PHILCO

TechRep Division
BULLETIN

In This Issue...

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TECHREP DIVISION
BULLETIN

Editorial . . .

by John E. Remich
Manager, Technical Department

SINGLE-SIDEBAND TRANSMISSION

One of the biggest factors limiting the growth of radio communications is the problem of accommodating the multitude of services that require space in the radio spectrum. The answer to the problem lies in either increasing the spectrum space or cutting down on the amount of space used by each transmitter. Most realistic of these alternatives appears to be an economy in the spectrum space needed by the various radio services. A number of solutions to the problem have been offered, but the most effective appears to be the use of the single-sideband method of transmission.

The single-sideband method is not a new development, having been used since the early 1920's, but until recently, it has not received the attention it deserves. The less intense demand for spectrum space prior to World War II and the problems of stable receiver design were probably important factors limiting its development. The FCC has now indicated that it will pursue a policy of adopting the single-sideband method as rapidly as possible. Consideration, of course, will be given to the phase-out of the double-sideband systems, which make up most of our present radio services. Phase-out will, of course, be gradual and orderly.

Recent developments in components and more stable receivers have placed single sideband transmission on a practical basis for large scale use. With all indications pointing to vastly increased use of single-sideband transmission, it would pay all field engineers to familiarize themselves with the principles and techniques involved. More and more publications are becoming available on this subject, but perhaps the most valuable at present is the *Proceedings of the IRE* for December, 1956. We highly recommend this publication as a source of single-sideband information.

I have been asked to order a number of sloping "V" antennas as shown on a wall chart in the Philco Construction Handbook on Communications Antennas. Some of the personnel here believe that this antenna is available in kit form, but we are unable to locate any military stock number for such kit. Can you provide any information concerning this matter?

Chester Holley
Philco TechRep Field Engineer

(In the Antenna Construction Handbook on page 39 there is an itemized list containing some 35 items and a table giving design data for the sloping "V" antenna. The way in which the data is listed could easily lead to the conclusion that the antenna is available in kit form. However, no such kit is available. Ed.)

As you know, carbon tetrachloride has been banned by the Department of the Army for use as a cleaning agent on electronic equipment because of the potential health hazard of breathing its fumes. This leaves a problem with respect to an alternate cleaning agent which has the same properties (i.e., will cut grease and oil without damage to rubber, plastic, and other types of insulation) and yet is safe to use. I would appreciate any information you may be able to furnish in this regard.

I. Margulies
Equipment Specialist

(To the best of our knowledge, a compound known as trichlorethylene, chemical formula $ClCH:CCl_2$, is being used as a replacement for carbon tetrachloride. This compound is also somewhat toxic, although not to the extent of carbon tetrachloride. Care should therefore be taken to provide adequate ventilation when using trichlorethylene to clean electronic equipment. Ed.)

*Considerable interest in the TechRep BULLETIN has been shown by many of the military personnel in this area. It has been suggested that a "New Books" column be incorporated to review newly released military electronics publications (not equipment instruction manuals), and that a short resume of the author's background, together with his present address, be included with each article that appears in the BULLETIN. Articles on the operations of military elec-*tronics organizations were also suggested as being interesting and informative.

Arthur W. Beahr
Philco Team Leader

(The suggestions given are the type in which we are most interested, and they are being considered at the present time. How about you other readers? Do these suggestions meet with your approval, and do you have any suggestions of your own for improving the BULLETIN? Ed.)

Our AC&W Squadron has received a low-current, low-power broadcast transmitter, the output of which is to be coupled directly into a 120-volt a-c outlet. The equipment is a package unit made up in California and no data or descriptions were furnished. I've been unable to locate any references, and have a number of questions. First, since the maximum transmitter output is 10 watts, how effective will the radiation coverage be? Second, since the commercial power to the 4160/2400-volt banks of the station are located close to the load requirement and is stepped from 208 volts to 120 volts as needed, will the transformer banks have to be bypassed? Third, a closed-loop antenna has been suggested. How effective would this be?

Robert A. Charles
Philco TechRep Field Engineer

(From what is known of power distribution systems at AC&W Squadrons, it would be difficult to distribute a program by means of the power lines. As is pointed out in an article entitled "Campus Carrier-Current System" by Philip J. Kiser in the May, 1955 issue of *Radio & Television News,* power transformers attenuate r-f signals rather severely. Other alternatives would be to utilize the base telephone system for distribution, or to individually wire each of the barracks and other buildings involved. Since the output you mention is comparatively high for this type of distribution, it may be possible to rig a suitable "antenna" system for covering the area of interest. For short runs, an ordinary twisted pair can often be used for an r-f line to feed such an "antenna." However, in case the latter distribution method is used, don't install too efficient an antenna, as the radiation must remain within the limits specified by F.C.C. or other controlling agency. Ed.)

A BEAM INDEXING COLOR PICTURE TUBE—THE APPLE TUBE

by G. F. Barnett, S. L. Parsons, G. W. Pratt, and M. Sadowsky,
Lansdale Tube Div., and F. J. Bingley, Engineering Services
Div., Philco Corp.

This article describes the Apple color picture tube, its dimensions, materials of construction, deflection and focus systems, and the geometry and deposition of the phosphor and secondary-emissive screen materials. The construction and operation of the electron gun, which produces two independent beams of very small cross section from a single cathode, are described in detail. Life test data and pilot production experience are discussed.

(Editor's Note: This is the second of a series of three related articles on the Philco Apple System. The first appeared in the November-December, 1956 issue of the BULLETIN. The articles originally appeared in the September, 1956 issue of the "Proceedings of the IRE," which is published by the Institute of Radio Engineers, Inc., and are reprinted with the Institute's permission.)

INTRODUCTION

THE APPLE CONCEPT as described in the previous paper places some very special requirements on the cathode-ray tube. The goal of the Apple development has been to design a tube in which the task of maintaining close tolerances is relegated to the manufacturing equipment rather than to the tube itself, where it would have to be faced every time a tube is made.

Corresponding to the many possible variations of Apple color systems, there are an equivalent number of variations of Apple tube designs. Rather than attempt to consider these in general terms, it is considered wiser to describe a specific representative example, the type of tube used in a system described in the previous article and utilizing circuits to be described in a succeeding article.

The Apple color picture tube (see figure 1) may be generally described as an all-glass, 21-inch, rectangular picture tube providing 260 square inches of useful screen area, having a diagonal deflection angle of 74 degrees, and us-

ing magnetic focusing and deflection. More specifically, the color television display system described in the preceding issue of the BULLETIN requires a picture tube that meets the following requirements:

1. The Apple tube must have a luminescent screen made up of vertical stripes of red, green, and blue phosphors

Figure 1. The Apple Color Picture Tube

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that are sufficiently close together to be visually unresolvable at normal viewing distances and yet far enough apart to permit resolution of each line by the writing beam.

2. Enough triplets must be present to resolve all of the detail conveyed by the luminance component of the signal.

3. The phosphors must be so chosen that satisfactory primary colors are produced when individually excited and a satisfactory white occurs when they are excited equally.

4. The spacing of triplets must be varied and the lines bent so that maximum circuit economy can be achieved by matching the triplet pitch at all parts of the raster to the normal sweep speed. This helps ensure constant index frequency all over the raster.

5. The lines must have sharp edges and constant width if accurate complementary colors are to be produced.

6. There must be secondary emission index-producing stripes as an integral part of the screen. The tube should be aluminized to improve the efficiency at high operating voltages and to provide a low secondary emission base for the index material.

7. The tube must have two electron beams, a writing beam and a pilot beam. These beams should be made to track each other so that the variations in the horizontal component of separation at the fluorescent screen is small. The pilot beam can be a low-current, low-resolution beam.

8. The index lines must have the same period as the color triplets and the position of the index lines with respect to the triplets must be varied in a predetermined fashion to be explained later.

9. Since the Apple tube utilizes the entire 260 square inches of the tube face for visible picture area, it is necessary to extend the index lines a slight distance beyond the visible raster on at least two sides to be sure to get an index signal at all points.

10. The writing beam must be small enough to resolve a single color line at a peak current of 1500 microamperes, including the effect of the spot motion during the time the peak current flows.

In addition to these special requirements arising from the system itself, it is desirable that the tube be suitable for mass production and utilize as much as possible existing facilities and techniques in its manufacture.

ELECTRON GUN

The color saturation obtainable at any particular brightness level in a beam-indexing tube is obviously limited by the spot size at the beam current associated with that brightness. If the spot is so large that it covers more than one primary color strip at a time, then desaturation of primary colors occurs. This consideration, plus that of reasonable structural resolution, made the development of an electron gun capable of producing a spot substantially smaller than usual in a monochrome tube a prime necessity for a beam-indexing tube. Small spot size is obtained in the Apple beam-indexing tube by ingenious utilization of electron optical principles, and by maximum simplification of the electron optics.

The electron gun is essentially of magnetic focus, triode design. Magnetic focusing was chosen over electric focusing for two reasons. First, for any particular tube-neck diameter, magnetic focusing permits the use of a larger lens diameter than does electric focusing. The beam diameter being the same in either, less aberration occurs in the larger lens. Second, the external magnetic lens can be accurately aligned to the electron beam after the tube is assembled, thus reducing tube scrap from gun misalignments.

The focused spot size has, as one limitation, the size of the first crossover of the electron beam. An extensive investigation was conducted to determine

the effect of electrode configuration on the formation of the first crossover. Equipotential plots were made of many configurations of elements using a resistor network to simulate, on a greatly enlarged scale, the fields that would exist between the electrodes involved. Ray traces made, utilizing these field plots, indicated the diameter and current density variation of the crossover vs electrode configuration and potential. These studies confirmed that there were no limits on crossover diameter precluding the development of a practical beam-indexing tube, but that a cathode loading higher than usual in picture tubes would be necessary to achieve this small crossover.

The required crossover diameter is secured by the use of close cathode-to-grid spacing, small grid aperture diameter, and a thin grid aperture, as shown in figure 2. Techniques were developed which made extremely close cathode-to-grid spacings possible by using a spacer ceramic which is lapped top and bottom to a specified height. The cathode-support ceramic is also lapped flat on one side, and the dimension from this surface to the top of the uncoated cathode is closely controlled. Cathode-spray thickness is also closely controlled.

The writing-grid aperture is 0.020 inch in diameter, and the beam has a bogie cutoff of 150 volts. The pilot-beam aperture is 0.014 inch in diameter, and produces a bogie beam cutoff of about 50 volts. The grid aperture is made electrically thin by countersinking the hole so as to leave the cylindrical portion only 0.001 inch thick.

