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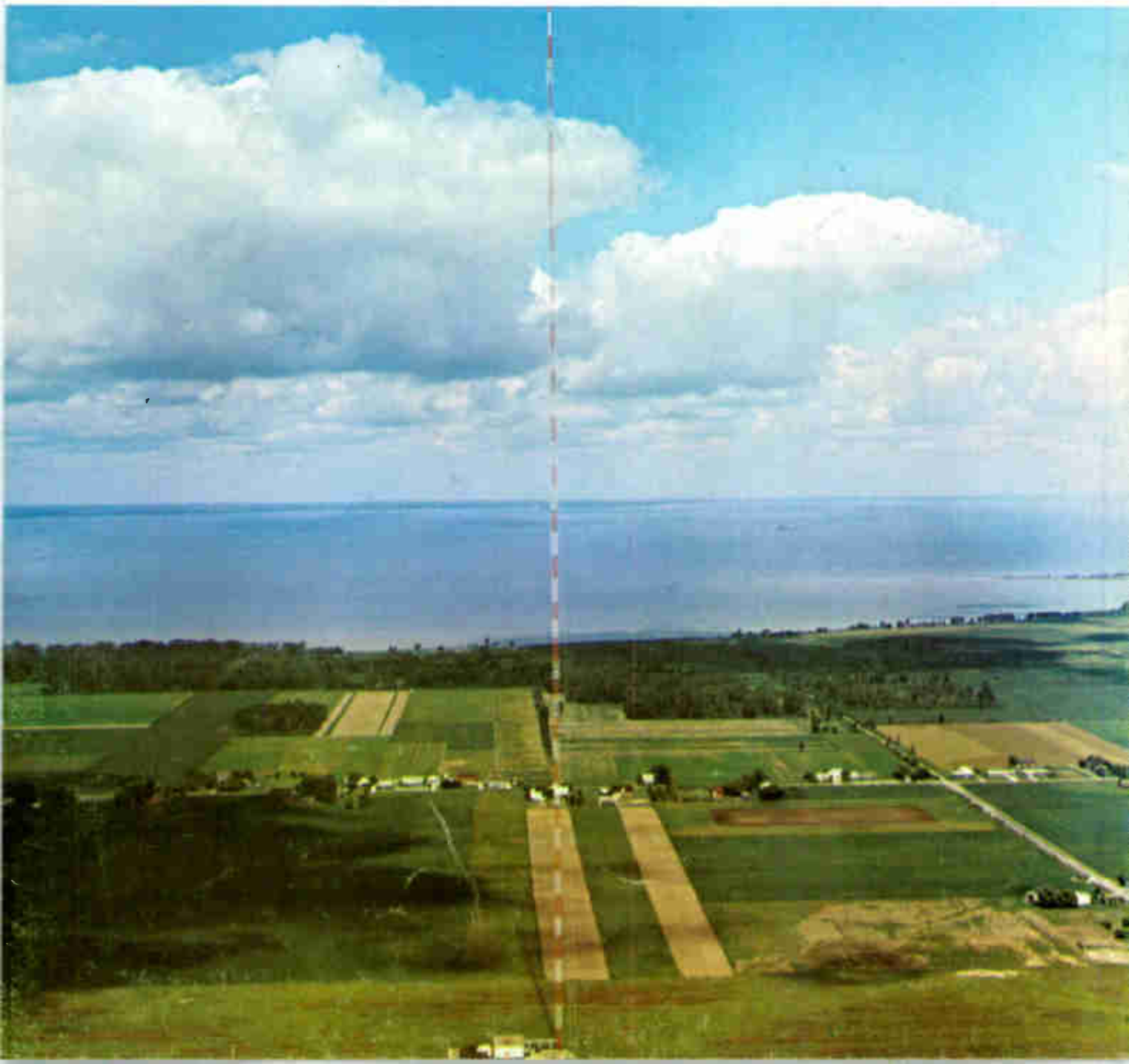
Broadcast Engineering

the technical journal of the broadcast-communications industry



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COHU ELECTRONICS, INC
SAN DIEGO DIVISION

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the technical journal of the broadcast-communications industry

Broadcast Engineering

Volume 9, No. 8 August, 1967

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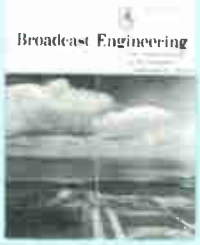
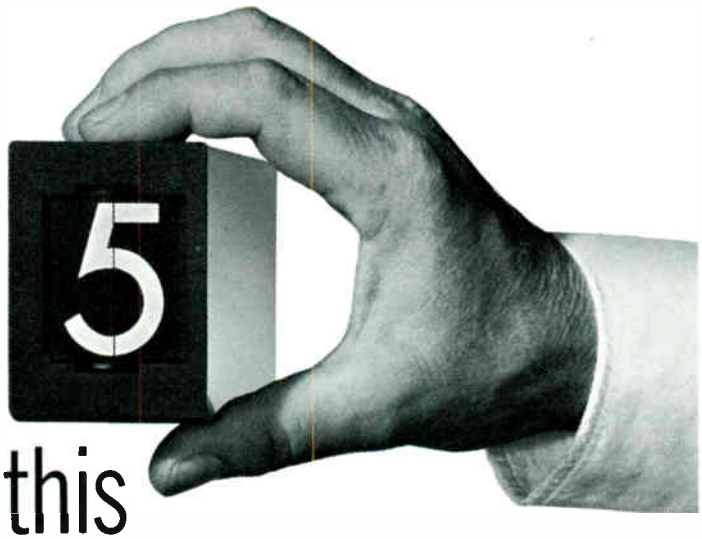
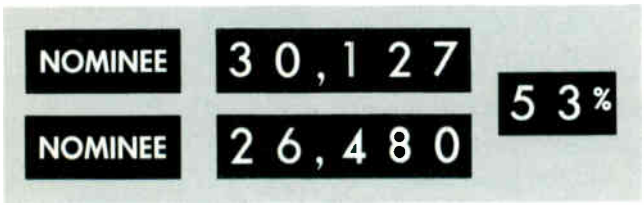


Capping the 1372-foot Stainless tower of Toledo's WDHO (Channel 24) is a 95-foot GE zigzag antenna. The combined above-ground height of 1467 feet permits coverage in the states of Ohio and Michigan and the Canadian province of Ontario. (Photo courtesy of General Electric Co.)

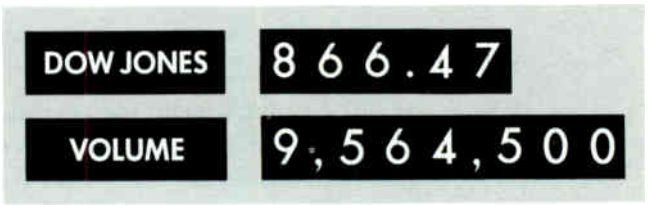
Look what your cameras can do with display units like this



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.
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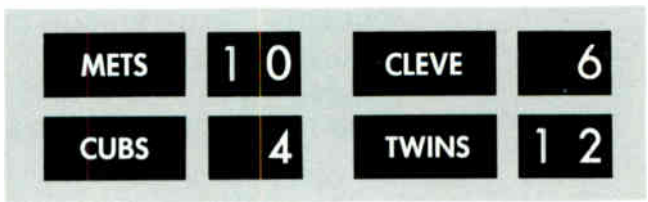

SPORTS – An easy set-up.
Just stack these units in a flat to suit any requirement. Custom designed matrix wiring also available for complete flexibility.

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.

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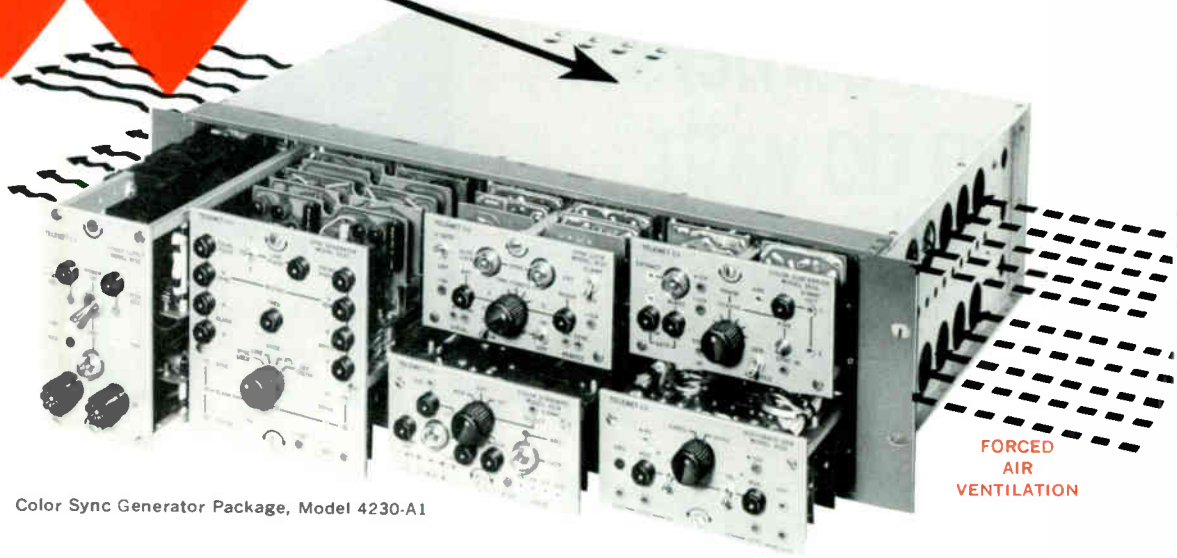
Circle Item 3 on Tech Data Card

THE "KIND-HEARTED" SYNC GENERATOR



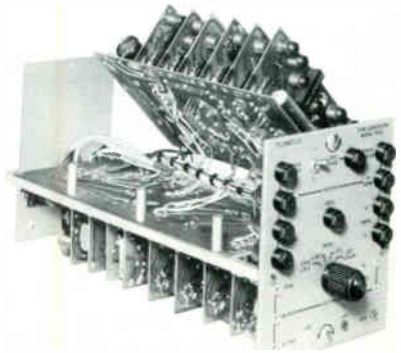
Color Sync Generator Package, Model 4230-A1

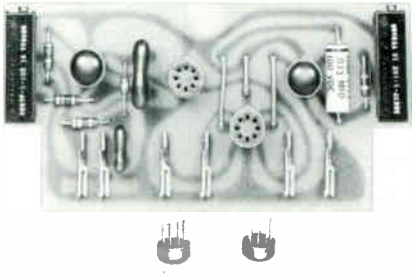
Most of today's sync generators use soldered-in microcircuits squeezed into a space that only a microbe could get in to repair. For very low priced generators, this is ideal—but MURDER for the broadcast engineers who have to maintain them. Here's why Telemet's new Model 4230-A1 is so "kind-hearted":

PLUG-IN UNITS WITH PLUG-IN SUBASSEMBLIES. PLUG-IN INTEGRATED CIRCUITS. ADEQUATE FRONT PANEL TEST POINTS (COLOR CODED). BLUE RIBBON CONNECTORS. "STRAIGHT THRU" FORCED AIR VENTILATION. MINIMUM NUMBER OF INTEGRATED CIRCUIT TYPES. EXTREMELY RUGGED CONSTRUCTION. INCORPORATES THE BEST FEATURES OF ALL TELEMET SYNC GENERATORS.

The basic equipment (frame, power supply and sync generator) is $1,800. Plug-in accessories include: Model 3533-A1 Automatic Sync Lock Module; Model 3536-A1 Automatic Sub-Carrier Regenerator Module; Model 3534-A1 Color Standard Module with Proportional Oven; Model 3532-A1 Dot Grating Module.

Most of the engineers at this year's NAB Show who looked inside this sync generator—bought it... confirming that our heart *was* in the right place.





▲ Plug-In Integrated Circuits Simplify Maintenance
◀ Hinged Circuitry for Easy Access

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Circle Item 4 on Tech Data Card

BOOK REVIEW

Field-Effect Transistors: J. Torkel Wallmark and Harwick Johnson, Editors; Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1966; 376 pages, 6" × 9", hard cover, $12.95.

The most recent addition to the growing list of commercially available semiconductor devices is the field-effect transistor. Curiously, knowledge of its operating theory predates many other semiconductor developments. This book traces the history of the device and then presents, in great detail, information regarding its theory, design, and application.

Most of the material in the work is quite advanced, but the authors have attempted to make the book as useful as possible by summarizing, at various knowledge levels, the treatment of each subject.

The first chapter is an introduction to field-effect transistors, and in effect is a summary of the entire book. Each subsequent chapter discusses, in detail, one aspect of the overall subject. Topics covered are: semiconductor surface physics, conduction through insulating layers, growth and properties of silicon dioxide films, theory of field-effect transistors, noise, radiation tolerance, MOS field-effect transistors, thin-film transistors, linear amplifier and attenuator circuits, high-frequency linear circuits, and digital-circuit applications. Two features are designed to assist the reader in more readily understanding the material presented: a list of common symbols and constants, and a discussion of the special terminology which applies to field-effect transistors and other semiconductor devices.

The book tends to stress principles rather than specific applications, and very little reference to field-effect transistors now in manufacture will be found. This tends to make the work a subject text rather than an applications handbook.

The book was written for physicists and engineers, and even the summaries require some knowledge of solid-state physics. In-depth treatments include the calculus. ▲

For years we've been offering a 30-day free trial, a full year's warranty on parts and labor, an increase in effective coverage, a guarantee of protection against overmodulation without distortion–but there are still a few of you who haven't tried AUDIMAX and VOLUMAX.

You sure are a tough audience!

Audimax reacts to any given program situation in exactly the same way as your best audio man would — only a lot faster and more efficiently. It eliminates distortion, thumping, pumping, audio "holes", and bridges through program pauses to eliminate the "swish-up" of background noise. It even returns the gain to normal during standby conditions. Wild claims? You bet. But we're willing to back them up with a 30-day free trial in your own studio. After that, send us $665 if you like it. If not, send it back — freight charges collect. What can you lose? By keeping average modulation up, everybody wins.

