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Type BFM
PORTABLE MEASURING EQUIPMENT FOR 4- MEGACYCLE COAXIAL CABLE CARRIER TELEPHONE SYSTEMS

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INTRODUCTION

The type BFM Portable Measuring Equipment was developed for supervision and maintenance measurements on coaxial cable carrier telephone systems.

It is designed to make possible point checks in the transmission band on the cable and can be used in all attended and unattended repeater stations along the line. The Equipment can be used when the line is in service without impairing the traffic on the line.

SECTION I

METHOD OF MEASUREMENT AND OPERATING PRINCIPLE

1-1 METHOD

The Measuring Equipment is based on measuring the levels of certain auxiliary line pilots which can be transmitted from the terminal station having frequencies in accordance with the recommendations of the CCIF. These auxiliary pilots are located in the gaps between adjacent line groups (see fig. 1) and will be transmitted at a level which is 9 db below that of the adjacent telephone channels. In addition to the auxiliary pilots the Measuring Equipment measures the levels of the ordinary line pilots 60 kc/s and 4092 kc/s.

1-2 OPERATING PRINCIPLE

The Equipment consists of the following instruments:

A) Selective Measuring Instrument type BFM110
B) Probe - BFM120
C) Power Supply - BFM130
D) Probe Termination - BFM140

The block diagram, fig. 2, shows the principal features of the Equipment. The line is bridged by a high-impedance transformer forming the probe. From this probe the signals are fed to the selective measuring instrument.

The principle of the latter instrument is that of a superheterodyne receiver. The incoming signal is preamplified in a selective amplifier using negative feedback, and is mixed in a converter stage with a local signal generated by a crystal controlled oscillator having 17 different quarts crystals, which can be individually switched in and out.

The frequencies of these crystals differ 249 kc/s from those of the corresponding line pilots, i.e. they are 309, 557, 805, 1057......4341 kc/s.

The beat-frequency of 249 kc/s passes a band-pass filter.

The cathode-coupled amplifier stage following the filter incorporates a voltage divider for changing the voltage range of the instrument. After final amplification in a negative feedback amplifier the amplitude of the signal is measured by means of a rectifier actuating the level meter on the front panel of the instrument.

For calibrating purposes the instrument incorporates a second crystal controlled oscillator with a frequency of 3040 kc/s.

The output of this oscillator can be standardized, and the total gain of the instrument can be checked by connecting the probe to the calibrating oscillator output.

Any variation in the total amplification can be compensated by means of an amplification-adjustment control.

The power supply (not shown in the block diagram) can be supplied either from an a-c power line or from a storage battery.

SECTION II

DESCRIPTION OF SELECTIVE MEASURING INSTRUMENT TYPE BFM110

The drawing No. 662-A1 appended to the operating instructions shows the complete circuit diagram of the Selective Measuring Instrument type BFM110.

2-1 PREAMPLIFIER

The preamplifier tube (tube No. 11) operates as a selective amplifier.

Negative feedback is produced by means of an impedance in series with the cathode.

This impedance consists of a series connection of the resistor F5, 2 kilohms, and the LC circuit F5 tuned to the intermediate frequency 249 kc/s, thus giving a peak amount of feedback at this frequency. The feedback is practically constant for all the pilot frequencies.

In this way an extra suppression of the intermediate frequency takes place in this stage without disturbing the amplification characteristics at the measuring frequencies.

The anode circuit consists of one of the 17 different resonant circuits $K_1 \ldots\ldots K_{17}$. These circuits, which can be switched in and out individually, are tuned to the 17 pilot frequencies and operate as filters for undesired signals.

The resonant impedance of all the circuits is the same, but the Q-value differs and is chosen so as to obtain a total attenuation of undesired frequencies of about 40 db.

2-2 MIXER

The mixer tube (tube No. 10) operates as an additive mixer with signal input to the control grid, and local signal input to the cathode.

The incoming signal from the preamplifier is attenuated in a capacitive voltage divider consisting of the condenser E4, 40 pF and the condenser D3, 80 pF in parallel with the mixer tube input capacity and one of the

17 different trimming condenser 3-40 pF. These trimming condensers provide for an individual calibration of amplification by the different measuring frequencies and they are switched in and out synchronously with the corresponding filters in the preamplifier stage.

The local signal is monitored by means of a crystal diode actuating a meter on the front panel of the instrument.

The local signal system incorporates a cathode follower (tube No. 3) and a 5:1 transformer (C5). The low output impedance of the cathode follower is further diminished by the use of the transformer, and due to this special arrangement the impedance in series with the cathode of the mixer tube is very low, giving nearly constant mixer gain over the frequency range in question.

The mixer tube is loaded with the intermediate frequency filter.

2-3 LOCAL OSCILLATOR

The local oscillator incorporates a quartz crystal controlled oscillator (tube No. 1), a buffer amplifier (tube No. 2), an output stage (tube No. 3), and a tube in series with the oscillator tube controlling the output (tube No. 4).

The circuit of the oscillator proper is that of a Colpitt's oscillator with grounded anode.

17 different quartz crystals can be switched in and out of the oscillator circuit synchronously with corresponding units in the preamplifier and mixer stage.

To avoid overloading of the crystals the amplitude of the oscillator is kept relatively low. The voltage across the crystal is of the order of 1 volt. This voltage is amplified in the buffer amplifier which gives off a driving voltage for the output stage of the order of 10 volts. This voltage is "measured" by means of a crystal-diode rectifier, pos. C5. The current from the rectifier controls the grid voltage of the series tube No. 4 in such a way that the driving voltage for the output stage will remain nearly constantly unaffected by the crystal used.

The correct operation value of the output is set by means of the potentiometer (200 kΩ, B7).

2-4 INTERMEDIATE FREQUENCY FILTER

The intermediate frequency filter incorporates 4 resonant circuits. Two by two the resonant circuits are inductively coupled with a coefficient of coupling which is slightly more than critical. The two band-pass filters formed in this way are capacitively coupled with a coefficient of coupling which is much less than critical.

The filter is contained in two boxes mounted side by side on the instrument chassis, each containing an inductively coupled pair of circuits.

The filter characteristics are treated in paragraph 8. The center frequency of the filter is 249 kc/s.

2-5 INTERMEDIATE FREQUENCY AMPLIFIER

The intermediate frequency amplifier incorporates two stages, viz. a cathode follower stage (tube No. 5) and a three tube amplifier stage using negative feedback (tubes No.s 6, 7 and 8).

