

MARCONI INSTRUMENTATION

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IN THIS ISSUE

BUILDING FOR THE FUTURE	page 105
DOUBLE BEAM OSCILLOSCOPE, TYPE TF 2202	„ 107
A.F. TWO TONE SIGNAL SOURCE	„ 114
SPECIAL VERSIONS OF COUNTER/FREQUENCY METER	
TF 1417/2	„ 118
SIDE-LOBE SUPPRESSION IN S.S.R.	„ 121

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MARCONI INSTRUMENTATION

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EDITORS

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Building for the Future

THE START OF 1964 saw the Engineering Department at Marconi Instruments both rehoused and reorganized. Mr. E. Garthwaite, Chief Engineer since 1950, relinquished management of the department and became senior technical advisor to the Managing Director while retaining responsibility for research in X-ray image intensifiers. Mr. A. G. Wray, a former editor of this journal, became Engineering Manager responsible for design and development, while research and advanced development became an independent department under Mr. H. V. Beck.

Both departments are housed in a new two-storey building which has increased the floor space of our factory at St. Albans by 32,500 sq. ft. to a total of 219,500 sq. ft. The new building provides bright, clean and quiet working conditions; it accommodates the Research Department and administrative offices on the ground floor and the design laboratories and engineering services on the upper floor. With the completion of this building a phase shift of 180° has been introduced into the site plan to give a front entrance in the more rural area of Hill End Lane, while Longacres now plays the secondary role of rear entrance.

Instrument design activities in the new organization have been divided into six product groups—signal generators and oscillators; counters; distortion and response analysers; power, voltage, impedance and microwave measurement; oscilloscopes; and X-ray image intensifiers.

Situated alongside the teams of electrical and mechanical designers is a range of auxiliary departments such as standardization, prototype wiring, technical publications and library, all of which are necessary to provide a comprehensive engineering service. Standardization has the primary objective of reducing the variety of components used in our instruments, so giving the user the advantages of reduced costs and simplified servicing. It also performs the valuable service of keeping the designers informed on new components so that our instruments stay abreast of the latest component improvements and developments. The prototype wiring section ensures that engineers' development models are wired in accordance with approved production standards, thereby reducing discrepancies in performance between prototype and production models. The highly skilled technique of designing and producing the master wiring layouts for printed boards is another important responsibility for this section. Technical publications prepare the instruction manuals that provide the essential link between designer and user, explaining how the instrument works and showing how it should be used and maintained to its best advantage.

Examples from four of the product design groups appear in this issue of *Instrumentation*. Representing the signal generator and oscillator groups is a two-tone test generator; this has been evolved by the Applications Engineering Department from an oscillator and an attenuator in our modular series and serves as an example of the flexible arrangements possible with these small units. Flexibility is also the keynote of the new double beam portable Oscilloscope type TF 2202 which has been designed for bench or rack mounting, mains or battery operation and laboratory or field use, and will be of particular interest to military and other organizations requiring a rugged instrument for mobile use.

Several special versions of the 10 Mc/s Counter/Frequency Meter are described on p. 118 showing that no general purpose instrument is ever comprehensive

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The Marconi Instruments technical library looks out on the main wing of the new engineering building. Access to the world's technical books plus an international selection of journals provide a comprehensive information service for the engineering and research staff

enough to meet all requirements, and illustrating our readiness to help users solve specialized measurement problems. In contrast, the TF 1349 Test Set on p. 121, a product of the group responsible for microwave measurement, has been specifically designed for a single purpose—testing the side-lobe suppression characteristics of secondary surveillance radar equipment. This system of aircraft identification has progressed a long way from the I.F.F. of the war years and the author has therefore included a useful summary of the present capabilities of the system.

Research, although not a new activity at Marconi Instruments, has now been separated from the more practical side of engineering in order to concentrate on the broader aspects of instrumentation philosophy. Forward thinking is a primary function of the Research Department, so as to ensure that what the Engineering Department designs in the future is what the customer needs. But, of course the duties of the two departments overlap since it is neither practical nor desirable to confine the functions of creative thought to one department and practical circuit design to the other—the Research Department may well evolve a basic concept to the stage where a model can be demonstrated and the Engineering Department will continue to originate new techniques and develop existing ones.

The activities of the research engineers and physicists range wide—bringing both short- and long-term benefits to the performance and usability of our instruments. Quick results can be seen from their evaluation or initiation of new systems, circuits or devices. A practical problem now under investigation is the measurement of spurious signals from frequency synthesizers, and studies are also being made into new readout methods for oscilloscopes and trends such as programmable instrumentation. There will be emphasis on long-term research into basic methods of measurement and the evolution of improved Company standards of fundamental quantities at high frequencies which will be reflected in greater accuracy in instrument performance. It is also hoped to co-operate with other interested organizations in the setting up of national standards.

With an eye to future product policy the Research Department is investigating growing requirements in new fields that might lead to new instrument product lines. Information of this nature is vital to the manufacturer of electronic measuring instruments since these should always be a step ahead of general electronic progress both in time and performance so as to be able to fulfil their essential role of evaluating the research and development achievements in the industries we serve.

J. R. H.

MARCONI
 INSTRUMENTS

 NEW
 DESIGN

Double Beam Oscilloscope . . . TYPE TF 2202

 by J. D. JULIAN,
 D. HOULDCROFT
 and R. PIGOTT

The TF 2202 is a portable transistorized double beam oscilloscope of rugged panclimatic construction. Time and voltage measurement accuracy is 5% and calibration check facilities are built into both Y amplifier channels.

Battery or mains operation is provided for, and the instrument is stabilized against mains or battery voltage variations or surges. The modular plug-together construction gives excellent accessibility to all parts of the instrument and yet provides a very rigid and versatile arrangement whereby a rack mounted or bench version (TF 2202R or TF 2202 respectively) may be provided using the same standard parts and components.

THIS OSCILLOSCOPE is designed more as an oscilloscope system rather than one particular instrument. Being modular in construction to give maximum versatility it can be built in both portable or rack mounting form, using the maximum number of common parts. Basic units are a main frame, display unit, 'Y' amplifiers, time base and 'X' amplifier unit, trigger delay unit and power supply. The display unit, incorporating the supply switch and indicator, is a fixture to the main frame which also contains the 'Y' amplifier output circuits and the interconnecting leads and sockets for the various plug-in units. The 'Y' amplifiers are designed as customer plug-ins and allow for possible future performance variants to be fitted. Time base, trigger delay and power supply units are also plug-in and readily removable for servicing. Furthermore the construction allows for a wide range of variants in any one or more units, so that different instrument types can be built from the same piece parts.

The general ruggedized bump- and vibration-proof construction of the instrument, together with its portability, make it particularly well suited for field or mobile use under a wide variety of environmental conditions. On the portable version the main frame is designed to be splash- or shower-proof and a protection cover, containing the instruction book, is provided for the front panel. Storage space for mains and battery leads is provided on one side of the instrument, as shown in Fig. 1, and attached to the other side cover is a tray for storage of a probe and other accessories. Access to 'Z' modulation facilities is through a hole in this same side cover which is normally plugged by a rubber grommet to maintain shower proofing.

Extensive use of transistors has allowed a compact construction with only radiation and convection cooling being required. Particular attention has been paid to providing a wide range of facilities and yet maintaining a simple control presentation. Signal delay on both channels, trigger delay, beam locate button, one shot lock-out and rearm facilities as well as a preset CAL switch position on each gain control are provided. The front panel layout is subdivided into five sections by the

plug-in modular construction, each of these with its own controls provides a logical grouping of related functions.

Vertical Deflection System

The vertical deflection system used in this oscilloscope is basically a d.c. to 6 Mc/s amplifier. Apart from the first stage, which uses a valve, all other active elements in the amplifier are semiconductors, thus ensuring the ruggedness and reliability commensurate with the remainder of the instrument.

The valve in the amplifier is a double triode and each half is used as a cathode follower, the signal being applied to one grid and a d.c. balance potential to the other. As well as being an impedance transformer between the source under examination and the main amplifier stages, the valve also acts as a safety device in preventing the application of dangerously large signals to the semiconductors in the event of accidental misuse of the oscilloscope.

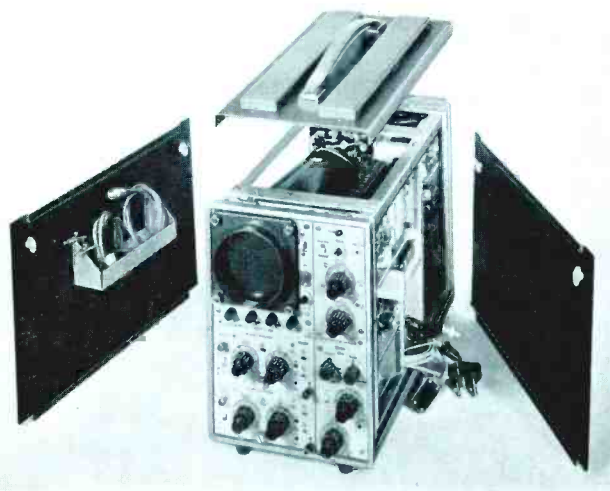


Fig. 1. Quick release side panels give immediate access to the lead stowage compartments and to all internal components

From the valve all stages of the amplifier are arranged in a balanced configuration, thus reducing d.c. drift and the effects of internal supply variations although, as will be shown later, the latter are practically negligible. In order to preserve the stability of the amplifier, the circuit configuration is arranged such that the gain is prescribed by the non-active elements, and variations due to changes in parameter of the active elements are of a low order.

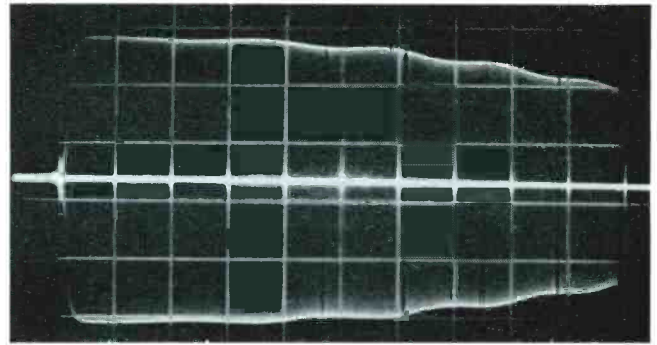
Critical examination of waveforms may be made by an oscilloscope, even though their rate of rise approaches that of the oscilloscope itself. Since it is often the section of the waveform which initiates the time base scanning generator that is of prime interest, it follows that the vertical deflection signal must be presented to the cathode ray tube delayed by the period of time that the time base generator requires to commence its scan. This is achieved by inserting a signal delay section comprising a suitably matched coaxial delay line between the cathode follower and the remainder of the amplifier. Since the signal at this point only appears on one side of the amplifier, only one section of line is required thus eliminating delay equalization problems. The signal for triggering the time base generator is taken from the output of the cathode follower before the gain and shift controls—other than the input attenuator—which therefore have no effect on triggering.

Amplification proper takes place in two stages, with isolating stages between them. Gain and shift controls are incorporated in the first of these stages, the latter being so arranged that under any conditions of signal and shift both the amplifier stages are always in a balanced condition when the spot lies on the centre line of the screen, thus minimizing frequency response variations with shift. The output stage is directly coupled to the tube plates and frequency compensation is achieved inductively in the collector load ensuring full screen deflection up to the amplifier cut-off frequency.

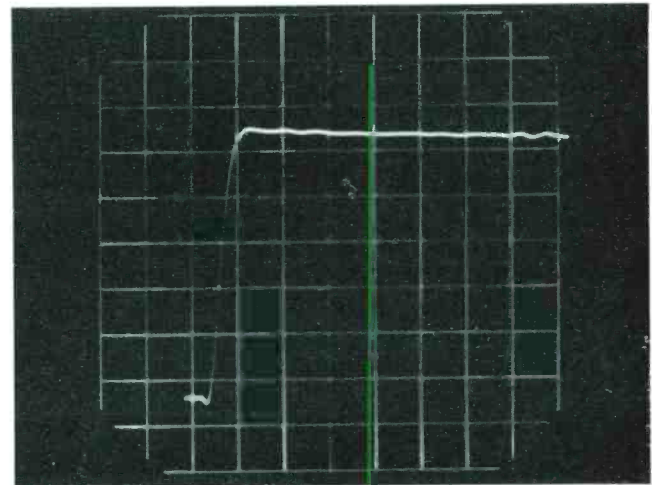
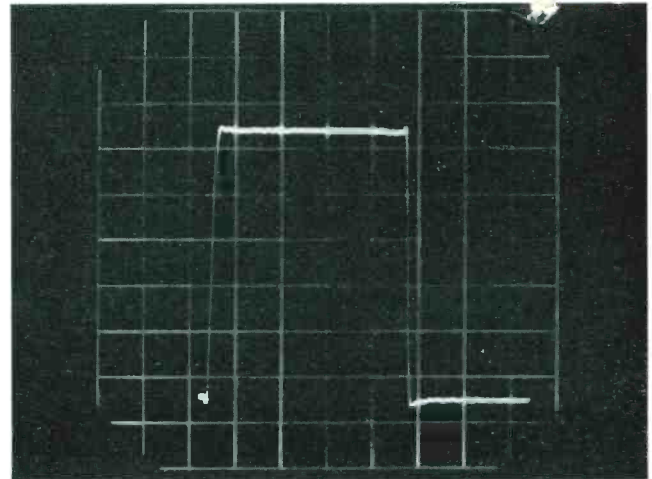
Extra sensitivity with reduced frequency response is provided and is selected by a front panel control switch. When this facility is used the degraded rise time of the oscilloscope does not warrant the signal delay required with the 6 Mc/s amplifier. The delay cable is therefore removed from circuit and a single stage balanced pre-amplifier substituted. Two high sensitivity ranges are provided and are obtained by varying the degeneration in this preamplifier section. When the preamplifier stage is in use, the trigger pick-off signal is taken from its output in order to boost the trigger signal applied to the trigger amplifier.

