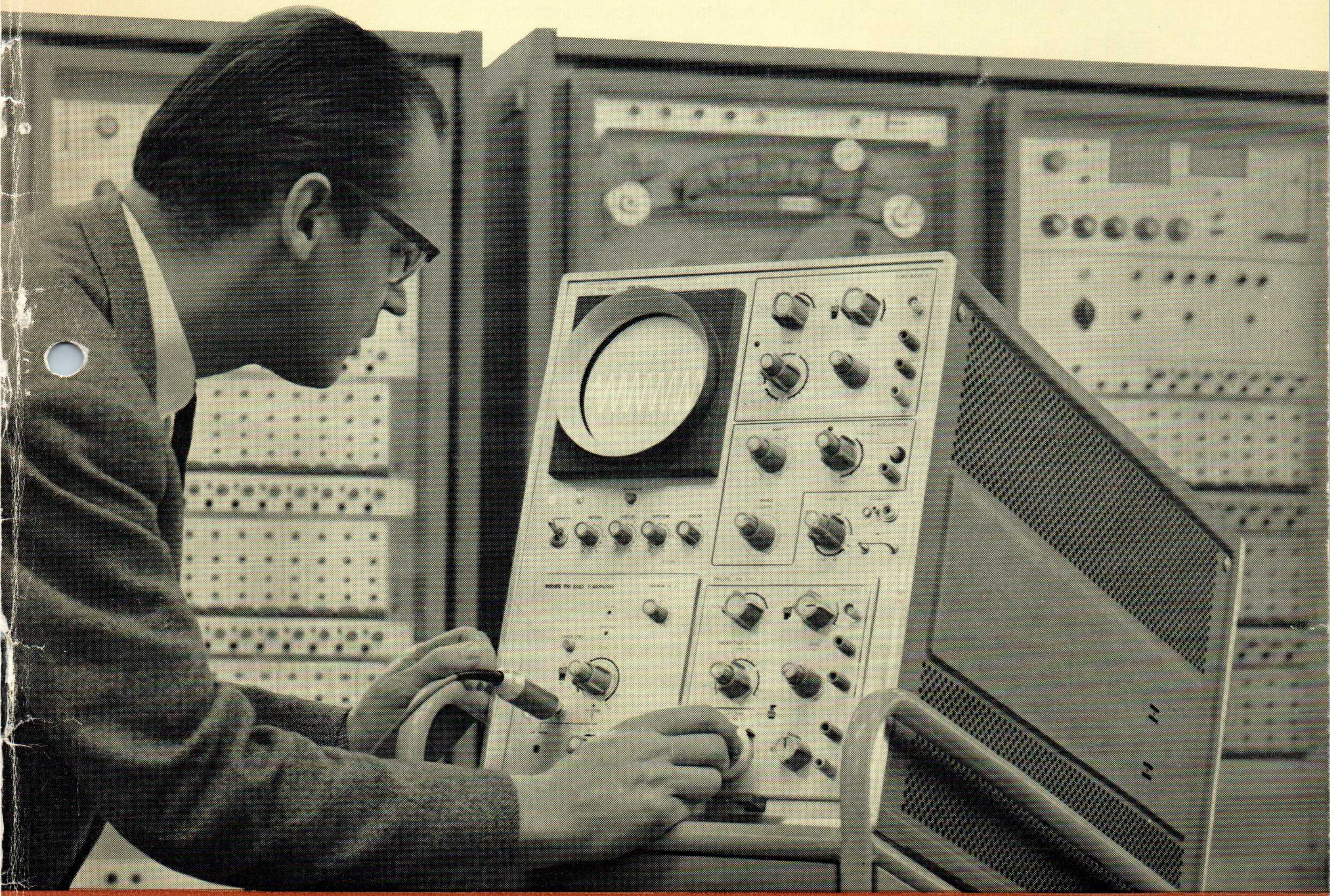
PHILIPS

electronic measuring and microwave notes



1966/3

published by n.v. Philips' Gloeilampenfabrieken / Eindhoven, the Netherlands

electronic measuring and microwave notes

Introduction The quarterly periodical Electronic Measuring and Microwave Notes, provides information about the application and design of Philips electronic measuring and microwave instruments and also surveys the new instruments which are regularly added to the Philips programme.
The information is intended to assist users in getting the maximum benefit out of instruments which they already possess and to help them in choosing new instruments which will best meet their particular measuring or microwave problems.

