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HO32e
BEAT-FREQUENCY
OSCILLATOR

OPERATING INSTRUCTIONS

**H032e
BEAT-FREQUENCY
OSCILLATOR**

OPERATING INSTRUCTIONS

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INTRODUCTION

The type HO32 Beat-Frequency Oscillator is a most versatile generator with several outstanding features and very fine data, hitherto unknown in low-priced instruments.

The beat-frequency principle employed enables the entire audio frequency range to be covered in a single sweep of the main dial which, in connection with the almost constant output in the entire range, provides for rapid and reliable measurements.

Most a.f. measurements can be made because the instrument can supply 4 watts to a matched load, 1 watt to any load between 2.5 Ω and 20 k Ω , 150 volts uncalibrated output voltage or 100 volts calibrated output voltage.

The small influence of line voltage variations on frequency and output voltage and the small drift during the warm-up period, provide for convenient operation.

Owing to the very low distortion and hum, even at output voltages of 100 volts, distortion measurements can be made on high quality set-ups without any extra filtering of the output voltage.

The possibilities of using the instrument as a frequency meter and as a voltage or output amplifier are also valuable features.

SECTION I GENERAL DESCRIPTION

1.1 OPERATING PRINCIPLE

The appended simplified block diagram shows the operating principle. Two h.f. oscillators operating at about 200 kc are connected to a mixer stage via two buffer stages.

The two frequencies, their harmonics and their sum and difference frequencies produced in the mixer stage are all fed to the low-pass filter which only allows the difference frequency to pass.

The difference frequency lies on the audio frequency range from 0 to 21 kc and is fed via a banana jack to the input potentiometer of the power amplifier.

The output of the amplifier is fed either to an output transformer or a resistive attenuator.

The output transformer provides for 5 different optimal load impedances, and the attenuator provides for a calibrated output voltage lying between 300 microvolts and 100 volts.

The banana input jack allows for the use of the output amplifier as a separate voltage or power amplifier, or as a frequency meter.

1.2 VARIABLE OSCILLATOR

The oscillator tube is the triode section of a triode-heptode (tube No. 1 in the appended wiring diagram).

The loose coupling of the tube to the high Q circuit and the low temperature coefficient condensers used in the circuit provide for a very stable frequency and consequently a low drift of the output frequency.

The frequency can be varied by about 150 cps by means of the ZERO ADJUSTMENT condenser, and 20.5 kc by means of the main dial.

When the main dial reads zero, the oscillator frequency is 200 kc, and when the dial reading is 20.5 kc, the frequency is 179.5 kc. With both frequency dials set against the stop at zero, the zero adjustment condenser is used to tune the oscillator to exactly the same frequency as

that of the fixed oscillator.

The signal on the grid of the oscillator triode is also fed to the grid of the heptode section. The heptode is used as a buffer stage and separates the oscillator from the heptode mixer (tube No. 3).

1.3 FIXED OSCILLATOR

The "fixed" oscillator is almost exactly equivalent to the variable oscillator.

The frequency can be varied by maximum 500 cps by means of the corresponding dial.

The signal at the grid of the oscillator triode is fed to the third grid of the heptode section which is operated as a buffer amplifier. The first grid of the heptode section is connected to the cathode, and the second grid is therefore operated as a diode anode. The current to the second grid is dependent upon the cathode temperature and consequently upon the line voltage. With rising line voltage the current rises and the voltage drops at Grids No. 2 and 4. Grid No. 4 acts as a screen grid against the signal grid No. 3, and the amplification drops. If the drop is as great as the added up rise in amplification in all other stages, the output voltage will not change. This independence of line voltage is obtained by setting the variable resistor in the lead of grids No. 2 and 4 to the optimal value.

The signal from the anode of the heptode section is fed to the first grid of the heptode mixer via a potentiometer and a band-pass filter with critical coupling.

The output signal level can be set to its correct value by means of the potentiometer.

1.4 MIXER

The heptode section of a triode-heptode operates as a mixer.

The fixed oscillator feeds a signal to the first grid via a buffer tube and a 200 kc band-pass filter. The low distortion and the low level of the signal provide for an audio-frequency output with very low distortion.

The third grid is fed from the buffer tube of the variable oscillator. The negative voltage at the grid is developed by rectification of the

signal and depends somewhat upon the setting of the variable resistor in series with the grid leak. This resistor and the potentiometer controlling the screen grid voltage are so set that the distortion is minimum.

The anode current of the mixer tube carries a great number of frequency components, but only the difference frequency component is allowed to pass the low-pass filter connected between the anode and the input potentiometer of the output amplifier.

1.5 LOW-PASS FILTER

The low-pass filter between the anode of the mixer tube and the input potentiometer at the power amplifier has a cutoff frequency of about 60 kc.

All frequency components arising from the mixing action of the mixer tube are attenuated by some 90 dB with the exception of the difference frequency between the two oscillators. The difference frequency lies in the 0-20,000 cps range. The 1 μ F coupling condenser feeding the signal to the input potentiometer attenuates a 1 cps signal by about 10 dB. The signal at the grid of the magic eye, which is connected to the top of the potentiometer, is therefore strong enough at the low frequencies present when making the zero adjustment, and the attenuation obtained at still lower frequencies prevent the surges in the supply voltage of the first three tubes from disturbing the output voltage.

1.6 OUTPUT AMPLIFIER

The input potentiometer of the output amplifier is connected to a switch mounted on a banana jack. With no plug inserted the audio output from the mixer is present at the potentiometer.

