from JEDEC release #4257, May 13, 1963

MACHLETT

ML-8130 DIRECT-VIEW STORAGE TUBE

DESCRIPTION & RATINGS

DESCRIPTION

The ML-8130 is a five-inch direct-view storage tube capable of storing high-brightness, flicker-free, half-tone displays of information. Displays can be erased instantaneously or gradually. The tube is designed for operation under extreme environmental conditions and is shielded from stray magnetic fields. Typical applications are:

1. Airborne search and fire control
2. Navigational radar
3. Airport surveillance
4. Transient studies
5. Weather radar
6. Data transmission systems requiring narrow band width

The tube is provided with a P-20 aluminized screen (see Fig. 1) coated on a flat faceplate of optical quality glass. With a view-screen voltage of 10 kV, the display brightness is in the order of 2000 foot-lamberts. Minimum writing speed of the tube is 300,000 inches per second. Faster speeds may be obtained by increasing write-beam current. Displays can be stored for 30 seconds or more. The rate of erasure can be controlled by changing the width, shape or frequency of a series of pulses applied to the backing electrode. The storage ability of the tube permits integration of weak signals and prolonged observation of transients. Half-tone displays may be obtained by amplitude modulation of the write-gun input signal. Precise alignment of guns and collimating electrodes contribute to the excellent uniformity of display over the entire view screen. Focusing and deflection of the electron beams are accomplished electrostatically, eliminating need for coils and simplifying magnetic shielding.

The ML-8130 is designed for military airborne operation and is intended to meet requirements of applicable military specifications. The tube, including its electrical terminals, is potted in a resilient silicone compound and enclosed in an effective, light-weight Netic Co-Netic magnetic shield. Leads from each electrode are brought out through the potting compound in flexible cables, which are an integral part of the tube assembly. These cables may be furnished in special lengths and fitted with terminal connectors as specified by the user. This external construction combined with the rugged internal construction of this tube assure its protection against vibration, mechanical shock, variations in environmental pressure, and stray magnetic fields. The construction also greatly simplifies tube installation.

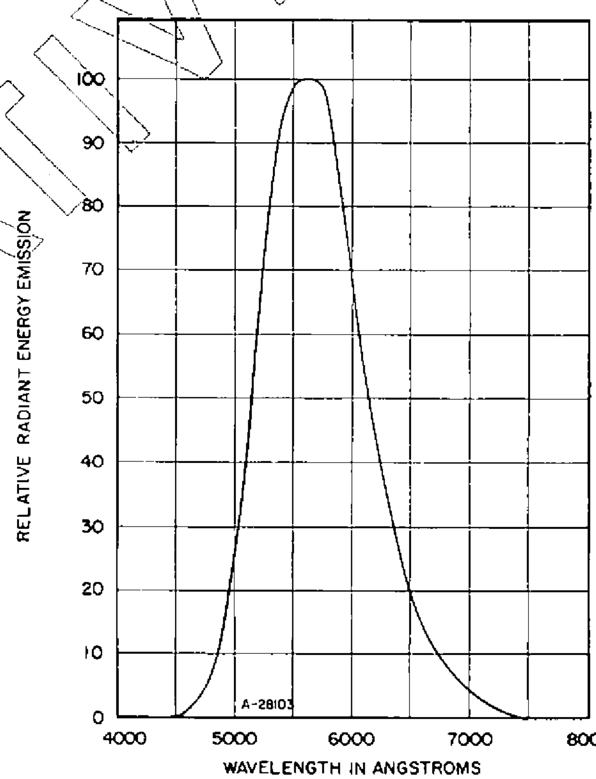


Figure 1 — P-20 Spectral Energy Emission Characteristics

PRINCIPLES OF OPERATION

Arrangement of Electrodes

Figs. 2 and 3 illustrate schematically the various internal components of the tube. Symbols used to identify electrodes are in accordance with JEDEC Publication No. 33 in which the prefix "w" denotes a component of the write-gun section and the prefix "f" denotes a component of the flood-gun section. The letter "g" denotes a grid, "h" a heater, "k" a cathode, and "D" a deflection plate.

