Source: Sound and Vision - Winter 1964/65

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A NEW WIDE-BAND GENERAL PURPOSE OSCILLOSCOPE with special features for use in television applications

THE TF2200 OSCILLOSCOPE is a recent addition to the Marconi Instruments range of Oscilloscopes and follows the pattern of maximum measuring accuracy with versatility. It has been primarily designed as a wide band general purpose oscilloscope but specific features for its use in television waveform measurements have been included. These features include a TV-differential plug-in unit with clamping facilities, a special TV frame triggering position and a multi-trigger selection for pulse and bar measurements.[1]

The instrument incorporates a 5-in. cathode ray tube giving a full 5 cm of display throughout the frequency range of 35 Mc/s. A 10-kV overall accelerating potential ensures adequate brilliance with writing speeds up to 10 nsec/cm.

Time and voltage measurements can be made by centimetre graticule or slide-back techniques, thus allowing both quick and accurate measurements to be carried out.

Delayed sweep facilities are included which enable any portion of a complex waveform, such as a single line in the case of a television signal, to be displayed.

The instrument is shown in Fig. 1 and consists of a main frame containing the 'Y' amplifier, cathode ray tube, power supplies and other services, with optional plug-in 'Y' pre-amplifiers on the lower left-hand side and trigger, time bases and 'X' amplifier occupying the whole of the right-hand side. This right-hand unit is a plug-in unit, only to be removed for maintenance or servicing, and is therefore held in position by front panel fixing screws.

The full block schematic diagram of the basic oscilloscope is shown in Fig. 2 with the television plug-in unit shown in Fig. 3.

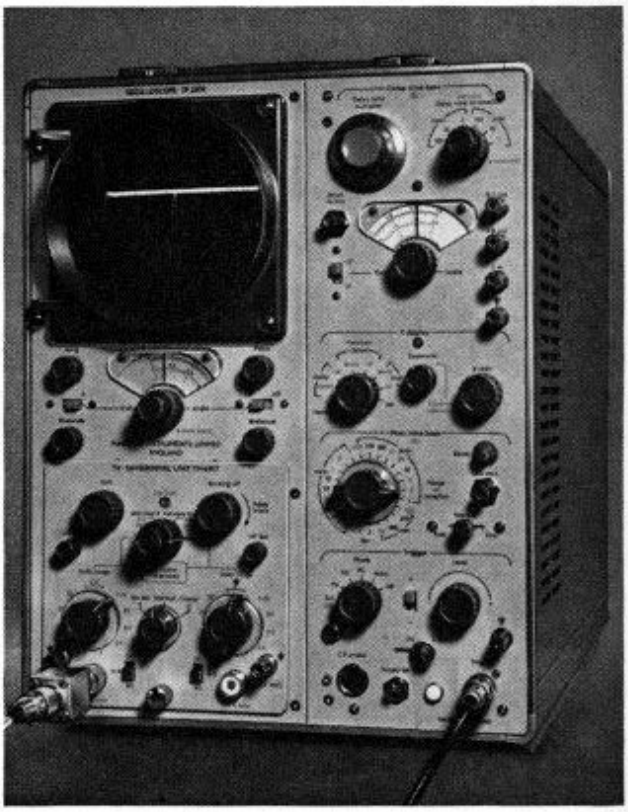


Fig. 1. Type TF2200 oscilloscope with TV-differential plug-in unit.

