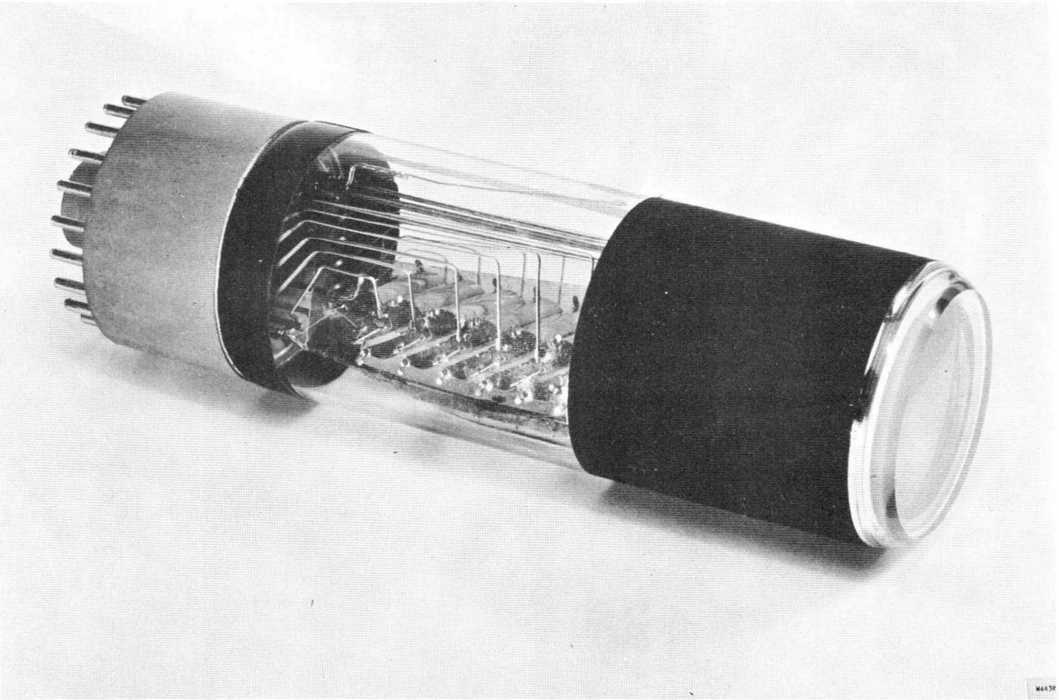
PHILIPS

56 AVP
56 UVP

PHOTOMULTIPLIER



The 56 AVP is 14-stage, very fast, high-gain photomultiplier tube, provided with a caesium-antimony, semi-transparent curved cathode having a diameter of 42 mm. The plane-concave poly-optical window simplifies and improves the optical coupling of scintillator to photocathode. The highly sensitive uniform photocathode has a typical sensitivity of 60 μA/lm and a spectral response that lies mainly in the visible region, with its maximum at 4200 Å, as shown in Fig.1, curve *A*.

The 56 UVP is the same type of tube provided with a plane-concave quartz window which extends the spectral response into the ultra-violet range, as shown in Fig.1, curve *U*.

Both types are intended for use in nuclear physics applications where a high degree of time definition or a high time resolution is required (fast coincidences, life of unstable particles, Cerenkov counters).

The 56 AVP and the 56 UVP are capable of delivering pulses at the anode with a rise time of 2.10^{-9} sec, thanks to a well-designed electron-optical system, and with very high peak values (up to 1 A). The transit time difference between electrons emitted from the centre of the cathode and those emitted from the edge is less than 5.10^{-10} sec.

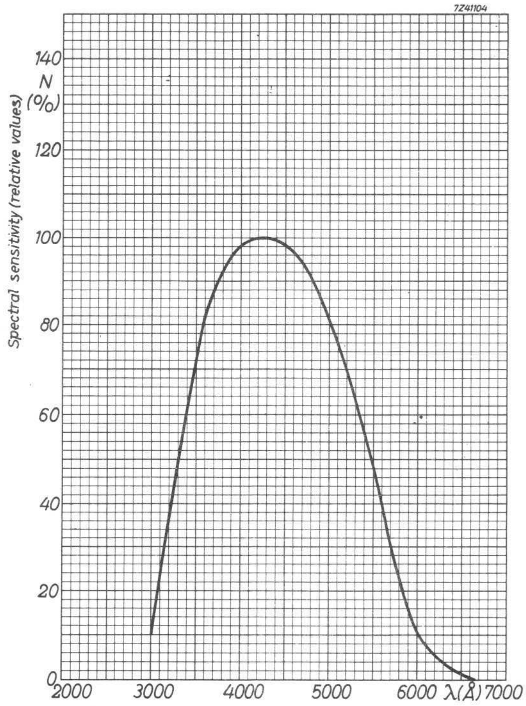


Fig. 1*a*. Spectral response "*A*".