Prior to the cathode follower an eleven-step two-stage attenuator is incorporated enabling a wide range of input signals to be investigated. One position on the attenuator switch provides for a square waveform of known amplitude, generated in the power supply sub-assembly, to be applied to the amplifier so that the gain may be standardized.

Physically the Y deflection amplifier is divided into two sections, the output amplification stage which is incorporated in the main frame of the oscilloscope and the main 'Y' amplifier and preamplifier which are in-



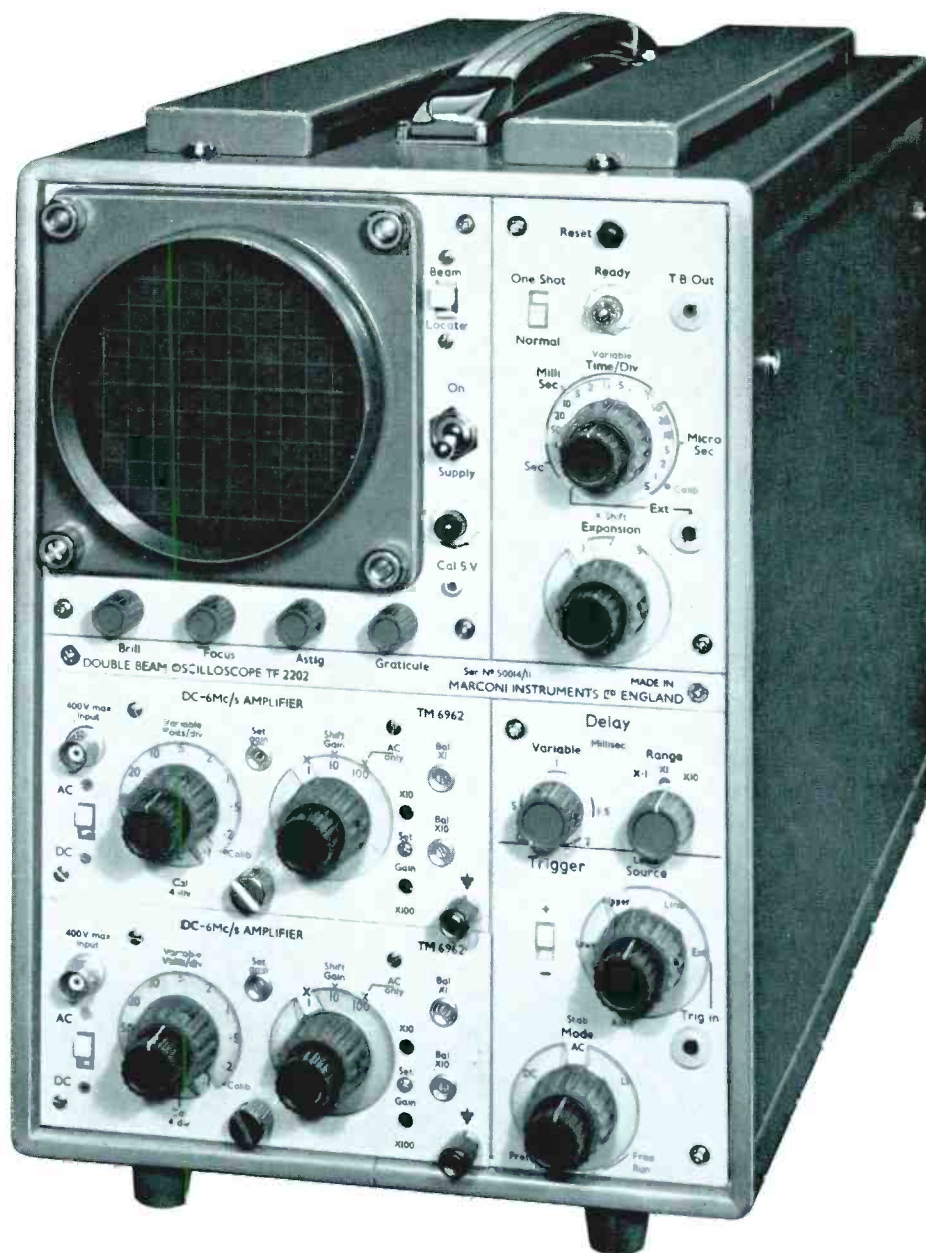
Sweep frequency technique shows the overall Y response of the oscilloscope up to 6.5 Mc/s at a sensitivity of 100 mV/div— $\times 1$ gain



*Response of the oscilloscope to an ideal pulse displayed at 100 mV/div sensitivity and 500 nsec/div timebase speed
Above: $\times 1$ expansion
Below: $\times 5$ expansion*

corporated in the plug-in unit. This system enables a variety of plug-in units to be designed for the oscilloscope without the need for duplicating the tube driving stage.

TF 2202 in bench mounting form showing the neat arrangement of Y controls at lower left, X controls at upper right, trigger and delay controls at lower right



Trigger and Delay Unit

Signals from either amplifier (UPPER or LOWER), the mains supply (LINE) when mains operated, or from an external source may be selected by the trigger source switch for the purposes of triggering the time base as shown in Fig. 2. A three position MODE switch marked D.C., A.C., L.F., determines the coupling of the input signal. In the L.F. position a.c. coupling is used and an integrating network is added to the circuit. This gives a useful facility when triggering from l.f. signals in the presence of h.f. noise or transients or when it is wanted to trigger from the field pulses in a TV waveform. The circuitry employed in the trigger and delay unit is fairly conventional as is shown by the block schematic in Fig. 2.

A protection circuit is provided at the input of the trigger circuit by a diode clipping arrangement against

accidental misuse or overload; this is followed by an emitter follower stage to maintain a reasonable input impedance and minimize loading. The trigger amplifier phase inverter stage following this provides for polarity and level selection of the trigger pulse relative to the input signal.

This is followed by a Schmitt type of circuit arrangement which can be modified to free-run by the AUTO switched positions of the LEVEL control. In the AUTO position a base reference line is provided at a low repetition rate on the 'X' axis of the cathode ray tube screen and yet automatic lock-in is possible to any incoming signal over a wide range of amplitude and frequencies. The wide range of input over which this AUTO circuit operates makes it extremely useful and for most purposes it is sufficient to use the AUTO position of the level control in conjunction with the PRESET position

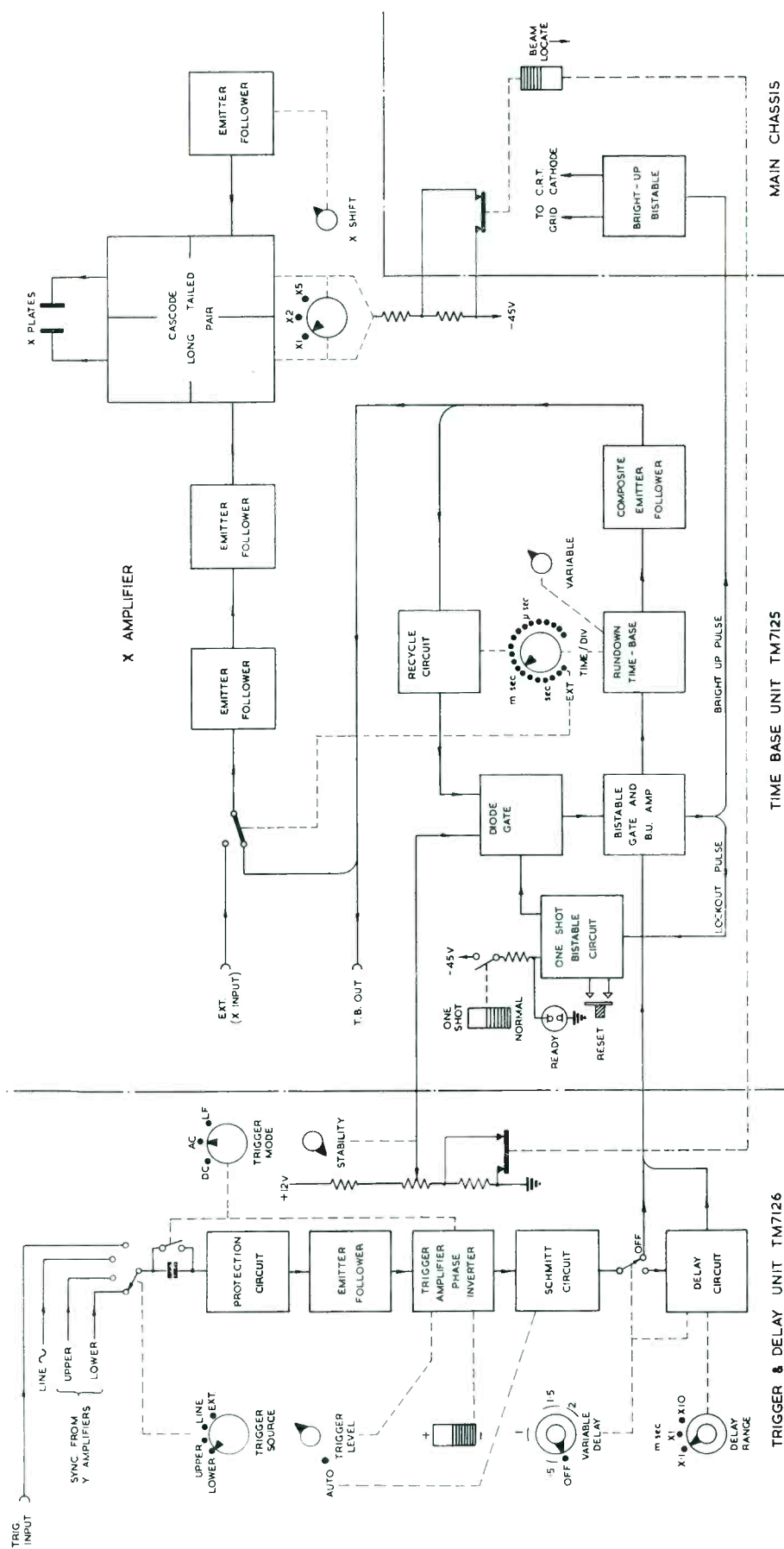
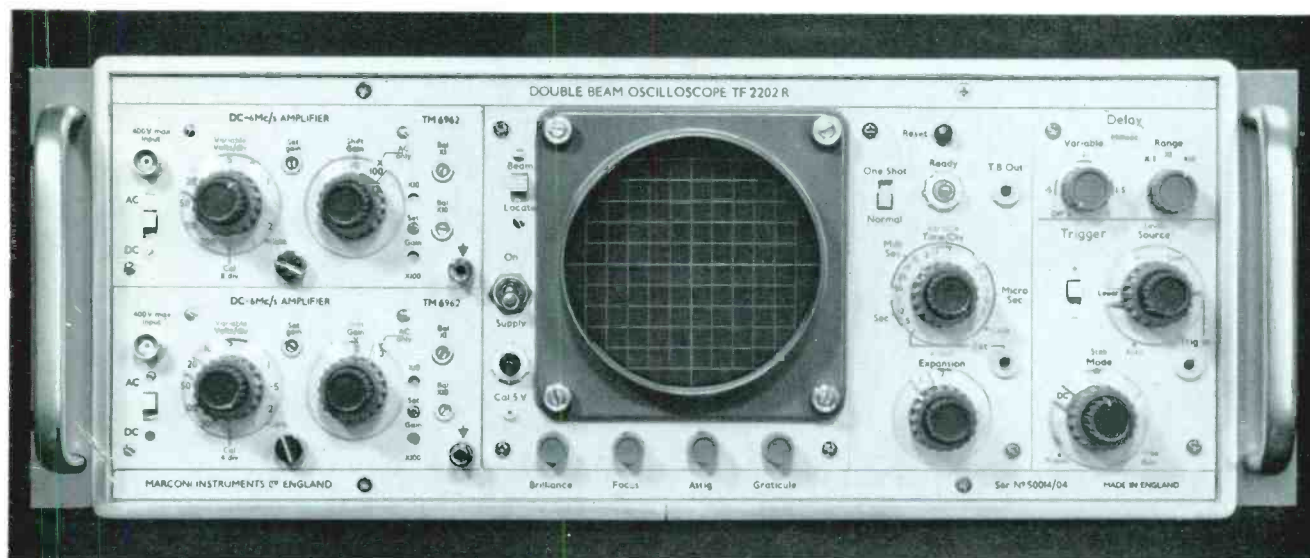


Fig. 2. Block schematic diagram of X deflection stages



In TF 2202R the units are rearranged to form a rack mounting instrument

of the STABILITY control. Either or both controls may however be brought into action as required for more exacting signal conditions. The STABILITY control when advanced to the FREE-RUN position allows the time base to free run and can be used to advantage when synchronizing on frequencies above 6 Mc/s.