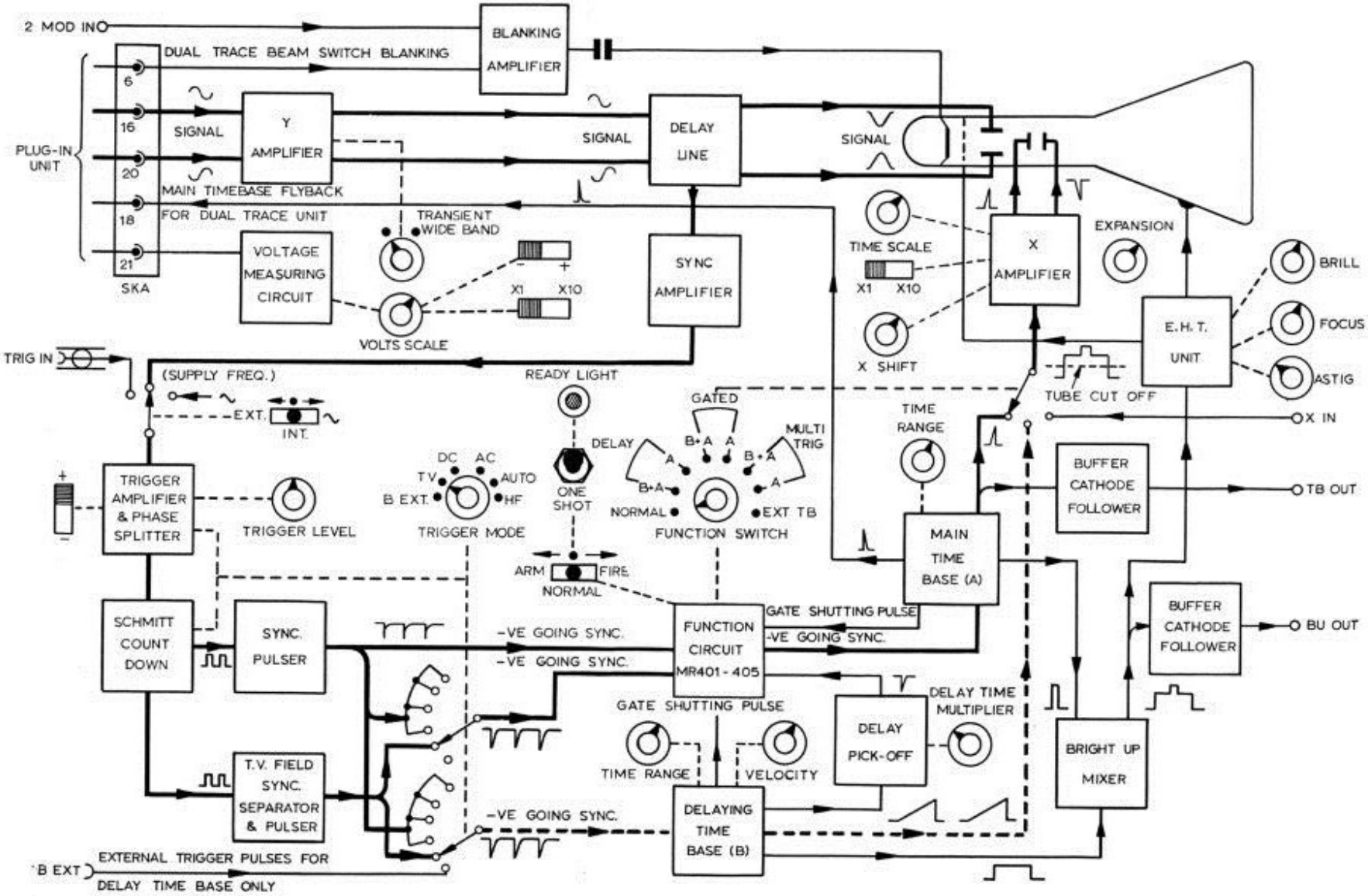


Fig. 2. Block schematic diagram of basic oscilloscope. This circuit is not functional by itself but needs the addition of a plug-in unit to make it operational.