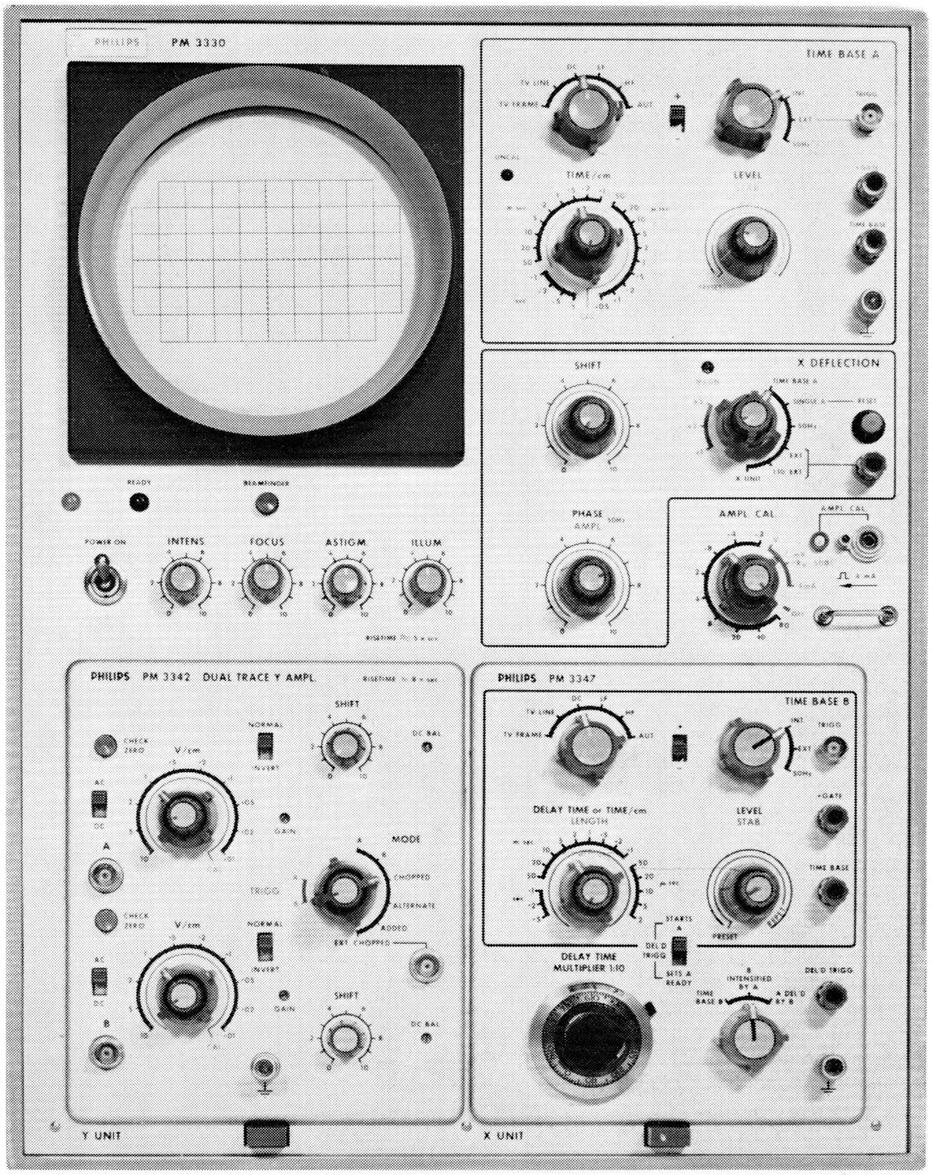
In this issue

General information If you are interested in regularly receiving the periodical Electronic Measuring and Microwave Notes and also in more information on the instruments please ask your Philips organisation. If there is no Philips organisation in your country enquiries may be sent to n.v. Philips, EMA Department, Eindhoven, the Netherlands.

Editor T. Sudar, n.v. Philips, EMA Department, Eindhoven.

