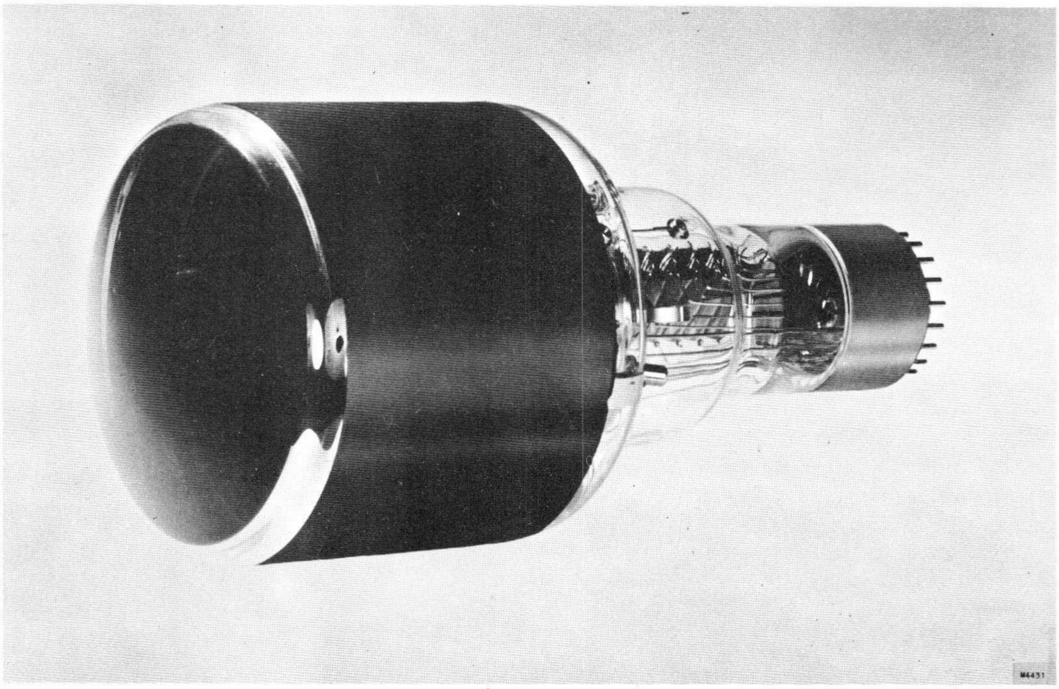
PHILIPS

58 AVP
XP 1040

PHOTOMULTIPLIER



The 58 AVP is a 14-stage, very fast, high-gain photomultiplier tube, provided with a caesium-antimony, semi-transparent curved cathode having a diameter of 110 mm. 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.

The tube is intended for use in nuclear physics applications where a high degree of time definition is required (fast coincidences, Cerenkov counters). The 58 AVP is capable of delivering pulses at the anode with a rise time of $2 \cdot 10^{-9}$ sec, thanks to a well-designed electron-optical system, and with very high peak-values (up to 1 A).

Notwithstanding the large cathode area, the transit-time difference between electrons emitted from the centre of the cathode and those emitted from the edges is approximately 10^{-9} sec.

The 58 AVP has a curved cathode and a curved outer window surface, a plan-concave plexiglass adapter is supplied with the tube.

The XP 1040 is completely equivalent to the 58 AVP, with the exception of the window which is plan concave itself.

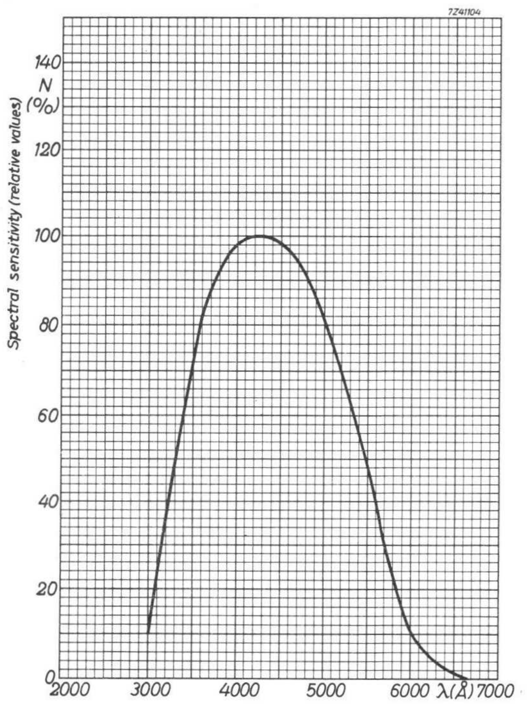
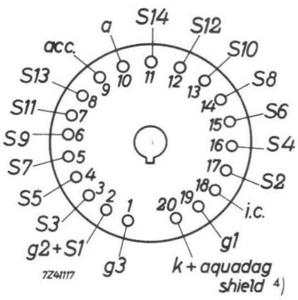


Fig. 1. Spectral response "A".