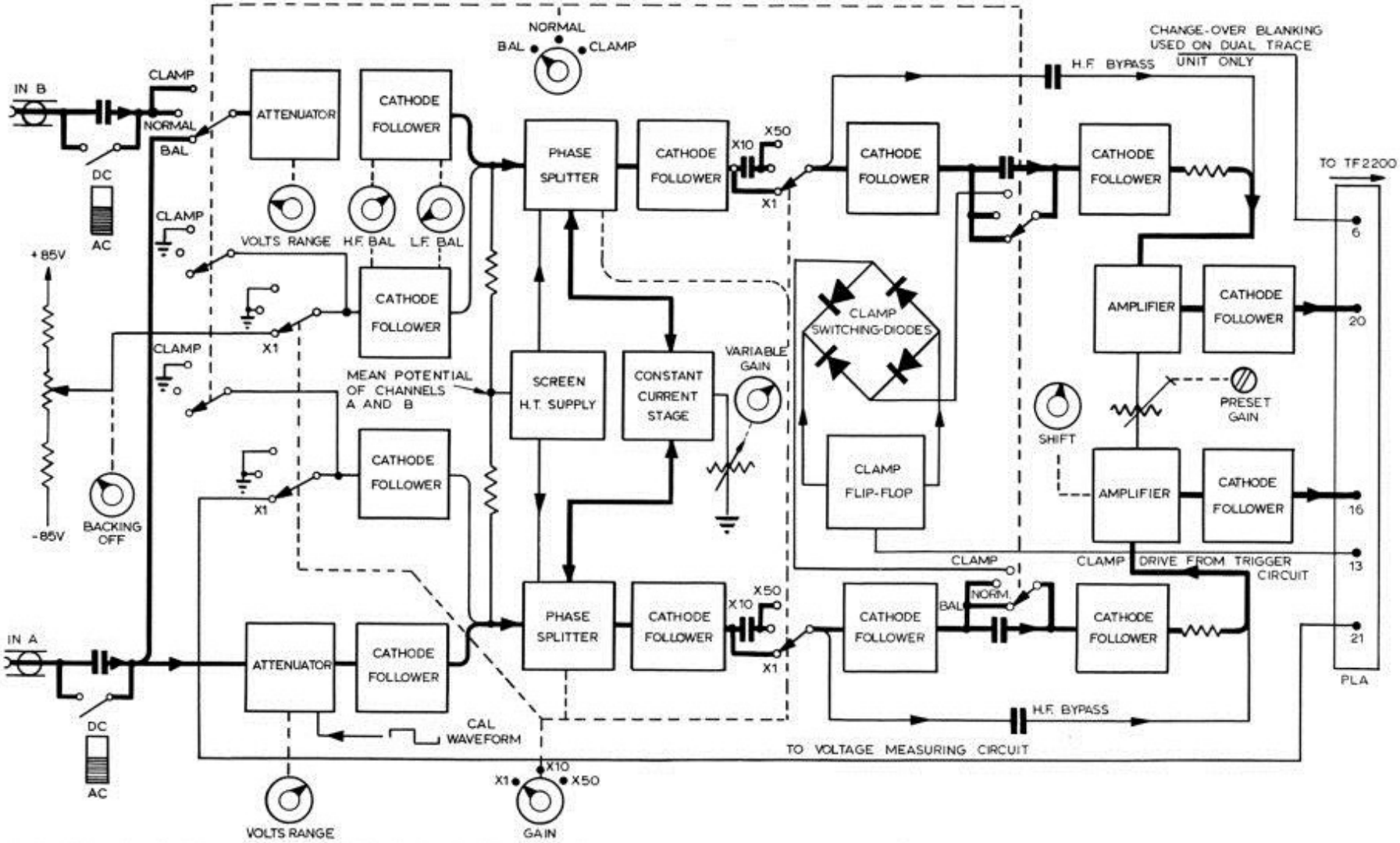


Fig. 3. Block schematic diagram of TV-differential unit. If a single input waveform is applied to either of the input sockets, it can be displayed in the normal manner; application of separate waveforms to the two inputs enables their difference in voltage waveform to be displayed.

Y AMPLIFIER

The Y amplifier consists of the normal shunt and series-compensated balanced d.c amplifier, the bandwidth of which is achievable due to the very sensitive c.r.t and the new output valves which have a very high gain–bandwidth product. The bandwidth without a plug-in unit is 3 dB down at 30 Mc/s for no overshoot. A transient wideband switch is included to extend the bandwidth to 38 Mc/s for c.w use, which gives approximately 15% overshoot on a fast step. For television work, however, such as a 3 Mc/s signal on a 34 Mc/s carrier, no overshoot will be present in this position.