This combination, then, of small, countersunk grid aperture and close cathode-to-grid spacing is primarily responsible for the small diameter first crossover, which is imaged on the screen by the simple electron optics described above, and results in greatly reduced spot size.
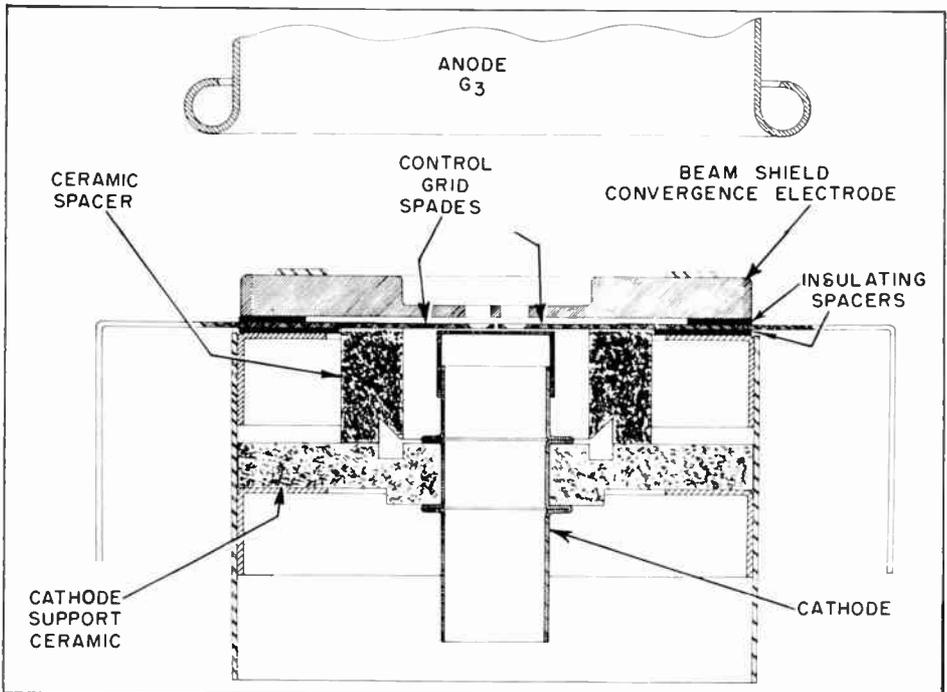

Figure 2. Schematic Line Drawing Showing Gun Details

The second requirement is that the two beams track each other. Since one beam is used to tell where the other beam is, the relative position of the beams must be known at all times. When this positional relationship of the two beams follows a predictable law throughout scanning, the beams are said to track. In order that this tracking relationship be independent of manufacturing variations in deflection yokes, the two beams must traverse the same portion of the deflection field at the same time. For the yoke designed for use with the tube, the optimum situation is for the two beams to originate as closely together as possible and cross each other at the center of deflection.

The two beams are formed close together by using a single cathode and two separate, coplanar control grids, each with its aperature close to the end of the piece, the ends being separated by 0.002 inch. The center-to-center separation of the two beams at the grid plane is only 0.029 inch.

Convergence of the two beams so as to cause them to cross at the center of deflection is obtained by a field lens type of convergence electrode. This lens slightly bends the two beams toward each other without any appreciable focusing effect. The convergence electrode is actually part of the beam shield, whose function will now be described.

The third special requirement of this beam-indexing tube arises from the need for preventing the control voltage of one beam from affecting the intensity or position of the other beam.

Without shielding, a signal applied to the control grid of one beam was found to produce both deflection and intensity modulation of the other beam. However, a simple shield between the two beams, in the region just above the grid apertures, effectively eliminates beam crosstalk as a limitation of the functioning of the system.

The beam shield takes the form of a thin, flat disc having two small holes with a bridge of metal between them.

This beam shield is not a conventional accelerating electrode, and every attempt has been made not to have it perform any accelerating function. If the beam shield is operated at such a potential as to accelerate the electron beam, it obviously becomes an electron lens of very small diameter. The beam would fill a substantial portion of this lens with resulting aberration.

Reduction of lens action is accomplished by operating the beam shield at its average free-space potential and by keeping the shield thin. By making field plots of the equipotentials in the region above the control grids, it was found that the equipotentials in this region are relatively flat and so are not appreciably distorted by a thin disc such as the beam shield. When operated at 600 volts the beam shield is, at worst, a very weak lens and produces only minor aberrations.

LUMINESCENT SCREEN

The luminescent screen of the Apple tube consists of a repeating array of red, blue, and green vertical stripes. The stripes are not contiguous but have 50 percent duty factor; that is, the spaces between the lines are as wide as the phosphor lines themselves. The spaces between the lines are filled in with a guard band, made of a dark-colored, nonluminescent material. The presence of this band insures accurate line width, improves color saturation, and enhances contrast under normal ambient light by reducing the reflectivity of the screen.

Correct white balance is built into the screen of the Apple tube by adjusting the relative efficiencies of the blue and green phosphors by the addition of varying amounts of nonactivated material so that scanning of the screen with a constant, unmodulated beam produces white.

The phosphor array is not quite the simple structure of repeated lines described above. The triplet pitch, as mentioned above is varied to match the normal sweep speed as shown in figure 3. Another example of matching the
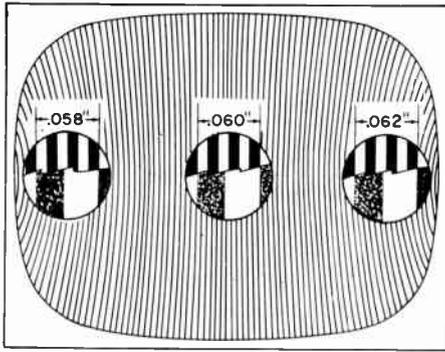
Figure 3. Line Drawing Showing Details of Screen Structure

screen geometry to the electron optics is the progressive curving of the phosphor lines from center to edge. This is much exaggerated in the drawing of the figure. The slight pincushioning corrects for the small amount of corner twist in the relative positions of the two beams caused by certain field parameters in the deflection yoke.

The guard bands and phosphor lines are placed on the inside of the tube face by a photoresist technique using dichromate-sensitized polyvinyl alcohol.

In order to cancel out any variations in the glassware of the tubes and thus increase possible glassware tolerances, the array of lines is placed on the face of the tube by a light projection system, schematically diagrammed in figure 4, in which the optical paths are made as nearly like the electron paths as possible. Thus, the projection lens has its optical center at the electron center-of-deflection. In order to make the exposure, the bulb is open at a point where a flared neck with a flare diameter of about 2½ inches may be sealed to the funnel.

The exposure equipment consists of the following:

1. A high-pressure mercury-arc light source.
2. A wide-aperture condensing lens.
3. A wide-angle projection lens.
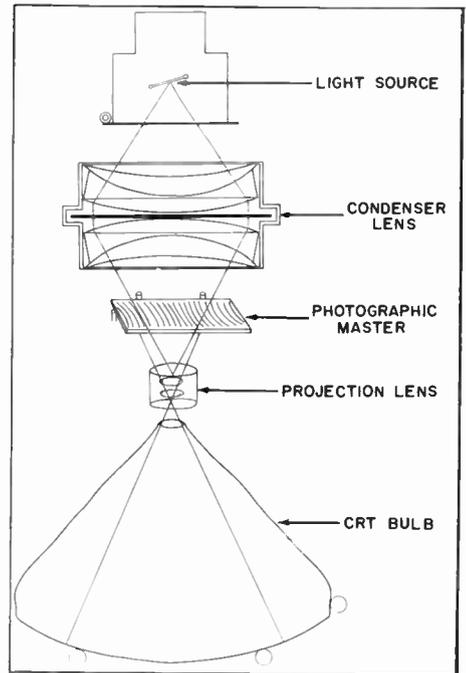4. A kinematic mounting for positioning the bulb.

Figure 4. Schematic Line Drawing of Projection System

5. A precision photographic line master.

The light source is conventional.

While of special design, both the condensing lenses and projection lenses were designed and produced using well-known techniques.

The kinematic mounting device, which permits simple, precise relocation of the bulb in the projector, uses six fixed, hardened steel balls. Three of them are in contact with the face of the bulb; two are in contact with one long side of the panel, and one with one short side. Relocation with 180-degree rotation is avoided by observing the location of the anode contact button.

The precision with which the phosphor lines can be placed on the tube with respect to each other depends upon the stability of the projecting equipment, accurate bulb-repositioning, and the precision of the line masters. Once the proper line masters have been prepared, however, precise reproductions of the

tube luminescent screens are achieved without difficulty. The precise screens are achieved without difficulty. The precise relative position of the lines is built into the glass photographic masters and thus need not be built into each tube.

A complete discussion of the preparation of the photographic line masters would require too much time to be covered in detail here. It has entailed the design and construction of unique equipment and the development of a number of unconventional techniques. With this equipment precision linear rulings on glass or metal are converted into sets of properly distorted photographic masters, one each for red, blue, green, black, and index line deposition.

During exposure from the inside, or gun side, of the face plate, hardening of the resist occurs from the surface down toward the glass as exposure proceeds. If the phosphor and photoresist were mixed, an absolutely uniform layer would have to be deposited; otherwise, heavy sections would be underexposed and not affixed to the glass, or if the exposure were long enough to ensure complete adherence of all desired areas to the glass, the phosphor particles acting as a dispersing medium, would reduce the precision and delineation of detail in the line pattern.

These difficulties are eliminated by first coating the bulb face plate with a film of clear photoresist, which is then exposed. The exposed photoresist film is coated with a phosphor slurry, dried, and washed off. The unexposed areas of resist wash off readily, carrying phosphor from these sections with them. The exposed areas remain, holding a uniform layer of phosphor which adheres to the exposed resist lines.

The dark guard bands are applied first using the above described process but substituting a dark, non-cathode-luminescent material for the phosphor. The red, blue, and green lines are then applied, one color at a time using the appropriate photographic masters, and

completely filling the spaces between the dark guard bands.

INDEX STRUCTURE

The final unique feature of the beam-indexing color tube is the index structure, which provides the required continuous monitoring signal. This signal is generated by the difference in secondary emission between an array of magnesium oxide stripes applied to the gun side of the aluminized screen and the bare aluminum between these stripes, as shown in figure 5. There are two contact buttons on one side of the tube envelope, and one of these is connected to the screen aluminum coating, making it possible to maintain the screen potential at approximately 27 kilovolts.

The second contact button connects to the bulb coating, which is maintained at 30 kilovolts. The 3-kilovolt differential between the screen and bulb coating potentials results in collection of the secondary electrons from the screen by the bulb coating.

The screen is aluminized in conventional fashion. An organic lacquer film is then applied, by a simple flow-on technique, to the gun side of the aluminum film. The lacquer strengthens and protects the aluminum during the application of the magnesium oxide stripes. The magnesium oxide stripes are applied to the lacquered aluminum in exactly the same way the phosphor lines were ap-
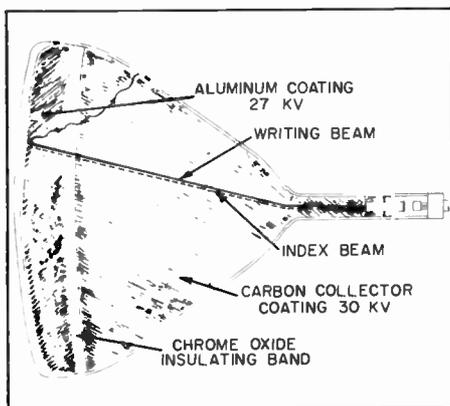

Figure 5. Cross Section of Apple Tube

plied to the glass, except that a different photographic master is used.

There is one magnesium oxide stripe per triplet. The index stripes are on a 40 percent duty factor; that is, 40 percent of the triplet width is magnesium oxide, 60 percent, bare aluminum. This has been found to give the maximum fundamental component index yield. The distortions built into the index lines, while related to the distortions built into the phosphor lines, contain a corrective component, the controlled displacement of the index stripes, to compensate for index transit-time variations and tracking variations. Transit time varies enough to produce a phase shift of over 90 degrees at sideband frequency between the center and edge of the screen. Making the transit time uniform is more difficult and expensive than moving the index structure laterally enough to compensate for it.

An interesting feature of the testing of the beam-indexing tube is the examination of the index structure. This may be done in detail by simply using the tube as though it were a monoscope and displaying the secondary emission pattern of the screen and index structure on a monitor tube.

PILOT PRODUCTION AND LIFE TEST

Several years of development work and many months of pilot production activity on the Apple tube have demonstrated its reproducibility in manufacture. Equipment requirements, other than those for the screening operation, are the same as those for the manufacture of monochrome tubes

Extensive, long-range life tests have failed to show any signs whatsoever of index deterioration with either shelf life or operating lifetime up to 10,000 hours. In fact, no measurable changes in index yield, for the whole screen or any part of it, have been noticed on any of several hundred life-test tubes.