Volumax for AM broadcasters costs the same as Audimax and limits peaks without side effects. Its action may be gentle or microsecond fast. That depends on the program waveform but the end result of the Audimax-Volumax team is **always a more even and pleasant sounding program that may be transmitted safely at much higher effective power levels.** There's another wild claim we'll back up with a free trial. Send for the pair on the same basis as above.

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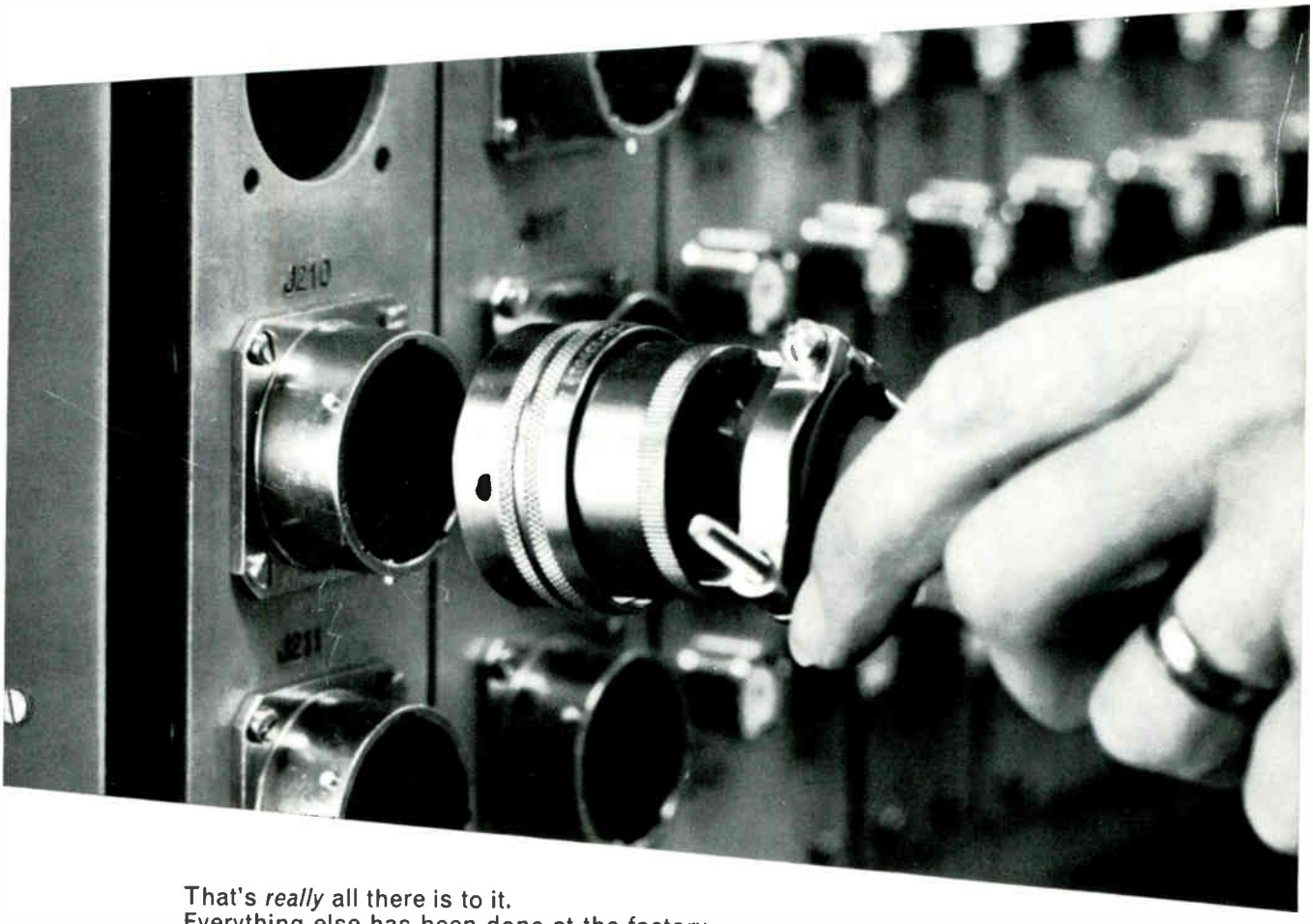

That's *really* all there is to it.
Everything else has been done at the factory.
The equipment was custom designed for you, in consultation with your station engineers. All cabling has been pre-formed. The equipment—or system—was completely checked out at the factory. Result—it starts functioning immediately, as naturally as though it had been there since the first day you went on the air.

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We'll be happy to send you all the technical details on this newest and finest tape cartridge system. Just jot down your name, station and address on this ad and mail it to us.

Basic Criterion series solid-state playback unit and recording amplifier. Available in slide-out rack panel mounting or trimline desk console. Mono or stereo. 1-, 2-, or 3-tone.

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Circle Item 10 on Tech Data Card

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.
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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 11 on Tech Data Card

AN AUTOMATIC PROGRAMMING AND LOGGING SYSTEM

*by Edgar C. Smith**—The design of a station-built radio automation system is presented.

When management decided to make our FM programming entirely separate from the AM operation, considerable thought was given to the problem of programming the FM operation in stereo for 17 hours daily. In order to make the operation economically feasible, the cost of operation had to be kept low. This required that salary expense for additional personnel be held at a minimum. Further, our stereo record library was not adequate for such a long schedule. It appeared that an automated taped-music service and automatic logging would help solve both problems.

We decided to acquire the taped music service and to install enough automated equipment to provide good programming. The decision to automate did not affect the work of the existing staff; in fact, additional help was acquired for the FM operation. The automatic system made possible a new service to the community, and it gave greater assurance that the operation would be a success economically.

Automation Requirements

A year of operation with a strictly sequential automation system convinced us that this method did not provide the flexibility and program variety we desired. This was because the sequential system allowed no more than six spots per hour, and the sequence of musical selections was always the same because each music reel had to play completely through. For these reasons, it was decided to acquire a new taped music service which would provide a 25-Hz tone at the end of each selection, and to build a control circuit which would be actuated by these tones. This arrangement would allow switching to be accomplished at the end of any selection.

The control circuit to be constructed would be required to perform the following functions:

1. Keep the program switching very close to the actual time desired, through the use of an accurate program clock.
2. Provide for switching music-tape decks between selections in a predetermined manner so that one reel would not play continuously. A good mix of selections on different reels was necessary.
3. Switch in other tape-playback units only at the end of a musical selection, during the running of which the clock had set up the control circuit.
4. Set up a symbol in a printing logger to identify the unit switched in.
5. Turn on an audio tape recorder and stop it after 20 seconds, to verify announcements and program content other than music.
6. Switch back to music and print the time when no other units were called for by the clock.
7. Alternate music machines as preset in a stepper-switch unit until other playback units were called for by the clock.

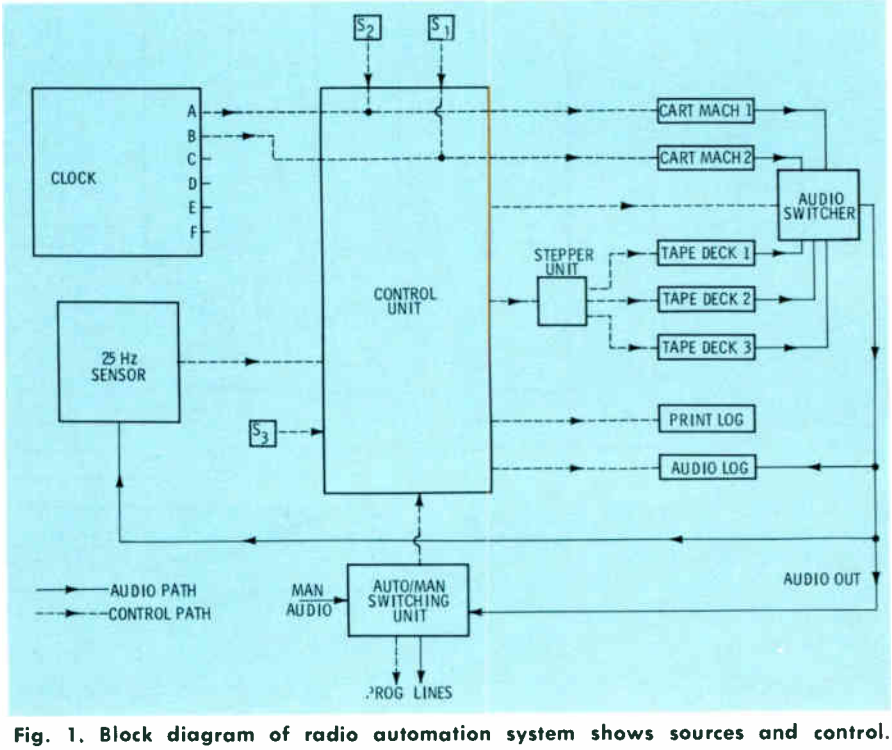

Fig. 1. Block diagram of radio automation system shows sources and control.

*Chief Engineer, WFIN and WFIN-FM, Findlay, Ohio

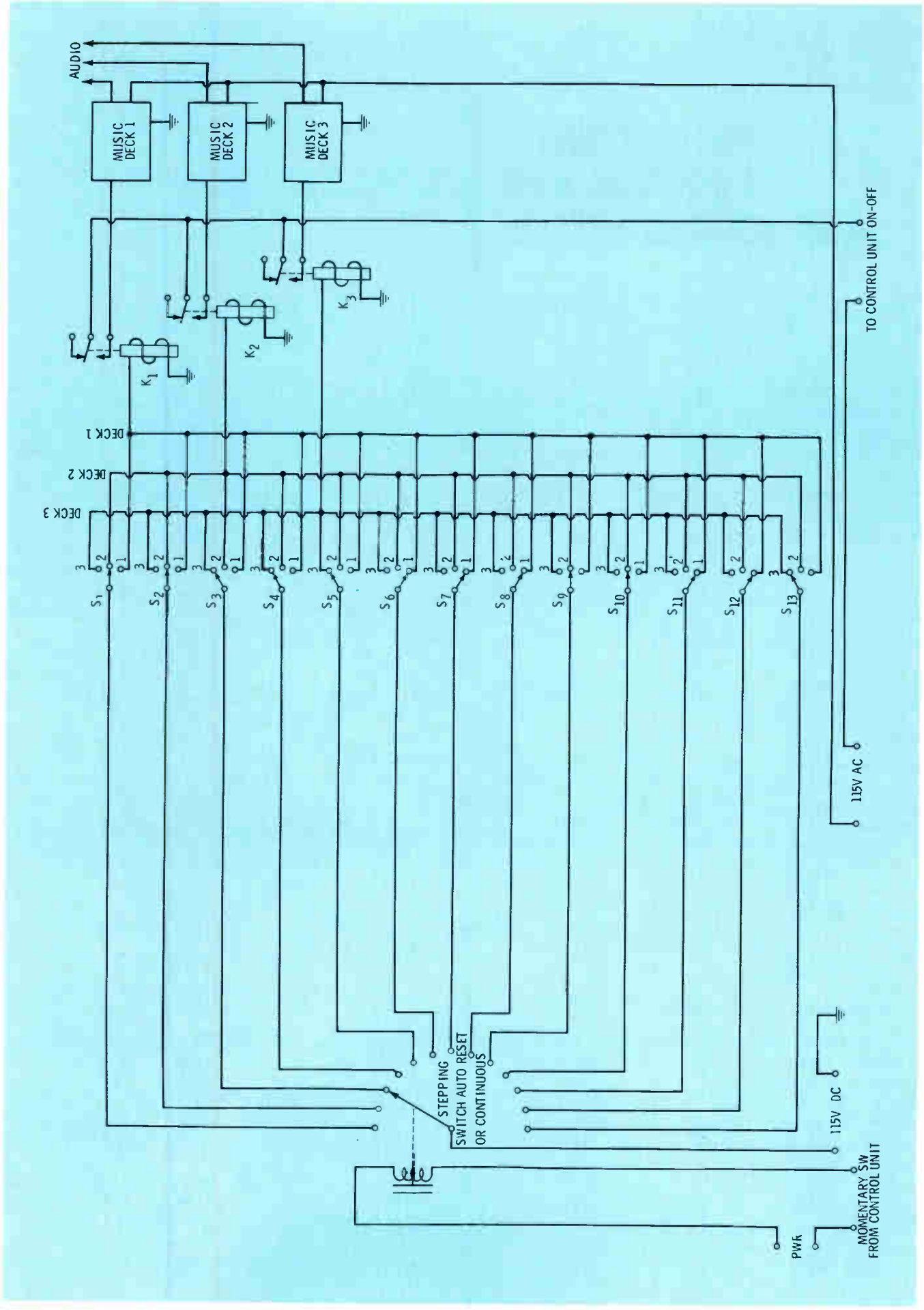

Fig. 2. Sequence of program material from three music decks is determined by selector switches and stepper switch.

Provision was also needed for manually switching in the different units, and the system would have to be capable of being interrupted for manual operation when desired.

The resulting installation consists of three 14-inch tape decks, two cartridge machines, the automatic control unit, a clock, a 25-Hz sensor and pulse generator, a printing logger, an audio logger, a stepper unit for selecting music-tape decks, an audio switching facility, and an automatic/manual switching unit. The complete arrangement is shown in Fig. 1.

Special Equipment

Special equipment designed or acquired for the system included the program clock, printing logger, stepper unit, 25-Hz sensor and DC-pulse generator, control unit, audio switcher, and automatic/manual switching unit.

Program Clock

In the clock we purchased, it is possible to preset the exact operating times for six circuits. Six single-pole, single-throw relays are used by the clock for this purpose. Up to 60 switching times per hour are possible. Switch-time duration can be varied from one to 20 seconds, but momentary closure is used in this installation.

Printing Logger

We purchased a printing logger which will print out the time to the second, AM or PM, the date, and one of six symbols to identify the unit being aired.

Stepping-Switch Circuit

The stepping-switch circuit is detailed in Fig. 2. It provides for presetting the sequence of three music-tape decks to give any desired mixture of musical content. The mix may be changed at any time, even during operation, by changing the positions of S1 through S13. The circuit can be expanded easily.

Relays K1, K2, and K3 are shown as switching the 115-volt AC circuit to the capstan motors and solenoids of the decks. This is necessary in our operation because of the type of tape decks used.

