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AN INTERMITTENT SIGNAL SIMULATOR FOR INTERCEPT EQUIPMENT TESTING

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AN INTERMITTENT SIGNAL SIMULATOR FOR INTERCEPT EQUIPMENT TESTING

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May 17, 1950

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ABSTRACT

A signal simulator has been designed and constructed to produce artifically the signal intercepts of rotating radars. It consists essentially of a pulse generator circuit (to simulate a transmitted signal) and a mechanical-optical gating unit (to simulate the rotating antenna patterns) and is intended for use inconjunction with standard r-f signal generators. The pulse generator produces pulse trains of variable pulse repetition frequency and variable pulse width, while the gate allows the pulses to modulate the r-f generator, which delivers the required signal to the receiver input. In actual tests the equipment proved satisfactory, certain minor limitations being noted.

PROBLEM STATUS

This is an interim report on this problem; work is continuing.

AUTHORIZATION

NRL Problem R06-17R (BuShips Problem S-1255.3 AR-R)

NE 071233

AN INTERMITTENT SIGNAL SIMULATOR FOR INTERCEPT EQUIPMENT TESTING

INTRODUCTION

In comparative studies of different receivers and indicators it is desirable to simulate the signal that might be introduced at the receiver input by narrow-beam rotating radars and d-f intercept antennas. It is further desirable to simulate as many combinations of transmitting and intercept equipments as possible with a minimum number of changes. To achieve this goal it is necessary to provide variable pulse repetition frequency and pulse width for the simulated radar modulating pulse plus adjustable beam widths and rotation rates for the simulation of both radar and intercept antenna patterns. A satisfactory simulator meeting these requirements has been developed at NRL. For simplicity in construction of the equipment, the antenna patterns are simulated by rectangular gates.

THE PRINCIPLE OF OPERATION

The principle of operation of the complete equipment is apparent from the block diagram (Figure 1). The problem encountered was readily resolved into two parts. First, to provide a pulse generator circuit to simulate the transmitted

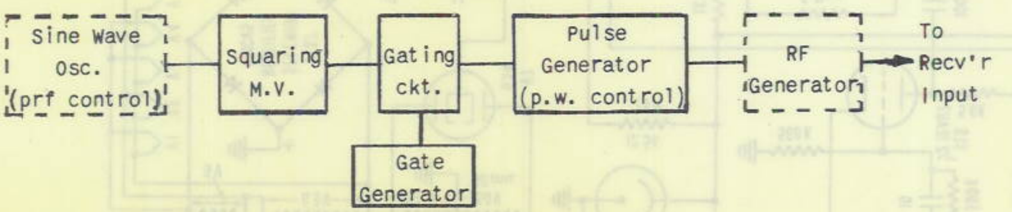

Figure 1 - Arrangement of components

signal (the upper row in the block diagram) and, second, to design a gate generating system to simulate the rotating antenna patterns (the lower block, Figure 1). The pulse generator produces pulse trains with variable pulse repetition frequency and variable pulse width. The gate, which allows these pulses to modulate the r-f generator and produce at the receiver input the required signal, is a relatively slow operating device and as such was constructed using a mechanical-optical system. Any r-f generator capable of external pulse modulation may be used.

