

MIL-S-19500/210B(NAVY)
 21 March 1969
 SUPERSEDING
 MIL-S-19500/210A(NAVY)
 20 September 1961

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, PHOTO
 TYPE 2N986

1. SCOPE

1.1 Scope. This specification covers the detail requirements for a NPN silicon phototransistor and is in accordance with MIL-S-19500, except as otherwise specified herein.

1.2 Physical dimensions. See figure 1.

1.3 Maximum ratings.

V _{CER} R _{BE} ≤ 10Ω	V _{CBO}	V _{EBO}	P _T			T _{stg}
			T _C = 25° C	T _C = 100° C	T _A = 25° C 1/	
80V	100V	7V	1.8W	1.0W	0.5W	-65° to +200°C

1/ Derate 2.8 mw/° C from T_A = 25° to 200° C.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for.

STANDARDS

MILITARY

MIL-STD-750 - Test Methods for Semiconductor Devices.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 General. Requirements shall be in accordance with MIL-S-19500, and as specified herein.

3.2 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined in MIL-S-19500.

3.3 Design, construction, and physical dimensions. Phototransistors shall be of the design, construction, and physical dimensions shown on figure 1.

3.4 Performance characteristics. Performance characteristics shall be as specified in tables I and II.

3.5 Marking. The following marking specified in MIL-S-19500 may be omitted from the body of the transistor at the option of the manufacturer:

- (a) Country of origin
- (b) Manufacturer's identification

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be in accordance with MIL-S-19500, and as specified herein.

4.2 Qualification inspection. Qualification inspection shall consist of the examinations and tests specified in tables I and II.

4.2.1 Inspection conditions. All electrical characteristic measurements shall be made in a light-tight environment less than 0.001 foot-candle.

4.3 Quality conformance inspection. Quality conformance inspection shall consist of groups A and B inspections.

4.3.1 Group A inspection. Group A inspection shall consist of the examinations and tests specified in table I.

4.3.2 Group B inspection. Group B inspection shall consist of the examinations and tests specified in table II.

4.4 Methods of examination and test. Methods of examination and test shall be as specified in tables I and II, and as follows.

4.4.1 Dynamic performance test. Upon request by the Government, the phototransistor shall be subjected to this test using 100 percent inspection. This test is not considered a selection criteria but guarantees dynamic performance under specific conditions. Only devices that pass the test shall be shipped on the contract or order.

4.4.1.1 The tolerances specified herein are the maximum allowable tolerances and shall not be exceeded by the test equipment errors.

4.4.1.2 References. The following references shall apply:

- (a) Schematic diagram of test circuit as shown on figure 2.
- (b) Chopper disk drawing as shown on figure 3.
- (c) Assembly drawing as shown on figure 4.
- (d) Drawing of typical output voltage waveform as shown on figure 5.

4.4.2 General requirements.

4.4.2.1 Power input shall be as follows:

- 30V, 100 ma., 0.1 percent regulation
- 120 Vac, 60 cycles, 8 amperes.

4.4.2.2 Equipment used for the test shall be as follows:

- (a) Tektronix Scope 545, 53/54C, or equivalent.

- (b) Disk (see figure 3).
- (c) Motor (any motor capable of sustained operation at 1800 rpm with ± 0.5 percent flutter).
- (d) Lamp, G. E. Airway Beacon, Mogul Bipost base, 1kw, 120 Vac, or equivalent.

4.4.3 Test and adjustment.

4.4.3.1 The five major units necessary to perform this test shall be as follows:

- (a) Light source.
- (b) Chopper disk.
- (c) Electric motor.
- (d) Mount for 2N986.
- (e) Electronic circuitry.