Decks with remote start-stop buttons can be switched easily by jumpering the start-button contacts and using K1, K2, and K3 to open and close the stop-button circuits.

Tone Sensor and DC-Pulse Generator

Fig. 3. represents a typical tone sensor for 25 Hz. It is not the exact circuit used in our system, but it is typical of units used for similar purposes. This tone sensor is needed to detect the 25-Hz signal at the end of each selection or message, and to provide a DC pulse to the control unit for switching.

The parallel-T circuit, between plate and grid of the 6AN8 pentode section, provides minimum negative feedback at 25 Hz. Consequently, the output has a peak at this frequency. The 25-Hz tone is rectified by the diode, and a positive voltage is applied to the grid of the triode section. The 2.2-megohm resistor and the 0.05-mfd capacitor prevent instantaneous transients from causing a false operation. When no tone is present, the triode section of the 6AN8 is biased to cutoff by means of the cathode resistor and the 22,000-ohm resistor. Presence of a tone causes the grid to go less negative, in turn causing plate current to increase to the point where the plate relay closes. The relay contacts discharge the 40-mfd capacitor through the automation control unit. It is important that the capacitor charge slowly through the 68,000-ohm resistor, in order to prevent a possible double action when switching. This is because part of a 25-Hz tone may remain on the tape machine after it has stopped. If the capacitor charges too fast, this remaining tone could cause a switching action when the machine is started again.

Precision parts should be used in the T circuit. Any accurate audio signal generator can be used to provide 25-Hz tones when preparing tapes, cartridges, etc.

Audio Switcher

Audio switching follows the lead established by the control unit. This circuit is very simple, and it will not be described here.

Control Unit

Fig. 4 is the schematic diagram of the control unit, which was designed and constructed for two tape-cartridge machines. The control circuit for each machine can be identified by the letters A and B in the relay and component designations. Cartridge machine A is controlled by SA, KA, KA1, KA2, and KA3. Cartridge machine B is controlled by SB, KB, KB1, KB2, and KB3. In order to include more playback units, it is necessary to add an additional control bank for each new unit.

Automatic/Manual Switching Unit

A means to interrupt the automatic system and transfer to manual operation through a regular audio console is provided by the automatic/manual switching unit. Its circuit is shown in Fig. 5. A single switch actuates K1, K2, and K3, which in turn effect a bypass of the automation system.

Control Unit Operation

The control unit operates as

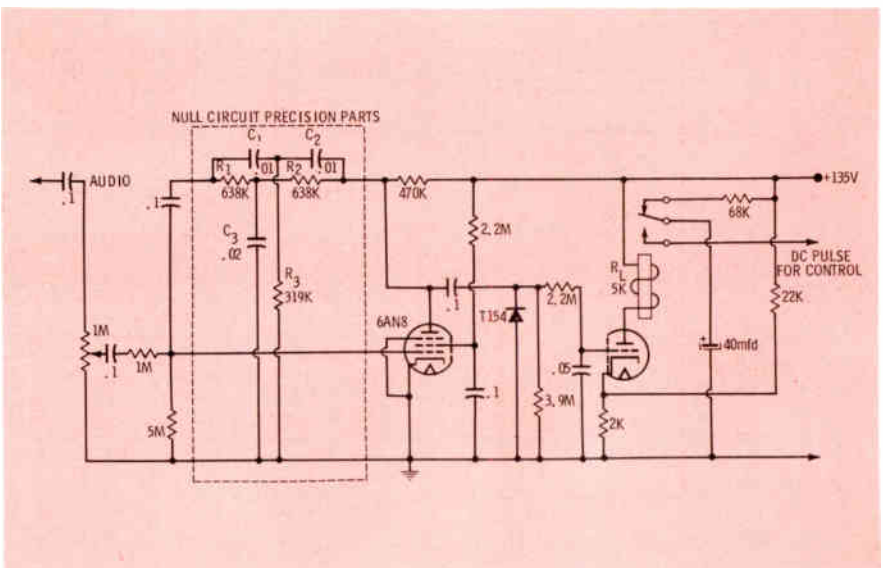

Fig. 3. Typical circuit used to sense the 25-Hz cue tones recorded on tapes.

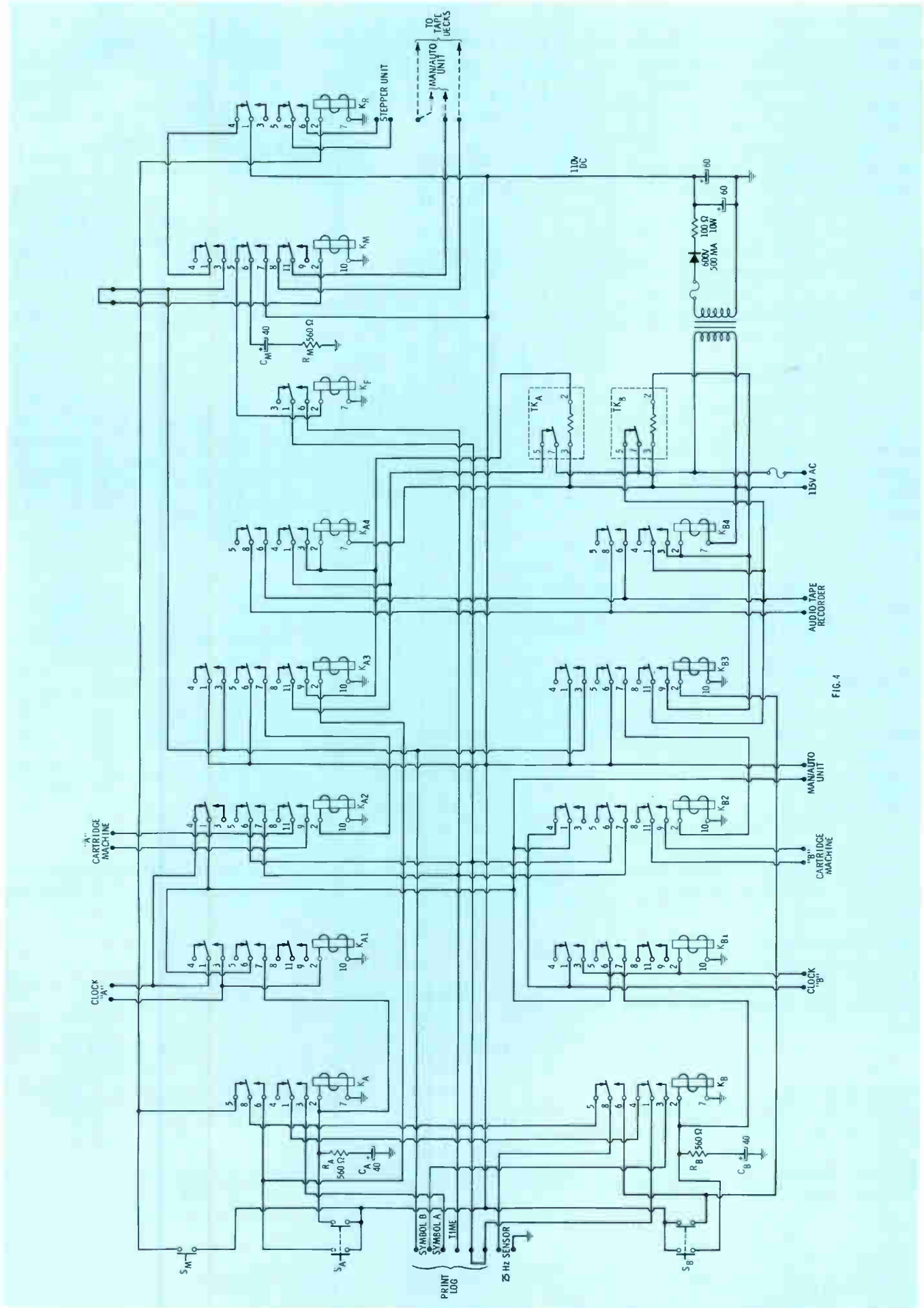

Fig. 4. Diagram of the control unit for the programming and logging system; provision is made for two cartridge units.

follows. Assume that one of the music decks is running and music is being aired, and at the end of each selection there is a 25-Hz tone. This tone is applied to a tone sensor in which a relay is made to connect a charged capacitor to the pulse circuit in the control unit.

If neither clock circuit has been set up, KR will be actuated momentarily after each selection, causing the stepper to switch the music decks for whatever mix has been preset.

If the "B" clock has closed during the music, KB1 and KB will hold until the selection has finished, at which time the pulse from the tone sensor will momentarily close KB3.

KB3 contacts 11 and 9 activate KB4. Contacts 1 and 3 activate KM, which holds. Contacts 6 and 7 activate KB2.

KM contacts 1 and 3 hold KM closed through KR contacts 1 and 4. KM contacts 11 and 8 stop the tape deck, and contacts 6 and 7 charge 40-mfd capacitor CM through 560-ohm resistor RM.

KB contacts 3 and 1 have set up symbol B in the printing logger. KB2 contacts 11 and 9 start cartridge machine B. Contacts 6 and 7 cause the printing logger to print the time and a "B" symbol. Contacts 1 and 4 release KB1 and KB.

KB is prevented from releasing immediately by its 560-ohm resistor and 40-mfd capacitor. If it releases too soon, the symbol might not be recorded, and, also, part of the pulse might get through to KA3 or KR through contacts 8 and 5, causing malfunction.

KB4 has been activated by KB3. It holds through its contacts 1 and 3 and TKB (thermal relay) contacts 5 and 7. Contacts 6 and 8 start the audio tape recorder for audio verification. Contacts 1 and 3 have also sent current through the TKB heater. After 10 to 20 seconds or more, TKB contacts 5 and 7 open, releasing K4B, which stops the audio recorder and removes heater current from TKB.

Cartridge machine B continues to the end of its message, and a 25-Hz tone causes another pulse from the tone sensor. Since KB and KB1 have been released, the pulse is passed on to KA3 if the clock has set up KA1 and KA. If not, the pulse is passed on to KR which closes momentarily, switches the stepper, and releases KM by opening contacts 1 and 4.

KM contacts 8 and 11 start the music deck. Contacts 5 and 6 connect the charged 40-mfd capacitor CM to KF.

KF closes momentarily, and contacts 6 and 1 cause the printing logger to print the time. No symbol is used for music decks because the lack of a symbol, in itself, provides identification for them.

SA and SB provide for manually starting units A and B. These DPDT switches are also used to actuate KA and KB to provide for printing the respective symbol. This is desirable in some instances. For example, at sign-on a cartridge is used, and the system is started by manually pushing the proper switch to start the cartridge machine.

SM actuates KR to release KM and switch back to music. This may be needed if a cartridge is blank or defective. If desired, a silence sensor can be used to perform this function and to give an alarm.

If the clock sets up both A and B circuits simultaneously, then B unit will play at the next pulse after the music selection, and A unit will play at the pulse following the B unit message. The next pulse returns the system to music.

Conclusion

Our automation system has worked successfully. Not every circuit and connection has been shown here in order to simplify the rather complex installation, but it is hoped that this description will give an understanding of what we set out to do and how we did it. ▲

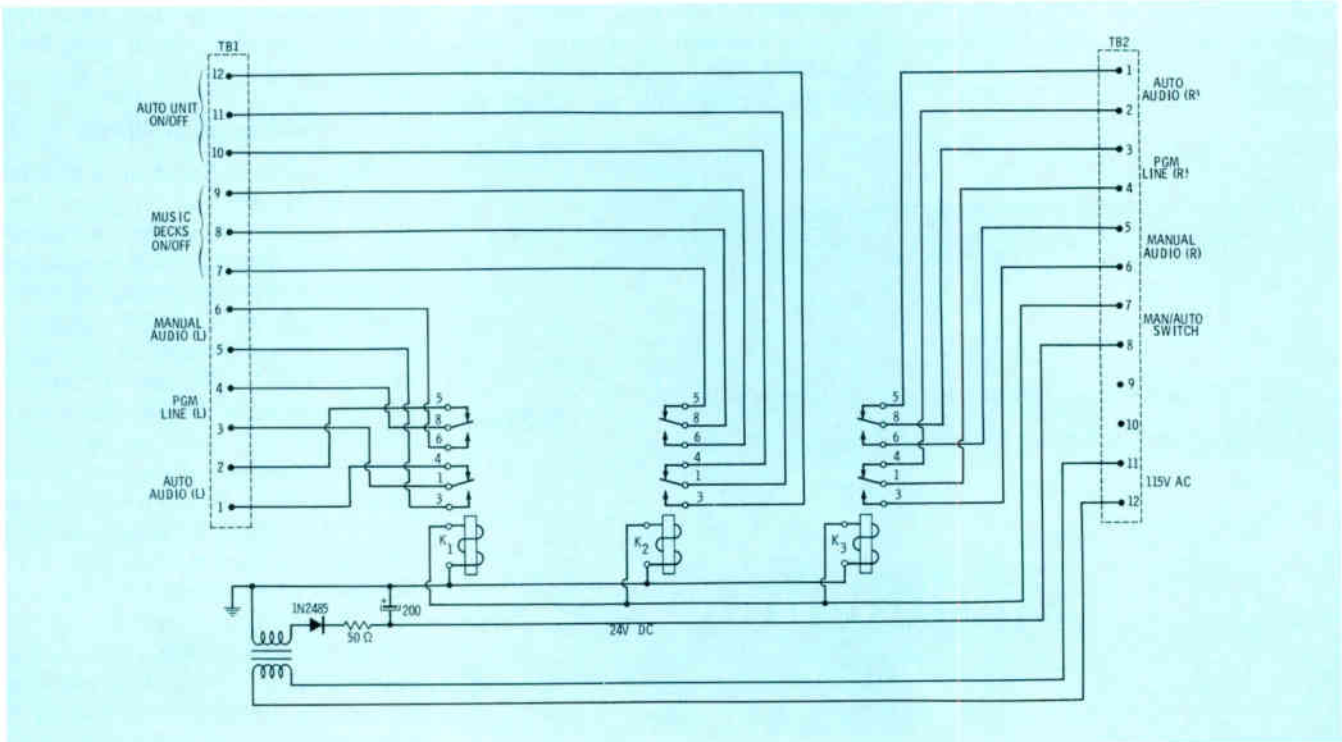

Fig. 5. This switching unit provides for the transfer of programming from the automatic mode to manual origination.

