

ML-8087

SCAN-CONVERSION STORAGE TUBE

DESCRIPTION:

The ML-8087 is a precisely constructed, dual-gun, electrical-signal-storage tube with a semiconductive storage medium. This tube is capable of receiving an electrical input of one scanning mode, holding or storing this information for various periods, and then generating a separate electrical output in the same or any other desired scanning mode during which time stored information is gradually erased.

Use of the ML-8087 for scan conversion or electrical-signal storage has been found to provide the following advantages:

1. High resolution (170 range rings/diameter or 680 TV lines)
2. Fast erase cycle (2 seconds maximum)
3. Gray levels or half-tones comparable to TV presentation
4. Wide storage range
5. High signal/noise ratio (15:1 to 80:1)
6. Rapid installation (mounting and adjustment accomplished in a few minutes)
7. Overall uniformity of display
8. Need for critical dynamic focusing of electron guns minimized
9. No need for spurious signal cancellation (no "crosstalk")
10. Fast writing speed (TV scanning rates or better)

Various possible applications of this tube are suggested by the following:

1. In air traffic control, use of the tube permits display of aircraft positions as a bright, flicker-free trace, with a fading trail indicating relative speed and direction.
2. The tube can be used to convert TV programs or TV video tape from one set of standards to another — for example, from British to U. S. scanning rates.
3. The storage ability and flexibility of the tube permit improved sonar displays.
4. By integrating a weak video signal over a number of scans, signal/noise ratios are improved and contrast enhanced.

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5. Three scan-converter tubes can be used to store three separate colors. Color of display portions, read on a color TV tube, permits identification of an additional parameter, such as the altitude of an aircraft.
6. In signal simulation equipment, the tube permits changing analogue information on a fixed time base to a variable time base with or without a controllable delay.
7. Video or informational bandwidth can be compressed by reading with a slow spiral scan, a slow TV-raster scan, or by a reduced sampling scan. Conversely, low frame-rate information can be converted into a flicker-free visual display by more rapid scanning.

The ML-8087 is an improved version of the TMA-403X, a storage tube of proven reliability. A new read gun, new storage electrode and new shading electrode permit higher resolution, faster erasing, decreased shading, and elimination of the need for spurious signal cancellation.

The tube uses only one magnetic deflection yoke and no external focus coils. This simplifies installation, since proper performance does not depend on the precise alignment of the tube with respect to external circuit elements. The deflection system of the tube is very flexible with respect to the types of scan employed. Off-centering of the write-or read-gun scan can be easily accomplished. The read gun can be scanned over only a portion of the written storage surface for partial read-out or erasure.

The writing operation in the tube utilizes bombardment-induced conductivity instead of secondary emission of the storage target. The resultant high writing speed minimizes delay after an erasure and permits inputs of very fast sweep rates.

A wide storage range (see Fig. 1) can be obtained by adjustment of a single control to vary collector electrode voltage.

This tube has been designed to meet applicable FAA specifications and sections of Military Specification MIL-E-1 pertaining to storage and cathode ray tubes.

PRINCIPLES OF OPERATION

Schematic Construction:

Figure 2 illustrates schematically the arrangement of electrodes within the tube. Symbols used to identify components are in accordance with JEDEC publication No. 33 in which the prefix "w" denotes a component in the write-gun section and the prefix "r" a component in the read-gun section. The letter "g" denotes a grid or anode, "h" a heater, "k" a cathode, and "D" a deflection plate. Table I identifies each electrode with reference to the symbol used and pin connection.

Write-Gun Section: The write gun is designed to focus a very-high-velocity electron beam on any point of the backing electrode (be). It consists of electrodes wh, wk, and wg1 to wg5.

Read-Gun Section: The read gun is designed to focus a medium-velocity electron beam on any point of the storage surface (ss). It consists of electrodes rh, rk, rg1 to rg7, and rD1 to rD4.

Storage Section: The storage section consists of electrodes ce, se, ss and be. The storage electrode consists of a very thin sheet of metal, the backing electrode (be), upon which is coated a semi-conducting material the surface of which is known as the storage surface (ss). This material has characteristics such that when struck by a medium-velocity electron beam, its secondary emission ratio is greater than one (the number of secondary electrons leaving the dielectric are greater than the number landing); any point on the storage surface (ss) can thus be positively charged with respect to backing electrode (be). When a point on the dielectric material is struck by a very-high-velocity electron beam, "charge carriers" are created within the dielectric and decrease the charge on the storage surface at that point. For the purpose of understanding operation, the storage electrode can be considered as a planar array of minute, discrete conductive areas (ss), each capacitively coupled with the backing electrode (be). The collector electrode (ce) collects electrons emitted by the storage surface. The corrector electrode, or "shading" electrode (se), corrects the field along the periphery of the storage surface to permit uniform collection of secondary electrons.

Automatic Priming Operation:

Prior to writing, the storage surface (ss) is uniformly charged to a positive potential with respect to the backing electrode. This is called "priming" and is accomplished as the backing electrode is at zero potential and the storage surface is scanned by the read-gun, operation of which will be described subsequently. The priming operation charges the storage surface to approximately the same potential as the collector electrode (ce). Erasing operations, described in later paragraphs, also prime the storage target.

Writing Operation:

Due to the high write-gun cathode potential, about -8kV, and consequent high electron velocity, the storage surface tends to be discharged at any point which is struck by the write-gun beam. The electron velocity is sufficient for electrons to penetrate the metal backing electrode and enter the semiconductive coating. The unperforated backing electrode, as compared to the mesh-type backing electrodes, does, however, minimize the transmission of write-gun electrons through the dielectric to the storage surface, where they would otherwise be picked up as a spurious signal by the read gun. The write-gun beam density can be modulated in accordance with electrical information input to the cathode (wk) or control grid (wgl) (see Fig. 3). At the same time, the beam can be scanned across the backing electrode under control of the deflection coil. Thus, an image can be established by the write gun in the form of a pattern of varying charges on the storage surface: fully charged, most positive, surfaces corresponding to "black" unwritten points; fully discharged, near 0-volt, surfaces corresponding to "white" written points; and areas charged to intermediate, less positive, potentials corresponding to various shades of grey, or half tones. The amplitude of the charge at any point, and consequently the amplitude of any stored signal, is primarily dependent on the write-gun beam current but also dependent on more fixed factors such as electron velocity, scanning speed and pulse repetition rates.

