



*Storage*

# PHILIPS

## test and measuring notes



1972/1

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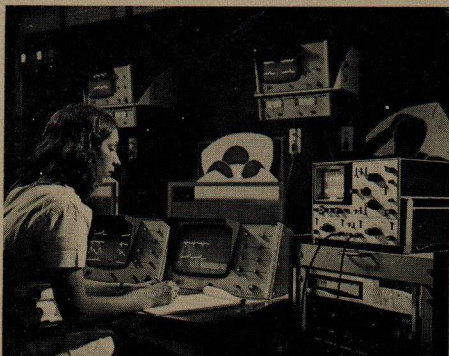
### Introduction

The periodical *Test and Measuring 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 needs.

### The front cover

of this issue shows the set-up of the new storage oscilloscope PM 3251 used for checking Philips electrocardiogram equipment



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### General information

If you are interested in regularly receiving the periodical *Test and Measuring Notes* and also in more information about the instruments please ask your Philips organisation. If there is no Philips organisation in your country enquires may be sent to n.v. Philips' Gloeilampenfabrieken, Test and Measuring Instruments Department, Eindhoven, the Netherlands.

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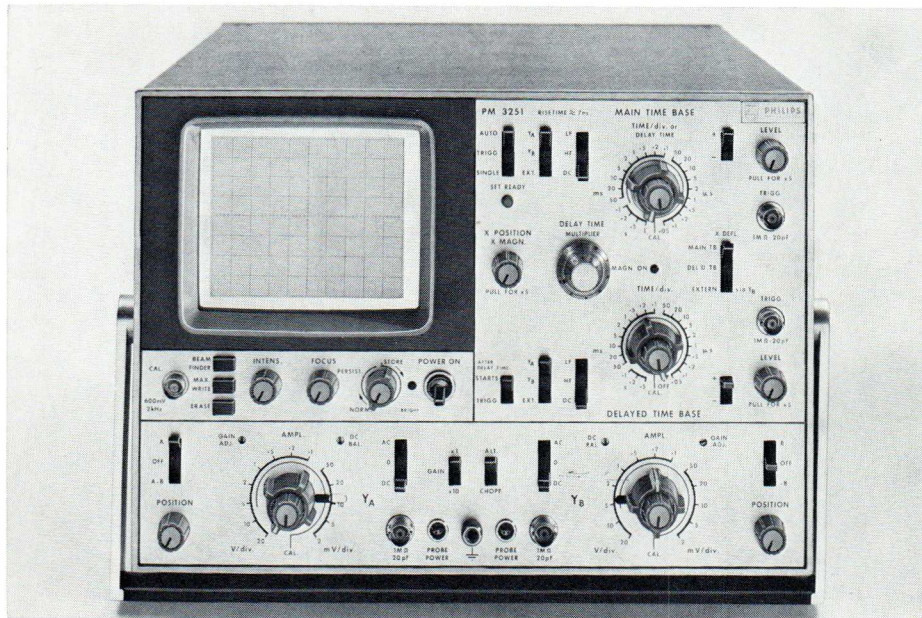
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# PM 3251, a 50 MHz storage oscilloscope with variable persistence and storage

by A. M. op de Weegh and J. Wouters



Present oscilloscopes suffer from three important disadvantages:

1. *Observation and study of single-shot events is only possible with photographic aid.*
2. *Low-frequency signals must be viewed on a flickering display, whilst high-frequency signals having a low repetition rate are barely visible because of their low intensity on the screen.*
3. *Mixed applications of low and high bandwidth at high or low sensitivities, especially in combination with storage, necessitate the use of more than one instrument for one job or the purchase of plug-in solutions.*

The disadvantages mentioned above are avoided with the new Philips PM 3251, a dual-trace 50 MHz storage oscilloscope featuring variable persistence and variable storage in addition to the normal mode of the instrument.

The storage mode of the PM 3251 can be used to store single-shot events for later viewing or easy photographing. Comparison of waveforms can be accomplished by storing them separately, and later, viewing them simultaneously. Storage time can be continuously adjusted up to a maximum which is in excess of two hours. The storage control serves also for adjustment of trace brightness, an increase in brightness being accompanied by a reduction in storage time.