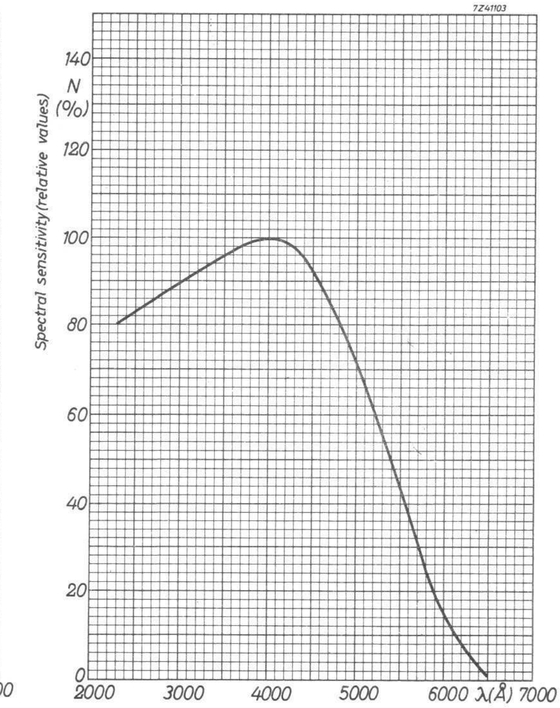


Fig. 1*b*. Spectral response "*U*".

PHOTOCATHODE

semi-transparent, head-on, curved surface

cathode material		*SbCs*
minimum useful diameter		42 mm
wavelength of maximum response		4200 ± 300 Å
luminous sensitivity[1])		
average		60 μA/lm
minimum		45 μA/lm
radiant sensitivity[2])		
average		50 mA/V
dark current	max.	$3.5 \cdot 10^{-15}$ A/cm^2

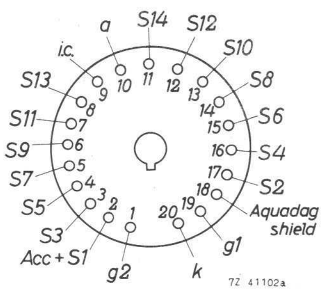
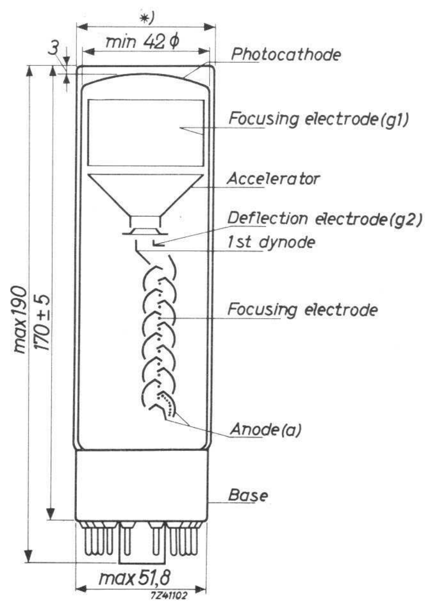


Fig. 2.

20-pin socket
type 40 466



*) 52.5 max. 56 AVP
53.5 max. 56 UVP

μ metal screening cylinder type 56 131; length 110 ± 1 mm; diam. 75^{+1}_{-0} mm.

For footnotes see page 3.