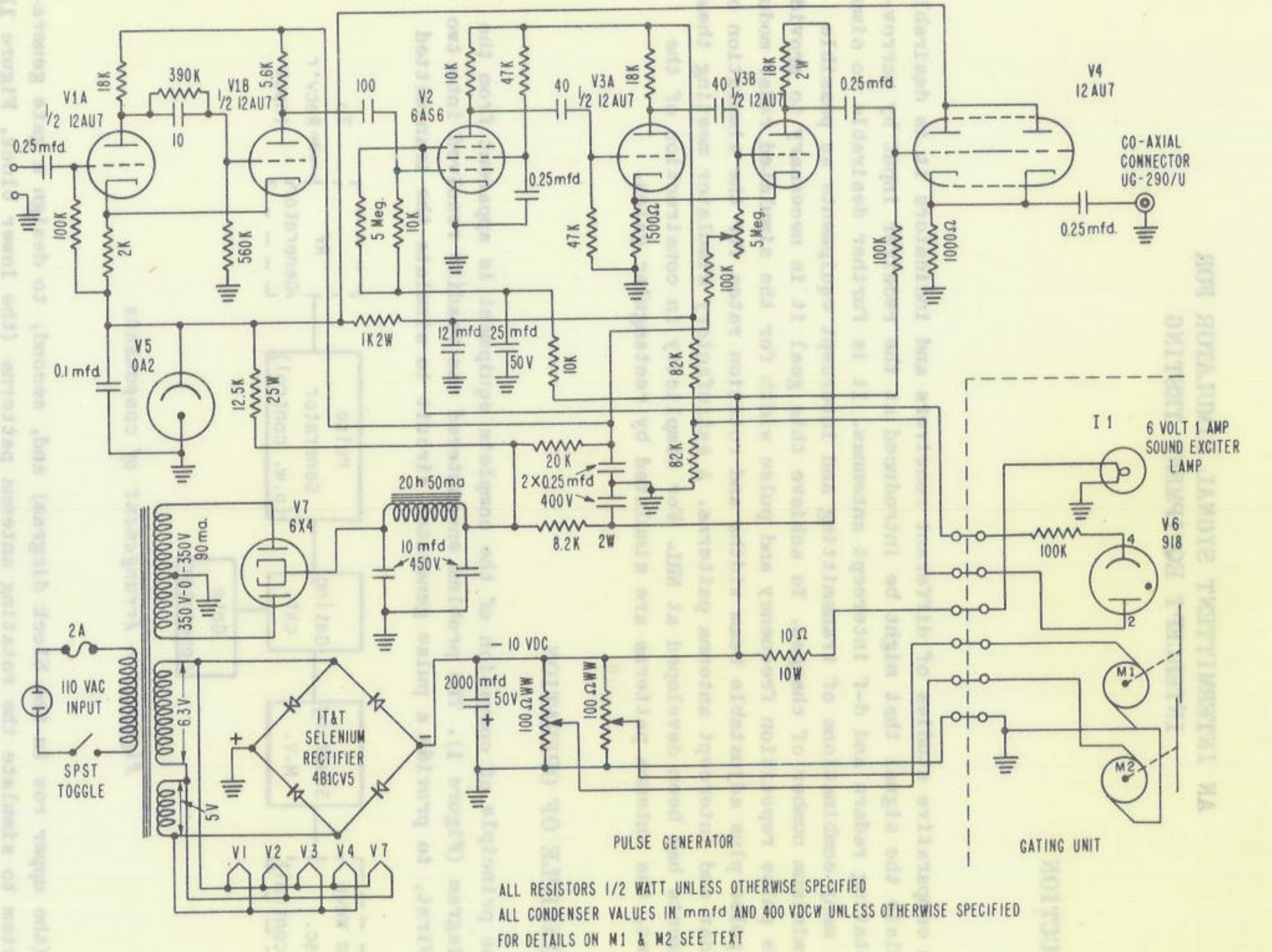

Figure 2 - Circuit diagram, pulse generator and gate

THE PULSE GENERATOR

To provide the pulse repetition frequency a variable frequency sine wave oscillator is used. The Hewlett-Packard 200 C is suitable. The output of the sine wave generator is squared through the use of a cathode-coupled d-c multivibrator (V1A & B, Figure 2) employing a 12AU7 tube. The output of the multivibrator is then differentiated and applied to grid 1 of the 6AS6 gating tube (V2, Figure 2). The signal from the gate generator is applied directly to grid 3 of the 6AS6. Grids 1 and 3 are normally biased to cut-off so that signals must be present on both grids simultaneously for the tube to conduct. Thus, only when the gate is "open" do the differentiated pulses from the first multivibrator appear on the plate of the gate tube. These negative pulses are differentiated by a network consisting of a 40-$\mu\mu$fd capacitor and a 47k resistor to derive from their trailing edges positive triggers which are applied to the grid of the first triode (V3A) of a one-shot cathode-coupled multivibrator (V3A & B). In the grid of the second triode (V3B) of this multivibrator is the 5-meg potentiometer which varies the pulse width from one to seven microseconds. The positive output of the pulse generator is fed through a cathode follower (V4) providing a low impedance at the output jack.