The a.c/d.c gain change due to thermal effects within the valves is very small and this feature is especially useful when examining the blanking level stability of a television waveform in which the video content is periodically changed from peak white to black level at 1 c/s.

A sectionalized delay line is incorporated giving a delay of 0·25 μs, thus allowing rise time measurements of the front edge of a fast pulse which is coincident with the start of the sweep generator.

The blanking amplifier used in conjunction with the dual trace unit to blank out the switching transients in the chopped position of the dual trace unit is also used to amplify and mix external signals to apply 'Z' modulation to the c.r.t.

The sync amplifier is fed from the first section of the delay line and has a bandwidth of d.c—30 Mc/s. This faithful replica of the c.r.t image which is passed to the trigger circuit allows selective triggering of complex waveforms.

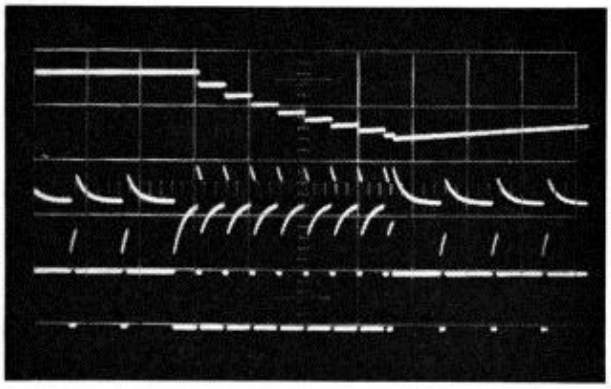


Fig. 4. *x*, 100 μs/cm; *y*, 20 V/cm. TV field separator waveforms. Lower trace, input signal. Middle trace, critically differentialled waveform. Top trace, output waveform.

TRIGGER CIRCUIT

The trigger circuit has the usual services such as internal/external, positive and negative, h.f, Auto, etc. However, to reduce the number of controls to give a stationary picture, no stability control is included either inside the instrument as a pre-set or as a front panel control.

In the TV position the television waveform is differentiated and fed to a triode biased beyond cut-off, the differentiator having a time constant of 18 ns. This produces a waveform as shown in the centre trace of Fig. 4. This method of frame pulse separation is superior to the usual integrator methods used on oscilloscopes, the latter method usually resulting in timing differences between odd and even fields.

When triggering in the TV position it is important to remember that for positive-going video signals the trigger polarity switch must be in the positive-going position to obtain the field separation; this position of the switch will give line-by-line black level clamping. The choice of sync bottom or blanking level for clamping is available when triggering from line pulses; only blanking level clamping is possible in the field sync mode for video signals of either polarity. To avoid d.c shifts, hum and varying video content affecting the synchronism, the TV trigger position is a.c coupled and the d.c is restored.

SWEEP GENERATORS

Both the main sweep and the delaying sweep are very similar, the differences being the sweep ranges, 2 s/cm to 50 ns/cm for the main sweep and 0·1 s/cm to 1 μs/cm for the delaying sweep. The delaying sweep also switches a variable velocity control which enables synchronism to be achieved with complex waveforms.

A further difference is in the unblanking voltages which in the main sweep is 10 V more positive than the delaying sweep, thus allowing a 10 V pedestal, which when mixed produces a bright dash for the duration of the main sweep scan when the delaying sweep is producing the c.r.t deflection. This enables the user to locate precisely where the main sweep is in relation to the delaying sweep and the input signal.

Both generators use an established principle of having an incoming signal operating a bistable stage which releases a miller grid via a release diode. The sawtooth waveform is fed back to the grid of the bistable by means of a recycling loop and thus at a suitable potential the circuit will return to its quiescent state.