PHASE STABILITY OF COAXIAL CABLE

*by Fred Mysliwiec**

The effects of temperature variations on coaxial cable used as AM transmission line can be minimized by selection of cable-dielectric type.

Directional antenna arrays are used by many AM broadcast stations. Since variations in the relative phases of individual antenna-element currents cause variations in the directional pattern, the FCC maintains strict requirements for phase control in AM arrays; the current field practice is to impose a tolerance of ±2° deviation from the licensed value of phase difference. Therefore, the phase stability of any portion of the system feeding RF energy to the array becomes important, and good phase stability in the coaxial transmission lines feeding the individual elements of an antenna is essential.

Some of the factors which effect phase stability in coaxial cables are temperature variations, bending, vibrations, mechanical variations, and humidity. This article, however, is concerned only with the effects of temperature variations, and its purpose is to show the advantage of using an air or foamed-polyethylene-dielectric cable in place of those which employ solid polyethylene as a dielectric. The advantage can best be shown by explaining how coaxial cable is effected by temperature variations, and then by presenting electrical-length data measured on cable samples over a wide temperature range.

*Andrew Corp.

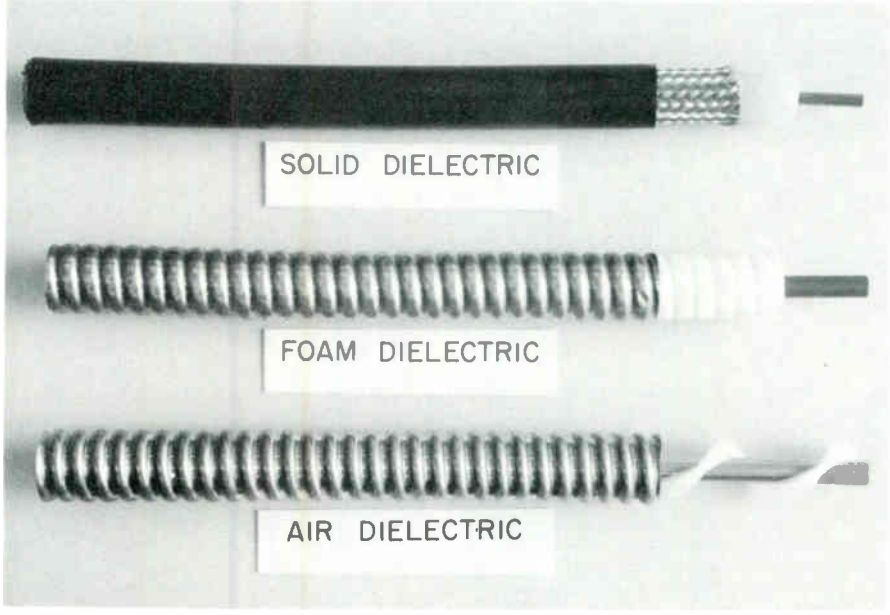

Fig. 1. Phase-temperature effects vary with type of construction employed.

Temperature Effects

The electrical length of a coaxial cable is the physical length of free space which exhibits an equivalent time delay. When a cable is exposed to temperature variations, its electrical length is affected by changes in the physical length of the conductors and by changes in the dielectric constant of the insulating material.

When the outer conductor of the cable is in the form of a solid metal tube, the physical length of the transmission line increases with temperature as determined by the coefficient of linear expansion of the metal. For copper, the coefficient is approximately +10 parts per million per degree Fahrenheit (PPM/°F). Conversely, a nonpolar dielectric material (such as polyethylene) ex-

hibits a decrease in density and a consequent decrease in dielectric constant with an increase in temperature. The velocity of propagation in the cable, which is inversely proportional to the square root of the dielectric constant, will therefore increase with increasing temperature. In a cable composed of copper conductors and a polyethylene dielectric, the increase in velocity in the cable partially offsets the increase of physical length caused by expansion of the copper conductors.

Measurements and Tests

Practical coaxial cable design requires that the inner conductor be supported by some means other than air, and a variety of dielectric materials and methods of construction are encountered. Most cables used at the present time employ polyethylene as the dielectric material, but the amount of the material used depends on the method of construction. The extent to which the dielectric influences cable behavior can be demonstrated most easily by conducting tests in a controlled environment.

Tests to measure the change in electrical length versus temperature (referred to in this article as phase-temperature coefficient) for three different cables were conducted. The cables were a 7/8" air-dielectric cable with a polyethylene helix dielectric, a copper-tube inner conductor, and a corrugated copper outer conductor; a 7/8" cable with foam dielectric (a combination of air and polyethylene) and a copper-tube inner and corrugated copper outer conductor; and RG-17/U, a cable with solid polyethylene dielectric and a solid copper inner and braided copper outer conductor. These cables are illustrated in Fig. 1. In the tests, phase-temperature characteristics were obtained over the temperature ranges of −40°F to 175° F for the foam- and solid-dielectric types, and −40° F to 218° F for the air-dielectric cable.

Stabilization

Before tests are conducted on coaxial cable, it must be stabilized. This problem arises because, during the first few heat cycles, permanent changes in the physical length of the cable occur. This is demonstrated by the behavior curve of unstabilized cable in Fig. 2. The first heating produced the curve from Point 1 to Point 2, and the cool-down response is represented by the line from Point 2 to Point 3. With subsequent heatings, lesser permanent length changes are observed (Points 5 through 11). When permanent changes become negligible with additional cycles, the cable can be considered stable, and tests for phase-temperature characteristics can be undertaken.

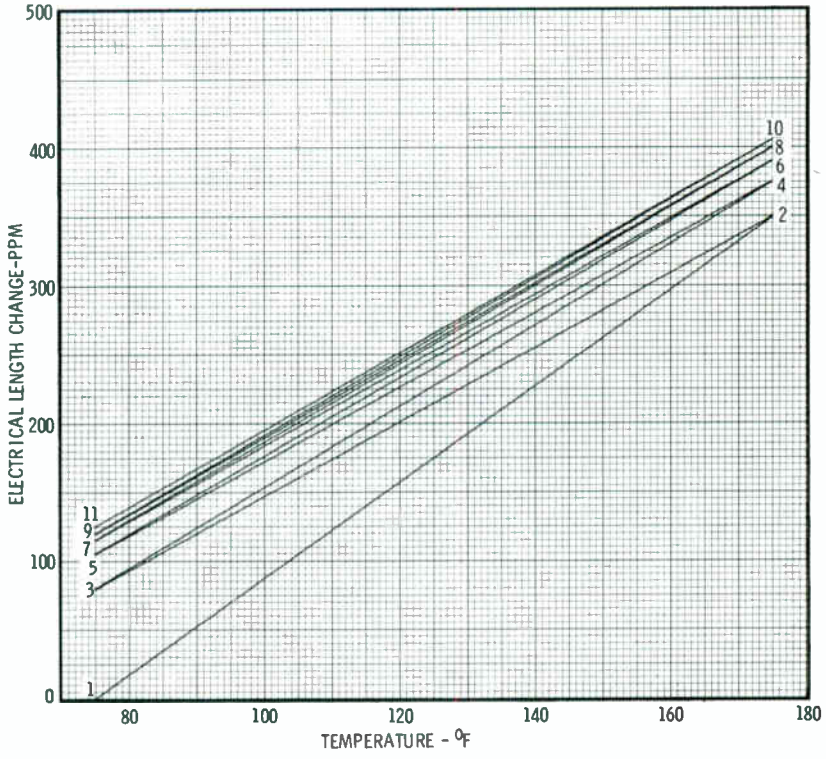

Fig. 2. Cable must be heat cycled in order to make it temperature stable.

Test Equipment and Method

When the three cables to be tested had been stabilized, they were heated in an oven (Fig. 3), allowed to cool to room temperature (70°), and then placed in a freezer (Fig. 4) where the temperature was lowered to −40°F. Measurements were

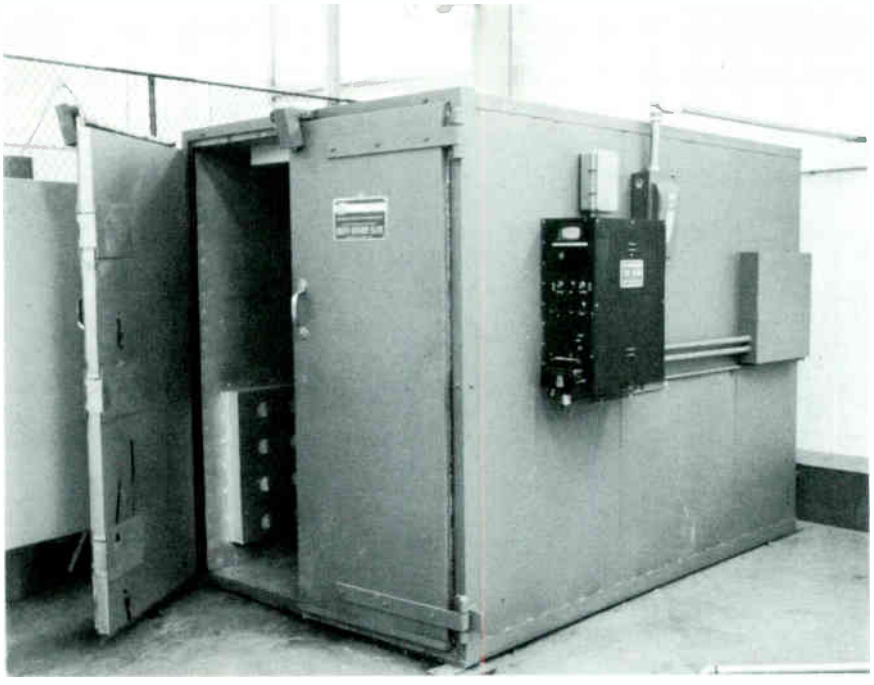

Fig. 3. Photo of oven used to stabilize cable and to heat cable in tests.

Fig. 4. This freezer made it possible to lower cable temperature to −40°F.

made for changes in electrical length at various temperatures for each of the cables during the time they were subjected to the temperature variations. A diagram of the instrumentation used for the tests is shown in Fig. 5, and a photograph of the test equipment is shown in Fig. 6.

The measurements were made by the comparison method of locating a null in the slotted line. With this method, a signal is fed from a signal generator to the line to be tested. The signal travels through the cable and is compared to the incident signal. By adjusting the position of the probe for phase, and the probe depth for magnitude, a very sharp null can be obtained. The length of the cable does not become a critical factor since the attenuation in the cable can be balanced by adjusting the probe in the slotted line.

The directional coupler at the generator end of the line isolates any reflected signals caused by discontinuities in the line or system from the incident reference signal. The signal impedances from the incident and slotted-line end of the cable are compared at the probe, and when they are exactly opposite conjugates, a very sharp null is obtained. Attached to the slotted line and probe carriage are an accurate scale and vernier which enables the null in the system to be located within 0.005 inch.

A standard reference cable was used in order to insure that good stability in the instrumentation was maintained. Since it has the lowest electrical-length change with temperature, an air-dielectric cable was used for the reference cable. This cable was used to check the instrumentation for stability before and after each set of data was recorded. From these measurements, the phase-temperature coefficients for the three different samples were obtained

The formula used to calculate the phase-temperature coefficient for change in electrical length was:

$$K = \frac{\triangle L \times 10^6}{L_t \times \triangle F} \qquad \text{(eq 1)}$$

where,

- K = Phase-temperature coefficient, or increase in electrical length in parts per million per degree Fahrenheit
- $\triangle L$ = Change in electrical length as noted by position of probe carriage in inches
- L_t = Length of cable sample in inches
- $\triangle F$ = Change in temperature in °F

Test Results

Fig. 7 shows the electrical-length variation versus temperature for the ⅞" air-dielectric cable. This cable has a minimum amount of polyethylene dielectric necessary to provide adequate support of the inner conductor. On the same graph is shown the coefficient of linear expansion for copper. The shifting of the curve

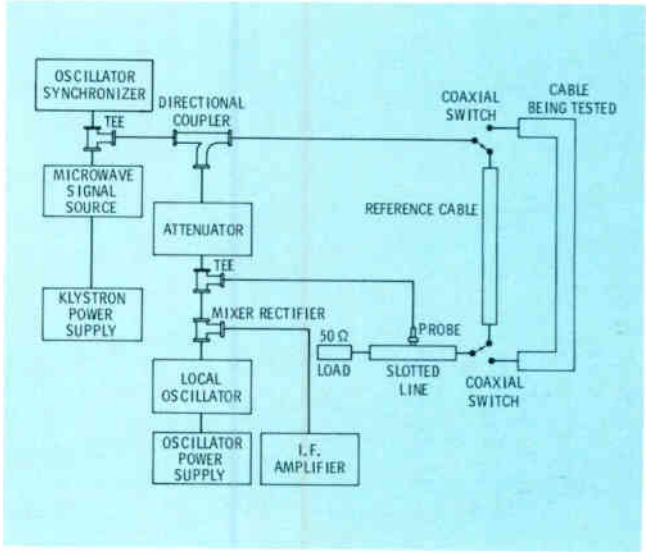

Fig. 5. Block diagram shows test instrumentation setup.