PHOTOCATHODE

semi-transparent, head-on, curved surface 1)	
cathode material	SbCs
minimum useful diameter	110 mm
wavelength of maximum response	4200 ± 300 Å
luminous sensitivity 2)	
average	60 μA/lm
minimum	45 μA/lm
radiant sensitivity 3)	
average	50 mA/W
dark current	max. 10^{-15} A/cm²



20-pin socket
type no. 40466

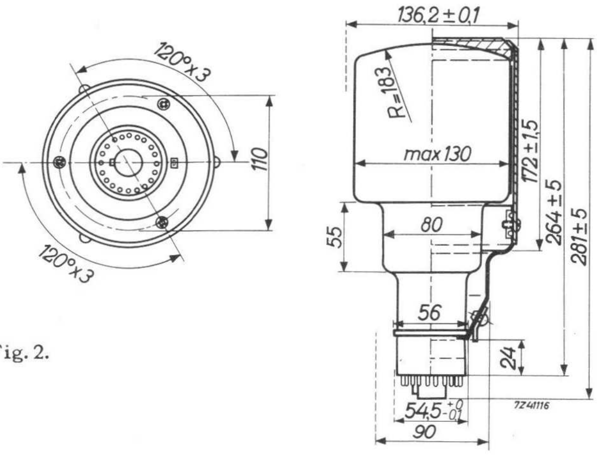


Fig. 2.

μ-metal screening cylinders			
	length (mm)	diam. (mm)	
type 56 129	150±1	132^{+1}_{-0}	tube without metal container
type 56 132	300±1	240^{+1}_{-0}	tube with metal container

For footnotes see page 3.

ELECTRON OPTICAL SYSTEM

tetrode type with high accelerating field[5)]

MULTIPLIER SYSTEM

number of stages	14
dynode material	Ag Mg OCs
capacitance anode to final dynode	7 pF
capacitance anode to all other electrodes	9.5 pF

TYPICAL CHARACTERISTICS (voltage divider type A)

gain at a total voltage of 3000 V[6)]	min.	10^8
anode dark current for a gain of 10^8	max.	10 μA
transit time fluctuation at 3000 V[7)]		
anode pulse width at half height		$2 \cdot 10^{-9}$ sec
anode pulse rise time		$2 \cdot 10^{-9}$ sec
transit-time difference between the centre of the photocathode and the edge at 3000 V		$\approx 10^{-9}$ 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		3500 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[8)]	min.	80 V
	max.	500 V
voltage between cathode and g_1	max.	300 V
voltage between cathode and *acc*	1400 – 1800 V	
voltage between cathode and $S_1 + g_2$	min.	250 V
	max.	800 V
voltage between g_3 and S_1	max.	100 V

---

1) The 58 AVP is delivered with a plexiglass plane-concave adapter and with a metal envelope, the XP 1040 has a plan-concave window itself.

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

3) At the maximum of the spectral response (4200 Å).

4) If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the metal envelope. In the near future the aquadag shield will be provided with an insulating layer.

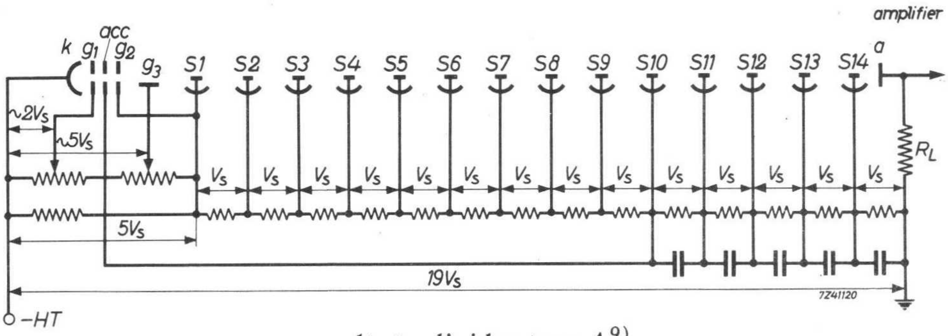
5) To avoid a high voltage on the first dynode the electron optical input system has been constructed as a tetrode. The first dynode voltage has a value of about 500 V while the high accelerating field is obtained by an electrode *acc*, which may have a potential equal to that of the tenth dynode or a subsequent dynode.

