A HOWARD W. SAMS PUBLICATION

OCTOBER 1967/75 cents

Broadcast Engineering

the technical journal of the broadcast-communications industry

how to ease into a deluxe color sync generator without straining your budget

In three easy steps, you can build your way economically to the same high quality deluxe color sync generator used by the major TV networks. Start out with Riker's basic EIA sync generator—four modules, rack frame and power supply—$2900. When your budget can afford the expansion, add two more modules for deluxe sync lock and you get the advantage of three selectable speeds for locking to an external composite video or sync signal. Cost: $790.

Now you're all set to step up to color. Add three more modules—$1985—and you have eased into Riker's widely used, field-proven Model 520-4CL Color Sync Generator with Deluxe Sync Lock. You now own the best sync generating system in the broadcast industry.

The Riker module at a time approach is the sensible way to build quality equipment into your facilities. Over the long term it's also the most inexpensive way. If you're interested in details on sync generators, write or call Riker—the one company in the TV broadcast industry offering a complete line of all solid-state instrumentation for video analysis, simulation and control.

RIKER

PRODUCTS FOR VIDEO ANALYSIS, SIMULATION & CONTROL

RIKER VIDEO INDUSTRIES, INC., 100 Parkway Drive South, Hauppauge, Long Island, N.Y. 11787 (516) 543-5200

Circle Item 1 on Tech Data Card

Circle Item 2 on Tech Data Card

publisher
Howard W. Sams

general manager/sales director
Donald W. Bradley

editor
William E. Burke

managing editor
James M. Moore

associate editor
Harold E. Hale

regional editors
George M. Frese, Northwest
Howard T. Head, Wash., D.C.
Robert A. Jones, Midwest
Allen B. Smith, North Central

research librarian
Bonny Howland

production
E. M. Rainey, *Manager*
Paul A. Cornelius, Jr., *Photography*

circulation
Pat Osborne, *Manager*

advertising sales offices

central and midwestern
Roy Henry
Howard W. Sams & Co., Inc.
4300 West 62nd St.
Indianapolis, Ind. 46206
291-3100

eastern
Alfred A. Menegus
Howard W. Sams & Co., Inc.
3 West 57th St.
New York 19, New York
MU 8-6350

southwestern
Martin Taylor
P.O. Box 22025
Houston, Tex. 77027
713-621-0000

western
LOS ANGELES OFFICE
G. R. Holtz
The Maurice A. Kimball Co., Inc.
2008 West Carson St., Suites 203-204
Torrance, California 90501
(213) 320-2204

SAN FRANCISCO OFFICE
The Maurice A. Kimball Co., Inc.
580 Market St., Room 400
San Francisco, California 94104
(415) EX 2-3365

foreign
LONDON W.C. 2, ENGLAND
John Ashcraft, Leicester Square
WHitehall 0525

AMSTERDAM
John Ashcraft, Herengracht 365
Telefoon 24 09 08

PARIS 5, FRANCE
John Ashcraft, 9 Rue Lagrange
ODeon 20-87

TOKYO, JAPAN
International Media Representatives, Ltd., 1, Kotohiracho, Shiba, Minato-Ku, Tokyo
(502) 0656

BROADCAST ENGINEERING is published monthly by Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, Indiana 46206. SUBSCRIPTION PRICES: U.S.A. $6.00, one year; $10.00, two years; $13.00, three years. Outside the U.S.A., add $1.00 per year for postage. Single copies are 75 cents, back issues are $1.00.

the technical journal of the broadcast-communications industry

Broadcast Engineering

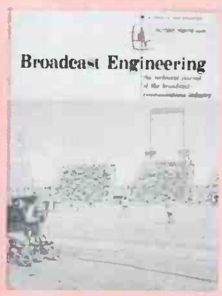
Volume 9, No. 10 October, 1967

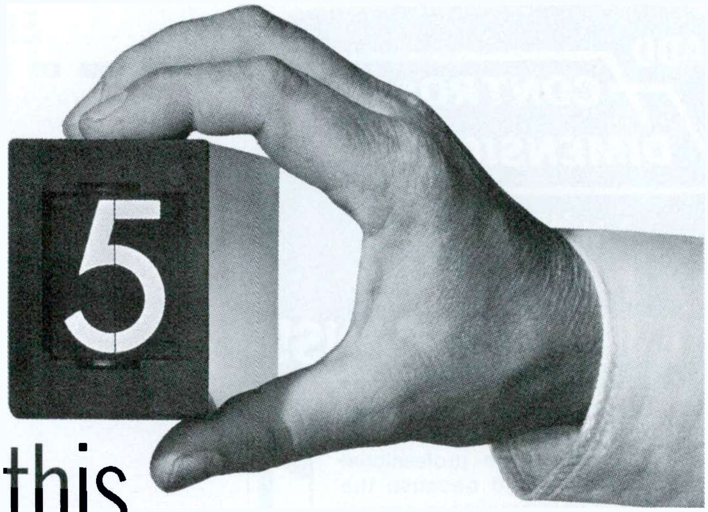
CONTENTS

Features

Departments

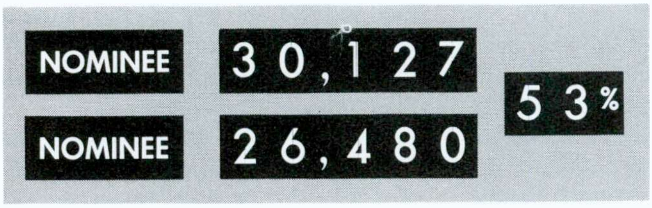
Soccer is the newest dimension in color sportscasting. This month's cover shows a pickup (by CBC) of a soccer match for CTV, Canada's private color network. An RCA color camera is covering a game between England and Mexico in the new "Autostade" at Montreal, directly outside the Expo '67 grounds. (Photo courtesy of RCA)



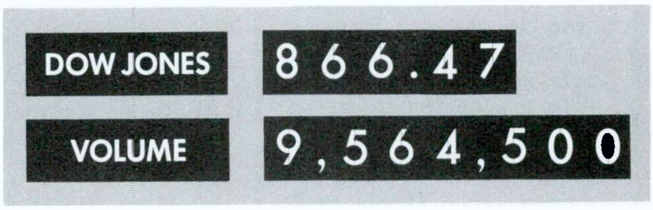


Look what your cameras can do with display units like this

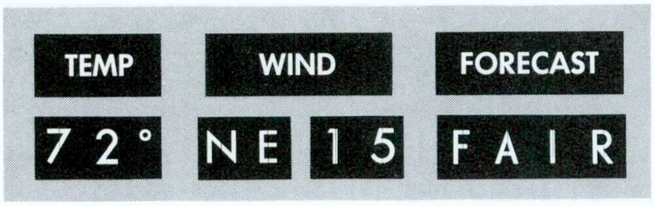
CBS Laboratories' Digital Display Units are part of a low cost, compact system that works daily wonders in any size TV studio!



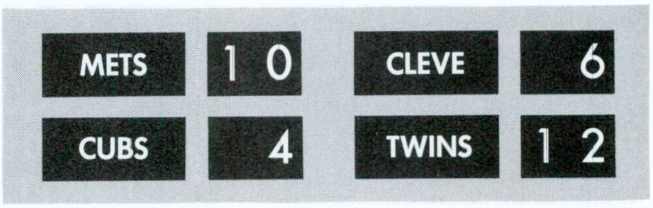
ELECTIONS–No contest.
These modular units were designed specifically for TV use to give optimum clarity up to 70 feet — from any camera angle up to 145 degrees.



STOCK REPORTS–Excellent for the long pull.
Rugged electro-mechanical operation is fool-proof and built to last. No bulb burn-out or the other problems of rear-illuminated displays.



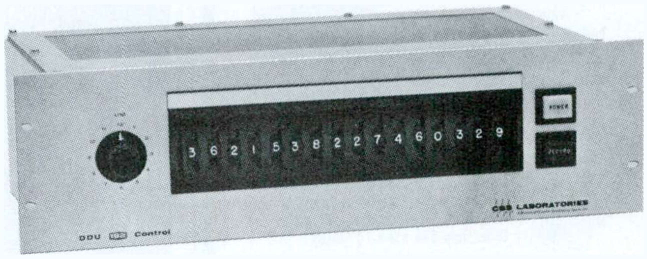
WEATHER–Cool operation.
Only 2.7 watts required per unit, with no power between postings. Glare-free even under the strongest lighting conditions.



SPORTS–An easy set-up.
Just stack these units in a flat to suit any requirement. Custom designed matrix wiring also available for complete flexibility.

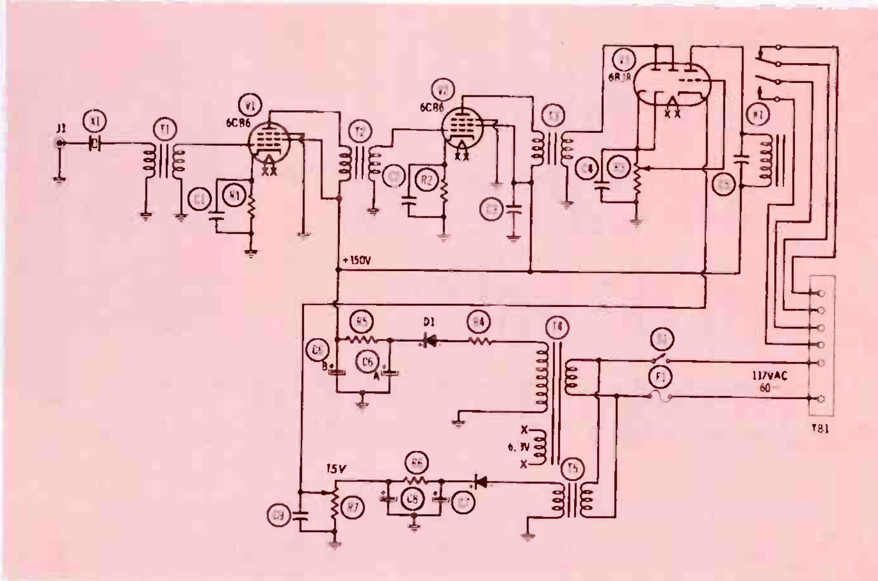
And all operated by one Controller that can handle 192 units — as many as 12 groups of 16 units each. This means up to 12 two-candidate election races; or runs, hits and errors for all major league teams; or 40 local stock issues plus volume and Dow Jones closing. A one-time investment for the professional way to take care of all your daily display needs.

Our engineers will even design your system for you. Don't take our word for it. Write or call us collect (203) 327-2000, and let us show you.



PROFESSIONAL PRODUCTS
CBS LABORATORIES
Stamford, Connecticut. A Division of Columbia Broadcasting System, Inc.

Circle Item 3 on Tech Data Card



Automatic Color Switcher

Some time ago, we felt the need for a video-AGC unit in the line to the transmitter for the purpose of maintaining a relatively constant level. At that time, no AGC units were available that would handle color satisfactorily. Because of this fact and the number of color broadcasts planned, a great deal of switching of the AGC unit in and out of the circuit was indicated.

The use of a toggle switch for this purpose was considered, but,

• *Please turn to page 40*

YEARS AHEAD

IN VIDEO SWITCHING DESIGN

SOLID-STATE VERTICAL INTERVAL SWITCHERS

■ AUTOMATIC SENSING FOR COMP/NON-COMP, SYNCHRONOUS/NON-SYNCHRONOUS OPERATIONS ■ INTEGRATED CIRCUITS, WITH INDEPENDENT POWER AND TRIGGER PULSE SUPPLY FOR EACH BUSS ■ EIGHT STANDARD MODELS OR CUSTOM DESIGNS ENGINEERED FOR STUDIO PRODUCTION, OR AUTOMATIC PROGRAMMING ■ SHORT TERM DELIVERY ■ MOST COMPACT SWITCHERS AVAILABLE

WARD ELECTRONIC INDUSTRIES

142 CENTRAL AVE., CLARK, NEW JERSEY 07066 • (201) 382-3700

Circle Item 6 on Tech Data Card

You can do it easily...with a TREISE COLOR PROCESSOR!

Now that big things are happening in network color, the logical next step for your station is to film your local news in color. You'll gain added interest from your community . . . enhance your value to advertisers . . . and brighten your profit picture. Treise makes it possible by offering you a fully automatic, professional quality processor that will have your local news "on the air" in color within minutes after the exposed film is loaded in the processor. This compact, self-contained unit can be operated in a 17′ x 9′ area, requires only simple plumbing and electric plug-in, and is so foolproof, anyone can run it!

Check these features: Warms up in only 20 minutes (instead of the usual 2 to 3 hours) • stays on temperature automatically • only processor in its price range that meets or exceeds all Kodak color requirements • even provides 50% additional first-developer time to permit full utilization of new EF Ektachrome film • operates up to 40 fpm (the ideal speed for most TV station needs). Want more data?

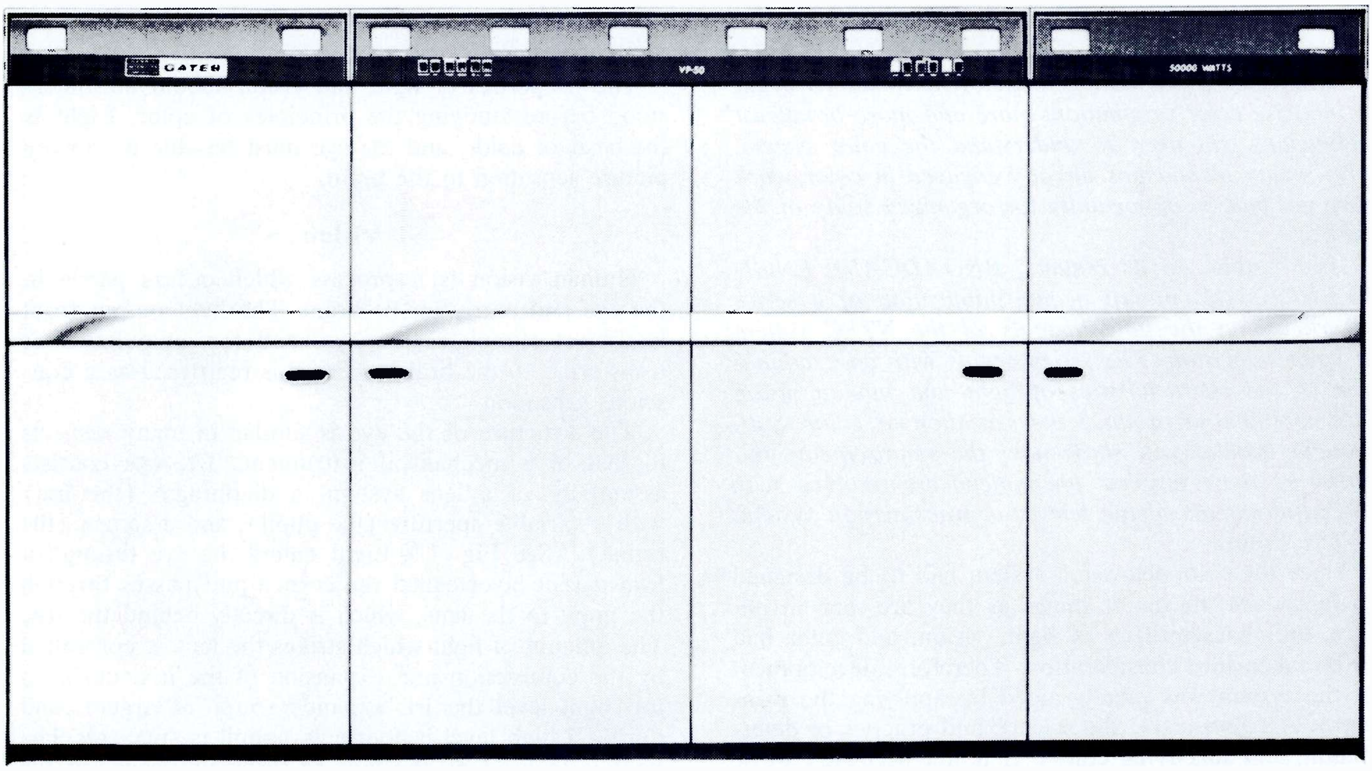
Write for free catalogs on Model MTV-30 (illus) and Model MT-20 (up to 70 fpm), plus our full line of color and B&W processors and accessories.

TREISE ENGINEERING, INC.

1941 First Street • San Fernando, California Phone (213) 365-3124

Circle Item 7 on Tech Data Card

First in its class... a vapor-cooled, high-efficiency 50,000-watt AM transmitter by Gates



Inside and out – the VP-50 is the first really new 50,000-watt transmitter in years . . . a breakthrough in engineering design utilizing vapor cooling.

Superb fidelity is combined with operating economy in the VP-50 transmitter. Lowest power consumption with only 80 kW at 0% modulation. Lowest tube cost of any 50 kW model.

Newest solid-state design with all-transistor circuits up to RF driver. Quietest operating transmitter in its class with no large blowers.

FCC-type accepted.

Want more information and complete specifications? Write or call (217) 222-8202 for complete information.

HARRIS INTERTYPE CORPORATION

GATES

GATES RADIO COMPANY
QUINCY, ILLINOIS 62301, U.S.A.
A subsidiary of Harris-Intertype Corporation

Circle Item 8 on Tech Data Card

COLOR-TV BASICS — COLORIMETRY

Part 1 of a series describing the basic principles of the NTSC color system.

As an increasing number of television stations begin or increase color origination, more and more broadcast technicians will need to understand the color system. Also, many technicians already engaged in color work have not had an opportunity for organized study of the subject.

As a service to its readers, BROADCAST ENGINEERING this month begins publication of a series of articles on the fundamentals of the NTSC system of color television. The series begins with an examination of the characteristics of light and human vision that combine to produce the sensation of color. Subsequent articles will show how the requirements imposed by these physical phenomena are resolved with the requirements of the television transmission system. ---The Editor

Since the color television system had to be designed to reproduce images of things as they are seen in nature, the characteristics of light, vision, and color had to be taken into consideration. Therefore, development of the system was greatly aided by applying the principles of colorimetry, the science and practice of determining and specifying colors. It is not necessary to be an expert colorimetrist in order to understand the make-up of the color picture signal; however, a better understanding of the color television system will be attained if some of the most important fundamentals of colorimetry are known. The principles of color as applied to television are slightly different than those which apply to other types of color reproduction.

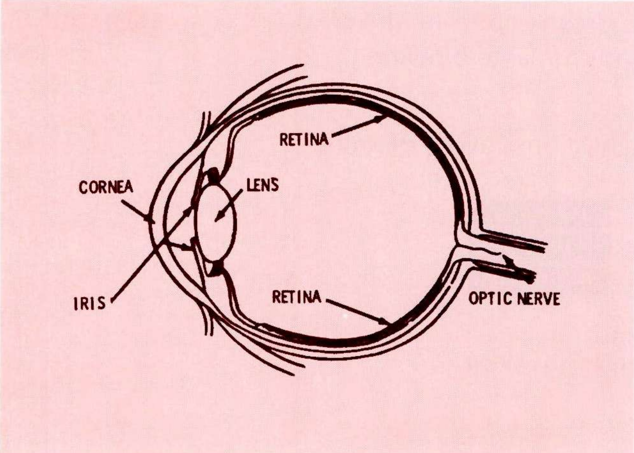


Fig. 1. Cross section shows structure of the human eye.

The properties of light and vision should be understood before studying the principles of color. Light is the basis of color, and the eye must be able to convey picture sensation to the brain.

Vision

Human vision is a process which occurs partly in the eye and partly in the brain. The light output from an object stimulates the eye, and this stimulation is transferred to the brain where it is registered as a conscious sensation.

The structure of the eye is similar in many respects to that of a mechanical instrument. The eye consists essentially of a lens system, a diaphragm (the iris) with a variable aperture (the pupil), and a screen (the retina). (See Fig. 1.) Light enters the eye through a transparent layer called the cornea and passes through the pupil to the lens, which is directly behind the iris. The amount of light which strikes the lens is controlled by the contraction and expansion of the iris; during a low light level the iris expands (pupil is larger), and during a high level it contracts (pupil is smaller). The light is focused by the lens to form an image on the back wall, or retina, of the eye. The light falling on the retina stimulates nerve terminals called rods and cones. These terminals are connected to the brain by a group of nerve fibers called the optic nerve, which furnishes the path by which the vision impulses are transferred from the eye to the brain.

The field of vision covers an angle of about 200 degress horizontally and 120 degrees vertically. In the central region of the field of vision, the eye is responsive to color and detail, whereas in the outer region it is chiefly sensitive to motion.

The limits of vision are determined mainly by four factors: intensity threshold, contrast, visual angle, and time threshold. Intensity threshold is the lowest brightness level that can stimulate the eye; it is very much dependent upon the recent exposure of the eye to light. When a person enters a darkened room, the eye is slow to reach its maximum sensitivity; the required time, which is usually about an hour, differs among individuals. When a person returns to a lighted area, the time needed for the eye to reach its maximum sensitivity is relatively short, just a matter of minutes.

Contrast represents a difference in the degree of brightness. The limit of vision with respect to contrast is the least brightness difference that can be perceived. The eye is sensitive to percentage changes rather than to absolute changes in intensity.

As an object is made smaller or is placed at a greater distance from the eye, the angle formed by the light rays from the extremities of the object to the eye becomes smaller. This angle is referred to as the visual angle. In order for the eye to respond, the visual angle must be such that the image covers a definite minimum area on the retina. This principle is used in eye tests in which the viewer is asked to read the smallest letters possible; those letters which he cannot read produce on the retina an image that is too small to be useful to the eye. The minimum visual angle is dependent upon the contrast and brightness of the image; for example, an object having sharp contrast could be distinguished at a narrow visual angle while an object having the same size but a lower contrast might not be visible. The same principle applies to a change in brightness; a very small object can be seen more easily at a high brightness level than at a low brightness level.

There is a minimum time during which a stimulus must act in order to be effective. This is called the time threshold. If the exposure interval is too short, the rods and cones of the eye do not have time to respond to an image on the retina. The time threshold is also dependent upon the size, brightness, and color of the object.

Other factors which pertain to the characteristics of vision are:

1. Sensitivity to detail is increased by high contrast, sharp edges, and motion.

2. Straight lines are more readily resolved than curved lines. Horizontal or vertical lines are more easily resolved than diagonal lines.

3. Altering the background of an object changes the appearance of the object; a gray object appears lighter when it is placed on a black background, but it appears darker when placed on a white background.

Light Sources

The foregoing has shown how the eye is capable of seeing. However, for this process to occur there first must be a source of light to illuminate the object seen. Two types of light will be considered. Light such as that coming from the sun or emitted from some artificial source such as an electric lamp is referred to as direct light. Indirect, or reflected, light is given off by an object when direct light strikes it. The difference between these two types of light is that indirect light is dependent upon direct light. When an object does not receive direct light, no light is given off unless the object possesses self-luminating properties.

Direct light falling upon an object is either absorbed or reflected. The larger the amount of light that is reflected by an object, the brighter the object will appear to the eye. In addition, the more intense the direct light source, the brighter the object will become.

Light is a form of radiant energy similar to X-rays and radio waves, and it is considered to travel by wave motion. As shown in Fig. 2, light which is useful to the eye occupies only a small portion of the radiant-energy spectrum. Along the top of the spectrum illustrated in Fig. 2 is the frequency scale, and along the bottom is the Angstrom-unit scale (1 Angstrom unit = 10^{-8} cm). Wavelengths in the region of light may be designated in microns (1 micron = 10^{-4} cm). These units are also shown along the bottom of the spectrum in the illustration. Light is made up of that portion of the spectrum between 400 and 700 millimicrons.

When all wavelengths of the light spectrum from 400 to 700 millimicrons are presented to the eye in nearly equal proportions, white light is seen. Thus white light is made up of various wavelengths, which are repre-

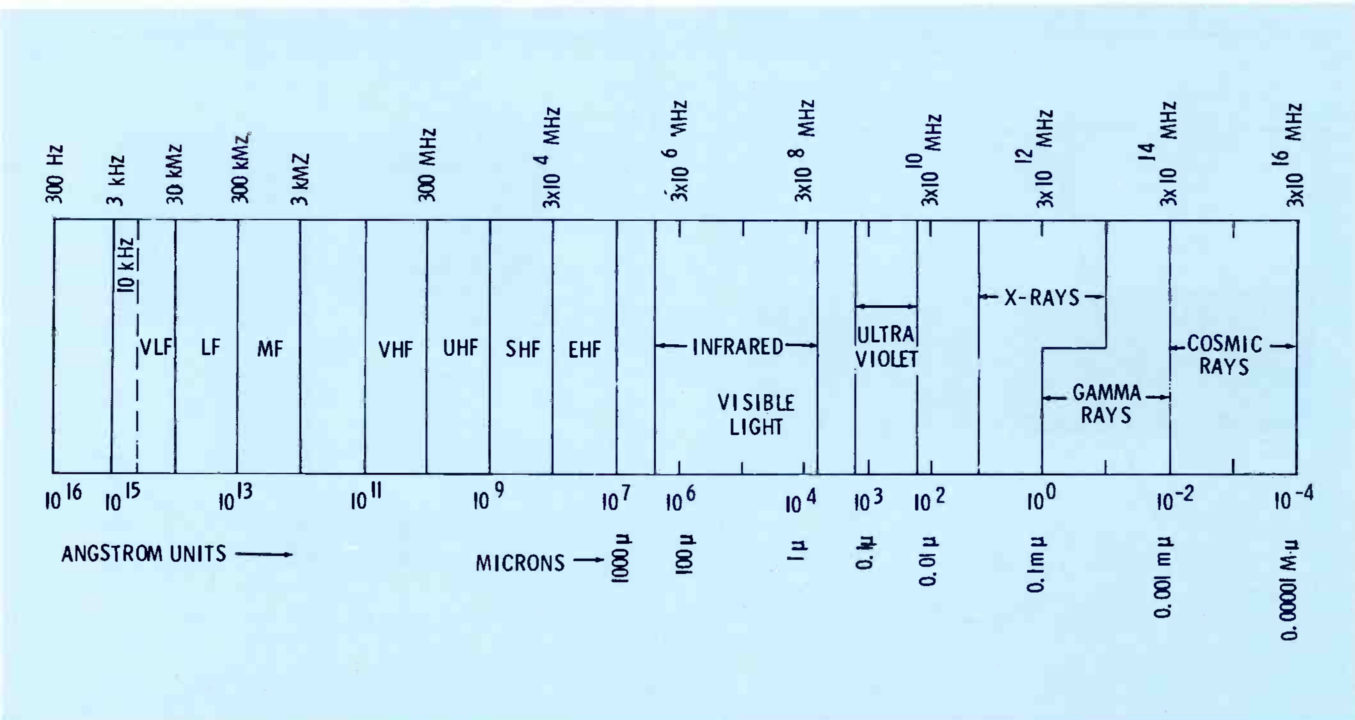


Fig. 2. This chart represents the classification of different wavelength regions of the radiant-energy spectrum.

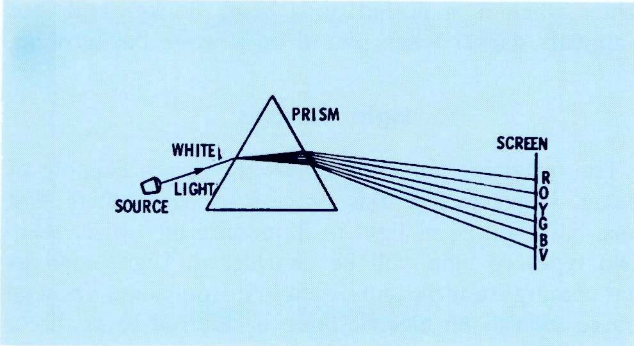


Fig. 3. Prism produces color from beams of white light.

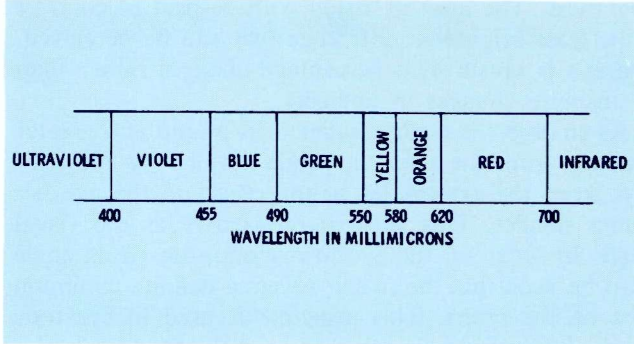


Fig. 4. Wavelength vs color relationship for visible light.

sentative of different colors. This composition can be demonstrated by the use of a prism, as shown in Fig. 3. The light spectrum is broken up into its constituent wavelengths, with each representing a different color. The ability to disperse the light by a prism stems from the fact that light of shorter wavelengths travels slower through glass than does light of longer wavelengths. Fig. 4 shows the relationship of the wavelengths and the colors of the light spectrum. Six distinct colors are visible when white light is passed through a prism. Since the colors of the spectrum pass gradually from one to the other, the theoretical number of colors becomes infinite. It has been determined that about 125 colors can be identified over the visible gamut. Fig. 5 shows the light spectrum in full color.

How Color Appears to the Eye

It has been shown that light possesses various wavelengths covering the visible spectrum, and the spectrum is divided into various colors. Even though the colors which make up a white light may be of equal intensities, the human eye does not perceive each color with equal efficiency. This fact is due in some way to the physical construction of the eye. It is believed that the cones of the retina respond to color stimuli and that each cone is terminated by three receptors. Each receptor is believed to respond to a different portion of the spectrum, with peaks occuring in the red, green, and blue regions, respectively. An average can be taken of the color response of a number of people, and a standard response for an average person can be derived. This standard response is shown in Fig. 5 and is called the luminosity curve for the standard observer.

An inspection of this luminosity curve shows that maximum response occurs at a wavelength of approximately 555 millimicrons and that less response is indicated on either side of that point. From this information, one may see that the average person's eye is most sensitive to light of a yellowish-green color and is less sensitive to blue and red lights.

There are three color attributes which are used to describe any one color or to differentiate between colors. These are: (1) hue, (2) saturation, and (3) brightness. Hue is a quality which is used to identify any color under consideration, such as red, blue, or yellow. Saturation is a measure of the absence of dilution by white light and can be expressed with terms such as rich, deep, vivid, or pure. Brightness defines the amount of light energy contained in a given color.

An analogy between a color and a radiated radio wave can be used to explain the three attributes of color. Hue, which defines the wavelength of the color,

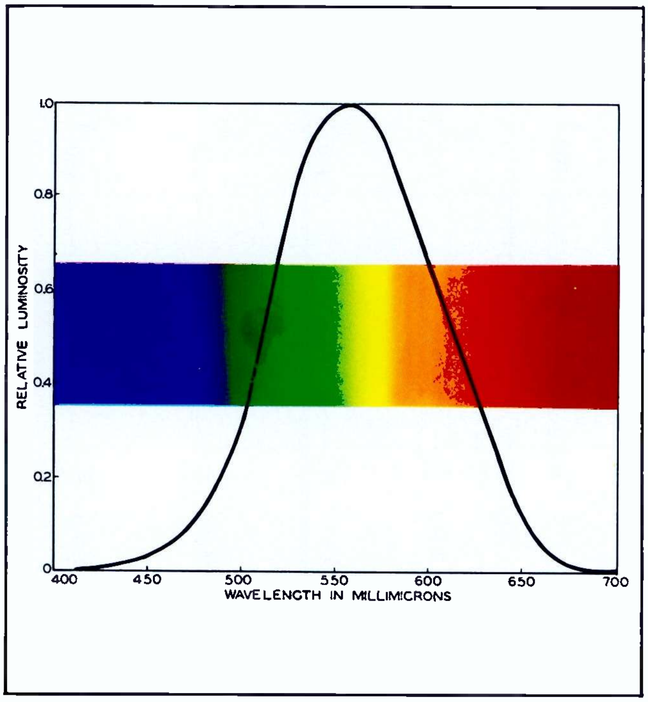


Fig. 5. Luminosity response of the eye depends on color.