The front cover of this issue illustrates the 60 MHz plug-in oscilloscope.

60 MHz plug-in oscilloscope with new measuring facilities



Acknowledgements
The editor wishes to acknowledge, with gratitude, the considerable assistance given to him by the following in the preparation of this publication:
F. Bregman, P. v. Ensbergen, H. Onstee, C. v.d. Oosten, J. Schuurman and all the autors of the articles written for this issue.

INTRODUCTION ON THE PM 3330

by J. Poole

Of all types of electronic measuring apparatus the oscilloscope has the most critically regarded specification and probably the one with the most variables. Of these the two things that users ask for most are more bandwidth and more sensitivity. Unfortunately these two, far from going hand in hand, are such that one can only be increased at the expense of the other. This is because an increase of either will increase the noise delivered by the amplifier. Thus a compromise has to be made leaving the user to choose between high sensitivity and wide bandwidth, when he would rather have both and will certainly need one at one time and the other at another. However in the PM 3330 steps have been taken to relieve the user of this difficult decision and these steps go even further, in that they open up new fields of measurement for him.
For example the PM 3332 plug-in unit with DC to 50 MHz bandwidth at 500 μV/cm sensitivity for the full bandwidth.

The PM 3330 is a plug-in 60 MHz oscilloscope. However the key to its wide range of measuring capabilities does not lie in a wide variety of plug-in units, but in the individual capabilities of each of them. This philosophy has been made possible by the development of special circuits for the plug-in amplifiers, which extend their measuring capacities to provide unusually large overlap.

Obviously the inclusion of these special circuits could not be allowed to jeopardize the reliability of the complete instrument. To this end each of the new circuits has been subjected to prolonged testing. As a further safeguard, wherever possibly, none of the components in either the classical or the newly development circuits, are run at more than 70% of their max. rating. Adequate temperature compensation has been incorporated throughout to ensure reliable and accurate operation regardless of changes in the ambient temperature over a wide range.

As an additional safeguard to the user, several of the first production instruments have been subjected to life tests under normal user conditions in the Philips concern; before any have been offered on the market.

It will be appreciated that, through this care for quality, every possible precaution has been taken to ensure that the instrument will not only meet its specification at the time of delivery but will continue to do so for many years to come.

Of course it is not enough when developing an oscilloscope for use in the laboratory simply to provide it with the best possible amplifiers. Thus to ensure that its amplifier capabilities are not wasted, the PM 3330 has been designed to give top class performance in all aspects of its specification. Furthermore the facilities incorporated in the instrument are sufficient to ensure that it is adequately equipped to carry out the most complicated measurements without the user having to resort to the use of external auxiliary units. Moreover the provision of the delaying time base as a plug-in unit; while the main time base is built-in, ensures that these comprehensive facilities are made available to the customer in the most economic way. Thus he needs not buy the delaying time base until it is needed, and when it is needed he only pays for the extra facility as the main time base remains part of the complete system. Furthermore there are 80 watts of power available for user built plug-ins in the 'X' aperture.

