REPORT CRPL-7-2 ISSUED SEPTEMBER 15, 1950

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
CENTRAL RADIO PROPAGATION LABORATORY
WASHINGTON, D. C.

DESCRIPTION OF FIELD INTENSITY RECORDING EQUIPMENT, ITS INSTALLATION, ADJUSTMENT AND CALIBRATION

BY

A. GLENN JEAN

DESCRIPTION OF FIELD INTENSITY RECORDING EQUIPMENT, ITS INSTALLATION, ADJUSTMENT AND CALIBRATION

BY

A. GLENN JEAN
U.A.R.S. - C.R.P.L.

Part I

The field-intensity records to be obtained will be relative values of field strength at a chain of stations using similar installation and the same operating procedure. The equipment will record the average of the logarithm of the field strength, but with a short time constant (of the order of 10 sec) so that the median values will approach the value of the medians which would result by recording the logarithm of the average value of field strength.

The antenna system consists of a monopole antenna supported on top of a small building. A 100-wire counterpoise system, having a radius of 100 feet and about seven feet above the surface of the earth, is fastened to a brass plate at the base of the antenna on the roof of the building. (See drawings and photographs.) This length antenna gives a relatively uniform radiation pattern in the vertical plane over the range of angles of arrival usually met with in recording oblique-incidence field intensities.

Antenna, transmission line, etc.

A "premax" vertical antenna is mounted on top of a seven-foot building and cut to a length of 17.5 feet. A coaxial transmission line (RG 8/U) is used to couple the antenna to the input of an antenna multicoupler. This length of line should be about the same in all the installations, with arbitrary length of 44 inches. Graphs showing the impedance looking through the 44 inches of RG 8/U into the 17.5-foot antenna over a range of 2 to 20 Mc have been obtained.

Antenna multicoupler

This unit is connected to the antenna with the 44-inch coaxial line. It comes from the factory equipped with a balanced input connector. It is modified in the field to an unbalanced input. (Refer to the Antenna Multicoupler Instruction Book, Figure 2.) Remove P 11 and install one of the unused coaxial fittings provided on the back of the chassis. It is necessary to provide a power cord and plug connected to P 12. Three input transformers are supplied

providing different input impedances. Each of these transformers can be readily changed from balanced to unbalanced connection by following the directions in the back of the instruction book (Figure 6). The 600-ohm input transformer, referred to in the instruction book diagrams as Fil. #3, is used.

This unit is described fully in the instruction book and it has been found to require very little maintenance. On the rear of the chassis is a ten-position switch that enables an operator to check the plate-plus-screen current of each of the stages. A 0-25 milliampere meter with plug and cable is provided in each shipment of equipment. This meter should be used about once per week to check on the condition of the ten individual, isolated channels in the antenna multicoupler.

The ten output connections are on the back of the chassis also. If only three stations are being recorded, seven of these output terminals will not be used; and if six stations are being recorded, four of these output terminals will not be used. Cables connect the output of the antenna multicoupler to the input of the NBS-1 type receivers.

Receivers, type NBS-1

The RF cables to the input of the NBS-1 receivers should be kept as short as possible, but allow enough slack to let the dust cover of the receivers be removed easily. The input to the receiver is connected unbalanced; the braid of the coaxial cable is connected to the ground terminal of the receiver. It is important that good ground connections be made on both ends of this RF cable. On the rear of the receiver chassis below the accessory socket is provided an AVC voltage output terminal. Special cables and connectors are shipped with the bridge unit to connect the output of the receiver to the input of the bridge.

The receivers are supplied with plug-in crystal oscillator units and crystals for the appropriate frequency to be recorded. The crystal-controlled high-frequency oscillators in the receivers are operated 455 kc above the incoming carrier frequency. To install this crystal oscillator unit, unplug the oscillator tube in the receiver (V-4). Refer to Figure 6, page 46, of the "Instruction Manual for the NBS-1 Receiver". After installing the crystal oscillator unit, the receiver dial should be tuned to the frequency which is to be recorded. At this point it is well to check for spurious oscillation in the receiver and to be sure that the crystal in use provides reliable, stable oscillations at the correct frequency. With the crystal oscillator

unit plugged in but with the crystal removed, the receiver may go into self-oscillation but in all known cases, this self-oscillation has ceased when the crystal was plugged in.