These units shall be arranged as shown on figure 4. The light source shall be mounted in front of the chopper disk, so that the light flux is incident upon the race of the disk. The lamp shall be mounted on a base so that the distance between disk and lamp is 2.5 feet. The lamp filament shall be operated at a color temperature of 2360° K. The chopper disk shall be mounted on a motor shaft so that it may be rotated at the proper speed. The 2N986 shall be mounted behind the disk and as close as practicable to the disk, but the maximum separation between the lens of the 2N986 and the disk shall not exceed 1/8 inch. The phototransistor shall be mounted so that the openings in the rotating disk permit light to be incident on the lens of the 2N986. The phototransistor mount shall be of such a type that it can be raised or lowered 10 degrees with respect to the horizontal axis. This allows 20 degrees of freedom in the vertical plane. The related electronic circuitry may be placed where it is convenient to connect the 2N986 with the rest of the circuit. The chopper disk shall be made as shown on figure 3. It shall have 30 holes spaced 12 degrees apart on a circumference of radius 3 inches. It may be made of bakelite, 1/8 inch thick and painted a dull black. The diameter of the disk holes shall be 1/6 inch.

4.4.3.2 Test procedure. The test procedure shall be as follows.

4.4.3.2.1 Turn on the power in the following order:

- (a) -30 dc volt transistor bias supply.
- (b) 120 Vac motor supply.
- (c) 120 Vac lamp supply. (Note. - The voltage on the lamp shall be increased until the color temperature of the filament is 2360° K.)

4.4.3.2.2 Adjust the motor speed to 1800 rpm, since frequency is given by:

$$f = \frac{NH}{60} \text{ Hz}$$

$$f = 900 \text{ Hz}$$

Where:

H = 30 holes

N = 1800 rpm

4.4.3.2.3 Connect a Tektronix Scope 545, or equivalent, to the output terminals as shown on figure 2. Make necessary adjustments on the scope to get a clear picture.

4.4.3.2.4 The output shall be ≥ 15 volts peak to peak, as indicated on the scope. If the value of the waveform is less than 15 volts, move the 2N986 in the vertical plane by adjusting the mount on which it is located.

4.4.3.2.5 If it is possible to get 15 volts or more by using the above mentioned procedure, the phototransistor is acceptable. Figure 5 shows a drawing of a typical output waveform.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be in accordance with MIL-S-19500.

TABLE I. Group A inspection.

Examination or test	MIL-STD-750		LTPD	Symbol	Min	Max	Unit
	Method	Details					
<u>Subgroup 1</u>			10				
Visual and mechanical examination	2071	---		---	---	---	
<u>Subgroup 2</u>			5				
Collector to base breakdown voltage	3001	Bias cond. D $I_C=100 \mu\text{A}$		BV_{CBO}	100		Volts
Emitter to base breakdown voltage	3026	Bias cond. D $I_E=100 \mu\text{A}$		BV_{EBO}	7		Volts
Collector to emitter breakdown voltage	3011	Bias cond. B $I_C=100 \text{ mA}$, $R_{BE} \leq 10 \Omega$, PW $\leq 167 \mu\text{sec}$, 1 per- cent duty cycle		BV_{CER}	80		Volts
<u>Subgroup 3</u>			5				
Illumination sensitivity		100 foot-candle $V_{CE}=22.5\text{V}$, $I_B=0$ 3000° K tungsten source (See figure 6)		I_{CE}	1	3	$\mu\text{A}/\text{ft-candle}$
Illumination sensitivity		100 foot-candle $V_{CE}=22.5\text{V}$, $I_E=0$ 3000° K tungsten source		I_{CB}	0.01	0.05	$\mu\text{A}/\text{ft-candle}$
Collector to base cutoff current (dark current)	3036	Bias cond. D $V_{CB}=80\text{V}$		I_{CBO}	----	0.01	μA
<u>Subgroup 4</u>			5				
Illumination sensitivity I_{CB} drift		100 foot-candle $V_{CE}=22.5\text{V}$, $I_E=0$ 3000° K tungsten source Test sequence of 8 hours on, 24 hours off and 8 hours on		ΔI_{CB}	----	± 2	Percent of initial I_{CB}
<u>Subgroup 5</u>			5				
Collector to emitter saturation voltage	3071	$I_C=150 \text{ mA}$ $I_B=15 \text{ mA}$		$V_{CE}(\text{sat})$	----	5	Volts

TABLE I. Group A inspection (cont'd.)

