

LEVELL

for

APPRENTICE CENTRE
AQUILA 455.

A.C. MICROVOLTMETERS
TYPE TM3 SERIES

&

BROADBAND VOLTMETERS

INSTRUCTION BOOK

OPERATING INSTRUCTIONS

Met dank aan Henk v.d. Ende
Ned. Ver. v. Historie v/d Radio

for

APPRENTICE CENTRE

AQUILA G.S.S.

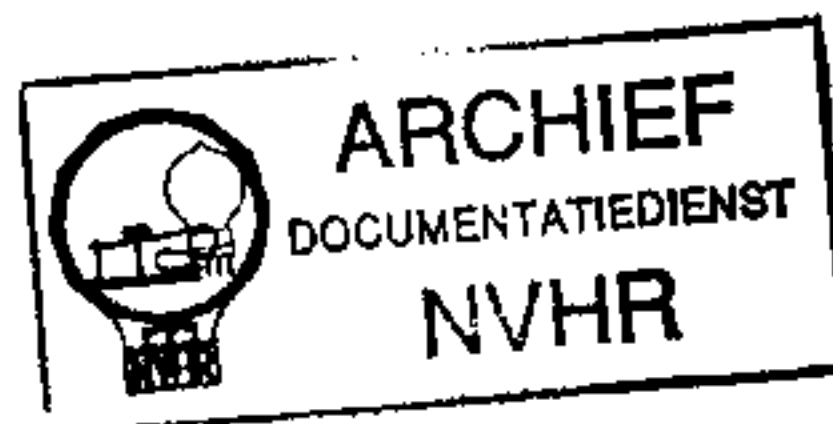
A.C. MICROVOLTMETERS

TYPE TM3 SERIES

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BROADBAND VOLTMETERS

TYPE TM6 SERIES



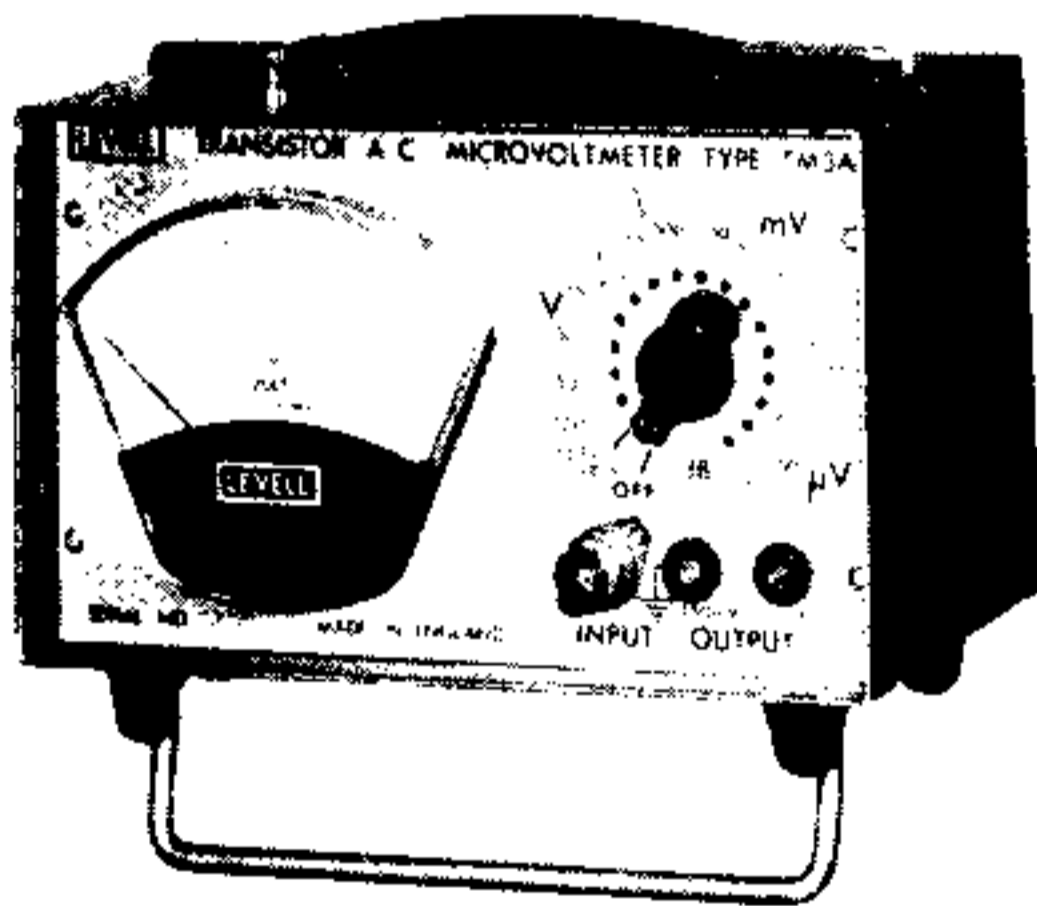
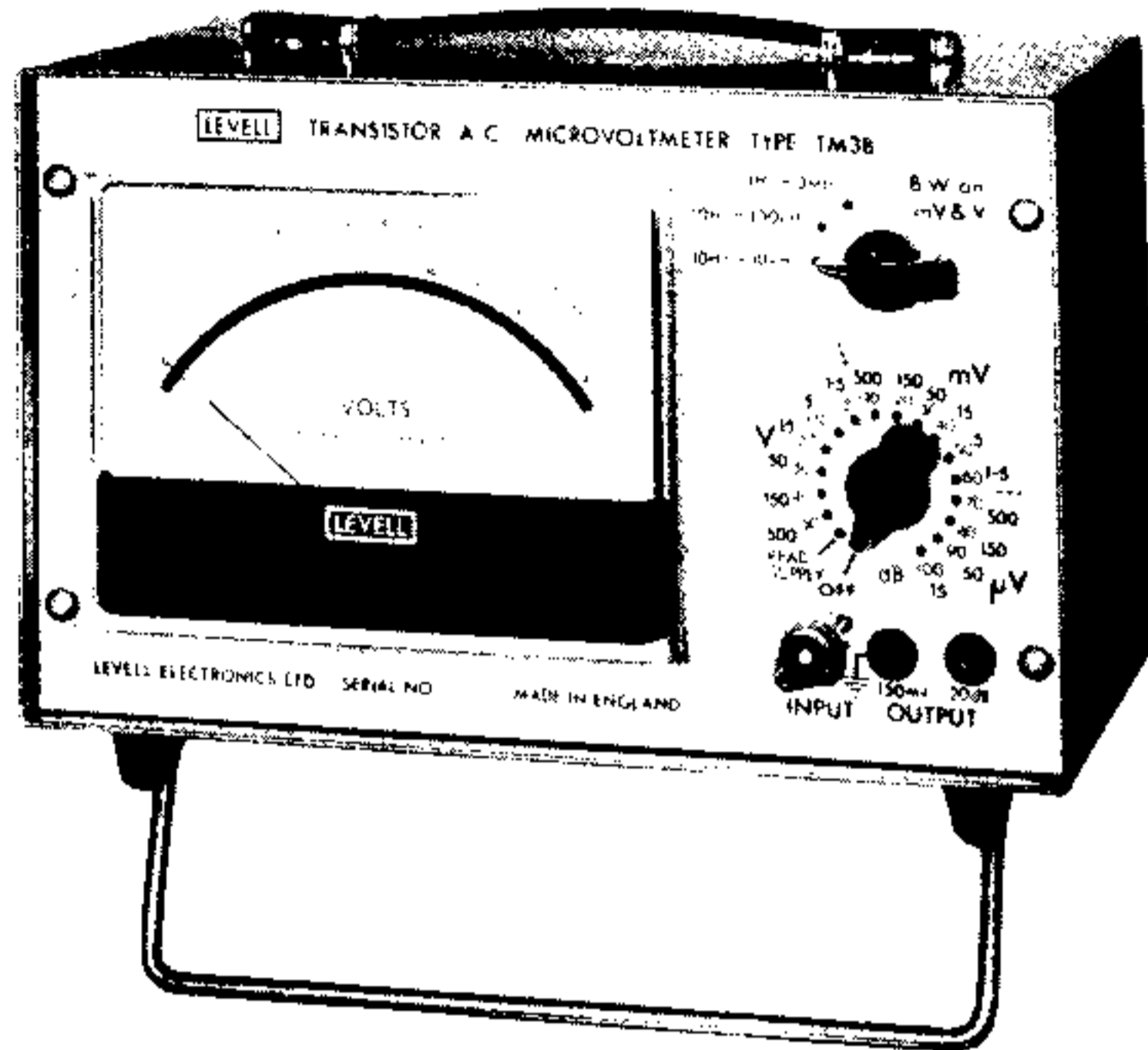
GUARANTEE

