SHORT COMMUNICATIONS

A CIRCUIT FOR THE OPERATION OF A SYNCHROTRON IN CONJUNCTION WITH A WILSON CLOUD CHAMBER*

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The output of betatron and synchrotron accelerators consists of a regular succession of pulses of a few microseconds duration. This fact is generally of little consequence in applications involving integrating exposures of detecting apparatus. The use of nuclear emulsions to detect disintegration products from nuclei and the induction of artificial radioactivity are the most important examples of this group. With the Wilson cloud chamber, however, it is essential to limit the irradiation of the cloud chamber to one or two output pulses which are timed to occur during the sensitive period following expansion of the chamber. The intense ionization produced by an accelerator, which is operated to give continuous output, paralyses the chamber and prevents the formation of tracks which are separately distinguishable.

The following account deals with a circuit allowing control of the number and timing of the X-ray pulses from a 14 MeV. electron synchrotron when operated in conjunction with a rubber diaphragm-type cloud chamber which has been described previously (Darby and Swan 1948). The chamber automatic control mechanism causes expansions to occur approximately once per minute and a timing signal for the circuit is derived at the completion of the movement of the expansion valve. Thus the synchronizing action is started at the beginning of the sensitive time, regardless of variations in the time taken for the mechanical motion. This signal gives rise to a gate pulse of variable duration which allows one of the periodically occurring electron injection trigger pulses to pass on and fire the injection modulator. After the time taken for acceleration, about eight milliseconds, an X-ray pulse is produced which occurs well within the sensitive time of most cloud chambers.

This method has the advantage of causing the least possible interference with the independent operation of the accelerator or cloud chamber. As it requires the continuous operation of the magnetic field of the accelerator, it might be undesirable for large accelerators, for which the amount of power dissipated between expansions would prove uneconomical. However, a similar method of synchronization has been successfully employed by Gaerttner and Yeater (1949) for a 70 MeV. synchrotron used in conjunction with a fast cycling expansion chamber.

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The Circuit and Its Action

The downward motion of the chamber valve assembly closes the contacts of a microswitch (S_1) which causes the thyratron in the A.C. synchronizing circuit (Chute 1943, V_1 in Fig. 1) to fire. This circuit is energized from the same A.C. supply which delivers power to the magnetic field of the accelerator and

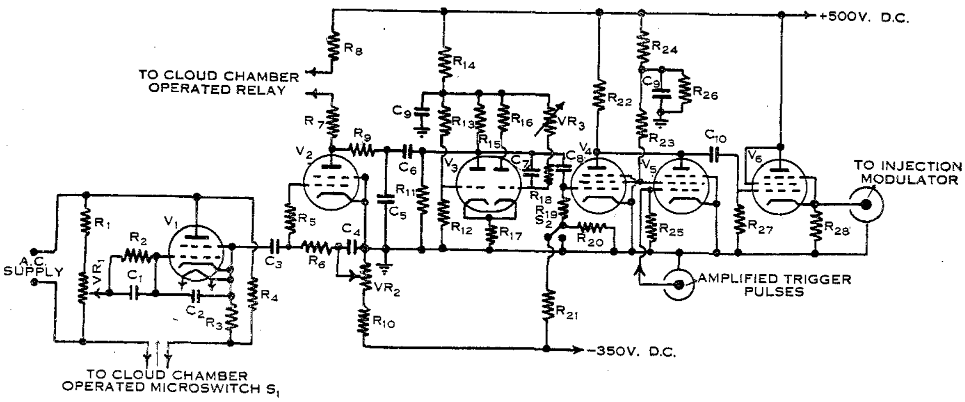

Fig. 1.—Schematic circuit diagram.

Valves

V_1, V_2	2050	V_4, V_5, V_6	6AC7
V_3	6SN7–GT		

Resistors

R_1, R_2, R_7, R_8, R_{11}, R_{21}, R_{27}	500,000 Ω	R_{14}, R_{15}, R_{28}	20,000 Ω
R_3	3,000 Ω	R_{16}, R_{17}, R_{23}	10,000 Ω
R_4, R_6	50,000 Ω	R_{19}, R_{20}, R_{25}	100,000Ω
R_5	5,000 Ω	R_{22}	250,000 Ω
R_9	50 Ω	R_{24}	60,000 Ω
R_{10}, R_{18}	1 MΩ	R_{26}	150,000 Ω
R_{12}	25,000 Ω	VR_1	250,000 Ω
R_{13}	75,000 Ω	VR_2, VR_3	1 MΩ

Condensers

C_1	2 μF.	C_5	0·1 μF.
C_2	0·005 μF.	C_7	0·2 μF.
C_3, C_6	0·0001 μF.	C_8	0·5 μF.
C_4, C_9	8 μF.	C_{10}	0·02 μF.

its purpose is to synchronize the subsequent timing sequence relative to the electron injection phase in the vicinity of zero magnetic induction. A small adjustable delay governed by the R–C values in the control grid circuit of V_1 allows fine timing control, if desired. As long as the microswitch is depressed, V_1 will conduct on alternate half-cycles and a train of positive timing pulses is delivered from the differentiating circuit connected to the cathode of V_1. Passing to the next stage, the first timing pulse will discharge condenser C_5. Subsequent pulses are blocked by the previous interruption of the high tension supply to

V_2, conveniently effected by means of a relay operating from the chamber control circuits. The output pulse from V_2 triggers a multivibrator (V_3) which responds by forming a negative gate pulse of adjustable width. In this way, the motion of the valve assembly gives rise to a synchronized gate pulse at the output from V_3.

In order to time the injection process, the trigger pulses are derived from a small peaker strip in the accelerator magnet fringing field. After sufficient amplification, each one of these pulses is made to cut off one valve (V_4) of a Rossi coincidence circuit. The synchronized gate pulse when applied to the second Rossi valve (V_5) produces the desired coincidence output pulse which then proceeds to trigger the injection modulator via a cathode follower stage (V_6). The width of the gate pulse is usually adjusted to allow only one coincidence pulse to occur. The modulator incorporates the required amount of discrimination.

Operation

In order to put the combined system into operation, it is first necessary to run the accelerator on normal continuous operation during which time the various controls can be adjusted to their optimum settings for maximum output. For this purpose, the switch (S_2) allows the application of a fixed bias to cut off V_3, and so every trigger pulse will fire the modulator, and the accelerator works at the normal rate. After the desired operating conditions have been achieved, S_2 is opened and the circuit is ready for single pulse operation. Bias of V_2 is adjusted to cause the thyratron to fire on the steepest portions of the timing pulses. Finally, by means of a manually operated microswitch which simulates the motion of the cloud chamber, the output pulse is again adjusted to a maximum by altering slightly the injection phase control. A monitor ionization chamber recording the intensity of each X-ray pulse as well as a triggered high speed cathode ray oscillograph are almost indispensable for this purpose. By means of the oscillograph, it is possible to verify that the modulator fires once, and only once, while adjustments are made to the circuit prior to successful operation. Once operating, the circuit requires very little adjustment provided the magnetic field conditions are substantially unaltered. An occasional alteration of the injection phase setting, say once an hour in the present instance, is all that is necessary.

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