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MODIFICATION OF LASER RANGEFINDER MX-9838( )/GVS-5 INTO A VISIO--ETC(U)
OCT 79 J M QUINN, J H WOODWARD DAAK20-79-C-0038

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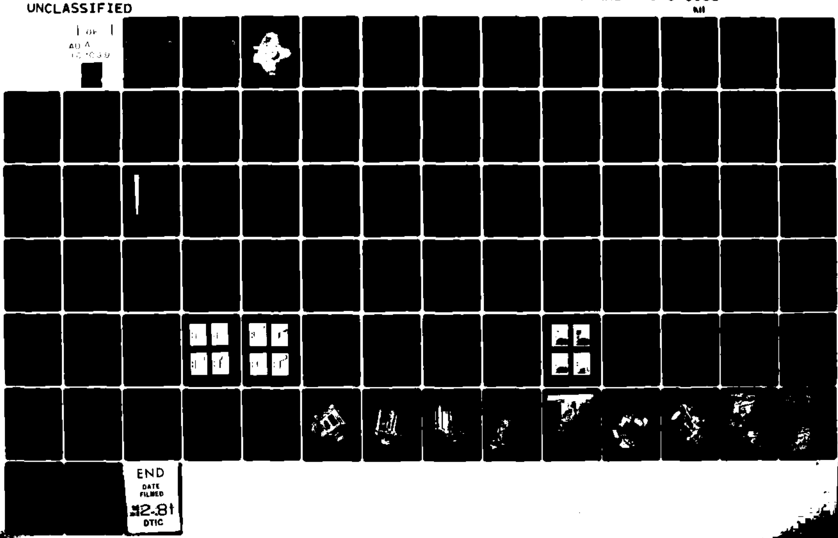

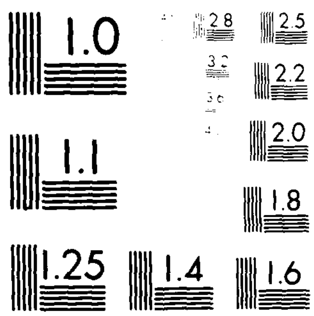

MICROCOPY RESOLUTION TEST CHART

LEVEL II

AD A107099

FINAL TECHNICAL REPORT

MODIFICATION OF LASER RANGEFINDER

MX-9838( )/GVS-5 INTO

A VISIOCEILOMETER

OPTICAL UNIT

By

J.M. QUINN - J.H. WOODWARD

OCTOBER, 1980

/Government Systems Division
~~Automated Systems~~
Burlington, Massachusetts 01803

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Modification of Laser Rangefinder
MX-9838( )/GVS-5 Into a Visioceilometer
Optical Unit.

VISIOCEILOMETER OPTICAL UNIT

MODIFICATION OF

AN/GVS-5

FINAL REP[redacted]T

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CONTRACT NO. DAAK-20-79-C-0038

CLIN 0003

Prepared By

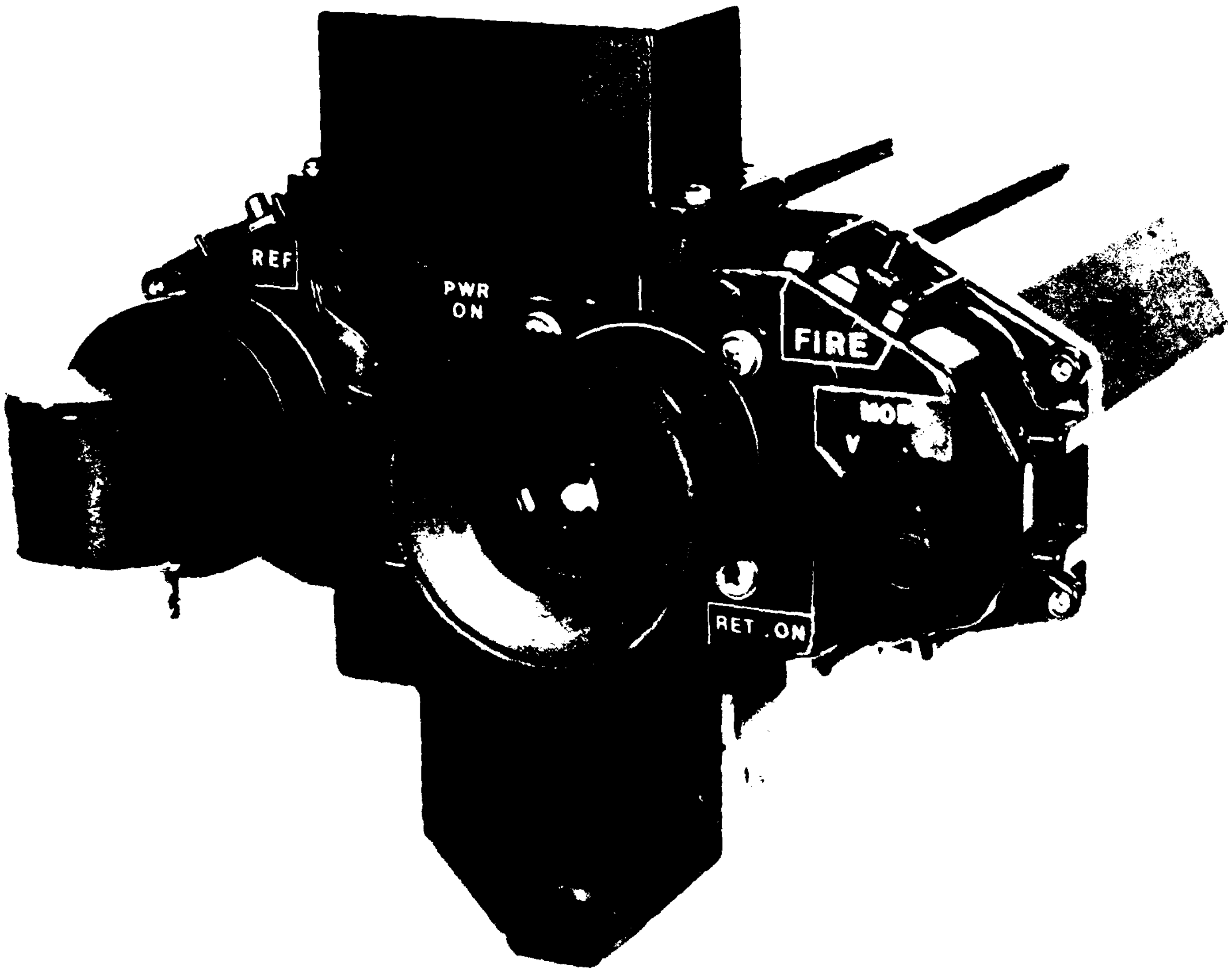
J.M. QUINN [redacted] J.H. WOODWARD

OCTO[redacted]79

RCA/Government and Commercial Systems Division
Automated Systems
Burlington, Massachusetts 01803

for

U.S. Army Night Vision and Electro-Optics Laboratories
Fort Belvoir, Virginia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VISIOCEILOMETER OPTICAL UNIT

FINAL REPORT

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VISIOCEILOMETER OPTICAL UNIT

FINAL REPORT

1.0 SCOPE OF REPORT

This ~~Final Technical~~ Report covers the research and development effort to modify an AN/GVS-5 Laser Rangefinder to perform the optical and display function of a hand held Visioceilometer. The effort was accomplished under U.S. Army ERADCOM Contract No. DAAK 20-79-C-0038. This report is supplied in fulfillment of CLIN No. 0003 in accordance with DD Form 1423, Exhibit B, sequence No.B001.

2.0 APPLICABLE DOCUMENTS

The following documents describe the technical tasks including hardware modification and interfaces, documentation, and spare parts.

2.1 Work Statement, Modification of AN/GVS-5( ) LRF for Visioceilometer Conversion, dated 27 June 1979, including "OU/SPU interface Document."

2.2 Enclosure 2 to Contract No. DAAK 20-79-C-0038: "AN/GVS-5 Modification for Visioceilometer Statement of Work.

2.3 Addendum to Statement of Work for Visioceilometer.

The foregoing documents, with the detailed Work Statement revised as of 15 October 1979 by RCA to incorporate the technical changes of the ADDENDUM cited in 2.1.3, are included in Appendix A.

2.4 TECHNICAL INTERCHANGE MEETING REPORT

A meeting among representatives of U.S. Army Atmospheric Sciences Laboratory, U.S. Army Night Vision and Electro Optics Laboratory, Lawrence Livermore Lab. (Visioceilometer Signal Processing Unit contractor), and RCA was held at RCA, Burlington, Ma. on 31 October 1979.

The RCA report of this meeting, EIP-0.5.4.1-290/JF, is included in Appendix A.

3.0 DETAILS OF TECHNICAL EFFORT

The report of the effort which follows is generally in the sequence of the Work Statement except that test reports are included in Section 4 or appendices referenced therein.

3.1 OPTICAL ASSEMBLY

An optical assembly from an MX-9838()/GVS-5 engineering development model supplied to RCA by NV & EO Labs, was modified by Leitz, Canada, the original manufacturer. The optical assembly was inspected by RCA prior to delivery to Leitz, with the following observations: 1) Scratch and dig level of objective lenses and eye lenses were within present specifications, 2) Minor sleeks were noted on the sighting eyepiece, but were not such as to necessitate replacement, 3) Exterior contamination noted would be removed in the normal rework and clean-up for delivery by Leitz.

3.1.1 MODIFICATIONS

RCA designed and provided to Leitz the drawing for the optics modifications. Copies of the drawings are separately supplied under CLIN 0004 of the contract.

3.1.1.1 RETICLE

The reticle was modified in accordance with RCA drawing 2399148-1 and Reticle Mask, drawing 2399149-1.

The crosshair and sighting circle pattern of the AN/GVS-5 reticle were retained. The window for the range display was enlarged to accomodate display of the 5 digit distance. The word METERS engraved above the display window was retained. Other engraving was deleted. A transparent letter C to the left of the distance display window and letter V to the right were incorporated in the reticle mask.

RCA drawing 2399149-1 shows the external display. The 5 digit, seven segment LED display and the LED for illuminating the C and V windows are moved back from the corresponding AN/GVS-5 positions to accomodate the increased dimensions. Certain of the bosses on the Main Body were cut down to permit the display assembly to be moved back.

3.1.1.2 RECEIVER OPTICS

The remainder of the changes to the optical assembly were necessitated by the increase in the field of view of the receiver from 1.0 to 3.0 angular mils diameter and the use of the larger diameter detector package of the C30919E detector. The following RCA drawings depict the changes:

2399142-1, Main Body Machining; 2399143-1, Mount, Lens 4; 2399144-501, Lens 4 and Mount Assembly, 2399145-1, Ring, Mounting, Detector/Preamp. Drawing No. 2399146-501 shows the Detector/Preamp assembly.

3.1.1.3 BORESIGHT

Subsequent to modification the optical assembly boresight was aligned by Leitz so that the sighting/receiving axis was parallel to the transmitter telescope axis within the 21 arcsecond (0.1 angular mil) AN/GVS-5 optical assembly spec.

The optical assembly was then subjected to six temperature cycles from $-50^{o}F$ to $+160^{o}F$. At the completion of test the boresight error was less than 10 arcseconds.

3.1.1.4 DETECTOR/PREAMP-RING ASSEMBLY

The Detector/Preamplifier was assembled and cemented into its mounting ring at RCA using a procedure similar to the AN/GVS-5 procedure, and was then installed in the modified optical assembly S/N 00013.

3.2 TRANSMITTER PULSE MONITOR

The design and implementation of the Transmitter Pulse Monitor proved to be one of the difficult tasks of the modification. The mechanical/optical design was difficult because of limited space available. The electrical implementation required an empirical determination of temperature characteristics of the assembly, then calculation and test of the compensating circuit. A further complication was the electrical noise generated by the high level (20 KV) flashlamp trigger pulse which could not be completely suppressed in the Pulse Monitor output circuit.

3.2.1 MECHANICAL/OPTICAL DESIGN

The AN/GVS-5 Laser Transmitter Module (LTM) output is elliptically polarized but manifests considerable polarization variation. For this reason dual 45° beamsplitter plates, one tipped about the x axis, the other about the y axis, are used to sample the transmitter beam. The plates are antireflection coated on one surface and uncoated on the other surface. Thus the first plate, through which the beam is transmitted from LTM to output telescope, reflects for the 90° polarization about 10% and for the 0° polarization about 1% of the incident energy. The energy reflected from the first plate is further reflected from the second plate which has crossed polarization, so that the energy to the detector is 10^{-3} (S polarization 10% x 1%, p polarization 1% x 10%) of the incident energy, independant of polarization. The energy passing through the second plate is absorbed, the reflected energy is diffused by a small fused opal glass diffuser to reduce the energy and eliminate hot spots.

Figure C12 ((90CN0804)) shows the sub-assembly of the optical assembly, electronics, and LTM. The beam splitter assembly appears in the lower center, between the Laser Transmitter Module and the transmitter telescope support.

3.2.2 ELECTRICAL DESIGN

The high level of signal available to the Transmitter Pulse Monitor detector precludes the necessity of a line driver for providing the output to the SPU. The requirement that the pulse width not exceed 10 nanoseconds further precludes integration of the transmitter pulse to obtain a monitor signal proportional to output energy. The decision was therefore made to provide an output signal which is an analog of the transmitter pulse envelope, with the peak amplitude of the monitor pulse proportional to peak transmitter power output. This signal is derived directly from the silicon PIN detector, Hewlett Packard type 5082-4204. A series resistor and thermistor provide temperature compensation. Adjustment of calibration is accomplished in the beam splitter assembly.

Initial tests of the circuit revealed a tail-off of the trailing edge of the monitor pulse. This is symptomatic of insufficient supply voltage so that the diode is not fully depleted. It was therefore necessary to provide a +50V dc supply for the diode. This was originally derived from the trigger circuit supply by means of an isolation diode, zener diode divider and storage capacitor. The circuit was subsequently altered to derive its voltage from the detector +550V supply to improve stability and reduce noise. The PIN diode is mounted in the beam splitter assembly. The remaining parts are mounted on the Power Conditioner board.

3.3 POWER SUPPLY

3.3.1 AN/GVS-5 SUPPLY

An AN/GVS-5, current production, power supply was procured and modified to provide a fixed +550 volt supply for the C30919E detector. A fixed voltage divided down from the regulated +12V was substituted for the AGC input to the AN/GVS-5 supply. Referring to power supply schematic drawing SM-D-852272, Rev. F, sheet 1, a 27K Ω resistor is connected between terminal E16 (+12V) and E11 (AGC input). A 43 Ω resistor is connected between terminal E11 and terminal E15 (GND). The +5V output of the power supply is not used in this system. Since this voltage is poorly regulated if left unloaded, a 220 Ω resistor is connected between terminal E4 (+5V) and terminal E3 (GND) to eliminate any potential noise. Referring to sheet 2 of this schematic a diode was inserted between terminal E20 and the junction of L6, CR30 and E25. The INITIATE signal is generated from the voltage at this terminal. The diode prevents voltage on terminal E7, present at system turn-on, from appearing on terminal E20. There is also a .01 µf capacitor added between terminal E9 (pulse forming network high voltage) and E8 (chassis ground). This capacitor was added to reduce power supply noise.

3.3.2 POWER CONDITIONER BOARD

The range counter circuit requires regulated +5 volts as soon as the POWER ON/OFF switch (S1) is actuated. Since the GVS-5 power supply is not activated until the FIRE switch (S2) is actuated, it was necessary to generate a regulated +5V from the input battery voltage. There is also a requirement for the +6V for the logarithmic amplifier and the detector preamplifier during the normal power supply operating time, but the power supply generates ±12V. Therefore additional regulators were included to reduce the ±12V to ±6V. A printed wiring board supporting these parts was designed, fabricated and installed in the location of the AN/GVS-5 video amplifier. The blocking capacitors between detector preamplifier output and logarithmic amplifier input were originally located on this board but were relocated to the mounting surface of the log amplifier during the integration of the unit. These are capacitors C4 and C5 of the Visioceilometer schematic diagram, SKJQ090980. Components of this assembly include two regulators type µA78MGU1C for the +5V and the +6 volts, one regulator type µA79MGU1C for the -6 volts and associated capacitors and resistors. There are also two selected resistors, R11 and R12, in the temperature compensation circuit for the detector preamplifier, thermistor TH1 and resistor R8 in the transmitter pulse monitor output circuit, diode CR3 and resistor R9 in the initiate circuitry, diodes CR1 and CR2, resistor R1 and capacitor C1 in the transmitter pulse monitor biasing circuitry, capacitor C2 for decoupling the detector high voltage and resistor R2 for the detector high voltage test point. The schematic diagram for this board is SKJQ290180. A marked up layout sketch is included in the drawing set.

3.4 RANGE COUNTER/DISPLAY MODULE

The number of functions on the range counter/display circuit board and the size of the required integrated circuits in conventional packaged form rendered the design of this circuit quite difficult. This was compounded by the fact that the five digit LED display assembly is wider than the four digit GVS-5 assembly and must be mounted at the back edge of the board. No parts in front of the display can exceed 0.07 inches in height. An etched wiring board having somewhat more area than the AN/GVS-5 range counter substrate was designed and fabricated to support the required parts. The circuit was designed around the Intersil ICM7208IPI integrated circuit counter-display driver, driving an HP 5082-7415 display. U1, U2 and associated resistors and capacitors provide the necessary control circuitry. The display timing is controlled by a CA555G timer IC. The schematic diagram for the range counter/ display board is SKJQ181279. A sketch of the layout is included in the drawing set.

3.5 CABLE AND CONNECTORS

The initial plan was to use Deutsch connectors for the interface connections and cable between the optical assembly and the signal processing unit. Delivery lead time quoted by Deutsch was excessive so a change was made to similar Burndy parts with shorter quoted lead time. This choice was fraught with problems also. RCA had expected to receive parts in time to supply them to LLL, but instead had to obtain coaxial and twisted pair contacts from LLL. The cable drawing, with connections and pin types, No. SKNR 791218-Rev. C. is included in the drawing set.

3.6 TRIGGER CIRCUIT

The original EDM trigger circuit was replaced by one from current AN/GVS-5 production. Modification planned to derive power for the pulse monitor detector was not required, so an unmodified production circuit was used.

3.7 PULSE FORMING NETWORK

The pulse forming network capacitor and inductor were replaced by current AN/GVS-5 production units, however they were relocated, as discussed under INTEGRATION, below.

3.8 DETECTOR PREAMPLIFIER

The RCA C30919E detector-preamplifier was used, as required by work statement. This assembly contains a temperature sensor and detector bias control circuit to minimize variation in detector responsivity as a function of detector temperature. Compensating resistors are individually selected for each detector and are mounted externally on the Power Conditioner Board. Data on responsivity, noise and linearity, as supplied by RCA Montreal, are included in appendix B.

3.9 LOGARITHMIC AMPLIFIER

The logarithmic amplifiers were supplied to RCA by Analog Modules to meet requirements established by RCA in conformance to agreements with ASL and NVL representatives.

The 25°C response curve supplied by Analog Modules for log amp S/N 80022202 shows that 1 volt input yields 0.8 volts output; the output decreases at the rate of 10 mv per (-) dbv to a residual noise level of 13 mv rms at -80 dbv. The 13 mv level corresponds to 116 microvolts equivalent input circuit noise for the logarithmic amplifier. Scale error is less than ± 1 db. Log amp S/N 80022201 in the OU follows this curve at 25°C. RCA measurements of S/N 80022202 at 25°C and temperature extremes (summarized in Appendix B) are somewhat different.

Amplifier input and output impedances are 50 ohms and rise time does not exceed 8 nanoseconds for large signals.

3.10 OPERATING CONTROLS

The AN/GVS-5 POWER ON switch is retained, the EDM FIRE switch is replaced by the two-position FIRE switch used for production AN/GVS-5's. The first position charges up the pulse forming network, readying the transmitter for operation. The second position initiates laser operation and the subsequent sequence of ceiling or visibility measurement. The function of the MIN RNG switch is changed to a display REFRESH switch. The measured quantity is displayed for 5 seconds after the FIRE button is fully depressed, then it extinguishes. Actuating the REFRESH switch causes the range to be again displayed for 5 seconds. The data is retained until power to the optical unit is interrupted or until a new measurement is initiated.