We undertake to repair, or replace free of charge, any components that fail within 12 months of the date of purchase of an instrument provided that the instrument is not, in our opinion, modified or misused. Instruments returned by post should be well packed to avoid damage. We recommend the use of two strong cartons, one to fit closely around the instrument and the other large enough to float the small carton in at least 2" thickness of wood wool.

LEVELL ELECTRONICS LIMITED, MOXON STREET, BARNET, HERTS., ENGLAND.

Telephone: 01-449 5028
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- 1Hz to 3MHz
- 5 μ V to 500V
- 80dB GAIN
- LOW NOISE
- PORTABLE



These portable instruments can be used as A.C. Voltmeters or A.C. Amplifiers. The frequency response extends from 1Hz to 3MHz. Sixteen ranges are provided in 10dB steps from 15 μ V f.s.d. to 500V f.s.d. with selection by a single rotary switch which also has "Off" and "Read Supply" positions. The meter in type TM3A has a scale length of 3 $\frac{1}{4}$ " (i.e. 8.3cm) whereas the meter in type TM3B has a scale length of 5" (i.e. 12.7cm) and is fitted with a mirror scale. A bandwidth switch is also fitted in type TM3B. Both instruments operate from a self contained battery but operation from an A.C. mains supply is possible by replacement of the battery with a LEVELL Power Unit.

There are two separate negative feedback amplifiers in the instrument. The gain of the first amplifier is varied in 10dB steps up to 80dB with negative feedback applied to stabilize the gain. The output is connected to panel sockets and to the input of the second amplifier which drives a full wave rectifier circuit and a moving coil meter. The negative feedback on this amplifier is such that the current in the meter is forced to bear a linear relationship to the input voltage. Full scale deflection occurs for an output of 150mV from the first amplifier. The input impedance of the second amplifier is high enough to present a negligible load to the output of the first amplifier so that the signal at the output sockets is free from distortion due to rectifier loading. An advantage of this arrangement is that the bandwidth of the instrument can be reduced by connecting reactive components across the output terminals. This is useful when measuring small signals over a limited frequency band as a reduction of the bandwidth also reduces the input noise level.

The instruments are ideal as oscilloscope preamplifiers as they have a low noise level, low microphony, no hum and can be independent of a mains supply. The cases stand on insulated feet and insulated hinged legs are provided for tilting the cases up by about 20°.

SPECIFICATION OF TYPE TM3 SERIES

VOLTMETER RANGES

15 μ V, 50 μ V, 150 μ V . . . 500V f.s.d. Linear black meter scales.

Accuracy: $\pm 1\%$ of reading $\pm 1\%$ of f.s.d. $\pm 1\mu$ V at 1kHz.

TM3A scale length is 3 $\frac{1}{4}$ " (i.e. 8.3cm) TM3B scale length is 5" (i.e. 12.7cm) and has mirror.

dB RANGES

-100dB to +50dB in 10dB steps. Red scale -20dB to +6dB relative to 1mW into 600 Ω .

FREQUENCY RESPONSE

On "mV" and "V": ± 3 dB from 1Hz to 3MHz, ± 0.3 dB from 4Hz to 1MHz.

On 500 μ V: ± 3 dB from 2Hz to 2MHz. On 150 μ V: ± 3 dB from 4Hz to 1MHz.

On 50 μ V: ± 3 dB from 7Hz to 500kHz. On 15 μ V: ± 3 dB from 20Hz to 200kHz.

Type TM3B bandwidth switch introduces a bandpass filter with bottom cut -3dB at 10Hz and top cut -3dB at 10kHz or 100kHz.

INPUT IMPEDANCE

Above 50mV: 4.3M Ω min. in parallel with 20pF max. from 1Hz to 3MHz.

On 50 μ V to 50mV: 5M Ω min. in parallel with 50pF max. from 200Hz to 200kHz.

On 15 μ V: 2M Ω min. in parallel with 50pF max. from 200Hz to 20kHz.

INPUT NOISE LEVEL

5 μ V r.m.s. max. on 15 μ V range with input shorted; 2.5 μ V max. for TM3B on B.W. 10Hz-10kHz.

20 μ V r.m.s. max. on 50 μ V range with 100k Ω source; 10 μ V max. for TM3B on B.W. 10Hz-10kHz.

AMPLIFIER OUTPUT

The output is a phase inverted undistorted replica of the input with the meter indicating the output voltage at a fixed sensitivity of 150mV f.s.d. Gain is 80dB on the 15 μ V range.