A continuously variable trigger delay arrangement is provided which allows a maximum of 20 msec delay with respect to an incoming trigger pulse and the commencement of a time base sweep. The circuit arrangement used for the delay generator consists of a variable amplitude sawtooth generator of the constant current type, coupled to a multivibrator which shapes the pulses required to trigger the time base. Delay is proportional to sawtooth amplitude and this is controlled by the setting of the DELAY VARIABLE control.

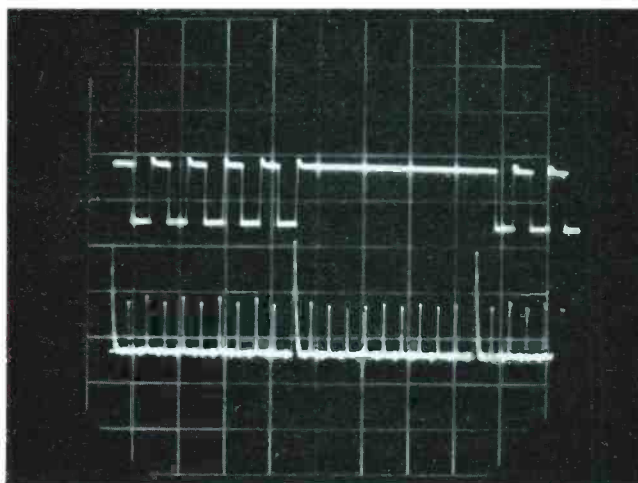
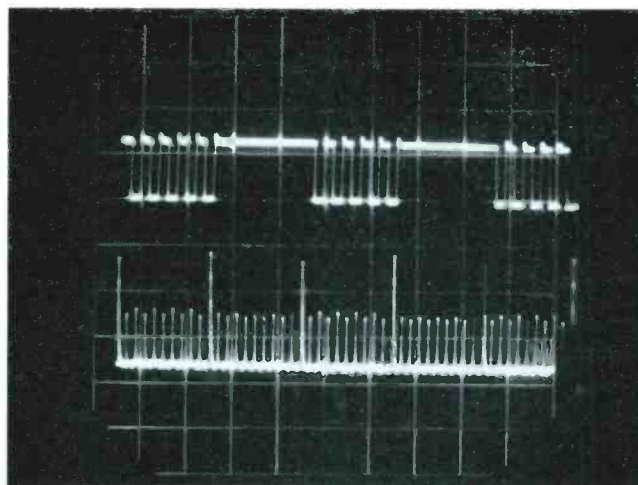
The Trigger and Delay Unit module is self-contained and all connections are through plugs and sockets; the unit can be removed by removing the two retaining screws on the front panel.

Time Base and X Amplifier

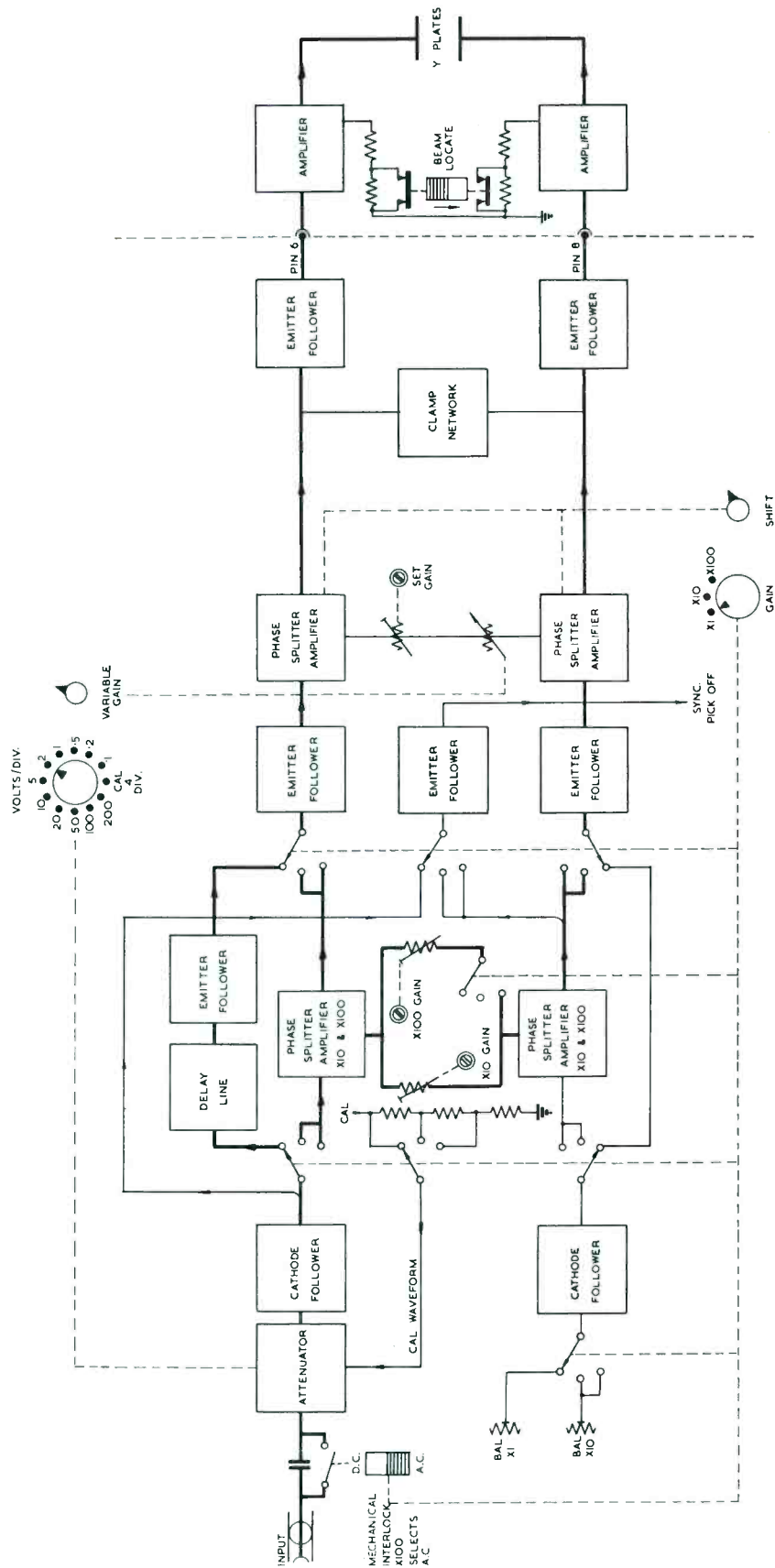
The sawtooth generator arrangement chosen for the time base is of the constant current type which, in conjunction with a special composite emitter follower arrangement, provides an extremely linear run-down sawtooth of some 20 V amplitude. This sawtooth is available at the front panel for external use a.c. coupled through a blocking capacitor.

One-shot lock-out and rearm facilities are provided by a bistable arrangement coupled into a diode gate and bistable gate drive circuits, see block schematic Fig. 3. The circuit can be brought into action by the ONE-SHOT NORMAL switch as and when required, this facility can be particularly useful for the photographic recording of transient or once-only phenomena.

19 time base ranges are provided together with $\times 1$, $\times 2$, and $\times 5$ expansion on the 'X' amplifier and a



Waveforms from a time base calibrating generator show the high linearity of the time base and, below, the effect of $\times 2$ expansion



MAIN CHASSIS

6Mc/s AMPLIFIER TYPE TM6962

Fig. 3. Block schematic diagram of Y deflection stages

variable control giving continuous cover between ranges. This gives a total range of 1.25 sec/div to 0.1 μ sec/div.

The 'X' amplifier consists mainly of two cascode stages coupled together in a long-tailed pair configuration with the gain or expansion control coupled into the common emitters. On external operation the amplifier gives a basic sensitivity of about 4V/div at $\times 1$ expansion.

The whole of the time base and 'X' amplifier arrangement is completely transistorized and self-contained in a modular constructed sub-unit. All connections in and out are via plugs and sockets and the unit is easily removable from the front panel by removing the two retaining screws.

Power Supply

The power unit enables the instrument to be driven either from a.c. mains or from batteries. Selection of the mode of operation is achieved by plugging the correct input lead to the input socket of the instrument. In order to supply the various voltage lines required for the oscilloscope when running from batteries, the input voltage is stabilized by a transistor stabilizer of the series type. The voltage so derived is converted to a square

wave by a transistor converter, this being applied to the primary of the main distribution transformer. The voltages available from the secondary windings of this transformer are rectified and smoothed before being distributed.

When the instrument is run on a.c. mains the supply is first transformed to a low voltage by means of a second transformer, rectified and smoothed, and then passed to the transistor stabilizer, as in battery operation. This type of power supply with a square waveform converter operating at a relatively high frequency results in the distribution transformer and individual line smoothing components being reduced to a small physical size.

The power unit sub-assembly also contains the calibration waveform generator. This derives a signal from one of the secondary windings of the high frequency supply transformer and shapes this to an improved square wave the amplitude of which is limited to an accurately maintained value. The output from this generator is supplied to both 'Y' deflection amplifiers and also to a socket on the front panel where it is available for calibrating other equipment or for the standardization of probes used with the instrument.

ABRIDGED SPECIFICATION

Display

Double-beam 4 in. flat-faced cathode ray tube.

Y Amplifiers— $\times 1$ Gain

BANDWIDTH: D.C. to 6 Mc/s or 5 c/s to 6 Mc/s.

RISETIME: Less than 55 nsec.

OVERSHOOT: Less than 2%.

SENSITIVITY: 100 mV/div. to 200 V/div. in 1-2-5 sequence (1 div. equals 8 mm.)

Y Amplifiers—High Gain

BANDWIDTH: $\times 10$: d.c. to 500 kc/s.
 $\times 100$: 15 c/s to 250 kc/s.

Vertical Deflection Facilities

VOLTAGE MEASUREMENT: By calibrated graticule.

Accuracy: $\pm 5\%$.

SIGNAL DELAY: Nominally 380 nsec.

CALIBRATION: Built-in calibrating source for $\times 1$, $\times 10$, and $\times 100$ GAIN range check.

INPUT IMPEDANCE: 1 M Ω shunted by 40 pF.

Trigger Amplifier

Triggers from internal, external, or supply frequency sources; positive or negative polarity.

SENSITIVITY:

Internal: 1 div of displayed waveform.

External: 1 V p-p.

INPUT IMPEDANCE: 80 k Ω shunted by 10 pF.

DELAY: 3 ranges: 0-200 μ sec, 0-2 msec, 0-20 msec.

Time Base

The time base will operate repetitively, triggered, auto-triggered, or with single shot lock-out facilities.

RANGE: 0.5 μ sec/div. to 0.5 sec/div. in 1-2-5 sequence with variable control extending slowest sweep velocity to 1.25 sec/div.

X EXPANSION: Three switched positions of 1, 2 and 5, extending the fastest sweep velocity to 0.1 μ sec/div.

TIME MEASUREMENT: By calibrated graticule.

Accuracy: $\pm 5\%$.

T B OUTPUT: A.C. coupled; normally 20 V p-p.

X Amplifier

BANDWIDTH: D.C. to 1 Mc/s.

SENSITIVITY: Nominally 4.5 V/div. at $\times 1$ expansion.

INPUT IMPEDANCE: 125 k Ω shunted by 20 pF.

Calibrator

Squarewave available on front panel for adjustment of probes. 5 V p-p $\pm 1\%$ at approximately 2 kc/s.