If a banana plug is entirely inserted, the two oscillators and the mixer tube are switched off from the anode voltage supply and the input potentiometer is connected to the input jack. (Simultaneously, a load equivalent to that of the three tubes is connected to the anode voltage supply.) In this way the amplifier can be used separately. The input impedance is 50 k Ω , and an input voltage of about 1 volt is sufficient to get the maximum output from the amplifier.

The amplifier consists of 2 tubes. The input tube is the pentode section of a triode-pentode, and the output tube is also a pentode.

The amplifier is operated with heavy negative feedback. A current proportional to the signal voltage at the anode of the output tube is fed to the cathode resistor of the input tube which has no cathode decoupling condenser.

The feedback provides for very low distortion, straight response and low internal impedance.

The output tube is either R-C coupled to a resistive output attenuator, or L-C coupled or transformer coupled.

1.7 OUTPUT ATTENUATOR

The attenuator has 10 steps with the readings MULTIPLY OUTPUT READING BY 0.3 - 1 - 3 - 10 - 30 mV or 0.1 - 0.3 - 1 - 3 - 10 V. Together with the 0 to 10 readings of the potentiometer marked OUTPUT the attenuator gives voltages up to 100 volts.

The 0 to 30 volt range (MULTIPLY OUTPUT READING BY 3) is obtained by reducing the negative feedback three times.

The 0-100 volt range (MULTIPLY OUTPUT READING BY 10) is obtained by using the output transformer as a choke and by switching off the resistor supplying the anode of the output tube in all the other attenuator settings.

The impedance of the choke drops at low and high frequencies. The distortion is therefore only at its minimum in the 100-5000 cps range and rises somewhat at lower and higher frequencies.

The feedback on the 0-30 and 0-100 volt ranges can be individually set by means of internal potentiometers, so it is possible to match the amplifier sensitivity on the two ranges to the fixed sensitivity on the 8 first ranges.

The output impedance of the attenuator is dependent upon the setting and is indicated on the front panel.

The total resistance of the series connected resistors forming the attenuator is 10 kilohms, and the combined values of the resistors and the output impedance of the amplifier determine the output impedance of the attenuator.

The 10 k Ω attenuator is switched off on the 0-100 volt range, and the output impedance is that of the amplifier alone.

The distortion is less than 0.1% at voltages lower than 10 volts in the 50-10,000 cps range. This generally applies also at voltages up to 30 volts and in the range 30-15,000 cps.

In the 0-100 volt range the distortion is about 0.1% in the major part of the frequency range but rises to about 0.5% at 30 and 20,000 cps.

The total hum is less than 0.1%. Generally the line frequency component and its third harmonic are only about 0.03% and its second harmonic is about 0.02%. The minimum line frequency hum is about 10 microvolts and must be added to the percentages mentioned.

The superimposed high frequency output originating from the two oscillators is only about 0.02%.

The frequency response is independent of the setting of the OUTPUT knob and only to a small degree dependent upon the setting of the attenuator.

For all settings, except the MULTIPLY OUTPUT READING BY 10, the response is within 0.3 dB from 20 to 21,000 cps, and within 1 dB from 10 to 21,000 cps. On the last range, 0 to 100 volts, the lower frequency limit increases to 30 cps owing to the decrease of the impedance of the choke coupling used on that voltage range.

The output voltage from the attenuator is present between terminal No. 1 (chassis) and terminal No. 3.

The input voltage to the step attenuator is present between the chassis and the terminal No. 4 and is obtained in volts by multiplying the reading of the OUTPUT potentiometer by 1, 3, or 10. The factor depends on the setting of the step attenuator and corresponds to the three different types of marks at the switch.

1.8 OUTPUT CHOKE

The output transformer is used as a choke with the switch in position 5 k Ω , and as an auto-transformer in the 2 k Ω position.

The signal is passed on to the two upper terminals through two series connected condensers in order to prevent noticeable d-c voltages across the load and in order to attenuate the output at frequencies below 10 cps, thus avoiding disturbances from surges in the power supply d-c voltage developed by surges in the line voltage.

With the switch at 5 k Ω , the signal is drawn from the anode of the output tube and from a tap on the primary of the transformer with the switch at 2 k Ω .

The feedback current to the cathode resistor of the input tube is always drawn from the common point of the two series connected condensers for all settings of the output switch. In this way the signal voltage at the anode of the output tube (or for the 2 k Ω position at the tap) is kept constant.

Therefore, switching from the 5 k Ω setting to the 2 k Ω setting varies the output voltage by only a few per cent if the load is 5 k Ω or higher, and if the output voltage is below 90 volts. At higher output voltages severe distortion will arise in the 2 k Ω setting.

The max. output voltage is 150 volts when the oscillator is unloaded and the switch set to 5 k Ω , and it can be obtained in the range from 50 to 10,000 cps.

The output voltage at the two upper terminals is obtained when the 0-10 OUTPUT reading is multiplied by 15, and is thus 0-150 volts.

Owing to the strong negative feedback the output voltage only drops about 1 dB when an optimal ohmic load is connected.

The maximum output in a 5 k Ω or a 2 k Ω load is 4 watts and can be obtained in the frequency range from 100 to 5,000 cps. In the major part of the range the distortion is generally below 2%.

3 watts are obtainable from 50 to 15,000 cps with a distortion of about 0.5% in the major part of the range from 100 to 5,000 cps.

1 watt into a 5 k Ω or a 2 k Ω load is obtained with less than 0.2% at 1 kc, generally with 0.1% distortion and with less than 0.5% and 1% distortion in the ranges 50-10,000 cps and 30-20,000 cps, respectively.