The MIN RNG SET potentiometer is replaced by a two position rotary switch; one position selects the CEILING function, the second position selects the VISIBILITY function.

The RET BRT potentiometer has been eliminated to improve clearance for the laser transmitter module (LTM), which is moved toward the control panel because of the beam splitter interposed between the transmitter telescope and LTM flange.

3.11 OPTICAL UNIT/SIGNAL PROCESSING UNIT INTERFACE

The interfaces are in accordance with the OU/SPU INTERFACE DOCUMENT which forms a portion of the Work Statement, except as follows:

The Energy Monitor/Start Signal pulse is an analog of the laser pulse envelope, thus its peak amplitude is proportional to transmitter peak power, rather than energy. The peak voltage falls within the specified range of 0.5 to 1.0 volts and the pulse width is between 5 and 10 nanoseconds at the half amplitude points.

The received signal analog output maximum peak signal does not exceed approximately 0.83 volt. At 0.5 volt signal input level the peak signal plus noise to rms noise ratio is approximately 2500 at the input. By virtue of the log amplifier compression, the log amp output signal to rms noise ratio should exceed 10,000.

The signal to rms noise ratio at the input to the log amplifier should exceed 384 for all signal levels above about 10^{-7} watts/cm^2 at the receiver aperture. The signal to rms noise ratio at the output of the log amplifier should exceed 384 for an input voltage of approximately 15 mv, corresponding to a signal level of approximately 1.5×10^{-8} w/cm^2 at the receiver aperture. (See para. 4.2).

4.0 OPTICAL UNIT INTEGRATION

4.1 NOISE ON SIGNAL LINES

The OU was assembled as planned, with the Logarithmic Amplifier mounted in the AN/GVS-5 battery well, with a coaxial input connector at the end of the well adjacent to the flashlamp trigger circuit. Power connections also passed through a small connector in the same region. When first energized in this configuration the following conditions were observed:

1. Noise bursts on the Energy Monitor/Start pulse output at the time of the flashlamp trigger pulse sometimes exceeded the 0.5 to 1.0 volt start pulse amplitude.

2. Low frequency noise from the flashlamp current pulse coupled into the log amplifier input causing large amplitude overshoot and undershoot of the output prior to and during the desired operating time of the receiver.

3. Noise output of the detector-preamplifier resulted in about 225 mv peak (450 mv pk-pk) output from the log amplifier (120 mv rms).

4.1.1 FLASHLAMP/PFN CURRENT PULSE

The peak current through the flashlamp is 300 to 400 amperes in an 80 microsecond pulse, initially supplied by the pulse forming network (PFN) capacitor, flowing through the inductor and flashlamp in series. The ground return is made at a single point, with no current loop through the structure. The high current however induces currents in structure and neighboring conductors. Attempts to shield parts within the tightly packaged AN/GVS-5 were unrewarding. Moving the input connections and power supply leads to the log amplifier as far as possible from the trigger circuit and PFN inductor were not significant in reducing noise.

The PFN capacitor, inductor and diode were removed from the AN/GVS-5 housing and located externally, although the laser module containing the flashlamp could not be remoted. The result was a significant improvement in noise output, but still inadequate for proper operation. A further step of routing the PFN output to the flashlamp through coaxial cable was not fruitful.

Next the log amplifier was removed from the unit and mounted above the control panel. A further significant improvement in noise output was observed.

At this point the PFN components were returned to the inside of the housing, but the originally unacceptable noise conditions recurred. It thus became apparent that the PFN could not be located in the AN/GVS-5 housing, at least without the major redesign which would be required by compartmentalization.

Two makeshift aluminum boxes were then fabricated. The PFN parts were mounted in one box located under the OU and fastened by two of the panel/housing screws. The log amp was mounted in the second box, similarly fastened above the OU. The two boxes were lined with thin Conetic sheet to provide additional magnetic shielding.

Noise was still excessive initially so variations in ground connections, grounding of shielding boxes and routing of wires were methodically investigated. The configuration which minimized log amplifier transient noise and laser energy monitor circuit noise had the following characteristics.

PFN housing grounded to control panel and housing by mounting screws.

PFN circuit low connected to inside of control panel through 22 Ω resistor.

Log Amp shielding box mounting insulated from control panel.

Log Amp connected to shielding box internally.

Log Amp ground return wire connected from a ground lug on the log amp case to the detector high voltage return pin on the power supply.

Detector-preamp circuit ground connected to a log amp ground lug through the shield of the coax which connects pre-amp output to log amp input.

Insulated, thin Conetic sheet wrapped around laser transmitter module.

4.1.2 DETECTOR PREAMPLIFIER NOISE

The Gaussian (or similar) noise output of the log amplifier when its input was connected directly to the detector preamplifier through a large blocking capacitor was of the order of 120 millivolts rms and $\pm$ 225 millivolts peak, corresponding to an equivalent input noise of about 400 microvolts rms and $\pm$ 1.3 millivolts peak. The predominant component of this noise appears to be preamplifier transistor noise, rather than detector noise, thus the characteristic appears to have a Gaussian rather than Poisson distribution.

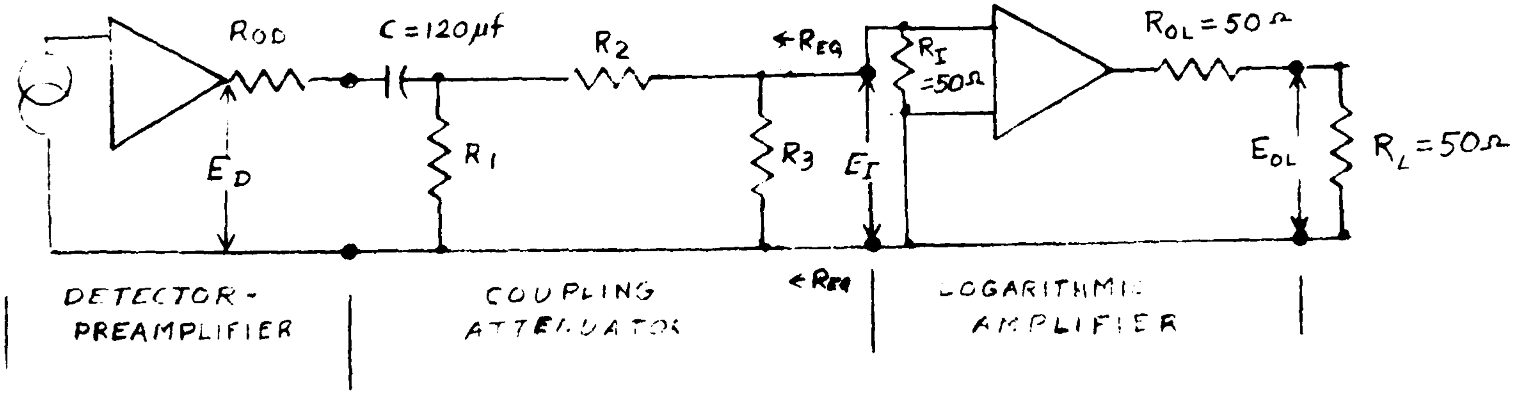
The equivalent input circuit noise of the log amplifier alone, when coupled to a 50Ω source, was approximately 115 microvolts. The high level of the detector preamplifier output noise and the high responsivity of the detector suggested that dynamic range might be enhanced by attenuating the preamplifier output.

Several configurations were tested. Results are given in Table 4-1.

TABLE 4-1

PREAMPLIFIER OUTPUT ATTENUATION

CIRCUIT	R_1 Ω	R_2 Ω	R_3 Ω	E_{OL} mV	E_I μV	E_I/E_D	$20 \log \frac{E_I}{E_D}$	E_{NOISE} AT R_I: $E_{I\,[illegible]}$ μV	E_{NOISE} AT R_I: $E_{I\,[illegible]}$ μV	E_D μV	R_{EQ} Ω
	← MEASURED			→	← CALCULATED						→
A	OPEN	OPEN	50	13	116	0	—	—	116	—	50
B	75	100	OPEN	48	174	.222	−13.1	106	138	477	119
C (REF)	OPEN	0	OPEN	120	398	.667	−3.5	387	95	580	25
D	OPEN	100	OPEN	67	216	.286	−10.9	166	139	580	125
E	OPEN	150	OPEN	58	195	.222	−13.1	131	145	589	175



Configuration C from Table 4-1 is the reference configuration with direct connection of preamplifier output to detector input. Configuration E was selected because it reduced the total noise by a factor of two relative to Configuration C but increased the load resistance for the detector preamplifier from 50 ohms to 200 ohms. The higher load resistance should increase the linear range of the detector preamplifier to offset the attenuation, thus maximizing the dynamic range of the detector preamplifier-logarithmic amplifier combination.

4.2 RECEIVER CHARACTERISTICS

The linear output limit of the detector preamplifier is estimated to be 3 to 4 volts into a 200 ohm load, maintaining the $>$0.5 V to 0.7 V linear range at the input to the log amplifier the same as specified for the detector preamplifier working into a 50 Ω load.

The maximum output of the logarithmic amplifier within the linear range of the receiver should exceed 740 millivolts, corresponding to an input signal of 500 millivolts. The rms noise floor of the receiver in the absence of background radiation is about 60 millivolts at the log amp output, corresponding to about 200 microvolts at the log amp input.

The responsivity of the detector-preamplifier attenuator combination is 10^5 volts/watt. For unity signal to noise ratio the receiver sensitivity calculates to be 2×10^{-9} watts at the detector, which corresponds to

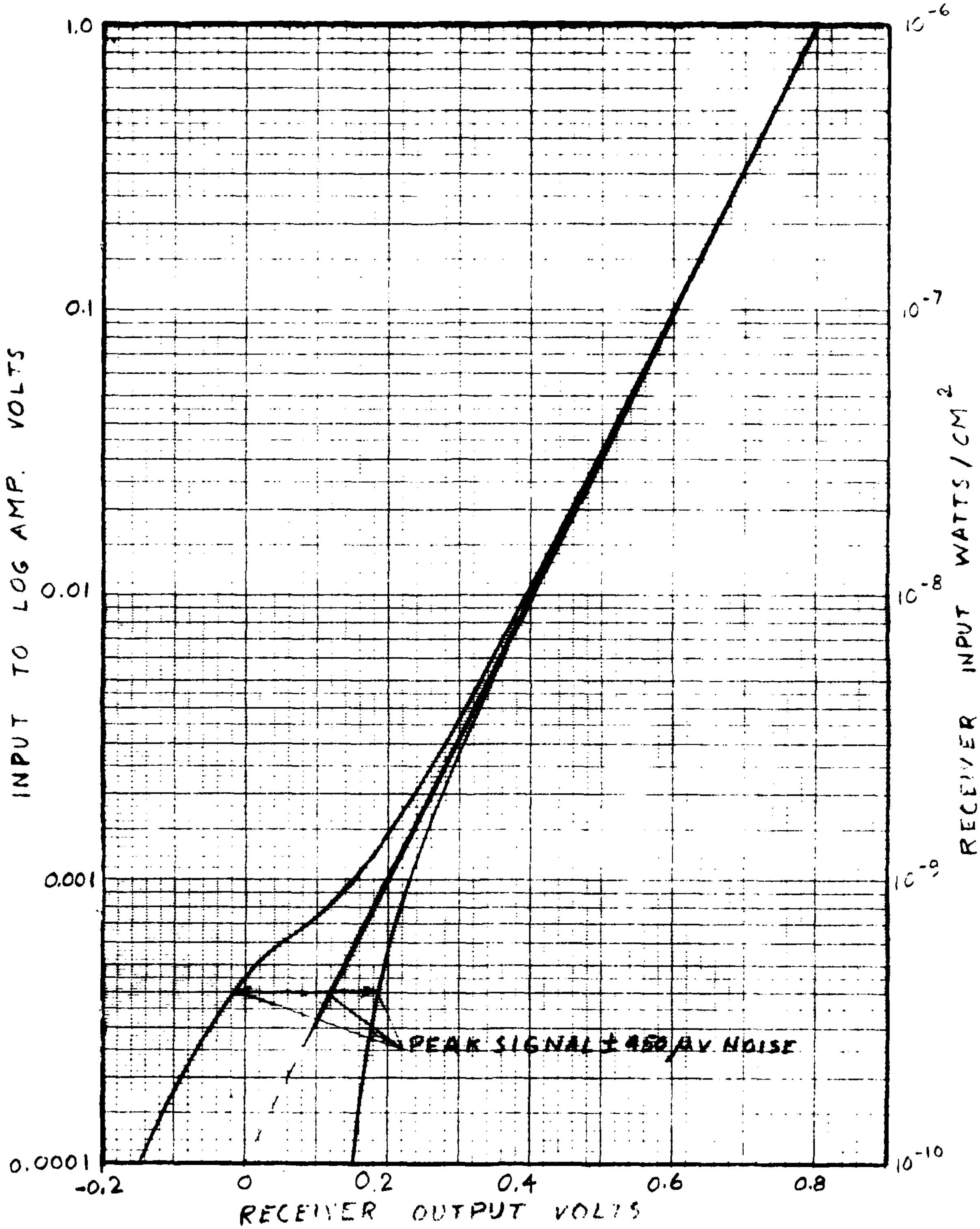


FIGURE 4-1

CALCULATED RECEIVER PERFORMANCE

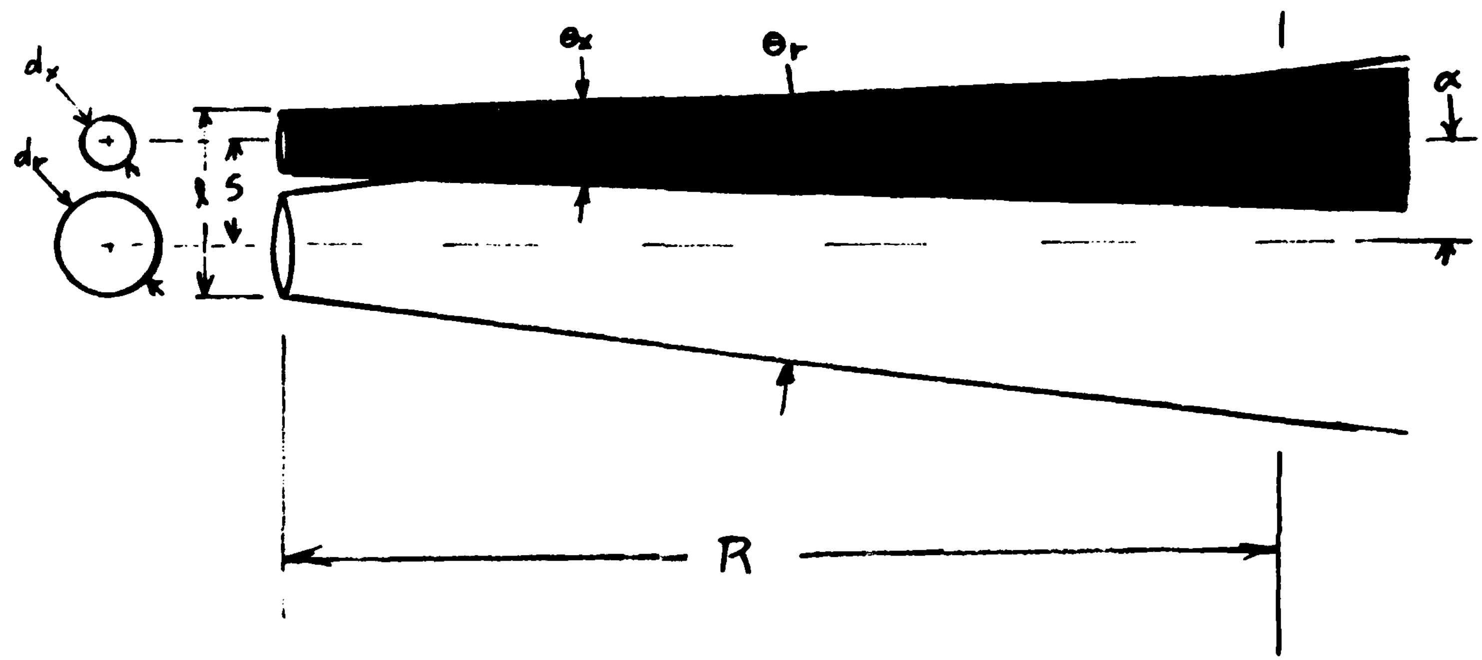
2×10^{-10} watts/cm^2 at the receiver aperture. Maximum signal within the linear range is estimated to be 5 to 8 x 10^{-6} watts at the detector, or 5 to 8 x 10^{-7} watts/cm^2 at the receiver aperture. This corresponds to a dynamic range of 67 to 72 db above the rms noise floor.

Figure 4-1 shows the calculated response of the receiver with ± 450 microvolts peak noise added to the signal. This should be representative of the OU receiver operation.

Any signal exceeding 1.5×10^{-2} volts at the input to the log amp, corresponding approximately to 1.5×10^{-8} w/cm^2 at the receiver aperture should produce a signal plus (rms) noise to noise ratio exceeding 384 to 1, in the absence of background radiation.

4.3 BORESIGHT AL' NMENT

The final alignment of receiver and transmitter axes was accomplished in the mounting of the transmitter module to the telescope. The specification requirement is that the receiver and transmitter be fully converged at a range of 100 meters from the Optical Unit. Figure 4-2 illustrates the geometry in the plane through the axes of transmitter and receiver telescopes. Divergence angles are exaggerated for illustration purposes. The following symbols and dimensions apply.



OPTICAL UNIT RECEIVER-TRANSMITTER
BORESIGHT

FIGURE 4-2

R = total beam convergence range

d_x = diameter of transmitter exit beam = 16 mm

d_r = diameter of receiver aperture = 50 mm

S = Separation of receiver and transmitter axes = 50 mm

ℓ = separation of extremes of apertures $= \frac{d_x}{2} + \frac{d_r}{2}$ = 83 mm

θ_x = transmitter beamwidth ($>$80% energy) = 1 milliradian

θ_r = receiver field of view = 3 milliradians

α = convergence angle between axes

From the simple geometry it can be shown that full convergence occurs when the equation

$$\ell + R\frac{\theta_x}{2} - R\frac{\theta_r}{2} = 0_1 \quad (\tan\frac{\theta}{2} \approx \frac{\theta}{2}) \quad \text{is satisfied.}$$

Thus

$$R = 2\ell \frac{1}{(\theta_R - \theta_x)} = 2 \times 83 \frac{1}{2 \times 10^{-3}}$$

$$= 83 \times 10^3 \text{mm} = 83 \text{ meters.}$$

If we allow for a possible 0.25 milliradian shift in boresight as a function of time, mechanical stress or temperature the beams should initially converge by 0.25 milliradians, or $\alpha = 0.25$, $\Delta\alpha = 0.25$

Then

$$R_{max} = 2 \frac{1}{(\theta_R - \theta_x) + 2\alpha - 2\Delta\alpha} = 83 \text{ meters}$$

$$R_{nom} = 2\ell \frac{1}{(\theta_R - \theta_x) + 2\alpha} = 66 \text{ meters}$$

$$R_{min} = 2\ell \frac{1}{(\theta_R - \theta_x) + 2(\alpha + \Delta\alpha)} = 55 \text{ meters}$$

The receiver and transmitter axes were initially converged by 0.25 milliradians to assure that the convergence range would remain below 100 meters. Note that even in the minimum convergence range condition, the beams remain converged with a margin of 0.5 milliradians.

4.4 ASL WHITE SANDS OPTICAL UNIT CHECK

Schedule compression of the ASL program resulting in part from the unexpected severity of Optical Unit integration problems and a funding hiatus necessitated that ASL perform tests of the OU with its makeshift external housings. These tests were accomplished in the period of 12 through 19 September 1980 at White Sands. Operation was reported to be satisfactory, although the need for correct placement of the eye to see the illuminated V or C mode indicators through the eyepiece was noted. This condition results from adding a fifth digit to the range display so that the mode LED separation is greater than the AN/GVS-5 optics can accomodate without imposing a critical viewing angle. If sufficient light is available it may be possible to put diffusing surfaces on the reticle for future units.