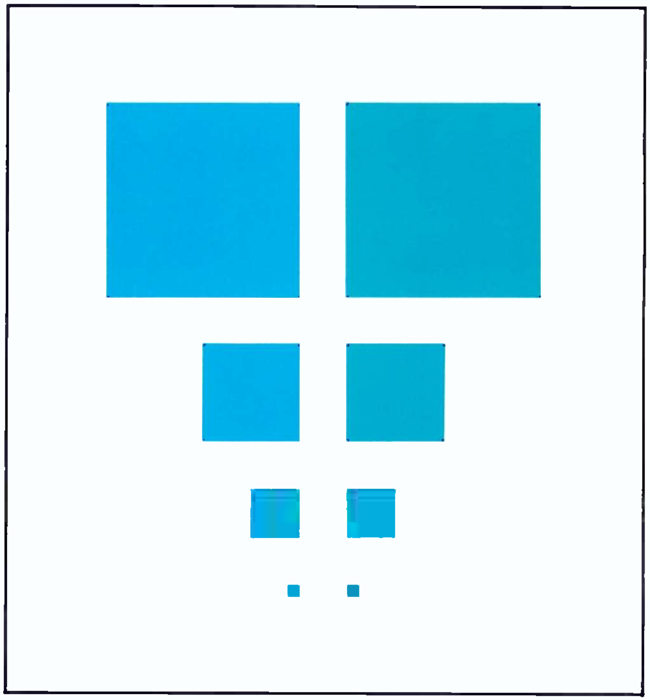


Fig. 6. Color perception depends on area of the object.

is analogous to frequency, which defines the wavelength of the radio wave. Saturation, which defines the purity of the color, is analogous to signal-to-noise ratio, which defines the purity of the radio wave. Brightness, which is governed by the amount of energy in the color, is analogous to amplitude, which defines the amount of energy in the radio wave. Brightness is a characteristic of both white light and color, whereas hue and saturation are characteristics of color only.

Saturation and brightness often are visualized as identical or interrelated qualities of color, but they should be considered as separate qualities. It is possible to vary either one of them without changing the other. For example, an oscilloscope presents a green trace on the face of the tube; this trace can be varied in brightness from visual extinction to a maximum brightness by rotation of the intensity control. An observer can become confused by the fact that the green color appears to be greener at low intensity levels than it is at higher intensities. This is often interpreted as an increase in saturation at the low intensity level. Actually, however, neither the hue nor the saturation of the trace color can change since these qualities are determined by the chemical properties of the phosphor. The brightness of the trace is the only variable when the intensity control is rotated. The deceiving change in saturation is caused by a change in the color response of the eye at low intensity levels.

In the foregoing example, the brightness level was varied without changing the saturation. Conversely, the saturation of a given color can be changed without varying the brightness, providing certain requirements are met during the process.

In nature, however, a change in saturation is usually accompanied by a change in brightness. This is exemplified by the fact that a pastel color generally appears brighter than a saturated color of the same hue when they are directly lighted by the same source. By changing the lighting on the pastel color (such as by placing it in a shadow), one can decrease the brightness of the pastel color, and it is conceivable that both colors can be made to have the same brightness. Thus, two colors of the same hue but of different saturation can have equal brightness levels.

Any given color within limitations can be reproduced or matched by mixing three primary colors, as will be explained later. This applies to large areas of color only. Color vision for small objects or small areas is much simpler, because only two primary colors are needed to produce any hue. This is because as the color area is reduced in size it becomes more difficult to differentiate between hues, and for small areas every hue appears as gray. At this point a change in hue is not apparent; only a change in brightness can be seen.

As an example, a large area of blue can be distinguished readily from a large area of blue-green; however, when these areas are reduced in size, it becomes more difficult to distinguish between the two colors. Fig. 6 illustrates this characteristic when it is viewed at arm's length.

Experiments have been made using sheets of multicolored paper cut in various sizes. A number of things were discovered as these pieces were reduced in size and viewed at a distance.

1. Blues become indistinguishable from grays with equivalent brightness.

2. Yellows also become indistinguishable from grays. In the size range where this happens, browns are confused with crimson and blues with greens; reds remain clearly distinct from blue-greens; colors with pronounced blue lose blueness; and colors lacking in blue gain blueness.

3. A further decrease in size results in reds merging with grays of equivalent brightness, and blue-greens become indistinguishable from grays.

When viewing extremely small objects, the ability of the human eye to identify color is lost, and only response to brightness remains. Fig. 7 shows clusters of colored dots of three different sizes. Note that a decrease in dot size makes color identification more difficult. (Hold the page at arm's length when viewing this figure.)

Another aspect of color vision is closely related to the persistence of vision exhibited by the human eye. If two objects of different hue are placed side by side and are shuttled back and forth at a sufficiently rapid rate, the two hues will appear as a third hue. This is true for both large and small objects.

Color Mixture

The production of color may be accomplished by either of two processes. The subtractive process is employed when paint pigments are involved, and the additive process is employed in color television. These two methods of producing color are rather different; it might be said that the additive process is just the reverse of the subtractive process.

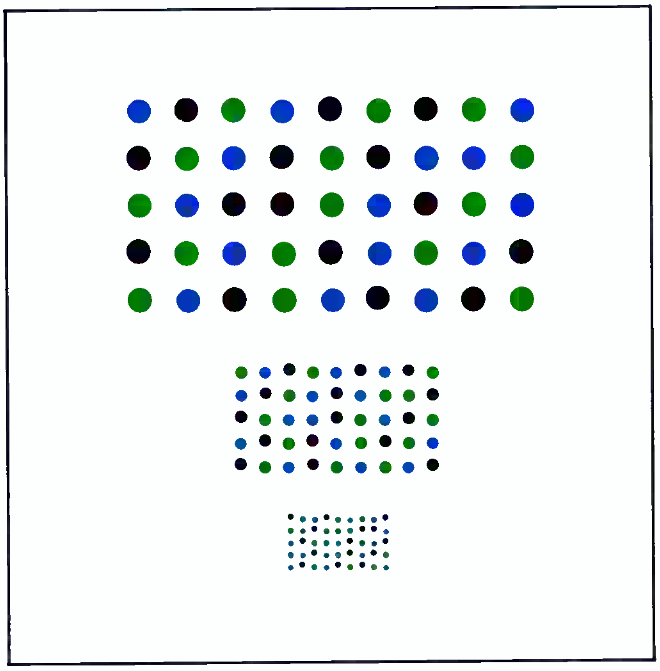
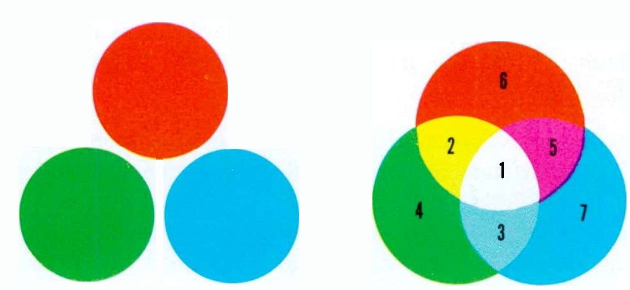


Fig. 7. The perception of color in small areas is poor.

The subtractive process is dependent upon incident light. Light falling on a painted picture is reflected or absorbed. If a certain section of the picture is treated with a red pigment, the light which is reflected is predominantly in the red region of the spectrum, and the section will appear red.

The additive process employs lights for the production of colors; the colors do not depend upon an incident light source. Self-luminous properties are characteristic of the additive colors, so since cathode-ray tubes contain self-luminance properties, it is only logical that the additive process would be employed in television.

The three primaries for the additive process of color mixing are red, green, and blue. Two requirements for the primary colors are that each primary must be different and that the combination of any two primaries must not be capable of producing the third. Red, green, and blue were chosen because they fulfilled these requirements and because it was determined that the greatest number of colors could be matched by the combination of these three colors.



(A) Three separate sources (B) Addition of primaries

Fig. 8. Red, green, and blue are the additive primaries.

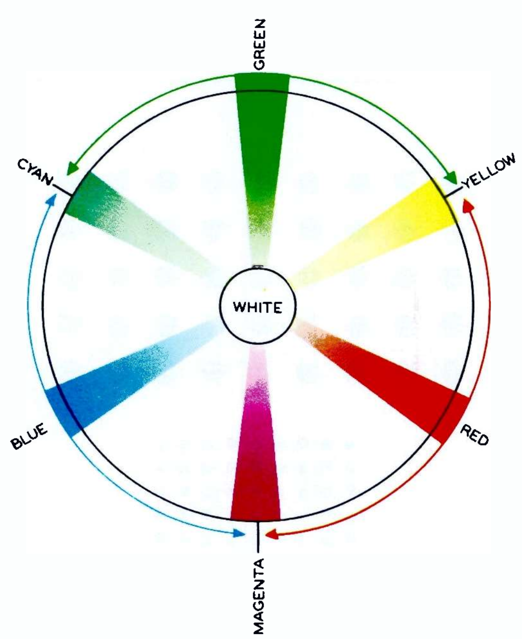


Fig. 9. A color circle illustrating combinations of colors.

Shown in Fig. 8 are the three additive primaries used in color television. Fig. 8A shows the primaries as three separate colored lights. Addition of the three colored lights is shown in Fig. 8B. When all three primaries are combined in a definite proportion, white is produced. Red and green combine to make yellow. The combination of red and blue produces magenta (bluish-red), while blue and green combine to make cyan (greenish-blue). Yellow, magenta, and cyan are the secondary colors that are the complements of blue, green, and red, respectively. When a secondary color is combined with its complementary primary, white is produced. For example, combining yellow with blue produces white. Cyan added to red results in white, and magenta plus green gives white. Carrying this one step further, the complementary colors when added together produce white. It should be mentioned that specific proportions of these colors must be used in order to produce white.

The foregoing points are shown diagrammatically in Fig. 9. This diagram illustrates that, when colors are mixed in certain proportions, these expressions apply:

Red + Green = Yellow,

Red + Blue = Magenta,

Blue + Green = Cyan,

Yellow + Blue = White,

Cyan + Red = White,

Magenta + Green = White.

Since yellow plus blue equals white and red plus green equals yellow, then

Red + Green + Blue = White.

Since the addition of the three primaries can produce white, the addition of the correct proportions of the three complementaries which are made up of the three primaries can also produce white. Therefore:

Cyan + Magenta + Yellow = White.

It is not necessary to overlap the primary colors in the additive process to produce a different color. Two sources of color may be placed in close proximity to each other, and at a certain viewing distance the two colors will blend together and produce the new color. The eye actually performs the additive process. This is referred to as the juxtaposition of color sources. For example, if blue and green are positioned close to each other but not overlapping, the two colors will be blended by the eye and will be seen as cyan when viewed from a distance.

CHART I.
Color Matching Rules.

1.
Any color, with limitations, can be matched by a mixture of three colored lights.

2.
The individual colors which make up a mixture cannot be resolved by the eye.

3.
The total brightness of a mixture is equal to the sum of the individual brightnesses of all colors in the mixture.

4.
If a color match is obtained at one brightness level, the match will be maintained over a wide range of brightness levels. If the brightness of the color to be matched is doubled, a perfect color match will be maintained if the brightness of each color in the matching mixture is doubled.

5.
A color equation can be used to express the formation of a color match. If a color (C) is formed by adding M units of color (M), N units of color (N), and P units of color (P), the resulting mixture can be written:

(C) = M(M) + N(N) + P(P).

6.
Color matches obey the law of addition.

If (M) = (N)
and (P) = (Q)
then (M) + (P) = (N) + (Q).

7.
Color matches obey the law of subtraction.

If (M) + (P) = (N) + (Q)
and (P) = (Q)
then (M) = (N).

8.
Color matches obey the transitive law.

If (M) = (N)
and (N) = (P)
then (M) = (P).

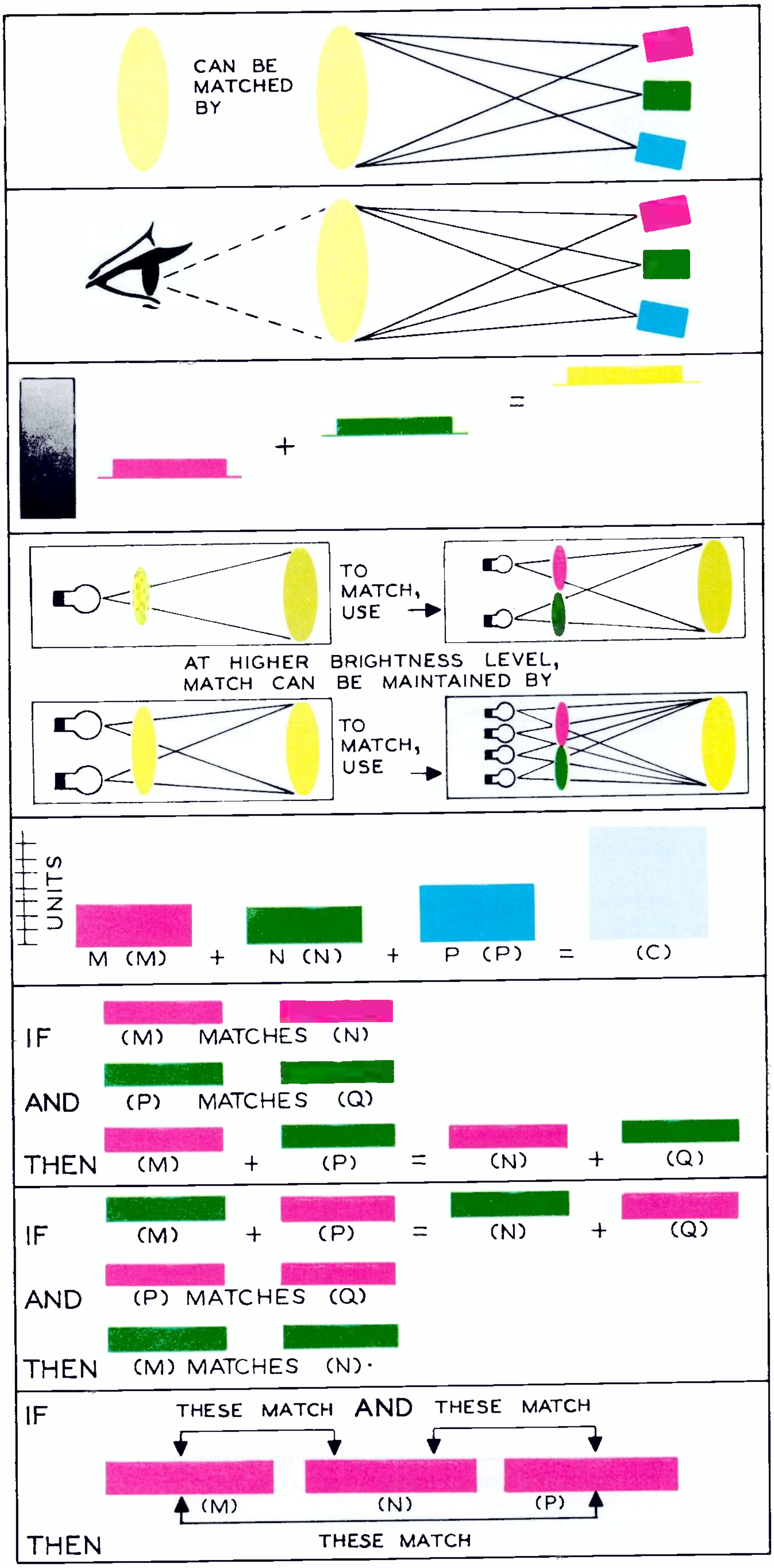


Fig. 10. Chart shows eight rules for color matching together with a diagrammatic example to illustrate each rule.

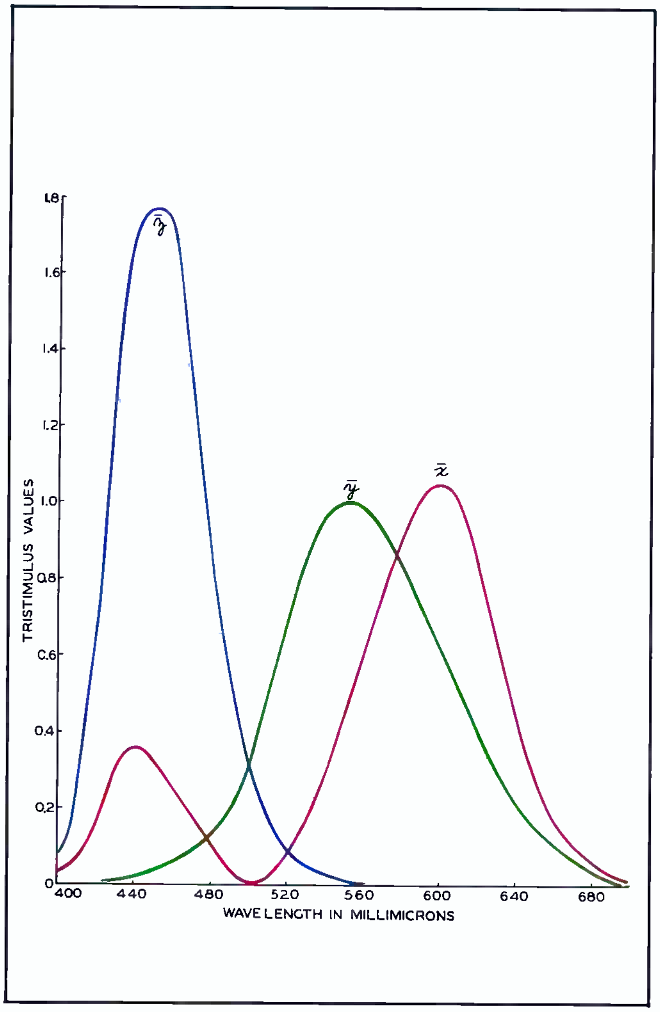


Fig. 11. Color-mixture curves based on data from tests.

Each additive primary contributes a certain percentage of the brightness in the white which results from mixture. With the total brightness of white considered as unity, green contributes 59 per cent of the total, red 30 per cent, and blue 11 per cent. Therefore, combining green with red results in a yellow with a brightness value of 89 per cent. Cyan has a brightness of 70 per cent, which results from 59 per cent of brightness from green and 11 per cent of brightness from blue. The third complementary color, magenta, has a brightness of 41 per cent, 30 per cent from red and 11 per cent from blue. Yellow contains the highest per cent of brightness of all of the primary colors and their complements, whereas blue contains the least amount of brightness. The relative brightness for each color is shown in Fig. 8B.

There are eight basic rules of colorimetry which apply to the process of color matching. These rules are stated in Fig. 10, which also contains an illustration applying to each rule. A knowledge of these rules is quite helpful in understanding how matching of color can be accomplished using three primary colors.

Color Specifications

Standards are necessary in all phases of industry, and particularly in television where a broadcast conforming to one set of transmission specifications could not be received on equipment designed for reception of a signal having different specifications. Similar difficulties would exist in the specification of colors if standards were not adopted. Such terms as "purple," "purplish-red," or "bluish-purple" obviously are inadequate when an accurate color match is required.

Standards for the specification of color were adopted by the Commission Internationale de l'Eclairage (CIE) at a meeting in 1931. (The English translation of this French name is International Commission on Illumination.) These standards provide that the red primary shall correspond to a light having a wavelength of 700 millimicrons, green to a wavelength of 546.1 millimicrons, and blue to a wavelength of 435.8 millimicrons.

In the development of a color matching and specification system, extensive color-matching tests on many observers were conducted using a colorimeter. This is a device which incorporates a photoelectric screen and a series of filters and optical lenses. The method used in these color-matching tests was as follows: One half of the colorimeter screen was illuminated with a spectral hue obtained by projecting the light from a standard source of white light through a prism. The hue was selected by moving a plate with a very narrow slit into position so that only the desired hue was allowed to illuminate the colorimeter screen. The other half of the colorimeter screen was then illuminated selectively by the observer with spectral hues of the three additive primaries—red, green, and blue. By the use of independent controls, the energies contributed by each of the primaries were varied by the observer until a color match was thought to be obtained. Each observer was subjected to a series of tests which constituted attempts to match several selected colors. In order to establish an average which could be considered as that of a standard observer, many persons were used with each performing similar tests. The results of these tests are known as tristimulus values for color-mixture curves and are illustrated in Fig. 11.

Tristimulus values are defined as the amounts of the primaries (red, green, and blue) that must be combined to achieve a color match with all the different colors in the visible spectrum (400 millimicrons to 700 millimicrons). As an example of how this graph is used, consider a color which has a wavelength of 520 millimicrons. The amount of the three spectral primaries needed to match this color can be read from the color-mixture curves. From the graph it can be seen that approximately .09 of red, .09 of blue, and .7 of green are needed.

The data contained in the color-mixture curves are not very practical for the specification of all colors. These curves contain information that is required to determine the amounts of the spectral primaries needed to match any saturated spectral color. They do not provide information necessary for the matching of desaturated colors; therefore, the need for a more useful means of specifying color is evident.

By the use of mathematical equations, the information contained in the color-mixture curves has been

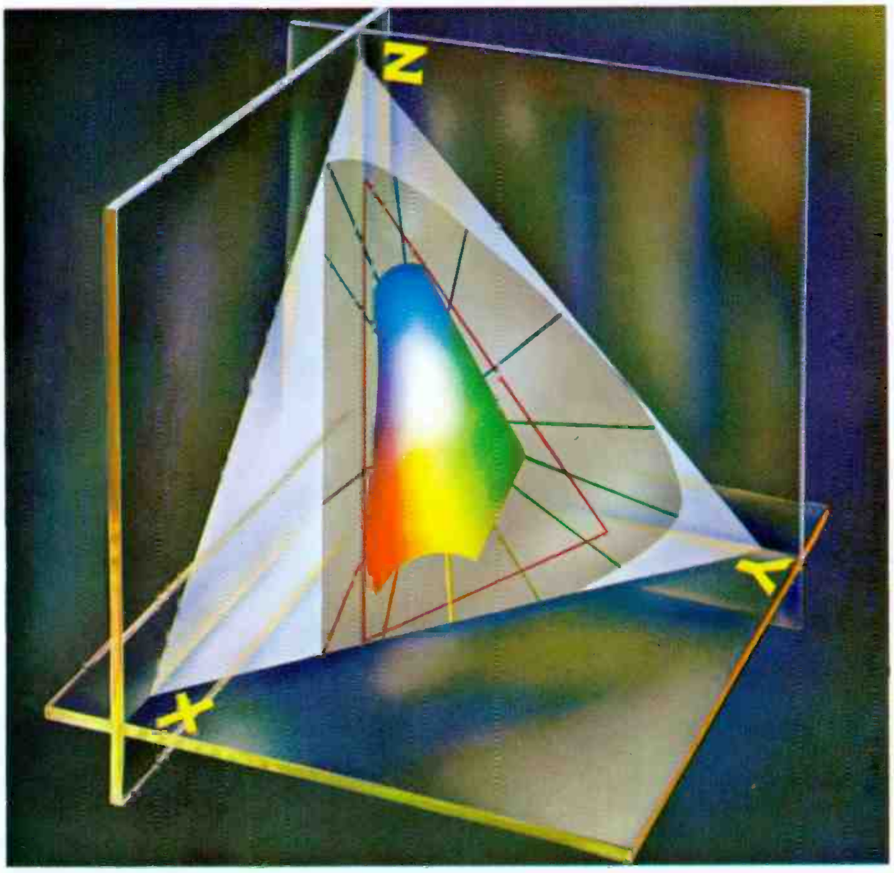


Fig. 12. Three-dimensional color representation based on color-mixture curves. Colors show capabilities of inks used in modern color printing method.

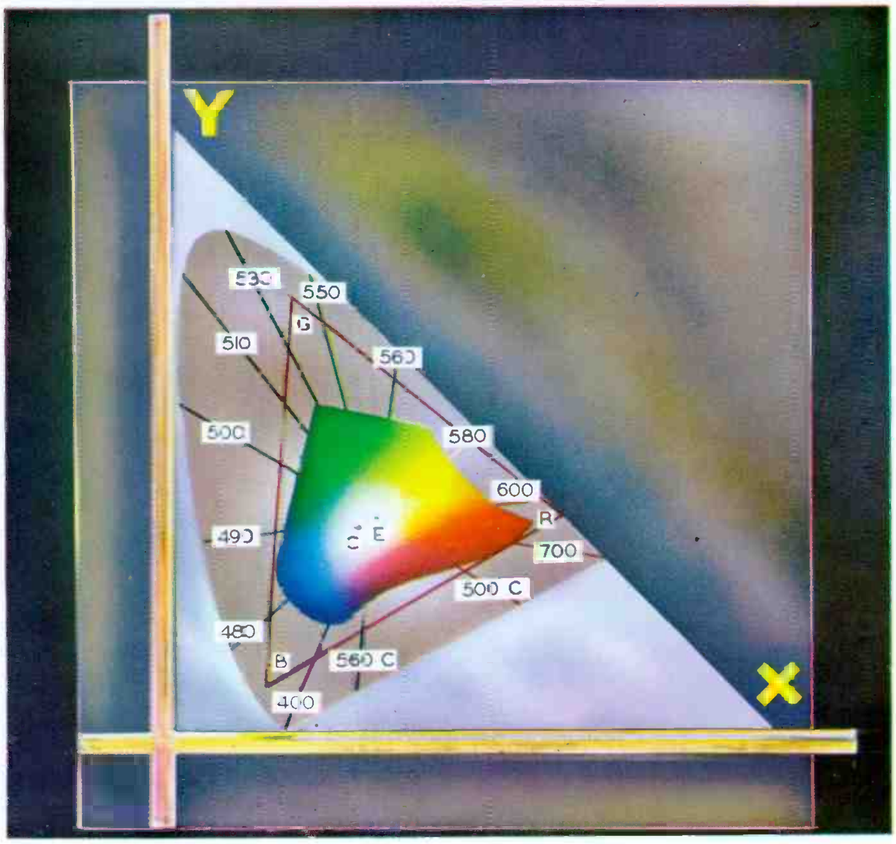


Fig. 13. Projection in the X-Y plane of the three-dimensional color diagram.

converted to a three-dimensional graphical representation of color. The conversion equations used to derive the three-dimensional coordinate values x, y, and z are:

$$x = \frac{\bar{x}}{\bar{x} + \bar{y} + \bar{z}} \quad (1)$$

$$y = \frac{\bar{y}}{\bar{x} + \bar{y} + \bar{z}} \quad (2)$$

$$z = \frac{\bar{z}}{\bar{x} + \bar{y} + \bar{z}} \quad (3)$$

where
$\bar{x}$ = values on the red color-mixture curve,
$\bar{y}$ = values on the green color-mixture curve,
$\bar{z}$ = values on the blue color-mixture curve.

Following are three example computations using these equations.

For a green color of 560 millimicrons, the values of $\bar{x}$, $\bar{y}$, and $\bar{z}$ are $\bar{x} = .6$, $\bar{y} = 1$, and $\bar{z} = 0$. Substituting these values into equations 1, 2, and 3 gives:

$$x = \frac{.6}{.6 + 1 + 0} = .375,$$

$$y = \frac{1}{.6 + 1 + 0} = .625,$$

$$z = \frac{0}{.6 + 1 + 0} = 0.$$

For a blue color of 480 millimicrons, the values are $\bar{x} = .1$, $\bar{y} = .15$, $\bar{z} = .78$. When these values are substituted into equations 1, 2, and 3,

$$x = \frac{.1}{.1 + .15 + .78} = .097,$$

$$y = \frac{.15}{.1 + .15 + .78} = .146,$$

$$z = \frac{.78}{.1 + .15 + .78} = .757.$$

For a red light of 600 millimicrons, the values are $\bar{x} = 1.06$, $\bar{y} = .62$, and $\bar{z} = 0$. Then

$$x = \frac{1.06}{1.06 + .62 + 0} = .63,$$

$$y = \frac{.62}{1.06 + .62 + 0} = .37,$$

$$z = \frac{0}{1.06 + .62 + 0} = 0.$$

If the procedure is repeated at regular intervals from 400 to 700 millimicrons, the results can be used to plot the curve shown in Fig. 12. The ratios shown in equations 1, 2, and 3 were set up so that the values for x, y, and z at any wavelength would equal unity when added together. Therefore, a similar curve can be shown on a two-dimensional plane; this curve constitutes a more useful diagram than that shown in Fig. 12. Any two of the quantities x, y, and z are sufficient to specify a chromaticity. The third quantity can be found, since $x + y + z = 1$. By plotting only the values for x and y on the X-Y plane or by projecting the curve of Fig. 12 to the X-Y plane, the result shown in Fig. 13 is obtained. The curve in this illustration is called the "CIE Chromaticity Diagram." (The projection shown in Fig. 13 was accomplished by photographing the structure shown in Fig. 12 from above and along the Z-axis. This eliminated the dimension on the Z-axis and provided a proportionate diagram having only X and Y axes.) The two-dimensional CIE chromaticity diagram shown in Fig. 13 is used extensively in the specification of color, since all colors contained within the locus of the CIE diagram can be specified in terms of X and Y.

In Fig. 13, the horseshoe curve, which is known as the spectrum locus, is graduated with numerals ranging from 400 in the left-hand corner to 700 at the extreme right. These figures represent the wavelengths of the various colors in millimicrons; the blues (including violet) extend from approximately 400 to 490 millimicrons, the greens extend from approximately 490 to 550 millimicrons, the yellows extend from approximately 550 to 580 millimicrons, and the reds (including orange) extend from approximately 580 to 700 millimicrons.

Any point which is not actually on the spectrum locus but which lies within this diagram can be defined as some mixture of spectrum colors. Since white is such a mixture, it falls within this area.

It might be well to point out that there is another method of specifying colors near the white region. This method uses degrees Kelvin to designate a particular color. (Degrees in Kelvin equal degrees in Centigrade plus 273.) As metal is heated to various temperatures, it changes in color from dull cherry red into a white as the temperature is increased. If the temperature is increased still further, the metal takes on a decidedly bluish cast. These colors can be shown on the chromaticity diagram by drawing an imaginary arc starting in the reddish region on the right side of the diagram and extending up through the orange into the white area and down toward the bluish region to the left. Such facts are of importance when considering the three standard sources of light and how they were specified by the CIE. These sources are known as illuminant A, illuminant B, and illuminant C.

Illuminant A was selected as a match in color to a conventional tungsten lamp. To achieve this, a tungsten filament was heated to approximately 2500 °K.

Illuminant B was selected to give an approximate match to direct sunlight. It was achieved in the same manner as illuminant A, except the tungsten filament was used with two prescribed liquid filters to give a color which matches 4800 °K.

Illuminant C gives a radiation which most nearly matches daylight. Tungsten filaments were used with the filter solutions arranged so that they would produce a color of approximately 6500 °K. Illuminant C is the only one of concern here. Because it is considered to be the most satisfactory from a viewing standpoint, it is the one which has been selected by the NTSC as the reference white for color television work. It is shown in the chromaticity diagram as point C.