Reading Operation

The read-gun beam can be deflected to impinge upon any point of the storage surface (ss) by means of the deflection plates (rD1, rD2, rD3, rD4). Due to the relatively lower velocity of read-gun electrons as compared to the write gun, conductivity is not induced at points struck by the beam, but the number of secondary electrons emitted from the storage surface is greater than the number landing. When the read-gun beam impinges upon a point which was previously written, and consequently negative with respect to the collector electrode (ce), the read beam tends to recharge it; electrons which are emitted from the storage surface are collected at the more positive collector electrode. This flow of electrons constitutes the output signal. When the read beam impinges upon an unwritten point, which is consequently at approximately the same potential as the collector electrode, electron flow to the collector is small and a minimum output signal is obtained.

The time necessary for recharging any storage surface point back to the potential of the collector varies inversely with read-gun beam current and directly with collector electrode voltage. The time during which an image is stored is therefore dependent upon these parameters (see Fig. 1). It will be noted that the reading gun serves also to erase the stored image.

Simultaneous Reading and Writing

Both guns are usually operated at the same time. Reading increases storage-surface potentials while writing decreases storage-surface potentials. Since, the read gun normally charges the surface at a slower rate than the write gun discharges it, written points remain visible as long as the write-gun beam impinges upon that point. When the write-gun beam moves, it will, however, leave a gradually fading trail.

Erasing Operation

Erasing of stored information is accomplished by charging all portions of the storage surface to a uniform positive potential with respect to the backing electrode. This occurs during normal scanning of the read gun as described previously. By read-gun scanning of only a portion of the storage surface, only that portion of stored information will be erased. Erasure leaves the storage surface primed, ready for another writing operation.

Since the rate at which the storage surface is charged by the read gun, and consequently the rate of erasure, is directly proportional to the read-beam current, provisions are made to increase the read-beam current to obtain faster erasure as follows:

During normal reading, the erase-focus anode (rg3) is at the same potential as accelerating anodes (rg2, rg4, rg5 and rg7) in order to obtain a beam of uniform density suitable for collimation. A large number of electrons (up to 95%) are intercepted by the collimating iris of anode (rg4), and the main-focus anode (rg6) is adjusted to obtain a very fine spot for high-resolution reading. During a fast-erase cycle, erase-focus anode (rg3) voltage is adjusted to focus electrons at the aperture of the iris of anode (rg4) so that almost all read-beam electrons pass through. This produces a somewhat larger spot at the storage surface. The

larger spot permits use of a still-higher beam current, which may be obtained, if needed, by raising the voltage of the read-gun control grid (rg1). The greater beam current recharges the negative portions of the storage surface more quickly and thus increases the rate of erasure. The maximum erase current is limited by the heat dissipating ability of the storage surface.

During the fast-erase cycle, the voltage of the backing electrode is switched in succession to +100 volts for one second, to -100 volts for one second and then to normal ground potential. Since the storage surface is capacitively coupled with the backing electrode, its potential will follow that of the backing electrode. During the cycle, additional current will flow from the storage surface to the collector. In addition, at the higher voltages, the dielectric material of the storage electrode becomes conductive. The net effect of the cycling operation is to obtain more complete erasure by bringing all points on the storage surface to a more uniform potential. This cycling procedure also increases the rate of erasure by itself, without any increase in beam current.

PERFORMANCE

Values given are for typical tubes unless otherwise specified.

Resolution with 50% Amplitude Modulation (#1):	
Range Rings per Diameter.....	170
Equivalent TV Lines per Diameter.....	680
Storage Time:	
Read Gun Not Operating.....	Several days
Read Gun Operating.....	See Fig. 1
Fast-Erase, <u>maximum</u> (#2).....	2 sec
Signal/Noise Ratio (#3).....	15:1 to 80:1
Signal/Shading Ratio, <u>minimum</u> :	
Over 90% of storage surface.....	5:1
Over 100% of storage surface.....	3:1
Signal/Background-Shading Ratio, <u>minimum</u> :	
Over 90% of storage surface.....	10:1
Over 100% of storage surface.....	8:1
Grey Level Capabilities, <u>minimum</u>	5

Notes on Performance

- #1a. If resolution were to be measured with parallel written lines orthogonal to the reading raster, instead of with PPI range rings, the resolution figure would be in the order of 820 TV lines.
- #1b. Resolution is dependent upon the read-gun focusing-anode (rg6) voltage as shown in Figure 4. In order to obtain maximum resolution in the center as well as on the edges of the target, a dynamic focusing voltage should be superimposed on the d-c voltage of the read-gun focusing anode (rg6) in accordance with Figure 5.

- #1c. To minimize gun astigmatism, the voltage of both deflecting plates of each pair should be fed symmetrically with respect to the voltage of anodes rg2, rg4, rg5 and rg7; i.e., the absolute values of deflecting plate voltages with respect to anode voltage should always be equal for each pair of plates (see Fig. 6).
- #1d. The write gun operates at very high cathode voltage and consequently does not require dynamic focusing.
- #2. Using fast-erase technique, the amplitude of the stored information can be reduced from a level of 100% to 7% in less than 2 seconds. This is the same as the noise level in a 945-line TV system. During this procedure the following conditions prevail:

Read-Beam Current, approximate.....	100 μ A
rg3 to rk Voltage.....	-190 to -230 Vdc
be Voltage to Ground (in indicated order):	
For 1.0 sec.....	+100 Vdc
For 1.0 sec.....	-100 Vdc
Then return to.....	0 V

- #3. Due to the homogeneous structure of the storage dielectric, the disturbance level is very low.

GENERAL CHARACTERISTICS

Electrical, Write-Gun Section

Heater Voltage, AC or DC (#1).....	6.3 \pm 10% V
Heater Current at 6.3 Volts.....	0.6 \pm 10% A
Focus Method.....	Electrostatic
Centering Method.....	Electromagnetic
Deflection Method.....	Electromagnetic
Total Deflection Angle, approximate.....	30 deg
Direct Interelectrode Capacitances:	
wgl to wh.....	3.5 pf
wk to all other electrodes.....	5.0 pf
wgl to all other electrodes.....	9.0 pf

Electrical, Read-Gun Storage Sections

Heater Voltage, AC or DC (#1).....	6.3 \pm 10% V
Heater Current at 6.3 Volts.....	0.6 \pm 10% A
Focus Method.....	Electrostatic
Deflection Method.....	Electrostatic
Total Deflection Angle, approximate.....	30 deg
Deflection Sensitivity in Volts Peak-	
to-Peak to Sweep a Major Diameter of Target (#2):	
Plates rD1 and rD2.....	250 v/dia
Plates rD3 and rD4.....	315 v/dia