ELECTRON OPTICAL SYSTEM

triode type with high accelerating field
(for adjustment, see Operational Considerations)

MULTIPLIER SYSTEM

number of stages	14
dynode material	*AgMgOCs*
capacitance anode to final dynode	7 pF
capacitance anode to all other electrodes	9.5 pF
capacitance g_1 to accelerator and first dynode	25 pF
capacitance g_2 to all other electrodes	7 pF

TYPICAL CHARACTERISTICS (voltage divider type A)

gain at a total voltage of 2000 V	min.	10^8
anode dark current for a gain of 10^8	max.	5 μA
transit time fluctuation at 2000 V [3]		
anode pulse width at half-height		2.10^{-9} sec
anode pulse rise time		2.10^{-9} sec
transit time difference between the centre of the photocathode and the edge at 2000 V [4]	max.	5.10^{-10} sec
linearity between anode pulse amplitude and input light flux		
with voltage divider type *A*	up to	100 mA
with voltage divider type *B*	up to	300 mA
max. peak currents with voltage divider *B*		500 mA to 1 A

LIMITING VALUES

max. total voltage		2500 V
max. anode current at continuous operation (in order not to overload the tube)		2 mA
max. anode dissipation		1 W
voltage between dynodes	min.	80 V
	max.	500 V
voltage between last dynode and anode [1]	min.	80 V
	max.	500 V
voltage between cathode and g_1	max.	100 V
voltage between cathode and S_1	min.	250 V
	max.	800 V
voltage between g_2 and S_1	max.	100 V

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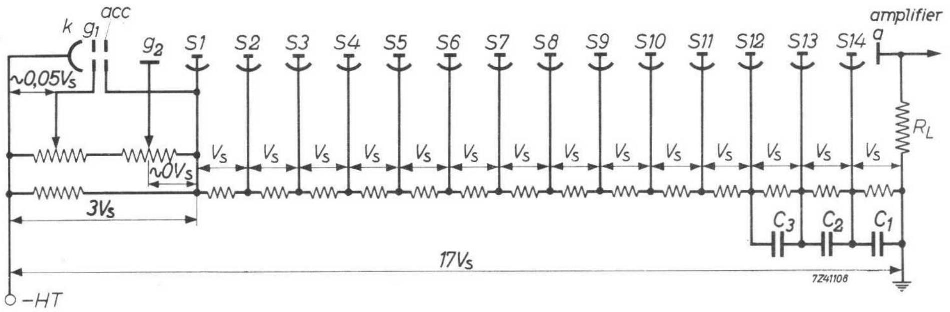
[1]) Measured with a tungsten ribbon lamp, having a colour temperature of 2850 °K.

[2]) At the maximum of the spectral response (4200 Å).

[3]) For an infinitely short light pulse.

[4]) In order to realize the smallest transit time differences, it is necessary to adjust the potential of g_1 such that the useful area of the photocathode only is actually used (see Operational Considerations).

OPERATING CHARACTERISTICS



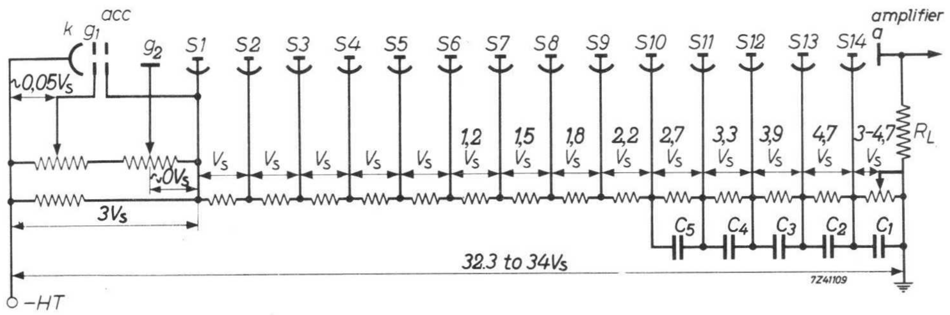
voltage divider type A[1])

- k = cathode
- g_1 = focusing electrode
- acc = accelerating electrode
- g_2 = deflector
- S_n = dynode nr. n
- a = anode

voltage between k and g_1 to be adjusted at about 0.05 V_s (see Fig. 5)

voltage between g_3 and S_1 to be adjusted at about 0 V_s (see Fig. 6)

decoupling capacitances $C_1 = 100q/V_s$, $C_2 = 100q/3V_s$, $C_3 = 100q/9V_s$, $C_4 = 100q/27V_s$ etc. with q = quantity of electricity transported by the anode.



voltage divider type B[1])

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be about 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode *acc*;
the deflector g_2.

[1]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling to a scintillator;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1. Fig.3 shows the electron path in the input system.

