ELECTRICAL

FACILITY FORM 602

N65-24995 (ACCESSION NUMBER)

37 (PAGES)

CR 62961 (NASA CR OR TMX OR AD NUMBER)

(THRU) 1 (CODE)

09 (CATEGORY)

GPO PRICE $

OTS PRICE(S) $

Hard copy (HC) 2.00

Microfiche (MF) .50

AUBURN RESEARCH FOUNDATION

AUBURN UNIVERSITY

AUBURN, ALABAMA

DEVELOPMENT OF FM TELEVISION TRANSMITTER

DEVELOPMENT OF RADAR ALTIMETER RETURN PULSE MEASUREMENT SYSTEM

M. A. Honnell, Technical Director

MILLIMETER PROPAGATION STUDY

E. R. Graf, Technical Director

PREPARED BY
MICROWAVE RESEARCH LABORATORY

SECOND QUARTERLY REPORT
1 June 1964 to 1 September 1964
CONTRACT NAS8-11184

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

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SECOND QUARTERLY REPORT, CONTRACT NAS8-11184

Foreward:

The information contained in this report summarizes the progress made by the Electrical Engineering Department under the auspices of the Auburn Research Foundation of Auburn University toward the fulfillment of the requirements prescribed in NASA Contract, NAS8-11184. Monthly reports have been submitted prior to this writing. Progress has also been reviewed by telephone and in meetings with Mr. T. A. Barr, Contract Supervisor, National Aeronautics and Space Administration, Huntsville, Alabama and the personnel of Auburn University.

Personnel:

The following mentioned personnel have actively participated on the project during this reporting period:

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M. A. Honnell - Technical Director and Professor of Electrical Engineering

E. R. Graf - Technical Director and Associate Professor of Electrical Engineering

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H. K. Miller - Assistant Professor of Electrical Engineering

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24995 over

Summary:

This report pertains to the results of tests on the model six FM Television Transmitters, the development of the radar-altimeter instrumentation system, and the millimeter wave study.

Five FM Transmitters of the Model six series (Serial No. 6,8,9,10 and 11) were built and tested during this period. The results of these tests are included in this report.

The circuitry of the radar altimeter return pulse measurement system was placed on Vector boards and rack mounted. This report contains a description of all modifications made on the system during the reporting period.

Part of the equipment for the millimeter propagation study has been installed and preliminary tests have been run on a liner material for the propagation chamber. It was concluded that the material was satisfactory for this purpose. AUTHOR

I. DEVELOPMENT OF FM TELEVISION TRANSMITTER

M. A. Honnell, W. E. Faust, H. L. Deffebach, and G. N. Miller

The following transmitters were delivered to the NASA Astrionics Laboratory:

1. Model 6 Serial No. 6
2. Model 6 Serial No. 8
3. Model 6 Serial No. 9
4. Model 6 Serial No. 10
5. Model 6 Serial No. 11

Preceding delivery, these transmitters were tested for video transmission quality and for frequency stability with respect to temperature.

An instruction manual for the Auburn University FM Television Transmitter was completed and delivered to Huntsville for use with these transmitters.

II. RADAR ALTIMETER RETURN PULSE STUDY

M. A. Honnell, W. E. Faust, R. B. Godfrey, L. B. Nolen,
J. T. Hannon, and H. L. Deffebach

A. Missile-Borne System

During the period covered by this report attention was focused on modifying existing circuits and adding new circuits to the return-pulse read-out system. (Figure 1 and Figure 2). This report consists mainly of explanations of these changes.

The circuit originally designed to gate out the transmitted pulse from the read-out system was not acceptable in that a 0.5-volt pedestal was developed during the gating interval. The pedestal had sufficient amplitude to trigger the following circuits in the system and give a false output signal.

A four-diode-gate (Figure 3) was designed in which the pedestal could be eliminated by proper biasing. The gate is designed so that when gating signals of opposite polarity are applied simultaneously, the input signal is blocked from the output. When the input is applied in the absence of the gating signals, it is transmitted without change to the output. The removal of the pedestal is accomplished by adjusting the amplitude of the gating pulses. The correct amplitude required is determined by the amplitude of the signal to be gated from the system and by the contact, or barrier potential, of the diodes used.

To obtain gating signals of opposite polarity, which are generated simultaneously, an amplifier was used in which a signal was taken from the emitter and from the collector. The amplitude of the two signals are adjusted by varying the emitter and collector resistances.

To insure proper triggering of the pulse train with each return pulse, it was necessary to incorporate a low-pass filter (Figure 4) preceding the saturating amplifier and trigger generator. The filter presented a clean pulse to the saturating amplifier and reduced the possibility of false triggers due to noise. The saturating amplifier is set to give a clean pulse of large amplitude with very small inputs.

The pre-transmit pulse fed to the read-out system from the altimeter is a negative 20-volt pulse of 110-microsecond duration. This pulse is considered to be too large and too long to be used as a gating signal in the return-pulse read-out system, therefore it is fed through a differentiator giving a sharp spike at the leading edge of the pre-transmit pulse. This spike is fed into the base of a saturating amplifier which produces a pulse of constant width and amplitude at its output. This pulse is used to key the gating circuit.

The power supply ordered for the read-out system will supply a well-regulated ± 28 volt direct current. The circuits in the system use various voltages below 28 volts, therefore it was necessary to build a Zener voltage-divider network to provide these voltages. The circuit of this network is shown in Figure 5. A photograph of the completed model is shown in Figure 6.

A model was built incorporating the system circuitry, i-f amplifier, Zener-voltage-divider network, and delay line into one compact unit. The circuits were wired on 3 x 4 1/2 inch Vector boards which were rack mounted. The other components of the system were fastened to the rack and the Zener voltage-divider network was fastened to the base for cooling purposes. A photograph of the model is shown in Figure 7. The individual Vector boards showing the circuits are shown in Figure 8.

B. Ground Station Recording System

Work has progressed on the ground station recording system and most of the equipment was ordered. The system was tested and is working satisfactorily. A block diagram of the system is shown in Figure 9. Several modifications were made since the last reporting period. The primary change was the addition of an amplifier-filter for the trigger circuits of the oscilloscopes. The circuit, as shown in Figure 10, consists of a buffer input, a low-pass filter, and a wide-band amplifier.

The input buffer is primarily an impedance-matching device used to match the filter to the seventy-five ohm input. It consists of two emitter-follower amplifiers, both biased on to prevent signal loss due to barrier potential. The first stage of the buffer has a variable bias so that it can act as a clipper for the low-frequency noise.

The filter is a constant-K pi-section with a cut-off frequency of 650 KC. Noise at one megacycle is attenuated by more than 20 decibels.

The amplifier is designed to saturate on a signal of 0.5 volt out of the filter. The output of the amplifier is an eight-volt pulse. To eliminate saturation of the system by low-frequency noise, a gain control is employed and the second stage is biased slightly below cut-off. The output of the amplifier drives a buffer stage for impedance matching to the seventy-five ohm termination.

By using this system any pulse with a peak-signal-to-rms-noise voltage ratio greater than 8db can be recovered to trigger the oscilloscope properly. The possibility of high-frequency noise which could cause the oscilloscope to trigger at the wrong time is virtually eliminated.

Several trial runs of the system were successful. Pictures were taken using Kodak Linagraph Pan film and a film speed of 3600 inches per minute (5 feet/second) continuous motion. With proper processing the results are clear and legible. The spacing between pictures allows displays greater than five centimeters in height on the oscilloscope before overlapping.

Investigation was made into the possibility of using a video recorder with the ground station. Several companies were contacted and information on several types of recorders was received. This information is compiled in Table I for easy cross-reference.

C. Transmission Link

The Resdel Engineering Corporation FM Transmitter, Model 91063, Serial Number 203, is being considered for use in the transmission link from the missile to the ground station. This transmitter was therefore tested and evaluated. These tests consist mainly of checking the pulse transmission quality and bandpass characteristics of the transmitter. The results of these tests, as well as information concerning the auxiliary equipment that will be used in conjunction with this transmitter are presented in the following paragraphs.

The Resdel transmitter requires a switching pulse fed to the vertical sync input to turn the transmitter on and to trigger the automatic-frequency-control loop in the transmitter. The required rectangular minus four-volt pulse having a duration of 190-microseconds at a repetition rate of 144 pulses per second is supplied by a one-shot multivibrator which will be incorporated in the radar return pulse processing system circuitry. A circuit diagram of the multivibrator is shown in Figure 11.

The ground station receiver requires the use of a de-emphasis network which is complimentary to the pre-emphasis network incorporated in the video input of the Resdel transmitter. The circuit diagram for this network is shown in Figure 12. As shown in Figure 13, which is a block diagram of the equipment setup used to test the pulse transmission quality of the Resdel transmitter, the de-emphasis network is placed at the input of the transmitter. Placing the de-emphasis network at the input gives a more representative test of the capability of the transmitter.

The pulse transmission quality of the Resdel transmitter was checked using the equipment setup shown in Figure 13. This test consisted of passing a one-microsecond, 1.4-volt pulse at a rate of 144 pulses-per-second through the transmission system. The pulse into the system and the pulse through the transmission link are shown in Figure 14. It is to be noted that the output pulse represents the over-all response of the transmitter and receiver. The trailing and leading edges of the transmitted pulse are shown in Figure 15. As shown, the rise time of the pulse is 0.1-microsecond.

