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EXPANDED SWEEP ATTACHMENT FOR THE NR-33 INTERCEPT RECEIVER

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ABSTRACT

The expanded sweep attachment for the NR-33 intercept receiver consists of a storage oscilloscope and a triggered non-linear raster generator. Circuit diagrams and descriptions are given, as well as installation instructions.

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EXPANDED SWEEP ATTACHMENT FOR THE NR-33 INTERCEPT RECEIVER

- L.G. Cox -

INTRODUCTION

The expanded sweep attachment for the NR-33 intercept receiver consists of a triggered 3-line non-linear raster generator driving a Hughes "Memoscope" storage oscilloscope. This generator is called the "sweep generator" to distinguish it from the linear raster generator. The Memoscope and the original NR-33 receiver have been modified.

The first two lines of the display are semi-logarithmic. The first half of the top line is written in 1 millisecond and the full line in 10 milliseconds; the first half of the middle line is written in about 100 milliseconds and the full line in 1 second. The bottom line is linear, and is written in 4 seconds. The first line of the display enables modulation details of a signal to be seen, and the remainder gives an indication of the total length of the signal. The intelligence contained in the signal is not recorded.

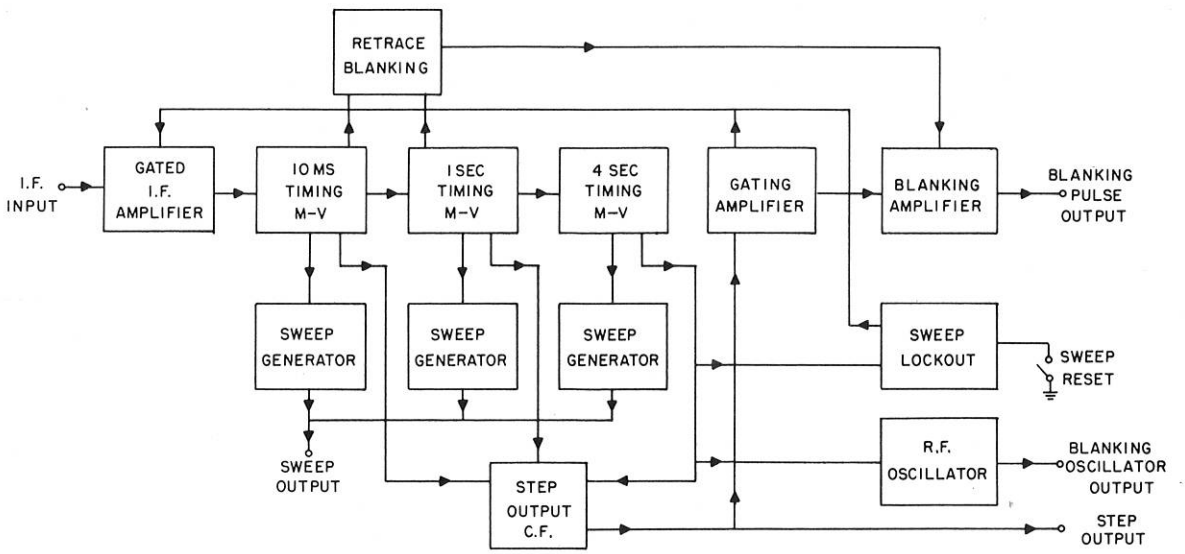


FIG. 1 BLOCK DIAGRAM OF SWEEP GENERATOR

GENERAL DESCRIPTION

The block diagram of the non-linear sweep generator is shown in Fig. 1. An intermediate-frequency signal exceeding the preset threshold level will trigger the 10-ms timing multivibrator, and its associated sweep generator will produce

a semilogarithmic two-decade sweep. The end of the 10-ms sweep will trigger the 1-second timing multivibrator, and a two-decade 1-second sweep will be produced. Similarly, the end of the 1-second sweep will trigger the 4-second timing multivibrator whose sweep generator will produce a linear sweep for the slow line. During the writing of the slow line a radio-frequency oscillator produces a small voltage to dim the Memoscope and minimize screen burning. A gating amplifier switches off the intermediate-frequency amplifier stage when the sweep starts, to prevent multiple triggering. At the conclusion of the slow sweep,the sweep lockout circuit operates a relay to hold the sweep generator inactive until the sweep reset switch is operated. The blanking amplifier and retrace blanking circuits blank the Memoscope, except during sweeps.