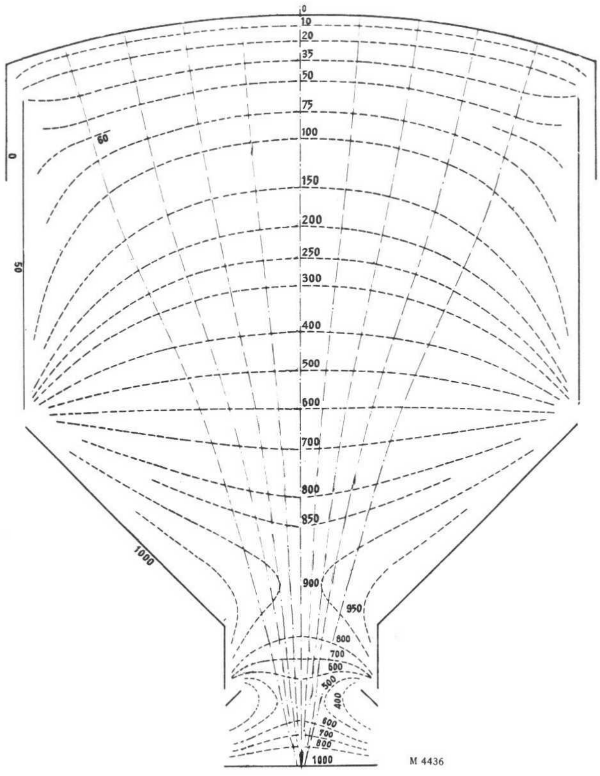


Fig. 3. Electron optical input system.

3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.4; the optimum value of the potential is about 0.05 V_S;

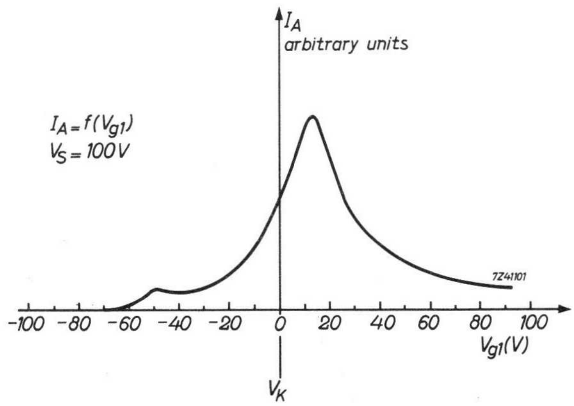


Fig. 4. Anode current variation with the adjustment of g_1.

b. the slightest transit-time fluctuations (the most homogeneous extraction field);

c. the most satisfactory uniformity of collection giving the most constant output pulse amplitude;

d. the useful cathode area can be controlled by giving the electrode g_1 a negative potential with respect to the photocathode, as shown in Fig.5*a*, *b* and c; obviously this variable electronic stop has the effect of reducing the dark current since the electrons emitted at the edge of the cathode do not reach the first dynode and consequently do not contribute to the anode current.

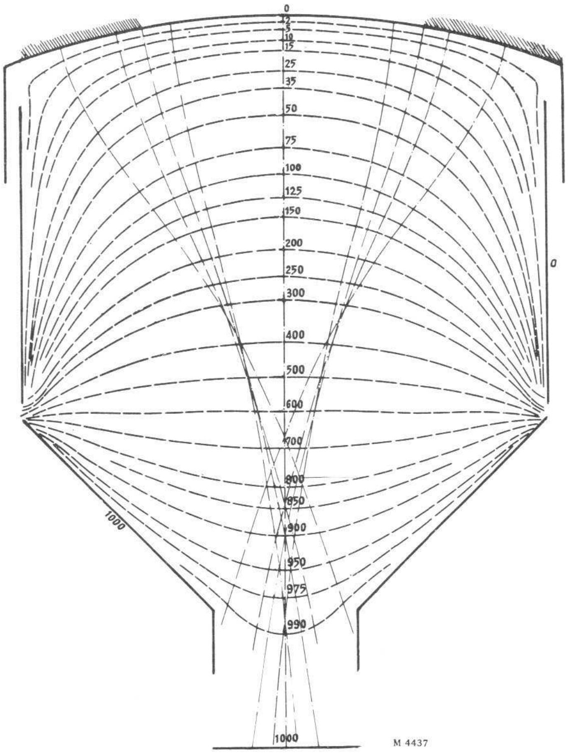


Fig. 5*a*.