The test equipment arrangement used to check the bandpass characteristic of the transmitter is shown in Figure 17. An audio-frequency sine-wave voltage is simultaneously applied to the video input of the transmitter and to the horizontal deflection circuit of the oscilloscope. The sine-wave voltage applied to the transmitter causes the voltage-controlled oscillator to sweep across a band of frequencies corresponding to the pass-band of the amplifier stages following the oscilloscopes. As shown, the output signal is monitored for its average power level and is applied, after attenuation, to a crystal detector. The detected signal is applied to the vertical deflection circuit of the oscilloscope providing a graphical display of the bandpass characteristic.

As a back-up for the Resdel transmitter, the Auburn University FM television transmitter to be used in conjunction with a frequency doubler is being prepared. A Microwave Associates Incorporated varactor frequency doubler, Model 8291 (1710MC), Serial Number 375A, was purchased for evaluation and testing. A transmission system consisting of this doubler and the Auburn transmitter was evaluated using the equipment setup shown in Figure 18. The transmitter supplied 6 watts of r-f power to the multiplier at 855 megacycles. An output power of 3.7 watts at 1710 megacycles was obtained from the doubler. Figure 19 shows a 0.7-volt, one-microsecond pulse that was passed through this transmission system. The leading edge of the transmitted pulse is shown in Figure 20. The rise time of the pulse, as seen, is 0.1-microsecond.

At present ruggedized multipliers similar to the Microwave Associates Model 8291(1710MC) are being constructed to satisfy missile-flight requirements.

III. MILLIMETER PROPAGATION STUDY

E. R. Graf, J. R. Richardson, and R. J. Sims

The complete grounding system and 3-phase primary power supply were installed in the millimeter laboratory. In addition, tubing for carrying cooling water to the carcinotron tubes has been installed along with the appropriate safety interlocks.

The carcinotron power supply, Manson model 795, and oscillator tube No. COE-20B were checked and found to be operating correctly. With these in operation, several tests were performed using the absorbent material obtained from B. F. Goodrich. The material, type VHP, has a thickness of 3 inches and is composed of rubber in the form of foam pyramids.

The results of the above tests were satisfactory. With an incident angle greater than 25°, there was almost total absorption by the foam material. Similar data was obtained when the material was wet. From these results, it was concluded that the material could serve as a liner for the propagation chambers.

A study conducted to determine the typical range of attenuation values under various test conditions has been completed. To obtain these values, the results of other experiments in this area were evaluated. These values varied from a low of .02 db/km to a high of approximately .04 db/km. No phase measurements were recorded in the results mentioned above.

An investigation is being performed to determine an appropriate measuring technique which will have the desired accuracy and sensitivity. These results will appear in future reports.

