BROADCAST TRANSMITTER MONITORING PRACTICE

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STUDY SCHEDULE NO. 43

For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind. Study each other step in this same way.

☐ 1. The Transmitter Operator's Job .... Pages 1-2

The duties and responsibilities of a transmitter operator are briefly previewed.

Finished July 7, 1960

☐ 2. Procedures Before Sign-On and After Sign-Off ..... Pages 2-4

The pre sign-on duties including "putting the transmitter in the air" and the after sign-off procedures of a standard broadcast station are given.

☐ 3. General Transmitter Operating Practice .... Pages 5-21

The usual operating duties such as supervising the transmitter operation and maintaining the operating log as well as the operation and use of compression amplifiers, frequency monitors, and modulation monitors are presented.

☐ 4. Meeting Emergencies .... Pages 21-25

In this section we consider the important subject of how to anticipate and locate the causes of the inevitable interruptions to transmitter operation.

☐ 5. General Maintenance .... Pages 25-28

Protective maintenance and inspection of the transmitter and associated equipment are considered here.

☐ 6. Answer Lesson Questions.

☐ 7. Start Studying the Next Lesson.

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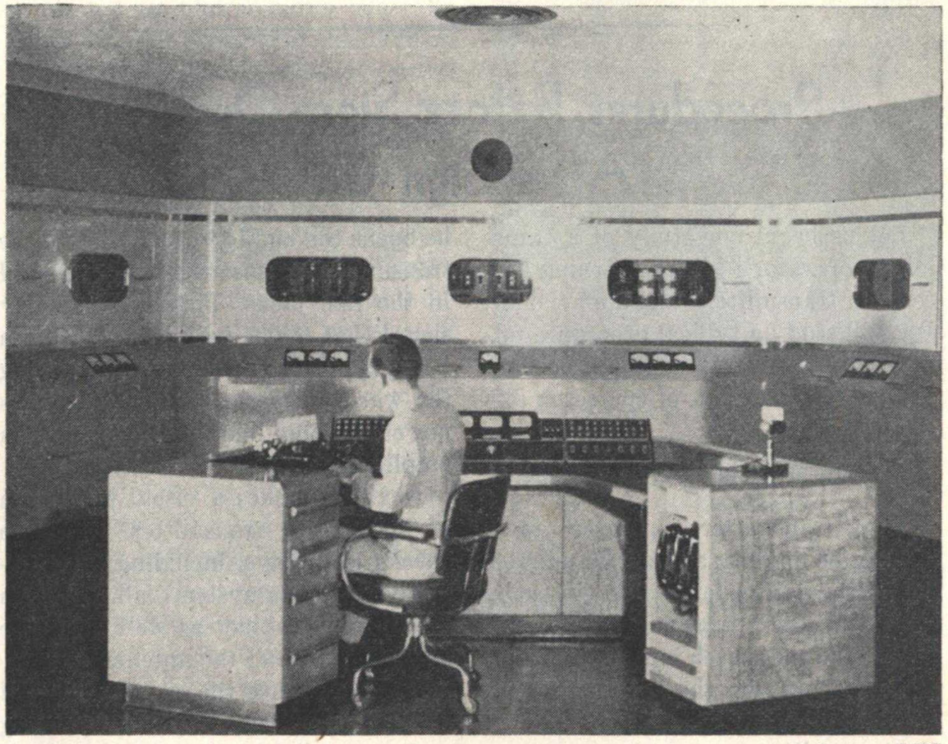
BROADCAST TRANSMITTER MONITORING PRACTICE

The Transmitter Operator's Job

OPERATING a broadcast transmitter calls for a man with a good technical training plus a thorough understanding and appreciation of the more intangible values of program material, which are greatly affected by his technique in operating his equipment. His technical duties consist essentially of turning the transmitter on some time ahead of the beginning of the day's program schedule for what is known as the "warm-up" period, during which all meter readings are checked, necessary tuning adjustments are made, and program level checks with the studio are run; keeping an accurate log, including frequency measurements; shutting down the transmitter after sign-



Courtesy WCBS

This is a general view of the transmitter control equipment used at WCBS a 50-kw. standard a.m. broadcast transmitter. The transmitter is arranged in a U shape around the control desks. The five glass panels shown permit observation of the tubes and other equipment for visual checking on transmitter operation. Switches and other controls at the operating position provide control of the transmitter and the audio signal applied to it. This is a modern transmitter that provides every facility for aiding the transmitter operator in performing his job.

off; and adhering to a maintenance schedule that includes making noise and distortion measurements and frequency runs of audio lines and all equipment at the installation.

During the daily operations schedule, he monitors the program constantly by means of a monitoring amplifier and loudspeaker, adjusts the line amplifier gain to keep the modulation as close to 100% as possible, maintains the transmitter output at the correct level, and logs meter readings every half hour to meet FCC requirements. He should also, as far as possible, anticipate trouble, and correct in the shortest possible time any breakdown or abnormal operation that develops.

The most important duty of a transmitter operator is to become thoroughly familiar with the circuits used at the transmitter where he is employed. He should be able to draw a schematic of all important circuits and a block diagram of the sequence of operation of starting relays in the power control circuits. Complete familiarity with the circuits and control units used at any installation gives a man the self-confidence necessary to avoid confusion or panic at times of technical trouble.

Later in this Lesson, you will learn some useful methods for meeting emergencies with broadcast equipment.

Procedures Before Sign-On and After Sign-Off

Let us begin our study of a transmitter operator's job by learning how to get a transmitter on and off the air. We will study a typical procedure followed by an operator; this procedure may vary somewhat, of course, in different stations.

PROCEDURE BEFORE SIGN-ON

The transmitter operator must usually be on duty at least 30 minutes before the daily operation begins so he can check the operation of the transmitter and the speech input equipment, and, working with the studio operator, check the lines between the studio and the transmitter.

The first thing the transmitter operator does is turn on the frequency monitor and modulation monitor so they will have time to stabilize. Next, he opens the audio program line to the transmitter by inserting a patch cord in the line jacks. This prevents any signal that might be on the line from being applied to the transmitter during the warm-up period. He then applies power to the line and compression amplifiers.

Next, he makes a visual inspection of the entire transmitter. He then checks the relays, including (in a directive antenna system) all relays in the phasing cabinet as well as in the coupling house at the antenna. (Phasing cabinets house the relays, coils, and condensers associated with the phasing and power division for directional antenna systems; they do not, of course, exist in stations that have only a nondirectional antenna.)

Next, he operates the relay armatures in the control circuit of the transmitter manually to make sure that no contacts are stuck. He also inspects all r.f. meters and makes a report of any bent hands or other indications of meter defects.

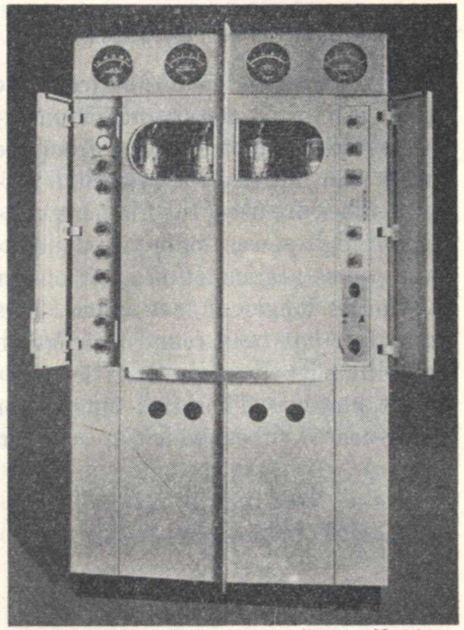
If safety gaps are used, he inspects them to make sure the spacing is approximately correct.

If the system is water-cooled, he starts the pumps and inspects the rate of flow meter. Water flow in water cooling systems must be normal before even the filament voltage is applied, since heat from the filament alone is sufficient to damage uncooled power tubes.

Air-cooled tubes differ in this respect; the air-blower motor generally starts with the pressing of the filament switch. The filament voltage control in such an installation is interlocked with the air blowers so that filament voltage cannot be applied unless the air is blowing through the ducts leading to the tube air fins. The interlock mechanism consists of a small damper device in the air stream. When this device is tilted by the air pressure, it closes a contact, thereby applying potential to close the interlock relay; closure of this relay allows filament voltage to be applied. Water cooling systems also use an interlock arrangement so that filament voltage cannot be applied until sufficient water flow is present, but the procedure differs in that the water pumps are started independently of the filament switch and must, of course, be started before the filament voltage can be applied.

After the cooling system is in operation, the operator turns on the filaments and checks the filament voltages. He then applies plate voltage to the exciter unit and checks the excitation of the final stage by noting the grid current meter reading of the final. If there is sufficient excitation, he then puts the carrier on the air by applying low voltage to the transmitter. He checks all meter readings carefully; if they show that operation is normal, he applies the high power.

Next, he checks all meters again, adjusts the filament and line voltages to the proper values, and adjusts the plate current of the final stage for nominal power output.



Courtesy Western Electric

Front view of the Western Electric 1-kw. 443A-1 transmitter. The controls at the sides of the front panel are normally covered by the small doors; this arrangement prevents accidental manipulation of the controls.

A check of the program line is then made. The control room operator is generally playing transcriptions or has the network program alive to check his own circuits. To do this, he has patched in the program line directly to the monitor amplifier. When he is satisfied that the program line is all right, the control room operator switches the audio signal off the line. The transmitter operator then removes the patching cord from the line jacks, thus reconnecting the program line to the transmitter. The entire system is now ready to operate, and the transmitter operator stands by waiting for the program to start.