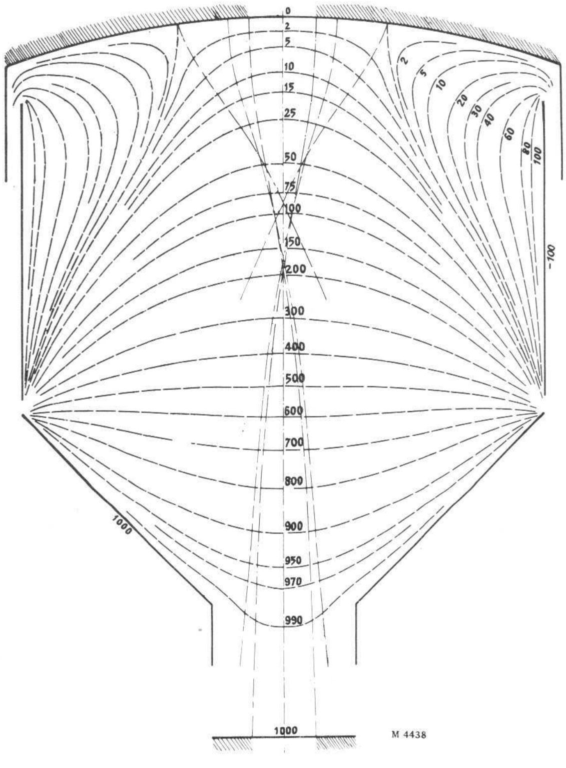


Fig. 5*b*.

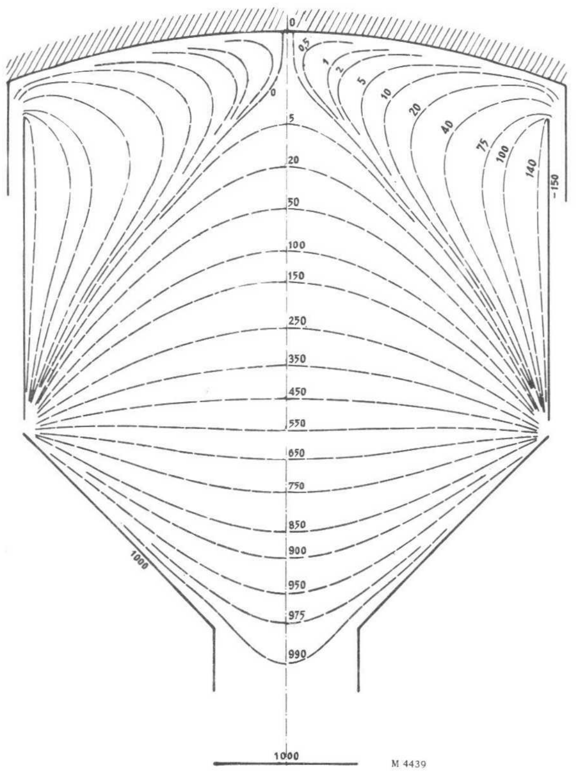


Fig.5c.

4. Because the first dynode cannot be placed parallel to the photocathode, the beam of primary electrons is deflected by the electrode g_2 to make it impinge at right angles to the first dynode surface. The deflector controls the point of impact on the first dynode and, since not the entire area of the dynode is active, the anode current is influenced by the potential of g_2. For adjustment see Fig.6.

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2000 V (see Fig.7).

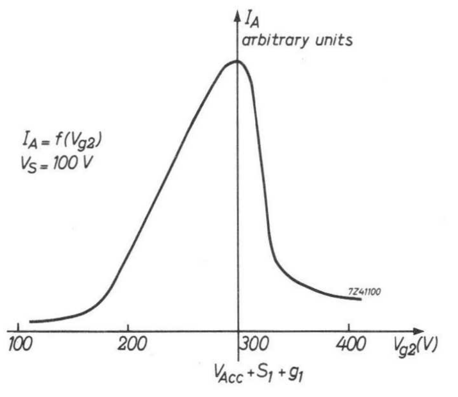


Fig. 6. Anode current variation with the adjustment of g_2.