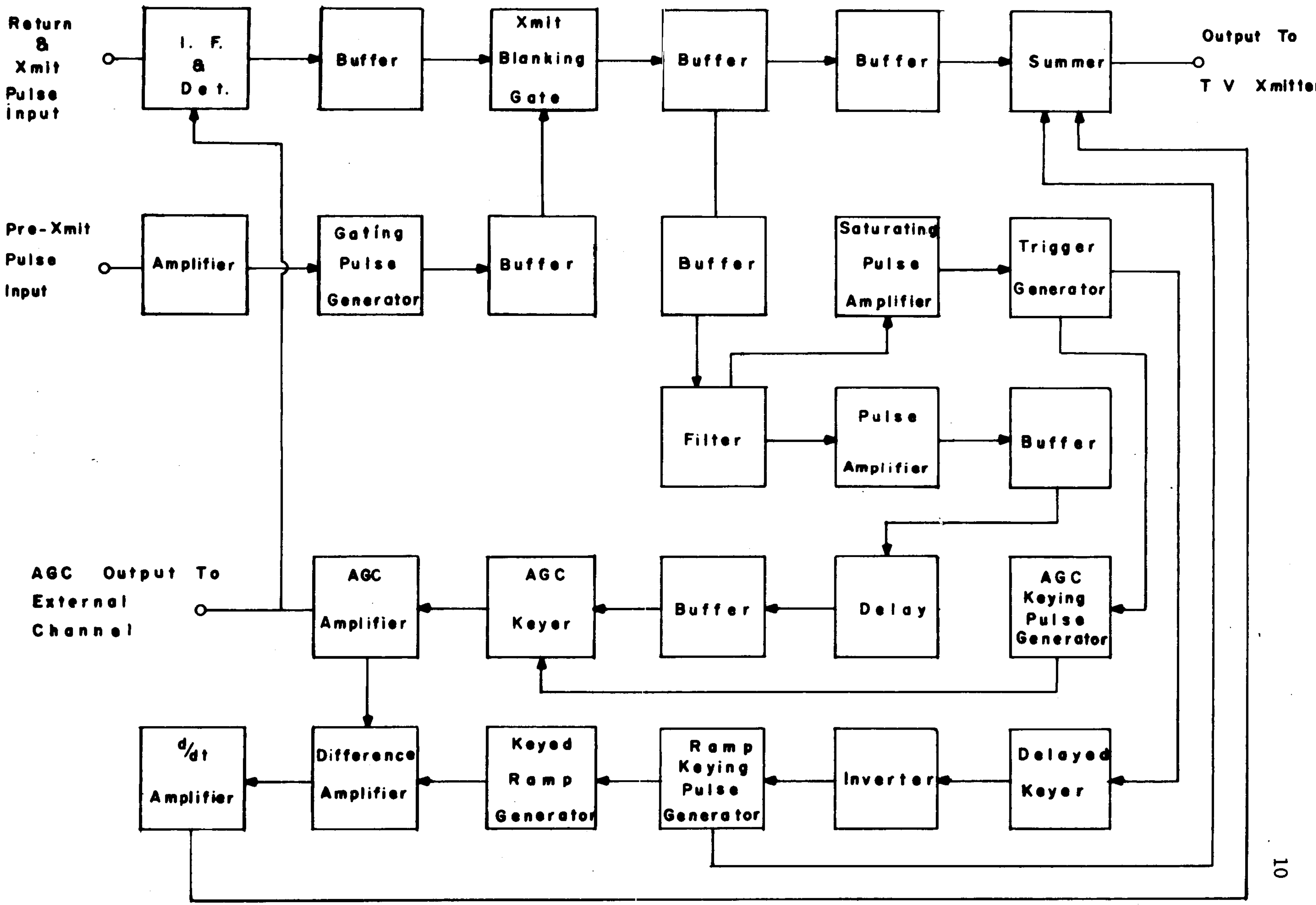


FIGURE I. BLOCK DIAGRAM OF SYSTEM FOR RETURN PULSE MEASUREMENT

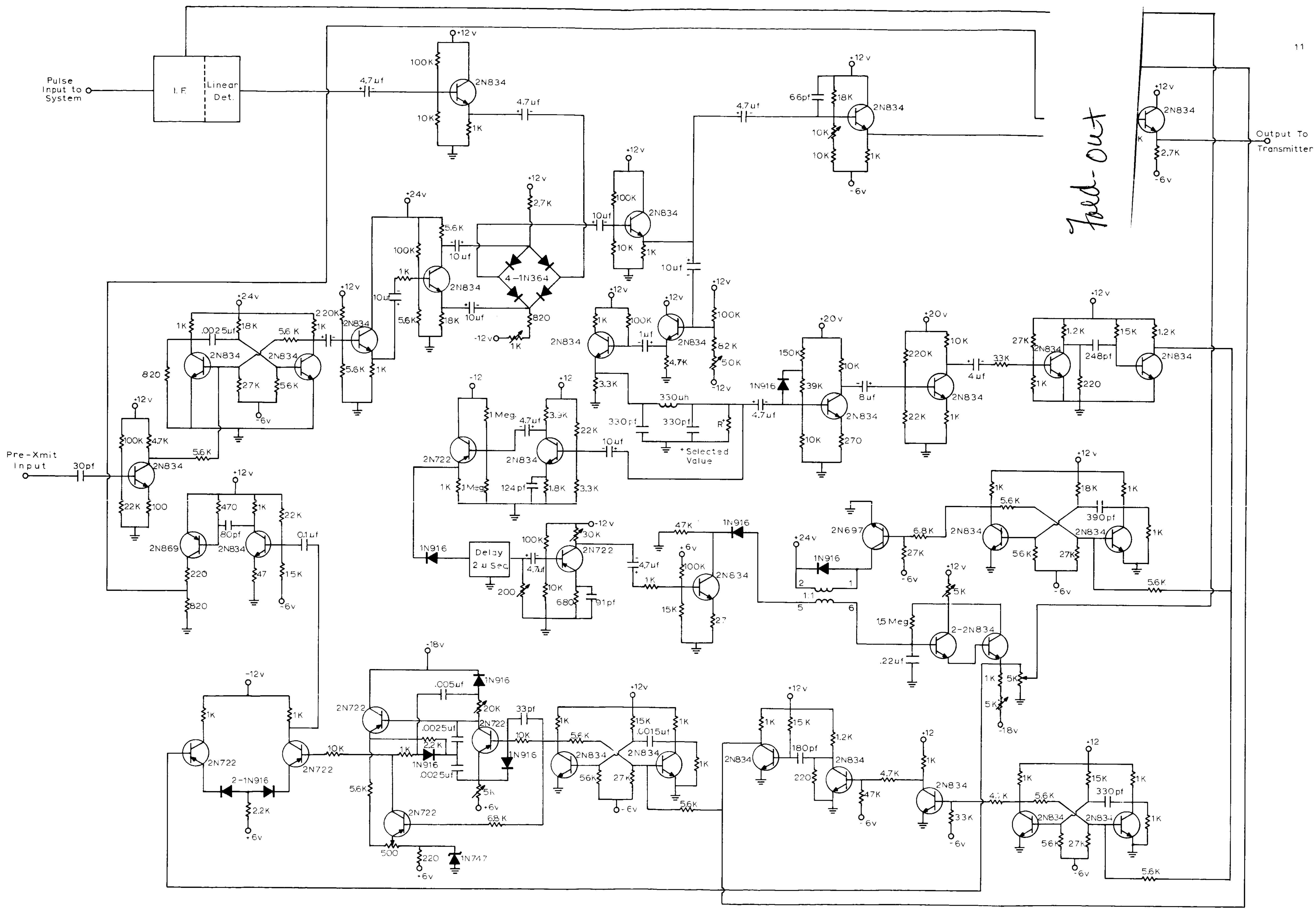


FIGURE 2. SYSTEM FOR RETURN PULSE MEASUREMENT

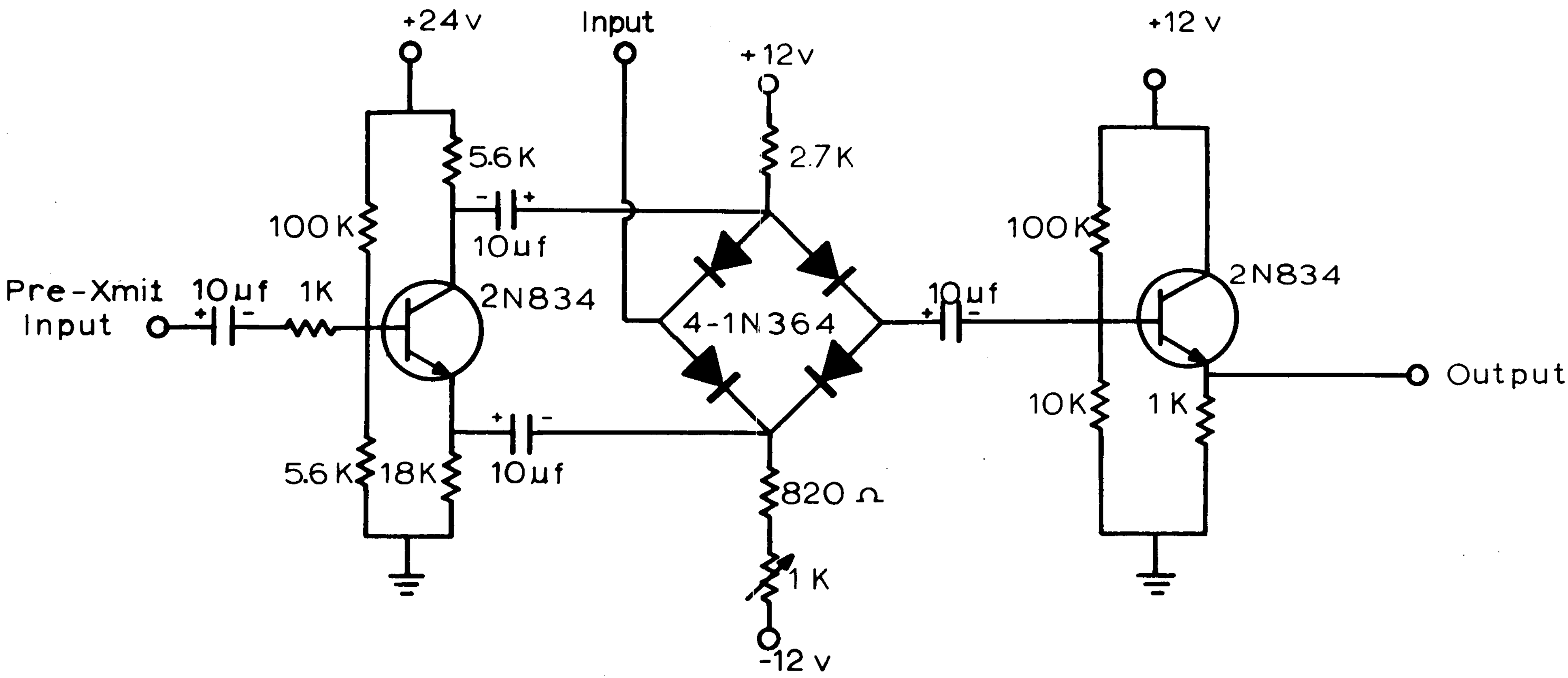


FIGURE 3. CIRCUIT DIAGRAM OF DIODE GATE AND AMPLIFIER.

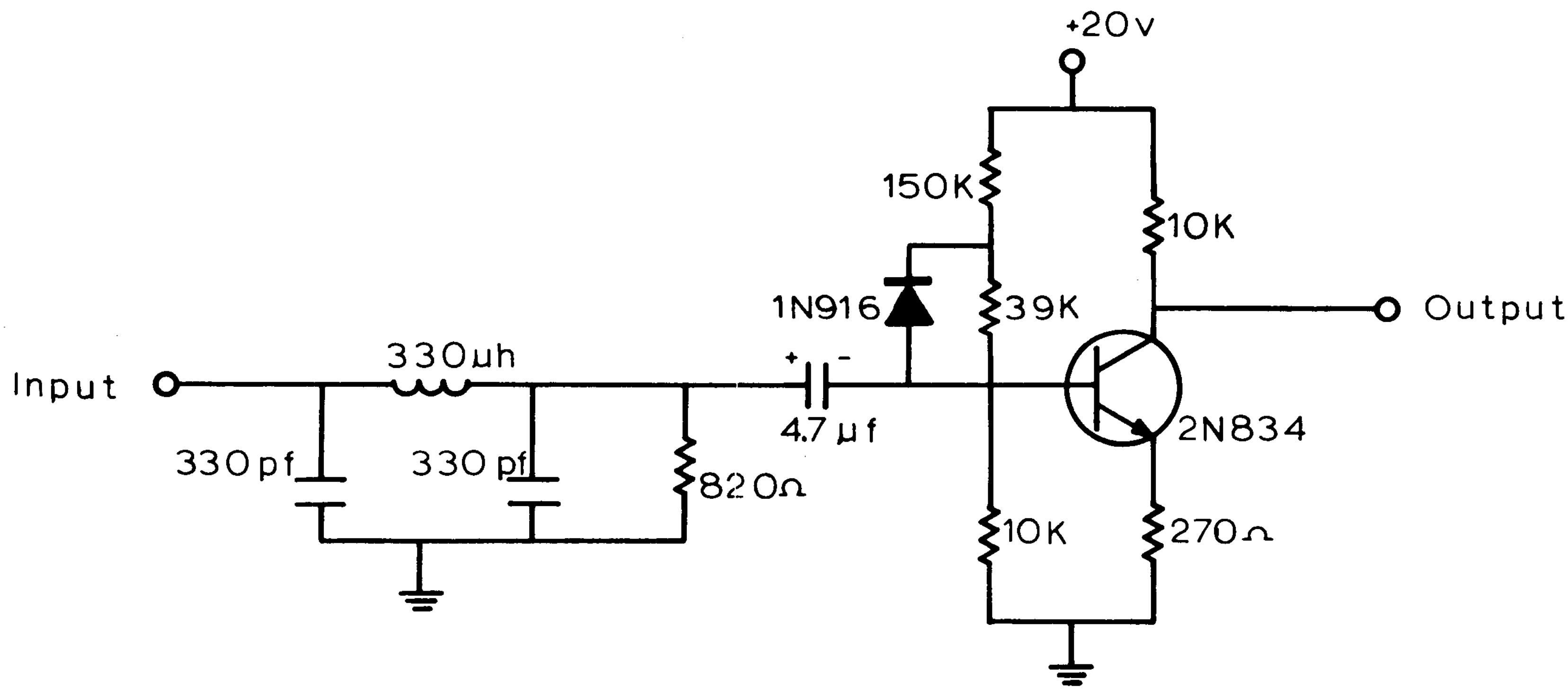


FIGURE 4. CIRCUIT DIAGRAM OF FILTER AND SATURATION AMPLIFIER.