The hum is less than 0.1% or 25 mV of each hum component, whichever is the greater.

The high frequency output is below 0.1%, generally only 0.02%.

The internal impedance is about 400 Ω in the 5 k Ω output position and about 300 Ω in the 2 k Ω position.

The frequency response is only to a very small degree dependent upon the load, provided that the load is optimal or above, and also ohmic.

In the range 50-10,000 cps the response is generally within 0.3 dB and within 1 dB from 20 to 20,000 cps if the output terminals are unloaded (for both output impedance settings) or if 1 watt is fed to an optimal ohmic load of 5 k Ω . If a 2 k Ω load is used, the frequency ranges are 60-10,000 and 30-20,000 cps.

1.9 OUTPUT TRANSFORMER

The output transformer has a secondary winding designed for an optimal load of 500 ohms and provided with taps for loads of 25 Ω and 5 Ω . The secondary is connected to terminal No.2 and terminal No.3. Terminal No.4 is connected to the anode of the output tube or to the 2 k Ω tap of the transformer primary.

When the movable strap connects the two lower terminals, one end of the secondary is connected to the chassis. With the secondary free it is possible to have symmetrical output voltages by connecting two resistors of the same value between the binding posts and the chassis. The sum of the resistors should not be too far from the optimal load from the interwinding capacities.

The distortion is dependent on the output and the load and is less than 0.2% at 1 kc and 1 watt into an optimal load of 5 Ω , 25 Ω , or 500 Ω corresponding to the setting of the output switch.

Generally the distortion is only about 0.1% or even less at 1 kc, less than 0.3% in the range 100-10,000 cps, and less than 1% in the range 50-20,000 cps when 1 watt is fed to an optimal ohmic load.

At 30 cps and 1 watt into an optimal load, the distortion is about 2%.

The maximum output of about 2.5 watts into an optimal ohmic load is obtainable in the range 50-20,000 cps.

The distortion is usually less than 1% from 100 to 10,000 cps, but may rise to some 5% at 40 and 20,000 cps.

The hum is less than 0.1% at 1 watt into an optimal load or at the corresponding voltage. At low output levels the residual hum is dominating. The hum components of the line frequency and its third harmonic are:

about 10 mV at the 500 Ω optimal load setting
about 2.5 mV at the 25 Ω optimal load setting
about 1 mV at the 5 Ω optimal load setting

The second harmonic component of the line frequency lies some 12 dB lower.

The high frequency component from the two oscillators is below 0.1%, generally only about 0.02%.

The frequency response is dependent upon the load because the leakage induction of the transformer gives a drop at the high frequency end of the audio spectrum when the transformer is loaded. But the low leakage induction provides for a response which is generally within 0.3 dB in the range 50-10,000 cps, and within 1 dB from 30 to 20,000 cps with 1 watt into an optimal ohmic load.

Unloaded, the response is within the same limits but with a tendency to a rise of the output voltage at high frequencies. This involves an optimum response when the ohmic load is somewhat higher than the optimal one.

Owing to the heavy negative feedback, a considerable mismatch can be tolerated.

It is possible to have 1 watt at 1 kc into any ohmic load between 2.5 Ω and 20,000 Ω . A mismatch of 1:2 only lowers the maximum output ob-

tainable by about 1.5 dB.

1.10 MAGIC EYE

The magic eye is used as a "Zero beat" indicator when the zero adjustment is made and also when the instrument is used as a frequency meter.

The magic eye is connected to the top of the input potentiometer via a cathode follower.

The setting of the potentiometer therefore has no influence on the deflection of the magic eye, and the cathode follower ensures minimum distortion even if the magic eye has some grid current.

1.11 POWER SUPPLY

The power supply consists of the line transformer, two contact cooled selenium rectifiers and R-C filter chains. One rectifier supplies the anode current of the output tube through one filter chain and all the other tubes and the screen grid of the output tube through another filter chain. The other rectifier supplies the d-c heater current of the mixer tube and the two oscillator and buffer tubes.

The anode voltage of the two oscillators, their buffer amplifiers and the mixer tube are stabilized by a glow discharge tube. When using the output amplifier separately, the first three tubes are automatically switched off and a loading resistor is switched on in order to prevent overloading of the glow discharge tube.

The line transformer can be switched to 110-115-127-200-220-240 volt 50-60 cps, line voltages by setting the turret with the built-in line fuse appropriately. The slow-blow fuse must be a 250 mA fuse when the turret is set to one of the 3 highest voltages, otherwise a 500 mA fuse.

The voltage at the positive terminal of the rectifier is adjusted to 320 volts, at nominal line voltage, with the semi-variable resistor between the transformer and the rectifier.

The heavy filtering of the d-c voltages provides for a very low hum level. The hum level is mainly determined by sources other than the ripple of the anode voltages.

The filaments of the a.f. tubes are heated from a centertapped 6.3 volt winding.

In order to ensure the maximum life of the output tube, it is advisable to operate the generator at the nominal line voltage.

SECTION 2

OPERATING INSTRUCTIONS

2.1 CONNECTION

Before connecting the instrument to the power line make sure that the line voltage selector is set at the correct voltage.

When the instrument leaves the factory, the selector is set at 220 volts unless otherwise stated in the order. Switching to 200 and 240 volt line voltage can be done without replacing the fuse, but if a 110, 115 or 127 volt line is used, the 250 mA fuse must be replaced by a 500 mA fuse.