The pulse generator unit also contains the power supply for the complete equipment, including the motors and the light in the gate generator. To provide the required 10 volts d.c. for these motors an IT&T selenium rectifier (Type 4B1CV5) is used to rectify the voltage from the two filament windings in series. A 2000-μfd condenser provides adequate filtering for this supply. The filaments of all 12AU7 tubes are connected across the two secondaries in series to equalize the drain on the two filament windings. Although the filaments receive only approximately 11.5 volts, these tubes work satisfactorily in this application. Top and bottom views of the complete pulse generator are shown in Figures 3 and 4 respectively.

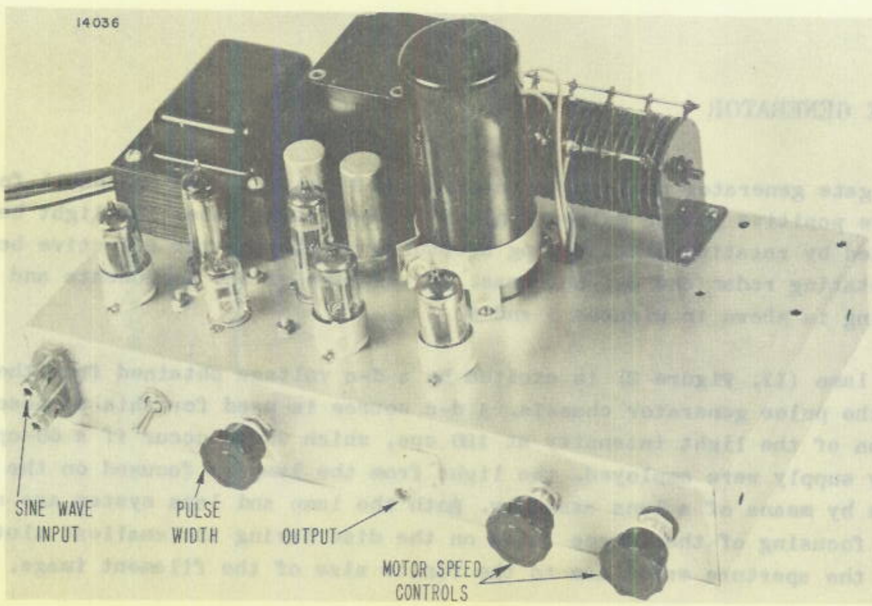

Figure 3 - Pulse generator, top view

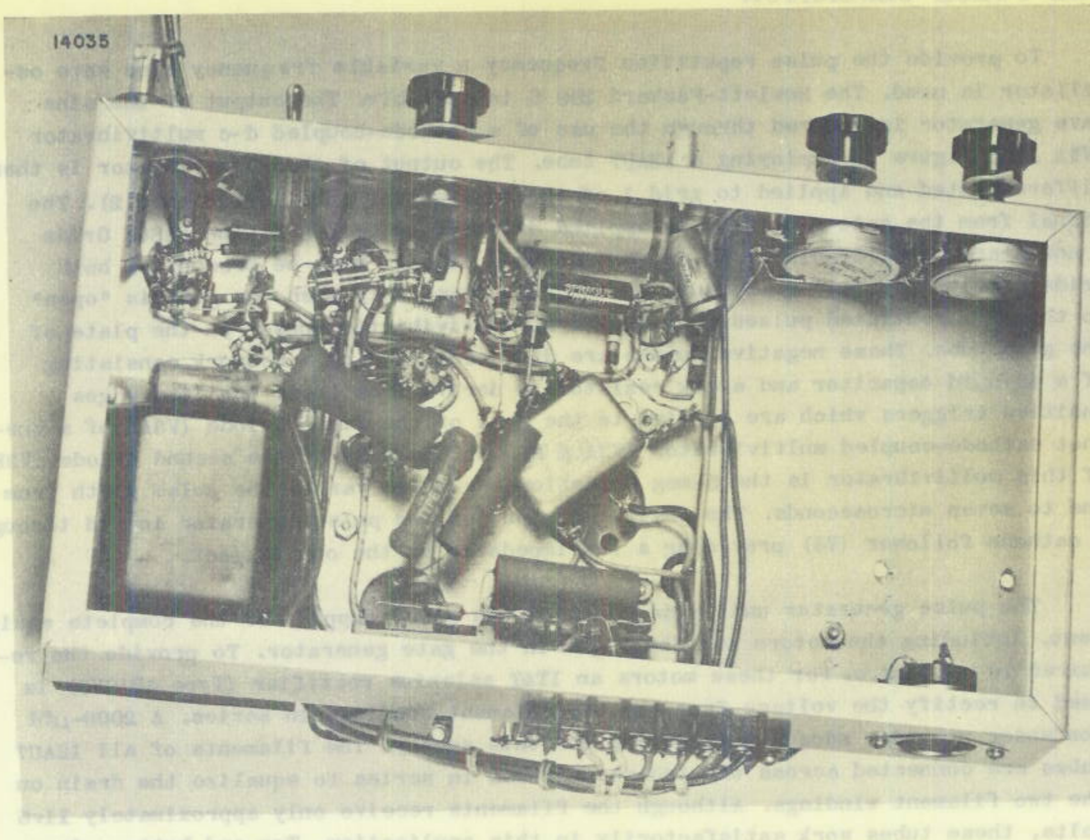

Figure 4 - Pulse generator, bottom view

THE GATE GENERATOR

The gate generator employs an interrupted light beam and photocell for producing the positive gating pulses applied to the gating tube. The light beam is interrupted by rotating discs having apertures simulating the effective beam widths of the rotating radar and d-f antennas. Arrangement of the components and associated wiring is shown in Figures 5 and 6.

The lamp (I1, Figure 2) is excited by a d-c voltage obtained from the power unit in the pulse generator chassis. A d-c source is used for this purpose to avoid modulation of the light intensity at 120 cps, which would occur if a 60-cps line frequency supply were employed. The light from the lamp is focused on the disc apertures by means of a lens assembly. Both the lamp and lens system are adjustable to allow focusing of the source image on the disc having the smallest slot, thereby reducing the aperture error due to the finite size of the filament image. Light