With reference to white, one other term which may be encountered is "equal energy white." This is shown on the chromaticity diagram as point E and can be described as white composed of equal amounts of energy from the three primary colors, red, green, and blue.

Since saturation of color is defined as the degree of freedom from white, the spectrum colors which lie directly on the horseshoe curve can be said to be 100 per cent saturated because they contain zero amount of white. At point E, only white light is present, so it can be said to be zero per cent saturated. Various intermediate percentages of saturation fall along a straight line drawn between any point on the spectrum locus and point E.

Referring again to the chromaticity diagram in Fig. 13, notice that the bottom of the horseshoe curve has been completed with a straight line drawn from purplish-blue to red. Although this line completes the curve, it should not be considered in the same sense as the rest of the horseshoe. The reason for this is that the colors along this line cannot be assigned dominant wavelengths within the limits of the spectrum; therefore, these colors are known as nonspectral colors. They can, however, be expressed as the complements of some of the spectrum colors which fall directly on the horseshoe curve. A line from 500 millimicrons has been extended through white to the straight line, and the point of intersection is labeled 500C; or, in other words, the nonspectral color at the point is the complementary color of the bluish-green of wavelength 500 millimicrons. The same thing is true of the line that has been extended from a wavelength of 560 millimicrons; 560C is the complementary color of a yellowish-green with wavelength 560 millimicrons.

When primary colors were selected for color-television work, it was found that those primaries must of necessity be limited by the color phosphors that were available for the picture tube. Fig. 13 shows the locations of the actual primaries (R, G, and B) that are used in color television. They define a triangle within the boundaries of the chromaticity diagram; the area within the triangle represents the range of colors that are obtainable when these primaries are used. In the NTSC triangle, red has a wavelength of approximately 610 millimicrons, green is approximately 540 millimicrons, and blue is approximately 470 millimicrons. At first glance, this triangle appears much smaller than the gamut of colors obtainable when ideal primaries are used. Closer inspection reveals, however, that the NTSC primaries fall very close to the saturated colors on the chromaticity curve. The red primary, for example, is actually on the curve.

Fig. 12 also shows the colors obtainable from modern printing inks. It is apparent that the NTSC color triangle covers a considerably larger area than does the gamut of printing inks.

Summary

The characteristics of human vision are important in that the eye is the instrument which judges the quality of color reception. Human vision is a remarkable function, but it has certain deficiencies and irregularities which limit its effectiveness. An understanding of these limitations is extremely helpful to anyone engaged in color television work. Examples of these limitations are: the luminosity response of the eye to various colors, intensity and time thresholds, contrast limitations, and the visual-angle requirements. It was also pointed out that certain illusions occur particularly with respect to brightness and saturation changes.

Treatment has been given to the two types of light sources, direct and indirect. In addition, the constituent colors and wavelengths of the light spectrum have been investigated. The attributes of hue, saturation, and brightness were described.

The development of the chromaticity diagram was covered in some detail. There were two major reasons for this: (1) The diagram is based upon actual tests of human vision, and this fact lends authority to the data which it presents; and (2) the NTSC triangle, which can be put to practical use, is based to a great extent upon the chromaticity diagram.

Since in the color television system the desired colors are produced by a mixing action, a thorough coverage of color-mixture rules has been presented. These rules are basic, and a knowledge of them will prove helpful in analyzing and adjusting color equipment.

Next month, consideration will be given to the requirements of the composite color signal. ▲

RADIO BROADCASTING ON MEDIUM FREQUENCIES

by *Alfred F. Barghausen*, James W. Finney*, and Ronald M. Fisher**

A detailed examination of the use of the medium-frequency band for broadcast purposes.

The Radio Spectrum

"Medium frequencies" lie within that portion of the radio spectrum between 300 kHz and 3000 kHz. This range is also designated in the International Radio Regulations of the International Telecommunications Union (ITU) as Band 6, since the frequency 10^6 Hz lies near its middle. The wavelength range corresponding to this frequency range is of the order of 100 to 1000 meters, and these are called hectometric waves. Frequency limits are arbitrarily assigned for convenience in telecommunication usage rather than on the basis of propagation characteristics and the mechanisms involved.

There are other frequency designations for the various bands. A uniform nomenclature of the frequency and wavelength bands as adopted by the ITU is given in Table 1.

Different propagation mechanisms, *i.e.*, methods whereby electromagnetic waves travel from the transmitter to the receiver, are involved in various parts of the spectrum. Each band or series of bands may involve more than one propagation mechanism at a time. Both the ground-wave and sky-wave propagation mechanisms, for example, are important at medium frequencies. Good-quality reception is simultaneously available at moderate distances by the ground wave and at long distances by the sky wave; at intermediate distances, phase-interference selective fading, caused by interference between the ground wave and a time-delayed sky wave, often seriously deteriorates the aural quality of the received broadcast signals. Due to ionospheric characteristics, however, the sky waves are present only during the hours of darkness.

TABLE 1. Nomenclature of Frequency Bands

Band Designation	Band No. *	Frequency Range†	Metric Subdivision
VLF	4	3-30 kHz	Myriametric Waves
LF	5	30-300 kHz	Kilometric Waves
MF	6	300-3000 kHz	Hectometric Waves
HF	7	3-30 MHz	Decametric Waves
VHF	8	30-300 MHz	Metric Waves
UHF	9	300-3000 MHz	Decimetric Waves
SHF	10	3-30 GHz	Centrimetric Waves
EHF	11	30-300 GHz	Millimetric Waves
	12	300-3000 GHz	Decimillimetric Waves

*Note that band b extends from 0.3×10^b to 3×10^b hertz and b may be either a positive or a negative integer or may be equal to zero.
†In international and national usage, the hertz (symbol: Hz) has been accepted alternatively with cycles per second (c/s) as the name for the unit of frequency. However, there is a strong tendency at present to use the hertz (31).

Frequency assignments are made by a government agency within each country. International coordination of frequency assignments is carried out by the International Frequency Registration Board (IFRB) of the ITU or by separate treaty between adjacent countries. In both cases, regulations are adopted which attempt to provide assignments which yield service areas adequate for the intended purpose. Whether or not the signals within the intended service areas are free from harmful interference depends, to a large extent, on the technical considerations used for making the frequency assignments.

Radio Broadcasting

Radio broadcasting is radio transmissions intended for general reception within geographic areas as distinguished from radio communications directed to specific receiving stations.

The frequency range 535 kHz to 1605 kHz is used exclusively on a worldwide basis for medium-wave radio broadcasting and is sometimes referred to as the "standard broadcast band." Each station is assigned a channel which is a band of frequencies occupied by the carrier and sidebands of the broadcast signal, with the carrier frequency at the center. Channels are designated by the carrier frequency.

In North American countries and Australia, frequency assignments are made to channels beginning at 540 kHz and having a bandwidth of 10 kHz. In the European area, Africa, and certain parts of South America, the channels begin at 539 kHz and have a bandwidth of 9 kHz.

The Service Area Concept

For purposes of frequency assignment and determination of effective range, the service-area concept is used for all three types of broadcasting—amplitude modulation (AM), frequency modulation (FM), and television (TV). Amplitude-modulated broadcasting is used exclusively in the standard broadcast band, and the effective range has been classified by the Federal Communications Commission (FCC) into three types of service areas as follows:

1. *Primary Service Area.* The area in which the ground-wave field strength is above a specified value

*Institute for Telecommunication Sciences and Aeronomy (formerly Central Radio Propagation Laboratory of the National Bureau of Standards), Environmental Science Services Administration, Boulder, Colorado.

and is not subject to objectionable interference or fading.

2. *Secondary Service Area.* The area in which the sky-wave field strength is above a specified value for a given percentage of the time and is not subject to objectionable interference.

3. *Intermittent Service Area.* The area in which the ground-wave field strength is above the specified value in 1, but the signal is subject to interference from the sky wave for a given percentage of the time.

While it is not specifically stated in the above definitions, broadcast service areas can be described accurately only by statistical methods, *i.e.,* the fraction of the locations within a specified area at which a specified grade (quality) of service is available for a given fraction or more of the time. The fraction of the time has traditionally been expressed as a percentage, but this introduces an essentially redundant factor of 100 which unnecessarily complicates the algebra of the statistics (1, 2, 3). It is possible to determine statistically the ratios of wanted signal power to interfering signal power necessary to produce sound of a quality acceptable to different observers in the presence of various types of interference (atmospheric noise, man-made noise, other stations, etc.). This is usually done for each type of interference and six different grades of service—Excellent, Fine, Passable, Marginal, Inferior, and Unstable—with a number of observers under controlled conditions. The ratio accepted by half of the observers for a given grade of service is chosen as the acceptance ratio for that grade of service and type of interference. Since the sky wave and even the ground wave may vary with time, it is also necessary to specify the required fraction of time that the acceptance ratio must be exceeded to define completely a given grade of service at a particular location. The location probability is then defined as the probability of receiving this quality of service for a given part of the time or more (3).

In AM sound broadcasting, service areas are shown by isoservice contours (4). These contours describe areas of equal service availability and not limits of service. In any given area within the isoservice contour, only a fraction of the population (the location probability times the population density) is expected to have service of a given quality available for a given fraction of the time or greater. This fraction representing the location probability varies from area to area and tends to decrease with increasing distance from the transmitter. Quality of service does not change abruptly, as might be inferred from a drawing of isoservice contours of various orders of magnitude, but shades gradually from service of high quality to service of low quality.

Ground-Wave Propagation

The ground wave can be defined as that part of the total received field which has not been reflected from the ionosphere or troposphere. For clarification, it is convenient to divide the ground wave into two components, a surface wave and a space wave (5, 6, 7, 8). Wait (9) has proposed that this surface wave be designated the Norton surface wave in order to distinguish it from other surface waves. The Norton surface wave, as the name implies, is the electromagnetic energy which is propagated over and diffracted around the earth's surface. The space wave is the sum of the direct and ground reflected waves and normally is only important at higher frequencies for line-of-sight transmissions, but may become dominant at lower frequencies if either or both the transmitting and receiving antennas are sufficiently high above the earth.

At medium frequencies when both antennas are located on the surface of the earth (as is often the case in standard broadcasting) the total received field is given by the Norton surface wave. Thus, the Norton surface wave completely determines the primary service area of a medium-frequency broadcasting station.

The propagation of the Norton surface wave is primarily dependent on three parameters: the frequency, the electrical properties of the earth, and the wave polarization. If these parameters are known, the total field induced by the Norton surface wave may be calculated to a high degree of accuracy. In practice, the frequency and wave polarization are known, but the electrical properties of the earth are a combination of complex quantities which, in the absence of measurements, can only be estimated.

Electrical Properties of Earth

The electrical properties of the earth may be expressed by three constants: the relative permeability, the dielectric constant, and the conductivity. The relative permeability is regarded as unity, and it remains to determine the dielectric constant, ε, and the conductivity, σ. These two constants influence ground-wave propagation as expressed in the equation for the complex dielectric constant relative to a vacuum. The relative importance of the two constants depends on the radio frequency. Although the values of ε and σ tend to vary together, exact solutions to the surface-wave equations show that at medium frequencies the conductivity has a larger influence on the field strength. At high frequencies, ε and σ have comparable effects on the field strength. At microwave frequencies the influence of the dielectric constant predominates, and the conductivity is of negligible importance.

The dielectric constant of free space is denoted by ε_0. The value for seawater is $80\varepsilon_0$, and for ice it is approximately $2\varepsilon_0$; average values for land surfaces vary from approximately $5\varepsilon_0$ to $30\varepsilon_0$. A mean value of the dielectric constant relative to free space of $(\varepsilon/\varepsilon_0) = 15$ for all land areas, and $(\varepsilon/\varepsilon_0) = 80$ for all water areas, can therefore be assumed in determining the primary service area of a medium-frequency broadcast station.

The importance of surface conductivity and frequency is illustrated in Fig. 1. Curves are shown for low (550 kHz) and high (1600 kHz) frequencies in the standard broadcast band. The curves are plotted as functions of distance and attenuation relative to free-space inverse distance for conductivities of 1 mmho/m and 30 mmhos/m for both frequencies. All values of conductivity are given in MKS units (milli-

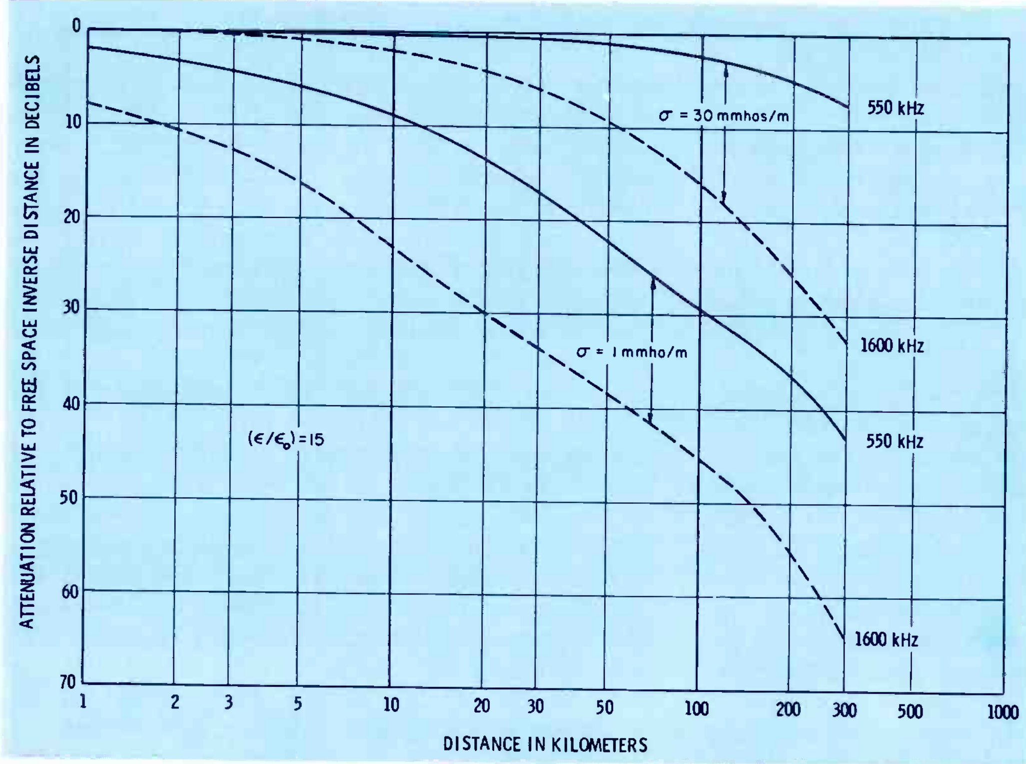


Fig. 1. Attenuation curves show the importance of surface conductivity.

mhos per meter, abbreviated mmhos/m). The attenuation above the inverse-distance field strength was determined from exact solutions to the surface-wave equations, based on the assumption of a completely homogeneous earth, *i.e.*, the dielectric constant and conductivity were assumed to be constant and uniform over the entire path.

Wave Polarization

Wave polarization is very important in medium-frequency broadcasting, especially in the propagation of surface waves and of long-distance sky waves in low-latitude areas. The presence of a conducting earth suppresses the propagation of horizontally polarized surface waves due to the cancellation effects between the parallel electric vector and the induced ground currents. With vertical polarization, the induced ground currents serve to restore or reinforce the surface wave in such a way that, for a perfectly conducting plane earth, the field strength at short distances will be equal to twice the field strength in free space. For the same conditions, the field strength of a horizontally polarized surface wave may be 80 to 100 dB below that of a vertically polarized surface wave. Therefore, vertical polarization is used exclusively by all medium-frequency broadcast stations.

The Importance of Ground Conductivity

To determine the service area of a broadcast station, some knowledge of the ground conductivity is essential. From the data in Fig. 1, it can be concluded that it is insufficient to classify the conductivity in broad descriptive terms, such as good, fair, or poor, or in broader terms such as a single value for all land areas. These general classifications may be sufficiently accurate for some administrative purposes, but indiscriminate usage for technical evaluation can result in errors of hundreds of square kilometers in the predicted total area receiving primary service. Alternatively, their use for estimates of field strengths at specific locations may give values which could be ± 20 dB in error. Therefore, a need remains to devise some method whereby more reliable estimates of conductivity can be assigned to specific areas.

The decrease in the field strength due to the spreading of radio waves with distance can be computed simply, since the field strength is inversely proportional to the distance from the transmitting antenna. This loss is represented graphically in Fig. 2 as a pair of adjacent scales with the inverse-distance attenuation (relative to the field at 1 km) in decibels opposite distance in kilometers.

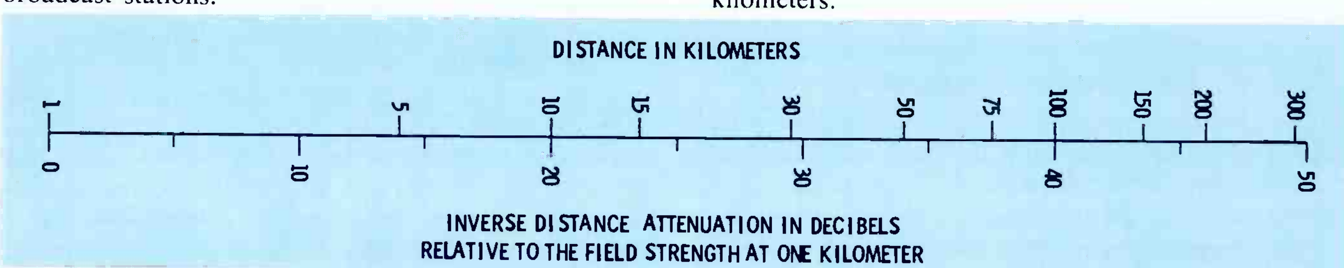


Fig. 2. This nomograph can be used to determine the attenuation due to spreading waves (inverse-distance loss).

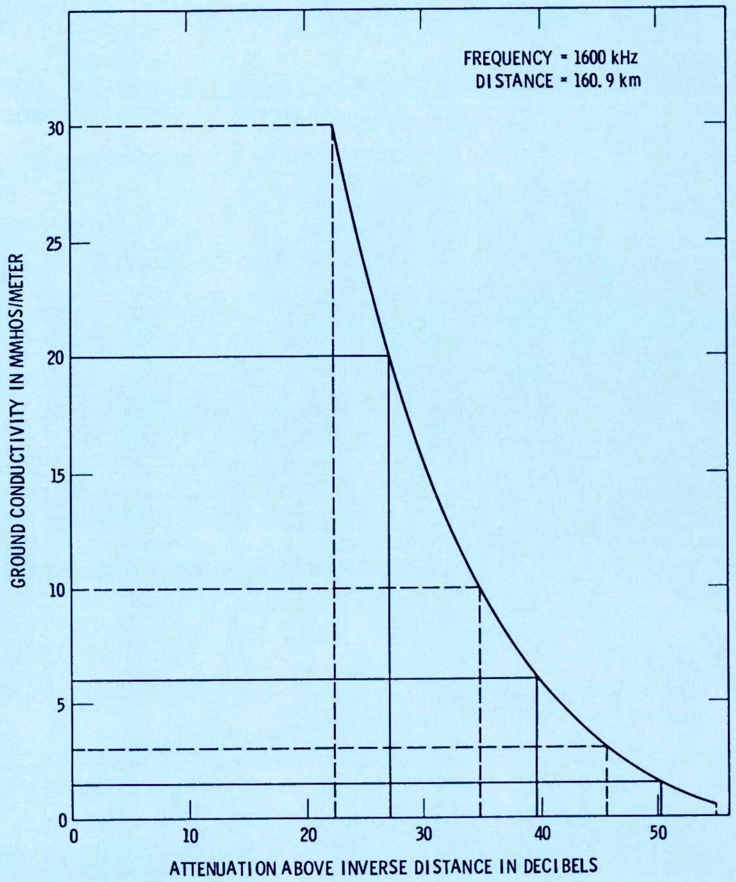


Fig. 3. Curve relates attenuation with ground conductivity values.

Since it is impractical to obtain the exact conductivity of a particular area, the total range of earth conductivities has been divided into three groups: 0 — 3, 3 — 10, and 10 — 30 mmhos/m. Seawater, having a conductivity of approximately 5000 mmhos/m, has been considered separately. The field strength (as calculated by Norton [5, 6, 10] and Bremer [11]) as a function of conductivity and dielectric constant for a spherical earth as shown in Fig. 3, was taken as a typical case for determining the number and range of the groups. The conductivities chosen to represent the groups were 1.5, 6, and 20 mmhos/m. As mentioned above, a mean value of the dielectric constant was assumed, *i.e.*, $15\varepsilon_0$ for land areas and $80\varepsilon_0$ for water areas. These conductivities were used in calculating the attenuation as a function of distance and frequency. Using Fig. 3 and similar curves for other frequencies and distances out to 300 km, the greatest possible error within any range would be 8 dB above or below the field strength calculated, using the reference conductivities.

The nomographs presented in Figs. 4 through 7 relate frequency and distance to attenuation above inverse distance for each of the four groups of conductivies. Normally the frequency and distance will be known, and with a straightedge on the proper nomograph, the attenuation in decibels can be obtained. It must be emphasized, as discussed above, that the use of these nomographs to calculate the field strength of the Norton surface wave is based on the assumption of a smooth spherical earth that is homogeneous and uniform in all respects.

Penetration Depth of Ground Waves

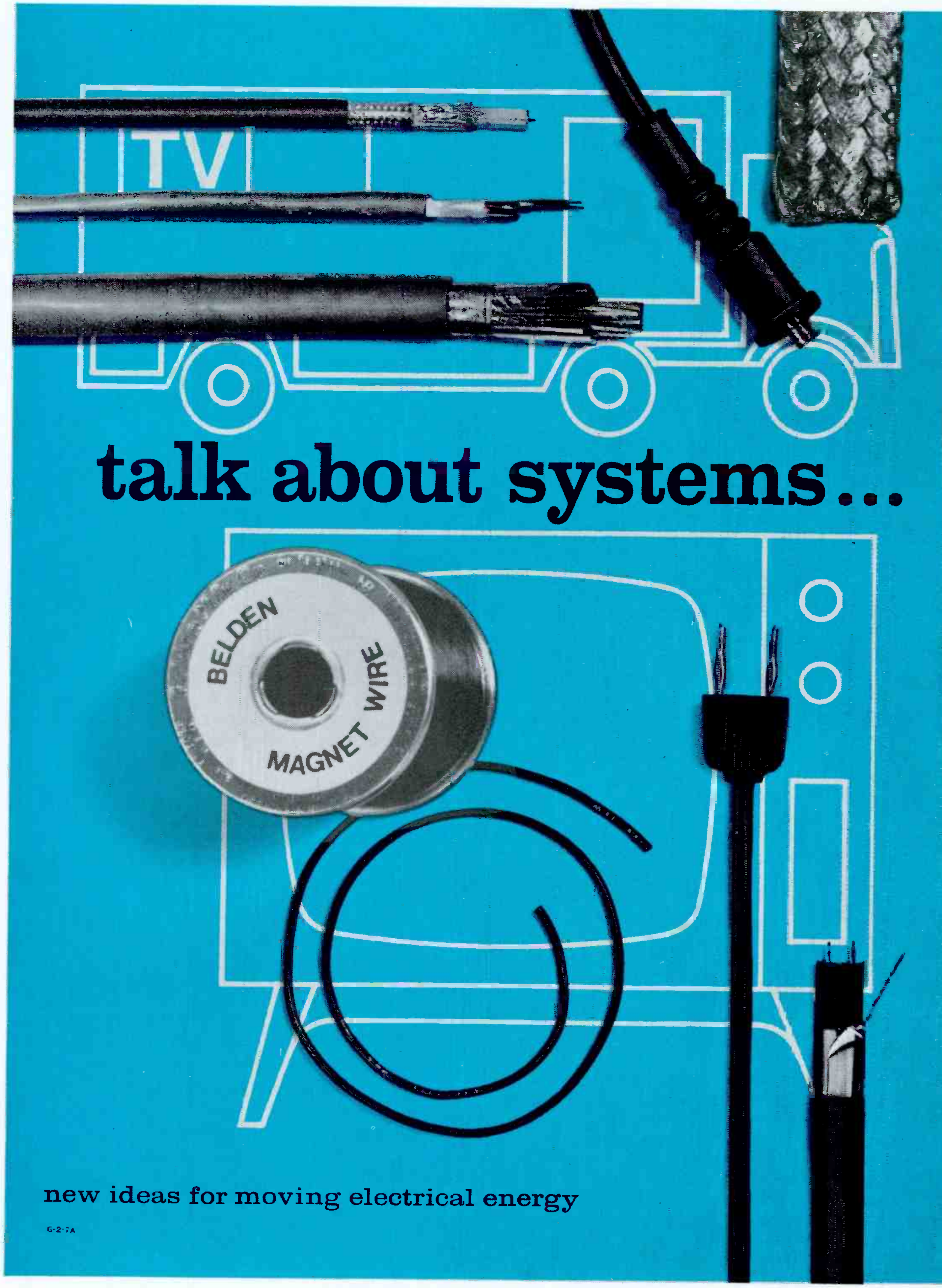
The electrical properties of most of the earth (expect seawater and certain land areas, *e.g.*, large deserts) are very nonuniform. This inhomogeneity exists not only horizontally across the ground, but vertically in depth, and further complicates any method of conductivity specification.

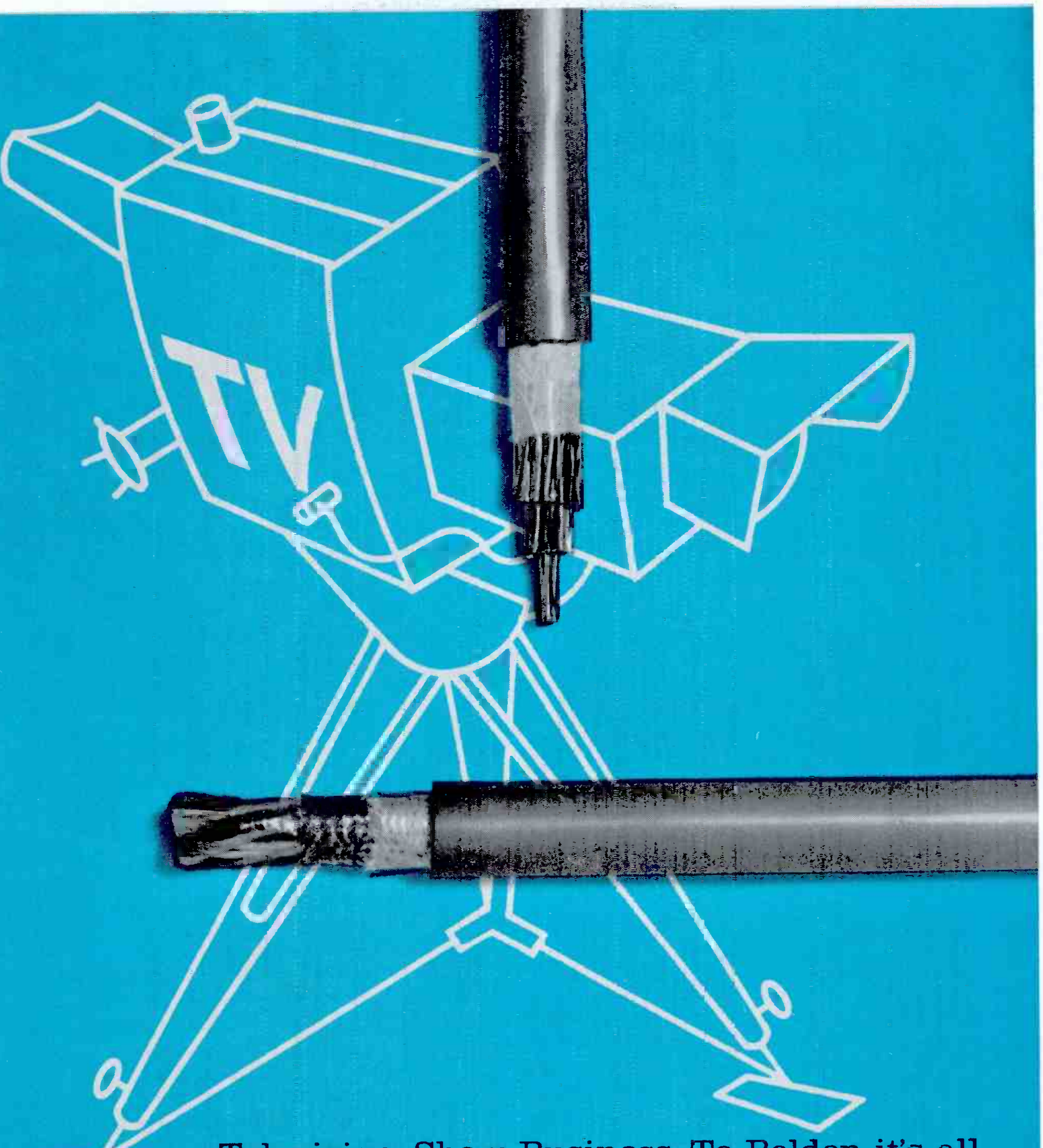
Vertical stratification of the earth, where different layers have different electrical properties, affects the propagated ground wave, since the electromagnetic energy at different frequencies penetrates to different depths. Table 2 shows the relative penetration depths for various frequencies and conductivities. These values were calculated on the assumption of maximum current density at the surface and an exponential decrease with depth. The depths tabulated are those values where the current density has decreased to approximately 37% of its surface value; this depth is called the skin depth.

It is apparent from Table 2 that low frequencies and low conductivities involve penetration depths which are usually below the surface agricultural soils. Con-

TABLE 2. Penetration Depths

Frequency (kHz)	Penetration Depth in Meters — Conductivity (mmhos/m)			
	1	3	10	30
100	46	28	17	10
500	20	11	7	4.5
1000	15	8.5	5	3
1500	12	7.5	4.5	2.5


TV
BELDEN
MAGNET WIRE
talk about systems...
new ideas for moving electrical energy
G-2-7A


TV

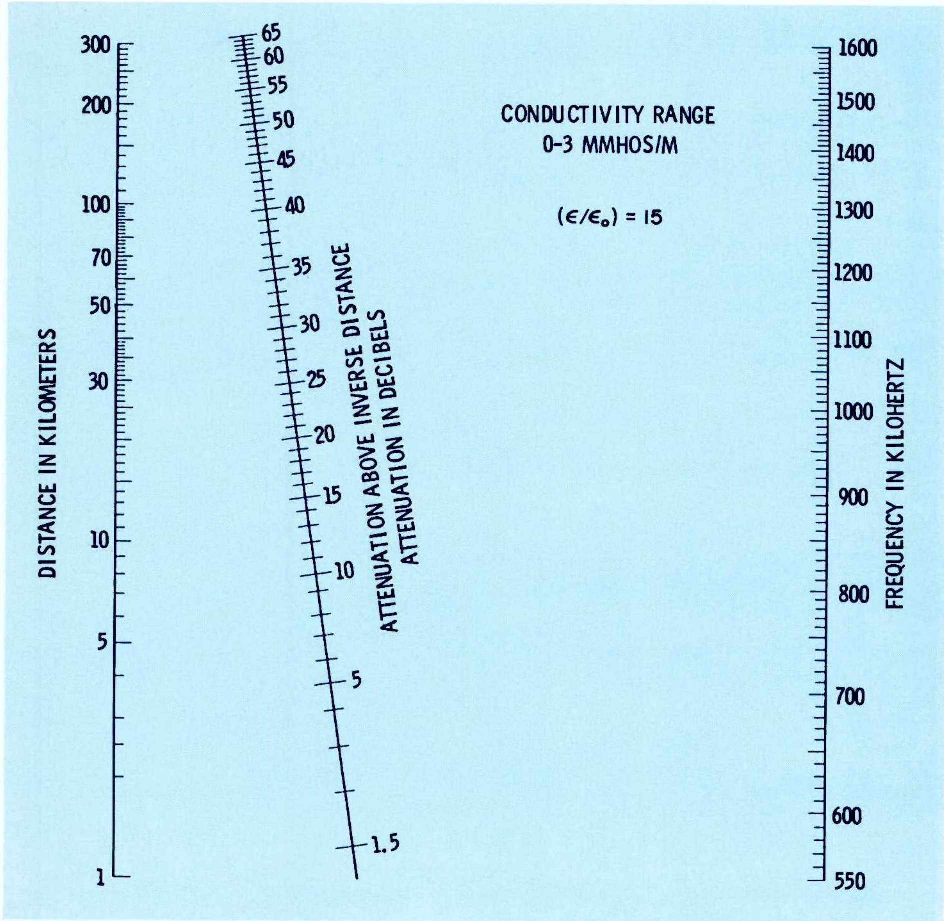


Fig. 4. Frequency-distance-attenuation nomograph for 0-3 mmhos/m.

versely, the surface soil may be most important at high frequencies if the conductivity is high, or again of lesser importance at low conductivity since the energy will penetrate to greater depths.