The fuse can be replaced through a hole in the back panel, but the instrument must be removed from the cabinet when the line voltage selector is to be reset. Use slow blowing fuses.

Switch on the instrument with the power switch OFF-ON and allow it to warm up for some minutes.

Connect the load to the two terminals in the middle.

2.2 OPERATING CONTROLS

2.21 Frequency controls

The beat-frequency oscillator has three frequency controls:

- (1) The main dial
with engravings from 0 to 20,500 cps. This dial varies the frequency of one of the oscillators between 200 and 179.5 kc.
- (2) The ZERO ADJUSTMENT knob
which varies the frequency of the 200-179.5 kc oscillator by about plus or minus 70 cps.
- (3) The auxiliary dial
with engravings from 0 to 500 cps which varies the frequency of the other oscillator between 200 and 200.5 kc.
The sum of the readings of the frequency dials gives the output frequency.

2.22 Output Controls

- (1) The 0 to 10 OUTPUT potentiometer varies the input voltage of the output amplifier between 0 and 1 volt.
- (2) The ATTENUATOR & IMPEDANCE SELECTOR with 15 positions combines a step attenuator with an impedance switch.

When the switch is set at one of the attenuator positions MULTIPLY OUTPUT READING by 0.3 to 10V, the output voltage is had by multiplying the readings of the two output controls. With the switch set at 10 V, the 10 k Ω attenuator is switched off, and the output terminals are not loaded in order to keep the distortion at a minimum.

The 5 k Ω - 2 k Ω - 500 Ω - 25 Ω and 5 Ω positions provide for maximum output with minimum distortion when resistive loads of the said value are connected.

The figures nearest to the shaft show the internal impedance between the two output terminals in the middle when the switch is set at 5 Ω - 25 Ω or 500 load for max. output. For all other settings of the switch the inner figures show the internal impedance between the second terminal from the top and the chassis terminal.

2.3 TERMINALS

All four output terminals are located to the right on the front panel. They can all take 4 mm banana plugs and wires.

The lowest terminal No. 1 is connected to the chassis.

The second terminal from the bottom No. 2 is connected to one end of the transformer secondary and to the chassis terminal with the grounding strap. The secondary winding is free when the grounding strap is swung aside.

Via the switch, the second terminal from the top No. 3 is connected to:

- (1) The step attenuator
- (2) The anode of the output tube

- (3) A tap on the primary of the output transformer
- (4) The secondary of the output transformer or its taps.

The top terminal No. 4 is always connected to the anode of the output tube except when the switch is set at position 2 k Ω LOAD FOR MAX. OUTPUT. Then it is connected to the 2 k Ω tap on the primary together with the terminal directly below.

The marks at the terminal correspond to the marks at the switch. With the switch set at one of the rectangular marks, the output tube operates with a resistor in the anode lead, otherwise with the output transformer. The open circuit voltage at terminal 4 is obtained by multiplying the readings of the OUTPUT potentiometer by the figures 1, 3, 10 or 15, depending on the setting of the switch.

When the switch is set to the 2 k Ω LOAD FOR MAX OUTPUT position, the OUTPUT potentiometer must not be set to more than 6.6 in order to prevent the open circuit from exceeding 100 volts, or 90 volts across a 2 k Ω load.

In this way an open circuit voltage of max. 3300 times higher than that simultaneously present at terminal 3 can be obtained at terminal 4 when the switch is set to one of the attenuator settings x0.3mV to x1V.

With the switch set at x3V, x10V, 5k Ω or 2k Ω the voltages at terminal No. 4 and terminal No. 3 are equal.

The input jack will take a 4 mm banana plug. When the plug is entirely inserted, the h-f tubes are switched off and only the output amplifier operates.

The input impedance is 50 k Ω and 1 volt is sufficient to get the maximum output from the amplifier.

The input voltage must not incorporate any d-c component so as not to disturb the operating point of the input tube of the amplifier.

The potentiometer OUTPUT controls the voltage fed to the grid of the input tube.

With the switch set position 500 Ω , 25 Ω , or 5 Ω LOAD FOR MAX OUTPUT the open circuit voltage at terminal No. 4 is about 3, 14 and 30 times higher than at terminal No. 3.

2.4 STEP-BY-STEP OPERATION

- (1) Be sure that the voltage selector is set at the line voltage available.
- (2) Connect the instrument to the power line and allow it to warm up for some minutes.
- (3) Turn both frequency dials against stop at zero cps.
- (4) Set the ZERO ADJUSTMENT knob so that the magic eye starts operating ("indicates zero beat") when the knob is turned away from this position.
- (5) Connect the load to the two terminals in the middle.
- (6) Set the output switch to the position determined by the voltage wanted or by the impedance of the load.

Use one of the positions MULTIPLY OUTPUT READING BY 0.3 mV up to 10 V if a specified voltage is wanted. Do not load the output terminals too heavily if the maximum accuracy is wanted. (A resistive load of ten times the internal resistance lowers the output voltage by 10%). The maximum output current obtainable is 25 mA with the switch set at positions 1 V, 3 V, and 10 V.

The average distortion is then within 1% on the major part of the frequency range, except in position MULTIPLY OUTPUT READING BY 3V when it is about 2%. At 10 mA the distortion figures are about 0.1% and 0.3%, respectively.