Between the two stages is introduced a voltage divider (BCD10) by means of which the sensitivity range of the instrument is selected. This voltage divider is calibrated in steps of 10 db or 1 Neper.

The feedback amplifier stage incorporates a tuned circuit B11 tuned to the intermediate frequency 249 kc/s thus giving a wide peak response around this frequency. Because of the amplifier selectivity, distortion from hum and other undesired signals is avoided.

Feedback is introduced by leading the current of the last tube through a resistor D11 in series with the cathode of the first tube.

Temperature compensation in the feedback network is accomplished by means of a nickel resistor C12 to minimize change in over-all sensitivity caused by variations in ambient temperature.

The degree of feedback is adjustable and by this means the amplification can be adjusted to compensate for any variation in the total amplification.

2-6 LEVEL METER

The output current of the feedback stage described in the preceding paragraph is measured by means of a rectifier coupling (B14) and a meter.

The meter is calibrated directly in Nepers or db.

The deflection of the meter is practically proportional to the mean value of the current.

The terminals (C15) make it possible to use an external meter or recorder. When using an external meter, the internal meter is automatically switched off.

2-7 CALIBRATION OSCILLATOR

The built-in calibration oscillator incorporates an oscillator tube (tube No. 9) and a quartz crystal for the calibration frequency 3040 kc/s.

The calibration oscillator is mounted inside a shield-box which also incorporates an attenuator for attenuating the oscillator amplitude to the desired calibration output.

To prevent leakage all supply and measuring leads are carefully filtered for the oscillator frequency before they are brought out through the shield.

The amplitude of the oscillator is calibrated by varying the anode voltage by means of the potentiometer E7, 20 kilohms.

The amplitude of the oscillator is determined by measuring the grid current.

When not in use the oscillator is inoperative, but the filament power is always on when the instrument is in use. The anode voltage of the oscillator is switched on by means of the push-button switch E8. By this operation the meter 0.2 mA E8 is automatically switched over to measure the grid current of the oscillator instead of the local signal at the cathode of the mixer.

The output of the local oscillator is available at a connector in the front panel. When calibrating the total amplification of the instrument, the probe head is plugged into the said connector.

2-8 SELECTIVITY

As shown in fig. 1 all the pilot frequencies are placed in empty gaps between the line groups (supergroups).

The distance between a pilot and the adjacent telephone channels is at least 4 kc/s (this holds good even of the 60 kc/s pilot because the lowest telephone channel is dropped when measurements are made on the 60 kc/s pilot).

The intermediate filter selectivity must be so high that distortion due to signals in the adjacent telephone channels to the pilots is small enough to keep the error in measurements below a suitable value.

If a maximum error of one per cent is tolerated, it can be shown that the signal-noise ratio at the input of a device indicating the a-c mean value, such as the level meter, must be 14 db.

In a coaxial-cable carrier telephone system the peak voltage of the signal in the adjacent telephone channels can reach a level of 17 db above the level of the pilot. Thus the intermediate frequency filter must be so designed that signals with frequencies of 249 ±4 kc/s are attenuated (14+17) db = 31 db.

If the level of the pilots is lower than the normal level, this selectivity is insufficient. Therefore the intermediate frequency filter is designed to attenuate a 249 ±4 kc/s signal by more than 40 db. Further the filter is designed to be flat within ±0.5 db for detuning within ±700 c/s with a view to any drift of the local oscillator.

The selection of an intermediate frequency of 249 kc/s is based on the following notions: It is desirable to place the local oscillator frequency in the empty frequency bands on the cable. There a leak of local signal will not disturb the traffic on the line.

When the frequency of the local oscillator is always the pilot frequency + 249 kc/s, the local signal is always placed in the empty bands, as will be seen from fig. 1.

Besides being sensitive to the signal frequencies the instrument is sensitive to the following frequencies:

1) intermediate frequency, IF = 249 kc/s
2) image frequency, $f_s + 2\,IF = f_s + 498$ kc/s
3) $n \cdot f_{osc} \pm IF$, when n = 2, 3, etc.

As appears from fig. 1 all the image frequencies are placed in the empty frequency bands, but IF is placed in the group 60-300 kc/s. The frequencies mentioned under item 3) are only of little importance, because they are higher than the image frequencies of all pilots but 60 kc/s, and the sensitivity of the instrument to these frequencies is always low due to the small amount of harmonics in the local oscillator signal.

Like the IF filters the filters $K_1 \ldots K_{17}$ must attenuate an undesired signal so much that a total attenuation of about 40 db is obtained up to the output terminals of the IF amplifier so as to avoid essential errors in measurement. Only signals on the IF and the image frequencies need be considered undesired signals.

Signals on the IF are most serious to measurement on the lower pilots, but due to the special selective feedback circuit used in the preamplifier the IF is always attenuated by about 17 db in addition to the attenuation in the filters $K_1 \ldots K_{17}$.

The IF amplification of the mixer tube is about 8 db higher than that of a signal which is to be converted.

Thus it is required that the filters $K_1 \ldots K_{17}$ attenuate the IF by

$$(40+8-17) \text{ db} = 31 \text{ db}$$

which is easily obtained even with filters of simple design.

Signals on the image frequencies are not transmitted on the cable, but telephone channels are placed 2 kc/s from the image frequencies. If the IF filter always attenuates a signal of 249 ±2 kc/s at least by 14 db, it is necessary that the filters $K_1 \ldots K_{17}$ attenuate the image frequencies by

$$(40-14) \text{ db} = 26 \text{ db}$$

which is also easily obtained in filters of simple design even in case of the higher pilot frequencies.

It is evident that no special requirements are made to the filters K_{15}, K_{16} and K_{17} because the image frequencies of the three corresponding pilot frequencies are far outside the transmission band on the cable.

SECTION III

DESCRIPTION OF PROBE TYPE BFM120 AND TERMINATION TYPE BFM140

3-1 PROBE TYPE BFM120

The drawing No. 893-A4 appended to the operating instructions shows the approximate physical layout of the probe type BFM120.

The probe includes a high-frequency transformer with a primary to secondary step-down = 10, giving an attenuation of the incoming signals of 20 db or 2.3 Nepers.

The probe input is a coaxial plug fitting the coaxial jacks in the terminal jacks where measurements are to be made.