The viewing screen (vs) is a coating of phosphor facing the electron guns. The backing electrode, or storage mesh (be), is a fine, metallic mesh, the gun-side of which is coated with a thin deposit of dielectric material, which functions as the storage surface (ss). The nature of the material used for the storage surface is such that it will maintain a pattern of charges for a considerable period of time. This surface, for analytical purposes, can be considered an array of minute, isolated storage areas each capacitively coupled with the backing electrode. The collector electrode (ce) is a high-transparency metal mesh in close proximity to the storage surface.

The remainder of the components comprise two electron-gun systems — one for viewing, the other for writing — as illustrated. Flood-gun grid fg3 is a conductive coating on the inside of the tube envelope. Flood-gun grid fg2 is a similar conductive coating electrically connected to write-gun grids wg2 and wg4.

Table A identifies each electrode with reference to the symbol used. Reference should also be made to electrode voltages given under "Typical Operating Conditions" in order to better understand the description of tube operation which follows.

TABLE A
TUBE CONNECTIONS

Symbol	Electrode	Internal Connection	Cable
fh	flood-gun heater	Pin 7	A
fh	flood-gun heater	Pin 8	A
fk	flood-gun cathode (I.C. to fh)	Pin 9	A
fg1	flood-gun control grid	Pin 6	A
fg2	flood-gun anode	Pin 10	A
fg3	flood-gun collimator	Cap 4	D
fg4	flood-gun collimator	Cap 5	D
ce	collector electrode (mesh)	Cap 3	D
ss	storage surface	N.C.	N.C.
be	backing electrode (storage mesh)	Cap 6	D
vs	view screen	Cap 1	C
wh	write-gun heater	Pin 1	B
wh	write-gun heater	Pin 14	B
wk	write-gun cathode	Pin 2	B
wg1	write-gun control grid	Pin 3	B
wg2	write-gun anode	Pin 10	A
wg3	write-gun focus electrode	Pin 13	B
wg4	write-gun anode	Pin 10	A
wD1	write-gun rear deflection plate	Pin 4	A
wD2	write-gun rear deflection plate	Pin 12	A
wD3	write-gun front deflection plate	Pin 5	A
wD4	write-gun front deflection plate	Pin 11	A
	I.C. to fg4. Do not use	Cap 2 & 7	—

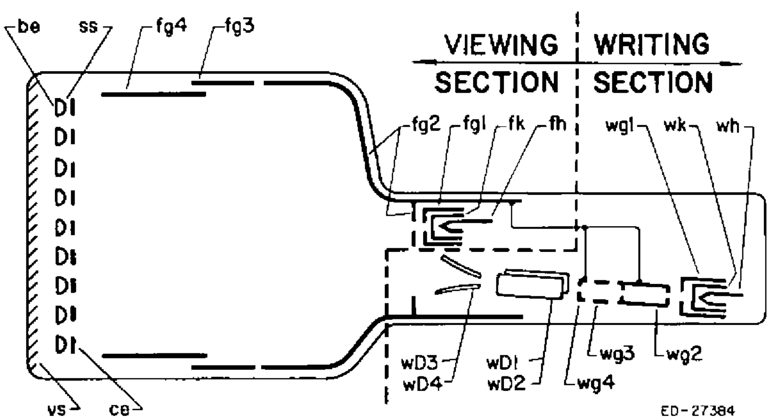
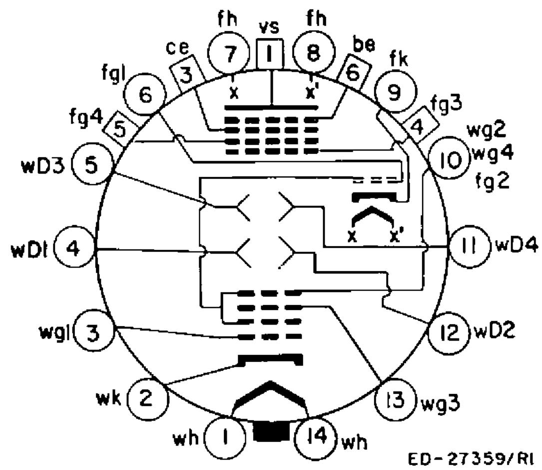


Figure 2 — Construction of Tube Shown Schematically



☐ SIGNIFIES BULB CONTACTS (NOT IN RELATIVE POSITIONS).

◯ SIGNIFIES PIN CONTACTS (IN RELATIVE POSITIONS).