The Memoscope uses a differential Y preamplifier, with the intermediate-frequency signal applied to the A input. A step output obtained from the sweep generator is applied to the B input to produce vertical separation between sweeps.

CIRCUIT DESCRIPTION

Refer to Fig. 1 and the full schematic, Fig. 2.

V1 is an intermediate-frequency amplifier tube. When its instantaneous plate voltage is less than the level set by the threshold potentiometer R7 the two diodes coupling V1 to V2 will conduct, triggering V2.

The cathode-coupled multivibrator comprising V2, when triggered, will produce a 10-millisecond positive pulse at the plate of V2B. When V9B normally conducts its plate potential is almost zero volts, but the pulse from V2B raises the cathode potential of V9B to about +50 volts and cuts off the plate current. When V9B is cut off the capacitors in the plate circuit start charging at a rate controlled by R2, the 10 ms sweep length potentiometer. An analysis of the time-base circuit is given by Markell [1]. The plate of V9B is coupled to the sweep output terminal by cathode follower V9A. When the positive pulse from the plate of V2B ends V9B starts conducting again and rapidly discharges the two sweep capacitors.

When V2B starts conducting again, the negative-going voltage change at its plate triggers the one-second multivibrator comprising V3. The operation of V2-V9 is almost identical to that of V3-V10. Owing to the larger sweep capacitors used it was necessary to have some capacitive coupling between the plate of V3B and the grid of V10B to ensure a rapid flyback at the end of the second sweep.

Operation of V4 is similar to that of V2 and V3. V11 is a linear sweep generator. As the voltage across the 4 mfd sweep capacitor rises, the voltage at the junction of the 220K charging resistor and the NE2 diode rises similarly owing to the

constant potential across the diode. This ensures a constant charging current and a fairly linear sweep. The three sweep circuits are coupled to the sweep output terminal by means of three cathode followers V9A, V10A, and V11A sharing a common cathode load. Only the cathode follower with the most positive grid will conduct appreciably.

The Memoscope contains a 10-mc/s oscillator which is used to blank the Memotron, except during sweeps. The brightness must be reduced during the slow line, but capacitive coupling of the 4-second dimming pulse would require an excessively large coupling capacitor to prevent differentiation. Hence, the oscillator tube V12B provides a small voltage which is applied in series with the main blanking oscillator output in the Memoscope. When V11B is conducting normally, the junction of the 15K and 68K resistors in its cathode circuit is at -30 volts, and V12B is cut off. When V11B is cut off, V12B starts to conduct and then oscillates. If a positive step voltage is applied to the grid of V12B the circuit will not oscillate; the 100K and 0.1 mfd network allows a gradual rise of grid potential which permits oscillation. The dual choke in the heater circuit of V12 minimizes 10-mc/s leakage and radiation from the power cable.

The step output voltages are derived from the three timing multivibrators. There are 220K current-limiting resistors and diode clamps from the plates of V2B, V3B, and V4B to +170, +180, and +190 volts, respectively, which are obtained from a voltage divider between the +325 and +150 volt supplies. The resistor/diode junctions are connected through three other diodes to the grid of the step cathode follower V12A. When a multivibrator is not triggered the potential of its B plate is about +140 volts, which is applied to the grid of V12A. When one of them is triggered the B plate rises to +280 volts, the respective diode clamp conducts, and the clamp voltage is fed to V12A. The output from V12A is coupled to the step output terminal through three NE2 gas tubes in series to provide the desired average d-c potential, negative before the sweeps start and positive during sweeps.