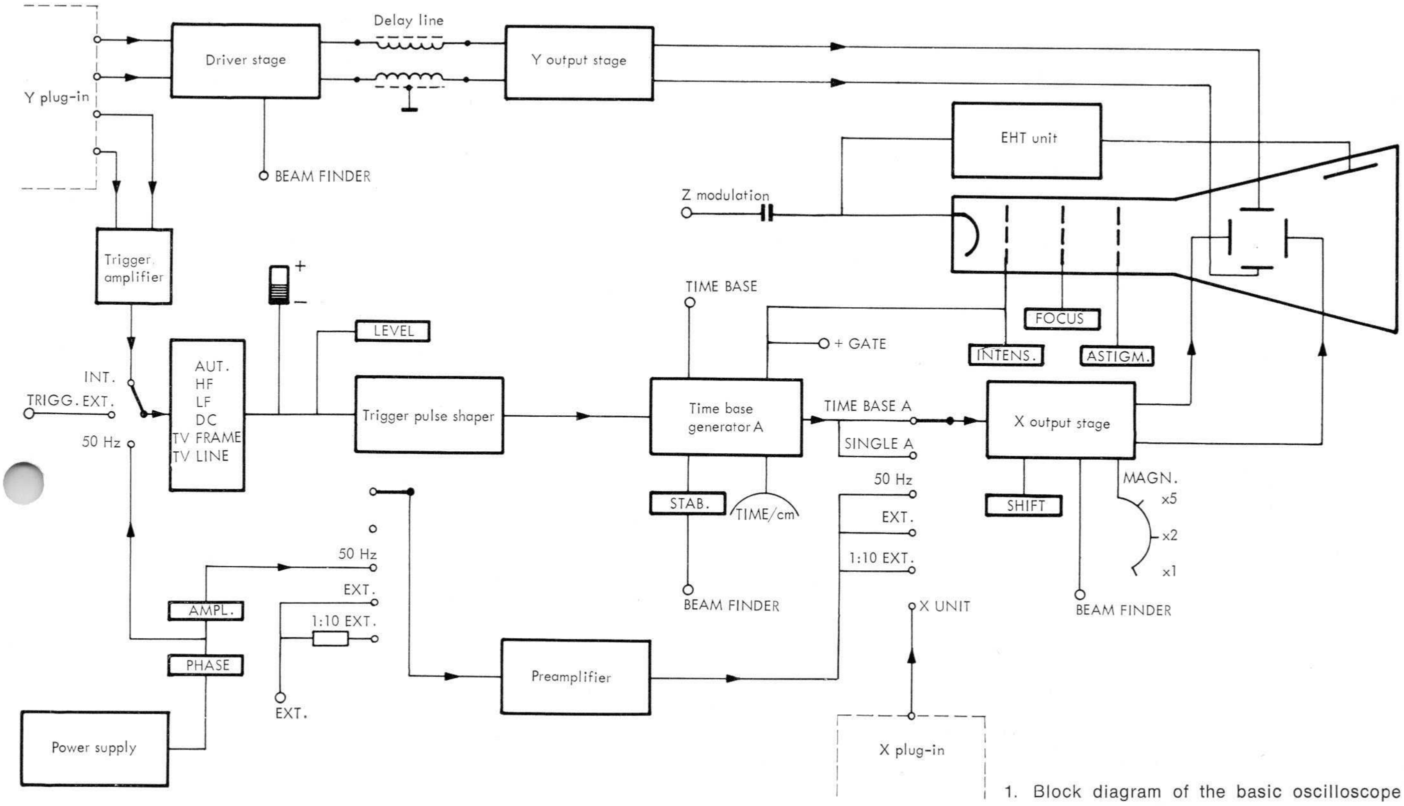
To further enhance the value of this instrument new developments have not been restricted to the plug-in amplifiers but have been spread throughout all the circuitry. These include such items as a complete overload and short circuit protection of the power unit and a specially developed cathode-ray tube which offers a 6 x 10 cm useful scan with a rise time of 5 ns using a conventional amplifier and without resorting to a mesh tube. Thus with 10 kV acceleration voltage a sharp, bright trace is obtained.

Tunnel diode triggering and careful circuit design have been made it possible to provide 60 nanoseconds of visible delay with only 150 nanoseconds of signal delay. In this way it is possible to study the start of pulses used to trigger the time base, including those with a poorly defined leading edge. Furthermore the maximum time base sweep speed of 10 nanoseconds per centimetre, using the 5 times expansion, makes the time base fully compatible with the amplifier rise time.

The vertical amplifier plug-in units offer some particularly interesting and valuable features, such as the special HF probe system, PM 9332, available with the wideband plug-in unit PM 3333. Though this is neither an attenuator nor a cathode follower probe, it offers the best features of both; wide bandwidth, high "tip sensitivity", small size, low capacitive loading and long lead. A second example is the high sensitivity, wide bandwidth, drift free plug-in unit PM 3332. This offers the sensitivity of a low frequency amplifier with true, DC coupled, wide bandwidth without drift and with low noise.

TECHNICAL DESCRIPTION OF THE MAIN FRAME PM 3330

by A. H. J. Sloots



1. Block diagram of the basic oscilloscope

The Philips cathode-ray oscilloscope PM 3330 is a 60 MHz instrument which has a wide range of applications. This is achieved by the utilization of plug-in units, each of which covers one or more fields of application. Plug-in units are available both for the Y and the X channels.