The probe is mounted at the end of a 2 meter long coaxial cable with a characteristic impedance of 75Ω.

The other end of the cable is furnished with a coaxial plug for connecting to the Selective Measuring Instrument type BFM110.

3-2 TERMINATION TYPE BFM140

The Termination type BFM140 is used for measurements at which the test jacks must be loaded with 75Ω.

The Termination consists of a short length of line including a 75 ohm resistor in parallel with the line.

At one end the Termination is provided with a coaxial jack fitting the probe input plug, and at the other end it is provided with a coaixal plug identical with the probe input plug.

The Probe and the Termination are stored in the cabinet cover of the type BFM110 during transportation.

SECTION IV

DESCRIPTION OF POWER-SUPPLY UNIT TYPE BFM130

The drawing No. 916-A3 appended to the operating instructions shows the complete circuit diagram of the Power-Supply Unit type BFM130.

The type BFM130 supplies the following voltages to the type BFM110 Selective Measuring Instrument:

approx. +150 volts, d-c, stabilized, for the mixer, preamplifier and oscillators (contact No. 4)

approx. +160 volts, d-c, for the IF amplifier (contact No. 3)

approx. 6.3 volts, a-c, for the heaters (contact No. 2)

The type BFM130 can be operated either on 220 or 110 volts, a-c, from the power line, or on 6 volts, d-c, from a storage battery. The main switch has 3 positions:

= OFF ∿

and is so designed that both the power line and a battery can be connected simultaneously without causing any damage, because when one is "on", the other will be "off".

By means of an internal voltage selector plug the Power Supply can be set to operate on 220 volts a-c or 110 volts a-c.

The instrument provides for the use of ordinary vibrators. It is built with 2 vibrators and 2 transformers, one supplying one of the anode voltages plus the heater voltage.

All current-carrying circuits of any importance are protected from overload by means of fuses which are accessible on the front panel, with one exception, viz. the 1 amp fuse between –6V and the chassis. The latter fuse is mounted in an open fuse holder on the inner chassis.

The two plate voltages and the battery voltage can be checked by means of the built-in voltmeter.

SECTION V

OPERATING PROCEDURE

5-1 CONNECTION

The equipment is prepared for use by removing the cabinet covers and connecting the Selective Measuring Instrument type BFM110, the Probe type BFM120, and the Power Supply type BFM130.

Before connecting the equipment to the power line, make sure that the line voltage and frequency are within the specified limits, and that the line voltage corresponds to the setting of the voltage selector plug in the Power Supply.

When using a storage battery, make sure that the battery voltage is 6 volts.

The Power Supply can be connected to both power line and storage battery at the same time.

The equipment is switched on with the power switch of the Power Supply Unit and is allowed to warm up for a few minutes.

5-2 OPERATING CONTROLS AND TERMINALS

All the controls required for the operation of the equipment are located on the front panels of the instruments.

(A) SELECTIVE MEASURING INSTRUMENT TYPE BFM110

(a) Frequency control

The frequency selector switch marked FREQUENCY kc/s allows the Selective Measuring Instrument type BFM110 to be tuned to any of the 17 different measuring frequencies.

The position 3040 is also used when adjusting the over-all amplification of the instrument, so it is marked CAL. in red color.

(b) Oscillator controls

The knob marked LOC. OSC. ADJUSTMENT controls the amplitude of the local-oscillator and is always set to a position where the amplitude meter needle rests at the red mark.

The START. CAL. OSC. pushbutton operates the calibration oscillator and switches the amplitude meter to indicate the calibration oscillator output.

The calibration oscillator output is standardized by means of the CAL. OSC. ADJUSTMENT by rotating this control until the amplitude meter needle rests at the red mark.

(c) Sensitivity controls

The sensitivity of the instrument is selected by means of the LEVEL RANGE switch. The most sensitive position is marked CAL., because this position is used when calibrating the instrument.

The over-all amplification of the instrument can be adjusted by means of the AMPLIFIER ADJUSTMENT control. When correct setting of this control is obtained, the knob is kept in place with a locking mechanism.

(d) Terminals

Two coaxial jacks are mounted in the instrument front panel. The jack marked PROBE HEAD provides for connecting the measuring cable with probe to the instrument. The calibration oscillator output can be drawn from the jack marked CAL. SIGNAL which will take the probe input plug. A multicontact connector provides for connection of the instrument to the type BFM130 Power Supply.

(B) POWER SUPPLY TYPE BFM130

(a) Power switch

The power switch is a three-position switch. The input power is off in the center position. The two other positions select either power input from an a-c line or from a 6 volt storage battery.

(b) Meter switch

Using the METER switch the voltages for the plate supply of the selective measuring instrument type BFM110 and the voltage of the storage battery can be measured on the meter.

(c) Terminals

The power line is connected to the terminals marked 220 V∿ or 110V∿, and the storage battery to the binding posts marked 6 V BATT.

The supply voltages for the Selective Measuring Instrument type BFM110 are available at the multicontact connector.

5-3 STEP-BY-STEP OPERATION

(1) Prepare equipment by connecting Selective Measuring Instrument type BFM110, Probe type BFM120, and Power Supply type BFM130.

(2) Connect Power Supply type BFM130 to a-c power line or to 6 volt storage battery, and switch on. Allow for a warm-up period of at least 5 minutes.

(3) Connect Probe type BFM120 to CAL. SIGNAL jack. Set FREQUENCY kc/s to CAL. and LEVEL RANGE to CAL. Rotate LOC. OSC. ADJUSTMENT until amplitude meter needle rests at red mark.

(4) Push START. CAL.OSC. button. Rotate CAL.OSC.ADJUSTMENT until amplitude meter needle rests at red mark. Rotate AMPLIFIER ADJUSTMENT until level meter reads zero, and lock the knob.

(5) Rotate LEVEL RANGE switch counter clockwise until it rests at stop.

(6) Connect Probe type BFM120 to test point. Set FREQUENCY kc/s to the desired frequency. Rotate LOC.OSC.ADJUSTMENT until meter needle rests at red mark.

Rotate LEVEL RANGE switch until suitable deflection is obtained on the level meter.

Read level meter and add reading to setting value of LEVEL RANGE switch.

(7) If 75Ω input impedance of Probe type BFM120 is desired, mount Termination type BFM140 on probe plug.

SECTION VI

MAINTENANCE

6-1 GENERAL

The Portable Selective Measuring Equipment consists of delicate instruments, so unnecessary repair or attempts to improve the accuracy should not be made.