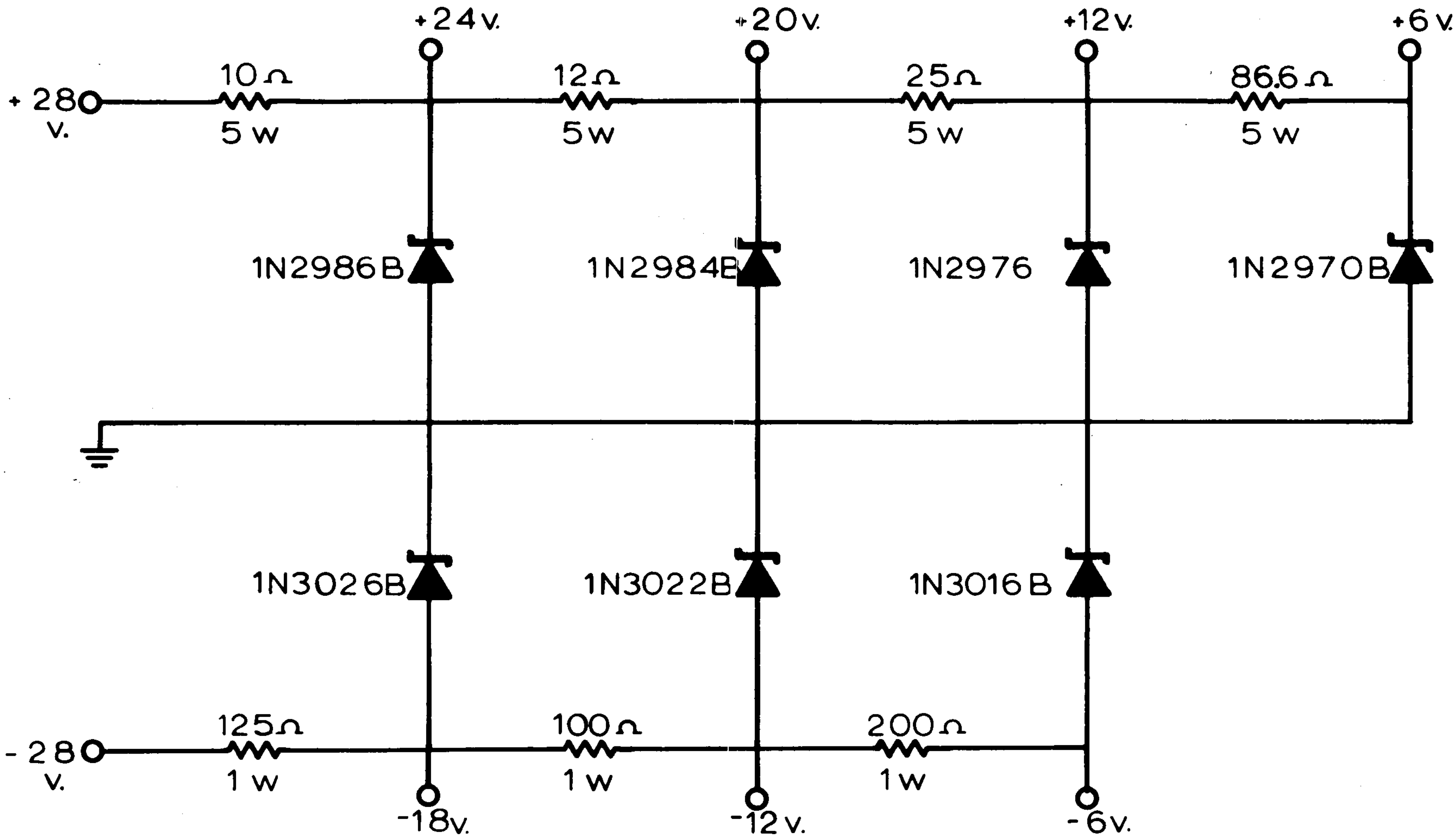


FIGURE 5. SCHEMATIC DIAGRAM OF ZENER VOLTAGE – DIVIDER NETWORK.

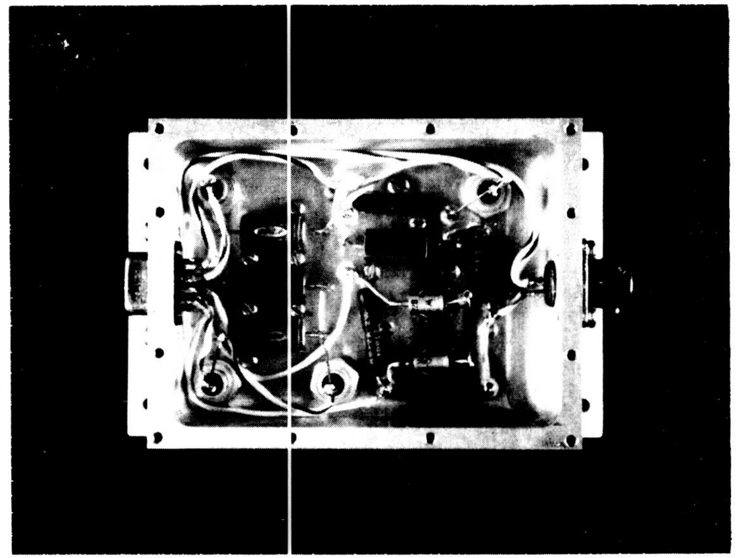


FIGURE 6. LABORATORY MODEL OF ZENER VOLTAGE-DIVIDER NETWORK.

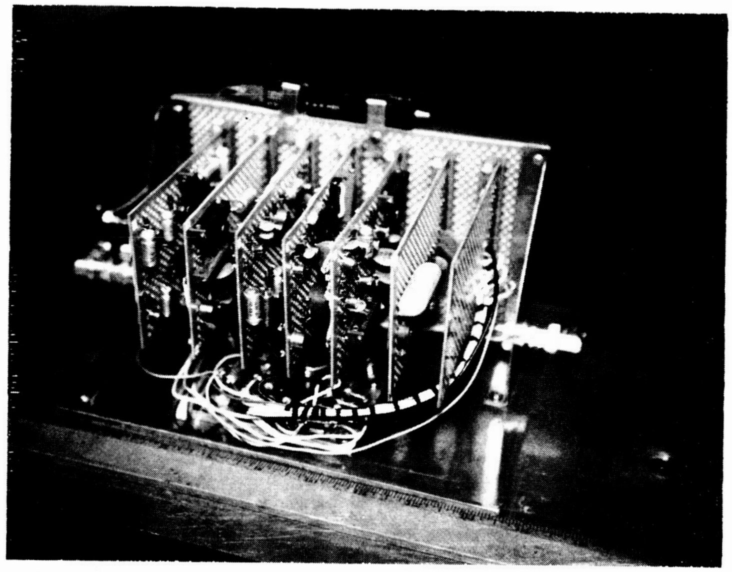


FIGURE 7. LABORATORY MODEL OF RETURN-PULSE READ-OUT SYSTEM.