Fig. 1 shows the block diagram of the basic oscilloscope. The Y signal derived from a Y plug-in unit, is symmetrically fed to the „delay line driver". The delay line gives a total delay of about 150 nsec. The cable is terminated on both ends in order to minimize reflections. The signal is fed via the output stage to the Y deflection plates.

The trigger signal is taken-off separately at the Y plug connector and fed to the trigger circuit via a trigger preamplifier. As the trigger signal is thus isolated from the Y signal, triggering will not be affected by the switching frequency when a multi trace unit is used. Triggering can be effected internally, externally or with an internal 50 Hz source. The apparatus offers the following triggering facilities: Automatic, HF, LF, DC, TV frame and TV line.

A tunnel diode trigger pulse shaper is used to convert the trigger signal into pulses, thus ensuring stable triggering.

These trigger pulses start time base generator A. The time base works on the principle of the Miller integrator. An X deflection switch affords selection of the following display modes:

1. Time base A
2. Time base A, single-shot
3. 50 Hz (phase and amplitude adjustable)
4. External 1 : 1
5. External 1 : 10
6. X unit

In modes 3, 4 and 5 the signal passes through a preamplifier.

With the selector in the X unit position, the X plug-in unit is brought into use; for instance for a second time base for delayed triggering purposes, or a special X amplifier. The selected signal is then fed via the X output stage, to the X plates.

The X output stage incorporates the x1, x2 and x5 expansion circuit.

The basic oscilloscope is also fitted with a beam finder. By pressing the beam finder button the amplification factors of the Y and X amplifiers are reduced so that the electron beam is not deflected beyond the display area. At the same time the time base A is made free-running. It is then a simple matter to adjust the image to the centre of the screen by operating the shift controls.

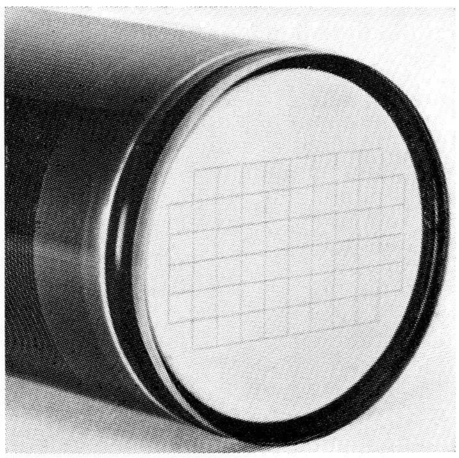
A few specific aspects will now be discussed in further detail.

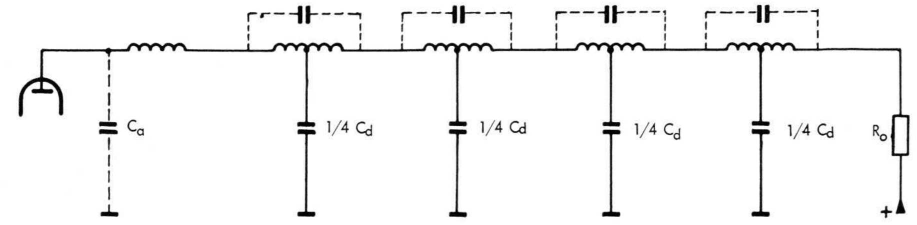
Cathode-ray tube

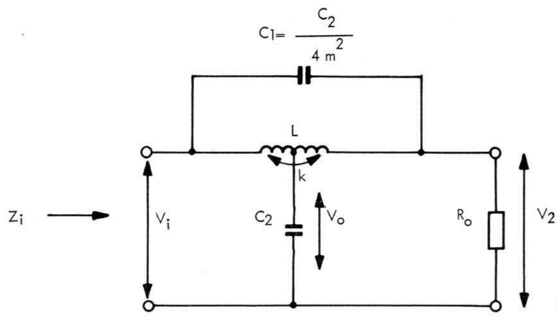
The type used is the Philips D13–16GH/1 (see fig. 2). The screen of the CRT incorporates a measuring graticule. This graticule is printed on the inner surface of the glass so that errors caused by parralex are obviated.