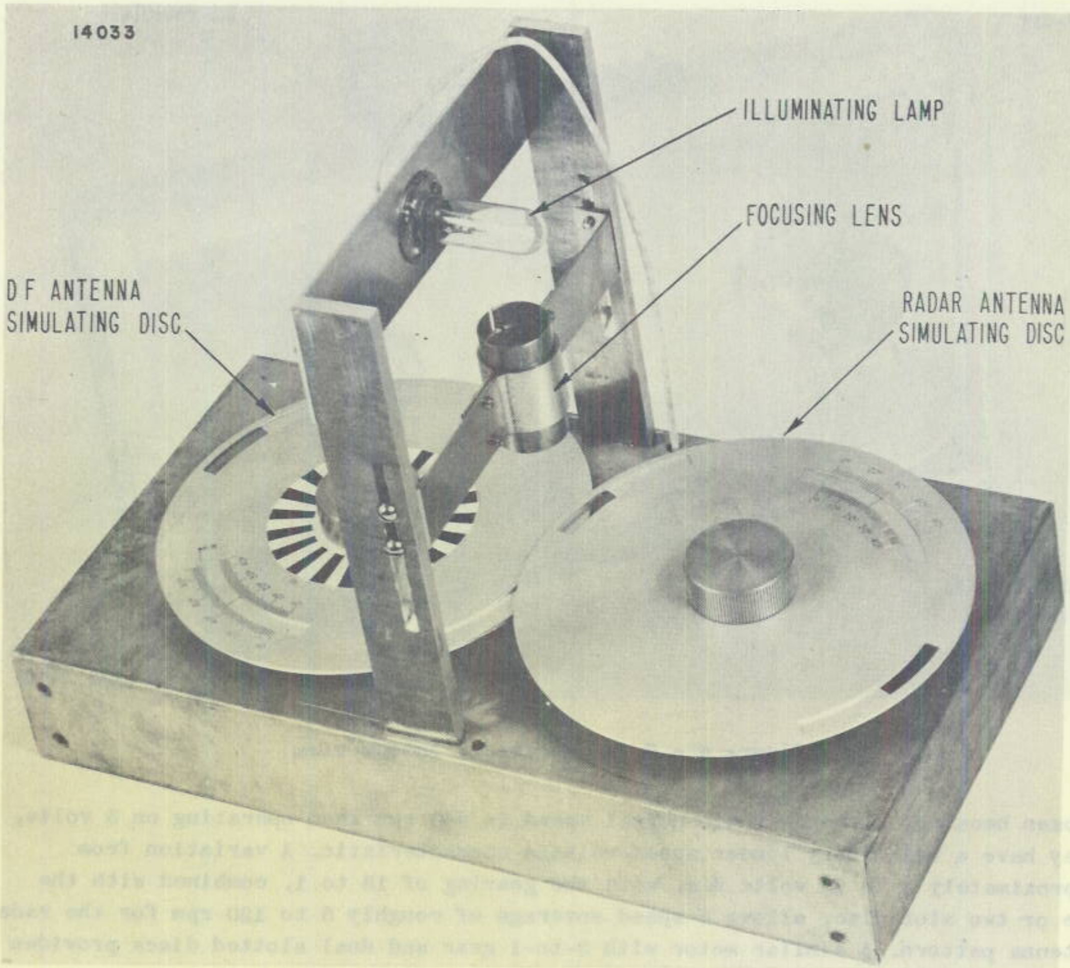

Figure 5 - Gate generator, top view

passing through the slots excites the phototube (V6 of Figures 2 and 6).

The discs are so constructed as to provide adjustable beam widths from 1 to 90 degrees and two ranges for speed control. To get this range of adjustment, either one or two slots per revolution of the disc may be used (Figure 7). This feature also allows an increased range of relative antenna rotation rate for less variation in motor speed. Two scales and two indexing marks are provided on the discs. To facilitate setting the beam width, one scale and associated index marker are red and the other scale and its marker are black.

The motors used (M1 and M2, Figure 2) are 5-volt d-c timing motors, series 9200, manufactured by the Haydon Mfg. Co.,[1] Forrestville, Connecticut. They were

[1] *These motors are presently available as d-c timing motors, series 5300, from the A. W. Haydon Company, Waterbury, Connecticut.*