NUMBERED CONTACTS ARE ENCAPSULATED IN THE MAGNETIC SHIELD OF THE ML-8130. REFER TO TABLE "A" FOR CONNECTIONS.

Figure 3 — Basing Diagram

Viewing

The flood gun produces a divergent beam of low-velocity electrons, which travel toward the storage surface. The collimating electrodes (fg3, fg4) align the electrons in a parallel path so that they continuously flood the storage surface with equal energy components. Collimation is essential so that the flood electrons will approach the storage surface in perpendicular paths, resulting in a uniform display.

The storage surface (ss), acting much in the same manner as a control grid in a triode, modulates the transmission of flood-gun electrons to the viewing screen. When the storage surface is at the same potential as the flood-gun cathode, 0 volts, all flood-gun electrons pass through openings in the storage mesh and are accelerated to the viewing screen causing it to fluoresce brightly. This condition, zero potential of the storage surface, is referred to as a condition of "saturated brightness". When the storage surface is charged to "cut-off voltage", about —8 volts, or some more negative voltage, electrons are repelled back to the collector electrode (ce) and none reach the viewing screen. The tube will then be in a "black" or "unwritten" state. With the storage surface at some intermediate voltage, some electrons reach the viewing screen and some are repelled. The screen will then fluoresce at some intermediate brightness in the "half-tone range". When a pattern of charges of different potential is applied to the storage surface, the charges ranging from cutoff voltage to zero potential, some electrons will reach the viewing screen and some will be repelled. The potential charge on any individual storage surface element determines the quantity of electrons passing through the mesh opening at that particular element. The flood electrons strike the phosphor screen at a point directly opposite this element. In this manner, the flood-gun electrons produce a visual image of the storage surface charges on the viewing screen. The overall degree of viewing brightness is determined by the view-screen voltage and the density of the flood-gun electrons. A higher view-screen voltage will produce greater acceleration of the electrons, causing them to strike the view screen with greater velocity and resulting in increased phosphor fluorescence (see Fig. 4).

When viewing-section voltages are first applied, the storage surface assumes a positive potential with respect to the flood-gun cathode due to close capacitive coupling with the backing electrode. A portion of the flood-gun electrons are intercepted by the collector mesh, but the remainder are decelerated to near zero velocity at the storage surface. Electron landing velocity is so low that the secondary emission ratio of the storage surface is less than unity; i.e., the secondary electrons lost due to collision are less than the primary electrons landing on the storage surface. The storage surface is consequently charged negatively to the same potential as the flood-gun cathode, and a condition of saturated brightness exists.

Since, in normal operation, the storage surface is always negative with respect to the flood-gun cathode, it can control transmission of flood-gun electrons but none of these electrons