Direct Interelectrode Capacitances:

rD1 to rD2.....	12 pf
rD3 to rD4.....	12 pf
rg1 to rk.....	2.5 pf
rk to all other electrodes.....	7.0 pf
rg1 to all other electrodes.....	10.5 pf
ce to all other electrodes.....	26 pf

Mechanical

Mounting Position (#3).....	Any
Dimensions.....	See Fig. 7
Pin Connections.....	See Fig. 8
Useful Storage Surface Diameter.....	2.0 inches
Deflection Coil Inside Diameter, minimum.....	2.087 inches

Bases:

Write gun.....	JEDEC B12-131
Read gun.....	JEDEC B14-38
Recessed small ball caps.....	JEDEC J1-22

Shielding Required: (#4):

Read Gun.....	magnetic
Storage Section.....	light
Weight, approximate.....	2.5 lbs

Notes on General Characteristics

- #1. One end of the heater should be connected externally to its cathode. The heater power supply must be suitably insulated to withstand the cathode potential with respect to ground.
- #2. See Note on Performance (#1c).
- #3. If it is necessary to operate the tube in vertical position, the write-gun end should be up.
- #4. The read-gun end of the tube should be enclosed in triple layer mu-metal shielding approximately .60" thick which covers the read gun section and extends beyond the storage section. In addition, the same shield or a separate shield should be used to prevent light from reaching the semiconductive surface of the storage target, which is photosensitive.

RATINGS

Ratings are absolute maximums unless otherwise specified.

All voltages are referenced to ground except where indicated otherwise.

Write Gun

wk Voltage.....	-10000 Vdc
wg1 to wk Voltage (+1):	
Maximum.....	-150 Vdc
Minimum.....	10 Vdc
wg2, wg3, wg5 Voltage.....	0 v
wg4 to wk Voltage.....	2.5 kVdc
Peak Beam Current (+2).....	2 µa

Read Gun

rk Voltage.....	-1500 Vdc
rg1 to rk Voltage.....	-150 Vdc
rg2, rg4, rg5, rg7 Voltage.....	-100 Vdc
rg3 Voltage:	
For normal read beam.....	-100 Vdc
For fast erase.....	-1800 Vdc
rg6 Voltage.....	-1500 Vdc
rD1 to rD2 Voltage, peak to peak (+3).....	600 vdc
rD3 to rD4 Voltage, peak to peak (+3).....	600 vdc
Peak Beam Current (+2).....	250 μ A

Storage Section

be Voltage:	
For normal read operation.....	0 V
For fast-erase operation.....	+100 Vdc
ce Voltage.....	50 Vdc
se Voltage.....	30 Vdc
Dynamic Output Signal Current.....	1.2 μ A

† Notes on Ratings

- †1. During initial applications of high voltage, the write-gun grid should be held at about -150 volts with respect to the write-gun cathode. A gradual rise in about 30 seconds is recommended to insure against grid decoupling effects.
- †2. It will be necessary to provide an automatic means of protection against sweep or bias failure so that the beams never remain stationary on any part of the storage surface.
- †3. See Note on Performance (+1c).

TYPICAL OPERATING CONDITIONS

All voltages are referenced to ground except where indicated otherwise.

Write Gun

wk Voltage.....	-8000 Vdc
wg1 to wk Voltages (See Fig. 3) (*1):	
Bias Voltage.....	-70 to -110 Vdc
Cutoff Voltage.....	-80 to -110 Vdc
wg2, wg3, wg5 Voltage.....	0 V
wg4 Voltage (*2).....	-5600 to -6400 Vdc
Peak Beam Current.....	0.75 μ A

Read Gun

rk Voltage.....	-1300 Vdc
rk Current:	
For 1 μ A normal read beam.....	110 μ A
For 100 μ A fast-erase beam.....	225 μ A
rg1 to rk Voltage:	
For Cut-Off.....	-50 Vdc
For 1 μ A normal read beam.....	-35 Vdc
For 100 μ A fast-erase beam.....	-20 Vdc
rg2, rg4, rg5, rg7 Voltage.....	-8 Vdc
rg3 Voltage:	
For normal read beam, voltage to ground.....	-8 Vdc
For fast-erase beam, voltage to rk.....	-190 to -230 Vdc
rg6 to rk Voltage (*3).....	+250 to +350 Vdc
Average Beam Current:	
For normal read operation.....	1 μ A
For fast-erase operation.....	100 μ A

Storage Section

be Voltage:	
For Normal read operation.....	0 V
For Fast-erase operation.....	+100 Vdc
ce Voltage.....	0 to 30 Vdc
se to ce Voltage (*4).....	12 Vdc
Dynamic Output Signal Current.....	0.6 μ A

* Notes on Typical Operating Conditions

- *1. Input video signals must be fed to wgl through a 10 kV capacitor.
- *2. The write-gun focus anode voltage should be set at 70% to 80% of the cathode (wk) voltage.
- *3. See Note on Performance (#1).
- *4. The corrector electrode (se) voltage is adjusted with respect to the collector electrode (ce) to maximize the signal/disturbance ratio. The correct voltage is one which provides maximum ratios for a wide range of storage characteristics.

TABLE I — TUBE CONNECTIONS

Symb.	Electrode	Write-Gun Base Pin	Read Gun Base Pin	Small Ball Cap
wh	write-gun heater	1	--	--
wh	write-gun heater	14	--	--
wk	write-gun cathode	12	--	--
wg1	write-gun control grid	13	--	--
wg2	write-gun accelerating anode	--	--	3
wg3	write-gun anode (conductive coating)	--	--	3
wg4	write-gun focusing anode	7	--	--
wg5	write-gun anode	--	--	3
be	backing electrode	--	--	A
ss	storage surface	--	--	N.C.
se	corrector (shading) electrode	--	--	1
ce	collector electrode	--	--	2
rh	read-gun heater	--	8	--
rh	read-gun heater	--	9	--
rk	read-gun cathode	--	7	--
rg1	read-gun control grid	--	5	--
rg2	read-gun anode	--	14	--
rg3	read-gun erase focusing anode	--	6	--
rg4	read-gun accelerating anode	--	14	--
rg5	read-gun anode (conductive coating)	--	14	--
rg6	read-gun main focusing anode	--	10	--
rg7	read-gun anode	--	14	--
rd1	read-gun vertical deflection plate	--	1	--
rd2	read-gun vertical deflection plate	--	2	--
rd3	read-gun horizontal deflection plate	--	12	--
rd4	read-gun horizontal deflection plate	--	13	--

A The backing electrode is connected to the metal ring at the center of the envelope.