Effective Values of Electrical Properties of the Earth

As previously mentioned, theoretical solutions of the Norton surface-wave field strength are determined as if the earth were homogeneous and uniform. Therefore, the accuracy of the calculations depends on the accuracy of the input values of the electrical properties of the earth, *i.e.*, its conductivity and dielectric constant. It is neither practical nor necessary, in most applications, to specify or determine the absolute conductivity and dielectric constant for all surface areas; instead, average or apparent values are determined and defined as the "effective" conductivity and "effective" dielectric constant. In this context, the "effective" electrical properties are not true constants of the material, and their use is valid only within a limited frequency range.

The "effective" conductivity (σ_{eff}) is the conductivity of a uniform homogeneous earth which would have the same effect on a propagated electromagnetic wave as that of a real earth. For certain areas, as in the case of a completely seawater path, the effective conductivity is equal to the actual conductivity; values may be assigned and the field strength calculated accurately.

For computing a complex attenuation function needed in the classical formulas, the effective dielectric constant (ε_{eff}) must be considered together with the effective conductivity (σ_{eff}).

Factors Which Determine the Effective Ground Conductivity

The importance and influence of a finitely conducting earth upon the propagated surface wave was recognized more than 50 years ago by Sommerfeld (12), but very little was published concerning the actual values of the earth's electrical properties until the early 1930's. Since that time many measurements have been carried out, and publications have been issued which describe the methods of measurement and report values of the effective conductivity in limited areas.

Several of these published reports give estimates of the effective conductivity in very small ranges (*i.e.*, 1, 2, 4, 8, 15, and 30 mmhos/m) for large areas such as the United States (13, 14), South Africa (15), and Canada (16). While the estimated values for those limited areas having measurements are probably reliable, there are vast areas without measurements where the values for these small ranges are doubtful because they were based on a rough correlation between the available measurements and broad classifications of surface soil types. Little or no attention was given to the influence of any other factors.

In other areas, such as the British Isles (17) and Norway (18), conductivity estimates were based on a correlation between measurements and soil types, but were extended to include the effects of subsurface geological-lithological formations. In Africa (19), effective conductivity estimates for the MF range were based solely on surface vegetation for all land areas except for those given above for South Africa (15).

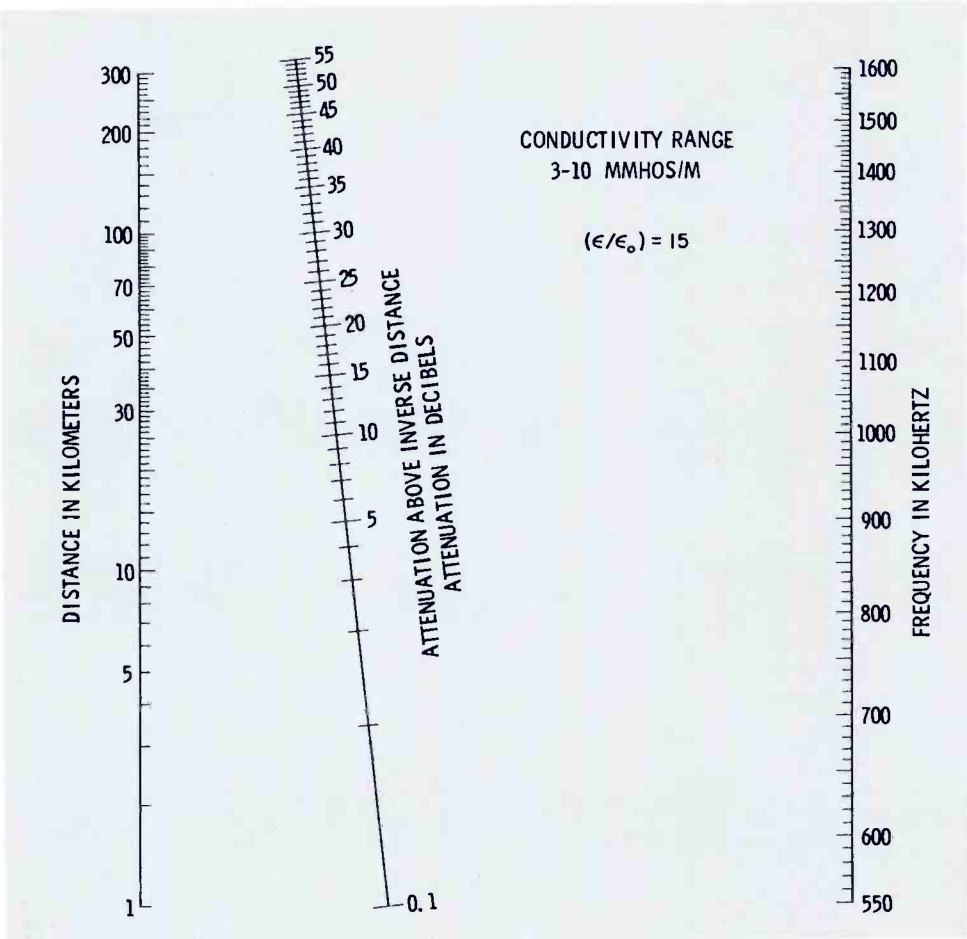


Fig. 5. Frequency-distance-attenuation nomograph for 3-10 mmhos/m.

The effective ground conductivity is dependent upon the relationship of many factors, the most important being the type, thickness, and *condition* of soils and rocks; the type of vegetation; the terrain roughness and land-water features; and to a lesser extent the climate. To understand the significance and relationship of these factors on the effective conductivity, it is necessary to study the electrical conduction of earth materials (rocks and soils), as well as the geophysical environment of the earth.

The principal factor which determines the conductivity of rocks and soils is their resistivity. The resistivity of dry earth materials can be easily measured in the laboratory (20). Under natural conditions, however, the resistivity is very much dependent on the water content, salinity, and in a complicated way on the manner in which the water is distributed throughout the material (21). This condition can only be sustained in its natural environment.

Geophysical environment factors include the study of lithology, geologic age, earth structure, temperature, climate, and vegetation.

All of the above factors are important in estimating the effective conductivity for a particular area, but the relative importance of each factor is not known, and much important information is not available for many areas. The attenuation due to vegetation, *e.g.*, heavy forest or jungle, is so great that useful ground waves are limited to very short distances (22). Areas of high-density ice and snow would have low effective conductivity values and therefore high signal attenuations.

Mountainous regions, considered in the category of terrain roughness, have low effective conductivities due, in part, to their geological-lithological structure. In addition, the height of the mountains may be on the order of several wavelengths when compared to the radio frequency, which causes further attenuation. Therefore, the influence of both roughness and geological-lithological factors on surface waves propagating into or over mountainous regions would be expected. In the medium-frequency range, the relative importance between these two factors in not known and requires further study.

The effective conductivity maps referred to for Canada and the United States were prepared and are issued by the Canadian Department of Transport (16), and the Federal Communications Commission (14). Copies of the maps may be obtained from the Telecommunications and Electronics Branch, Department of Transport, Ottawa, Canada, and the Federal Communications Commission, Washington, D.C. Measurements taken in many new areas have become available since these maps were prepared. These indicate serious discrepancies between the assumed and actual values for the narrow conductivity ranges used. In addition, since the maps were prepared by independent governments without exchange of information, discontinuities exist at the international boundary. These are not important, however, when the broader conductivity ranges of the nomographs are used.

Norelco cameras are used for top shows on 2 of the 3 major networks ...there must be a reason

ABC's Lawrence Welk Show is enjoyed by millions each Saturday night...televised with Norelco Plumbicon color cameras.

There is. First a superior color picture that enhances fine programs. A picture with snap, with sharpness of detail, and free of noise and lag.

There are other reasons, too. The Norelco Plumbicon* camera has a unique optical system that utilizes light to the maximum—performs beautifully even at very low light levels and over high contrast ranges.

Finally, the Norelco camera scores consistently with networks, group and independent stations from coast to coast by its simplicity of operation, reliability and unmatched handling ease.

Send for the brochure, "The camera that sees eye to eye with the viewer," for a complete description of the newest generation Norelco PC-70. For a live demonstration at your station, contact our representatives, Visual Electronics.

Awarded to Philips for Outstanding Achievement in Engineering for the Development of the Plumbicon Tube

Emmy©

Norelco

PHILIPS BROADCAST EQUIPMENT CORP.

299 Route 17, Paramus, New Jersey 07652

*Registered trade mark for television camera tubes.
N.A.T.A.S. ©1949

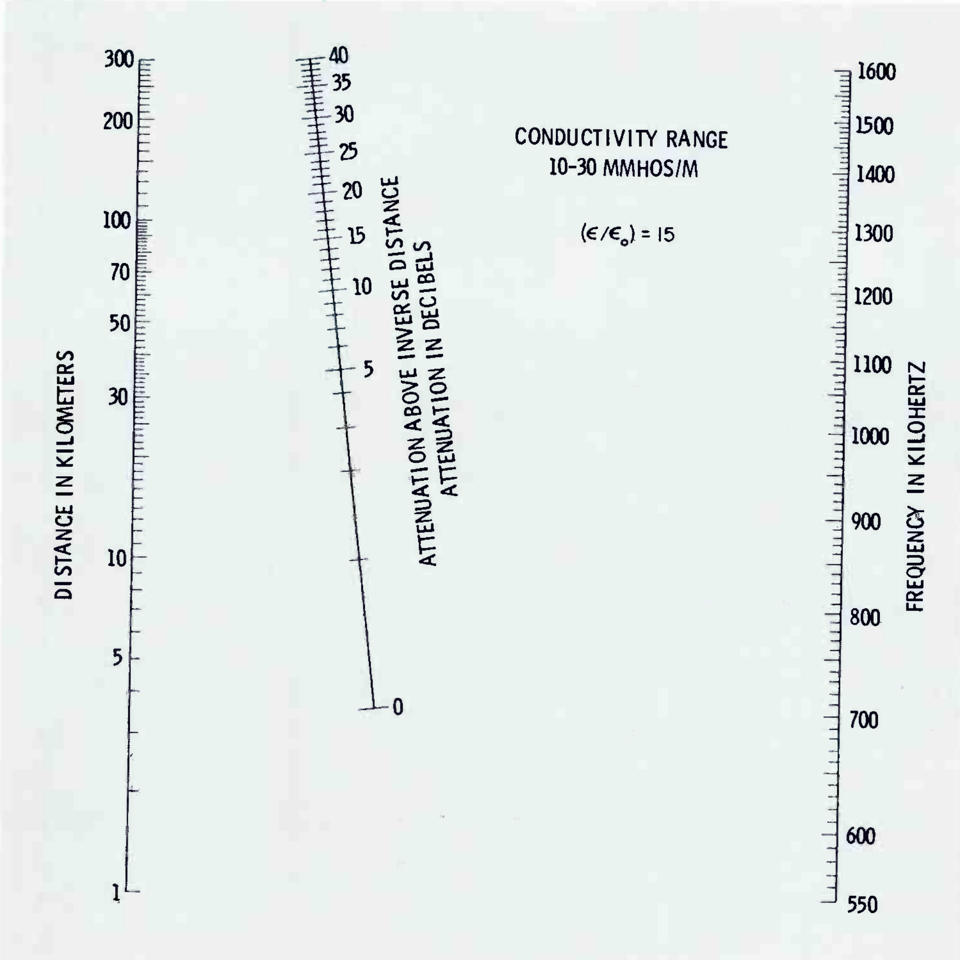


Fig. 6. Frequency-distance-attenuation nomograph, 10-30 mmhos/m.

Ground-Wave Propagation Over Mixed Conductivity Paths

If the effective conductivity for the entire path is a fixed value within the specified range, the attenuation for the Norton surface wave can be calculated, as shown by the nomographs in Figs. 4 through 7. As is evident from effective conductivity maps published for certain areas (14, 16), there will be many situations where the surface wave will traverse a path over which the effective conductivity changes from one range to the next higher or lower. In this case, a mixed path exists, and some method of calculation is necessary to account for this decrease or increase in attenuation.

There is no known theoretical solution to the problem although some progress is being made (23). The empirical methods for a solution to this mixed-path problem, developed by Eckersley (24), Millington (25), and Somerville (26), now receive widespread use. Perhaps the best-known method is that of Millington, although the Somerville method described by Kirke and called the equivalent-distance method is used in the United States (4). The Millington method is the only method which meets the criteria of reciprocity, *i.e.*, the transmitter and receiver may be interchanged and the same result is obtained. Also, it shows better agreement with theoretical results and practical observations.

The Millington method involves two calculations, one in the forward direction (*i.e.*, the normal path) and one in the reciprocal direction (*i.e.*, interchanging the transmitter and receiver locations). The geometric mean (arithmetic mean when the attenuation is given in decibels) of the two calculations is then the correct estimate of attenuation.

As an example of the use of this method, suppose it is desired to determine the attenuation above the inverse-distance attenuation at 1000 kHz for a 200-km path composed of an effective conductivity in the range 10-30mmhos/m for the first 80 km and 0-3 mmhos/m for the remaining 120 km. Using the appropriate nomographs of Figs. 4 through 7, the computation is performed as follows:

Forward Direction:

Atten (80 km at 10-30 mmhos/m) = + 9 dB
Atten (80 km at 0-3 mmhos/m) = + 34.2 dB
Atten Difference = 9 − 34.2 = − 25.2 dB
Atten (200 km at 0-3 mmhos/m) = + 44.7 dB
Therefore atten (200 km mixed path)
= 44.7 − 25.2 = 19.5 dB

Reciprocal Direction:

Atten (120 km at 0-3 mmhos/m) = + 38.2 dB
Atten (120 km at 10-30 mmhos/m) = + 12.9 dB
Atten Difference = 38.2 − 12.9 = + 25.3 dB
Atten (200 km at 10-30 mmhos/m) = 19 dB
Therefore atten (200 km mixed path)
= 19 + 25.3 = 44.3 dB

Thus, the reference attenuation for this path is the

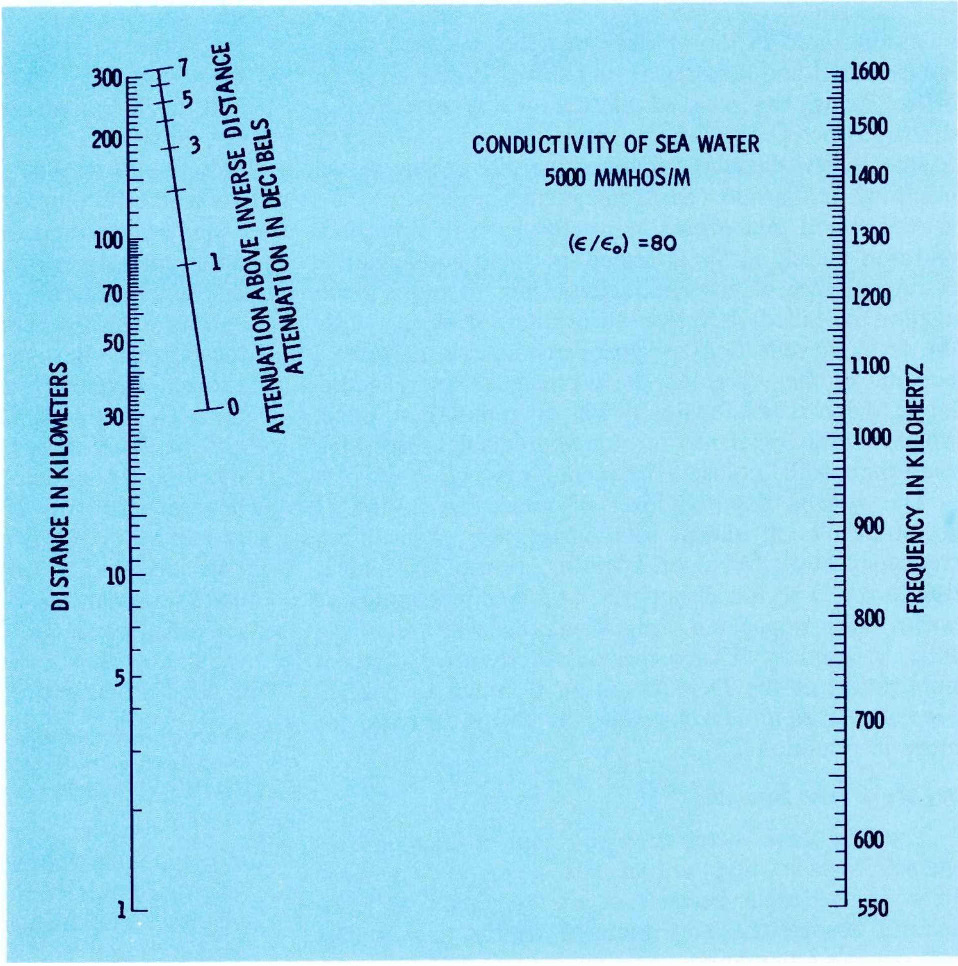


Fig. 7. Frequency-distance-attenuation nomograph for 5000 mmhos/m.

arithmetic mean of the forward and reciprocal attenuations, and is 31.9 dB.

According to the equivalent-distance method, the attenuation at 200 km for the mixed-path example illustrated above is approximately 5.5 dB greater than that computed by the Millington method.

Sky-Wave Propagation

The area defined as the secondary-service area of a medium-frequency broadcast station receives this service by reflections from the ionosphere. A brief description of some of the physical properties of the ionosphere and the propagation characteristics of MF sky waves follows.

The Ionosphere

The ionosphere is a region of ionized gases which surrounds the earth. It is composed of gas molecules and atoms from which electrons are detached by ultraviolet light or X-rays from the sun, or by high-speed electrons or protons released from the Van Allen belts. The sun is the greatest single source of these high-energy particles, and thus tends to control the state of ionization within the ionosphere. For convenience, the ionized region of importance to radio propagation is divided into four layers, according to height and intensity; these are called the D, E, F1, and F2 layers. They are not, however, distinctly separated layers, but rather overlapping regions of ionization which vary in thickness from a few to hundreds of kilometers. A shallow, or region of lower density, is sometimes evident between the E and F1 layers. The number of layers, their heights, and their electron density vary from hour to hour, day to day, month to month, season to season, and year to year. In the presence of the earth's magnetic field, the ionosphere acts as a birefringent medium.

The electron density and its variation with time are the most important properties of the four layers for radio communication. The radio frequencies reflected depend on the density; the higher the density of a layer, the higher is the frequency of waves it will reflect. The maximum radio frequency which is reflected from each of the four layers is called the critical frequency of the layer; higher frequencies penetrate the layer. Changes in the ionosphere are detected primarily by shifts in the critical frequencies which indicate increasing or decreasing electron density.

The secondary service area of a medium-frequency broadcasting station is determined primarily by the D and E regions. The F region may be important when the critical frequency of the E layer falls to a low value and the propagation path is relatively short.

Since the radiation effects from the sun exert the controlling influence on the electron density within each region, the highest critical frequencies are present during daylight hours. While D-region ionization is usually insufficient to support the reflection of radio waves in the medium-frequency range, it does cause considerable absorption of the penetrating waves.

Absorption is the process whereby part of the wave energy is dissipated by collisions of the excited electrons with molecules of air. The wave sets the electrons in motion, and in the absence of collisions the energy is reradiated and restored to the wave. In the presence of collisions, the ordered motion of the electrons is destroyed before or during reradiation, and the energy from the wave takes the form of thermal energy of the electrons or thermal (electromagnetic) noise.

Absorption that occurs below the level of reflection, and thus mainly in the D region, is called nondeviative. A second type of absorption important to radio propagation is called *deviative* absorption; it occurs near the level of reflection or wherever there is a marked bending of the wave. As the wave nears its reflecting level, there is a slowing down or retardation effect which allows sufficient time for appreciable absorption even though the collision frequency may be low.

The normal daytime level of ionization in the D region results in almost total absorption of medium-frequency waves. At night, however, most of the ionization in the D region disappears, and medium-frequency waves are propagated long distances with relatively little absorption. The reader is referred to a recent publication of the Department of Commerce, entitled *Ionospheric Radio Propagation,* by Dr. K. Davies, for more information (27).

Sky-Wave Field Strengths

The sky-wave field strength from a medium-frequency broadcasting station has a marked increase from day to night because of the reduction in ionospheric absorption. This increase begins near sunset and reaches a maximum value near midnight local time. Near sunrise, the absorption effect of the D region begins, and the field strength decreases rapidly to its low daytime value.

Daytime sky-wave fields are of negligible importance in medium-frequency broadcasting, since they are of insufficient strength to overcome the limitations due to atmospheric noise. Occasionally, however, daytime sky-wave field strengths may be sufficient for practical operation at moderate distances beyond the ground-wave range, if high transmitter powers are used and local radio interference and atmospheric noise conditions are favorable.

Nighttime sky-wave fields are of sufficient amplitude, even with moderate transmitter powers, to overcome normal noise limitations out to distances of 2000 km and beyond.

Factors Affecting Signal Strength

Ionospheric absorption is only one of several factors which affect the loss of power in medium-frequency sky-wave transmissions. The main sources of power loss are:

1. Equipment mismatch losses,
2. Antenna radiation losses,
3. The spatial or distance loss due to the spreading of the wave,
4. Ionospheric absorption,
5. Multipath interference losses (fading),
6. Polarization coupling losses,
7. Losses or gains caused by defocusing or focusing in reflection from a curved or wavy ionosphere.

Some of these losses may be determined readily, as, for instance, those due to 1, 2, and 3, which also apply to ground waves. The others are not easily ascertained, and, in fact, some are not necessarily net power losses but involve a redistribution. If recognized, some of these losses may be substantially reduced or completely overcome by employing appropriate techniques. As an example, a propagated radio wave of any polarization, upon entering the ionosphere, involves a redistribution of energy into two components called the ordinary and extraordinary waves. This redistribution of energy depends on the magnetic dip latitude, propagation direction, frequency, and transmitting-antenna polarization. The extraordinary wave tends to be almost totally absorbed and thus is of little use for any communication purpose. In middle latitudes, the energy distribution between the two component waves tends to be approximately equal, while in low latitudes unequal energy distribution may take place, which for certain conditions can result in substantial losses. Again, focusing involves a redistribution of power flux over the ground so that a decrease in one area is balanced by a greater concentration elsewhere.

Characteristics of the Long-Term Variations of Sky-Wave Field Strength

The received sky wave is composed of a number of component waves of different amplitudes and phases. The amplitude of the resultant wave is the vector sum of these components. Fading results as the components arrive in and out of phase. Long-term variations are related to the 11-year sunspot cycle, the season, the nocturnal hour, and the variations of terrestrial magnetism. Long-term recordings of sky-wave transmissions throughout the band are used to derive semi-empirical formulas for the relationship between the above factors and the median sky-wave field strength. If sufficient measurements are taken, it is possible to predict, with a certain reliability, the cumulative distribution of sky-wave field strengths for the entire medium-frequency band. Such quantitative estimates of propagation characteristics help to determine how well a broadcast station will meet requirements for satisfactory service.

Propagation curves of the sky-wave field strength as a function of frequency and distance for any percentage of the nights in a year, or any other long period, have been derived from long-term measurements of medium-frequency broadcasting stations (28).

Primary Ground-Wave Service Limited by Sky-Wave Interference

Because of interference effects, the presence of the sky-wave reflected from the E layer after sunset considerably limits ground-wave coverage. If the ratio between the sky-wave field strength and ground-wave field strength, as well as the phase angle between the two waves, were constant, the resultant magnitude of the received signal would be constant. Of course, if the ground-wave and sky-wave signals were of equal amplitude and 180° out of phase, the resultant amplitude would be zero. Since the sky wave is not constant in amplitude or phase, the resultant signal exhibits irregular variations, called fading.

Fading may be manifested either as selective fading, group fading, or a combination of both. Selective fading occurs when the carrier and sidebands do not fade in unison. It may produce severe distortion of the signal. Group fading, in which the amplitudes of the carrier and sidebands fade together and phase relationships are maintained, does not distort the signal, and so constitutes a problem only if noise or interfering signals are strong. During nighttime hours, selective fading is one of the important factors in limiting coverage at medium frequencies.

This reduction in the primary service area at night may be estimated by determining the distance at which the predicted median sky-wave field strength is equal to the calculated ground-wave field strength. This represents an approximate limit of the primary service area for any particular broadcasting station, and in actual practice would involve a range of distances due to the variability of the many factors which influence the sky-wave field strength.

The vertical polar diagram of the transmitting antenna is important in the determination of the range in which interference between the ground wave and sky wave occurs. Base-fed vertical antennas of different electrical heights have different vertical polar diagrams. Radiation at the high vertical angles decreases with increasing antenna length up to approximately 0.5 wavelength. On the assumption of sinusoidal current distribution and operation over a perfectly conducting plane earth, the optimum vertical antenna length is approximately 0.5 wavelength for maximum primary ground-wave service range.

The use of two or more vertical radiating elements arranged in some geometrical configuration and excited electrically produces radiation patterns which increase or decrease the radiated energy in both the horizontal and vertical directions. This configuration is called a directional antenna. Directional antennas have received widespread use in medium-frequency broadcasting for two important reasons:

1. To direct the radiation to heavily populated areas and away from sparsely populated areas.
2. To provide mutual protection to other cochannel or adjacent-channel stations for a more efficient utilization of the medium-frequency band.

Standardized optimum designs exist which have been shown in practice to perform with a very high degree of approximation to the theoretical maximum. In specified directions and dependent on the number of elements and their configuration, gains of 3 to 9 dB in the horizontal plane may be realized over a single-element antenna.

Minimum Field Strengths for Satisfactory Broadcasting Service

The determination of what constitutes a satisfactory signal in the absence of station interference involves an evalution of the atmospheric noise levels to be expected, the levels of man-made noise in cities and towns, and finally the determination of a satisfactory acceptance ratio for a broadcast service.

Atmospheric Noise

Extensive atmospheric-noise data on a world-wide basis have been compiled, and reliable estimates of the noise level with which a wanted signal must compete may be determined for any specific area. Atmospheric noise varies with frequency, time, and geographic location. The highest values are encountered during the summer evening hours (1600-2000 LMT) in all geographic latitudes. The lowest values occur during the winter morning daytime hours (0800-1200 LMT). For any season and time period, notice must be taken of the variability of noise field strength. For instance, during the summer evening hours the difference between the noise field strength exceeded 10% and 50% of the time may be as high as 17 dB (29).

Man-Made Noise

In many locations, man-made noise is a more limiting factor than atmospheric noise for at least part of the time. Man-made noise may arise from any number of sources, such as power lines, industrial machinery, ignition systems, etc., with widely varying characteristics. In general, cities or towns have the highest man-made noise levels, although isolated rural areas may have high levels due to the proximity of high-voltage power lines. The noise level within cities or towns varies widely between industrial, commercial, and residential areas. Curves showing the man-made noise level for these areas, similar to the atmospheric-noise curves, are not available. However, reasonable estimates of the minimum acceptable ratio to insure satisfactory broadcast service have been made from limited surveys.

Signal-to-Noise Ratios

The ratio of necessary RF carrier signal to the median hourly rms value of atmospheric noise is approximately 40 dB at the limit of the specified service area. This value is based on a number of measurements under the steady-state conditions required for 90% listener satisfaction. The value is dependent on receiver characteristics, mainly the bandwidth, but is representative for the most common types of broadcast receivers in use, *i.e.*, a bandwidth of 5 kHz and a minimum operating sensitivity of 36 dBu (30). (The abbreviation dBu indicates dB relative to 1 μv/m.)

Recommended Minimum Values of Field Strength for the Specific Grades of Service

Two grades of service for medium-frequency broadcasting are the primary service and the secondary service, both as defined previously. The recommended values of field strength necessary to provide these services are (4):

Primary Service (ground wave)	
City or town business-industrial areas	80-94 dBu
City or town residential areas	66-80 dBu
Rural areas	40-60 dBu
Secondary Service (sky wave)	
Rural areas only	54 dBu 50% of the time

Satisfactory secondary service cannot be rendered to cities or towns unless the sky-wave field strength approaches in value the ground-wave field strength required for primary service. The recommended values for primary service to rural areas as a consequence of atmospheric noise are subject to wide variation depending on the geographic location, season, and time of day.

International Rules and Procedures Governing Medium-Frequency Broadcasting

There are no uniform international rules and regulations governing medium-frequency broadcasting. Established practices, however, have led to a somewhat uniform procedure that is followed on an international basis.

Broadcasting in North America

Medium-frequency broadcasting in the United States is governed by strict rules and regulations set forth by the Federal Communications Commission. Almost identical rules and regulations have been adopted by separate international treaties between the United States and Mexico, Canada, Cuba, Dominican Republic, and the Bahama Islands.

By these treaties, the 107 channels within the band 535 to 1605 kHz have been divided into the following general classes:

Clear channels—Reserved for those stations which are intended to render service over wide areas free of objectionable interference within their primary service areas and over all or a substantial portion of their secondary service areas. Clear-channel stations are limited to maximum power of 50 kw, except for certain channels assigned to Mexico.

Regional channels—Reserved for those stations that operate with powers not in excess of 5 kw and render only a primary service. Stations operating on regional channels do not have secondary service areas, and the primary area at night is limited by sky-wave interference from cochannel stations.

Local channels—Reserved for those stations which operate with powers not in excess of 1 kw daytime and 0.25 kw nighttime. The primary service area of a station operating on any such channel may be limited as a consequence of interference. Local-channel stations do not have secondary service areas, and the primary service area at night is limited by sky-wave interference from cochannel stations.

Broadcasting in Central and South America

Most countries within this region are members of the International Telecommunications Union, which has adopted general rules and regulations pertaining to medium-frequency broadcasting. In most instances, agreements between adjacent countries are made on a case-by-case basis to prevent undue interference between cochannel and adjacent-channel assignments.

In general, stations with high transmitter power are requested to use the following assignment plan:

1. Channels in the low end of the band when only the ground-wave service area is to be served.
2. Channels in the upper end of the band when it is chiefly a question of serving the sky-wave service area.
3. Intermediate channels when both the ground-wave service area and sky-wave service area have to be served.