Examination or test	MIL-STD-750		LTPD	Symbol	Min	Max	Unit
	Method	Details					
<u>Subgroup 5 (cont'd.)</u>							
Small signal short circuit input impedance	3201	V _{CB} =30V I _E =100 μA f=1 kHz		h _{ib}	100	300	Ohms
Small signal open circuit output admittance	3216	V _{CB} =30V I _E =100 μA f=1 kHz		h _{ob}	---	0.1	μmho
Small signal open circuit reverse voltage transfer ratio	3211	V _{CB} =30V I _E =100 μA f=1 kHz		h _{rb}	0.05	1.5	x 10 ⁻⁴
<u>Subgroup 6</u>							
Collector to base cutoff current (dark current)	3036	Bias cond. D V _{CB} =80V T _A =150° C	10	I _{CBO}	---	25	μA
Photo current rise time		(See figure 7)		t _r	---	1	μsec
Photo current fall time		(See figure 7)		t _f	---	10	μsec
Axial angle of acceptance		Measured from center line perpendicular to base of header (See figure 8)				±10	Degrees

TABLE II. Group B inspection

Examination or test	MIL-STD-750		LTPD	Symbol	Min	Max	Unit
	Method	Details					
<u>Subgroup 1</u>							
Physical dimensions	2066		15	---	---	---	---
<u>Subgroup 2</u>							
Solderability	2026		10	---	---	---	---
Thermal shock temperature cycling)	1051	Test cond. C		---	---	---	---
Thermal shock (glass strain)	1056	Test cond. A		---	---	---	---
Moisture resistance	1021	---					
End points: Illumination sensitivity		100 foot-candles V _{CE} =22.5V 3,000° K tungsten source		ΔI _{CE}	---	±25	μA/ft-candle

TABLE II. Group B inspection (cont'd.)

Examination or test	MIL-STD-750		LTPD	Symbol	Min	Max	Unit
	Method	Details					
End points: (Cont'd)							
Collector to base cutoff current (dark current)	3036	Bias cond. D $V_{CB}=80V$		I_{CBO}	---	0.1	μA
Collector saturation voltage	3071	$I_C=150\text{ mA}$ $I_B=15\text{ mA}$		V_{CE} (sat)	---	5.5	Volts
<u>Subgroup 3</u>			10				
Constant acceleration	2006	20,000 G		---	---	---	---
Shock	2016	Nonoperating 500 G, 1 msec; 4 planes- $X_1, X_2,$ Y_1, Y_2 , 5 blows in each plane		---	---	---	---
Vibration fatigue	2046	Nonoperating		---	---	---	---
Vibration variable frequency	2056	---		---	---	---	---
End points: (Same as for subgroup 2)							
<u>Subgroup 4</u>			20				
Barometric pressure, reduced (altitude operation)	1001	8 mm Hg		---	---	---	---
Measurement to be made during test:							
Collector to base cutoff current (dark current)	3036	Bias cond. D $V_{CB}=80V$		I_{CBO}	---	0.01	μA
<u>Subgroup 5</u>			20				
Salt atmosphere	1041						
End point							
Collector to base cutoff current (dark current)	3036	Bias cond. D $V_{CB}=80V$		I_{CBO}	---	---	μA
<u>Subgroup 6</u>			20				
Lead fatigue	2036	Test cond. E					
<u>Subgroup 7</u>			$\lambda=5$				
Operating life	1026	$V_{CB}=50V$ $P_C=500\text{ mW}$ $I_C=10.0\text{ mA}$					

TABLE II. Group B inspection (cont'd.)

Examination or test	MIL-STD-750		LTPD	Symbol	Min	Max	Unit
	Method	Details					
<u>Subgroup 7 (cont'd.)</u> End points: (Same as for subgroup 2)							
<u>Subgroup 8</u> High temperature life (non-operating)	1031	T _{stg} =200° C	$\lambda=5$	---	---	---	---
End points: (Same as for subgroup 2)							

6. NOTES

6.1 The notes specified in MIL-S-19500 are applicable to this specification.

User activities:
 Navy - AS, OS, MC, CG, SH

Preparing activity:
 Navy - EC

(Project 5961-N229)