The following circuitry is used to shut off the blanking oscillator of the Memoscope during sweeps, and to switch it on during retraces. The step voltage is applied to the grid of the gating amplifier (V6A) which is consequently cut off before the sweep starts and conducting heavily during sweeps. The center taps of the two pairs of resistors in series from the plate of V6A to the -150 volt line are positive before the sweeps occur and negative during the sweeps, biasing off both V1 and V6B. Similarly the output from V6B will be negative before the sweeps and positive during the sweeps. The positive pulse is used to gate off the blanking oscillator in the Memoscope. A three-millisecond multivibrator (V5), which is triggered by the end of the fast and medium sweeps, overrides the bias on V6B to provide retrace blanking.

The 150-volt voltage regulator comprising V8 supplies screen and plate voltages to V1, and also provides the proper voltages, through a bleeder, to the clamp diodes.

The sweep speed at the start of the first line is so great that additional brightening is required. When V2 is triggered the negative pulse from the plate of V2A is differentiated by a .02 mfd capacitor and an 82K plus 12K voltage divider, and the resultant negative pulse is applied to the Memotron cathode. A diode eliminates the positive blanking pulse which would occur at the end of the multivibrator pulse.

The amplitude of the first step at the step output terminal is only about five volts positive. This resulted in a delay of about a millisecond in switching off the Memoscope blanking oscillator at the start of the sweep. This delay was reduced to about 10 microseconds by driving the blanking pulse output terminal directly from a voltage divider placed between the plate of V2B and the cathode of V9B, through an auxiliary NE2 neon lamp. The output from the neon lamp is about -30 volts before the sweep starts, and +20 volts during the first line. Similarly, a differentiating circuit and a diode from the plate of V4B to the blanking pulse output terminal ensures rapid cutoff at the end of the sweeps.

Sweep lockout tube V7 is normally cut off with -20 volts bias. When the plate voltage of the multivibrator tube V4A rises rapidly, the grid of V7 is driven positive, and the tube conducts heavily. This closes the relay in the plate circuit. The relay has two sets of normally open contacts. One set applies negative bias to the grid of V1 to maintain the intermediate-frequency amplifier cutoff and prevent retriggering of the sweep generator. The other set grounds the control grid of V7 to keep V7 conducting and the relay closed until the sweep reset switch is operated.

MODIFICATIONS

a) Memoscope

Several minor electrical changes were made in the Memoscope. The time constant of the Memotron cathode brightening circuit was so small that the brightening waveform was being differentiated, so the 0.0015 mfd coupling capacitor was paralleled with a 0.1 mfd,3 kv capacitor. An attenuator consisting of two 470 ohm resistors in series was connected between the preamplifier A input socket and ground, the center point of the resistors being connected to the A input. This was done to reduce the intermediate-frequency input level compared with the step level, and was necessary because there is a common gain control for A and B channels. A BNC chassis connector was fitted on the right side of the Memoscope, and wired in series with the secondary of the 10 mc/s oscillator coil, to allow injection of a small-amplitude 10 mc/s signal to reduce brightness during the slow sweep. The final electrical modification was the addition of a Ferroxcube dual filament choke and two .01 mfd bypass capacitors at the input power socket to filter

the excessive 10 mc/s leakage and minimize radiation from the power cord.

Several mechanical modifications were made, principally to reduce vibration of components. Spacers were added at the center of the Fiberglas board supporting the main filter capacitors to reduce flexing, and a bracket was added from the rear of the preamplifier attenuator switch to the side rails for the same purpose. The transistor and the zener diode in the preamplifier power supply were tied down with nylon cord and polyfoam. Polyfoam blocks were wedged on top of the type 1X2 rectifiers of the cathode-ray tube supply to hold them firmly in place.

b) NR-33 Receiver

Most of the modifications of the NR-33 receiver affect the intermediate-frequency amplifier. An AGC system was incorporated in the intermediate-frequency amplifier to minimize triggering due to slow signal variations. This was accomplished by rectifying the output from the plate of the final intermediate-frequency amplifier stage and applying it to the signal grid of the mixer stage through a long time constant RC network. Since additional gain was necessary after the application of AGC, the value of the plate load resistor of the mixer stage was increased from 1K to 3.3K.