At completion of all of the tests that could be accomplished by ASL prior to unavailability of their computer the OU was returned to RCA.

4.5 FINAL CONFIGURATION OF OPTICAL UNIT

During the period of the ASL tests two machined housings and supports were fabricated, chemically treated, and painted at RCA. The housings were to replace the makeshift boxes for the Pulse Forming Network and Logarithmic Amplifier.

Upon return of the Optical Unit to RCA from ASL the noise was remeasured and oscillograph photos were taken to confirm the performance of the unit. The OU was then disassembled, appropriate holes were drilled in the bottom and top edges of the control panel, and the housing supports and wiring were installed. The log amp and PFN parts were then installed in the new housings and the unit was checked out. Noise performance was equal to or better than with the makeshift housings. No magnetic shielding material was placed in the housings, but a magnetic shield wrapped around the laser transmitter module within the OU had to be retained.

The OU paint was touched up and photographs were taken to document the configuration. See Appendix C. Final assembly included O-rings installed in the log amp and PFN housings in an attempt to maintain pressure integrity for environmental protection of the OU. Some pressure leakage was still observable, however the OU should be rainproof even though not immersion proof.

4.6 CONNECTION AND OPERATION

4.6.1 INTERCONNECTION OF OU AND SPU

The OPTICAL UNIT (OU) is connected to the SIGNAL PROCESSING UNIT by a four foot cable, supplied with the OU. It receives its power from a 24 V nickel cadmium battery, type BB-516, in the SPU.

4.6.2 OU CONTROLS AND DISPLAYS

PWR switch, 2 position rotary, ON powers the OU range counter and the MODE display in the sighting telescope reticle plane. MODE display, C to the left of the digital display or V to the right is always illuminated when PWR switch is ON. Power to the receiver and transmitter is enabled, but controlled by the two position FIRE push button.

The operating MODE is selected by the two position V (visibility) or C (ceiling) rotary MODE switch. This switch illuminates the appropriate display in the OU eyepiece and provides a logic 1 (+5V) to the SPU for the Ceiling mode or a logic 0 for the Visibility mode, through the interface cable.

The FIRE pushbutton switch is depressed and held in its first position to power the receiver and charge the laser energy storage capacitor. This function takes less than a second. During this time the digital range display is blanked. Upon reaching full charge the least significant range bit (LSB) zero is displayed.

When the FIRE switch is fully depressed the laser transmitter operates and the digital display is blanked. (To assure correct operation the button should be fully depressed not less than one nor more than fifteen seconds after the full charge zero is displayed).

When the first range data pulse is received from the SPU the LSB zero will be displayed. If additional pulses are received they are counted and displayed. Display of only the LSB zero indicates an error. Whether a single pulse or several pulses are transmitted the digital range indicator will remain displayed for 5 seconds, then blank.

The digital display will again be displayed when the REF (refresh) switch is pressed. It will remain displayed as long as the REF button is depressed or for 5 seconds, whichever is longer.

The last range will be available until prime power is interrupted or the counter is reset by the next FIRE switch actuation.

4.7 CHARACTERISTICS SUMMARY

Input Prime Power	20-30 V d-c
Standby-no display	$I \approx 15$ ma
Transmitter charging	$\bar{I} < 1A$; 0.4 to 0.8 sec
Receiver Operating	$I < 0.2$ A
Receiver OFF, Range Displayed	$I \leq 0.07$ A

Transmitter

Energy Output	10 to 20 mj typical
Pulse Width	6 to 7 ns nominal
Peak Power Output (W_T)	1.5 to 3 MW typical

Transmitter Pulse Monitor (to SPU)

Load Resistance	50 Ω (at SPU)
Peak Output Voltage ($\hat{E}_O$)	0.5 to 1.0 V, (0.8 V typical at 25°C)
Output Calibration	$\hat{W}_T = 3.11 \times 10^6 \times \hat{E}_O$ ($\pm$5%)
	$J_t = 20.9 \times 10^{-3} \times \hat{E}_O$

Initiate Signal (to SPU)

Standby	Logic 0 (0 V)
Start Charge (First FIRE switch position)	Logic 1 (+5 V)

Mode Select (to SPU)

Visibility	Logic 0
Ceiling	Logic 1

Receiver Output (to SPU)

Load Resistance, R_L	50 Ω (at SPU)
Maximum Output, E_{LMAX} (overload)	0.83 V, approx., measured
Dark Noise Output, E_{LN}	60 mv rms, measured
Rise Time, T_R	10-15 ns, estimated

Transfer Characteristic	$E_L \approx 0.8V + 0.2 \log (\frac{W_{IN}}{cm^2} \times 10^6)$
E_L vs. W/cm^2 optical input	$\approx 2.0 + 0.2 \log (\frac{W_{IN}}{cm^2})$ for
(calculated)	$E_L \lessapprox 0.8V \approx$
	$(\frac{W_{IN}}{cm^2}) \lessapprox 10^{-6} (\frac{W}{cm^2})$
Maximum Output, Linear Region	E_L = 0.74 to 0.80 V, estimated
Droop	< 0.35% in 20 us, estimated

Sensitivity

Noise floor $(\frac{S}{N} = 1)$	2×10^{-10} w/cm^2, calculated
Maximum Input for Linearity	5×10^{-7} to 10^{-6} w/cm^2, estimated
Dynamic Range	$\frac{5 \times 10^{-7}}{2 \times 10^{-10}} = 2500:1 \cong 68$ db (voltage) to 74 db. estimated

TABLE 4-2

LASER PULSE MONITOR 25°C CALIBRATION

A Laser Output mj (meas.)	B Monitor Pulse (meas.)	C mj/V (A/B) Calc.	D Pulse Width ns (meas.)	E mw/V (C/D) (Calc)
16.2	.76	21.3	6.8	3.13
16.3	.80	20.4	6.6	3.09
16.6	.80	20.8	6.7	3.10
16.7	.785	21.3	6.8	3.13
17.7	.845	20.9	6.7	3.12
18.2	.85	21.4	6.8	3.15
18.3	.875	20.9	6.7	3.12
18.6	.915	20.3	6.6	3.08
19.2	.91	21.1	6.8	3.10

Av.	20.9(3)mj/v	6.7(2) ns	3.11 mw/v
σ	.37 mj/v	.078 ns	.021 mw/v

Estimated Precision of Measurement

$\pm$0.05 mj	$\pm$0.01v	$\pm$0.2 ns
0.3%	1.2%	3%

$$\text{mj output} \approx 20.9 \times \hat{E}_p$$

$$\text{mw output} \approx 3.11 \times \hat{E}_p$$

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The modification of an MX-9839/GVS-5 laser rangefinder into a Visioceilometer Optical Unit was accomplished and a functional unit resulted. However, the mechanical packaging was not straightforward.

Aside from the relocation of the PFN components and logarithmic amplifier outside of the MX-9838 housing, the internal packaging of the range counter display, laser transmitter-pulse monitor assemblies, the voltage regulator circuit and detector pre-amplifier was very constricted. A small number of additional units can be manufactured in the same manner for experimental purposes, but a more extensive program incorporating some or all of the recommendations below should be undertaken if an integrated mechanical package and improved performance are to be achieved.

5.2 RECOMMENDATIONS

5.2.1 RECEIVER TRADEOFF STUDY

A tradeoff study of the receiver performance requirements versus detector-preamplifier and logarithmic amplifier characteristics is desireable. The interrelated characteristics of responsivity, NEP, bandwidth, and dynamic range of the detector pre-amplifier should be reassessed because the specified RCA C30919E assembly apparently was not optimum. Noise seemed excessive, responsivity and bandwidth may have been greater than necessary. (In addition the package size is mechanically incompatible with the MX-9838 optics housing and control panel).

Once the optimum combination of achievable characteristics for the detector pre-amplifier is established, the requirements for a compatible logarithmic amplifier can easily be specified.

5.2.2 DETECTOR PREAMPLIFIER PACKAGING

A detector-preamplifier packaged in a TO-8 container as is the AN/GVS-5 detector would facilitate mechanical, optical and electrical integration. Such a unit containing the temperature sensing diode but not the compensation circuitry is obtainable. The temperature compensation loop could easily be implemented using an external IC operational amplifier and the AN/GVS-5 detector power supply which functions as a dc amplifier with a gain of 75.

This unit could presumably be tailored to optimize its characteristics, as determined in the suggested receiver study.

5.2.3 LOGARITHMIC AMPLIFIER

RCA measurements of logarithmic amplifier S/N 80022202 (Analog Modules, type LA-80-P-RCA) show a significant displacement and change in slope of the transfer characteristic curve as a function of temperature. In conjunction with the respecification of the log amp the variation of its transfer curve with temperature should probably be minimized and controlled.

Although the log amp meets its rise time specification of 8 ns for large signals, its small signal rise time appears to be about 15 ns and fall time about 20 ns. Although the large signal fall time appears to be long it is difficult to establish that this is not a result of pulse generator pulse tail combined with the logarithmic compression.

The suggested receiver tradeoff study should establish whether improved characteristics would offer any advantage and also establish their feasibility.

5.2.4 MECHANICAL DESIGN

The items listed below should be considered in the event an ED program is undertaken.

A. Redesign control panel and housing to incorporate compartmentalization with a view to internal mounting of log amp and PFN parts, increasing laser transmitter module panel clearance, and eliminating battery housing.

B. Redesign connector mounting for less protrusion.

C. Convert range counter display assembly to hybrid microelectronics to reduce size and enhance packaging.

D. Investigate enhancing viewing angle of "V" an . "C" mode displays in the reticle plane.

5.2.5 POWER SUPPLY

The possibility of incorporating the + and - 5 volt regulators and +50 volt pulse monitor supply in a modified AN/GVS-5 power supply could be investigated. This would facilitate internal packaging of the OU.

APPENDIX A

DEFINING TECHNICAL DOCUMENTS

OF

MODIFICATION OF AN/GVS-5( ) LRF

FOR

VISIOCEILOMETER CONVERSION

Work Statement

Modification of AN/CVS-5( ) LRF for

Visioceilometer Conversion

1. (Change, See Addendum to Work Statement)

SCOPE

This task comprises modification of one Laser Rangefinder MX-9838/GVS-5( ) supplied for the purpose by ERADCOM. The modifications affect the optical assembly, power supply, detector, "start" pulse, generator, controls, battery compartment, trigger circuit, laser transmitter and control panel.

A. Optical Assembly

(1) Replace prism assembly with a new assembly containing reticle mask with display window lengthened by 25%, left hand circular LED window replaced by a window in the shape of a letter C, right hand window shaped like letter V, and the following lettering deleted: "LOW BATT," and "MULT TGT."

(2) Increase display optical relay element sizes, if required, to accomodate 5 digit display and LED's.

(3) Modify casting to accomodate revised lens #4 mount and larger detector pre-amplifier module (RCA C30919E).

(4) Replace receiver field stop with 3 mrad diameter field stop.

(5) Fabricate lens #4 mount, detector mounting ring and detector clamp.

(6) Assemble parts, including detector assembly, focus and boresight receiver and transmitter telescope so that the 3 milliradian receiver field of view completely encompasses the 1 milliradian
1. transmitter beam at ranges of 80 to 100 meters (design goal).

B. Transmitter Pulse Monitor

Interpose between the Laser Transmitter Module (LTM) output and transmitter telescope a polarization insensitive beamsplitter coupled to a suitable silicon PIN detector followed by a line driver, with temperature compensation for quantum efficiency variation in the PIN diode. Required performance (-5°C thru +60°C):

- Monitor error $\leq$ 5.0%

- Pulse width $\leq$ 10ns (FWHM)

- Monitor voltages exceeding the valid output (Vo) range (0.5 $\leq$ Vo $\leq$ 1.0 volt dc), when sensed by the SPU, shall initiate an error indication in the display.

C. Power Supply

Replace power supply with production unit (SM-D-852009) connected for instant fire and modify AGC input circuit of power supply to provide output voltage adjustable to any fixed voltage between 500 and 600 volts.

D. Range Counter-Display

Replace the range counter-display with a counter (CMOS compatible) having the following characteristics: 4 decade counters with LED drivers and latch for driving a 5 digit, 7 segment, LED display. Must accept and count up to 10,000 pulses at 52 kilobit rate corresponding to a 99,990 meter range. Must include a 5 second timer for range display and "refresh" input to repeat display. Must provide drive for Visibility and Ceiling LED's, and low battery power indication by blinking the display or lighting decimal points. The low battery indication shall be exercised when the battery voltage drops to 21.5 $\pm$ 1 vdc.

The following display sequence or its equivalent is required:

- when system is turned on and the fire switch is depressed halfway the display shall be blank

- upon reaching full charge the LSD zero and the mode indicator shall be displayed.

- after laser fires, the display shall again blank

- when the first pulse is received from the SPU, two zeros shall be displayed. Two zeros will indicate an error. If additional pulses are transmitted they shall be counted and displayed. Whether a single pulse or several pulses are transmitted the range and mode indicator shall be displayed for 5 seconds and then blank.

- the counter shall reset with the next laser pulse or when the power is turned off.

E. Controls and Optical Panel

(1) Modify panel to physically accomodate C30919E Detector-Preamplifier.

(2) Replace battery cap with hole plug, which accomodates a recessed, male interface connector, Deutsch type, with 2 coax and six pin connections.

(3) Change MIN RNG pot to a two position mode switch.

(4) Change function of MIN RNG switch to Display Refresh switch.

(5) Change panel marking to agree with new control functions.

(6) Replace FIRE switch with Instant Fire switch.

F. Interconnecting Cable

Provide 4 foot cable (retractable type preferred), four #28 and two #22 wires, male and female Deutsch cable connectors for both ends of cable, with strain relief and weatherproof encapsulation for interconnection of Optical Unit and the Signal Processing Unit.

G. Internal Wiring

Interconnect all circuits, controls, and connectors to extent that interface information is supplied by ERADCOM. Use existing flexible printed wiring as far as possible.

H. Trigger Circuit

Replace trigger circuit module with production unit for "instant fire" operation.

I. Transmitter

Replace transmitter housing with production unit housing.

J. Receiver

Provide and integrate a video amplifier into the Optical Unit such that the dynamic range of the detector/preamplifier may be compressed to the input requirements of the Signal Processing Unit as defined in the OU/SPU interface document. The video amplifier's inputs must be matched to the output characteristics of the detector/preamplifier to optimize the receiver performance. These characteristics include, but are not limited to, small signal bandwidth, full power bandwidth, impedance matching and dynamic range. In addition, linearity (conformity) errors of the video amplifier shall be $\leq \pm$ 2 db with respect to the input over the dynamic range of the detector/preamplifier and over the temperature range -5° thru $+60^{\circ}$C.

K. Other Tasks

(1) Provide 4 additional detectors, C30919E, in mounting rings.

(2) Provide 2 sets of all engineering sketches used to perform modifications, including mechanical and wiring changes, module interconnection and interface wiring connections.

L. Environmental

Design for operation over temperature range of -5°C (23°F) to $+60^{\circ}$C (140°F).

M. Testing

(1) Boresight Alignment - Test transmitter/receiver boresight
1. versus temperature over ranges of -50°F to 160°F and provide test data. Include sufficient measurement at intermediate temperatures to characterized boresight behavior.

(2) Detector/Preamp Module - Test module performance and provide characteristics data for each module. Include pertinent parameters as responsivity and linearity, recovery time, output voltage and impedance, and variation of these parameters with temperature.

(3) Logarithmic Amplifier - Test amplifier performance and provide test data. Include transfer characteristics, recovery time, small and large signal bandwidth and temperature characteristics.

*(The above test data may be used by ERADCOM to evaluate and analyze the overall system performance It is of interest to know the repeatability of the transfer characteristcs from device to device and within the device from cycle to cycle. Nonlinearity and/or any abnormal behavior in the device shall determine the degree of compression needed in the microprocessor elsewhere in the system.)

* The above is for information purposes only.

OU/SPU INTERFACE DOCUMENT

1. (Change. See Addendum to Work Statement)

The OU and the SPU shall be interconnected by an electrical cable. The interface characteristics of this cable are as follows (all logic levels must be CMOS compatible):

(1) Power Line - 24 volts nominal (one military type BB-516( )/U battery) are provided to the OU from the SPU when the SPU Main Power Switch is activated.

(2) Power Return - #22 size wire minimum

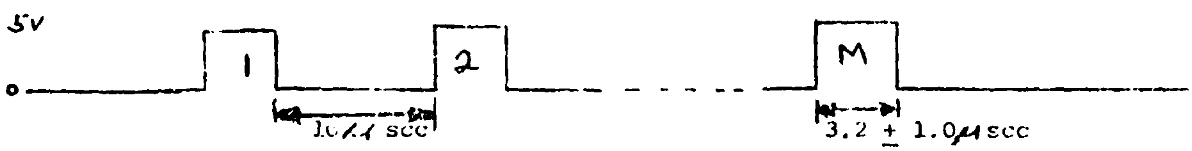
(3) Mode Select - The OU shall provide a voltage level to the SPU to indicate the selected mode of operation as follows: Logic "1" (5 volts) for the Ceiling mode and logic "0" (0 volts) the Visibility mode.

(4) Initiate Signal - Upon activation of the OU Fire Switch (first stop) a logic "1" (5 volts) shall be provided.

(5) Energy Monitor/Start Signal - The OU shall transmit via coax (terminated in 50 ohms), a pulse (pulse width $\leq$ 10 nsec @ FWHM) whose amplitude shall be a linear function of the transmitted laser output energy. The valid amplitude range of this pulse must be 0.75 $\pm$ 0.25 volts. Voltage amplitudes exceeding this range shall be treated by the SPU as a malfunction in the laser transmitter

(6) Analog Output - The receiver output signal video amplifier output shall be transmitted via coax terminated in 50 ohms. The
1. maximum peak-to-peak amplitude of this signal shall be 2 volts (0 to 2 volts).
The peak signal to RMS noise ratio shall be no less than 384.

(7) Display Information - Serial clock pulses shall be transmitted to the OU via a "twisted pair." One line shall carry the signal and the other shall be a return (separation from the 24 volt return may be required). The waveform of the transmitted data is nominally:



Where M is equal to N/10 +1, N is the actual range in meters. The initial and final states of the transmitted data are logic "0".

AN/GVS-5 MODIFICATION FOR VISIOCEILOMETER
STATEMENT OF WORK

- RCA WILL MODIFY ONE (1) EDM AN/GVS-5 (GFE) FROM ERADCOM FOR THE VISIOCEILOMETER.

- MODIFICATIONS WILL BE MADE TO THE FOLLOWING ITEMS:

- OPTICAL ASSEMBLY	(MODIFY)
- POWER SUPPLY	(NEW)
- DETECTOR	(NEW)
- START PULSE GENERATOR	(NEW)
- CONTROLS AND CONTROL PANEL	(MODIFY)
- BATTERY COMPARTMENT	(NEW)
- TRIGGER CIRCUIT	(NEW)
- LTM	(MODIFY)

- THERE IS NO FORMAL ACCEPTANCE TEST FOR THE DELIVERABLE HARDWARE (THE HARDWARE IS NOT AN END ITEM IN ITSELF). ACCEPTANCE WILL BE MADE OF THE DATA.

- RCA WILL PROVIDE TWO (2) SETS OF ENGINEERING SKETCHES, INCLUDING MECHANICAL AND WIRING CHANGES, MODULE INTERCONNECTION AND INTERFACE WIRING CONNECTIONS.

- ENGINEERING TESTING SHALL CONSIST OF INFORMAL TEMPERATURE ENVIRONMENTAL TESTS AT -5^{o} and $+60^{o}C$.

- PACKING/PACKAGING WILL BE TO BEST COMMERCIAL PRACTICE.

- WORKMANSHIP SHALL BE IN ACCORDANCE WITH RCA STANDARD PRACTICE.