Cathode emission problems at present loadings are not substantially different from those associated with monochrome tubes, and are believed to be less troublesome than might be encountered in tubes having more internal hardware, or multiple guns.

A comparison of the finished Apple tube with a monochrome tube, as in figure 6, shows the same size envelope for the same size picture. Compared to other color tubes, the Apple tube presents the largest picture size in proportion to the envelope size.

No metal sealing flanges are present, and no new techniques of equipment for making large panel funnel seals are required by the tube manufacturer.
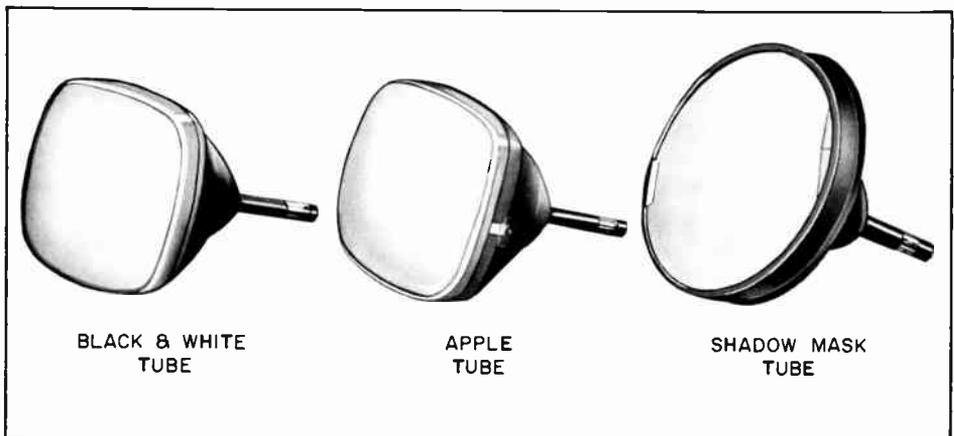

BLACK & WHITE TUBE

APPLE TUBE

SHADOW MASK TUBE

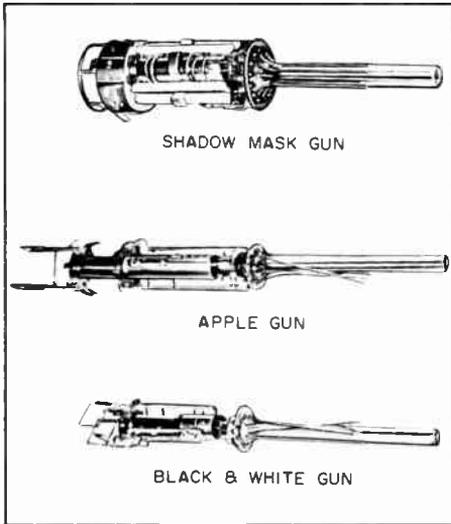*Figure 6. Monochrome, Apple, and Shadow Mask Tubes*

Figure 7. Monochrome, Apple, and Shadow Mask Guns

The electron gun, shown in figure 7, is more like a monochrome gun than it is like any multiple beam gun used in other types of color reproducing tubes.

CONCLUSION

In conclusion, the beam-indexing color picture tube is believed capable of producing high-quality monochrome and full-color pictures. Resolution and brightness are outstanding.

In the opinion of the authors the tube permits potentially lower-cost manufacture than other types of color tubes.

Its manufacturability and life potentiality have been demonstrated to be satisfactory.

ACKNOWLEDGEMENT

TECHNICAL TERMINOLOGY

In the interest of providing more precise (see below) meanings for the many technical terms involved in the electronics field, the following definitions of terms are given in IRE Standards on Electronic Computers: Definitions of Terms, 1956.

ACCESS TIME—A time interval which is characteristic of a storage unit, and is essentially a measure of the time required to communicate with that unit. Many definitions of the beginning and ending of this interval are in common use.

ACCUMULATOR—A device which stores a number and which, on receipt of another number, adds it to the number already stored and stores the sum.

ACCURACY—The quality of freedom from mistake or error, that is, of conformity to truth or to a rule. Accuracy is distinguished from precision as in the following example: A six-place table is *more precise* than a four-place table. However, if there are errors in the six-place table, it may be either *more or less accurate* than the four-place table.

KEYING WESTINGHOUSE MW TRANSMITTERS FOR AIR/GROUND USE

by Joseph R. Caselli

Philco TechRep Field Engineer

This article is not intended as instruction material on Westinghouse MW transmitters, but should be of interest to personnel involved with installation and maintenance of this equipment.

EXPERIENCE HAS SHOWN that considerable trouble is encountered when keying MW transmitters that are used for air/ground communications at normal Globe-Comm transmitter sites. In order to rectify this situation, the system used to key the transmitter was modified; however, no attempt was made to modify the transmitter itself.

The present GlobeComm arrangement for airways provides for changing d.c. to tone through VFTG (voice frequency telegraph) equipment (up to 12 channels). The tone is then transmitted via Philco CMT-4 and CLR-6 equipments to the transmitting site. At the transmitter site, the tone is demodulated, and the resulting d-c output is used to energize the push-to-talk relay in the MW transmitter. The specific methods used in MW-1 and WM-2 (Westinghouse nomenclature) transmitters are somewhat different, and the keying-changes applied to each will be listed separately later in the text. The basic airways transmitting scheme is outlined in the block diagram shown in figure 1.
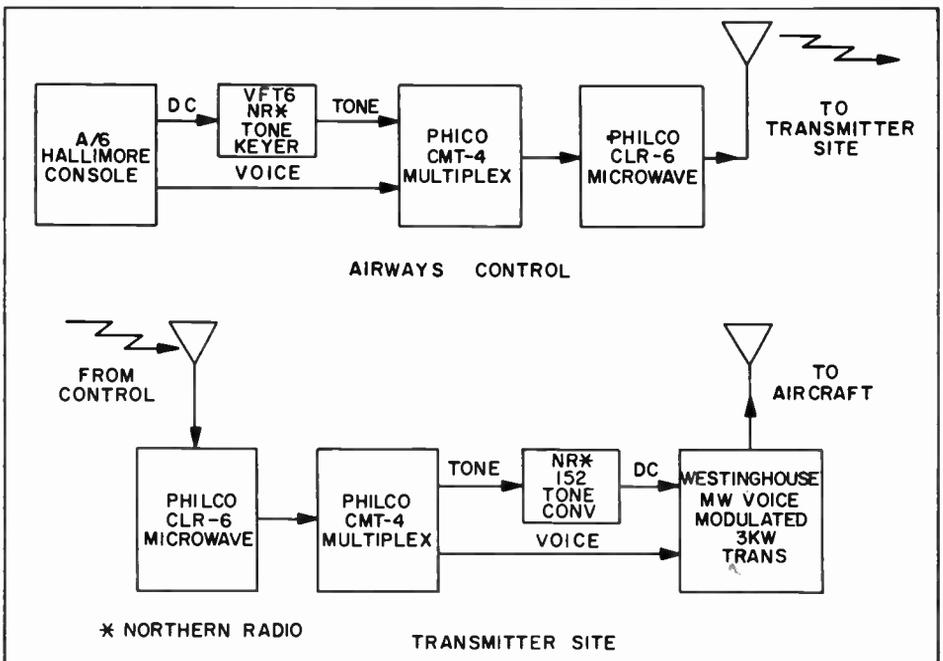
The difficulty with the GlobeComm

Figure 1. Block Diagram of the Basic Airways Transmitting System

keying system, when used with MW transmitters, lies with keying the high-voltage circuits. The d-c output from the Northern Radio 152 converter energizes relays which in turn energize high-voltage relays in the transmitter to apply high voltage to the modulator and r-f amplifier tubes. When these high-voltage relays are de-energized, a current in excess of 1.2 amperes at 4000 volts is suddenly interrupted through the modulation choke. The back e.m.f. caused by this interruption draws an arc across the high-voltage relay contacts to ground, and thereafter it becomes a race as to whether the high-voltage fuses blow or the power-supply overload circuit breakers trip. In either case, disrupted communications result until maintenance personnel can replace the fuses or reset the circuit breakers.

The minor changes which follow can be used to remedy this undesirable condition. Briefly, these changes keep all appropriate high-voltage relays in the transmitter energized and thus maintain high voltage on the power-amplifier and modulator tubes at all times. Control of the transmitter and modulator is then accomplished through the low-level stages. When it is desired to key the transmitter, the keyer tube grid is grounded through relay contacts K203B, as shown in figure 2. When it is desired to modulate the transmitter, the push-to-talk relay (K203) is energized, and it removes the high bias from the modulator driver stage by grounding the grid of this tube through a resistor and relay contacts K203C. When the transmitter is not being keyed, no plate current is obtained from either the power amplifier or modulator tubes because of the lack of excitation in the r-f unit and the cutoff condition of the modulator driver tube.

The changes outlined below are specifically for MW-1 transmitters, and are affected at the GlobeComm relay panel located in the rear of the power supply. (Reference: Print number GC 36133, latest revision 20 Sept. 54, figure 4, modified schematic.) The changes will affect one bank of MW-1 equipment, which includes three modulators, three r-f units, and one power supply. Figure 2 shows the modified circuit of only one modulator and one r-f unit, although the modification of all three is discussed. To modify the MW-1 transmitter keying circuits, proceed as follows:
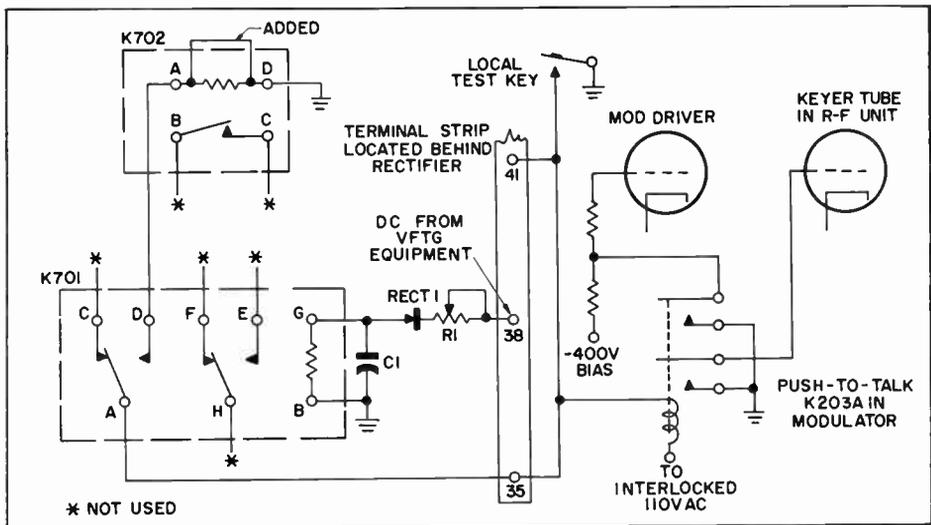

Figure 2. Modified Circuit for One R-F Unit and One Modulator. Modifications for Other R-F Units and Their Associated Modulators are Identical

1. Remove leads from equipment side of terminals 39, 46, and 53, and connect to terminals 37, 44, and 51, respectively. This change will keep all high-voltage relays energized at all times, through interlocked circuits.

2. Remove and tape leads on relay side of terminals 35, 36, 39, 40, 41, 42, 43, 46, 47, 48, 49, 50, 53, 54, and 55. These leads are unused.