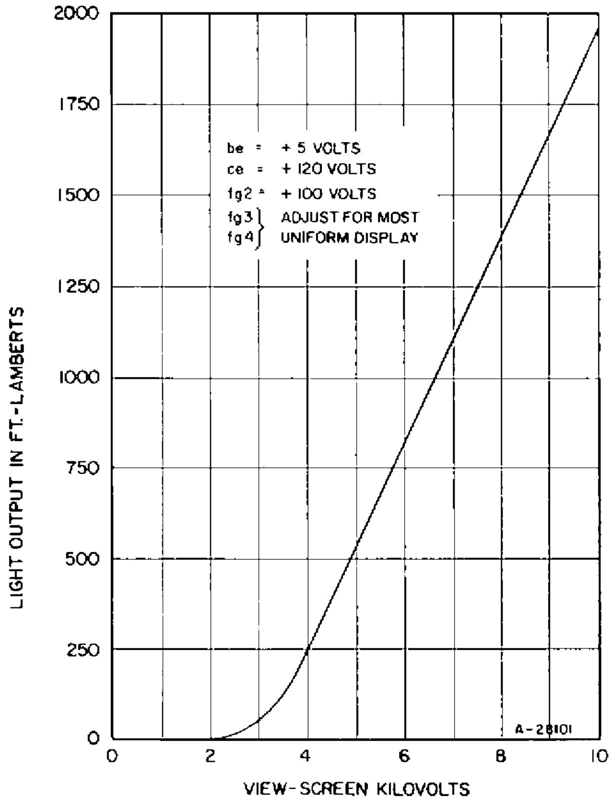


Figure 4 — Average Light Output

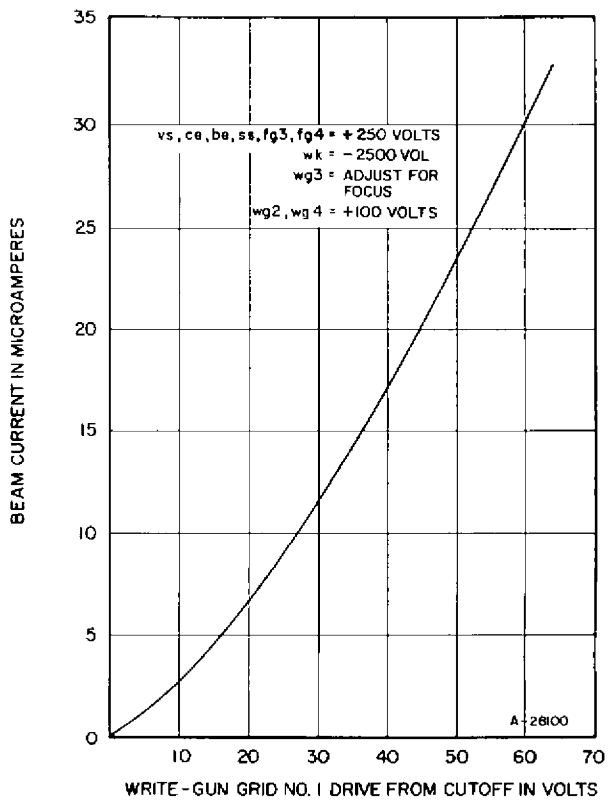


Figure 5 — Write-Gun Transfer Characteristics

will strike it and modify its charge. A negative voltage pattern on the storage surface is thus unaffected by the flood-gun emission and would exist indefinitely were it not for ion currents, which are described subsequently under "Erasing", and insulation leakage.

Writing

The writing gun is similar to electron guns used in industrial and military cathode ray tubes of the type which employ electrostatic focus and deflection. Its beam may be modulated in the same manner (see Fig. 5). It is a high-resolution-gun yielding a low-current high-velocity beam. The cathode is normally operated at a potential of —2000 volts with respect to the flood-gun cathode.

Before writing can take place, the storage surface must be at a negative, cutoff potential with respect to the backing electrode; the tube is then in a "black", unwritten state. This is accomplished by the erasing operation, which will be described subsequently.

After the writing beam is deflected, it passes through the collector mesh and strikes the dielectric coating on the backing electrode. It impinges with sufficient velocity for the dielectric to yield a secondary emission ratio greater than unity (the number of electrons emitted by the collision is greater than the number landing). With the collector at a positive potential and in close proximity to the storage mesh, complete collection of secondary electrons is possible. The net effect is to charge each individual scanned element of the storage grid in a positive direction. The amount of stored charge on each of the elements is proportional to the energy of the writing beam at the instant of impact. Thus, with the beam being modulated and scanned, a pattern of charges of different potentials is established on the storage surface. These potentials range anywhere between storage surface cut-off voltage and the zero potential of the flood-gun cathode (see Fig. 6). During the writing operation, the storage surface cannot build up any charges more positive than flood-gun cathode potential due to the nullifying action of flood-gun electrons. As described previously, under "Viewing", a voltage pattern written on the storage surface produces a visual image on the view screen due to the action of the flood-gun electrons.

Erasing

With the flood gun in operation, the amount of time a charge pattern can be stored on the storage surface is limited by ion current. Ions are produced by collisions of flood-gun electrons with residual gas molecules in the tube. Positive ions between the collector electrode and the flood gun are repelled from the storage surface by the positive-potential collector electrode. Positive ions between the collector electrode and the storage surface are attracted to the negative-potential storage surface neutralizing its charge and slowly changing the surface potential to a level of saturated brightness. Maximum image storage time is thereby limited to a period of about one minute. The loss of charge due to ion current, which is called "ion writing", also limits the time