A load of 200k Ω and 50pF may be connected with negligible loss of accuracy or frequency response.

MAXIMUM SAFE INPUT VOLTAGES

On 15 μ V to 50mV ranges: 250V D.C., 100V A.C. up to 20kHz, 30V A.C. above 20kHz.

On 150mV to 500V ranges: 750V A.C. peak plus D.C.

TEMPERATURE

The above characteristics are at 25°C but only minor divergencies exist from -10°C to +45°C.

CONNECTIONS

The input socket accepts Belling Lee L734 plugs but type BNC can be fitted to special order.

The input test lead is 36" (i.e. 90 cm) long, capacity 35pF, and terminated by crocodile clips.

The output sockets accept two 4 mm. banana plugs at $\frac{3}{8}$ " spacing.

POWER SUPPLY

One type PP9 battery, life 1000 hours; or, A.C. mains when a LEVELL Power Unit is fitted.

SIZES AND WEIGHTS

TM3A: 5" x 7 $\frac{1}{4}$ " x 4 $\frac{1}{2}$ " (i.e. 13 cm x 18.5 cm x 11.5 cm) 4 $\frac{1}{2}$ lb (i.e. 2kg)

TM3B: 7" x 10 $\frac{1}{4}$ " x 5 $\frac{1}{2}$ " (i.e. 18 cm x 26 cm x 14 cm). 8 lb (i.e. 3.6kg)

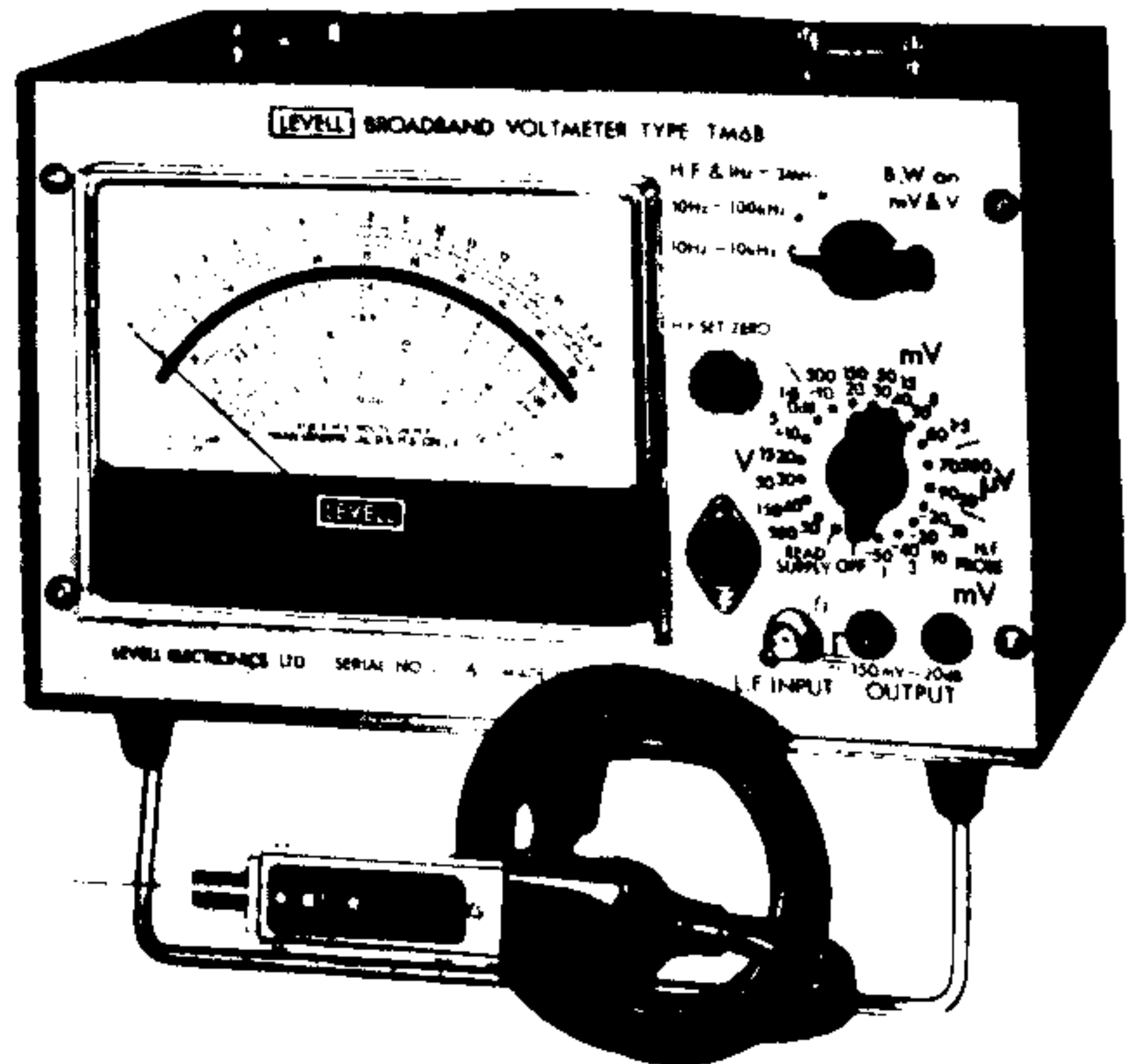
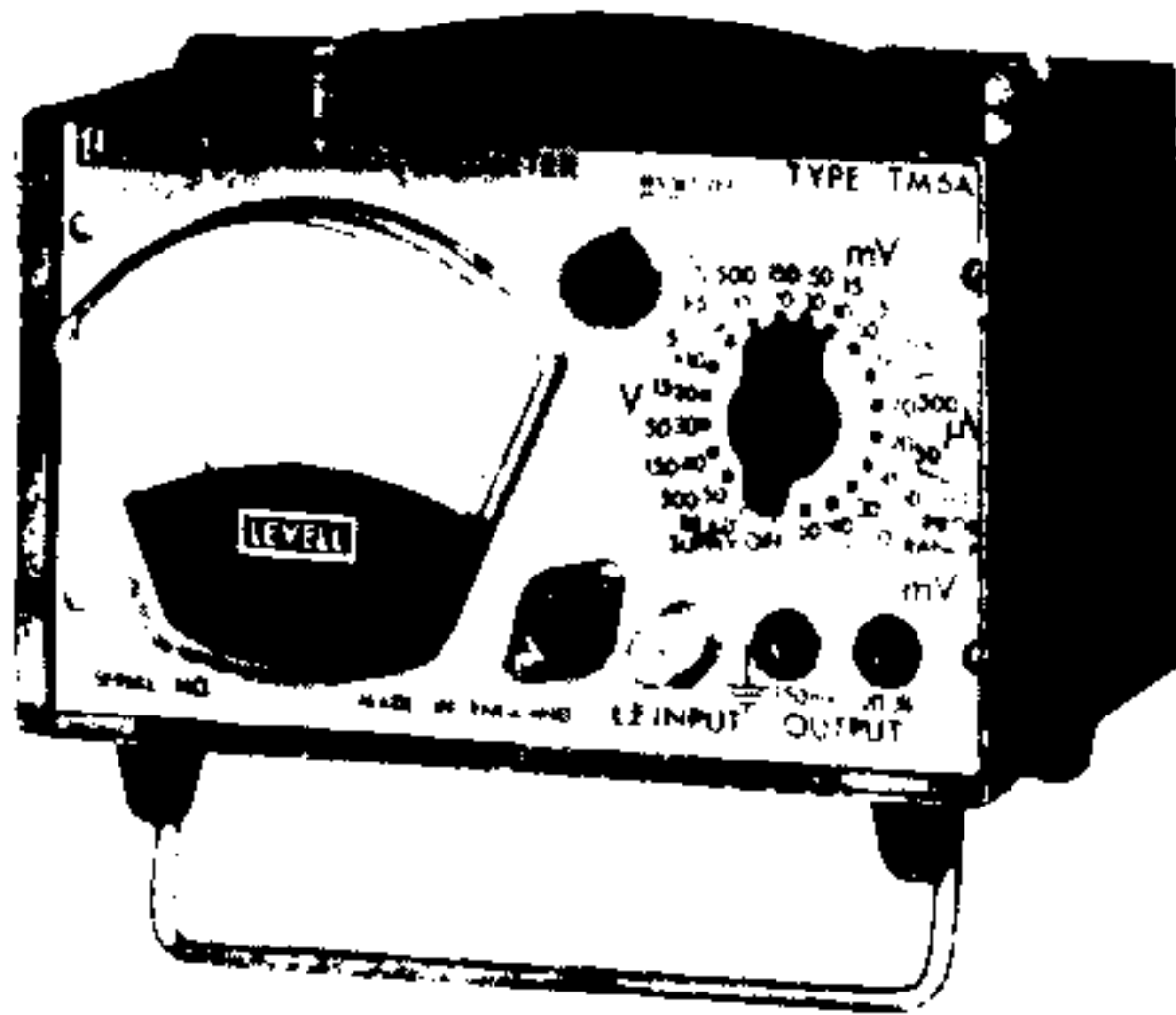
LEATHER CASES