STORAGE CHARACTERISTICS CURVES

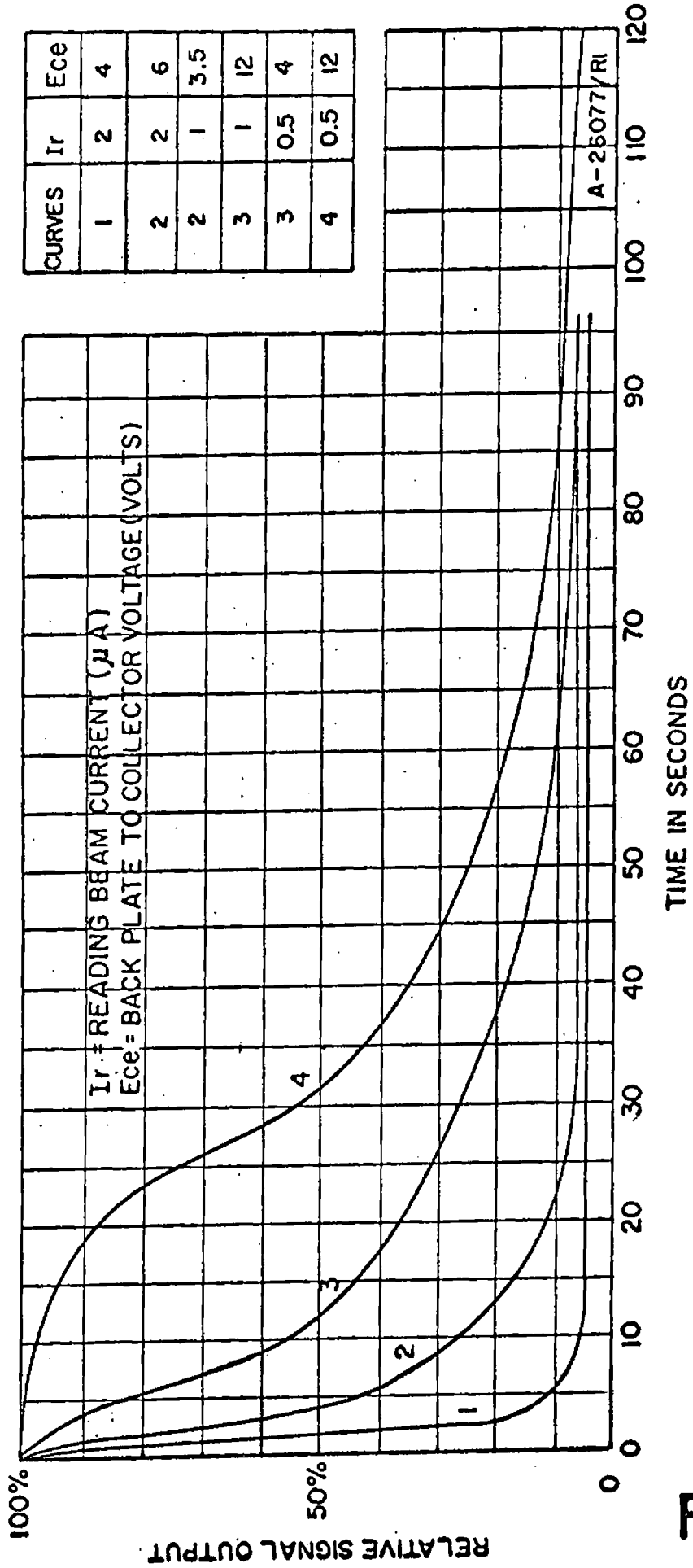
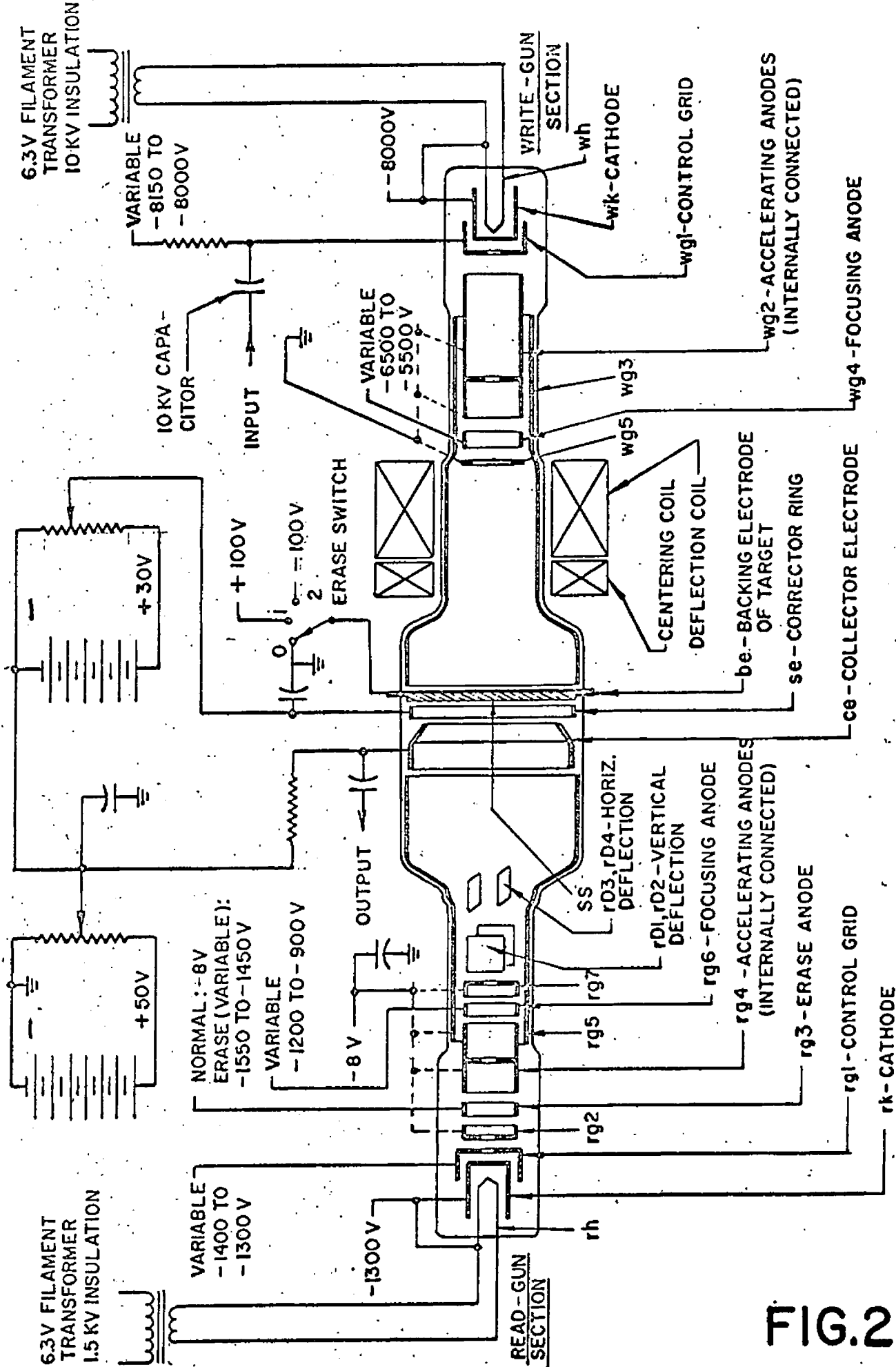