There was some distortion present in the intermediate-frequency output owing to loading of the cathode follower by the detector on large negative peaks; hence the audio detector was changed to a half-wave system. A detector current meter was added in series with the cold end of the volume control to allow the operator to set the intermediate-frequency level more easily. An additional intermediate-frequency output terminal was added to drive the expanded sweep generator. This terminal was fed by a .01 mfd discap from the cathode follower.

Two other changes were made in the NR-33 receiver. An extra power outlet socket was added to the distribution panel to supply power to the new sweep generator, and the two series Thyrite varistors in the regulated cathode-ray tube supply were replaced by a 3150 volt corona regulator, to give better regulation.

INSTALLATION

To install this equipment the following connections must be made:

1) NR-33 power supply to Expanded Sweep Generator
2) NR-33 intermediate-frequency output to Expanded Sweep Generator and to Memoscope A INPUT (A BNC T connector will allow this parallel connection)

3) Sweep reset switch and cable to SWEEP RESET
4) The following connections must be made between the Expanded Sweep Generator and the Memoscope:

   a) STEP OUTPUT to preamplifier B INPUT
   b) BLANKING PULSE to EXT BLANK
   c) BLANKING OSC to BNC connector on right side of Memoscope
   d) SWEEP OUTPUT to EXT SWEEP
   e) CATHODE BRIGHTENING to jacks on rear deflection plate board of Memoscope. The shield of the cable is connected to GRND, the center conductor to CATH.

5) Memoscope power cord to 115v 60 cycle supply

DO NOT SWITCH MEMOSCOPE ON YET!

OPERATION

After installing the Expanded Sweep Attachment first carry out the normal switching-on procedure for the NR-33 receiver. Before switching on the Memoscope, adjust controls as follows:

INT	-	fully counterclockwise
FLOOD GUN	-	off
STORAGE	-	fully counterclockwise

Then turn on the Memoscope, and adjust INT so that the dot on the control is about opposite the N of INT. Turn on the FLOOD GUN, and turn STORAGE about three-quarters on. The TIME/DIV switch must be at EXT SWEEP, X10. The preamplifier controls are adjusted as follows: MILLIVOLTS/DIV at 1000, MV/DIV MULTIPLIER at 2, and input selector at d-c (A-B).

Set the detector current at 40-50 μamp, operate the SWEEP RESET switch; the expanded sweep attachment is ready to operate as soon as a large enough signal is received by the NR-33 receiver. The sweep generator may be triggered by increasing the detector current momentarily, and the H POS, V POS, horizontal gain and preamplifier gain controls set to give a suitably positioned display of the proper size. The STORAGE control is set just above the point where the trace remains indefinitely, and the INT is adjusted to the lowest point at which the full width of all lines is written.

To reduce the possibility of damage to the Memotron tube, before switching off the Memoscope:

1) press ERASE button,
2) turn STORAGE control fully counterclockwise,
3) turn FLOOD GUN to OFF; then switch off Memoscope.

If the NR-33 is to be switched off before the Memoscope at any time, first remove the coaxial cable connected to the EXT BLANK connector on the Memoscope.

PRESET CONTROLS

The eight preset controls on the expanded sweep attachment are:

R1 - first line period - controls the period of the fast multivibrator V2.
R2 - first line length - controls the charging rate of the fast sweep capacitors.
R3 - second line period - controls the period of the medium multivibrator V3.
R4 - second line length - controls the charging rate of the medium sweep capacitors.
R5 - third line period - controls the period of the slow multivibrator V4.
R6 - third line length - controls the charging rate of the slow sweep capacitor.
R7 - threshold - controls the intermediate-frequency level necessary to trigger the fast multivibrator.
R8 - step level - adjusts the fast step output voltage.

