INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with rectangular 13 cm diagonal flat face and metal-backed screen, provided with internal graticule. The high sensitivities of this mesh tube, together with the sectioned y-deflection plates, render the tube suitable for transistorized oscilloscopes for frequencies up to 100-250 MHz.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g9(\ell)}$	15	kV
Display area		100 x 60	mm^2
Deflection coefficient, horizontal	M_x	9,9	V/cm
vertical	M_y	3	V/cm

SCREEN

	colour	persistence
D13-451GH/45	green	medium short

Useful screen area	min.	100 x 60	mm^2
Useful scan at $V_{g9(\ell)}/V_{g4}$ = 10,			
horizontal	min.	100	mm
vertical	min.	60	mm
Spot eccentricity in horizontal direction		± 8	mm
Spot eccentricity in vertical direction		± 6	mm

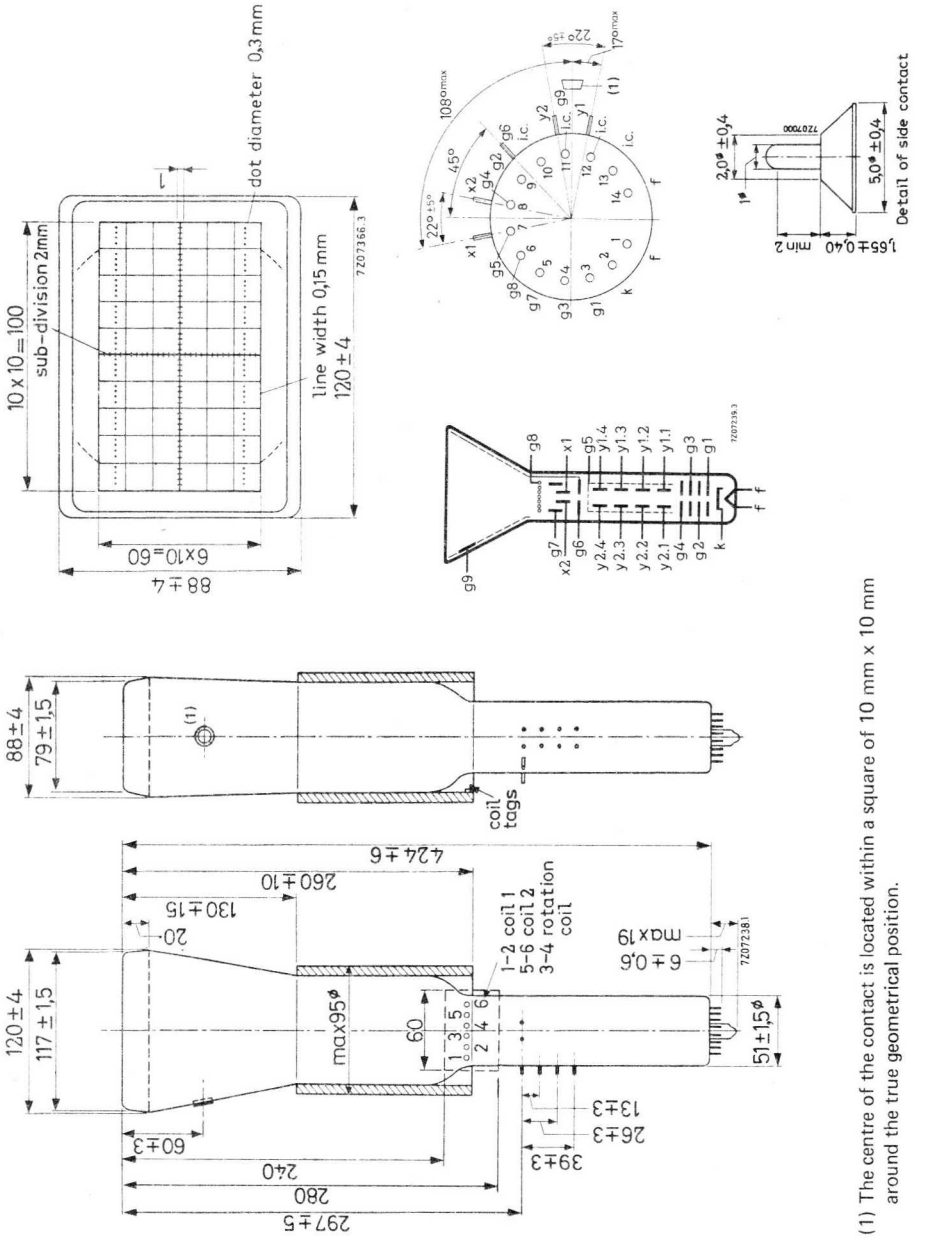
The scanned raster can be shifted in vertical direction and aligned with the internal graticule by means of correction coils mounted on the tube (see page 6).
For illumination of the internal graticule see page 8.