FIG. 1



NOTE: VOLTAGES SHOWN ARE TYPICAL. DOTTED LINE INDICATES INTERNAL CONNECTION.

SCHEMATIC ARRANGEMENT OF ML-8087

FIG. 2

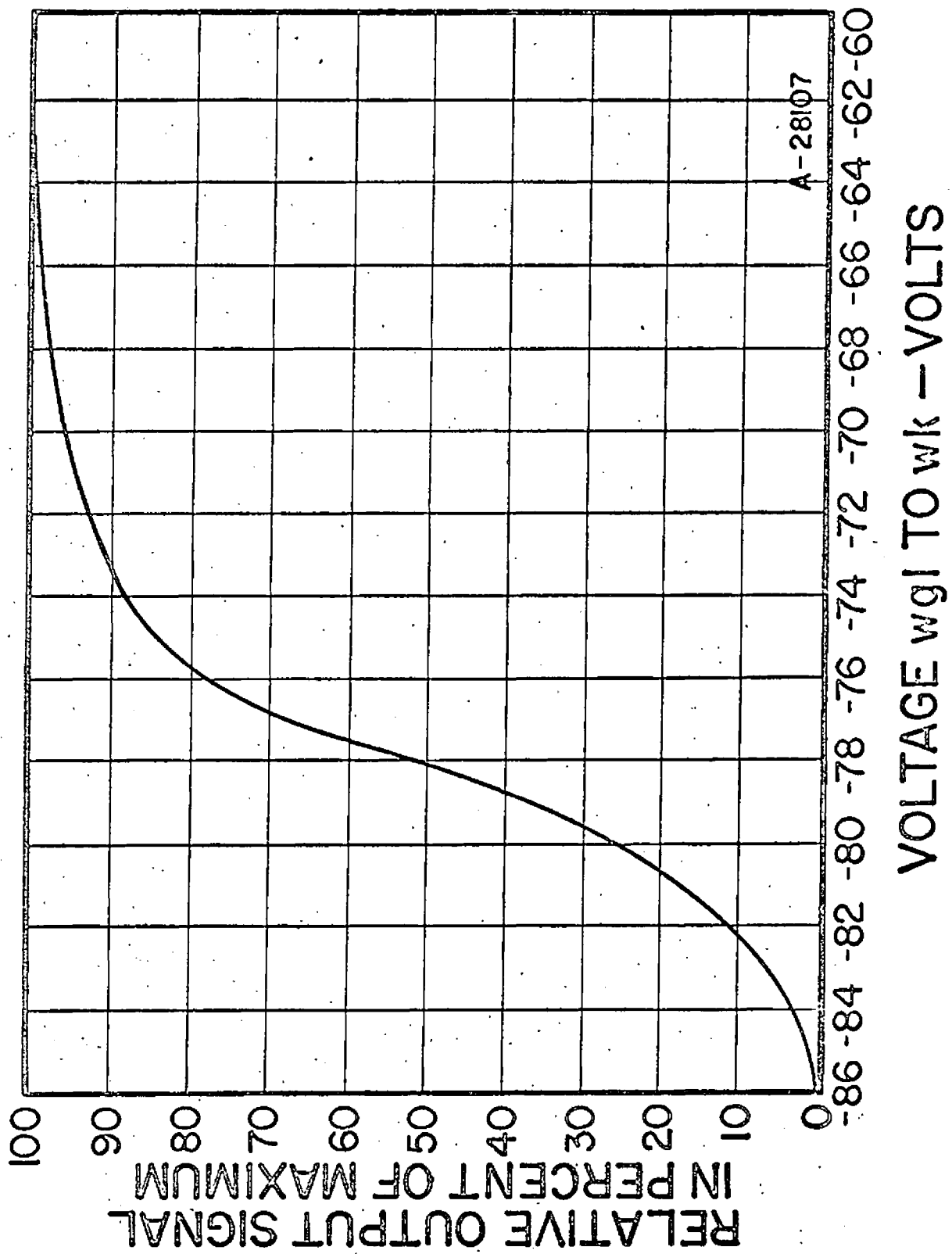