To ensure that the horizontal deflection of the spot coincides exactly with the internal graticule, a magnetic field is produced by a coil mounted inside the mu-metal magnetic screen surrounding the tube. The direction and intensity of the magnetic field are variable.

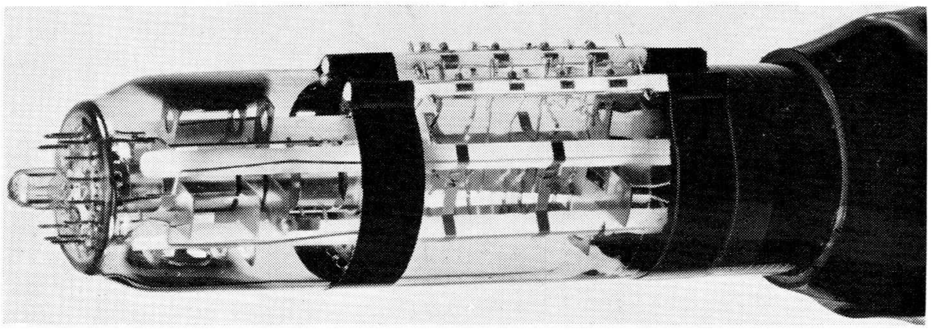
2. Internal graticule and helix of the cathode-ray tube







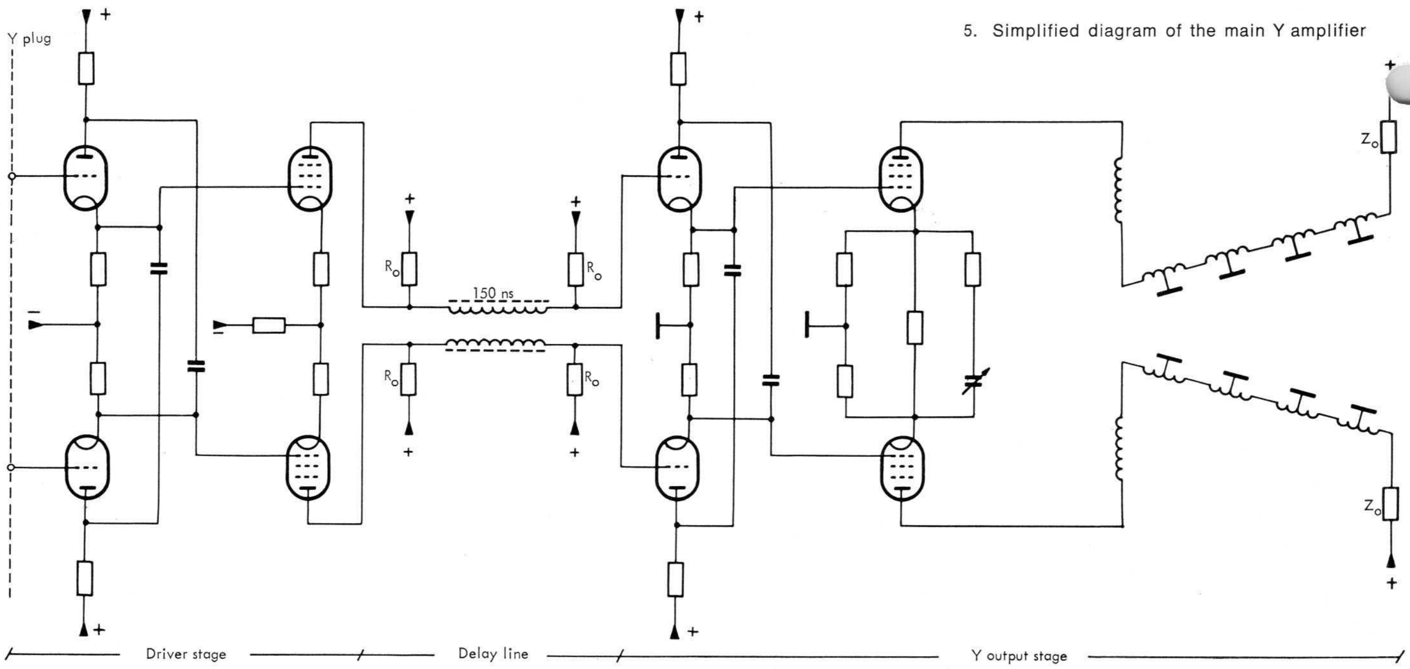
3. Deflection plates included in a filter