Such repairs as may become necessary should be made by skilled personnel only, provided with sufficient equipment to ensure that the repair is properly made.

When transporting, handling, and operating the Equipment with care, its useful life will be prolonged, and trouble will be reduced to a minimum.

The instruments should be protected from dust and moisture. It is advisable to keep the cover on the instrument cases when the Equipment is not in use and from time to time to inspect the exterior of the instruments for dust, dirt and corrosion.

6-2 REMOVING THE INSTRUMENT FROM THE CABINET

Both the Selective Measuring Instrument and the Power Supply can be removed from the cabinet when the four fixing screws along the edge of the front panel have been removed.

6-3 TUBE REPLACEMENT

In general the tubes of the Equipment require no replacement until they cause some kind of trouble.

All tubes, except that inside the calibration oscillator box, of the type BFM110 Selective Measuring Instrument, can be readily replaced when the instruments are removed from the cabinets.

Tubes with average characteristics can be used for any replacement.

Only one type of tubes is used in the Selective Measuring Instrument type BFM110, and for replacement purpose a spare tube can be placed in the special spare-tube-socket on the instrument chassis.

6-4 ALIGNMENT OF TUNED CIRCUITS IN THE SELECTIVE MEASURING INSTRUMENT TYPE BFM110

It is no easy job to align the tuned circuits in the Selective Measuring Instrument type BFM110 and if not absolutely necessary, attempts to improve the tuning of the different filters and tuned circuits should be avoided.

If, however, an error can be referred to a tuned circuit, it can be readjusted when observing the following precautions:

(a) I.F. filter

The I.F. filter must be tuned to a center frequency of 249 kc/s within ±0.05 per cent.

A signal source of this accuracy must therefore be available for the alignment.

The IF signal can be introduced without disturbing the wiring by removing the tube No. 3 and connecting the signal source between the cathode contact of the tube socket and the instrument chassis.

As a preliminary adjustment the four tuned circuits in the filter are tuned to the center frequency. This adjustment is made with a loading resistor of 50 kΩ across the first and the last tuned circuit. The terminals of the first circuit is available when the cover plate of the rf section of the instrument is removed.

The loading of the first circuit is perhaps most easily carried out by connecting the 50 kΩ resistor between the anode of tube No. 10 and the chassis.

The output level of a 249 kc/s signal is observed at the level meter. A suitable angle of deflection is set by means of the LEVEL RANGE switch.

The four trimming screws of the IF filter are now turned to such positions that give maximum deflection on the level meter.

This adjustment must be carefully made, and it is advisable to ensure that the 249 kc/s signal lies within the limits of ±0.05 per cent all the time.

When proper tuning of all the four circuits has been obtained, the loading of the input and output terminals is removed.

The filter characteristic around the center frequency is now checked by detuning the signal source by known values and determining the corresponding variations in filter response by means of the level meter.

Small adjustments of the trimming screws of the first and the last coil may be necessary for resetting the filter characteristic to the specified values, because the loading resistors used by the preliminary adjustment introduce some capacitive loading too.

(b) Resonant circuits K_1 ...... K_{17}

The anode circuits K_1 ..... K_{17} (see complete diagram, drawing No. 662-A1) must be tuned to the corresponding measuring frequencies.

The alignment of these circuits is made by means of the coil trimming screws. However, the tuning of the circuits is impaired by the setting of the corresponding trimming condensers in the capacitive voltage divider between the amplifier stage and the mixer stage. Thus, a readjustment of one of the circuits K_1 ..... K_{17} must be accomplished with a check of the amplification of the instrument at the corresponding measuring frequency and vice versa.

A signal source with a very accurately known output level must be used for the alignment of the circuits K_1 ..... K_{17} and the voltage divider trimmers. The level must be known within 0.5 per cent.

The signal source is connected to the input terminals of the instrument, and the output level is measured on the level meter.

(c) Resonant circuits F5 and B11

The resonant circuits F5 and B11 (see complete circuit diagram, drawing No. 662-A1) are both tuned to the I.F., 249 kc/s.

These circuits are re-aligned by setting the frequency selector switch to 308 kc/s and connecting a signal generator set to read 249 kc/s to the input terminals of the instrument.

The level meter deflection is set to at suitable value by means of the level range switch and the signal generator output.

The circuit F5 is readjusted by turning the trimming screw of the coil until a minimum deflection of the level meter is obtained.

The feedback resistor D13 should be short-circuited before readjusting the circuit B11. (Note: The total amplification will increase by about 20 db). The trimming screw of the coil is then turned until the level meter reads maximum.

6-5 ADJUSTING THE BUILT-IN CALIBRATION OSCILLATOR IN THE SELECTIVE MEASURING INSTRUMENT TYPE BFM110

If required, the output level of the calibration oscillator can be reset by adjusting the trimmer condenser F10, which is accessible through a hole in the oscillator box.

The calibration oscillator output must be compared with the output of a signal source tuned to 3040 kc/s, and with an accuracy of the output level within 0.5 per cent. The comparison is made by substitution.

6-6 SERVICING THE POWER SUPPLY TYPE BFM130

Provided that the instrument is not exposed to damage or overload, the life expectance of the components of the BFM130 approaches infinity, except for the vibrators, and the Power-Supply Unit needs no special care and maintenance when in regularuse.

(a) Vibrators

The vibrators are the most delicate components of the BFM130, their life expectance being about 1000-2000 hours. If a vibrator is worn out or fails to work, it should be replaced with a new one of the same make and type. Such a replacement can be made without any further inspection of the Power Supply. If a vibrator is suspected or rendering unsatisfactory performance, or if a vibrator has been replaced with one of another type or make, it is recommended to inspect the a-c waveform across one of the transformer windings by means of an oscilloscope.

In the illustration figs. 3a-f six typical waveforms are shown, viz.

3a Buffer capacitance too small. Add capacitance until the waveform approaches 3b.

3b shows the "ideal" waveform with inductive load. This waveform should be aimed at on the transformer JS1615.

3c Buffer capacitance too large. Remove capacitance until a waveform like 3b has been achieved.

3d This illustration shows contact-bouncing, a hardly inevitable phenomenon in vibrators. The degree of bouncing shown here can be ignored. In general the slightly idealized waveforms shown in the illustrations will be superimposed by bouncing ripple.