Z Modulation

Input requirements, 10 to 15 V p-p.

Power Supplies

196 to 264 V a.c., or 98 to 132 V a.c.; 110 W. Or 21.6 to 29 V d.c.; 80 W.

BINDER REMINDER

A NEAT BINDER to contain copies of Volumes 8 and 9 of *Marconi Instrumentation* has now been made available so that readers and librarians may keep copies of the bulletin in a convenient form for reference. It is bound in red rexine and copies can be inserted without punching and opened flat. These binders are available at a cost of 12s. each, post free. To simplify the transaction please send remittances when ordering.

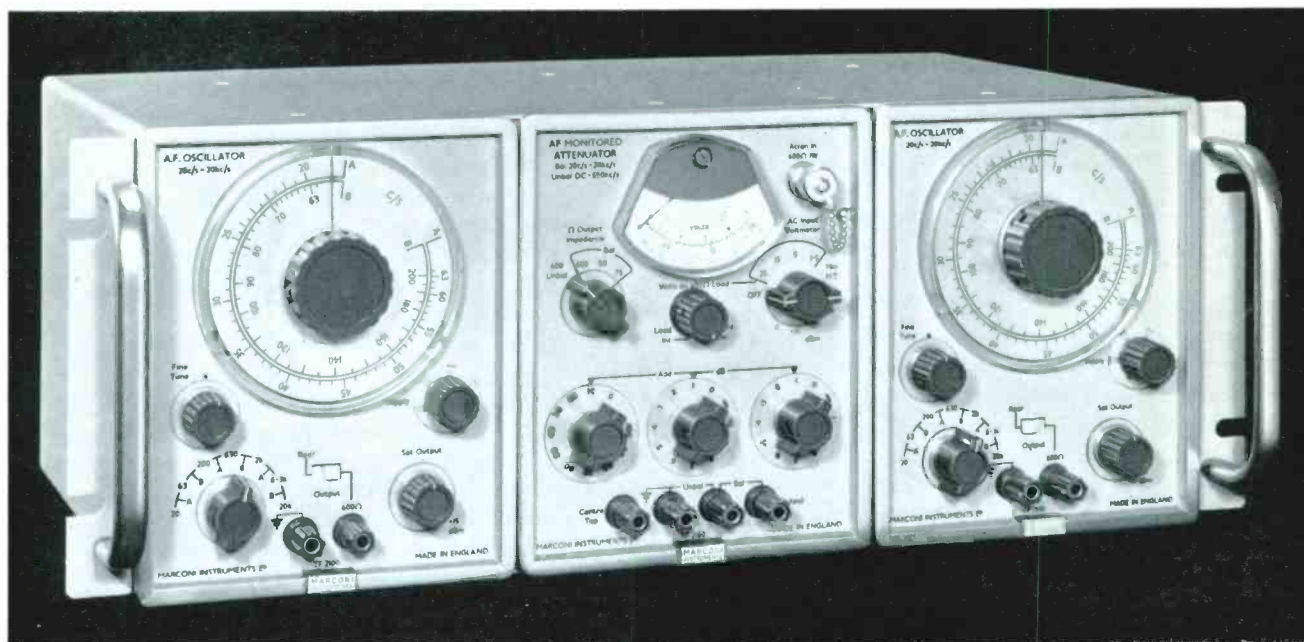


Fig. 1. Two Tone Signal Source Type TF 2005R

A.F. Two Tone Signal Source

by
M. F. STANLEY
and
M. J. TANT,
B.Sc., A.C.G.I.,
Graduate I.E.E.

A complete signal source for intermodulation testing is described. It consists of two A.F. Oscillators type TF 2100 and one A.F. Monitored Attenuator type TF 2160/1M1 assembled in a rack mounting case. Two separate tones are available in the range 20 c/s to 20 kc/s and inherent intermodulation is better than 80 dB down on either tone. An application of the instrument is given for intermodulation testing of a single sideband transmitter.

IN A PREVIOUS ISSUE of *Instrumentation*¹ the ability of our new modular range to cater for specialized customer requirements has been described. A need has recently arisen for a two tone a.f. signal source for intermodulation testing. This requirement is met by assembling two TF 2100 A.F. Oscillators and a TF 2160/1M1 A.F. Monitored Attenuator into a TM 7010, Rack Mounting Case. The complete assembly is shown in Fig. 1.

The first section of this article describes the operation of the equipment. This is followed by an assessment of the inherent intermodulation caused by the paralleling of the two A.F. Oscillators. In conclusion, an application of the instrument is shown for intermodulation testing of a single sideband transmitter.

Operation

The Oscillators may be brought into circuit independently, by use of the existing output switches situated above the front panel terminals of each Oscillator.

Because the two Oscillators are connected directly in

parallel it is necessary when setting the output level of one to simulate the shunt impedance of the other. This is done by making use of the fact that the Attenuator internal load resistor when switched in with zero attenuation appears directly across the attenuator input.

The procedure for setting the output level is as follows:

- (1) Disconnect the two tone source from the load under test.
- (2) Turn the termination switch to LOAD INT.
- (3) Turn the attenuator switches to 0 dB.
- (4) Connect one Oscillator only to the Attenuator by pressing the output switch of one Oscillator to the position marked REAR, and the other output switch to the position marked OUTPUT.
- (5) The Oscillator that is connected may now be set to the desired level, as indicated by the input voltmeter of the attenuator.

- (6) Interchange the oscillators by reversing the settings of both the output switches and adjust the output level of the other oscillator. Now connect both oscillators by pressing both output switches to REAR and disconnect the internal load by turning the termination switch to LOAD EXT.

The output impedance of the signal source with no attenuation will be that of two Oscillators in parallel, i.e. $300\ \Omega$, and the open circuit voltage levels at the output will be as set up in (5) and (6) above. If the attenuator is inserted, the input voltage to the attenuator will be reduced to two thirds of the initial value, providing that it is fed into a matched load. The attenuator may thus be used in the normal manner, as indicated by the following example:

To obtain two tones, each at 1 mV, matched into a $600\ \Omega$ external load.

Carry out operations (1) to (6), setting each Oscillator to give an indicated level of 1.5 V.

Set the Attenuator to 60 dB, whereupon the input voltage to the Attenuator will be $1.5\text{ V} \times \frac{2}{3} = 1\text{ V}$, for each tone, and the output voltage will be 60 dB down on 1 V, or 1 mV, for each tone, with external matched load.

The output impedance of the two-tone signal source will, in fact, appear as that indicated by the output impedance switch, for all settings of the Attenuator greater than 10 dB.

When it is desired to use the instrument as a single tone signal source the Oscillator not in use should be disconnected, either by pressing the OUTPUT/REAR switch to OUTPUT, or by breaking the plug and socket connection at the rear. If this precaution is not taken, and the unwanted Oscillator simply switched off, it will remain as a nonlinear load across the output of the Oscillator in use, giving rise to distortion.

Inherent Intermodulation

Mention has been made in a previous *Instrumentation*² article, of the extremely good output linearity of the A.F. Oscillator. This results from the very low output impedance of the Oscillator itself, which is further buffered from external loading by a $600\ \Omega$ series resistor and a $600\ \Omega$ T pad, thus enabling two A.F. Oscillators to be connected directly in parallel with very low resultant intermodulation between them.

Inherent intermodulation terms of better than 80 dB down on either signal are obtained, while no part of the individual module specification is impaired. As intermodulation testing is such a searching criterion for distortion measurements, the very low inherent intermodulation of this equipment allows for the testing of high quality a.f. recording, transmission and reproduction systems.

It was found that normal wave analyser techniques did not allow sufficient sensitivity to substantiate the above claim of 80 dB. Recourse has therefore been made to band stop filter networks to achieve the necessary increase in sensitivity.

A description of measurement of the inherent intermodulation due to four typical sets of test tones now follows. Two examples each of the S.M.P.T.E. and the C.C.I.F.³ methods are quoted.

S.M.P.T.E.

Briefly, the tones used are related in amplitude by the ratio 4 to 1, the larger amplitude signal being of low frequency, and the smaller signal being above 1 kc/s. Intermodulation between the two tones results in amplitude modulation of the higher frequency tone by the low frequency tone.

Measurement of intermodulation between two tones at 425 c/s and 2 kc/s, rejecting the 425 c/s tone, with a band-stop filter, has shown no intermodulation terms worse than 100 dB down on the 2 kc/s tone. These frequencies have been chosen as suitable for speech transmission systems, typically of bandwidth 300 c/s to 3 kc/s.

The test has been repeated for tones at 100 c/s and 5 kc/s, as suitable for the testing of a.f. amplifiers and no intermodulation terms could be detected, although the Wave Analyser with filter was capable of resolving 100 c/s sidebands of the 5 kc/s tone down to -90 dB. So, any intermodulation terms present are better than 90 dB down.

C.C.I.F.

In this method, two tones equal in amplitude and relatively close in frequency are used, and the resulting intermodulation terms occur at the sum and difference frequencies of these tones and their harmonics.

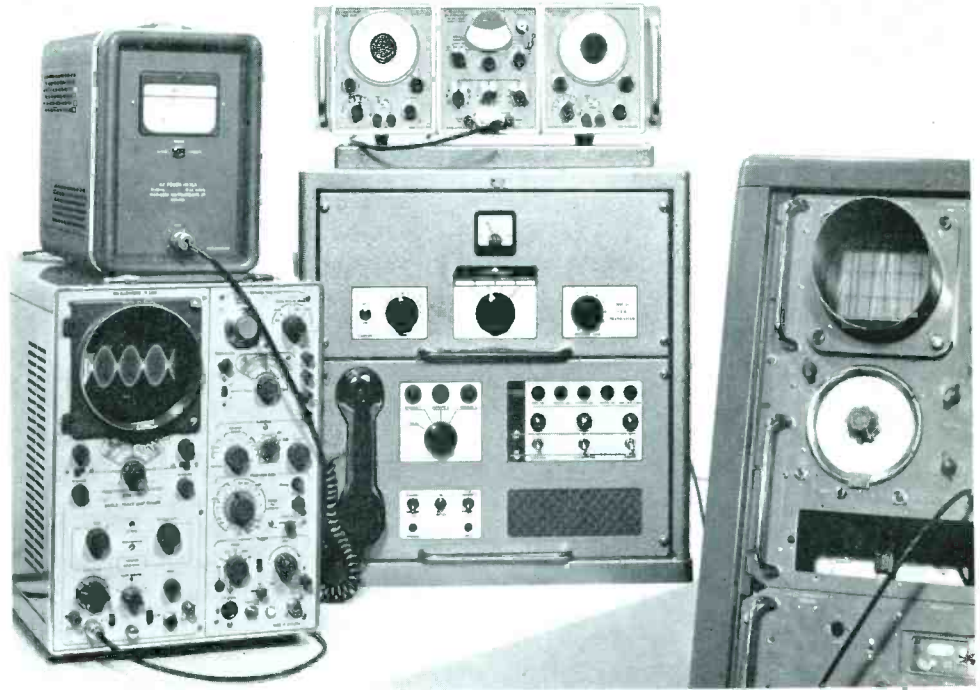
Measurement of inherent intermodulation for two tones at 9 kc/s and 10 kc/s, as typical for beat note distortion testing of a.f. amplifiers, has shown intermodulation terms better than 100 dB down on either tone. When two equal tones at 1.1 kc/s and 1.775 kc/s were used the resultant intermodulation terms were again better than 100 dB down on either tone. The seemingly odd frequencies of 1.1 kc/s and 1.775 kc/s, find use in intermodulation testing of i.s.b. and s.s.b. systems. The terms resulting from modulation distortion occur at different frequencies from those due to power amplifier distortion, only odd order terms of which appear within the transmitted sideband and also, as spill over, into the forbidden sidebands.

Transmitter Test

The bandwidth conservation potentialities of i.s.b. and s.s.b. systems depend upon the linearity of the transmitter networks, maladjustments of which can cause additional frequency components to appear in the forbidden sideband, as well as distortion terms in the transmitted sideband.