PROCEDURE AFTER SIGN-OFF

As soon as the program from the studio is finished, the operator immediately removes plate voltage from the entire transmitter. When tungsten filament tubes are used, the filament voltages of high-power final r.f. and modulator tubes are sometimes left on for 3 minutes longer at low values. This procedure has been found to lengthen tube life slightly; not all stations follow it, however. Thoriated-tungsten or oxide-coated tubes, which are used in lower-powered stages, are always operated at normal filament voltage for maximum tube life, and this reduced-voltage operation is neither necessary nor useful for them.

Next, the operator removes the filament voltage entirely. He allows the water pumps or air blower cooling system to run 5 to 8 minutes after the filament voltages are removed so that the heat retained by the tubes will be dissipated. Five to eight minutes is the usual time allowed for stations with ratings up to 5 or 10 kw. In 50-kw. transmitters using water-cooling systems, the water is left circulating for 10 to 20 minutes after filament voltages have been removed. Once the cooling system has been shut off, the procedure after sign-off is complete. In many stations, however, a regular maintenance schedule then goes into effect. We will describe such a schedule later in this Lesson.

General Transmitter Operating Practice

During the regular broadcast schedule, it is the responsibility of the transmitter operator to keep the transmitter output at the proper level, to maintain the program level at a point consistent with good engineering practice and the type of program in progress, and to locate and repair any troubles that may occur.

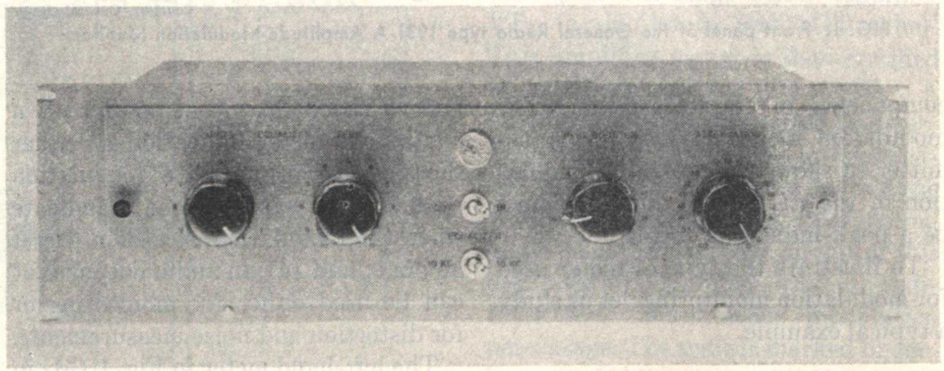
MAINTAINING THE POWER LEVEL

Although the power level is set to the correct value at the beginning of the operating schedule, the power output will vary as the tubes and other components warm up and as the power-line voltage varies. The transmitter operator must therefore make adjustments during the day to maintain the proper level.

The FCC permits the power output to vary a maximum of 5% above or 10% below the correct value for short periods of time. The operator makes periodic checks during the day on the antenna current (a measure of the output power). If the current varies from the proper value, he brings it to normal by varying the plate voltage of the final r.f. stage.

MODULATION LEVEL

The level-indicating meters used at the studio and transmitter must necessarily differ in characteristics because of their different functions. The VU meter at the studio end is an r.m.s. full-wave indicating device that follows as faithfully as possible the effect produced in the ear by the sound waves emanating from a monitoring loudspeaker. At the transmitter, however, where modulating voltages are concerned, a fast-acting peak-indicating device is necessary and is specified by



Courtesy RCA

The RCA type BE-1A Variable Line Equalizer. This is a typical line equalizer and is used at broadcast transmitters for equalizing unloaded program telephone lines up to ten miles in length to a frequency response of ± 1 db in the range 30 to 15,000 cycles. After such an equalizer as this has been initially adjusted there will be little occasion to change the controls, however, it is frequently the transmitter operator's job to periodically check the frequency response of the entire audio system, and to make whatever corrections are necessary by means of an equalizer of this or a similar type.

the Federal Communications Commission. Such a meter is necessary because the peak factor (ratio of peak to r.m.s. values) of speech and music waves may be 10 db or more, and, when these peaks occur in rapid succession and cause overmodulation, interference may be caused in adjacent channels, and there is danger of a breakdown in circuit components of the transmitter. The modulation meter used at the transmitter to show percentage of modulation of the r.f. carrier therefore must be a peak-indicating meter.

To illustrate the type of meter used for modulation monitoring, let us study a typical example.

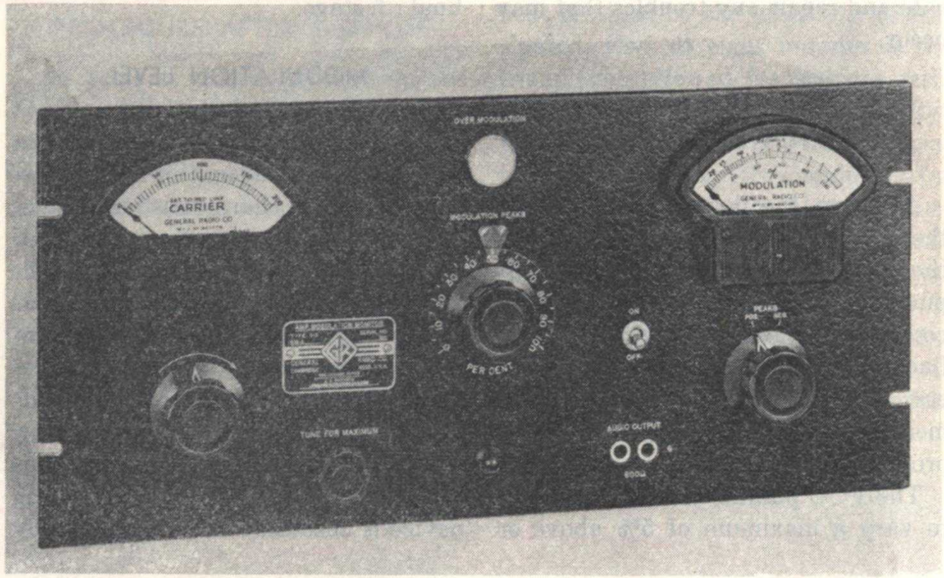
A.M. MODULATION MONITORS

The General Radio type 1931-A Amplitude-Modulation Monitor is shown in Fig. 1. The simplified schematic of this modulation monitor and its equivalent, the RCA WM-43A, is shown in Fig. 2.

Before we go into the details of the operation of these modulation monitors, let us first examine their general features.

Basically, either monitor provides: (1) a means of checking carrier shift and variations in output power; (2) a continuous meter indication of either the positive or negative modulation peaks; (3) a warning light to indicate when the modulation exceeds a preset amount; and (4) an audio output that can be used either for monitoring or for distortion and noise measurements.

The left-hand meter in Fig. 1 (M_1 in Fig. 2) is used to indicate the carrier amplitude. The knob beneath the name plate is used to adjust C_1 in the tuned circuit L_2-C_1. The output voltage of this tuned circuit is applied to



Courtesy General Radio

FIG. 1. Front panel of the General Radio type 1931-A Amplitude-Modulation Monitor.

the right diode of VT_1, where it is rectified. The average d.c. current indicated by M_1 is a measure of the carrier power. The knob beneath M_1 in Fig. 1 is used to adjust the meter deflection to the red reference line at midscale. This is done by varying the coupling between L_1 and L_2. Thus, if the transmitter carrier power should vary, the deviation can be noted on the scale of the meter. Any excessive carrier shift during modulation (due to improper transmitter adjustment) can also be noted. (The maximum permitted by the FCC is 5%.)

A portion of the audio component of the signal across R_2-R_3 is applied through C_4 to the linear amplifier VT_4. This stage is a cathode follower that provides low-impedance (600-ohm) audio output that can be taken from the front panel by a standard two-plug patch cord to operate either an external monitor or distortion and noise measuring equipment (to be described in a later Lesson).

Some of the audio signal is taken from R_4-R_5 to operate M_2, the % Modulation meter on the right side of the panel. The audio signal is amplified by a two-stage linear amplifier VT_2 (a duo-triode 6SN7-GT tube). This amplified signal is then rectified by the diode rectifier (½ of VT_3). A switch marked Peaks is used to determine whether the positive or the negative modulation peaks will operate the v.t.v.m. section of VT_3. A quick-acting meter M_2 in the cathode circuit of this degenerative amplifier v.t.v.m. indicates the instantaneous modulation percentage. The scale is marked linearly up to 110%. Although 100% is the maximum permissible on negative peaks, the positive peaks can, on an unsymmetrical modulation waveform, exceed 100% without "splatter."

