

FIG. 1—Simple circuit diagram for thyatron-controlled electro-magnetic system (A) and grid control via hand-capacitance bridge (B)

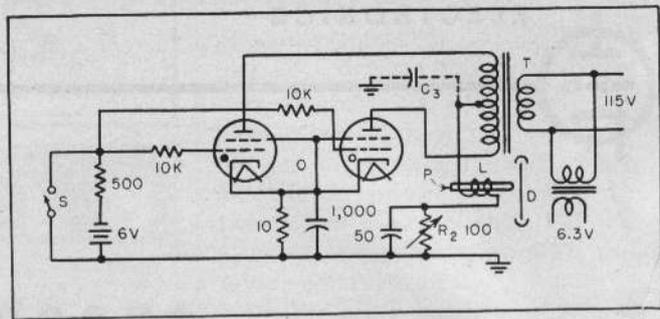


FIG. 2—Practical direct a-c type thyatron circuit free from mechanical contacts. Thyratrons are connected in push-pull arrangement

Electronic Drums

Tube-timed drums can develop much higher beat rates, with beats having more abrupt acoustical wavefronts than can be generated conventionally. Volleys of beats can be repeated indefinitely with precision and without change in quality

TWO WAYS of using a solenoid-actuated plunger to obtain drum beats have been developed.* One system uses contacts on a plunger with a single thyatron. The other uses a pair of thyratrons without plunger contacts. A coder can repeat a volley of drum hits.

Several techniques are possible for the input circuits. With the system shown in Fig. 1A, the performer uses one, two or three fingers to operate a feather-light contact spring *S* to generate voltage pulses. The pulses operate the output stage *O* driving the electromagnetic system *LMP*. Finger operation, although effortless in terms of the driving power of the spring contact *S*, is just as tiresome in the long run as the conventional, manual drum-stick operation.

Figure 1B shows a hand-capacitance bridge *CZ₁Z₂Z₃E'* used to eliminate the work represented by the driving power of the spring. Moving one or more fingers in the air causes unbalance of the bridge and a pulse output to be im-

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proved by pulse-shaping networks.

While 60-cycle operation of the bridge is possible with the impedances *Z₁*, *Z₂* resistive and *Z₃* capacitive, better results have been obtained with 400-cycle operation and phase compensation.

Pulse Forming

The main problem in electronic operation of a drum lies in the forming of proper pulse-power output and the utilization of this output under high-efficiency conditions in an oscillating electromechanical system of required transient response. This response should be characterized by short rise and decay time and freedom from jitter, overshoot and multiple hits.

There are two reasons for multiple hits on single pulses generated via the switch *S*. One consists of undesirable transient response and the other of power-supply pulsations when a-c or poorly filtered d-c is used.

The first experimental model built consisted of a class-C, push-pull beam-tube circuit, which was discarded because of insufficient output. The second model at first utilized one thyatron tube (2050 or 2D21) in the circuit shown in Fig. 1 and yielded good efficiency and sufficient output. In the accompanying photograph, the electromagnetic moving system can be seen on top of the drum (it may be mounted inside the drum) and the electronic circuit chassis on the bottom of the U-shaped wooden rack, serving as support and transport case.

The electromechanical system in Fig. 1A consists of a solenoid *L* surrounded by a bell-shaped laminated iron yoke *M* of about two inches axial length, inside which a plunger or laminated slug *P*, moves axially. The design is similar to that of a hypothetical field-coil-operated electrodynamic loudspeaker in which the center, cylindrical core would be free to move back and forth in axial direction, sliding in the concentric air gaps of the ends of the cylindrical core.

* U. S. Patent Appl.
Nr. 191,550.



Operator playing the electronic drum. The electromagnetic system is mounted above the drum diaphragm

The black part of the slug in Fig. 1A is laminated iron, the white part is a brass extension carrying the glove-skin-covered button that hits the diaphragm or drum skin *D*. The stroke is approximately $\frac{1}{2}$ inch. The slug *P* is spring-loaded away from the drum skin *D* and just prior to the hit it breaks the contact *S*, thus discontinuing the thyatron plate current.

Since the cathode potential restoration is determined by the time constants R_1C_1 , R_2C_2 and that of the moving system with the capacitor C_3 , and since the contact *S* is only closed a few hundredths of a second, the thyatron will not fire again when the slug approaches its rest position away from the drum skin. The design should be such that one complete cycle of operation has a period shorter than the interval between two sequential pulses on the thyatron tube grid. Actually, the circuit elements R_1C_1 , C_3 , C_2 are included to show various ways to influence the transient performance.

To be useful, the electromagnetic system must have rather uncon-

ventional characteristics, particularly in view of the fact that the power level approaches or exceeds one kilowatt. The proper solution in obtaining precise operation lies basically in the adaptation of negative-feedback principles and essentially in the use of a servo-type loop. Simple circuits in accordance with this principle were tried on the first hard vacuum-tube model but were not found equally applicable to the thyatron model.

Damping Systems

Good results have been obtained by applying nonlinear mechanical damping to the moving system. With electromagnetic transducers, one method consists of sidewise spring loading of the moving slug with the spring loading released by the magnetic field. In the ON stroke, the slug rides free in the well-oiled airgaps, while in the OFF stroke, the slug rides with high friction. It stops dead against the rubber cushion catching the slug at the end of the OFF stroke.

By use of such methods, it was possible to excite the magnet

forcefully almost during the entire ON stroke. The limit is set by the heat dissipation in the coil *L*, causing it to burn out. Coil resistances from 10 to 100 ohms were tried.

Due to the high peak power required by the unit, the power-supply problem is somewhat difficult. Since portable instruments are of interest, power supplies utilizing such sources will have to be designed.

Improved Version

A new circuit, Fig. 2, was developed to cut in half the uncertainty of the starting time. With this circuit, one of the two push-pull plate-connected tubes will fire each 120th second. Since unfiltered a-c is used, heavy and expensive power-supply components are eliminated. The entire power supply may consist of a line transformer *T*. In both this and the previous circuit, volume is controlled by a series resistor R_2 of a few hundred ohms in the electro-magnet lead.

One of the most important features of the circuit in Fig. 2 is that the switch in series with the electromagnetic system has been eliminated. The unfiltered a-c used extinguishes the thyatrons repeatedly. This circuit has been used with satisfactory results but the acoustical power delivered by the drum was too high for comfortable listening in a living room.

For still larger outputs, needed to operate large bass drums in concert and dance halls, heavier types of thyatrons may be inserted and a heavier line transformer used. The power drawn from the line may then exceed that comfortably handled by a 15-amp house fuse.

One of the recorders, or coders, used in the development work described, consists essentially of a motor-driven drum with spokes which close a switch momentarily during rotation. When used as a signal generator in laboratory experiments, this device produced and repeated endlessly a volley of drum hits.

More reliable recorders may be built in form of magnetic wheels or rings or may utilize reels of magnetic tape. The simplest arrangement is to use a conventional tape recorder, followed by proper pulse-shaping circuits.