ADDENDUM TO STATEMENT OF
WORK FOR VISIOCEILOMETER

1. Page 1, para A (6), 4th line - Substitute - "design goal of 80 to 100 meters" for ranges of 100 meters and beyond".

2. Page 4, para. M, line 2 - Substitute - "-50 F to 160 F" for "-5 C to 160 C".

3. OU/SPU Interface Document - Substitute - "0 to 2 volts" for " (1 to -1 volt perferred)".

4 The following listed items will be supplied as spares for this contract:

ITEM	QTY
Power Supply	2 each
Logarithmic Amplifier	1 each
Detector Pre-Amplifier	1 each
Video Amplifier	2 each

RCA-AUTOMATED SYSTEMS
BURLINGTON, MASSACHUSETTS

INTERNAL CORRESPONDENCE EIP-0.5.4.1-290/JF

DATE: 5 November 1979

TO: Distribution

FROM: J. S. Furnstahl

SUBJECT: TECHNICAL INTERCHANGE MEETING ON VISIOCEILOMETER AT RCA-B - 31 OCT 79

REFERENCE: CONTRACT DAAK20-79-C-0038

ATTENDEES:

Mr. J. F. Gibson	-	NV&EO Lab, Ft. Belvoir, Va.
Mr. W. J. Lentz	-	Atmospheric Science Lab, White Sands, NM
Dr. J. S. Randhana	-	Atmospheric Science Lab, White Sands, NM
Mr. J. F. Kordes	-	Lawrence Livermore Lab, Livermore, Ca.
J. Hallal	-	RCA-B
R. C. Guyer	-	RCA-B
J. H. Woodward	-	RCA-B
J. M. Quinn	-	RCA-B
N. L. Roberts	-	RCA-B
J. S. Furnstahl	-	RCA-B
E. B. Galton	-	RCA-B (part-time)

The technical aspects of the program, including the various interfaces, were discussed. The Lawrence Livermore Lab is designing the Signal Processing Unit which interfaces with the RCA Modified AN/GVS-5 into a Visioceilometer System.

The following action items and understandings resulted from the subject meeting:

1.0 All communications which impact the contract shall go through J. Gibson, NV&EO Lab (tel: 703-664-6969). Technical communications shall be engineer-to-engineer. All such communications shall be documented by the engineer with copies to Furnstahl, Hallal, Waldstein and Woodward.

2.0 Provide a budgetary cost estimate to NV&EO Lab for long lead material for possible second or third Visioceilometer, including portions of the Optical Assembly, connectors, etc. ACTION: RCA - Quote to be submitted by 16 Nov 79 via telephone (J. Furnstahl to coordinate).

3.0 Detector Preamp - Determine bandwidth, frequency and rise time. ACTION: RCA-J. Woodward - by 7 Dec 79.

4.0 Provide three AN/GVS-5 Battery Holders, including bottom contact, to Lawrence Livermore Laboratory, P.O. Box 5507, Livermore, Ca. 94550, attention of J. F. Kordes, L-524. ACTION: RCA - J. Furnstahl - by 1 Dec 79.

5.0 Clarifications - S.O.W. of referenced contract

a. Section D - Range Counter Display

1. Second paragraph, line 1: Add the word "numerical" between the words "following" and "display".

2. Second paragraph, 2nd "bullet": Delete the words "and the mode indicator".

b. Section E, Note (2)

RCA will use a similar interface connector to the Deutsch type, due to long lead time delivery. (Burndy connectors P/N G4B1288SPNH, G6F 1288SNH, G6F1288PNH, and G4B1288SNH). LLL will investigate Burndy connector deliveries and advise RCA. RCA may be able to supply one pair of connectors (SPU panel and cable mate) if received in time to be of use.

c. Section F, first line

RCA will not use a mechanical type retractor - will roll up and tie in a diameter appropriate to the specified minimum bend radius of the coax cable used.

6.0 Section F. Interconnecting Cable and
Section G. Internal Wiring - S.O.W. of referenced contract

ACTION: RCA to define and provide wiring information to J. Kordes, Lawrence Livermore Lab by 30 Nov 79.

7.0 Lawrence Livermore Lab and RCA will provide their own ends of the interface connectors; however, see 5.0, b. above.

8.0 OU/SPU Interface Document to referenced contract

Change item (6), line 3, within the (....) from: (-1 to 1 volt preferred) to: (linear range shall be 0 to 1 volt).

9.0 Investigate possible change to the referenced contract as follows: Delete the two spare Logarithmic Amplifiers (type AM/LA-80-EE) and substitute a more expensive Logarithmic Amplifier (type AM-LA-80-WL) proposed by ASL for use in the Visioceilometer. ACTION: W. Lentz, ASL, will discuss with J. Gibson, based on a "no cost" contract change. The lead time is approximately 40 days ARO. RCA to determine NVL intent so design can be finalized. (J. Furnstahl/J. Gibson)

J. S. Furnstahl
J. S. FURNSTAHL

/iv

Distribution

H. C. Center
E. B. Galton
R. C. Guyer
J. Hallal
E. B. Marmer
S. B. Mesnick
J. M. Quinn
N. L. Roberts
J. H. Woodward

J. F. Gibson, NV&EO Lab
J. F. Kordes, Lawrence Livermore Lab
W. J. Lentz, Atmospheric Science Lab
J. S. Randhana, Atmospheric Science Lab

APPENDIX B

TEST DATA SUMMARY

B-1.0 LOGARITHMIC AMPLIFIER

B-2.0 LASER PULSE MONITOR

B-3.0 PHOTODIODE PREAMPLIFIER MODULE

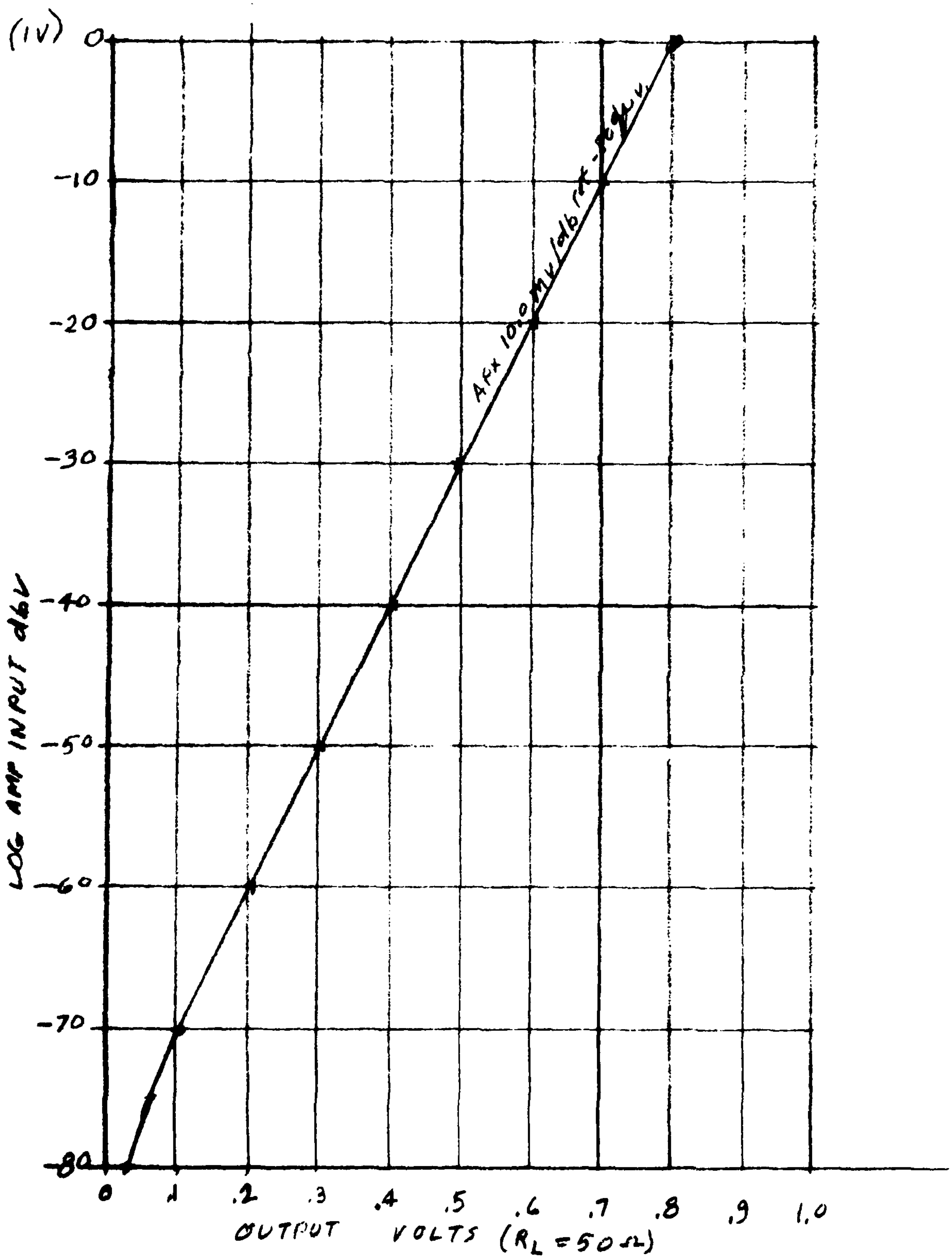
B-1.1 LOGARITHMIC AMPLIFIER TEST SUMMARY

B-1.1.1 A measured transfer curve for Logarithmic Amplifier, Analog Modules P/N LA-80-P-RCA, S/N 80022202, was supplied by the vendor. The curve is replotted in Figure B-1. The data supplied for S/N 80022201 is essentially identical.

B-1.1.2 Transfer characteristics of logarithmic amplifier S/N 80022202 were measured at approximately 25°C, -5°C and +60°C at RCA. Measurements were made after the module had been operating in the Visioceilometer Optical Unit for several weeks, then removed and replaced by S/N 80022201.

The logarithmic amplifier was installed in a Tenney Jr. temperature chamber and powered by regulated + and - 6 volt supplies.

A Hewlett-Packard pulse generator, Model 8013B, was adjusted to supply 1 volt peak, 100 nanosecond pulses into a 50 Ω attenuator, Kay Electric Co. Model 432D. The output of the attenuator was fed to the (50 Ω) input of the log amp under test through a 50 Ω coaxial cable. The output of the log amp was connected through a 50 Ω cable, terminated in a 50 Ω coaxial termination, to a Tektronix Oscilloscope Model 7834. The input to the log amp. was decreased in 10 db steps by the attenuator from 0 dbv to -80 dbv.



TRANSFER CHARACTERISTIC: 25°C - VENDOR DATA

LOGARITHMIC AMPLIFIER S/N 80022201 8--02

FIGURE B-1

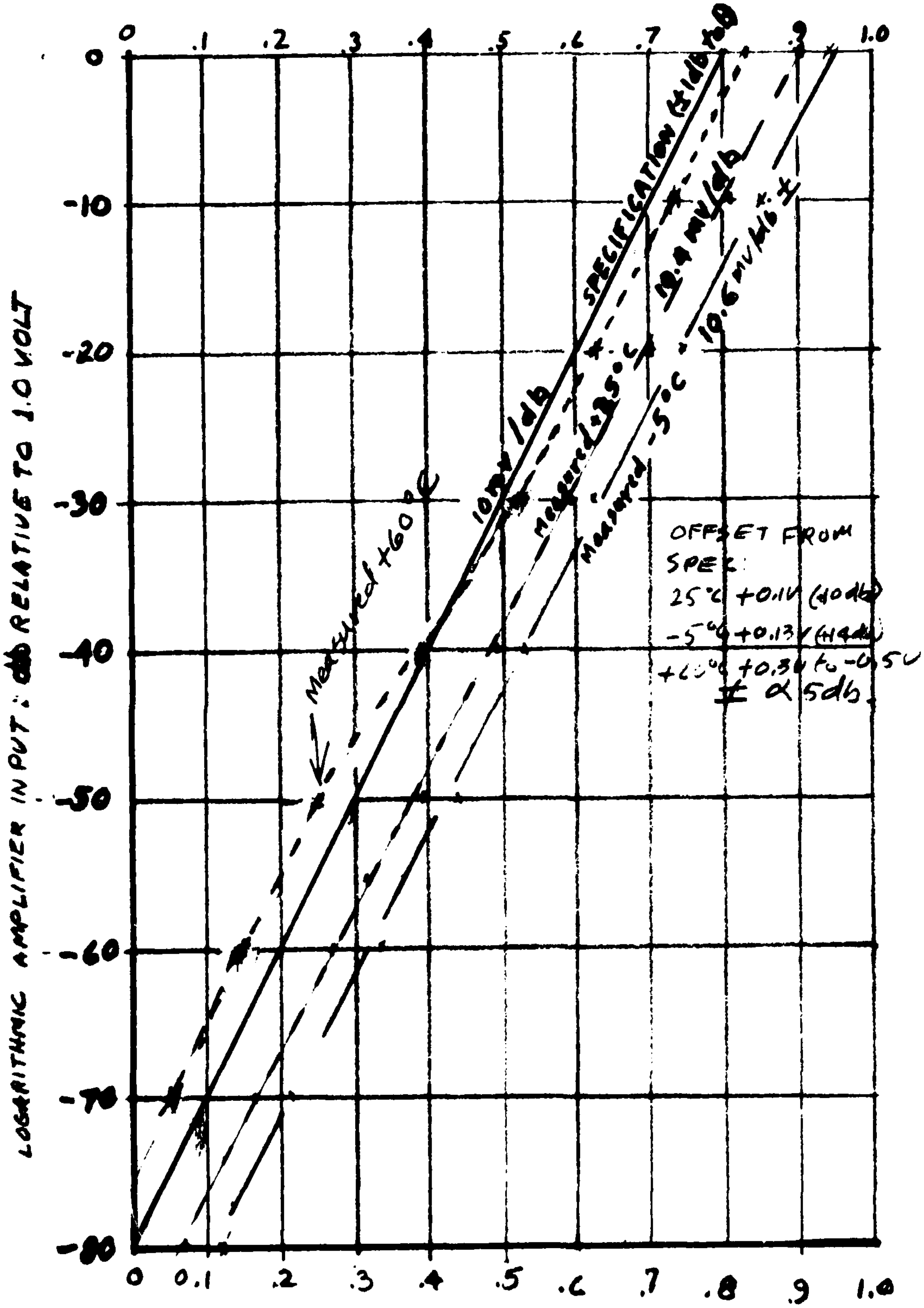
At each step the output pulse waveform of the log amplifier was displayed on the oscilloscope, stored and photographed with a Polaroid camera.

The same tests were performed with the log amp temperature stabilized at 25°C, -5°C and +60°C. The results of the tests are plotted in figure B-2.

Representative waveform data for the 25°C tests is shown in figures B-3 and B-4. Figure B-3-1 is the pulse at the input to the attenuator. B-3-2 through B-4-4 are log amplifier output pulses for input levels of 0 dbv-B-3-2, -20 dbv. - B-3-3, -40 dbv-B-3-4, -50 dbv-B-4-1, -60 dbv-B-4-2, -70 dbv-B-4-3, and -80 dbv-B-4-4.

B-1.2 PULSE MONITOR CIRCUIT DATA

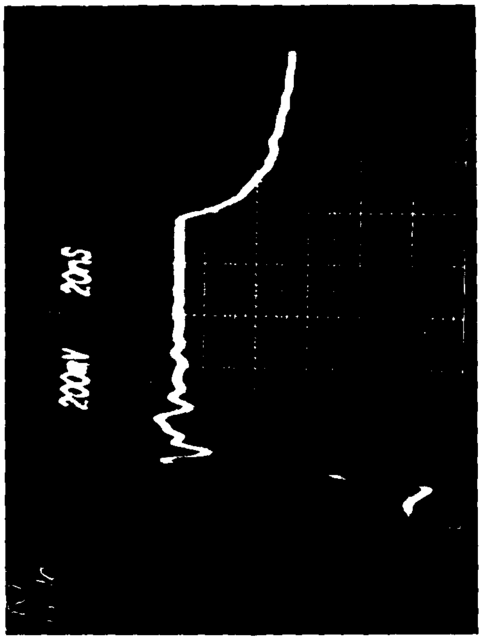
Many temperature runs were made with the transmitter pulse monitor and AN/GVS-5 transmitter in the Tenney Jr. chamber and an EG&G Model 580 Radiometer monitoring output external to the chamber. From this data the circuit, part values and characteristics of the required thermistor were established and temperature compensation was verified. After installation of the pulse monitor beam sampler and detector circuit in the Optical Unit a calibration run was made at laboratory ambient temperature, approximately 25°C. The laser module output energy was measured using an EG&G Radiometer, Type 580,

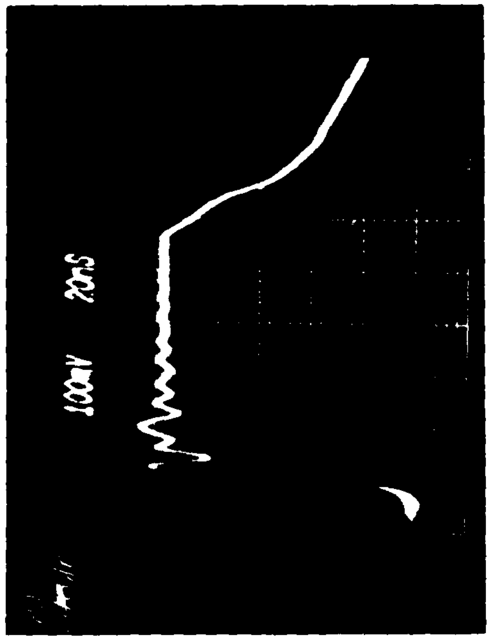


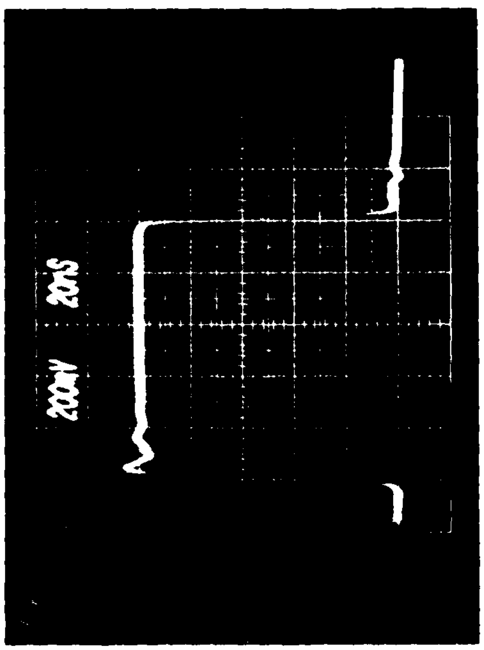
LOGARITHMIC AMPLIFIER OUTPUT - VOLTS

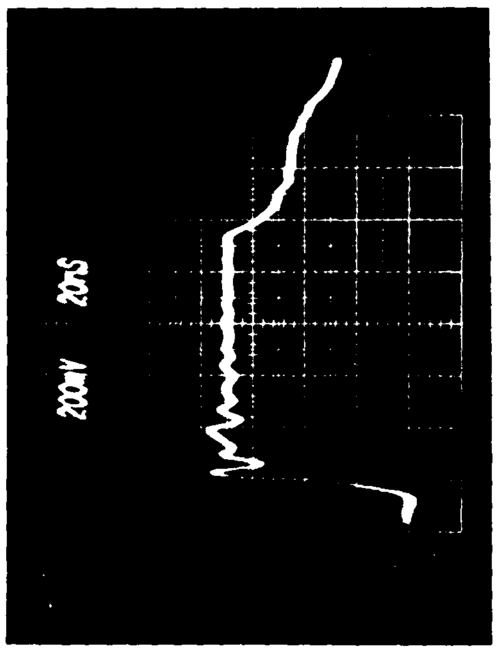
TRANSFER CHARACTERISTIC VS TEMPERATURE
ANALOG MODULES P/N LA-80-P-RCA S/N 80022202