One section of the two-gang poten-

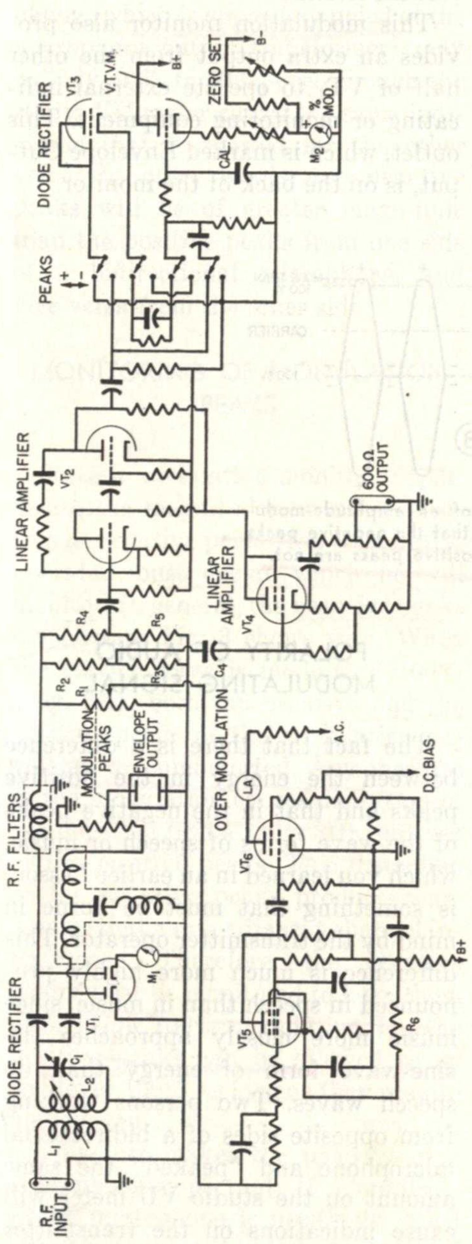


FIG. 2. This is a simplified schematic of the General Radio type 1931-A amplitude modulation monitor. The RCA WM-43A has exactly the same diagram.

tiometer controlled by the Modulation Peaks knob R_1 applies a portion of the audio voltage to the over-modulation indicator circuit. This signal is first applied to amplifier VT_5. Because the cathode of VT_5 is connected to B+ through resistor R_6, the bias on VT_5 is quite high; R_1 can be adjusted so that only the peaks of the audio voltage are fed to the grid of VT_5 with

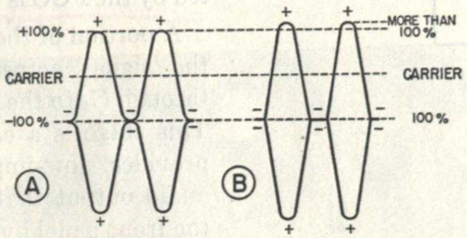


FIG. 3. The envelope of an amplitude-modulated r.f. signal. Notice that the negative peaks are limited, but the positive peaks are not.

sufficient amplitude to cause the tube to operate. The amplified peak is then coupled to VT_6, which is a type 2050 thyratron tube with 60-cycle a.c. on its plate. This tube is biased so that it normally will not conduct. When a modulation peak in excess of the value set on the Modulation Peaks dial is applied to VT_6, the amplified signal will cause VT_6 to conduct as long as the over-modulation is present, and the lamp LA in series with the a.c. on the plate of VT_5 will light.

As the scale of the Modulation Peaks dial in Fig. 1 shows, the dial may be set so that LA will flash for any value of modulation from 0% to 100%. Generally, however, it is set at about 85%, since this is a convenient value that will give the transmitter operator a good indication of how often high values of modulation are encountered.

If the light flashes too frequently, indicating excessive overmodulation, the operator must take some action to correct the situation.

This modulation monitor also provides an extra output from the other half of VT_1 to operate external indicating or monitoring equipment. This outlet, which is marked Envelope Output, is on the back of the monitor.

POLARITY OF AUDIO MODULATING SIGNAL

The fact that there is a difference between the energy in the positive peaks and that in the negative peaks of the wave forms of speech or music, which you learned in an earlier Lesson, is something that must be borne in mind by the transmitter operator. This difference is much more highly pronounced in speech than in music, since music more closely approaches the sine-wave form of energy than do speech waves. Two persons working from opposite sides of a bidirectional microphone and "peaked" the same amount on the studio VU meter will cause indications on the transmitter modulation meter that are far from equal. Assume, for example, that the modulation monitor is set to indicate

the magnitude of negative peak modulation, and the indication of one voice is close to 100%. The indication of the voice from the other side of the microphone (which is oppositely poled at the microphone output transformer) may be only 40% to 50%, even though the studio VU meter shows the same indication that it showed for the other voice. In other words, the negative peaks will be of greater magnitude than the positive peaks from one side of a bidirectional microphone, and vice versa from the other side.

MONITORING OF MODULATION PEAKS

Since a modulation monitor can indicate the magnitudes of either positive or negative peaks, the transmitter operator must decide which he will monitor. In general, the negative peaks are chosen. Fig. 3 shows why. When the carrier wave is modulated 100% (Fig. 3A), both the negative and the positive peaks of the modulation envelopes are undistorted. Any increase in the modulation causes distortion of the negative peaks (Fig. 3B), but not of the positive peaks. This distortion of the negative peaks produces harmonics that cause adjacent channel interference. Therefore, the negative peaks must be monitored to keep them at or below 100% modulation, but the positive peaks can be allowed to go well over 100% as long as they remain undistorted.

This fact makes the polarity of a microphone important. If a unidirectional microphone is positively poled (that is, connected to its output transformer so that the major part of its output energy is concentrated in the positive peaks of its output) the average modulation will be considerably higher than it would be if the energy were mainly in the negative peaks. If a microphone is not correctly poled at the studio, the transmitter operator can change the polarity by using patch cords to interchange the connections between the line and amplifier jacks.

To make this matter of maximum permissible modulation clearer, let's review briefly the analysis of an amplitude-modulated wave. When a carrier is modulated with a pure sine tone (Fig. 3A), the degree of modulation is expressed as:

$$m = \frac{E_{ave} - E_{min}}{E_{ave}}$$

where E_{ave} is the average envelope amplitude and E_{min} is the minimum envelope amplitude.

The peaks and troughs of the envelope contain equal amounts of energy. When the degree of modulation is 1.0—in other words, when the minimum envelope amplitude is zero in the above equation—the modulation is complete (or 100%, expressed in terms of percentage modulation), and the envelope varies through the maximum range possible without amplitude distortion. This variation of the amplitude of the radio wave generates side bands differing in frequency from the carrier by the frequency of the modulating signal. It is the energy in the side bands that conveys the intelligence being transmitted.

When the envelope variation is not sinusoidal, the positive and negative peaks are not equal, and it is necessary to define the percentage modulation in a different manner for the peak and troughs of the envelope:

Positive Peak Modulation

$$= \frac{E_{max}—E_{ave}}{E_{ave}} \times 100.$$

Negative Peak (Trough) Modulation

$$= \frac{E_{ave}—E_{min}}{E_{ave}} \times 100.$$

You can see from the second of these equations that the trough modulation cannot exceed 100%, since the minimum voltage cannot be less than zero. It is, however, possible for the positive peak voltage to be more than twice the average (or carrier) voltage, in which case positive peak modulation will exceed 100% modulation.

It is a common belief that the FCC prohibits modulations greater than 100%. Actually, the FCC definition of maximum modulation is as follows: "The term 'maximum percentage of modulation' means the greatest percentage of modulation that may be obtained by a transmitter without producing in its output more than 10 percent combined audio harmonics." This definition is logical: in an amplitude-modulated transmitter, the band width of the carrier wave and side bands (which is what the FCC is interested in controlling) depends *not* upon the degree of modulation, but upon the highest frequency to be transmitted.

This means that, regardless of the degree of modulation, adjacent channel interference cannot occur if the modulating frequency is kept below 5000 cycles (since the band width of standard broadcast stations is 10 kc.).

However, if there is overmodulation on the negative peaks (meaning that the negative peaks of the modulating voltage are so large that they cause the voltage applied to the r.f. amplifier plate circuit to become slightly negative), distortion occurs that produces harmonic frequencies above 5 kc. It is these frequencies that cause adjacent channel interference. That is why the negative peaks, rather than the positive peaks, should be monitored.

A cathode-ray oscillograph is invaluable as a supplementary modulation meter, because the screen pattern shows at once whether the negative peaks are being distorted, or clipped. If they are, the screen pattern has an appearance similar to that shown in Fig. 3B.

COMPRESSION AMPLIFIERS

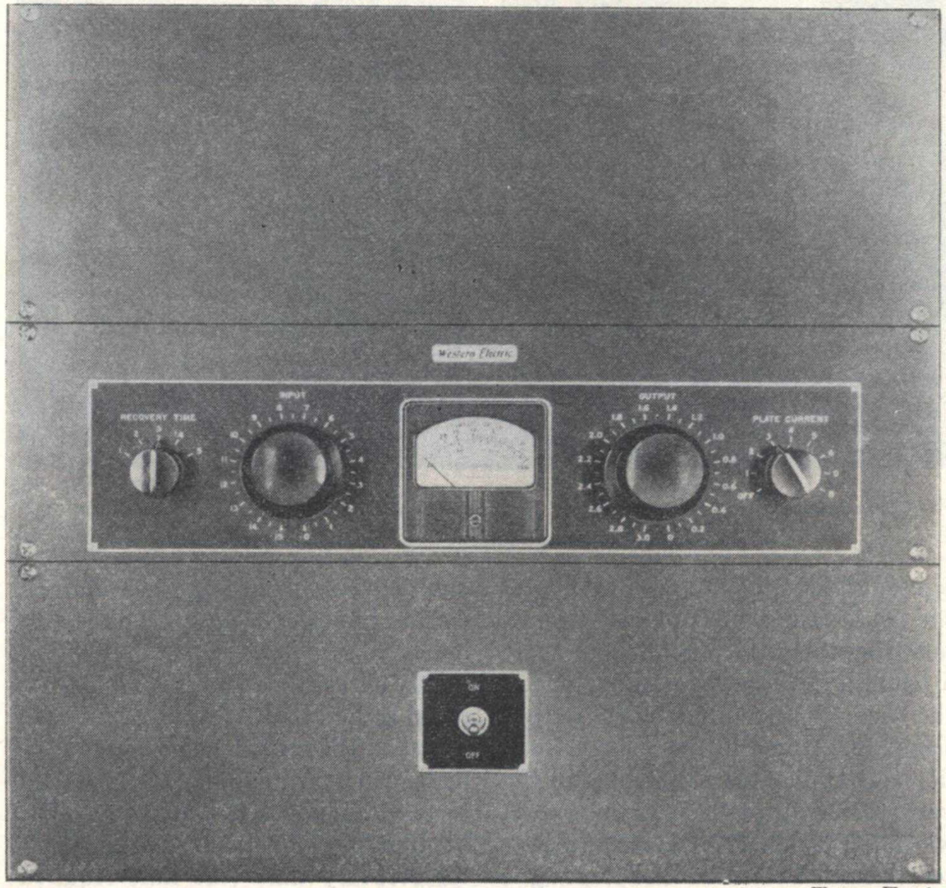
In any signal transmission system, there is an upper limit to the amount of input power that may be safely applied. In an amplitude-modulated radio transmitter, the breakdown voltage limits of circuit components, and distortion caused by excessive harmonics and spurious radiation impose a certain definite limitation. Within this limit, however, it is desirable to maintain the highest possible input level when the type of program warrants, in order to obtain the most effective use of the available facilities.