3e This waveform shows a vibrator failure named "single-footing", i.e. one contact fails to close, due to dust, oxidization, etc. This failure is predominant among new vibrators or vibrators which have been out of use for several months. It will often disappear after a short time, but if it appears regularly or is permanent, the vibrator must be replaced.

3f This waveform will be found across the transformer JS1616 and is due to the heavy resistive load of the heater current.

The vibrator circuit of the BFM130 is so designed that both shunt-drive vibrators and vibrators with separate drive contact can be used. If a vibrator fails to start, try to knock it, e.g. with the handle of a screwdriver. If it still fails to start, replace it. If new vibrators fail to start, an attempt should be made to have them replaced from the supplier.

(b) Fuses

All fuses, except C7, 1A (see circuit diagram No. 916-A3) are mounted on the front panel of the Power Supply type BFM130 and can be readily replaced. The fuse holders indicate the fuse values.

The fuse C7, 1A serves as a protection to the storage battery if the positive pole is grounded by mistake. The fuse is mounted inside the instrument in a small fuse holder on the chassis.

If a fuse burns out, replace it. If the new fuse burns out immediately, it means that some defect has occurred in the BFM130 or the BFM110. The defect must be traced and remedied before a new fuse is inserted. Never replace a fuse with a larger one.

6-7 OPERATING VOLTAGES AND CURRENT OF THE SELECTIVE MEASURING INSTRUMENT TYPE BFM110 AND POWER SUPPLY BFM130

The voltages and currents listed on next page can be used as references when servicing the instruments. These values are mean values from a series of measurements, and deviations up to 20% may usually be neglected. The voltmeter should have a negligible consumption (vacuum-tube voltmeter).

BFM110

VOLTAGE MEASUREMENTS

(all voltages measured to chassis)

from		d-c volts	a-c volts
power connector contact No.	2		6.3
	3	160	
	4	145	
tube No. 1	pin No. 2	40-65	
	5	135	
	6	65	
tube No. 2	pin No. 2	2.1	
	5	85	
	6	130	
tube No. 3	pin No. 2	1.5	
	5	130	
tube No. 4	pin No. 5	40-65	
tube No. 5	pin No. 2	35	
	5	135	
tube No. 6	pin No. 2	2.9	
	5	135	
	6	135	
tube No. 7	pin No. 2	2.8	
	5	80	
	6	140	
tube No. 8	pin No. 2	2.8	
	5	80	
	6	140	
tube No. 9	pin No. 1	−6 - −12	
	5	15-60	
tube No. 10	pin No. 2	2.1	
	5	130	
	6	100	
tube No. 11	pin No. 2	11	
	5	130	
	6	90	

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CURRENT MEASUREMENTS

Current through power connector contact No.	2	1.9 amps, a-c
	3	30 mA, d-c
	4	34 mA, d-c

B F M 1 3 0

VOLTAGE MEASUREMENTS

(all voltages measured to chassis)

from power connector contact No.	2	6.3 volts,	a-c
	3	160 -	d-c
	4	145 -	d-c

B F M 1 3 0

CURRENT MEASUREMENTS

Total primary consumption

at operation on	220 volts,	a-c	250 mA, a-c
- - -	110 -	-	500 - -
- - -	6 -	d-c	8.5 amps, d-c

SECTION VII

SPECIFICATIONS

1) CONSTRUCTION

The Equipment consists of the following instruments:

A) Selective Measuring Instrument type BFM110
B) Probe - BFM120
C) Power Supply - BFM130
D) Termination - BFM140

2) SELECTIVE MEASURING INSTRUMENT TYPE BFM110

Measuring frequencies:

60 kc/s	2296 kc/s
308 -	2544 -
556 -	2792 -
808 -	3040 -
1056 -	3288 -
1314 -	3536 -
1552 -	3784 -
1800 -	4092 -
2048 -	

Measuring range:

The instrument is calibrated in Neper or db. When calibrated in Nepers, the full-scale sensitivity of the instrument proper is

–2.8 to –10.8 Nepers
(0 Neper = 0.775 volt)

The entire range is divided in 9 sub-ranges in steps of 1 Neper.

The positions of the level range switch are so designated that the levels read apply to measurements with probe.

The indicating meter is calibrated in Nepers from –1 to +0.5 (probe attenuation = 2.3 Nepers, range switch positions designated –1, –2 ......–9).

For calibration in db the full-scale sensitivity of the instrument proper is

–25 to –95 db
(0 db = 0.775 volt)

The entire range is divided in 8 sub-ranges in steps of 10 db. The positions of the level range switch are so designated that the levels read apply to measurements with probe.

The indicating meter is calibrated in db from −10 to +5. (Probe attenuation = 20 db, range switch positions designated −10, −20 ......−80).

Input impedance:

(75 +j0) ohms

Selectivity:

All irrelevant signals transmitted on the cable are attenuated more than 40 db.

The IF filter characteristic is flat within 0.5 db on the range 249 ±700 c/s.

Signals that deviate more than ±4 kc/s from the signal frequencies are attenuated by more than 40 db.

Calibration oscillator:

The instrument is provided with a built-in calibration oscillator for the measuring frequency of 3040 kc/s with an output level of −7 Neper or −60 db (0 Neper = 0 db = 0.775 volt).

The total amplification of the instrument can be checked and readjusted by connecting the probe to the output jack of the calibration oscillator.

Accuracy:

The over-all accuracy is within ±0.5 db.

The various circuits of the instrument contribute to the measuring error in the following manner:

Preamplifier, filter and voltage divider:	approx.	±0.2 db
Mixer	-	±0.2 db
IF-filter	-	±0.3 db
IF-amplifier and level meter	-	±0.2 db
Calibration oscillator	-	±0.2 db

Change in indication due to variations in supply voltage

When the instrument operates in conjunction with Power Supply type BFM130, the relation between supply voltage and indication is as follows:

At operation from a-c power line: Change in indication smaller than 0.03 db per % variation in voltage.

At operation from 6 volt storage battery: Change in indication smaller than 0.08 db per % voltage variation.

Rapid change in indication due to vibrator beat smaller than 0.1 db.

Change in indication due to slow variations in supply voltage can be compensated for by adjustment of the total amplification.

Change in indication due to ambient temperature:

For increasing ambient temperature the indication will decrease. This change will be smaller than 0.05 db per degree centigrade and can be compensated for by adjusting the total amplification.