3. Remove leads on relay side of terminals 37, 44, and 51, and connect to terminals 35, 42, and 49, respectively. This change places ground on modulator push-to-talk relay K203 when K702, K704, and K706 in the GlobeComm relay panel are energized.

4. On relays K702, K704, and K706, short out relay coil by connecting jumper wire between terminals A and D of each relay. This change provides ground at terminal A of each of these relays.

5. Connect jumpers between terminals 36 and 41, 42 and 48, and 49 and 55. This change allows the transmitter to be keyed locally.

The changes required to modify MW-2 transmitters used for airways control are even simpler, and the resulting circuits perform the same electrical functions as do those just described for the MW-1. These changes merely place jumper wires at terminal strips located in the ducts behind the transmitter. To modify the MW-2 transmitter keying circuits, proceed as follows:

1. Using jumpers, connect the following terminals: DT-1 34 to DT-1 32, DT-2 34 to DT-2 32, and DT-3 34 to DT-3 32. This change keeps high-voltage relays energized through interlocked circuits.

2. Using jumpers, connect the following terminals: DT-1 45 to DT-1 46 to DT-1 27, DT-2 45 to DT-2 46 to DT-2 27, and DT-3 45 to DT-3 46 to DT-3 27. This change allows the transmitter to be keyed locally.

The changes described above have been in effect at some of the NEAC bases for a considerable period and have successfully eliminated the malfunctions described at the beginning of this discussion.

A T-17 MICROPHONE TEST SET

by M/Sgt. David D. Blackmer

This article describes a method of accurately and quickly checking T-17 carbon microphones, and also describes an easily constructed test set which provides a go no-go check of these microphones.

(Editor's Note: The author wishes to thank Mr. Jiro Amagi, a Japanese National, and T/Sgt. H. A. J. Steenkolk for the help they provided with the layout and construction of the test set.

An AM TRANSMITTER may be transmitting many watts of r-f power, but if the carrier is unmodulated the r-f power output is useless as far as conveying intelligence is concerned. Many aircraft transmitters in use today use the T-17 microphone at the input of the modulating system, and a great many of these have no doubt been red-tagged on the assumption that an ohmmeter check (performed as preventive maintenance) from ring to sleeve, provides an accurate indication of its condition. After noticing that some of these red-tagged microphones performed normally, an accurate log was kept on 50 microphones routed through the maintenance shop. This log indicated the ohmic value, the current rating in ma., and the a-c voltage output of the element. From the information gathered, there seems to be no correlation between the ohmic value (measured with a PSM-6, for example) and the dynamic characteristics obtained using the T-17 test set which is described in this article.

In order to establish a go no-go test for these microphones, the following equipment was assembled: An audio oscillator; a small audio amplifier; a 5-inch speaker mounted on a baffle with a 2-inch hole at its center fitted with a large rubber grommet; an oscilloscope; and an ART-13 transmitter equipped with a low-frequency oscillator.

For use in testing microphones, this equipment is connected together as shown in the block diagram of figure 1. The audio oscillator and amplifier are set to provide a 1000 c.p.s. output signal from the speaker. During the test the microphone is pressed firmly against the rubber grommet in the speaker baffle. The ART-13, adjusted to provide a medium load into a dummy antenna, is keyed using the microphone press-to-talk switch, and the oscilloscope connected to the output of the ART-13 is set to indicate the modulated r-f envelope. In this way each microphone can be checked under identical operating conditions, and its relative output can be indicated on the scope by computing the percentage of modulation.

With this equipment setup some unusual information was obtained. Microphones with resistance values (using a PSM-6) from 100 ohms to 3000 ohms produced modulation percentages from 75 to 100 percent without any correlation between the ohmic value and the percentage of modulation. For example, a microphone with 1000 ohms resistance did not produce as much modulation as one with 100 ohms, and some with 2000 ohms resistance produced 95 percent modulation as compared to 75 percent for those having resistance values of 200 to 300 ohms, etc.

The problem at this point was to design a simple tester which would provide the same relative indications that were obtained with the more elaborate setup shown in figure 1. With this in
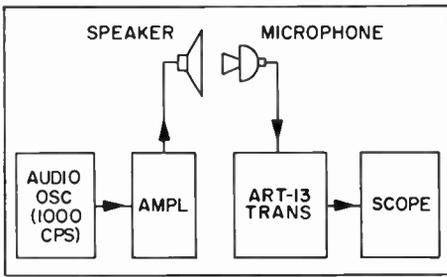
Figure 1. Block Diagram of Equipment Setup
for Checking T-17 Microphones

mind, a rough breadboard circuit layout was made which would provide meter indications of 45 to 70 ma. with a correspondingly high-voltage output for those microphones which produced modulation percentages of 75 to 100 percent in the foregoing tests. Thus a go no-go point was established using 65 or 70 percent modulation as the lowest acceptable value. The test set, shown schematically in figure 2, was then made and was subsequently fitted into a small carrying case. The values of the meter shunt and multiplier resistors, shown in figure 2, must be selected to give appropriate readings depending on the type of meter which is used. With switch SW1 closed, the unit will produce an audio signal which can be used to check the percentage of modulation with an ART-13 and an oscilloscope as described earlier. Ordinarily, the switch is left open as shown. (As a note of interest, switch SW1 may be shunted with an open-circuit jack, and the unit can then be used as a code practice oscillator.) By adding switch SW4, shown in figure 3, the unit becomes a small amplifier and listening tests may be made.
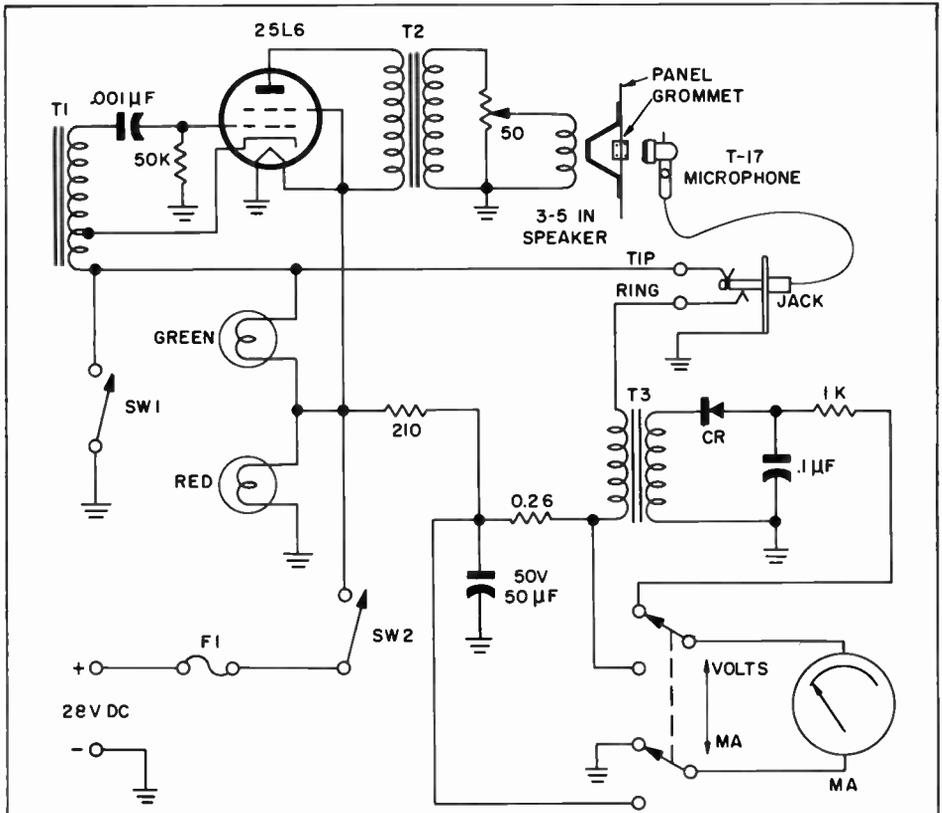

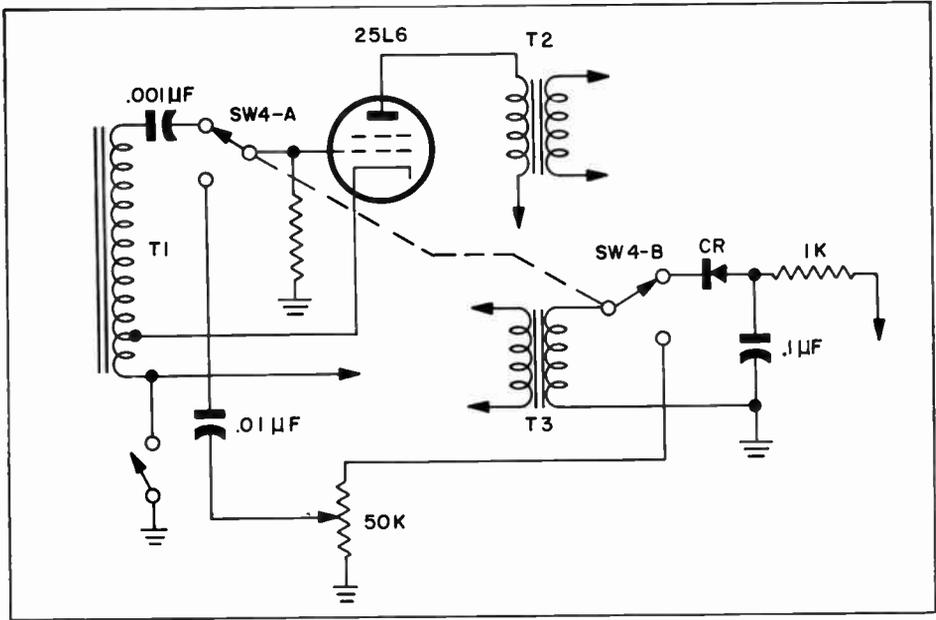Figure 2. Schematic Diagram of T-17 Microphone Test Set

Figure 3. Circuit Modification to T-17 Microphone Test Set to Adapt It for Listening Tests

T1 may be any of several small transformers available from stock which will produce a signal from 500 to 1000 c.p.s. T2 is a small a-c/d-c replacement output transformer. T3 may be almost any carbon microphone-to-grid transformer. As indicated in figure 2, 28 volts, d.c., is used for the heater and plate supply.

This test set provides a quick and accurate dynamic check of the condition of any T-17 microphone. The condition of the microphone switch is shown to be satisfactory if the green pilot lamp lights and the oscillator starts operating at the same time. The go no-go points may be marked on the face of the meter with red paint.

CONSTRUCTION OF EARTH PROFILE CHARTS

by Robert W. Roberts

Philco TechRep Field Engineer

This article describes an easy method of constructing earth profile charts for any particular problem when standard charts do not quite fit the job, or are not readily available.

IN MANY CASES of propagation studies the vertical coverage, or earth profile, charts that are available do not quite fit the particular problem at hand. Usually, the profile charts used in radar work provide a coverage of 300 miles in range by 60,000 feet in altitude, and those used in communication work provide a coverage of 100 miles in range by 10,000 feet in altitude. Earth profile charts tailored to fit any specific set of conditions can be constructed quickly and easily by using the procedure given below. These charts will show range in nautical miles, with the earth's curvature based upon 4/3 of the earth's radius to

allow straight lines to represent radio paths.