In other words, the modulating speech or music should be maintained at as high a level as possible for the type of program material, yet overmodulation must be sufficiently limited to avoid undesirable effects. This is accomplished to a certain extent, of course, by the control room operator, who adjusts the program level as indicated by the volume indicator to about 8 or 10 db below the single-frequency level required for 100% modulation. The effectiveness of this method is

limited to a great extent by the reaction time of the operator and his familiarity with the program in progress.

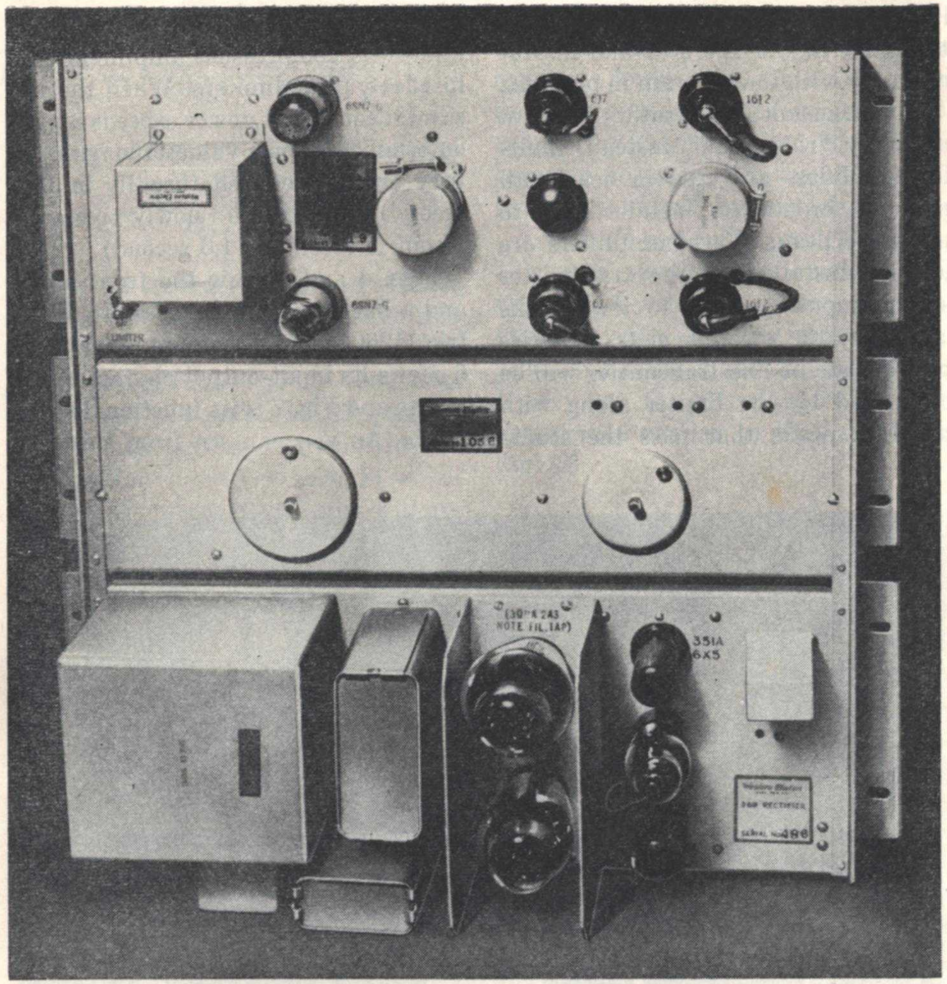
The transmitter operator does not normally "ride gain." Instead, limiting amplifiers are used in nearly all modern broadcast installations to minimize peaks. These amplifiers are usually installed at the transmitter speech input position so that peaks caused by the wire line characteristics between studio and transmitter will be controlled by the limiter along with program peaks that pass the studio control operator. These amplifiers, known as compression amplifiers, are in effect, peak limiters. When the instantaneous peak power exceeds a predetermined input value, the gain is very quickly reduced (usually in .001 second) and more slowly restored (from .2 second to 1.0 second).

Figs. 4 and 5 show the front panel and a back view of the Western Electric 1126C compression amplifier; Fig. 6 shows its input-output characteristic curve, and Fig. 7 is its functional schematic. As you can see from this last



Courtesy Western Electric

FIG. 4. The control panel of the Western Electric 1126C program-operated level-governing amplifier (also called a compression amplifier).



Courtesy Western Electric

FIG. 5. Back view of the Western Electric 1126C amplifier. The control panel, shown in Fig. 4, is in the center.

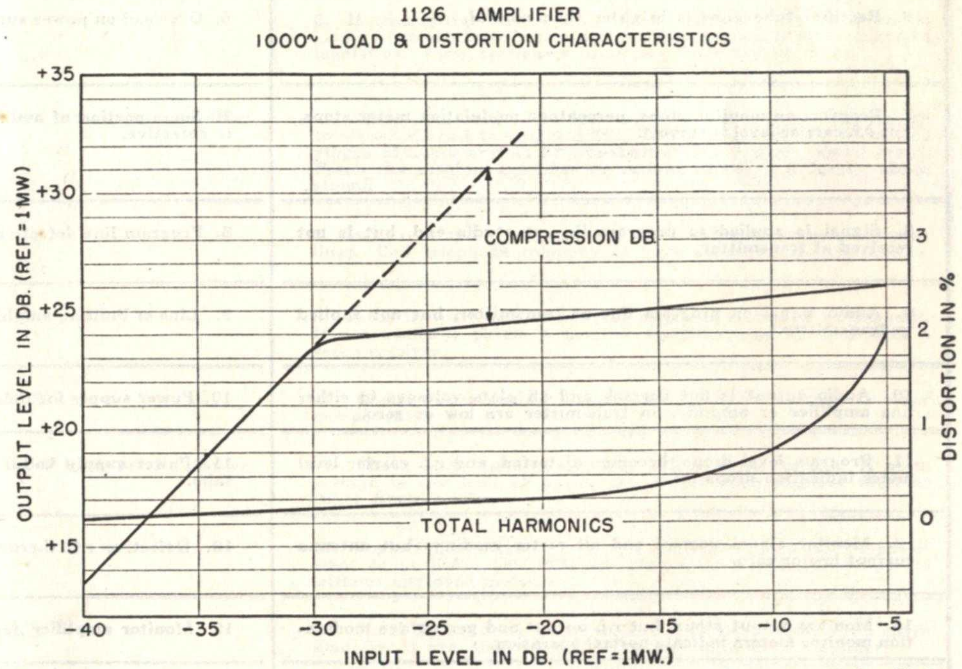
figure, attenuators are used to control the levels of the input to and the output from this unit. The dials of these attenuators are shown at either side of the meter in Fig. 4. Part of the output signal is rectified in the control rectifier and applied as a d.c. bias to the vario-losser stage to reduce its gain when the signal level exceeds a preset amount. The amount of limiting is indicated by the meter pointer, which is normally at the right of the scales and deflects to the left when limiting occurs. Limiting of up to 20 db can be indicated.

At the extreme right on the front panel is the operating knob of a switch (marked Plate Current) by which the meter can be switched into circuits used to test the stages of the limiter. The knob at the left of the panel controls the recovery time (the time required for the gain to return to normal after a peak compression); adjustment of

this control will be discussed later.

Proper Use. A compression amplifier, properly operated, is a very useful and important link in a broadcast installation. However, it must be remembered that it is meant to be a *peak-limiting* device, not a volume limiter. The amount of gain reduction is a function of the *peak* amplitude. In actual practice, this gain reduction is intended to be small (3 to 5 db maximum) to prevent much reduction in the dynamic range of the signal, (the ratio of lowest to highest volume in the signal content). A compression amplifier, properly operated, will show about 3 to 5 db of *intermittent* gain reduction on the *peak-reading* compression meter that indicates the amount of limiting occurring.

However, a compression amplifier cannot be successfully used as a volume compression device. That is, it is not practical to increase the average modulation level and depend on a compression amplifier to prevent overmodulation on peaks. This cannot be done because the device has a certain attack time (the time required for the compressing action to start) as well as a recovery time. If the duration of a peak is short compared to this operating time (attack time plus recovery time), a portion of the energy in that peak will escape limiting action. As a result, the limiting of peaks is incomplete, particularly at the higher frequencies, and, if the average signal is so high that a great amount of compression is continually taking place, a large amount of adjacent channel interference will occur. This is particu-



Courtesy Western Electric

FIG. 6. This graph shows the distortion characteristics of the Western Electric 1126C amplifier for a 1000-cycle input.