FIG. 3

ML-8087 HORIZONTAL RESOLUTION AS A FUNCTION
OF DEVIATION FROM OPTIMUM FOCUS
VOLTAGE OF READ GUN

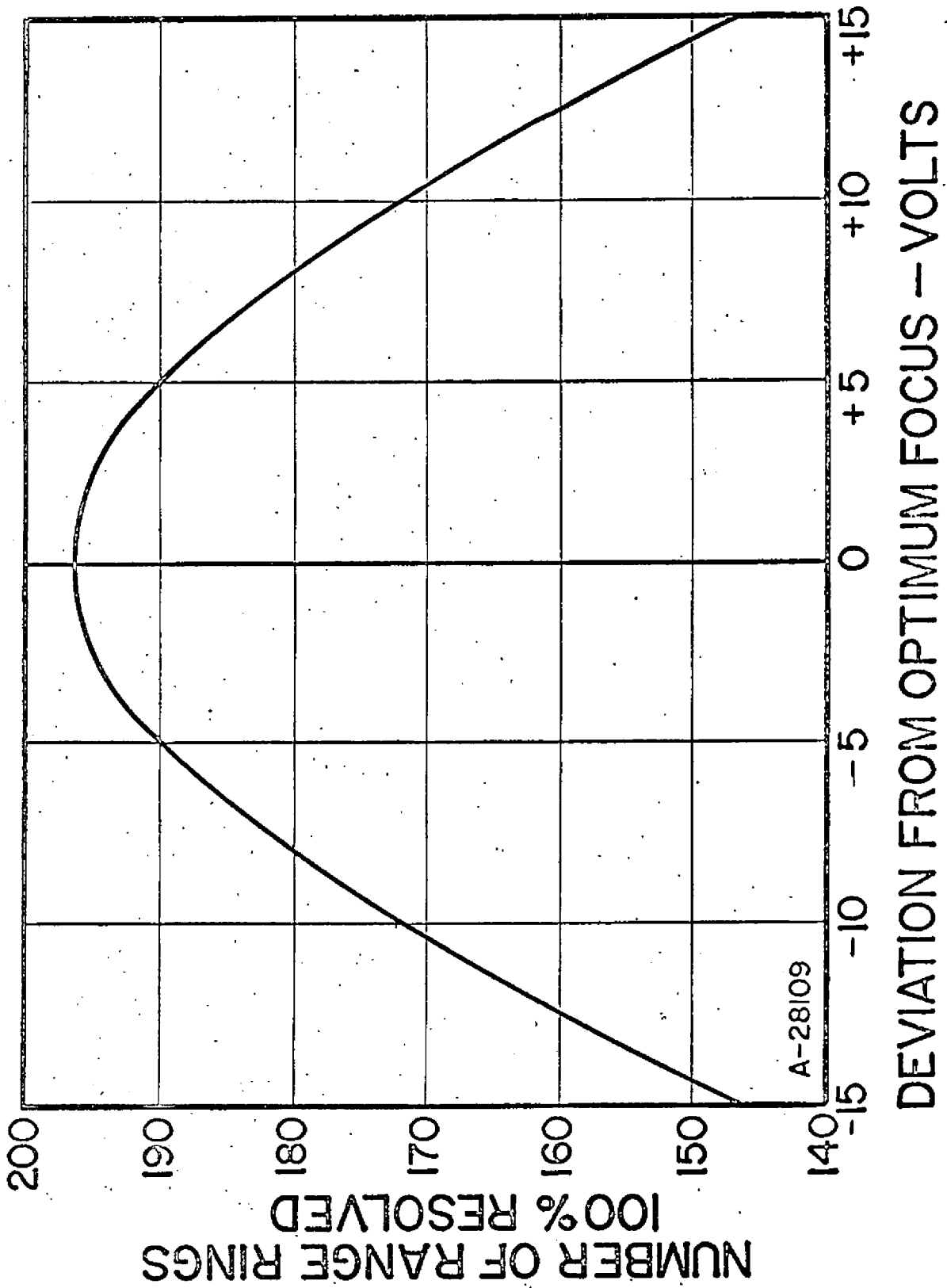