The first step in the construction of a chart is to determine the scale, which depends upon the size of the paper, the extremes of horizontal and vertical distances involved, and the amount of detail desired for the problem under consideration. After determining the scale, construct a right angle as shown in figure 1, where line AB is a horizontal line from the point of origin (A) on the earth's surface to a distant point (B), and line AC is the vertical line from point A to altitude C. Along line AB, using the scale selected, locate a series of equidis-
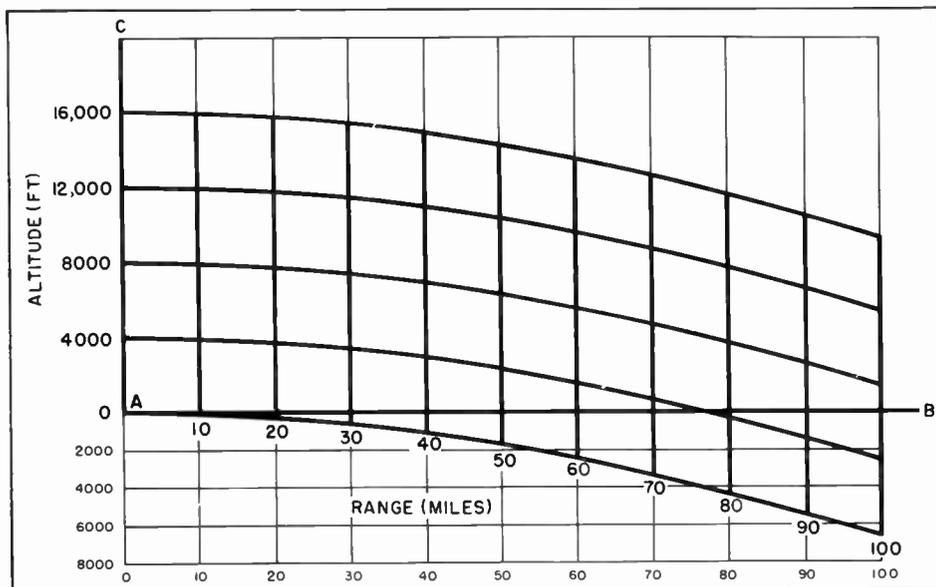

Figure 1. Method of Preparing Earth Profile Chart for Radar Line-of-Sight Studies

tant points to represent the desired range intervals. Through each of these points, draw a vertical line parallel to line AC, extending the line above and below horizontal line AB. Next, locate a point on each vertical line, to represent the 4/3 earth's curvature, by measuring downward from line AB a distance proportional to the height in feet as given for that range in Table 1. For example, on the vertical line corresponding to a range of 20 nautical miles, the distance measured downward from line AB should be proportional to 265 feet. Connect these points with a smooth curve.

Measuring from this curve, locate points corresponding to the desired altitude intervals along each vertical line, and connect all of the points for each interval with a smooth curve. To complete the chart, label the range intervals (horizontally) in nautical miles, and the altitude intervals (vertically) in feet.

The completed chart, shown in figure 1, is of the type generally used for radar coverage computations; however, using the same techniques, a symmetrical chart for communication line-of-sight studies may be constructed by placing line AC in the middle of the chart and plotting

TABLE 1. RANGE VERSUS HEIGHT DATA FOR USE IN CONSTRUCTING EARTH PROFILE CHARTS

| Range in Naut. Miles	Height in Feet	Range in Naut. Miles	Height in Feet	Range in Naut. Miles	Height in Feet	Range in Naut. Miles	Height in Feet
1	1	23	351	45	1,343	135	12,087
2	3	24	382	46	1,403	140	12,999
3	6	25	415	47	1,465	145	13,944
4	11	26	448	48	1,528	150	14,923
5	17	27	483	49	1,592	160	16,979
6	24	28	520	50	1,658	170	19,167
7	32	29	558	55	2,006	180	21,489
8	42	30	597	60	2,388	190	23,942
9	54	31	637	65	2,802	200	26,529
10	66	32	679	70	3,250	210	29,248
11	80	33	722	75	3,731	220	32,100
12	96	34	767	80	4,245	230	35,085
13	112	35	812	85	4,792	240	38,202
14	130	36	860	90	5,372	250	41,452
15	149	37	908	95	5,986	260	44,834
16	170	38	958	100	6,632	270	48,349
17	192	39	1,009	105	7,312	280	51,997
18	215	40	1,061	110	8,025	290	55,777
19	239	41	1,115	115	8,771	300	59,690
20	265	42	1,170	120	9,550		
21	292	43	1,226	125	10,363		
22	321	44	1,284	130	11,209		
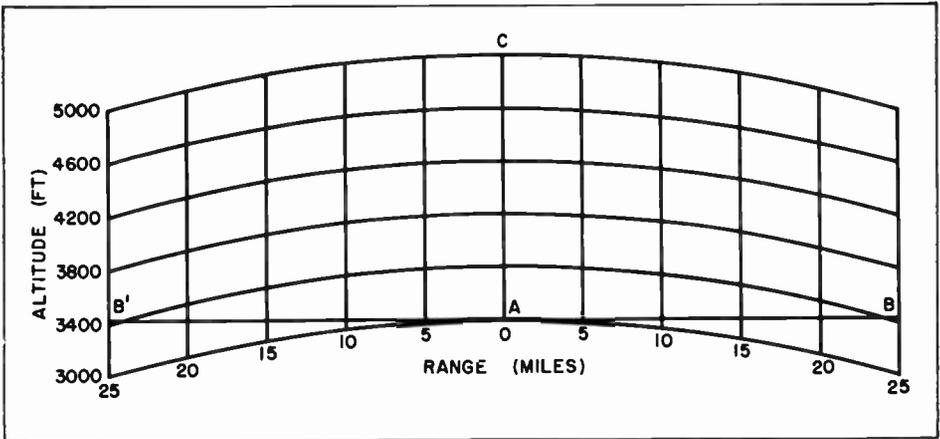
Figure 2. Method of Preparing Symmetrical Earth Profile Chart
for Communication Line-of-Sight Studies

range and altitude on each side of the line, as shown in figure 2. Values assigned to figure 2 were selected to demonstrate that the bottom curve can represent the sea level curvature of the earth (4/3 radius), or any altitude up to 15,000 feet, with essentially no error to the indicated line of sight.

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"What's Your Answer?"

The problem presented in this issue was submitted by Philco TechRep Field Engineer Bob Silberstorf some time ago. We think it's a good one, so, with apologies for the delay, here it is.

In the figure below, the impedance as seen looking into the network from terminals 1 and 2 will vary with the frequency of the applied a-c voltage. Will there be more than one frequency at which the impedance is maximum, and, with the values given, at what frequency or frequencies will maximum impedance occur?
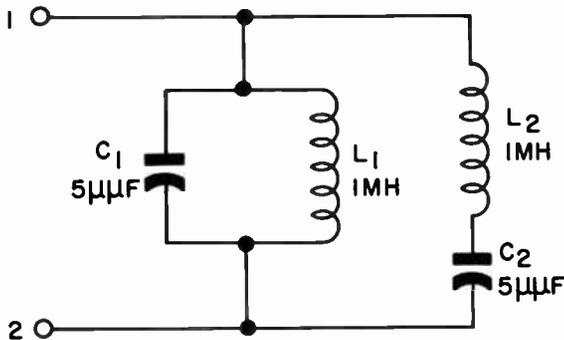
TRANSISTOR TRANSMITTER POWERED BY FLASHLIGHT CELLS

Forrest Bigelow, W3FBL, of Laverock, Pennsylvania, has rolled up an impressive list of 40-meter contacts in six months operation, using a Philco transistor transmitter and ground-plane beam. (See figure 1 for comparison of "S" reports on transistor and kilowatt transmitters.) His best DX contact so far is KH6KD in Hawaii, with whom he keeps a regular schedule at 3:00 A.M. Eastern Standard time on 7050 and 7073 kc. Other QSO's (message relays) include WAS (worked all states) and VE1, 2, 3, and 7 (Halifax to Vancouver).

A TRANSISTOR TRANSMITTER which employs flashlight cells as a source of power has been successfully used to make a number of DX contacts on the 40-meter band. The main features of this transmitter are described below, and a few suggestions on the construction and operation of the transmitter are included for those who might be interested in building a similar rig.

DESCRIPTION OF RIG

The complete transmitter, powered by flashlight cells, is a crystal-controlled oscillator-amplifier with 120 milliwatts input and employing Philco type SBDT (surface barrier diffused transistor) and SB100 transistors. The antenna consists of two vertical ground planes with 40-foot radiators spaced a quarter wave apart. Only one of these ground planes
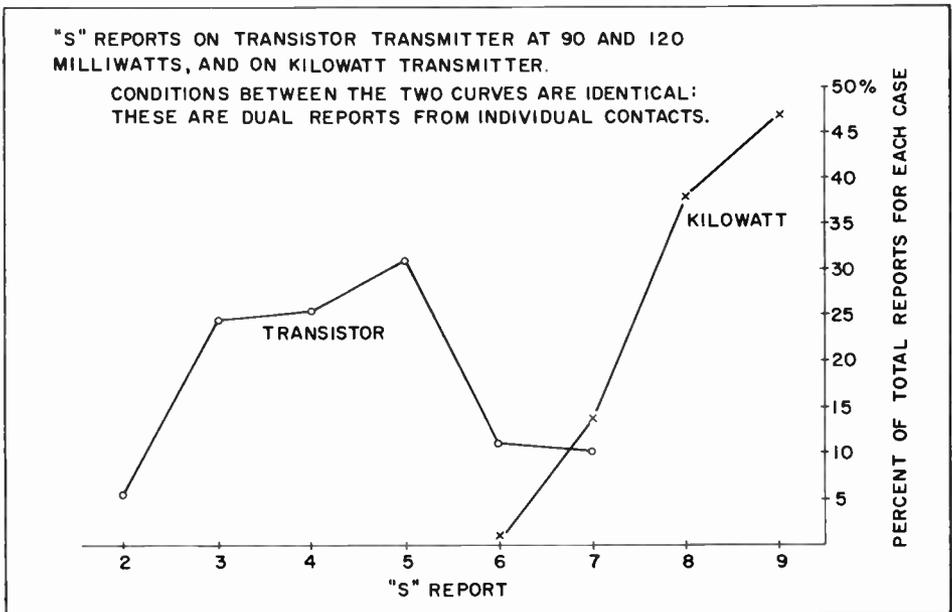

Figure 1. "S" Report Comparison Between Transistor and Kilowatt Transmitters
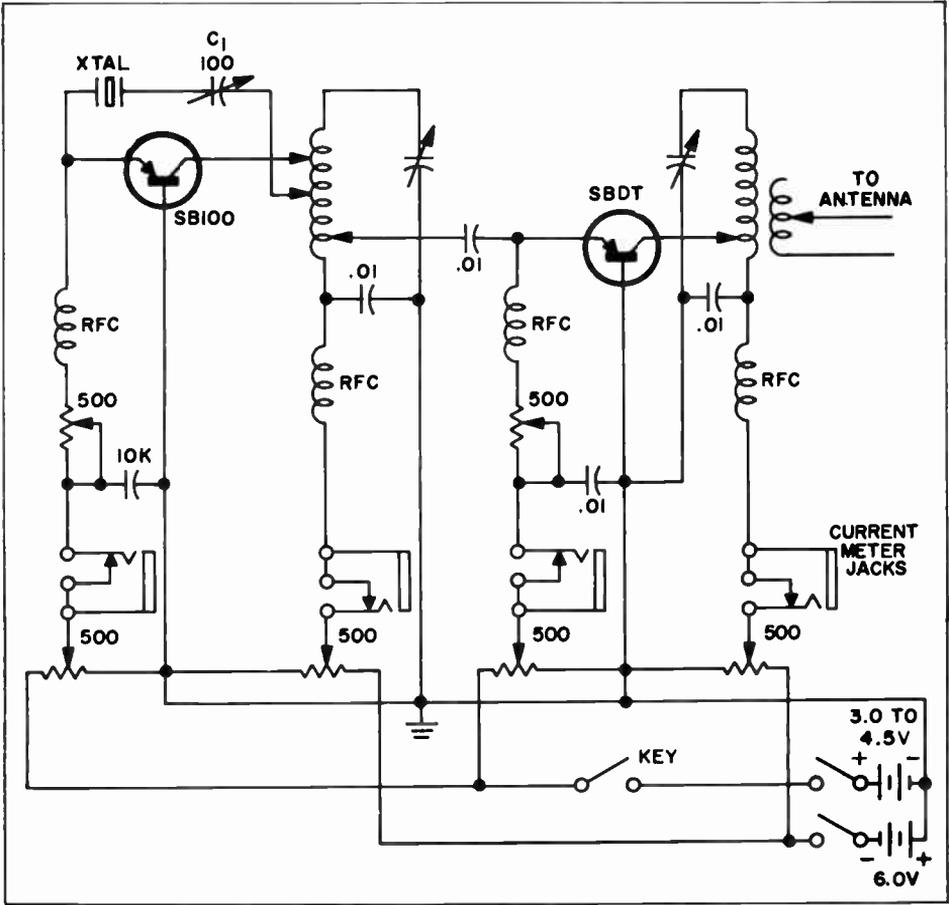
Figure 2. Schematic Diagram of Transistor Transmitter

is driven, the other serving as a parasitic reflector.