There are no international restrictions on transmitter power, and a number of stations throughout the world operate with powers in excess of 1000 kw.

Several countries within Central and South America have adopted internal frequency-assignment plans which assign certain medium frequencies to classes similar to those adopted by the North American countries. However, the channels assigned for a specific class do not necessarily follow the recommendations of the ITU.

Concluding Remarks

The nomographs presented and the effective-conductivity maps referenced, may be used for the calculation of the primary service area or field strength from a standard AM broadcast station operating in the medium-wave band out to a distance of 300 km. This distance is the approximate limit of primary service to urban and rural areas provided by moderate-power (5 to 10 kw) standard AM broadcast stations, depending, of course, on the frequency, antenna, and intervening path conductivity.

At night, interference from the station's own sky wave reduces the effective ground-wave (primary) service to distances much less than those obtained during daytime hours. This report describes the physical process causing this reduction in service and the availability during nighttime hours of a good-quality broadcast service provided by the sky-wave field to distances far beyond the maximum ground-wave range.

Values of field strength derived from the graphs should be considered only as estimates pending further study of the effective-conductivity maps used to define the surface conductivity for this frequency range. ▲

Sample Computation

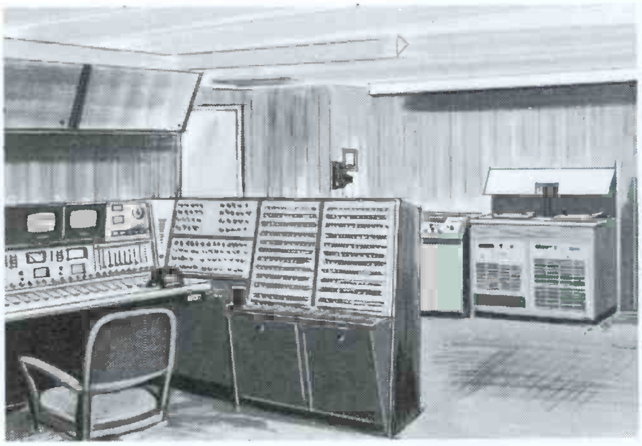
As an example of the use of the nomographs and maps in this article, the primary service provided by a typical AM broadcast station will be computed.

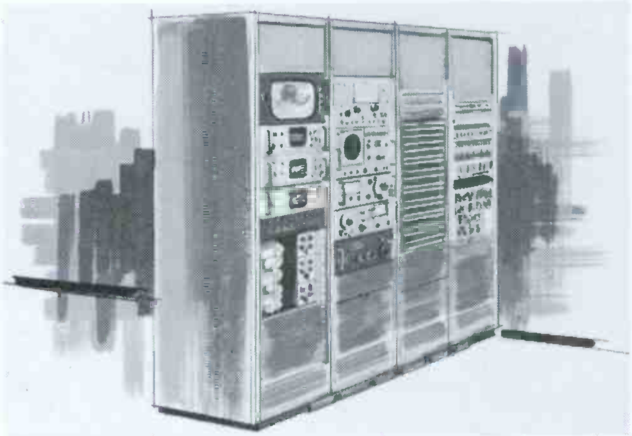
Broadcast frequency assignments may be obtained from the IFRB-ITU list. This list, published yearly, shows all notified assignments by frequency, setting forth the city and country, transmitter power, geographical coordinates of the transmitter, and hours of operation. Other listings are published regularly by private organizations and official government agencies for the particular government concerned, such as the listing published by the FCC entitled, "Official List for Information Setting Forth Notified Assignments of Standard Broadcast Stations of the United States." Similar lists are available for Canada, Mexico, and most Central and South American countries.

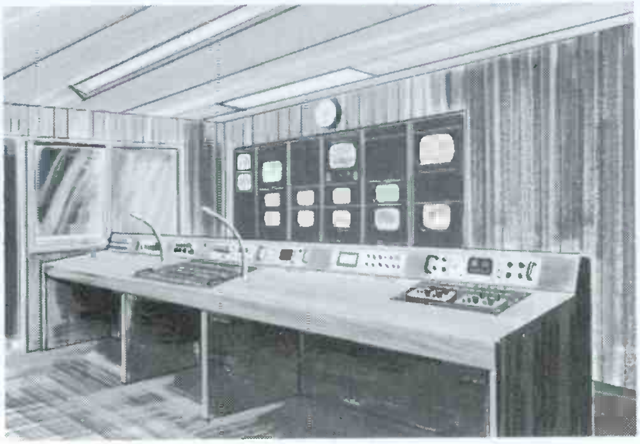
This example will be based on a station operating as follows:

Frequency:	590 kHz
Transmitter power:	5 kw
Hours of operation:	Unlimited
Polarization:	Vertical
Antenna height:	140 m above ground (99.5 electrical degrees)

A lossless, short vertical dipole operating over a perfectly conducting plane earth will radiate a field strength in the horizontal plane equal to 300 mv/m







Circle Item 11 on Tech Data Card

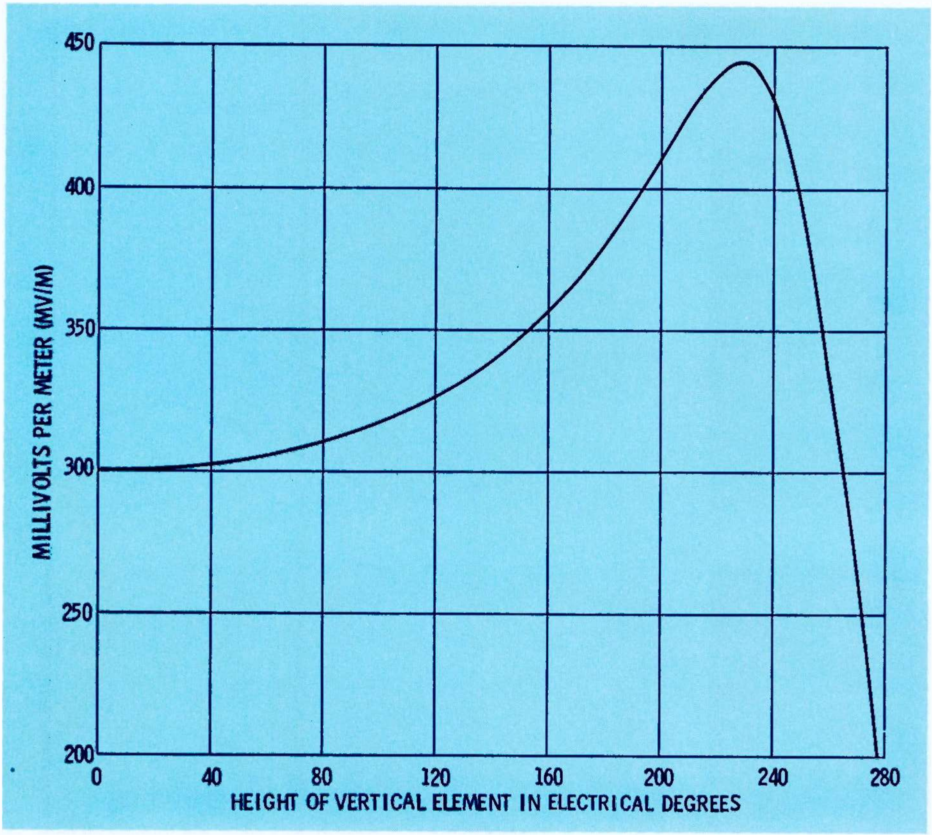


Fig. 8. Field strength at one mile is dependent on height of tower.

at 1 km for 1 kw of transmitter power. The theoretical radiation at 1 km for other vertical antennas up to 0.76 wavelength in height is shown in Fig. 8. Measurements have shown that these theoretical values are attained for vertical antennas above about one-quarter wavelength in height if suitable ground screens are used at the base. The main purpose of ground screens is to reduce the ground losses of circulating currents in the immediate vicinity of the antenna. Grounded vertical antennas less than 0.25 wavelength (90 electrical degrees) have large base currents and consequently have higher losses when operating over an imperfectly conducting earth. Therefore, short vertical antennas require good ground systems if reasonable efficiencies are to be obtained. As an example, the field strength at 1 km for a 0.125-wavelength (45 electrical degrees) vertical antenna at 1000 kHz without a ground system will be approximately 150 mv/m, or 6 dB less than that obtained for a perfectly conducting plane earth; the earth's effective conductivity is assumed to be 10 mmhos/m. A ground system consisting of 120 equally spaced copper wire radials from the antenna base, 0.25 wavelength long, will provide a radiated field within 2 dB of the theoretical maximum.

For the subject station, the height of the antenna is 99.5 electrical degrees (0.276 wavelength), and Fig. 8 indicates this antenna will radiate a field strength of 315 mv/m for 1 kw or 704 mv/m for 5 kw ($315 \times \sqrt{5}$) at 1 km. This corresponds to 117 dB above 1 μv/m (dBu).

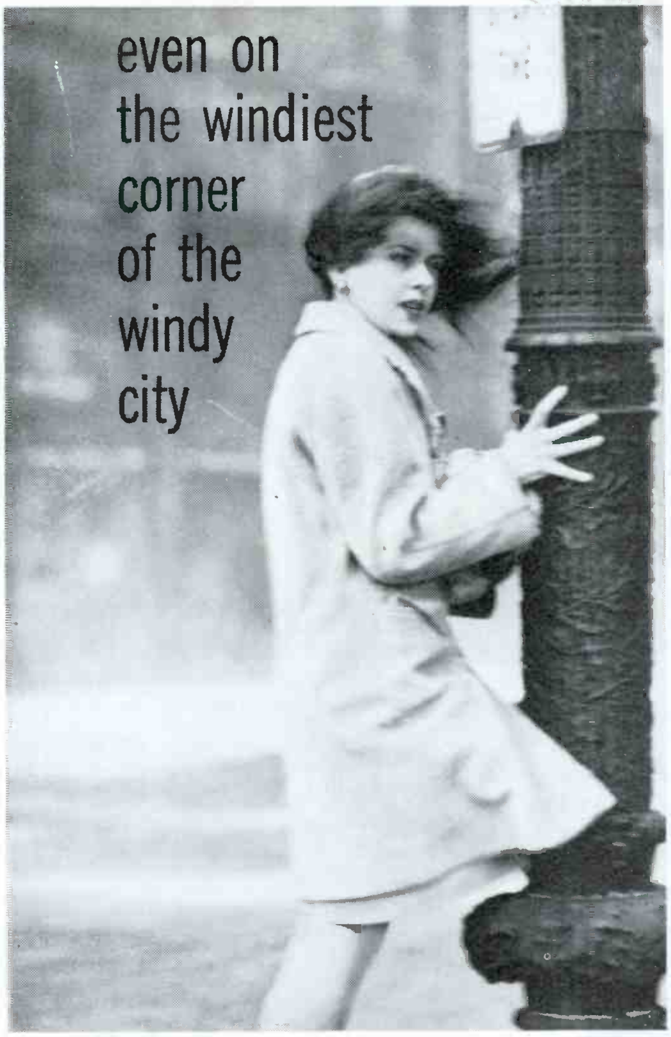
The estimated effective conductivity for the vicinity of the station is in the range 10-30 mmhos/m, and the nomograph of Fig. 6 corresponding to this range should be used for all computations.

It is desired to know the expected field strength at a distance of 100 km. From Fig. 2 the inverse-distance attenuation is found to be 40 dB, and from Fig. 6 the attenuation above inverse distance is 3.5 dB. Therefore, the field strength at 100 km from this station, operating with a power of 5 kw on 590 kHz, is 43.5 dB below the unattenuated field strength (117 dBu) at 1 km, or 73.5 dBu (117−43.5). This value is well above the minimum required for satisfactory reception in city or town residential areas during daytime hours, but may be limited to a higher value at night due to sky-wave interference from cochannel assignments.

References

1. Norton, K. A. and L. Gainen. *A Study of the Geographical Distribution of Population on the Coverage Obtainable from a National Television System.* Ad Hoc Committee for the Evaluation of the Radio Propagation Factors Concerning the Television and Frequency Modulation Broadcasting Services in the Frequency Range Between 50 and 250 Mc, October 1950.
2. Kirby, R. S. "Measurements of Service Area for Television Broadcasting," *I. R. E. Transactions on Broadcast Transmission Systems,* PGBTS-7 (February 1957), 23-30.
3. *Measurement of Field Strength for VHF (Metric) and UHF (Decimetric) Broadcast Services, Including Television,* CCIR Report 228. Geneva: ITU, II, 1963.
4. FCC. *Rules and Regulations,* Vol. III, Pt. 73, Radio Broadcast Services. Washington, D.C.: Supt. of Doc., U. S. Government Printing Office, 1964.
5. Norton, K. A. "The Propagation of Radio Waves Over the Surface of the Earth and in the Upper Atmosphere, Pt. I," *Proc. I. R. E.,* 24 (October, 1936), 1367-1387.
6. Norton, K. A. "The Propagation of Radio Waves Over the Surface of the Earth and in the Upper Atmosphere, Pt. II," *Proc. I. R. E.,* 25 (September 1937), 1203-1236.

7. Norton, K. A. "Physical Reality of Space and Surface Waves in the Radiation Field of Radio Antennas," *Proc. I. R. E.*, 25 (September 1937), 1192-1202.
8. Norton, K. A. "Space and Surface Waves in Radio Propagation," *Physical Review*, 52 (July 1937), 132-133.
9. Wait, J. R. "A Note on Surface Waves and Ground Waves," *IEEE Trans. on Antennas and Propagation*, AP-13 (November 1965), 996.
10. Norton, K. A. "The Calculation of Ground-Wave Field Intensity over a Finitely Conducting Spherical Earth," *Proc. I. R. E.*, 29 (December, 1941), 623-639.
11. Bremmer, H. *Terrestrial Radio Waves*. New York, N. Y: Elsevier Publishing Co., 1949.
12. Sommerfeld, A. "The Propagation of Waves in Wireless Telegraphy" (in German), *Ann. der Phys.*, 28 (March 1909), 665-736.
13. Kirby, R. S., J. C. Harman, F. M. Capps, and R. N. Jones. *Effective Radio Ground-Conductivity Measurements in the United States*, NBS Circular 546. Dept. of Commerce, February 26, 1954. (Out of Print)
14. Fine, H. "An Effective Ground Conductivity Map for Continental United States," *Proc. I. R. E.*, 42 (1954), 1405-1408.
15. Vice, R. W. "A Survey of Ground Wave Propagation Conditions in South Africa," *IEE Transactions of South Africa*, 45 (April 1954), 139-150.
16. Ireland, G. C. "A Provisional Ground Conductivity Map for Canada," *Proc. I. R. E.*, 49 (1961), 1674-1678.
17. *Some Measured Ground Conductivities in the British Isles and Their Geological Correlation*, Research Report K062, British Broadcasting Corp., 1944/10.
18. Eliassen, K. A. "A Survey of Ground Conductivity and Dielectric Constant in Norway Within the Frequency Range 0.2 - 10 Mc/s," *Geofys. Publikasjoner*, XIX (1959), 5-30.
19. *Report by the Preparatory Meeting of Experts, African LF/MF Broadcasting Conference*. Geneva: CCIR, February 1964.
20. Smith-Rose, R. L. "Electrical Measurements on Soil with Alternating Currents," IEE (British), 75 (1934), 221-237.
21. Card, R. H. "Earth Resistivity and Geological Structure," *Trans. AIME*, 138 (1940), 380-398.
22. Herbstreit, J.W. and W. Q. Crichlow. "Measurements of the Attenuation of Radio Signals by Jungles," *Radio Sci. J. Res. NBS*, 68D, No. 8 (1964), 903-960.
23. Wait, J. R. and L. C. Walters. "Curves for Ground Wave Propagation over Mixed Land and Sea Paths," *IEEE Trans. on Antennas and Propagation*, AP-11 (January 1963), 38-45.
24. Eckersley, P. P. "The Calculation of the Service Area of Broadcast Stations," *Proc. IRE*, 18 (July 1930), 1160-1194.
25. Millington, G. "Ground Wave Propagation over an Inhomogeneous Smooth Earth," *Jour. IEE* (London), Pt. III, 96 (January 1949), 53-64.
26. Kirke, H. L. "Calculation of Ground-Wave Field Strength over a Composite Land and Sea Path," *Proc. I. R. E.*, 37 (May 1949), 489-496.
27. Davies, K. *Ionospheric Radio Propagation*, National Bureau of Standards Monograph 80, Department of Commerce. (For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402—Price $2.75)
28. Barghausen, A. F. "Medium Frequency Sky Wave Propagation in Middle and Low Latitudes," *IEEE Trans. on Broadcasting*, BC-12 (June 1966), 1-14.
29. *World Distribution and Characteristics of Atmospheric Radio Noise*, CCIR Report 322. Geneva: ITU, II, (1963).
30. *Performance Specifications for Low-Cost Sound Broadcasting Receivers*, CCIR Recommendation 415, Geneva: ITU, V, (1963).
31. IEEE Standards Coordinating Committee 14 (Quantities and Units). "IEEE Recommended Practice for Units in Published Scientific and Technical Work," *IEEE Spectrum*, 3 (March 1966), 169-173.



Shure's remarkable new SM50 omnidirectional cynamic microphone is SELF-WINDSCREENED! It is strikingly immune to wind noises and explosive breath sounds—making it ideal as a dependable "workhorse" microphone for remote interviews, news, sports pick-ups and a variety of field and studio applications. The five-element built-in windscreen makes it virtually pop-proof in close talking situations. And unlike other "built-in" windscreens, this one is "unitized" and self-contained with no bits or pieces to re-assemble after cleaning. In fact, you can actually rinse dirt, saliva, lipstick and other screen-clogging foreign matter out of the windscreen assembly under running water as often as needed—or replace the "unitized" assembly if necessary in a matter of seconds.

Additionally, the SM50 is the cleanest sounding professional microphone at anywhere near its price class. It delivers highly intelligible, natural and pleasing speech and vocal music that is especially full-bodied and rich in the critical mid-range.

It is extremely rugged and will require little or no down time as the years go by. Too, when comparing it to other moderately priced omnidirectionals, it is lighter in weight, supremely well-balanced for "handability," has a detachable cable, and a rubber mounted cartridge for minimizing handling noises. The SM50 is worthy of your most serious consideration.

For additional information, write directly to Mr. Robert Carr, Manager of Professional Products Division, Shure Brothers, Inc., 222 Hartrey Avenue, Evanston, Illinois.

SHURE SM50

OMNIDIRECTIONAL DYNAMIC MICROPHONE

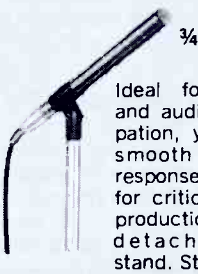
SHURE PROFESSIONAL MICROPHONES . . . FOR BETTER AUDIO

MODEL SM56
CARDIOID
DYNAMIC

Extremely versatile in studio, control room, and remote use. Also widely acclaimed for rhythm recording. Bright, clean sound. Exceptionally uniform cardioid pattern gives optimum control of environment.

MODEL SM33
UNIDIRECTIONAL
RIBBON

Warm, smooth sound for studio, control room, and scoring stage. Super-cardioid directional pattern. Compact, yet rugged.



MODEL SM76
¾" OMIDIRECTIONAL
DYNAMIC

Ideal for interviews and audience participation, yet unusually smooth wide range response (40-20 KC) for critical music reproduction. Instantly detachable from stand. Steel case with Cannon connector.

MODEL SM50
OMNIDIRECTIONAL
DYNAMIC

Self-windscreened and pop-free for news, sports, remotes, and interviews. Also ideal for many studio and control room applications. Comfortably balanced for hand or stand use. Natural response.

Circle Item 14 on Tech Data Card

Engineers' Exchange

(Continued from page 6)

because of the possibility of human error, the idea was rejected in favor of a unit designed to achieve automatic switching. This approach was possible because burst and other color information are transmitted at the color-subcarrier frequency of 3.58 MHz. Consequently, the unit could be designed to trigger on a substantial voltage at that frequency.

In order to effect more positive operation, not only is the RF section tuned sharply to 3.58 MHz, but a series crystal filter arrangement is included in the input to further sharpen the response at that frequency. The power supply is built in, and the unit may be coupled into the video circuitry coming in from network or any other circuit, either bridging or terminating at 75 ohms with a resistor across the input.

Potentiometer R3 adjusts the input to the grid of the relay-amplifier section of V3, and potentiometer R7 adjusts the bias to the cathode of the same tube section. Either control could be eliminated, if desired, by experimenting with appropriate fixed resistances for substitution. However, to make the unit as flexible as possible in every way, both were included in the original version. The unit will trigger on composite signals of from as low as one-quarter volt to as high as desired because these levels can be adjusted.

The cost of all components was less than $40. The unit can also be used to turn on a warning light, sound a buzzer, or key any other device when a color burst comes on.

—*John B. Broughton*

Parts List

C1—0.01 mfd, 600 V
C2—0.01 mfd, 600 V
C3 0.01 mfd, 600V
C4—0.05 mfd, 600 V
C5—0.01 mfd, 600 V
C6—20/20 mfd, 250 V electrolytic
C7—50 mfd, 50 V electrolytic
C8—50 mfd, 50 V electrolytic
C9—0.1 mfd, 600 V

R1, R2—4700 ohm, 1 watt
R3—500K pot, 2 watt; Clarostat 47-500k-S, 155-93
R4—10 ohm, 1 watt
R5—670 ohm, 2 watt
R6—100 ohm, 1 watt
R7—500-ohm pot, 2 watt; Clarostat 53C1-500-S, 325-195
D1, D2—1N1084 silicon-diode rectifier

T1, T2, T3—Band-pass transformer, 3.58 MHz, RCA 112869
T4—125 V, 50 ma, 6.3 V, 2 amp, Thordarson 26R38
T5—12.6 V filament transformer, Triad F-44X

K1—DPDT Plug-in relay, 5 ma, 10K, Potter & Brumfield Type KCP-11, 217
J1—Jack SO-239
F1—2-amp slow-blow fuse
S1—SPST line switch
TB1—6-terminal strip
X1—3.58-MHz crystal
Chassis—Aluminum 13" × 4¼" × 2⅝"

The world's most powerful FM stations use JAMPRO antennas!

CKVL-FM MONTREAL

604 Kilowatts of ERP is radiated through this Jampro 16 Bay dual polarized FM antenna. The CKVL-FM pole, located high above the Bank of Commerce building, enjoys a dominant place in the Montreal skyline.

KQUE-FM HOUSTON

The highest powered FM antenna in the United States is a Jampro dual polarized model J16B/16V. Each of sixteen bays produces 280 kw for a total ERP of 560 Kilowatts!

Why Jampro? More power per dollar!

JAMPRO

Write for Jampro's new brochure on circular polarized FM antennas.

ANTENNA COMPANY
6939 POWER INN ROAD SACRAMENTO, CALIFORNIA

Circle Item 15 on Tech Data Card

A SYSTEM FOR SEPARATE REPEATER ORIGINATION

by W. H. Lindenbach*

Cartridge tape supplies separate commercials to individual markets of a two-station "network."

When Radio Southern Manitoba established a repeater station 40 miles northwest of the main studio location at Altona, Manitoba, an almost entirely new audience was gained. CFAM (1290 kHz), the original station, covers an approximately circular area around Altona, and CHSM (1250 kHz) covers Winnipeg and an area to the east. The patterns of the two stations are shown in Fig. 1.

Products and services of general interest can be advertised on both stations, but many businesses are concerned only with their local area. For these concerns, a system was developed by RSM whereby different spots for each area are run at the same time. This permits a more attractive rate structure for the smaller, local advertiser, and the commercial potential for the system is considerably improved. Further, each of the two stations can acquire an individual image.

* Radio stations CFAM and CHSM, Altona and Steinbach, Manitoba.

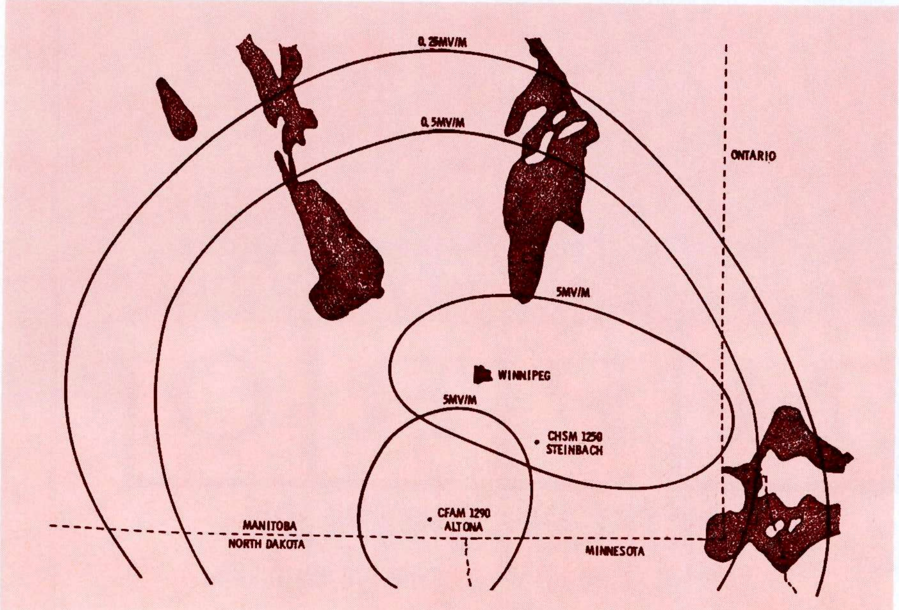


Fig. 1. Map shows coverage of primary station CFAM and repeater station CHSM.

System Concept

Commercial spots for the system originate in four cartridge-tape playback units. Each unit can be used individually for conventional playback through the console as shown in Fig. 2A. The console output, during combined-mode programming, is supplied to both transmitters via a wire line to CFAM and a microwave studio-transmitter link (STL) to CHSM.

In the split mode, the console is out of the circuit (as shown in Fig. 2B). The cartridge playbacks are connected directly to the wire lines and the STL. When the switch is up, Cartridge 2 supplies CFAM, and Cartridge 1 supplies CHSM. With the switch down, Cartridge 4 supplies CFAM and Cartridge 3 supplies CHSM.

This arrangement increases versatility by making it possible to pair a spot with any other of identical length. Also, with two pairs of playbacks, "split" spots may be run "back-to-back", i.e., one after the other, as is often necessary when a split spot pair is run next to a split ID.

Circuitry

The complete system includes audio units and circuitry for control and signal routing.

Audio Section

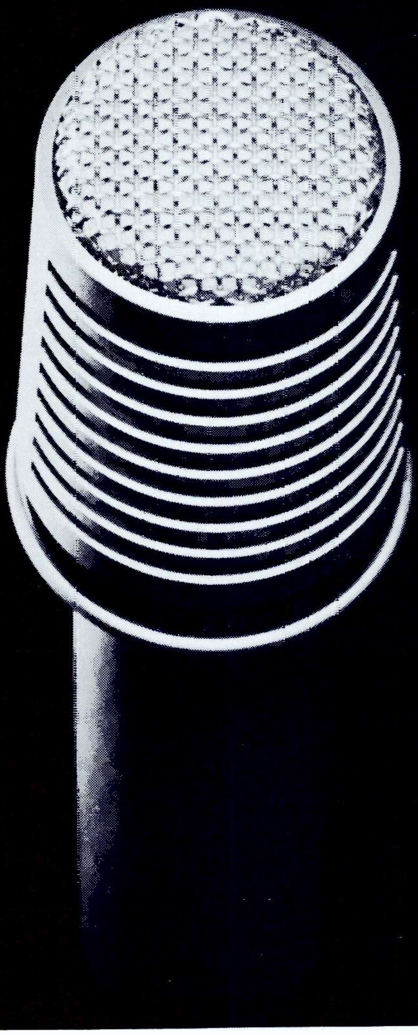
The audio circuit, shown in Fig. 3, includes the four cartridge-tape playback units, the console, a level-control amplifier, an AGC amplifier with low-level input, (−42 VU), six mode-switching relays designated K01 through K06, and a connection to the control-room program-monitor system. Terminals and patch jacks are omitted in Fig. 3 for clarity, and the relays are shown in the released condition which results in the combined mode. When all relays are operated, the split mode results. K02 is a latching relay which is pulsed to select cartridge units 1 and 2 as Pair I, or units 3 and 4 as Pair II.

Common Mode. The cartridge-unit outputs are supplied to two console inputs through K01 and an arrangement of attenuators. These attenuators combine two cartridge-unit outputs into one console input. The parallel-connected 15-dB pads are matched to the console by 10-dB, 300/600-ohm taper pads.

The console high-level output is supplied to the center position of S23, through K05 to the level-control amplifier; the amplifier output goes to the CHSM program terminal and on to the STL and CHSM transmitter. The level-control amplifier output also goes to K04, to a 600/600-ohm line transformer, and to the CFAM program terminal. The

The NEW two-way microphone system

Might look like other microphones... but it's totally different!



You're looking at a revolutionary concept in cardioid microphone design — actually two microphones in one. It is a microphone system with two independent capsules. Like a high-quality two-way speaker system, one capsule responds to low and the other to high frequencies with a built-in crossover network at 500 cycles.

Go ahead . . . pick up the new AKG D-200E two-way microphone and try it! Then ask your most severe critic to listen.

Look for this symbol! It signifies this exclusive concept — a product of AKG research.

AKG

MICROPHONES • HEADPHONES

DISTRIBUTED BY
NORTH AMERICAN PHILIPS COMPANY, INC.
100 EAST 42nd STREET, NEW YORK, NEW YORK 10017

5-67

Circle Item 16 on Tech Data Card

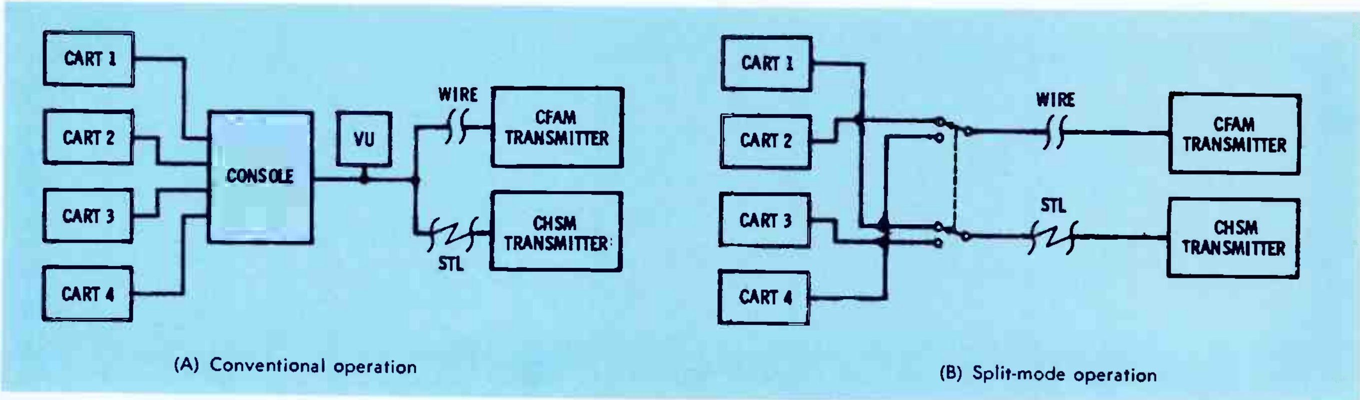


Fig. 2. Commercial spots for the system originate in four cartridge units and can be delivered to either operation.