Cases are available as optional extras. They are stiffened with board and felt lined. Shoulder straps are detachable and it is possible to use an instrument whilst in a case.

LEVELL

BROADBAND VOLTMETERS TYPES TM6A & TM6B

- measure **MICROVOLTS** from 1Hz to 450MHz
- **LOW NOISE**
- **PORTABLE**



These portable instruments measure signals down to microvolt levels over the wide frequency range from 1Hz to 450MHz. The appearances are similar to LEVELL Transistor A.C. Microvoltmeters types TM3A and TM3B with the addition of H.F. ranges using an H.F. probe. Eight H.F. ranges are provided from 1mV f.s.d. to 3V f.s.d. with a sensitivity of 300 μ V from 300kHz to 400MHz and 500 μ V at 450MHz. Fourteen L.F. ranges are provided from 50 μ V f.s.d. to 500V f.s.d. with a sensitivity of 10 μ V from 2Hz to 2MHz.

The meter in type TM6A has a scale length of 3 $\frac{1}{4}$ " (i.e. 8.3 cm) whereas the meter in type TM6B has a scale length of 5" (i.e. 12.7 cm) and is fitted with a mirror scale. An L.F. Bandwidth switch is also fitted on type TM6B. Both instruments operate from a self-contained battery but operation from an A.C. mains supply is possible by replacement of the battery with a LEVELL Power Unit.

The L.F. ranges use identical circuits to those of LEVELL Transistor A.C. Microvoltmeters types TM3A and TM3B except for the omission of the 15 μ V and 150 μ V ranges.

The H.F. ranges use semi-conductor circuits to chop the H.F. signal at a frequency of 20Hz approximately. The chopped signal is then detected by a full wave circuit which has a square law characteristic at signal levels up to 30mV. The output from the detector circuit is thus a square wave at a frequency of 20Hz with an amplitude proportional to the square of the amplitude of the H.F. input signal. This square wave is amplified and fed into the meter rectifier circuit. The H.F. ranges from 1mV f.s.d. to 30mV f.s.d. are obtained by switching the gain of the amplifier. These ranges are extended up to 3V f.s.d. by a switch that introduces an input attenuator of 40dB on the probe. An H.F. set zero control is provided to balance the chopper circuits in order to prevent indications due to chopper spikes on the 1mV range. The adjustment of this control is much less dependent upon temperature than the zero control found in voltmeters of the variety that detect the H.F. signal directly and then measure the very low D.C. output from the detectors. LEVELL Broadband Voltmeters use no mechanical choppers and are adequately temperature compensated and protected against overloads. The total power consumption is only 10mA from one 9V battery.

The voltmeter responds to true r.m.s. on the H.F. ranges. On the L.F. ranges it responds to the mean and is calibrated in terms of r.m.s. for a sinusoidal input.

SPECIFICATIONS OF TYPES TM6A & TM6B

L.F. VOLTAGE RANGES

50 μ V, 500 μ V, 1.5mV, 5mV, 15mV . . . 500V f.s.d. Linear black meter scales.

Accuracy: $\pm 1\%$ of reading $\pm 1\%$ of f.s.d. $\pm 1\mu$ V at 1kHz.

TM6A scale length is 3 $\frac{1}{4}$ " (i.e. 8.3 cm) TM6B scale length is 5" (i.e. 12.7 cm) and has mirror.

L.F. dB RANGES

-90dB, -70dB, -60dB, -50dB . . . +50dB. Red scale -20dB to +6dB relative to 1mW into 600 Ω .

L.F. FREQUENCY RESPONSE

On "mV" and "V": ± 3 dB from 1Hz to 3MHz, ± 0.3 dB from 4Hz to 1MHz.

On 500 μ V: ± 3 dB from 2Hz to 2MHz. On 50 μ V: ± 3 dB from 7Hz to 500kHz.

Type TM6B bandwidth switch introduces a bandpass filter with bottom cut -3dB at 10Hz and top cut -3dB at 10kHz or 100kHz.