The receiver should now be aligned with the crystal oscillator unit in service. A frequency meter (BC 221) is tuned to the correct carrier frequency, preferably by beating it against the incoming carrier which is to be recorded. Loosely couple the Bc 22 to the input of the receiver, being careful not to overload the latter, and align the IF transformers (See Figure 6, page 46 of the NB -1 Manual.) T-3, T-2, T-1 and the first and second RF trimmers for maximum receiver output. The method of measuring the relative out ut of the receiver may vary according to field conditions, but if it is known that the bridge and Brown Recorder units are operating correctly, it is recommended that this combination be used. Alternatively, a vacuum tube voltmeter or a high impedance voltmeter may be employed, though the latter will load the AVC voltage circuit slightly. After the receiver is in operation, the antenna trimmer and dial tuning should be checked with the aid of the BC 221 loosely coupled to the antenna lead-in of the receiver, and with the antenna connected to the receiver. This last procedure should be repeated each day or at least twice each week, depending upon the temperature variations, vibration of the equipment, etc.

The receiver is in the IF "sharp" position, RF gain full-on, and BFO "off', but this latter control does not affect the AVC voltage output of the NBS-1. Next, adjust the BFO trimmer T-4 (Figure 6, page 46 of the NBS-1 manual) so that zero beat occurs when the front-panel dial reads zero, with the crystal oscillator unit in service and after the IF alignment has taken place.

Bridge-oscillator unit

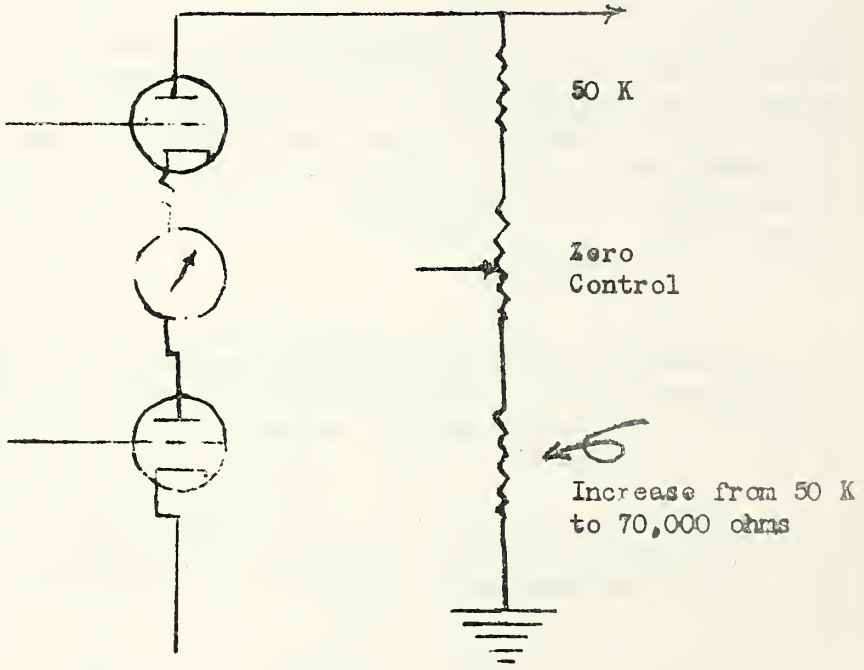
The bridge-oscillator unit has two separate channels (refer to the schematic diagram packed with the unit itself). Note that the two input channels can be paralleled with a switch provided on the back of the chassis. In operation this switch is left open so that only one channel of the bridge is used, namely, the short time constant side.

In the input circuit is a ladder attenuator used to divide the AVC voltage down from the order of volts to millivolts for the Brown "Elektronik" Recorder which has full-scale deflection with five millivolts input.

Following the ladder attenuator is a switch that has a "calibrate and "operate" position. Note that the switch by-passes the integrating

circuit when in the "calibrate" position, so that there is no delay in output voltage from the bridge with a changing input voltage. This is convenient when calibrating the equipment; otherwise, it would be necessary to wait about ten or 15 seconds for the recorder to reach each of the calibration points. Records are made with the switch in the "operate" position. On the front panel of the bridge units the channels are referred to as channel number one and channel number two. Channel number one usually has the shorter time constant but this should be determined experimentally to be sure that records are being made with the shorter time constant, which is of the order of ten seconds.

Next is the vacuum tube circuit with a 5 ma meter in the cathode-to-plate circuit of the twin triode tube. Note that this meter will read upscale with decreasing values of input voltage opposite to the "S" meter on the receiver. The zero control is for the purpose of adjusting the zero level of the signal recorded on the Brown recorder. The sensitivity control is primarily intended to adjust the spread between calibration points, and the step attenuator is simply a voltage divider. It will be found that all these controls interact somewhat, e.g., the sensitivity control is affected by the zero control. If it is found that there is not enough spacing between the lower calibration points the value of the resistor shown can be increased from 50 K to about 70,000 ohms.



