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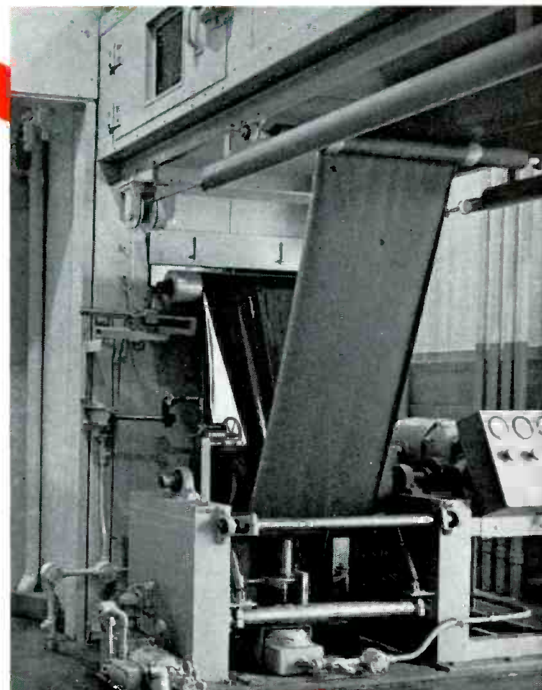
THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY

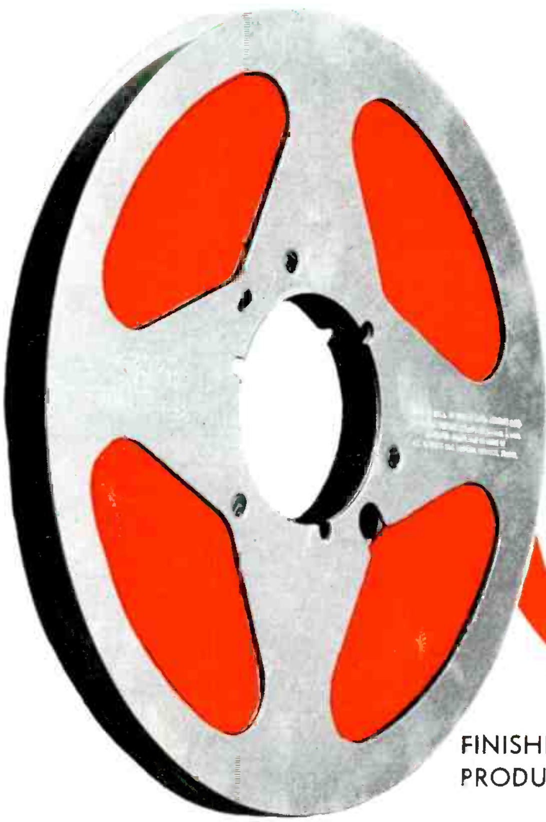
IRON OXIDE



COATING AND DRYING

MAGNETIC TAPE:

What you should know about types, uses and manufacturing processes



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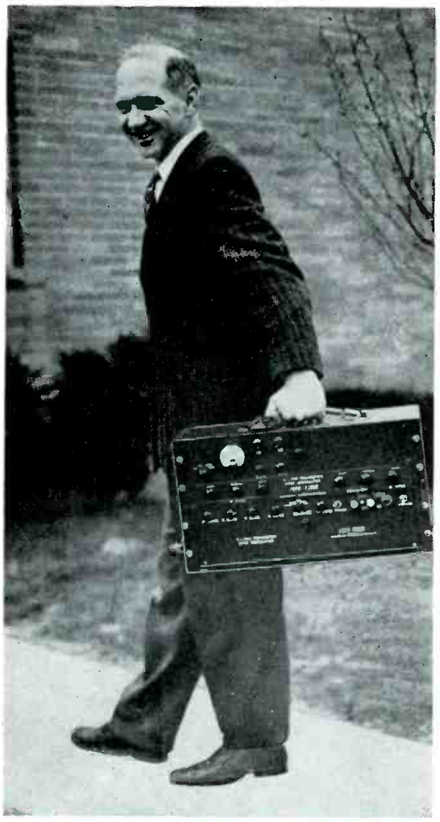

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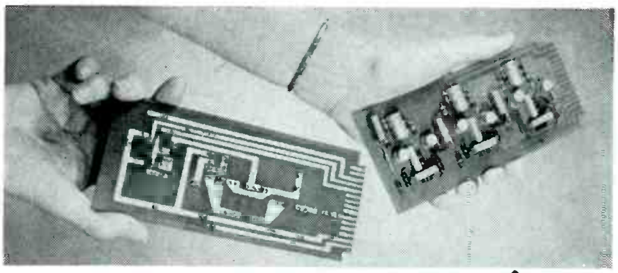

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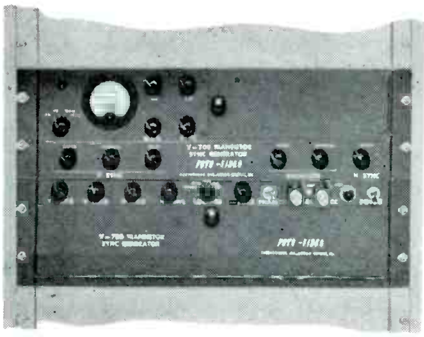

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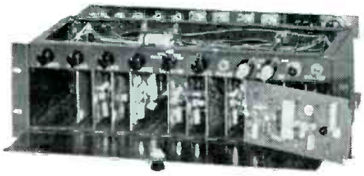

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THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY

VOLUME 2 JUNE, 1960 NUMBER 6

Contents

Departments

Cover

Programming for both television and radio is becoming increasingly dependent on magnetic tape. To acquaint our readers with the types of magnetic tape in current usuage and the techniques of tape production, Broadcast Engineering this month is publishing an article which tells the story of magnetic tape. The cover picture shows the steps in production from iron oxide particles to finished product.

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DESIGN FEATURES OF A BROADCAST TRANSMITTER KIT

A new development in the broadcast equipment field is the availability of kits. The new 1000/250 watt transmitter kit offered by Bauer Electronics Corp. is described in this article.

By PAUL GREGG*

THE "do-it-yourself" trend has reached the broadcast equipment field with the introduction of the Bauer Model 707 AM transmitter. The design was based on an existing one-kilowatt Bauer model but has been simplified mechanically to meet the modern concept of "kit form" electronics.

Not only did this simplification make the transmitter easier to build, it also provided a layout that permits complete component accessibility. Note in Figures 2 and 3 the case with which every component can be reached. All wiring is accomplished with just one harness which is supplied with the kit, properly laced, and with each wire number coded. All small components are mounted on well marked component boards (such as Fig. 4). Eleven of these insulated boards are used in various sections of the transmitter. An illustrated assembly instruction book shows the correct placement of each part and outlines each step of the wiring.

The average assembly time is 100 hours. When a Bauer kit transmitter is completed the builder sends a notice to the manufacturer, who then sends a representative to the station to run a proof-of-performance on the completed transmitter. When the representative is satisfied that the transmitter meets factory specifications he installs the Bauer nameplate and it is ready for use.

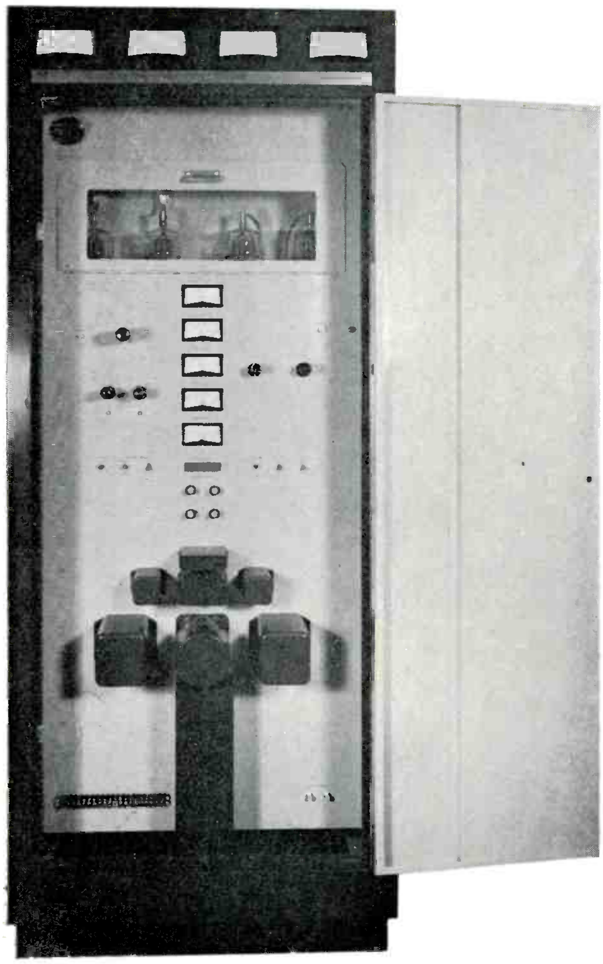

Figure 1. The Model 707 showing the front panel.

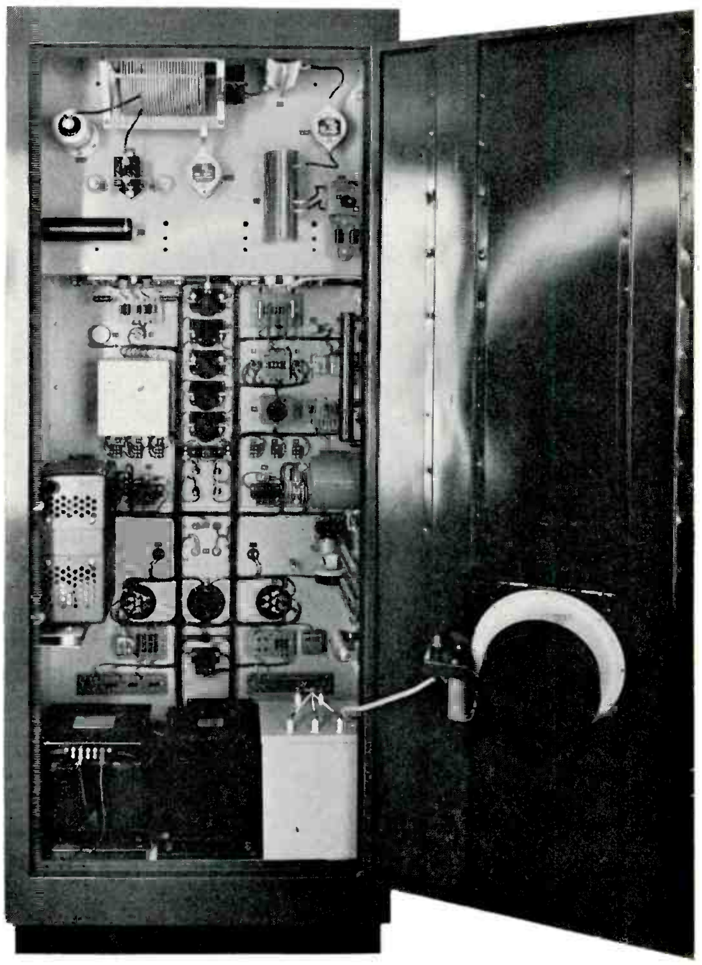

Figure 2. Rear view of completed transmitter.

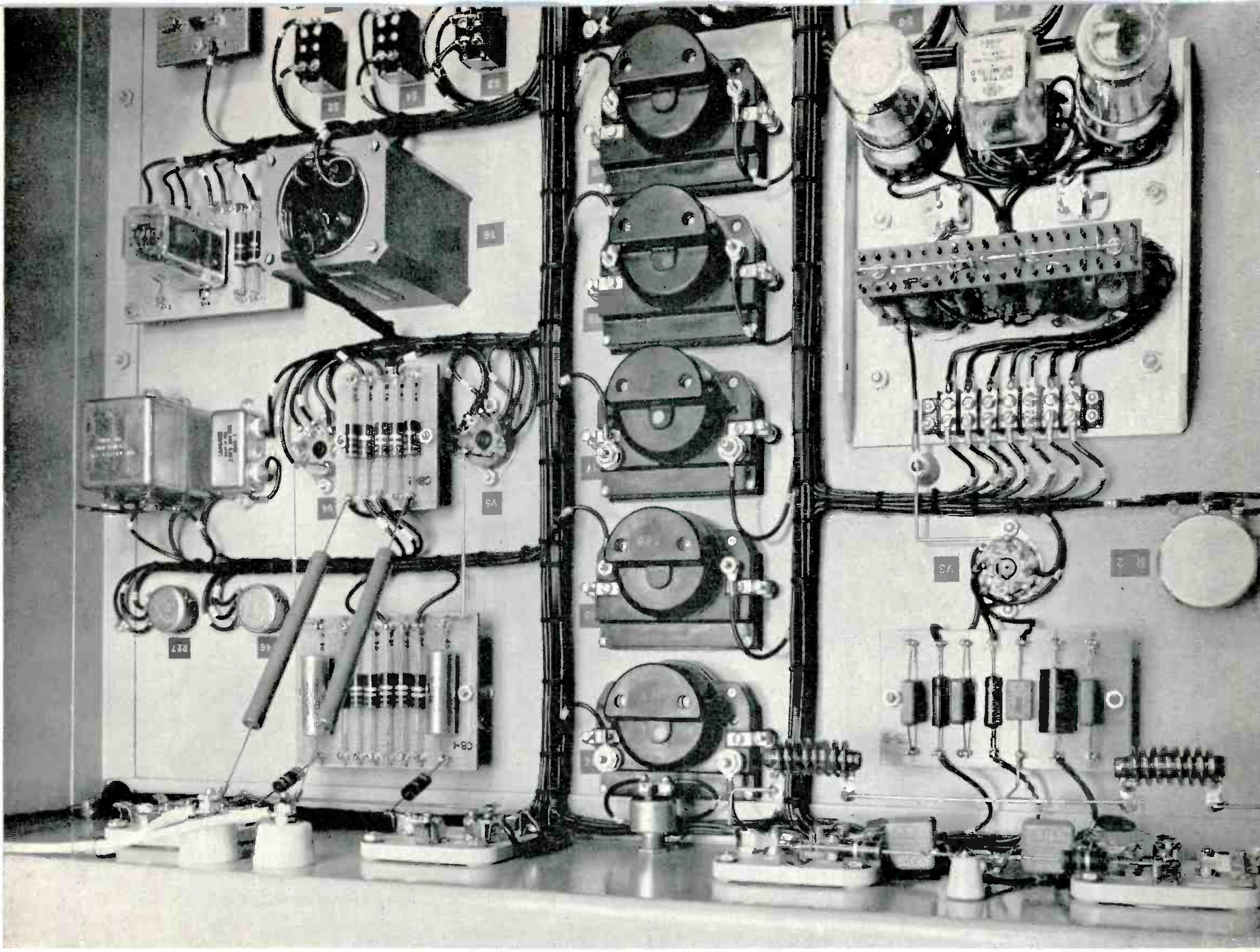

Figure 3. Closeup of transmitter rear.

The RF Section

Looking from the rear (Fig. 2) the RF section is on the left side of the transmitter. Figure 3 shows a closeup of the oscillator-buffer section with the cover removed. This section is assembled on a separate shielded chassis, factory wired and checked, to insure stability. There are provisions for two vacuum crystals and either one can be selected by a relay which is controlled from a switch on the front panel or remotely. The vacuum crystal supplied with the Model 707 is capable of controlling the carrier frequency with an accuracy of ± 5 cps without the use of heaters, thermostats or ovens.

The oscillator is a Type 6AG7 connected in an electron-coupled circuit and is followed by another Type 6AG7 functioning as a Class A buffer. The driver is a Type 6CA7/EL-34 operating as a Class C stage. The driver excites two Type 4-400A tetrodes operating in parallel as a plate modulated power amplifier. A motor-driven rheostat in the cathode circuit of the final stage controls output power so as to compensate for variations in line voltage. The final tank circuit is unique in that tuning is accomplished through the use of a variable vacuum capacitor, a top quality method not usually found in one-kilowatt transmitters.

The transmitter is designed to match a 50-ohm unbalanced load. The RF output circuit provides the required impedance transformation and adequate harmonic suppression through the use of a "Pi" network followed by a "Tee" network. Additional suppression of second harmonic output is provided by connecting the load to the "Pi" network coil at a point where the impedances of the coil and a fixed capacitor are series resonant at the second harmonic frequency. A simple adjustment of this circuit provides harmonic suppression well beyond that required by the new FCC rules made effective last Jan. 1.

The Bauer Model 707 was one of the first transmitter type accepted by the FCC under these new rules. In looking at Figure 2 you will no-

(Continued on page 24)

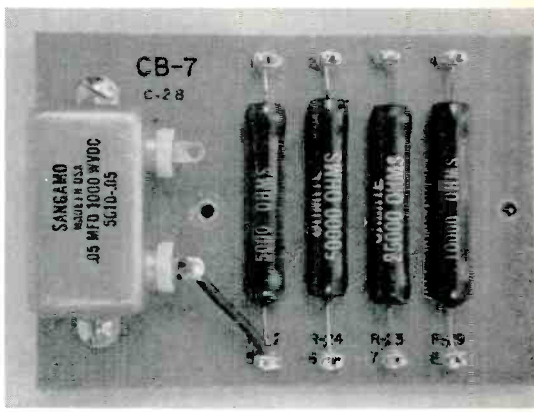

Figure 4. Component board of the low voltage power supply.

*Bauer Electronics Corp., Burlingham, Calif.

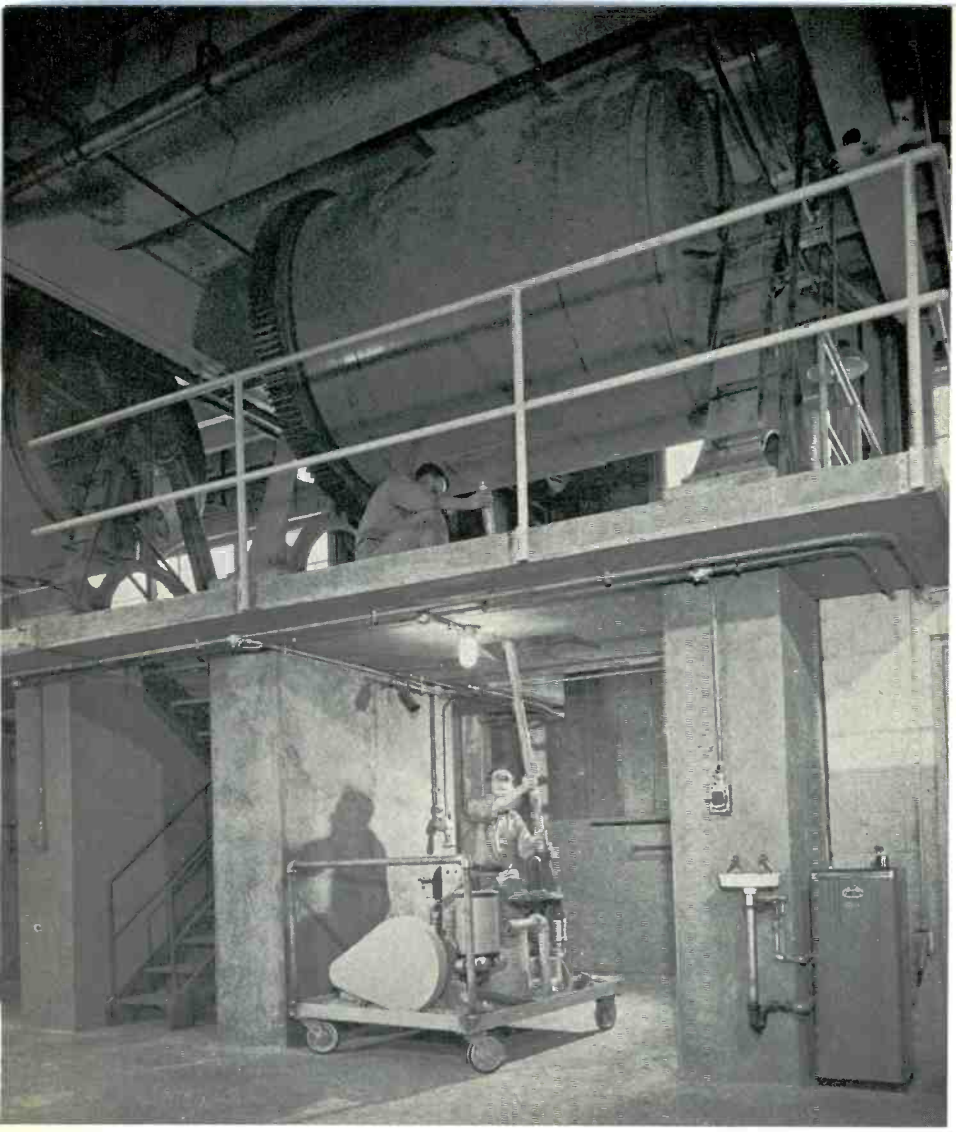

Figure 1. In one of the first steps of magnetic tape manufacture, treated iron oxide and the binding agents are mixed together in ball mills. As the drum (above) rotates, steel balls pulverize the oxide. Here, men are shown pumping the finished coating material into storage tanks.

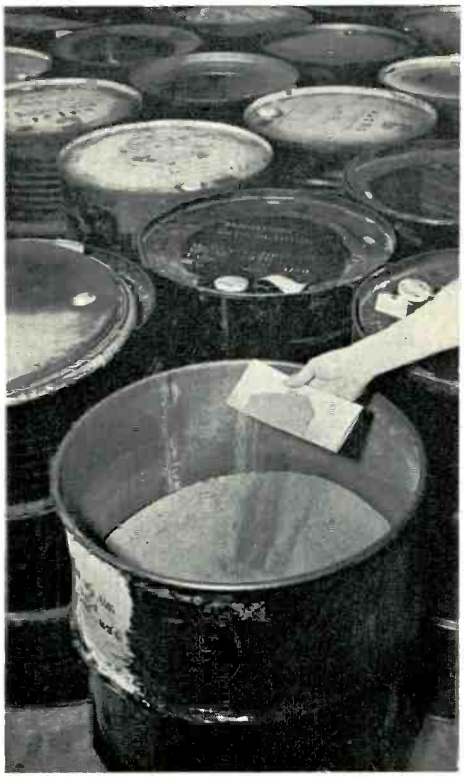

Figure 2. The basic ingredient of recording tape's magnetic coating is iron oxide. Interestingly enough, the oxide is not magnetizable before being processed.

THE MANY

By DANIEL E. DENHAM*

MAGNETIC tape has changed as often as a chameleon since the first commercial tape, Scotch brand No. 100, a black oxide product on a paper backing, appeared on the market in 1947.

To meet the diversified applications found for recording tape during the succeeding 13 years, variations have become necessary in oxide and backing materials, thickness and toughness, width and length—even in the form in which tape is used. The result: today there is virtually a tape for every purpose—a variety often confusing to the novice recordist.

But the professional recording engineer who needs a tape that will play back radio scripts faithfully after long-term storage appreciates having a tape available specifically for this purpose.

His need, however, is quite different from that of a geophysicist, who uses magnetic tape belts in seismic recording to locate pools of oil far beneath the earth's surface.

Similarly, a tool control technician using tape to direct automatic milling machine operations has tape requirements greatly divorced from those of a TV producer who "freezes" his live shows on video tape for immediate playback. And the missileman launching satellites to record outer space data requires a much more critical magnetic tape than the home recordist who makes high-fidelity audio recordings simply for his personal enjoyment.

Whatever their game, the tape they are using is basically the same as that used for every other purpose—whether it be sound or electronic signal recording. Magnetic tape is

*Magnetic Products Division,
Minnesota Mining & Mfg. Co.

FACES OF MAGNETIC TAPE

There are many types of magnetic tape being manufactured today. This article describes these types and explains how and where each type should be used.

nothing more complicated than plastic "ribbon" coated with finely powdered iron oxide.

This, however, is where magnetic tape's simplicity ends.

The highly technical skills involved in formulating the oxide and precision-coating it uniformly onto the backing makes magnetic tape manufacture anything but an uncomplicated procedure.

All manufacturers today use the red gamma ferric (gamma FE_2O_3) oxide introduced by Minnesota Mining & Mfg. Co. in 1948 which prompted a mass switch to tape throughout the broadcasting industry. Available are three different grades of oxide, based on fineness of the oxide particles and smoothness of coatings. The more expensive types have better frequency response, lower noise, and cause less headwear.

In pigment form, the oxide is mixed with a binder (a complex blend of resins and plasticizers) before being coated on the backing material. The tape then is dried in ovens which cause solvents in the binder to evaporate, leaving the oxide particles permanently bonded in place in a uniform coating only ⅙th the thickness of a human hair.

Making essentially flawless magnetic tape is a tricky operation. First, the oxide particles to be magnetized must be held in perfect suspension, so each drop of the liquid to be "painted" onto the backing holds exactly the same amount of magnetic material.

This coating must be applied so evenly that miscroscopic examination will reveal no bumps (for video tape, the thickness tolerance is plus or minus nine one-millionths of an inch) and held onto the tape so firmly that it will not rub off under pressures which may reach 10 tons per square inch.

Finally, the air around the tape when it dries must contain no more than one particle of dust for every 12 cu. ft. of atmosphere. Dust control measures at 3M's Hutchinson, Minn., plant are rigorous. The hospital-like tape coating areas feature white surgical-style coats for technicians, pneumatically controlled doors, robot-operated coating equipment, and powerful vacuum systems for keeping air dust-free.

Cause of all this fussiness is a minute gremlin called "dropout"—an imperfection in the coating which causes signal loss in recording. Irregularities of this nature are especially bothersome in high performance recorders such as used in computers where thousands of "bits" of information are packed into each linear inch of tape.

For example: Were a dust particle to become imbedded in the coating creating a tape flaw as small as

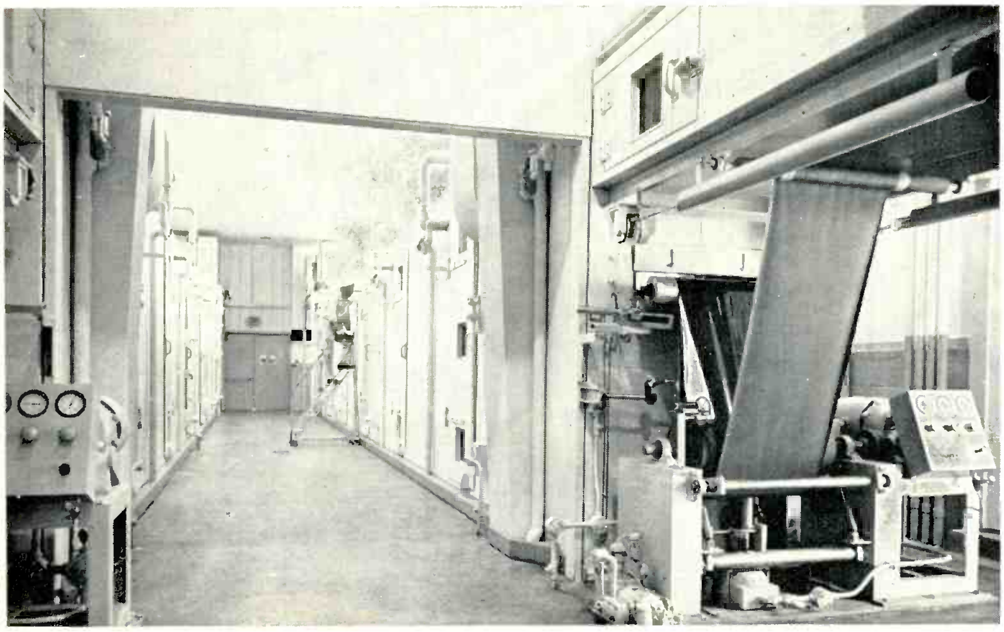

Figure 3. After the tape has been coated with oxide, it travels through this drying oven. The tape, processed in 24-inch widths, moves at a constant speed under exact temperature and humidity control.

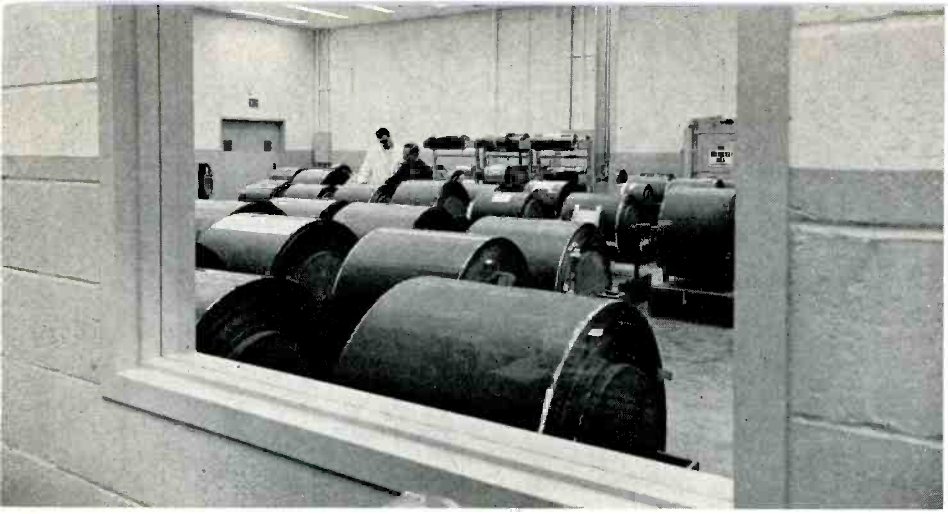

Figure 4. Jumbo rolls of magnetic tape are shown before being cut and wound onto separate reels.

1/10th of a mil (1/10,000 of an inch), a computer processing a payroll conceivably could drop a hundred dollars from your paycheck.

And in video recording, signal loss will result from imperfections as tiny as a 30-millionth of an inch. The complexity of quality control of video tape becomes apparent when one considers that a single 64-minute roll of the tape has an area as large as a tennis court. The critical requirements of video recording are reflected, too, in the fact that, after three years, one company — 3M — still is the only manufacturer able to produce video tape in commercial quantities.

All magnetic tape would be alike if various uses didn't demand differences in:

- Kind of material used for backing.
- Thickness of backing.
- Formulation of oxide and binder.

Two plastic materials commonly are used for magnetic tape backing — cellulose acetate and polyester film. Unless otherwise specified, the word "plastic" on a box of recording tape means that the backing is made of cellulose acetate. This tape is very popular because it meets all normal recording requirements and costs the least per foot of tape. Acetate first appeared 12 years ago in "Scotch" brand No. 111, which has remained the international standard of the recording industry ever since.

Under conditions of excessive heat or humidity, polyester backing—also known as Mylar—is worth its extra cost (45 per cent higher than acetate). A film form of Dacron, polyester has greater resistance to heat and humidity changes and greater strength than acetate. It is especially useful for long-term storage because it contains no plasticizers. In acetate tape, these plasticizing agents may eventually evaporate, leaving the tape brittle.

However, polyester also has a disadvantage. Under extreme tension, it may stretch. Although the likelihood of this happening is the exception rather than the rule, it is troublesome if the stretched tape contains critical information. Acetate tape, on the other hand, will stretch only slightly before it breaks and any breaks can be repaired by splicing. For this reason, most of the major record companies make their master recordings on acetate-backed tape.

A new development in magnetic tape backing, which is becoming popular for applications involving frequent repeat, continuous play and constant handling is called "Tenzar." This sturdy base material is tear-, stretch-, and moisture-resistant — yet is priced in the same range as standard acetate-backed tapes. Twice as strong as acetate, Tenzar has 16 times greater tear-resistance and will not dry out or become brittle during hot storage. Religious radio programs, which mail recorded tapes to all parts of the world, have found Tenzar's economy and its ability to withstand extremes of temperature and humidity especially suited to their broadcasting purposes.

Tape commonly is available in three backing thicknesses. For greatest strength, it is produced with 1½-mil backing which provides 1200 feet of tape on a standard 7-inch reel. To obtain half again as much playing time, manufacturers put out 1-mil backings, thus obtaining 1800 ft. of tape on the same diameter reel. This reduction in thickness reduces the strength of the tape, but 1-mil polyester is actually stronger than 1½-mil acetate tape. However, it also is more prone to stretching than is 1½-mil acetate.

Decreasing backing thickness even further to ½-mil makes it possible to wind twice as much tape on the same reel, providing twice as much playing time. However, paring the thickness of the backing to ½-mil cuts its strength still further. To compensate for this loss of strength and the stretching problem, polyester-backed tape has been developed which is pre-stretched (usually referred to as "tensilized"). This tape is twice as strong as 1-mil polyester "extra play" tape—but also is roughly 15 per cent more expensive per foot.

The big advantage of double-length (½-mil) tape is that a full hour may be recorded on a standard 7-inch reel at the speed of 7½ ips—as opposed to the half hour possible with a reel of 1½-mil tape.

As tapes became thinner and thinner, recording engineers discovered a new problem—"print-through," the transfer of a signal from one layer of tape to another when recorded tape is stored for long periods of time. The backing of the tape acts as an insulator thus preventing the magnetic field on one layer from magnetizing the next layer.

"Low print" tape has been developed to reduce print-through. By using a modified form of oxide dispersion, the print level is reduced by about 8 db, enough to minimize the problem. Of course, print-through also can be combatted by keeping the recording volume low. If recorded tapes are to be kept for an extremely long period of time, however, the extra 15 per cent paid for low print tape will be money well-invested.

Another improved oxide provides extra output for increasing the dynamic range in sensitive recording applications. These "high output" tapes achieve signal-to-noise ratios from 6 to 12 db greater than conventional tapes and prevent "overloading" in passages where the dynamic range varies widely. Because of its greater potency, the oxide formula-

(Continued on page 27)

FM Multipath Transmission Vagaries

An analysis of the distortion and intermodulation products resulting when an FM receiver is subject to reception of a signal that has travelled over two or more different paths from the transmitter.

By DWIGHT "RED" HARKINS
Harkins Radio Corp., 4444 E. Washington St., Phoenix, Ariz.

THE R.F. energy transmitted by an FM broadcast station is in the band of VHF frequencies that tends to reflect as well as reradiate from large objects. The voltages induced in the receiving antenna often are made up from energy that has travelled directly as well as other signals from the same transmitter that have reached the receiver by being reflected or reradiated from an object in the vicinity. Large steel framed buildings, hills, mountains, as well as large masonry structures with their plumbing and wiring all cause considerable reflections to take place.

The reflected signals always arrive later at the receiving antenna due to the longer path followed. The signal which arrives late is not in phase with the direct transmission due to the time lag. The phase relationship at any given instant cannot be predicted as it varies all the way from zero to 180 degrees.

In the more simple form of short bounce reflected signals, complete cancellation of the direct signal can result. Whether the carrier is modulated or not does not affect this cancellation. However, when the two signal paths differ by greater distances, the phase differences will vary during program modulation causing amplitude modulation to be produced. This effect produces distortion in the modulation components that often makes the station's signal unusable.

Ever since the advent of FM, the multipath distortions have been observed especially in the cities which have many steel buildings. Even though elaborate outside antennas are used, audio distortion will be evident in many locations on at least one of the stations received. Often the receiver is located in a shadow so that all the energy picked up is reflected from other buildings or large hills located nearby.

Sometimes the condition is similar to that caused by overmodulation of the transmitter. On low level passages, the recovered audio will sound excellent but with higher modulation severe distortion results. The distortion is in the form of high order harmonics and intermodulation very similar to that which results when a pickup cartridge has too much fuzz on its needle. The same sound is heard when listening to selective fading on an AM broadcast station.

Now that FM is also being used for multiplex transmission, the effects of multipath transmission are also noticed in this application. The most troublesome thing is the intermodulation of the subcarrier by the main channel audio products. The crosstalk produced can be of an extreme nature making commercial reception impossible. Another peculiarity noticed on occasion has been in locations where the timing of the multipath signals has caused complete cancellation of the supersonic subcarrier just as if it were not being transmitted.

(Continued on page 19)

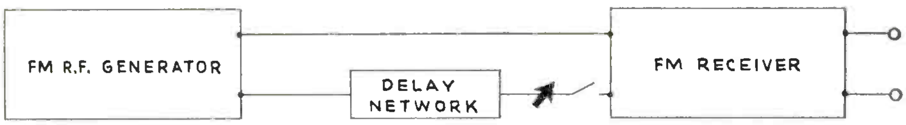

Figure 1. Arrangement for simulating FM multipath reception.

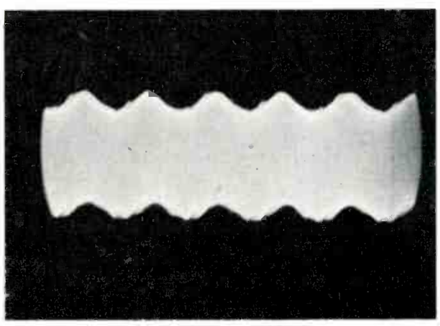

Figure 2. The amplitude modulation resulting on the 10.7 mc. I. F. carrier due to multipath reception. The modulating frequency is 10,000 cps at 100 per cent deviation.

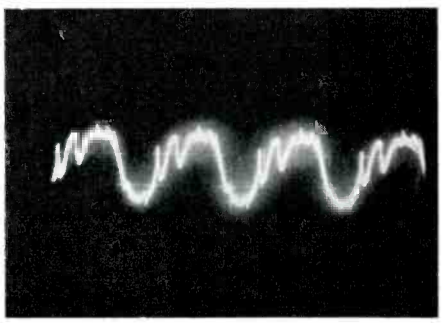

Figure 3. Complex distortion appearing at discriminator output when delay is increased to 5 microseconds for the simulated reflected signal. Modulating frequency is 10,000 cps deviating 100 per cent.

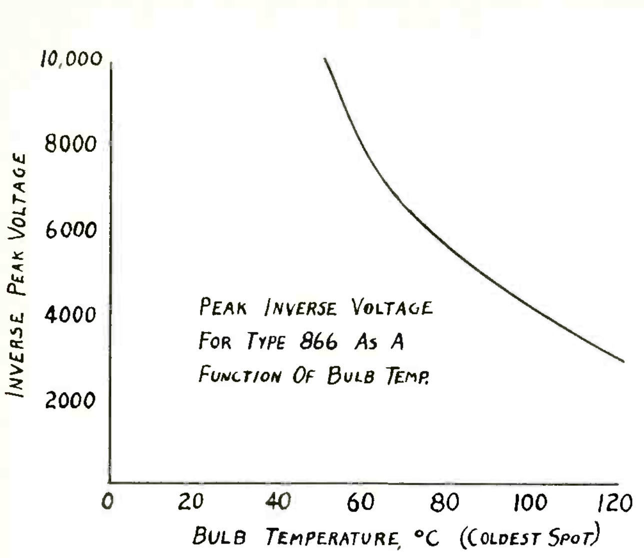

Figure 1.

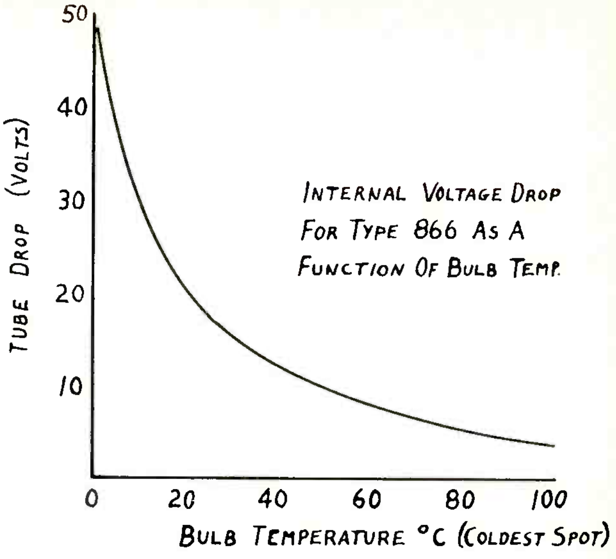

Figure 2.

The Care and Testing of The Mercury Rectifier

By JAMES F. LAWRENCE, JR.*

THE MERCURY vapor rectifier is one of the most practical and widely used devices for changing alternating current to direct current in broadcast and communication transmitters. While the mercury rectifier is somewhat notorious for its abrupt and sometimes unpredictable failure, it will provide many thousands of hours of reliable service in properly designed equipment.

The operation is basically the same as for any other hot cathode diode except for one very important innovation. A few drops of mercury have been placed in the tube envelope. The low pressure in the tube together with heat from the filament causes the mercury to vaporize. Contrary to popular belief the current does not flow through the vaporized mercury. The mercury vapor is simply a source of ions (a positive charge) whose purpose is to neutralize the space charge that always exists around the electron emitting cathode. The space charge is a cloud of useless electrons which impede the flow of useful electrons from the cathode to the anode or plate. The space charge is one of the things which causes the high internal resistance in high-vacuum type rectifiers.

When a positive potential of 10 to 15 volts is applied to the plate (negative side to the cathode) the mercury vapor becomes ionized. The positive ions collide with, and neutralize the negative space charge electrons, leaving the way clear for heavy current flow through the tube. While this is a rather sketchy explanation of the internal workings of the mercury rectifier, it should be sufficient to help explain some of the unique characteristics of the device.

Unlike the high vacuum rectifier whose voltage drop is proportional to load current the mercury rectifier maintains an almost constant voltage drop regardless of load current, up to a certain point, that is. If the current is increased beyond the maximum emission capability of the cathode, emission fade and possible disintegration of the cathode will occur. This effect takes place in a normal tube when the voltage drop due to excess current reaches 22 volts.

The space charge neutralization permits the use of electrode structures that would not be practical in high vacuum tubes. The plate can be small in proportion to the current rating because the low internal voltage drop makes the power dissipation at the plate small. Low internal voltage drop also makes increased cathode-plate spacing possible. The cathode emitting surface can be shielded or out of direct line with the plate because the mercury ions are able to penetrate into all parts of the structure. This makes possible the usual wide crimped ribbon or woven type cathode element which provides a large emitting area in a small volume at relatively low temperature.

Vapor filled tubes are given average rather than RMS current ratings. This specifies the maximum current that the tube can carry continuously without excessive

*President, Teletronix Engineering Co., 4688 Eagle Rock Blvd., Los Angeles 41, Calif.

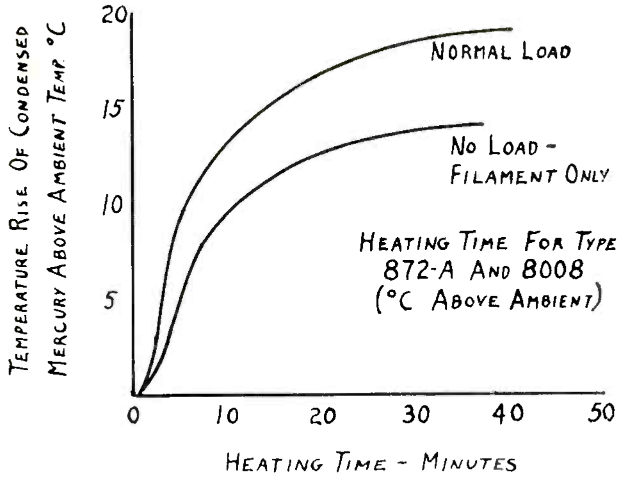

Figure 3.

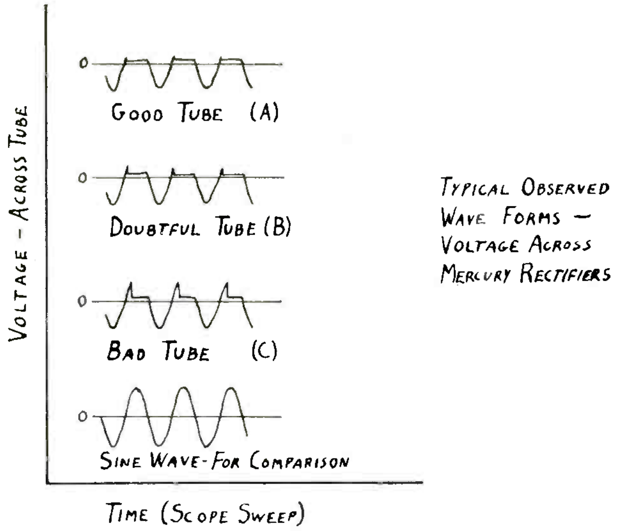

Figure 4.

heating of the anode, cathode, and other parts. Average current is important in such a tube because the power to the plate of the tube is the product of the instantaneous tube voltage and instantaneous plate current. Since the voltage is fairly constant and independent of tube current (within ratings) the average power is the product of the tube drop (10-15 volts) and the average tube current. The tubes are also given a peak current rating, this rating specifying the maximum current that the tube should be permitted to reach in each conducting cycle.

The peak-inverse-voltage rating is the maximum safe instantaneous negative potential that may be applied to the tube without the possibility of conduction or arcing in the reverse direction due to breakdown of the mercury vapor. The inverse voltage which causes vapor breakdown is called flash-back or arc-back voltage. Operation of the tube at temperatures above the normal can induce arc-back, even at voltages well within the normal rating. Typical variation of the inverse peak voltage capability and internal tube drop with temperature for the type 866 is shown in Fig. 1 and 2. It is apparent from these graphs that correct condensed mercury temperature is important to reliable tube operation. The range usually extends from about 30 deg. C. to 80 deg. C. Since the upper temperature limit determines the allowable peak voltage, a tube operating at very low voltage can be safely allowed to exceed the upper temperature limit. The lower temperature limit is set by the allowable tube drop, which increases with decreasing temperature. Decreased efficiency and cathode disintegration can result from lower than normal temperature, particularly when the tube is handling current near full rating.

Mercury vapor temperature is measured at the coldest spot on the tube. This is generally a point on the envelope near the base. Under normal operating conditions this temperature will be 10 to 20 deg. C. above the ambient temperature. A plot of heating time vs. temperature rise above ambient for the type 872A and 8008 is shown in Fig. 3.

Several methods are used to test mercury rectifiers. One method used for many years consists of mounting a thermometer on the glass envelope and observing the bulb temperature during operation. A rise above normal temperature indicates that the tube is nearing the end of its life. This temperature increase is brought about by the increased internal power dissipation which is in turn caused by increased ionization voltage. If the voltage drop across a normal tube is observed on an oscilloscope the voltage wave will appear as shown in Fig. 4A. A weak tube will exhibit a spike (Fig. 4B and 4C) which is caused by the increased ionization voltage required to fire the tube.

A second method of determining the tube life makes use of gradual increase in ionization voltage which occurs as a tube deteriorates. As pointed out previously the normal conduction or ionization voltage for all mercury vapor rectifiers is between 10 and 15 volts peak (not RMS volts). This effect may be observed by applying an ac voltage between the cathode and plate which is gradually increased until the tube fires. The amplitude of voltage which caused the tube to fire is measured and provides an indication of tube condition. If an ac voltmeter is used to measure this voltage its reading must be multiplied by 1.4 to convert from RMS voltage to a peak value, since it is the peak or crest of the voltage swing which initiates the ionization. Ionization can be indicated by a dc milliameter connected in series with the tube.

A refinement of this method is to connect the vertical input of an oscilloscope across the tube and actually observe the voltage wave form as ionization occurs. Typical observed wave forms are shown in Fig. 4.

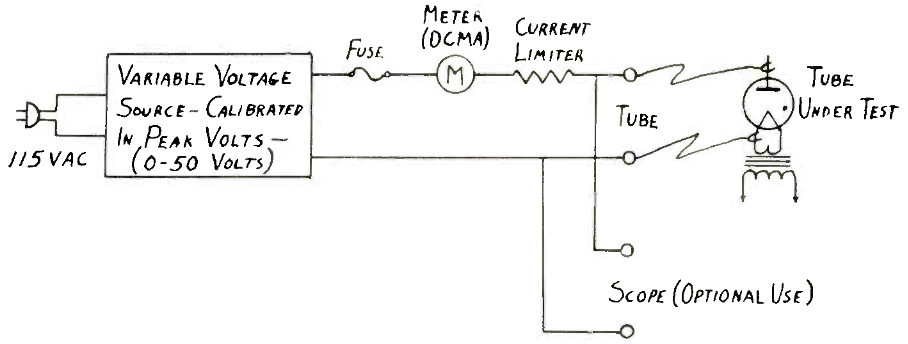

Figure 5. Basic Mercury Rectifier Test Circuit.

Direct measurement of ionization voltage is utilized in the Teletronix mercury rectifier tester, which is a commercially available instrument for testing all types of mercury rectifiers. The basic circuit for the tester is illustrated in Fig. 5.

The tube is tested while operating from the existing equipment filament supply for a test under typical operating conditions. The tester leads are simply clipped to the tube plate connection and filament terminal and a calibrated ac voltage increased until ionization occurs. Ionization is indicated on the tester meter. The ionization voltage can be measured at regular intervals, and as it increases to values much in excess of 15 volts the tube can be replaced. By observing the gradual increase in ionization voltage the tube life can be predicted. Auxiliary jacks are provided on the instrument for connection of an oscilloscope if actual observation of the wave form is desired.

The point at which a tube should be replaced depends on the operating current and the voltage that it is required to handle. Tubes which are operated close to maximum ratings may fail at 20 volts, while tubes which are loafing along may continue to operate without arc-back even though the ionization voltage is up around 30 or 40 volts. If equipment reliability is important and if the tube is heavily loaded, it is best to replace it when the voltage reaches 20 or 25 volts. Rectifiers must be given 5 to 10 minutes to warm up before testing even when ambient temperature is above 20 deg. C. It is best to check the tube just after equipment shut-down, since it will be near its normal operating temperature.

There are factors other than low emission which can cause tube failure or arc-back. One common cause is the presence of gas other than mercury vapor. A gassy rectifier is indicated by a change of the usual blue glow to a blue-green color. Gas allows the rectifier to conduct in the reverse direction, which in turn causes an increase in dissipation and eventual arc-back. The ionization voltage will usually remain within the good tube range, but when ionization voltage measurement is attempted the tube will begin to conduct very slightly when only a few volts are applied, and the conduction current will gradually increase until the characteristic sharp rise occurs when the mercury ionization point is reached.

Arc-back in a good rectifier can be caused by RF feeding into the power supply circuit. Open bypass capacitors, spurious oscillation in implifier circuits, and improper RF shielding can cause this type of trouble.

Extremes in ambient temperature (temperature of air surrounding tubes) can cause improper tube operation. The condensed mercury temperature must lie within the range of 20 to 70 deg. C. Remote transmitter installations, particularly those on mountain tops, as is usually the case with FM and TV stations, are often required to operate in buildings where the temperature has dropped below freezing.

The 872-A, as an example, will require more than 30 minutes warm-up time at normal filament voltage to come up to a temperature which is 19 deg. C. above ambient. It is obvious from Fig. 3 that the rectifier may not operate properly when the ambient is below freezing, and may not operate at an ambient of 10 to 15 deg. C. above freezing if the filament voltage is slightly low. The rate of temperature rise graph is based on a tube in still ambient air, not a tube which is blower cooled.

All mercury rectifiers must be "run in" prior to application of plate voltage when initially placed in service. This "run in" consists of applying filament power for at least 10 minutes, preferably 30 minutes to remove condensed mercury from the filament and plate. In order to save time when replacement is necessary, the tube may be "run in" and then stored in an upright position until installed in the transmitter. It is not necessary to repeat the "run-in" unless the tube has been inverted and the mercury splashed on the elements.

Larger tubes such as the 869B, 857B and 575A should have filament voltage applied slowly during the initial "run-in" period to reduce the possibility of the mercury boiling off of the filament so rapidly that trapped mercury raises and damages the oxide coating.

Low filament will cause a good tube to arc back, particularly if the tube is operating near full load and if the ambient temperature is low. Low filament voltage is usually caused by loose transformer connections and dirty socket contacts.

In order to prevent mercury rectifier failure:

1. Test tube at regular intervals, such as each maintenance period and record ionization voltage.

2. Maintain ambient temperature of 20 to 60 deg. C.

3. Make certain that correct filament voltage is present at tube pins.

4. Clean socket and filament pins occasionally.

5. Provide sufficient warm-up time, particularly when ambient temperature is low.

Figure 6. The Teletronix mercury vapor tube tester.

The Electronic Predictor

By PROFESSOR VON DER SNIKRAH

ONE of the encouraging aspects of field engineering junkets aside from seeing the country (if you like to travel) is the occasional opportunity of discovering unusual electronic developments in the broadcast industry.

Recently, while on a field trip below the border checking up on some of our firm's illegal transmitter installations to make sure that they were in proper operation, our crew ran into some amazing developments engineered by Don Jose El Liveb, little known Mexican electronic genius and amateur toreador.

It all started when we engaged Don Jose to help us in our measurements of dielectric leakage in connection with unaccountable losses of the special fluid transmission line used to feed the 3 megawatt FM transmitter. (Ed. Note: See August issue of BROADCAST ENGINEERING for complete details.)

We really didn't need the "local" assistance but in Mexico there is a law that requires the employment of local citizens to work alongside any who are from out of the country.

At any rate, during our usual exhaustive tests of the quality of the tranquilizing fluid used in the transmission lines, Don Jose in a surge of exuberance unfolded to us the most amazing story ever told. By the time our tests were all completed and the reports translated into Spanish for filing with the Departamento de Difusion (Mexico's equivalent to the F.C.C., known as D.D.D. in Mexico) we had gained the full confidence of our Mexican friend. We were invited to spend a day or two at his home workshop to see his invention first hand.

Travelling by burro to the other side of the mountains, we were quite surprised to find such an elaborate setup at the ranch Don Jose owned. Since his home had never been fully completed he called it "La Mitad Hacienda" which in English meant "Half Hacienda." After enjoying some of the famous tequila tranquilizer we were ushered into his private workshop to witness his new development in operation.

The compact, neat, well engineered device as pictured in Fig. 1 proved to be a mighty midget in its performance. Representing a forerunner of "things to come", the unit is completely transistorized in a compact but rugged container designed for table top use anywhere in the station. An ideal unit for the desk of the chief engineer, it will find many applications in this country if the Mexican authorities will allow it to be exported.

Actually, the device is a form of computer made compact for this application. Using special cartridges of tape, the machine can be "loaded" with pre-recorded information varying in lengths from 20 seconds to 45 minutes. When a cartridge is placed into position on top of the instrument, it automatically "cues" itself

(Continued on page 37)

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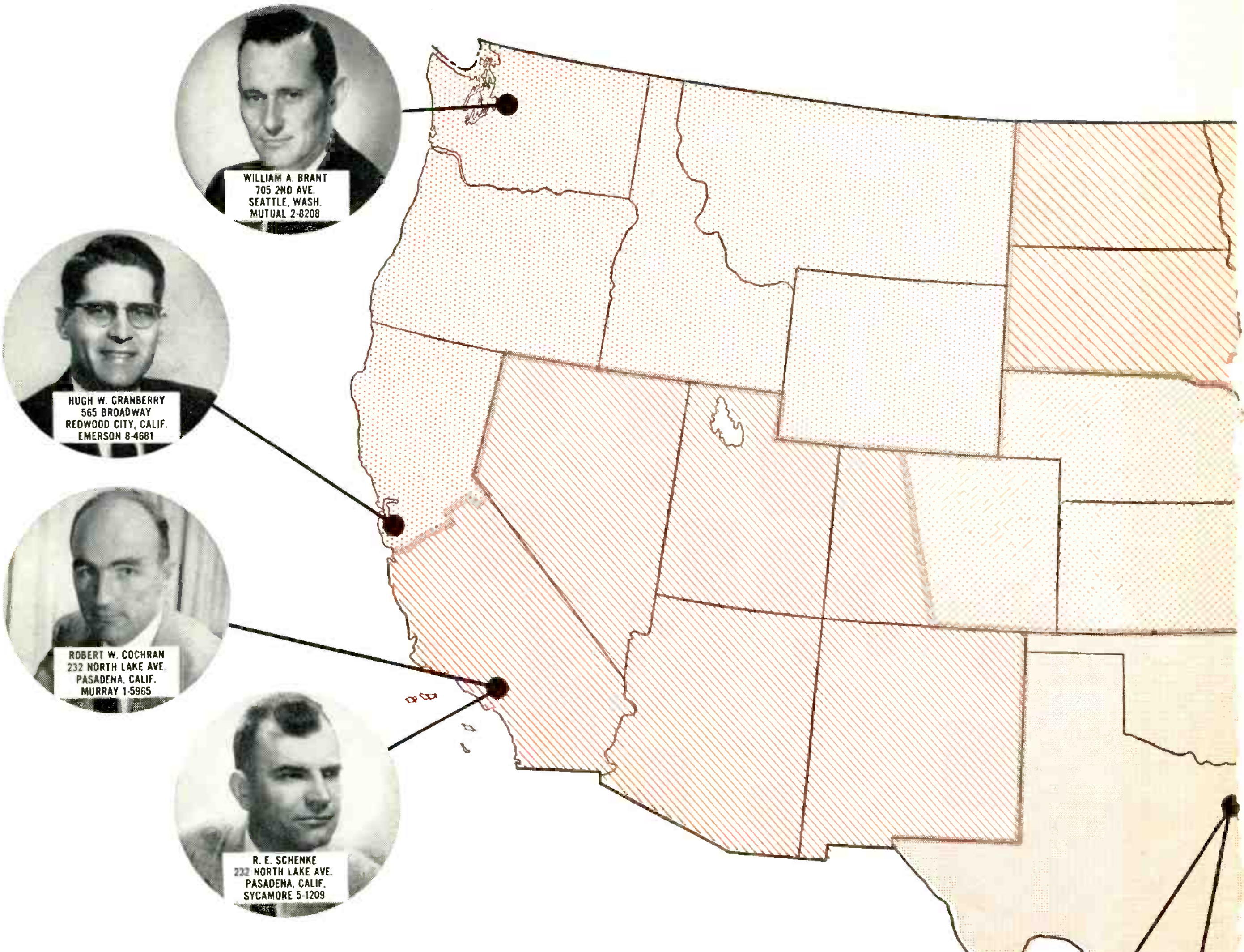

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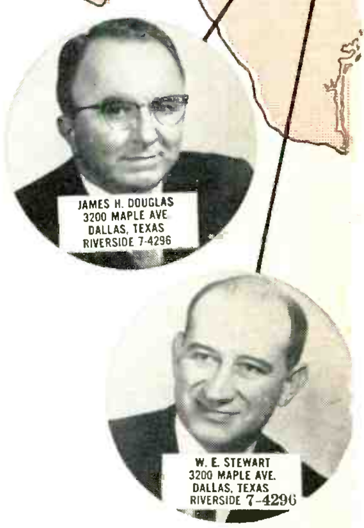
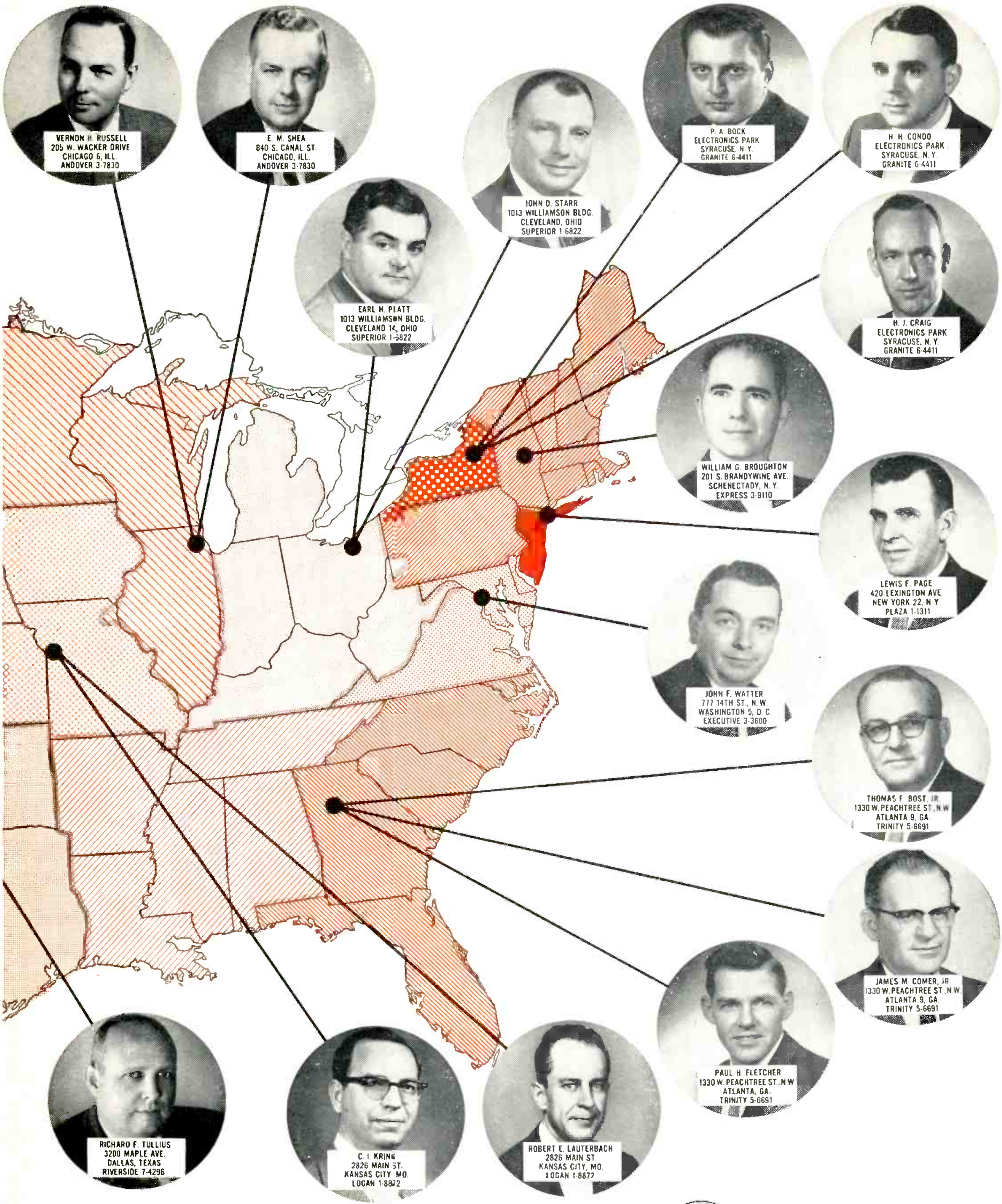




GENERAL ELECTRIC

FREQUENCY MEASUREMENTS IN THE BROADCAST FIELD

By C. A. CADY and W. P. BUUCK*

NOT MANY years ago, this industry was enjoying the relatively simple problem of frequency measurements associated with AM broadcasting. With the advent of FM and television broadcasting and the extension of the broadcast spectrum upwards toward 1000 Mc, the frequency measurement problem became much more complex. The significance of this change has never been fully realized by all members of the broadcast fraternity. As a result, complications arise which are not always anticipated, and interim solutions hastily devised are not very satisfactory.

Many of our old-timers will recall the days when purchase of a frequency monitor was sufficient to solve all their frequency measurement problems. That this situation does not exist today is well known, but the reasons behind this condition are not so universally understood. Perhaps the very success of the original monitors is in itself partly responsible for the misconception that many people have today regarding such devices. Some of the factors affecting the use of frequency monitors which were of no particular significance a decade or more ago are now much more important. It is the purpose of this article to discuss in detail some of these factors in order that a better understanding of the problem may result.

Some Characteristics of Frequency-Measuring Devices

Let us begin by pointing out that all frequency-measuring devices have certain fundamental characteristics. Among these are:

1. Accuracy (or tolerance)
2. Long-term drift rate
3. Short-term stability
4. Resolution (or precision)

Accuracy—All frequency-measuring devices have a stated "accuracy." There are two ways of defining this, either as (1) plus or minus a given number of cycles per second, or (2) plus or minus a given percentage of the operating frequency. In broadcast practice the accuracy required is customarily stated as plus or minus a certain number of cycles. This results from the requirement that the bandwidth occupied by a given broadcast service is usually a fixed number of cycles. However, most frequency-measuring devices such as crystal oscillators, meters, etc., have their accuracies specified as percentages of the operating frequency, of full-scale deflection, etc. If the frequency of a crystal oscillator is multiplied many times before the final output frequency is reached, one can easily see that it will not be long before even a small "inaccuracy" expressed as a percentage becomes a large number of cycles at the operating frequency.

Accuracy is a very general statement and needs further elaboration. It appears to be a well established custom to expect that, if a device is purchased "to an accuracy of (say) 500 cycles," any given set of measurements made with that device could have a maximum total spread of 1000 cycles, because a device that is "accurate" within 500 cycles of a standard value is permitted both plus and minus deviations of 500 cycles from that value. The "±" symbol is not always included in the accuracy statement, but by custom and definition it is implied.

If one wants a device with a maximum total spread of 500 cycles, he has two choices. (1) If established definitions are followed, an instrument having an "accuracy of ±250 cycles" can be used, or (2) if he is really interested only in the "total spread," the requirement might be changed to read "a total spread (or drift) of 500 cycles." Note that the latter expressly avoids the term "accuracy." (1) and (2) above are not completely equivalent. In (1), for example, the frequency is required to remain within ±250 cycles of a defined center value (i.e., zero error), and a total spread of 500 cycles can thus be expected. In (2) only the spread or drift is specified, and it can possibly be all in one direction from a stated value.

Long-Term Drift Rate—All frequency standards have a finite drift rate. This is caused principally by component aging in a physical sense. All crystal oscillators, however carefully executed in design and workmanship, will eventually change in frequency enough to carry them outside their initial *accuracy* specifications. It is just a matter of time.

In general, the long-term drift rate is a measure of how long a period of time the particular device may be relied upon to provide use-

*General Radio Co., West Concord, Mass.

ful measurements for the intended purpose.

Short-Term Stability — In addition to a finite drift rate, any frequency measuring device is characterized by short-term variations which are usually small by comparison. These effects may be caused by such things as the cycling of a temperature-control system, line-voltage variations, etc. Such factors are usually influenced more by design techniques than by inherent physical characteristics of the components used.

Resolution (Or Precision)—These terms are synonymous, and both are quite often confused with "accuracy." In general, *resolution,* or precision, as applied to a frequency-measuring device, is merely an indication of the smallest incremental change in frequency that can be resolved or detected by the device itself. The *resolution* of an instrument must at least be as good as its stated *accuracy,* otherwise the stated accuracy cannot be realized.

In most well designed equipment, the *precision* is better than the stated *accuracy.* This sometimes leads to confusion due to misunderstanding of the intended purpose. In such cases, where, for example, it is possible to read a meter much more *precisely* than the stated over-all instrument *accuracy,* the usefulness may be merely in the ability to discern small *changes* in meter deflections during specialized tests of short duration. Any attempt to use this *resolution* to obtain greater *accuracy* is generally not successful.

Broadcast Frequency-Measuring Instruments

There are several commonly used methods of measuring frequency, but perhaps the two chief categories are (1) the *direct* measurement of frequency and (2) the *indirect* (or difference) method. The first category is represented by such devices as digital-counter-type frequency meters, and by certain types of heterodyne frequency meters. The second category is represented by frequency-deviation meters, of the type commonly found in most broadcast monitors.[10] Each has its preferred area of use, as will be shown later.

Direct-Frequency-Measuring Devices—In recent years, the digital-counter-type frequency meter has been gaining in popularity as a versatile device for frequency measurements. It not only is simple to use, but it is quite versatile and covers a wide frequency range. Basically, these devices include a reference crystal oscillator and a digital display system. The reference oscillator is a principal factor in determining the over-all *accuracy* of the device, while the digital display can produce eight-figure *resolution.* These properties make the counter attractive where a large number of frequencies are to be measured.

Since counters are direct reading in cycles, they do not lend themselves very conveniently to the measurement of frequency *error,* or *deviation* from a particular, odd-valued frequency. There is no theoretical reason why digital-type deviation meters cannot be made, but to date the more practical aspects of the problem seem to have limited advances in this direction.

Deviation-Frequency-Measuring Systems—It is quite often convenient to measure a frequency in terms of deviation from an "assigned value". In such cases, the "assigned value" may often be an odd number, and direct measurement of frequency is difficult to interpret. In broadcast practices, the operator is not particularly concerned with what his exact *frequency in cycles* per second happens to be, but he is vitally concerned with how far he may be from the *specified* channel frequency. Because of this, it has long been customary to calibrate "frequency deviation monitors" in terms of *cycles deviation* from a desired center value. This arrangement tells the operator at a glance just how close to the limits he may be operating and the direction of his frequency error as well.

Basically, these devices include a reference crystal oscillator and a limited-range display system, usually consisting of a comparatively simple metering circuit. The over-all accuracy of the system is dependent upon *both* the crystal reference oscillator and the metering circuits. The latter fact may often be overlooked. It is not uncommon to find all sources of error in a broadcast frequency monitor of this type attributed by the station operator to the reference crystal oscillator alone.

Broadcast frequency monitors often obtain their *resolution,* or ability to read "cycles deviation from a center value", by employing heterodyne techniques, in which the metering circuits operate from a predetermined intermediate frequency. The IF bandwidth must be wide enough to accommodate frequency modulation in some instances. One common arrangement in widespread frequency-monitor use employs an IF of 150 kc with a deviation-meter scale calibration range of 3-0-3 kc. If the smallest meter division is 100 cycles (deviation), then one can readily see what degree of circuit stability is necessary to achieve this "100-cycle" figure. Since the *actual* meter range is 147-150-153 kc (although the meter may be calibrated 3-0-3 kc), a stability of 100 cycles is 100-150,000, or 0.066 per cent in terms of circuit stability. Fortunately, by suitable circuit-design techniques,[10] this stability figure can be halved, thus bringing it to a value of 0.13 per cent which is representative of the best commercially obtainable components.

Direct versus Deviation Frequency Meters (Digital-versus-Analog) — Recognizing that two basic systems of frequency measurement are in use, let us compare their points of difference.

Both types employ precision crystal reference oscillators, which are subject to the same basic conditions of long-term drift and short-term stability. Considerable effort has been expended in the design of the modern crystal oscillator for use in broadcast monitors, but it is doubtful that the crystal oscillators used in digital counters today are so highly developed as those used in deviation monitors. This is illustrated by short-term stability tests on counters, which often disclose frequency variations* of 1 part in 10^7, as compared to 1 part in 10^8 for a modern frequency deviation monitor.[10] The oscillators employed in digital counters are easily checked against such standards as WWV, while the broadcast frequency-deviation monitor, master crystal oscillator, with its odd frequency value, has in the past been considered very difficult to check. The second part of this paper, however, deals with a straight-forward solution to this problem.

The indicator circuits of counter-type frequency meters have wide range, usually 0-2 Mc or 0-10 Mc, and have a resolution of ±1 "count"

*i.e., Greater than the resolution of the digital-counter system.

TABLE 1

Reference Source	Frequency	Power	(part in 10^9) Accuracy of Carrier Frequency	(parts in 10^9) Incremental Adjustments of Carrier Frequency	(parts in 10^9) Accuracy of Standard Time Intervals
Rugby, England GBR	16 kc	300 kw	± 5	±10	
Rugby, England MSF	60 kc	10 kw	± 5	±10	± 5±1 microseconds
Boulder, Colorado KK2XEI	60 kc	2 kw	±10	± 1	
Rugby, England MSF	2.5	2 kw	±10	± 5	±10±1 microseconds
	5.0	2 kw	±10	± 5	±10±1 microseconds
	10.0	2 kw	±10	± 5	±10±1 microseconds
	2.5	0.7 kw	±10	± 1	±10±1 microseconds
Washington, D.C. WWV	5	8 kw			
	10	9 kw			
	15	9 kw			
	20	1 kw			
	25	0.1 kw			
	5	2 kw	±10	± 5	±10±1 microseconds
Maui, T.H. WWVH	10	2 kw			
	15	2 kw			

The above data are from CCIR Report No. 66, 1956.
Time signals only are broadcast from:
Ottawa, Canada—CHU at 3330 kc, 7335 kc, and 14670 kc.
Annapolis, Maryland—NSS at 122 or 162, 5870, 9425, 12804, 17050, 22581 kc.
Cesium Beam Standards—Maximum deviation between two units, 1 part in 10^{10}.
Reference: "Proceeding of 11th Annual Symposium on Frequency Control," Fort Monmouth, New Jersey, U.S.A.S.E.L.

or digit. To obtain this wide range and resolution, many individual "decade counters" and a time-base generator are employed. This adds up to a very large number of vacuum tubes. Provision is usually made to "self check" the counter operation by application of one or two known frequencies. Such features are very desirable, but when the answers do not check out properly, the operator is left with the problem of determining which point in a complex system, involving many tubes, is at fault. Anyone familiar with computer logic will have no trouble locating the fault, of course.

The indicator circuits of frequency-deviation monitors are narrow range, commonly 3-0-3 kc for television aural monitoring or 30-0-30 cycles for AM broadcast use. This narrow range is employed in order to obtain the required *resolution,* 100 cycles or 1 cycle, respectively, for the metering circuits used. Such systems employ what amounts to an intermediate-frequency amplifier driving very stable metering circuits. This is accomplished using a small number of vacuum tubes. The metering circuit itself may be highly developed and consist of precision components in the interests of stability, yet it generally contains surprisingly few components. This makes for less difficult servicing, when trouble arises. Self-checking features may not be entirely built into the monitor, but since most of these devices operate at either low audio frequencies, or low ultrasonic frequencies in the range of 150 kc, a simple checking means can be had by calibration against an external oscillator. Part II of this paper shows the simple operations involved in checking out metering circuits of this type.

Another contrasting feature of the well designed frequency-deviation meter is that it can operate continuously for upwards of 15,000 hours (two years at 24 hours per day) without excessive tube replacements. It is doubtful that a counter-type frequency meter, of the type currently available, will do the same; moreover, tube replacements would constitute a major item of expense.

From an economic viewpoint, the present prices of digital frequency meters alone are comparable to that of a complete station monitor for television, yet the latter performs in addition many other functions necessary to the television broadcaster.

There is no inherent difference in the ultimate accuracy that can be attained using either system of frequency measurement, since they both depend upon crystal oscillators as basic references. The present resolution of one cycle (or 1/10 cycle) of existing digital systems can be matched by appropriate extension of the "deviation-meter" techniques.

Frequency Monitors and Their Present Usage

In the early stages of development of any system, some parts of the system are apt to be more refined than others. At that stage in the development, a checking device is necessary for monitoring system performance. Eventually however, all components tend to reach the same state of development, and then the question naturally arises as to the necessity for the continuing use of checking devices. Modern transmitters are very reliable devices, and their frequency stability is generally good. This leads some operators to conclude that the monitor is now superfluous. The fallacy in this conclusion is evidenced by such situations as the existence of standby transmitters, and the presence of *two* crystals in most transmitter exciter units.

Perhaps another contributing factor is the almost complete absence in many stations of any maintenance schedule for transmitter monitoring equipment. On the whole, transmitters are given preferential treatment in terms of maintenance, and no doubt this is as it should be, for the transmitter is more vital to station economics. Nevertheless, a monitor does serve a very useful function and often with a minimum of service attention. No doubt, a good portion of the difficulty rests with equipment manufacturers who have not, in the past at least, made servicing of equipment physically attractive. This situation has been improved by modern design techniques.[10]

No frequency measuring device, or monitor, constitutes an absolute reference by itself. It must be periodically checked against a reference source, and this is usually accomplished by outside frequency-measuring services, where available. Again the conclusion may be drawn that only this type of frequency measurement is necessary in the station. This argument overlooks the fact that such services are not available *continuously*, and periodic checks alone will not guard against sudden failure of the transmitter's exciter-frequency control. A local reference frequency and continuously operating indicator system is still necessary to cope with this type of problem.

The availability of a standardizing signal from such a source as WWV does not in itself solve the problem, as will be shown later. Auxiliary apparatus is necessary to make use of such standardizing signals,[5-7] and the continuity of reception of WWV is often poor in many parts of the country.

Broadcast Frequency-Measuring Services

There are many frequency-measuring services available to broadcasters, but their coverage is not nationwide, and stations in the UHF television bands suffer due to their limited transmission range. Notably, the larger metropolitain areas are adequately covered by such services, and in these areas the broadcaster has little trouble getting his transmitter's frequency checked. This is perhaps quite fortunate, for, in these highly congested areas, off-channel operation could cause serious interference problems.

Up to now at least, the isolated VHF TV stations and limited-range UHF-TV stations have not been cited by the FCC. The absence of immediate television interference has not been a cause for concern. That this situation could not go on indefinitely was recognized and the situation is rapidly changing.[11]

To the broadcaster who telephones his frequency-measuring services for a "frequency check", the rapidity with which he receives his answer is deceiving. Too often he assumes that, since the frequency-measuring service merely picks up his carrier frequency and "measures" it, the frequency-measuring services can themselves as readily make a simple "frequency check" of their own reference frequency standard against a national standard such as WWV. This is usually not true, especially if the utmost precision is required. To understand the problem fully would involve the complete understanding of how a primary frequency standard operates.[5] More is given on this subject in a following section, but suffice it to point out here that it would not be unusual to find that it took the frequency-measuring service 24 hours, or longer, to determine their own frequency-standard accuracy in terms of WWV. This is because they must resort to *time* comparison, as contrasted to a *direct-frequency* comparison, in order to gain the necessary accuracy their high standards require. This is usually better than 1 part in 10^8.

Frequency Standards

There are a growing number of sources of standard frequency and time. The best known to most broadcasters is perhaps WWV (and WWVH in Hawaii)[2] which have long been operated by the National Bureau of Standards. NSS, the Naval Observatory Time-Signal Standard has also been available for many years, but its use by broadcasters has been somewhat limited. Recent years have seen the growth of numerous other sources of frequency and time standards, notably those in the low r-f spectrum. Table 1 shows a listing of available sources, together with pertinent characteristics of each.

The development of frequency standards has reached the point where it is becoming increasingly difficult to intercompare them, because of the increasing demands placed upon the resolution of the measuring systems and the limitations in transmission between widely separated points.[1-8] It is not within the scope of this paper to discuss the intercomparison of frequency standards, but it is of interest to know how accurately a broadcaster can measure a frequency by reference to a National Standard, such as WWV.

WWV as a Reference Standard

In using WWV (or WWVH) as a reference standard one must be concerned with many factors, among which are (1) characteristics of the source itself, (2) characteristics of the transmission path between source and point of reception, and (3) the resolution of the measurement or comparison system. Taking these factors in order we have the following:

1. *Source Characteristics*—The signals emitted by WWV and WWVH have a finite accuracy *at the point of transmission*. As is shown in Table 1, the accuracies of the carrier frequencies are held to several parts in 10^9 per day, and the time signals to within a few milliseconds per day. These figures represent the "corrected values" as published by the U. S. Naval Observatory Time-Signal Bulletins.[9] From these, the day-to-day variations in the frequency of WWV are shown to be about 1 part in 10^9, and the frequency accuracy may be in error by as much as 8 parts in 10^9 based upon (UT2) Universal Time.

2. *Transmission Characteristics*—Much has already been published concerning the reception of WWV on each of its many standard frequencies.[2-5] These data point out the limitations on reception due to fading[7] and Doppler-shift effects.[8] The fading problem is an old one and is probably well understood by most persons. Several ingenious methods have been devised in attempts to overcome this problem. The Doppler-shift effects are not quite so universally recognized, and the rather severe limitations that this characteristic alone can impose on any direct-frequency comparison system are often overlooked.

If direct-frequency comparisons are attempted between two sources of frequency, widely separated geographically, the Doppler-shift effects may seriously limit the over-all accuracy with which the two systems may be compared. For example, the 5-Mc signal from WWV as received in Boston, Mass., may have a Doppler frequency shift of some 5 parts in 10^8. Note that this amounts to a loss of an order of magnitude in comparative frequency accuracy over the original accuracy at the point of transmission. It is, therefore, not possible to make use of a *direct-frequency comparison* system over this distance at this frequency if the ultimate accuracy available from WWV is desired. Resort could be made to other methods, but if a *direct-frequency comparison* is desired, then one must be close enough to WWV to avoid Doppler shift (i.e., within the groundwave propagation area). Alternative solutions involve (a) a lower standard-frequency transmission which will have less Doppler shift[3-6] (i.e., not have skywave propagation) at the requisite distances involved, or (b) the measurement of *time*, as will be explained later.

3. *Resolution of Frequency-Comparison Methods* — We have seen from 1. and 2. that *direct-precise-frequency comparisons* can best be made only between two stable frequency sources not dependent upon skywave transmission. Under these conditions, two sources of frequency can be directly intercompared by requiring only that the receiving apparatus have the required resolution. For example, a system comparing two 100-Mc signals, and readable to 1 cycle, would suffice to give an overall resolution of 1 part in 10^8. If the same 1 cycle precision were readable between two 1000-Mc signals, we would then have a resolution of 1 part in 10^9, etc.

If low-frequency signals are to be intercompared, we find that the 1-cycle resolution permitted by the measuring apparatus may not be sufficient for the accuracy required. In such cases, we may attempt to improve the resolution of the system by reading fractional cycles (i.e., as in the case of digital counters readable in 1/10-cycle steps). Even this gains us very little, and an alternative is to multiply the two frequencies being intercompared up to the 100-Mc or 1000-Mc range. In this process, however, we must carefully control the phase stability of the multipliers[13] to avoid introducing extraneous phase shifts, which if great enough in magnitude, can result in frequency "jitter" or short-term instability.

Time Versus Frequency Measurments

Because the broadcaster is chiefly concerned with the frequency of his transmitter, the measurement of "time" has been perhaps limited to the control of station breaks and commercials. It may not have occurred to him that "time" may be measured even more accurately than frequency, especially when faced with such transmission limitations as just noted. In fact, many frequency-measuring services make their accuracy checks against WWV, or other standards, in terms of time[2-5] rather than frequency.

One of the main reasons for comparing primary frequency standards on the basis of time (rather than a direct-frequency comparison), is that many of the short-term transmission effects can be averaged. For example, if we attempt the direct comparison of frequency, the Doppler shift reduces the reception accuracy of the 5-Mc signal received from WWV at Boston, Mass., by about 5 parts to 10^8. This is due to the random fluctuations in the actual received frequency of the 5-Mc signal at Boston. What is needed to overcome this condition is a means for averaging the fluctuations in the received signal over a period of time long when compared to the fluctuation rate. If this is done, the Doppler shifts, or resultant fluctuations in frequency, are integrated and we can then achieve a more accurate comparison of average frequency.

Since time and frequency are reciprocal, we can solve the problem by measuring time error and converting this to the equivalent frequency error in order to determine the correction to be applied to a local standard. Continuing the previous example, if we operate a local standard oscillator at 5 Mc and use an output derived from it to drive a clock or syncronometer, we may then compare the time generated by the local oscillator with that of WWV. If both "clocks" are set to agree at a specified time, and perhaps 24 hours later the local time is again compared to the *time* signals from WWV, we can determine the time error per 24-hour interval. Since there are 86,400 seconds per 24 hours, a time error of 0.1 second would be an error of 1 part in 864,000, or about 1.2 parts in 10^6. Syncronometers used in modern primary standards can resolve time into milliseconds with ease, thus giving a resolution of about 1.2 parts in 10^8 per day.

Since this system measures time error in terms of elapsed time between readings, the resolution of the system can be enhanced by merely increasing the time between measurements. It is not useful to carry this procedure much beyond the point where it results in a resolution which exceeds the stability of WWV during the total measurement interval, however.

From the foregoing, it can be seen that the problems of utilizing WWV to its maximum accuracy at distances remote from the source can be solved but not without the expenditure of time for measurement and money for complex apparatus. Up to the present, the broadcast industry has been fortunate in that the required accuracy has not been great enough to result in the complexities just noted. However, as new techniques are developed[12] and the requirements for system frequency stability become more stringent, we may come face to face with this problem sooner than we now realize. It is important, therefore, that the industry acquaint itself with some of these problems before that day arrives.

REFERENCES

1. M. Boella and I. E. N. Torino, "Some Measurements on the Fluctuation of the Standards Radio Frequencies and of the Time of Arrival of the Standard Time Signals Received from WWV," U.R.S.I. (International Scientific Radio Union), v. VII, July, 1948, p. 173.
2. V. E. Heaton, National Bureau of Standards, Washington 25, D.C.; "Measuring Time and Frequency in Hawaii," TELE-TECH, March, 1951.
3. J. A. Pierce, "The Diurnal Carrier Phase Variations of a 16-kc Transatlantic Signal," PROCEEDINGS OF THE IRE, May, 1955, p. 584.
4. J. M. Steele, "The Standard Frequency Monitor at the National Physical Laboratory," PROCEEDINGS OF THE IRE, v. 102, March, 1955, Part B, pp. 155-165.
5. F. D. Lewis, "Frequency and Time Standards," PROCEEDINGS OF THE IRE, September, 1955.
6. J. A. Pierce, "Intercontinental Frequency Comparison by Very-Low-Frequency Radio Transmissions." PROCEEDINGS OF THE IRE, May, 1957, p. 794.
7. R. S. Blume, "Fade-Cancelling Zero-Beat Indicator for Reception of Standard Radio Frequencies," REVIEW OF SCIENTIFIC INSTRUMENTS, September, 1957, p. 703.
8. I.R.E., "Doppler Shift of the Received Frequency from the Standard Station Reflected by the Ionosphere," October, 1957, p. 1408.
9. Bulletins, "U. S. Naval Observatory Time Signals," FINAL TIMES OF RECEPTION, UT2 (approx. monthly).
10. C. A. Cady, "A New Television Transmitter Monitor," NARTB, April, 1956.
11. R. L. Day, "The Use of a Mobile TV Monitoring Unit in an Enforcement Program," IRE TRANSACTIONS OF PGBTS, February, 1957.
12. W. L. Behrend, "Reduction of Co-Channel TV Interference by Precise Frequency Control of TV Picture Carriers," IRE TRANSACTIONS PGBTS, February, 1957; RCA REVIEW, v. XVII, No. 4, December, 1956.
13. J. K. Clapp and F. D. Lewis, "A Unique Standard-Frequency Multiplier," 1957 IRE CONVENTION RECORD PGI, Part 5, p. 131.

". . . many types of receiver circuits have been used . . ."

MULTIPATH starts on page 7

Since our whole concern with the matter has been prompted by our efforts to obtain satisfactory multiplex reception in critical areas such as New York City, San Francisco, and Chicago, we have attempted to correlate the observations made while field testing and making installations of multiplex receivers. During the past five years, many different types of receiver circuits have been used with considerable variation in results. Different configurations of I.F. amplifiers, limiters, and frequency detectors have been used in our efforts to overcome crosstalk and noise problems. Coincidentally, some circuits have been less susceptable to multipath caused distortions.

With the more recent advent of highly portable transistorized FM receivers, the effects of multipath transmission have been easier to observe since the receiver can be taken to locations not normally used.

In order to make controlled tests and comparisons of circuits a test setup was devised that would produce multipath conditions. As shown in Fig. 1 the test hook up consisted of an FM exciter used as a signal generator which was coupled to the receiver under observation both directly and through a delay network. The strength of the two signals could be adjusted over a wide range in order to duplicate conditions encountered in the field.

The first convenient place to observe the signal is immediately after the mixer in the I.F. amplifier prior to limiting. Using a 600-ft. roll of RG 8 U for the time delay, the exciter was modulated with a 10,000 cps tone deviating 100 per cent (± 75 kc). The 10.7 signal observed on scope is shown in Fig. 2. The amplitude modulation resulting in the reception of two equal strength signals from the same generator source with one signal being delayed is readily observed. With no modulation applied to the carrier, the signal appeared to be normal.

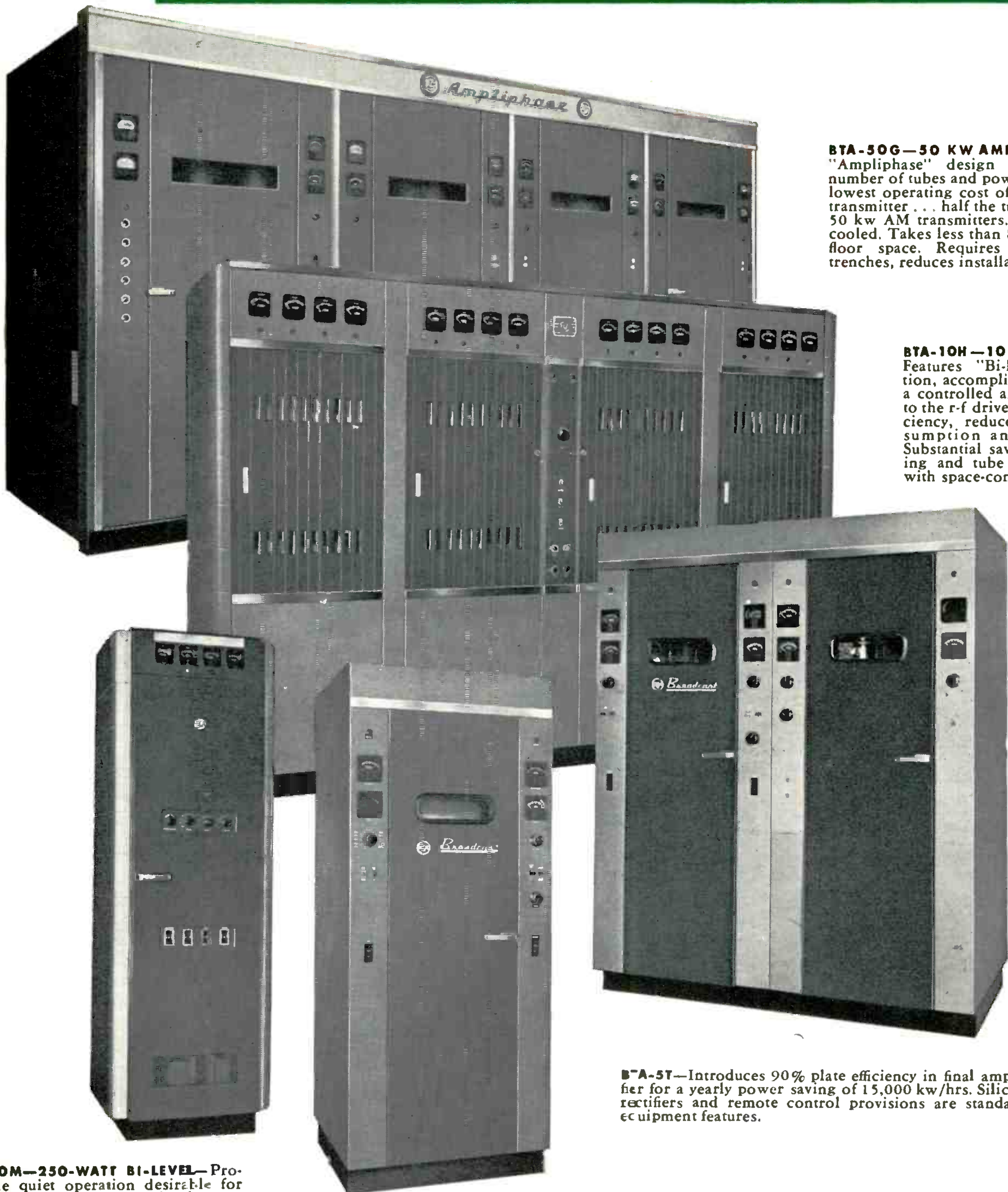
By adjusting the ratio of signal strengths to each other many changes took place that varied the amount of AM to an extent to where at times it was equivalent to 100 per cent and caused carrier clipping. In all cases, the higher the applied modulating frequency, the more noticeable the effect.

In order to recreate conditions similar to a two path signal made up of a reflected signal that travelled a mile farther than the direct one, a time delay of 5 microseconds was introduced. In Fig. 3 the resultant distortion to the 10,000 cps tone is shown. In this case, the scope was connected to the discriminator output.

The experiments to date have revealed that less multipath distortion is measured with discriminators having broad band width. The receivers with highest sensitivity also appear to have less distortion produced. With a fast acting limiter circuit and high sensitivity, the distortion is not produced until the "hole" created in the carrier by the AM effect goes below the threshold of limiting.

With the renewed interest in FM broadcasting, the research and development of receiver circuits has been reactivated.

the truth about...



BTA-50G—50 KW AMPLIPHASE—The "Ampliphase" design greatly reduces number of tubes and power costs, assures lowest operating cost of any 50 kw AM transmitter . . . half the tube cost of older 50 kw AM transmitters. Completely air-cooled. Takes less than 80 square feet of floor space. Requires no under-floor trenches, reduces installation costs.

BTA-10H—10 KW BI-LEVEL—Features "Bi-level" modulation, accomplished by adding a controlled amount of audio to the r-f driver, increases efficiency, reduces power consumption and distortion. Substantial savings in operating and tube costs combine with space-conserving design.

BTA-5T—Introduces 90% plate efficiency in final amplifier for a yearly power saving of 15,000 kw/hrs. Silicon rectifiers and remote control provisions are standard equipment features.

BTA-250M—250-WATT BI-LEVEL—Provides the quiet operation desirable for control room installation. Simple one-control tuning. Distortion-free "Bi-level" modulation, excellent frequency response. Uses only 10 tubes of three tube types. An ideal "economy package."

BTA-500/1R—Low power consumption and high-fidelity performance are features of these 500 and 1000-watt transmitters. Ideal for remote control, with all provisions designed-in. Color has been added, and now these units are available with red, green, blue, or gray doors to enhance any installation.

REMOTE CONTROL EQUIPMENT—RCA Remote Control Equipment provides facilities to switch program lines, adjust plate or filament voltage, operate a line variac control on emergency transmitter, control Conelrad switching, operate power contactors and reset manual overload breakers, from any desired control point, regardless of transmitter design or power.

RCA AM transmitters

SINCE 1929 RCA broadcast transmitters have been widely acknowledged as *the* best. During this period they have been the transmitters most often chosen by those stations which wanted, and could afford, the very best. Thus they early became, and have remained, the standard to which all others are compared.

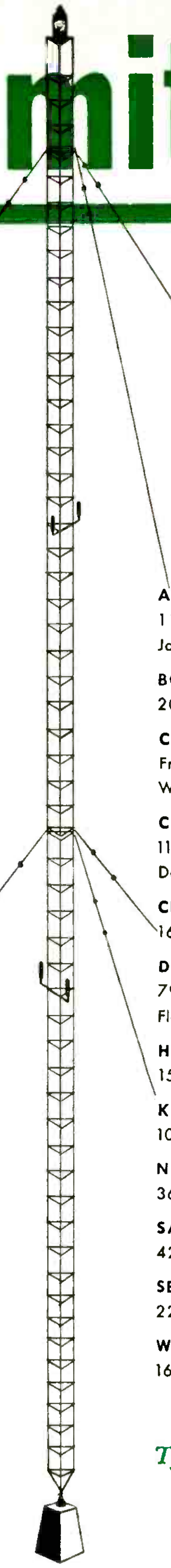
Unfortunately, some stations have believed that they could not afford such quality—no matter how much they wanted it. Today any station can "afford" one of these top-quality transmitters. In fact, it is hard for us to see how a station can afford *not* to buy one.

Why is this so? Simply because today RCA transmitters cost only a very little more than the lowest-priced (sometimes no more). And the small extra original cost (if any) is more than made up for by these two *facts:*

1. **RCA transmitters are generally less expensive to operate.** This is so because in almost every power class RCA transmitters either use less power, or have lower tube cost (in some cases both).

2. **RCA transmitters almost always have higher resale value.** This becomes very important when you go to higher power, or if you should decide to sell your station.

What is the moral? Simply this: don't jump to the conclusion you can't afford RCA. We believe you can, and we would like an opportunity to prove it. Call our nearest *AM Specialist* (see list). He will be glad to go over your situation with you, give you the benefit of his (and RCA's) broadcast equipment knowledge, and leave with you a complete and fair proposition. With such *facts* at hand you can make a correct decision. There's absolutely no obligation. You owe it to your station to find out. Act now!



See Your Nearest RCA Broadcast Sales Representative

ATLANTA 3, GA.
1121 Rhodes-Haverty Bldg.
Jackson 4-7703

BOSTON 16, MASS.
200 Berkeley St., Hubbard 2-1700

CAMDEN 2, N. J.
Front & Cooper Streets
Woodlawn 3-8000

CHICAGO 54, ILL.
1186 Merchandise Mart Plaza
Delaware 7-0700

CLEVELAND 15, OHIO
1600 Keith Bldg., Cherry 1-3450

DALLAS 35, TEXAS
7901 Empire Freeway
Fleetwood 2-3911

HOLLYWOOD 28, CALIF.
1560 N. Vine St., Hollywood 9-2154

KANSAS CITY 6, MO.
1006 Grand Ave., Harrison 1-6480

NEW YORK 20, N. Y.
36 W. 49th Street, Judson 6-3800

SAN FRANCISCO 2, CALIF.
420 Taylor Street, Ordway 3-8027

SEATTLE 4, WASH.
2250 First Ave., South, Main 2-8350

WASHINGTON 6, D. C.
1625 K Street, N. W., District 7-1260

Typical AM Tower

RADIO CORPORATION of AMERICA
BROADCAST AND TELEVISION EQUIPMENT
CAMDEN, N. J.

FM MULTIPLEXING REGULATIONS FINALIZED

Many new uses for FM multiplex techniques are now authorized by the F.C.C.

THE USES of FM multiplex techniques are now greatly expanded due to a recent ruling by the Federal Communications Commission. The original ruling establishing Subsidiary Communications Authorizations for FM broadcasters primarily permitted background music services and storecasting. For several years these authorizations have only been granted for transmission by multiplexing. Since it became increasingly evident that multiplex techniques could be used for many purposes other than those prescribed in the regulations, the Commission has explored these uses and had requested comments from the industry.

As a result of the study new regulations have been formulated which expand the use of FM multiplexing to other broadcast uses. Under the new regulations the program content must be of a broadcast nature and is intended for a limited segment of the public who wish to subscribe. This includes such services as background music, storecasting, detailed weather forecasting, special time signals, and other material of a broadcast nature expressly designed and intended for business, professional, educational, religious, trade, labor, agricultural or other groups. In addition to the foregoing program uses the multiplex channels can now be used for the transmission of signals which are directly related to the operation of FM broadcast stations. This includes relaying of material to other FM and standard broadcast stations, remote cueing and order circuits, remote control telemetering functions associated with authorized STL operation, and other similar uses.

The F.C.C. study explored many uses for FM multiplexing including slow-scan video transmission of advertisements, stock market reports, doctor paging, and traffic light control. Specific issues on which the commission requested comments were the following:

What limitation should the Commission impose upon the types of subsidiary communications which an FM station may provide?

Should an FM station be permitted to use subsidiary communications for relay purposes?

Should the number of subsidiary communications channels employed by a single FM broadcast station be limited, and, if so, what should be the limit?

To what extent, if any, should subsidiary communications be permitted to affect the quality of the broadcast channel?

Should specific sub-channel frequencies be allocated for subsidiary purposes? What quality and performance standards should be applied to the sub-channels?

Should an FM broadcast station be permitted to transmit subsidiary communications at times when it is not providing a broadcast service on its main channel?

To what extent should a license holder be permitted to enter into contracts or arrangements with other parties to provide program material for subsidiary communications or to lease the rights to the multiplex channels?

Comments on Multiplex Limitations

Approximately 40 broadcast stations filed comments on multiplex limitation. The general position was that no absolute limitation should be placed on the types of subsidiary communications which an FM station may provide. Many FM enthusiasts other than broadcasters expressed concern that any enlargement in the permissible scope of SCA services would tend to encourage a great expansion of non-broadcast multiplexing and thereby compromise main channel quality and undermine the development of wide-band FM stereophonic broadcasting. Among the uses suggested by stations were transmission of news photographs by facsimile, slow-scan TV, paging signals, servomechanism control pulses, musical A pitch, stock market quotations, detailed weather reports, remote pickup and cueing intelligence, studio transmitter administrative messages, transmitter telemetry and radio teletype. The telephone interests and licensees in the Domestic Public Radio Services filed opposition to any expansion of subsidiary undertakings on the part of FM stations. Organizations providing radio paging and communications services for hire emphasized their status as common carriers and their responsibility to service the public without discrimination pursuant to published tariffs. They stated that it would be unfair to be placed in competition with a service which could skim the cream off of the existing market for paging services. Traffic light control as a subsidiary service to be provided by FM broadcasters was supported by the International Municipal Signal Assn. The General Electric Co. opposed non-broadcast operations in the FM broadcast band as a matter of allocations principle. In summary the expansion of non-broadcast subcarrier operations in the FM broadcast band was generally opposed by listeners, telephone interests, communications services, and a broad segment of the electronic manufacturing industry while the only substantial endorsement of such expansion came from the broadcast industry.

Use of Multiplex for Relaying

The proposal to use multiplex subcarriers for relay purposes was opposed by the telephone interests and supported by the broadcast industry. The broadcasters' main interest in multiplex relaying focused on the program relaying services which have been and are being rendered by a few FM stations under temporary authorizations such as feeding baseball or other programs to a network of AM or FM stations on a subcarrier channel. Education stations requested that they be authorized to use subcarriers for the establishment of educational network systems. The conclusion drawn from the many comments favorable to FM relaying was that it should be limited to the relaying of programs of a broadcast nature.

Number of Channels

The majority of comments disapproved of any limitation on the number of subcarriers which would be permitted. There was some sentiment for limiting the number of channels to three or less; however, the majority disapproved of any limitation on the theory that the types of programming provided on the subchannels would automatically limit the number which could be successfully used at any given installation.

Most commenters disapproved of any reduction in main channel quality. Proponents of wide band stereophonic FM systems stated that some degradation of main channel quality would be an inevitable by-product of the multiplex systems.

Broadcast interests were generally opposed to a subchannel allocations plan and to the application of performance standards to such subchannels. Those favoring such measures were, for the most part, seeking the allocation of a single stereophonic channel which would standardize the manufacture of stereophonic adapters and indirectly discourage the pirating of functional music programs.

Some FM broadcasters who derive substantial revenue from their subsidiary operations would like to schedule such operations beyond the required 36 hours per week minimum main channel programming without an obligation to program the main channel during the extended hours. A few broadcasters and some others branded the idea a misuse of frequencies allocated to FM broadcasting.

The only substantial interest in the propriety of multiple subchannel leasing arrangements was expressed by FM broadcasters, most of whom advocated the continuance of such arrangements in view of the existing requirement that each licensee be responsible for, and in control of, all activities conducted on its authorized subchannels.

As a result of the comments from interested parties and other considerations the Commission has adhered to its policy that the character of specialized multiplex operations should not run completely counter to that of a broadcast operation. It stated that to permit the use of the broadcast band for other types of services would be equivalent to a reallocation of broadcast frequencies. The rendition by FM broadcast stations of radio paging and other services of a completely non-broadcast character would cause serious and unwarranted financial hardship to many licensees in the Domestic Public Radio Services, according to the Commission. The conclusion is that the public interest would not be served by allowing FM broadcasters to provide any signalling, control, telemetering, or communications service basically unrelated to broadcast operation. The final decision was to expand the permissible scope of FM multiplex operations to the extent indicated previously in this article. Questions concerning the use of multiplexing by educational stations are to be considered in connection with other rule amendments now pending.

Concerning the technical issues, the Commission finding was that the existing engineering standards are adequate for SCA purposes. At a later date a specific subcarrier frequency for stereophonic broadcasting and other performance standards may be formulated if found necessary.

With respect to subcarrier operation during periods of main channel inactivity, it was found that such use either with or without periodic main channel identification would be basically incompatible with the concept of SCA operation as an adjunct to regular FM broadcasting.

Pirating

A number of FM broadcasters providing background music services have complained that their transmissions are being pirated by non-subscribers who have purchased or assembled suitable multiplex adapters. In this connection the Commission states that section 605 of the Communications Act is contravened by the unauthorized reception of FM multiplex programs intended solely for reception by industrial, mercantile, and other subscribers. The Federal Communications Commission does not exercise licensing jurisdiction over the manufacture, sale or use of radio receivers nor is it responsible for the enforcement of section 605 of the Communications Act and the only action which it takes is to refer such matters to the Department of Justice for prosecution or other measures.

". . . vacuum tubes have been eliminated in circuits . . ."

TRANSMITTER KIT starts on page 2

tice the dummy antenna switch. The built-in dummy load is made up of four "ohmspun" grids mounted in the outgoing air stream. Since all the dummy antennas used in the broadcast band are reactive, a means is provided in the Model 707 to automatically cancel out this reactance at any frequency and provide a pure resistive load.

The AF Section

Looking from the rear (Fig. 2) the AF section is on the right side of the transmitter. Four tubes are used in this section. A pair of push-pull 6SJ7's drive a pair of push-pull 4-400A tetrodes operating as Class AB-1 modulators. 8DB of inverse feedback is provided over the two audio stages. One interesting feature of the design is that the modulator plate current when fully modulated does not vary more than 10 per cent over a 30 to 12,000 cycle range. The over-all response of the transmitter is flat within ± 1.5 db over a 30 to 12,000 cycle range. Distortion is below 2 per cent and noise is down — 64 db.

The Power Supplies

Vacuum tubes have been eliminated in all high voltage, low voltage and bias rectifier circuits in the Bauer Model 707 in favor of semiconductor units. Type 1N2071 silicon diodes are used exclusively, 16 in the low voltage supply, 4 in the bias supply and 56 in the high voltage supply. The low voltage supply is located on the left side of the transmitter (Fig. 2—lower left). The bias supply is located on the lower right and the high voltage rectifier (two plug-in sections) is located on the right above the modulation transformer.

Standard bridge rectifiers are used throughout and transformer center taps play an important part in the low and high voltage supplies. The tap on the low voltage supply provides the 400 volts necessary for the low level audio stages and the oscillator-buffer section. In the high voltage section the center tap provides the 1500 volts necessary for power reduction thus providing a transmitter that draws no more power during the cutback operation than any of the many 250-watt transmitters now in use.

An interesting feature of the power cutback circuit is that the reduced final plate voltage has an additional filter allowing excellent noise specifications (—64DB) at 250 watts. When reducing power a reduction in drive to the final and a 6DB reduction in the audio input are automatic. Power cutback to 500 or 250 watts is standard equipment on the Bauer 707. Cutback is essential for the Class IV station with a lower nighttime power and is a bonus for the kit builder who can perform initial tune-up at low power.

The Control Circuits

With the use of semi-conductor power supplies the Bauer control circuits were greatly simplified and automatic starting was provided. Actually, only one master start-stop switch is necessary since the silicon power supplies require no warmup time. High voltage comes on automatically as soon as there is sufficient grid drive to the final tubes to close an underdrive relay. The master start-stop switch is of the new illuminated bar type (Fig. 1—middle), three inches long and easy for even the newest third-class operator to find. An interesting feature of the control circuit is a "second chance" device that automatically resets the overload relays in the event of an outage. This circuit is adjustable so that single short overloads will not take the transmitter off the air although continued overloads will. The relay protective system can be easily reset by remote control. The modulator and final RF stages, as well as the high-voltage transformer, are well protected by reliable delay-type overload relays that eliminate nuisance outages due to momentary overloads. Low voltage and control circuits are fused by the new indicator type fuse holders.

An additional feature found in the Bauer 707 is automatic voltage control. A Sola constant voltage transformer of the new low harmonic type (Fig. 2—left side) maintains all filament and low voltage supplies within one per cent. Filament rheostats that require manual adjustment are hereby eliminated and tube life is extended.

Cooling of tubes and components is controlled through the use of a pressurized cabinet. Filtered air is drawn in by a high quality blower on the rear door, circulated throughout the cabinet, and then forced through the 4-400A tube sockets for maximum cooling. All switching and control functions are pre-wired to the main terminal board making remote control a simple matter. In addition the plate voltage and plate current kits are built in—a standard part of the 707 circuitry. Note in Figure 1 the number of meters, nine in all, providing continuous metering of all circuits.

Summary

The engineer who builds the 707 kit can gain valuable experience during the construction period. Also he achieves a familiarity with the transmitter that will prove very helpful over the years that he will service it. Since professional tools are supplied with every kit he will be able to turn out a first class transmitter and capture the personal satisfaction that goes with a job well done.

Minnesota
Minneapolis
Electronic Expeditors, Inc.
FEderal 8-7597

Mississippi
Jackson
Ellington Radio, Inc.
FL 3-2769

Missouri
Kansas City
Burstein-Applebee Company
BAltimore 1-1155

New Jersey
Camden
General Radio Supply Co.
WA 2-7037

New Mexico
Alamogordo
Radio Specialties Company, Inc.
HEmlock 7-0307
Albuquerque
Radio Specialties Company, Inc.
AM 8-3901

New York
Buffalo
Genesee Radio & Parts Co., Inc.
DElaware 9661
Mineola, Long Island
Arrow Electronics, Inc.
Pioneer 6-8686
New York City
H. L. Dalis, Inc.
EMpire 1-1100
Milo Electronics Corporation
BEekman 3-2980
Sun Radio & Electronics Co., Inc.
ORegon 5-8600
Terminal Electronics, Inc.
CHelsea 3-5200

Ohio
Cincinnati
United Radio Inc.
CHerry 1-6530
Cleveland
Main Line Cleveland, Inc.
EXpress 1-1800
Pioneer Electronic Supply Co.
SUperior 1-9411
Columbus
Buckeye Electronic Distributors, Inc.
CA 8-3265
Dayton
Srepco, Inc.
BAldwin 4-3871

Oklahoma
Tulsa
S & S Radio Supply
LU 2-7173

Oregon
Portland
Lou Johnson Company, Inc.
CApital 2-9551

Pennsylvania
Pittsburgh
Marks Parts Company
ELectric 1-1314
Philadelphia
Almo Radio Company
WAlnut 2-5918
Radio Electric Service Co.
WAlnut 5-5840
Reading
The George D. Barbey Co., Inc.
FR 6-7451

Tennessee
Knoxville
Bondurant Brothers Company
3-9144

Texas
Dallas
Graybar Electric Company
RIverside 2-6451
Houston
Busacker Electronic Equipment Co.
JAckson 9-4626
Harrison Equipment Company
CApitol 4-9131

Utah
Salt Lake City
Standard Supply Company
EL 5-2971

Virginia
Norfolk
Priest Electronics
MA 7-4534

Washington
Seattle
Western Electronic Supply Company
AT 4-0200

West Virginia
Bluefield
Meyers Electronics, Inc.
DAvenport 5-9151

Wisconsin
Milwaukee
Electronic Expeditors, Inc.
WOodruff 4-8820

". . . a problem is oxide rub-off on recording heads . . ."

MAGNETIC TAPE starts on page 4

tion of high output tapes has made possible narrower magnetic tracks without sacrificing output level. Cost is roughly 40 per cent higher than standard tapes.

Magnetic tape's signal storing ability makes it extremely valuable for non-sound as well as sound recording; consequently the electronic age is demanding increasingly critical magnetic tapes for instrumentation applications. The trend in data processing toward packing more data into less space has led to the development of specialized oxides with shorter wave length recording properties, which permit the recording of higher frequencies at lower speeds, thus allowing more information to be concentrated in a shorter section of tape.

One of the biggest problems faced by computer operators is oxide rub-off on recording heads due to the rapid start/stop operations involved. To eliminate this cause of dropouts, "sandwich" tape was developed. With better resolution through improved high frequency response, improved short wave length output, and higher pulse density, a high potency oxide is protected in sandwich tape by a 50 micro-inch plastic layer which prevents the oxide from contacting any part of the recording system, thereby eliminating all wear on the oxide itself and greatly reducing equipment wear.

Another new coating formulation designed to combat the oxide rub-off problem is featured in "heavy duty" instrumentation tapes. The first magnetic tape with extra-tough binder materials similar to those used in video tape, heavy duty tape has 1,000 times greater conductivity than conventional tape thereby reducing static charge buildup which causes tape to "stick" to equipment. The long-wearing coating minimizes rub-off and withstands extreme heat without binder deterioration.

Magnetic tape comes in a variety of shapes and sizes — the familiar quarter-inch tape commonly found on home-type recorders is but one. Tape used for audible range recording also is available in ½, ¾ and 1-inch widths on reels with diameters ranging from 3 to 14 inches. Lengths vary from the 150-ft. "living letter" size to the 7200-ft. "extra play" size.

All recordists are acquainted with the clear plastic reels ordinarily sold with tape. But sound tape also is packed on colored reels (for coding purposes), on metal reels (for professional recorders), on hubs (cores, for users of bulk tape), or in cartridges (plastic enclosures used on special cartridge-type players). In addition, it comes in the form of perforated magnetic film for sprocket-driven motion picture sound recorders, and magnetic laminate for laminating oxide sound tracks to raw film stock.

Instrumentation magnetic tapes are available in standard widths ranging from ¼-inch to 2 inches and on special order in sizes all the way up to 22½ inches wide. Lengths vary from 1250 ft. to 9600 ft. on 10½- or 14-inch metal reels.

Other "shapes" instrumentation recording has found for the magnetic medium include double perforated 35mm magnetic film for sprocket-driven machine tool control equipment; magnetic belts and discs for geophysical seismic recording; oxide dispersion solutions for coating computer memory drums; magnetic transfer paper and typewriter ribbons impregnated with magnetic oxide solution; strips of magnetic tape on bank ledger sheets for automatic checking account updating.

As satellites probe deeper into outer space magnetic tape in still another variety goes where man has not been able to go, reporting the mysteries it encounters. A lubricated Moebius (endless loop) tape in a recorder only 5½ inches wide delivered the first voice from space (that of President Eisenhower, in his famous Outer Space Yuletide message of 1958).

And when the first astronaut orbits the earth a ½-inch wide magnetic tape in a tiny magnesium recorder will accompany him to record his voice commentary, the physiological effects on his body, and the environment of his historic flight.

Magnetic tape has undergone quite a metamorphosis during its first decade of existence; with the Space Age influence, perhaps by the end of its second decade the recording tape we know so well today will be unrecognizable.

AMENDMENTS AND PROPOSED CHANGES OF F.C.C. REGULATIONS

FM MULTIPLEX

Section 3.293 is amended to read as follows:

§ 3.293 Subsidiary communications authorizations.

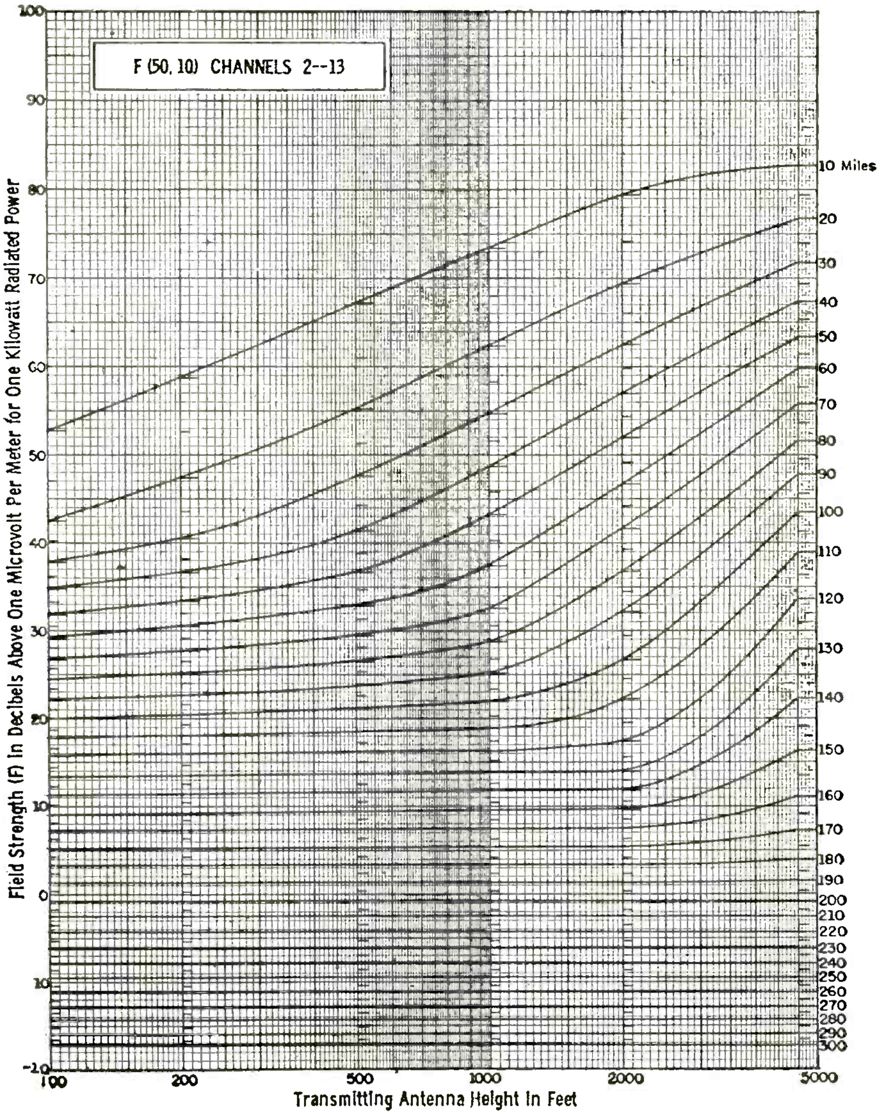
(a) A FM broadcast licensee or permittee may apply for a Subsidiary Communications Authorization (SCA) to provide limited types of subsidiary services on a multiplex basis. Permissible uses must fall within one or both of the following categories:

(1) Transmission of programs which are of a broadcast nature, but which are of interest primarily to limited segments of the public wishing to subscribe thereto. Illustrative services include: background music; storecasting; detailed weather forecasting; special time signals; and other material of a broadcast nature expressly designed and intended for business, professional, educational, religious, trade, labor, agricultural or other groups engaged in any lawful activity.

(2) Transmission of signals which are directly related to the operation of FM broadcast stations; for example: relaying of broadcast material to other FM and standard broadcast stations: remote cueing and order circuits; remote control telemetering functions associated with authorized STL operation, and similar uses.

(b) Applications for Subsidiary Communications Authorizations shall be submitted on FCC Form 318. An applicant for SCA shall specify the particular nature or purpose of the proposed use.

(c) SCA operations may be conducted without restriction as to time so long as the main channel is programmed simultaneously.



INTERIM POLICY ON VHF TELEVISION CHANNEL ASSIGNMENTS; TELEVISION ENGINEERING STANDARDS

Further Notice of Proposed Rule Making

1. The proposed Field Strength Charts issued with the original Notice of Proposed Rule Making inaugurating this proceeding (FCC 60-1, adopted Jan. 4, 1960) have been extensively reviewed by the Radio Propagation Advisory Committee (RPAC), composed of industry and Government engineers. As a result of this study, RPAC has recommended that the Commission adopt only one set of Field Strength Charts, the set consisting of one chart to show the F (50,10) fields, one to show the F (50,50) fields and one to show the F (50,90) fields. As explained below, separate charts for the low VHF and high VHF bands are unnecessary.

2. RPAC reports that the assumption that there was a linear height gain when receiving antennas were raised from 10 to 30 feet (an assumption on which the charts in the present rules and the charts proposed in the original Notice in this proceeding were based), led to the erroneous conclusion that for average terrain median fields at 30 feet were higher in the upper VHF channels than in the lower VHF channels. The data have been reanalyzed and measurements were separated into three groups: i.e., low VHF (54-88 Mc), FM band (88-108 Mc), and high VHF (174-216 Mc). This analysis showed that the measured height gain used to convert measurements from 10 feet to 30 feet was 1.7 db above the linear height gain in the low VHF band, 1.3 db below the linear height gain factor in the FM band, and 3.4 db below the linear height gain factor in the high VHF band. This would indicate that the actual height gain factor decreases with increasing frequency. This trend appears to be more consistent with recent observations that height gain is less in rough terrain than in smooth terrain. Since terrain of a given topography appears rougher to high frequencies than to low

frequencies, the relationship between frequency and height gain can be supported. When the data which provided the basis for the Commission's present rules are replotted using the revised height gain factors there is no appreciable difference between the low VHF and high VHF service fields. RPAC therefore concludes that separate curves for the low VHF and high VHF bands are unnecessary.

3. The Field Strength Charts set forth below have been prepared on the basis of the RPAC recommendation. Comments are invited on the charts below, which are to be substituted for the charts appended to the notice of Jan. 4, 1960.

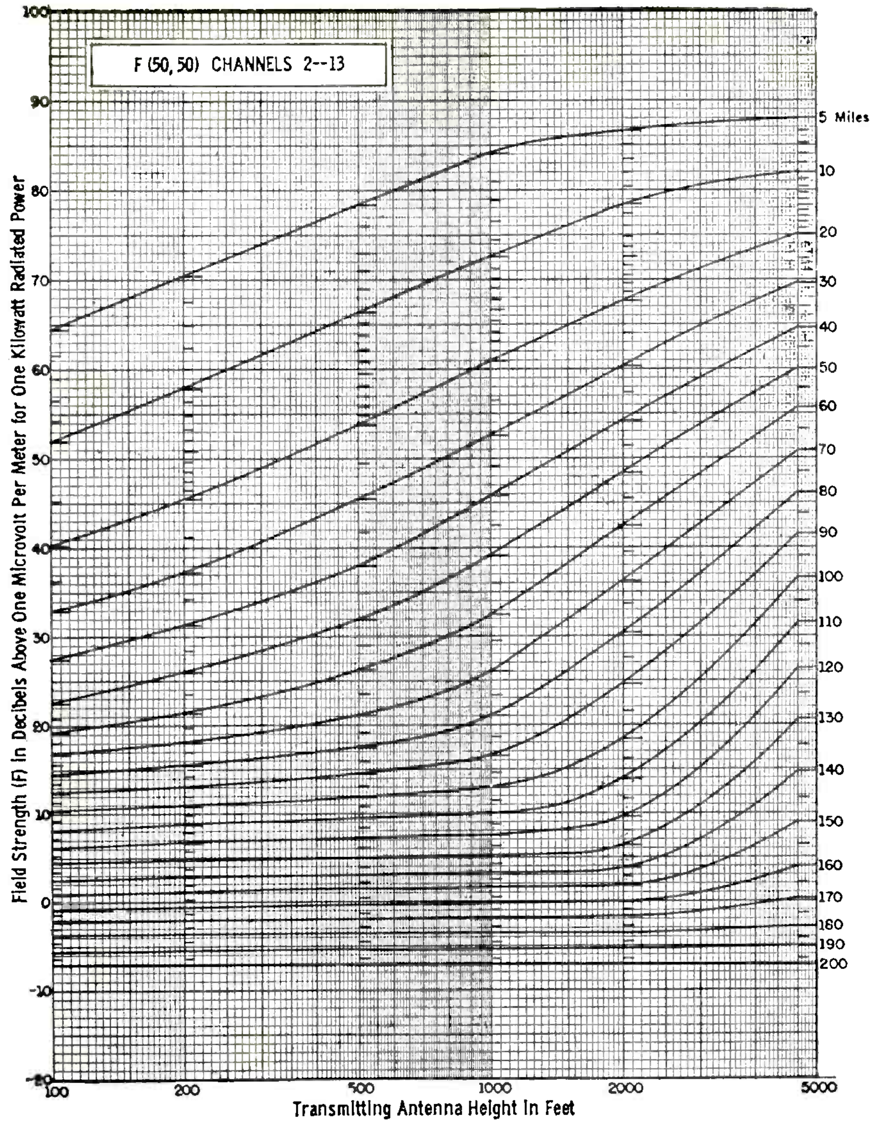
4. These charts, like our present Field Strength Charts, are statistical curves empirically derived from measurements made upon a large number of stations, in a variety of locations, under a variety of conditions and the revision proposed herein is only an effort to refine the charts in the light of additional and more recent data. Individual measurements may be expected to vary — widely in some cases—from the median values represented by these curves; and even groups of measurements made of a single station would not be expected to agree substantially with the statistical medians of the curves. Nevertheless, as the best tools available for the purpose, we propose the use of standard field strength charts for estimating the statistical service range of TV stations and the statistical probability of interference between TV stations. Until a practical method for predicting field strength can be developed for making more accurate estimates, we must rely upon statistical average curves for the most orderly and efficient administration of the television broadcast rules.

5. The original notice of proposed rule making in this proceeding did not make clear the status of existing TV stations insofar as compliance with the proposed new service field requirements over the principal city. It is proposed to permit existing stations to continue to operate with their present facilities, on condition that any subsequent changes in the facilities would not result in their providing lesser service fields than they are now providing over the principal city. This policy would also apply to applicants who are in hearing at the time the proposed new requirements are adopted, if such action is taken by the Commission.

Transmission of Stereophonic Programs on Multiplex Basis

1. Notice is hereby given of proposed rule making in the above-entitled matter.

2. On March 16, 1955, the Commission adopted a Report and Order (Docket No. 10832) amending certain of its rules and regulations to permit FM licensees to obtain Subsidiary Communications Authorizations (SCA) to engage in certain limited types of nonbroadcast services. These were described as involving specialized



programming consisting of "news, music, time, weather, and other similar program categories". Subsequently, on July 2, 1958, the Commission adopted a Notice of Inquiry (Docket No. 12517) seeking the opinion of interested persons as to whether or not additional uses for multiplexing should be permitted in the FM broadcast band. A survey of the comments received revealed a wide-spread interest in FM stereophonic broadcasting and accordingly a Further Notice of Inquiry in Docket No. 12517 was adopted on March 11, 1959, seeking specific comments with regard to the subject of stereophonic broadcasting. The closing date for comments in proceedings under Docket No. 12517 was March 15, 1960.

3. As a token of the broad interest in stereophonic broadcasting, the Electronics Industries Association organized the National Stereophonic Radio Committee (NSRC) consisting of six panels membered by outstanding technical personnel in the industry and devoted to the purpose of developing and recommending to the Commission a set of standards for stereophonic radio. Fourteen proposals for compatible FM stereophonic systems were submitted to the NSRC by interested persons and organizations. As a result of the Committee's studies, seven systems were eliminated either because they were withdrawn by the proponent or rejected as impractical. The remaining seven systems were analyzed theoretically and the results submitted to the Commission on March 14, 1960, as comments in Docket No. 12517. While these systems were submitted by individuals or electronic organizations and therefore were originally identified by proponents' names, they have been identified in the comments as NSRC systems 1, 2-a, 2-b, 3, 4, 4-a, and 5.

4. In addition to the seven systems on which comments were offered by NSRC, petitions for the institution of rule-making proposing FM stereophonic systems were submitted by Dwight Harkins and the Philco Corp. The system proposed by Mr. Harkins is substantially identical to NSRC system No. 1 and Mr. Harkins' petition will be considered in relation to that system. Comments were submitted in Docket No. 12517 by Richard S. Svorec and Elwood W. Lippincott concerning their own individual systems. Both of these systems were submitted to the NSRC and rejected as being impractical. The Commission also rejects these two systems as being impractical within the general framework of its FM rules and allocation policies, because of excessive out-of-band radiation.

5. The Commission desires to consider further each of the seven systems reported by the NSRC as well as a proposal separately submitted by the Philco Corp. Accordingly, the substance of proposed changes in the Commission rules to accommodate each of these systems is set forth below. For convenience, the numerical series used by NSRC is continued with the Philco system designated as system No. 6.

6. Although each of the systems is to be evaluated as a whole, the ultimate choice of technical standards may not necessarily lead to the adoption of any one of the systems in its entirety. Consideration must be given the varying objectives sought in the systems, such as relative simplicity of receiver design, low subcarrier noise level, conservation of spectrum space used for transmission of stereophonic information, compatibility with existing two-station stereophonic broadcasts, and others.

7. Comments, while not limited in scope, are desired specifically on: (1) the definitions set forth below; (2) the technical aspects of each of the proposals set forth below, supported insofar as possible by mathematical computations, engineering analysis, and the results of field tests and experience; (3) the need for or desirability of suitable frequency and modulation monitors for use with the respective systems and the technical specifications for such monitors; (4) the need for or desirability of increases in transmitter power output to offset reductions in main channel modulation; (5) the approximate cost and practicability of transmitter modifications; and (6) the cost and relative simplicity of stereophonic receivers or adaptations of existing receivers for the respective systems.

8. Further, the Commission desires that the proponents whose systems are set forth below submit information concerning the identity of persons or organizations applying for or holding patents on FM stereophonic broadcast transmission and reception systems and apparatus, and information with respect to the arrangements that will be employed for the licensing of patents for competitive distribution and use of such systems and apparatus.

9. The Commission is of the opinion that any stereophonic system adopted should be based upon standards capable of rendering as high a quality of service as the art can provide, consistent with economic and other factors involved, without significant degradation of the service now provided under existing FM

rules. Accordingly, comments are desired on any increase in stereophonic quality which may result from a variation of system parameters (such as subcarrier frequency, frequency deviation of the subcarrier, percentage modulation of the main carrier by the subcarrier, etc.) of each of the systems proposed below.

10. Comments expressing personal preferences but unsupported by engineering analyses are not desired, since adequate provision was made for the submission of such comments in Docket No. 12517. Comments of an engineering nature concerning stereophonic broadcasting submitted in response to the Further Notice of Inquiry in Docket No. 12517 will be given appropriate consideration in this proceeding and need not be resubmitted.

11. The amendments herein proposed are issued under the authority of sections 301, 303 (a), (b), (c), (g), and (r) of the Communications Act of 1934, as amended.

12. Pursuant to applicable procedures set out in § 1.213 of the Commission rules, interested persons may file comments on or before July 29, 1960, and reply comments on or before Aug. 8, 1960. In reaching its decision on the rules and standards of general applicability which are proposed herein, the Commission will not be limited to consideration of comments of record, but will take into account all relevant information obtained in any manner from informed sources.

13. In accordance with the provisions of § 1.54 of the Commission rules, an original and 14 copies of all written comments shall be filed with the Commission.

A—Definitions[1]

Crosstalk (general). The electrical signal appearing in one channel due to the presence of an electrical signal in another channel.

Stereophonic separation. The ratio of the audio signal in the right (left) stereophonic channel to the stereophonic crosstalk that signal produces in the left (right) stereophonic channel.

Left (or right) microphone signal. The electrical output of a microphone placed so as to convey the intensity, time and location of sounds originating predominantly to the left (or right) of the center of the performing area.

Left (or right) signal (general). The electrical signal comprised of the left (or right) microphone signal, or a derivation thereof, either exclusively or in part, such as to convey to the listener through suitable reproducing means the time, intensity and location of a sound or sounds predominantly to the left (or right) of center of the performing area.

[1]These definitions are generally applicable to all systems proposed here, although certain substitutes and additional defintions are included under individual systems.

Pilot carrier. A continuous control signal used to regenerate the correct frequency and phase of the reference subcarrier.

Stereophonic sound reproducing system. A sound reproducing system in which a plurality of microphones, transmission channels and loudspeakers is arranged so as to provide a sensation of spatial distribution of the sound sources to the listener to the reproduction.

Monophonic signal. A signal intended for non-stereophonic sound reproduction.

Compatible stereophonic radio signal. A signal which may be received with existing receivers so as to provide a satisfactory composite of the stereophonic signal sound and provide otherwise acceptable performance.

Main channel modulation. A signal having a frequency or frequencies in the range 50 to 15,000 cycles and which frequency modulates the main carrier.

Subcarrier. A signal having a frequency in the range 15 kc to 75 kc and which frequency modulates the main carrier.

Subcarrier channel modulation. A signal having a frequency or frequencies in the range of 50 to 15,000 cycles and which modulates the subcarrier.

B—Stereophonic Transmission Systems Proposed for FM Broadcast Stations

System 1: The sum of the left and right signals (L plus R) frequency modulates the main carrier, while the difference signal (L minus R) frequency modulates the subcarrier. In the receiver, which may be specially built, or an adapter used in conjunction with an existing receiver, the sum and difference signals are combined and the left and right signals (L and R) are separated and reproduced. The proposed operating conditions for this system do not leave subcarrier spectrum space for the transmission of additional subcarriers.

Technical Standards. (a) Frequency modulation of the subcarrier shall be used.

(b) The subcarrier frequency shall be 50 kc plus or minus 500 cycles.

(c) 100 per cent modulation of the subcarrier shall be plus or minus 25 kc.

(d) The modulation of the main carrier by the subcarrier shall not exceed 50 per cent.

(e) The total modulation of the main carrier, including the subcarrier shall meet the requirements of § 3.268.

(f) The subcarrier transmitting system shall be capable of transmitting the same modulation frequency band as the main carrier as given in § 3.317 (a) (2). The pre-emphasis time constant shall have the same value, 75 microseconds, for the subcarrier channel as that of the main channel.

(g) At a frequency of 400 cycles and at modulation percentages of 25, 50 and 100 per cent, the combined audio-frequency harmonics of the subcarrier systems shall not exceed a root-means-square value of 2.5 per cent. Measurements shall be made employing 75 microseconds de-emphasis in the measuring equipment and 75 microseconds pre-emphasis in the transmitting equipment, and without compression if a compression amplifier is employed.

(h) Sum-and-difference matrixing shall be used with the sum combination applied to the main channel and the difference combination to the subcarrier channel.

(i) Time delay correction shall be applied to the main and subcarrier modulation input channels such that the received main channel output is delayed 32.5 plus or minus 1 microseconds with respect to the received subcarrier channel output.

(j) The difference in amplitude response between main channel (L plus R) audio and subcarrier audio (L minus R) shall be within plus or minus 0.4 db.

(k) The subcarrier output noise level (frequency modulation) shall be in accordance with § 3.317 (a) (4) assuming a frequency swing of plus or minus 25 kc for 100 per cent modulation.

(l) Cross modulation of the main channel into the subcarrier channel shall not be greater than 40 db down from 100 per cent subcarrier modulation.

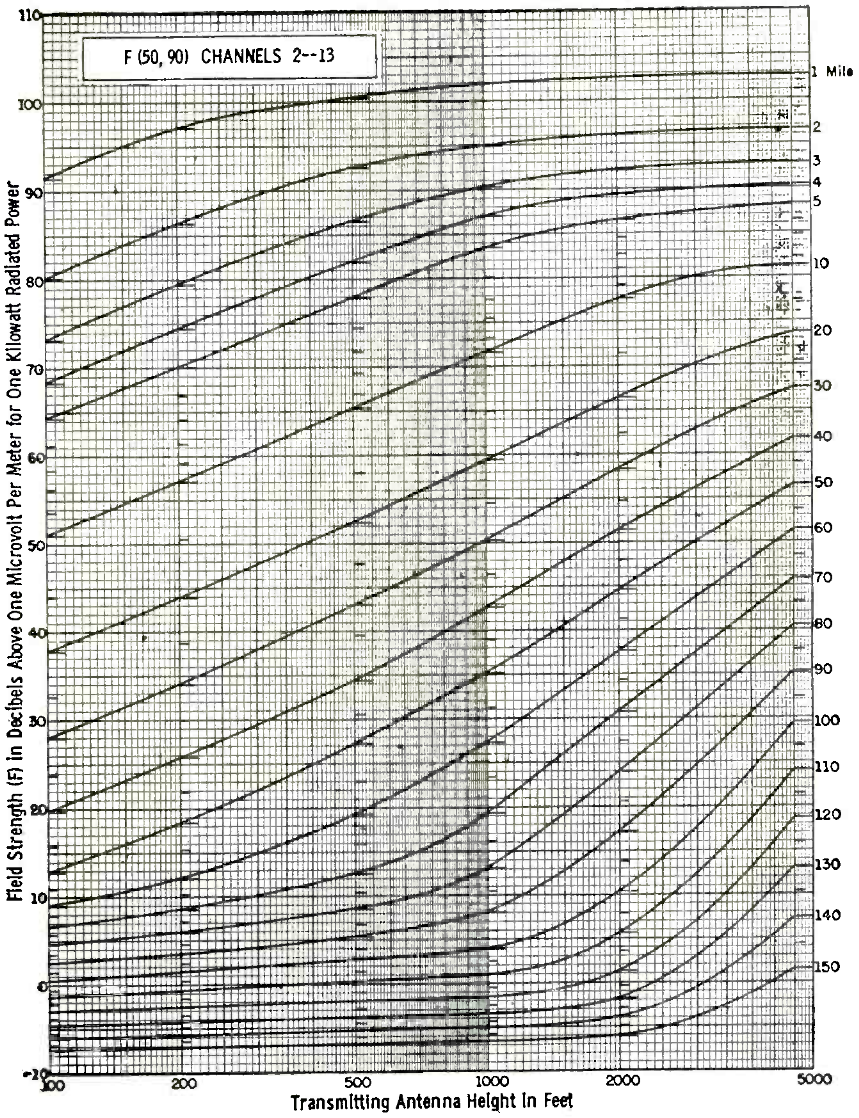
(m) 100 per cent modulation of plus or minus 25 kc is on a peak-voltage peak-deviation basis. When program is substituted for full tone modulation at 400 cycles, a program crest factor of 10 db will be assumed so that, for the same VU meter reading as the tone, the program level will be attenuated 10 db for 100 per cent modulation.

System 2A:

Technical Standards. (a) The modulating signal for the main channel shall consist of the arithmetic sum of the left and right signals.

(b) The frequency of the stereophonic subcarrier shall be 29,500 cycles plus or minus 100 cycles. The frequency range 20,000 to 39,000 cycles shall be reserved for stereophonic use only.

(c) Modulation of the main carrier by the stereophonic subcarrier shall be not less than 15 nor more than 20 per cent.



(d) Frequency modulation of the subcarrier shall be used.

(e) The audio frequency response on the stereophonic subcarrier shall be flat plus or minus 1 db to 7500 cycles, down 3 db at 8000 cycles and down at least 30 db at 9500 cycles. This restriction of audio frequency shall be accomplished by means of a filter which is phase linear to at least 7500 cycles.

(f) A total deviation of plus or minus 9.5 kilocycles on the subcarrier shall correspond to 100 per cent modulation.

(g) The modulating signal for the subcarrier shall consist of the stereophonic right channel only.

(h) The pre-emphasis of the audio modulation applied to the subcarrier shall be in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 150 microseconds.

(i) A delay line shall be installed in the main carrier audio channel. This delay line shall not affect the amplitude response of the main channel audio, but shall delay all frequencies in the 50 to 7500 cycle range when received on a multiplex receiver having an excess time delay in the subcarrier receiver circuit of 40 microseconds, so that signals in the frequency range 50 to 7500 cycles which are broadcast simultaneously on the main carrier and subcarrier shall arrive at the main carrier and subcarrier detector outputs with a delay differential not to exceed 3 microseconds.

System 2B: An audio feed device at the transmitter mixes the left and right signals, (L and R), to produce the audio signal (L minus ½R) for frequency modulation of the main carrier and a signal (R minus ½L) to frequency modulate the subcarrier up to audio frequencies of approximately 8000 cycles. Space remains for transmission of other subcarriers. The composition of the main channel modulating signal (L minus ½R) may provide a measure of compatibility between multiplexed FM stereophonic broadcasting using this system and two-station stereophonic broadcasting, where the second station transmits the (R minus ½L) audio signal.

Technical standards. (a) Frequency modulation of the stereophonic subcarrier shall be used.

(b) The center frequency of the stereophonic subcarrier shall be 41 kilocycles, plus or minus 100 cycles.

NOTE: As an alternative subcarrier frequency, 29.5 kc is proposed.

(c) Modulation of the main carrier by the stereophonic subcarrier shall be within the range 15 to 20 per cent, as measured by an approved FM station monitor or other approved means. During periods of multiplex transmission with one or more subcarriers under SCA, modulation of the main carrier by all subcarriers re than 30 per cent as M station monitor or uns.

tion of plus or minus e stereophonic sub- nd to 100 per cent

...-frequency response of the ...ereophonic subchannel modulator shall be within plus or minus 2 db between 50 cycles and 8000 cycles, as measured by multiplex station monitor or other approved means, and shall match within limits of plus or minus 1 db the response of the main-channel modulator over the same frequency range.

(f) Harmonic distortion of the transmitted subcarrier audio signals within the range 50 cycles to 8000 cycles shall be less than 3 per cent, as measured with multiplex station monitor or other receiving means at the station, with 8 kc deviation.

(g) 150 microsecond pre-emphasis shall be employed in the audio input circuit of the stereophonic subchannel modulator.

(h) A low-pass filter shall be employed in the audio-input circuit of the stereophonic subchannel modulator to restrict the bandwidth occupied by the stereophonic subcarrier. This filter shall provide audio cut-off at 8 kilocycles, with response down at least 3 db at 8 kc; down at least 30 db at 10 kc.

(i) Noise, including power-supply hum, shall be held at least 60 db below 100 per cent modulation, as measured at the output of a monitor receiver, with subcarrier modulation by a 400-cycle tone as reference.

(j) Audio signals from the left stereophonic program channel shall modulate the main carrier at a level not to exceed 70 per cent on program peaks, as referred to oscilloscope measurement of peak level or reading of meter on a standard FM station monitor with correction for crest factor of .... db. Audio signals from the right stereophonic channel shall modulate the stereophonic subcarrier at a level not to exceed 100 per cent on program peaks, corresponding to deviation of plus or minus 9.5 kc of the subcarrier. In the event that licensee elects to simultaneously transmit stereophonic program signals by FM/AM or other simulcast method and FM multiplex method, the audio signals from the right stereophonic program channel shall be applied to the AM transmitter, or other associated simulcast transmitter, and to the subcarrier modulator.

(k) In the event that the licensee employs a transmitting matrix to attain improved monophonic reception of the main channel signals during transmission of stereophonic program signals, matrix configuration shall be such that predominantly left signals shall be applied to the main channel, and predominantly right signals applied to the multiplex subchannel. Mixed signals from the two stereophonic channels shall be applied to the two transmission channels 180 degrees out-of-phase with respect to each other and equal in amplitude to provide their cancellation, and stereophonic separation of left and right channels, at stereophonic receiving points without requirement of special dematrixing networks in receivers used by the public.

Definitions. (a) Compatible stereophonic radio signal—

(1) As related to monophonic reception by a listener to the FM main channel only during stereophonic transmission, a compatible stereophonic radio signal is one which will provide satisfactory reception of the stereophonic signal source, and provide otherwise acceptable performance.

(2) As related to operational compatibility with respect to simultaneous transmission of stereophonic programs by FM/AM or other publicly-used simulcast method and a new, improved method, a compatible stereophonic radio signal is one which will provide satisfactory reception of a stereophonic broadcast program either by FM/AM or other simulcast receiver or by a receiver adapted to utilize the new method, as selected by the listener.

(b) FM stereophonic broadcast — Transmission of stereophonic sound employing the FM main channel and associated transmission means at an FM broadcast station employing a compatible stereophonic radio signal.

(c) Two-channel stereophonic broadcast system—A stereophonic sound system in which two transmission channels are used.

System 3: This system differs from others proposed here, in that no attempt is made to have the left and right output signals reproduce the left and right microphone signals for stereophonic reception. The subjective stereophonic effect is attained by producing variations of the instantaneous envelope amplitude in the left and right receiver output signals to produce what is called the "precidence effect". The necessary stereophonic information which is referred to as a "directional signal", is transmitted on a subcarrier which is frequency modulated to a maximum of plus or minus 500 cycles. The sum of the left and right signals (L plus R) frequency modulates the main carrier. Additional space remains for other subcarriers.

Definitions. (a) Stereophonic sound—Reproduced acoustical energy which provides essentially the sense of auditory perspective in the listening environment that is inherent in the source environment.

(b) Stereophonic transmission — The simultaneous transmission of two related signals in such a way that existing monophonic receivers can receive a compatible program signal and that stereophonic receivers can receive the same program stereophonically.

(c) Compatible audio signal—An acceptable monophonic signal derived from a stereophonic transmission.

(d) Direction signal—A signal derived from the left and right channels of a two channel stereophonic transmission, which can be used to operate on the compatible audio signal to achieve stereophonic reproduction.

Technical standards. (a) For stereophonic transmission the response of the transmitting system (with pre-emphasis applied) between 21 and 23 kilocycles/second shall not be below that at 400 cycles/second.

(b) For stereophonic transmission, the transmitting system output noise level between 19 and 25 kilocycles/second shall be at least 40 db below 100 per cent modulation.

(c) The modulating signal for the main channel shall be the compatible audio signal.

(d) A subcarrier shall be transmitted which shall cause the main carrier to deviate by plus or minus 7.5 kilocycles/second plus or minus 10 per cent.

(e) The subcarrier frequency shall be 22 kilocycles/second plus or minus 0.1 per cent.

(f) The subcarrier shall be frequency modulated by the direction signal so that when this has its maximum positive value, corresponding to a stationary source on the extreme left, the subcarrier frequency shall increase by 500 cycles/second plus or minus 2 per cent. When the direction signal has its maximum negative value, the subcarrier frequency shall decrease by 500 cycles/second plus or minus 2 per cent. Between these limits the subcarrier frequency shall be a linear function of the direction signal.

(g) The subchannel shall be capable of transmitting variations due to the direction signal down to zero frequency without attenuation, and up to 100 cycles/second with an attenuation of not more than 3 db. Such attenuation should increase very rapidly above 150 cycles/second.

(h) The total modulation of the main carrier, including that due to the subcarrier and any other multiplex signals authorized under § 3.293, shall be in accordance with § 3.268.

(i) The main channel signal and the subchannel signal shall not be subjected to differential time delays greater than 5 milliseconds.

(j) The amplitude of any components of the compatible audio signal, or of any distortion or intermodulation products due to it or any other multiplex signals, shall be at least 30 db below the level corresponding to peak deviation of the main carrier in the band 19 to 25 kc/seconds.

System 4: The main carrier is frequency modulated by the sum of the left and right signals (L plus R), and by a double sideband suppressed subcarrier signal. The audio modulation for the subcarrier is the difference signal (L minus R). The main carrier is also frequency modulated at a low percentage by a pilot carrier at the fundamental subcarrier frequency, or, alternatively, the first subharmonic of this frequency.[2] Space is left for additional subcarriers.

Specifications are as follows:

Technical Standards. (a) The deviation of the main carrier by (L plus R) audio with a left or right signal only shall be plus or minus 35 kc or $46\frac{2}{3}$ per cent modulation.

(b) The deviation of the main carrier by the 39 kc[3] pilot subcarrier shall be $6\frac{2}{3}$ per cent of the maximum allowable (plus or minus 75 kc) deviation.

(c) The pilot subcarrier shall be in phase with the modulated subcarrier when a left signal only is used and is instantaneously deviating the main carrier downward in frequency.[3]

(d) The subcarrier shall be suppressed carrier amplitude modulated with (L minus R) audio.

(e) The deviation of the main carrier by (L minus R) subcarrier with a left or right signal only shall be plus or minus 35 kc or $46\frac{2}{3}$ per cent modulation.

(f) Total modulation of main carrier shall meet the requirements of § 3.268.

(g) The present § 3.317(a) (2) should be designated (2) (i) and should apply to stereophonic channel, main channel and subcarrier channel when transmitting system is referred to.

Add subparagraphs (2) (ii) and (2) (iii) as follows:

(ii) The difference in amplitude response between main channel (L plus R) audio and the subcarrier channel (L minus R) envelope shall be within 0.3 db.

(iii) The phase difference between the main channel (L plus R) audio and the sub-carrier channel (L minus R) envelope shall be within 3° for all modulating frequencies using a left or right signal only.

NOTE: If the separation between left and right channels is better than 26 db it will be assumed that paragraph (2) (ii) and (2) (iii) have been complied with.

Definitions. (a) the term "multiplex transmission" means the simultaneous transmission of two or more signals within a single channel. For simultaneous stereophonic FM broadcasting and the transmission of facsimile or other signals, the sub-carrier frequencies are a 39 kc double sideband amplitude modulated subcarrier with $6\frac{2}{3}$ per cent pilot carrier and a 67 kc, frequency-modulated subcarrier.

(b) Percentage modulation. For stereophonic FM Broadcast stations a frequency swing of plus or minus 75 kc is defined as 100 per cent modulation for the composite modulating signal which includes $6\frac{2}{3}$ per cent (plus or minus 5 kc deviation) pilot subcarrier, 93⅓ per cent (plus or minus 70 kc deviation) main channel (L minus R) and 93⅓ per cent (plus or minus 70 kc deviation) subcarrier channel (L minus R).

NOTE: When the main channel reaches its maximum value, the subcarrier channel simultaneously reaches its zero value.

System 4A: The main carrier is frequency modulated by the sum of the left and right signals (L plus R) and by a double sideband suppressed subcarrier signal. The audio modulation for the subcarrier signal is the difference signal (L minus R). The main carrier is also frquency modulated at a low percentage by a pilot carrier at 19 kc, which is the first subharmonic of the subcarrier frequency. Spectrum space remains for transmission of other subcarriers. Specifications are as follows:

Technical Standards. (a) The modulating signal for the main channel shall consist of the arthmetic sum of the left and right signals.

(b) A pilot carrier at 19,000 cycles plus or minus 5 cycles shall be transmitted that shall modulate the main carrier between maintained limits of 8 and 10 per cent.

(c) The subcarrier shall be the second harmonic of the pilot carrier and shall cross the time axis with a positive slope simultaneous to each crossing of the time axis by the pilot carrier.

(d) Amplitude modulation of the subcarrier shall be used.

(e) The subcarrier shall be suppressed to a level less than 1 per cent modulation of the main carrier.

(f) The subcarrier channel shall be capable of accepting audio modulating frequencies from 50 to 15,000 cycles.

(g) The modulating signal for the subcarrier shall be equal to the arithmatic difference of the left and right signals.

(h) The pre-emphasis of the audio modulation applied to the subcarrier shall be in accordance with § 3.317 (a) (2).

(i) The sum of the sidebands resulting from amplitude modulation of the subcarrier shall not cause a peak deviation of the main carrier in excess of 45 per cent when only the left (or right) signal exists; at the same time in the main carrier channel, the deviation when only the left (or right) signal exists shall not exceed 45 per cent.

NOTE: The individual maximum modulation capabilities of the main carrier channel and the subcarrier channels is 90 per cent since the former reaches a maximum when the latter is zero and vice versa.

(j) Total modulation of main carrier including pilot carrier shall meet the requirements of § 3.268.

(k) At the instant when only a positive left signal is impressed on the system, the L plus R main carrier channel shall cause an upward deviation in the main carrier frequency; and the L minus R sidebands signal and the subcarrier shall cross the time axis simultaneously and in the same direction.

(l) The ratio of peak main channel deviation to peak subchannel deviation when only a steady state left (or right) signal exists shall be within plus or minus 10 per cent of unity for all levels of this signal and all frequencies from 50 to 15,000 cycles.

(m) The phase difference between the zero points of the L plus R main carrier channel signal and the L minus R sidebands envelope on the subcarrier channel, when only a steady state left (or right) signal exists, shall not exceed plus or minus 3° from 50 to 12,000 cycles and plus or minus 10° from 12,000 to 15,000 cycles.

(n) Cross-talk into the main channel from the subchannel shall not exceed minus 30 db.

(o) Cross-talk into the subchannel from the main channel shall not exceed minus 30 db.

(p) For required transmitter performance all of the information in § 3.254 shall apply with the exxception that the maximum modulation to be employed is 90 per cent rather than 100 per cent.

(q) For transmitters and associated equipment the relevant portions of this paragraph shall apply as well as all of § 3.317 with the following exceptions:

(1) In (a) (2) change "15,000 cycles" in the first sentence to "53,000 cycles".

2) In (3) change first sentence to "Considering the system with only L plus R main carrier channel modulation for any frequency between 50 and 15,000 cycles and at modulation percenttage of 25, 50 and 90 per cent the combined audio frequency harmonics, etc., etc."

Also add new paragraph as follows:

Considering the system with only L minus R subcarrier channel modulation for any frequency between 50 and 15,000 cycles and at modulation percentages of 25, 50 and 90 per cent the combined audio frequency harmonics measured in the output of the system shall not exceed the values given in the following table:

Modulation frequency	Distortion (per cent)
50-100 cycles	4.0
100-7500 cycles	3.0
7500-15,000 cycles	3.5

(3) In (4) change "15,000 cycles" in first sentence to "53,000 cycles".

(4) In (5) change "15,000 cycles" in first sentence to "53,000 cycles".

Definitions. (a) FM Stereophonic Broadcast—Transmission of stereophonic sound employing a compatible stereophonic radio signal.

(b) Subcarrier—The subcarrier is a frequency in the range of 18 to 75 kc which frequency modulates the radiated carrier.

System 5: The main carrier is frequency modulated by the sum of the left and right signals (L plus R) and by a subcarrier at 23.625 kc. The subcarrier is amplitude modulated by the difference audio signal (L minus R), with lower sideband components suppressed which would fall less than 15 kc from the main carrier frequency. Spectrum space remains for transmission of other subcarriers.

Technical Standards. (a) The modulating signal for the main channel shall consist of the arithmatic sum of the left and right signals.

(b) The frequency of the subcarrier shall be 23,625 cycles, plus or minus 5 cycles.

(c) The modulation of the main carrier by the subcarrier shall be 37.5 per cent.

(d) Amplitude modulation of the subcarrier shall be used.

(e) The subcarrier channel shall be capable of accepting audio modulating freqquencies from 50 to 15,000 cycles.

(f) The lower sideband of the subcarrier shall be attenuated for all frequencies below 15,000 cycles by at least 40 db.

(g) The modulating signal for the subcarrier shall be equal to the arithmetic difference of the left and right signals.

(h) The pre-emphasis of the audio modulation applied to the subcarrier shall be in accordance with the impedance-frequency characteristics of a series inductance-resistance network having a time constant of 300 microseconds.

(i) The amplitude modulation index of the subcarrier shall be a maximum of 50 per cent when only the left (or right) signal exists; at the same time in the main channel, the deviation when only the left (or right) signal exists shall not exceed 31.25 per cent.

(j) The radio of peak main channel deviation percentage to subchannel peak amplitude modulation percentage when only a steady state left (or right) signal exists shall be $\frac{31.25}{50}$ for all levels of this signal to be measured at 100 cycles.

(k) Except for the differential phase angle introduced by the different pre-emphases, the phase difference between the zero points of the L plus R main carrier channel signal and the L minus R sidebands envelope on the subcarrier channel, when only a steady state left (or right) signal exists, shall not exceed plus or minus 3° from 50 to 12,000 cycles and plus or minus 10° from 12,000 to 15,000 cycles.

(l) The total modulation of the main carrier including the subcarrier shall meet the requirements of section 3.268.

(m) Cross-talk into the main channel from the subchannel shall not exceed minus 30 db.

(n) Cross-talk into the subchannel from the main channel shall not exceed minus 30 db.

(o) For required transmitter performance all of the information in § 3.254 shall apply with the exception that the maximum modulation to be employed is 62.5 per cent rather than 100 per cent.

(p) For transmitters and associated equipment the relevant portions of this paragraph shall apply as well as all of § 3.317 with the following modifications.

(1) In (a) (2) change "15,000 cycles" in the first sentence to "39,000 cycles".

(2) In (3) change first sentence to "Considering the system with only L plus R main carrier channel modulation for any frequency between 50 and 15,000 cycles and at modulation percentages of 25, 50 and 62.5 percent the combined audio frequency harmonics, etc., etc."

Also add new paragraph as follows:

"Considering the system with only L minus R subcarrier channel modulation for any frequency between 50 and 7,500 cycles and at modulation percentages of 25, 50 and 75 per cent the combined audio frequency harmonics measured in the output of the system shall not exceed the values given in the following table:

Modulation frequency	Distortion (*percent*)
50-100 cycles	4.5
100-7,500 cycles	3.0

(3) In (4) change "15,000 cycles" in first sentence to "39,000 cycles."

(4) In (5) change "15,000 cycles" in first sentence to "39,000 cycles."

System 6: The main carrier is frequency modulated by the sum of the left and right signals (L plus R). The 32 kc subcarrier is suppressed, single sideband, amplitude modulated by audio frequencies above 500 cycles in the difference signal (L minus R). Output signals of the two stereophonic channels are identical at audio frequencies below 500 cycles. The following technical specifications were furnished by the Philco Corporation in a petition to the Commission dated February 12, 1959:

(a) A modulation signal corresponding to the sum of the audio signals of the two stereophonic tracks shall fall in the frequency band 30 to 15,000 cycles.

(b) A modulation signal corresponding to the difference of the audio signals of the two stereophonic tracks shall fall in the frequency band 32,000 to 17,000 cycles according to its difference frequency from a reference carrier signal.

(c) The reference carrier signal shall have a frequency of 32,000 cycles. It shall be added to the signals of paragraphs (a) and (b) at a level of 20 db below the peak level of the sum of the modulation signals of paragraphs (a) and (b). The phase of the added reference carrier signal shall be the same as the phase of the carrier component generated by the beat between the sum and difference modulation signals of paragraphs (a) and (b) when the right track only is modulated.

(d) No difference frequency signal shall exist except for audio track signals which will pass through a high pass RC filter with a low frequency cut-off of 500 cps.

(e) The FM sound transmitter shall have a constant deviation characteristic versus frequency. The sum and difference modulation signals (paragraphs (a) and (b) shall have an amplitude characteristic versus frequency providing high frequency pre-emphasis corresponding to a 75 microsecond time constant characteristic.

[2] In comments submitted in Docket No. 12517, Zenith Radio Corporation proposes a pilot subcarrier at 19.5 kc instead of 39 kc, and proposes slightly altered values of deviation and percentage modulation in paragraphs (a). (b) and (e). In the alternate proposal, paragraph (c) applies to the second harmonic of the 19.5 kc pilot subcarrier.

[3] See Footnote No. 2.

Professor Snikrah starts on page 11

to the exact starting point and waits there until the start button is operated either on the unit itself or remotely if desired. If needed, the unit can be used over 300 times a day.

A companion unit (not illustrated but very similar) prepares the tapes. Like all units of this type, some knowledge of the machine is necessary in order to gain full benefits from its many uses. Its first function, then, is to store many bits of information (the smaller ones are affectionately called "tidbits"). After all the information is stored by magnetic memory means, it may be reactivated at any future time desired. A very handy feature.

In order for the device to correlate the information stored and make an accurate prediction, the only thing that is necessary is to make sure that the tapes are recorded with the proper coding pulses and that at the time of playback, the time and date be added together with any information that might have changed since the original tape cartridge was "pre-coded".

For example, in order to predict the failure time of the big "bottle" in the final amplifier of your rig, all that is necessary is to supply the original tape the information regarding previous tube life over a period of several years, the manufacturers predicted life, the operating voltages that are different than those recommended, unusual ambient temperature conditions, breakdowns of auxiliary equipment, etc. Then at time of playback, any new information is added before pushing the start button. Such little "tidbits" as the date the new man was being broken in on the staff is vital at this time.

The complete operation is almost instant and the prediction will appear on the externally mounted electronic blackboard also invented by Don Jose. Since space is limited in this publication, the complete details are omitted. (Don Jose wouldn't give them to us anyway.)

Many valuable uses immediately suggest themselves around the busy radio or TV station and it might be interesting to relate some applications that are foreign to our industry. For example, Don Jose loaded a tape while we were watching with various information about his activities the past few days while he had been busy with us. He then loaded the tape into the playback unit in order to obtain a prediction as to when his wife was going to be angry at him. The electronic blackboard immediately spelled out "MUCHO PRONTO".

Don muttered something that sounded like, "I should have stuck to the bulls," and ushered us out with apologies.

On the way to the airport, lugging our proof of performance gear, my partner and I agreed, "If this machine could be taught English, it will be a real sensation."

EDITOR'S NOTE: *Don Jose Ross El Liveb is one of the more prominent citizens of his country, being the owner of a large cactus distillery. His hobbies are amateur bull fighting and electronic development. Somewhat modest, this publication of his developments may help bring the bull from under the basket.*

Industry News

Ginsburg Appointed Manager of Advanced Video Development

Charles P. Ginsburg, who led the development of the Ampex Videotape television recorder, has been appointed manager of advanced video development for Ampex Professional Products Co. Ginsburg, who joined Ampex in 1952 to head the Videotape recorder project moves into his new position after having served as manager of video engineering since March, 1959. In the new assignment Ginsburg will carry out longer range development programs. Recognized by the broadcasting industry for his outstanding contributions, Ginsburg received the David Sarnoff Gold Medal Award in 1957 and the Vladimir K. Zworykin television prize in 1958 for his development work on the Videotape recorder.

New Manufacturer of Muzak Background Music Amplifiers

Ray B. McMartin, president of Continental Mfg., Inc., inspects an engineering prototype of the Model 920 amplifier which was scheduled to come off Continental's line starting June 1. In addition to doing subcontract work for many electronics firms, and marketing a line of custom receivers for the broadcast industry under the trade name McMartin, Continental also manufactures and markets world-wide a complete line of Hi-Fi components and radio intercom systems under the trade name Harmony.

RCA Reports Rise in Portable Sales

The Radio Corp., of America has reported a 72.3 per cent increase in sales of portable radios in the first quarter of 1960 over the same period last year. The sales represented the biggest quarterly increase in RCA's 35-year history of marketing portable radio sets.

Standards for 16mm and 8mm Lenses

"American Standard Threaded Lens Mounts for 16mm and 8mm Motion Picture Cameras" has been approved and published by the Americans Standards Assn. The standard specifies the dimensions required for mechanical and optical interchangeability of lenses for 16mm and 8mm motion picture cameras. For 16mm cameras with threaded lens mounts, threads having a nominal major diameter of 1 inch are often specified. Similarly, for 8mm motion picture cameras, threads having a nominal major diameter of ⅝-inch are in common use. In the newly revised standard, reference to the A, B, C, D dimensions for interchangeability has been changed to W, X, Y, Z so as to avoid confusion with the mount designations, D and C. Continuous type motion picture cameras are not applicable to this standard due to the types of optical systems employed in such cameras. American Standard PH22.76-1960 is available at 35¢ per copy from the American Standards Assn., Dept. PR154, 10 East 40th St., New York 16, N. Y.

Weiland Now Manager Of Video Engineering

Lawrence Weiland, National Broadcasting Co. executive credited with several outstanding engineering innovations, has been named manager of video engineering for Ampex Professional Products Co. Formerly manager of advanced planning for engineering at NBC in New York, Weiland joined Ampex April 1. Weiland, while supervising NBC's engineering projects in TV tape operations, served as a member of the original industry committee which established TV tape recording standards.

Technical Hints

Check Modulation Monitor Calibration With Oscilloscope

When proof-of-performance measurements are made at 100 per cent modulation, connect an oscilloscope across the terminals of the modulation monitor input (R.F.). Several modulation monitors tested have been down 2 db at 50 cycles. This means that they were reading 80 per cent when the level was actually 100 per cent as observed on the oscilloscope. Without the scope if the transmitter level had been increased until the modulation monitor read 100 per cent the distortion would be much too high and the transmitter would be blamed. The modulation monitors checked with the scope from 100 to 5000 cycles.

ART MOORE,
WMCA,
Kearney, N. J.

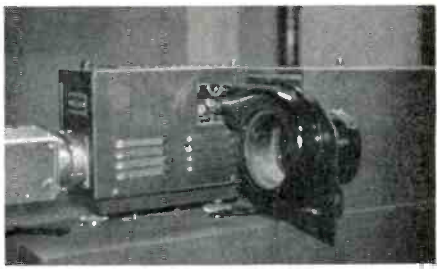
Eliminating Pulse Noise

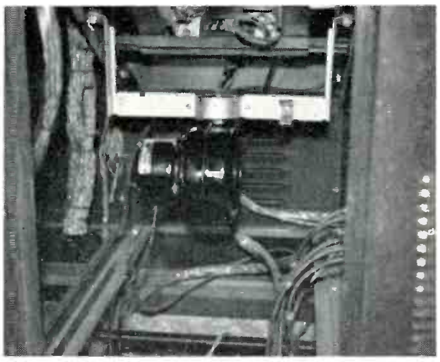
If your station is experiencing pulse noise on "beeper phone" recordings, you might check your news machines. Our machine produced ignition type noise pulses on beeper calls. Either turning off the machine during recording sessions or installing line noise filters on the A.C. line at the machine and/or beeper unit, will eliminate the noise.

JOSEPH KISH, JR.
Chief Engineer, WTIG
Massillon, Ohio

Saving On Replacement Blowers

Expensive miniature blowers and fans can be replaced with industrial type blowers priced at a fraction of the cost of original equipment replacements. The photographs show the low cost motors on a Vidicon camera and on a studio master monitor. As these blowers have more air capacity, we have found that our





equipment is operating much more efficiently. Expensive tube replacement has been cut by 75 per cent. The motors have been in use for approximately one year with no trouble.

CHAMP SMITH,
KARK-TV,
Little Rock, Ark.

Classified

Advertising rates in the Classified Section are ten cents per word. Minimum charge is $2.00. Blind box number is 50 cents extra. Check or money order must be enclosed with ad.

EQUIPMENT FOR SALE

TV VIDEO MONITORS—8Mc., Metal cabinets starting at $189.00. Never before so much monitor for so little cost. 30 different models, 8" thru 24". Miratel, Inc., 1083 Dionne St., St. Paul, Minn. 2-60 11t

TEFLON COAXIAL TRANSMISSION LINE 1⅝", 51 ohm. Unused. Suitable for AM, FM, VHF-TV, Communication Systems, and some Microwave frequencies. RETMA flanges. Write: Sacramento Research Labs., 3421-58th Street, Sacramento 20, Calif. 2-60 6t

Vidicon Tubes Type 6198 New, at bargain rates. All types TV equipment bought and sold. Al Denson, Box 85, Rockville, Conn. 4-60 3t

Gates BFE-10A 10 watt FM transmitter/exciter. Used on an average of 25 hours per week for eight months of each of the past three years. Good condition. Address inquiries to: WXPN, 3417 Spruce Street, Philadelphia 4, Pa. 6-60 1t

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Cambridge Crystals Precision Frequency Measuring Service. Specialists for AM-FM-TV. 445 Concord Ave., Cambridge 38, Mass Phone: TRowbridge 6-2810. 3-60 12t

AM, FM, TV Applications, proofs, measurements. Paul Dean Ford, Broadcast Engineering Consultant, 4341 South 8th St., Terre Haute, Ind., Crawford 4496. 4-60 6t

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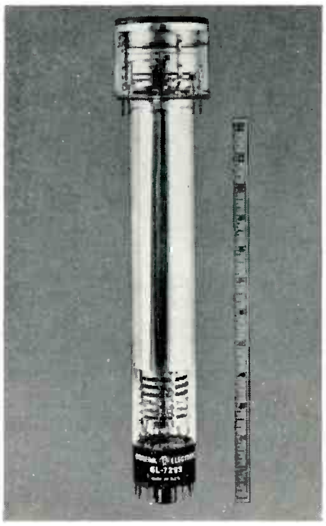
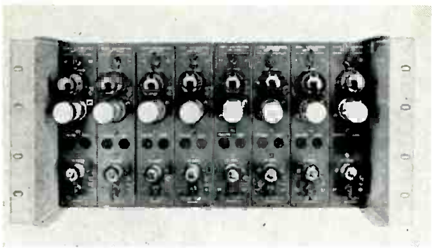
Product News



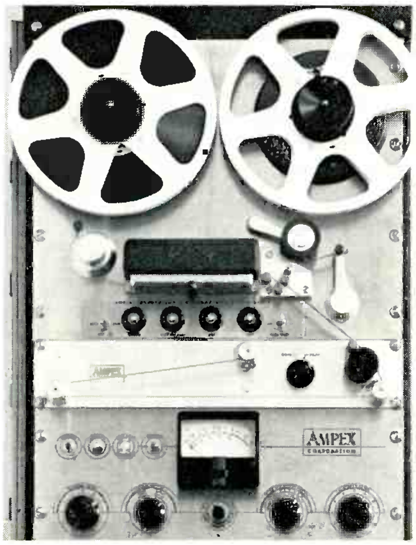
NEW IMAGE ORTHICON

A new image orthicon tube, type GL-7293, has been introduced by the General Electric Co. The new tube minimizes portholing and edge-effect, both of which are noticed using the standard 5820 according to General Electric. A field mesh in the scanning section of the new tube is responsible for the improvement. The electrical effect of the field mesh is to improve beam landing by creating a more uniform electric field in back of the target. This minimizes landing and shading errors, reduces geometric distortion, and provides sharper transition from black to white without spurious effect. Corner resolution in the monitor presentation is nearly as sharp as at the center of the picture. Features of the new tube make it easier for television directors and camera crews to set up a picture, because fewer adjustments of camera controls are needed for optimum performance. The GL-7293 is interchangeable, electrically and physically, with the 5820, but differs slightly in construction and operation. The new tube is designed primarily for studio use, and for outdoor pickup where light levels are adequate. Utilizing a glass target, the new tube has a photocathode identical to that of the 5820. Spectral response is close to that of the human eye, which enables the new tube to portray tonal gradations accurately.



VIDEO DISTRIBUTION AMPLIFIERS

A completely new line of modular amplifiers for color and black-and-white video distribution is now available from the Daven Co., Livingston, N. J. One or a combination of the new video amplifiers will solve the majority of commonly encountered video distribution problems, according to Daven. Four examples of the units in the VA line are the VA-P-101 Video Distribution Amplifier developed for systems requiring a simple one input, one output unity-gain unit, eight of which can be mounted into a shelf 8¾ inches high which mounts in a standard relay rack; the type VA-P-102 Sync Adding Amplifier which allows sync to be added to one or more distribution amplifiers; the VA-P-103 Video Distribution Amplifier which is a one input one output unit with a nominal gain of 3 db and is intended to compensate for equalizer losses and the VA-P-201 which is a multiple output type of amplifier for simultaneously feeding 3 identical signals to several different points. All are plug-in models. A new four-page folder containing complete technical information on the entire line is available from Daven. Address requests to Mr. E. L. Grayson, the Daven Co., Livingston, N. J.



DELAY LOOP

A new delay loop accessory for Ampex recorders is available from Ampex Professional Products Co., Redwood City, Calif. The unit is intended to provide protection to broadcasters in airing live telephone interviews. The few second delay time allows the moderator to monitor the program before playing back the recording on the air. The accessory panel contains an additional playback head and idler plate.

HIGH-POWER WATER LOADS

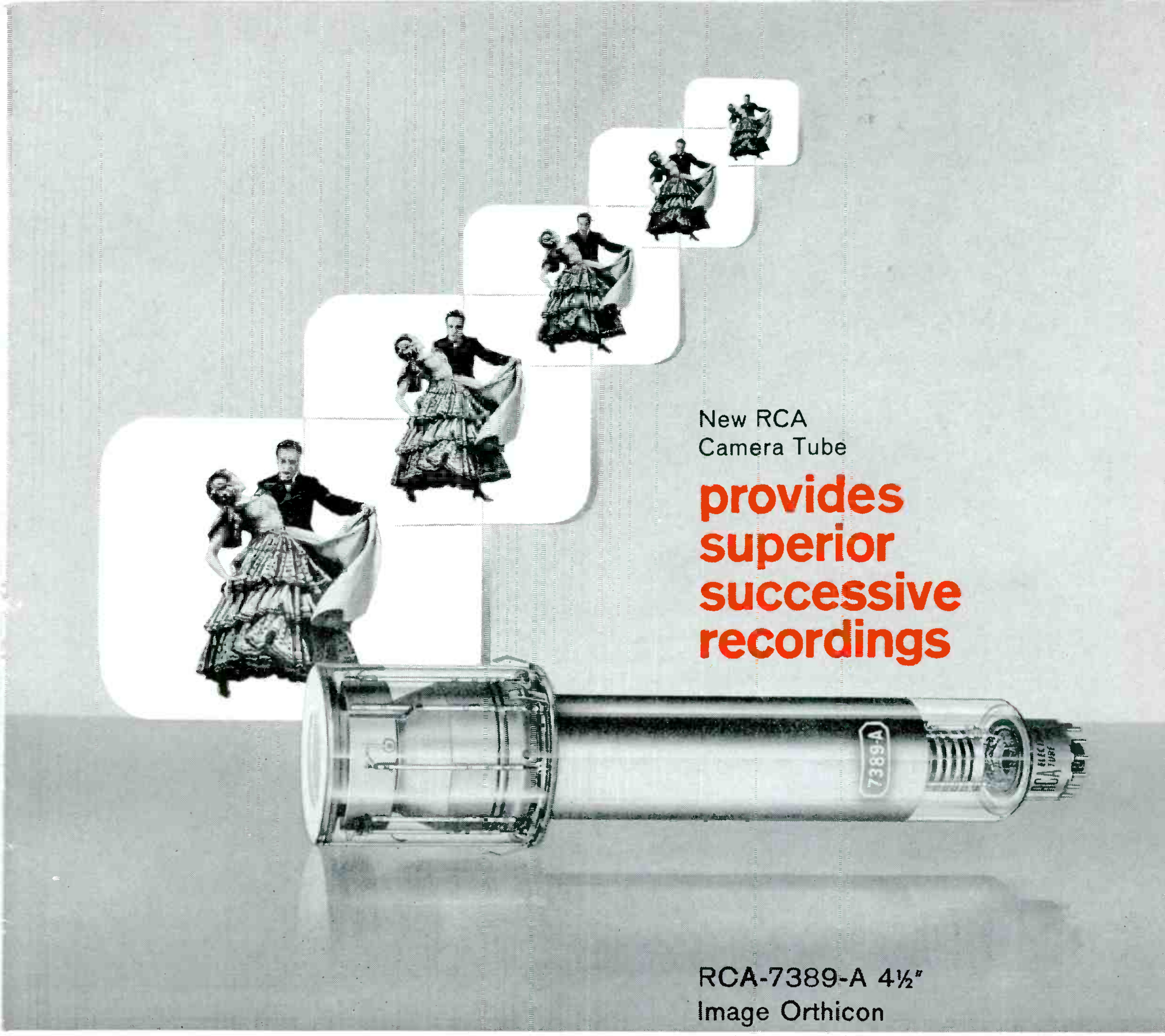
Three new high-power water loads of the 3⅛-inch, 50-ohm coaxial type are now being produced by Eitel-McCullough, Inc. The dummy loads provide flat terminations and accurate RF power measurements for high-power UHF transmitting equipment. An RF sampling probe is included. The three units have EIA standard RF connections and standard water-hose connections. The loads have been tested to over 50 KW average power. Additional information can be obtained from Eitel-McCullough, Inc., San Carlos, California.

NEW DYNAMIC MICROPHONE

A new dynamic cardioid microphone is now available from Electronic Applications, Inc. Stamford, Conn. The AKG D 11 N covers the full audio spectrum and offers a bass-attenuation switch for voice that cuts 8 db at 200 cycles when needed. Sensitivity is 2.5 microvolts per millibar at 1000 cps and the cardioid pattern provides —15 db attenuation at 180 degrees. The mike has a molded high-impact-polystrol case, a built-in folding table stand, a receptacle for a standard miniature 3-pin plug, and four foot shielded cable. The mike is unaffected by temperatures from —20 degrees to 160 degrees. The microphone is imported from Vienna by Electronic Applications.

BROADCAST STEREO EQUALIZER

Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill., has introduced its M66 broadcast stereo equalizer which enables stations to compensate for the recorded frequency curve of stereo as well as monophonic recordings. It provides a choice of RIAA, flat, and roll-off playback characteristics. The second control lever shown provides a selection of monophonic or stereo positions.



makes possible good broadcast-quality pictures even after a series of successive recordings

If successive recording quality is a major problem with you, a 4½" camera equipped with an RCA-7389-A Image Orthicon will give you the initial picture quality you need to overcome it. The picture signal provided by this new 4½" camera tube is of such excellent quality that it permits a series of successive high quality recordings. The large target area makes possible a much higher signal-to-noise ratio, greater resolution and better half-tone values than any 3-inch tube can produce.

For live broadcasting, however, or making copies from a single master, you need look no further than RCA's regular line of performance-proved 3-inch Image Orthicons. Whether you're programming in color or black-and-white, there's a standard RCA camera tube to do the job—and give you better picture quality than that provided by the best TV receiver. The new RCA-7513 Image Orthicon, for instance, can be used either for color or black-and-white, and provides sharp, noise-free pictures remarkably free from "halo" and edge effects and having excellent corner resolution.

Your local RCA Distributor of broadcast tubes carries a complete line of RCA Image Orthicons. Get in touch with him for full information on any type you may need, or write RCA Commercial Engineering, Section F-115-0, Harrison, N. J.

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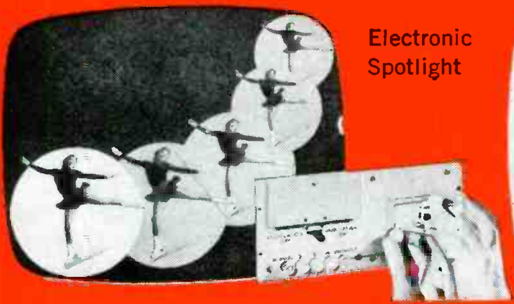
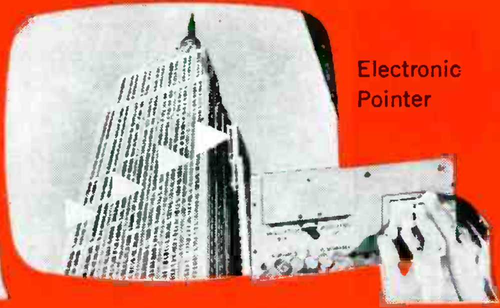


Electronic Spotlight



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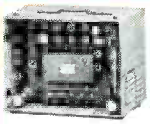
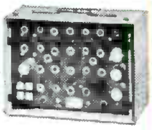
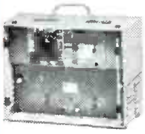


490WA1 Waveform generator. Generates keying signals for the 72 different wipes.



490SA1 Switching Amplifier. Combines two picture signals in accordance with applied keying waveform.



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