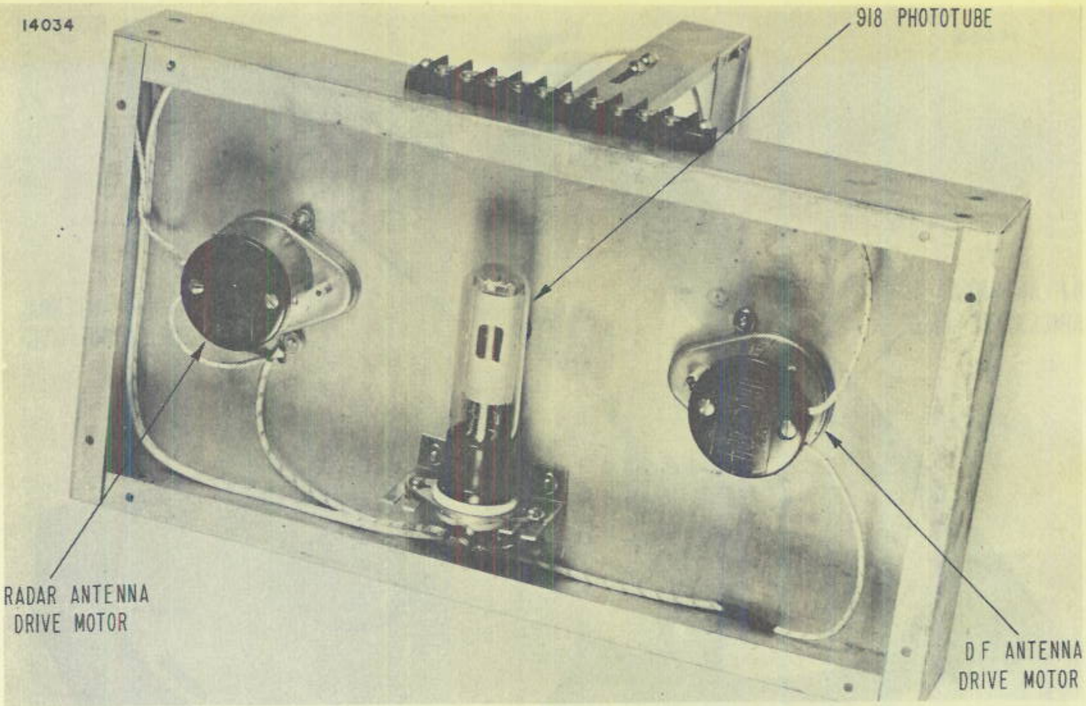

Figure 6 - Gate generator, bottom view

chosen because, although their normal speed is 900 rpm when operating on 5 volts, they have a relatively linear speed-voltage characteristic. A variation from approximately 2 to 12 volts d.c. with the gearing of 15 to 1, combined with the one or two slot disc, allows a speed coverage of roughly 5 to 120 rpm for the radar antenna pattern. A similar motor with 3-to-1 gear and dual slotted discs provides coverage from 30 to 600 rpm for the d-f antenna pattern. Though the motors were originally designed to provide normal speed at an input of 5 volts, they are rated for continuous operation at a maximum of 12 volts. The speed of the motors is ajusted by means of the 100-ohm, 2-watt potentiometers shown in Figures 2, 3, and 4.