8-dB taper pad at the amplifier output matches the two paralleled 600-ohm loads.

The console low-level output (program bus) is supplied to the AGC amplifier input via K03. The high-level AGC output is applied to the lower position of S23, called the "emergency program source" switch, since it can select the output of the AGC amplifier or the recording control room in case of failure of the console amplifier.

The monitor signal originates in a conventional CFAM off-air pickup, which is supplied to the monitor boost amplifier via S24, the monitor selector switch, and to the monitor power amplifier.

Split Mode. Operation in the split mode will be considered with program originating in Pair I: Cartridge Unit 1 supplying CHSM and Unit 2 supplying CFAM. Relays K01, K03, K04, K05, and K06 are operated, and K02 is latched in the Pair I position.

The output from Cartridge Unit 2 (at +8 VU) is supplied to the operated contacts of K01, to the Pair I contact of K02, and then to the CFAM VU meter. Then it is balanced by a 600/600-ohm transformer, dropped in level 50 dB, applied to K03, and to the AGC-amplifier input at the correct level. (−42VU). Relay K03 also terminates the console program-bus output in 600 ohms, since the bus is now disconnected from the AGC-amplifier input. The AGC-amplifier output is applied to the CFAM program terminal through K04 and the line transformer. Contacts on K04 also replace the CFAM line-transformer load on the level-control-amplifier output with 600 ohms.

Output from Cartridge Unit 1 (also at +8 VU) is supplied to the CHSM VU meter through K01 and the Pair I contacts of K02, then to K05 and the level control-amplifier input. Relay K05 also terminates the console high-level output in 600 ohms through S23. The level-control-amplifier output is applied to the CHSM program terminal.

At the CHSM VU meter, output from Cartridge Unit 1 is also supplied to a bridging transformer through K06. The signal is attenuated 40 dB and applied to the combining pad, (which is simply two pads with outputs in parallel) and combined with the off-air CFAM signal, which is at a level 10-dB higher than the CHSM signal. The operator can distinguish one from the other by adjusting the monitor volume control in the monitor boost amplifier. When the volume is turned down, he hears the CHSM spot only; when the volume is high, he hears the CFAM spot predominantly.

All equipment necessary to system is contained in console-mounted cabinet.

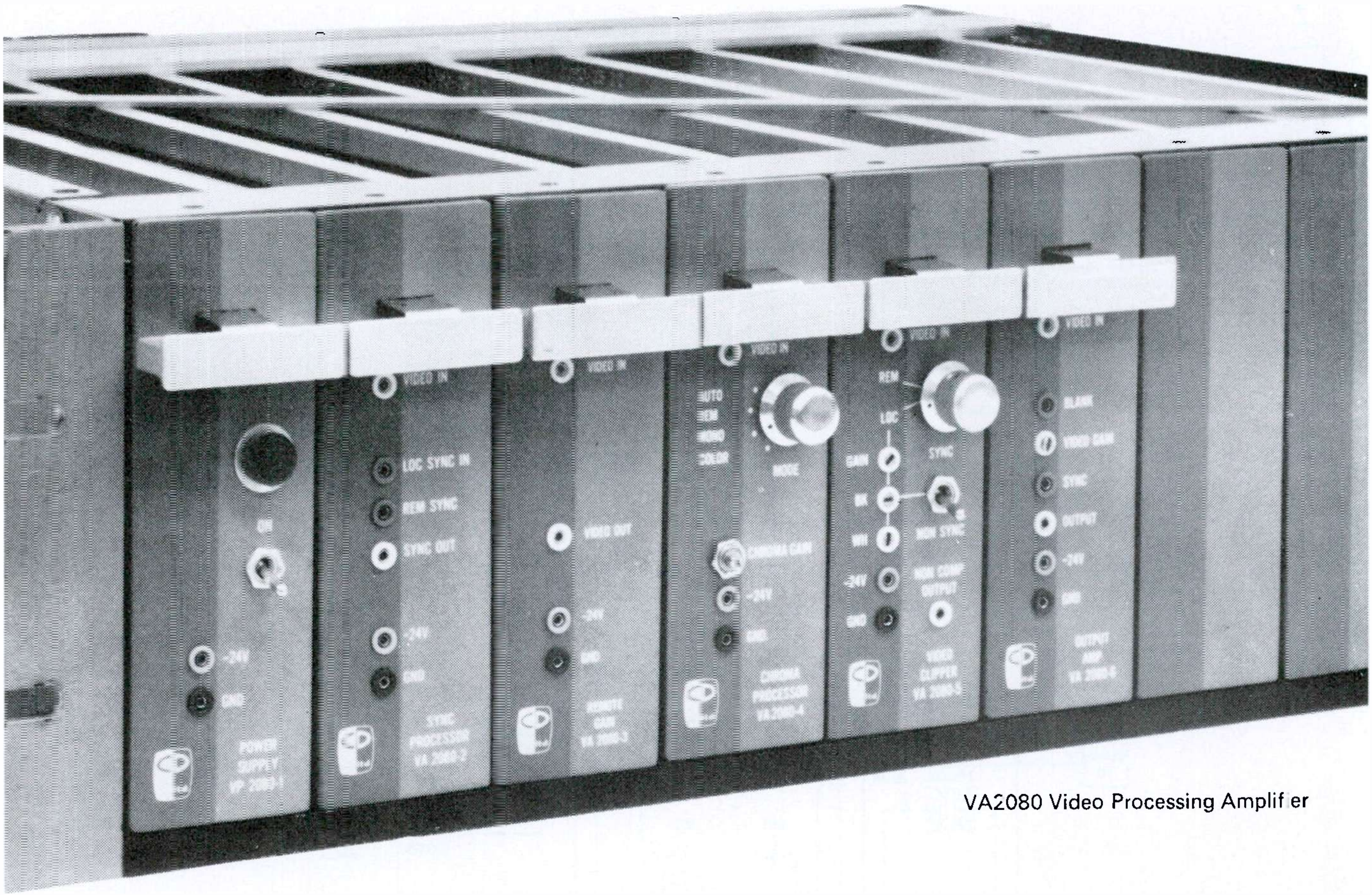
Control Section

There are two identical control units—one for each pair of cartridge units. When the operator presses the START push button, the control unit operates all the audio relays and starts the cartridge units. Two conditions are imposed on the start function: (a) both cartridge units of the pair about to start must be loaded with cartridges, and (b) the other pair must not be running. If these two conditions are not met, the control unit does not respond to the START button, thus providing protection against operator error.

The end of the split-mode period is signaled by "end-of-message" secondary cue tones recorded on the cartridge tapes. The control unit senses these cues, and when two have been received, indicating both messages are finished, it releases the audio relays, returning the system to the combined mode and permitting the other pair to start if and when desired.

If the end-of-message cue fails, or if it is necessary to return to the combined mode immediately, a REVERT push button is pressed. It simulates the reception of two end-of-message cues.

Pilot lights provide conditionary supervision to indicate the operating mode of the system. A green light indicates the combined mode, and a red one is illuminated for the split mode. One set of these lights indicates if either of the control-unit cartridge-unit pairs is in the split mode. Two amber READY lights, one for each control unit, operate when two cartridges are inserted. When a cartridge pair is started in the split mode, the corresponding



VA2080 Video Processing Amplifier

Set it-
Forget it!

Once the operator has set the VA2080 Video Processing Amplifier, no adjustment is necessary to maintain stability and crisp picture transmission. Performance of the clipping circuits is unexcelled—maintaining 0.2% linearity to within two IRE units of clipping level. Expandable from monochrome to colour, or from studio to transmitter applications by the addition of modules. Back porch clamping is used on all models—exclusive in this price class.
The initial cost of the VA2080 series is much lower than you might expect—lower than any other proc amp in its class. As to proof of performance, more than 300 VA2080 installations are now in use! Find out more about the dependable, trouble-free VA2080. Write, wire or telephone Central Dynamics for a convincing demonstration.

CENTRAL DYNAMICS CORPORATION

HEAD OFFICE: 903 Main St., Cambridge, Mass. 02139

Circle Item 17 on Tech Data Card

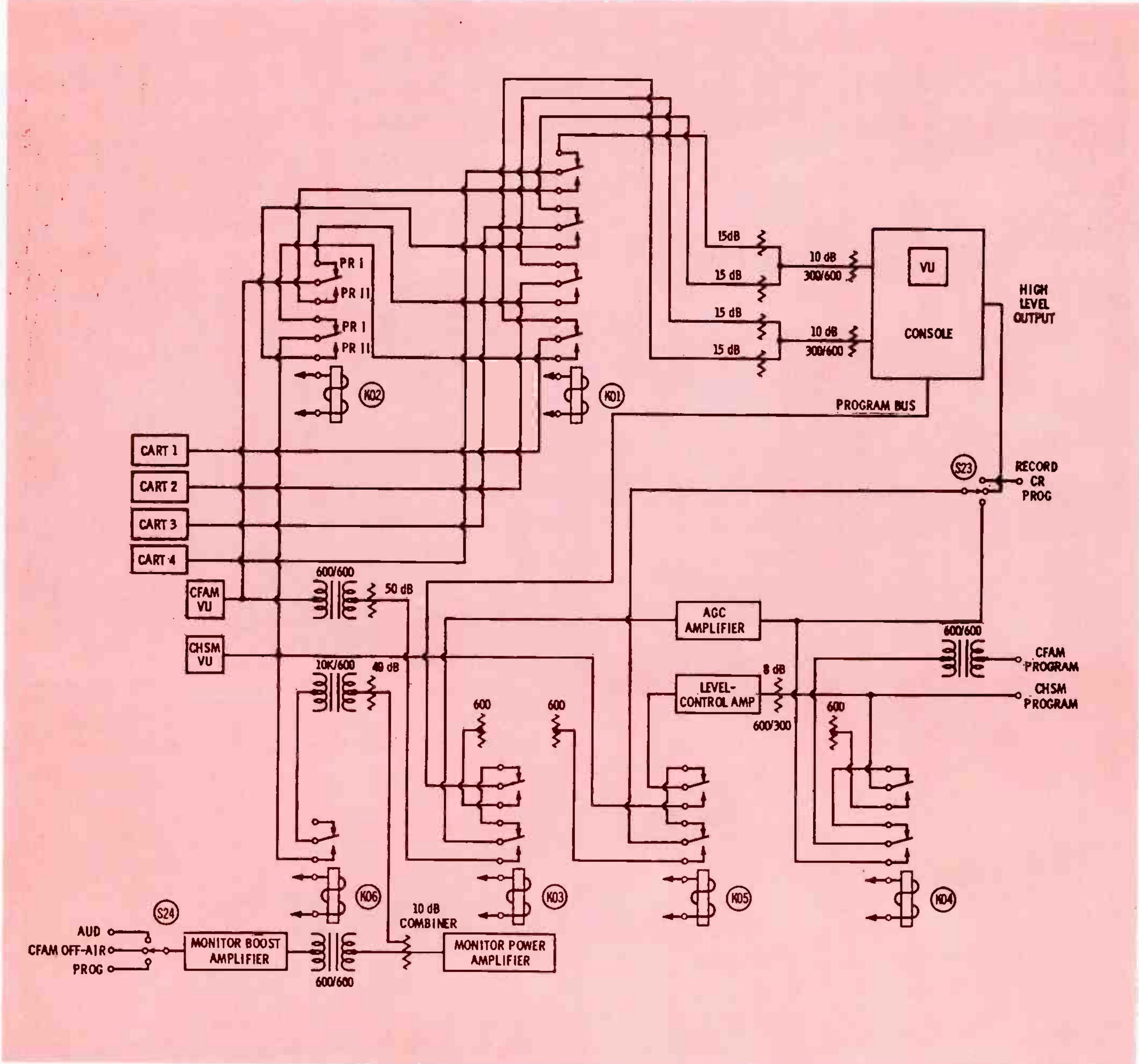


Fig. 3. Audio circuit includes cartridge units, console, level-control amplifier, AGC amplifier, relays, and connections.

READY light goes off and does not go on again until the pair has returned to the combined mode and at least one cartridge has been removed and replaced. Thus, the READY light answers the operator's question, "Has this pair of spots gone on the air yet?" The answer is not always obvious; during a busy period it is hard to remember which pair should be started next and which should be reloaded.

Operation

The complete circuit of one control unit is shown in Fig. 4. Relay numbering indicates location, e.g., K12 indicates the second relay in the Pair I control unit.

Start Relay K11 Operation. Relay K11 starts the Pair I cartridge units, locks run relay K12 into the operated condition, pulses the Pair I coil of audio relay K02, and provides status indication to the READY-light supervisory circuit.

A study of the K11 coil-control circuit shows that the coil will not be energized unless the following occur together: (a) the START push button is pressed, (b) K22, the Pair II run relay, is released, insuring that Pair II is not in the split mode, and (c) K13 and K14 are operated. The coils of the latter two relays are connected so that they operate when cartridges are inserted in Cartridge Units 1 and 2. Relay K11 operates momentarily.

Run Relay K12 Operation. Relay K12 is in a self-locking circuit which operates all audio relays except latching relay K02. It prevents Pair II from starting when Pair I is in the split mode, and it supplies voltage to two end-of-message sense relays preparatory to sensing these cues. When K12 is operated, Pair I is in the split mode.

If K15 or K16 and K19 are released and K11, the start relay, operates momentarily, K12 will operate, and because one of its own contact sets is in parallel with the start relay contacts, it will lock. K12 will release if both K15 and K16 operate together, or if K19 operates. When K12 releases, Pair I returns to the combined mode.

End-of-Message Cue-Sense Re-

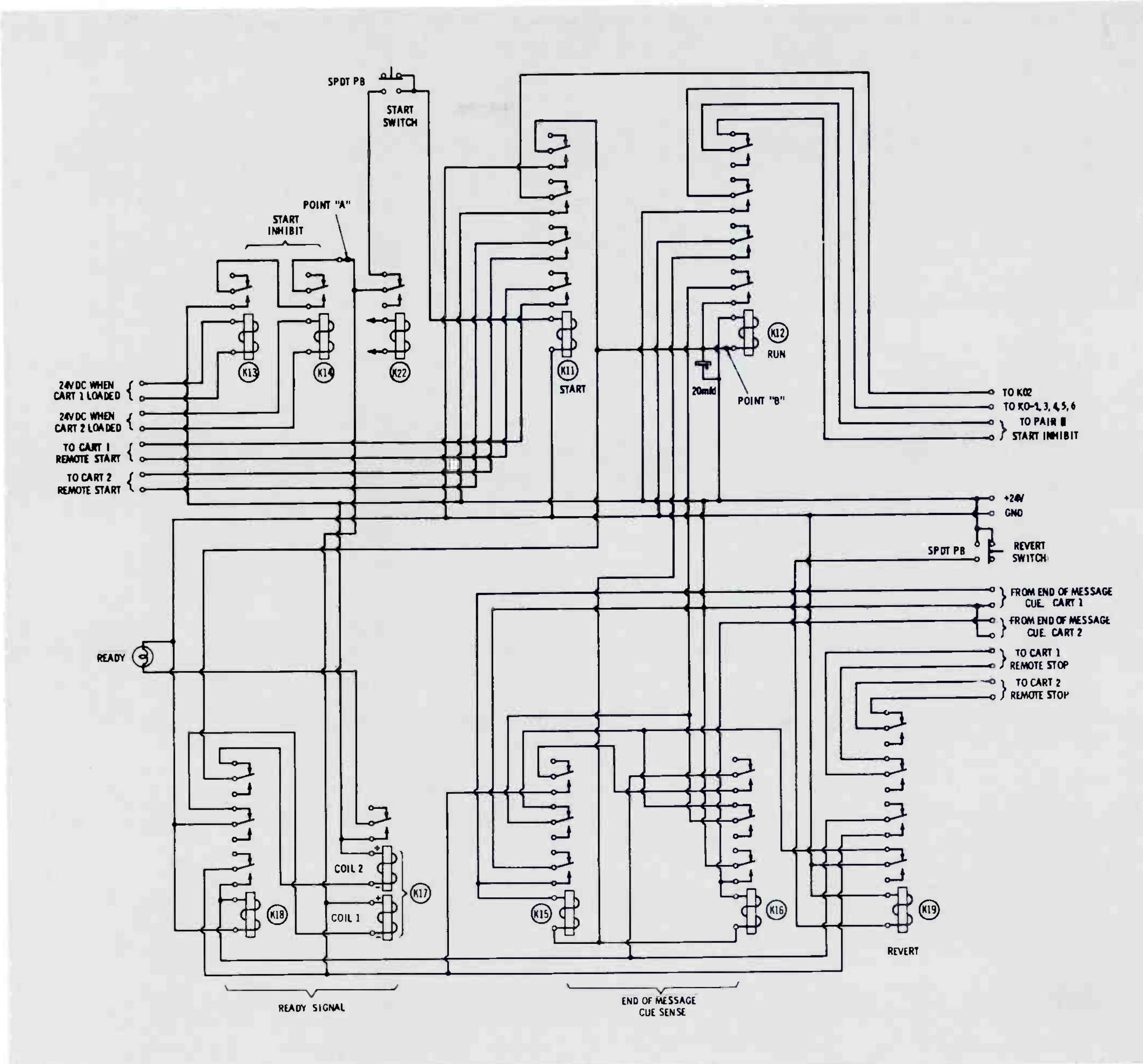


Fig. 4. Diagram of one control unit shows sequence of relays which control operation of two tape-cartridge sources.

lays K15, K16 Operation. These relays are in a self-locking circuit and sense end-of-message cues from Cartridge Units 1 and 2 in order to release K12 when two cues are received.

If run relay K12 is operated (Pair I in split mode) and an end-of-message cue is received from Cartridge Unit 2, K16 will lock. As described under operation of run relay K12, if both K15 and K16 operate, K12 releases, and if K12 releases, K15 and K16 release immediately thereafter.

Ready Light Control Relays K17 and K18 Operation. These relays provide a supervisory indication by means of the READY light. Only when cartridges have been loaded into the Cartridge Units 1 and 2, and prior to playing in the split mode, is the READY light on.

Relay 17 has two coils, to which voltage is applied with opposite polarity; if voltage is applied to Coil 1 or 2, K17 operates, but if voltage is applied to both coils the relay does not operate.

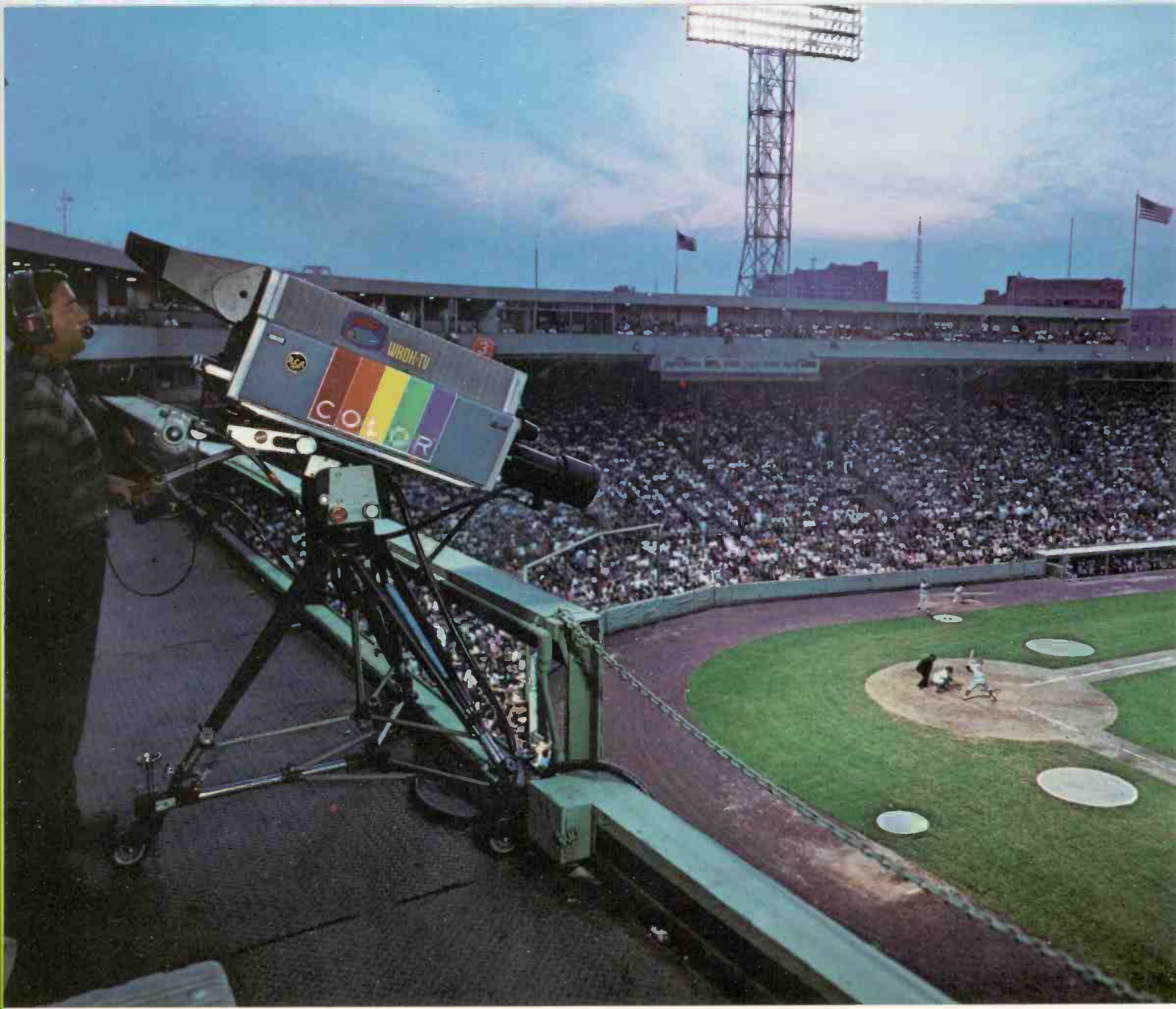
When Cartridge Units 1 and 2 are loaded, +24 volts DC appears at point "A" (Fig. 4), as described under "Start Relay K11 Operation." Coil 1 of K17 is energized through the normally closed contacts of K18, and K17 operates, turning the READY light on.

When run relay K12 is operated (Pair I in split mode) the coil (point "B") is grounded as described under "Run Relay K12 Operation." Coil 2 of K17 is energized through the normally closed contacts of K18; the field of Coil 1 is canceled, and K17 releases, turning the READY light off.

When cartridges are inserted in Cartridge Units 1 and 2, +24 volts DC appears at point "A," but K18 can operate only if K15 and K16 operate together (two end-of-message cues received), or if K19, the revert relay, operates. When K18 operates, it is locked by a pair of its own contacts.

Relay K18 operates at the end of the split-mode period; it opens both coil circuits of K17. Initially, K17 was released because both coils were energized with opposite

Day or night...WHDH-TV gets great pictures with "big tube" color cameras



WHDH-TV, Boston, is using four TK-43 "big tube" color cameras to put an extra wallop in baseball telecasting. Whether during the day — under ideal conditions — or at night when light levels range from 40 to 120 ft. candles, their color pictures have consistent sharpness and brilliance.

Let's hear how Phil Baldwin, Vice-President, Engineering, WHDH, sizes it up in his own words. "I've never seen sharper pictures than we get with our RCA cameras. This even goes for our center field camera at night, which picks up all the color and detail of the spectators sitting in the stands behind home plate. You simply can't get sharper pictures."

So pleased are the people at WHDH with their RCA color cameras that they also have two TK-42's in the studio and two more TK-43's in a mobile unit now being built — making a total of eight "big tube" cameras. Ten years of all-color telecasting back up everything WHDH is doing today. Their experience with color proves that where the picture counts — RCA's got it — with the "big tube" TK-42's and TK-43's.

If you are interested in the very finest color pictures under a variety of everyday conditions, get the facts on RCA's "big tube" color cameras. Call your RCA Broadcast Representative. Or write RCA Broadcast and Television Equipment, Building 15-5, Camden, N. J. 08102.

THE MOST TRUSTED NAME IN ELECTRONICS

Form 3J5182-A Trademark(s)® Registered Marca(s) Registrada(s) Printed in U.S.A.

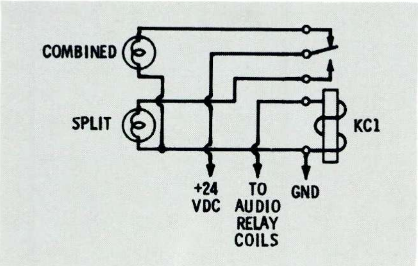


Fig. 5. Relay controls lamps to show mode in which stations are operating.

polarity; now it remains released because both coil circuits are open, and the READY light stays off. Relay K18 remains locked until + 24 volts DC is removed from point "A" by removal of at least one cartridge from Cartridge Units 1 and 2, and release of K13 or K14. Relay K17 remains released because, although both coil circuits can now be completed through contacts on K18, +24 volts DC has been removed from point "A" by the release of K13 or K14, and ground has been removed from point "B" when, at the end of the split mode, K12 was released. Now the cycle can begin again, with the insertion of two cartridges resulting in the presence of +24 volts DC at point "A" and the operation of K17, which turns on the READY light.

Revert Relay K19 Operation. If the end-of-message cues are not received at the end of the split-mode period, they may be simulated by pressing the REVERT push button, which operates K19. Two sets of contacts on this relay are connected to the remote stop terminals of Cartridge Units 1 and 2. Other contacts operate K18 to keep the READY light off, and release run relay K12 to return the system to the combined mode.

Complete Cycle Description. When cartridges are inserted in Cartridge Units 1 and 2, K13 and K14 operate. +24 volts DC is applied to K17 Coil 1, and it operates to turn on the READY light. If Pair II is not in the split mode, K22 will be released, and the coil circuit of start relay K11 can be completed by pressing the START push button. Relay K11 operates momentarily to pulse audio relay K02 into the Pair I position, start Cartridge Units 1 and 2, and operate run relay K12.

When K12 operates, it locks, energizes K17 coil 2 (with polarity opposite to that of coil 1) causing K17 to release and turn the READY light off, grounds the coils of K15 and K16 (end-of-message cue sense relays) readying them for operation, operates all audio relays except K02, and opens the start relay coil circuit in Pair II. Pair I is now in the split mode, and Cartridge Units 1 and 2 supply audio to the two transmitters.

When Cartridge Unit 1 detects an end-of-message cue, K15 operates and locks; when Cartridge Unit 2 detects a cue, K16 operates and locks. The opposite sequence is possible, but when both are operated, run relay K12 is released, the Pair II start-relay coil circuit closes, the audio relays are released, K15 and K16 are released, and Coil 2 of K17 is denergized. But, while K15 and K16 were operated, K18 operated and locked, and both coil circuits of K17 opened to keep the READY light off. The 20-mfd capacitor across the coil of K12 is necessary to slow down the interaction between K15, K16, and K12, so that K18 has time to operate and lock.

Pair I is now out of the split mode, and Cartridge Units 1 and 2 recue their cartridges to the beginning of the next spot. When one cartridge is removed, K18 releases and the cycle is complete.

Mode Supervisory Signaling. Fig. 5 shows KC1, the contacts of which operate the mode-supervisory lights. The KC1 coil is connected across the audio relay coils so that it operates when the system (Pair I or II) is in the split mode, turning off the COMBINED light and turning on the SPLIT light.

Using the System

Initially some difficulty was experienced with dust in the audio relay contacts. All contacts operate under dry switching conditions and are therefore very sensitive to contamination. Replacement of the open latching relay with an enclosed unit, and periodic cleaning of the contacts of the other audio relays, prevented further problems.

To minimize switching transients, K01, K03, K04, and K05 are make-before-break relays.

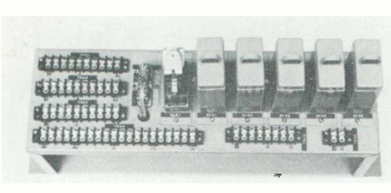
Access to all circuits via patch jacks proved useful during troubleshooting. By nature, opportunity to observe difficulties is short, and means for simulating operation is necessary if programming interruptions are to be avoided.

Considerable difficulty was encountered with instability in the end-of-message cue detector circuitry in the cartridge units. The circuit is temperature-sensitive; all electrolytic capacitors had to be replaced because of changed values.

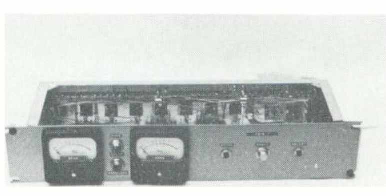
It was expected before split operation was begun that our greatest difficulty would be the proper timing of the cartridges that were to run in pairs so that they would finish together. However, the announcers found no difficulty in "reading to the clock" and maintaining plus or minus one-second conformity in a 60-second spot. Two categories are used together: 30 seconds and 60 seconds.

To reduce chances of error during a busy period, a color coding system was developed for cartridges and cartridge machines.

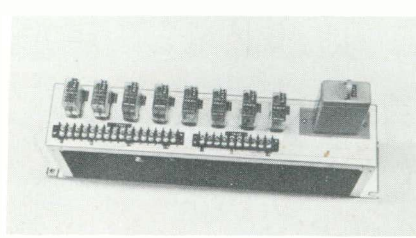
The cost of parts for the control units, power supply, audio relays, and mountings was under $400. ▲



Audio-relay chassis contains relays and connections to audio circuitry.

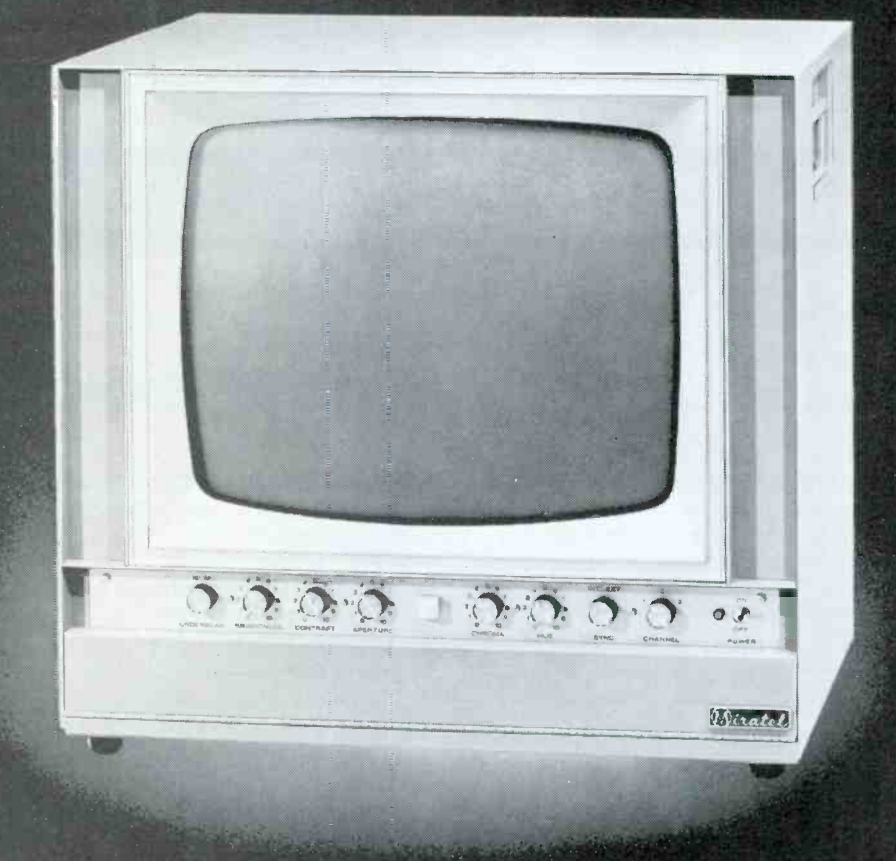


Pair I control unit has VU meters for observation of outputs to stations.