HEATING : indirect by a.c. or d.c. ; parallel supply

Heater voltage	V_f	6,3	V
Heater current	I_f	300	mA

MECHANICAL DATA

Dimensions in mm



(1) The centre of the contact is located within a square of 10 mm x 10 mm around the true geometrical position.

MECHANICAL DATA (continued)

Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length (socket inclusive)	max.	449	mm
Face dimensions	max. 124 x	92	mm^2
Net weight	approx.	1100	g
Base	14-pin all glass		
Accessories			
Socket	type 55566		
Final accelerator contact connector	type 55563A		
Side-contact connector	type 55561		
Mu-metal screen	type 55568		

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	4,8	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	4,8	pF
$y_{1.1}$ to all other elements except $y_{2.1}$	$C_{y_{1.1}(y_{2.1})}$	1,2	pF
x_1 to x_2	$C_{x_1x_2}$	2,5	pF
$y_{1.1}$ to $y_{2.1}$	$C_{y_{1.1}y_{2.1}}$	0,8	pF
Control grid to all other elements	C_{g_1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING	electrostatic
DEFLECTION	double electrostatic
x plates	symmetrical
y plates	symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces 90° (see "Correction Coils")

LINE WIDTH

Measured with the shinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current I_ℓ = 10 μA

Line width	l.w.	0,40	mm

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g9(\ell)}$	15	kV
Post deflection shield voltage (mesh) w.r.t. V_{g7}	$V_{g8/g7}$	-12 to -18	V
Geometry control electrode voltage	V_{g7}	1500 ± 70	V [1]
Interplate shield voltage	V_{g6}	1500	V [2]
Deflection plate shield voltage	V_{g5}	1500	V [2]
Astigmatism control electrode voltage	V_{g4}	1500 ± 50	V [3]
Focusing electrode voltage	V_{g3}	400 to 550	V
First accelerator voltage	V_{g2}	1500	V
Control grid voltage for visual extinction of focused raster	V_{g1}	-40 to -100	V
Deflection coefficient, horizontal	M_x	9,9	V/cm
		max. 11	V/cm
vertical	M_y	3	V/cm
		max. 3,3	V/cm
Deviation of linearity of deflection		max. 2	% [4]
Geometry distortion		see note 5	
Useful scan, horizontal		100	mm
vertical		60	mm

1) This tube is designed for optimum performance when operating at the ratio $V_{g9(\ell)}/V_{g4}$ = 10. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The asigmatism control electrode voltage should be adjusted for optimum spot shape. for any necessary adjustment its potential will be within the stated range.

4) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25 % of the useful scan by more than the indicated value.

5) A graticule, consisting of concentric rectangles of 100 mm x 60 mm and 98 mm x 58,2 mm is aligned with the electrical x axis of the tube.
With optimum correction potentials applied the edges of a raster will fall between these rectangles.