BROADCASTING SYSTEM TROUBLE-SHOOTING GUIDE

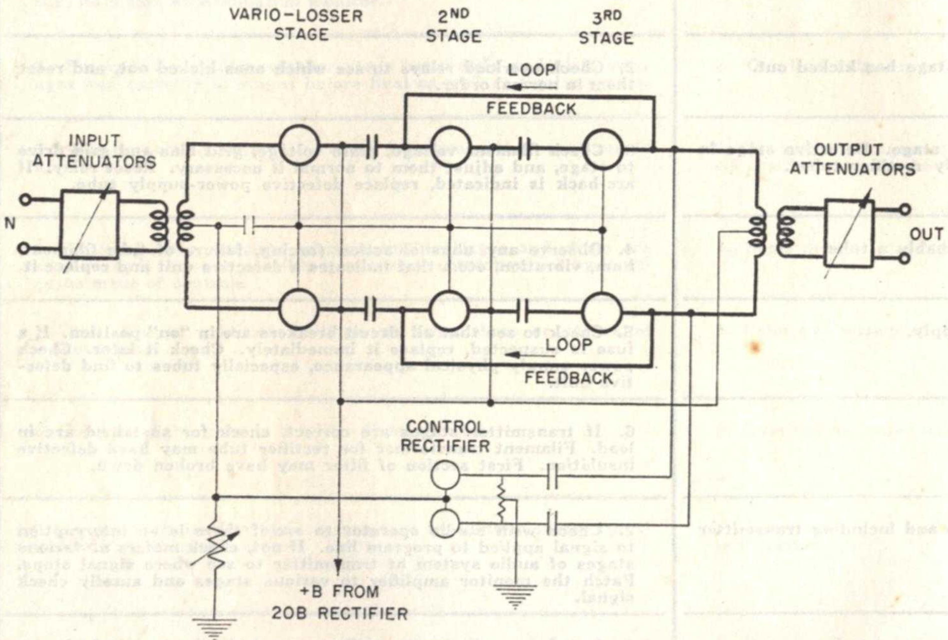
(This chart shows the more common troubles but does not include all possible defects.)

OBSERVED EFFECTS	PROBABLE CAUSES	REMEDIES
1. Program on monitor speaker stops completely and plate voltage, plate current of final stage, and antenna current drop to zero. R.F. level zero on modulation monitor.	1. Overload relay for final stage has kicked out on a temporary overload.	1. Reset final overload relay. If the overload was only momentary, normal operation will be resumed.
2. Program on monitor speaker stops completely and plate voltages and currents of stages before final as well as final are zero.	2. Overload relay in an intermediate stage has kicked out.	2. Check overload relays to see which ones kicked out, and reset them in normal order.
3. When resetting protective relays for a stage they continue to kick out.	3. Incorrect voltages or drive for the stage. Defective stage in r.f. section. Arc-backs in power supply rectifier tubes.	3. Check filament voltage, plate voltage, grid bias and grid drive to stage, and adjust them to normal if necessary. Reset relay. If arc-back is indicated, replace defective power-supply tube.
4. If overloading persists when normal voltages and drive are applied, or if it is not possible to adjust to correct values by usual adjustment of controls.	4. Some part of stage is defective, probably a tube.	4. Observe any unusual action (arcing, failure of tube filament, hum, vibration, etc.) that indicates a defective unit and replace it.
5. No plate or grid bias voltage on some stage or stages of transmitter.	5. Failure of some part of that power supply.	5. Check to see that all circuit breakers are in "on" position. If a fuse is suspected, replace it immediately. Check it later. Check power supply physical appearance, especially tubes to find defective unit.
6. Rectifier tube glow is brighter than normal.	6. Overload on power supply.	6. If transmitter stages are correct, check for sustained arc in load. Filament transformer for rectifier tube may have defective insulation. First section of filter may have broken down.
7. Program on monitor stops, percentage modulation meter stops, but r.f. carrier level is correct.	7. Some portion of audio system up to and including transmitter is defective.	7. Check with studio operator to see if there is an interruption to signal applied to program line. If not, check meters at various stages of audio system at transmitter to see where signal stops. Patch the monitor amplifier to various stages and aurally check signal.
8. Signal is applied to program line at studio end, but is not received at transmitter.	8. Program line defective.	8. Switch to spare program line or to order (private telephone) lines. Call telephone company to have defective line repaired.
9. Audio signal on program line at transmitter, but not applied to transmitter.	9. Line or limiting amplifier is defective.	9. Patch in spare line or limiting amplifier around defective unit. If not available patch in monitor amplifier, and monitor with a radio receiver.
10. Audio output is not normal, and all plate voltages in either line amplifier or amplifier in transmitter are low or zero.	10. Power supply for these amplifiers defective.	10. Check power supply visually to find defective tube or other components.
11. Program level drops, becomes distorted, and r.f. carrier level meter indication drops off.	11. Power supply voltage to final is reduced because of defective tube.	11. Check plate voltage, current, and antenna current. If plate voltage is low look at power supply for open filament rectifier tube. Replace tube.
12. Monitor signal normal and all meter readings but antenna current low or zero.	12. Defective r.f. thermocouple for antenna current meter.	12. Replace thermocouple as soon as possible. If no exact replacement is available ask FCC for temporary authority to operate without approved meter.
13. Monitor output stops, but r.f. output and percentage modulation monitor meters indicate normal operation.	13. Monitor amplifier defective.	13. Check by monitoring program on ordinary receiver. If a spare amplifier is available patch it in to replace monitor amplifier.
14. Transmission line arcs over on normal modulation peaks when pressurized line is used.	14. Reduced pressure on line has permitted moisture to enter, and has reduced arc-over voltage of line.	14. Check on line nitrogen pressure, restore to normal. If line is moist allow dry nitrogen to clear line or use desiccant (drying agent).

larly noticeable during transmission of the music of dance orchestras composed of brass instruments having high peak powers at high frequencies.

In every use, it is desirable for the compression amplifier to have a short attack time. A time of .001 second is usual. The optimum recovery time is different for different types of program material, however, so it is made adjustable in this instrument. Piano music, for example, sounds a little unnatural when the recovery time is too short, producing an effect similar to inadequate damping of the strings after they are struck. If the recovery time is made too long, however, the gain will be reduced for a large proportion of the total time, resulting in unnatural transmission of certain passages in musical compositions. The recovery time used in most installations is adjusted from 0.6 second to 1.0 second.

► When a transmitter operator sees the over-modulation lamp on his monitor light time after time, he is apt to consider that the studio operator is not doing his job. This is not necessarily true, however; as you know, the studio operator has no meter or instrument that shows him the actual modulation produced by the program he is monitoring, and it can easily happen that a program kept at the proper level according to his meters will produce overmodulation at the transmitter. Further, the transmitter operator generally has no indicator that shows whether the incoming program is properly monitored according to the standards of the studio operator. The compression meter on the compression line amplifier, indicating the amount of peak compression occurring, is the nearest approach to such a meter at the transmitter. This meter is a peak-indicating device, however, and will show a greater indication on instruments, such as a piano, that produce sharp wave fronts. Therefore, if you become a transmitter operator, do not be too quick to condemn the studio man when over-modulation occurs; very likely his control board gives no hint of it.



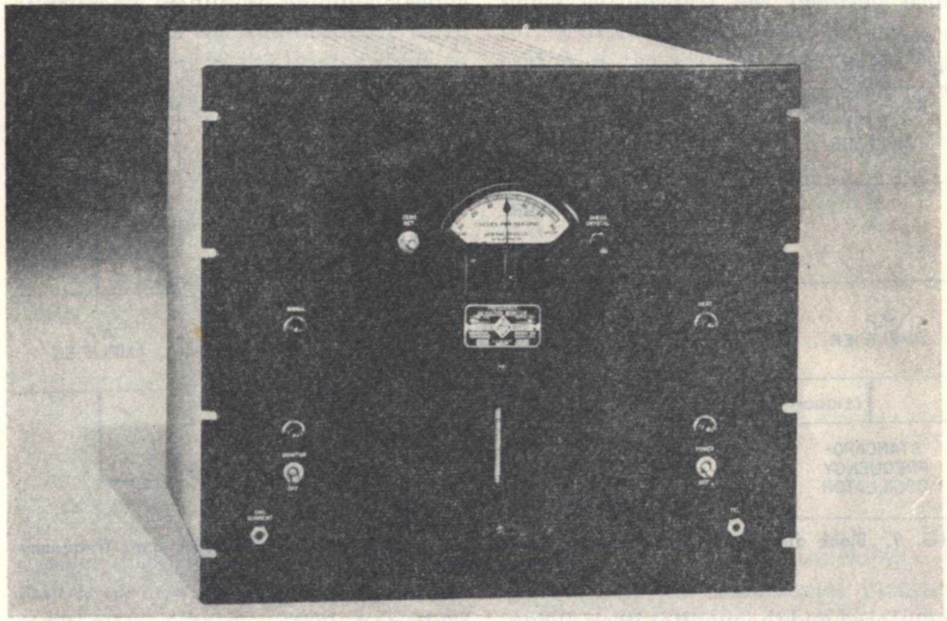
Courtesy Western Electric

FIG. 7. Simplified schematic diagram of the Western Electric 1126C amplifier. The large circles in this diagram represent stages (tubes and other components).

FREQUENCY DEVIATION MONITORS

The FCC requires that all standard broadcast stations maintain their center frequencies within 20 cycles of the assigned values, and that an approved monitor unit be used to measure this deviation. The General Radio Type 1181-A and RCA WF-48A frequency deviation monitors are practically identical instruments used for this purpose. The General Radio monitor is shown in Fig. 8.

The meter at the center of the panel, which indicates directly in cycles the frequency deviation of the carrier, is marked from 30 c.p.s. High to 30 c.p.s Low. Immediately beneath this meter is a thermometer that shows the temperature of the crystal oven in the monitor. Four pilot lamps are used to indicate operation of the unit. The lamp just above the power on-off switch in the lower right hand corner shows when the unit is turned on. The power is usually left on continuously to keep the crystal at a constant temperature and thus to minimize frequency drift. When the station is off the air, the monitor may be turned off by the switch at the lower left side of



Courtesy General Radio

FIG. 8. The front panel of the General Radio 1181-A frequency deviation monitor.

the panel without removing the oven temperature control circuit. The third pilot in the upper right hand corner will light up when the crystal oven is being heated. This light will, therefore, switch on and off during the day as the oven temperature varies slightly.