The transmitter circuit is shown in figure 2. Although the circuit itself appears to be without novelty, the actual transmitter incorporates several features which enhance efficiency and stability. The tank coils are large (4″ diameter in the amplifier) and of heavy wire; in fact they would be suitable for a kilowatt rig. Hence, their unloaded Q is high, which is very important in such service.

Bus wires and connections suitable for handling a kilowatt are also used to reduce losses. The philosophy, "Here are small currents, so small wire and poor connections can be employed," was dis-carded in favor of maximum efficiency.

Grounded-base configuration is used in the amplifier, to reduce feedback through the transistor. Because of this reduction and the relatively small capacitances of the surface barrier transistor, neutralizing is unnecessary. Although the small capacitance feedback present is regenerative, instead of degenerative as it would be if common emitter circuitry were used, no difficulty has been experienced with oscillation or instability.

The circuit incorporates several potentiometers to permit individual adjustment of the emitter and collector circuits for maximum transmitter output. While these potentiometers may be re-

placed by suitable resistors, they are particularly helpful in adjusting the collector voltage and current to the exact point for optimum operation. A transistor provides maximum power output at a rather critical collector voltage, which is not strictly predictable from the characteristic curves. Increasing the voltage up to a certain level increases the output, but raising it above this level results in no greater output (or actually decreases it) and is very likely to damage the transistor.

Damage to the transistor by excessive collector voltage is characterized by fracturing of the base layer, and is indicated by a continuously high collector current reading and by an ohmic resistance between collector and emitter of only a few hundred ohms. Such damage will occur before the applied d-c voltage reaches the rated breakdown voltage of the transistor, because the r-f voltage in the circuit will effectively add to the d-c voltage to produce an instantaneous voltage that is much higher than the d-c voltage. Such damage may also be caused by resonating the tank while the antenna (or other load) is disconnected, especially when operating with a high supply voltage.

Incorporated in the transmitter is an efficient heat sink for the amplifier transistor, to permit operation of the transistor above its maximum ratings. The heat sink used at first was a tight-fitting brass tube to which fins were soldered. This sink slipped over the transistor case. An improved heat sink used later incorporates an ice bath for more efficient cooling.

The ice bath heat sink consists of a tin can tank large enough to hold two ice cubes, and covered with asbestos sheeting to reduce "sweating." Soldered upright, at the side of the tank, is a ⅜″ I.D. section of tubing with its bottom soldered shut to make a liquid-tight well. Coil dope is painted above the upper edge, to serve as an insulator in case the transistor leads happen to touch the tubing.

The well houses the transistor, which has a section of tight-fitting tubing slipped over its case. The well is filled with silicone oil to cover the transistor assembly, including a portion of its leads. Another version of the ice bath type heat sink uses finely divided aluminum particles in the oil to increase its thermal conductivity.

Thus, water and ice cubes in the tank cool the oil which, in turn, cools the transistor and permits increased power input by about 30%. Even without increase of input, use of this type of heat sink is good insurance against transistor failure.

SUGGESTIONS ON CONSTRUCTION AND OPERATION

In constructing transistor equipment, it is important to ground the frame of the soldering iron or gun to the chassis before doing any soldering, to prevent leakage current from the iron from damaging the transistors. Even soldering with an ungrounded iron to a transistor circuit held in one's hand can result in damage if the current charging the body capacitance to ground should happen to flow through a transistor. Any a-c operated test equipment should also be grounded before connection to the circuit.

In building the rig described above, series dropping resistors or inductors in the collector supply should be minimized since, although safe potentials may be achieved while the key is closed, current reduction or stoppage caused by opening the key will cause the collector voltage to rise. However, some resistance in the emitter supply circuit is essential to ensure temperature stability and to lessen the danger of current "runaway" and ruination of the transistor. About 100 ohms has been found satisfactory for this purpose. Excessive power input will fracture the crystal through heating.

Both tank coils should be tapped at every turn, for empirical determination of proper matching, which is quite im-

portant for maximum output. In the case of the final, it has been observed that, for a given antenna load, one turn away from the optimum collector tap will reduce the output by two-thirds.

C1 is not a simple blocking capacitor, but is a phasing adjustment to be set at the point that provides the best stable oscillator operation under keying conditions. For optimum results, both the capacitor and its tap to the coil should be adjusted. C1 also permits a small change in frequency to get out from under QRM (interference).

Collector current in the amplifier should be monitored, but the reading obtained is not a good indication of power output. Some means of measuring feeder current or (preferably) antenna excitation should be used to indicate relative power output.

Operating a transistor with a power input in excess of its ratings is not without an element of risk. However, it is possible to operate one for many (even hundreds of) hours before failure occurs if the following precautions are observed.

1. Monitor the output and use no more collector voltage and/or current than necessary to give maximum power output.

2. Keep the transmitter away from a high power rig that is in operation. Otherwise enough energy may enter the transmitter rig to damage the transistors, as it would any diode.

3. Watch the collector current closely. If it rises gradually or abruptly, decrease the collector voltage and current immediately. An increase in current is evidence of thermal runaway or alteration of transistor characteristics.

4. If there is a choice between extra-high voltage and extra-high current for a given r-f output, choose the current as the lesser danger.

5. If operating the transistor beyond its ratings, do not resonate the final tank without a load.

6. Avoid intermittent short circuits, especially in the collector circuit, as they may cause voltage transients to be produced.

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ADJUSTMENT OF OUTPUT FREQUENCIES, NORTHERN RADIO TONE KEYERS

by Robert A. Hamilton

Philco TechRep Field Engineer

This article describes a simplified procedure devised to allow adjustment of output frequencies on a particular tone keyer by personnel having little training or familiarity with the equipment.

A SIMPLIFIED PROCEDURE for the adjustment of the output frequencies of the Northern Radio Tone Keyers of the wide shift (240 cycles) type, has been devised and put into use at this location. It enables maintenance personnel of the lower skill levels to make the rather critical adjustments, since little test equipment is involved. The procedure depends upon the availability of the AN/FRC-10 Terminal Equipment.

Output at the center frequency of the tone keyer to be adjusted is selected from the appropriate mark or space channel oscillator in the terminal and trunked to the operating location of the
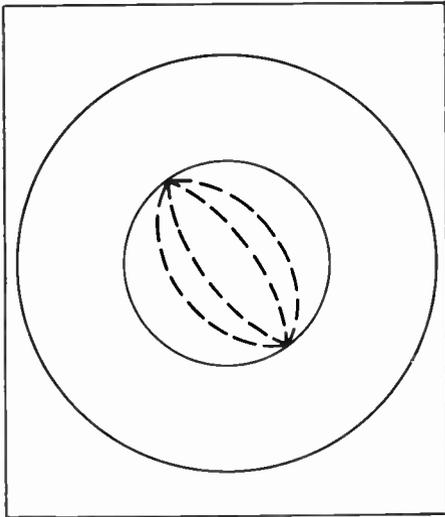

Figure 1. Standard Lissajous Pattern Showing a One-to-One Frequency Ratio. The Dashed Lines Indicate Patterns Obtained with Various Phase Differences.
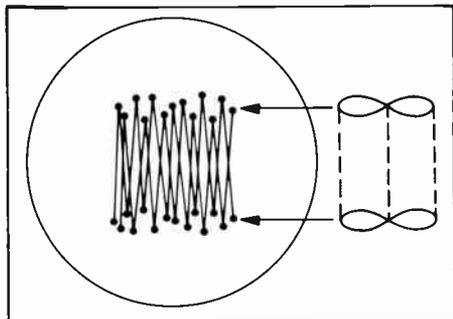
tone keyer. There it is applied to the vertical input of an oscilloscope, through a series-connected .01-μf capacitor. Output from the tone keyer is applied to the horizontal input of the oscilloscope through a second series-connected .01-μf capacitor. The capacitors are necessary to prevent interaction between the two signals. Loading of both signals occurs, since the tone keyer is adjusted while feeding its normal output line. With suitable gain adjustments on the oscilloscope amplifiers, the manufacturer's adjustment procedure may be followed to obtain a Lissajous figure having a one-to-one ratio, as illustrated in figure 1. Mark and space adjustments are then accomplished by applying both the reference frequency and the output of the keyer to the oscilloscope vertical input, while feeding the 60-cycle test signal to the horizontal input. The resulting display will have the appearance of a rotating cylinder with amplitude variations at the top and bottom of the cylinder occurring at the difference rate between the 60-cycle signal and the difference between the reference frequency and the mark or space output frequency. When correct adjustment of mark or space is made, the peaks at the top and bottom of the pattern will form a horizontal figure eight, as shown in figure 2. Since only two possible frequencies beating with the reference frequency could give the two-to-one ratio, it is only necessary to make the space frequency the lower of the two tones.

Accuracy of the center frequency setting will be directly proportional to the error in the output of the 85-cycle base oscillator in the terminal equipment multiplied by the number of the harmonic of this frequency which corresponds to the center frequency of the keyer. The accuracy of the mark and space frequencies will be directly proportional to this error plus or minus the error in the 60-cycle power source.

Although this procedure was devised for adjustment of the wide shift keyers, suitable changes would permit its use in adjusting 12 of the narrow shift types. The six channels of the terminal equipment have mark and space frequencies that correspond to the center frequencies of the first 12 of the 18 available narrow shift keyers.

In this case, center frequency adjustments would be made as described for the wide shift type. Mark and space adjustments would be made using the 85-cycle base oscillator output instead of the 60-cycle line frequency. As an example, the first keyer in this line has a center frequency of 425 cycles. Mark and space shift points are 42.5 cycles above and below this frequency, respectively. Beating the center frequency and the keyer output frequency against 85 cycles would give the familiar figure-eight pattern. However, it would be necessary to run an additional trunk line for 85-cycle signal.

TECH INFO MAIL BAG

Here is another method of measuring phase shift in a transformer, submitted by H. Buschman.

While there are many methods that can be used for phase measurement, the null residual method is best suited for field use, and gives quite accurate results. The wattmeter method is limited to large phase angle measurements only, and often cannot be used at all because of the lack of a suitable wattmeter.

The accompanying circuit diagram illustrates the null residual method of phase measurement for both step-down and step-up transformers. The only test components required are a low-phase shift potentiometer and a VTVM. Problems encountered in the application of the method are phase shift in the potentiometer and noise which tends to obscure the null. In some commercial instruments based on the same principle, a filter is inserted in the VTVM leads to reduce noise and harmonics.