4. CRT with filter

A second coil system is attached to the neck of the CRT. Correct adjustment of the currents through these coils, will ensure that the X and Y deflection are exactly perpendicular and that the useful scan is central for uniform vertical overlap of the graticule. By employing a resistance helix it was possible to select an anode/ post acceleration voltage ratio of 1 : 6.
The useful display area of the CRT is 6 x 10 cm and the deflection coefficient in the Y direction is 6 Volt/cm. Unblanking pulses generated by the time base, during the sweep, are DC coupled to the grid of the CRT via a floating grid supply located in the EHT supply.
When a multi trace plug-in unit is used, the cathode is connected to a transistor amplifier. The latter receives blanking pulses from the unit. These pulses are generated during switch-over when operating in the chopped mode.
The intensity of the beam can be modulated by connecting the modulating signal to the cathode via the built in coupling capacitor.
In order to obtain a large bandwidth, the deflection plates are divided into four pairs, and each pair forms part of an "m"-derived bridged T network (see fig. 3).
The absolute transfer value of V_2/V_i, i.e. the amplitude frequency response of the filter between the output and input, will be unity if the filter is terminated with its characteristic impedance, i.e. $\sqrt{L_k/C_k}$ and

$$C_1 = \frac{C_2}{4m^2}, \text{ where } m = \sqrt{\frac{1+k}{1-k}}$$



5. Simplified diagram of the main Y amplifier

The input impedance Z_i then equals R_0 thus Z_i is independent of frequency.
The voltage transfer to the deflection plates V_0/V_i is expressed by the equation:

$$\frac{V_0}{V_i} = \frac{1}{1 - \omega^2 \frac{LC_2}{4\,m^2} + j\omega \frac{\sqrt{L\,C_2}}{2}}$$

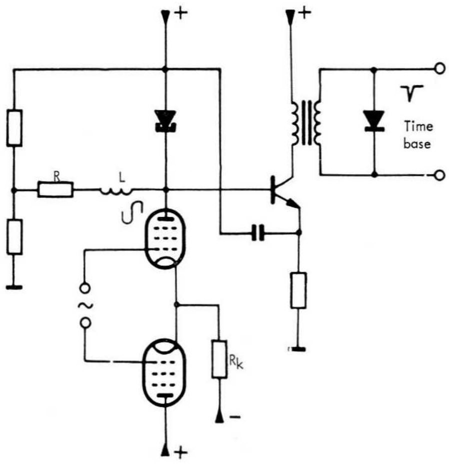
The output voltage V_0, for a unity step function V_i is:

$$V_0 = 1 - \frac{2}{\sqrt{4-m^2}} e^{-\frac{m^2}{R_0C_2}t} \times \sin\left(\frac{m}{R_0C_2} t \sqrt{4-m^2} + \arccos\frac{m}{2}\right)$$

For $m^2 = 3$ the overshoot is 1%. By means of this filter and a 600 Ω anode resistor, as well as extra feedback in the cathode circuit a bandwidth of about 80 MHz has been obtained for the output stage.
The capacitance $C_2/4\,m^2$ is the self capacitance of the coil. Fig. 4 shows this filter fitted to the cathode-ray tube.