The line period controls may be adjusted by using a triggered oscilloscope with a calibrated sweep or an audio oscillator with square wave output. The positive triggering voltage is obtained from the plate of V2B, and R1, R3, or R5 is adjusted to make the positive waveforms from the plate of V2B, V3B, or V4B end at 10 ms, 1 second, or 5 seconds after the trigger. If an accurate square wave oscillator is available, its output may be applied to the expanded sweep attachment instead of the intermediate-frequency output from the NR-33 receiver. With the oscillator set to 1000 cycles, the output level is increased until the sweep generator is triggered, and R1 is adjusted to give 10 complete cycles on the first line. Similarly with the frequency set to 20 cycles, R3 is adjusted to give 20 complete cycles on the first and second lines. R5 may be adjusted by means of a sweep second watch or clock.

After the period controls are adjusted, the line length controls are then adjusted to give three lines of the same length. The threshold control R7 is adjusted to make the sweep generator fire at about 60-70 microamperes detector current, and the step level control R8 is adjusted to make the level of the first step at the STEP OUTPUT terminal about +5 volts, as viewed with a d-c oscilloscope.

VOLTAGE CHART

The typical d-c voltages listed in the following table are given only as a guide.

Actual operating voltages may vary by as much as 20% owing to variations in resistor values and vacuum tube plate currents. All readings were taken with a vacuum-tube voltmeter.

TABLE I

TYPICAL VOLTAGES IN NON-LINEAR RASTER GENERATOR

TUBE NO.	TUBE TYPE	PIN NUMBER									NOTES
		1	2	3	4	5	6	7	8	9	
V1	6AH6	-35	0	*	*	+150	+150	0			1
V1	6AH6	0	+1.5	*	*	+120	+150	+1.5			2,3
V2	12AT7	+325	+12	+23	*	*	+130	+23	+23	*	3
V3	12AT7	+325	+12	+23	*	*	+130	+23	+23	*	3
V4	12AT7	+325	+12	+23	*	*	+130	+23	+23	*	3
V5	12AT7	+325	+12	+23	*	*	+130	+23	+23	*	3
V6	12AT7	+220	-30	0	*	*	+40	+0.5	0	*	1
V7	6AH6	0	+1.0	*	*	+290	+175	+1.0			1
V8	OA2	+150	0	-	0	+150	-	0			
V9	12AT7	+325	0	+6	*	*	0	0	-0.5	*	3
V10	12AT7	+325	0	+6	*	*	0	0	-0.5	*	3
V11	12AT7	+325	0	+6	*	*	0	0	-0.5	*	3
V12	12AT7	+325	+125	+130	*	*	+325	-27	0	*	1

Notes: * All tube heaters are operated at approximately +95 volts.
1 Lockout relay closed
2 Reset switch actuated
3 Sweep not triggered

COMPARISON OF DISPLAYS

The appearance of a short group of pulses on the NR-33 linear display and also on the expanded sweep display is shown in Fig. 3. The pulsed signal had equal on-off times, a 500-cycle repetition rate, and a duration of approximately 100 milliseconds. It may be noticed that the first line has a 10-μsec delay in starting, and

the second line a 3-μsec delay due to the retrace blanking voltage. These delays could be reduced by using separate retrace blanking multivibrators for the first and second lines, but this was not considered necessary.

CONCLUSION

The expanded sweep attachment was designed and constructed as a simple experimental addition to the NR-33 intercept receiver, to display amplitude modulation details and give an indication of the total length of a signal. The attachment will display modulation at rates as high as 50 kc/s, but does not include calibration facilities, or calibrated scales. Comparative calibration is possible by injecting the output of a square wave oscillator of suitable frequency after photographing the original display.

Acknowledgment

The author is indebted to Mr. G. Evans for many valuable suggestions and discussions.