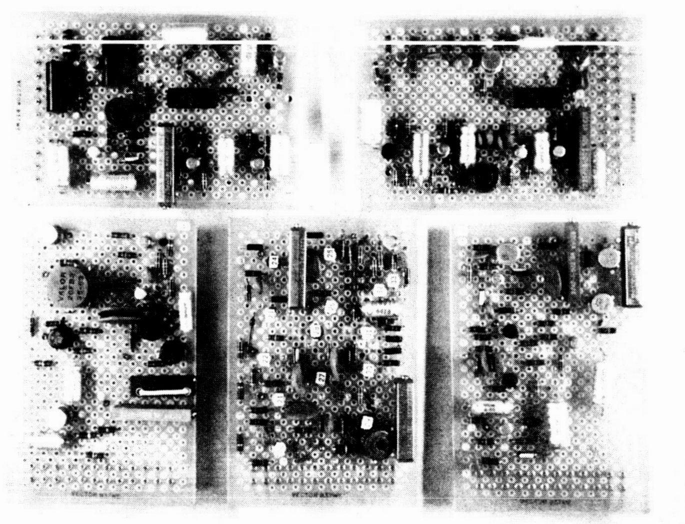


FIGURE 8. VECTOR BOARD LAYOUT OF RETURN-PULSE READ-OUT SYSTEM

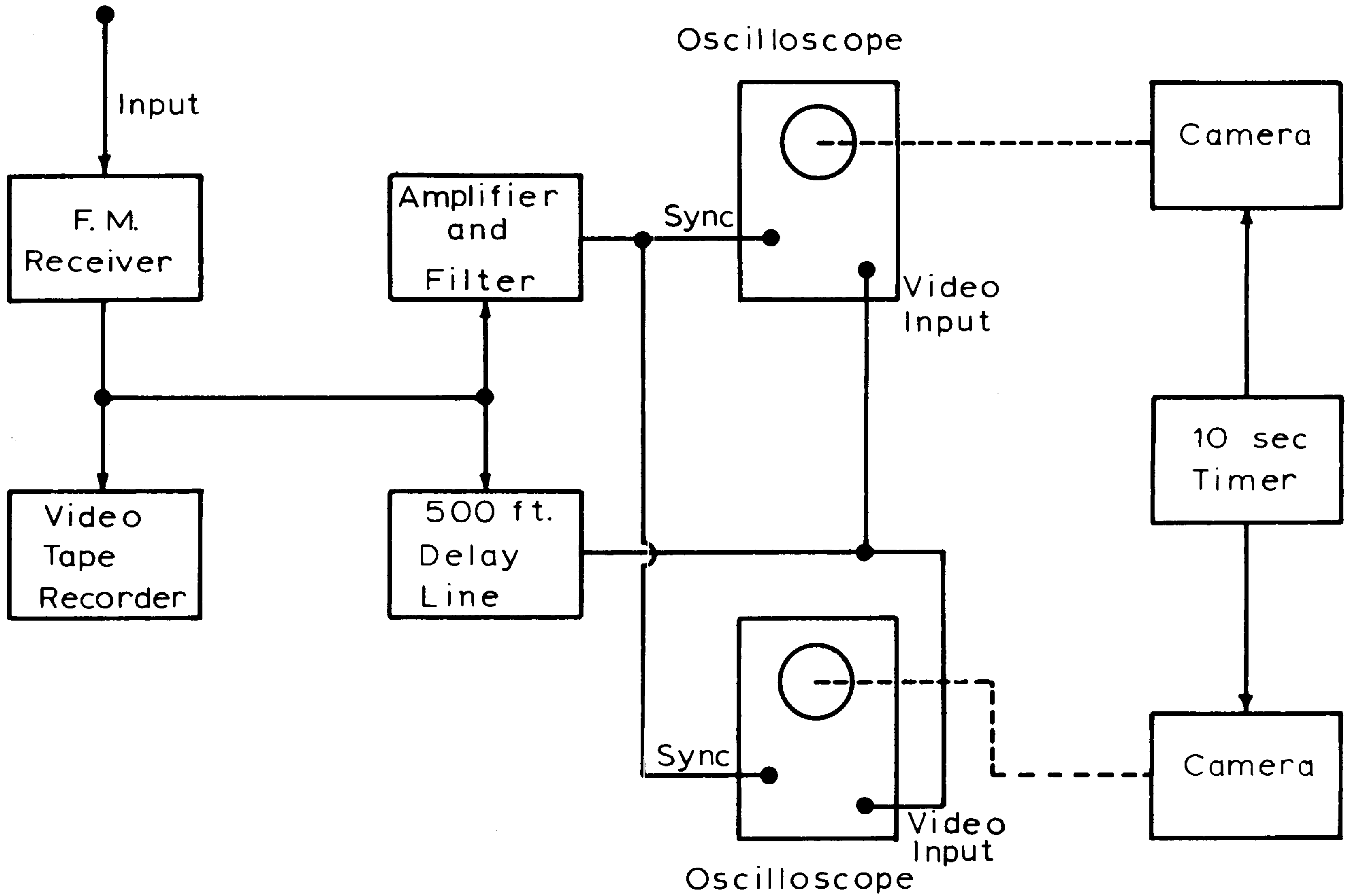


FIGURE 9. BLOCK DIAGRAM OF GROUND STATION

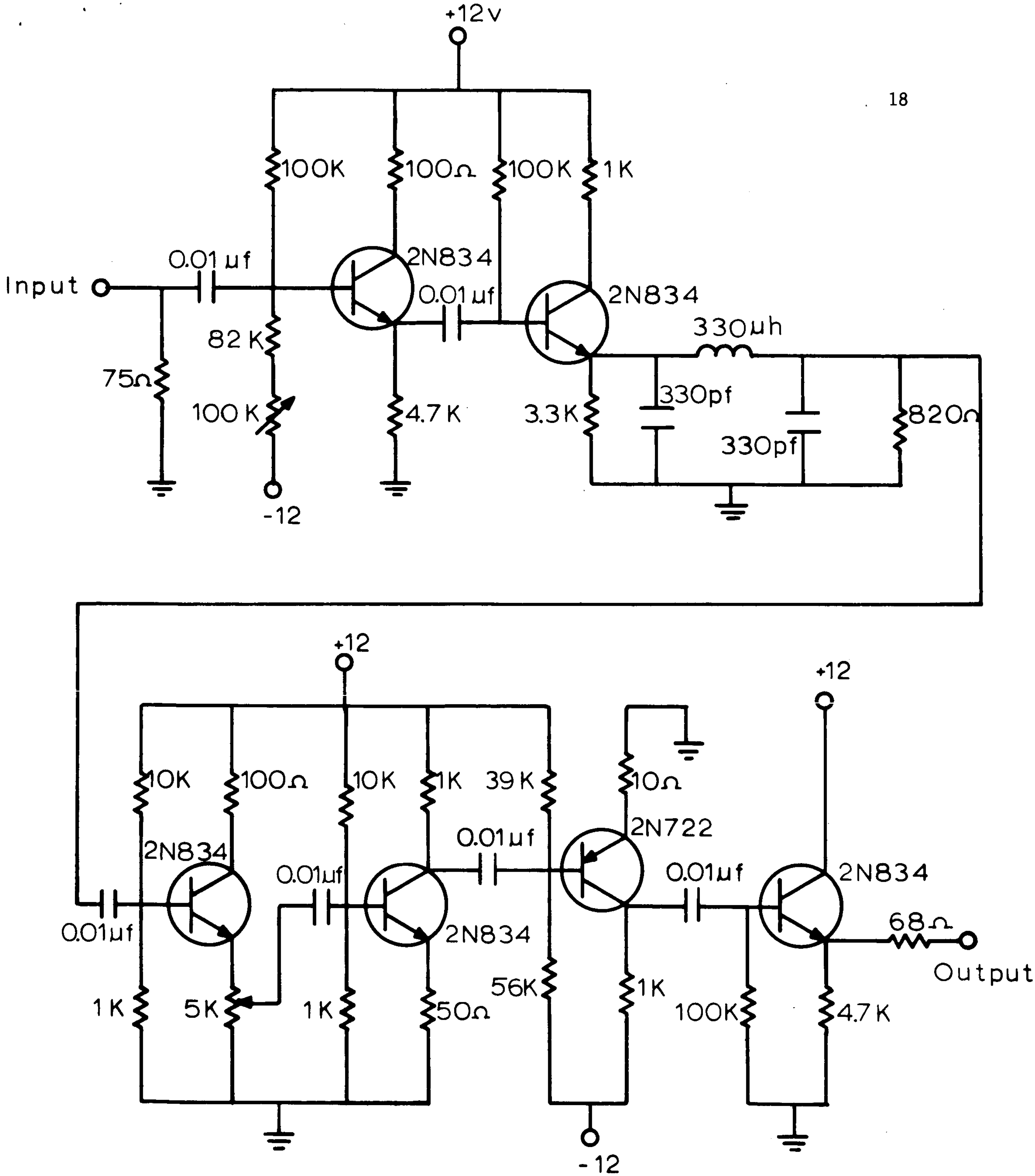


FIGURE 10. CIRCUIT DIAGRAM OF AMPLIFIER - FILTER FOR TRIGGER ON GROUND SYSTEM.

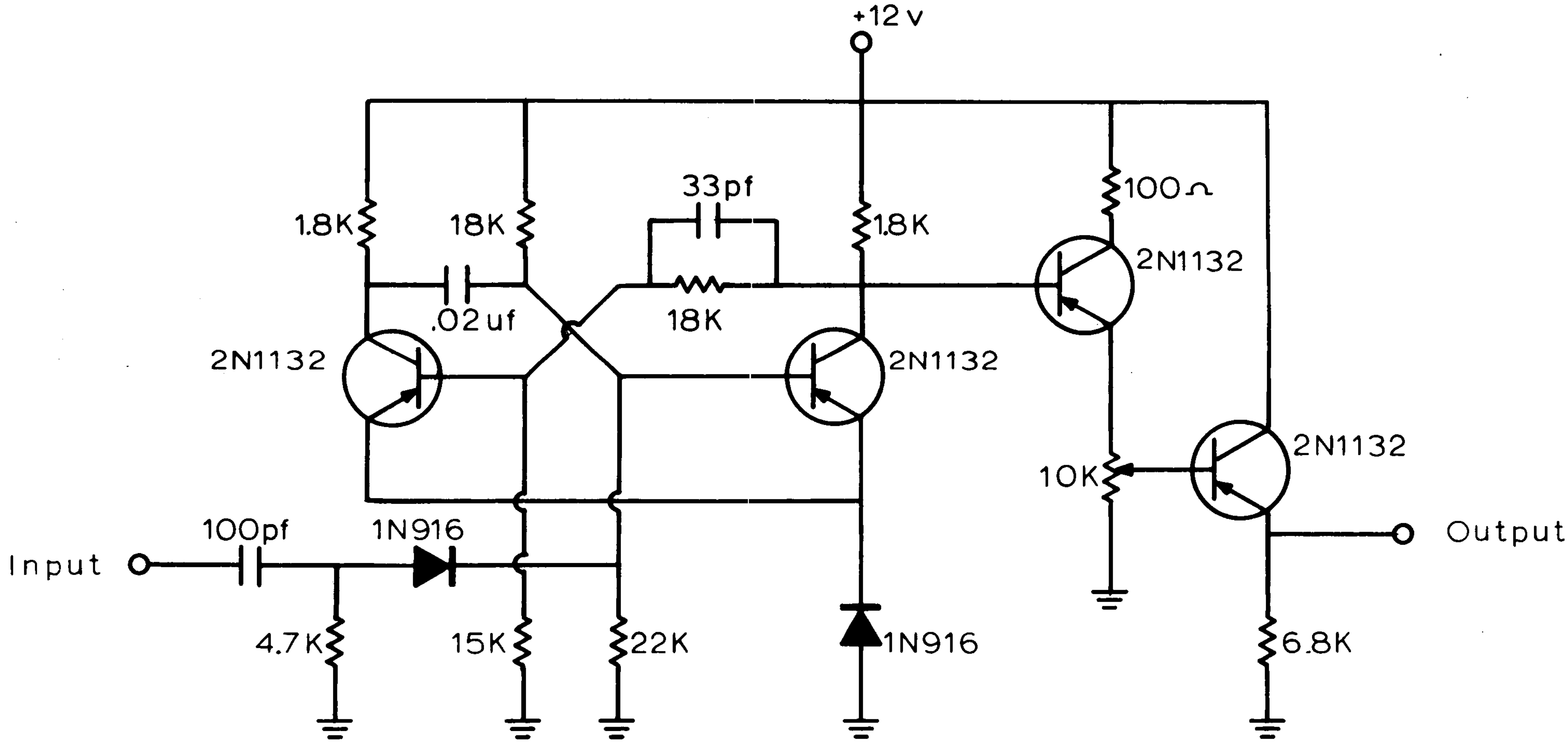


FIGURE 11. CIRCUIT DIAGRAM FOR THE 190-MICROSECOND ONE-SHOT MULTIVIBRATOR THAT SUPPLIES THE VERTICAL SYNC TO THE RESDEL TRANSMITTER.