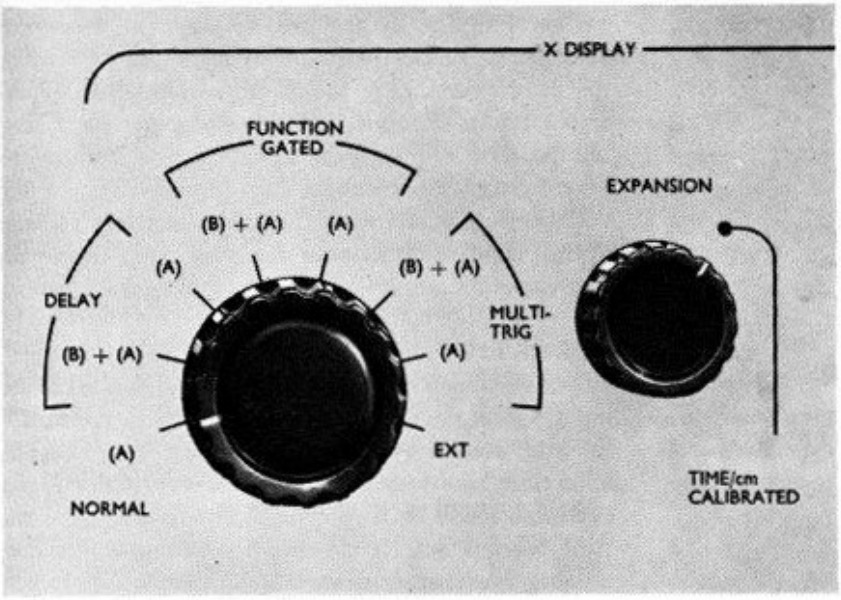


Fig. 5. Function switch details.

An unusual feature of the sweep generator is, however, that the bistable stage has been designed to eliminate the necessary adjustments to enable the circuit to respond to trigger pulses.

DELAY PICK-OFF

The delaying sweep is fed to one side of a Schmitt circuit, the other side being connected to the delay time multiplier control which dictates the voltage level on the ramp at which the Schmitt changes state and consequently the delay time between the commencement of scan and the output of a fast negative-going edge used to operate the main sweep generator.

FUNCTION SWITCH

This allows the various time base functions to be selected without any external links being required. The function switch details are shown in close-up in Fig. 5, and it can be seen that in each of the three conditions, Delay, Gated and Multi-trig, the delaying sweep can be displayed on the c.r.t with the main sweep as a brightened portion to facilitate rapid setting of delay position with respect to signal.

A further function is a single-shot facility which can be used when photographing single transients. A 3-position front panel switch is used to select either the arm condition, which allows a trigger pulse to fire the sweep generator once only, or the fire position, which allows manual operation of the main sweep.

X-AMPLIFIER

This consists of a single-phase splitter stage, the sweep being applied to one grid and the measuring and shift potentials being applied to the other grid. The amplifier can be driven externally and is a.c coupled to the X "in" terminal.

E.H.T

Semiconductor diodes are used for the 1-kV cathode and grid supply of the c.r.t to eliminate any brightness flicker whilst a valve voltage doubler is used to produce +9 kV for the final anode.

A feature of this unit is that a test point inserted in the circuit enables an oscillator to be connected to drive the circuit so that faults can be found under operating conditions without the need for tiresome component substitutes.

POWER SUPPLY

Four h.t lines are produced, all fully stabilized and referred to a single −150-V set-up potential derived from a neon stabilizer. Where necessary valve heaters are run from a series stabilized transistor regulator referenced to a 3·4 V-zener diode.

TV DIFFERENTIAL UNIT

The difference amplifier has a sensitivity of 50 mV/cm at 20 Mc/s or 28 Mc/s in the wideband position, 5 mV/cm at 8 Mc/s (a.c coupled only) and 1 mV/cm at 800 kc/s (a.c coupled only). L.f and h.f balance controls enable the rejection to be set to a maximum on any range at any frequency without disconnecting the test signals. ±10 V of backing-off is available on the 50-mV/cm position and proportionally higher

amounts can be backed off on higher settings of the input attenuator.