Circuit for Pair II control unit is identical to that of the Pair I unit.

BBRC/Miratel *Brings You...*



The Phantom – This is probably the newest and least-known broadcast television color monitor available to the industry today. It's reliable. It has exceptional color fidelity. It's priced from $775 to $1275. And it's available off the shelf right now. We think it's the answer to your color monitor needs. You probably would, too. If you knew more about it. A look at our color monitor data sheet, followed by an evaluation of the MC19 in your operation, will settle that matter.

Ball MIRATEL

MIRATEL DIVISION • BALL BROTHERS RESEARCH CORPORATION • 3600 RICHARDSON STREET • NEW BRIGHTON • ST. PAUL, MINNESOTA 55112

Circle Item 18 on Tech Data Card

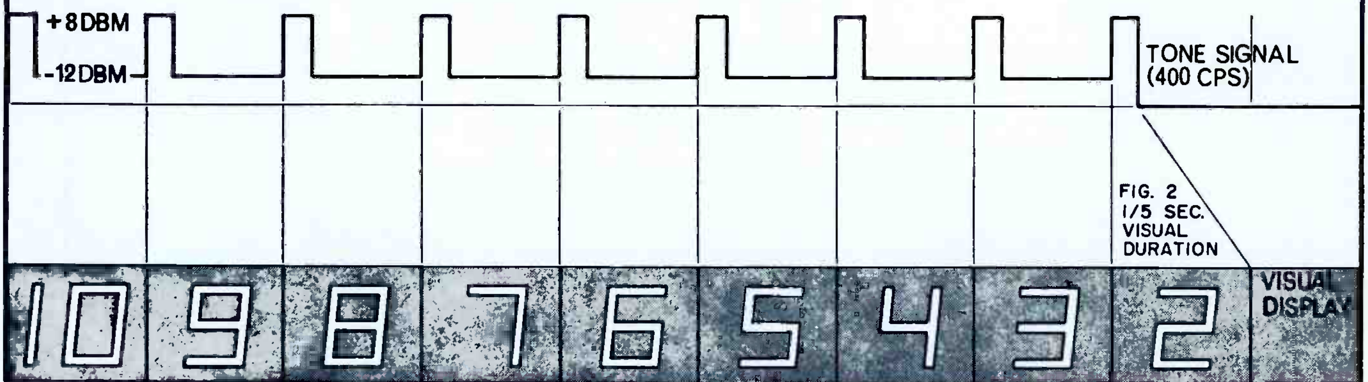
VIDEO-AUDIO CUEING SIGNALS

($1,145.00 CAN.—$1,199.00 U.S., F.O.B. Buffalo)

DQ-1 RHL ELECTRONIC DIGITAL GENERATOR

Model DQ-1, now being used by broadcast centres in Canada and the U.S. is the answer to Video-Audio Cueing Signals. It provides a signal similar to the Academy Leader used in the film industry.

Both the video and audio information are supplied superimposed on the program channels with Fail-Safe protection.



The video cueing signal—electronically generated numerals, from 10 to 2, occur at 1 second intervals. The audio signal consists of a 400-cycle tone at +8 dBm of 1/5 second duration, coincident with the numeral changes. (CSA and SMPTE Standards). Completely self contained in 1.75" x 19" of rack space, the DQ-1 requires only the loop thru program video, eliminating the need for additional cameras and equipment to insert the cueing signals. With the DQ leader, quick accurate video tape cueing can be accomplished for playback.

Years of technical experience in television broadcasting stand back of the many new advances developed by Richmond Hill Laboratories. Designed, engineered and manufactured in Canada, and used by broadcasters on all six continents, the wide range of RHL solid state equipment includes: Studio Switching Equipment • Synchronizing Pulse Gen • Video Test Signal Gen • Special Effects Gen • Colour Bar Gen • Video DA • Pulse DA • Clamping Amplifiers • Digital Cue Gen • Digit Gen • Clock System Driver • Routing Switching Equipment (Audio/Video)

All RHL products carry a 5-year warranty, backed by skilled craftsmanship, quality components and rigid control . . . important factors in building a fine record of service to the television broadcast industry.

FOR COMPLETE DETAILS AND SPECIFICATIONS WRITE

rhl

RICHMOND HILL LABORATORIES LIMITED

1610 MIDLAND AVENUE, SCARBOROUGH, ONTARIO, CANADA

PHONE (416) 757-3631/cable RICHILL/TELEX RHL TOR 02 29803

Circle Item 19 on Tech Data Card

October 1967

We interrupt this magazine to bring you...

Late Bulletin from Washington

by Howard T. Head

Review of Communications Policy Under Way

President Johnson, in a special message to Congress, has called for a comprehensive review of the country's national telecommunications policies. A special task force of high officials has been set up to report to the President within 12 months.

The emphasis in the President's message is on the expansion of world-wide communications through the use of space satellites. The message points out the need for a choice between general-purpose satellites, to serve all communications needs, and special-purpose satellites, such as those proposed for domestic television relaying by the American Broadcasting Company, the Ford Foundation, and others (November 1965 Bulletin).

Although the emphasis in the message is on space communications, the task force has also been directed to review the usage of the entire spectrum as a whole. This review, together with the continuing rapid expansion of CATV and the growing land-mobile demands on the spectrum, is certain to have a significant impact on television broadcasting of the future.

New Painting and Lighting Requirements

The Commission has amended Part 17 of its Rules governing the painting and lighting of towers so as to bring these requirements into conformity with similar FAA regulations governing nonradio structures. The principal changes involve towers of 1500 feet above ground or higher. One little-noticed change, however, would exempt many structures under 200 feet in height from any painting and lighting requirements. No existing painting and lighting may be abandoned, however, without prior FCC approval.

Existing towers not conforming with the new requirements must be brought into compliance with them no later than September 5, 1970.

Relaxation of Transmitter-Visibility Rules Sought

The National Association of Broadcasters (NAB) is preparing to file a petition requesting a relaxation of the Rule which requires that transmitters not operated by remote control be visible from the operator's position. Many stations, particularly those employing combined studios and transmitters, have found compliance with this Rule quite difficult, and have resorted to a variety of mirrors, holes-in-walls, and even closed-circuit television cameras to provide the required visibility. The new NAB proposal would require only that the transmitting equipment and the operator be on the same premises.

Installations not now meeting the visibility requirement must, in order to comply fully with the Rules, be operated by remote control. This is a particularly burdensome requirement in the case of AM stations employing directional antennas; these stations must submit a skeleton proof of performance in support of a remote-control application, and repeat the proof of performance annually.

Many Stations Request Presunrise Authorization

The Commission is being deluged with requests for Presunrise Service Authority (PSA) under the provisions of new Rules (August 1967 Bulletin). AM stations may request PSA's which permit presunrise operation as early as 6:00 a.m. with a power up to 500 watts, employing the station's daytime facilities. The use of auxiliary transmitters, which are not required to meet performance standards, is permitted when operation is undertaken under a PSA. Fulltime stations may also take advantage of the new Rules, and a surprising number are doing so -- the advantage being that nondirectional operation requires neither a first-class operator on duty nor a daily antenna inspection at the transmitter.

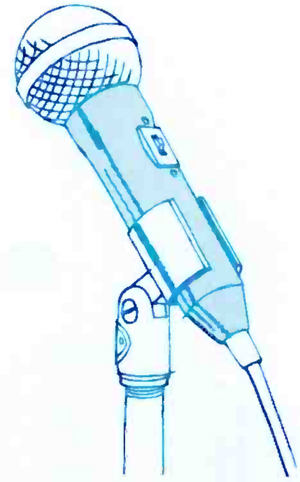
A substantial number of stations are requesting the Commission to reconsider the new Rules. Daytime-only stations feel that they could have been given more power and an earlier sign-on, while fulltime stations are objecting to the interference which will be received from the daytimers.

Short Circuits

The Commission has prodded the leading television-receiver manufacturers to improve the ease of tuning of UHF receivers. . .The Commission has ordered several VHF television translators in Cumberland, Maryland, to shift to UHF to protect local VHF reception and CATV distribution. . .The tests to determine the feasibility of land-mobile/television channel sharing in the Washington, D.C. area (May 1967 Bulletin) are indicating far less interference to television reception than had been expected. . . Several educational television stations have received permission to transmit music with slides during classroom-program breaks. . .The Commission no longer recognizes the 50 uv/m contour as the limit for rural service for FM stations. . .The Commission has rejected an application from a clear-channel station for regular operation with 750-kw power -- several experimental applications for higher power are still pending (October 1966 Bulletin).

Howard T. Head. . .in Washington

Why is Belden specified by most broadcast engineers?

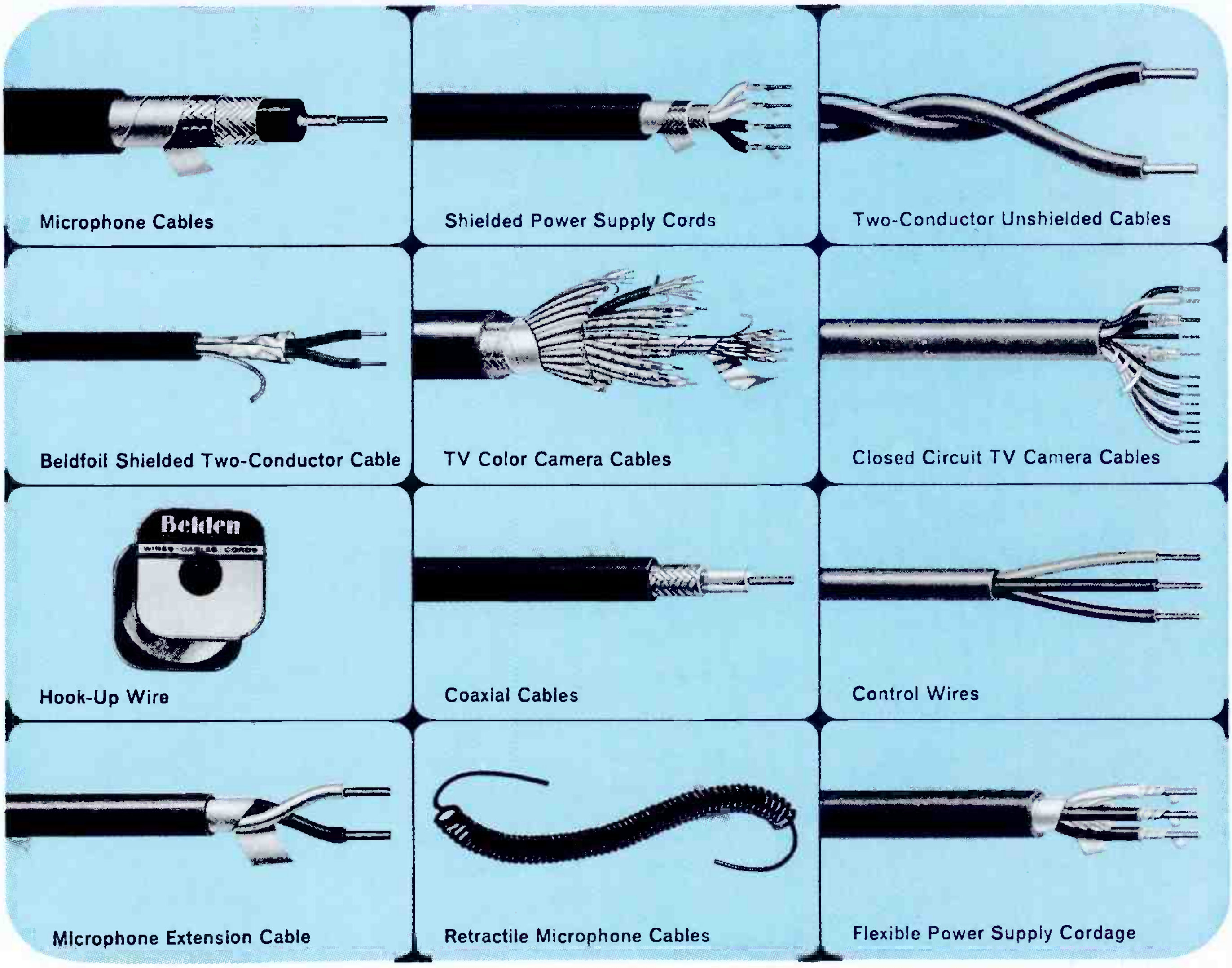


Belden designs and manufactures a complete line of audio, camera, and control cables to meet every TV and radio broadcasting, recording studio, and remote control need.

Many Belden Audio and Broadcast Cables feature Beldfoil* shielding. This superior cable shield provides 100% protection against crosstalk . . . increases electrical reliability . . . reduces cable diameter and weight . . . is easier to terminate . . . usually lower in cost.

Here is just a part of this complete line, available from stock. Ask your Belden Electronics Distributor for complete information. Request also a copy of the latest Belden Electronics Catalog.

*Belden U.S. Pat. 3,032,604
Belden Trademark—Reg. U.S. Pat. Off.



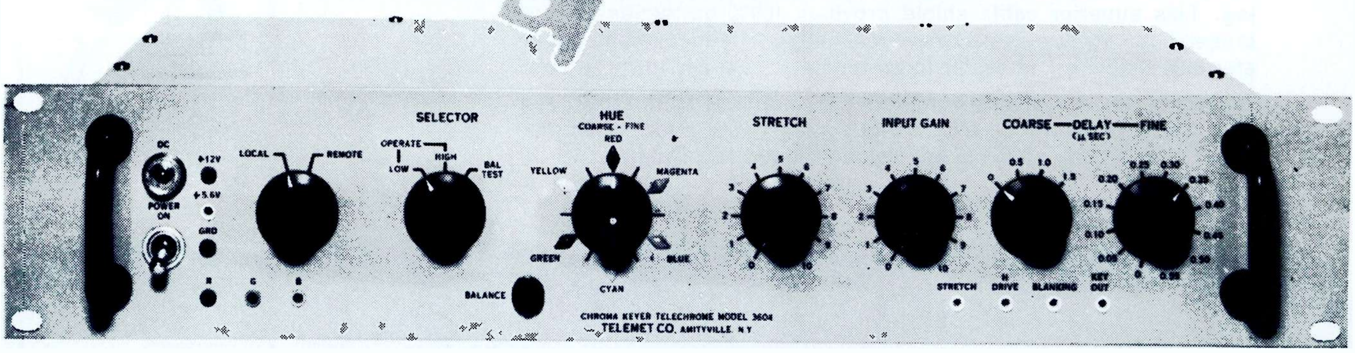
8-5-6AA

see your Belden Electronics Distributor

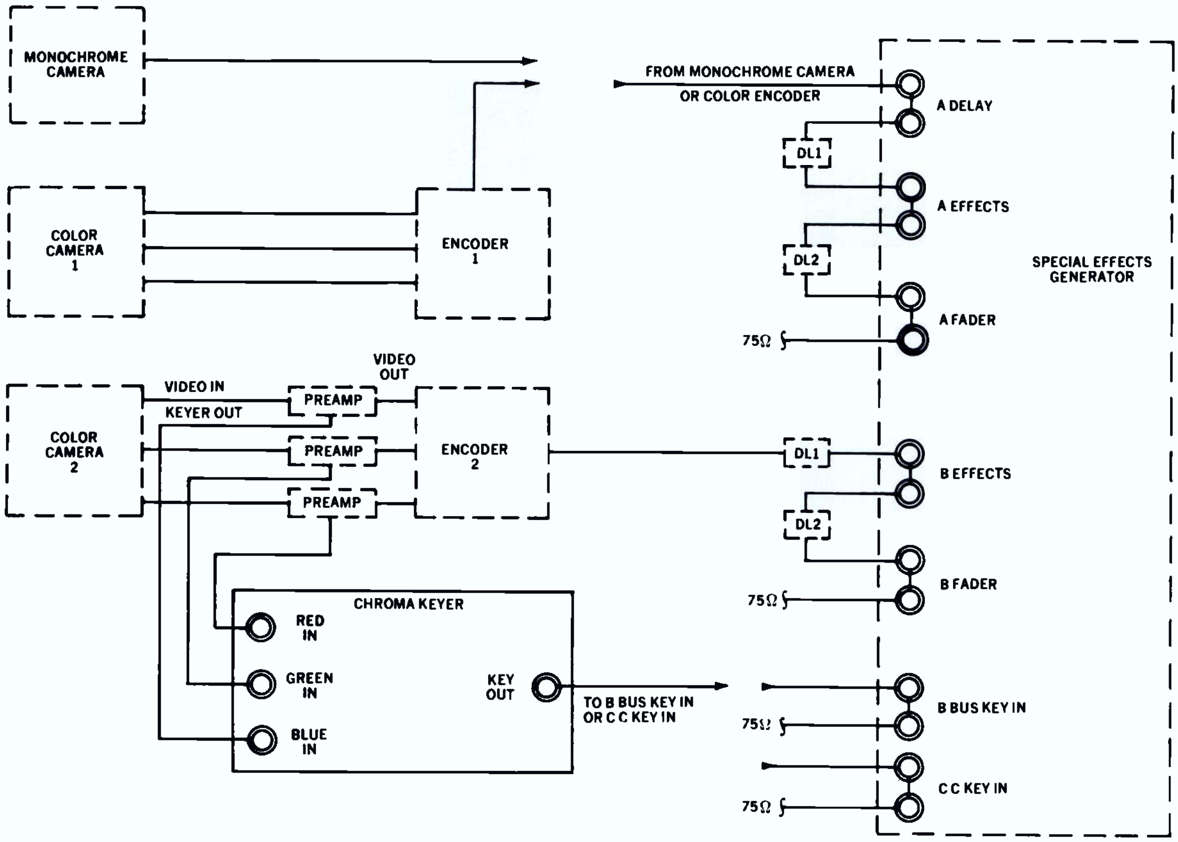
BELDEN electronic wire and cable

BELDEN CORPORATION • P.O. Box 5070-A • Chicago, Illinois 60680

TELEMET'S "KEY" TO VERY SPECIAL EFFECTS



CHROMA KEYER MODEL 3604-A1



Can be used with all cameras plus 4-PLUMBICONS. Internal power supply included. Will key on any color. Solid state throughout.

GIANNINI SCIENTIFIC CORPORATION

TELEMET COMPANY

185 DIXON AVENUE / AMITYVILLE, NEW YORK 11701 / PHONE: (516) 541-3600

Circle Item 21 on Tech Data Card

NEWS OF THE INDUSTRY

INTERNATIONAL

New TV Outlet for Mexico City

A new commercial television channel in Mexico City has been granted to **Corporacion Mexicano de Radio y Television** (Mexican Radio and Television Corp.). To be the fourth outlet for the city, the station will operate on channel 13.

Program production will begin when new studios are completed in the early part of next year, and broadcasting operations are expected to begin in the latter part of 1968.

NATIONAL

Southern California Sales Office

Andrew California Corp. has enlarged and relocated its Southern California sales office. The office is located at 615 N. Euclid Avenue and will be supervised by Mr. Donald Crumm, newly appointed District Manager.

Engineering and manufacturing operations will continue at their present location in Claremont, California. Inquiries concerning antenna and transmission line products should be directed to the new sales office.

Washington, D.C. Office

The Washington, D. C. office of **Collins Radio Co.** has been moved to a new location in the Washington area. The new location is Rosslyn Plaza, 1611 North Kent Street, Arlington, Virginia.

Main Office Move

Webster Engineering Co. has moved its main office to new and larger facilities at 1136 Gail Lane, Sleepy Hollow, Dundee, Ill. Partial stocking of some lines of broadcast equipment will make fast delivery possible in emergency cases.

Pilot Satellite Program Proposed

The **Communications Satellite Corp.** has filed with the FCC a proposed pilot satellite program to provide all types of domestic communications services, including commercial and educational TV.

As envisioned, the program will consist of two satellites (at 97° and 103° W. longitude) and 34 earth stations of various capabilities (mostly receiving stations in the Mountain and Pacific time zones). An illustrative distribution of service consisted of one ETV and three commercial color television signals to each of two time zones, 3600 trunk voice channels between Los Angeles and New York,

and 800 multipoint channels linking New York, Los Angeles, the Northwest, and the Southeast.

News Transmission Network

The first phase of a new nationwide news transmission network, engineered, furnished, and installed by **Lenkurt Electric Co., Inc.,** a subsidiary of **General Telephone & Electronics Corp.,** was cut into service on June 27 by the **Associated Press** in Los Angeles. The first phase, which cost some $850,000, connects AP Bureaus in the cities of Los Angeles, San Francisco, Portland, Seattle, Spokane, Salt Lake City, Phoenix, Albuquerque, Dallas, Oklahoma City, Denver, and Kansas City. At a later date, the "backbone" transmission system will interconnect AP Bureaus in 12 midwestern, 10 southeastern, and three northeastern cities.

The data system operates at 75 words per minute and has 22 Teletype or teletypesetter circuits within the bandwidth of one standard telephone circuit. AP officials said the new nation-wide network, when completed late next year, will serve more than 4200 newspaper and broadcast-station members in the U. S.

ORGANIZATIONS

Central Canada Broadcasters' Association

The Central Canada Broadcasters' Association will hold its annual convention on October 22, 23, and 24 at The Inn on the Park, Toronto. This will be a joint engineering/management function, with separate programs for the two groups.

George W. Bartlett, NAB vice-president for engineering, will address the engineering luncheon on October 24. Technical papers to be presented at the convention include: "Circular Polarization of FM and TV Antennas," "A New System of Intrical Pulse Distribution for TV," "Technical Requirements in Education Television," and "Technical Advances in Communications."

Equipment exhibits will occupy the west wing of the Inn on the Park.

Something to buy or sell?
Use the Classified.

When engineers get together, the conversation turns to pickups.

PHOTOGRAPHED BY FRANZ EDSON AT THE CAPITOL TOWER, HOLLYWOOD.

It's an irresistible topic.
Especially since Stanton came out with the Model 500 stereo cartridge.
That's an engineer's pickup, if there ever was one.
Beautiful curve—within 1 db from 20 to 10,000 Hz, 2 db from 10,000 to 20,000 Hz.
Fantastically small moving system to trace the wildest twists in the groove.
Light weight (only 5 grams!) to take advantage of low-mass tone arms.
And, of course, Stanton's legendary quality control.
No wonder engineers use the Stanton 500 for critical broadcasting and auditioning applications.
And to impress other engineers with their pickupmanship.
(Available with 0.7 or 0.5-mil diamond, $30; with elliptical diamond, $35.
For free literature, write to Stanton Magnetics, Inc., Plainview, L.I., N.Y.)

STANTON

Circle Item 24 on Tech Data Card

Daytime Broadcasters Association

A meeting of the Daytime Broadcasters Assn. was held in Chicago's Sherman Hotel on August 10 and 11 to discuss the effects of the new FCC presunrise rules. In clinic sessions, both legal and technical aspects were treated.

An introductory speech was delivered by Ray Livesay, chairman of the association's board of directors, in which the history of the DBA's efforts with regard to presunrise operation were traced. The speaker observed that while some stations will gain from the new rules, others will lose hours of operation.

In other talks, legal effects were discussed by Ben Cottone, Washington counsel for the DBA; the technical consequences were dealt with by Everett Dillard, a Washington consulting engineer; and the FCC's point of view was presented by Wallace E. Johnson, assistant chief of the FCC Broadcast Bureau.

IEEE

The Broadcasting Group of the Institute of Electrical and Electronics Engineers will hold its Western Conference on Broadcasting November 9 and 10, 1967 at the Ambassador Hotel in Los Angeles. The purpose of the conference is to offer broadcasters an opportunity to "gain first-hand knowledge of solutions found and proposed for current and future problems."

Approximately 300 engineers, managers, and university students are expected to attend the meetings. They will hear papers presented on interference-producing ground coupling, laser communications, satellite broadcasting, antenna design, color TV, and CATV.

NAB

Members of the NAB's 1968 Broadcast Engineering Conference Committee have been announced.

Appointed chairman is Albert H. Chismark, director of engineering for the Meredith Broadcasting Co., Syracuse, N.Y.

Other Committee members are LeRoy Bellwood, chief engineer, KOGO-TV, San Diego; William S. Duttera, director, allocations engineering, NBC, New York; George Jacobs, engineering director, Corinthian Broadcasting Corp., New York; Leslie S. Learned, vice-president for engineering, MBS, New York; Clure H. Owen, manager of allocations, ABC, New

York; James D. Parker, director, transmission engineering, CBS Television Network, New York; Robert J. Sinnett, vice-president for engineering, WHBF, Rock Island, Ill.; John T. Wilner, vice-president in charge of engineering, The Hearst Corp., Baltimore; and Benjamin Wolfe, vice-president for engineering, Group W, New York.

SMPTE

The Society of Motion Picture and Television Engineers has announced the recipients of several of the society's annual awards. The SMPTE Journal Award was given to Walter C. Snyder, of the Eastman Kodak Co., for his 1966 paper, "An investigation of Agitation in a Continuous Immersion Film Process."

The 1967 Herbert T. Kalmus Gold Medal Award went to John M. Waner, also of Eastman Kodak. Recipients of the award are honored for their contributions to the development of color films, processes, techniques, or equipment.

Other awards were: Eastman Kodak Gold Medal Award to Samuel L. Postlethwait (Purdue University); 1967 Progress Medal Award to Gordon A. Chambers (Eastman Kodak); SMPTE Scholarship Fund Award to L. David Pratt (Rochester Institute of Technology); and honorary membership to Dr. John G. Frayne (prominent audio scientist and technical author).

TRANSACTIONS

In a series of transactions, **Riker Video Industries, Inc.** has acquired several electronics manufacturing firms. The first was **Continuous Progress Education, Inc.,** which designs, manufactures, and installs audio-video communications systems for schools. Next came the purchase of **ITV, Inc.,** designer and installer of CCTV equipment. Most recently acquired were **Richmond Hill Laboratories, Ltd.** and **Leitch Research and Development, Ltd.,** both of Toronto. Richmond Hill Laboratories, manufacturing arm of the Canadian complex, produces transistorized broadcast items which will complement Riker's regular line.

Visual Electronics Corp. has acquired the assets of **KRS Instruments,** a division of **Datapulse Inc.** The newly acquired facility manufactures cartridge tape recording and playback equipment for application in the professional broadcasting and data-instrumentation fields.

PERSONALITIES

Mr. **Heinz Blum** has been promoted to the position of senior vice-president in charge of advanced engineering of **Entron, Inc.** He will be responsible for the implementation of new research and development programs for products to be manufactured in two to five years.

Elton B. Chick has been appointed general manager of WCIN, Cincinnati, one of the **Rounsaville Radio Stations.** For the past 2½ years, Mr. Chick, a 20-year Rounsaville employee, has been general manager of WLOU, Louisville. Previously, he held an executive engineering position for all the Rounsaville stations. Mr. Chick replaces **Donald K. Clark,** who was transferred to the Rounsaville facility in Tampa, as general manager of Radio Station WDAE.

Anaconda Astrodata Co. has appointed **Bruce Walters** to the newly created position of director of manufacturing. Mr. Walters will be responsible for all facets of manufacturing operations at the Anaheim plant.

Two appointments have been announced by **Philips Broadcast Equipment Corp. Rupert F. Goodspeed** will be product manager, broadcast equipment; and **Abe Jacobowitz** will be sales manager of television broadcast equipment. Mr. Goodspeed came to Philips from RCA, and Mr. Jacobowitz was formerly with Communications Industries Corp.

OBITUARIES

Mr. **Charles J. Starner,** 59, manager of VHF television transmitter engineering for the RCA Broadcast and Communications Products Division, died July 15 at his home in McMurray, Pennsylvania.

An RCA employee since 1940, Mr. Starner was known in the broadcast industry for his design work in the medium- and short-wave transmitter field. He graduated from Gettysburg College with a BSEE degree and was a member of the Institute of Electrical and Electronics Engineers.

Mr. **Joe Davis,** long-time KXLY television studio supervisor and design engineer, died recently. He was 55 years old and had been with KXLY Radio, and later Television, for 21 years.

Hugo Gernsback, pioneer in electronic invention, author, and publisher died on Saturday, August 18, in New York City. He was 83 years old.

In 1925, Mr. Gernsback founded radio station WRNY, and three years later, with the help of Pilot Radio Corp. engineers, started television broadcasts. Postage-stamp-size images were received on crude scanners owned by 2000 amateurs in the New York area.

During his long publishing career, Mr. Gernsback put out more than 50 magazines, including the first radio magazine, *Modern Electrics* in 1908, and the first science-fiction publication, *Amazing Stories* in 1927. He is widely credited with having written the first true science-fiction story, and with coining the term itself.

His awards and associations include: Marconi Memorial Wireless Pioneer Medal, Veteran Wireless Operators, 1950; Gold Medal of Luxembourg, Grand Order of Oaken Crown; Silver Jubilee Trophy, Belgian Society Helios, 1953. Member American Physics Society, AAAS; founder Wireless Association of America.

At his death, Mr. Gernsback held 80 scientific patents. He was editor-in-chief of *Radio-Electronics* and other publications. ▲

NEW PRODUCTS

For further information about any item, circle the associated number on the Tech Data Card.

Light Fixture
(51)

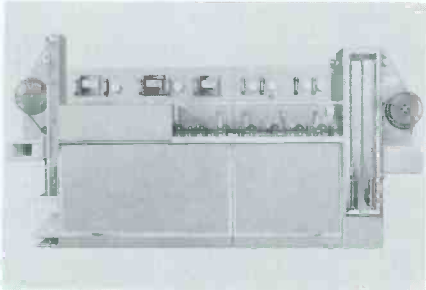
A lensless light fixture that approaches the intensity range of a standard 2K Fresnel unit has been introduced by **ColorTran Industries, Inc.** The Model LQF10-50 Super-Beam "1000" permits focusing from spot to flood with a ratio of 11 to 1.

Using a 1000-watt (3200°K) tungsten-halogen quartz single-ended frosted lamp, the LQF10-50 operates directly from 120 volts, AC or DC, without boosting, and produces 50 to 560 footcandles at 20 feet from the flood to spot focus positions. The two- and four-leaf barndoors rotate 360° and fold flat.

Motion picture and television models are available. The MP version (LQF10-50) weighs 10¼ pounds and can be stand mounted or supported by standard grip equipment. Focusing is accomplished by rotating a plastic knob on the bottom of the housing. The TV version (LQF10-50/TV) weighs 11 pounds and is supplied with a yoke incorporating a C-clamp for mounting. A steel loop (for pole operation) replaces the plastic knob for focusing the TV model. Both units are

MOVING?
Don't lose touch . . .
RECEIVE BE AS USUAL
(INCLUDE OLD AND NEW ADDRESS)
BROADCAST ENGINEERING
CIRCULATION DEPT.
4300 W. 62nd St.,
Indianapolis, Ind. 46206

priced at $125, and the same group of accessories is available for the MP and TV versions.



TV Color Processor
(52)

The Model MTV-30 color processor has been designed by **Treise Engineering, Inc.** to meet television needs. The self-contained unit occupies 17′ × 9′ of floor space. Stated warm-up time from ambient 70° to the required 100-110° is 20 minutes; a "proportional control" system provides controlled amounts of heat to maintain proper temperature. All tanks are insulated for minimum heat loss, and all solution pumps are "magnetic coupled" to avoid pump sealing problems.