L.F. INPUT IMPEDANCE

Above 50mV: 4.3M Ω min. in parallel with 20pF max. from 1Hz to 3MHz.

On 50 μ V to 50mV: 5M Ω min. in parallel with 50pF max. from 200Hz to 200kHz.

H.F. VOLTAGE RANGES

1mV, 3mV, 10mV . . . 3V f.s.d. Square law green scales.

Accuracy $\pm 4\%$ of reading $\pm 1\%$ of f.s.d. at 30MHz.

H.F. dB RANGES

-50dB, -40dB, -30dB . . . +20dB. Green scale -10dB to +3dB relative to 1mW into 50 Ω .

H.F. RESPONSE

± 0.7 dB from 1MHz to 50MHz, ± 3 dB from 300kHz to 400MHz, ± 6 dB from 400MHz to 450MHz.

H.F. PROBE INPUT IMPEDANCE

On 100mV to 3V: 3pF in parallel with 600k Ω . On 1mV to 30mV: 10pF in parallel with 6k Ω .

INPUT NOISE LEVELS

7 μ V r.m.s. max. on 50 μ V L.F. range with input shorted; 3 μ V max. for TM6B on B.W. 10Hz-10kHz.

20 μ V r.m.s. max. on 50 μ V L.F. range with 100k Ω source; 10 μ V max. for TM6B on B.W. 10Hz-10kHz.

200 μ V r.m.s. max. on 1mV H.F. range.

AMPLIFIER OUTPUT

On L.F. ranges the output is a phase inverted undistorted replica of the input with the meter indicating the output voltage at a fixed sensitivity of 150mV f.s.d.

Gain is 70dB on the 50 μ V range.

On H.F. ranges the output is a square wave at 20Hz with amplitude proportional to the square of the input signal and 270mV p.p. at f.s.d.

A load of 200k Ω and 50pF may be connected with negligible loss of accuracy or frequency response.

MAXIMUM SAFE INPUT VOLTAGES

On 50 μ V to 50mV L.F. ranges: 250V D.C., 100V A.C. up to 20kHz, 30V A.C. above 20kHz.

On 150mV to 500V L.F. ranges: 750V A.C. peak plus D.C.

On 1mV to 30mV H.F. ranges: 350V D.C., 250V A.C. up to 20kHz, 30V at 1MHz, 10V above 10MHz.

On 100mV to 3V H.F. ranges: 500V D.C., 350V A.C. at any frequency.

TEMPERATURE

The above characteristics are at 25 $^{\circ}$ C but only minor divergencies exist from -10 $^{\circ}$ C to +45 $^{\circ}$ C on the voltmeter and 0 $^{\circ}$ C to 35 $^{\circ}$ C on the H.F. probe.

CONNECTIONS

The L.F. input is a B.N.C. socket on the panel. The H.F. input is a B.N.C. socket on the probe.

The input test lead is 36" (i.e. 90 cm) long, capacity 35pF and terminated by crocodile clips.

A high impedance pin tip and earth lead with clip are supplied for use with the probe.

POWER SUPPLY

One type PP9 battery, life 1000 hours on L.F. ranges and 400 hours on H.F. ranges; or, A.C. mains when a LEVELL Power Unit is fitted.

SIZES AND WEIGHTS

TM6A: 5" x 7 $\frac{1}{4}$ " x 4 $\frac{1}{2}$ " (i.e. 13 cm x 18.5 cm x 11.5 cm) 5 $\frac{1}{2}$ lb (i.e. 2.5 kg)

TM6B: 7" x 10 $\frac{1}{4}$ " x 5 $\frac{1}{2}$ " (i.e. 18 cm x 26 cm x 14 cm) 9lb (i.e. 4 kg)

LEATHER CASES

Cases are available as optional extras. They are stiffened with board and felt lined. Shoulder straps are detachable and it is possible to use an instrument whilst in a case.

1. Connection of Power Supply

Remove the back of the instrument and connect the 9V battery (Ever Ready type PP9 or equivalent) by means of the snap fastener connection provided.

A LEVELL Power Supply Unit type PU8S may be fitted in place of the battery when operation is required from an A.C. mains supply. The Earth Connection on the Power Unit must be joined to the case of the instrument.

Replace the back of the instrument taking care to ensure that the back screws are tight so there is good electrical contact between the back cover and the instrument case.

Switch on the instrument to the "Read Supply" position and note that the pointer is between the supply limits marked on the scale after allowing 10 seconds for the needle to settle to a stable reading.

2. Use as a Voltmeter from 1Hz to 3MHz.

Turn the instrument off and set the mechanical zero adjustment on the meter for zero deflection after the instrument has been off for at least 30 seconds. Turn the Bandwidth switch on type TM3B and TM6B clockwise.

Turn the instrument to a suitable voltage range and LEAVE THE INSTRUMENT SWITCHED ON FOR AT LEAST TWO MINUTES BEFORE ATTEMPTING TO TAKE A READING. The instrument contains large electrolytic capacitors to maintain the low frequency response and these capacitors take time to acquire charge when the instrument is first switched on. Connect the L.F. input lead to the signal to be measured and read on the voltage scales.

When measuring low input signals using the microvolt and millivolt ranges it will be necessary to ensure that there is good screening of the input lead. It is also necessary that the input lead should be screened from any connection made to the output terminals.

The output terminals may be used to feed an oscilloscope so that the signal waveform may be observed whilst the measurement is

being made. The oscilloscope will generally have a negligible effect upon the performance of the voltmeter up to 1MHz but at higher frequencies the loading effect of long connecting leads and the input capacity of the oscilloscope could give an error in the reading. The presence of such an error can easily be determined by removal of the oscilloscope lead from the output socket of the voltmeter.

3. Use as a Voltage Amplifier from 1Hz to 3MHz.

The gain between the input and output terminals is 70dB when the instrument is on the 50 μ V range. It will be noticed that the red dB mark in the 50 μ V position of the switch indicates -90dB and the output terminals are marked -20dB. The actual gain as an amplifier being the difference between these two signal markings. The reason for marking the panel -90dB is that the decibel scales on both the meter and switch are relative to standard reference level of 0dB = 1mW into 600 Ω .

The output as an amplifier is 150mW for the meter reading 15 divisions on the 0 to 15 scale but it is usually possible to get an output of 1 volt from the instrument as an amplifier at frequencies up to 1MHz. The meter then indicates just over full scale value and is mechanically limited. It is quite safe to operate in this condition without fear of damage to the meter or other components.