FIG. 4

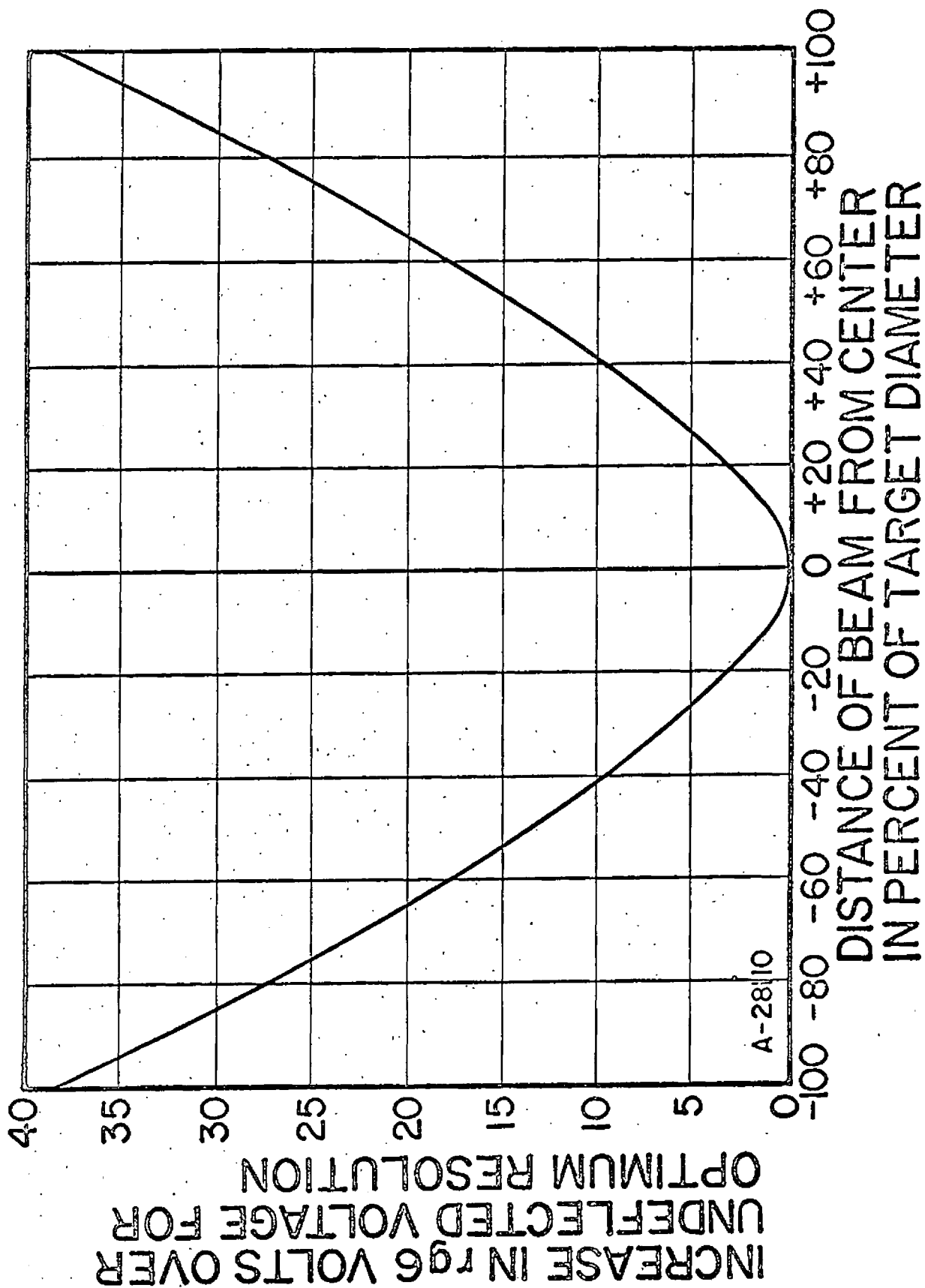


FIG. 5

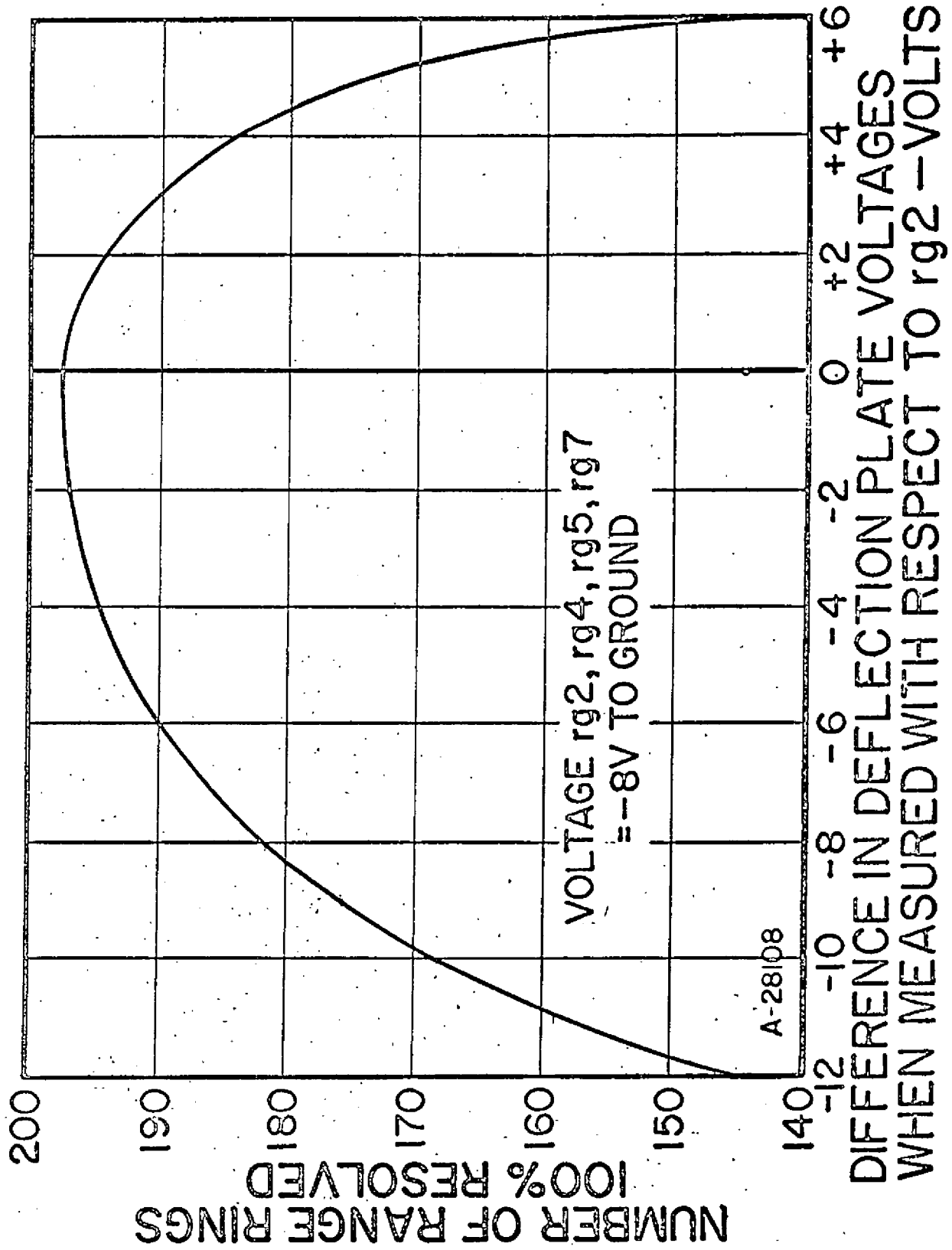
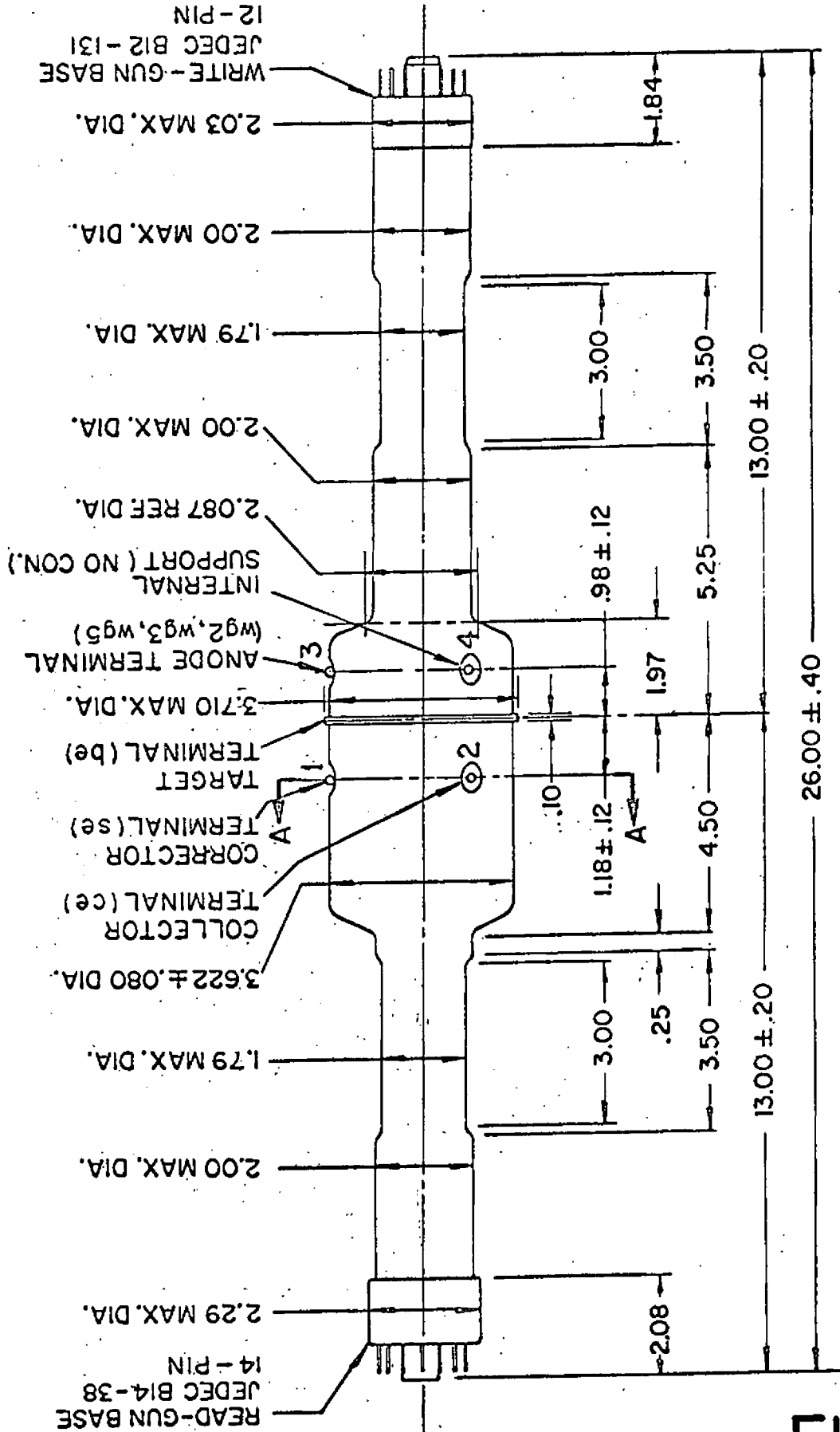