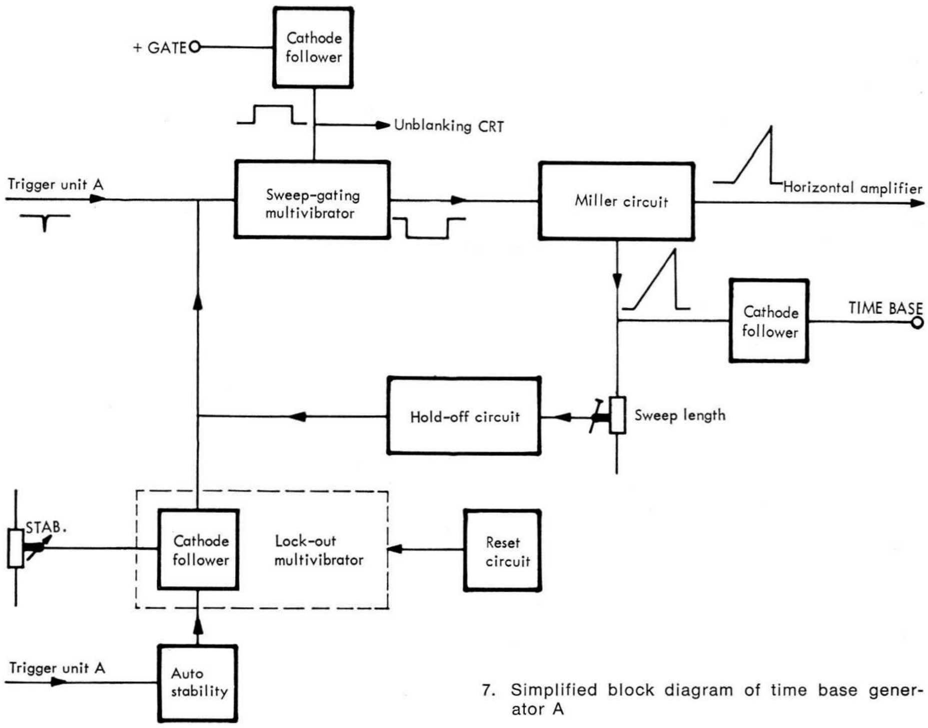
Vertical amplifier
This amplifier is a wideband DC amplifier consisting of two stages (see fig. 5). The simple design ensures faithful response to step functions.
The delay line driver is equipped with high g_m frame grid pentodes E810F.
Apart from the usual feedback circuitry for stabilizing amplification, the cathode circuit also contains several RC networks with different time constants, which serve to compensate losses due to the skin effect of the delay line. As valves with high mutual conductance have a large input capacitance, they must be driven from a voltage source with a very low output impedance, which is obtained by using a cross coupled cathode follower. This is also the reason why the output stage, containing very high g_m tubes (E55L) is preceeded by such a cathode follower. At the same time the delay line is given a better termination, so that reflections are to a large extent suppressed.
Besides the usual feedback circuitry in the cathode circuit of the input stage for stabilizing the amplification, there is a high frequency correction network for step function adjustment.
The delay line consists of two magnetically coupled spiraled cables in the same screening, which has a characteristic impedance of about 270 Ω.

Triggering
In position DC of the trigger mode selector the trigger signal is DC coupled to the trigger circuit whilst AC coupled triggering is provided in the other positions. In position "Automatic" the time base is free-running without a trigger signal. This gives a bright trace even at the shortest sweep times of the time base generator. As soon as a signal is applied, a special circuit automatically resets the time base for stable triggering. To achieve this the trigger signal is rectified, and the DC voltage thus obtained is fed to the time base stability circuit, bringing the time base circuit into triggered operation.
In the positions TV frame and TV line raster pulses and the line pulses respectively, are selected from a complete video signal for triggering.
Fig. 6 shows a simplified diagram of the trigger pulse shaper.
The internal trigger signal is fed symmetrically. The trigger unit is provided with a tunnel diode circuit so that a stable triggering, reliable up to high frequencies is obtained. Operation is explained in appendix, page 9.
As the voltage drop across the tunnel diode amounts to about 0.5 volts, and the time base circuit needs trigger pulses of about 2 volts, an NPN transistor is inserted for amplification. At the collector a 1 : 1 transformer transfers the signal to the time base input circuit. This transformer also differentiates the signal, but the positive-going spikes are practically short circuited by a diode (see fig. 6). The remaining negative spikes are used to trigger the time base.



6. Simplified diagram of the trigger unit with tunnel diode

Time base generator A
Fig. 7 shows the block diagram of the time base generator A. Incoming negative trigger pulses from the trigger unit actuate the sweep gating multivibrator which supplies:
– A negative-going pulse which starts the Miller circuit
– A positive-going unblanking pulse to the cathode-ray tube grid to ensure that the forward moving trace is visible on the screen
– A positive gate pulse via a cathode follower, available at socket + GATE
The Miller 'run-up' circuit, driven by the sweep-gating multivibrator, supplies a linear positive-going sawtooth:



7. Simplified block diagram of time base generator A