Generally, the larger the transformer, the smaller the phase shift. A transformer, when unloaded, usually has a phase shift opposite to that when fully loaded, and it is thus possible to load the transformer until the phase shift passes through zero. In the case of a regular power transformer, adjusting the load for zero phase shift may be

difficult. Also since most power transformers usually work near saturation at rated voltage, an overvoltage excitation may markedly increase the phase shift.

To measure the phase shift of a transformer by the null residual method, proceed as follows: Connect the equipment as shown in the appropriate illustration, and adjust the potentiometer for a minimum VTVM indication. Note the VTVM reading for the null condition, and then measure the secondary voltage. The null voltage is quadrature (plus noise and harmonics), and E_{quad}/E_{sec} = radians phase shift (for small angles), where 17.5 milliradians = 1°. An isolation transformer in the power cord is necessary if the VTVM terminals are isolated from ground. Remember that the potentiometer must be included in the secondary loading.

(This seems to us like a very good method for measuring phase angles in the field. A vector picture of the situation when the VTVM is nulled is shown in the figure, where kE_p is some fraction of the primary voltage appearing at the potentiometer wiper, E_{sec} is the vector representing the secondary voltage, and E_{quad} is the vector representing the difference between these two voltages at the null point; this latter voltage is seen to be in quadrature with (at right angles to) the primary voltage for the null condition.

It appears from the figure that the approximation,

$$E_{quad}/E_{sec} = \text{radians phase shift}$$

should be used with care for phase angles which are large. More accurate results for all phase angles will be obtained by use of the relationship:

$$\theta \text{ (phase shift)} = \sin^{-1} \frac{E_{quad}}{E_{sec}}$$

It should be emphasized that very few commercial vacuum-tube voltmeters are arranged so that a voltage other than ground can be applied to both terminals. This would require the use of the isolation transformer as suggested by Buschman. Ed.)

STEP-DOWN USE   STEP-UP USE
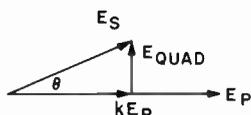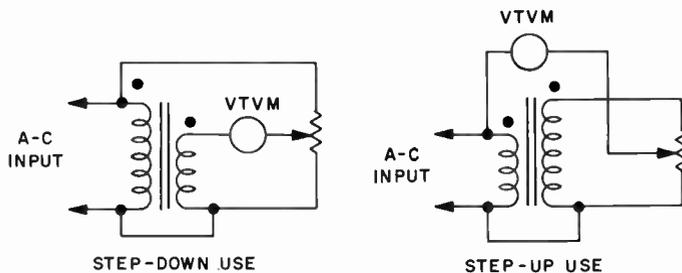
A REMOTE CONTROL CHANNEL SYSTEM FOR THE AN/GRC-27

by Benford K. Cruitt
Philco TechRep Field Engineer

The remote control channel selector system described in this article was specifically designed to fit the needs of an AC&W organization, although it could be adapted for other installations. The purpose is to change channels simultaneously on the R-278/GR and the T-217/GR, and at the same time give a visual indication of the channel selected.

GENERAL

In THE PAST, various systems of remote control, each with its own merits and shortcomings, have been devised for AN/GRC-27 installations. Equipment has been manufactured for this purpose, but thus far none has solved all the problems which arise from the many different types of installations using the AN/GRC-27 equipment.

While this article does not pretend to provide a universal solution, it does show how a satisfactory remote control system was provided at one location where four complete AN/GRC-27 equipments and four remote control positions were in use. The same system could easily be expanded to meet the needs of other locations. Included in the system is a remote antenna selector switch to operate the antenna selector relay (K-1204) in the T-217/GR. Incorporated also in the system is an equipment selector box which enables an entire AN/GRC-27 system to be patched to any one of the other positions. This feature makes for rapid change of equipment by unskilled personnel.

The various basic features of this system have been in use for some time, although this is the first known installation in which all of the features have been combined into one system.

DESCRIPTION OF SYSTEM

The general layout of the system is shown in figure 1. The selector-indi-cators (also illustrated in figures 4 and 5) are mounted at the operating position and are connected to the equipment selector box by a 20-conductor telephone cable using AN type connectors. Through the patch plugs and cables the circuits are carried to receptacles and on to terminal strips, where they are connected by jumper wires to the proper equipment cable pairs. The selector box in this installation was mounted on the main distribution frame (refer to figure 2).

Switch assembly S-1101 used in the selector-indicator is issued complete with wafer sections. These wafers are not used. In their place on the switch frame are mounted two S-1102A wafer sections. All hardware shipped with S-1101 is used. Selection of any one of ten channels is accomplished with only four wires by grounding particular combinations of one or more of the wires. This feature is discussed in detail in the manuals referenced at the end of this article.

A standard shaft size knob (figure 3) with a large outside diameter was used to mount a disk. A shaft size drill bit was run through the center to permit the shaft to extend through the knob. The type knob used was one upon which a calibrated dial had been mounted by three small screws. These screws were used to hold the disk to the knob. The knob is locked to the shaft by its set-
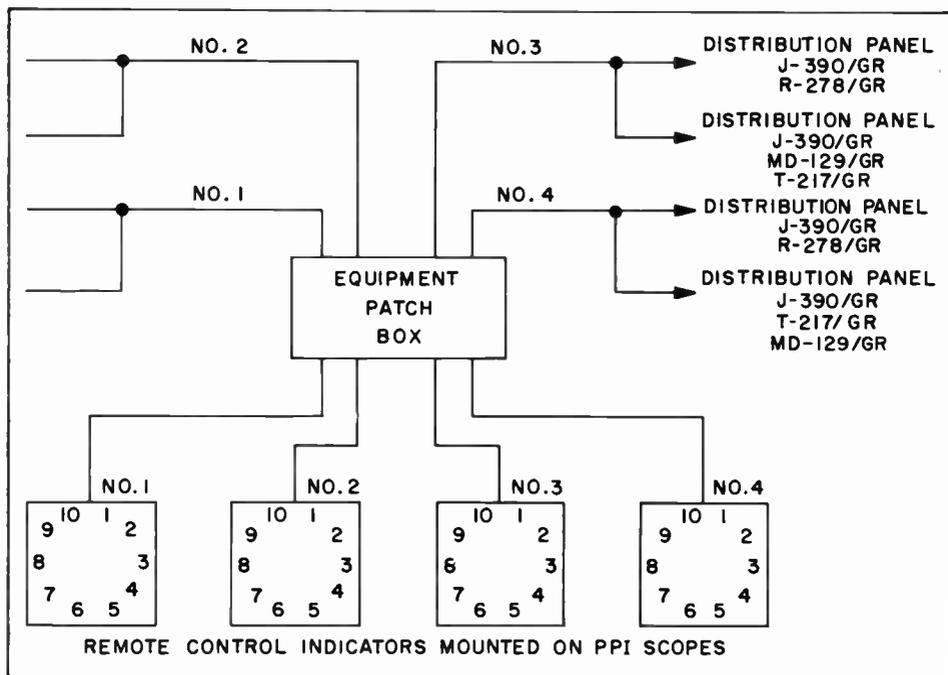
Figure 1. Interconnecting Cabling Between Units

screw when the system has been checked out. The ¼" hole in the disk allows light to shine through on the selected channel number brightly, while the disk shades the remaining numbers so that they are illuminated only slightly. The red plastic sheet is used to eliminate the glare of the illuminated numbers.

The numbers on the face of the selector-indicator were drawn in pencil and then drilled with a small drill, as shown in figure 5. Placement of the numbers on the face of the indicator is very critical, since any number not exactly in the correct position will not be properly illuminated by the revolving disk.

The partition and disk were fabricated locally from scrap aluminum. Lamp holders are mounted so that the bulbs give an even distribution of light over the face of the disk.

The equipment selector box was not designed to eliminate existing patch panels, but to supplement these facilities with a control system which will expedite the necessary changes in the AN/GRC-27 system in a simple manner and with a minimum of instruction to personnel.

Four selector-indicator boxes are cabled into the equipment selector box. Normally the circuits are plugged P-1 to S-1, as shown in figure 2. In the event that trouble is encountered in the equipment or lines of the first system, an entire system plugged into another position not in use at the time may be patched into this defective system and normal operation restored. The same method of patching may be accomplished for all positions.

The terminal strips (figure 6) used are of the feed-through lug type, and a hole is drilled in the top of the selector box for each lug. The strip which holds the Jones-type receptacles (see figure 7) was fabricated locally from scrap aluminum and bolted in place in the box, in
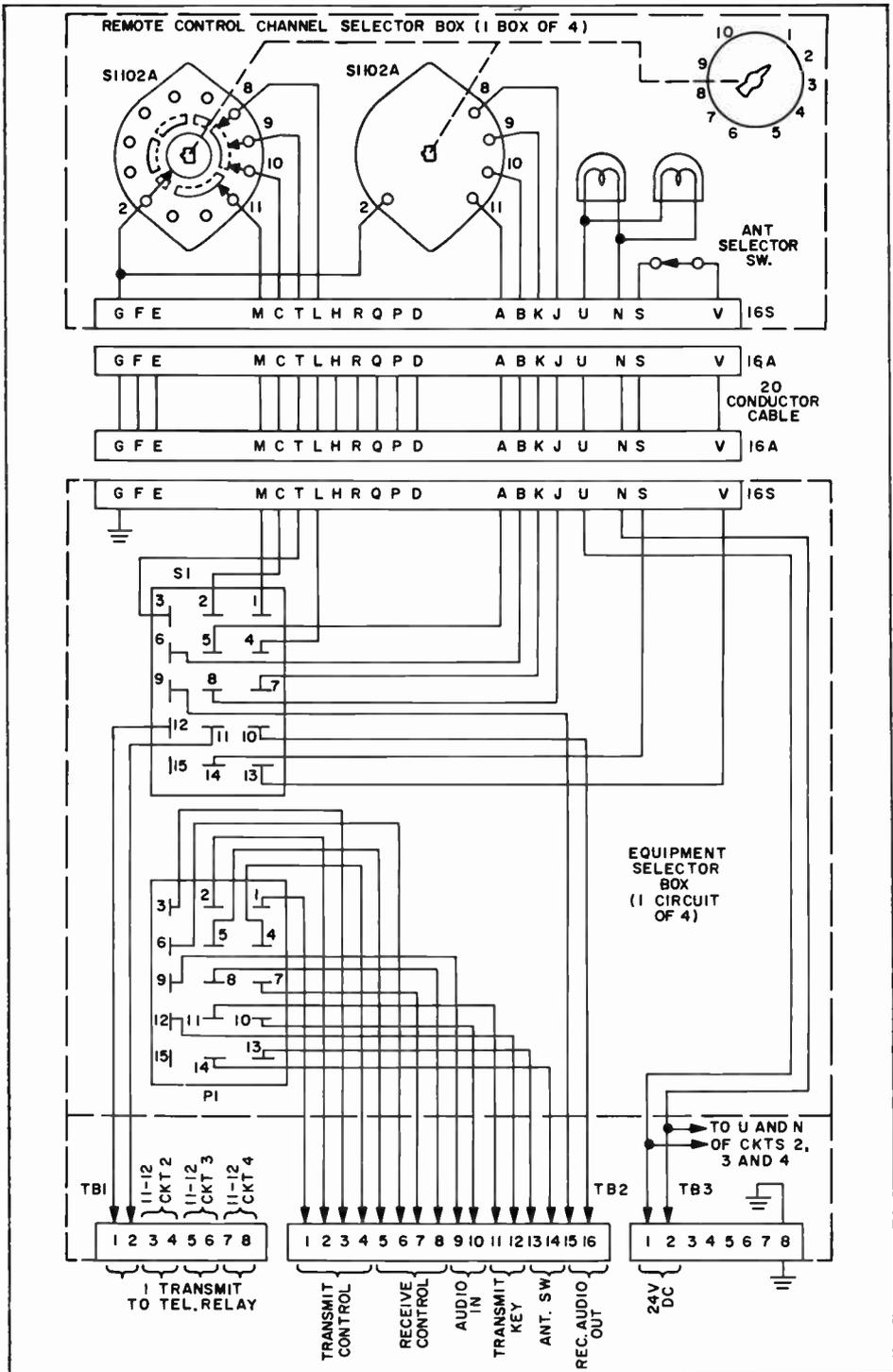
Figure 2. Schematic Diagram of Selector-Indicator and Equipment Selector Box
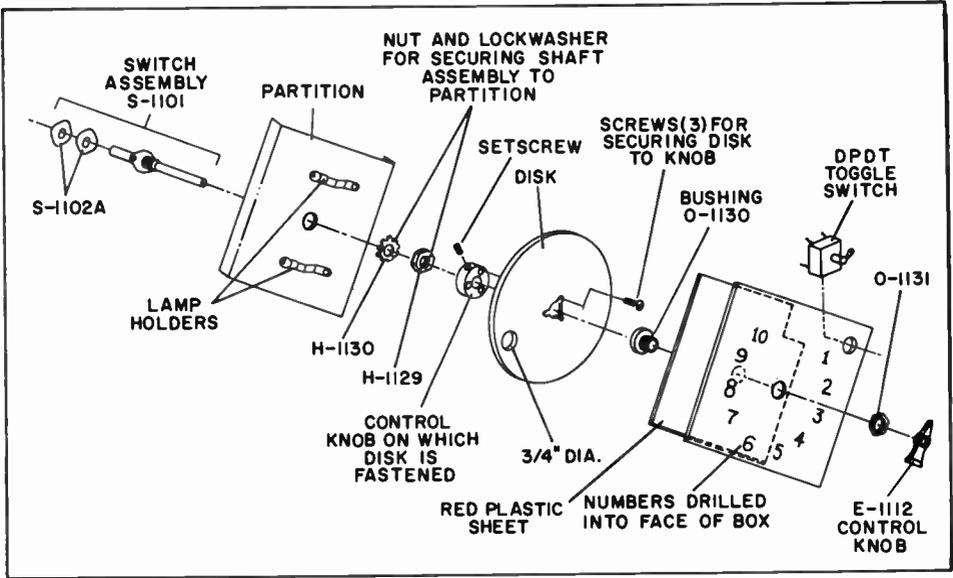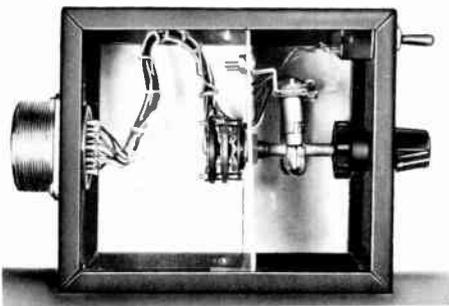
Figure 3. Construction of Selector-Indicator