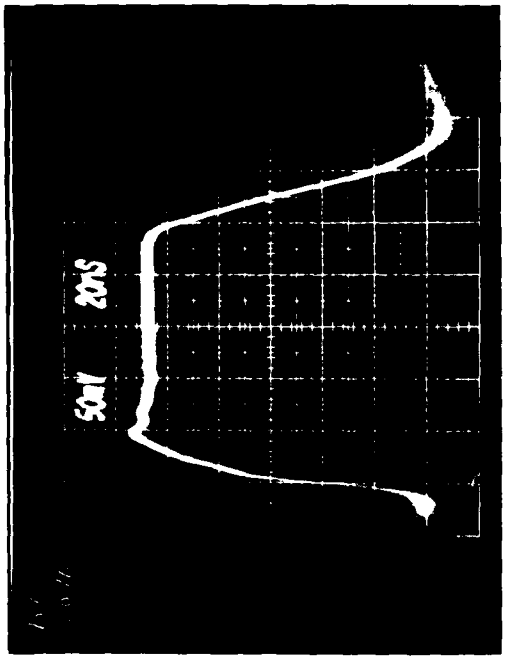
FIGURE B-2

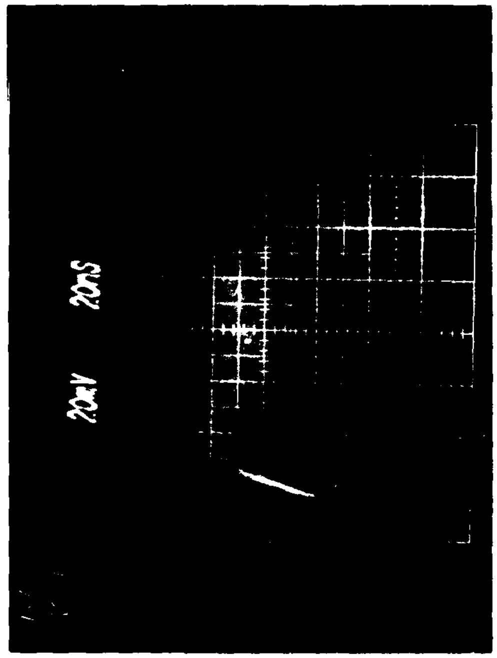

200mV 20nS

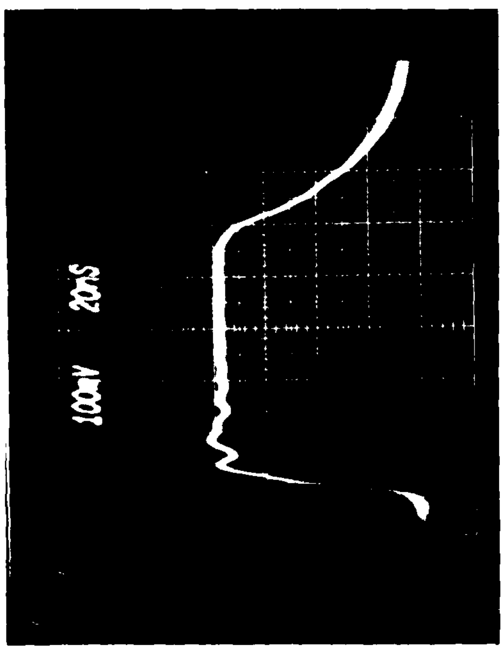

100mV 20nS

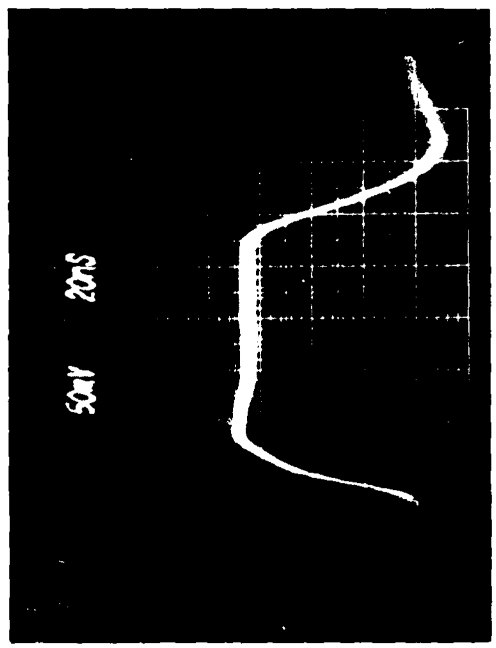

200mV 20nS


200mV 20nS


50mV 20nS


20mV 20nS


100mV 20nS


50mV 20nS

with narrow beam adapter, detector head and digital indicator unit. The output from the laser pulse monitor circuit was connected by 50 Ω coaxial cable to a Tektronix Model 7834 storage oscilloscope, with 50 Ω cable termination at the scope. Each monitor pulse waveform was stored and photographed with a Polaroid camera and identified with the corresponding energy output. The calibration curves extrapolated from this data are plotted in figure B-5. This data is tabulated in Table 4-2 of the report.

Figure B-6 shows a typical pulse monitor output pulse. Representative waveform photographs for four of the calibration points, with corresponding energy outputs are shown in figure B-7. Pulse width and peak amplitude were derived from the photographs.

B-1.4 DETECTOR-PREAMPLIFIER DATA

Data supplied by RCA, Montreal for five Photodiode-Preamplifier modules, S/N 0052, 0062, 0074, 0086 and 0093 is given in Figures B-8 thru B-15. S/N 0052 is installed in the Optical Unit.

TABLE B-1

LOGARITHMIC AMPLIFIER S/N 80022202

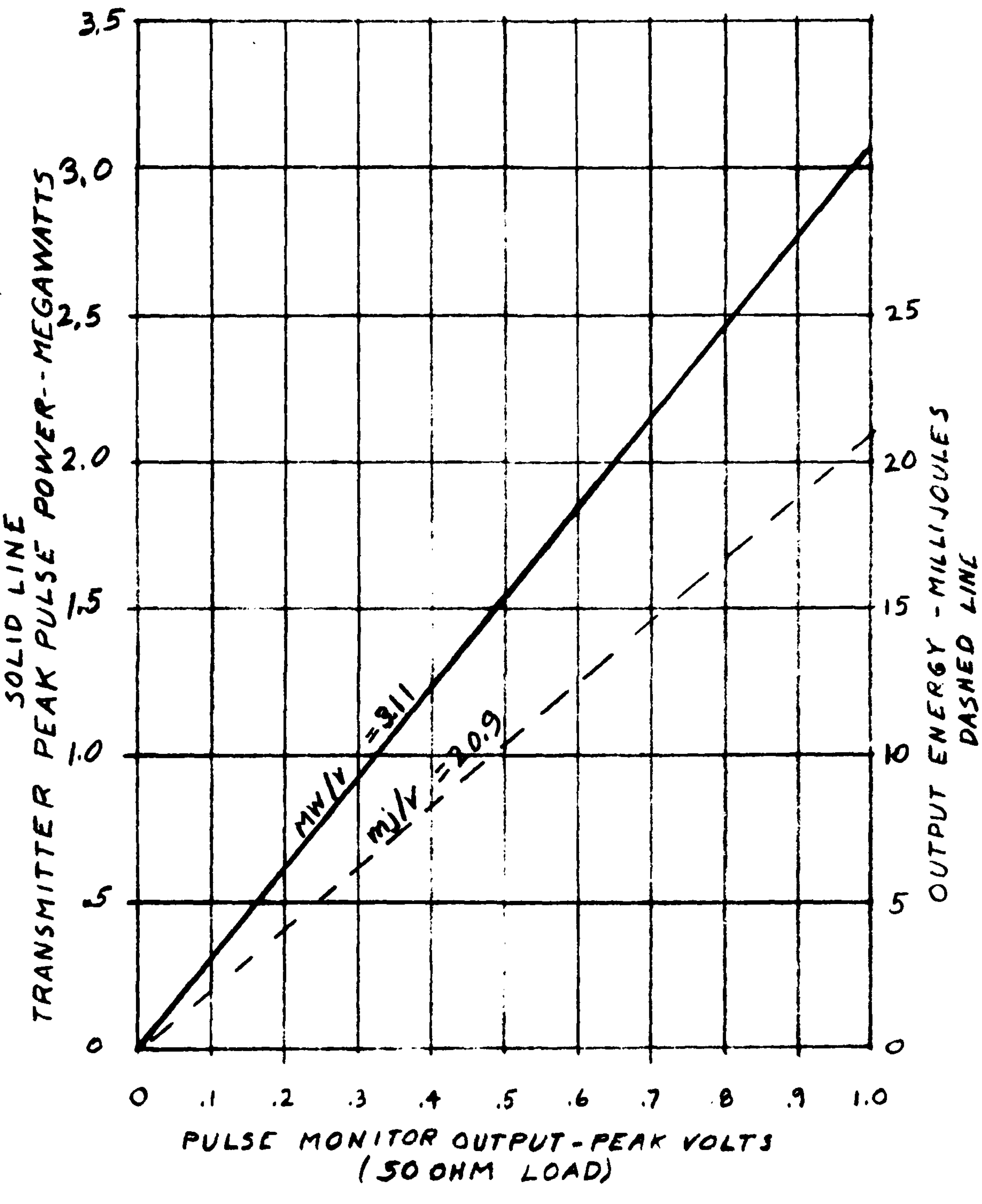
OUTPUT VOLTAGE

VS

INPUT - dbv

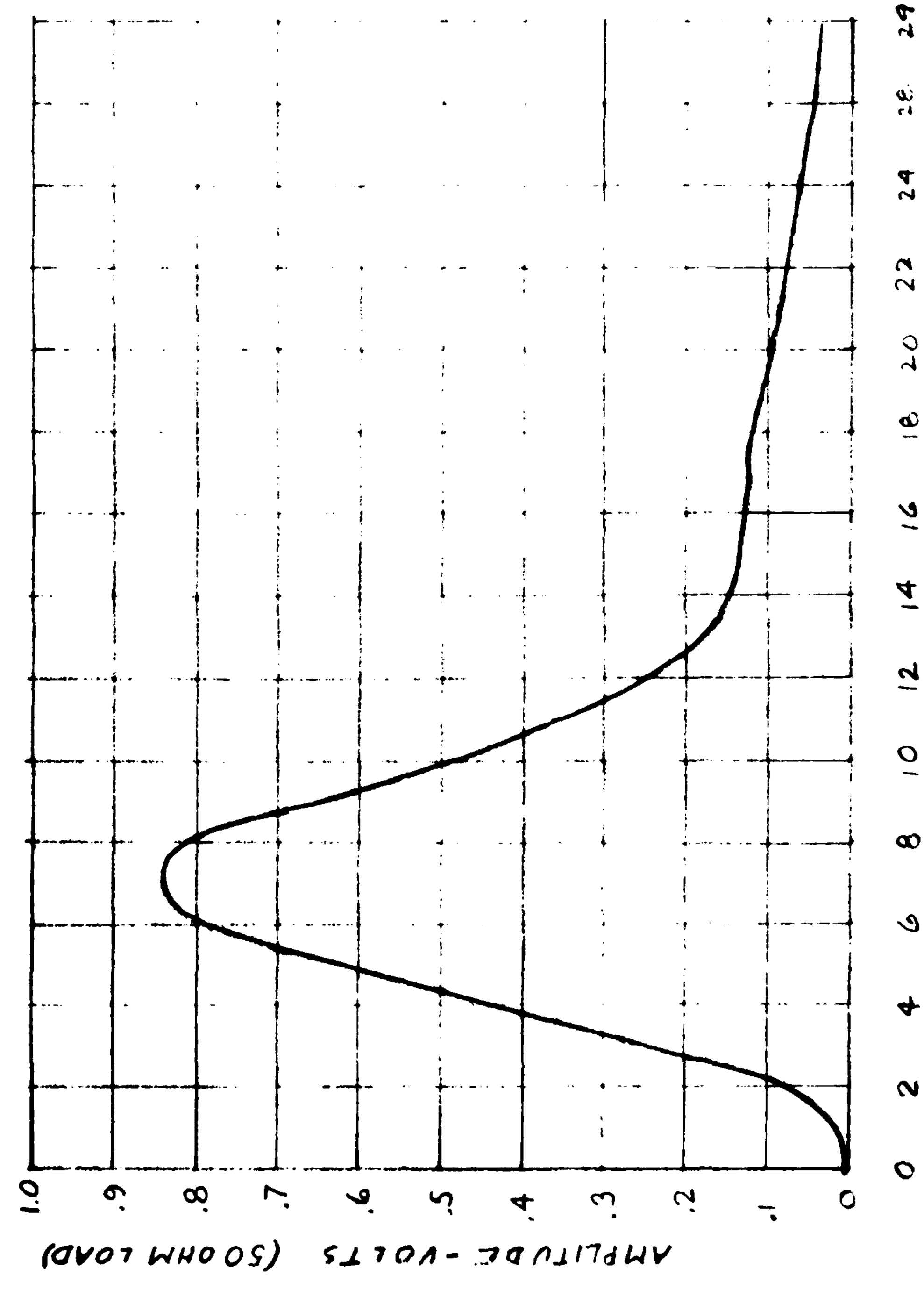
VS TEMPERATURE

INPUT dbv		25°C OUTPUT VOLTS		-5°C OUTPUT VOLTS		+60°C OUTPUT VOLTS
0 (1V)		.90		.94		.83
-10		.82		.86		.73
-20		.70		.74		.62
-30		.59		.62		.52
-40		.49		.53		.39
-50		.39		.44		.25
-60		.27		.33(5)		.14
-70		.16(5)		.21		.50
-80		.07		.12		-



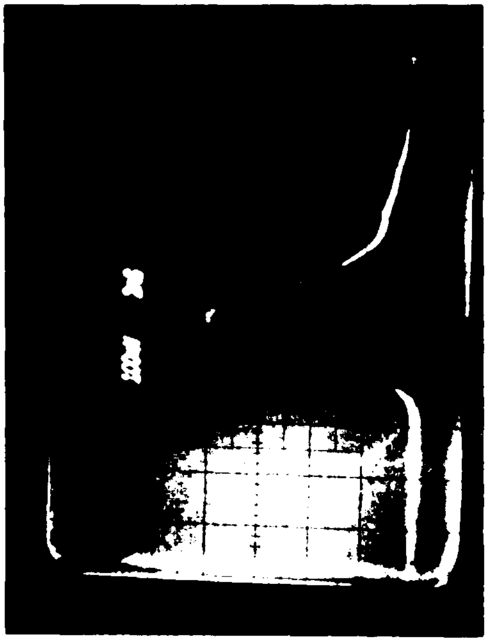
SOLID LINE
TRANSMITTER PEAK PULSE POWER - MEGAWATTS
OUTPUT ENERGY - MILLIJOULES
DASHED LINE
MW/V = 3.11
mj/V = 20.9
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
25
20
15
10
5
0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
PULSE MONITOR OUTPUT - PEAK VOLTS
(50 OHM LOAD)

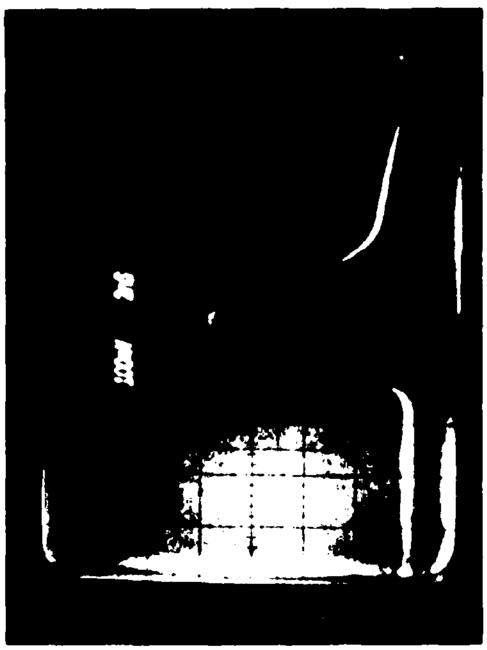
FIGURE B-5

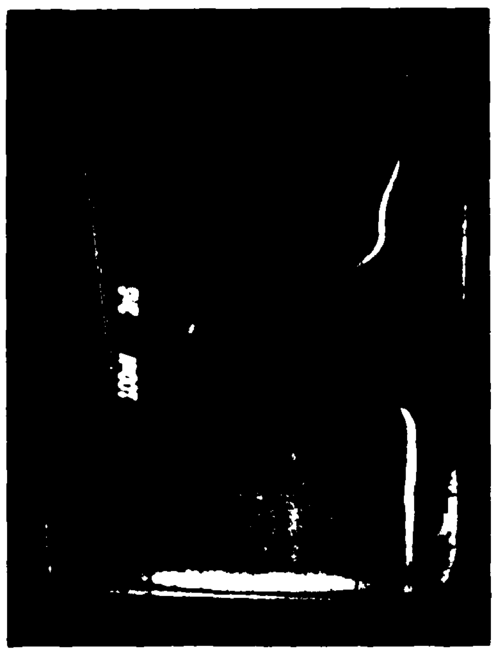


LASER PULSE MONITOR OUTPUT -- TYPICAL 25 °C.

FIGURE B-6





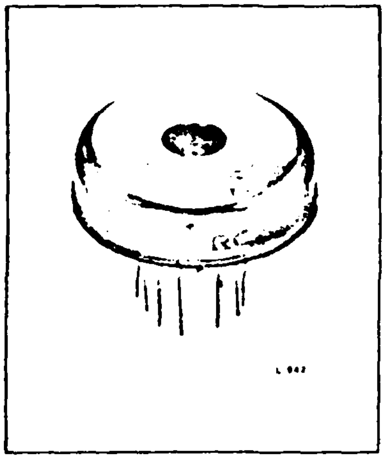


RCA ElectroOptics and Devices

Photodiode

Developmental Type

C30919E



Photodiode-Preamplifier Module

Completely Hybridized Temperature-Compensated Silicon Avalanche Photodiode-Preamplifier Module

- Responsivity Temperature Compensated to ± 10% for 1060 nm
- Modules Can be Supplied That are Responsivity Temperature Compensated for Other Wavelengths Upon Request
- Responsivity at T_A = 25° C –
  1 x 10^6 V/W at 900 nm
  2.5 x 10^5 V/W at 1060 nm
- System Noise Equivalent Power (NEP) at T_A = 25° C –
  2 x 10^{-14} W/Hz$^{1/2}$ at 900 nm
  8 x 10^{-14} W/Hz$^{1/2}$ at 1060 nm
- Wide Range of Amplifier Operating Voltages
- System Bandwidth (3 dB point) – DC to 40 MHz
- Fast Time Response – Rise and Fall Times, 10 ns Typical
- Hermetically-Sealed Modified 25-mm Package
- Low Power Consumption

RCA Developmental-Type C30919E is a completely hybridized temperature compensated silicon avalanche photodiode-preamplifier module for the detection of radiation of wavelengths between 400 nm and 1100 nm. This device is especially useful in a wide variety of applications including laser detection, data transmission, optical communications, and spectrometry where ambient temperatures may vary.

The module consists of a silicon avalanche photodiode, a high frequency amplifier, a temperature sensing element, and associated circuitry for temperature compensation of the photodiode responsivity all of which are in hybrid form and have been packaged in a hermetically sealed 25-mm diameter package.

The avalanche photodiode used in the module is made using a *"reach-through" structure which will provide high* responsivity up to 1060 nanometers and beyond. The "reach-through" structure also allows fast rise and fall times to be achieved without "pulse-tailing" effects. Because the fall time has no "tail", the responsivity of the C30919E is constant and independent of modulation frequency over the full system bandwidth from DC to 40 MHz.

To obtain the wideband characteristics, the output of the module should be AC (capacitively) coupled to a 50-ohm termination. The module must not be DC coupled to loads of less than 500 ohms.