Intermodulation occurs between pairs of sidebands in an i.s.b. or s.s.b. system with carrier suppressed. The only terms which are transmitted, however, are those which fall within the pass band of the tuned power

Fig. 2. Equipment used for two tone testing of a Marconi S.S.B. Transmitter/Receiver type HSR 21 consists of TF 2200 Oscilloscope, TF 1020A R.F. Power Meter, the Two Tone Signal Source, and OA 1094A Spectrum Analyser



amplifier, and the frequencies of these terms are given by equations 1 and 2 for lower sideband transmission.

$$\text{Frequency of intermodulation term} = (n+1)(f_c - f_1) - n(f_c - f_2) \dots\dots\dots 1$$

$$\text{Frequency of intermodulation term} = (n+1)(f_c - f_2) - n(f_c - f_1) \dots\dots\dots 2$$

Where:

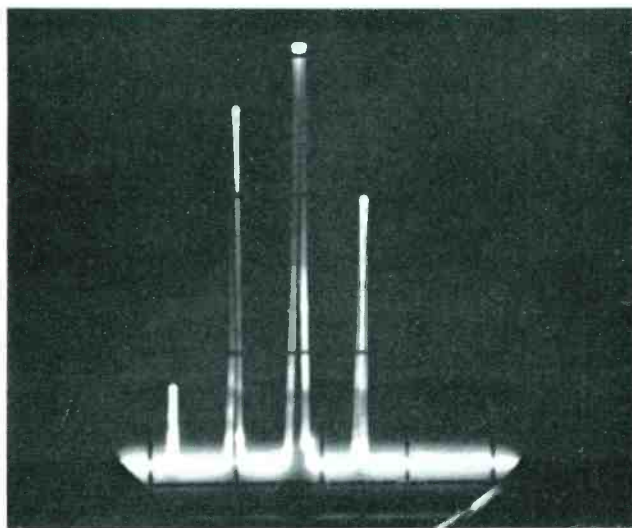
f_c = carrier frequency

f_1 and f_2 = test tone frequencies.

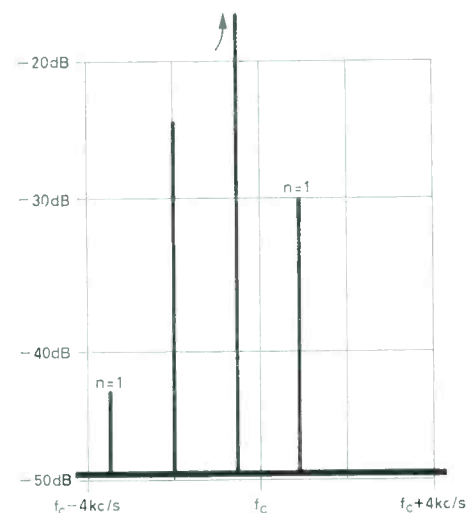
and $(2n+1)$ is the order of the distortion term in the power series representation of the transmitter transfer characteristic. Equations 1 and 2 may be re-written as follows:

$$\text{Frequency of intermodulation term} = f_c + n(f_2 - f_1) - f_1 \dots\dots\dots 3$$

$$\text{Frequency of intermodulation term} = f_c - n(f_2 - f_1) - f_2 \dots\dots\dots 4$$

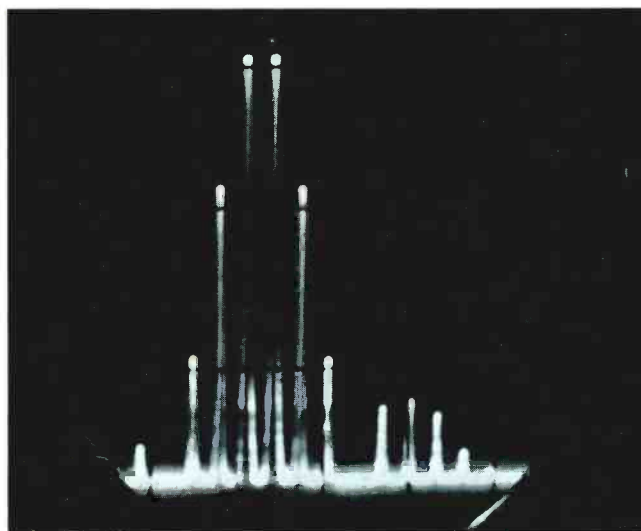


Oscillogram

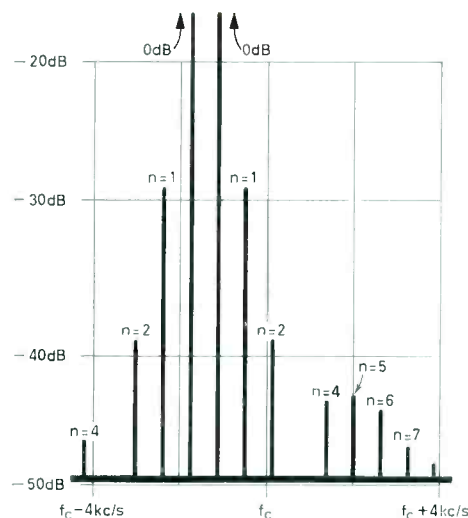


Idealized

Fig. 3. Transmitter output, with two tone modulation at 425 c/s and 2 kc/s, carrier suppressed, as viewed on OA 1094A Spectrum Analyser at 10 kc/s sweep width and 3 sec sweep time



Oscillogram



Idealized

Fig. 4. Transmitter output, with two tone modulation at 1.1 kc/s and 1.775 kc/s, carrier suppressed, as viewed on OA 1094A Spectrum Analyser at 10 kc/s sweep width and 3 sec sweep time

From equation 3 it can be seen that, for $n(f_2 - f_1)$ greater than f_1 , the distortion occurs in the forbidden sideband, and as distortion in the transmitted sideband for $n(f_2 - f_1)$ less than f_1 . Equation 4 results in distortion in the transmitted sideband.

Two tone tests have been made on an s.s.b. transmitter, the arrangement of which is shown in Fig. 2. Both the C.C.I.F. and the S.M.P.T.E. methods were used, and the transmitter output monitored on an OA 1094A Spectrum Analyser.

Fig. 3 illustrates the transmitter output with two tone modulation at 425 c/s and 2 kc/s using the S.M.P.T.E. method. The carrier is suppressed and coincident with the centre vertical graticule. Intermodulation terms can be seen at 3.575 kc/s below the carrier and 1.15 kc/s above it. These two terms correspond to third order distortion and may be derived from equations 3 and 4 for $n=1$.

Fig. 4 illustrates the transmitter output with two tone modulation at 1.1 kc/s and 1.775 kc/s using the C.F.C.I.

method. The carrier is suppressed and coincident with the centre vertical graticule. Intermodulation terms corresponding to $n=1, 2$ and 4 can be seen in the lower sideband, and terms corresponding to $n=1, 2, 4, 5, 6$ and 7 may be seen in the upper forbidden sideband.

The transmitter was operating under similar conditions for each test, and comparison of Figs. 3 and 4 shows that higher order terms are observable in the C.C.I.F. method than in the S.M.P.T.E. method.

This test procedure formed the basis of the original requirement for a two tone signal source, and it is in common usage as a fast and searching technique for evaluating transmitter linearity.

REFERENCES

1. Cain, W. D., 'Modular Electronic Instruments', *Marconi Instrumentation*, June 1963, 9, p. 25.
2. Sargent, L. M., 'A.F. Oscillator Type 2100', *Ibid.*, p. 28.
3. Waddington, D. E. O'N., 'Distortion Measurement in Audio Amplifiers', *Ibid.*, December 1963, 9, p. 79.

ABRIDGED SPECIFICATION

Oscillators (Two identical units)

FREQUENCY RANGE: 20 c/s to 20 kc/s in six bands. Each oscillator can be adjusted independently.

AMPLITUDE:

Reference level: Up to +10 dBm from each oscillator independently.

Attenuation range: 111 dB in 0.1 dB steps.

Spurious Signals

HARMONIC DISTORTION: Less than 0.05% between 63 c/s and 6.3 kc/s when using unbalanced output.

Generally less than 0.1% under other conditions.

INTERMODULATION: Below -80 dB with respect to the signals.

HUM: Below -80 dB with respect to the signals.

SPECIAL VERSIONS OF COUNTER/FREQUENCY METER TF 1417/2

by M. W. G. HALL,
A.M.Brit.I.R.E.

Six modified versions of the 10 Mc/s Counter/Frequency Meter have been produced to suit special applications. The additional facilities offered include multi-period measurement, multi-period frequency ratio measurement, fast sampling and increased accuracy for time measurement.

The TF 1417/2 is a fully transistorised 10 Mc/s Counter/Frequency Meter of extreme versatility¹. To enable this instrument to meet certain users' specialised requirements the following series of modified versions has been evolved.

- TF 1417/4M1** Allows 10 period averaging for increased accuracy in period measurement.
- TF 1417/5M1**
 1. Input 'A' modified to have an input impedance of 1 M Ω .
 2. Inputs 'B' and 'C' provided with a means of identifying the trigger-level control setting.
- TF 1417/6M1** Has facility 1 of TF 1417/5M1.
- TF 1417/7M1** Has facility 2 of TF 1417/5M1.
- TF 1417/8M1** Allows multi-period frequency ratio measurements.
- TF 1417/9M1** Fast sampling version.

A more detailed description of each variant and its application is now considered.

TF 1417/4M1. The FUNCTION switch may be set to a position labelled PERIOD B. A signal applied to input socket B then operates the main gate after being suitably squared and amplified. The counter displays the number of timing units derived from the internal time base

timing divider chain which occur within the period of the input waveform. The indication is in the units selected on the FREQUENCY-TIME control, i.e. seconds, milliseconds or microseconds.

The specified accuracy for period measurement is 0.03% to 0.3% depending upon input level. This possible error, which is due to hysteresis in the level at which triggering occurs, can be reduced by making the measurement over several periods. This can conveniently be done by dividing the input frequency in otherwise unused decade counting units (D.C.U.) of the time base divider chain, since the largest timing units will not be required.

To perform this function it is required that the output of the B input amplifier is switched from the main gate circuit to the input to the 0.1 c/s D.C.U. (which has been disconnected from the 1.0 c/s D.C.U.). The output from the 0.1 c/s D.C.U. is then switched to operate the main gate. The switching is performed by AND/OR diode gate logic as shown in Fig. 1. Amplifiers are included to sharpen rise-times and restore the loss of amplitude incurred in passing through the diode gates.

TF 1417/5M1. For certain nucleonics measurements it was required to be able to measure the time interval between defined points on a waveform. In addition, an input impedance of approximately 1 M Ω was required on the A input channel.

One solution to the latter problem is the insertion of a cathode follower between the attenuator and the input amplifier unit. Although this move involves a departure from the all-solid state concept of the counter the present availability of small, rugged, low consumption valves and the existence within the instrument of suitable supplies indicated such a course. A triode was therefore mounted close to the A input socket. The attenuator components were changed to provide the desired input impedance of 1 M Ω and the trigger-level control, normally arranged to be centred about zero potential, was re-arranged to centre at approximately 1 V, the quiescent potential of the valve cathode.

Since the TF 1417/2 does not possess trigger level controls which could readily be calibrated it was decided that another system must be chosen to provide accurate indication of the triggering level. The pulses in question were to be viewed on an oscilloscope and so the operation of the trigger was used to produce a "bright-up" pulse. The output from the trigger amplifier board

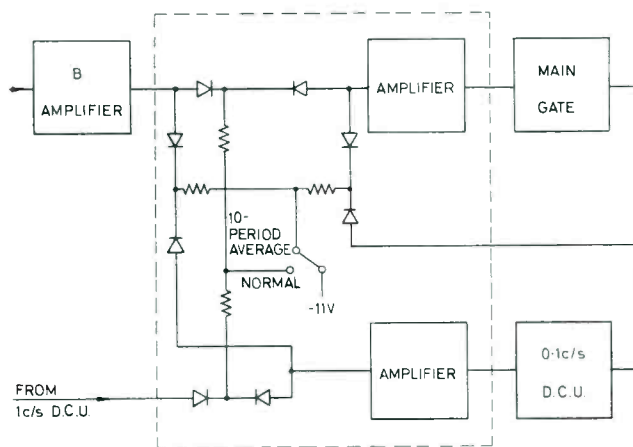


Fig. 1. Block schematic diagram of switching circuit of TF 1417/4M1

Many counters are put to many uses on land but at least one has gone to sea and is being used on fishery research so that trawlers like the Bryher, of Lowestoft, can net the best possible catch



is a square wave derived from a Schmitt circuit. As described in the earlier article¹ the mark/space ratio may be varied by adjustment of the trigger level control, the leading edge being coincident with the triggering event. This square wave is differentiated and, after amplification, gives either positive or negative going pulses of approximately 3 μ sec half amplitude duration at a socket on the rear of the instrument for direct connection to the oscilloscope.

Many oscilloscopes, such as the Marconi Instruments type TF 1331, require some 10 V peak of negative going signal to provide adequate trace brightening. On the other hand, more sophisticated oscilloscopes possess a bright-up amplifier and these, of which the TF 2200 is an example, require a signal of approximately 3 V peak of positive polarity. Either output may be obtained, as desired, by the alteration of one connection.

TF 1417/6M1 and **TF 1417/7M1** are, as previously stated, versions containing only the high impedance input or bright-up modifications respectively.