Use the LOAD FOR MAX OUTPUT setting of the output switch nearest to the impedance of the load connected if the maximum output effect is wanted with minimum distortion. 1 watt can be fed to any impedance between 2.5Ω and $20,000\Omega$ in the major part of the frequency range. A maximum of 4 watts with about 1% distortion is obtainable in an ohmic load of $5\text{ k}\Omega$ and $2\text{ k}\Omega$.

- (7) Feed the voltage to be amplified to the banana jack AMPL. INPUT if the beat-frequency oscillator is to be used as an amplifier only.

Do not feed any d-c voltage to the input. Insert the banana plug entirely in order to switch off the oscillator part. The frequency response is straight up to about 100 kc with the switch set at one of the attenuator positions.

The power output data are the same as those for the beat-frequency oscillator.

The maximum voltage amplification is 150.

- (8) Feed the unknown frequency to the jack AMPL. INPUT when the beat-frequency oscillator is used as a frequency meter. Do not insert the banana plug entirely so as not to switch off the oscillator part.

Rotate the frequency dials until the magic eye indicates a "zero beat". If the impedance of the source is much lower than 50 k Ω , insert a resistor of at least 50 k Ω in series with the external source so as to obtain a sufficiently clear "zero beat".

SECTION 3 MAINTENANCE

3.1 GENERAL

The type HO32 Beat-Frequency Oscillator is an instrument of such advanced design that only skilled persons with sufficiently high quality test gear should make any necessary repairs.

Conservative ratings for all components and tubes in general ensure a long period of troublefree service, however, the instrument should be switched off when not in use, or at least run idle with the output switch set at one of the R-C attenuator output settings where the anode dissipation of the output tube is reduced to about 6 watts.

In order to ensure a minimum of frequency drift, the louvres on top of the cabinet should not be covered up.

3.2 REMOVING THE INSTRUMENT FROM THE CABINET

The Beat-Frequency Oscillator can be removed from the cabinet when the line cord has been removed and the 6 fixing screws along the edges of the front panel have been removed.

3.3 TUBE REPLACEMENT

All tubes except the output tube are operated far below their maximum ratings and will generally provide for several thousand hours of faultless operation. If trouble occurs before the tubes are worn out, it generally manifests itself as hum or distortion.

3.31 Tube No. 1 is a type ECH81 or 6AJ8 triode-heptode operated as an oscillator (200 kc to 179.5 kc) and as a buffer amplifier. A worn out tube gives rise to frequency variations exceeding the normal one which is 1 cps for 5% on the line voltage. If the output from the heptode to the mixer is below the normal value (about minus 2.5 to 4 volts at grid No. 3 of the mixer tube), the distortion cannot be adjusted to the normal low level by resetting the potentiometers for minimum distortion. Neither will the frequency response be within the limits specified. Tubes with a too low insulation resistance between heater and grid may give rise to hum, but this error occurs only in very few tubes. Some tubes

give rise to hum due to pick-up from the field of the line transformer.

As a rule, the tube can be replaced right away.

Check distortion, hum and response after the replacement.

- 3.32 Tube No. 2 is a type ECH81 or 6AJ8 operating as an oscillator and buffer amplifier in the 200 kc to 200.5 kc frequency range.

In a worn out tube line voltage variations may give rise to excessive frequency variations and output voltage variations even if the potentiometer controlling the screen grid voltage has been reset.

The heptode section of the tube compensates for the line voltage influence on the amplification of all the other tubes so it may become necessary to reset the potentiometer P1, "INDEPENDENCE OF LINE VOLTAGE VARIATIONS", because the other tubes are worn, especillay the mixer tube.

The tube can be replaced right away, however, an aged tube is preferable because the P1 potentiometer need not be reset. Otherwise P1 has to be reset after about 100 hours operation of tube No. 2. Only few tubes cannot compensate for the influence of the line voltage variations when potentiometer P1 has been reset.

- 3.33 Tube No. 3 is a type ECH81 or 6AJ8 triode-heptode operating as a mixer.

Check the frequency response, the distortion and the hum after replacement and reset the potentiometers P2 and P4 MIN. DISTORTION, if required.

A few tubes give rise to too much hum, and very few tubes cause too high distortion. Many of them can be adjusted to about 0.01% distortion or even less.

Use run-in specimens to avoid readjustment during the first hundred hours of operation.

If required, minimum distortion can generally be obtained by resetting the internal potentiometer P2 only. This potentiometer is mounted nearest to the front panel and is accessible through the top louvres in the left hand side of the cabinet.

- 3.34 Tube No. 4 is a type ECF80 or 6BL8 triode-pentode. The triode section is operated as a cathode follower which drives the magic eye. The pentode section is the input tube of the amplifier.

The pentode gives an amplification of about 100 times when no feedback current is fed to the cathode.

The tube can be replaced right away. Check its operating voltages after replacement.

- 3.35 Tube No. 5 is a type EL84 or 6BQ5 output pentode operated slightly below its maximum ratings.

The instrument should not operate on a line voltage permanently higher than the nominal one so as to have the possibility of obtaining a normal length of the useful life of the tube (1,000 hours are predicted by the manufacturer).

The tube can be replaced right away. Check the operating voltages after replacement.

- 3.36 Tube No. 6 is a type EM84 magic eye which can be replaced right away.

- 3.37 Tube No. 7 is a type 150-B2 or a type OA2 glow-discharge tube stabilizing the 150 volt anode voltage for the h-f tubes.

3.4 ADJUSTMENT OF TRIMMERS AND CORES

- 3.41 The trimmers and the cores of the coils of the two circuits are so set that the frequency is 200.00 kc with the dials set at zero and 180.00 kc and 200.500 kc with the dials set at 20 kc and 500 cps, respectively. (ZERO ADJUSTMENT knob at mid-scale).