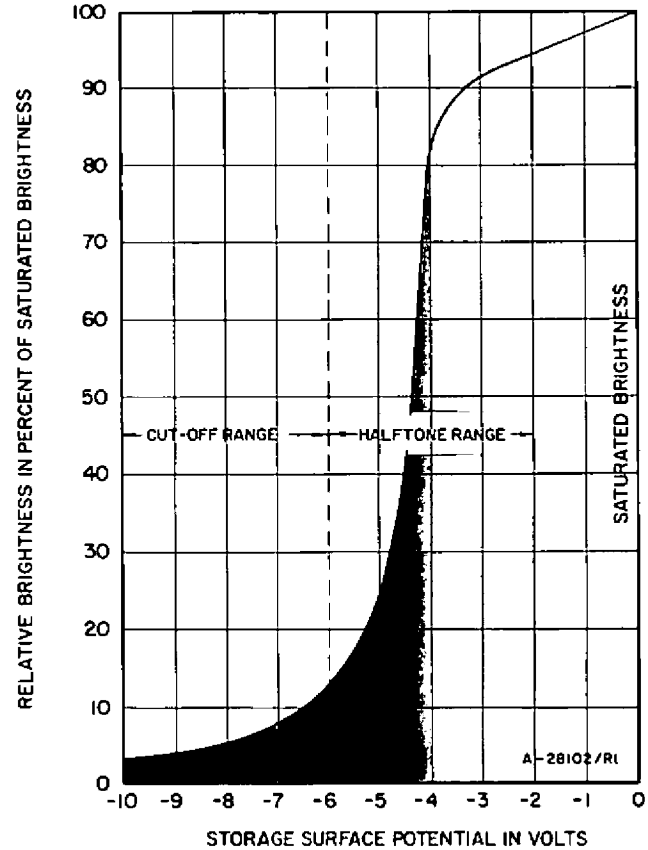


Figure 6 — Storage Characteristics

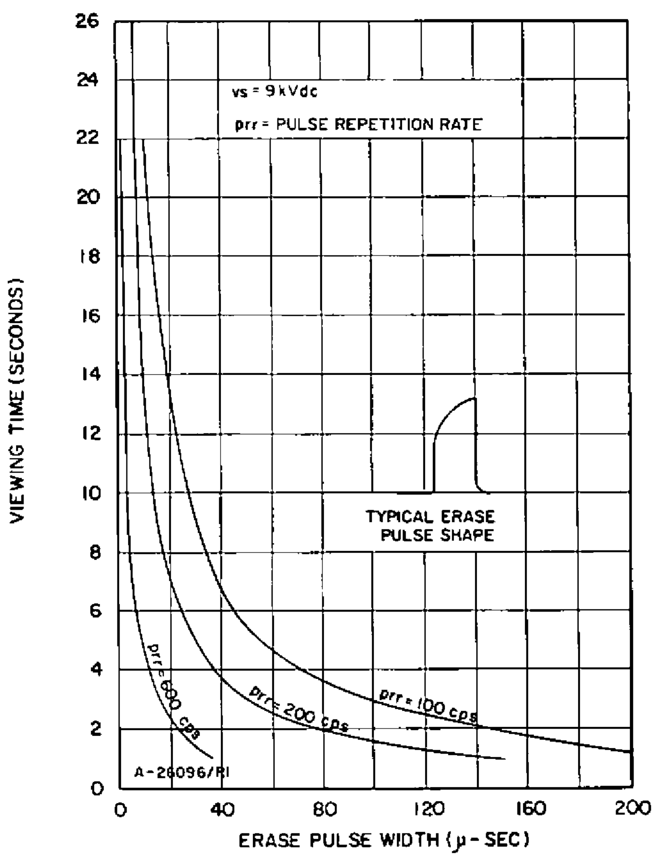


Figure 7 — Erase Characteristics

available for writing and viewing following intentional erasure to a black, unwritten state.

To erase an image intentionally, a series of positive-going pulses is applied to the backing electrode. This is termed "dynamic erasure" and permits a gradual fade-out of stored information.

When a positive-going pulse is applied to the backing electrode, the storage surface, due to capacitive coupling, will also become more positive. Electrons from the flood gun are then attracted to positive areas of the storage surface. Since flood-gun electrons are low-energy electrons, the secondary emission ratio at the storage surface is less than unity and the storage surface becomes less positive. At the end of each pulse, the backing electrode returns to its original, lower positive voltage. The voltage of each element of the storage surface will then follow the drop in backing-electrode voltage to a voltage which is more negative than before the pulse was applied. After a number of erase pulses of sufficient duration have been applied, all written areas of the storage surface will have acquired the same potential as the flood-gun cathode. At this point the storage surface potential will return to a negative value which is at or below cut-off. The tube is then in a "black", unwritten state, and the image has been erased. By limiting frequency or width of the pulses, the time required for complete erasure can be extended (see Fig. 7).