6) See Fig. 4.

7) For an infinitely short light pulse.

8) See Fig. 6.

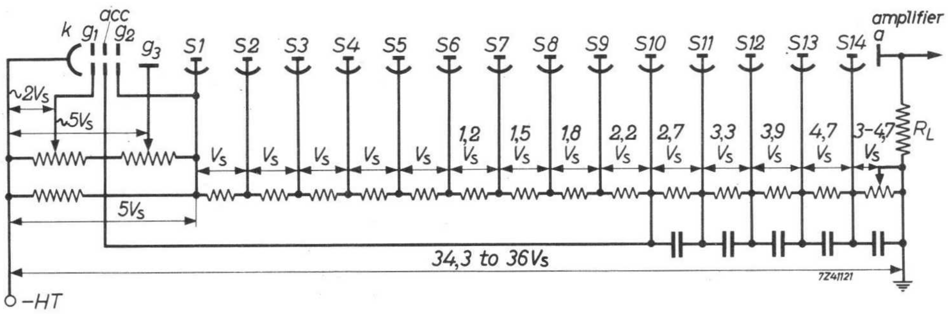
OPERATING CHARACTERISTICS



voltage divider type A[9)]

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
g_3 = deflector
S_n = dynode nr. n
a = anode

voltage between k and g_1 to be adjusted at about 2 V_s.
voltage between g_3 and S_1 to be adjusted at about 0 V_s
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[9)]

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 will be $2 \cdot 10^{-9}$ F.

In the case of high counting rates and large peak power outputs, 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 five elements:
the photocathode k
the focusing electrode g_1
the focusing electrode g_2
the accelerating electrode *acc*
the deflector g_3.

---

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

To reduce the transit-time fluctuations and geometrical time spread, this system has the following advantages.

1. The photocathode is curved, with a curvature radius of 183 mm. To facilitate optical coupling to scintillators the tube is delivered with a plexiglass plane-concave adapter.
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-accelerating voltage of about 1500 V (to be connected to the tenth or a subsequent dynode) 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.**