The output impedance of the type TM3 series is 100 Ω in series with 6.4 μ F. The output impedance of the type TM6 series is 100 Ω in series with 6.4 μ F and in series with the parallel combination of 820 Ω and 0.01 μ F. The errors due to these source impedances are negligible when the load impedance is greater than 200k Ω in parallel with less than 50pF.

The L.F. dB ranges are scaled relative to a reference level of 0dB = 1mW into 600 Ω but the input socket is not terminated and the input impedance is high compared with 600 Ω throughout the L.F. bandwidth. The input is coupled through an isolating condenser so that D.C. may be superimposed on the A.C. input.

4. Restriction of the Bandwidth of the Instrument on L.F. Ranges.

It is often useful to restrict the bandwidth of the instrument in order to reduce the noise component on the more sensitive ranges. This may be done by connecting a capacitor or High Q inductor

across the output terminals or by use of the bandwidth switch that is provided on the types TM3B and TM6B. The meter indicates the voltage appearing across the output terminals (150mV f.s.d.) and the amplifier driving the output terminals has an output impedance as stated in section 3 except that use of the restricted bandwidth positions on the switches of types TM3B and TM6B will reduce the $6.4\mu\text{F}$ component to be only $0.6\mu\text{F}$.

Placing a capacitor across the output terminals introduces an integrator between the output of the first amplifier and the meter amplifier. A capacity of the order of $0.1\mu\text{F}$ restricts the top bandwidth to approximately 15kHz for TM3 series and 1.6kHz for TM6 series.

5. Use of H.F. Ranges of type TM6 series.

Set the mechanical adjustment on the meter to zero after the instrument has been switched off for at least 30 seconds. Turn the range switch fully clockwise to the 1mV range. Connect the H.F. probe supply cable to the socket on the voltmeter panel. Set the switch on the probe to the +40dB (i.e. $\times 100$) position in which the probe input attenuator is in circuit. Do not connect any input to the BNC socket on the probe.

LEAVE THE INSTRUMENT SWITCHED ON FOR AT LEAST TWO MINUTES ON THE 1mV RANGE then slowly adjust the "H.F. Set Zero" control for minimum deflection on the meter. It should normally be possible to set the control so the reading is less than $200\mu\text{V}$ on the 1mV scale. This reading is due to thermal agitation noise that is inherent in the probe circuits. A high reading can however be caused when the probe is located in the field of a nearby high powered radio transmitter. Care must be taken in this event to ensure that the screws on the probe cover and rear panel of the instrument are tight and that the input socket is covered with a metal cap whilst the zero is set.

Connect the H.F. input to the BNC socket on the H.F. probe and select a suitable range from the four H.F. positions on the range switch. Move the probe switch to the 0dB position for maximum sensitivity.

The H.F. dB ranges are scaled relative to a reference level of 0dB = 1mW Into 50 ohms but the probe socket is not terminated and the input impedance is high compared with 50 ohms throughout the H.F. bandwidth. The input is coupled through an isolating

condenser so that D.C. may be superimposed on the A.C. input.

A high impedance pin tip and a short earth lead with clip are provided to permit the probe to be used for measuring signal levels at various points on circuit boards. The pin tip comprises a pin that is inserted in the centre of the BNC socket and a polythene insulator that is pushed over the pin and into the socket in order to give support to the pin. The pin and insulator are easily removed together by pulling out the pin with a pair of pliers.

Care must be taken to avoid a mains ripple between the case of the probe and the case of the TM6 instrument since such a signal will cause a measurement error and prevent the H.F. set zero control being set so the reading is less than $200\mu\text{V}$. The most common cause of this trouble is duplication of earth connections. Suppose for example that a mains power unit is fitted in the instrument, or an oscilloscope is connected to the output sockets, then the cases of these items will be connected to the earth pins on the mains plugs to satisfy safety regulations. The case of the voltmeter will thus be joined to a potential that is nominally earth. The probe earth may however be coupled to a signal source which is in turn connected to the earth pin on another mains plug that is located in a mains socket remote from that which is used for the voltmeter connection. There may be several millivolts of mains ripple existing between these two earth points which could cause trouble. The solution is to avoid low impedance duplication of earth connections. The earth connection to an oscilloscope may for instance be effectively isolated by connection of a 47Ω resistor in series with the earth lead that connects to the voltmeter output socket.

6. Use of Amplifier Output on H.F. Ranges.

The output is a square wave at 20Hz with amplitude proportional to the square of the input signal. The output is 270mV peak to peak when the meter indicates 15 on the 0/15 scale. This output may be used to drive a pen recorder after suitable amplification and rectification.

7. Adjustment of Preset Controls of TM3 and TM6 series (L.F. Ranges)

Turn the bandwidth switch fully clockwise on TM3B and TM6B. Turn the range switch to 15mV. Inject a 1kHz signal to give 150mV across the output sockets then adjust "Meter Sensitivity"

preset control so that meter reads 15 on top scale.

Inject 15mV at 1kHz and adjust the "Gain" preset control so that the gain between the input and output sockets is 20dB.

Adjust the bias preset control for less than $\pm 50\text{mV}$ D.C. across the output sockets.

The "Rin" preset control adjusts the input resistance which should be set to be $9\text{M}\Omega$ at 200Hz on the $50\mu\text{V}$ range. This should be done by injecting a signal to give 500mV across the output sockets and taking the measurements at these sockets. This will eliminate errors due to noise. It will not damage the meter movement even though it will be hard over on f.s.d.

The "Cin" preset control adjusts the input capacitance which should be set to be 40pF at 20kHz on the $50\mu\text{V}$ range. This should be done with 500mV across the output sockets as above.

Inject standard voltages at 1kHz and check the accuracy of the 50mV, 15mV..... $500\mu\text{V}$ ranges. Adjust the "Gain" preset control if necessary to balance the errors on these ranges. The $150\mu\text{V}$, $50\mu\text{V}$ and $15\mu\text{V}$ ranges should then be within specification after taking into account the inherent wide band noise which can be detected on these ranges.

The 40dB preset control adjusts the accuracy of the 5V, 1.5V, 500mV and 150mV ranges. The 80dB preset control adjusts the accuracy of the 500V, 150V, 50V and 15V ranges. Neither of these controls should be adjusted until the accuracy of the 50mV to 1.5mV ranges has been set to an optimum. The adjustment should then be made at 60Hz using external standard attenuators. The two trimmer capacitors on the range switch set the frequency responses of the ranges controlled by the 40dB and 80dB presets. These trimmers should be adjusted so that the instrument has the same sensitivity at 600kHz and 60Hz. The instrument must be in its case with the lid firmly in position for these checks.