This bridge is adjusted to give a zero point on the Brown recorder chart about one inch from the lower edge of the chart and to have about 3 or 3.50 (as necessary) log uv (60 or 70 db above one microvolt) at the upper end of the chart, also about one inch from the margin. The relative separation of the intermediate calibration points is a function of the bridge control adjustments and must be arranged by trial and error.

The oscillator portion of the bridge oscillator unit is not used; it was intended to be used with the HRO type receiver. It is suggested that the unused tubes in the bridge oscillator unit be removed from the sockets and maintained as spares.

Brown "Electronik" Recorder

The Brown "Electronik" Recorder is described briefly in the instruction book which is packed with the recorder. An additional schematic wiring diagram prepared by CRPL is included in the shipment to each station. The recorders are to be run at a chart speed of one inch per hour. None of the factory supplied gears will provide this particular chart speed; it is necessary to use the brass gears supplied separately, especially cut at CRPL for this purpose. This recorder is provided with a print wheel that prints a dot on the paper once each 15 seconds at a chart speed of one inch per hour. In addition, it is expected that each station will be supplied with pens and recording ink also, in the event that a continuous pen record might possibly be employed in the future.

The Brown "Electronik" Recorder has two separate channels which are paralleled in this particular application, so that each carrier recorded is sampled once each 15 seconds. The two channels are tied together inside the case of the instrument on the panel strip immediately below the standard cell. (See Figure 1466-11.)

If immersion oil is available, it is recommended that the slide wire be immersed with the oil manufactured by the Brown Company. (See instruction manual.)

This recorder is too wide to mount in the standard relay rack but it can either be mounted on the panel as described in the manual in Drawing No. 12-G-68, or a much neater installation can be made by cutting out the relay rack to accommodate the recorder. Details for this are available in the CRPL Drawing No. 287C-2.

Standard Signal Generator

The Measurements Corporation Model 80 standard voltage generator is used to calibrate the field-intensity recording equipment. The oscillator tube life can be greatly prolonged by keeping its plate

voltage turned off between calibration periods. This can be done by turning the external pulse switch "on". See Figure 1-1 and Schematic Diagram 6-1 in the Model 80 Standard Voltage Generator Manual. The filament supply should be left on continuously.

The frequency and output controls are interacting. Increasing the output of the signal generator will slightly detune its frequency. For this reason the BC 221 frequency meter should be used to check the frequency of the standard voltage generator after the output adjustment has been made for each calibration point.

This instrument is calibrated to give the dial-indicated value of microvolts across the fifty-ohm termination of cable #80-ZH-4. The six db pad should be used at all times because it greatly reduces the reactive component of the impedance looking back into the signal generator cable.

Coaxial fittings enclosing a fifty-ohm resistor used to terminate cable #84-Z2-2 have been made and will be sent to each station. Until these fifty-ohm termination fittings are received, cable #84-Z2-2 may be used to connect the signal generator to the antenna multicioupler while calibrating the field-intensity recording equipment.

It is recommended that the model 80 signal generator be shelf-mounted as shown in the sketches of the rack-mounted equipment. This instrument, like the Brown recorder, will not fit into the standard relay rack, hence shelf-mounting is required. This instrument should not be used for calibration purposes while removed from the external metal cabinet. This is mentioned because, although it will fit into a relay rack with the cabinet removed, the unwanted radiation is too great for accurately calibrating the field-intensity equipment. An advantage of the shelf-mounting is that mechanical vibration is reduced since it is not necessary to move the instrument during the calibration procedure.

One of the most frequent faults with the model 80 has been found to be failure of the 955 oscillator tube. When this tube fails, or is reduced in output, the output meter will not come up to the "red line". Occasionally this symptom appears in spite of a good 955 tube, in which case the band switch should be rocked back and forth until a better electrical connection is made by the switching contacts. The 955 must have a very high GM to work properly and the spare tubes sent to the stations are chosen with this in mind.

IF alignment of crystal-controlled NBS-1 receivers

The high-frequency oscillator tube (V-4) is removed from its socket and replaced with the plug-in crystal oscillator unit. The appropriate crystal is plugged into the crystal oscillator unit.

A good vacuum tube voltmeter or a 20,000-ohm per volt voltmeter, such as the Simpson supplied with each station shipment, is used to measure the AVC voltage output during the alignment procedure. The regular recording equipment is one of the best indicators but usually the operator cannot observe the recorder while adjusting the IF trimmers.