With a rectangular erasing pulse, all elements of the storage surface are discharged at the same rate; the less-positive, or low-brightness, areas will disappear first; and half-tones disappear before high-brightness areas. With a more sawtooth-shaped erase pulse (see Fig. 7), the less-negative, high-brightness areas are discharged for a longer period of time during each pulse. With proper selection of pulse shape, it is then possible to preserve low-brightness detail during the entire erase cycle.

With this tube, the amplitude of the erase pulse is not ordinarily varied to change the rate of erasure. For optimum rendition of half-tones, the proper erase-pulse amplitude is that which allows the storage surface to be charged to exact cut-off potential by the erasing operation. If the erase-pulse amplitude is less than the optimum value, all portions of the storage surface will not return to cut-off voltage after removal of the erase pulse, and complete erasure is not possible. If the erase-pulse amplitude is greater than the optimum value, the storage surface might return to a value which is more negative than cut-off voltage ("blacker than black") when erase-pulse operation is terminated. The latter condition would adversely affect the quality of subsequent writing operations.

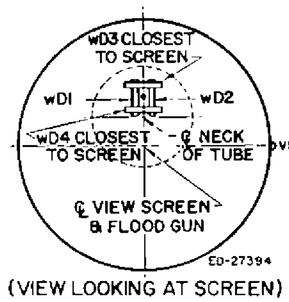


Figure 9 — Deflection Plate Orientation

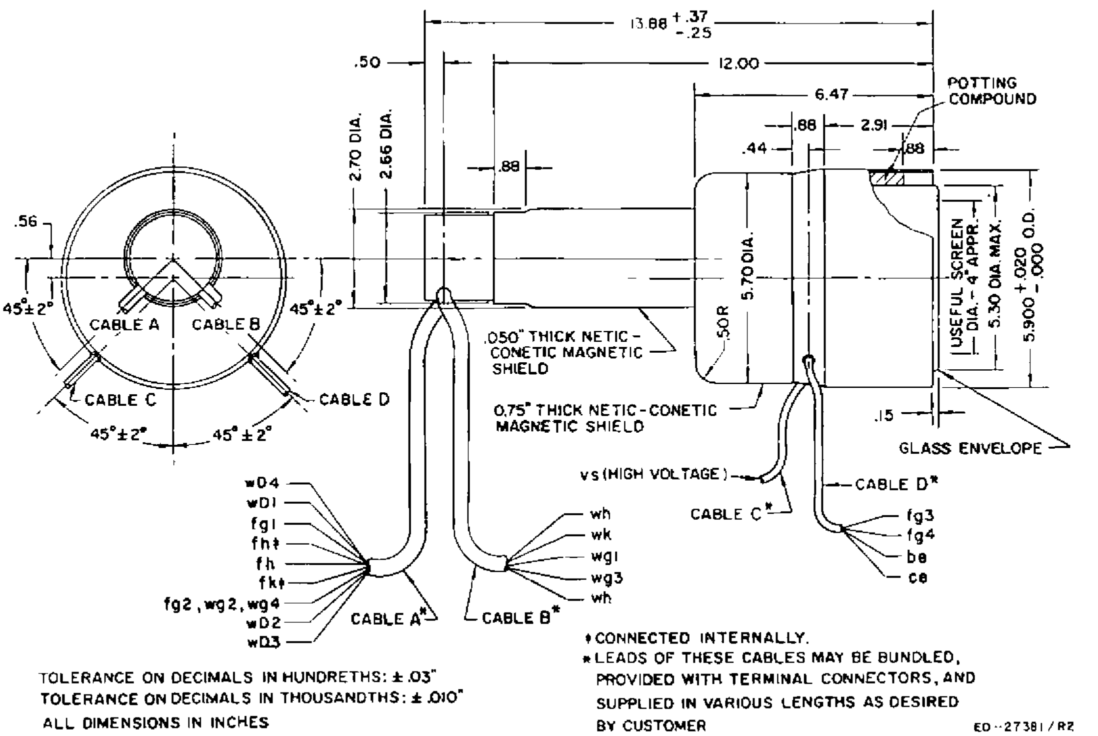


Figure 8 — Dimensions — ML-8130

PERFORMANCE

Values given are for typical tube unless otherwise specified.