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g9(\ell)}$	max.	16,5	kV
		min.	9	kV
Post deflection shield voltage	V_{g8}	max.	2400	V
Geometry control electrode voltage	V_{g7}	max.	2400	V
Interplate shield voltage	V_{g6}	max.	2400	V
		min.	1350	V
Deflection plate shield voltage	V_{g5}	max.	2400	V
Astigmatism control electrode voltage	V_{g4}	max.	2400	V
		min.	1350	V
Focusing electrode voltage	V_{g3}	max.	2400	V
First accelerator voltage	V_{g2}	max.	1800	V
		min.	1350	V
Control grid voltage,				
negative	$-V_{g1}$	max.	200	V
positive	V_{g1}	max.	0	V
Cathode to heater voltage,				
cathode positive	V_{kf}	max.	200	V
cathode negative	$-V_{kf}$	max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	max.	500	V
	$V_{g4/y}$	max.	500	V
Screen dissipation	W_ℓ	max.	8	mW/cm^2
Ratio $V_{g9(\ell)}/V_{g4}$	$V_{g9(\ell)}/V_{g4}$	max.	10	
Average cathode current	I_k	max.	300	μA

CORRECTION COILS

The D13-451../45 is provided with a coil unit consisting of:

1. a pair of coils for
   a. correction of the orthogonality of the x and y traces (which means that the angle between the x and y traces at the centre of the screen can be made exactly 90^{o}).
   b. vertical shift of the scanned area.
2. a single coil for image rotation (aligning the x trace with the x lines of the graticule).

Orthogonality and shift

The currents required under typical operating conditions are max. 4 mA per degree of angle correction and max. 2 mA per millimeter of shift; the maximum required current for both puposes taken together does not exceed 18 mA.
These values apply to a tube operating with a mu-metal shield closely surrounding the coils.
If no such shield is used they have to be multiplied by a factor K(1<K<2) the value of which depends on the dimensions of the shield and approaches 2 for the case no shield is present.
The d.c. resistance of the coil is approx. 220 Ω.

Image rotation

The image rotation coil is concentrically wound. Under typical operating conditions a current of max. 45 mA will be required for complete correction. The d.c. resistance of this coil is approx. 550 Ω.

Circuit diagrams

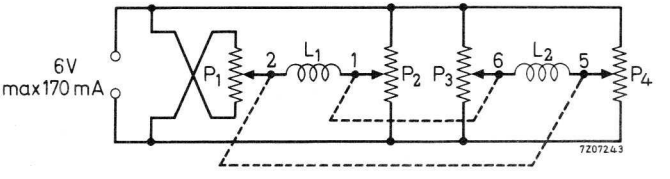


Fig. 1

P_1, P_2 potentiometers 220 Ω, 1 watt; ganged
P_2, P_3 potentiometers 220 Ω, 1 watt; ganged

With the above circuit almost independent control for shift and angle correction is achieved. This facilitates the correct adjustment to a great extent. The dissipation of the potentiometers can be reduced considerably if the requirement of independent controls is dropped (see Fig. 2).

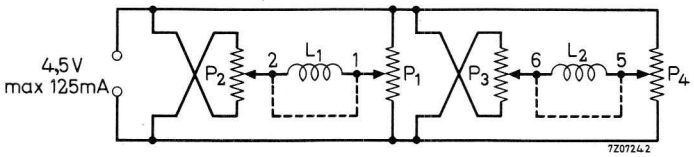


Fig. 2

P_1, P_2 potentiometers 220 Ω, 1 watt; ganged
P_3, P_4 potentiometers 220 Ω, 1 watt; ganged

A further reduction of dissipation can be obtained by providing a commutator for each coil (see circuit Fig. 3).
The procedure of adjustment will then become more complicated but it should be kept in mind that a readjustment is necessary only when the tube has to be replaced.

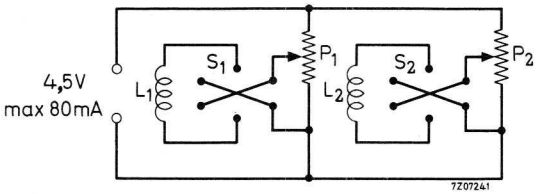


Fig. 3

P_1, P_2 potentiometers 220 Ω, 1 watt
S_1, S_2 commutators

A suitable circuit for the image rotating coil is given in Fig. 4.