The adjustment of speed on the radar antenna disc is checked by the use of a stop watch, a method only moderately accurate. Since, however, most of the present radar antennas are adjusted in this same manner, it was presumed to be sufficiently accurate for this equipment. In the test setup used with this equipment the speed of the intercept antenna disc was continuously monitored by a Hewlett-Packard electronic tachometer through the use of a stroboscopic pattern (Figure 5). The rate of rotation was also set with the aid of this instrument.

When the slots representing their respective antennas line up, the light from the lamp strikes the cathode of the type 918 phototube (V6, Figure 2) producing a positive voltage on grid 3 of V2, the gating tube. This allows pulses to modulate the r-f generator (such at Navy TS 403) for the duration of the gate as previously

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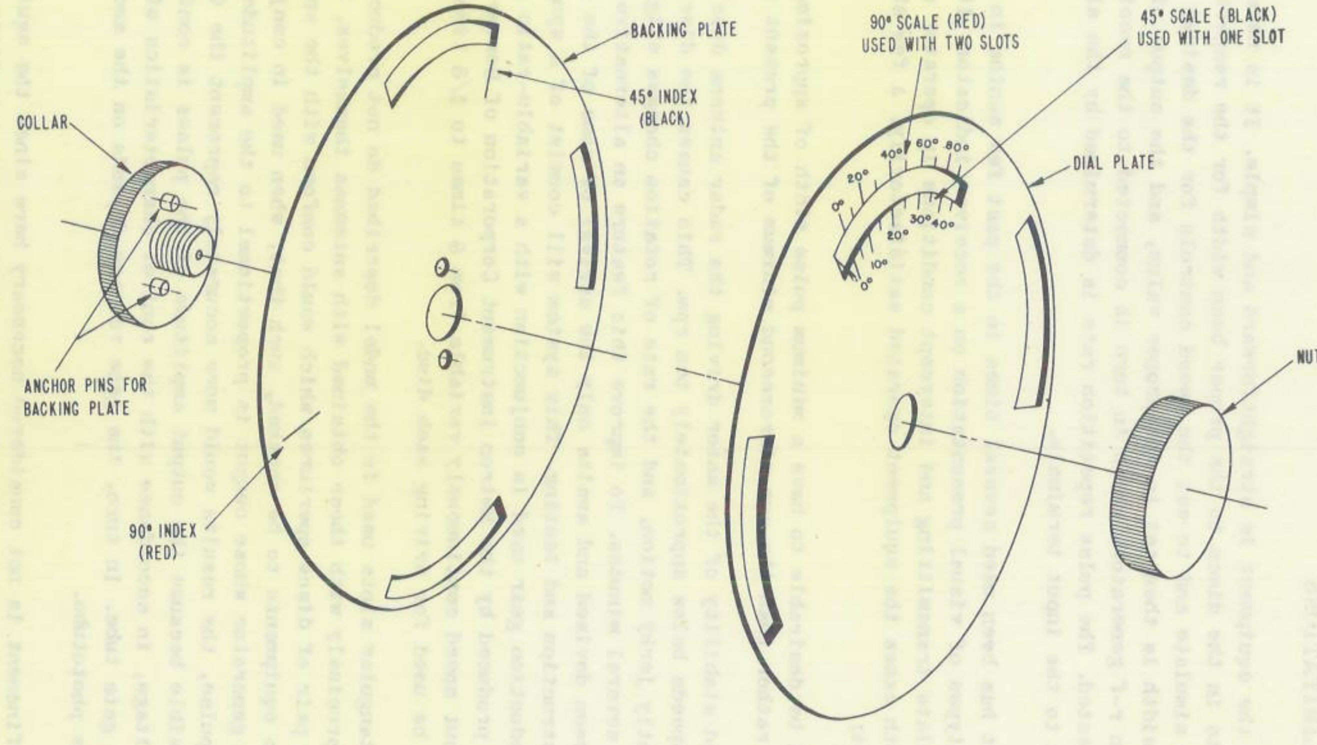

Figure 7 - Gating disc, exploded view

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explained. All voltages for this unit are obtained from the power supply in the pulse generating unit.

OPERATION AND LIMITATIONS

Operation of the equipment is straightforward and simple. It is necessary only to adjust the slots in the discs to the proper beam width for the respective equipments they are to simulate and to set the speed controls for the desired rotation speed. The pulse width is then set to the proper value, and the output of the unit is connected to an r-f generator, which in turn is connected to the receiver and indicator to be tested. The pulse repetition rate is determined by the sine wave frequency applied to the input terminals.

The equipment has been used several times in the past few months in the testing of different types of visual presentation on a receiver indicator. It has also been used to simulate transmitting and intercept conditions in operator and equipment tests. In both cases the equipment operated satisfactorily. A few shortcomings have been apparent:

1. It would be desirable to have a minimum pulse width of approximately 1/2 microsecond rather than the one-microsecond minimum of the present unit.

2. The speed stability of the motor driving the radar antenna disc is insufficient at speeds below approximately ten rpm. This causes the disc to rotate with a slightly jerky motion, and the rate of rotation changes slightly over a period of several minutes. To improve this feature an alternative drive system has been devised and awaits only the arrival of some of the components for its construction and testing. This system will consist of a synchronous motor and reduction gear used in conjunction with a variable-ratio gear box. The latter, produced by the Metron Instrument Corporation of Denver, Colorado, with an output speed continuously variable from 6 times to 1/6 times the input speed, will be used for driving each disc.

3. The rectangular slots used in the model described do not produce results conforming precisely with those obtained with antennas themselves. There could be cut in a pair of discs apertures which would conform with the antenna patterns of two equipments to be checked, such that, when used in conjunction with an r-f generator whose output is proportional to the amplitude of the modulating pulse, the results would more accurately represent the true condition. This is possible because the output amplitude of the pulses is controlled by the gate voltage, in accordance with the control characteristics of the third grid of the gate tube. In turn, the gate voltage depends on the amount of light striking the phototube.

But this refinement is not considered necessary here since the equipment is intended only as an approximate simulator for actual operating conditions.

CONCLUSIONS

An equipment has been developed which it is believed may be useful in comparing the effectiveness of different intercept equipments under actual operating conditions without the use of complete and complicated setups. There are also possibilities that the equipment might be used for training of personnel under simulated actual operating conditions, although no work has been carried on toward this end. Finally, the equipment offers the advantage of providing signal simulations using standard signal generators and receivers.

* * *

NAVY-DPPO PRNC. WASH., D.C.