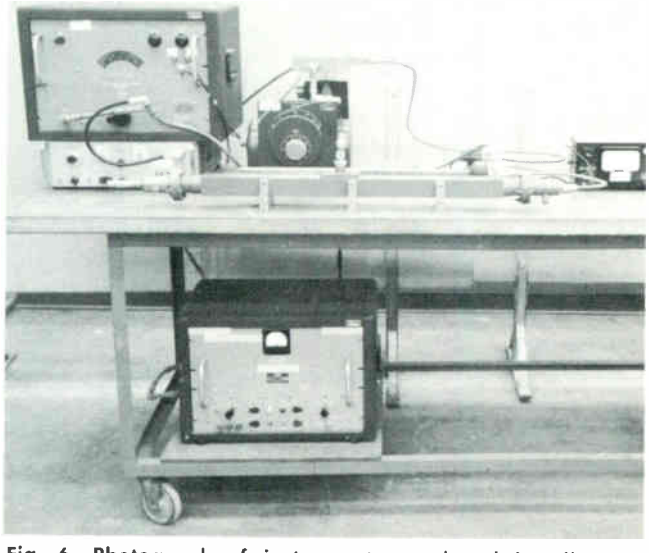

Fig. 6. Photograph of instruments employed in all tests.

from copper to that of the air-dielectric cable is due to the compensating effect of adding polyethylene insulation to the cable. As this graph indicates, it is possible to compensate an air-dielectric cable by using the right amount of polyethylene insulation to obtain a very low phase-temperature coefficient over a limited temperature range. Since the dielectric constant versus temperature for polyethylene is not a linear relationship, compensation over extremely wide ranges of temperature is not possible for very critical requirements. The phase-temperature coefficient of the air-dielectric cable is positive over the entire temperature range measured. This is because the increase in physical length which results from the expansion of the copper conductors exceeds the small amount of velocity increase in the cable caused by the change in dielectric constant of the polyethylene.

Also shown in Fig. 7 is the phase-temperature characteristic of the 7/8" foam-polyethylene-dielectric cable. Since this cable contains a larger amount of dielectric material than an air-dielectric cable, the change in velocity in the cable more than compensates for the physical expansion in the copper conductors. This property of a foam-dielectric cable gives it a negative phase-temperature coefficient over the range tested. The nonlinear property of dielectric-constant change with temperature for polyethylene is clearly demonstrated by the changing slope of this curve.

In Fig. 8, the phase-temperature characteristics for the three cables tested are shown together for comparison. As this figure shows, the solid-dielectric cable has a very large phase-temperature coefficient in comparison to the two other cables tested. A solid-dielectric cable, such as the RG-17/U tested, appears as an overcompensated cable since it contains more polyethylene than air- or foam-dielectric cable.

Phase Variations in Directional Antennas

With the information and data obtained from this experiment, the variations to be expected in a directional array using coaxial feed lines can be determined by means of a

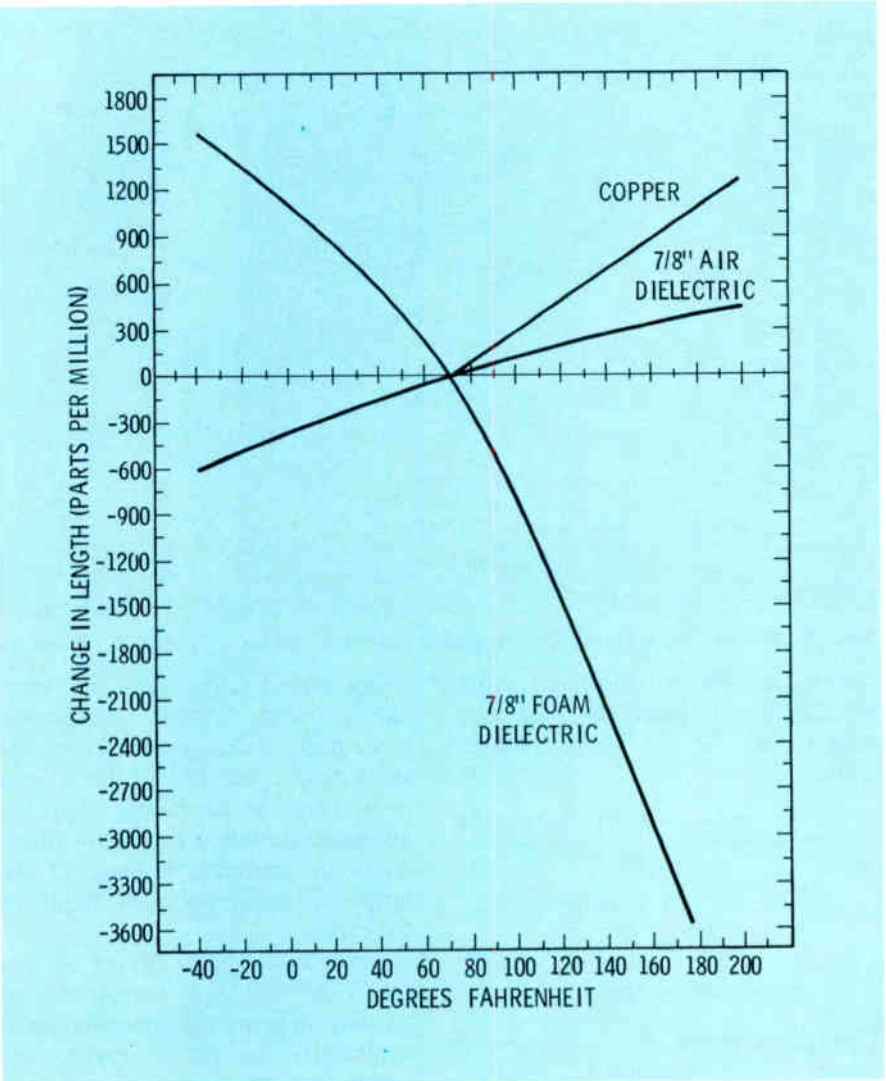

Fig. 7. Electrical-length variation versus temperature for 7/8" coaxial cables.

sample calculation. An arbitrary set of conditions typical for an AM directional antenna has been chosen. Assume a two-tower directional array in which the line feeding one tower is 500 feet longer than the other; only the length differential is important, since relative phase change is the parameter to be considered. From these conditions and the measured data, the change in phase for each of the cables can be obtained.

Frequency: 1 MHz
Length of Cable: 500 feet
Temperature Range: −20°F to +140°F (−20°F for cable exposed to winter weather, +140°F for cable exposed to summer sun)
Wavelength in Air: 11,810 inches

From the conditions stated, the values listed in Table 1 were determined from the formula:

$$\lambda_c = \lambda_a \times V_c \quad \text{(eq 2)}$$

where,

λ_c = Wavelength in the cable
λ_a = Wavelength in air
V_c = Relative velocity in the cable referred to light as unity

From the values listed in Table 1 and from the phase-temperature curves, the change in electrical length can be determined for a 500-foot length of cable when the following formula is applied:

$$\triangle L = \frac{(K_2 - K_1)(l \times 12)}{10^6} \quad \text{(eq 3)}$$

where,

$\triangle L$ = Change in electrical length in inches
K_1 = Phase-temperature coefficient at temperature 1
K_2 = Phase-temperature coefficient at temperature 2
l = Length of cable in feet

From the change in electrical length, the change in phase can be

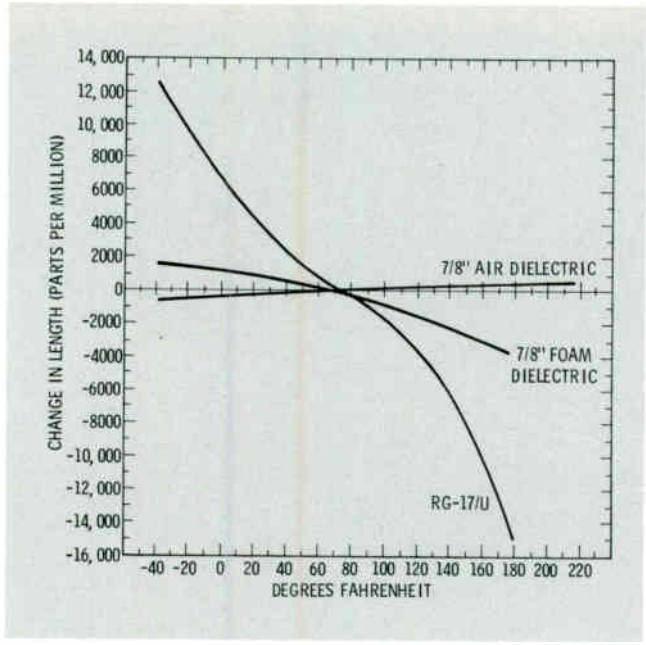

Fig. 8. Phase-temperature characteristics for all cables.

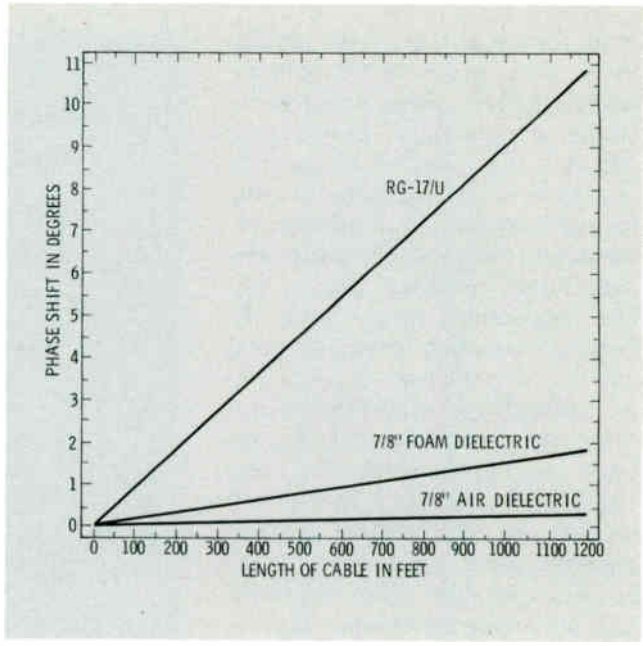

Fig. 9. Phase change vs cable length for three cables used.

determined. Shown below is a sample calculation using the data obtained for the ⅞" air-dielectric cable.

$$\triangle L = \frac{[+260-(-480)]\,(500\times 12)}{10^6}$$

$$= \frac{+\,740\times 6000}{10^6}$$

$$= 4.44 \text{ inches}$$

$$\text{Change in phase} = \frac{4.44 \text{ inches}}{30.2 \text{ inches/Electrical degree}}$$

$$= 0.147^\circ$$

The changes in phase for the three cables tested are listed in Table 2. These values are a result of calculations using the arbitrary set of conditions stated. From this table, it can be seen that, for the sample case, the RG-17/U has by far the largest phase change with temperature. Fig. 9 shows the phase change versus cable length over a certain temperature range for the three cables tested. Without considering other parts of the system, the results show that when RG-17/U is used to feed an AM directional array, the allowable deviation in relative phase could be exceeded because of the large change in electrical length of the cable.

Since other parts of the system (such as antenna matching and phasing network components) also contribute to phase error, the amount of phase shift due to the cables should be kept as low as possible. If one-half of the total phase error is allotted to the coaxial feed lines, the phase change in the cables must be held to ±1°. As can be seen from the table, the only cables acceptable (under the assumed conditions) would be those with air or foam dielectric.

For cables of different construction and material, the change in phase-temperature coefficient with temperature varies greatly. For the cables tested, the amount of variation over the temperature range of −40°F to 175°F was between −20.4 and −266.0 PPM/°F. The variation for the ⅞" air-dielectric cable tested over the temperature range of −40°F to 218°F was between 1.92 and 6.20 PPM/°F.

Table 1. Cable Electrical Lengths

Cable Type	Wavelength in Cable	Vc	Inches/Electrical Degree
⅞" air dielectric	10,870 inches	0.92	30.2
⅞" foam dielectric	9,330 inches	0.79	25.9
RG-17/U	7,680 inches	0.65	21.3

Table 2. Phase Variation in Cable

Cable Type	Change in Electrical Length	Change in Phase
⅞" air dielectric	4.44 inches	0.147°
⅞" foam dielectric	−21.4 inches	−0.826°
RG-17/U	−97.8 inches	−4.59°

Conclusion

The importance of knowing the phase-temperature characteristics of the cables to be used for feeding an AM directional array has been established. This knowledge can be useful in determining the relative changes of current phases due to temperature changes in unequal-length feed lines. ▲

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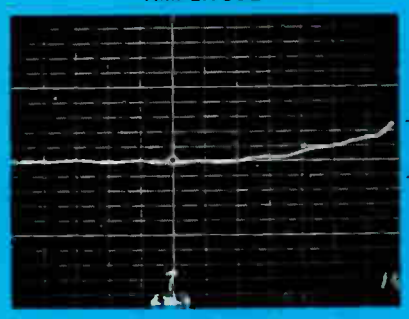

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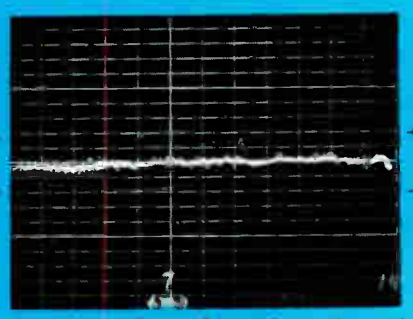

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BROADCAST ANTENNAS ON THE EMPIRE STATE BUILDING

by Thomas R. Haskett—This is a description of how a multitude of FM and TV stations broadcast from the "world's most unusual antenna site."

On May 1, 1931, construction was completed on what is still the world's tallest building—the Empire State Building in New York City. Less than eight months later, a television transmitting antenna had been erected atop the structure (a point originally designed as a mooring mast for dirigibles). During the ensuing 36 years, television and FM radio signals have continued to be transmitted from this location. Today, 22 stations share the site.

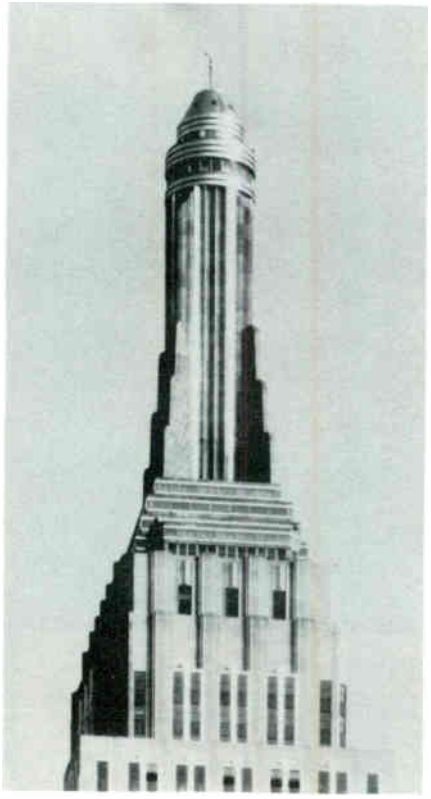

Fig. 1. 1931 Empire State TV antenna had separate visual, aural elements.