A coarse adjustment of the trimmers can be made by setting the trimmer for the variable oscillator so that the total capacity is 535 pF and the trimmer for the fixed oscillator so that the capacity is 555 pF. This measurement must be made with the top of the coil disconnected and the tube mounted.

It will probably only be necessary to reset the trimmers after replacement of a defective condenser in one of the oscillator circuits.

- 3.42 Adjustment of the 200 kc band-pass filter cores L3 and L4 (positions G4 and G5 in the wiring diagram) is made by trimming to maximum output with the 500 cps dial set at about 250 cps.
- 3.43 The capacity (position C1) between grid No. 1 of the mixer tube and the top of the 179.5 to 200 kc circuit is so adjusted that the distortion at 30 cps output is minimum, generally below 0.1%.
The latter capacity is present between a piece of wire (connected to grid No. 1) and the lead to the trimmer of the circuit.

3.5 ADJUSTMENT OF DIALS AND KNOBS

- 3.51 The 0 to 20.5 kc dial is correctly mounted if the small mark on the dial is exactly opposite the index line when the rotor of the condenser stops at the stator at maximum capacity). Before this check can be made it is necessary to turn the stop adjustment screw behind the dial sufficiently counter clockwise. Turn back the screw after the check.
- 3.52 The 0 to 500 cps dial is correctly mounted if the short line at zero is opposite the index line when the left-hand edges of the rotor plates are flush with the surface of the shield between the stator and the rotor. Adjust the stop adjustment screw after having made the check so that the dial stops at zero again.
- 3.53 The correct mounting of the 0 to 10 OUTPUT knob is that giving the minimum error on the major part of the dial. This is generally the case when the output voltage rises very much immediately after the knob has passed the zero line of the dial.
- 3.54 The mounting of the ZERO ADJUSTMENT knob is not at all critical, and is generally done so that the capacity is maximum when the knob points at 10.

3.6 ADJUSTMENT OF THE INTERNAL POTENTIOMETERS

- 3.61 Potentiometer P1: INDEPENDENCE OF LINE VOLTAGE VARIATIONS (position E3 in the diagram) compensates for the influence of line voltage variations (see also section 1.3).

The potentiometer is accessible through the hole farthest from the front panel in the bottom of the cabinet.

Usually the potentiometer needs no readjustment until the tubes have become worn, or when a tube (generally tube No. 1, 2 or 3) has been replaced.

- 3.62 Potentiometer P2: MIN. DISTORTION (position F4) varies the grid leak of grid No. 3 of the mixer tube and, together with P4, determines the distortion of the audio output.

The potentiometer has a slotted shaft and is accessible through the louvres at the left on the top of the cabinet.

Of the two visible potentiometers, P2 is mounted nearer to the front panel.

Minor changes in the distortion occurring when the tubes have become worn, can be eliminated by means of P2 (if not, by means of P2 and P4).

- 3.63 Potentiometer P3: A. F. OUTPUT (position F4) determines the 200 to 200.5 kc input signal to grid No. 1 of the mixer and accordingly, the level of the output voltage. It is so set that the calibrated output voltage is correct, e.g. 10 volts at 1kc.

The P3 potentiometer has a slotted shaft and is easily accessible through the round hole on top of the cabinet. It must be readjusted when a tube has been replaced or when one of the potentiometers P1, P2 or P4 has been readjusted.

- 3.64 Potentiometer P4: MIN DISTORTION (position E6) determines the screen grid voltage of the mixer tube and has the major influence on the distortion.

The P4 potentiometer has a slotted shaft and is accessible through the hole in the bottom of the cabinet nearest to the front plate.

The P4 potentiometer must be readjusted when tube No. 3 (the mixer tube) has been replaced and possibly after a run-in period of some one hundred hours.

- 3.65 Potentiometer P6: CAL. $\times 10$ (position D8) provides for a fine control of the amplification when the switch is set to position MULTIPY OUTPUT READING BY 10 V, by varying the shunt of the feedback resistor.

The potentiometer is placed on the mounting strip of the switch.

- 3.66 Potentiometer P7: CAL $\times 3,000$ (position E8) is equivalent to P6 and mounted directly beside it.

3.7 OPERATING VOLTAGES AND CURRENTS AT NOMINAL LINE VOLTAGE

| <u>Tube No.</u> | <u>Pin No.</u> | <u>Volts d-c</u> | |
|-----------------|----------------|-------------------|------------------|
| 1 | 1 | 85±15 | |
| | 2 | -4±1 | |
| | 4 | 12.6 V d-c | |
| | 5 | 6.3 V | |
| | 6 | 140±10 | 7.5 V 200 kc |
| | 8 | 40±5 | 2.7 V 200 kc |
| | 9 | -4±1 | |
| 2 | 1 | 14±7 | 3 mV 200 kc |
| | 4 | 19 V d-c | |
| | 5 | 12.6 V d-c | |
| | 6 | 90±40 | 2 V 200 kc |
| | 7 | -4±1 | |
| | 8 | 40±5 | |
| | 9 | -4±1 | |
| 3 | 1 | 50±10 | |
| | 2 | 0 | 120±30 mV 200 kc |
| | 3 | 1.4±0.2 | |
| | 4 | 6.3 V d-c | |
| | 5 | 0 V | |
| | 6 | 65±20 | 7±3 V 200 kc |
| | 7 | -3.6±1.4 | |
| 4 | 1 | 250±5 | |
| | 2 | 0 | |
| | 3 | 80±10 | |
| | 4 & 5 | 3.15 a-c | |
| | 6 | 80±20 | |
| | 7 | 1.6±0.2 | |
| | 8 | 16±2 | |
| | 9 | 0 | |
| 5 | 3 | 7.5±0.5 | 1.1±0.5 V 1 kc |
| | 4 & 5 | 3.15 a-c | |
| | 7 | 150±15 (& 250±10) | 10 V 1 kc |
| | 9 | 250 | |
| 6 | 1 | 16±2 | |
| | 3 | 19±3 | |
| | 4 & 5 | 3.15 a-c | |
| | 6 | 250±5 | |
| | 7 | 130±30 | |
| | 9 | 130±30 | |