The variable persistence capability is especially useful when viewing signals having low repetition rates. Adjustment of persistence time can permit viewing of a complete trace, with fade-away just sufficient to prevent interference. The display persistence can be readily adjusted to eliminate flicker without losing high resolution. Without using additional knobs the variable persistence mode can be used also to 'fill out' HF signals having low repetition rates, the signal being built up in the oscilloscope memory until a clear picture is obtained.

The new Philips storage and variable persistence oscilloscope PM 3251 combines the excellent characteristics of the new Philips half-tone storage tube L14 - 110 GH with the HF dual trace and double time-base facilities of the easy-to-operate general-purpose 50 MHz portable PM 3250 oscilloscope

The dual-bandwidth approach of the PM 3251 permits this compact instrument to be employed as a low-frequency high-input sensitivity ( $200 \mu\text{V}/\text{cm}$  at 5 MHz) instrument for applications such as are found in physics and medical work, audio modulation, acoustics etc., where previous instruments could only be used with special plug-in units. Where bandwidth is perhaps more important than extremely high input sensitivity, such as in computer development work, telecommunications etc., then the PM 3251 can be used in its  $2 \text{ mV}/\text{cm} - 50 \text{ MHz}$  operating mode simply by the throwing of a switch. And don't be afraid of going higher if required; the instrument will trigger perfectly up to 100 MHz.

## Large screen small-size storage CRT

Fitting a storage CRT in a portable 50 MHz oscilloscope presents both mechanical and electrical problems. The tube had to be small enough to fit into the same space as that occupied by the conventional tube of the PM 3250 oscilloscope whilst at the same time housing all the additional storage elements.

The solution is the new rectangular (14 cm diagonal), flat-faced, direct-view storage tube, type number L 14-110GH; a product of the professional-CRT group of the Philips-Elcoma division. Its large screen provides a useful display area of  $8 \times 10$  divisions and permits careful examination of several traces. This new tube makes possible a considerable increase in writing speed. The isolation between the flood guns and the normal deflection system has been improved. But above all, problems of damage to the storage mesh caused by operating at very high intensities in the normal mode have been virtually eliminated. This is achieved by the improved production methods that are used in the preparation and installation of the mesh.

### Operating a storage oscilloscope

The conventional storage oscilloscope is not often an easy instrument to operate. This, in itself, is a disadvantage; but add to it the fact that misuse can result in permanent damage to the storage tube and the full significance of the problem facing the user becomes apparent.

There are two dangers. One, is that most bi-stable storage tubes age quite rapidly with each storage hour and the user must remember to switch back to 'normal' as soon as possible. The other, is that half-tone storage tubes are known to be over sensitive to very high intensities when used in the normal mode.

The PM 3251 is not a conventional oscilloscope. It has been designed with the avoidance of these problems in mind. The

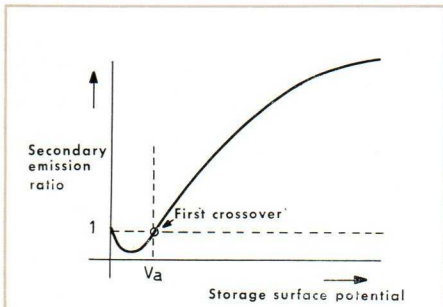
PM 3251 has only three more controls (a switch and two pushbuttons) than the well-proven PM 3250 on which it is based.

Operational simplicity is inherent, also, in the ergonomic design of the front panel layout. As an additional safeguard, the PM 3251 is fitted with an entirely new Philips storage tube. A tube which virtually eliminates problems of storage mesh damage. It is of the half-tone type and has been designed to be much more operator proof than previous storage tubes. It has, also, the outstanding feature that its operational life is comparable to that of a conventional CRT and is significantly longer than that of most storage tubes employing the bi-stable principle.

layer surface and the number of electrons arriving (secondary emission ratio) plotted as a function of the surface potential. At a potential of about  $V_a$  volts the number of electrons leaving the surface is equal to the number arriving. This point is called the first cross-over (secondary emission ratio = 1).