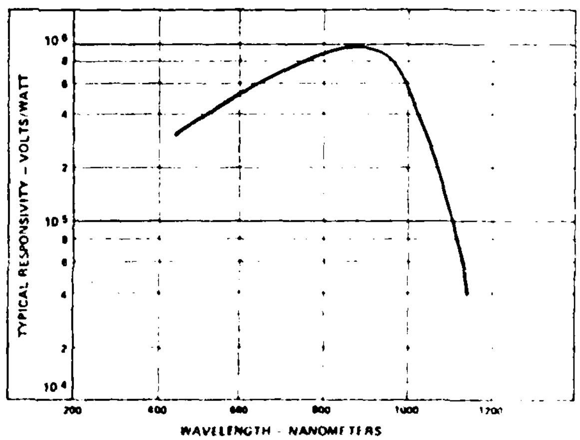


Figure 1 – Typical Spectral Responsivity Characteristic

For further information or application assistance on these devices, contact your RCA Sales Representative or Photodetector Marketing, RCA, Ste. Anne de Bellevue, Quebec, Canada H9X 3L3 (514) 457-9000

Developmental type devices or materials are intended for engineering evaluation. The type designation and data are subject to change unless otherwise arranged. No obligations are assumed for notice of change or future manufacture of these devices or materials.

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

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FIGURE B-8 R13

Maximum and Minimum Ratings, Absolute-Maximum Values

Photodiode Bias:

Voltage	600	max.	V
Current	100	max.	μA
Preamplifier Voltage	± 12.5	max.	V
	± 5.5	min.	V

Incident Radiant Flux, Φ_M:

Average value	0.05	max.	mW
Peak value	0.5	max.	mW

Ambient Temperature:

Storage, T_{stg}	−50 to +100	°C
Operating, T_A	−40 to +70	°C

Mechanical Characteristics

Photosensitive Surface:

Shape	Circular	
Useful area	0.5	mm^2
Useful diameter	0.8	mm
Approx. Field of View	150	deg

Electrical Characteristics

At T_A = 22° C, unless otherwise noted[a]

At high voltage of 550 volts and preamplifier voltage of ± 6.0 V DC.

	Min.	Typ.	Max.	Units
Responsivity:				
At 900 nm	0.8	1.0	–	MV/W
At 1060 nm	0.2	0.25	–	MV/W
Variation of responsivity over temperature range −40 to +70° C	–	± 10	± 25	%
Noise Equivalent Power (NEP)				
f = 100 kHz, Δf = 1 Hz				
At 900 nm	–	0.02	0.05	$pW/Hz^{1/2}$
At 1060 nm	–	0.08	0.2	$pW/Hz^{1/2}$
Output Spectral Noise Voltage Density:				
f = 100 kHz –100 MHz Δf = 1 Hz	–	20	40	$nV/Hz^{1/2}$
Output Impedance	–	25	50	Ω
System Bandwidth, f_o (3 dB point)	30	40	–	MHz
Rise Time, t_r:				
λ = 900 and 1060 nm 10% to 90% points	–	10	15	ns
Fall Time				
λ = 900 and 1060 nm 90% to 10% points	–	10	15	ns
Linear Output Voltage Swing	0.5	0.7	–	V
Voltage Swing	–	–	2	V
Output Offset Voltage	0	−1.5	−3	V
Supply Current	–	6	10	mA

[a] All measurements are made with the device AC (capacitively) coupled into a 50 Ω termination.

Warning – Personal Safety Hazards

Electrical Shock – Operating voltages applied to this device present a shock hazard.

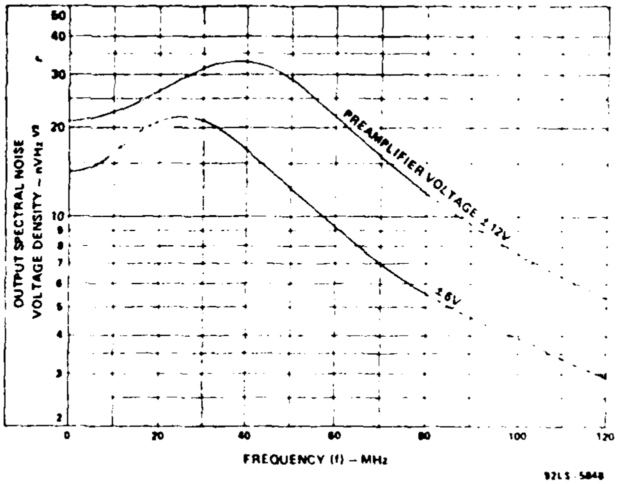


Figure 2 – Typical Output Spectral-Noise Voltage-Density As a Function of Frequency

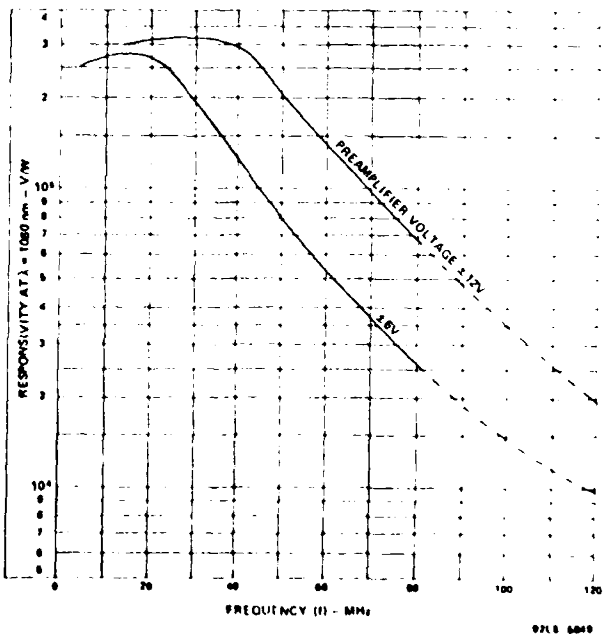


Figure 3 – Typical Responsivity at λ = 1060 nm As a Function of Frequency

FIGURE B-9

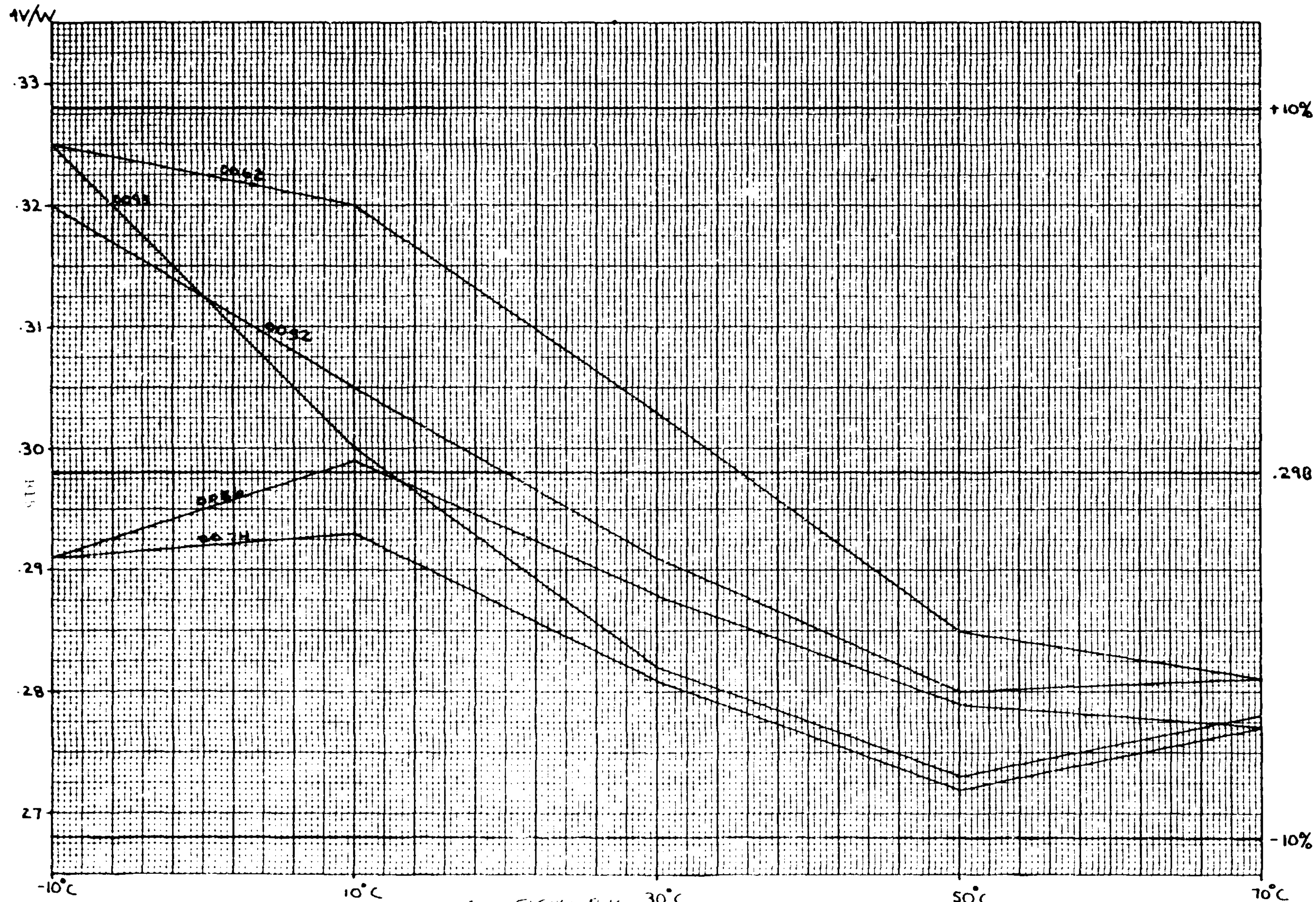
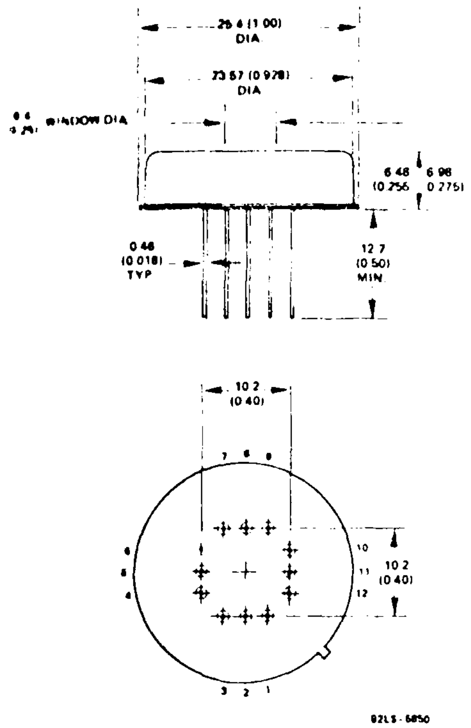


FIGURE B-10



Dimensions in parentheses are in inches.

Figure 4 – Dimensional Outline

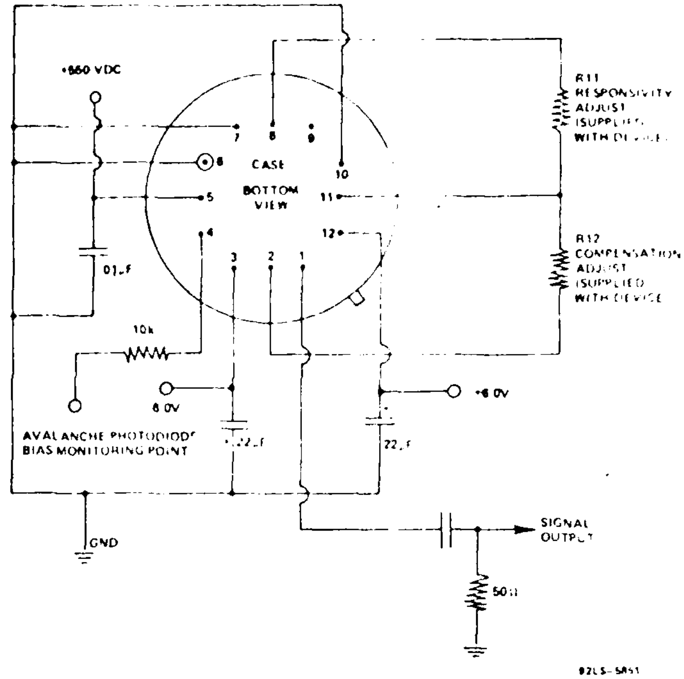


Figure 5 – Schematic of C30919E (Bottom View of Device)

SELECTED C30919E S/N 0052

RESPONSIVITY 3.0×10^{5} V/W $\pm10\%$, $\lambda=1060$nm

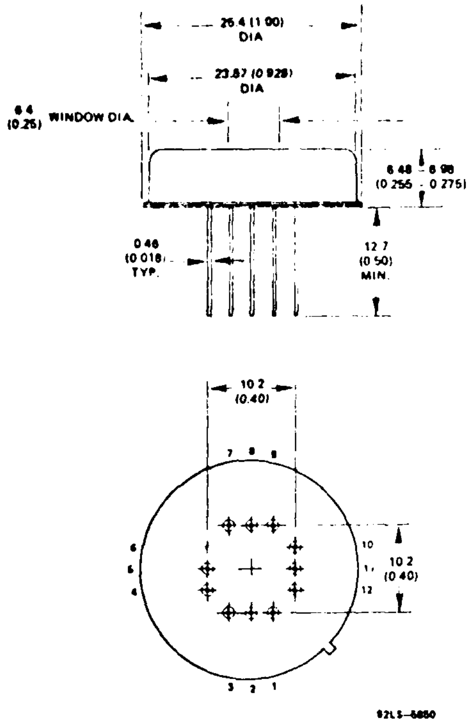
RESPONSIVITY MEASURED AT -10°C, $+10^{\circ}$C, $+30^{\circ}$C, $+50^{\circ}$C, $+70^{\circ}$C

t_r & t_f $<$ 10ns

NEP $\leq 10^{-13}$ W/$\sqrt{Hz}$, $\lambda=1060$nm

LINEAR OUTPUT VOLTAGE SWING $\geq$0.5V

Figure B11



Dimensions in parentheses are in inches.

Figure 4 – Dimensional Outline

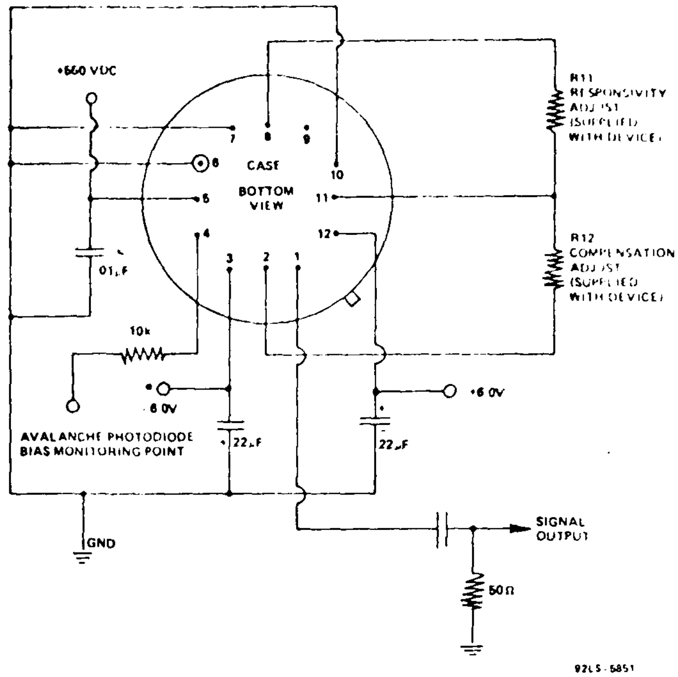


Figure 5 – Schematic of C30919E (Bottom View of Device)

SELECTED C30919E S/N 0062

RESPONSIVITY 3.0×10^5 V/W $\pm 10\%$, $\lambda = 1060$nm

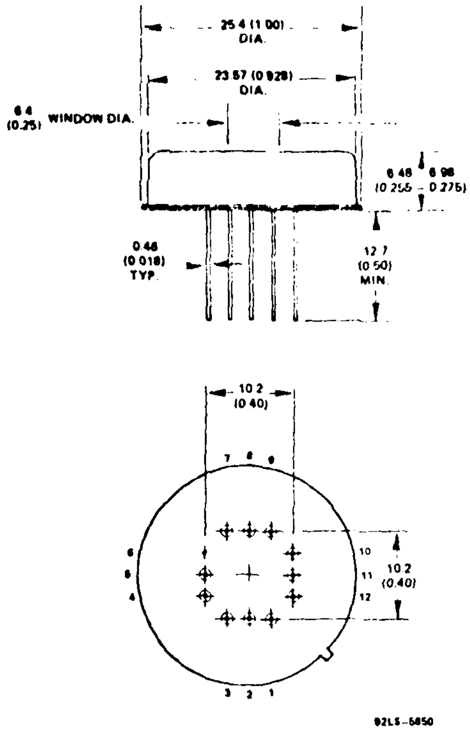
RESPONSIVITY MEASURED AT -10°C, $+10^{\circ}$C, $+30^{\circ}$C, $+50^{\circ}$C, $+70^{\circ}$C

t_r & $t_f \leq 10$ns

NEP $\leq 10^{-13}$ W/$\sqrt{Hz}$, $\lambda = 1060$nm

LINEAR OUTPUT VOLTAGE SWING ≥ 0.5V

Figure B-12



Dimensions in parentheses are in inches.

Figure 4 – Dimensional Outline

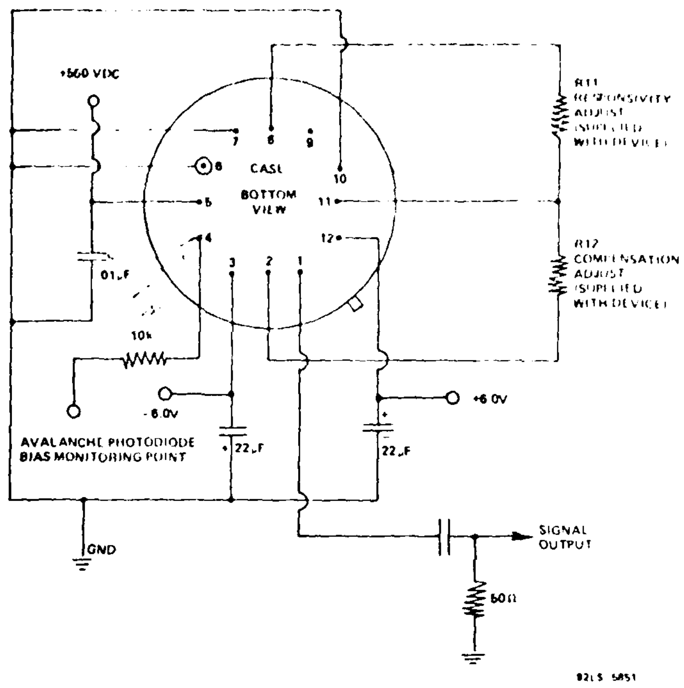


Figure 5 – Schematic of C30919E (Bottom View of Device)

SELECTED C30919E S/N 0074

RESPONSIVITY 3.0×10^{5}V/W ±10%, λ=1060nm

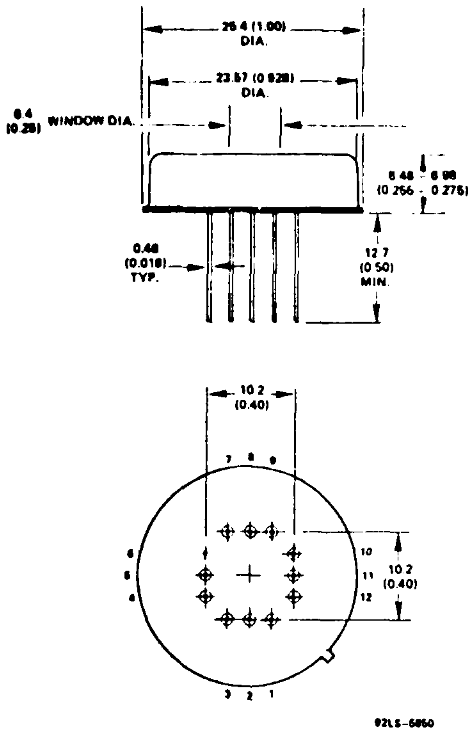
RESPONSIVITY MEASURED AT -10°C, $+10^{\circ}$C, $+30^{\circ}$C, $+50^{\circ}$C, $+70^{\circ}$C

t_r & t_f ≤ 10ns

NEP $\leq 10^{-13}$W/$\sqrt{Hz}$, λ=1060nm

LINEAR OUTPUT VOLTAGE SWING ≥0.5V

Figure B-13



Dimensions in parentheses are in inches.