Early History

The original tenant at the pinnacle of the mooring mast (the topmost portion of the building) was the National Broadcasting Company. NBC began experimental television transmissions from the first Empire State antenna on December 22, 1931 (Fig. 1). Separate transmitters for visual and aural transmissions were used, with the call letters W2XF and W2XK, respectively.

These two transmitters were operated concurrently with another NBC television transmitter already located at the New Amsterdam theatre studio on 42nd Street. This earlier station carried the call letters W2XBS (later transferred to the Empire State transmitter) and operated on approximately 2 MHz with 60-line, mechanically scanned picture signals. The first experimental transmissions from the Empire State Building were 120-line pictures using mechanical scanning of both film and live subjects. (These are believed to be the first high-power, high-frequency transmissions received and monitored by means of the kinescope, or cathode-ray picture tube. At that time, the tubes had green fluorescent screens, since the white phosphor later used for black-and-white television had not yet been developed.) The Empire State tests, even though at a line rate twice that of the W2XBS 60-line tests, indicated that greater resolution would be required for a satisfactory public television service.

In 1934, NBC, cooperating with Major Edwin H. Armstrong, provided the high-power VHF transmitting facilities for tests of frequency modulation. These test transmissions continued until late in 1935, when the facilities were required for a continuation of the NBC-RCA television field tests. A new antenna with horizontal polarization was installed in 1936, and a new series of tests using 343 scanning lines per picture was initiated from Empire

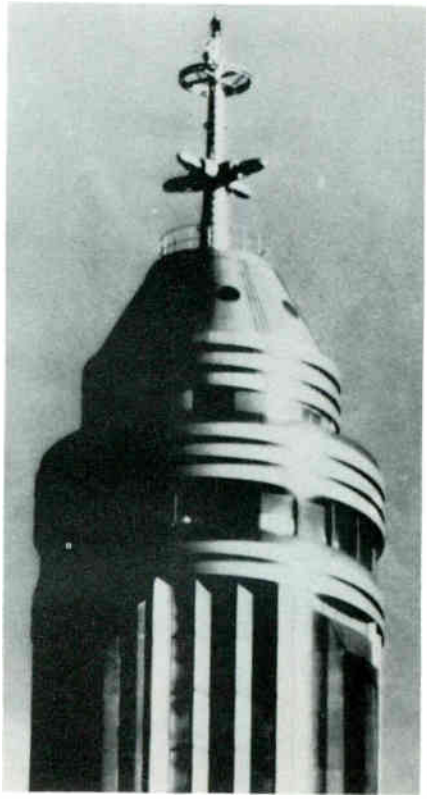

Fig. 2. 1939-1946 antenna had visual (lower) and aural (upper) elements.

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Type	Description
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7389C	4½"tube — field mesh; with close mesh-to-target spacing.

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8626	Equivalent to 8625, with 95 ma filament for transistorized cameras
8507	Low lag, high sensitivity characteristics; 600 ma filament
8541	Equivalent to 8507, with 95 ma filament for transistorized cameras
8572	Low lag characteristics for film application, monochrome or color; 600 ma filament

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State. These tests used for the first time a fixed relationship between visual and aural carriers so that receivers could be designed with a single tuning control. The tests also marked the first use of the iconoscope camera.

By 1938, NBC had again remodeled its antenna on the building. The experimental station, then designated W2XBS, broadcast a picture with 441 scanning lines. Transmission was within the range of 45 to 50 MHz, with various picture-to-sound carrier spacings.

A new NBC antenna was installed by February of 1939 (Fig. 2), and in January 1940 the company began regular FM operation from an antenna at the same site. (This station was W2XDG, operating on 42.6 MHz.) Shortly thereafter, the first National Television System Committee began work to recommend a TV system and standards to the FCC. The present system of 525 lines was adopted by the Commission early in 1941, and operating licenses were soon issued. On July 1, 1941, NBC began operation of a commercial television station. WNBT (now WNBC-TV) started its transmissions on channel 1 (50-56 MHz) from the antenna atop Empire State.

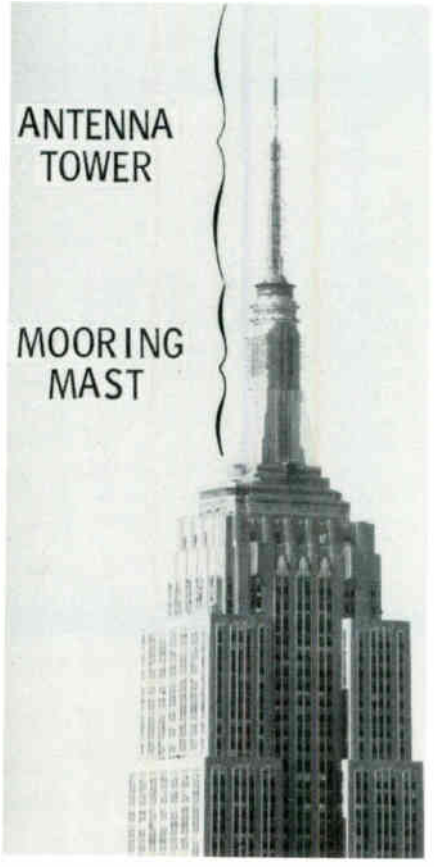


Fig. 3. Empire State Building today is shared by 22 FM and TV stations.

During the years of World War II, further experimentation advanced the television art. In 1946, NBC installed still another new antenna at the top of the building. This one transmitted the visual and aural signals of WNBT (which had begun operation on its present assignment of channel 4 on May 9, 1946). It also radiated the signal of the NBC FM station (now WNBC-FM) and experimental television signals on 288 MHz.

In 1941, there were two commercial TV stations in New York City. In 1944, a third took the air. By the end of 1948, six stations were operating in the metropolitan area, and in 1949, a seventh began broadcasting. Each transmitted from a different site — a situation that presented problems to both broadcasters and their audiences. Each station had to bear the expense of its own tower, or lease space on a tall building in Manhattan. TV viewers had the problem of rotating the antenna when they switched channels. To solve these problems, a project began to take form in 1949 which contemplated using the Empire State Building as the antenna location for several New York City television stations.

Multistation Site

Work began in 1950 on the multiple TV/FM antenna installation. Many engineers were involved in the research, design, testing, and construction of the multiple array. Among them were Dr. Frank G. Kear (Kear and Kennedy), John B. Dearing and Herman E. Gihring (RCA), and O. B. Hanson and Raymond F. Guy (NBC).

Prior to initial construction of this new antenna structure, the American Broadcasting Company had moved its transmitter to the Empire State Building and utilized an antenna at the top of the NBC supporting mast. Later in the year, during construction of the multiple-antenna structure, ABC's WJZ-TV (now WABC-TV) used an interim antenna mounted atop the mooring mast but tilted 15° from vertical. The NBC station did the same, for mutual isolation.

By December 1951, work was completed on the multiple-antenna installation. It was designed and built so that each of the five television and three FM stations could employ the maximum radiation permitted by the FCC. As shown in Fig. 3, the tower becomes progressively narrower as its height increases. This construction was dictated by the principles of good mechanical design. Since the wavelength, and consequently element size, decreases with increasing frequency, the antennas were generally arranged for increasing frequency with increasing height. The NBC antenna was an exception to this rule for two reasons: As original tenant at Empire State, NBC had prior rights to position on the tower. Also, since NBC chose a superturnstile antenna, it had to be on top; the slim steel pole would not support additional antennas above it.

In addition to handling the signals of five television stations, the tower was designed to radiate transmissions from three FM stations. The NBC FM transmitter output was triplexed into the NBC TV antenna. The ABC and CBS FM signals were diplexed into a single set of dipoles installed within the CBS TV antenna near the bottom of the tower.

In June of 1951, WNBT began transmissions from its antenna on the tower. In August, WPIX (channel 11) and what is now WABC-TV (channel 7) started using their facilities on the structure. WABD (now WNEW-TV, channel 5) joined the other stations in October, and WCBS-TV (channel 2) was operating from its new facilities by December. The ABC and CBS FM stations began operating from their common antenna in March of 1952.

With five of the then existing seven New York metropolitan area TV stations transmitting from the Empire State Building, the trend soon reached the other two. In 1952, WATV (now WNDT, channel 13), began transmitting from an antenna mounted on the mooring mast of the building. An additional installation was made during 1953, and in December WOR-TV (channel 9) began transmission from an antenna at the top of the mooring mast, just below the multiple-antenna tower. Sister station WOR-FM followed in

1956, utilizing an antenna just below the base of the multiple-antenna tower. In 1958, WNEW-FM began operation from an antenna within the WNEW-TV array.

When, in 1961, the FCC planned a test of UHF television in a metropolitan area, the Empire State Building was chosen as the antenna site. For the first (and so far only) time in its history, the Commission itself became a broadcast licensee. WUHF started transmitting November 1, 1961 from an antenna located on the four corners of the tower, beside the WCBS-TV array, near the tower base. The station (on channel 31) was later donated to the City of New York and became WNYC-TV.

By 1965 a ninth TV station had come on the air in the New York area—WNJU-TV (channel 47) licensed to Linden, N. J. It began transmitting May 16, 1965 from an antenna on the mooring mast of the building.

Combined FM Operations

By the fall of 1959, nearly 20 FM stations were operating in New York City. With five stations already transmitting from Empire State and six others expressing an interest in using facilities on the building, the possibility of a commonly shared FM antenna arose. Rather than simply tack on antennas one by one, it seemed advantageous to investigate the possibility of a master antenna. The Empire State Building Co. asked Dr. Kear for an opinion on the possibility of a master FM antenna. He recommended a feasibility study, which was undertaken by Alford Manufacturing Co. Dr. Kear and his associates then began design, in conjunction with the testing and construction of several scale models by Fred Abel, Andrew Alford, Harold H. Leach, and Nelson R. Powers, all of Alford Manufacturing Co.

In March of 1965, three New York FM stations agreed to lease space on the proposed master FM antenna; shortly thereafter, construction of the array was begun by Alford Manufacturing. As can be seen in Fig. 4 and the other photos, space on the mooring mast was limited. The best available location seemed to be the stainless-steel bands surrounding the 102nd-floor observation deck. Through the use of a scale model, various combinations of 8, 12, and 16 dipoles were tried, until tests proved 16 to be the optimum number for each bay. This configuration provided the required circularity in the horizontal plane together with a VSWR of less than 1.10 to 1 from 90 to 108 MHz and less than 1.20 to 1 from 88 to 90 MHz. One of the dipoles is seen in Fig. 5.

Dual polarization was incorporated into the antenna by orienting each dipole 45° away from the horizontal. Each dipole is fed 22.5° out of phase with respect to its neighbors; this arrangement was found to give satisfactory patterns and a low standing-wave ratio. The dipoles are arranged into groups of four, each group being fed by one element of a four-way fork. Each bay contains 16 dipoles, and there are 2 bays. A transfer panel allows feeding both bays, or either bay in case of an emergency.

Each station is connected to the antenna through a multiplexer which offers a high degree of attenuation to all frequencies except that of the input station. All multiplexers are connected in a line, and beyond the last station is an extra, unmultiplexed input. If any station's multiplexer should be put out of service, that transmitter may be coupled to the last input for emergency operation. Normal isolation from transmitter to transmitter varies from 26 to 55 dB. The antenna will accommodate 17 stations of up to 10 kw.

On December 9, 1965, WQXR-FM became the first station to begin transmitting from the master FM antenna. During 1966, seven more stations installed transmitters in the building and used the master array; January, WHOM-FM; February, WLIB-FM and WOR-FM; March, WBAI and WNCN; September, WNYC-FM and WPIX-FM. On February 1, 1967 WRFM became the ninth station to transmit from the master FM antenna.

1967 Facilities

Today the Empire State Building occupies a unique position in the broadcast industry. It furnishes leased vertical space of 317 feet for the antennas of 22 stations. Between the 80th and 85th floors are housed 35 separate broadcast transmitters

Fig. 4. "Yagi" arrays are for ch 13.