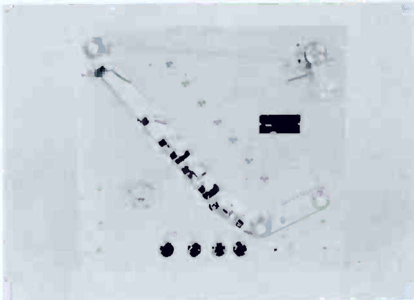
The MTV-30 processor is designed to handle all types of *Ektachrome* film. It operates up to 40 fpm. All primary chemicals are individually controlled by proportional pneumatic systems, and all film-transport elements are completely removable from the processor for maintenance and inspection. Replenishers are metered by means of gravity-fed flowmeters. Drying is achieved by a system that combines conventional and impingement methods.

Crab Pedestal
(53)

The new Gibraltar crab pedestal is for use with broadcast TV cameras and similar large instruments weighing up to 200 pounds. This **Quick-Set, Inc.** pedestal provides crab or tricycle steering selected by shifting a lever. A steering column is mounted on the end of the right rear arm and carries a 12-inch steering wheel which controls the direction of movement.

The central pedestal contains an elevator mechanism which provides 20 inches of height adjustment by turning the hand wheel. The pedestal accommodates all standard Gibraltar heads and, with available adapters, other makes of heads.

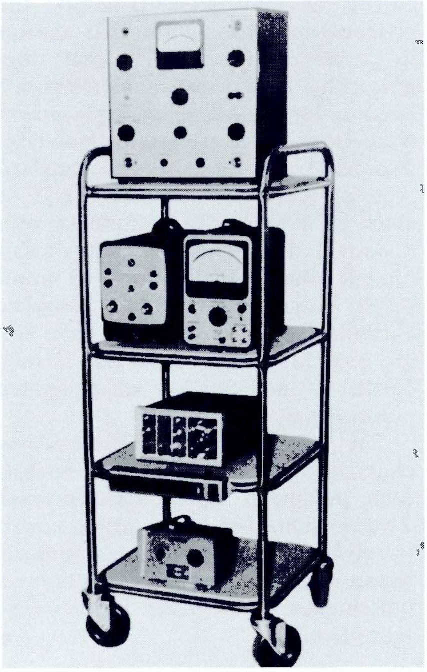
The standard pedestal is provided with 8" × 1½" wheels equipped with brakes and cable guards; 10" × 3½" pneumatic wheels are available, as well as other sizes and types of wheels on special order.



Tape Delay Recorder
(54)

Delay continuously variable from

25 to 375 msec at 30 ips is provided by the **Audio Instrument Co.** Model 303 time-delay recorder. The unit is equipped to provide multiple-head operation, and as many as 15 playback heads can be accommodated.



Mobile Lab Cart
(55)

A four-deck mobile instrument cart, the CE-1500-6, is available from **Cambridge Electronics, Inc.** Mounted on 4-inch swivel casters, the cart provides 1800 square inches of space, with outlets and live cord available.

The cart is made of 1-inch stainless steel with solid deck platforms welded to the legs. Each laminated deck rests on ⅜-inch steel rods spaced 3½ inches apart. If desired, the deck can be removed to let the instruments rest on the grille to allow for heat circulation.

Overall dimensions of the unit are 58⅝″ × 24⅝″ × 31¼″, with the top deck 55″ from the floor. Decks are 21″ × 29″ and are spaced, from the bottom up, 13, 14, and 17¼ inches.

Helical-Scan Video Tape
(56)

A family of video tapes designed specifically for helical-scan recorders has been placed in production by **Memorex Corp.** The 79 series of video tapes features a new binder formulation designed to provide extra durability, fewer dropouts, and longer still-frame life. The tape is also intended to provide higher S/N ratio and low abrasive characteristics for longer head life. The tapes are available for all helical-scan recorders in all standard configurations and lengths.

Transmitter Logger
(57)

The AL-400 is designed for the economy-minded station that desires to possess continuous line chart logging. This **Rust Corp.** equipment displays a full 24-hour logging segment with front-panel parameter notation. The basic unit offers all the standard Autolog features, such as 62 days of chart on a single roll, calibration with a pointer that is visible when adjusting, all solid-state circuitry, and front-panel adjustments. The complete charting system is mounted on a single 3½ inch high standard 19-inch panel; it includes a self-contained power supply.

The patented Rust continuous line charting system samples and records each parameter every eight seconds. Twelve inches of chart paper equals twenty-four hours of logging. Rubber-stamp scales customized to station requirements are included in the basic unit price. ▲

Something to buy or sell? Use the BE Classified.

ENGINEERS' TECH DATA

ANTENNAS, TOWERS, & TRANSMISSION LINES

70. CCA—Data sheet provides information about the CCA-FMA-6710R FM circularly polarized antenna.
71. DELHI—Twelve-page catalog concerns towers and masts for Citizens-band and similar applications.
72. JAMPRO—JCP series of circularly polarized FM transmitting antennas is subject of catalog.

AUDIO EQUIPMENT

73. ATLAS SOUND—Catalog 566-67 contains illustrations and specifications of public-address speakers, microphone stands, and accessories.
74. ELECTRO-VOICE — Microphones, public-address speakers, and accessories are shown in Catalog 167.
75. GATES—Sixteen-page booklet, "The Most Complete Line of Consoles From Gates," presents information about line of audio consoles.
76. QUAM-NICHOLS—Catalog 67 provides information about speakers for public-address, background-music, general-replacement, and other applications.
77. STANFORD INT'L—New 1968 catalog of MB (West German) microphones and headsets is offered.
78. SUPERSCOPE—31-page catalog "All the Best From Sony" features Sony/Superscope tape recorders, magnetic tape, microphones, and accessories. Additional catalog has technical specifications and retail prices of consumer and professional microphones.
79. SWITCHCRAFT — Bulletin 172 describes battery-operated studio mixer, "Studio MixMASTER" Model 307TR.
80. UNITED RADIO SUPPLY—Specifications and block diagram of the Kustom Electronics broadcast console are available.
81. VEGA—Syncron S-10 cardioid condenser microphone is subject of brochure.

CATV EQUIPMENT

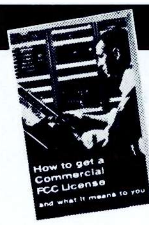
82. AEL—Short-form catalog is titled "Colorvue Advanced Design CATV Distribution Equipment."
83. AMPHENOL—Four-page brochure describes line of transmission and drop-line cable for CATV applications.
84. DYNAIR—Data sheet is about Series-4000 solid-state modular CATV demodulator, heterodyne converter, and audio-video modulator.

COMPONENTS & MATERIALS

85. BELDEN—56-page Catalog 867 covers lines of electronic wire and cable.
86. BRADY—Bulletin 100.1 describes pocket-size book of adhesive wire markers and matching terminal markers.
87. CHERRY—Series of "Snap/Reed" switches for low-energy switching is featured in brochure.
88. DIALIGHT—Catalog Sheet L-206 depicts indicator lights accommodating incandescent T-2 bulb with telephone slide base; Sheet L-207 depicts transistorized indicator light for integrated circuits.
89. MAGNECRAFT—Catalog 268 shows general- and special-purpose relays; Product Data Bulletin 671 shows Class 88K power switching relay.
90. SCANBE—Panels, drawer slides, handles, circuit cards, card-mounting components, and other hardware items are included in eight-page catalog.
91. TROMPETER—Catalog M-4 gives information on line of coax, twinax, and triax matrix and multipole, multithrow switches.
92. WESTINGHOUSE—Electrical and mechanical characteristics of line of plastic-encapsulated semiconductor rectifiers are presented in 12-page illustrated booklet.
93. ZERO—Twelve page Catalog SS-67 offers line of RFI-shielded vertical, slope-front, and low-silhouette "Space Series" electronic enclosures.

LIGHTING EQUIPMENT

94. COLORTRAN — **ColorTran News**, Issue 3, has application stories of interest to the motion-picture and television industries.



95. MOLE-RICHARDSON—Supplement No. 1 to Catalog K illustrates seven new quartz lighting fixtures and several other products. Twenty-page price list for the company's products also is available.
96. PACKAGED LIGHTING SERVICES—Descriptive catalog of lighting equipment includes quartz-iodine conversion units for existing studio spotlights and scoops.

MICROWAVE & STL EQUIPMENT

97. MICROLINK/VARIAN — Company offers description and specifications of new TVL Series TV relay equipment.
98. RHG ELECTRONICS—Solid-state FM microwave relay equipment is listed in eight-page Catalog 67b.

MISCELLANEOUS

99. TEXAS ELECTRONICS—Specification sheet is about Model 445 indicating and recording system for wind direction and velocity.
100. WALLACH—Storage-cabinet brochure includes data on new cabinet for storage of three-inch tape boxes.

RECORDING & PLAYBACK EQUIPMENT

101. AMPEX—Case histories are related in Bulletin G195, about the **Cue-Matic** audio recorder, and Bulletin G228, about instructional use of broadcast and closed-circuit video-tape recording equipment. Also offered is Bulletin V119 on Multilock system synchronizer for synchronous operation of two or more audio or video recorders.
102. CROWN INT'L—Four-page brochure gives information about Crown Pro 800 recorders with computer-logic transport control.
103. JOA—Data and prices for new tape cartridges and reconditioning services are offered.
104. METROTECH—Six-page brochure describes 500 Series recorders, reproducers, and slow-speed loggers.

105. RAYCO—BASF magnetic tape in "Perma-Store" library box is illustrated in information sheet.
106. SPARTA—Series R-310 professional tape recorders are subjects of information sheet.
107. TELEX—Magnecord Model 1021 for monophonic and Model 1022 for stereophonic recording are described in brochure. The Viking Model 230 tape transport is subject of additional material.

REFERENCE MATERIAL & SCHOOLS

108. CLEVELAND INSTITUTE OF ELECTRONICS — Pocket-size plastic "Electronics Data Guide" includes formulas and tables for: frequency vs wavelength, dB, length of antennas, and color code.

TELEVISION EQUIPMENT

109. ALLEN AVIONICS—Catalog of delay lines and filters for video and pulse applications is available.
110. BURKE & JAMES—Eight-page publication provides list of lenses for television use.
111. CLEVELAND ELECTRONICS — A 52-page quick-reference step-down die-cut catalog gives information on vidicon, **Plumbicon**, and image-orthicon deflection components.
112. COHU—Data sheets are for 9840 Series color video encoder, 2610/2620 Series chroma detector, and 3207 Series self-contained **Plumbicon** cameras.
113. COLORADO VIDEO—Descriptive sheet for Model 301 Video Analyser, for displaying TV waveforms on picture monitor, is given.
114. KALART—Literature package includes material on Kalart/Victor 16-mm TV projector, **Tele-Beam** large-screen TV projector, 16-mm sound motion-picture projectors, and projection TV in the schools.
115. KAPPA—Catalog DL-1&10A lists video cable simulators and other electromagnetic delay lines.
116. TELEMATION—Four-page, two-color brochure presents Model TMV-600 **Cablecaster** video control center for CATV and similar applications.
117. VITAL—Literature describes Model VI-500 color stab amp with AGC, and Models VI-10A and VI-20A video and pulse distribution amplifiers; new features are listed.
118. WARD—Brochure tells about TS-200 solid-state vertical-interval video switching systems.

TEST & MEASURING EQUIPMENT

119. BALLANTINE—Solid-state AC voltmeter, Model 303, is shown in specification sheet.
120. B & K—Bulletins are available for the following instruments: Model 2409 AC voltmeter/amplifier; Model 4240 simulated voice mechanism, for testing telephone transmitters and handsets; Model 2410 AF voltmeter/amplifier; Model 2417 rms voltmeter; Model 2006 heterodyne voltmeter; and Model 3350/51 electroacoustic transmission measuring system, for tests on telephone handsets.
121. DELTA—Literature has as its subject the Model RG-1 solid-state receiver/generator for use with impedance bridges in antenna-system measurements.
122. HEWLETT-PACKARD — Eight-page brochure, "Cable Fault Locating Instruments," details the use of electronic instruments in the maintenance of cable plants.
123. TEKTRONIX—Information is offered on Type 526 TV vectorscope, Type 529/RM529 TV waveform monitors, TV accessories, and TV vertical-interval test signals.
124. TV ZOOMAR—Fliers show TV **Colorgard** meter for balancing color TV monitors, "Newsbreaker 400" color-film processor, and HTS studio equipment.

TRANSMITTERS & ASSOCIATED EQUIPMENT

125. BAUER—Catalog sheet gives information and specifications on Model FB-10J 10,000-watt AM transmitter.

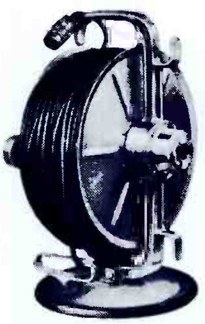
Circle Item 47 on Tech Data Card

a
sound investment
for the Broadcast Industry...

REMOTE CONTROL MIKE REELS

Specially designed reels. Remote control by drum, push button or station relay. 115 volt reversible chain driven motor. 2 to 8 conductor slip rings available. 150′ cable capacity.

POWER CABLE REELS



I.E.R.'s level wind Port-O-Reels protect and prevent mike or extension cord break-downs. Up to 400′ cable capacity.

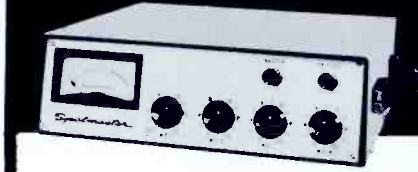
Write for Specification Data on the most complete line of Remote Control Reels and Port-O-Reels.

INDUSTRIAL ELECTRIC REELS INCORPORATED
1503 CHICAGO ST.
OMAHA, NEBRASKA 68102

Circle Item 49 on Tech Data Card

Advertisers' Index

SPOTMASTER
Solid-State Portable
REMOTE AMPLIFIER



The RA-4CA is a lightweight, four-channel portable mixer amplifier specifically designed for remote broadcast or auxiliary studio use. It is completely self-contained and operates from either AC or batteries (switching automatically to battery operation if AC power fails); runs as long as 200 hours on low-cost "D" cells. It offers four microphone channels with master gain and P.A. feed, all controlled from the front panel. Lightweight construction (just 11 pounds with batteries), a convenient carrying handle and a snap-on front cover mean the RA-4CA can be easily set up to operate anywhere. For further information, please write or call today:

Spotmaster

BROADCAST ELECTRONICS, INC.
8810 Brookville Road
Silver Spring, Maryland 20910
Area Code 301 • 588-4983

all solid state

AM MODULATION MONITOR

The Metron Model 506B-1 Amplitude Modulation Monitor is a high quality instrument, field-proven for several years.

- **FCC Type Approval 3-127**
- **Compact—Only 5¼" high on a standard 19" rack**
- **All solid state circuits—silicon transistors for greater reliability.**
- **Low Cost—only $550.00.**

When you replace your present AM Monitor, buy the Metron 506B-1, your best value.

Metron **METRON INSTRUMENTS, INC.**
1051 South Platte River Drive Denver, Colo. 80223

Circle Item 48 on Tech Data Card

Professional Services

VIR JAMES
CONSULTING RADIO ENGINEERS
Applications and Field Engineering
345 Colorado Blvd.
Phone: (Area Code 303) 333-5562
DENVER, COLORADO 80206
Member AFCCE

JAMES C. McNARY
Consulting Engineer
National Press Bldg.
Washington 4, D. C.
Telephone District 7-1205
Member AFCCE

CAMBRIDGE CRYSTALS
PRECISION FREQUENCY MEASURING SERVICE
SPECIALISTS FOR AM-FM-TV
445 Concord Ave. Phone 876-2810
Cambridge, Mass. 02138

AMPEX HEAD ASSEMBLY RECONDITIONING SERVICE for all Ampex professional model recorders. This professional service features precision relapping of all heads for maximum head life. Your assembly is thoroughly cleaned and guides are replaced as required. Price includes optical and electrical inspection and complete testing on Ampex equipment in our plant. Full track or half track assemblies . . . $35.00. One to two day service. "Loaner" assemblies available if necessary. LIPPS, INC., 1630 Euclid Street, Santa Monica, California 90404. (213) EX 3-0449. tf

CRYSTAL AND MONITOR SERVICE — Frequency change and repair service for AM monitors including G.R., RCA, Gates, W.E., and Doolittle; also H-P 335B FM. AM monitors bought and sold. What have you, what do you need? New or regrinding of AM crystals for RCA, Gates, Bliley, W.E., and J-K oven holders, repairs, etc. Fastest service, reasonable prices. Over 25 years in this business. Eidson Electronic Co., Box 96, Temple, Texas 76501, Phone 817 773-3901. 2-67-tf

Kits serviced, shipped. Professional, reasonable. Also small broadcast rack and table units, carts, tuners, limiters. Write: 109 Pinetree, Woodbridge, Va. 4-67-tf

VIDEO TAPE RECORDER AUDIO HEAD ASSEMBLY SERVICE
Precision relapping of all heads and supporting posts, including cleaning and testing. Ampex head assembly with "cue" tracks, $75.00 complete. RCA units also relapped. One to two day service. LIPPS, INC., 1630 Euclid St., Santa Monica, Calif. 90404. (213) EX 3-0449. tf

JOHN H. MULLANEY and ASSOCIATES
Suite 71,
1150 Connecticut Ave., N.W.
Washington, D. C. 20036
Phone 202-223-1180
Member AFCCE

ROSNER TELEVISION SYSTEMS

ENGINEERS	CONTRACTORS
120 E. 56 St. New York N. Y. 10022	230 Newtown Rd. Plainview N. Y. 11803

Swift, professional service on your tape cartridge rebuilding needs. All work fully guaranteed — virtually no audio dropout with our splicing technique! Write Broadcast Equipment Rebuilders, Route 2, Box 723, Connellys Springs, N. Carolina 28612. 10-67-tf

Classified

Advertising rates in the Classified Section are fifteen cents per word. Minimum charge is $2.00. Blind box number is 50 cents extra.

Equipment for Sale

CO-AXIAL CABLE Heliax, Styroflex, Spiroline, etc. Also rigid and RG types in stock. New material. Write for list. Sierra-Western Electric Co., Willow and 24th Streets, Oakland, Calif. Phone 415 832-3527 5-66-tf

Television / Radio / communications gear of any type available. From a tower to a tube. Microwave, transmitters, cameras, studio equipment, mikes, etc. Advise your needs—offers. Electrofind Co., 440 Columbus Ave., NYC. 212-EN-25680. 8-64 tf

CARTRIDGE TAPE EQUIPMENT

Completely reconditioned and guaranteed. Spotmaster Model 500 Record/Playbacks, $350.00. Model 505 Playbacks $250.00. 30-day money-back guarantee on all equipment.

BROADCAST PRODUCTS COMPANY
18804 Woodway Drive, Derwood, Maryland, 20855
(301) 926-4600 3-67-12t

Audio Equipment bought, sold, traded. Ampex, Fairchild, Crown, McIntosh, Viking. F. T. C. Brewer Company, 2400 West Hayes Street, Pensacola, Florida. 3-64-tf

50,000 connectors SO 239, PL 259, F-59, F-61—also cable assemblies. Manufacturer's over stock. AVA Electronics & Machine Corp., Box 224, Upper Darby, Pa. 10-67-1t

Everything in used broadcast equipment. Write for complete listings. Broadcast Equipment and Supply Co., Box 3141, Bristol, Tennessee. 11-64-tf

"AUDIO EQUIPMENT — Whatever your needs, check us first. New and used. Ampex, Altec, AKG, EV, Fairchild, Neumann, Langevin, Rek-O-Kut, Uher, Viking. Send for equipment list." Audio Distributors, Inc., 2342 S. Division Ave., Grand Rapids, Michigan 49507. 6-66-tf

Spring hanger (53) for 3" or 3⅛" transmission line, noninsulated. TCA Tower Co., 4325 Bankhead Hwy., Mableton, Georgia 30059 9-67-2t

Large selection of good-quality surplus equipment including distribution amplifiers, power supplies, stab amps, audio equipment, telop projector, master monitors, image orthicon tubes, CRT tubes, camera cable, and many other items. For complete list, write Box 182, Broadcast Engineering. 9-67-2t

New turntables, tone arms, preamplifiers, cartridge machines, equalizers, tape recorders, studio equipment. Professional brands. Write for special offers. We buy, sell, trade, lease. Audiovox, P. O. Box 7067, Ludlam Branch, Miami, Fla. 33155. 9-67-tf

Complete UHF Package. TTU-1B RCA Transmitter, Filterplexer & TFU-24DL Antenna (Ch. 24). Sync Generator, TK-10 Live Camera, Dage Vidicon Film Camera, 2 Holmes LTD 16mm Projectors, 2 RCA TP 16 Film Projectors, 35mm Dual Slide Projector, all associated input gear to build a complete studio transmitter. For further information, contact: H. J. Eskew, Chief Engineer, WICD Television, Champaign, Illinois. Phone: Area 217, 352-7673. 10-67-1t

TTU-1B RCA Transmitter, Filterplexer, TFU-6 RCA antenna (Ch. 33) General Radio Station Monitor. For further information, contact: H. J. Eskew, Chf. Eng., WICD Television, Champaign, Illinois. Phone: Area 217, 352-7673. 10-67-1t

Equipment for Sale (Continued)

For Sale: RCA TT2BH Transmitter now on Ch. 13, $15,000. Sideband & harmonic filters also available. Contact H. L. VanAmburgh, C.E., WGAN-TV, Portland, Maine, 207 772-4661 for details. 10-67-1t

Receive pictures from APT Weather Satellites. Limited supply of facsimile machines for receiving high quality (8x8") pictures. Like new, complete, fully guaranteed. Lowest price anywhere. For complete details, write: Newsome Electronics, Dept. S, 2670 Pinetree, Trenton, Michigan 48183. 10-67-1t

For Sale: Gates SA-39 peak limiting amplifier. Just taken out of service. Good condition. $195. Joe Brewer, WZYX, Cowan, Tennessee. 10-67-1t

Equipment Wanted

We need used 250, 500, 5K & 10K Watts AM Transmitters. No Junk. Guarantee Radio Supply Corp., 1314 Iturbide St., Laredo, Texas 78040. 3-66-tf

Complete instruction manual for Dumont Television Transmitter, Series 9000 in good condition. Write to Leo Voien, Box 2512, Sioux City, Iowa 51106. 9-67-2t

SPOTMASTERS WANTED—Model 500 Record/Playbacks and Model 505 Playbacks. Send full details to: BROADCAST PRODUCTS COMPANY, 18804 Woodway Drive, Derwood, Maryland 20855 (301) 926-4600. 10-67-6t

Employment

IMMEDIATE OPENINGS—Qualify for any of the following positions: Technicians for RCA Closed Circuit Television equipment, Cameramen, Maintenance men, Video Tape men, Video Engineers. RCA Rep. 143-08 94th ave., Jamaica, New York, or (212) 297-3344. 7-67-tf

Wanted: Experienced first ticket to assume assistant chief position. All fringe benefits and top monetary compensation. Station converting to color. Apply—R. Vincent, Manager, KCND-TV, Box 191, Pembina, N. Dakota. 701-825-6292. A McLendon station. 8-67-3t

TV engineer with first class license interested in gaining knowledge through experience with latest high band color video tape equipment and Plumbicon color cameras. Equipment on hand and installation to commence within a few weeks. Get in on the beginning. Call the Chief Engineer collect, 313-239-6611. 8-67-tf

Electrical Engineers needed immediately for TV/Radio stations, manufacturers, and CATV for all positions. Send well prepared resume to Nationwide Broadcast Personnel Consultants, 645 North Michigan Avenue, Chicago, Illinois, 60611. We have openings for all qualified applicants and the employer pays our fee. 10-67-tf

REGIONAL SALES MANAGER—EAST

Nation's leading supplier of time-weather, news, and local origination equipment for CATV seeks top-notch sales engineer type. CATV background not necessary, but good understanding of video systems equipment desired. Excellent opportunity for willing-to-travel go-getter. Contact: Mr. K. D. Lawson, Sales Mgr., TeleMation, Inc., 2275 South West Temple, Salt Lake City, Utah 84115, (801) 486-7564. 10-67-1t

Immediate opening for Broadcast Engineer. All color station, second class license or better required. Send resume to WNYS-TV Channel 9, Syracuse, Inc. P.O. Box 9, Syracuse, N.Y. 13214. 10-67-tf

Job Headquarters for all Radio and Television Engineers. Immediate openings exist in 9 western states and elsewhere for qualified engineer and technical personnel. All categories from trainees to experienced transmitter maintenance, chief, assistant chief, live color video maintenance and technical operations. Send us your complete resume now. The AMPS Agency, 3924 Wilshire Blvd., Los Angeles, California 90005. Telephone DU 8-3116.
By Broadcasters—For Broadcasters 11-66-tf

Radio Station KTRM in Beaumont, Texas on the Gulfcoast has an opening for 1st Class Engineer. Preferably with some technical experience. No board work. Phone 713-892-4990 between 2 PM & 12 midnight. Ben Hughes, Chief Engineer. 10-67-1t

IMMEDIATE OPENINGS for experienced control room and transmitter engineers. Top pay scale and all fringe benefits. Miami's first full-color TV Station. Write R. Paasch, CE, Channel 7, P.O. Box 1118, Miami, Fla. 33138. 10-67-1t

Business Opportunities

UNUSUAL OPPORTUNITY

For a growing manufacturing firm, to acquire valuable patents and trade mark rights on latest accessories for large and small recording tape and movie film. SPECIAL point-of-sale package. SPECIAL reel, etc. P.O. Box 01141, Cleveland, Ohio 44101. 8-67-3t

Training

To advance in electronics, knowledge and ability are required. Grantham offers correspondence and resident instruction, in depth, leading to the degree of Associate in Science in Electronics Engineering. G.I. Bill approved. Credit for previous training and experience allowed. Free Catalog. Write: Dept. E-2, Grantham School of Electronics, 1505 N. Western Ave., Hollywood, California 90027. 6-67-tf

Miscellaneous

RADIO AND TELEVISION STATIONS for sale in all parts of United States. Qualified buyers may receive further details by writing to Inter-Media Communications Corporation, 246 Fifth Avenue, New York, New York 10001. 1-67-12t

Technical

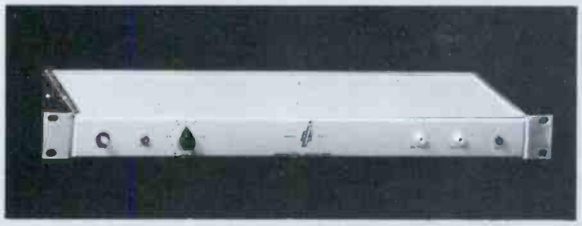
WESTERN MICHIGAN—Immediate openings for Television Control Room Engineers. Excellent fringe benefits; good pay; NBC affiliate; full color facilities. Phone collect, or write: MR. CHARLES F. ROBISON, Chief Engineer, WOOD TV, Grand Rapids, Michigan 616-459-4125. 10-67-3t

MOVING?

Don't lose touch . . .
RECEIVE BE AS USUAL

(INCLUDE OLD AND NEW ADDRESS)

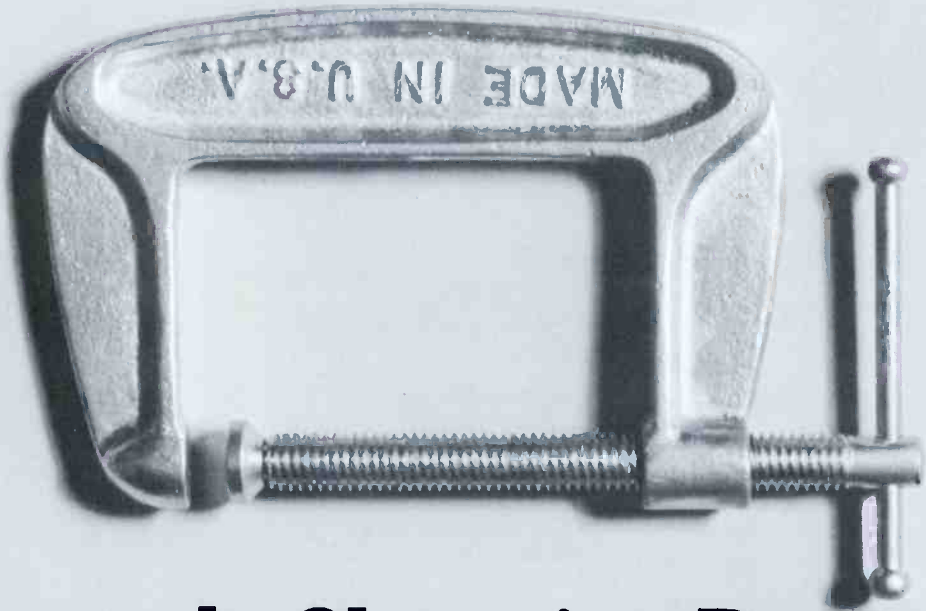
BROADCAST ENGINEERING
CIRCULATION DEPT.
4300 W. 62nd St.
Indianapolis, Ind. 46206



The TC1 Clamping Amplifier employs tip clamping to remove low frequency signal deficiencies without disturbing burst and other chrominance information in or about blanking or back porch levels. The clamped stage utilizes a field effect transistor driven by a balanced bridge circuit. This advanced design technique produces highly effective and stable clamping. Where else can you get this much quality and dependability in a Clamping Amplifier for only $325.00? Let us send you more information.

Write or wire or phone collect:
Ray Weiland, President.
INTERNATIONAL
NUCLEAR CORPORATION
608 Norris Avenue
Nashville, Tennessee 37204
(615) 254-3365
"Transistorizing the Television Industry"

INTERNATIONAL
NUCLEAR CORP.



The only Clamping Device more simple and foolproof than International Nuclear's New TC1 Clamping Amplifier.

Your RCA broadcast tube distributor gives you

SUPPORT IN DEPTH

with VIDICONS to meet all your needs

For live color—color film pick-up—closed circuit—general broadcast use—your RCA Broadcast Tube Distributor provides the VIDICONS you need—when you need them! Just as important is the latest technical literature from RCA. *He has it.* Product inventory to meet your needs NOW? *See him.* In total—your RCA Distributor offers you support in depth to help you do your job better.

CHECK THESE ADVANTAGES!

- Resolution—Up to 1100 TV lines limiting resolution or 60% response to 400 TV lines
- Spectral Response—Panchromatic with high sensitivity in *all* chroma channels
- Highest sensitivity and lowest lag of *any* commercial vidicons
- Clean pictures—Due to stringent spot criteria

CHOOSE FROM THESE TUBE TYPES:

RCA type	Application notes
4478 4488	low-cost vidicons for non-critical closed-circuit applications
7038 7735B	broadcast-quality pick-up for studio and closed-circuit applications
8507A	separate mesh variant of the 7735B featuring high resolution and high signal uniformity . . . primarily for military and industrial applications
8572	separate mesh variant of 7038 featuring high resolution and high signal uniformity . . . for broadcast film cameras
4493 4494 4495	live color pick-up in TK-42 transistorized camera
8480/V1 8134/V1	for color film pick-up in transistorized TK-27 . . . no other tube type will do

AVAILABLE FROM YOUR RCA BROADCAST TUBE DISTRIBUTOR

RCA Electronic Components and Devices, Harrison, N. J.

RCA® The Most Trusted Name in Electronics

Ask your RCA Broadcast Tube Distributor about the comprehensive, new "RCA VIDICONS" booklet CAM-700