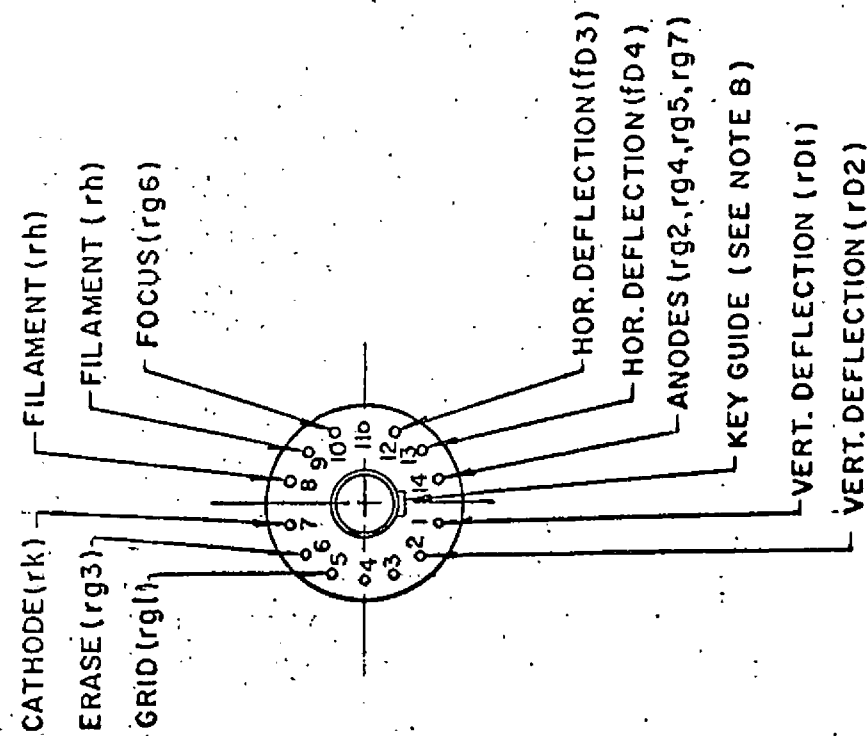
FIG. 6



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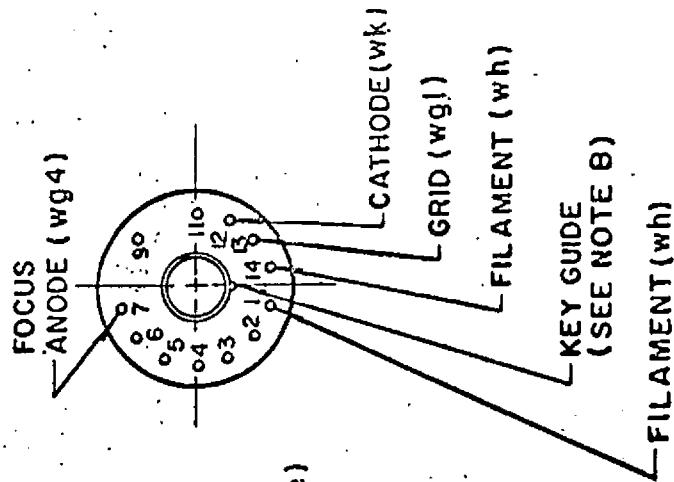
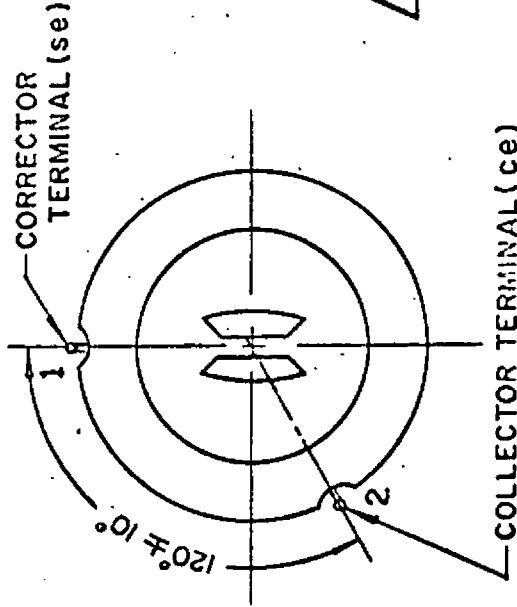
ALL DIMENSIONS IN INCHES

FIG. 7



NOTE A:
ANGULAR RELATIONSHIP OF HORIZONTAL DEFLECTION PLATES TO CORRECTOR TERMINAL NOT TO VARY MORE THAN 15°

NOTE B:
THE KEY GUIDES ON BOTH BASES ARE IN LINE WITH EACH OTHER & DIAMETRICALLY OPPOSITE TO THE CORRECTOR TERMINAL



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PIN CONNECTIONS
READ GUN

SECTION "A - A"

PIN CONNECTIONS
WRITE GUN

FIG. 8