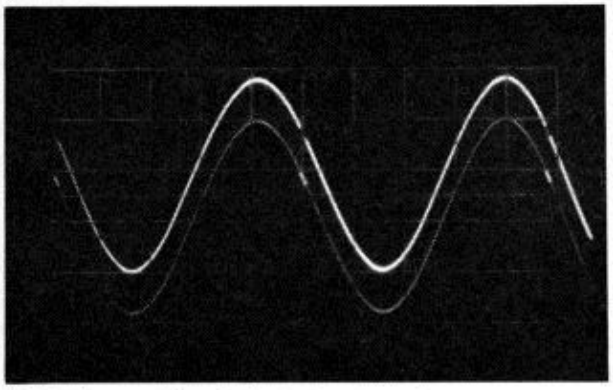
Shift, measuring and backing-off voltages may be used with both signal inputs in the d.c coupled positions, thus facilitating difference measuring of v.l.f signals superimposed on large standing voltages. A 1, 2, 5 sequence attenuator extends the range from 50 mV/cm to 50 V/cm and a pre-set gain control enables the gain to be set using the internal calibrator.

With the unit switched to the 'clamp' position the two sides of the balanced amplifier are shorted together for 4 μs by means of a driven diode bridge every time a trigger pulse leaves the trigger circuit. This periodically discharges the series capacitors and d.c restores to some chosen level, depending on the setting of the shift control and trigger polarity switch. This enables rectangular waveforms of half period between 4 to 400 μs to be clamped such that any hum or l.f content will be removed. The clamp circuit has been specifically designed to minimize waveform disturbance during the switching period by only using the l.f components of the clamp output, the h.f components being obtained from a bypass capacitor. Using this position a television signal can be clamped to sync bottom or blanking level regardless of d.c variations or hum content. Fig. 6 illustrates the use of the clamp when looking at a sync pulse train with four times its amplitude of added 50 c/s waveform.

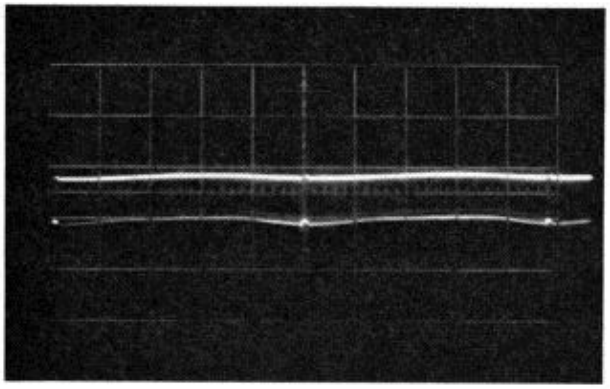
OPERATION

When viewing a composite video signal applied to the input socket, the trigger mode switch is set to TV internal when a field locked display results. On the main time base normal setting, however, both odd and even fields will be displayed alternatively unless the time base is set slow enough to count-down thus missing every other field.

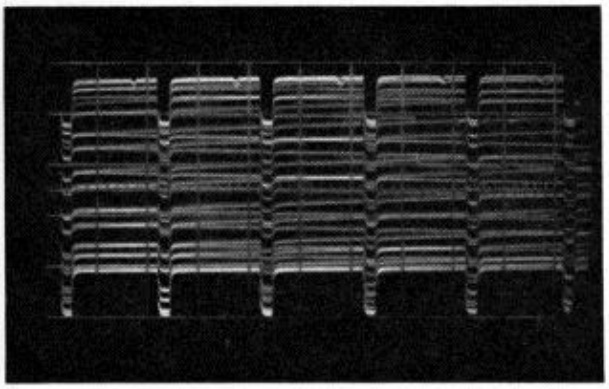
On all the delaying sweep positions a fixed waiting