Reference

1. Markell, J.H., "Non-linear Sweep Circuits for Countermeasures Indicators", NRL Report 3939, Feb. 7, 1952 (Confidential)

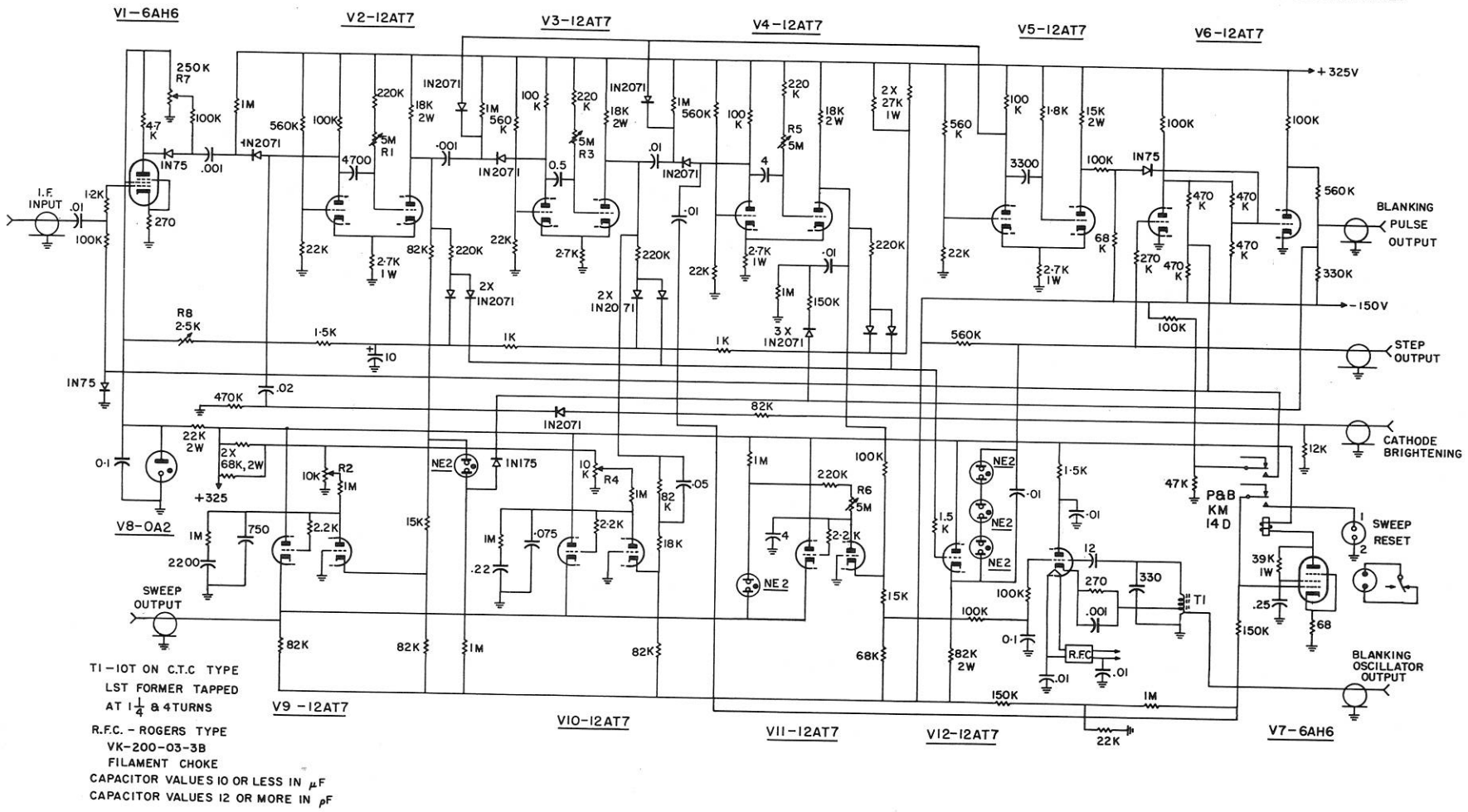
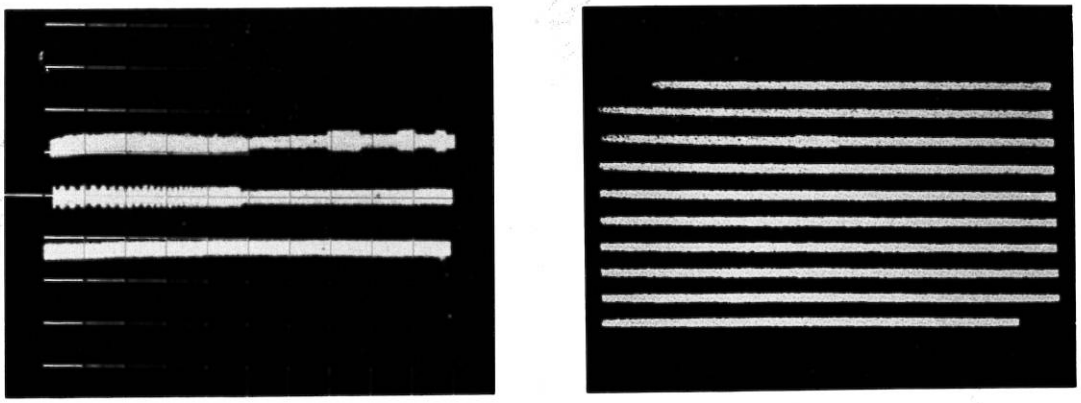
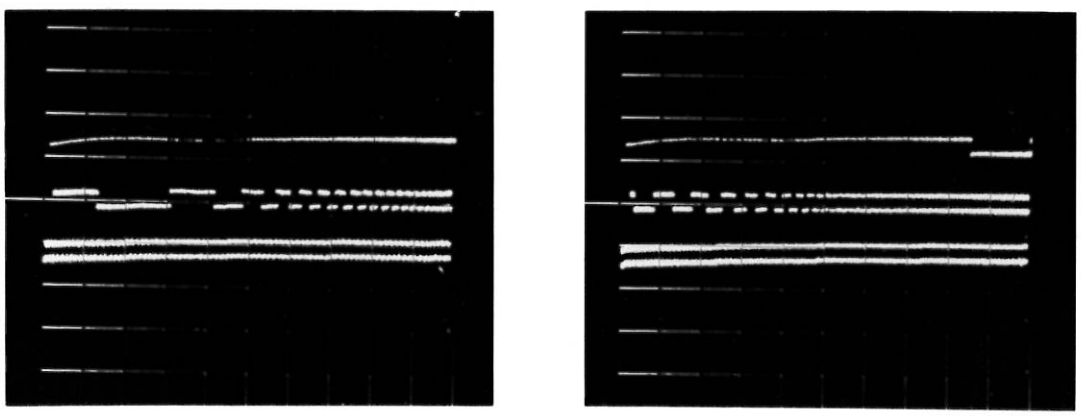


FIG. 2 CIRCUIT DIAGRAM OF SWEEP GENERATOR

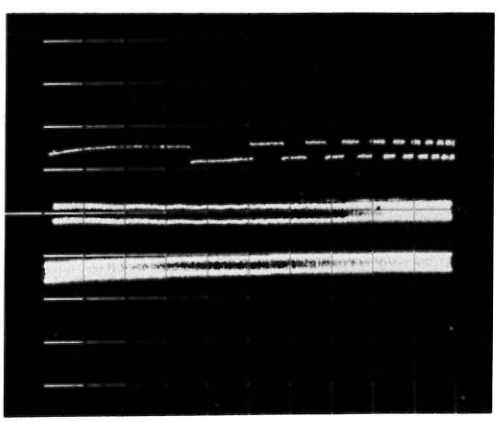


(a) EXPANDED SWEEP (b) LINEAR SWEEP

FIG. 3 NR-33 DISPLAYS WITH A SHORT PULSED SIGNAL



(a) 20 CYCLE (b) 100 CYCLE



(c) 1000 CYCLE

FIG. 4 EXPANDED SWEEP DISPLAY WITH SQUARE WAVE CALIBRATION