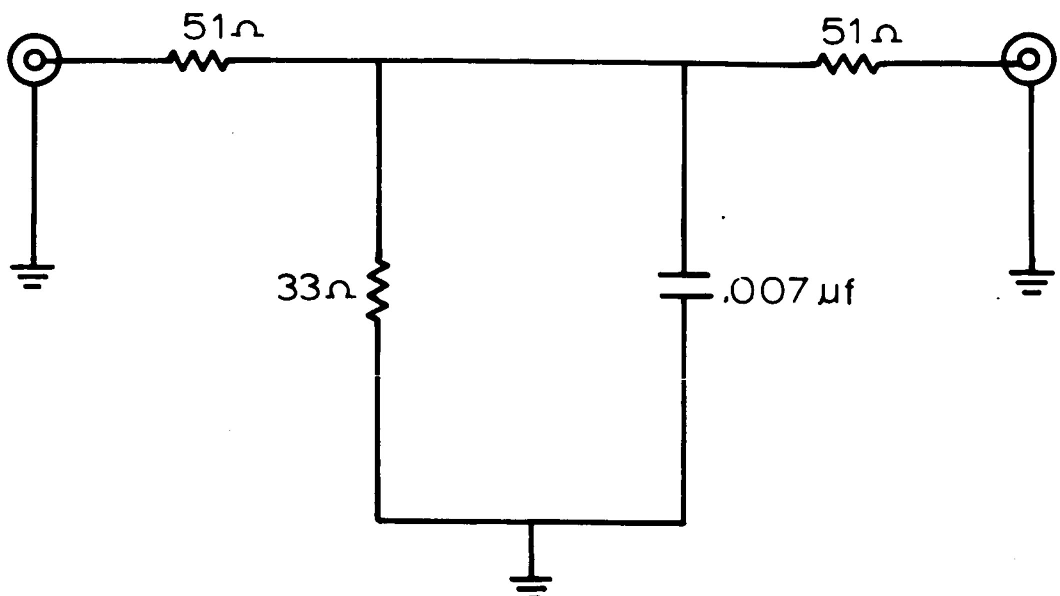


FIGURE 12. CIRCUIT DIAGRAM OF DE-EMPHASIS NETWORK USED TO COMPENSATE FOR ACTIVE PRE-EMPHASIS NETWORK IN RESDEL TRANSMITTER.

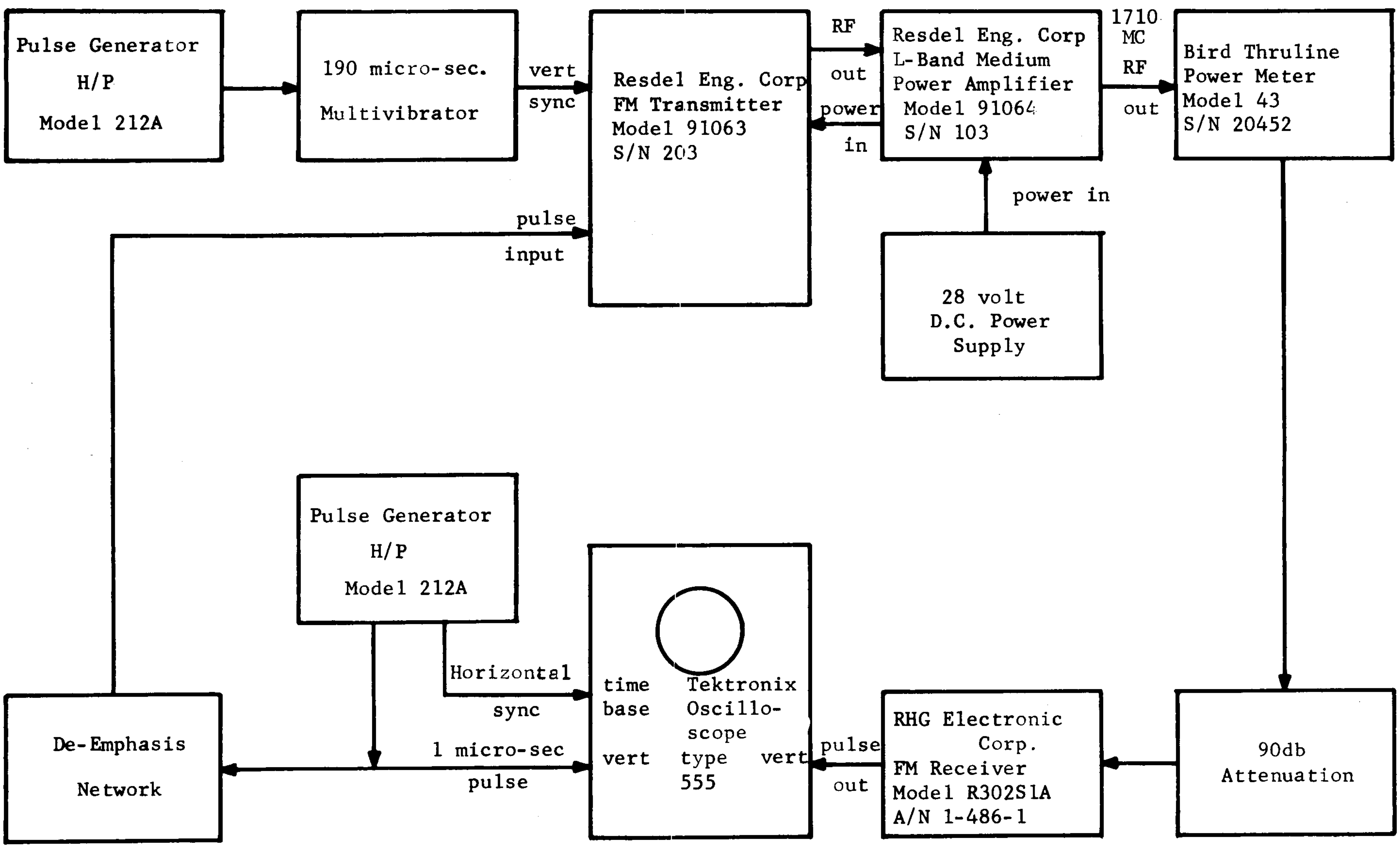


FIGURE 13. - Block Diagram of Equipment Used to Evaluate Pulse Transmission Quality of the Resdel Engineering Corp. FM Transmitter.

INPUT PULSE

OUTPUT PULSE

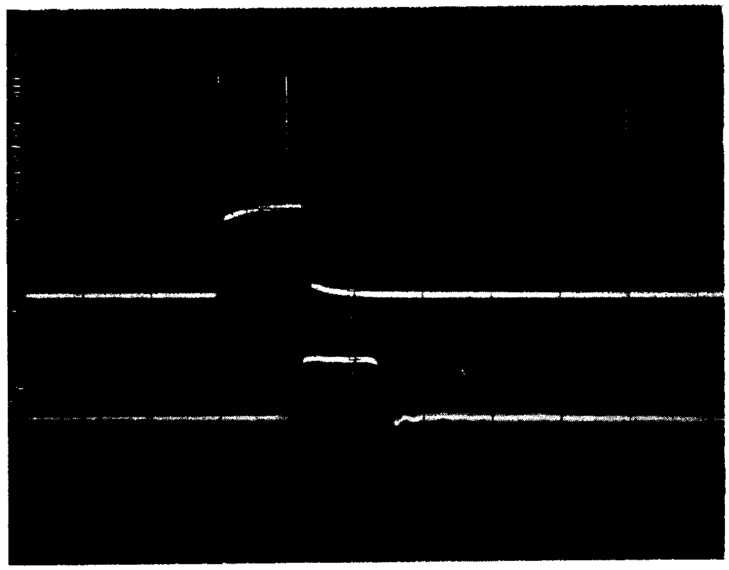
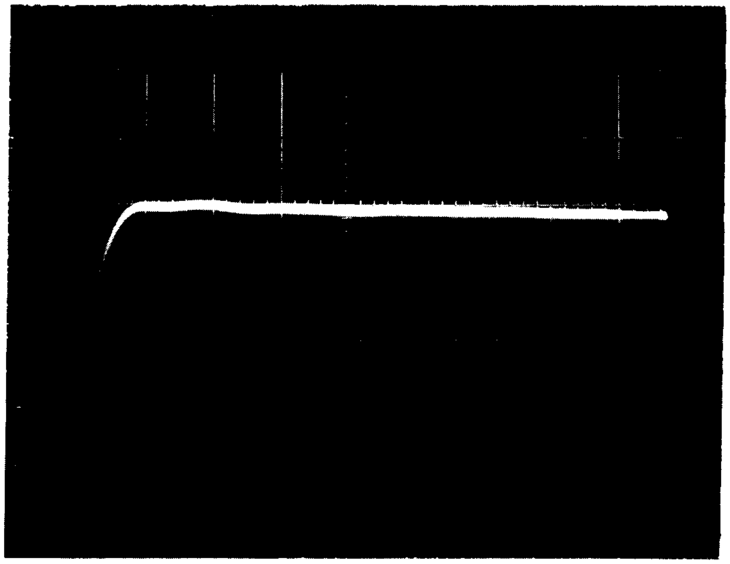
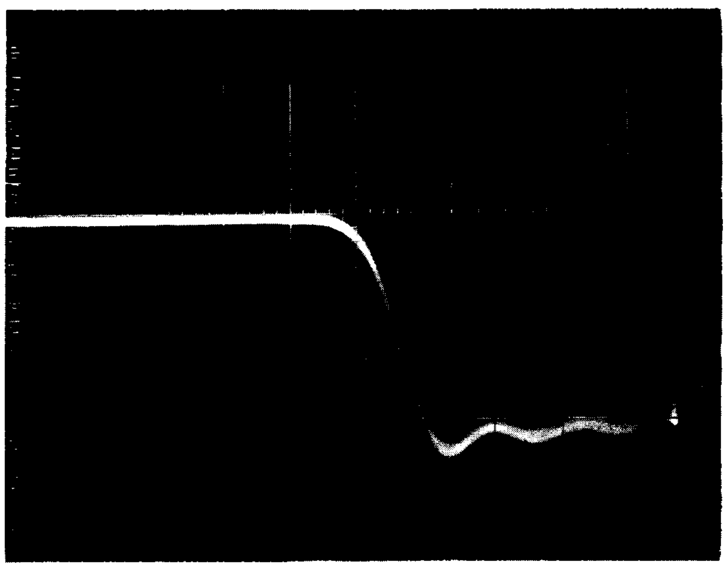


FIGURE 14. PULSE PRESENTATION INDICATING A 1.0-MICROSECOND PULSE INTO AND OUT OF A TRANSMISSION SYSTEM CONSISTING OF THE RESDEL TRANSMITTER AND POWER AMPLIFIER.