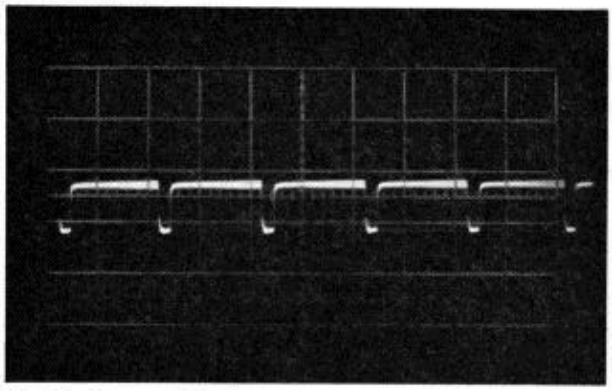
(a) *x*, 4 μs/cm; *y*, 1 V/cm. Field display without clamp.



(b) *x*, 4 μs/cm; *y*, 1 V/cm. Field display with clamp.



(c) *x*, 50 μs/cm; *y*, 1 V/cm. Line display without clamp.



(d) *x*, 50 μs/cm; *y*, 1 V/cm. Line display with clamp.

Fig. 6. Television sync pulse train with four times its amplitude of added 50 c/s waveform.

time of 30 ms (adjustable for 60 field sec and operation) is switched in on the TV position. Thus only odd or even fields are displayed on sweep speeds faster than a field period. The depression of the beam locate button causes a field change to occur on a random chance basis. This fixed waiting time allows the delayed display to be greatly enlarged when locking for test signals in the post field pulse region yet still maintaining odd or even field lock.

Individual portions of the waveform may be examined either in the delayed or gated mode, and if two lines on each field contain pulse and bar signals conforming to certain timing requirements, these may be viewed in the superimposed sliding bar type display using the Multi-trig position.

Line-by-line pulse and bar measurements for equipment or line testing are particularly simple to make, and a special 'K' factor graticule to Post Office standards is available for quick assessment of the equipment rating. Pulse and bar generators can be set up accurately using the TF2200 because of the wide bandwidth. Changing the bandwidth from 20 Mc/s to 28 Mc/s by means of the Transient-wideband switch alters the height of a 625 line T pulse by only $\frac{1}{4}\%$, the wideband position being the one most nearly correct.

A signal of 1 V p-p at a 40 V d.c potential can be displayed at one screen diameter by backing-off in the d.c coupled position or by d.c restoring with the clamp in the a.c coupled position depending on the measurement requirements.

For differential measurements the l.f and h.f balance adjustments enable the rejection to be set to about 40 dB even on complex waveforms and on any attenuator setting.

This may be checked if suspected, without disconnecting the signals under test. Fig. 7a shows a line frequency waveform with a ramp of 1 V amplitude fed to both input sockets of the TV-differential unit. Fig. 7b gives the resultant waveform at a sensitivity of 0·05 V/cm with the l.f and h.f controls maladjusted. Fig. 7c shows a common mode rejection better than 40 dB with correct control adjustments.

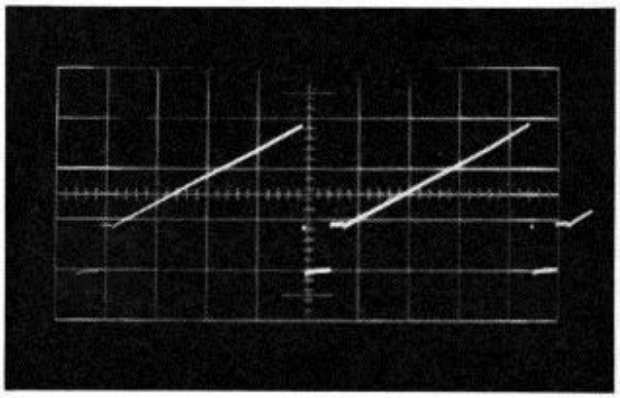


Fig. 7a. *x*, 20 μs/cm; *y*, 0·5 V/cm. Ramp waveform at line frequency applied to both input sockets with channel B earthed.