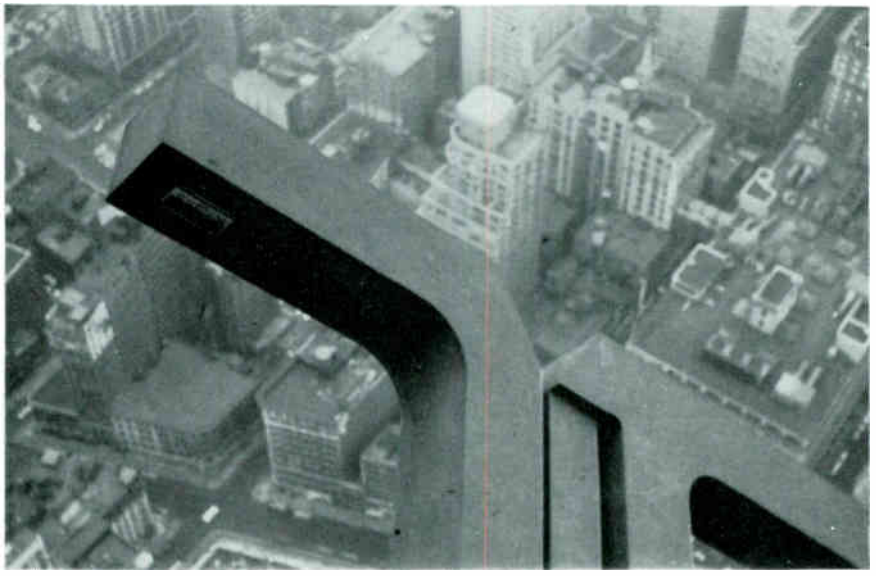
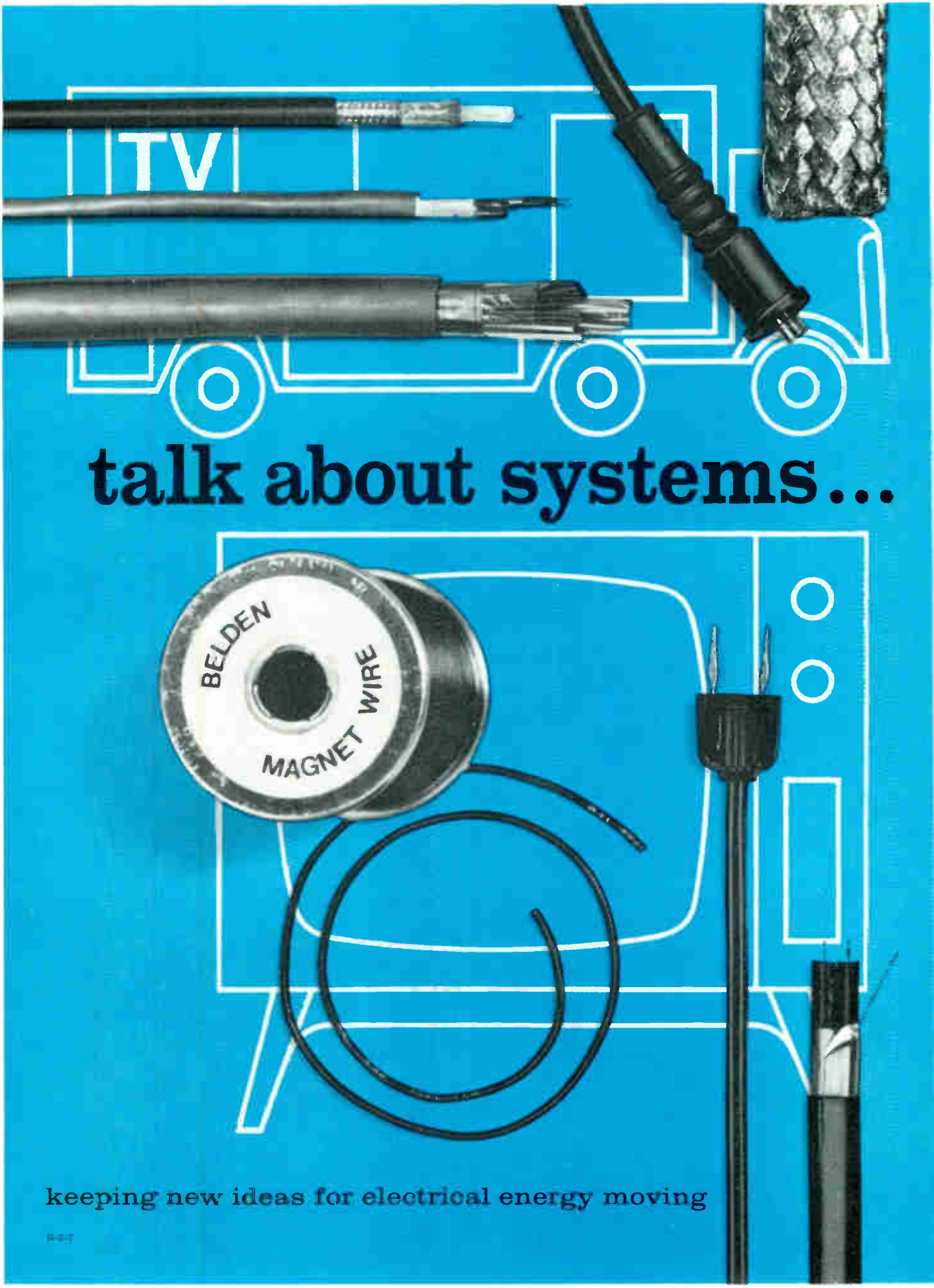


Fig. 5. One element of the master FM antenna seen from window on 102nd floor.



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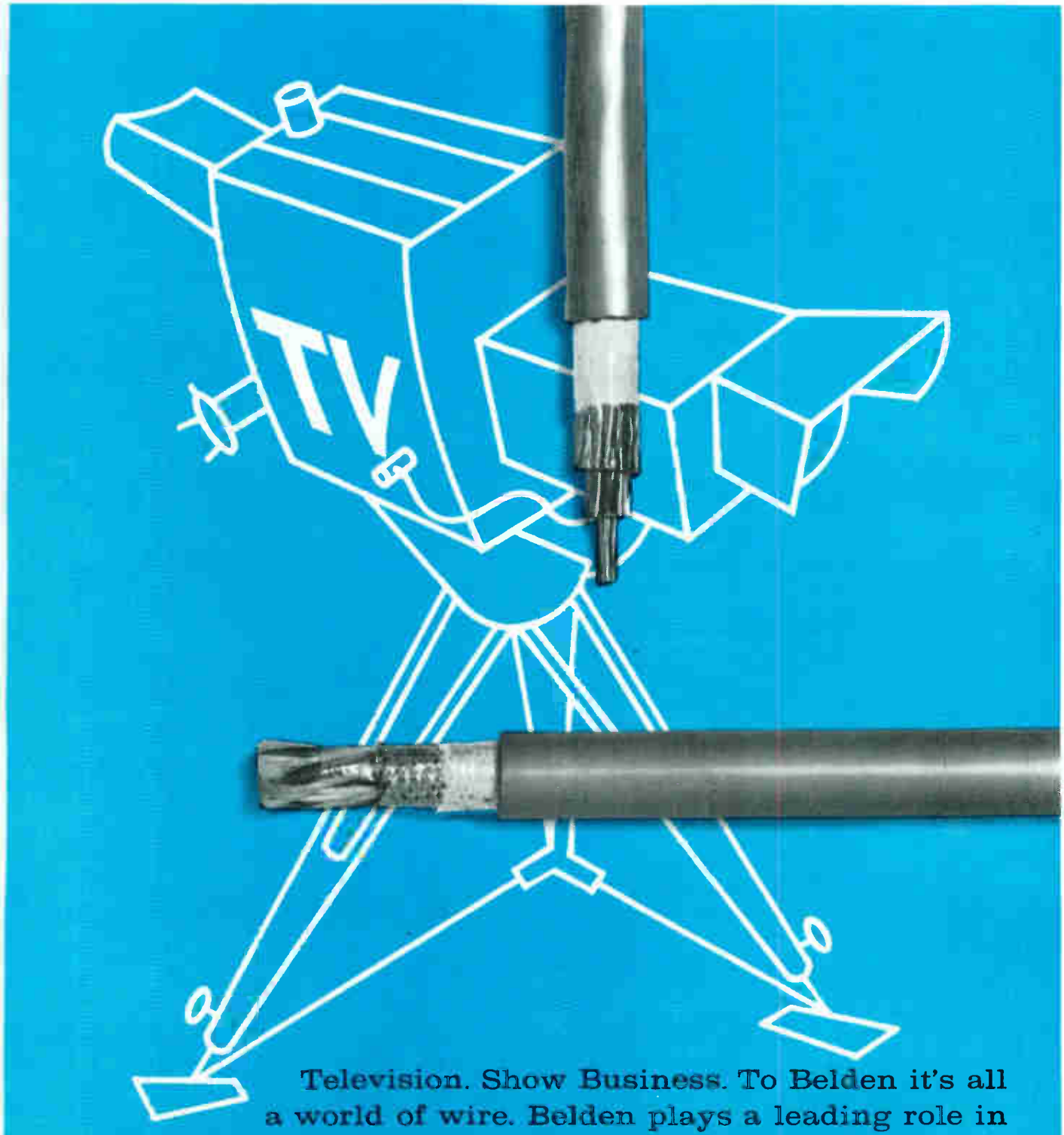

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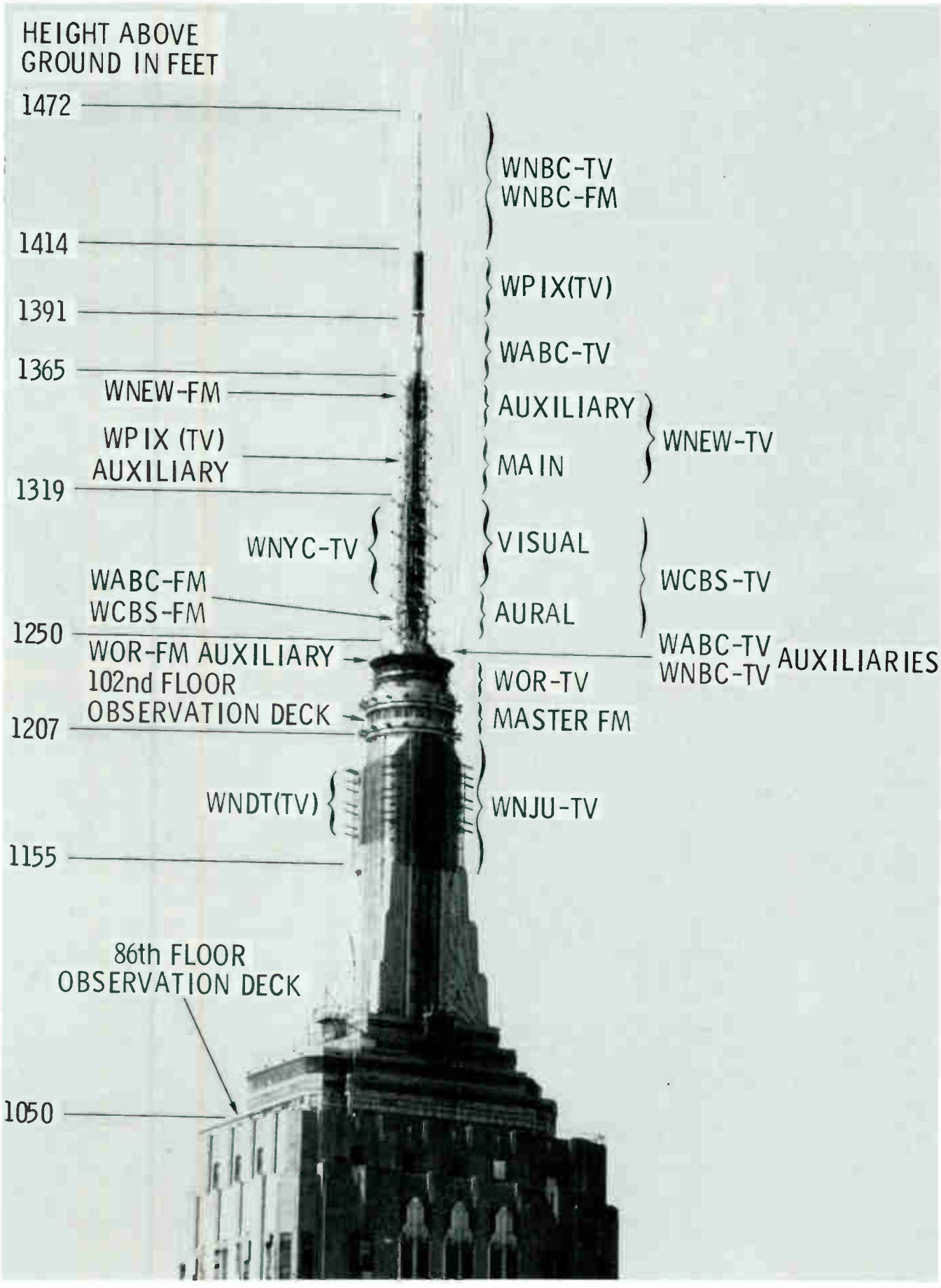


Fig. 6. A detailed view of the upper portion of the Empire State Building showing locations of transmitting antennas.

with a combined total RF output power of over 400 kw. The Empire State Building Co. owns the master FM antenna and leases it to individual FM stations — perhaps the only such situation in the world. The company also has responsibility for general maintenance of the TV tower.

The tower is provided with a code beacon, and there is obstruction lighting at three lower levels. The mooring-mast section of the building is illuminated by floodlights. FCC rules with respect to tower painting are waived in favor of tower lighting 24 hours per day.

Stations currently transmitting from the building are listed below in order of their position from the top of the tower (Fig. 6).

WNBC-TV (ch. 4): 25.7 kw visual, 5.13 kw aural at 1445 ft.*

WNBC-FM (97.1 MHz): 1.1 kw at 1445 ft. WNBC visual, aural, and FM signals are triplexed into a single 4-bay superturnstile antenna 56 ft in length.

WPIX (TV) (ch. 11): 100 kw visual, 20 kw aural at 1400 ft, using a zigzag antenna 23 ft in length. (Also auxiliary antenna at 1325 ft level.)

WABC-TV (ch. 7): 110 kw visual, 11 kw aural at 1380 ft, using a Z-type antenna 25 ft in length.

WNEW-FM (102.7 MHz): 4.1 kw horizontal, 4.1 kw vertical at 1360 ft. A special single-bay antenna is used. It consists of 4 horizontal dipoles on the tower faces, and 4 vertical dipoles on the corners. All dipoles are positioned between the upper two bays of the WNEW-TV array.

WNEW-TV (ch. 5): 37.1 kw visual, 5.5 kw aural at 1330 ft. A five-bay antenna 56 ft in length is employed. The upper two bays are used as an auxiliary antenna, while the lower three bays are used as the main antenna.

WPIX (TV): This station also has a single set of dipoles at the 1325-ft level as an auxiliary antenna. (Main antenna at 1400 ft.)

WCBS-TV (ch. 2): 42 kw visual, 8.32 kw aural at 1300 ft. A five-bay antenna 65 ft in length is used. The upper three bays are for visual, and the lower two bays for aural transmission.

*Power is ERP, and height above average terrain, in all cases.

WNYC-TV (ch. 31): 890 kw visual, 89 kw aural at 1290 ft. A special antenna, utilizing vertical slots in a colinear traveling-wave array 40 ft in length is in service. There are 24 slots, or bays, in each element.

WABC-FM (95.5 MHz): 1.5 kw at 1270 ft.

WCBS-FM (101.1 MHz): 1.5 kw at 1270 ft.

WABC-FM and WCBS-FM are diplexed into a single-bay antenna consisting of four horizontal dipoles mounted on the tower faces between the two lower bays of the WCBS-TV array.

WABC-TV and WNBC-TV: These stations have auxiliary antennas at the 1250-ft level (the very top of the mooring mast).

WOR-FM: An auxiliary antenna is located just below the base of the TV tower.

WOR-TV (ch. 9): 155 kw visual, 31 kw aural at 1240 ft. A special 2-bay antenna 8 ft in length is in use. Each bay consists of 24 dipoles equally spaced around the top of the mooring mast, approximately 35 ft in diameter.