Figure 4 – Dimensional Outline

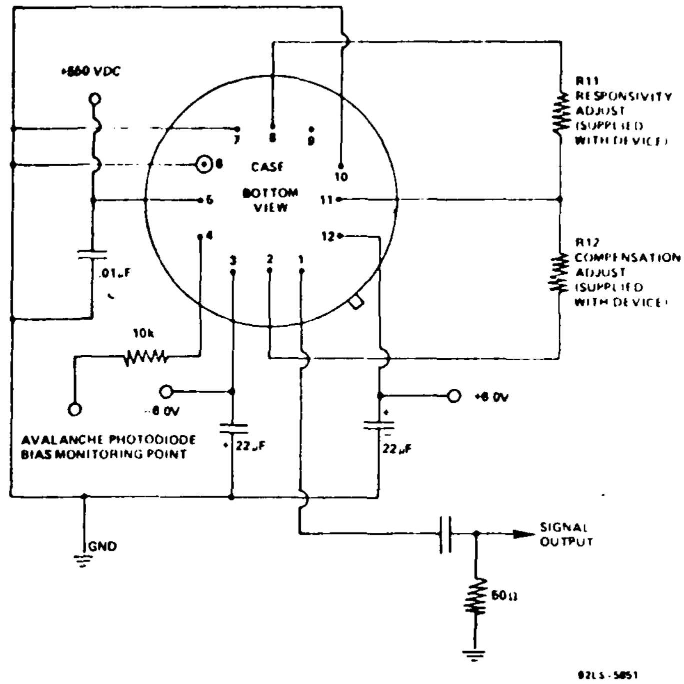


Figure 5 – Schematic of C30919E (Bottom View of Device)

SELECTED C30919E S/N 0086

RESPONSIVITY 3.0×10^{5} V/W $\pm$10%, λ=1060nm

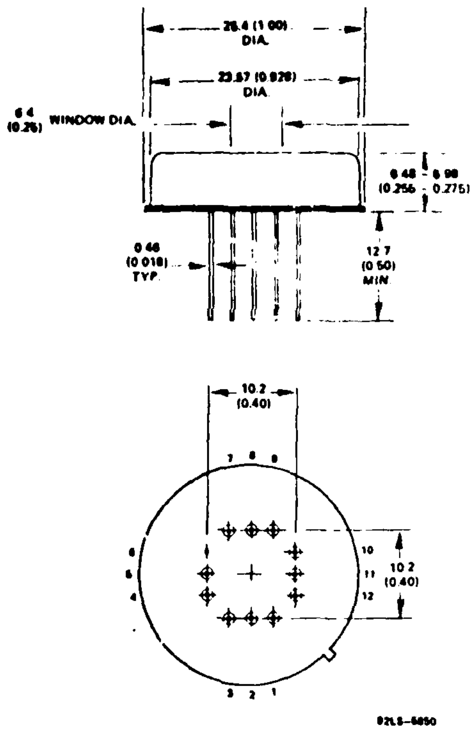
RESPONSIVITY MEASURED AT -10^{o}C, $+10^{o}$C, $+30^{o}$C, $+50^{o}$C, $+70^{o}$C

t_r & t_f $\leq$ns

NEP $\leq 10^{-13}$ W/$\sqrt{Hz}$, λ=1060nm

LINEAR OUTPUT VOLTAGE SWING $\geq$0.5V

Figure B-14



Dimensions in pare[illegible]

Figure 4 — Dimensional Outline

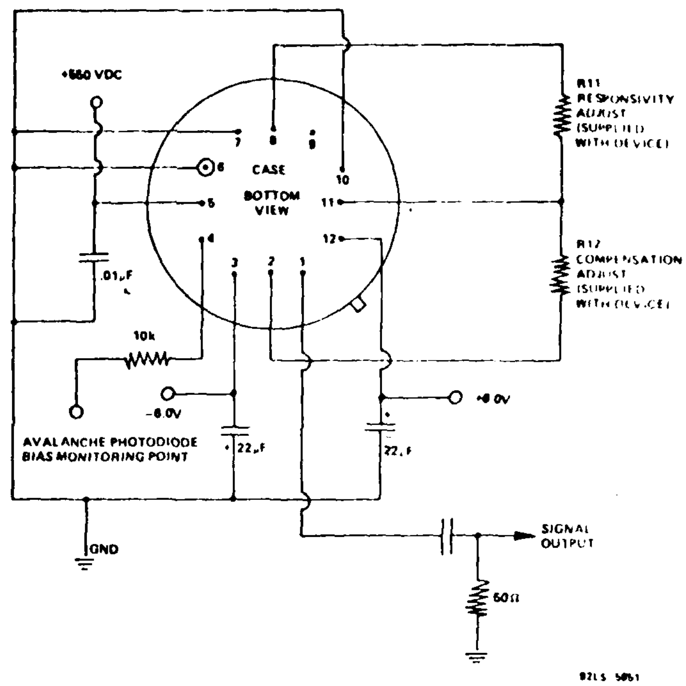


Figure 5 — Schematic of C30919E
(Bottom View of Device)

SELECTED C30919E S/N 0093

RESPONSIVITY 3.0×10^{5}V/W $\pm10\%$, λ=1060nm

RESPONSIVITY MEASURED AT -10°C, $+10^{\circ}$C, $+30^{\circ}$C, $+50^{\circ}$C, $+70^{\circ}$C