7

ab8 mA (i > 5mA at nominal line voltage -10%)
(i < 15mA at nominal line voltage +10%)

SECTION 4 SPECIFICATIONS

4.1 FREQUENCY

4.11 Range:

0-21 kc

0-20.5 kc for main dial

0-500 cps for auxiliary dial

4.12 Accuracy:

$2\% \pm 2$ cps

4.13 Stability:

Less than 15 cps during the first hour after a run-in period of 15 minutes. Afterwards, less than 2 cps per hour.

A line voltage variation of 5% will cause a frequency drift of about 1 cps.

4.2 OUTPUT

4.21 Attenuator Output:

300 μ V to 100 volts in 10 ranges, one terminal grounded. The following relations exist between the output voltage ranges and the output impedances:

| <u>Ranges:</u> | <u>Output impedance:</u> | |
|----------------|--------------------------|------|
| 0-3 mV | 3 | ohms |
| 0-10 mV | 10 | - |
| 0-30 mV | 30 | - |
| 0-100 mV | 100 | - |
| 0-300 mV | 300 | - |
| 0-1 V | 900 | - |
| 0-3 V | 2,000 | - |
| 0-10 V | 30 | - |
| 0-30 V | 90 | - |
| 0-100 V | 300 | - |

The accuracy is better than 5% of full scale reading, provided that the level is correctly adjusted to full scale level in one of the 10 ranges, and provided that the output is unloaded.

The frequency response at attenuator output is within:

0.3 dB from 20 to 21,000 cps, and

1 dB from 10 to 21,000 cps on all ranges except the 0 to 100
voltage range where the response is
within:

0.3 dB from 30 to 21,000 cps.

When the attenuator is unloaded, the distortion is:

Less than 0.1% from 50 to 10,000 cps.

Less than 0.2% from 20 to 21,000 cps, except on the 0-100
voltage range where the distortion is less than 0.3%
and at mid-band approx. 1% at 30 cps.

A maximum of 25 mA is available in the case of attenuator
output in the greater part of the frequency range with less
than 2% distortion. An output of 10 mA with less than 0.3%
distortion is available in the greater part of the frequency
range.

In the case of unloaded attenuator output, the hum is:

Less than 0.05% 50 (60) cps

Less than 0.02% 100 (120) cps

Less than 0.05% 150 (180) cps

for every setting of the step attenuator from 0.3 to total out-
put or:

10 μ V 50 (60) cps

10 μ V 150 (180) cps

whichever is the greatest.

In the case of unloaded attenuator output the superimposed h-f
voltage is:

Less than 0.03%

Line voltage variations of 5% cause less than 1% variation in the
output level.

4.22 L-C Output:

Optimal load impedances at L-C output:

5 k Ω . Output direct from anode of output tube

2 k Ω . Output from tap on transformer primary.

Internal impedance of generator:

400 Ω at 5 k Ω optimal load setting

300 Ω at 2 k Ω optimal load setting

Frequency response at L-C output:

5 k Ω optimal load setting:

At 70 volts, unloaded, or 1 watt to a 5 k Ω resistive load:

Within 0.3 dB from 50 to 10,000 cps

Within 1 dB from 30 to 21,000 cps

2 k Ω optimal load setting:

At 50 volts, unloaded, or 1 watt to a 2 k Ω resistive load:

Within 0.3 dB from 50 to 10,000 cps

Within 1 dB from 30 to 21,000 cps

Distortion with an optimal resistive load:

At 1 Watt, 1 kc: less than 0.2% (typically 0.1%)

At 1 Watt, 50 to 10,000 cps: Generally less than 1%

At 4 Watts, 1 kc: Generally less than 2%

Hum:

Less than 0.1%

Generally: 0.03% 50 (60) cps
 0.02% 100 (120) cps
 0.03% 150 (180) cps

Or: 25 mV 50 (60) cps
 1 mV 100 (120) cps
 25 mV 150 (180) cps

whichever is the greatest.

High frequency voltage superimposed on output voltage:

Less than 0.03%

4.23 Transformer output:

Optimal load impedances: 5 Ω , 25 Ω , 500 Ω

One terminal grounded or both free

Internal impedance of generator:

3, 10 and 200 ohms, respectively

Frequency response at transformer output:

At 1 watt to an optimal resistive load or unloaded:

Within 0.3 dB from 50 to 10,000 cps

Within 1 dB from 30 to 21,000 cps

Distortion at transformer output:

Optimal resistive load:

At 1 watt; 1 kc less than 0.2%. Usually 0.1%

At 1 watt: Generally less than 1% - 50 to 21,000 cps

At 2.5 watts: Usually less than 1% at 1kc

Hum at transformer output:

Less than 0.1%

Generally: 0.03% 50(60)cps

0.02% 100(120) cps

0.03% 150(180) cps

Or: At 500 Ω setting: 10 mV 50(60) cps

1 mV 100(120) cps

10 mV 150(180) cps

At 25 Ω setting: 2.5 mV 50(60) cps

0.5 mV 100(120) cps

2.5 mV 150(180) cps

At 5 Ω setting: 1 mV 50(60) cps

0.2 mV 100(120) cps

1 mV 150(180) cps

whichever is the greatest.