The receiver dial is tuned until the desired carrier is heard. The BC 221 frequency meter is then zero beat against the incoming carrier. Usually the incoming signal is fading making it difficult for the operator to distinguish between alignment adjustments and fading. To reduce this difficulty, the BC 221 frequency meter is coupled loosely to the input of the receiver (with the antenna still connected) to reduce the range of the fading. If the BC 221 should drift off the correct carrier frequency during the alignment procedure, it should be retuned to zero beat with the carrier. The IF transformers are then peaked for maximum AVC voltage. (See Figure No. 6, NBS-1 manual, page 46.) The adjustments made are L-16, L-18, L-19, L-20, L-21 and L-27. The order in which these adjustments are made is not important.

The receiver RF gain control is full on and the IF selectivity is in the "sharp" position.

To adjust the BFO so that zero beat occurs with the CWO control set at 0, adjust L-28 of T-4.

The main dial is again adjusted for maximum AVC voltage and left in this position. The antenna trimmer should be peaked for maximum AVC voltage with the antenna connected and receiving the desired carrier, preferably at a time when fading is not too rapid to effect a careful adjustment.

The IF alignment should be checked once each month in the manner described above. The receiver dial tuning and antenna trimmer adjustments should be made once each day. In the event that the detuning is appreciable, (of the order of 1 or 2 db), a calibration should be made before and after retuning the dial and trimmer.

Note that in the above procedure the BC 221 was used as a source of stable voltage; the dial calibration was not depended upon. Errors of the order of 1 kc can be made by depending upon the dial calibration of the BC 221. The IF selectivity curve of the NBS-1 receiver is only 4 kc wide in the "sharp" position at the 6 db points (Figure No. 1, page 44 of the NBS-1 manual).

Daily calibration of field-intensity equipment

After the receiver has been properly aligned, the bridge unit adjusted, etc., the following procedure is followed in calibrating each unit of the equipment once each day and before and after any adjustment of the equipment which will produce a change in the calibration points:

The transmitters are arranged to be off the air for five minutes each 20 minutes; one of the recording units can be calibrated during one of these intervals. With the station off the air it is possible to get an accurate calibration, especially at the lower points, where unwanted pick-up might prevent distinguishing between, say, zero and 1 uv.

Before the station goes off the air, zero-beat the output of the BC 221 frequency meter against the incoming carrier. Next, zero-beat the standard voltage generator against the frequency meter and keep it at zero-beat with the frequency meter throughout the remainder of the calibration procedure. Be sure to tune the standard voltage generator (model 80) to the frequency meter and not vice versa.

With the antenna connected, adjust the receiver for maximum response to the frequency meter by tuning the main dial and antenna trimmer. These adjustments are not changed until the next calibration. disconnect the antenna from input to receiver. Encircle the dot printed on the chart corresponding to the zero input level of the recorder. This is done with zero output from the standard voltage generator and with the frequency meter temporarily turned off by switching the front of panel switch from "high" to "low" range.

In successive steps, adjust the output voltage of the standard voltage of the standard voltage generator to the values shown in the left-hand column of the table below:

Signal Generator Output		Scale Marks
0.00		0.00 uv
1.00	microvolts which is	0.00 log uv
3.16	" " "	0.50 log uv
10.00	" " "	1.00 log uv
31.6	" " "	1.50 log uv
100.00	" " "	2.00 log uv
316.00	" " "	2.50 log uv
1000.00	" " "	3.00 log uv
3160.00	" " "	3.50 log uv
10,000.00	" " "	4.00 log uv

The last calibration mark need only exceed the highest level being recorded by about 30%.

The point on the field-intensity record corresponding to each of these signal-generator output levels, is encircled and identified as follows: 0.00 uv, 0.00, 0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00. The first point is identified as 0.00 uv but it is not necessary to write log uv after the other points.

During the calibration, always tune the standard voltage generator to zero-beat with the frequency meter after the output level of the generator is changed. Note, however, that the frequency meter must then be turned off until the next change in level is made.

After the calibration points are marked with increasing output, the points are checked rapidly in the reverse order. Since only five minutes are available for this calibration procedure, it is a good idea to put on the lower level points first. Then, if the station should come back on the air while the upper level calibration points are being made, it is not nearly so likely that these points will be influenced by the incoming carrier.

The BC 221 frequency meter is used as a source of frequency stable RF voltage in the above procedure. The frequency calibration of the dial is not depended upon to be correct; the instrument is simply zero-beat against the incoming carrier. It is good practice to log the BC 221 settings for each of the frequencies recorded, to be used in tuning the signal generator to these proper frequencies at times when the station is not being received such as, for example, during disturbed periods.