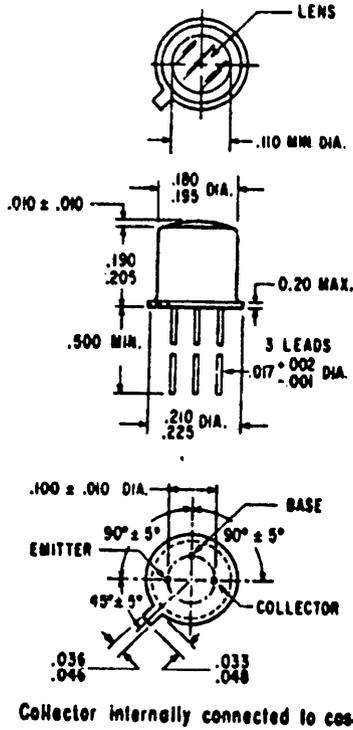


Figure 1 - Dimensions of phototransistor type 2N986.

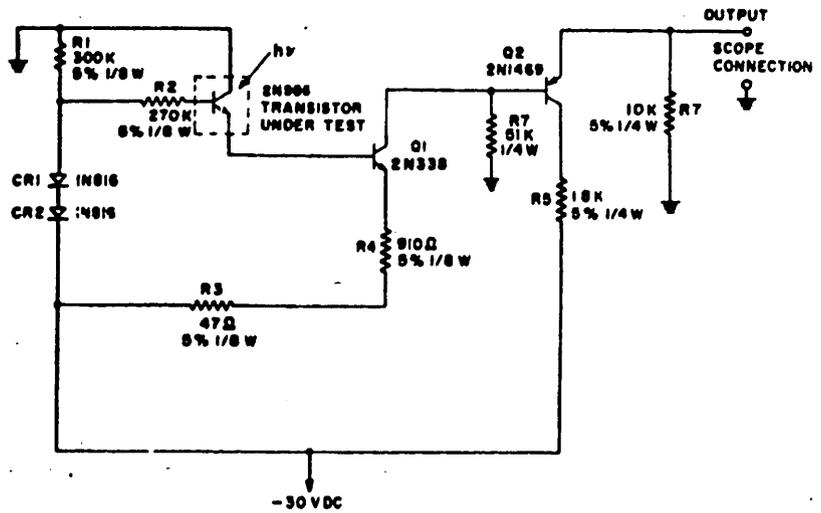


Figure 2 - Schematic diagram of phototransistor 2N986 test circuit.

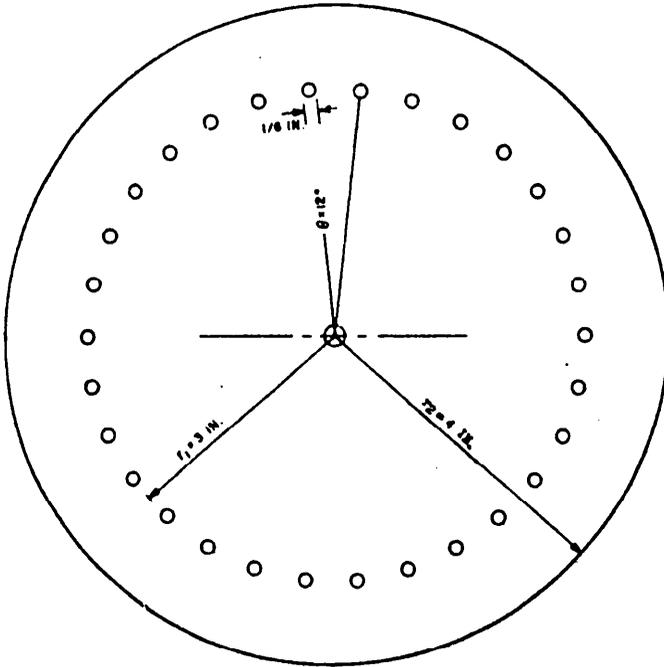
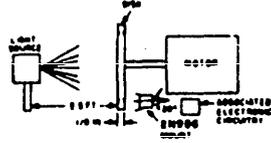


Figure 3 - Scale drawing of optical chopper disk.



**Light source - GE Airway Beacon
 #DM-T 20 BF-120M or equivalent.**

**Motor - Capable of sustained operation at 1800
 RPM with ± 0.5 percent flutter.**

**Disk - As indicated, disk will have 30 holes
 spaced 12 degrees apart on a 3 inch
 radius.**

**Phototransistor mount - Shall be made so that
 it can be adjusted
 ± 10 degrees from
 the horizontal axis.**

Figure 4 - Mechanical layout of electro-optics.