TF 1417/8M1. An account² has recently been published of a system for the measurement of signals and narrow band noise at low frequencies. The method employs an oscilloscope which is arranged to scan only in the Y direction via a direct-coupled amplifier. A ruled grating is placed in front of the cathode-ray tube screen so that the light output is modulated as the spot is deflected. A photo-multiplier tube collects the emitted light and provides a signal which may be fed to the counter.

It is required to measure the ratio of the number of output cycles from the photo-tube in a given number of cycles of the input function. The standard instrument has the ability to measure the ratio of two inputs, but for

multi-period frequency ratio measurement it is necessary to provide a method whereby one function may be divided by 10, 100 etc. to provide a suitable gating period. This may be done by utilising the existing chain of time base decade counter units.

This will enable the user to select divisions of 10^1 , 10^2 etc. to 10^7 . The C input amplifier may be used to amplify the input which is to determine the gating period and also to shape it so that it is suitable to drive the divider binaries. The necessary switching to obtain this new function with its consequent re-routing of signals and alteration to the manner of operation the gate drive circuitry is achieved by further use of the d.c. controlled diode gate switching, a feature of the TF 1417 series. Fig. 2 shows the circuit in block diagram form.

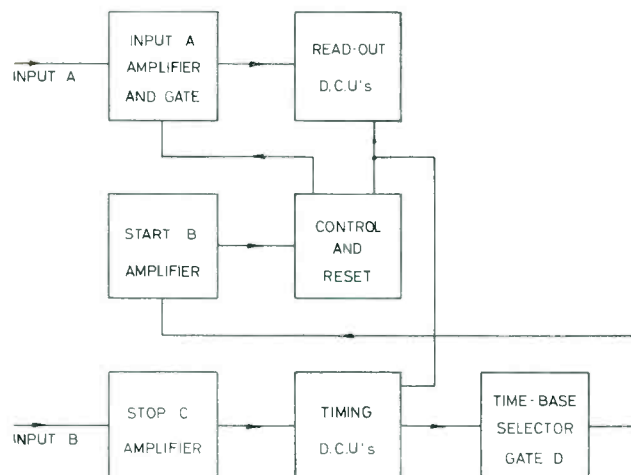


Fig. 2. Block schematic diagram of TF 1417/8M1

This modification also permits multi-period measurements in 0.1 μ sec timing units when the controls are set so that the FUNCTION switch is at TEST and the multi-period facility is selected by its controlling toggle switch. Again, periods from 10 to 10^7 may be counted.

TF 1417/9M1. The TF 1417/2 provides an output at a rear mounted multi-way socket which is in 4 wire 1-2-4-8 weighted binary decimal code. This is primarily intended for printer drive, but since it is an instantaneous indication of the quantity counted it immediately suggests programming, or recording by processes other than conventional electro-mechanical printers.

For measurements at a radio star observatory it was required to provide the fastest possible sampling with the recording to be carried out on magnetic tape. This has been achieved by minor changes to the control circuitry and by arranging that it is not necessary to wait more than about 30 msec before a new counting sequence is initiated by an output from the selected time base d.c.u.

On the standard version the final and penultimate timing d.c.u.'s are connected so as to reset to 9 by means of the same reset pulses that are used to clear the read-out to zero. This normally means that the first output pulse from the previous d.c.u. (10 c/s) will immediately produce an output from each of the succeeding units, apart from the delay inherent in the circuit. However, it is possible that the 10 c/s d.c.u. may have to 'fill up' before it can trigger the following units. This means a wait of 100 msec. It was found that the maximum time saving which could be obtained was to arrange for this unit to reset to 8, otherwise the first time base pulse occurred before the end of the delay imposed by other circuitry which cannot conveniently be modified. The delay is approximately 15 msec, which will be the approximate minimum re-cycling time for short gate times. It increases to approximately 30 msec at the longest gate time with the addition of the delay in obtaining a time base pulse.

REFERENCES

1. Ostler, R. I., 'Counter/Frequency Meter Type TF1417/2', *Marconi Instrumentation*, December 1963, 9, p. 97.
2. Sutcliffe, H., 'Measurement of Signals and Narrow-Band Noise at Low Frequencies', *Proc. I.E.E. (Electronics Quarterly)*, September 1963, 110, p. 1619.

ABRIDGED SPECIFICATIONS

The salient points of the amended specifications are as follows, all other details being as for the standard instrument.

TF 1417/4M1:

Period Measurement, accuracy
 $\pm 0.003\%$ ± 0.1 μ sec with 2.5 V input.
 $\pm 0.03\%$ ± 0.1 μ sec with 250 mV input.

TF 1417/5M1:

1. Input A (frequency and totalising count).
 Input impedance, 1 M Ω with less than 30 pF in parallel.
 Sensitivity. 250 mV r.m.s to 5 Mc/s.
 500 mV r.m.s to 10 Mc/s.
 Max input level. ± 60 V peak on $\times 1$ attenuator setting.
 ± 200 V peak on other attenuator settings.
2. Oscilloscope bright-up pulse.
 Negative going pulse of approximately 5 V amplitude, and half amplitude duration 3 μ sec.
 or
 Positive going pulse of approximately 10 V amplitude and half amplitude duration 3 μ sec.

TF 1417/6M1: As item 1 of TF 1417/5M1

TF 1417/7M1: As item 2 of TF 1417/5M1

TF 1417/8M1: Multi-period frequency ratio, for periods of 1 to 10^7 of second input frequency. Multi-period accuracy, with 1V input:—

$\times 1$ period:	0.1%, or 1 part in 10^3
$\times 10$ period:	0.01%, or 1 part in 10^4
$\times 100$ period:	0.001%, or 1 part in 10^5
$\times 1,000$ period:	0.0001%, or 1 part in 10^6
$\times 10,000$ period or greater:	3 parts in 10^7

TF 1417/9M1:

Display control cover, variable from between 15 and 30 msec, depending on time base range, to a maximum of 0.5 sec.

Side-Lobe Suppression in S.S.R.

by R. J. LUDBROOK
 B.Sc., Graduate I.E.E.

Secondary Surveillance Radar (S.S.R.) has, over the past few years, developed from an accessory for a primary radar system to being a major aid to Air Traffic Control as an independent system. In this article a short account is given of the operation of the system and of its comparisons with primary radar. Special mention is made of a particular facility, that of side-lobe suppression, and a complete test equipment designed especially to test the side-lobe suppression characteristics of airborne transponders and field monitors is described.

SECONDARY SURVEILLANCE RADAR differs from primary radar in that the aircraft itself transmits a reply upon receipt of the interrogation pulse or pulses from the ground station, rather than just acting as a reflector. The original form of S.S.R. was as the wartime I.F.F. (Identification, Friend or Foe) used in conjunction with a primary radar system for identification of a friendly aircraft already observed on the primary radar. The aircraft was fitted with a transponder which on the receipt of pulses from the ground transmitter, transmitted a succession of pulses to a pre-arranged code. Considerable effort has been spent both in the U.K. and the U.S. on the application of this system to civil air traffic control not just as a means of identification but as a radar system in its own right.

Increasing density of air traffic makes recognition more difficult on a primary radar and a means of identification is useful. This can be achieved using a transponder in the aircraft which is interrogated by the primary radar pulse. However, the multiplicity of primary radar frequencies renders such a system impracticable and an independent S.S.R. system is necessary. Besides giving information as to range and position the usefulness of S.S.R. may be extended to cover altitude and flight information by suitably coded replies from the transponder. There are some disadvantages to the system and certain problems peculiar to S.S.R., one of these being the need for side-lobe suppression.

Comparisons between Primary and Secondary Surveillance Radar¹

The principal advantage of primary radar is that it does not require associated equipment in the aircraft and

therefore receives replies from all aircraft that are within range. Secondary radar, however, not only requires aircraft equipment, but this equipment has to be of an internationally agreed specification to make universal use of its facilities. Primary radar suffers from the disadvantage that the strength of the echo depends very much upon the effective reflecting area of the aircraft which varies considerably according to its size and its aspect while the transponder in an S.S.R. system has its aerial designed to have minimum gain variation.

The interference problem is common to both systems but in different forms. With primary radar, echoes are received from any object within range including ground returns. To reject these, which are permanent and usually unwanted, a technique such as Moving Target Indicator (M.T.I.) is used. Although in S.S.R. replies are only received from aircraft equipped with transponders, replies will be received due to interrogation from other ground stations.

One aspect which is particularly important in secondary radar is that of interrogation by side-lobes of the aerial characteristic. A ground aerial for any radar system is beamed, i.e. it sends out power predominantly in one direction although power is transmitted to some degree in all directions, the extent depending on the aerial configuration. A diagram plotted around the aerial showing the locus of equal power points would show a predominant beam, or lobe, accompanied by smaller lobes at the sides, hence 'side-lobe', and a fairly small but approximately constant ring of low power. A pulse sent out on such an aerial on a primary radar will produce an echo which will be received by the same aerial and this will have the effect of squaring the aerial

S.S.R. can provide three dimensional information on the aircraft position



polar diagram which would thus emphasize the main beam, the side-lobes being reduced to very small proportions. In a secondary radar however, the strength of the reply from the aircraft is independent of the strength of the interrogation it receives above a certain level and it could therefore reply to interrogation from the aerial side-lobes in addition to the main beam with consequent ambiguity at the shorter ranges, which can extend out to 40 nautical miles.

It is possible to reduce this effect by two methods. One method is to use a sensitivity time control (S.T.C.) in the ground receiver which reduces the gain of the receiver as the range reduces in accordance with a predetermined law derived from the radar equation. The disadvantage of this system is that it reduces the full vertical coverage obtainable from the aerial. The other method is known as Side-Lobe Suppression and makes use of the relative amplitudes of the Control and Interrogate pulses from the ground station to tell the transponder whether to reply or not. This method will be described more fully later.

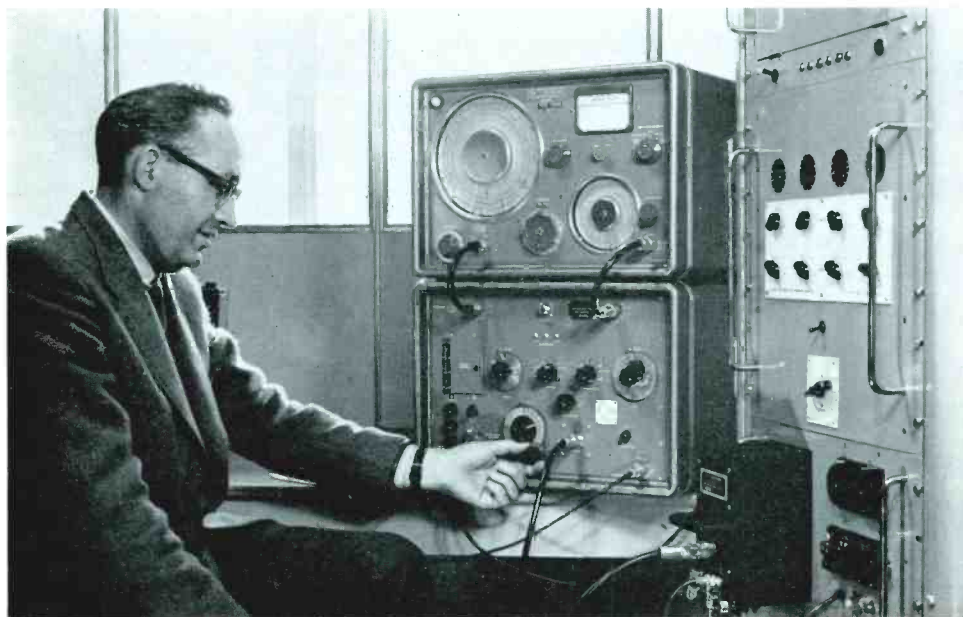
Moding and Coding in S.S.R.²

To avoid overloading the transmitter in the aircraft transponder it is desirable to keep the interrogation of the aircraft to a minimum. The interrogation therefore consists of two or more pulses in each train to prevent interrogation by random single pulses. Two interrogation pulses will give satisfactory discrimination and also provide for side-lobe suppression but the spacing between the pulses has been the subject of international discussion, especially since there is also a system whereby a third control pulse may be inserted between the two interrogate pulses to obtain side-lobe suppression facilities. The existence of the military I.F.F. equipment using Mode 3 (8 μ sec spacing) without side-lobe

suppression complicates matters since this means that a civil S.S.R. system with side-lobe suppression would have to be compatible with the military system. The International Civil Air Organization (I.C.A.O.) sixth COM. meeting of 1957 standardized on Mode B (17 μ sec spacing) for side-lobe suppression and Mode A (8 μ sec spacing) without side-lobe suppression, the latter coinciding with the military Mode 3. Because of the possibility of using the coded reply from the transponder for other purposes besides identification, range and azimuth information, such as altitude and flight information other modes have been devised, namely Modes C and D, of 21 and 25 μ sec spacing respectively. The particular mode to which the transponder will reply and the consequent code sent out by the transponder will be selected by the pilot.