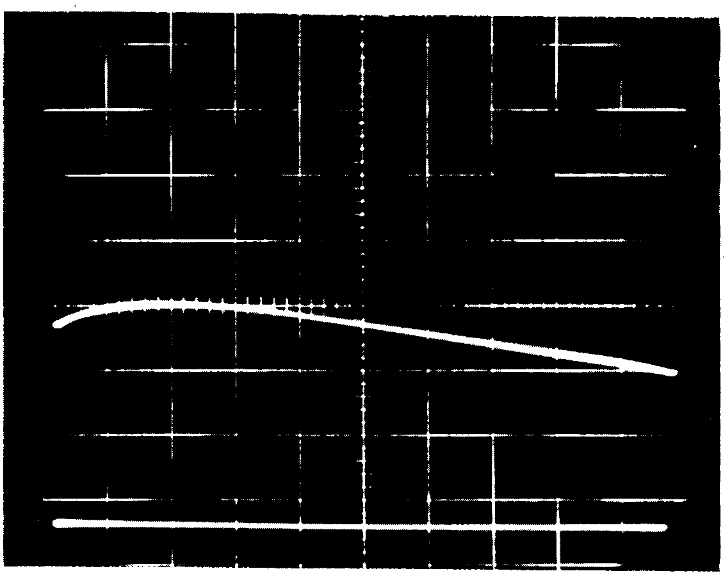


Leading Edge



Trailing Edge

FIGURE 15. PULSE PRESENTATION INDICATING THE LEADING AND TRAILING EDGE OF A 1.0-MICROSECOND PULSE THAT WAS TRANSMITTED THROUGH THE TRANSMISSION LINK. THE HORIZONTAL SWEEP IS 0.1-MICROSECOND PER CENTIMETER



1704 1710 1716

MC

FIGURE 16. BANDPASS CHARACTERISTIC OF THE RESDEL ENGINEERING CORPORATION FM TRANSMITTER, MODEL 91063, SERIAL NUMBER 203.

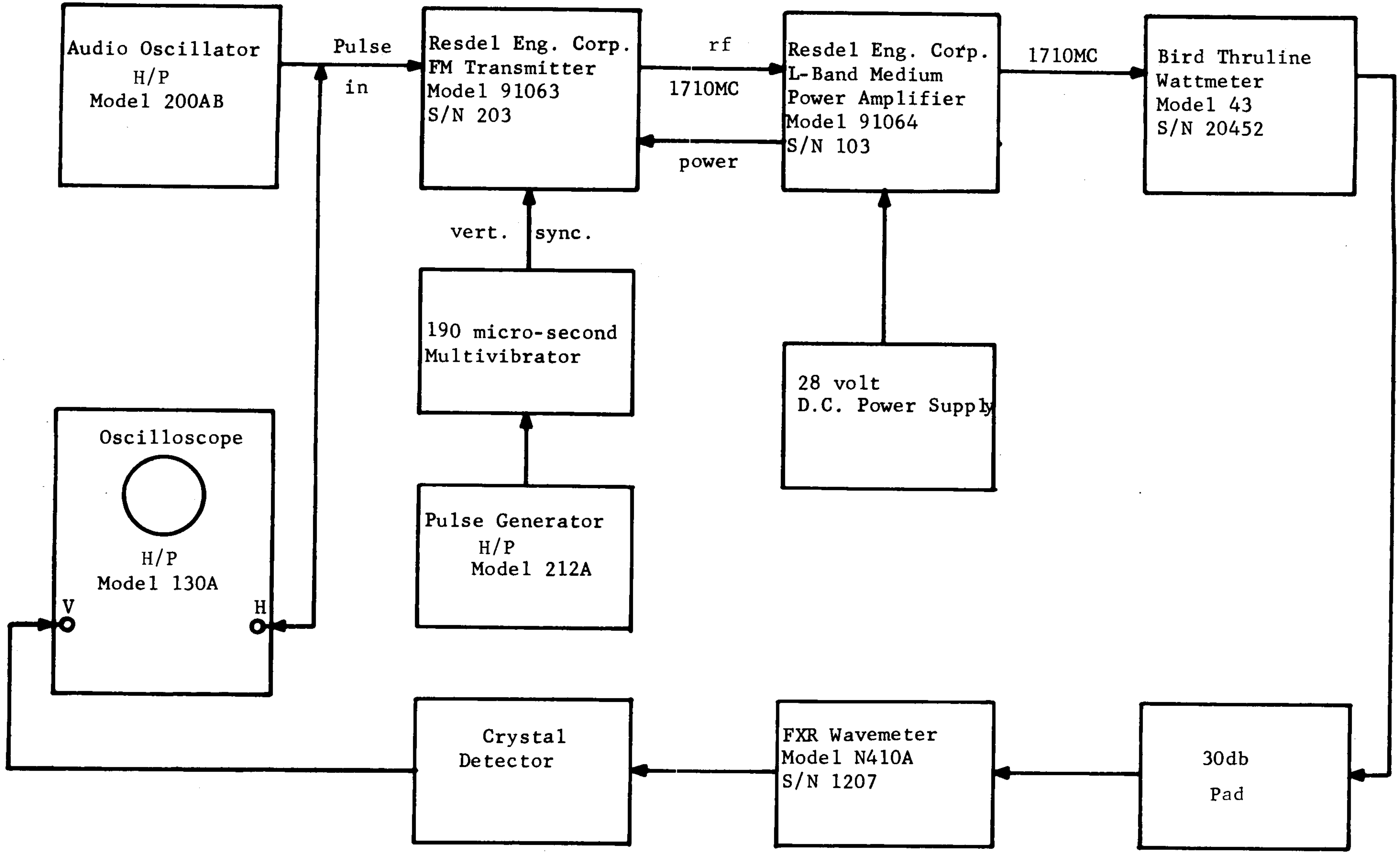


FIGURE 17. Block Diagram of Test Setup Used for Checking the Bandpass Characteristic of the Resdel Transmitter.