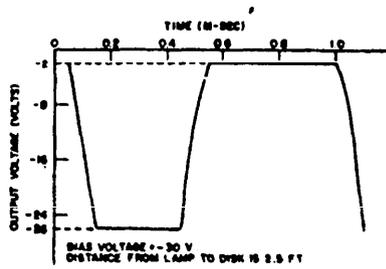
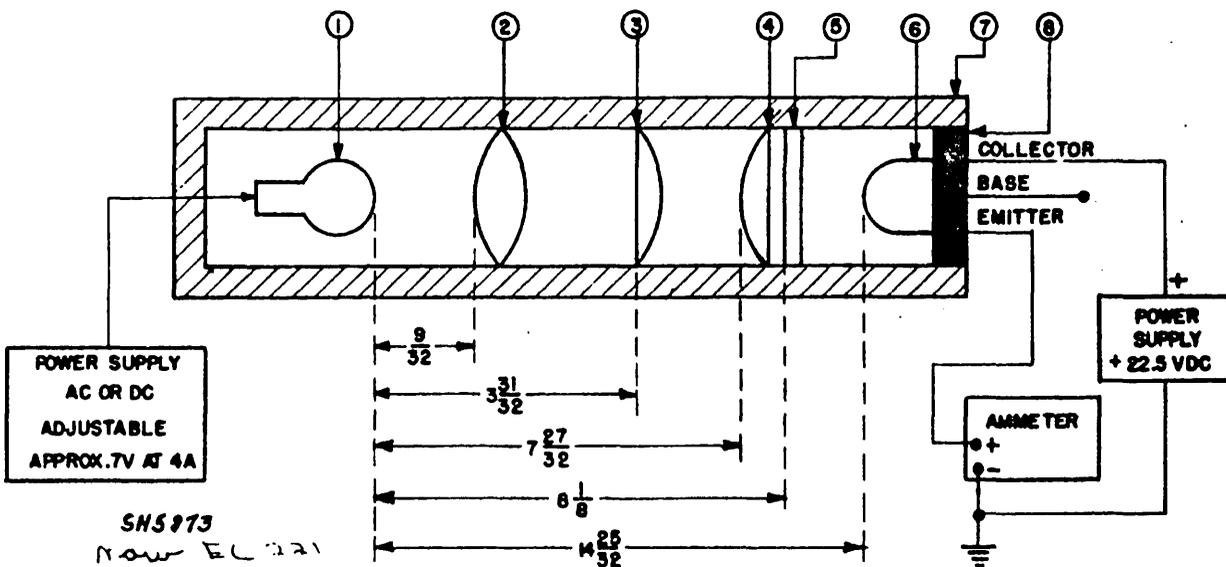
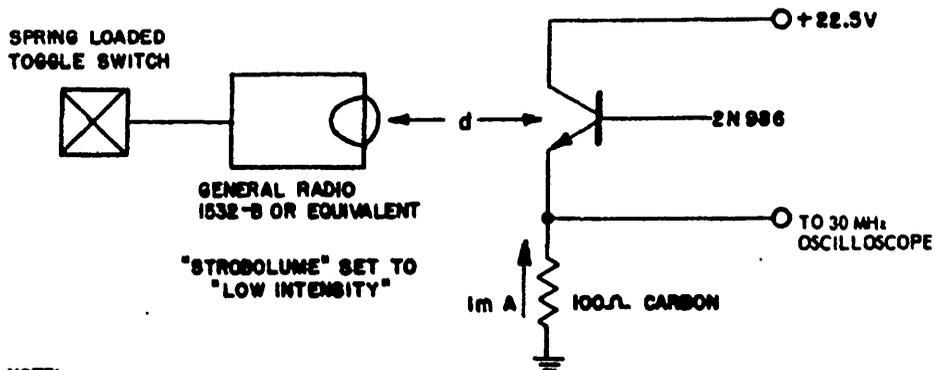


Figure 5 - Output voltage waveform.