The transmission of the various interrogation modes from the ground presents more of a problem. In some areas it may be necessary to interrogate in both Modes A and B so as to observe movements of both military and civil aircraft. This involves interlacing of the interrogations by transmitting alternately ABABAB etc. With the introduction of the additional modes, pulse-to-pulse interlaces such as ABCABC or ACBCACBC can be used, but the extension to ABCD interlace would reduce the interrogations in a particular mode in a given time such as to cause a reduction in reply probability. The actual method to be used will depend on the number of modes to be used and will most likely be decided by each particular authority controlling the ground services.

After interrogation at a frequency of 1030 Mc/s by the particular mode selected the transponder will reply after an accurate time interval with a pulse train at a frequency of 1090 Mc/s. This pulse train will consist of two framing pulses with 20.3 μ sec spacing between which may be six pulses at 2.9 μ sec spacing or twelve at



Complete Side-Lobe Suppression Test Set, consisting of the Test Set 506 type TF 1349 (shown right) and the U.H.F. Signal Generator TF 1060/2, together with the System Monitor.

Since the Monitor depends for its accuracy on the side-lobe suppression characteristics of the Transponder it is necessary to use a precise differential attenuator to produce the necessary pulse amplitudes at the correct mode spacing

1.45 μ sec. The presence or absence of any or all of six pulses gives 64 possible combinations which are called codes, or with 12 pulses 4,096 codes. By suitable decoding equipment in the ground receiver each code can represent different information in accordance with the mode employed—for example, the aircraft transmitter may be designed to operate in conjunction with an altimeter and each code will represent a certain 'slice' of altitude. The number of codes used for normal A.T.C. purposes will be 64 or 4,096. A number of altitude codes used in mode C can represent changes of altitude at 500 ft or 100 ft intervals from ground to 127,000 ft. Mode D can be used to give individual flight plan identification.

Side-lobe Suppression³

It has been stated earlier that side-lobe suppression is necessary in S.S.R. to prevent the interrogation of the transponder by the side-lobe of the ground aerial polar diagram. It is possible to obtain the desired results with two or three interrogation pulses, but the two pulse system will be considered. The system uses two aerials which are combined in one scanning assembly and are the same effective height above ground to match the vertical interference patterns. One aerial, to which the first interrogation (Control) pulse in mode B is applied is semi-directional (see Fig. 1); the other, to which the second interrogation (Interrogate) pulse is applied, is



Control/Interrogator aerial installed at London Airport (Crown copyright. By courtesy of Ministry of Aviation).

directional and has a 3 dB beam width of 2.5° . By adjusting the pulse power to each aerial so that the locus of equal field strength of each aerial is as shown in the diagram, then within the required arc of interrogation the pulse amplitude will be equal and a transponder within this arc will thus receive two equal amplitude pulses.



Test Set 506—A Differential Pulsed Attenuator

General Description

The test set is designed for use with the U.H.F. Signal Generator type TF 1060/2. Video pulse trains are generated consisting of one, two or three pulses, at a repetition frequency which is continuously variable in one range from 250 to 2000 c/s. Individual pulse widths are such that the r.f. pulses from the TF 1060/2 can be varied from 0.3 to 3 μ sec in width, and the spacing between first and third pulses is selected by a switch, either to give preset intervals corresponding to modes A, B, C and D or continuously variable from +5 to +27 μ sec. The second pulse if selected may be varied from -5 to +10 μ sec relative to the first pulse. These pulse trains modulate the U.H.F. Signal Generator which is set to the required frequency and the resulting pulse modulated r.f. signal fed back to the test set and applied to the differential attenuator. This enables the amplitude of either pulse in a two pulse train or of one or two pulses in a three pulse train to be varied +10 to -15 dB relative to the other. By suitable selection with the Function switch the variable pulses can be either the control or interrogate pulses as required.

The pulsed r.f. signal at the output socket may be monitored by applying to the built-in crystal detector with its following video amplifier, observing the video pulses on a wideband oscilloscope such as the Marconi TF 1330 or TF 2200. A trigger pulse for the oscilloscope is provided at the SYNC. OUT socket and occurs 5 μ sec before the first modulating pulse.

A facility also exists for triggering the test set from an external source, with either single or double pulses of p.r.f. 200-2000 c/s. The instrument has been designed to be mounted below the signal generator, forming a complete test equipment.

Functional Diagram

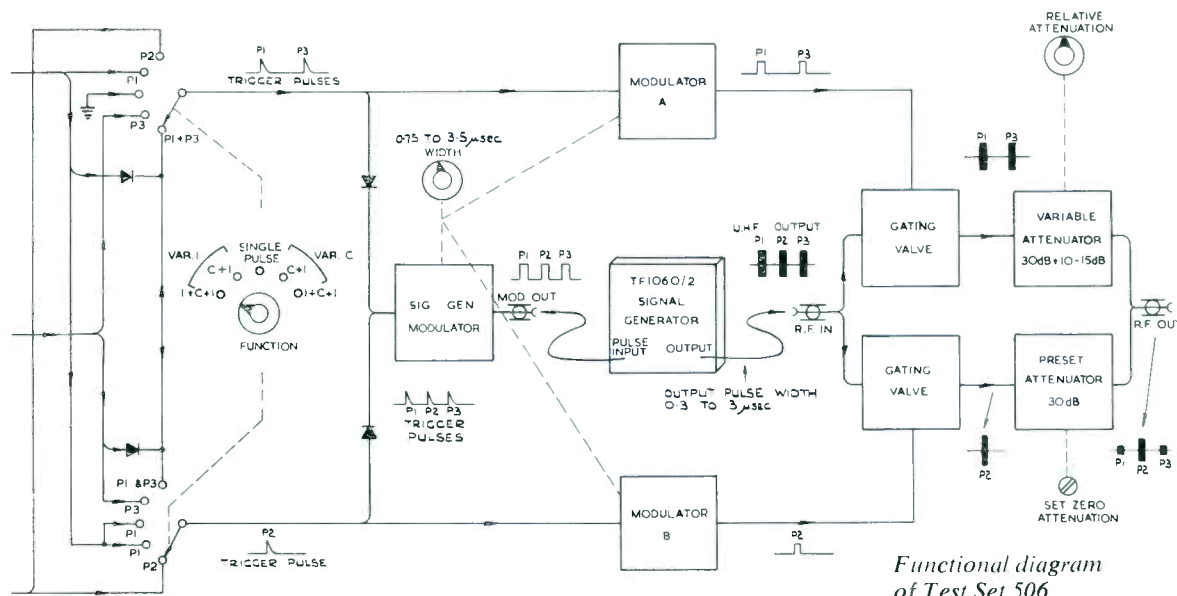
The differentiated output of a free running multivibrator or external pulse amplifier provides a negative trigger pulse at the required p.r.f. The timing of this pulse is $t_0 - 10 \mu$ sec where t_0 is the time of the first (datum) output pulse. The trigger pulse is applied to both a 5 μ sec delay line and to the 2nd pulse delay generator.

Consider first the 5 μ sec delay line. The resulting pulse is now at $t_0 - 5 \mu$ sec and after inversion is applied to a second 5 μ sec delay line giving, after inversion and differentiation a positive trigger pulse timed at $t_0 \mu$ sec. The negative pulse at $t_0 - 5 \mu$ sec is also applied to the sync amplifier to give a positive sync pulse and to a further amplifier to trigger the 3rd pulse delay generator. The length of the output pulse from the delay generator (triggered at $t_0 - 5 \mu$ sec) is decided by the PULSE INTERVAL controls, and a trigger pulse is derived from the rear edge.

The second pulse delay generator is similar except that it is triggered at $t_0 - 10 \mu$ sec and therefore the positive trigger pulse derived from the rear edge of the output pulse can start earlier than that from the 3rd pulse delay generator, the actual timing depending on the setting of the 2nd pulse preset control.

Thus we now have three positive trigger pulses, one fixed relative to the sync pulse and timed at t_0 , the others variable with respect to t_0 depending on the settings of the 3rd pulse interval controls and the 2nd pulse preset control. The three pulses are now applied to the two-pole FUNCTION switch which diverts the pulses into two channels. Depending upon the position of the switch the distribution of the pulses, P1, P2 and P3, is as follows:

Function Selector	Channel A	Channel B
1	P1 + P3	P2
2	P3	P1
3	—	P1
4	P1	P3
5	P2	P1 + P3



Functional diagram of Test Set 506

Those pulses in channel A are applied to modulator A and those in channel B to modulator B. The pulses are also combined in a third channel which thus may contain one, two or three pulses. In this third channel the pulses trigger the signal generator modulator which is a monostable multivibrator providing an output pulse for every trigger pulse, whose width depends on the setting of the WIDTH control. The output pulses are then applied to the U.H.F. Signal Generator type TF 1060/2 in the PULSE MOD. position and set to 1030 Mc/s, thus producing one, two or three r.f. pulses.

The r.f. pulses from the Signal Generator are fed back into the Test Set and applied to the parallel inputs of two r.f. amplifier stages which are biased off in the absence of a gating pulse. However, modulators A and B, which are similar to the signal generator modulator, produce pulses when triggered which are applied to the gating inputs of the two r.f. amplifiers. When the r.f. pulse applied to the amplifier coincides with the gating pulse applied to the same amplifier an r.f. output pulse results. For example, with the FUNCTION selector in position 1 the 1st and 3rd trigger pulses are applied to modulator A and then to the r.f. gating amplifier in path A. The 2nd trigger pulse is applied to modulator B and then to the r.f. gating amplifier in path B. Since in this function all three trigger pulses are applied to the signal generator modulator, there will be three corresponding r.f. pulses applied to both gating stages. In path A the gating amplifier will only be switched on by the first and third gating pulse and thus only r.f. pulses 1 and 3 will appear at the output of this stage. Similarly in path B the gating amplifier will only be switched on by the second gating pulse and only pulse 2 will appear at the stage output.

The output from each amplifier is fed into an attenuator, variable in the case of path A and preset in the case of path B. The attenuator outputs are combined in a common coaxial line feeding the output socket. Thus for a given r.f. level any pulse reaching the output socket via path B will have an amplitude set by the present attenuator and any pulse via path A will

have an amplitude variable from +10 dB to -15 dB relative to that from path B. In the example quoted, i.e. in position 1, the output will consist of three r.f. pulses, the first and third being variable relative to the second. The first pulse is fixed in position relative to the sync pulse, while the second and third are variable from -5 to +10 μ sec and +5 to +27 μ sec respectively relative to the first.

By use of the FUNCTION switch and the INTERVAL controls one, two or three r.f. pulses may be obtained with any one or two pulses variable in amplitude relative to the other, with variable pulse width and p.r.f.

The WIDTH control, which adjusts the video pulse width from the signal generator modulator and hence the r.f. pulse width from the signal generator, also varies the width of the gating pulses from modulators A and B so that the minimum r.f. pulse spacing of 1.8 μ sec may be achieved for 0.8 μ sec pulses. The video pulse width to modulate the signal generator is 0.5 μ sec longer than the required width of the r.f. pulse because the leading edge of the r.f. pulse from the TF 1060/2 is delayed by approximately 0.5 μ sec.

So that the relative positions and amplitudes of the r.f. pulses may be observed on an oscilloscope, a detector is incorporated in the instrument followed by a video amplifier. The output may be taken directly from the detector in the case of large amplitude pulses or from the video amplifier for small pulses.

This instrument, in conjunction with the U.H.F. Signal Generator type TF 1060/2, is thus able to produce suitable combinations of r.f. pulses at the required spacing and relative amplitudes to simulate the performance of the transmitter and thereby check the transponder for correct operation. Full details of the facilities are given in the abridged specification below.

REFERENCES

1. Terrington, D. G. 'The Application of Secondary Surveillance Radar to Air Traffic Control.' Paper read at U.S.A. Federal Aviation Agency, International Aviation Research and Development Symposium, Atlantic City, April 1961.
2. Editorial, 'Secondary Radar and I.C.A.O.', *World Aviation Electronics*, December 1961, 1, p. 193.
3. Terrington, D. G. 'Altitude Telemetry in Conjunction with Air Traffic Control', *British Communications and Electronics*, September 1960, 7, p. 660.

ABRIDGED SPECIFICATION

of TF 1349 with TF 1060/2

R.F. Pulses

WIDTH: 0.5 to 2.0 μ sec continuously variable for multiple pulses and 0.3 to 3.0 μ sec for single pulses.

RISE AND DECAY TIMES: Less than 0.1 μ sec and 0.2 μ sec respectively.