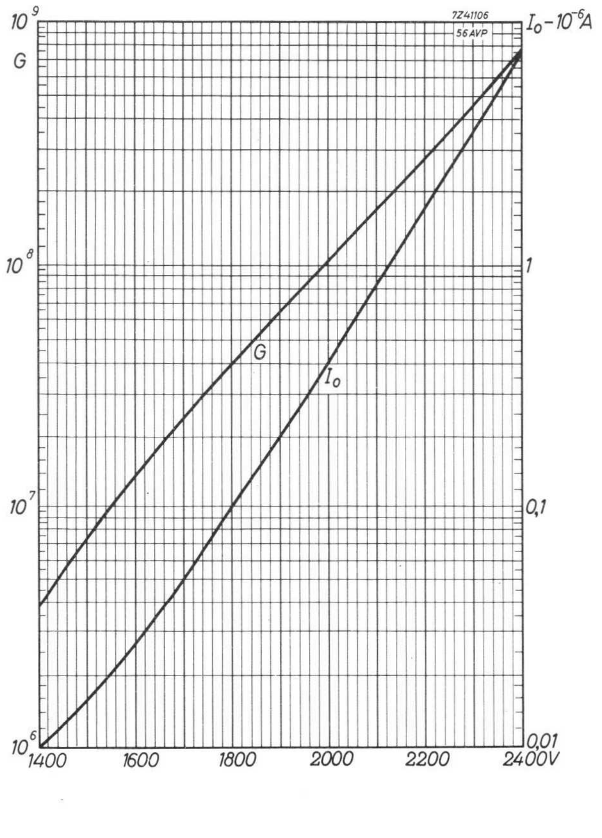


Fig.7. Gain (G) and dark current (I_a) as a function of the total voltage (voltage divider *A*).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

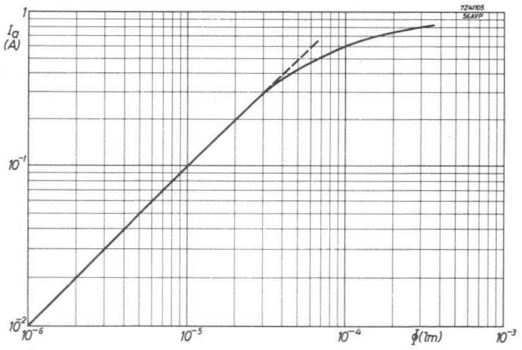


Fig.8. Linearity between anode pulse amplitude and input light flux (voltage divider *B*).

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact such short pulses are needed for time measurements only, so not for spectrography purposes. If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.8 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type *B*. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig. 9 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that for equal high tension the gain of the tube is smaller for voltage divider type *B* than for one according to type *A*. In practice, therefore, it will be preferable to use the *A* type distribution, or a distribution between *A* and *B* (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} and so on, maintaining the same progression.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

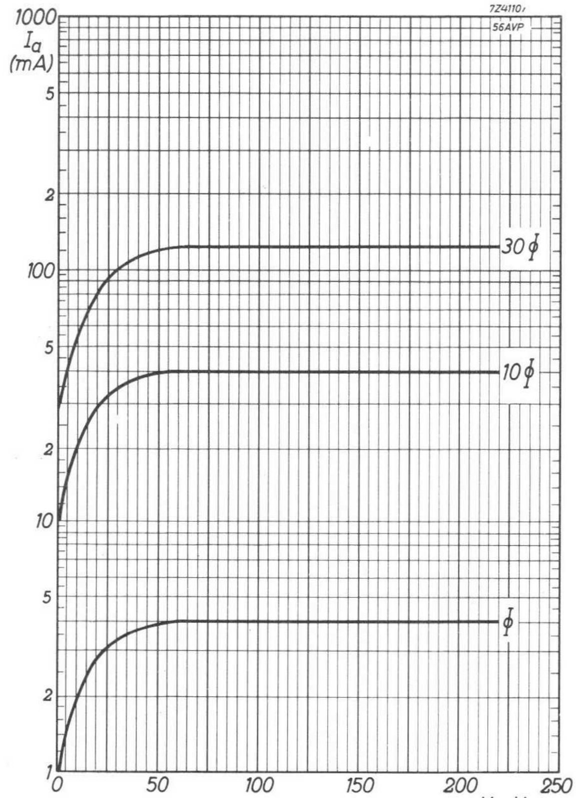


Fig.9. Anode current variation as a function of the voltage between last dynode and anode.

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