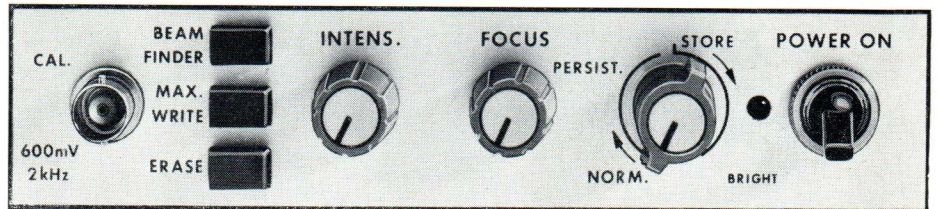
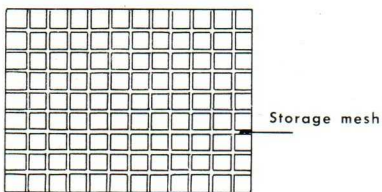
If the surface is bombarded with electrons of higher energy, the surface potential rises, because more electrons are leaving than arriving.

If the surface is bombarded with electrons with energies lower than at  $V_a$  volts, the surface potential decreases, because fewer electrons are leaving than arriving. A practical value of  $V_a$  for a suitable type of non-conducting material is between +15 and +45 V.

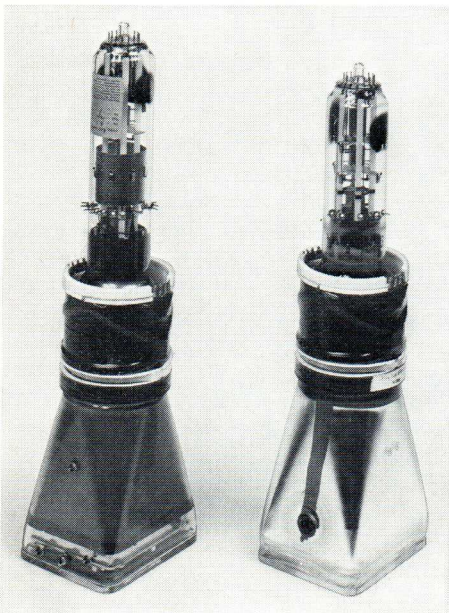
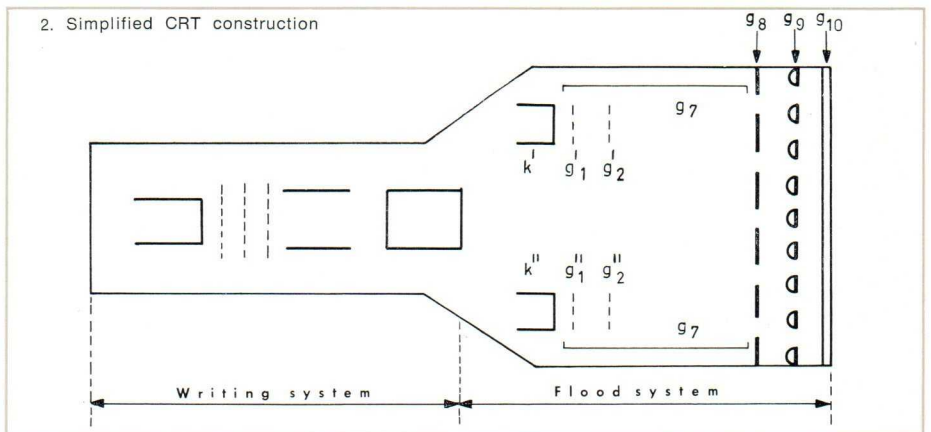


1. Secondary emission ratio

3. Mesh construction used for collector and storage grids



Specific storage controls of PM 3251 limited to one switch and two buttons



New Philips storage tube L14 - 110 in comparison with standard tube D14 - 160

### Storage principle

The PM 3251 storage oscilloscope contains a storage-mesh the storage time of which can be varied so that it can be used like a normal CRT, but with variable persistence of the displayed signal.