PULSE TRAINS: *Switch selected groups:* Control and double interrogate pulses. Control and single interrogate pulses. Single pulse.

SPACING:

Interval between datum pulse and 3rd pulse: Switch selected: 8, 17, 21 and 25 μ sec, and preset within range 5 to 27 μ sec.

Continuously variable from 5 to 27 μ sec.

2nd pulse position: Preset within range -5 to +10 μ sec relative to datum pulse.

Repetition Frequency: 250 to 2000 pulse trains per second continuously variable.

Differential Attenuator

ATTENUATION: Path A—continuously variable from +10 dB to -15 dB ± 0.25 dB relative to path B.

Path B—fixed at approximately 30 dB insertion loss.

CODING: Individual control (C) and interrogate (I) pulses are automatically routed via paths A or B depending on

the position of the Function selector as follows:

Function Selector	Pulse Train	Attenuation Path
1	I+C+I (Var. I)	A-B-A
2	C+I (Var. I)	B-A
3	Single Pulse	B
4	C+I (Var. C)	A-B
5	I+C+I (Var. C)	B-A-B

FREQUENCY: 1030 Mc/s, bandwidth 35 Mc/s.

IMPEDANCE: 50 Ω .

SYNC PULSE: 5 μ sec ± 0.1 μ sec before datum modulating pulse.

EXTERNAL TRIGGER: Single or double pulses, p.r.f. 200 to 2,000 p.p.s.

Summaries of Articles appearing in this issue

RESUME D'ARTICLES PUBLIES DANS LE PRESENT NUMERO

OSCILLOSCOPE À DEUX VOIES TF 2202

Le TF 2202 est un oscilloscope à deux voies, portatif et transistorisé, de construction robuste et adaptée à tous les climats. La précision des mesures des tensions et du temps est de 5%. Le dispositif de vérification de l'étalonnage est incorporé aux voies de l'amplificateur vertical.

L'appareil est alimenté indifféremment par le secteur ou par piles. Il est stabilisé contre toute variation de tension ou surcharge provenant soit du secteur soit de la pile. La construction modulaire enfichable simultanément assure une excellente accessibilité à toutes les parties de l'appareil tout en permettant un montage parfaitement rigide autorisant une grande souplesse d'emploi grâce au fait qu'il est livrable, soit pour montage sur baie soit sur table (TF 2202R ou TF 2202, respectivement) et ce, en utilisant les mêmes pièces ou organes.

Page 107

GÉNÉRATEUR DE SIGNAUX BASSE-FRÉQUENCE À DEUX FRÉQUENCES PORTEUSES

On décrit un générateur de signaux complets pour contrôler l'intermodulation. Il comprend deux oscillateurs basse-fréquence TF 2100 et un atténuateur de contrôle TF 2160/IM1, montés dans un coffret à montage sur baie. Deux notes séparées sont disponibles dans la gamme de 20 Hz à 20 kHz, l'intermodulation propre

étant meilleure que -80 dB sur les deux fréquences. Une utilisation intéressante de cet appareil est le contrôle d'intermodulation d'un émetteur à bande latérale unique.

Page 114

VERSIONS SPÉCIALES DU COMPTEUR-FRÉQUENCEMÈTRE TF 1417/2

Il existe six versions spéciales du compteur/fréquence-mètre 10 MHz prévues pour des utilisations particulières permettant la mesure de périodes multiples, et du rapport de fréquence à périodes multiples, un échantillonnage rapide et une précision encore plus grande pour mesurer le temps.

Page 118

CONTRÔLE DE LA SUPPRESSION DES LOBES SECONDAIRES DES RADARS SECONDAIRES DE VEILLE

Au cours des dernières années, le radar secondaire de veille n'est plus accessoire de radar primaire qu'il était, il est devenu l'élément essentiel et indépendant, des centres de contrôle de la navigation aérienne.

Le but de cet article est de le décrire brièvement en le comparant au radar primaire. La possibilité de supprimer les lobes secondaires est examinée ainsi que le matériel nécessaire pour contrôler les caractéristiques de suppression des radiophares d'avion ainsi que celles des dispositifs de contrôle sur le terrain.

Page 121

ZUSAMMENFASSUNG DER IN DIESER NUMMER ERSCHEINENDEN BEITRÄGE

DOPPELSTRAHL-OSZILLOGRAPH TF 2202

Das Gerät TF 2202 ist ein tragbarer und mit Transistoren bestückter Doppelstrahl-Oszillograph in stabiler und klimafester Ausführung. Die Genauigkeit der Zeit- und Spannungsmessungen ist 5%. Beide Y-Verstärkerkanäle sind mit Einrichtungen zur Prüfung der Eichung versehen.

Das Gerät ist sowohl für Batterie- als auch für Netzbetrieb eingerichtet und gegen Schwankungen oder Spitzen in der Netz- oder Batteriespannung stabilisiert. Die Bauweise mit durch Stecker verbundenen Modulen (Untereinheiten) ergibt eine ausgezeichnete Zugänglichkeit zu allen Teilen des Gerätes und ist dabei eine sehr stabile und anpassungsfähige Anordnung, bei der Ausführungen für Gestellmontage (TF 2202R) oder Tischgehäuse (TF 2202) aus den gleichen normalen Bau- und Schaltungsteilen zusammengesetzt werden können.

Seite 107

DOPPELTON-MEßSENDER

In diesem Aufsatz wird der ganze Meßsender für intermodulationsmessungen beschrieben. Er besteht aus zwei Tonfrequenzgeneratoren TF 2100 und einer Eichleitung mit Pegelanzeige TF 2160/IM1, die in einem Gehäuse für Gestellmontage zusammengebaut sind. In dem Bereich von 20 Hz bis 20 kHz stehen zwei unabhängige Tonfrequenzen zur Verfügung. Der Differenztonfaktor ist besser als -80 dB bei jeder der beiden

Tonfrequenzen. Ein Anwendungsbeispiel für das Gerät bei der Intermodulationsmessung an einem Einseitenband-Sender wird angeführt.

Seite 114

SONDERAUSFÜHRUNGEN DES ZÄHL- UND FREQUENZMEßGERÄTES TF 1417/2

Für besondere Anwendungszwecke wurden 6 Sonderausführungen des 10 MHz Zähl- und Frequenzmeßgerätes hergestellt. Die hierbei sich ergebenden zusätzlichen Möglichkeiten umfassen: Messungen über mehrere Perioden, Messung von Frequenzverhältnissen über mehrere Perioden, schnelle Folge der Meßzeiten und erhöhte Genauigkeit bei Zeitmessungen.

Seite 118

MESSUNG DER NEBENZIPFELDÄMPFUNG BEI SEKUNDÄR-RUNDSICHTRADARANLAGEN

Sekundär-Rundsichtradargeräte wurden in den letzten Jahren aus einer Zusatzeinrichtung für Primär-Radaranlagen zu einem unabhängig arbeitenden, wichtigen Hilfsmittel in der Flugsicherung entwickelt. Dieser Aufsatz ist ein kurzer Bericht über die Arbeitsweise der Anlagen und deren Vergleich mit Primär-Radaranlagen. Es wird auf eine Besonderheit, die Nebenzipfelunterdrückung, besonders hingewiesen. Ein vollständiges Prüfgerät, welches speziell zur Messung der Nebenzipfelunterdrückung bei Bord-Rückmeldegeräten und Feldstärkekontrollgeräten entwickelt wurde, wird beschrieben.

Seite 121

SOMMARIO DEGLI ARTICOLI PUBBLICATI IN QUESTO NUMERO

OSCILLOSCOPIO A DOPPIA TRACCIA TF 2202

Il TF 2202 è un oscilloscopio transistorizzato portatile a doppia traccia di robusta costruzione pancinematica. La precisione delle misure di tempo e di tensione è di 5% ed in entrambi i canali di amplificazione Y sono incorporati mezzi per il controllo della taratura.

Lo strumento è previsto per funzionamento con alimentazione sia a pile che dalla rete, ed è stabilizzato contro variazioni o sbalzi improvvisi della tensione di rete o di quella delle pile. La costruzione modulare con innesti a spina rende ogni parte dello strumento estremamente accessibile, pur risultando in un complesso molto rigido e versatile così da consentire la realizzazione, mediante l'impiego dei medesimi pezzi e componenti normalizzati, di versioni per montaggio su rack standard o da tavolo (rispettivamente TF 2202R o TF 2202).

Pagina 107

SORGENTE DI SEGNALI AD AUDIOFREQUENZA DUPLICI

Si descrive una completa sorgente di segnali per prove di intermodulazione, costituita da due oscillatori ad audiofrequenza tipo TF 2100 ed un attenuatore per bassa frequenza, con strumento di controllo, tipo TF 2160/IMI, il tutto contenuto entro un cofano per montaggio su rack standard. Due segnali distinti sono disponibili a frequenze comprese fra 20 Hz e 20 kHz e l'intermodulazione residua interna ha un valore inferiore a -80 dB rispetto all'uno od all'altro segnale. Viene indicata un'applicazione dello strumento per prove di intermodulazione di un trasmettitore a banda laterale unica.

Pagina 114

VERSIONI SPECIALI DEL CONTATORE/FREQUENZIMETRO TF 1417/2

Sei versioni modificate del contatore/frequenzimetro da 10 MHz sono state prodotte per convenire ad applicazioni speciali. Le prestazioni addizionali offerte comprendono misura su più periodi, misura del rapporto di frequenze su più periodi, campionamento rapido ed accresciuta precisione nelle misure di intervalli di tempo.

Pagina 118

VERIFICA DELLA SOPPRESSIONE DEI LOBI LATERALI NEL RADAR DI SORVEGLIANZA SECONDARIO

Il radar di sorveglianza secondario ovvero a risposta (noto in inglese con la sigla S.S.R. dalle iniziali di Secondary Surveillance Radar) si è trasformato in questi ultimi anni da un accessorio di un sistema radar primario (diretto) in un importante mezzo di assistenza per il controllo del traffico aereo quale, sistema indipendente. In questo articolo si dà un breve ragguaglio del funzionamento del sistema e dei punti di raffronto con il radar primario. Si discute in modo speciale un aspetto particolare, cioè la soppressione dei lobi laterali, e viene descritta una completa apparecchiatura di prova specificamente progettata per verificare le caratteristiche di soppressione dei lobi laterali di ripetitori di impulsi aviotrasportati e di monitori campali.

Pagina 121

RESUMENES DE ARTICULOS QUE APARECEN EN ESTE NUMERO

OSCILLOSCOPIO DE DOBLE HAZ TF 2202

El TF 2202 es un osciloscopio de doble haz, portátil, transistorizado, pancinámico, de construcción robusta. Su precisión es del 5% en medidas de tiempo y tensión. El dispositivo de comprobación de calibración va en los dos canales de amplificación Y.

Se alimenta por baterías o por la red. Estabilizado contra variaciones de la tensión de alimentación. Su construcción modular, enchufable, permite el fácil acceso a todas las partes del aparato, siendo al mismo tiempo rígida y adaptable. Existen las versiones de bastidor y caja (TF 2202R y TF 2202 respectivamente), que utilizan los mismos componentes y partes normalizados.

Página 107

FUENTE DE SEÑAL DE DOS TONOS, EN A.F.

Se describe una fuente de señal, completa, para pruebas de intermodulación. Consiste en dos osciladores de A.F., tipo TF 2100, y un atenuador controlado, de A.F., tipo TF 2160/IMI, montados en una caja, en bastidores. Producen dos tonos separados en el margen de 20 Hz a 20 kHz. La intermodulación propia es mejor que -80 dB en cada tono. Una aplicación del aparato es la prueba de intermodulación en transmisores de banda lateral única.

Página 114

VERSIONES ESPECIALES DEL MEDIDOR CONTADOR DE FRECUENCIA TF 1417/2

Se han fabricado seis versiones del medidor contador de frecuencia, de 10 MHz, para aplicaciones especiales. Dichas versiones comprenden medidas de multi-períodos, de relación de multi-períodos de frecuencia, muestreo rápido, y mayor precisión en las medidas de tiempo.

Página 118

PRUEBA DE SUPRESION DE LOBULO LATERAL EN R.V.S.

El radar de vigilancia secundario (R.V.S.), durante los últimos años, ha pasado de ser un accesorio del sistema de radar principal, a convertirse en una ayuda importante del control de tráfico aéreo, como sistema independiente. En esta artículo se explica brevemente el funcionamiento del sistema y se le compara con el radar principal. Se hace mención especial de una característica particular: la de la supresión del lóbulo lateral, y se describe un equipo de prueba, completo, proyectado especialmente para probar las características de supresión de lóbulo lateral de los transmisores de respuesta del avión y de los controles de tierra.

Página 121

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