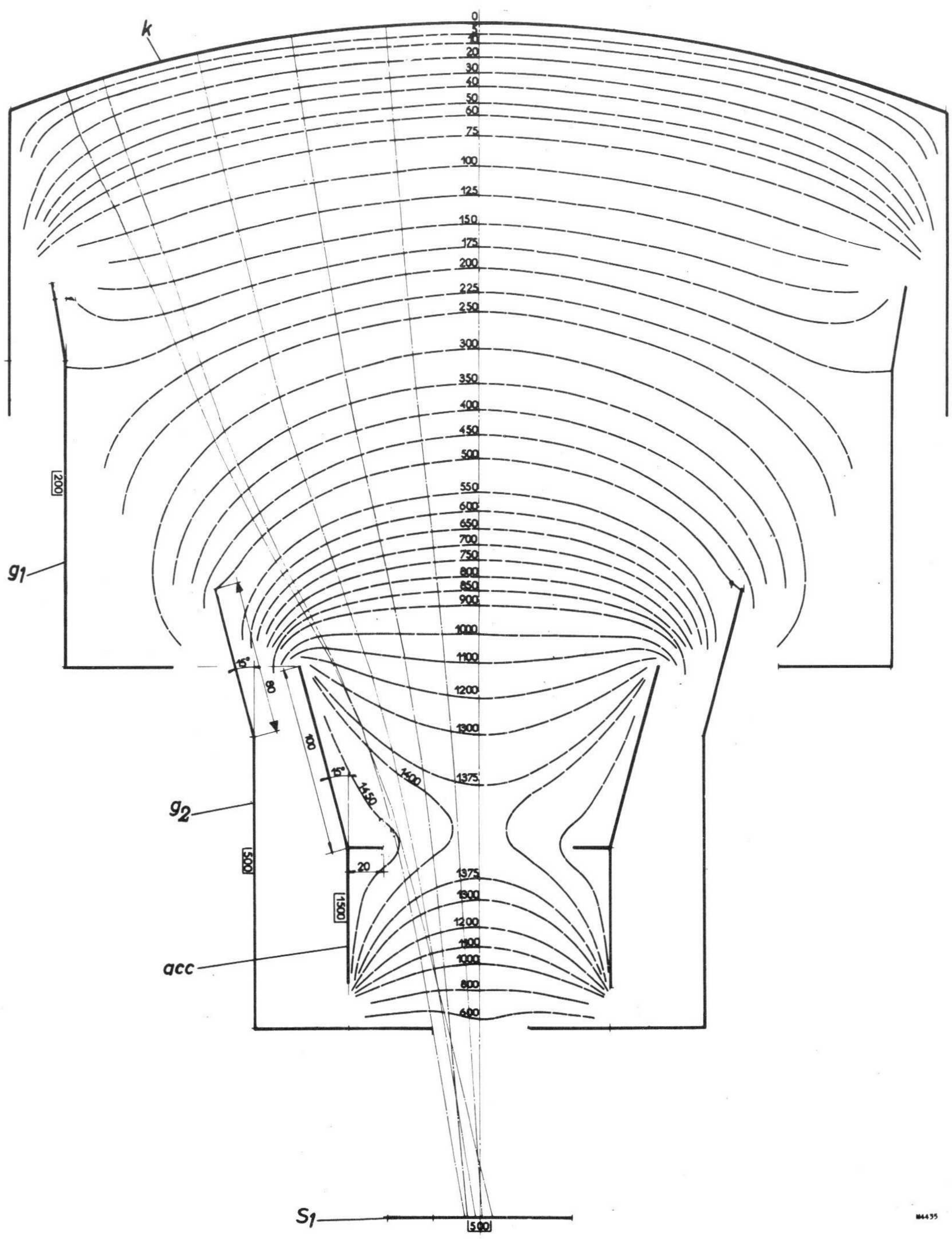


Fig. 3. Electron optical input system.

3. The potential of the 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); the optimum value of the potential is about 2 V_s.

(*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.

4. Because the first dynode cannot be placed parallel to the photocathode, the beam of primary electrons is deflected by the electrode g_3 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_3.

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2000 V (see Fig.4). 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.

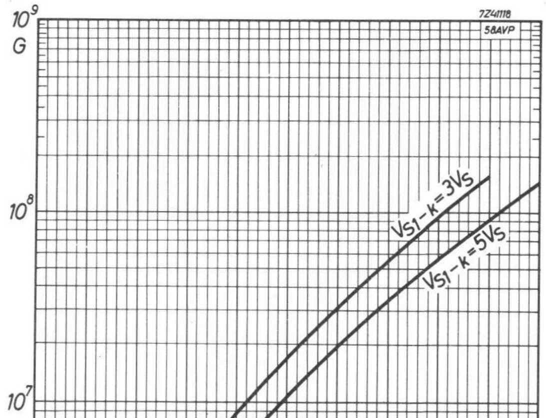


Fig.4. Gain as a function of the total voltage (voltage divider type *A*).

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 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.5 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.

Fig. 5. Linearity between anode pulse amplitude and input light flux (voltage divider type B).

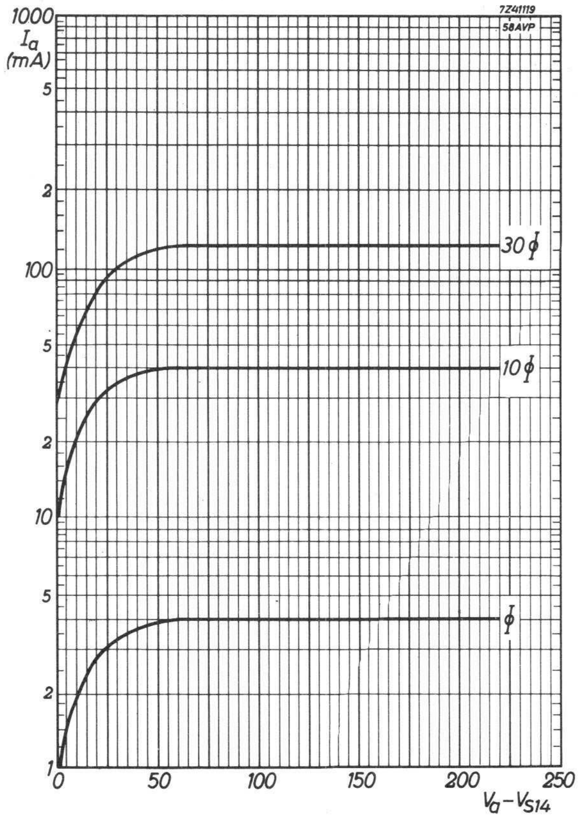


Fig. 6. Variation of the anode current as a function of the voltage between final dynode and anode.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig.6 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that for equal high tensions 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} etc., maintaining the same progression).

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