The storage of information takes place by writing the signal information from the normal electron (writing) gun into a storage layer of high quality, non-conductive material, so forming a positive charge pattern by secondary emission of electrons. This charge pattern on the storage surface remains for a considerable length of time, even when the writing gun is switched off. It is made visible on the phosphor viewing screen by a second electron beam the electrons of which are allowed to strike the phosphor via the positively charged positions on the storage layer.

The basis for storage of information on the non-conductive material is the secondary emission ratio curve, as shown in fig. 1. This curve shows the ratio between the number of electrons leaving the storage-

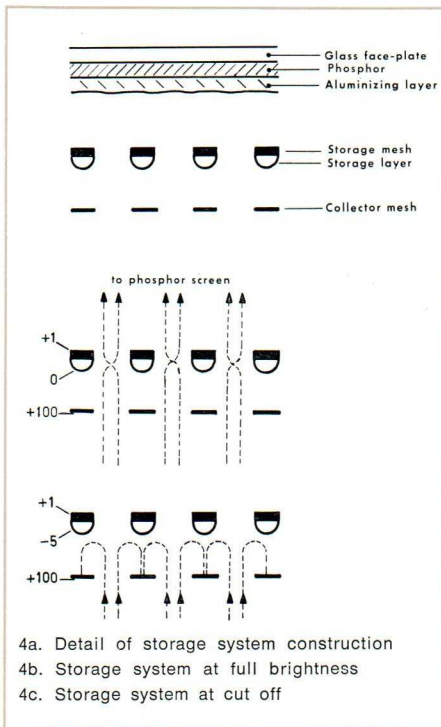
### Storage tube construction and operation

As shown in fig. 2, the PM 3251 storage CRT contains two systems: the 'Writing' system and the 'Flood' system. Construction and operation of the writing part is identical to that of a conventional CRT and will not be dealt with here.

The flood system consists of a pair of flood guns operated in parallel, both having a cathode  $k$ , a control grid  $g_1$  and an accelerator grid  $g_2$ . Common to both flood guns are the flood-beam collimator  $g_7$ , the collector mesh  $g_8$ , the storage mesh  $g_9$  (carrying the storage layer), and the phosphor viewing screen  $g_{10}$ .

The flood guns are physically located just outside the horizontal deflection plates. The cathode potential is at  $-50$  V. A cloud of electrons is emitted by each flood gun cathode. These clouds are combined, shaped, and accelerated by the two control grids  $g_1$  and  $g_2$  and by the collimator  $g_7$  (which is formed by a coating on the inside of the tube). The positive voltage on the collimator is adjusted so that the flood-gun electron cloud just fills

the CRT viewing screen. The cloud is further accelerated towards the storage mesh and viewing screen by the collector mesh  $g_8$ . After passing through the collector mesh, the flood electrons are further controlled by the potentials on the storage mesh and storage-layer surface. Shown in fig. 3 are the storage and collector meshes both with approximately 40  $\mu\text{m}$  apertures. The cathode-side of the storage mesh is coated with a non-conductive material, on which the storage of information takes place, fig. 4a. The capacitive coupling that exists between the storage mesh and the storage-layer surface is essential for the operation of the store and erase functions. The storage mesh rests normally at a potential of approximately +1 V with respect to the



flood gun cathodes. The potential at the storage-layer surface is controlled by Write and Erase routines fed to the storage mesh and varies between 0 V and negative. Fig. 4b shows that when the storage-layer surface is at 0 V, the majority of flood electrons pass through the holes of the mesh and reach the viewing screen. The remaining electrons are repelled by the storage-layer surface and picked up by the collector mesh. When the storage-layer surface is made negative (fig. 4c), the number of electrons passing the storage mesh is reduced considerably. At a certain value (the cut-off level), no electrons are passed. The post-accelerator voltage (approximately 6 kV) is connected to the phosphor viewing screen. As soon as flood electrons are allowed to pass the storage mesh they are accelerated by this high potential and strike the phosphor, thereby causing it to emit light. The storage mesh  $g_9$  (fig. 2) can be compared with the control grid of a triode. Just as the triode grid potential controls