The fourth pilot lamp, upper left, is particularly important to the operator: it indicates excessive frequency difference between the transmitter being monitored and the monitor itself. Thus, failure either of the transmitter to maintain the proper frequency or failure of the monitor to indicate the frequency drift correctly will operate this lamp. This warning light will, of course, operate during the warm-up period of either the monitor or the transmitter crystal ovens.

The block diagram of this monitor is given in Fig. 9. Let us investigate its action.

Basically, a highly stable standard-frequency oscillator whose frequency is "offset" by 1000 cycles (999 kc. for a 1000-kc. carrier, for example) is used as the reference. This signal is amplified and fed to the mixer stage. The r.f. voltage from the transmitter is amplified in another r.f. stage and also applied to the mixer. The output of the mixer stage is the difference between the two signals, which is 1000 cycles ± the frequency deviation of the transmitter. This signal (which is a sine wave) is then amplified and applied to a peak-clipping amplifier, where it is converted to a square wave. This square wave is amplified and applied to the frequency meter to indicate the frequency deviation directly.

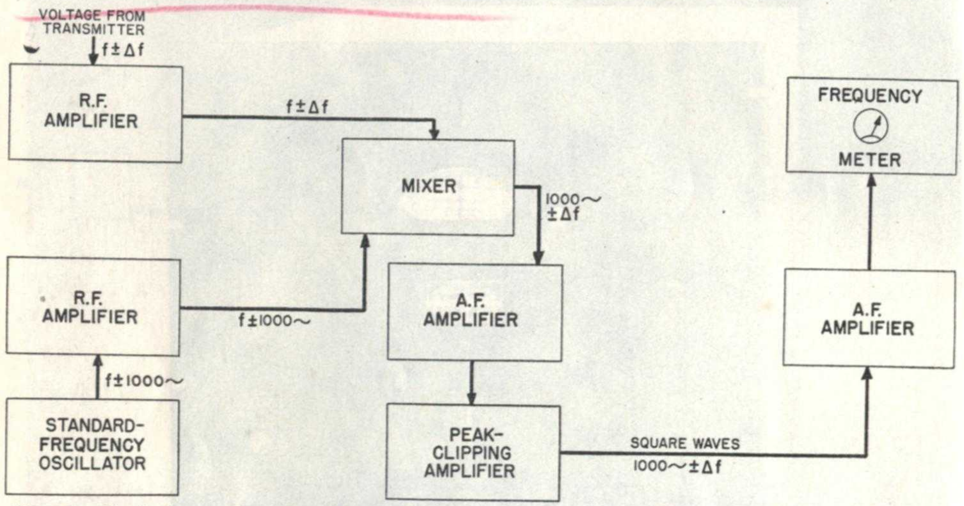


FIG. 9. Block diagram of the General Radio 1181-A and the RCA WF-48A a.m. frequency deviation monitors.

If the carrier is "on frequency," the output of the mixer will be 1000 cycles, which, when applied to the frequency meter, will give a center scale deflection, marked zero. If the transmitter frequency should drift to say, 30 cycles above the correct value, the a.f. output will be 1030 cycles, causing the frequency meter pointer to indicate 30 cycles high.

You may be curious as to why this difference frequency is converted into a square wave in a peak-limiting stage before being applied to the frequency deviation meter. This is done so that the signal used to operate the meter will be constant in amplitude even if the amplitude of the incoming signal varies. This makes the measurement of frequency deviation independent of modulation.

The action of this peak-limiting stage is shown in Fig. 10. If the input sine wave has the amplitude of wave D, it is clipped in the limiter stage to produce the square wave E. If the amplitude of the input signal increases (as it does on modulation peaks), producing a wave with the amplitude of F, the clipping level remains the same, and the output is still the square wave E. Thus, the output of the peak limiting stage is independent of the amplitude of the incoming signal.

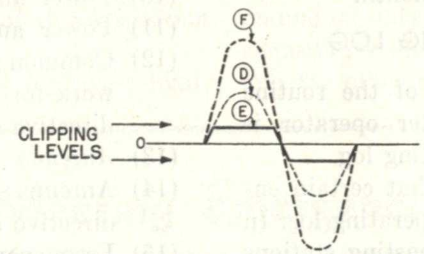


FIG. 10. How clipping a sine-wave signal at fixed levels will produce a square-wave output whose amplitude is practically independent of the amplitude of the sine-wave input. This principle is used in the General Radio 1181-A and RCA WF-48A frequency deviation monitors.

For this reason, the frequency monitor just described does not have to be connected to an unmodulated stage of the broadcast transmitter. As a matter of fact, this monitor operates from a short antenna that picks up the modulated r.f. signal in the immediate vicinity of the transmitter.

The station frequency monitor is periodically checked by comparing it with a commercial primary frequency standard. This check is made after the regular daily schedule is completed, when no modulation is being applied to the carrier. The station operator calls the nearest monitoring service by telephone, states the call letters and assigned frequency of the station, and requests a frequency check. As soon as the monitoring service has picked up the carrier on its equipment, the monitoring engineer informs the station operator of the exact frequency of the station at that time. For example, let's say that the station monitor shows —5 cycles, and the commercial monitor service reports that the station is —3.5 cycles. (Commercial monitor services report in tenths of cycles.) This shows that the station's frequency monitor is 1.5 cycles off in the negative direction. The station operator then adjusts the crystal trimmer condenser in the transmitter until his frequency monitor shows an indication of minus 1.5 cycles. The official primary standard service then reports that the station is directly on frequency. Upon receiving this O.K. from the official monitoring service, the station operator adjusts his frequency monitor to zero. Both the transmitter and the frequency

DATE____________________ WX____________________

DAILY TRANSMITTER LOG

TIME	1 ST. AUDIO	2 ND. AUDIO	3 RD. AUDIO	C.O. P.C.	BUF. P.C.	INT. P.C.	EX.P.A. P.C.	P.A. P.C.	P.A. P.V.	P.A. T.C.	P.A. G.C.	COM. I.P.	ANT. NO.1	ANT. NO.2	FREQ.
5:57AM	.005	.107	.168	.017	.021	.100	.250	.730	8.5	5.1	.175		7.23		+2
6:18	.005	.108	.169	.017	.021	.100	.250	.735	8.45	5.1	.176		7.23		+1.5
6:30	.005	.108	.169	.017	.021	.099	.250	.730	8.5	5.1	.176		7.23		+1
7:00	.005	.109	.170	.017	.021	.100	.250	.730	8.5	5.1	.176		7.22		+1

FIG. 11. Section of a typical daily transmitter log. The meanings of the column headings are given in the text. A section of this log (not shown) provides space for the operator's signature, notes, and times of operation.

monitor are then correctly adjusted.

These frequency checks are generally made only once a month.

THE OPERATING LOG

An important part of the routine duties of a transmitter operator is maintaining the operating log.

The FCC requires that certain entries be made in the operating log. In addition, many broadcasting stations require the logging of additional information. For example, the FCC requires that each 30 minutes an entry be made in the log indicating the plate voltage and plate current of the final r.f. amplifier stage, the antenna current, the frequency monitor reading, and the temperature of the crystal control chamber (if a thermometer is used). As shown in the typical log in Fig. 11, however, additional readings may be recorded. In this case, the items (with the ones required by the FCC in italics) are:

(1) First audio
(2) Second audio
(3) Third audio
(4) Crystal oscillator plate current
(5) Buffer plate current
(6) Intermediate power amplifier plate current
(7) Exciter-power amplifier plate current
(8) *Power amplifier plate current*
(9) *Power amplifier plate voltage*
(10) Power amplifier tank current
(11) Power amplifier grid current
(12) Common input to phasing network for two antennas (when directive array is used)
(13) *Antenna No. 1 current*
(14) Antenna No. 2 current (when directive array is used)
(15) Frequency deviation (as indicated on the station's frequency monitor).

The entries required will, of course, vary from one station to another, depending on the equipment used and on the requirements of the chief engineer or technical department.

The main reasons for these additional readings are to facilitate trouble-shooting and to assist the operator in anticipating trouble. By recording these readings periodically, the operator becomes familiar with the correct values, and is therefore able to notice any significant change quickly. Experience shows him what such a change indicates and how to correct the situation.

The FCC requires entries covering (1) the time when the carrier is applied to the antenna and when it is removed, (2) the time each program begins and ends, and (3) the cause and duration of each interruption to the carrier wave. In addition, the station management usually requires that a record of interruptions to programs be entered in the log.

When the antenna system is high enough to require warning lights, it is a part of the duties of a broadcast operator to control them and to make appropriate entries in the log. If the lights are manually controlled, the time that the lights are turned on and off must be recorded. A daily visual inspection of the operation of the lights must be made and the time of this inspection must be logged.

In case of failure of a tower light, the nature of the failure, the time that the failure was observed, and the time and nature of the adjustments, repairs, or replacements made are entered in the log. In case the failure is not corrected in 30 minutes, the time that the Airway Communications Station of the Civil Aeronautics Administration (CAA) was notified and the time that the light went on again (and notice was again given to the CAA) are also a part of the operating log.

Operators are generally required to sign the log to indicate when they go on and off duty. This is done to fix responsibility for transmitter operation and for other station records.

Meeting Emergencies

It is, of course, the first duty of the transmitter operator to keep the station on the air. If it goes off the air, he must get it back on again as soon as possible. Supposing you become a transmitter operator, let us see what you should do when trouble develops.

First of all, it is important for you to be mentally prepared to meet emergencies. The best way to achieve this preparation is for you to become thoroughly familiar with the circuits of your transmitter—so familiar that you can draw the essential ones from memory. We mentioned this before, but it is important enough to be worth repeating.

We are going to describe what you should do to locate the defective section and stage quickly. Remember that the most common source of trouble in any stage is tube failure, which generally requires very little time to correct unless the faulty tube is a power or modulator tube cooled by forced air or water. Plate current readings, which show if a tube has lost emissive ability or has ceased to conduct altogether, offer a quick way to locate a defective tube. Often a visual inspection will show whether a tube has a broken filament or is otherwise defective.

As soon as the monitoring loudspeaker indicates an interruption or a distortion of the program, look at the modulation monitor to get the first hint of the source of trouble. The modulation monitor has an r.f. input indication meter (the left-hand meter in Fig. 1) whose pointer is at a definite place on the scale (generally 100) when the transmitter is working properly. If the trouble should be in the r.f. section of the transmitter, it is obvious that this r.f. input will change from the normal value. If no program is heard, yet the modulation monitor shows that the carrier amplitude and modulation are normal, the trouble must be in the monitoring amplifier itself.

If the r.f. input reading is normal, but both the modulation monitor and the loudspeaker show either no or erratic modulation, then the trouble most likely lies in the audio section of the transmitter, in the line amplifier, in the program line from the studio to the transmitter, or is at the studio itself. If the program stops suddenly, or becomes noisy or distorted, check with the studio control room at once to ascertain if the program is normal at that point. If the program is normal there, then the trouble may be in the line between the control room and the transmitter. Usually a spare line amplifier is installed for use in emergencies when the regular line amplifier fails, and this may be turned on and patched into the monitoring amplifier to check the program coming in from the program line. Some installations have a means of switching the monitoring amplifier from the r.f. rectifier to the program line; this permits a quick comparison between the quality of the signal as it comes in and its quality as it is radiated. In any case, it is always possible to check the incoming signal from the program line in any installation; if this incoming signal is non-existent or faulty, then put the spare program line into use by notifying the studio to feed the program into this line and switching it at the transmitter to the input of the regular line amplifier. If the program is normal at the studio and a check shows that a signal coming in from the program line is faulty, then this change in program lines should clear up the trouble. If it does, notify the local telephone company test board of this condition, and the company will locate and repair any faults.

If the check of the incoming signal from the program line indicates that the signal is normal, the trouble lies in the line amplifier or in the speech input circuits of the transmitter itself (assuming, for the present, that all r.f. circuits are normal). Usually a quick glance at the plate current meters of the speech input tubes in the transmitter will indicate whether or not the trouble lies there, since any faulty component or tube will cause a deviation in the normal plate current of that stage. If all speech input plate currents are zero, then the trouble most likely will be found in the power supply associated with them. If all currents are normal, you have eliminated all likely possibilities with the exception of the line amplifier itself. All broadcast installations have some emergency provision for a line amplifier: either a spare may be inserted in the circuit by means of patch cords or switches, or the monitoring amplifier may be used. If the monitoring amplifier is used, the station can be monitored with an ordinary receiver.

In the above discussion, we assumed that the first glance at the modulation meter showed that the r.f. input from the final stage was normal. If this r.f. input indication is zero or low, then obviously the trouble lies in the r.f. section of the transmitter, and you should, therefore, check for the trouble in that part of the equipment. Here again, observing plate current and grid current meters will aid in quickly determining which is the faulty stage.

When the transmitter is shut down because of the operation of a protective overload relay in the control circuit system, you can quickly trace the

cause of the failure if you are thoroughly familiar with the operational sequence of the control system. Fig. 12 illustrates a simplified basic control circuit of a transmitter. You should be able to sketch a diagram of this sort for the control circuits of your transmitter showing the pilot lights (where used) associated with each control. However complex the system, a diagram of this sort will let you trace the sequence of operation of the control functions. For example, if pilot light #5 ceases to operate while pilot light #3 is operating, the bias voltage has failed, probably causing an overload relay to operate and remove the high voltage. Temporary overloads, of course, sometimes cause an overload relay to trip, in which case you can return the carrier to the air by closing the plate potential switch again.

Control circuits may be thought of as being divided into two types: those that open or close the primary circuits of the various power supplies, and those whose functions are purely protective. Controls of the first type are interlocked so that they may be energized only in proper operating sequence. Filament power, for example, cannot be applied until the water or forced-air cooling system has gone into operation; this prevents the filaments of large power tubes from being damaged by heat. After the filament voltage has been applied, the plate voltage relay will not operate until the time delay relay (which usually has a delay of 20 to 30 seconds) has closed; this makes it certain that the tubes have reached their proper operating temperatures before application of high voltage. You should memorize the operational sequence of all control relays, because doing so will let you find the cause of failure with a minimum loss of time on the air.

POWER SUPPLY FAILURES

Automatic circuit breakers are used on the power line side of all modern transmitters. These circuit breakers operate to a "trip" position when they are overloaded; you can easily see when one is in this position, and can reset it quickly.

Fuses are still used in many older installations. If you suspect a fuse is faulty, replace it rather than take the time to test it.

Transmitter power supplies differ

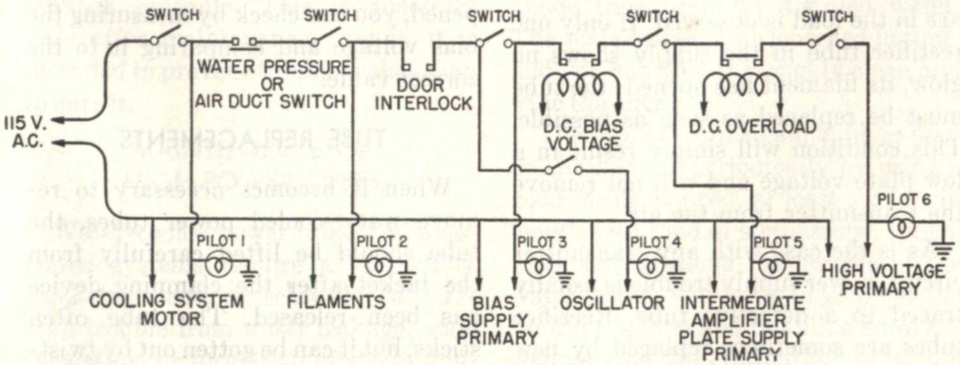


FIG. 12. A diagram of the protective and control circuits of a typical transmitter. You should be able to draw a corresponding sketch for any transmitter you may work with.

little from receiver power supplies except in size and in the fact that high-power supplies work from three-phase lines, thus requiring less filtering and securing better regulation. The rectifier tubes are nearly always of the mercury-vapor type to conserve power loss and to secure good voltage regulation for varying secondary loads under modulation. Usually any failure in large power supplies is made obvious by physical evidence of damage, such as sustained arc-overs or a smoking part. Voltage dividers, bleeder resistors, condensers, or transformers that have passed excessive current are usually visibly damaged.

A rectifier tube glows blue when it is passing current. If no such glow is seen in any of the rectifier tubes with the plate switch closed, the circuit is obviously open. When you have had enough experience with your transmitter, you will be able to judge the amount of current passing through the tubes by the brightness of the glow. If an unusually large amount of current flows through the rectifier tubes, the defect is most likely to be in the filament transformer or the first section of the filter system, and these should be the first examined unless a sustained arc in the load is observed. If only one rectifier tube in the supply shows no glow, its filament has opened; the tube must be replaced as soon as possible. This condition will simply result in a low plate voltage and will not remove the transmitter from the air.

As is the case with any transmitter circuit, power supply trouble is usually traced to a defective tube. Rectifier tubes are sometimes replaced by new tubes at the expiration of their rated life though they are not defective. This minimizes "on-air" failures.

Mercury-vapor rectifier tubes seldom fail instantaneously, since they usually arc-back several times before complete failure. An arc-back, or passage of current in the opposite direction within the tube, is sometimes a difficult fault to determine in polyphase systems, since the protective devices will react almost instantly to remove the high voltage. Most of the modern transmitter installations use a small magnetic device, known as an arc-back indicator, that is placed in series with each high-voltage rectifier tube in the circuit. A passage of current in the wrong direction will cause a small solenoid to drop down, indicating that an arc-back in the associated tube has occurred. This tube may then be immediately replaced and normal operation resumed.

Other types of power supply failures will cause the protective devices to kick out. For example, a short circuit (or any other circuit failure that causes the voltage output to decrease) in the grid bias supply for the final amplifier stage will cause increased current flow that will cause the overload relay to operate, thus removing the plate voltage. If you suspect that this has happened, you can check by measuring the bias voltage and comparing it to the correct value.

TUBE REPLACEMENTS

When it becomes necessary to remove water-cooled power tubes, the tube should be lifted carefully from the jacket after the clamping device has been released. The tube often sticks, but it can be gotten out by twisting gently back and forth while you lift. Extraordinary precautions must

be taken in the installation of a new tube in the water jacket. First, you should coat the movable metal parts of the jacket with a light film of oil to prevent corrosion. Then place the tube gently in the jacket, and, after it is correctly seated, fasten the retaining studs or jacket clamping device firmly into place to force the flange of the plate into solid contact with the water-tight jacket. The electrical connections may then be made. Take care that the wires are not near or do not touch the glass bulb. Should this precaution be neglected, puncture of the glass from corona discharge is apt to occur. Take particular care, also, to make the connection between hose and jacket tight and clean. Because of electrolysis, trouble may develop at this point, and close inspection every two or three weeks is advisable.

Air-Cooled Tubes. Forced-air-cooled tubes are simpler to replace than are water-cooled tubes. The method of mounting and cooling is considerably simplified. The water jacket has been replaced by a hollow porcelain mounting into which the tube with its attached fins is placed. No clamping device is necessary, and the anode connection is on the chrome-plated rim at the top of the porcelain mounting that forms the seat for the anode. Since electrical connections must therefore be made only to the grid and the filament, a defective tube may be replaced quickly.

Permanent mechanical repairs of water cooling systems usually require considerable time. For this reason, leaks should be temporarily sealed by using rubber or friction tape when at all possible. Permanent repairs should then be made after "sign-off" to avoid loss of "on-air" time.

