camera shutter has to be very precise because the picture will be spoiled if the shutter opens too soon or closes too late.

We have investigated the behavior of neon lamps kept in the dark for extended periods, and when exposed to visible and to ultraviolet light and have found very interesting results:

1. Neon lamps will strike readily if exposed to sunlight, artificial light, or ultraviolet light when the pulse from a univibrator is applied to the lamps. A. G. E. 4*W* Ozone lamp with an ultraviolet transmitting filter was used as the source of ultraviolet light.

2. The lamps take some time to become quiescent (meaning by "quiescent" that they do not strike readily). This time seems to be of the order of 15 min as a minimum, but it varies within very wide limits for different lamps.