Zero signal output level:

The output indication of the instrument with probe input short-circuited is of the order of −11 Nepers or −100 db, 0 N = 0 db = 0.775 volt (referring to the probe input terminals). This holds true of all measuring frequencies except 60 kc/s where the zero signal output level is about −10 Nepers or −85 db, 0 N = 0 db = 0.775 volt.

Deviation of local oscillator frequencies:

Max. deviation of the local oscillator frequencies from the nominal value is ±200 c/s.

Vacuum tubes:

11 type 6AK5 or 403B or EF95

Supply voltages and current requirements:

The following voltages and currents are required for the operation of the instrument:

6.3 volts, a-c	1.9 amps
160 volts, d-c	30 mA
150 volts, d-c, stabilized	34 mA

Generally the instrument is supplied from a type BFM130 Power Supply.

Operating position:

Front panel horizontally or vertically positioned.

Construction:

The instrument is mounted in a rugged grey-finish steel case with detachable cover in which the type BFM120 Probe, the type BFM140 Termination, and the instruction manual or a notebook are stored when not in use.

The case is provided with two strong carrying handles and with rubber feet on four sides. The top is provided with knobs which fit the rubber feet of the type BFM130 instrument.

Dimensions:

265 x 308 x 525 mm^3, over-all

Weight:

22 kilos with accessories stored in cover

3) PROBE TYPE BFM120

Attenuation:

20 db = 2.3 Nepers

The attenuation curve is flat within 0.1 db from 60 kc/s to 4 Mc/s.

The attenuation has increased by 0.1 db at 4 Mc/s and by 0.2 db at 6 Mc/s.

Input impedance:

When the measuring cable is terminated in an impedance Z = (75+j0) ohms (the input impedance of the Selective Measuring Instrument type BFM110), the input impedance is

$$|Z_i| > 3 \text{ kilohms}$$

in the frequency range 60 kc/s to 4.1 Mc/s.

Construction:

The probe fits the hand well. The body is of aluminum alloy in black crackle finish. The Probe is provided with a coaxial input plug which fits the measuring jacks of the terminal racks, and a 2 m long flexible cable with a coaxial plug for connection to the type BFM110 Selective Measuring Instrument.

When not in use, the probe is stored in the cover of the type BFM110 Selective Measuring Instrument.

Weight:

Probe with cable weighs 530 grams

4) POWER SUPPLY TYPE BFM130

Voltage supplied:

The instrument is especially designed for supplying the following voltages to the type BFM110 Selective Measuring Instrument:

6.3 volts, a-c, for filament current supply
160 volts, d-c, for anode current supply
150 volts, d-c, electronically stabilized, for anode current supply

Power supply:

The instrument can be supplied either from a 220 or 110 volt 50-60 c/s power line, or from a 6 volt storage battery.

Consumption:

When loaded with the type BFM110 Selective Measuring Instrument, the primary consumption is:

250 mA	at operation on	220 volts,	a-c
500 -	- - -	110 -	-
8.5 A	- - -	6 -	d-c

Vacuum tube:

1 type 150C1K or OD3

Operating position:

Front panel horizontally or vertically positioned

Construction:

The instrument is mounted on a rugged grey-finish steel case with detachable cover in which all the connecting cables are stored when not in use.

The case is provided with two strong carrying handles and with rubber feet on four sides. The top is provided with pins which fit the rubber feet of the type BFM110 instrument.

Dimensions:

221 x 308 x 525 mm^3, over-all

Weight:

19 kilos with accessories stored in cover

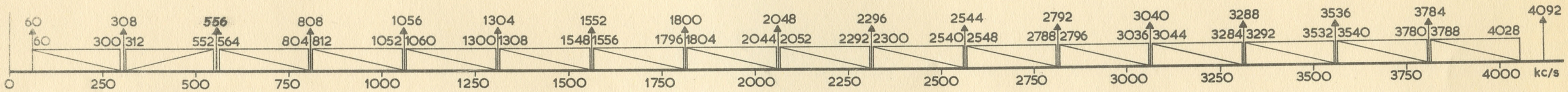
5) TERMINATION TYPE BFM140

The Termination type BFM140 consists of a short length of coaxial line provided with a coaxial jack fitting the input plug of Probe type BFM120 in one end and a coaxial plug equal to the probe input plug in the other. The Termination includes a 75 ohm resistor in parallel with the line.

Value of resistor:

75Ω ±0.5 per cent

FIG. I

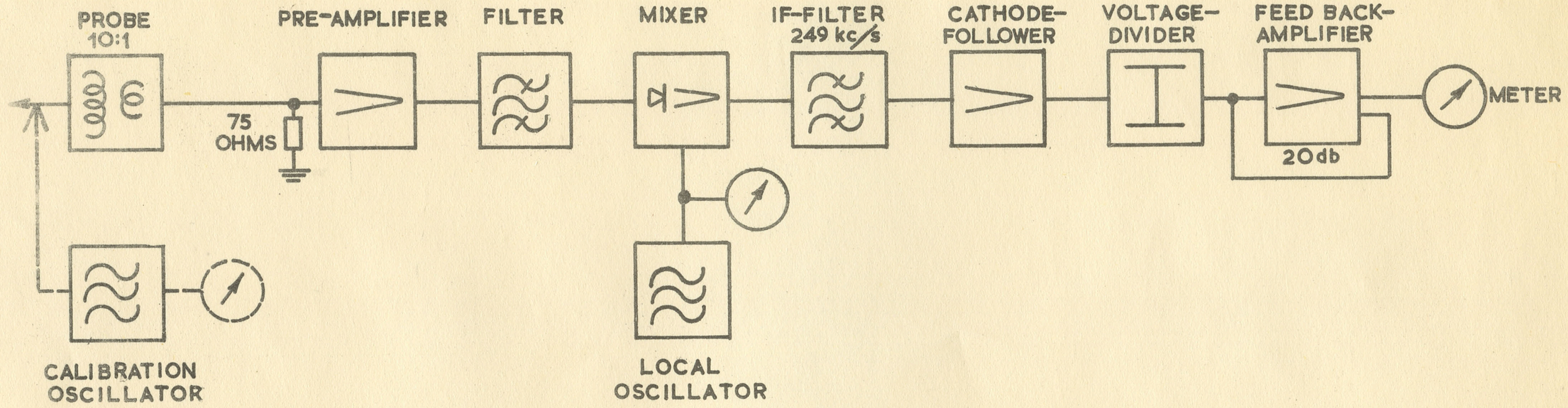


FREQUENCY SCHEME FOR
4-MEGACYCLE COAXIAL CABLE
CARRIER TELEPHONE SYSTEM

RADIOMETER

1005-A4

FIG. 2



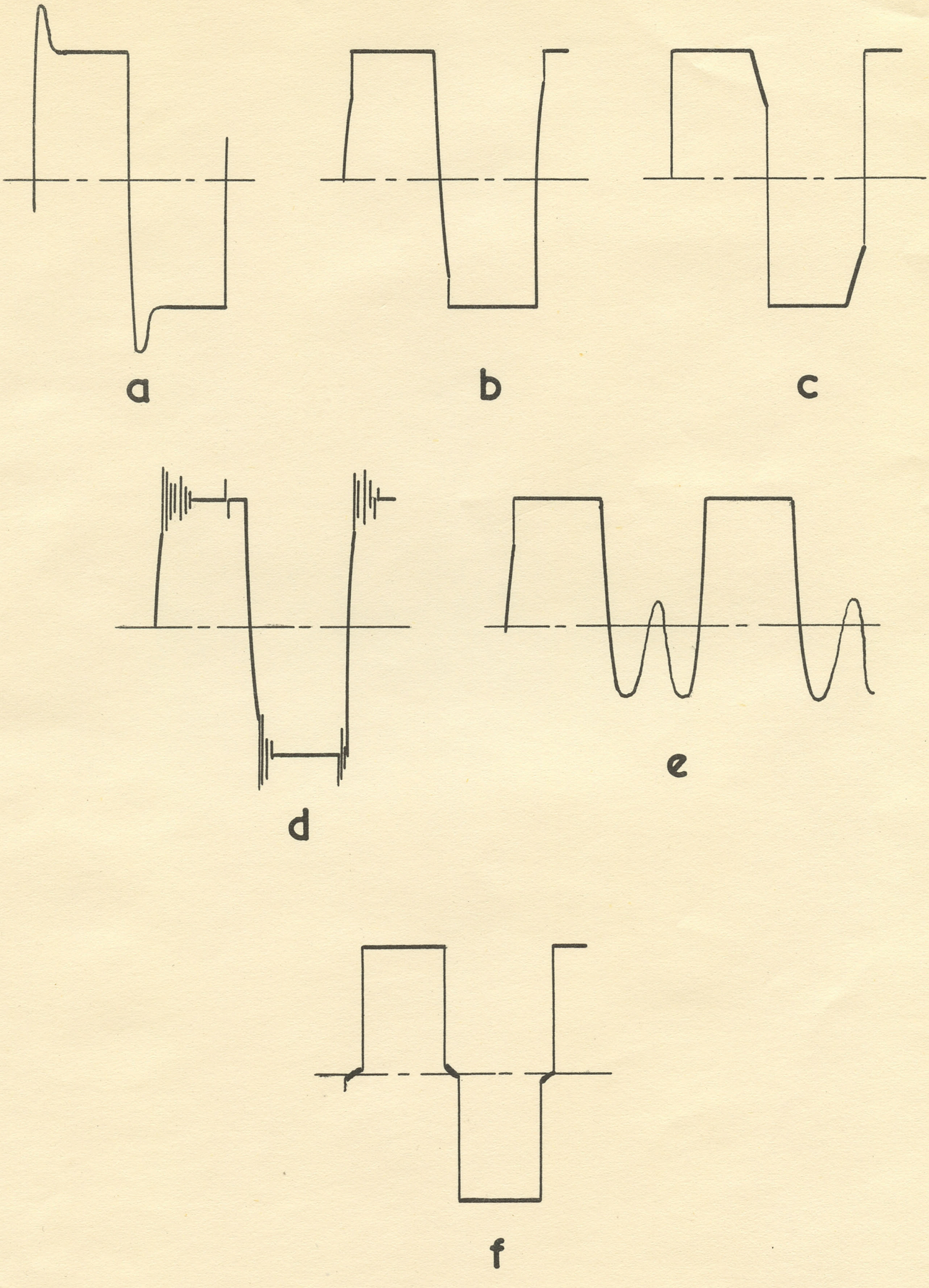
PORTABLE SELECTIVE MEASURING EQUIPMENT

TYPE BFM 110

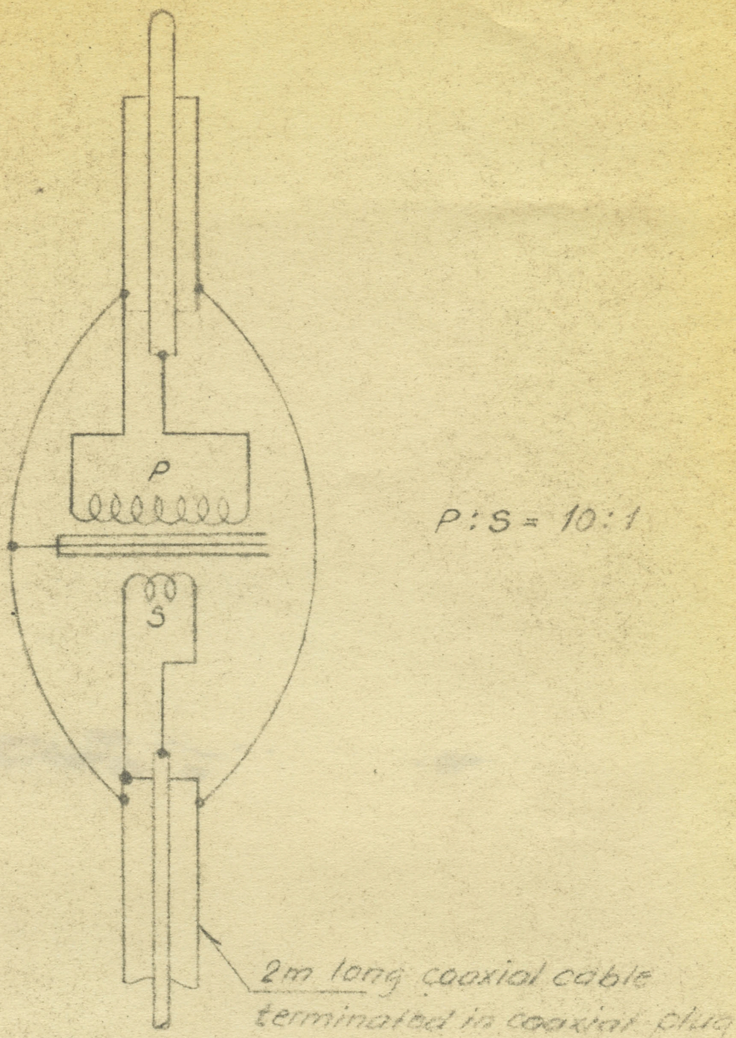
RADIOMETER

912-A4

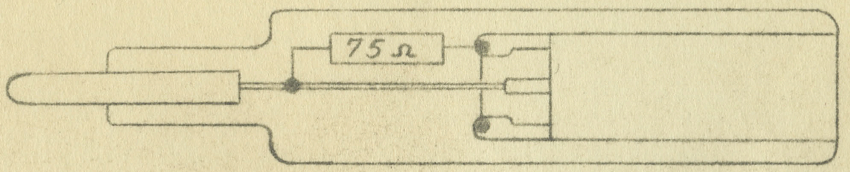
FIG. 3



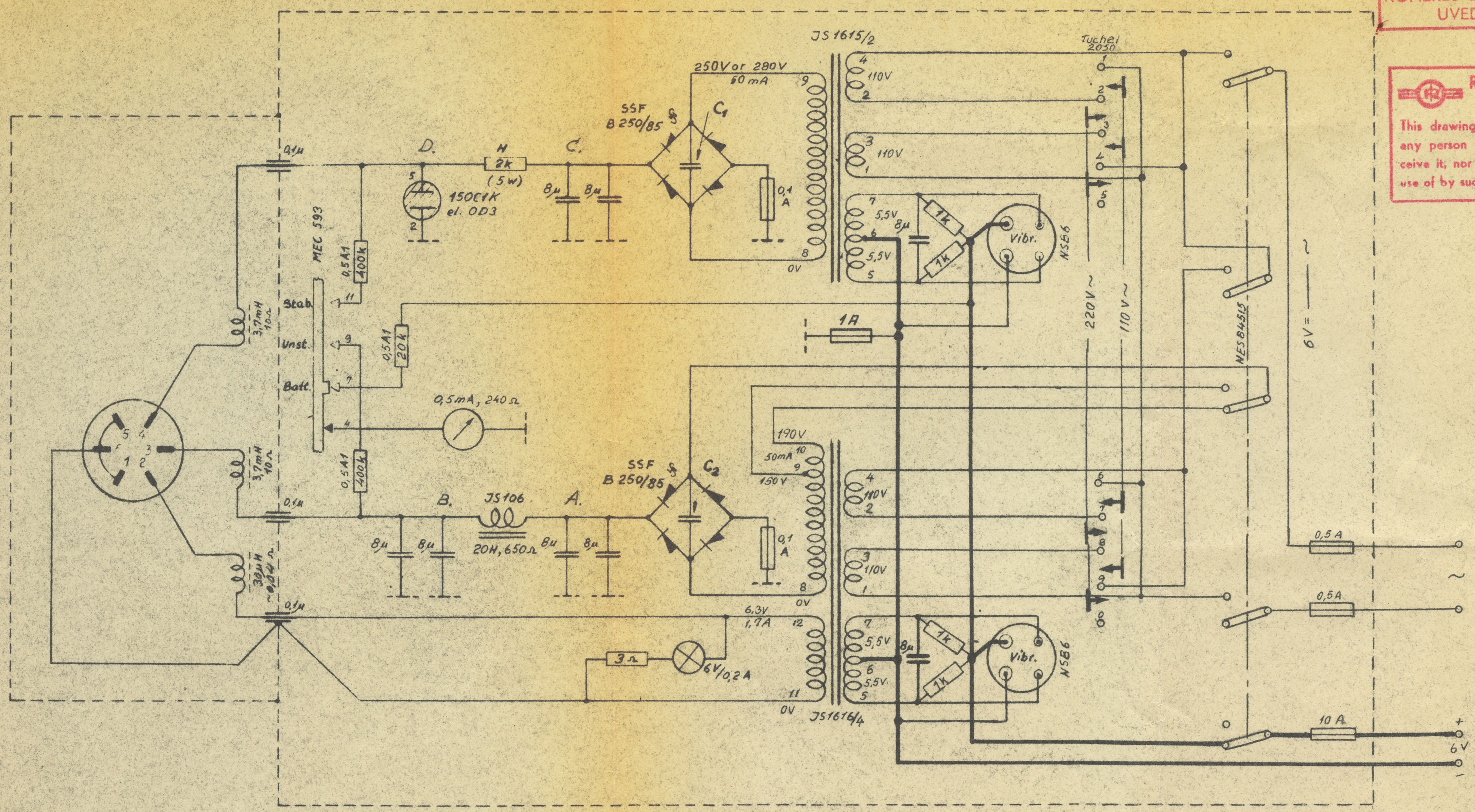
VIBRATOR WAVEFORMS



RADIOMETER KØBENHAVN	Maal.	Tegn.	PH	5/8-52
		Konf.		/
		Norm.		/
PROBE, type BFM 120a / 121a approx. physical layout.	Erstatter: 893-A4			
	Erstatt. af:			



RADIOMETER KØBENHAVN	Maal.	Tagn.	EP	2/12 53
	~	Konf.		/ -
				/ -
Termination type BFM 140a approx. physical layout	892-A4			
	Erstatt. af:			



C_1, C_2 : 0 ..... 20 nF, depending upon the Vibrator type and make.

RADIOMETER

Power Supply
Type BFM 130 b
Diagram

Tegn	IJ	19/11.54

916-A3

Erstattet af:

R_1 pos. E4 ~ 80 kΩ; R_2 " D5 ~ 10 kΩ; R_3 " E8 ~ 3 kΩ

R_4 pos. C6; R_5 " C7; R_6 " C7; R_7 " C8 } ~ 0,8 MΩ

R_8 pos. D13 ~ 10 Ω

C_1 " E4 ~ 5 pF

11 tubes: 403 B or 6AK5 or EF95

RADIOMETER KØBENHAVN

SELECTIVE MEASURING INSTRUMENT
BFM 110 b. B/N
Diagram from nr. 19354

Maalestok ~	Tegn.	HM.	20/1-56
	Konf.		/
	Erstatter	786-A2	

662-A1

Erstattet af: