NRI news

October/November 1962

Courtesy U.S. Air Force

F-104A "STARFIGHTER" ARMED WITH WINGTIP-INSTALLED SIDEWINDER GUIDED MISSILES. THIS IS AN EXAMPLE OF INFRARED TECHNOLOGY. IN THIS ISSUE WE HAVE AN INTERESTING ARTICLE ON THIS SUBJECT. **SEE PAGE ONE.**

ALSO IN THIS ISSUE

NRI NEWS

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Editorial: QUALITY

When buying, you demand the quality you pay for. When the shoe is on the other foot and you are rendering service, shouldn't you be just as concerned with quality?

Your livelihood depends upon the quality of your work. Obviously, if you do superior work and thereby bring in more money for your employer, you will deserve a better salary and will have greater job security. And, likewise, the shop owner who makes the decision to render only high quality service will enjoy greater prestige than his brothers who are content to work at minimum standards.

Now, in addition to good pay, you should hope to get something extra called job satisfaction from your work. Many factors work together to determine the amount of satisfaction you receive from your job, but the two most important are a feeling that the work you are doing is worthwhile and that your employer and customers are happy with its quality. Consistent, high quality workmanship will earn for you the recognition and praise essential to a high level of job satisfaction.

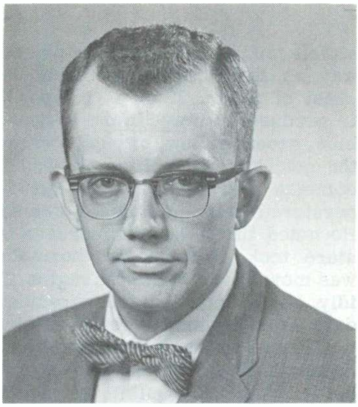
Some of you may feel that going the "quality route" will reduce your work output. This need not necessarily be the case, for many factors such as soldering techniques, proper use of tools, use of efficient troubleshooting techniques, etc. have an important bearing on the quality of your work and may actually reduce servicing time. You will also find that doing only high quality work will greatly reduce the number of "call-backs" which in itself represents a time saving.

Remember, that in rendering high quality service, you are merely applying the "Golden Rule" to one more area of your daily living.

J. M. Smith
President

About our cover .... "AND CARRY TWO BIG STICKS" -- newest aircraft-firepower combination of U. S. Air Force is shown in this in-flight photo of the F-104A "Starfighter." Now entering service with the 83rd Fighter-Interceptor Squadron at Hamilton Air Force Base, Calif., Lockheed's superswift "Starfighter" packs a Sidewinder on each wing, providing double knock and punch for defense of America's homeland. The seek-and-destroy missiles use an infrared tracking device to "home in" on targets. Able to climb as fast as it flies straight and level, the "Starfighter" is powered by General Electric's J-79 turbojet engine.

The Fundamentals of Modern Infrared Technology



by Hugh R. Carlon

U. S. Army Chemical Research and Development Laboratories Army Chemical Center, Maryland

Mr. Carlon is a graduate chemical engineer who completed the NRI Course concurrently with his college education. He then accepted a position in professional electronic work with the U. S. Army Chemical Research and Development Laboratories. A chance train meeting with NRI's Director of Education, Mr. Dunn, showed that it is a pretty small world and led to the preparation of this exclusive NRI News article, "The Fundamentals of Modern Infrared Technology."

An air-to-air missile streaks accurately to its target. . . an earth satellite transmits important ground observations to its tracking stations. . .a crime detection laboratory determines the chemical composition of a fragment of paint. . .an invisible cloud of highly poisonous gas is detected before it can reach unsuspecting persons in the area. . .a huge rocket thunders from its pad at Canaveral on a perfectly controlled course. . .an accurate determination is made of the temperature of the moon's surface. . .. Though seemingly unrelated these are all specific examples of infrared technology in action. Each depends upon the use of "light" invisible to the human eye, yet constantly radiated by every living and inanimate thing around us. More properly, infrared may be thought of as "heat radiation."

Most of us have at some time observed the spectrum of colors produced when a glass prism is placed in a beam of light. It is a

Christmas Suggestions

Each year, as the holiday season approaches, we receive many inquiries from students, graduates -- their friends and relatives -- who want to buy a particular test instrument, tool or accessory as a Christmas present.

Whether you're a full or part-time technician, hobbyist or beginner, our CONAR DIVISION offers a complete line of nationally-known instruments and other quality products to fit any pocketbook.

To help you in making a selection (and dropping hints to the wife or girl friend), this issue of NRI News and the next will feature a listing of suggested gifts for NRI men. See pages 14, 15, 16, and 19. If you have a particular item in mind which is not listed here, watch for it in the December-January issue -- to be mailed about November 20th.

Use CONAR'S convenient payment plan if you wish -- just 10% down -- terms as low as $5.00 per month. You'll find an order blank for cash or time-payment orders on page 17.

A relative or friend may order for you. We'll ship to any address you designate. But as a suggestion, place your Christmas order early. Mail moves a bit slow during the holidays. Rest assured, we'll do everything possible to speed things along -- and help you have a truly Merry Christmas!

simple matter to orient the prism in such a way as to cause the spectrum to fall on a sheet of paper. Thus, a "rainbow" of colors is produced, always in the sequence: Violet, blue, green, yellow, orange, and red. In 1800, the scientist Sir William Herschel, using a common thermometer, measured the temperature of various portions of this spectrum. He noted that a general increase in temperature took place as the thermometer bulb was moved toward the red region. Then, quite idly, he continued his measurements into the dark area beyond the red and was astounded to find that the temperature was considerably higher in this area than in any of the visible color regions. Quite by accident, "the infrared" had become known to science.

Fig. 1 is a representation of a portion of the infrared region (and all the visible region) of the electromagnetic spectrum. We are dealing here with radiation exactly like radio and television waves, x-rays, radar beams, and the like. However, we customarily classify these portions of the spectrum in terms of wavelength rather than frequency, not unlike the ham operators' designation of the "20-meter band". We see in Fig. 1 that portion of the spectrum from 0.4 to 10 microns in wavelength, one micron being equal to 0.000001 meter. We are thus concerned here with the electromagnetic spectrum from 0.0000004 to 0.000010 meter in wavelength. The figure shows that portion of the spectrum, extending from 0.4 to 0.7 micron, to which the human eye is sensitive. Note that the peak radiation power occurs in the infrared so that:

Equation 1 $$W = \frac{2960}{T + 273}$$

where W is the wavelength in microns at which peak radiation occurs and T is the temperature of the radiating source in degrees Centigrade. Suppose, for example, that a "Globar" resistor, (a common infrared source), is heated electrically to 1330°C. Equation 1 states that the energy peak will occur at about 1.8 microns. Fig. 1 shows that only the left-hand "tail" of the energy curve will appear in a region of the spectrum to which the eye is sensitive. The observer will conclude that the source is "red hot" simply because his eye responds only to that energy "spilling" past 0.7 micron into the red portion of the visible spectrum. Similarly, a tungsten lamp filament at 2600° C looks "white hot" because its energy curve overlaps the entire visible spectrum, emitting all colors in abundance. Any source at a temperature below that which will produce sufficient energy to stimulate our eye is said to emit no light, although such a body may actually emit an enormous amount of infrared energy.

Infrared targets are normally classified as "passive" or "active". Passive targets depend on naturally-occurring radiation arising from their normal temperatures. Buildings, airstrips, and the surfaces of the earth and moon would be designated as passive targets. Active targets are so named since some fuel or power source is required to maintain them at an artificially high temperature. Active targets include jet exhausts, Globar resistors, and fires. An infrared detector must

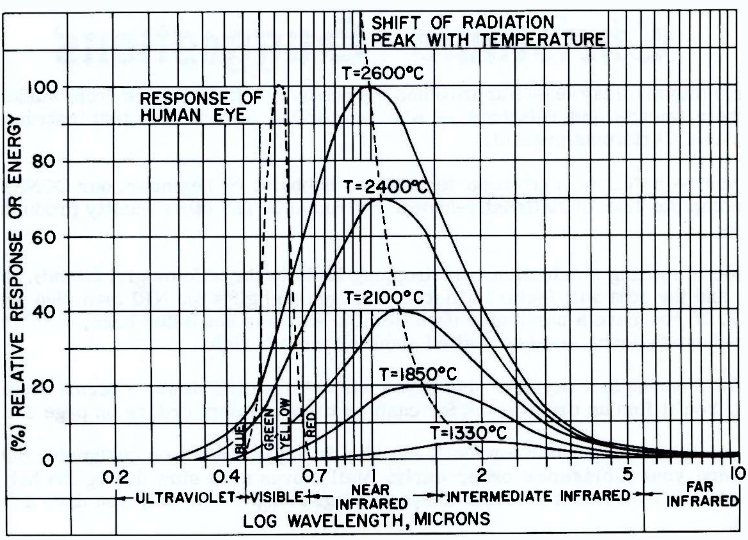


FIG. 1. The Visible and Infrared Spectrum.

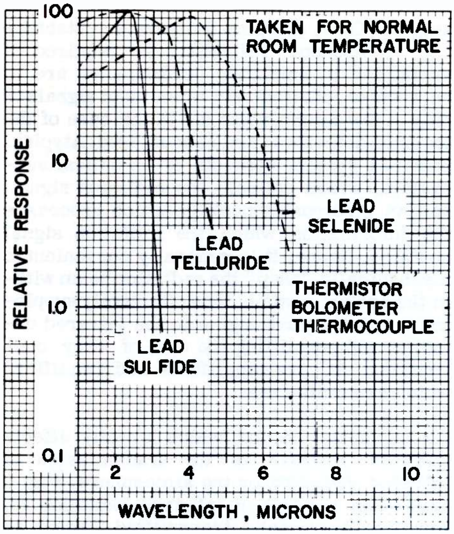


FIG. 2. Spectral responses of various infared detectors.

sense the presence of infrared radiation from any of these sources in much the same manner as the eye senses visible radiation. The application for which an infrared system is designed will determine whether an active or a passive target will be available.

Photocell devices are found in numerous pieces of equipment which use white light signals to open doors, count items, turn on appliances, and so forth. But photocells are usable only into the very "near" infrared region, having little value beyond about 1 micron. Special infrared detectors have been developed for use in a rapidly growing multitude of infrared gear. (See Fig. 2).

"Thermal" detectors depend upon the heating effects of infrared for operation. This type includes the thermistor bolometer and thermocouple. The thermistor bolometer (Fig. 3) consists of two tiny flakes of blackened oxides of manganese and nickel, each less than 10 microns thick, mounted in a small button about 5/8" in diameter. An infrared-transmitting window is hermetically sealed across the button, and the unit is evacuated. One flake is covered with a shield to protect it from radiation while the other is exposed to the infrared signal. The two flakes are connected in two arms of a bridge circuit (Fig. 4A) and biased by a center-grounded battery. The flakes have a resistance of about 2 megohms each, but this resistance is very dependent upon temperature. A change in radiation reaching the active (unshielded) flake as opposed to that reaching the compensating (shielded) flake will cause an unbalance voltage to appear at the input capaci-

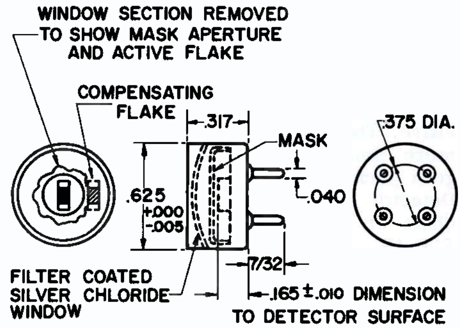


FIG. 3. Detector - preamplifier connections.

tor feeding the preamplifier stage. If the radiation signal is interrupted at a regular rate, or "chopped", an AC signal will be produced. The amplitude of this signal will be in direct proportion to the energy content of the infrared signal. A detector of this type can respond to "chopping frequencies" of 20 or 30 cps before its response begins to fall off, but is useful even at frequencies of 100 cps or more. The compensating flake offsets the effects of changes in ambient temperature on the detector.

The thermocouple is an old but very useful thermal detector. The junction of two dissimilar metals will produce a voltage, when

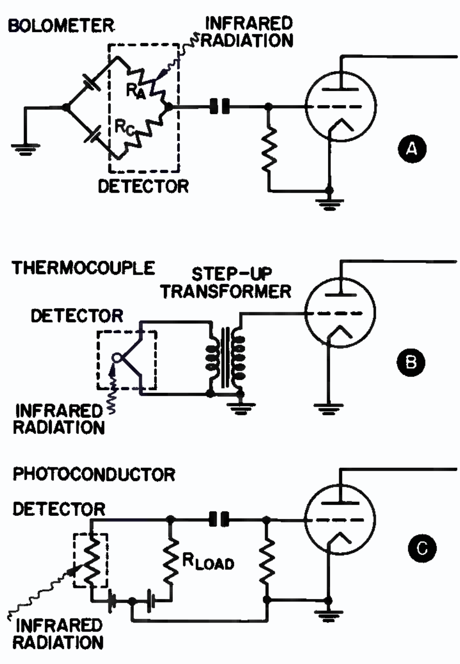


FIG. 4. Thermistor bolometer detector.

heated, which is proportional to the degree of heating. Such a junction is housed in an evacuated button similar to that described for the bolometer. By careful design, couples may be produced which are rugged and sensitive. The chopping frequency is somewhat more limited for this detector, permitting good performance to about 20 cps or more. Detector impedances may be from 5 to 20 ohms or so. A typical circuit is shown in Fig. 4B.

Photoconductors are tiny semiconductor crystals which depend upon the nature of infrared radiation itself to change their electrical resistances. Representative materials include lead sulfide, lead telluride, lead selenide, specially treated germanium, and indium antimonide. Cells made from these materials are generally much more sensitive than thermal detectors (as an example, a lead sulfide cell is easily 100 times more sensitive to radiation than either the bolometer or the thermocouple; see Fig. 2). However, photoconductors are not usable for wavelengths beyond about 7 microns at present. Resistances for these detectors are typically in the hundreds of thousands of ohms, permitting their use in circuitry of the type shown in Fig. 4C. Chopping frequencies of several kc may be used with these cells.

It would be desirable at this point to explain more fully the need for chopping the infrared beam. We know that DC amplifiers are subject to considerable drift, since the operating point of each stage is determined by the voltages and gains of preceding (and, in the case of transistor circuits, succeeding) stages. Thus, extreme temperature stability and component reliability is required if variations in amplifier performance are to be avoided, particularly when input signals of only a few micro-volts (as in the case of the thermal detectors) are encountered. A typical infrared system consists of an optical subsystem, which collects the radiation signal, and an electronics package which processes the information which the radiation signal contains. Hence, it is generally convenient to mechanically "chop" the radiation beam within the optical system, thus effectively supplying a square-wave signal to the infrared detector and permitting the use of very conventional AC pre-amplifiers and amplifiers which are drift-free.

An additional factor which greatly affects infrared systems is the transmission of infrared radiation by the atmosphere. Fig. 5 shows the percent of infrared radiation vs. wavelength normally transmitted through an atmospheric path of one mile. The spectral regions where no infrared transmission occurs are caused by water vapor and carbon dioxide absorptions. For example, no transmission occurs from 5.3 to 7.7 microns, as shown in Fig. 5. By comparison, other spectral regions, as from 7.7 to 14.7 microns, transmit very well. Such regions are called "atmospheric windows."

We may select or reject various portions of the infrared spectrum through the use of infrared optical "filters." Such filters, which are analogous to tuned circuits or combinations of tuned circuits in radio, can be made to transmit desired wavelengths while ab-

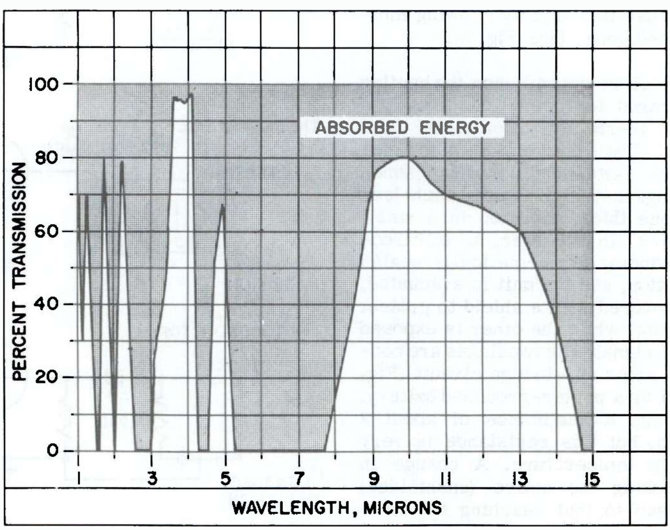


FIG. 5. Normal atmospheric infrared transmission over a one-mile path.

sorbing others, much as does the atmosphere. These filters are simply inserted in the optical system of a given piece of equipment in the same way that sunglasses are placed over the eyes to prevent exposure to undesirable wavelengths. The optical filters permit a great variety of tasks to be performed. Fig. 6 presents a random selection of materials which have been used as filters to date. The curves presented are "transmission spectra," relating wavelength to the percent of total energy incident upon the filter which will be transmitted through it, much as in Fig. 5. As an example, consider the spectrum of the metal germanium (Fig. 6). Suppose that we wish to construct an infrared intruder device which uses a Globar resistor source operated hot enough to be easily visible to the eye. Suppose, further, that a beam of energy from this source is sent out across a broad meadow, reflected from a mirror, and received upon its return by an optical-collecting system containing a chopper. Thus, an AC signal will be produced at the detector, and therefore at the output of the signal amplifier, so long as the beam is unobstructed. If an intruder breaks the beam, the signal will be lost at least momentarily, and we can arrange an alarm circuit to tell us this. Secrecy is an obvious additional requirement for the system. This can be accomplished by placing a wafer of germanium or other suitable optical material over our infrared source, thus removing all visible radiation from the beam while retaining the bulk of the infrared signal.

If this were a military situation, our potential intruder might well have an infrared search set, enabling him to look across our terrain for any source of radiation in the region from 1 to 7 microns (using a photoconductor detector). But we could still conceal our presence if we were to use a long-wavelength (thermal) detector in our device with an indium antimonide filter over the source, thus removing all energy below about 7.2 microns from our beam. Such considerations are constantly explored in the design of military infrared equipment.

With our present knowledge of infrared fundamentals, we are ready to discuss the operation of several more complex types of infrared equipment, equipment such as performs the jobs mentioned briefly in the introductory remarks of this article.

Many laboratories are interested in determining the chemical composition of samples brought to them for analysis. The infrared spectrophotometer provides a quick means for making such determinations. It is based on the principle that virtually every known substance has an infrared spectrum all its own. Its spectrum is so unique that it may be called the "fingerprint" of the substance. The spectrophotometer is an instrument which sweeps through a range of infrared wavelengths (frequencies) while recording the percent of radiation at each wavelength which is transmitted by the sample, in exactly the same manner as we might obtain the frequency response curve of an audio amplifier by sweeping an audio oscillator connected to its input through a desired range while observing and plotting the corresponding output voltages using a VTVM. Fig. 7 shows the

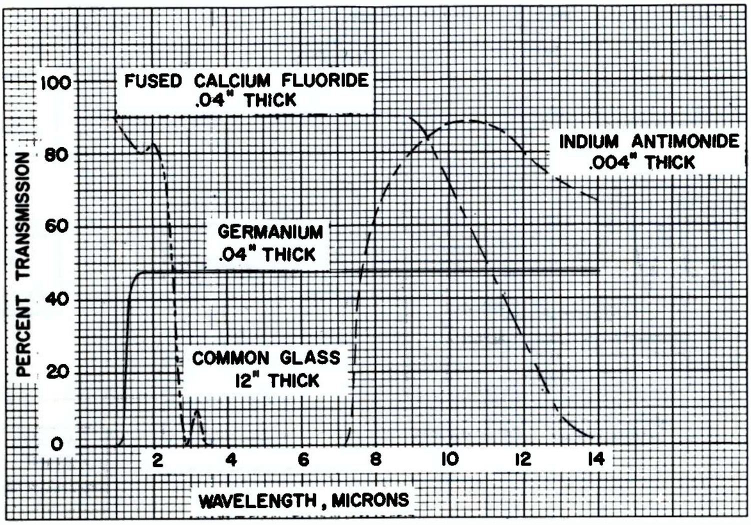


FIG. 6. Infrared transmission curves for various materials.

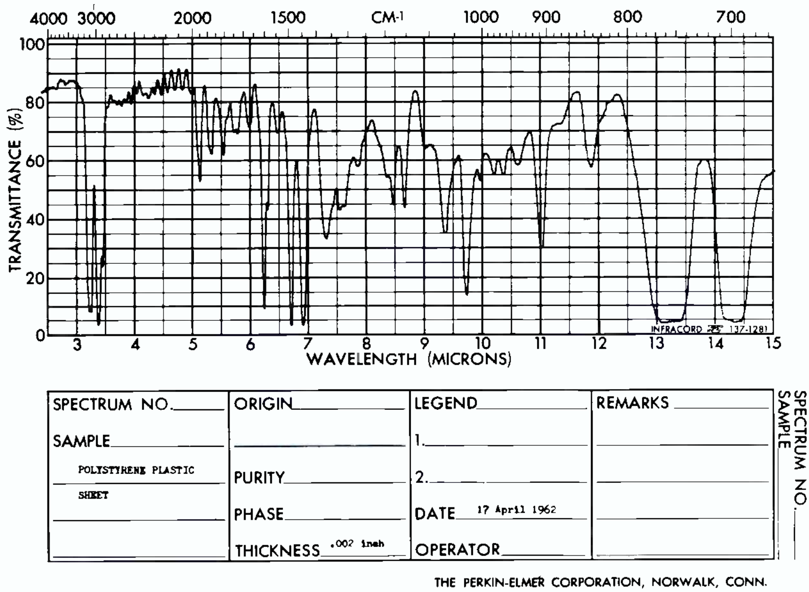


FIG. 7. Analytical infrared spectrum.

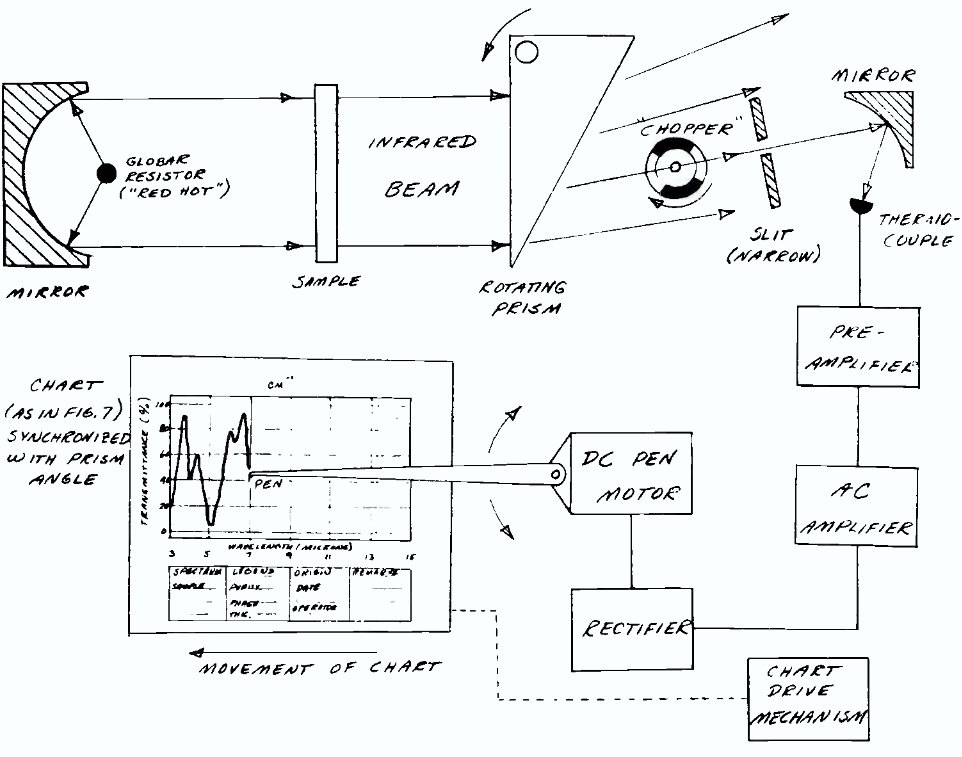


FIG. 8. Simplified infrared spectrophotometer.

infrared spectrum thus obtained for a sheet of clear polystyrene plastic (such as is used in business envelope windows, candy boxes, and so forth). No other material has a spectrum exactly the same. The many absorption bands are due to inter-atomic and molecular structures within the plastic.

A very simple spectrophotometer is diagrammed in Fig. 8. The prism, which spreads the infrared beam into a spectrum (just as Herschel observed in the visible region during his measurements) is rotated slowly in synchronism with the chart drive mechanism. The "fan" of radiation (the spectrum) is thus swept over the slit as the prism moves. A very narrow wavelength band is all that can reach the thermocouple detector by passing through the chopper at any given time. Thus, a spectrum of almost pure wavelengths is "seen" by the detector as scanning proceeds, and the pen records the amount of absorption at each wavelength by the unknown sample in the beam. The entire spectrum is recorded automatically in about 10 minutes.

Another widely-used infrared instrument is the temperature-measuring two-color pyrometer. A simplified diagram of such a device is shown in Fig. 9. Radiation from a furnace or other very hot or inaccessible active target is received by the instrument and examined at two specific wavelength bands to determine the ratio of energies emitted by the target at these wavelengths. Since the target radiation will have an energy distribution dependent upon its temperature as shown in Fig. 1, the ratio of energies for two known wavelengths will correspond to only one such possible curve. Hence, the ratio circuit may be calibrated to read temperature directly on a suitable meter or recorder.

When it is desired to transmit infrared signals over distances of hundreds of yards or many miles, attention must be paid to the atmospheric transmission spectrum (Fig. 5) discussed previously. Suppose we wish to build an instrument which will warn us of the presence of a toxic gas which is colorless in the visible, but has a strong absorption band at 11 microns. We can build an infrared receiver similar to the pyrometer which we have discussed, with the differences that we would use a thermal detector, and would select our optical filters to transmit a band near

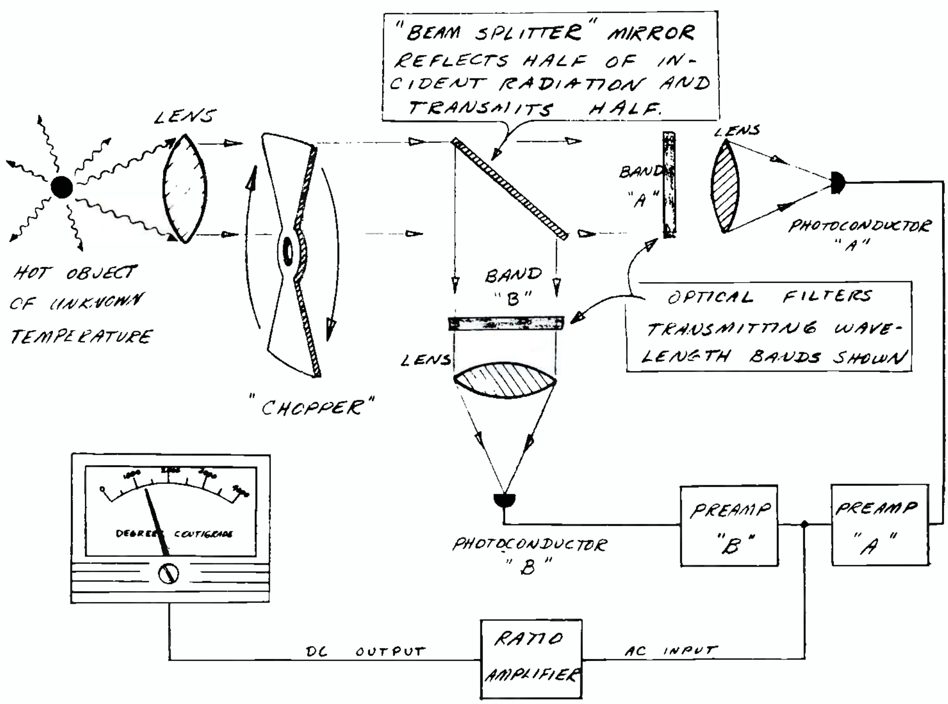


FIG. 9. Simplified color pyrometer.

11 microns and another at a wavelength where the gas has no absorption. . .say, 10 microns. Although the gas may have other, even stronger, absorption bands in other portions of the infrared spectrum, we shall select the 11 micron region since it lies within an "atmospheric window". Here we may operate almost continuously without fear of losing our signal due to atmospheric absorption or even fairly heavy fog. If we transmit our infrared beam over a path of, say, 500 yds., and then examine the ratio of energies at the two wavelengths selected in our receiver, we can tell immediately whether any of the toxic gas is present in the beam. If gas were there, the 11 micron band would be partially absorbed and our ratio device would tell us this. On the other hand, if both our wavelengths should disappear or become diminished simultaneously, we would look for a solid object blocking the beam rather than suspect the presence of the gas. Thus our "reference" wavelength at 10 microns gives us a better idea of what is actually happening than would a single 11 micron band by itself.

By far the most "glamorous" aspects of infrared technology include heat seeking rockets, trackers (devices for determining the course of large rockets at launch), and reconnaissance earth satellites. Most of us have heard stories concerning the "Sidewinder" air-to-air missile and its incredible record of effectiveness. Launched from a jet fighter at any enemy jet fighter or bomber, this little missile will frequently burrow right into the afterburners of its prey before detonating its explosive charge. This missile uses choppers, photoconductor detectors, optics, and electronics very similar to those we have discussed. The principle is simple, really. The main "eye" is located beneath a special protective glass dome in the nose of the missile. At launch, the eye affixes itself on the jet plume of the enemy aircraft to be destroyed. If the missile is off course, correction signals are developed in servomechanisms which control the "steering" fins near the Sidewinder's nose. The correction signals continue until the missile has reached its mark. It is difficult to underestimate the Sidewinder's ability if you have watched its eye follow the movements of a lighted cigarette several hundred feet away. Even with the missile so demonstrated comfortably resting on a display pedestal, it gives one an eerie feeling to watch the steering fins move in imagined flight.

Infrared trackers play an important role in the launching of virtually every major American space vehicle. Radio and radar communications are often unreliable during blast-off and initial flight of a huge rocket. Since the inertial guidance systems which will determine the rocket's heading with fantastic accuracy do not always function perfectly, it is necessary to monitor the rocket's path during flight to verify the trajectory. Infrared trackers perform very satisfactorily with active targets of such fantastic energy content as is available in rocket plumes, and are unaffected by the launch itself. And, of course, rockets monitored at lift-off by infrared trackers can deposit satellites such as Tiros (the weather satellite) in orbit, satellites stabilized in their flight by infrared horizon sensors.

The author has attempted in this brief article to present a background of infrared technology on which discussions of existing infrared equipment could be based. It is hoped that the reader will derive from these paragraphs an awareness of the present capabilities of this comparatively new science.

ARE YOU MISSING ANYTHING?

Have you ever asked yourself what the things are that you want most out of life? That is the first step one has to take to get them! Most of us drift with the stream we happen to be in, because drifting is easy. Changing requires imagination, initiative -- and courage.

Being restless is no crime, but doing nothing about it can be -- a crime against our self-respect and our status as free human beings. Of course there may be circumstances you can't change, no matter how much you wish you could. But have you tried? It is the effort you make -- the attempt -- that tests your character.

Maybe you are getting all you want out of life; maybe you like things just as they are. There's nothing wrong with that. Making money, perhaps, is all it takes to keep you happy. On the other hand, possibly you are missing something even more satisfying. Isn't it a good idea to find out?

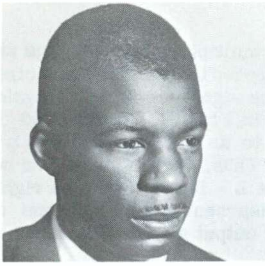
TIME OF THE SIGNS

Tired of having small foreign cars take up valuable space, a Texas hotel has added a special parking lot. It's called "Ellis Island."

SIGN on a steep mountain grade, "Speed limit 30 mph. Compacts, do your best."

. . . on an Idaho roadside, "Don't Just Sit There, Nag Your Husband!"

. . . at an Illinois railroad crossing, "Average train passes this crossing in 14 seconds -- whether your car is on it or not."



FM Multiplex Stereo

By
Harry Taylor

NRI STAFF

FM stereo multiplex, in general terms, is a system in which one FM station can transmit full stereo.

Stereophonic sound, as you know, requires at least two separate audio paths which are commonly referred to as "audio channels." Each of these channels consists of a microphone, a medium to carry the signal and a loudspeaker to reproduce the sound. A simple stereo system such as you might find in an auditorium is shown in Fig. 1.

Notice that the loudspeaker on the left side of the auditorium is connected to the microphone on the left side of the stage and the microphone and loudspeaker on the right are also connected together; the sound picked up by each microphone is reproduced by the loudspeaker associated with it.

Any sound, such as a person speaking, playing a musical instrument, or singing at position "X" on the stage would be picked up equally by both microphones, since both microphones are the same distance from the source of the sound. The audio output at both loudspeakers then would be the same. If a listener were at position "A" in the audience, he would hear the sound coming from both loudspeakers with equal volume. His directional sense of hearing would tell him that the sound is coming from the center of the stage.

Sound originating at position "Y" would be stronger at the left microphone and the left loudspeaker. This would indicate to the listener that it is coming from the left side of the stage. The opposite would be true of the signals if the source were at position "Z." The greater level of sound would be picked up by the right microphone and reproduced by the right loudspeaker.

Regardless of the particular system used, stereophonic reproduction must have two separate audio channels so that the listener will know the direction as well as the volume, tone, etc., of the sound.

In this basic stereo system, we have shown wire or cable connecting the various units together. The use of wiring definitely limits the distance between the performance and the listener. The listener must be near the performance when it takes place. The use of recording tape and discs and radio transmission extends the range of stereo listening far beyond the practical limits of any wire or cable circuit.

Until recently, it was necessary to use recordings or two radio stations and two receivers to provide stereo. FM multiplex stereo offers better service than could be made available through FM-AM stereo and at less cost than with either tape recordings or discs.

If you had only the FM or AM receiver and were tuned to an FM-AM stereo broadcast, you could hear only the sound being picked up by one of the two microphones on the stage. In effect, you hear only "half" of the broadcast. In the FM multiplex system, the listener with an ordinary FM receiver would hear the sound from both microphones as if it were a regular monophonic broadcast; the listener with an FM stereo system would hear the two separate audio channels.

As you will see later, FM stereo transmission has built-in compatibility. This was one of the prime considerations when the system was adopted.

The audio signals picked up by the two microphones are fed into a unit which "encodes" them or changes their form. The coded sig-

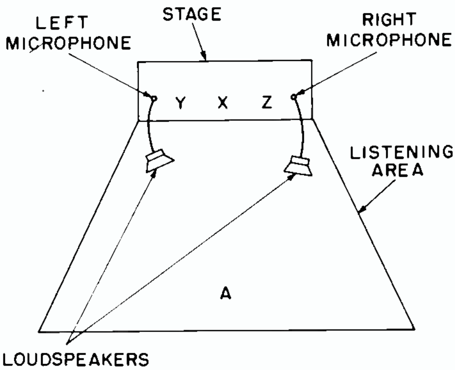


FIG. 1. Basic stereo system.

nals are (1) the combined outputs from both microphones and (2) an additional signal which carries the information as to which channel or microphone is closer to the source of the sound. These two outputs of the encoder are fed into the FM transmitter and transmitted as a complex signal. Any FM receiver tuned to the proper frequency can pick up the signal. A regular FM receiver, however, cannot decode the complex signal; it can only reproduce the main channel. Since the combined output of the two microphones is sent on the main channel, the receiver reproduces the sound as if it were a monophonic broadcast.

An FM receiver which is specially adapted to decode the stereo will, when tuned to the same station, pick up both the main channel signal and the sub-channel signal. The latter is necessary to route the signal to the proper audio amplifier and loudspeaker.

At the broadcasting end of the stereo multiplex system, the signals from the two microphones are fed into a "matrix" circuit. This circuit changes the two individual audio signals into a sum signal and a difference signal. For illustration, a simplified matrix circuit is shown in Fig. 2. Notice in Fig. 2A that the microphones feed into a resistor network which adds their signals. The input voltages add across the network to form a signal of greater amplitude. Thus, the L + R signal which we have shown is actually very much like the signal broadcast by a monophonic system.

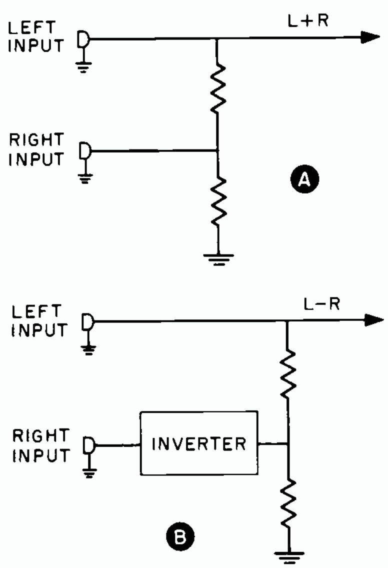


FIG. 2. Simplified matrix circuit.

In stereo multiplex, however, the same audio signals are fed into an additional circuit which inverts the signal from the right microphone, as shown in Fig. 2B. The inverted "R" signal, referred to as "-R", is fed into a resistive network. Thus, the output of the network in Fig. 2B is L - R, or left minus right signals. Three resprsentative conditions of matrix input and output signals are shown in Fig. 3.

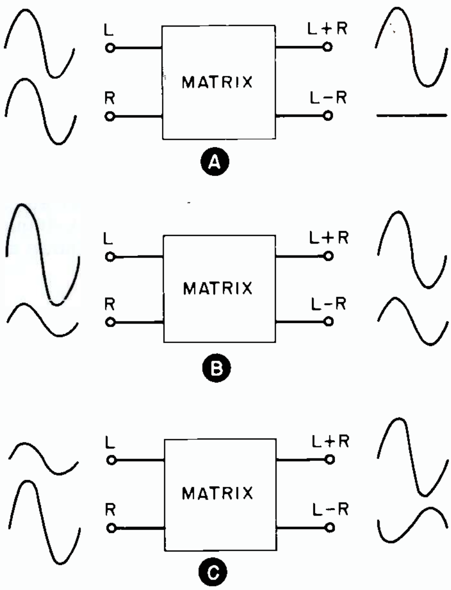


FIG. 3. Matrix input and output signals when (A) L is equal to R, (B) L is greater than R and (C) when R is greater than L.

If both microphones pick up identical signals, the inputs would be identical, as shown in Fig. 3A. The two signals would add to form the L + R and subtract to form the L - R. Note that there is no difference signal.

When the left input signal is greater than the right signal, as shown in Fig. 3B, the L + R is the sum of the two. The difference signal is the lower amplitude right input signal subtracted from the left input. The L - R then is in phase with the sum signal, but of lower amplitude.

The third example (Fig. 3C) shows a strong signal from the right microphone and a weak left microphone output. The L + R is identical to the L + R signal in Fig. 3B. The L - R or difference signal, however, is reversed in phase. The right signal is predominant. Thus, the L - R reflects this condition.

Regardless of whether the left or the right microphone is closer to the source of the sound or if the distances are equal, the

L + R will be the sum of the two microphone output signals. Except for total amplitude, the L + R is very much like the output of a monophonic system.

From the matrix, the sum and difference signals are sent ultimately to the FM transmitter. To prevent interference between the two signals, the L - R is put on a subcarrier before transmission. The L - R amplitude modulates the 38 kc subcarrier in the 38 kc modulator. This is illustrated in Fig. 4.

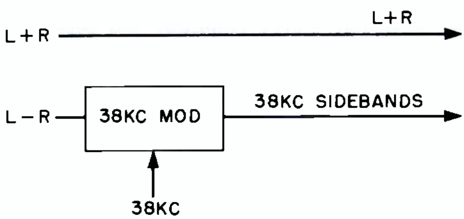


FIG. 4. Diagram showing L-R signal path.

The subcarrier modulation is usually performed by a balanced modulator circuit. When both the subcarrier and the L - R are fed to the circuit, a double sideband suppressed carrier signal appears at the output. If, however, no L - R is present, the subcarrier is balanced out and no output signal results.

If you are familiar with amplitude modulation, you know that a large percentage of the AM transmitter output power goes into the AM carrier. Since the carrier contains no information, this is wasted energy. Another advantage of suppressing the 38 kc subcarrier is that, unless there is a difference in the signals picked up by the two microphones, there is no L - R and no 38 kc signal at the transmitter. Therefore, more of the transmitter power can be used for the L + R.

A block diagram of a multiplex transmitting system is shown in Fig. 5. In the diagram you can see that the 38 kc subcarrier is actually the output of a 19 kc oscillator which has been amplified and doubled in frequency. The 19 kc is then fed to the mixer along with the L + R and the L - R sidebands which were produced by the subcarrier modulator.

The mixer in Fig. 5 is in reality a linear adder. It adds the voltage levels of the three signals without altering the signals themselves. Thus, at the input to the transmitter, the multiplex stereo signal consists of 19 kc and the two sidebands of 38 kc superimposed on the L + R signal. This composite signal is then transmitted.

Each of the three signals modulating the FM transmitter occupies a separate band of frequencies within the transmitter frequency spectrum. Notice in Fig. 6 that the L + R lies within the range of 50 cps to 15,000 cps, the 19 kc signal is 4 kc higher and the L - R sidebands are from 23 to 53 kc. FM transmitters are capable of transmitting frequencies up to 75 kc. Thus, all three signals required for stereo can be transmitted without interfering with each other.

Earlier we stated that the stereo receiver must be able to decode the composite signal in order to reproduce the full stereo signal. Let us see how this is accomplished.

When the receiver is tuned to a station transmitting stereo multiplex, it picks up the FM carrier. The rf and i-f stages select and amplify the modulated carrier. The demodulator stage which follows removes the modulation from the carrier. In the case of stereo reception, the output of the FM demodulator is the composite signal which was present at the output of the mixer at the transmitter.

A low-pass filter (known as a de-emphasis network) is provided at the output of the demodulator in a regular FM receiver. This

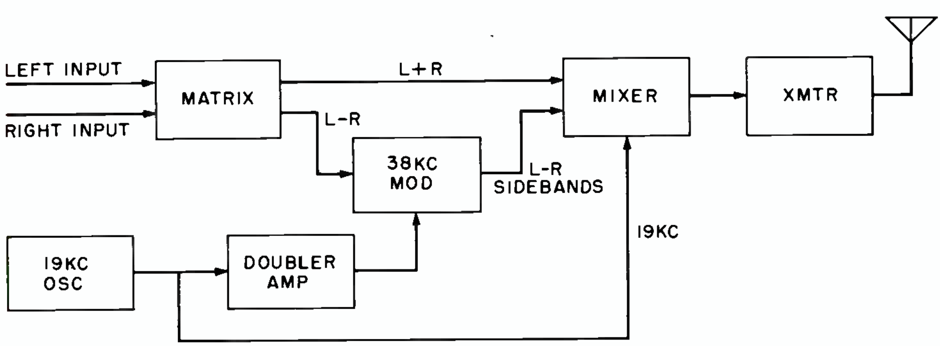


FIG. 5. Block diagram of stereo multiplex transmitter.

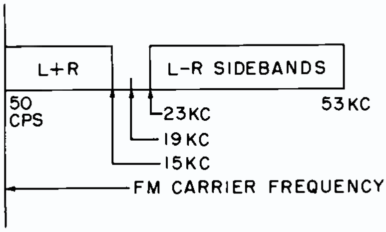


FIG. 6. Frequency distribution of FM multiplex signal.

filter passes only frequencies below about 15 kc. Thus, only the L + R is amplified by the audio section of the receiver and fed to the loudspeaker.

No de-emphasis network is employed at the output of the demodulator in a stereo receiver. The output consists of any signals which modulate the transmitter. The full range of frequencies is fed to the multiplex decoder unit commonly called the multiplex adapter.

The multiplex adapter has one basic function -- to recover the stereo signals which were picked up by the two microphones. To do this, the multiplex adapter separates the sum, difference and 19 kc signals applied to its input. The 19 kc is either amplified and doubled in frequency to develop 38 kc or used to synchronize an oscillator which generates 38 kc. Refer to the block diagram in Fig. 7. The resultant high amplitude 38 kc is reinserted into the L - R sideband signal. This subcarrier reinsertion converts the double sideband suppressed carrier signal into a standard AM signal which can be detected in the usual manner to recover the original L - R, or difference signal. The receiving matrix is basically the same as the matrix that we discussed earlier. It adds the L + R and L - R to get the left channel audio signal and subtracts the L - R from the L + R to obtain the right channel signal.

$$\begin{array}{r} L + R \\ +\ (L - R) \\ \hline 2L \end{array} \qquad \begin{array}{r} L + R \\ -\ (L - R) \\ \hline 2R \end{array}$$

Due to attenuation and amplification of the signals between the microphones and the matrix, the 2L and 2R merely indicate left and right rather than twice the amplitude of the signals. Once the two audio signals are separated, they are fed through output jacks to a regular stereo amplifier and separate loudspeakers.

A simplified schematic of a multiplex adapter is shown in Fig. 8. The L + R, L - R sidebands and 19 kc are applied to the grid of V_1. The amplified composite signal appears at the plate and at the inputs to the three filter networks. C_2 couples the L + R to the 15 kc low-pass filter consisting of L_1 and C_6. Across R_5, then, we have only the L + R signal.

The L - R sidebands are passed by the series resonant filter C_3 and L_2. This LC circuit is designed to resonate at 38 kc and pass the band of frequencies from 23 to 53 kc.

C_4 couples the 19 kc into the 19 kc filter L_3 and C_8 in the V_2 grid circuit. This parallel resonant circuit is sharply tuned to reject all other frequencies. The 19 kc is amplified by V_2 and coupled through L_4 and L_5 to the grid of V_3. This stage also amplifies the 19 kc. The parallel tuned circuit at the plate of V_3, however, is tuned to 38 kc. Thus, the frequency induced into L_7 is the 38 kc subcarrier.

The 38 kc is inserted into the L - R sideband signal which is present at the junction of L_2 and R_7. The regular AM signal thus developed

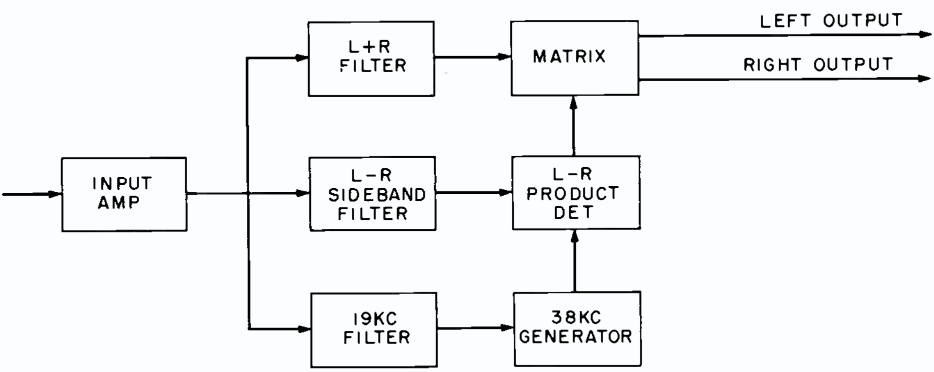


FIG. 7. Block diagram of FM multiplex adapter.

is detected by the two diode detector circuits. Notice the diode connections. An L - R signal of positive polarity is developed at the junction of D_1 and C_{12} and an identical signal of negative polarity is present at the junction of D_2 and C_{13}. These two signals are plus L - R and minus L - R, respectively.

The L + R signal present across R_5 is fed into the matrix between R_9 and R_{11}. There it adds to the positive L - R at the output of D_1 and subtracts from the negative L - R across C_{13}. The left channel audio which appears at the junction of R_8 and R_9 is coupled through the low-pass filter network C_{14}, R_{12}, and C_{15} to the left channel audio output jack. The right channel audio passes from the junction of R_{10} and R_{11} through the low-pass filter C_{16}, R_{13}, and C_{17} to the right channel output. The audio is fed from the multiplex adapter into the amplifiers.

One of the primary reasons for FCC's choice of this particular FM stereo system is its versatility. This versatility lends itself to more than one approach to the decoding process. As such, there are multiplex adapters on the market which use completely different circuits and operate on different principles. The circuit in Fig. 8 represents only one of these.

When compared to monophonic FM transmission, FM stereo has a shorter usable range. That is, the receiver must be relatively close to the transmitting station for high quality reproduction of the sound. Combining three signals into one at the transmitter means that there is less power for each of them.

FM stereo has another drawback when compared to the AM-FM stereo system. This problem is separation between the left and the right channel audio outputs. Because the tuning of the various resonant circuits is rather critical and phase shift in the coupling and amplifier circuits is somewhat touchy, some of the audio crosses from one channel to the other. This lowers the directional effect and realism of the audio output.

FM stereo is one of the greatest advances in radio broadcasting in recent years. Therefore, we can expect to see changes in the system as well as increasing popularity.

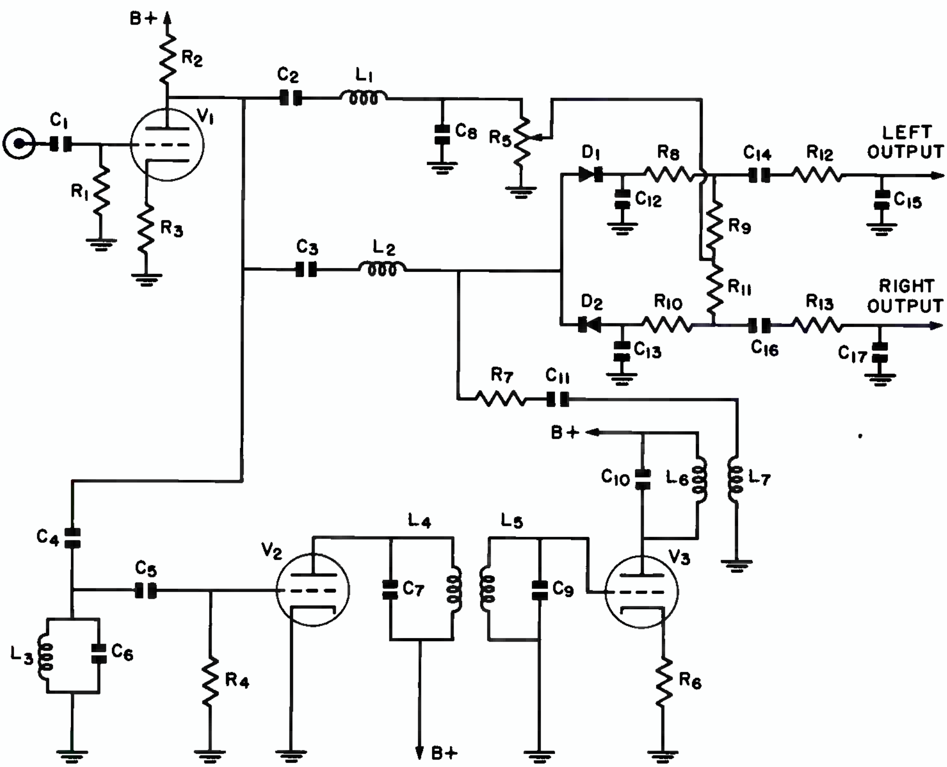


FIG. 8. Simplified schematic of multiplex adapter circuit.

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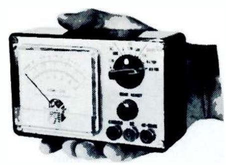

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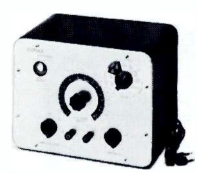

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80.01-90	9	9	230.01-240	24	22
90.01-100	10	10	240.01-250	25	23
100.01-110	11	11	250.01-260	26	24
110.01-120	12	11	260.01-270	27	25
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7	.34	.58	.65	.77	.95	1.16	1.38	1.59
8	.36	.63	.71	.84	1.05	1.29	1.54	1.78
9	.38	.68	.77	.91	1.15	1.42	1.70	1.97
10	.40	.73	.83	.98	1.25	1.55	1.86	2.16
11	.42	.77	.89	1.05	1.35	1.67	2.02	2.34
12	.44	.81	.95	1.12	1.45	1.79	2.18	2.52
13	.46	.85	1.01	1.19	1.55	1.91	2.34	2.70
14	.48	.89	1.07	1.26	1.65	2.03	2.50	2.88
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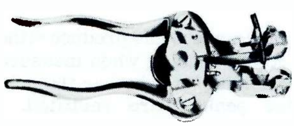

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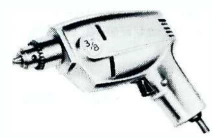

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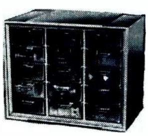

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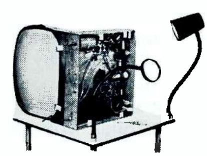

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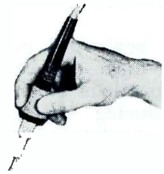

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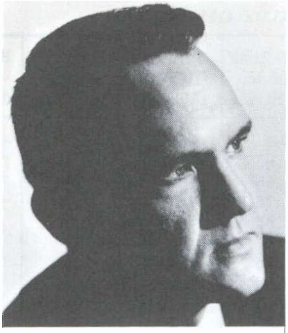


Practical Peak-to-Peak Measurements

By
Ed Beach
NRI STAFF

Servicemen normally use three instruments in measuring ac voltages: vtvm's, vom's and oscilloscopes. Which of these instruments the technician uses in any situation depends upon (1) the instrument he happens to have readily at hand; and (2) the nature of the ac voltage he wants to measure. Unfortunately, most technicians let condition (1) dictate the type of instrument he uses in a given situation when condition (2) should ALWAYS determine the right instrument to use.

In order to know which measuring method to use in any situation, we must first see exactly what each of the three instruments can do.

VOLT-OHMMETERS

The ac function of most service type vom's consists of a simple diode rectifier ahead of the basic dc voltmeter circuit. Those instruments employing a simple half-wave rectifier may give a false reading in the presence of a dc component if the leads are not properly connected to the circuit under test. The better vom's that use a bridge-type rectifier are not affected by a dc component. ALL vom's, however, suffer from two severe limitations. First, they are calibrated only for sinusoidal voltages. Second, even the better instruments produce undesirable circuit loading. Typical ac sensitivities for usual instruments are 1000 ohms-per-volt to 5000 ohms-per-volt. So long as the instrument is used to measure sinusoidal voltages in low impedance circuits, it will perform satisfactorily.

The scales of most vom's are marked in root-mean-square or effective values. These calibrations are useful and necessary when measuring strictly sinusoidal signals, but are absolutely useless when any other type of signal voltage is to be measured. Sine waves will be encountered when dealing strictly with power transformers, single tone tests of audio amplifiers, and rf measurements. Most other signals measured will be non-sinusoidal in nature and will not correctly actuate the ac movement of the vom.

Fig. 1A shows a typical sine wave that has an average value of zero over one cycle. The positive and negative peaks are equal at +E and -E, respectively. Fig. 1B shows the same sine wave with a considerable second harmonic component present that is due, perhaps, to slight slipping in an audio output stage. Notice that the positive peak is broader than the sine wave but does not reach +E volts, while the negative peak is narrower than the corresponding peak of the sine wave and is larger than -E volts.

This distorted sine wave would produce either a higher or a lower reading when measured with a vom, depending on whether the positive or negative peaks were rectified. In either case, the indicated RMS value would not be accurate.

The positive peak in Fig. 1B has been reduced in amplitude by exactly the same amount the negative peak has been increased, however, so the PEAK-TO-PEAK voltage of the signal is the same as that of the sine wave or 2E volts peak-to-peak. This is a significant point to keep in mind.

VTVM's

Vacuum tube voltmeters are only slightly better than the average vom when it comes to measuring ac voltages. They have a slight

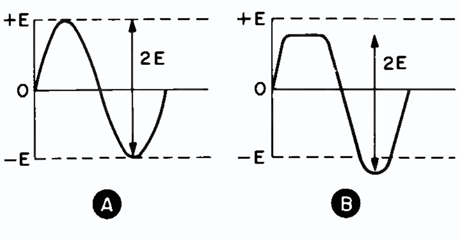


FIG. 1. Sine wave, A; sine wave with second harmonic distortion, B.

edge when it comes to circuit loading because of their higher input impedance and are not affected by any dc component present, but they still suffer in non-sine wave signal measuring capability.

The rectifier circuit employed by most vtvm's is shown in Fig. 2. This circuit is essentially

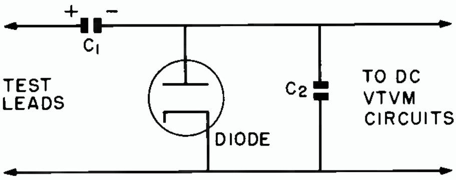


FIG. 2. AC portion of a typical vtvm.

a peak reading voltmeter arrangement. Capacitor C_1 charges to the peak value of the negative part of the applied voltage and remains so charged. The very high impedance dc vtvm circuits do not appreciably discharge C_1, but merely indicate the charge it has assumed. C_2 tends to smooth any short term variations in amplitude of the input. The scales are calibrated on the assumption the applied voltage is a sine wave, so fairly good results are obtained, as long as the applied signal is a sine wave!

For example, suppose the signal shown in Fig. 1B were to be measured by the vtvm using the circuit of Fig. 2. Since the negative peak of the signal is larger than the positive peak of the equivalent sine wave, an erroneously large reading would result. If the test leads of the vtvm were reversed and applied to the circuit, the second reading would be lower than the first reading. This is because, as far as the meter is concerned, the smaller positive peak is now the negative peak, and thus a lower peak voltage reading will result. This points out a good practice to follow if you ever have any doubts as to whether a signal you are measuring is sinusoidal or non-sinusoidal. If reversing the leads of the vtvm produces significantly different ac indications on the meter, you can be sure the signal you are measuring is not a sine wave.

OSCILLOSCOPES

Many technicians believe that the oscilloscope is the only practical way to measure any ac signal -- sinusoidal or non-sinusoidal. Under certain conditions, this is true. An oscilloscope will faithfully display the SHAPE of the signal you are measuring, but as far as giving an indication of magnitude, this is another matter. If the oscilloscope is properly CALIBRATED, you can make measurements with it regarding the amplitude, period, etc. The scope, more than any of the other ac instruments, will give a true picture of the applied signal.

Even the scope will give only relative indications if it is not properly CALIBRATED. Scopes are usually calibrated in peak-to-peak volts rather than RMS or peak, or average, and for very good reason.

The RMS or effective value of an ac voltage is the value of the ac signal that tells how much work it can do in terms of an equivalent dc voltage. This is the only reason for the existence of the RMS voltage -- to equate it to a dc voltage. Mathematically, RMS voltages are related to complex voltages by means of the peak-to-peak value of voltage and the particular shape of the signal. Fig. 3 shows three common waveshapes: a sine wave, a rectangular or pulse waveshape, and a triangular or sawtooth waveshape. The formulas indicated for each of the waveshapes relates the peak-to-peak value of the wave to its RMS value. Mathematically, every waveshape known may be related to the RMS or effective value by way of the peak-to-peak value of the wave. Thus, it would seem the peak-to-peak value of an ac signal would be the most valuable

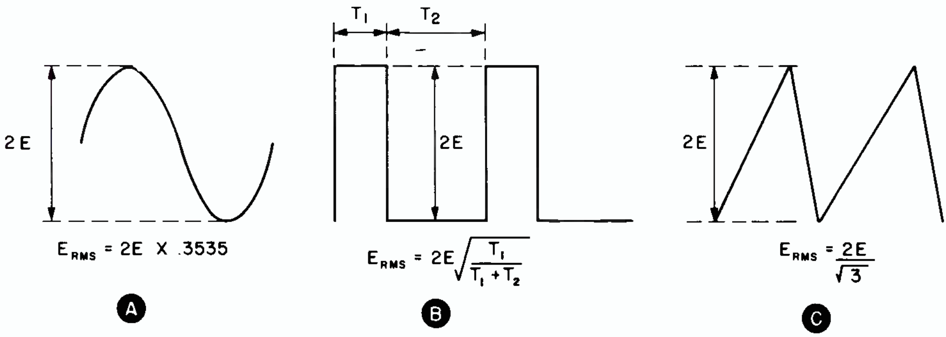


FIG. 3. Relationship between peak-to-peak and RMS for sine wave, A; rectangualr wave, B; sawtooth, C.

value to know for any ac signal. And so it is. If you know the peak-to-peak value of any signal voltage and its waveshape, you can determine its effective value easily. Most of us are not graduate mathematicians, however, so why bother with these conversions from peak-to-peak to RMS, etc.? The answer is that we are just as well off knowing the peak-to-peak readings as knowing the RMS values for any given waveshape. Television manufacturers recognize the fact that most of us are not mathematicians but they do know the value of the peak-to-peak measurement. If we do not know how to measure these peak-to-peak signals or know what to expect from them, we are not taking full advantage of the information available to us in our work. This information supplied to us by the manufacturers of television receivers can be invaluable in running down difficult servicing problems in everyday jobs.

But how do we accurately measure a grid drive signal to a crt? Easy, with a scope or an adapter for a vtvm.

Most scopes supply a test signal at 60 cycles from the filament voltage for purposes of calibrating the vertical amplifiers in terms of peak-to-peak voltages. This is fine as long as the line voltage is at the rated value and the attenuators in the vertical input are accurate. If either or both of these conditions do not exist, it is impossible to make accurate peak-to-peak measurements with an oscilloscope.

An auxiliary calibrator may be used that does not depend on (1) ac line voltage or (2) the vertical attenuators of the scope. Later on we will describe such an auxiliary calibrator you can easily construct for your scope, but first let's see how to make accurate peak-to-peak measurements.

PEAK-TO-PEAK MEASUREMENTS

Earlier we indicated that the usual vtvm measured one or the other of the peaks of an ac signal and automatically translated this peak reading into an equivalent RMS value for a sine wave. Reversing the connections of the meter would read the opposite peak, and a different reading would result if the signal were non-sinusoidal. This fact leads us to the conclusion that a device could be constructed to read first one peak and then the other and give an indication of BOTH peaks, for a true peak-to-peak reading.

Fig. 4A shows a capacitor and diode connected to read the negative peaks of an input signal. Fig. 4B shows a positive peak reading circuit. It is reasonable to assume that we could combine the two functions shown in Fig. 4 into one unit that will measure both the positive and negative peaks at the same time. Fig. 5 shows such a circuit. C_1 and D_1 measure the negative peaks of the input, and C_2 and D_2 measure the positive peaks of the input signal. The dc output voltage taken from the plate of D_1 to the cathode of D_2 is a measure of the peak-to-peak voltage of the input signal.

Those of you who are "old hands" at electronics will recognize this circuit for what it really is; a full wave voltage doubler power supply. In this application, however, we will not call upon the circuit to supply any appreciable amount of power since we are only interested in peak-to-peak voltage measurements. If a high resistance vom or vtvm were to be connected across D_1 and D_2, the capacitors C_1 and C_2 would not discharge appreciably and a true indication of the peak-to-peak voltage of the complex waveshape would be obtained. The dc voltage measured across D_1 and D_2 would then be exactly the peak-to-peak value of the applied signal voltage, whether it is sinusoidal or not, since each peak is measured independently.

Modern electronic technology has made available to us diodes suitable for use in a practical circuit like that of Fig. 5. Silicon rectifiers are practically ideal for use in such an application because of their extremely high ratio of conducting to non-conducting resistance. Vacuum diodes are acceptable in such an application. However, the silicon diodes are preferred because of their low cost, small size, and low power requirements; no filament power is wasted.

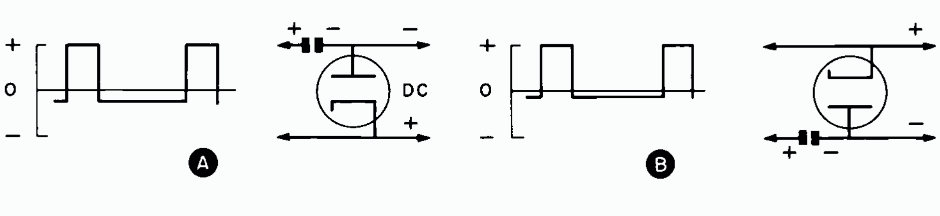


FIG. 4. Peak reading circuit connected to measure negative peaks, A; positive peaks, B.

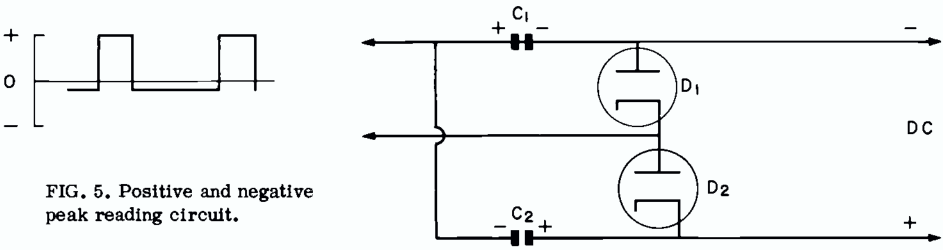


FIG. 5. Positive and negative peak reading circuit.

A PEAK-TO-PEAK PROBE FOR VTVM's

Here is a practical probe that can be constructed following the principles set forth in the paragraphs above. It will allow practical peak-to-peak measurements to be made with any vtvm or sensitive vom.

The value of capacitor that you should use for C_1 and C_2 in Fig. 5 is determined by two main factors: The input impedance of the dc voltmeter used, and the lowest frequency ac signal you wish to measure. If you plan to use this probe only with a vtvm, the input impedance will be constant regardless of the voltage range selected. If it is used with a vom, the input impedance will depend upon the voltage range, being lowest on the lowest voltage range. The design procedures to follow will allow you to select the components for your particular application if it happens to be different from that described.

The lowest frequency signal you are likely to encounter when measuring peak-to-peak voltages is the vertical field rate of 60 cycles in television. Audio signals may be as low as 20 cycles or so. However, it is seldom necessary to measure the peak-to-peak value in audio servicing, so we shall assume a low frequency limit of 60 cycles for the vtvm probe.

The circuit of Fig. 5 is shown arranged somewhat differently in Fig. 6. D_1 and D_2 are shown as semiconductor diodes, and C_1 and C_2 now appear to be across the output of the rectifier. Resistance R represents the input impedance of the vtvm across which the dc voltage is developed.

C_1 and C_2 are effectively in series as far as the output signal voltage is concerned, and are shunted by the rather high resistance R. In order for the rectifier to give accurate indications at the lowest frequency, R must not discharge C_1 and C_2 appreciably between the peaks of the input signal. Experience has shown that if the time constant of R and the effective capacity of C_1 and C_2 in series is at least 20 times the period of the lowest ac signal to be measured, accurate results will be obtained. The period of a 60-cycle signal is 1/60 second or 16,667 microseconds in more convenient units. R for vtvm's will be on the order of 11 or 12 megohms. Thus, the time constant for a 60-cycle signal should be $20 \times 16{,}667 = 333{,}340$ microseconds. Using a value of 12 megohms for R would require an effective value of $333{,}340 \div 12 = 27{,}777$ μμf or .03 μf. C_1 and C_2 will both be the same value capacitor so in this case they should have a value of $2 \times .03$ μf or .06 μf. Just to be on the safe side we will use a value of 0.1 μf for C_1 and C_2 since this is the next largest convenient standard value of capacitor. This will allow us to measure ac signals lower in frequency than 60 cycles if need be, also. Values of 0.1 μf at C_1 and C_2 will allow the probe to be used down to a frequency of 33 cps with a 12 megohm vtvm.

CONSTRUCTING AND USING THE VTVM PROBE

The four components of the peak-to-peak probe may easily be housed in a small aluminum box such as the one shown in Fig. 7. In use, the vtvm is set to measure dc volts and is connected to the probe as shown in Fig. 6. The peak-to-peak voltage is read directly from the dc voltage scale. The peak-to-peak scales of the Model 211 and similar vtms's are used only on the ac ranges of the vtvm and only when measuring sinusoidal signals.

Notice that the ground lead of the vtvm is not directly connected to the circuit under test. Two entirely separate leads must be brought out from the probe to connect to the circuit under test.

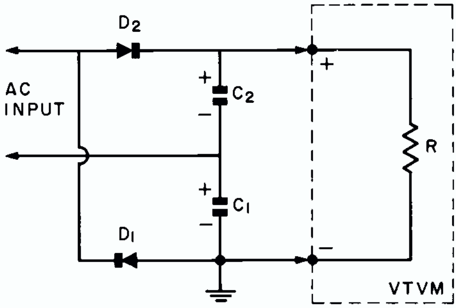


FIG. 6. Peak-to-peak probe for vtvm's.

The output terminations of the probe should be chosen to connect conveniently to the particular vtvm you intend to use the probe with. The probe shown in Fig. 7 is being used with a CONAR Model 211, so the positive terminal is an insulated pin jack and the negative terminal is merely the other end of a 1/2" machine screw used to fasten a two-lug terminal strip to the inside of the box. All the parts are mounted inside the box on the two-lug terminal strip and the lug of the pin jack. Parts placement is not critical.

In use, when first connecting the probe to a circuit, the two capacitors will be uncharged and a rather high initial current will be present. This large charging current will momentarily load the circuit under test, but only momentarily. The vtvm should be switched to the highest dc range at first, even when measuring signals known to be low in amplitude, to avoid slamming the vtvm needle off scale as the capacitors charge.

The voltage rating (peak inverse voltage or piv) of the silicon diodes and the ratings of the two capacitors will determine the largest signal the probe can safely handle. Most service type diodes have a piv of around 400 volts. This means that the largest ac signal you can safely measure would be a 400V peak-to-peak signal. This does not include any dc component such as would be present if the signal were measured at the plate of an amplifier tube, for example. Where there is a dc voltage along with the ac signal, the combined peak-to-peak voltage and dc voltage present must not exceed the piv rating of the diode. This means, for instance, if we use the probe to measure the ac signal at the plate of a tube that has 200V dc present, the peak-to-peak voltage must be no larger than 200V p-p if we want to avoid damaging the diodes. This is really no hardship when you stop to consider the largest video signal present in the ordinary TV receiver is only on the order of 80V to 150V p-p.

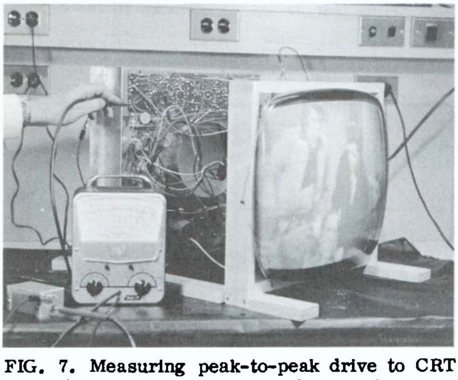


FIG. 7. Measuring peak-to-peak drive to CRT with special probe and Model 211 vtvm.

If you want to extend the range of the probe, it is only necessary to increase the piv of the two diodes. You can easily double this rating by connecting two similar diodes in series for each of the diodes shown in Fig. 6. Using standard 600V units for C_1 and C_2 will allow a maximum peak-to-peak voltage of 1200V, with suitable diodes, since the two are in series.

AN OSCILLOSCOPE CALIBRATOR

Using the peak-to-peak probe described above will enable you to make peak-to-peak measurements quite easily. However the reading of a vtvm will tell nothing about the shape of the signal being measured.

When properly used, the oscilloscope can give not only the peak-to-peak voltage readings but also give the shape of the signal. Generally speaking there are two ways of measuring the peak-to-peak value of a signal displayed on a scope: by calibrating the scope screen and by comparison.

To calibrate the scope screen, a signal of known amplitude is applied to the vertical amplifier of the scope. The gain controls are adjusted to produce a convenient deflection on the screen; one inch, two inches, five centimeters, etc. The screen is then calibrated in terms of the reference input signal.

Using the comparison method, the signal under observation is adjusted to a convenient height on the scope screen. The input signal is removed and a variable calibrated signal is connected to the scope. The variable signal is adjusted to produce the same deflection the first signal produced and the voltage is read directly from the calibrated signal source.

The scope calibrator that we are going to describe may be used with any oscilloscope either as a direct calibrator or in the comparison manner.

Fig. 8 is the schematic of the scope calibrator, and Fig. 9 shows the inside parts arrangement of a typical unit.

A small power transformer, T_1, is used to supply two different signal levels to the basic peak-to-peak circuit described earlier. Instead of using a vtvm as the indicator, a milliammeter is used with the proper series multipliers as a voltmeter to indicate the peak-to-peak voltage at the arm of the 250K pot R_1. Adjustable meter shunt multipliers were used so the calibrator could be accurately calibrated. The two 20 µf capacitors need be only 150V electrolytic units. D_1 and

D_2 are, as before, 400 piv silicon diodes. The switch S allows two ranges for the calibrator: 10 volts full scale, and 100 volts full scale. These ranges were chosen because the 1 ma. meter would then be direct reading 0 -1 with multipliers of 10 and 100.

Fig. 9 shows how the parts were mounted in the unit built by the author. The aluminum box dimensions are 5-1/4" × 3" × 2-1/8" which is adequate for the few parts needed for the calibrator. Parts placement is not critical at all, and probably you will be able to come up with a much better layout of the parts. The small rectangular unit with the three leads to the left of the multiplier potentiometers is a dual silicon diode containing the two diodes D_1 and D_2.

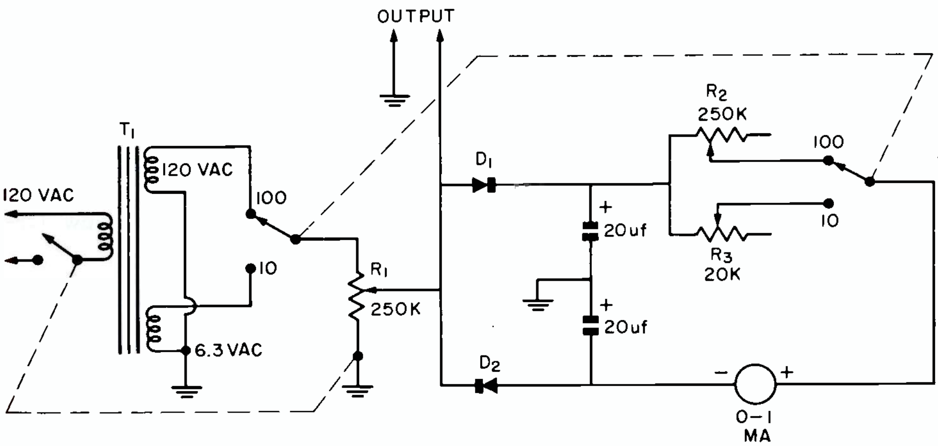


FIG. 8. Scope calibrator diagram.

After completing the calibrator, you will have to calibrate the meter circuit. Turn the unit on and switch to the 100V position with S. Connect a vtvm across the two 20 µf capacitors and set R_2 for maximum resistance. Advance R_1 and watch the reading of your vtvm. When it gets to about 110V, adjust R_2 to bring the milliameter pointer toward 1 ma. The voltage indicated by your vtvm will drop as you decrease R_2, so adjust R_1 to bring the voltage back up. Alternately adjust R_1 and R_2 until the vtvm reads 100V at the same time the milliameter is at full scale.

Adjust R_1 to bring the voltage down, and change over to the 10V range. Proceed to adjust R_1 and R_3 in the same manner as just described to give a 10-volt full scale reading on the milliammeter as indicated by the vtvm. This completes the calibration of the unit. Just so you won't accidentally turn the multiplier pots R_2 and R_3, it is suggested that you place a spot of nail polish on the shafts of the pots to keep them in place.

To use the scope calibrator, connect the "output" leads to the vertical input of your oscilloscope. Adjust R_1 for the desired peak-to-peak voltage as indicated on the meter and set the vertical gain controls for a convenient indication on the screen. For example, Fig. 10 shows the calibrator connected to a CONAR Model 250 scope set to measure the 100 V p-p signal. Although the calibrator is shown with the Model 250 scope in Fig. 10, it will find its greatest use with scopes that have no provision for vertical calibration. The built-in calibration of the Model 250 is adequate for most service requirements. The vertical gain and attenuator controls of the scope have been adjusted to produce a one-inch deflection on the screen. Now, with the calibrator removed, the scope is ready to measure any signal with a calibrated sensitivity of 100 volts per inch without further adjust-

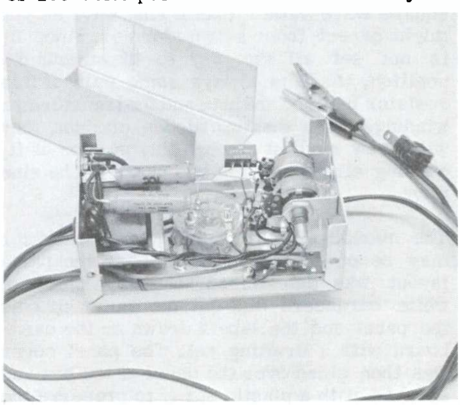


FIG. 9. Inside view of scope calibrator.

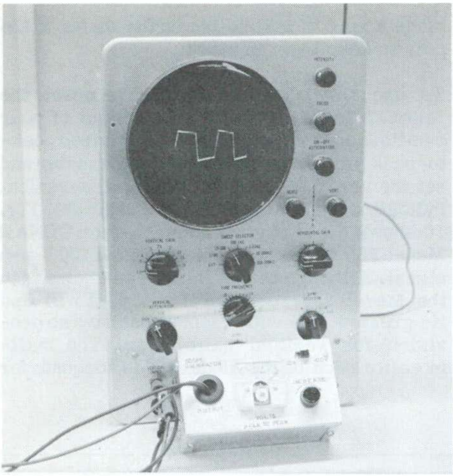


FIG. 10. Calibrator connected to produce 100V PP signal.

ment of the vertical controls of the scope. Any other convenient values may be used for the measurements. For example, to measure low level signals, you may require 5 volts peak-to-peak to produce a half-inch deflection. Set the calibrator for 5V and adjust the scope controls for a half-inch deflection.

To use the calibrator in the comparison method, adjust the scope for a convenient height signal from the circuit under test. Note the peak-to-peak deflection on the scope and, without changing the settings on the gain controls, disconnect the circuit under test and connect the calibrator to the scope. Adjust R_1 of the calibrator to produce the same deflection the test circuit produced and read the voltage directly from the meter.

You will notice in Fig. 10 that the waveshape displayed on the screen of the scope is a square wave rather than a sine wave as you might expect from a transformer. Since R_1 is not set all the way to the maximum position, there is always some part of this resistor between the arm and the transformer winding. When the two diodes conduct, they will draw current through this portion of R_1 causing clipping of the two peaks of the sine wave.

The markings on the panel of the calibrator may be of interest to you. After the parts layout was determined, a small piece of white cardboard was cut the same size as the panel and the labels drawn on the cardboard with a drafting set. The panel cover was then glued over the panel of the box and sprayed with a plastic spray to preserve the lettering.

ELECTION BALLOT

All NRI Alumni members are urged to fill in this ballot carefully. Mail your ballot to National Headquarters immediately.

FOR PRESIDENT (Vote for one man)

☐ John Berka, Minneapolis, Minn.

☐ J. Arthur Ragsdale, San Francisco, Calif.

FOR VICE PRESIDENT (Vote for four men)

☐ Dave Spitzer, Brooklyn, N. Y.

☐ James Kelley, Detroit, Mich.

☐ Patrick Boudreaux, New Orleans, La.

☐ Frank Zimmer, Long Island City, N. Y.

☐ Walter Berbee, St. Paul, Minn.

☐ Howard Tate, Pittsburgh, Pa.

☐ Michael Lesiak, Taunton, Mass.

☐ Eugene DeCaussin, Hollywood, Calif.

SIGN HERE:

Your Name ....

Your Address ....

City .... State ....

Polls close October 25, 1962. Mail your complete Ballot to:

T. E. Rose, Executive Secretary

NRI ALUMNI ASSOCIATION

3939 Wisconsin Ave.

WASHINGTON 16, D.C.

IMPORTANT ANNOUNCEMENT

The NRI Alumni Association has local chapters in a number of the larger cities. NRIAA Executive Secretary Ted Rose visits most of these chapters about once a year.

On his visits this year he will be accompanied by Mr. J. B. Straughn, NRI Chief of Consultation Service. Mr. Straughn will conduct a service forum during which he will discuss and demonstrate the test equipment used in Radio-TV service work and will answer questions about test equipment and service problems. He will also answer questions on the latest developments in color Television.

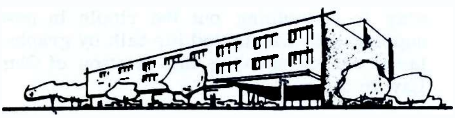
All NRI students and graduates in each chapter's area are cordially invited to attend these meetings as guests of the chapters. Here is a rare opportunity to meet Mr. Straughn and to see him demonstrate Radio-TV test equipment and techniques, -- hear his answers to questions on current service problems. An attractive door prize will be raffled off among those who attend.

The visits are scheduled as follows (see "Directory of Local Chapters" on Page 29 for information on place and time):

Chapter	Date
Southeastern Mass.	September 26
Flint (Saginaw Valley)	October 10
Detroit	October 12
New York City	November 1
Springfield, Mass.	November 2
Hagerstown (Cumberland Valley)	November 8
Philadelphia-Camden	November 12
Pittsburgh	December 6
New Orleans	January 8
San Antonio	January 10
Minneapolis-St. Paul	April 11

Any changes will be indicated in later announcements which will appear in subsequent issues of the NRI News.

NRI ALUMNI NEWS



JOHN BERKA FIRST CHOICE FOR PRESIDENT

John Berka of the Minneapolis-St. Paul Chapter is the first choice for President of the NRIAA for the coming year.

Berka has been a candidate for a Vice Presidency and the Presidency, respectively, in the last two years. Although he was not successful in either of those elections, nevertheless he has not only retained his popularity but has also strengthened his appeal. Chairman of the Minneapolis-St. Paul Chapter in 1955, he has since then filled the post of Technical Adviser to the Chapter. He is invaluable in this post.

Second choice for the Presidency is J. Arthur Ragsdale of the San Francisco Chapter. The odd thing about this is that Ragsdale came close to being a candidate for a Vice Presidency, too. But he received more votes as a candidate for President than for Vice President, in spite of the split in votes for him.

The membership seems to follow the practice of consistently returning or attempting to return Vice Presidents to office. Three of the present incumbents have been nominated as Vice President: David Spitzer, Brooklyn, N. Y., James Kelley, Detroit, Mich., and Water Berbee, St. Paul, Minn. The other candidates are Eugene DeCaussin of Hollywood, Calif., Michael Lesiak, Taunton, Mass., Howard Tate, Pittsburgh, Penna., Frank Zimmer, Long Island City, N. Y., and Patrick Boudreau, New Orleans, La.

It seems necessary every election to call attention to the fact that only members of the NRI Alumni Association are eligible to vote. Members are to vote for one man for President and four for Vice Presidents, by means of the ballot included in this issue. Mail your ballot in time to arrive in Washington by midnight, October 25. Winners will be announced in the December-January issue.

Chapter Chatter

DETROIT CHAPTER members have been discussing a plan to buy a still projector to project schematic diagrams, etc. on a large screen to aid in the various Chapter talks and demonstrations. Such a projector has been found by other Chapters to be a valuable addition to these demonstrations.

The Chapter held its customary annual Stag Party at the close of the last season. Delicious food and drink were served. Entertainment included recorded music furnished by Ellsworth Umbreit and movies were exhibited by Roger LaPere. It was an enjoyable occassion.

Chairman Jim Kelley felt that the meetings were lively and interesting last season and he believes that the enthusiasm will carry over into the new season.

NEW YORK CITY CHAPTER'S Frank Zimmer once again made another valuable contribution to his fellow members in a talk on assembling, connecting and hooking up a quite elaborate stereo system.

Chairman Dave Spitzer has worked out some ambitious programs for the new 1962-1963 season. Tom Hull has lined up a series of talks on various Electronic subjects. Jim Eaddy has planned a much-needed program in which he will discuss and demonstrate transistor test equipment. One of the Chapter's newer members, Joseph Bradley, will prove his value as a member with talks, discussions and demonstrations of what to do with transistors.

The Chapter always has a question-and-answer period to cover any subject the members present may want to discuss. This is an important part of every meeting and the members feel that they get a great deal of practical help and benefit from this feature.

At the final meeting of last season Chairman Dave Spitzer obtained and exhibited a movie called, "Friendship 7," the complete report of John Glenn's orbital flight, in full color. The members found this an intensely interesting and absorbing film. Chairman Spitzer heartily recommends it to all Chapters. Those interested should write to United World Film Service, 1445 Park Avenue, New York 29, N.Y.

PITTSBURGH CHAPTER Chairman Howard Tate was justifiably proud of the good attendance that the Chapter enjoyed even during the summer months. Howard has every reason to be, for better than fair attendance cannot usually be counted upon during the vacation months.

Former Chairman Tom Schnader put on a demonstration on how to adjust the i-f and oscillator in transistors. Use was made of all types of generators, according to the book, and Tom demonstrated how a good bench man does it and the difference between an ac-dc set and a transistor set as to the alignment requirements, etc. Using the Chapter's transistor board and the necessary generators and power packs and tools brought in by Chairman Howard Tate, Tom put on an excellent two-hour meeting with this program.

Here is an interesting note on the Chapter's publication "CIRCUITER" of which Howard Tate is the editor: Two new members have joined the Chapter as a direct result of reading this paper. They are Howard Earl of E. Liberty, and Joseph Chelko of Natrona Heights. Our congratulations, gentlemen!

SAN FRANCISCO CHAPTER admitted two new members, Joseph Tchang and Filbert Gonzalez. Our congratulations, gentlemen!

Phil Stearns brought in a receiver which had a bad hum but no other sound. Andy Royal and Reg Seby discovered the filament circuit was hooked to the grid pin of the audio output tube.

Ross Alexander spoke on the part filters play in smoothing out the ripple in power supplies. He illustrated his talk by graphs on large charts showing the relation of Ohm's Law to the subject.

Using the Chapter's mock-up radio receiver built on peg board, Chairman Ed Persau and Treasurer Charles Kilgore demonstrated, with the aid of a scope and a VTVM, how failures in the input and output of filter capacitors can affect the operation of a receiver. Changes in voltage, rupple and hum were seen on the scope as a high power factor, a change in capacitance and an open condenser were set up in the filter.

Rubin Ellis gave a demonstration of signal tracing on the mock-up radio in which he used his new Conar Signal Tracer which he had just built from a kit.

SOUTHEASTERN MASSACHUSETTS CHAPTER was pleased at the return of three former members after a leave of absence of considerable duration. The three were warmly welcomed back to the fold.

Manuel Figuerirredo gave another of his highly informative and practical talks, this time on an important problem in servicing transistorized equipment: how to check transistors without taking them out of the circuit.

Ernest Grimes brought in a projector which he made from plans he had obtained. The projector functioned well.

IN MEMORIAM

A casualty of the past summer was the death of Louis E. Grossman of New Orleans. He was the organizer and first chairman of the New Orleans Chapter and in 1956 was elected National President of the NRI Alumni Association.

Mr. Grossman was born in New Orleans, graduated from the Newman School, and then attended Cornell University. He was in the investment business and was a member of the Board of Directors of the Raceland Bank and Trust Company, Raceland, La.; a member and past master of Hiram Lodge No. 70, Free and Accepted Masons; also a member of the Grand Consistory of Louisiana Ancient and Accepted Scottish Rite Masons and of Jerusalem Temple, Ancient and Accepted Order of Nobles of the Mystic Shrine.

Mr. Grossman's passing is a real loss to many people and organizations. All have lost a strong supporter and valuable friend.

Directory of Local Chapters

Local chapters of the NRI Alumni Association cordially welcome visits from all NRI students and graduates as guests or prospective members. For more information contact the Chairman of the chapter you would like to visit or consider joining.

CHICAGO CHAPTER meets 8:00 P. M., 2nd and 4th Wednesday of each month, 666 Lake Shore Dr., West Entrance, 33rd Floor, Chicago. Chairman: Frank Dominski, 2646 W. Potomac, Chicago, Ill.

DETROIT CHAPTER meets 8:00 P. M., 2nd and 4th Friday of each month, St. Andrews Hall, 431 E. Congress St., Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Mich., VI-1-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 8:00 P. M., 2nd Wednesday of each month at Chairman Andrew Jobbagy's Shop, G-5507 S. Saginaw Rd., Flint Mich., OW 46773.

HAGERSTOWN (CUMBERLAND VALLEY) CHAPTER meets 7:30 P. M., 2nd Thursday of each month, at homes or shops of its members. Chairman: George Fulks, Boonsboro, Md., GE2-8349.

LOS ANGELES CHAPTER meets 8:00 P. M., 2nd and last Saturday of each month, 5938 Sunset Blvd., L. A. Chairman: Eugene DeCaussin, 5870 Franklin Ave., Apt. 203, Hollywood, Calif., HO 5-2356.

MILWAUKEE CHAPTER meets 8:00 P. M., 3rd Tuesday of each month, at home of Treasurer Louis Sponer, 617 N. 60th St., Wauwatosa, SP4-3289. Chairman: Philip Rinke, RFD 3, Box 356, Pewaukee, Wis.

MINNEAPOLIS-ST. PAUL (TWIN CITIES) CHAPTER meets 8:00 P. M., 2nd Thursday of each month, Walt Berbee's Radio-TV Shop, 915 St. Clair St., St. Paul. Chairman: Paul Donatell, 1645 Sherwood Ave., St. Paul, Minn., PR 4-6495.

NEW ORLEANS CHAPTER meets 8:00 P. M., 2nd Tuesday of each month, home of Louis Grossman, 2229 Napoleon Ave., New Orleans. Chairman: Herman Blackford, 5301 Tchoupitoulas St., New Orleans, La.

NEW YORK CITY CHAPTER meets 8:30 P.M., 1st and 3rd Thursday of each month, St. Marks Community Center, 12 St. Marks Pl., New York City. Chairman: David Spitzer, 2052 81st St., Brooklyn, N. Y., CL 6-6564.

PHILADELPHIA-CAMDEN CHAPTER meets 8:00 P. M., 2nd and 4th Monday of each month, K of C Hall, Tulip and Tyson Sts., Philadelphia. Chairman: John Pirrung, 2923 Longshore Ave., Philadelphia, Pa.

PITTSBURGH CHAPTER meets 8:00 P. M., 1st Thursday of each month, 436 Forbes Ave., Pittsburgh. Chairman: Howard Tate, 615 Caryl Dr., Pittsburgh, Pa., PE-1-8327.

SAN ANTONIO ALAMO CHAPTER meets 7:30 P. M., 2nd Thursday of each month, National Cash Register Co., 436 S. Main Ave., San Antonio. Chairman: Thomas DuBose, 127 Harcourt, San Antonio.

SAN FRANCISCO CHAPTER meets 8:00 P.M., 1st Wednesday of each month, 147 Albion St., San Francisco. Chairman: E. J. Persau, 1224 Wayland St., San Francisco, Calif., JU 4-6861.

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8:00 P. M., last Wednesday of each month, home of John Alves, 57 Allen Blvd., Swansea, Mass. Chairman: James Donnelly, 30 Lyon St., Fall River, Mass. OS 2-5371.

SPRINGFIELD (MASS.) CHAPTER meets 7:00 P. M., 1st Friday of each month, U. S. Army Hdqts. Building, 50 East St., Springfield, and on Saturday following 3rd Friday of each month at a member's shop. Chairman: Norman Charest, 43 Granville St., Springfield, Mass.

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