General Maintenance

As you have already learned, one of the duties of a transmitter operator is maintaining an after sign-off maintenance schedule. This is generally *preventive* maintenance, that is, it is intended to prevent trouble rather than to cure it.

MAINTENANCE OF HIGH-POWER TUBES

Water-cooled power tubes and associated systems require a reasonably rigid maintenance schedule to forestall trouble from water leakage, scale formation, or formation of steam bubbles. Scale formation, if and when it occurs, will prevent adequate transfer of heat from the anode to the water. After removing the tube carefully in the manner described earlier, rinse the anode thoroughly in distilled water. The scale will become loosened in time, and you can then thoroughly clean and wipe the anode.

The formation of steam bubbles may be checked for periodically by using a good insulating rod, at least six feet in length, as a kind of stethoscope, which, when moved along the outside of the water jacket, will bring to your ear the familiar hissing and bubbling noise accompanying the formation of steam bubbles around the tube anode. Since plate voltage is applied near the area in which the end of the rod moves, this test may be dangerous if the rod is not a good insulator. A length of six feet of high grade insulating tubing is recommended. There should also be a grounding arrangement on the tube itself as an added safety feature.

In recent years, cooling by forced air has largely replaced water-cooling systems for transmitters up to and including 50-kw. ratings. A typical forced-air system consists of one or more blowers, mounted beneath the high-power tube, that force air past large copper fins, or radiators, that are fastened to the tube. The air flows from the blowers to the tube through canvas ducts.

Blowers are equipped with dust filters to prevent dust particles from being deposited on tubes and transmitter components. The canvas air ducts should be removed about once a month. (Be sure to mark their positions in some manner so you can replace them properly.) Clean between the fins of the tube, especially in against the anode, with a cloth. Take care not to damage the mercury air-flow interlock switches on the blower housing that are used to prevent application of filament voltage until the proper amount of air-flow is attained. Both sides of the air-flow vanes (half-circle discs that operate the mercury interlock switches) should be cleaned.

Clean between the blades of the blower fans with a vacuum cleaner. Brush the corners of the fan blades with a small brush, and use a vacuum to pick up dust from inside the bottom of the blower frames.

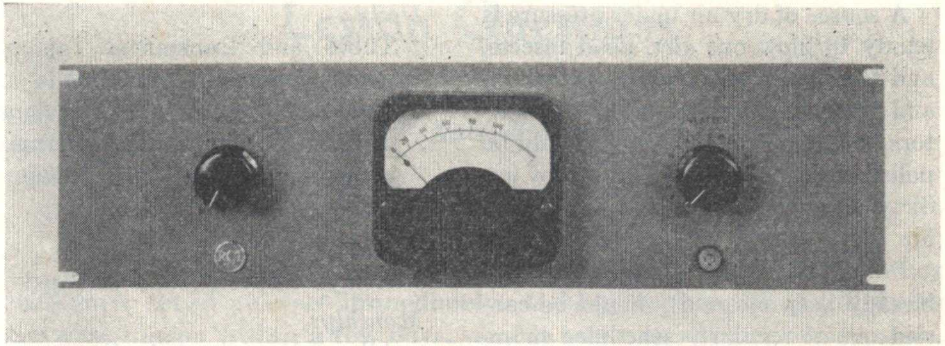
After all blower channels are cleaned, start the blowers and check the air-flow vanes to make sure the mercury switches work properly. Turn the canvas ducts inside out and clean them thoroughly. New air filters should be installed about every 3 or 4 months, depending on the amount of dirt collected.

MAINTENANCE OF RELAYS

The most vital part of a relay insofar as routine maintenance is concerned is the relay contacts. Satisfactory performance of relay contacts depends a great deal on correct maintenance methods.

Most relay troubles are caused by film formed on the contacts by deposits of grease from the atmosphere. Carbon also may be formed on a contact, since carbon is the residue of burnt grease, and sometimes forms in small rings about the point of contact, eventually building up so high that the contacts remain permanently open. Regular and correct cleaning of the contacts is the most important step in relay maintenance. Ordinary paper should never be used, since a certain amount of fuzz is apt to cling to the points even though you can't see it. Files should not be used either, since filing a contact may change its shape and mass, and all relays are carefully designed to operate in a particular way with a certain size and shape of contact points.

Contacts that are not extremely dirty can usually be cleaned by dragging a thin glazed paper of high quality through the contacts with normal pressure on the arms. In more severe cases of film deposit, very fine emery paper may be used if the contacts are carefully washed and wiped afterward. Make a swab for washing by cementing a fine chamois over the end of a



Courtesy RCA

In broadcast systems it is frequently necessary to measure the program VU level at several points in the audio system. The RCA type MI-11265 Volume Indicator can be used for this purpose. A standard VU meter is employed and the left hand switch permits observation of the volume level in any of 10 different circuits. To provide for measuring levels above the 1 dbm (such as limiter or line amplifier outputs) basic level of a VU meter, the right-hand knob controls a 0-40 db attenuator so that levels up to +40 db can be measured.

very thin strip of bakelite. Dip this into carbon tetrachloride and use it to wash the contacts. Use a dry chamois to wipe off the residue.

A file may be necessary when the contacts have become stuck as a result of an extremely high-potential "flash," such as, for example, relays in antenna circuits sometimes suffer during an electrical storm. When filing is necessary, the contacts should be washed and wiped as stated above.

PROTECTIVE GAPS

All protective gaps on transmission lines and tower bases should be regularly cleaned and inspected for proper spacing. Whenever these gaps flash over because of high potential, carbon is formed and a certain amount of "burn" occurs that gradually wears away the metal. The gaps should be adjusted at regular intervals and replaced when they have become seriously deteriorated.

FIRE PROTECTION

Another important matter for routine checking is the fire protection system of a transmitter. Since the rules on this vary from one locality to another, we will not discuss the matter fully here. You should, however, be thoroughly familiar with the location and proper operation of the fire extinguishers generally located near the transmitter. They should also be periodically checked to see that they are in proper operating condition.

SCHEDULES OF MAINTENANCE

A routine maintenance program carried out at definite scheduled periods greatly reduces the likelihood of failures at any transmitting installation. Regular maintenance schedules do much to increase useful life and to prevent many component failures.

A collection of dust and dirt in a transmitter causes a number of troubles. Cleanliness of equipment is frequently overlooked until voltage insulation is reduced to the point where arc-overs and leakage currents are apt to occur. Higher relative humidity conditions of summertime or southern locations tend to make such conditions worse.

A source of dry air under pressure is handy to blow out dirt, dead insects, and the like from variable condensers and from inaccessible corners. Insulators and similar components should be polished with a dry cloth or, if they are dirty, cleaned with carbon tetrachloride.

Power tube maintenance (which has already been covered) should be carried out at regularly scheduled intervals.

Periodic frequency checks as well as noise and distortion measurements constitute a part of any maintenance schedule. A steady tone of 1000 cycles is fed into the speech input equipment, the gain of which is adjusted to give a reading on the modulation meter to which all other frequencies are referred. A check is then made of the frequency characteristics of the entire system to insure a proper frequency response. Distortion measurements and frequency will be discussed in greater detail later.

In general, the average period of routine maintenance schedules will run about as follows:

Daily:

Tubes and transmitter components cleaned. Reports made of any part showing physical signs of deterioration or strain. Permanent repair of any faulty component necessary.

Weekly:

Relays inspected and serviced.

Monthly:

All parts tightened. Frequency check with Official Monitoring Service made.

Every 3 months:

All tower lights and associated tower lighting control devices inspected. Any necessary adjustments, replacements, or repairs made. (These must be recorded in the station operating log).

4 to 6 Months:

Frequency runs made of lines, audio equipment, and transmitter. Noise and distortion measurements made on same. Fan blower motors or water pump motors oiled. Air filters on air-cooled transmitters replaced.

Lesson Questions

Be sure to number your Answer Sheet 43RC.

Place your Student Number on *every* Answer Sheet.

Most students want to know their grade as soon as possible, so they mail their set of answers immediately. Others, knowing they will finish the next Lesson within a few days, send in two sets of answers at a time. Either practice is acceptable to us. However, don't hold your answers too long; you may lose them. Don't hold answers to send in more than two sets at a time or you may run out of Lessons before new ones can reach you.

1. Why is it necessary to continue the forced cooling system of high power stages even after the transmitter is turned off?
2. What are the permissible tolerances in the power output of a standard a.m. broadcast station?
3. What is the maximum carrier shift permissible in a standard a.m. broadcast station?
4. Why is a fast-acting meter used to indicate modulation percentage in the modulation monitor at the transmitter?
5. When the light flashes on the front panel of the modulation monitor, what is indicated?
6. Which peak, positive or negative, must be monitored in order to determine when overmodulation splatter is occurring?
7. What is the advantage of keeping the maximum energy of an unsymmetrical audio signal on the positive side of the modulation envelope?
8. What warning is given in the RCA WF-48A and GR 1181-A frequency monitors when the frequency deviation between the monitor and transmitter becomes excessive?
9. What would be possible indications that a vacuum tube in a transmitter has subnormal filament emission?
10. If the final amplifier grid bias supply suddenly becomes short-circuited in a regular transmitter installation, what will likely result?

HOW AND WHY

There is an exceptionally fine quotation I want to pass on to you. I do not recall the name of the author, but the truth in the quotation makes it unforgettable. Here it is:

> *"The man who knows HOW will always have a job—the man who knows WHY will be his boss."*

Your N.R.I. training fits this thought perfectly. You are being taught HOW to operate broadcast and communications equipment, so you can be sure of work in this, your chosen field. Also, your training gives you the background of WHY transmitters and receivers function as they do.

We want you to have an assured future and every opportunity to advance to the top. You will need only the touchstone of a little practical experience to weld "HOW and WHY" training into a single, compact unit of knowledge that can lead you wherever you wish to go.

J. E. SMITH