8. Adjustment of Preset Controls of TM6 series. (H.F.Range)

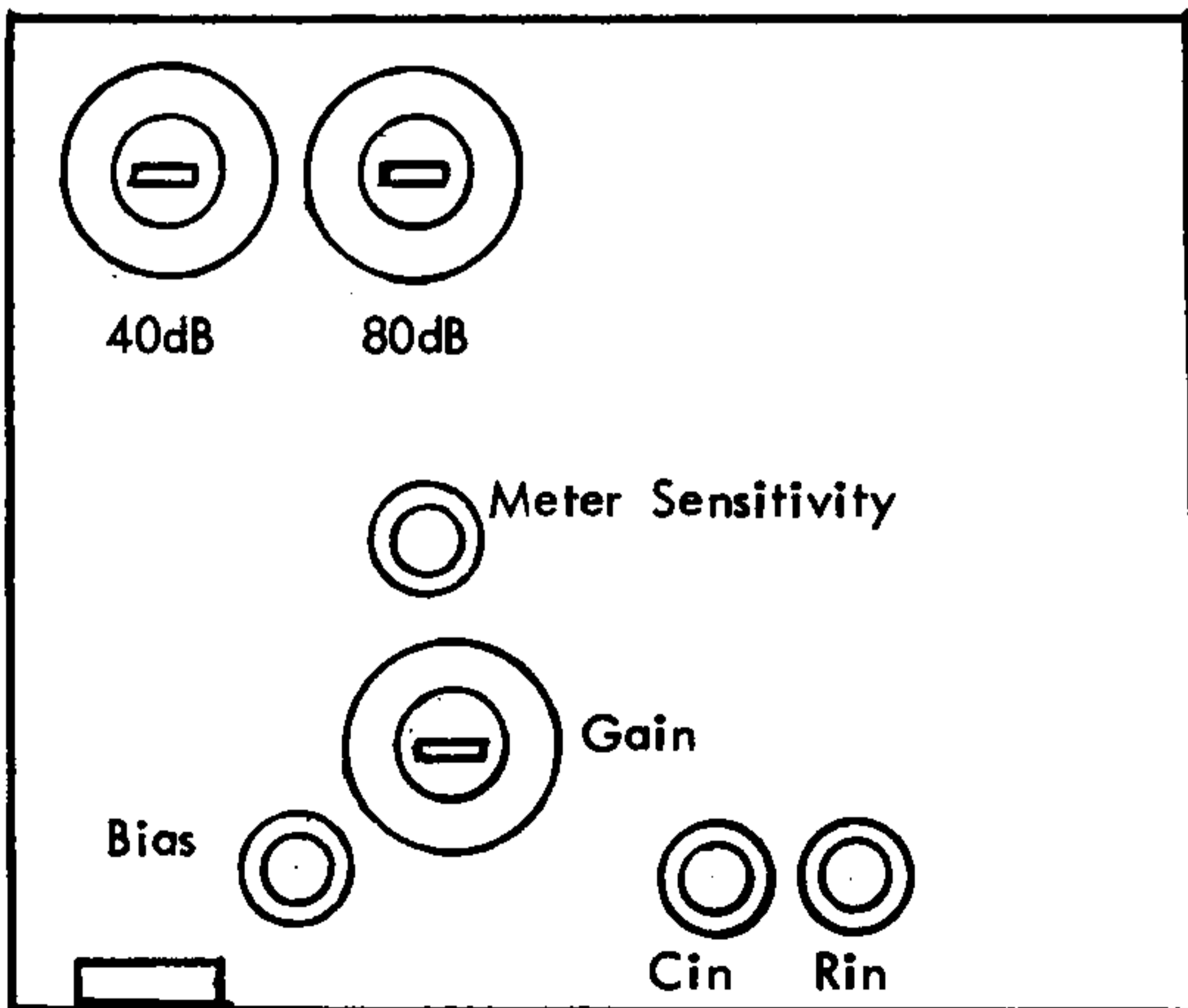
These adjustments should be carried out after the preceding checks. Connect the Probe Unit to the H.F. input and turn the range switch to 30mV on the green scale. Inject 30mV at 30MHz and adjust the Probe preset control (through the hole in the case) so that the meter reads correct at 30mV. Remove the input signal

and set the Probe attenuator slide switch to X100. Set the range switch to 1mV on the green range.

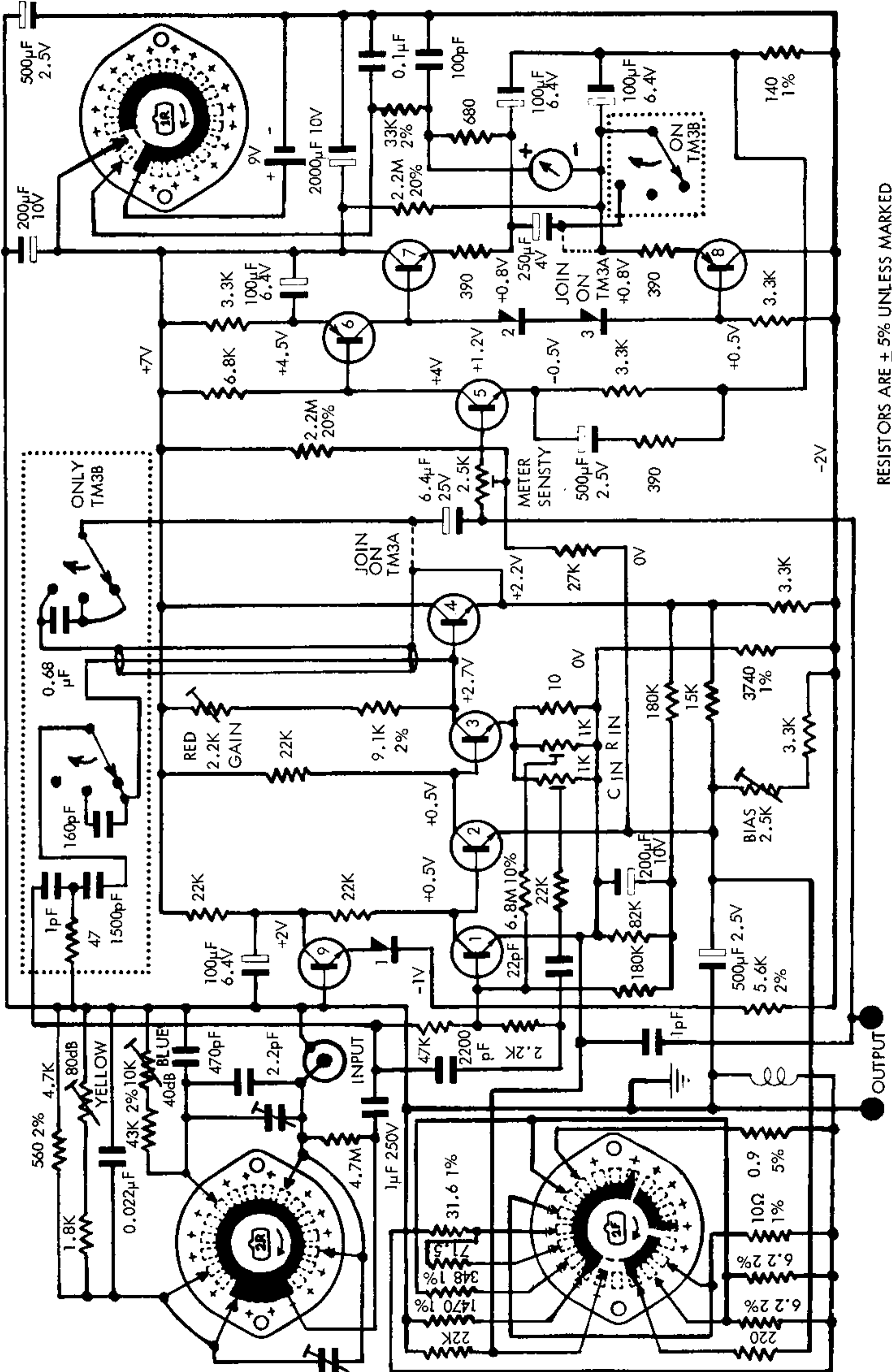
Connect a CRO between the junction of the 820Ω & $6.4\mu\text{F}$ (near J4 and J5) and earth. Adjust the H.F. Zero control on the front panel and the preset capacitor located near the rear of the H.F. input socket, to obtain pulses of less than $\pm 500\text{mV}$ on the CRO. Then remove the CRO. Set the Probe attenuator to X1, inject 1mV at 30MHz and adjust the 1mV preset control so that the meter reads correct at 1mV. This preset control is located on the printed circuit. (On early models it is located on the bracket between the meter and the printed circuit.)