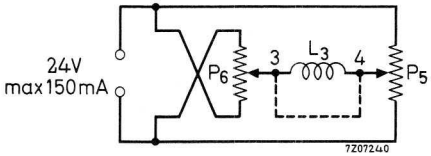


Fig. 4

P_5, P_6 potentiometers 500 Ω, 3 watt; ganged

The following prodedure of adjustment is recommended:

a. Align the x trace with the graticule by means of the image rotating coil.

b. With the tube fully scanned in the vertical direction, the image has to be shifted so that the graticule is fully covered. With the circuit according to Fig. 1 this is done by means of the ganged potentiometers P_1 and P_4.

c. Adjustment of orthogonality by means of the ganged potentiometers P_2 and P_3. A A slight readjustment of P_1 and P_4 may be necessary afterwards.

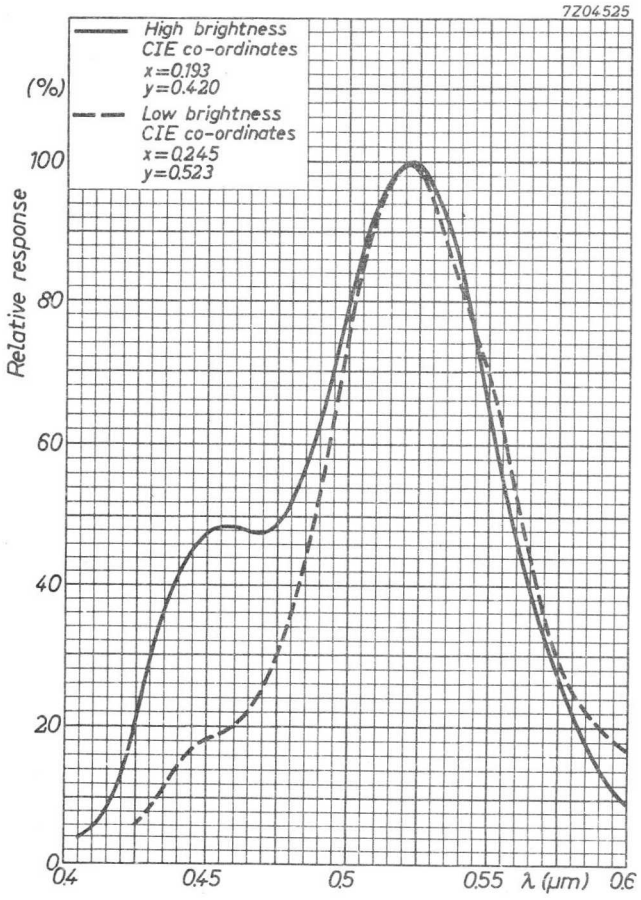
d. Readjustment of the image rotation if necessary.

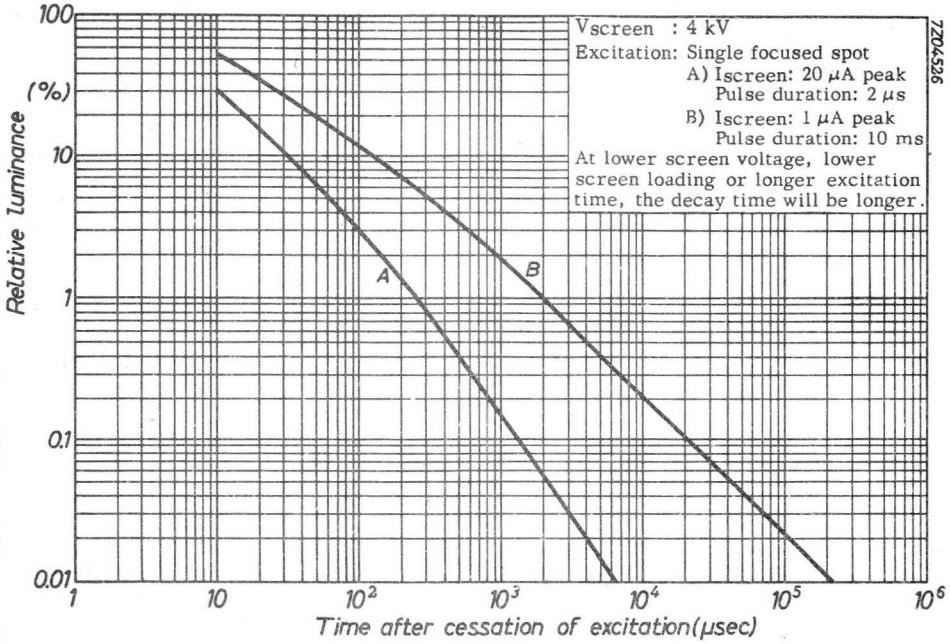
With a circuit according to Fig. 2 or 3 these corrections have to be performed by means of successive adjustments of the currents in the coils.