High frequency voltage superimposed on output voltage at transformer output:

Less than 0.03%

4.3 AMPLIFIER SEPARATELY

4.31 Input

Sensitivity: 1 volt for maximum output

Impedance: 50 k Ω resistive

4.32 Output

In general the same as for the oscillator. With R-C attenuator output, the upper frequency limit is about 100 kc.

4.33 Amplification

0 to 0.003 - 0.01 - 0.03 - 0.1 - 0.3 - 1 - 3 - 10 - 30 - 100 and 150 times, depending on the setting of the output switch and the OUTPUT potentiometer.

4.4 TUBES

3 ECH81 or 6AJ8

1 ECF80 or 6BL8

1 EM84

1 150B or OA2

1 EL84 or 6BQ5

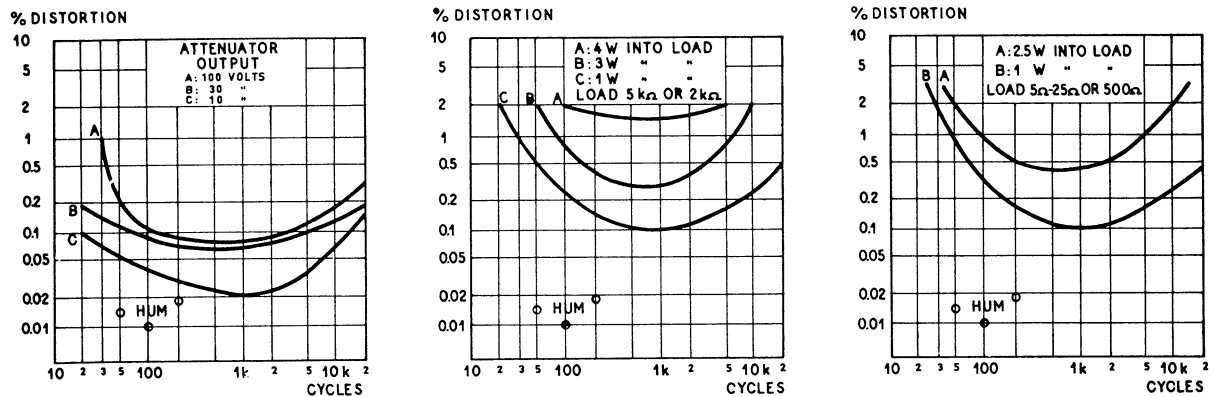
4.5 POWER SUPPLY

Voltages: 110-115-127-200-220 or 240

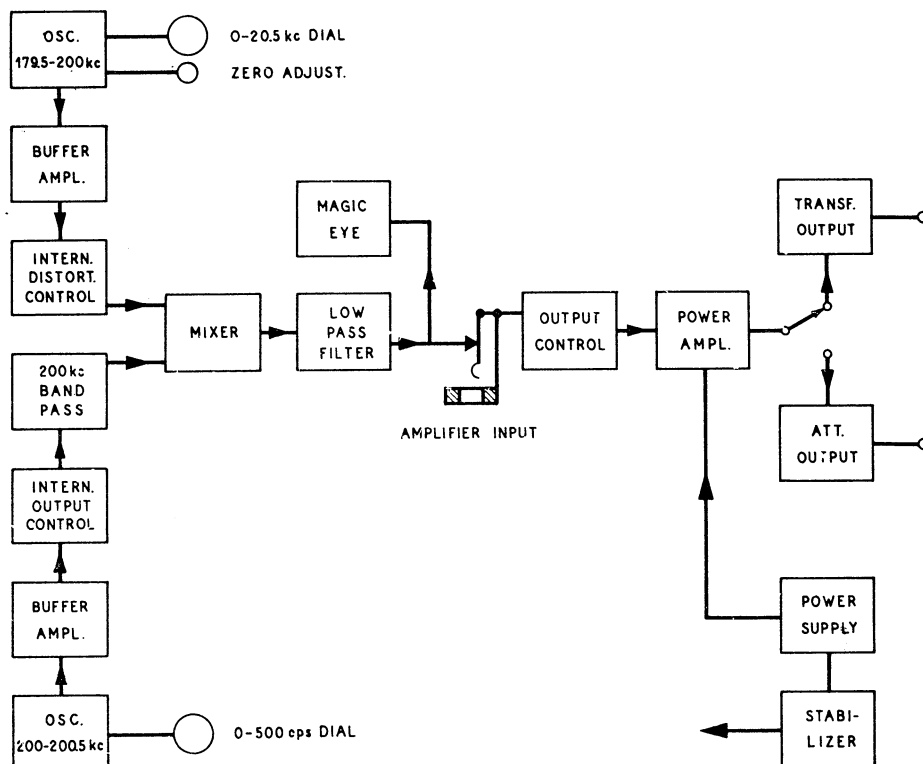
Frequencies: 50 to 60 cps

Consumption: 50 watts

HO 32 BEAT-FREQUENCY OSCILLATOR



TYPICAL CURVES SHOWING DISTORTION AND HUM



BLOCK DIAGRAM