### Technical specifications

The technical specification of the PM 3251 is identical to PM 3250 except for the following:

#### STORAGE CRT

**Type:** New Philips L14-110GH post accelerator half-tone storage tube; 8 kV accelerating potential, P31 phosphor

**Graticule:** 8 x 10 div. internal graticule  
 1 div. = 0.9 cm

#### Persistence:

**Normal:** natural persistence of P31 phosphor (10  $\mu\text{s}$ ... 1 ms)

**Variable:** continuously variable from < 0.3 s to > 10 min.

**Storage:** Storage time: continuously variable between > 2 hours at minimum brightness to > 10 minutes at maximum brightness

#### Writing speed:

> 100 cm/ms in variable persistence mode  
 > 1.2 cm/ $\mu\text{s}$  in max. write mode

**Erase:** Push button operated. Erasure takes 500 ms approx.

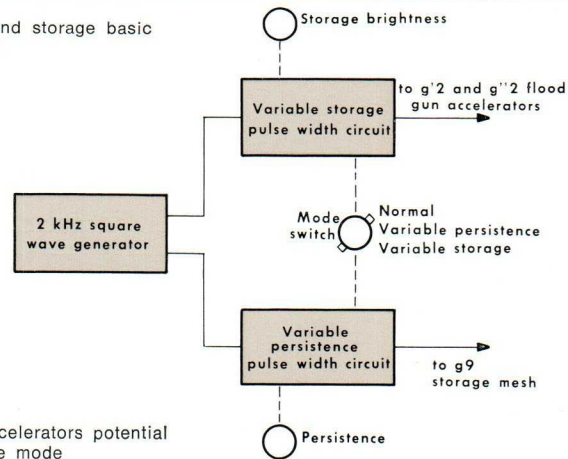
### GENERAL

**Dimensions:** Same as for PM 3250  
**Weight:** 18.5 kg approximately  
**Environmental:** Same as for PM 3250  
**Power requirement:** max. 120 W  
**Voltage and frequency range:** Same as for PM 3250

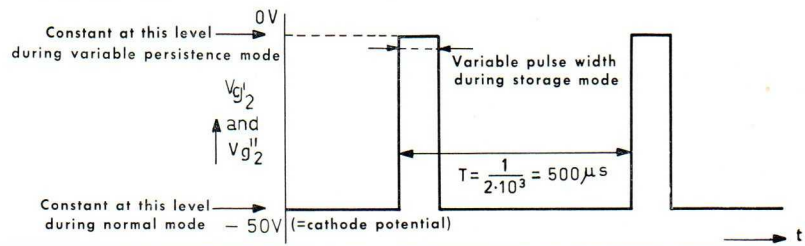
### Summary of PM 3250 specifications

50 MHz at 2 mV/div  
 5 MHz at 200  $\mu\text{V}/\text{div}$   
 Dual trace with differential possibility  
 Big 8 x 10 cm display  
 Main and delayed time base with calibrated delay time multiplier  
 Complete and independent triggering  
 Full range of accessories

### 5. Persistence and storage basic pulser circuit



### 6. Flood gun accelerators potential during storage mode



anode current, so the flood storage mesh potential controls the current of flood electrons to the screen and thus the intensity of the trace. An operator control for varying the brightness during storage will be discussed later.

### Writing and storage

Let us assume that the storage-layer surface has been prepared by an Erase routine (to be discussed later) such that it is below the cut-off level: no flood electrons can reach the screen. When we now activate the writing cathode and let the electron beam move over the storage-layer surface, the high potential difference ( $-1500$  V) existing between the cathode and this surface will cause the electrons to arrive at the surface with energy much in excess of first crossover. The surface will be charged in a positive direction wherever the electrons strike. The highest potential that can be reached is 0 V (flood gun cathode potential), any value above this would attract flood electrons, so reducing the surface to its original 0 V po-

tential. We have seen in fig. 4b that those areas of the storage-layer surface that are charged to near zero volts, allow the post-accelerator field to 'reach through' and capture floodgun electrons. Thus, the pattern of charge on the storage-layer surface is made visible on the screen.