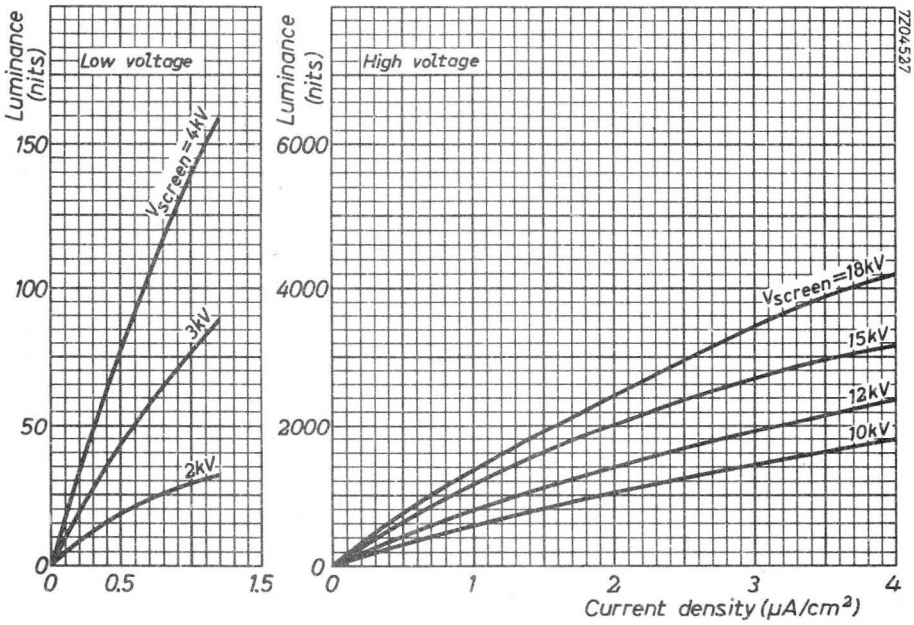
The most convenient deflection signal is a square wave form permitting an easy and fairly accurate visual check of orthogonality.

ILLUMINATION OF THE GRATICULE

To illuminate the internal graticule a light conductor (e. g. of perspex) should be used. In order to achieve the most efficient light conductance, the holes for the lamps and the edge adjacent to the tube should be polished, and the distance between the perspex plate and the tube should be as small as possible. It is advisable to apply reflective material to the outer circumference and, if possible, also to the upper and lower faces of the light conductor. The thickness of the conductor should not exceed 3 mm, and its position relative to the faceplate of the tube should be adjusted for optimum illumination of the graticule lines.


7Z04525
High brightness
CIE co-ordinates
x=0.193
y=0.420
Low brightness
CIE co-ordinates
x=0.245
y=0.523
(%)
100
80
60
40
20
0
Relative response
0.4
0.45
0.5
0.55
λ (μm)
0.6


Vscreen : 4 kV
Excitation: Single focused spot
A) Iscreen: 20 μA peak
Pulse duration: 2 μs
B) Iscreen: 1 μA peak
Pulse duration: 10 ms
At lower screen voltage, lower screen loading or longer excitation time, the decay time will be longer.
7204526
Relative luminance
(%)
100
10
1
0.1
0.01
A
B
1
10
10²
10³
10⁴
10⁵
10⁶
Time after cessation of excitation (μsec)


7204527
Low voltage
Luminance (nits)
150
100
50
0
Vscreen=4kV
3kV
2kV
0
0.5
1.5
High voltage
Luminance (nits)
6000
4000
2000
0
Vscreen=18kV
15kV
12kV
10kV
0
1
2
3
4
Current density (μA/cm²)