Set the range switch to 30mV and inject 30mV at 30MHz. Reset the Probe preset control so that the meter reads 30mV on the green scale.

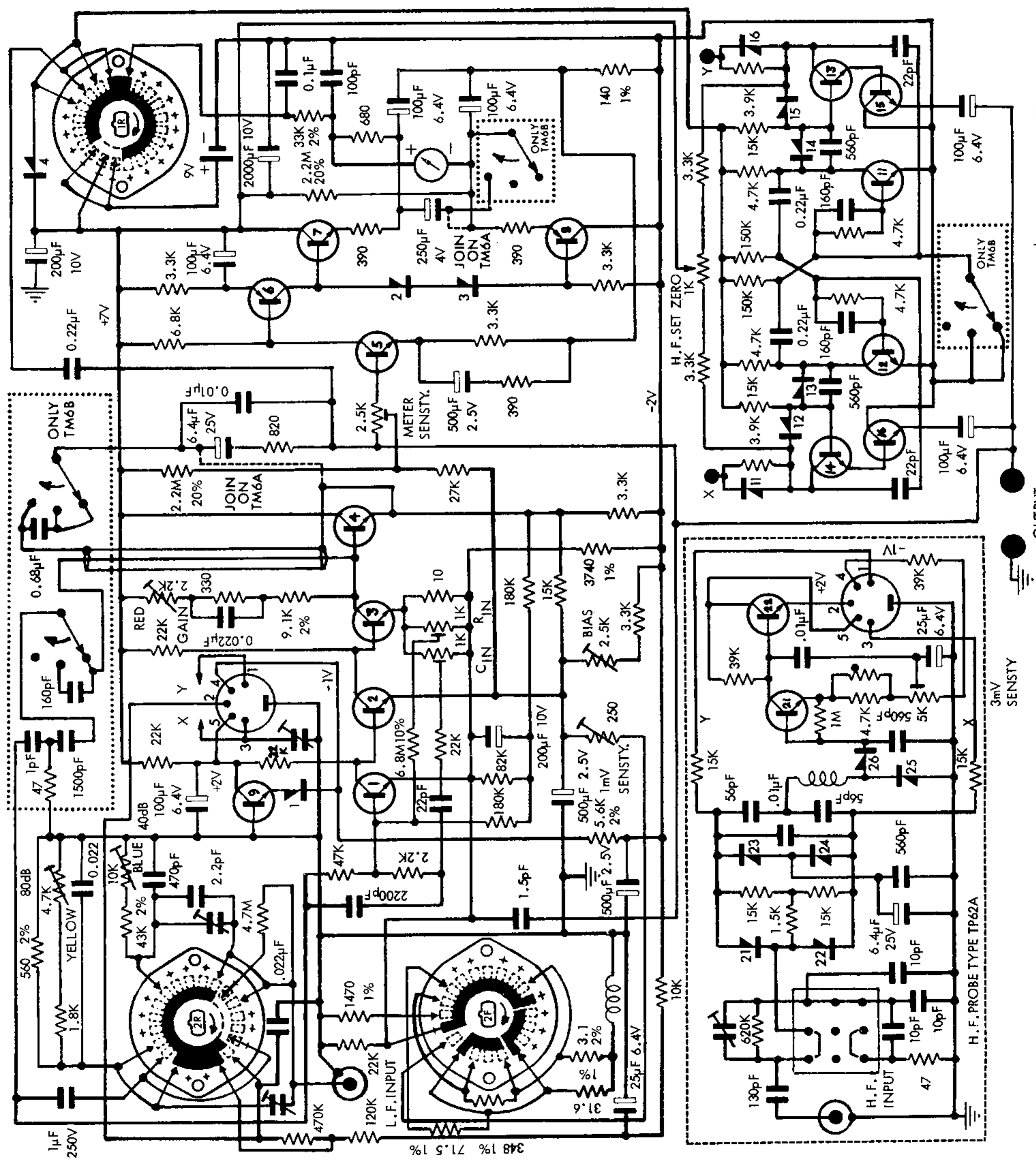
Set the Probe attenuator switch to X100 and check the accuracy of the attenuator at 300mV. The accuracy of the X100 attenuator may be adjusted by bending the $620\text{k}\Omega$ resistor located on the Probe attenuator switch near the Probe input. This will vary the apparent capacity across this resistor which is shown as a preset capacitor on the circuit diagram of the Probe. The Probe cover must be secured by its screws during these checks.



1mV (TM6 only)



RESISTORS ARE ± 5% UNLESS MARKED



RESISTORS ARE ± 5% UNLESS MARKED