The potential of the flood gun accelerators  $g'_{1/2}$  and  $g''_{1/2}$  is controlled by the upper of the pulser circuit shown in fig. 5. Depending on the operator mode selected, the accelerator grids are either continuously at cathode potential (Normal mode), continuously at +50 V (variable persistence mode) or pulsed positively at variable width (variable storage mode); see fig. 6. The storage brightness has a linear relationship with the pulse width selected. When the mode control is set to minimum brightness, the pulse will be almost cut off, and storage time will be maximum.

## Erasure

Erasure of stored information can be done in two ways: by the Manual-Erase function or, in the variable persistence mode, by the Auto-Erase function.

### Manual Erase

In the manual-erase mode the potential at the storage mesh is varied in accordance with the curve of fig. 7a. The corresponding curve for the storage-layer surface potential is shown in fig. 7b.

When the ERASE button is pressed (and held)  $t_1$ , the storage mesh is changed to the same potential as the collector mesh (+100 V). The storage-layer surface follows to almost the same potential by capacitive coupling. Since this surface is then being bombarded by electrons with energies

much higher than that at first crossover the entire surface potential becomes strongly positive and all information in the storage layer is overruled.

The surface potential cannot increase much beyond +100 V because the collector mesh would then repel the emitted electrons back to the storage surface, tending to decrease its potential.

When the ERASE button is released,  $t_2$ , the storage mesh returns to +1 V and the storage-layer surface follows to the same potential by capacitive coupling but then decays to zero volts by the action of the flood-gun electrons.

After 200 milliseconds,  $t_3$ , the storage mesh is automatically raised to +11 V. It is held there for 400 milliseconds. The storage-layer surface follows to +10 V by

capacitive coupling but immediately starts decaying towards zero volts by capturing flood-gun electrons.

At the end of the 400 milliseconds,  $t_4$ , the storage mesh is brought back to +1 V. This reduces the storage-layer surface from zero volts to -10 V. The erasure cycle is now complete, and the system is ready for the input of new information.

### Auto Erase

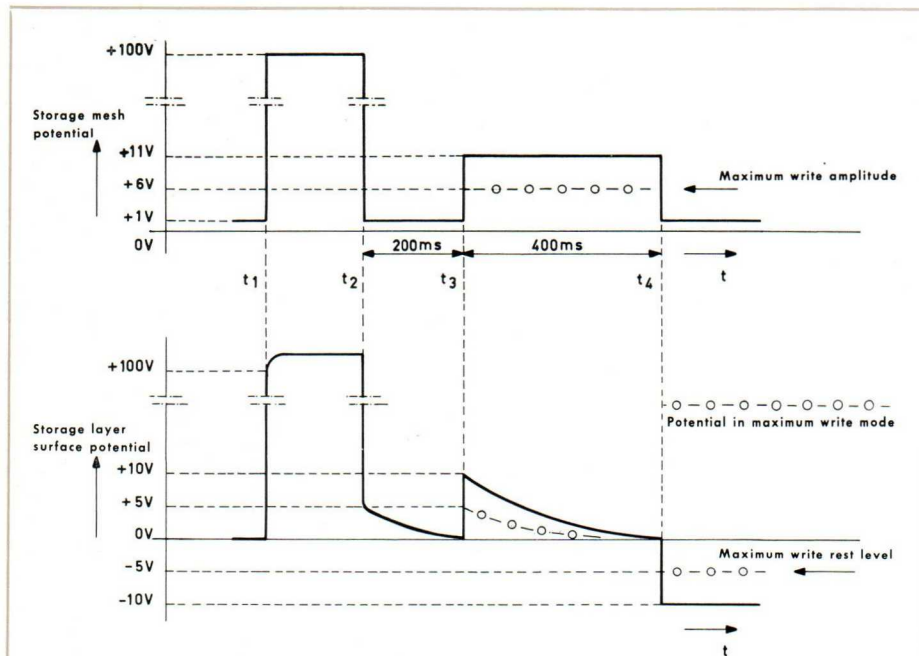
In the auto-erase mode, recovery of the storage-layer surface potential to below cut-off level is accomplished after a number of automatic cycles of pulsed erasure. This is done by connecting a 2 kHz square-wave signal from the pulser circuit of fig. 5 to the storage mesh  $g_2$ . This signal, and the corresponding potential at the storage-layer surface, are shown in figs. 8a and 8b. As in the manual-erase cycle, the storage-layer surface potential follows the voltage changes on the mesh. However, during each pulse the surface is moved positive and attracts and captures flood-gun electrons, tending to lower the potential by an amount  $\Delta V$ . If this procedure is repeated many times the rest potential at the storage-layer surface will eventually pass the cut-off level and the stored trace will be erased.