t_r & t_f $\leq$ 10ns

NEP $\leq10^{-13}$W/$\sqrt{Hz}$, λ=1060nm

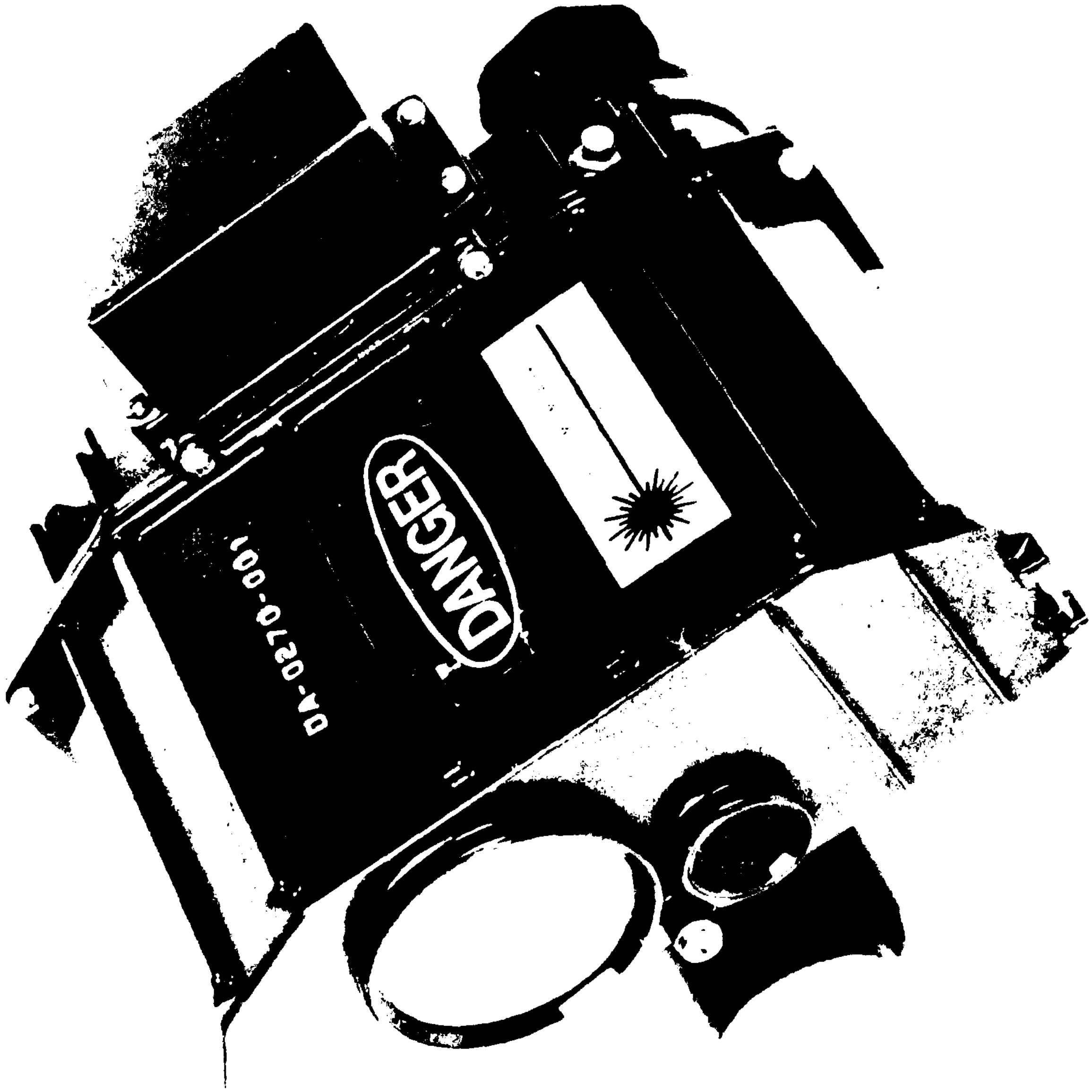
LINEAR OUTPUT VOLTAGE SWING $\geq$0.5V

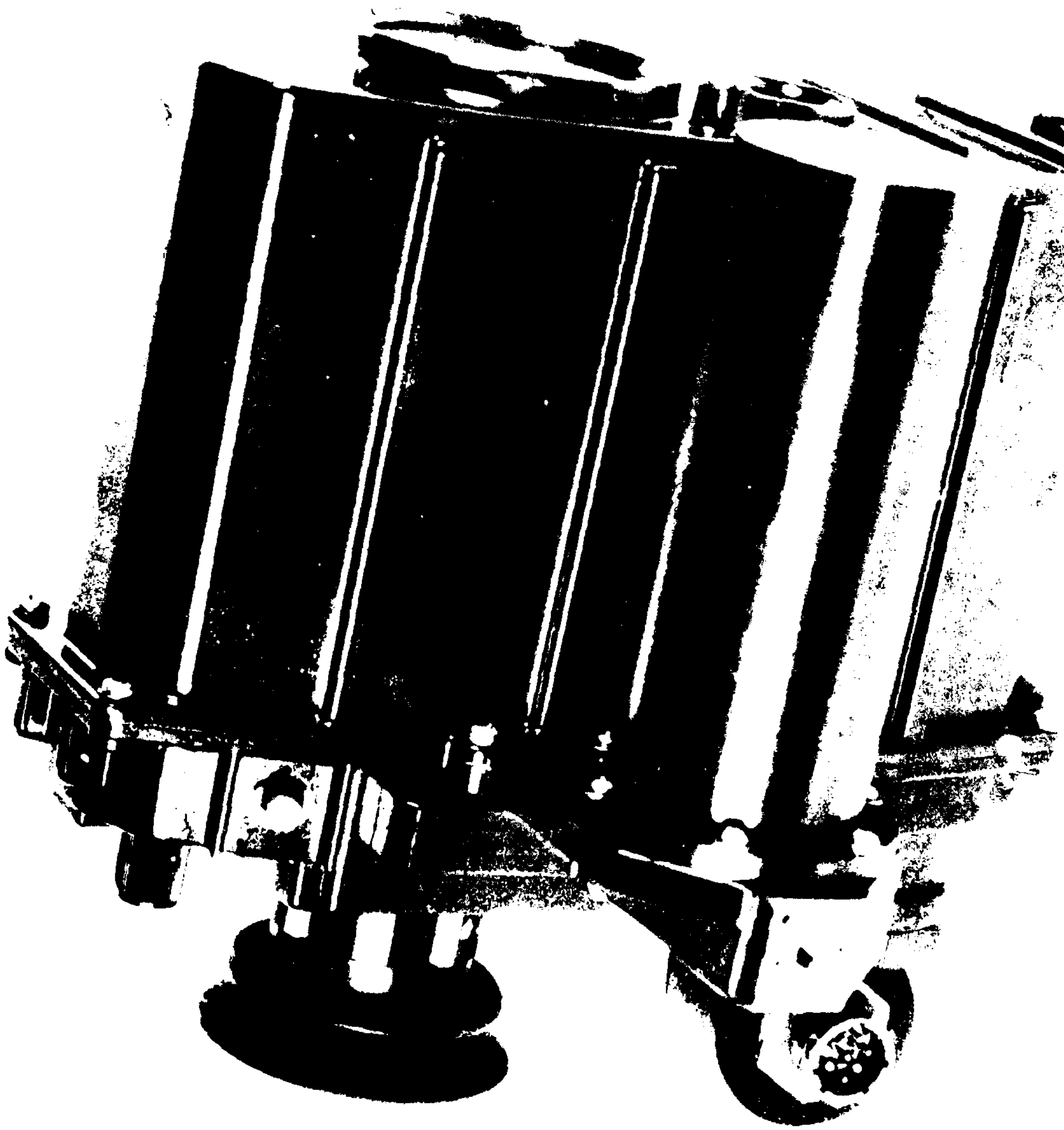
Figure B-15

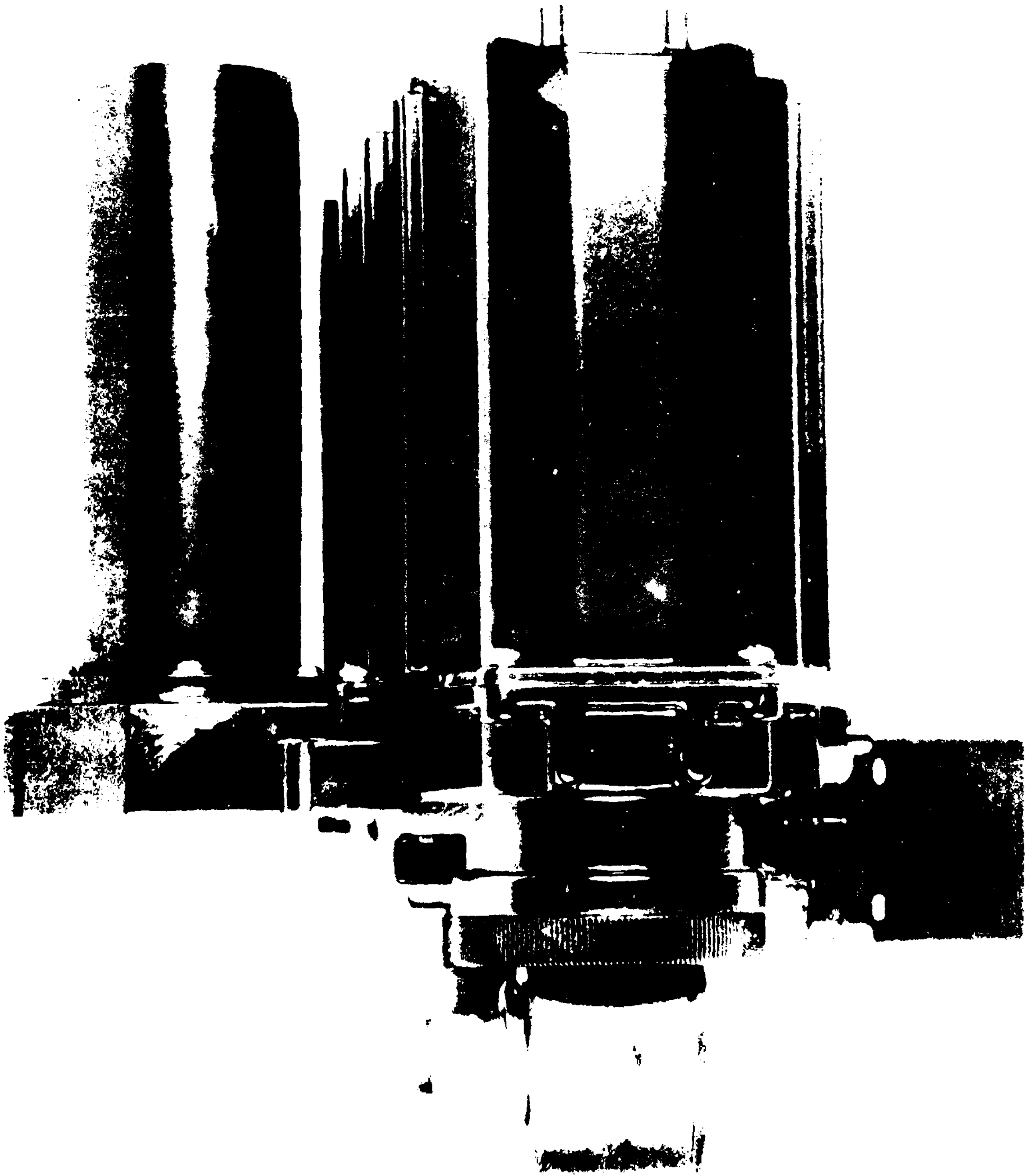
APPENDIX C

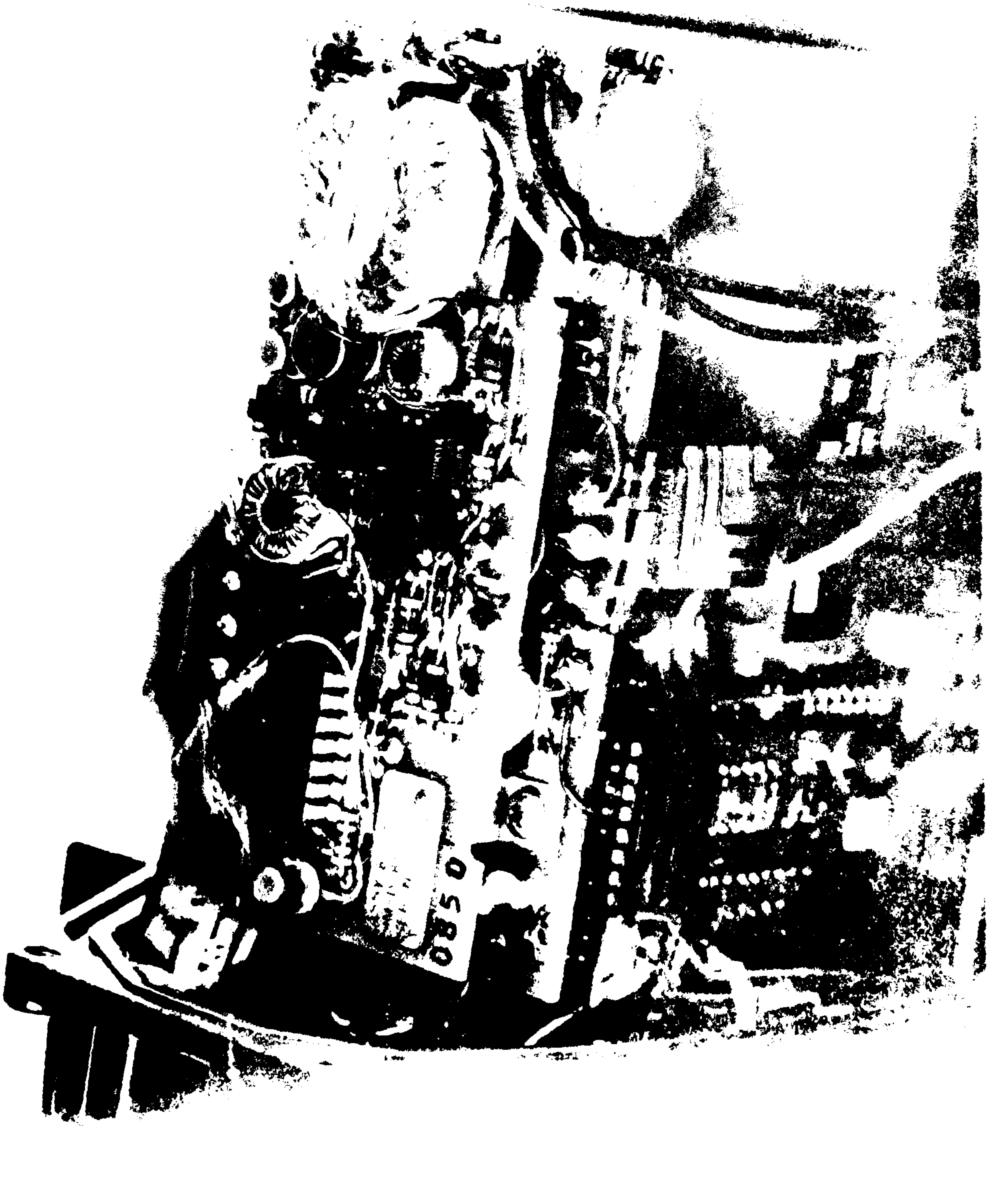
VISIOCEILOMETER OPTICAL-UNIT

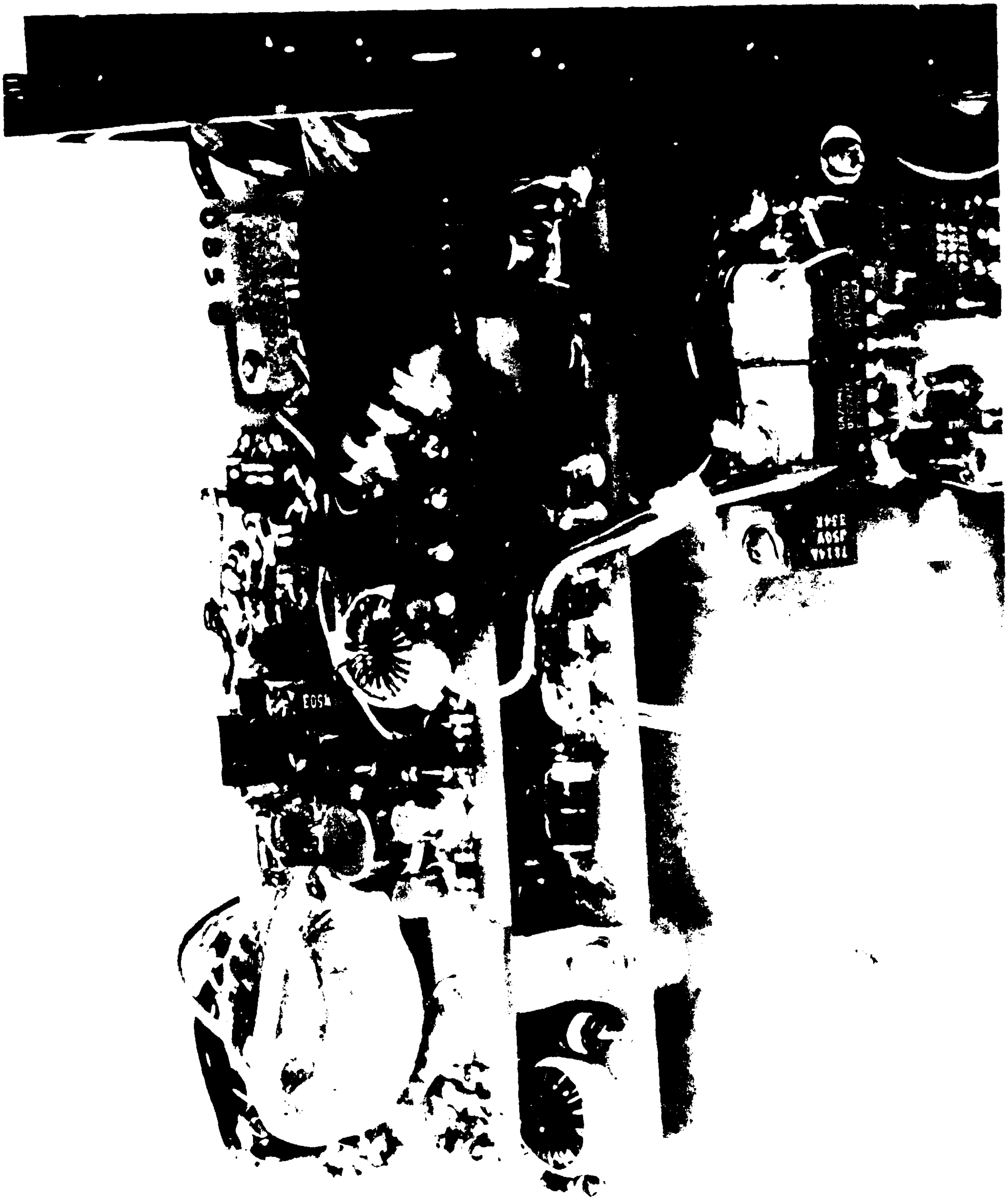
PHOTOGRAPHS

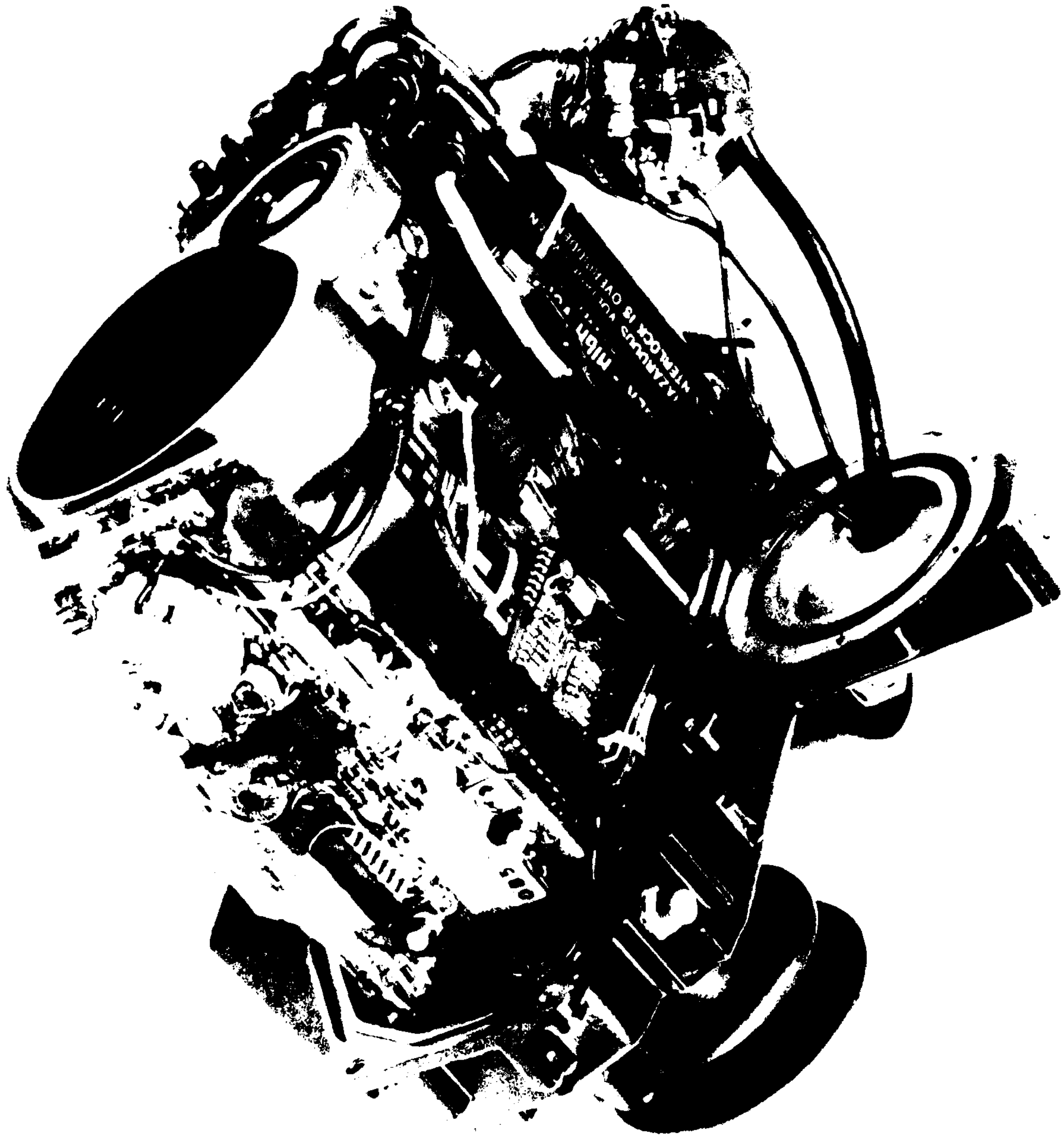

DANGER
DA-0270-0-001

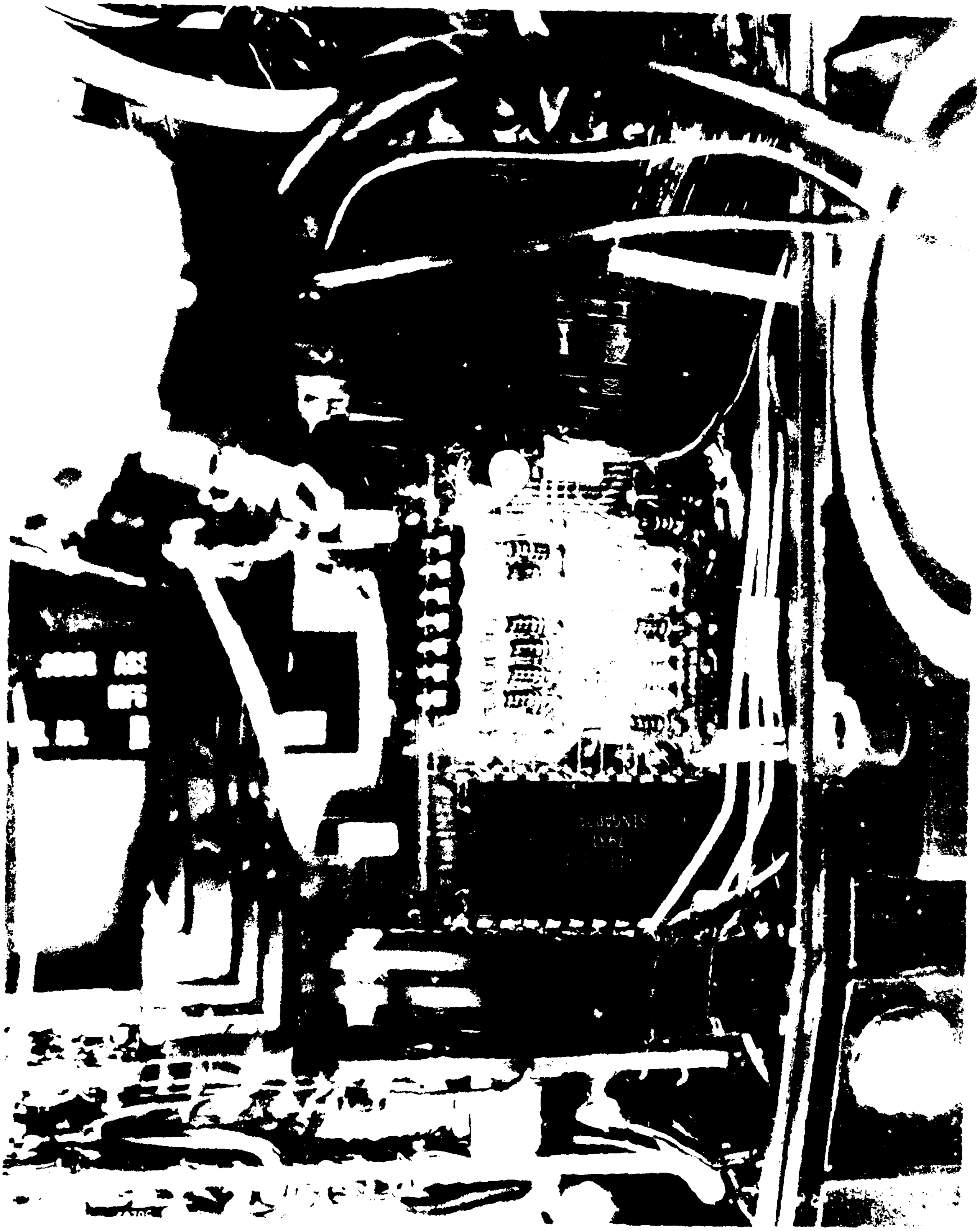


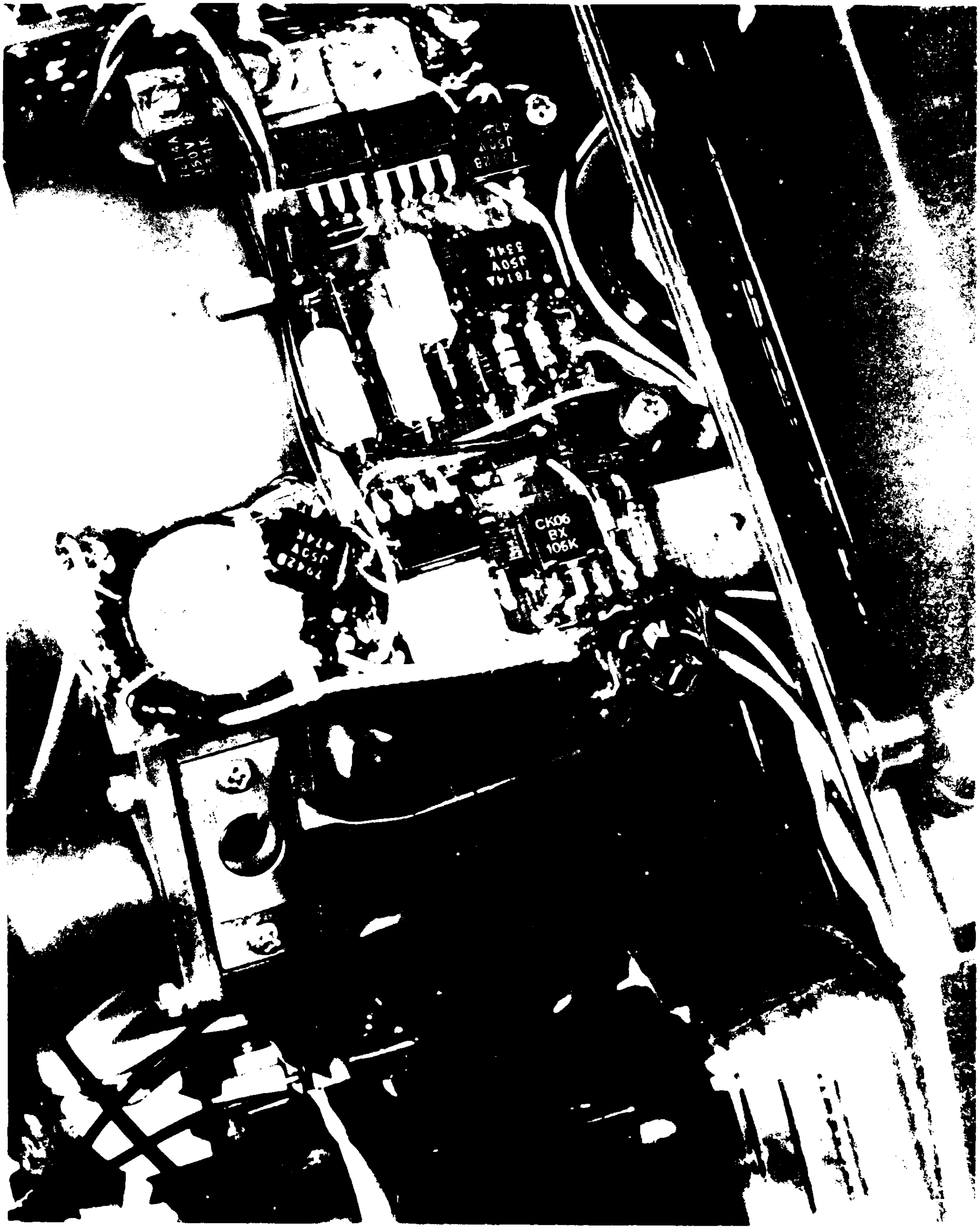








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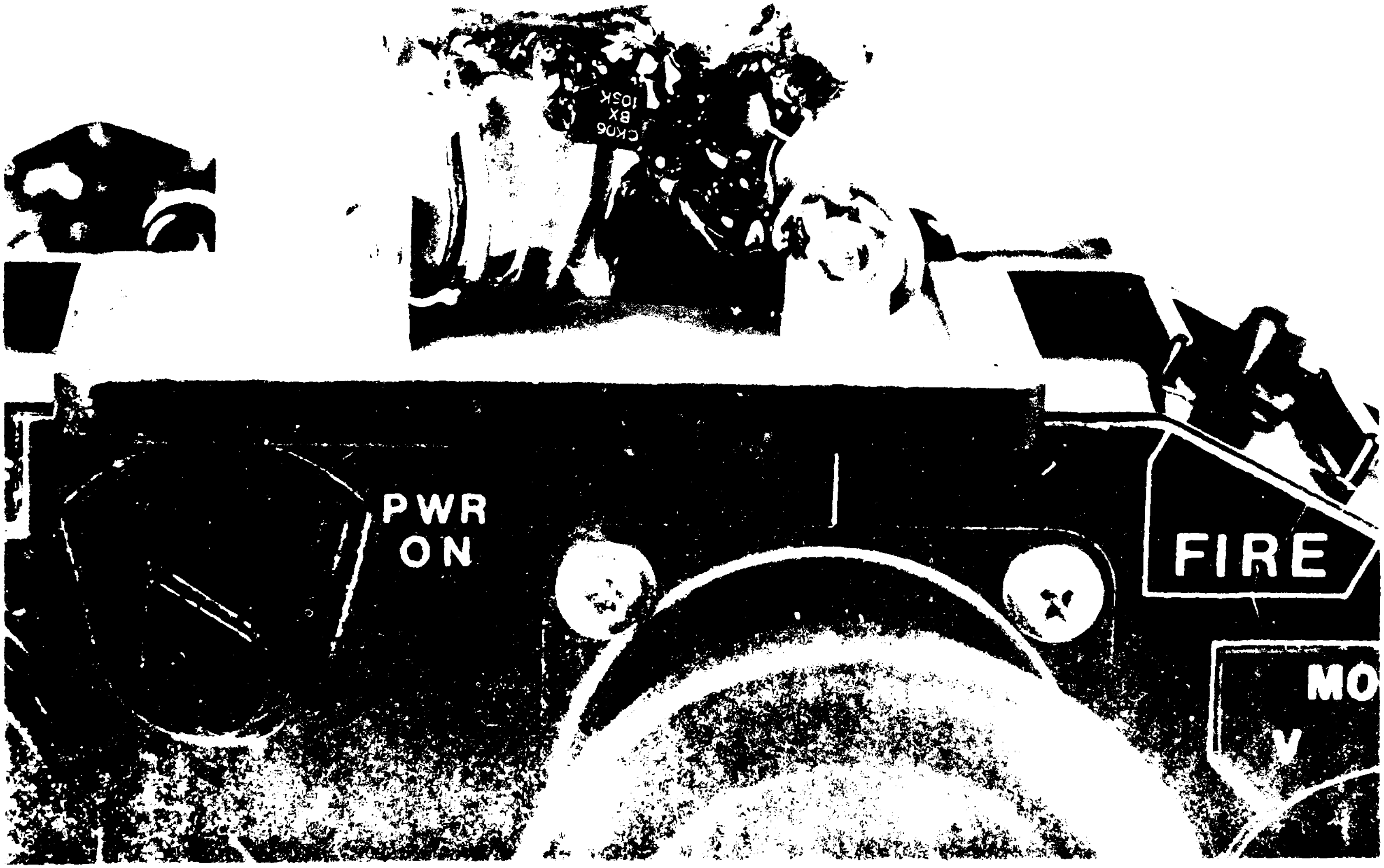
BX
106K



CK06
BX
105K
PWR
ON
FIRE
MO

DAT
FILM
2-