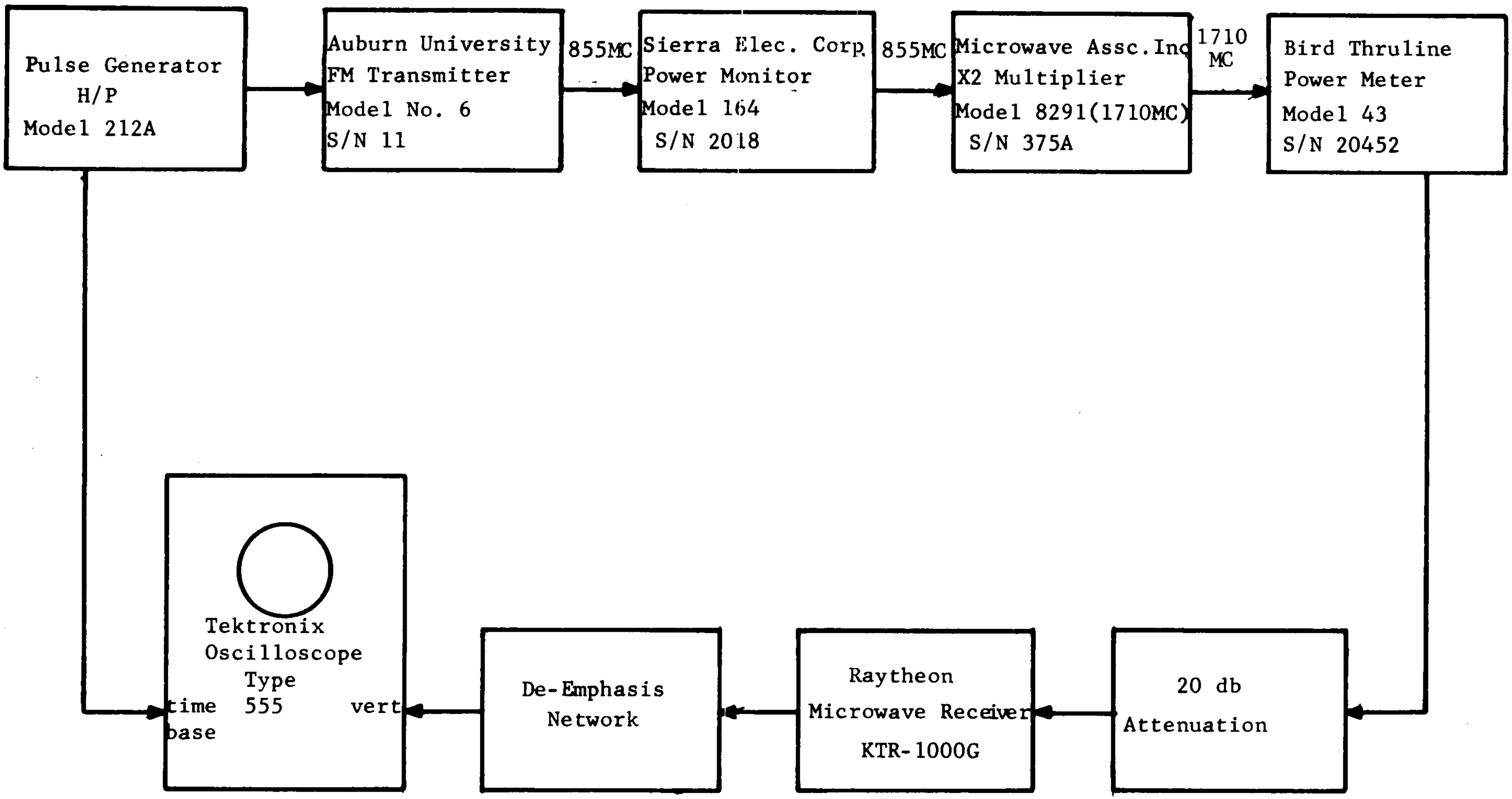
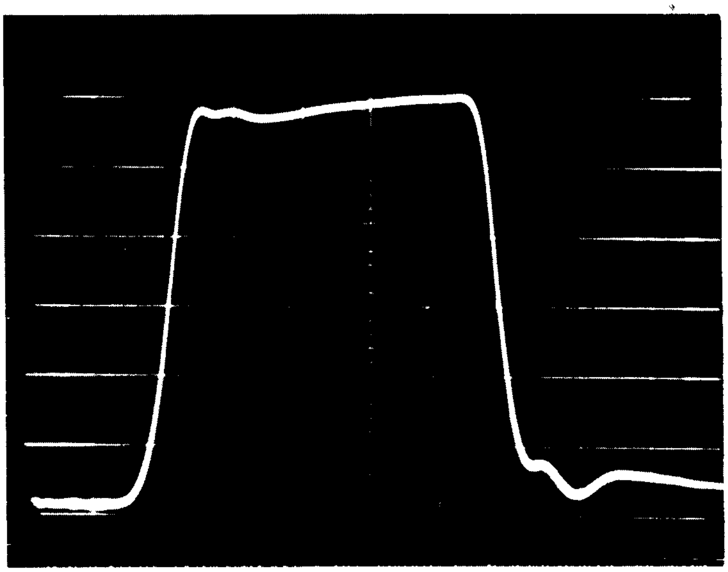
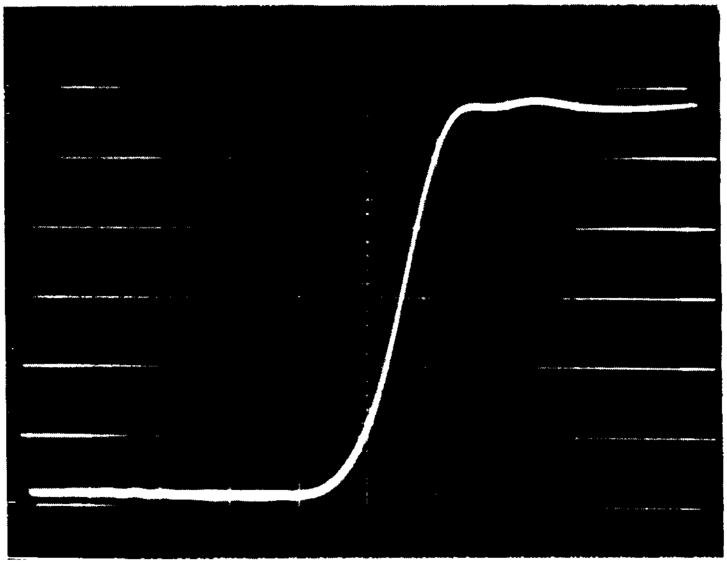


FIGURE 18.- Block Diagram of Equipment Used to Evaluate Pulse Transmission Quality of a Transmission Link Consisting of the Auburn Transmitter and a Varactor Frequency Doubler.



1 cm = 0.2-μsec

FIGURE 19. PULSE PRESENTATION INDICATING A 1.0-MICROSECOND PULSE PASSED THROUGH A TRANSMISSION LINK CONSISTING OF THE AUBURN UNIVERSITY TRANSMITTER AND A VARACTOR DOUBLER.



1 cm = 0.1-μsec.

FIGURE 20. LEADING EDGE OF A 1.0-MICROSECOND PULSE PASSED THROUGH THE AUBURN UNIVERSITY TRANSMITTER AND DOUBLER.

MODEL	Precision Instrument	Machtronics MVR-15	Ampex VR-1500	Ampex VR-1100	RCA TR-4-CVR	RCA TR-22	SONY PU-100
COST	$12,150.00		$11,900.00	$40,000.00	$69,500.00	$79,500.00	
WEIGHT	75#	83#	100#	800#	800#	1400#	145#
WIDTH	24"	24 7/16"	29 7/8"	42 1/4"	33"	55"	17 1/2"
DEPTH	15"	13 7/32"	17 3/8"	24 1/2"	24"	27"	16 3/4"
HEIGHT	12"	10 3/8"	14 5/8"	60" or 74"	66"	72"	25"
POWER	105/125 volts 50/60 cps 350 watts	395 watts @ 117 volts 60 cps	105/130 or 200/250 volts 50/60 cps 3.0 amps	115 v 50/60 cps < 2.4 KVA	105/125 VAC 60 cps 1.5Kw 210/250 VAC 50 cps 1.5Kw	105/125 v 60 cps 2Kw 210/250 v 50 cps 2Kw	117 ± 5% 3.5 amps
TAPE WIDTH	1"	1"	2"	2"	2"	2"	2"
REEL	10 1/2" max		12 1/2" max	14"	12 1/2"	14"	7" max
TAPE SPEED	7 1/2 in/sec	7 1/2 in/sec	3.7 in/sec	7 1/2 or 15 in/sec	7 1/2 or 15 in/sec	7 1/2 or 15 in/sec	5 3/4 in/sec
TOTAL TIME	96 min for 3600 ft	96 min for 3600 ft	4 HR on 12 1/2" reel	96/192 min	64/128 min (12 1/2)	96 min on 14"	63 min on 7"
REWIND TIME	3 min for 3600 ft	3 min	80 sec for 8" reel			5 min on 14"	4 min
STOP TIME	Less than 2.0 in					0.2 sec	
START TIME	5 sec max	6.0 sec max				2 sec from standby	
MOUNT	Portable	Portable	Portable	------	Built in casters	-----	Portable
BAND-WIDTH	3.5 to 4.0 mc	± 3db to 3.5 mc. down 6db at 3.8 mc	± 1.50db to 3.0 mc	± 2db to 4 mc	Switchable 4.0, 5.0, 6.0 mc	Switchable ± 1.5db to 4 or 5 mc	330 lines
S/N (P-P/RMS)	Less than 100 mv noise on 1v sig.	40db	40db or better	40db	As per bandwidth 40db, 36db, 32db	Per bandwidth 40db, 37db	43db
TRANSIENT	Less than 0.25μs on 0.1 R.T. pulses	0.2μs for 0.1 μ sec R.T. pulse		Better than 0.2	As per bandwidth 130NS, 110NS, 85NS	Less than 0.15μs Less than 12% O.S.	
VIDEO INPUT	75Ω 0.5 to 1.4VP-P	75Ω 0.5 to 1.4VP-P	75Ω 0.8 to 1.2VP-P	75Ω 0.5VP-P min	75Ω 0.5-1.4VP-P	75Ω 0.5 to 1.4VP-P	75Ω
VIDEO OUTPUT	75Ω 0.5 to 2.0VP-P	75Ω 0.5 to 1.4 VP-P	75Ω 1.0V ± 10%		75Ω 0.5 to 1.0VP-P	0.5 to 1.0VP-P	
AUDIO INPUT	200K 1 millivolt min	Select 5 impedances	600 ohms			600Ω 0-36DBM	600Ω
AUDIO OUTPUT	600 ohms	600/150 ohms	600 ohms			150/600 ohms	
HEAD LIFE	Warrented for 250 HR	- - -	- - -	- - -	100 HR prorated 300 HR AVE LIFE		Warrented for 500 HR 1000 HR AVE LIFE
DELIVERY DATE	30-60 days	- - -	- - -	- - -	3 months	3 months	
DIS-ADVANTAGES	Switching transient No tape counter	Switching transient No stop motion	Switching transient No stop motion	Switching transient No stop motion	No stop motion	No stop motion	Switching transients
FEATURES	2 video outputs Stop motion Remote control Lubricated for life Transistorized Plug in modules Extender for test Single record button for video & audio Tally lights Erase facility	2 audio channels Transistorized Tape timer Make video dubs Fast forward Switching meter for audio channels Elapse time meter Can select 5 different audio inputs Seperate heads for each audio channel	Transistorized Plug in modules Tape counter On the spot replace- ment of heads Seperate audio Seperate video erase Tally lights Can operate on 200/250 volts with simple transformer tap change	Monitoring facility 2 DIFF AUDIO Transistorized Remote control Vertical lock Can be supplied with TV monitor	3 video outputs 1 channel for 5 kilobit storage Remote control Tape timer Continuous 4 heads Built in crystal timing reference	2 audio channels and cue channel Transistorized Plug in modules Indicator lights for malfunction Remote control Electronic editing	Transistorized Modular construction Stop motion Slow motion Remote control Index counter Automatic stop at end of reels "Rotocoil" for clearer pictures

TABLE 1: COMPARISON CHART OF VIDEO RECORDERS FOR GROUND SYSTEM.