When the pulse width is increased as shown in fig. 8c the drop in surface potential is increased also ( $\Delta V'$ ) and fewer cycles of the square-wave are needed to complete the erasure.

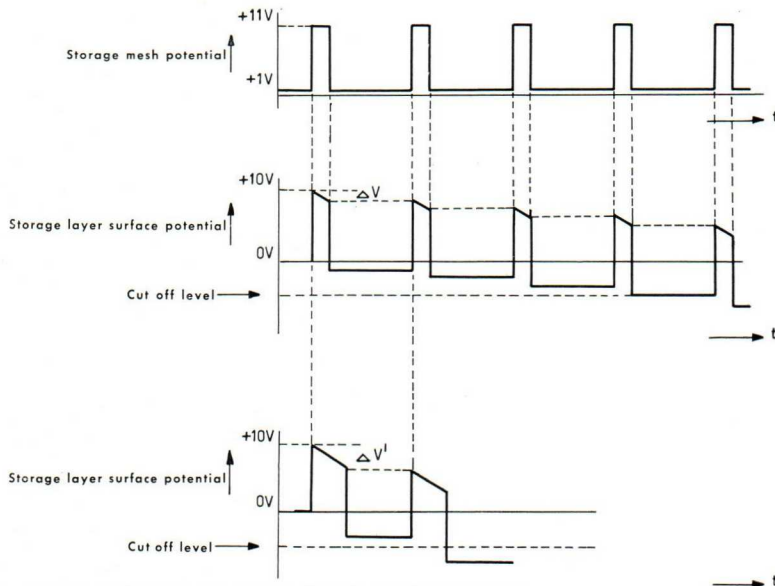
Varying the pulse width is accomplished by means of the variable persistence control (PERSIST.) of the PM 3251. Persistence can be adjusted between 0.3 sec and 10 minutes.

### Maximum write mode

The secondary emission of electrons from the storage-layer surface caused by the bombarding flood-gun electrons, must charge the surface from its erased potential of -10 V to the storage threshold (cut-off level) of about -5 V before flood electrons can be captured by the post-accelerator (fig. 7b). Thus, the writing speed of the CRT can be enhanced by erasing the surface to just below this writing threshold. By pressing the button "Max. Write" the amplitude of the erase pulse, shown in fig. 7a during  $t_3 - t_4$ , is reduced by approximately half. This results in a rest level after erasure of around -5 V. As the storage surface potential is raised to near the threshold potential, a part of the electron cloud is permitted to pass on to the screen, resulting in a light green background illumination. Although the contrast ratio is reduced, the writing speed for fast single-shot signals is increased between 10 and 20 times.



7a. Storage-mesh potential during erasure cycle  
 7b. Storage-layer surface potential during erasure cycle



8a. Storage-mesh potential during variable persistence mode  
 8b. Corresponding storage-layer surface potential containing information  
 8c. Same as 8b but persistence adjustment shorter (bigger pulse width)