1. General Electric #15 Indicator Bulb, or equivalent.
2. Edmund Scientific Co. Pyrex Aspheric Condenser #40, 223, or equivalent.
3. Edmund Scientific Co. Plano Convex Lens, or equivalent, diameter=35 mm. Focal Length = 61 mm.
4. Same as 3.
5. Edmund Scientific Co. Iris Diaphragm #30,118, or equivalent.
6. 2N986 under test.
7. Light-tight tube.
8. Removable cap to light-tight tube. Provisions shall be made to adapt a light meter and color temperature meter to insert in the space left by the removable cap; in order to calibrate light intensity at 100 foot-candles and color temperature at 3000° K, before testing.

Figure 6 - Columnated light source for luminous sensitivity measurements of 2N986.



NOTE:
 ADJUST DISTANCE "d" UNTIL 0.1V PEAK IS READ ACROSS
 100Ω RESISTOR THEN READ 10%-90% RISE TIME AND
 FALL TIME.

SN5874 Now EC 222

Figure 7 - Rise and fall time test for 2N986.

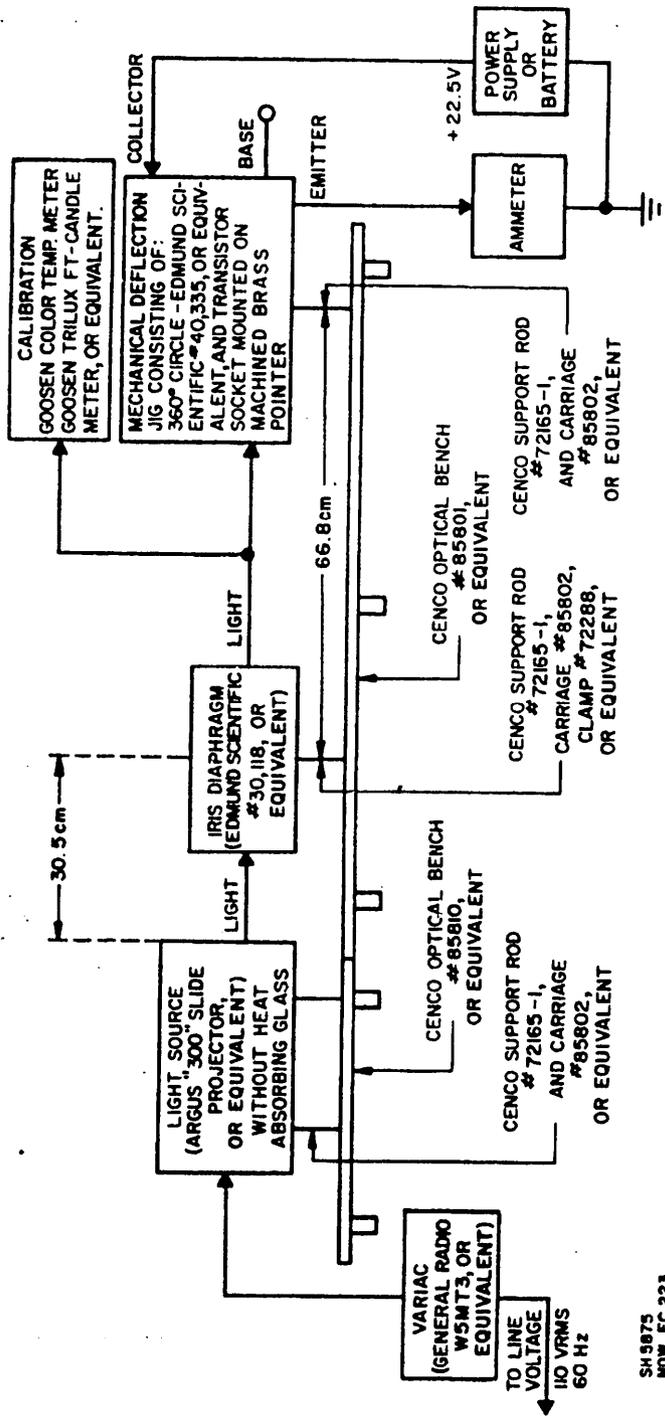


Figure 8 - Axial angle of acceptance test apparatus.

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