Writing Speed, *minimum* (10 μA beam current)	300,000	in/sec
Light Output (vs voltage = 10 kV), *minimum*	1700	ftL
Written Resolution (10 μA beam current)	60	lines/in
Erase Time (single-pulse erasure)	50 to 250	ms
Half Tones, *minimum*	5	
Deflection Factor Uniformity	4	%

GENERAL CHARACTERISTICS

Optical

Phosphor Type (See Fig. 1)	P-20 Aluminized
Fluorescence	Green-Yellow
Phosphorescence	Green-Yellow
Faceplate	Flat, optical-quality glass

Mechanical

Overall Length	13⅞	in
Maximum Diameter	5 15/16	in
Useful Screen Diameter, *minimum*	4	in
Base (encapsulated)	See Fig. 8	
Mounting Position	Any	
Weight Less Leads, approximate	5¾	lbs

Electrical

Heater Characteristics, Flood or Write Gun:		
Heater Voltage, AC or DC	6.3 ± 10%	V
Heater Current Per Gun at 6.3 Volts	0.6 ± 10%	A
Focusing Method, Write Gun	Electrostatic	
Deflection Method, Write Gun	Electrostatic	
Deflection Orientation	See Fig. 9	
Deflection Factors:		
wD1, wD2	25 to 40	V/in/kV
wD3, wD4	25 to 40	V/in/kV
Direct Interelectrode Capacitances, approx.:		
wk to all other electrodes	10	pf
wg1 to all other electrodes	14	pf
wD1 to wD2	6	pf
wD3 to wD4	16	pf
wD1 to all other electrodes	13	pf
wD2 to all other electrodes	12	pf
wD3 to all other electrodes	13	pf
wD4 to all other electrodes	13	pf

RATINGS

Ratings given are absolute maximum values unless otherwise specified. All voltages are referenced to fk unless otherwise specified.

General

Altitude	70000	ft
Pressure, absolute	45	psi
Ambient Temperature:		
Minimum	−55	°C
Maximum	+85	°C

Viewing Section

fh Peak Voltage:		
fh negative	180	v
fh positive	180	v
fk Voltage	0	v
fg1 Voltages:		
Negative bias	125	Vdc
Positive bias	0	Vdc
Positive peak	0	v
fg1 Circuit Resistance	1.0	Meg
fg2 Voltage	150	Vdc
fg3 Voltage	200	Vdc
fg4 Voltage	300	Vdc
fg4 Circuit Resistance, *minimum*	1000	ohms
ce Voltage	300	Vdc
ce Circuit Resistance, *minimum*	1000	ohms
be Voltage	200	Vdc
be Circuit Resistance	5000	ohms
vs Voltage	11000	Vdc
vs Dissipation	10	W
vs Circuit Resistance, *minimum*	1.0	Meg

Writing Section

wh Peak Voltage:		
wh negative †	180	v
wh positive †	180	v
wk Voltage	−3000	Vdc
wg1 Voltages:		
Negative bias †	125	Vdc
Positive bias †	0	Vdc
Positive peak †	2	v
wg1 Circuit Resistance	1.0	Meg
wg2 Voltage	150	Vdc
wg3 Voltage	−2500	Vdc
wg4 Voltage	150	Vdc

TYPICAL OPERATING CONDITIONS

All voltages are referenced to fk unless otherwise specified.

Viewing Section

fk Voltage	0	Vdc
fg1 Bias Voltage	0 to −50	Vdc
fg2 Voltage	100	Vdc
fg3 Voltage	15 to 40	Vdc
fg4 Voltage	25 to 50	Vdc
ce Voltage	120	Vdc
be Voltage	2	Vdc
vs Voltage	9000	Vdc

Writing Section

wk Voltage	−2000	Vdc
wg1 Bias Voltage †	−30 to −60	Vdc
wg2 Voltage	100	Vdc
wg3 Voltage †	280 to 660	Vdc
wg4 Voltage	100	Vdc

†Voltages referenced to wk.

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