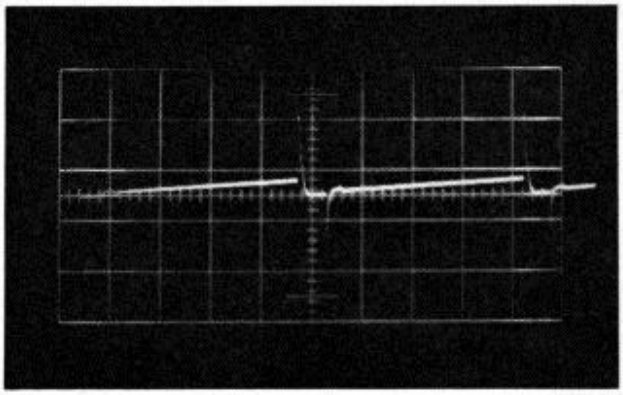


Fig. 7b. *x*, 20 μs/cm; *y*, 0·05 V/cm. Showing common mode rejection of (a) with h.f and l.f controls maladjusted.

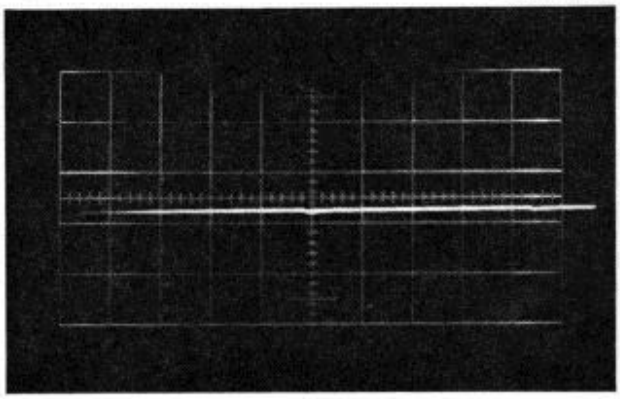


Fig. 7c. *x*, 20 μs/cm; y, 0·05 V/cm. Showing common mode rejection with controls adjusted correctly.

SPECIAL VERSIONS

To extend the use of the instrument even further, special modifications have been carried out to suit specific user requirements. Two such modifications are detailed as follows.

In assessing the performance of television video equipment using the sine-squared pulse and bar waveform in conjunction with a K-factor graticule, it is necessary to adjust the sweep speed accurately to 333 ns/cm. On the standard TF2200, which is a general purpose instrument, this involves careful adjustment of sweep speed and X amplifier gain, etc. To avoid these tiresome adjustments the fastest sweep range can be deleted and one of 333 ns/cm substituted.

A further problem carrying out sine-squared pulse and bar measurements is the requirement to strobe a particular line from each alternate interlaced field. In this condition the oscilloscope triggers at field frequency, provides the delaying sweep and then displays the desired line. The requirement is, therefore, that the main sweep is at either 100 μs or 3·33 μs duration with a repetition rate of 25 per second and the delay between triggering the oscilloscope and the main sweep initiation varying up to 20 ms. High writing speeds are thus required which the TF2200 is quite capable of producing.

However, recourse can be made to the function switch position labelled 'Delay Gated' where in this condition the delaying sweep operates a diode gate which then permits the main sweep generator to be fired by the next trigger pulse. Any jitter between the initial trigger pulse and the portion of the waveform under examination, also any slight inherent jitter in the action of the delaying sweep, is eliminated.

Using the variable delay will cause the display to jump from one repetitive portion of the signal to the next and, therefore, no detailed exploration of the waveform would be possible.

An additional delay circuit is added to enable extra variable delay to be introduced whilst operating in the gated mode. This variable range is in excess of 100 μs so that a sine-squared pulse appearing as video information on a particular line can be isolated and examined in detail on the special sweep range of 333 ns/cm.

Two further Y plug-in units which can be obtained for operation with the TF2200 are the single-trace unit giving a wider band performance and a dual-trace unit for multi-channel displays.

REFERENCE

1 J. D. Middleton: Oscilloscope Type TF 2200; *Marconi Instrumentation*, Vol. 8, No. 8.