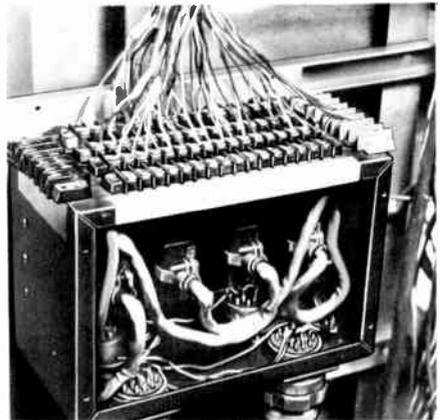*Figure 4. Side View of Selector-Indicator*

Figure 6. Equipment Selector Box, Showing Terminal Lugs and Interconnecting Cables
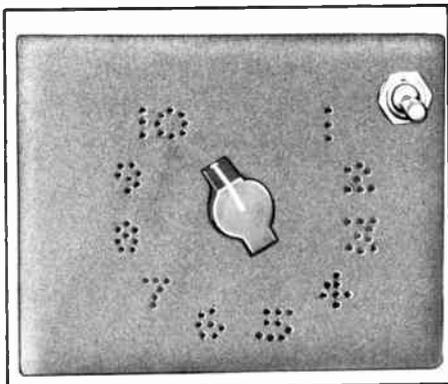

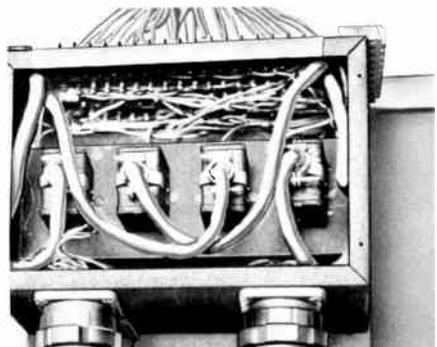*Figure 5. Front View of Selector-Indicator*

Figure 7. Equipment Selector Box, Showing Jones Plugs and Interconnecting Cables

order to allow sufficient clearance for the receptacles and wiring in the rear of the box.

The connections made between the equipment selector box terminal strips and the equipment are listed in Table 1, and the parts list is given in Table 2.

TABLE 1
SELECTOR BOX TERMINAL STRIP CONNECTIONS

TB1 (1 of 1)	1 } To Ckt #1 (transmit connections) of radio control relay 2 } in telephone relay rack 3 } To Ckt #2 (transmit connections) of radio control relay 4 } in telephone relay rack 5 } To Ckt #3 (transmit connections) of radio control relay 6 } in telephone relay rack 7 } To Ckt #4 (transmit connections) of radio control relay 8 } in telephone relay rack
TB2 (1 of 4)	1 To pin C of J-1404 on J-390/GR at MD-129/GR 2 To pin D of J-1404 on J-390/GR at MD-129/GR 3 To pin E of J-1404 on J-390/GR at MD-129/GR 4 To pin F of J-1404 on J-390/GR at MD-129/GR 5 To pin A of J-1214 on J-390/GR at R-278/GR 6 To pin B of J-1214 on J-390/GR at R-278/GR 7 To pin C of J-1214 on J-390/GR at R-278/GR 8 To pin D of J-1214 on J-390/GR at R-278/GR 9 } 10 } To audio output from R-278/GR 11 } To key and modulate connecting pins G and H of 12 } J-1404 on MD-129/GR 13 } To pins V and P of local control cable terminals on 14 } J-390/GR 15 } To receiver connections of radio control relay in tele- 16 } phone relay rack
TB3 (1 of 1)	1 } 2 } To any 24-volt source 3 | 4 | 5 } Not used 6 | 7 | 8 To ground

TABLE 2
PARTS LIST

DESCRIPTION	QUANTITY
SELECTOR-INDICATOR BOX	
Aluminum utility box, 5″ x 6″ x 4″, black crackle finish, Bud Cat. No. AU-1029*	1
Lamp holder, bayonet base type*	1
Lamp (T-313)*	2
Switch (S-1101), rotary, 2-pole, 12-position**	1
Switch section (S-1102A), rotary, wafer**	2
Nut (H-1129), hexagon**	1
Washer (H-1130), lock**	1
Knob (E-1112), bar, black bakelite**	1
Setscrew (H-1162)**	2
Bushing (O-1130)**	1
Nut (O-1131), lock**	1
Switch (S-1202), toggle, SPST**	1
Receptacle, AN-3102-28-16S**	1
4″ diameter disk (fabricated from scrap)	1
Red plastic sheet, 4″ x 5″ x 1/6″ type used by draftsmen	1
EQUIPMENT SELECTOR BOX	
Aluminum utility box, 6″ x 9″ x 5″, black crackle finish, Bud Cat. No. AU-1040*	1
Jones receptacle, No. S-315-CCT*	4
Jones plug, No. P-315-CCT*	4
Terminal strip, length 5″, Jones No. 28F706*	2
Terminal strip, length 6¼″, Jones type*	4
Aluminum strip for mounting receptacles (fabricated locally)	1
INTERCONNECTING CABLES	8
Cable clamp, for plug AN-3057-16a*	8
Connector plug, AN-3106B-28-16P**	Required Length
20-conductor rubber covered telephone cable**	

* Purchased locally
** Supplied through supply channels

Only one basic solution is believed possible for the switch and lamp problem given in the last issue, and that solution is shown in the two figures below. Figure 1 shows the circuit as it might be drawn using the original layout of parts, and figure 2 presents a simplified arrangement of the circuit for ease of tracing. While minor circuit variations can be obtained by interchanging resistors or relocating certain switches, these variations do not differ basically from the circuit shown.
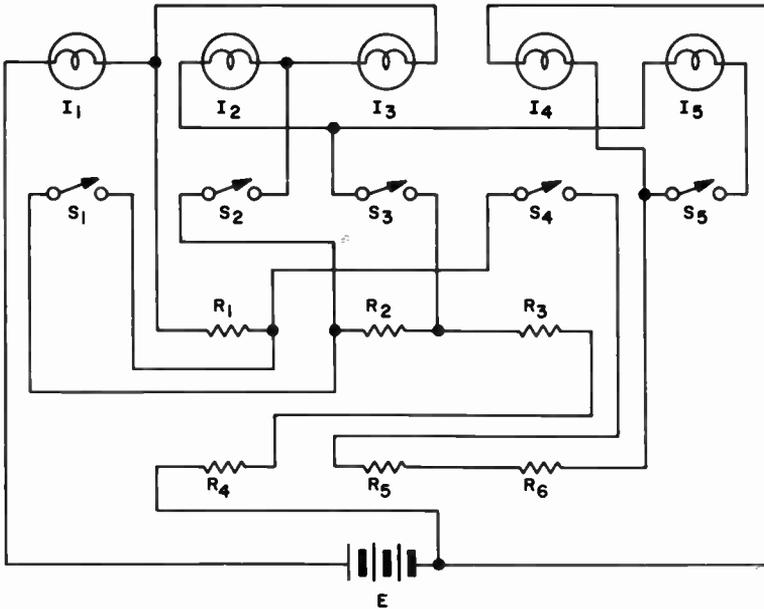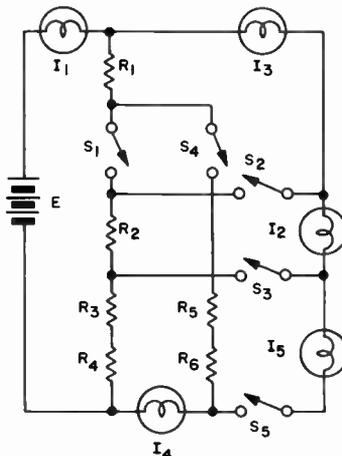

Figure 1

Figure 2

CONSULTING, PROJECT, AND FIELD ENGINEERING
CONTRACT AUGMENTATION

ELECTRONICS   •   COMMUNICATIONS

POWER PLANT   •   REFRIGERATION

ELECTROMECHANICAL AND SPECIAL SYSTEMS

STANDARDIZED TRAINING

COURSES   •   TRAINING DEVICES

INSTRUCTORS

for

EDUCATIONAL INSTITUTIONS

ARMED FORCES   •   INDUSTRY

PHILCO
TECH REP
WORLD WIDE
SERVICE

COMPLETE PUBLICATIONS FACILITY FOR PREPARATION
OF TECHNICAL MANUALS *such as—*

MAINTENANCE HANDBOOKS   •   OPERATIONAL HANDBOOKS

ILLUSTRATED PARTS BREAKDOWNS   •   CATALOGS

ENGINEERING REPORTS   •   SPECIAL PROJECTS