Master FM Antenna: Each of the two bays consists of 16 dipoles equally spaced around the mooring mast above and below the 102nd-floor observation deck. Height is 1220 ft. Stations now using the array:

WBAI (FM) (99.5 MHz): 5.4 kw horizontal, 3.8 kw vertical

WHOM-FM (92.3 MHz): 5.4 kw horizontal, 3.8 kw vertical

WLIB-FM (107.5 MHz): 2.0 kw horizontal, 1.45 kw vertical

WNCN (FM) (104.3 MHz): 5.4 kw 3.8 kw vertical

WNYC-FM (93.9 MHz): 5.3 kw horizontal, 3.7 kw vertical

WOR-FM (98.7 MHz): 5.4 kw horizontal, 3.8 kw vertical

WPIX-FM (101.9 MHz): 5.4 kw horizontal, 3.8 kw vertical

WQXR-FM (96.3 MHz): 5.4 kw horizontal, 3.8 kw vertical

WRFM (FM) (105.1 MHz): 5.2 kw horizontal, 3.7 kw vertical

WNDT (TV) (ch. 13): 178 kw visual,, 34.7 kw aural at 1180 ft. A stacked 6-bay yagi, 27.5 ft in length, is employed.

WNJU-TV (ch. 47): 234 kw visual, 46.8 kw aural at 1180 ft. In use is a special 4-bay vertical-slot antenna 52 ft in length. The antenna consists of two sections which are mounted on the north and south faces of the mooring mast.

The Future

Some time ago, a feasibility study was conducted by a consulting engineering firm for the Empire State Building Co. This study showed that the mooring mast could hold several more UHF antennas. Currently a CP is held by WTVE (ch. 41), licensed to Paterson, N. J., which proposes another antenna on the building. Another FM station is considering using the master FM antenna. Also, WABC-FM, WCBS-FM, and WNDT plan to install new antennas during the summer of 1967.

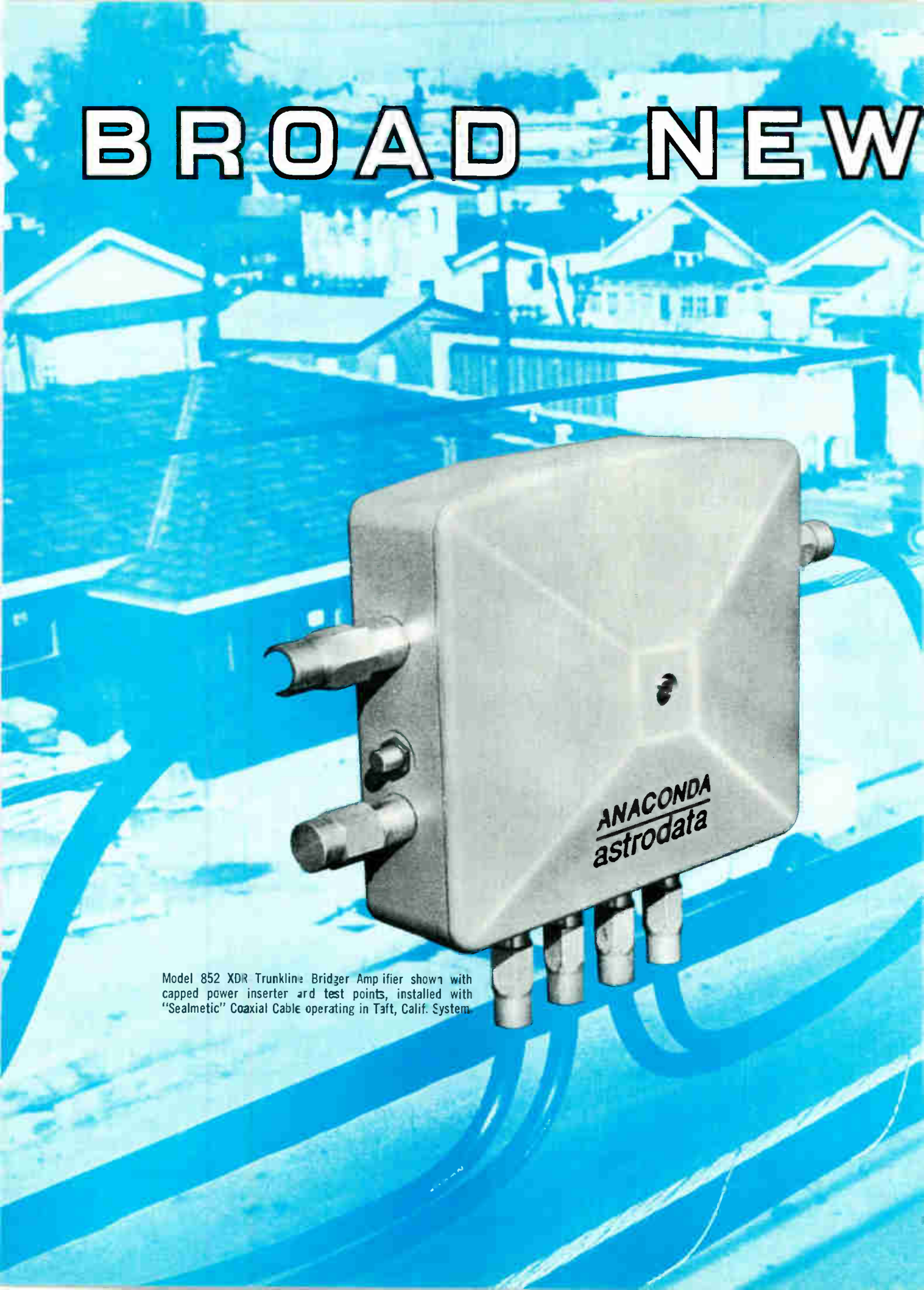
The world's most unusual antenna site may not exist much longer. Recently, the Port of New York Authority has been planning the construction of twin 110-story skyscrapers in Lower Manhattan. Independent studies by Alford Manufacturing Co. and Jansky and Bailey have shown that the proposed towers would cause ghosting to some viewers watching some of the TV stations presently on the Empire State Building. Several solutions to the program have been advanced, one being to relocate antennas from Empire State to the new, taller structures (to be known as the World Trade Center).

Whatever the future of the Empire State Building antenna site, it remains a monument to the ability of broadcast engineers and stations to cooperate for their mutual welfare and for the public benefit.

Acknowledgements

The author wishes to thank the various engineers of the stations, networks, and companies mentioned for their assistance in preparing this report. He is especially grateful to Thomas J. Buzalski of NBC, John F. Garrety of the Empire State Building Co., Dr. Frank G. Kear of Kear and Kennedy, Harold H. Leach of Alford Manufacturing Co., and Robert M. Morris, formerly of ABC and NBC. ▲

BROAD NEW



Model 852 XDR Trunkline Bridger Amp ifier shown with capped power inserter ard test points, installed with "Sealmetic" Coaxial Cable operating in Taft, Calif. System

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REPLACEMENT OF AN EXISTING PHASOR

by Robert A. Jones and Donald L. Markley***

With careful planning, accurate measurements, and correct installation procedures, it is possible to replace a phasor without exceeding permissible radiation limits.

There are many cases in which a directional AM station may find it necessary or desirable to modernize or upgrade its phasing equipment. Sometimes an existing phasor can be adapted for new requirements, but in other cases the solution may be complete replacement of the unit.

Phasor replacement may occur when the station changes its pattern, increases power, or adds a second pattern. For some stations, and increasingly so for those built during the late 40's and early 50's, existing phasors are beginning to show their age. Increased losses and failing components are a warning sign that replacement may be in order.

At WITY (Danville, Illinois), the original phasor had been modified to provide a second pattern a number of years ago. Experience had shown that the new pattern was difficult to adjust and control because there were no front-panel controls, and there was significant interaction between patterns. A decision was made to replace the unit.

The original phasing circuit was basically a satisfactory design; consequently, the new unit was based upon it. A few modifications were necessary, however, to resolve the adjustment and control difficulties. These consisted of tuning controls for the front panel and a few extra components.

Planning

Careful planning and very careful preliminary phasor measurements and adjustments are essential for minimum tuning difficulty when a new phasor has been installed. At WITY everything was planned so that the normal broadcasting schedule of the station was not interrupted. It is believed that a review of the method used will be useful to those contemplating phasor replacement.

Preliminary Measurements

The first step was to check the monitor points for both daytime and nighttime patteerns, and then to compare the results with the requirements of the station license. This was done to determine whether the pattern was in correct adjustment before any construction commenced. If the new phasor were adjusted to indicate the same base current ratios and phases as the old unit, then it seemed logical to assume that the same monitor-point readings would be obtained with the new unit. At WITY, it was found that the existing monitor-point measurements and other pattern parameters were all within FCC tolerances of the licensed values. If the pattern had not been within limits, the next step would have been to adjust the old phasor to the correct pattern.

Impedance Adjustments

The next step was to set the taps on all coils in the new phasor to approximately the same position as those in the old phasor. (If the size, diameter, or spacing of the new coils is different, this fact must be taken into consideration in tap placement.) At WITY, we had designed for the same basic phase shift and impedance transformation in each branch circuit. This served as a good first adjustment to place the new component values in the right "ball park."

Next, an RF bridge was used to adjust the new phasor circuits. It is necessary that the broadcast carrier be off during these measurements because it would be too strong for the bridge to be nulled. Our bridge measurements were made during the experimental hours, but they could have been made at any time the station was off the air. Each transmission line was terminated with a 52-ohm resistor at the point where the line left the old phasor. The bridge was connected at various points to "look into" the phasor toward these resistors, and the readings taken from the old phasor were then duplicated in the new. This technique permitted us to adjust for the original impedance. By using resistors in place of the towers, we insured that the tuning of one circuit would not be reflected into another circuit through mutual coupling between the towers. It should be pointed out that there were no changes in any of the towers or antenna tuning units, and therefore bridge measurements there were not required.

The schematic of the old phasor is shown in Fig. 1. The circles numbered 1 through 6 show the points at which the circuit was opened for the bridge readings. Only one point

*Consulting Engineer, La Grange, Ill., and BE Midwest Regional Editor.
**Consulting Engineer, Mapleton, Illinois.

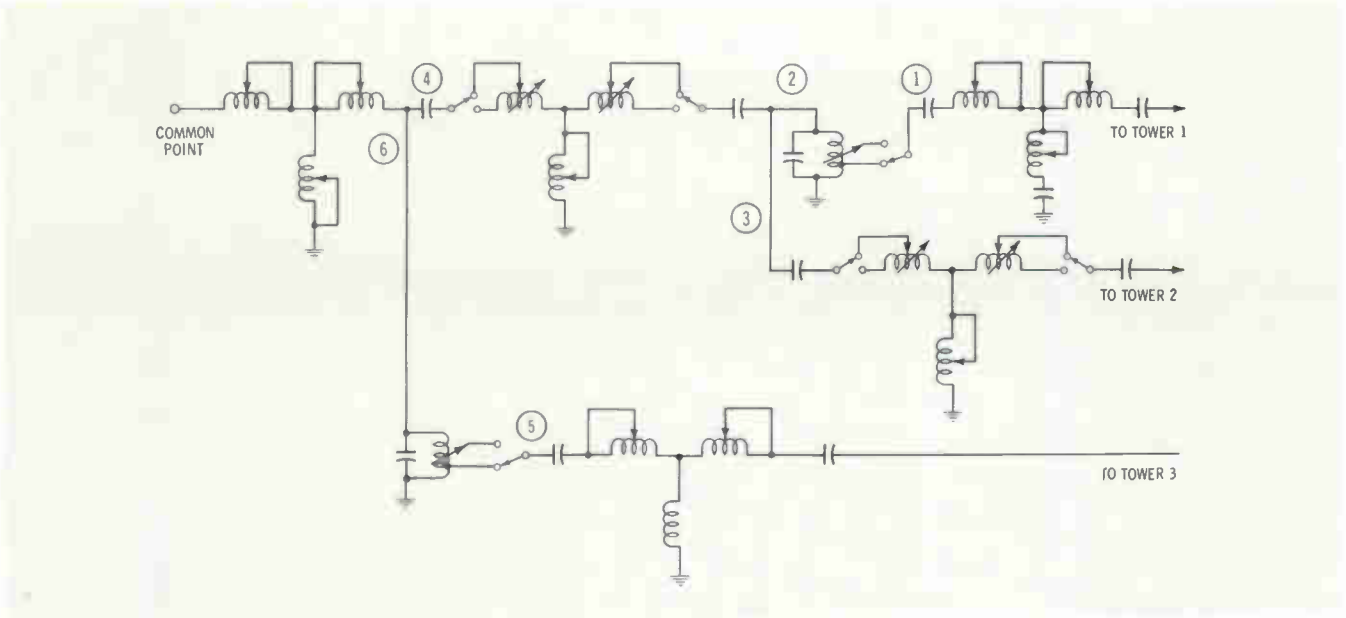


Fig. 1. The old phasor was difficult to adjust, and there was a considerable amount of interaction between elements.

was disconnected at a time, and all measurements were made at the operating frequency. Fig. 2 shows the new phasor with the corresponding locations numbered. When these circuits are balanced, care must be taken so that the coil taps are not moved very far in equalizing the impedances. The danger is that the phase shift may be altered excessively. By interrupting the circuit in the manner described, it is possible to adjust the new circuits, one at a time, to the same overall conditions as existed in the old phasor.

Testing the New Unit

Following completion of the preliminary impedance adjustments, temporary jumpers were connected between the new and old phasors. The new phasor cabinet had been moved close to the rear of the existing one, and a piece of RG-17/U coaxial cable was connected between the transmitter output and the new phasor. Three short straps were then connected from the transmission line terminals in the new phasor to the same points in the old unit, after the lines had been disconnected from the circuits in the old phasor. Also, a wide copper grounding strap was connected between the new cabinet and the station ground. With these connections, tuning and adjustment could proceed on the new unit during the experimental hours, yet the old phasor could be returned to service very quickly when it was time to resume programming.

After the jumpers were connected, the common-point circuit was adjusted to the correct impedance value for each pattern. The new phasor was then energized. The front-panel controls were trimmed up until the desired operating parameters were obtained on each of the patterns. The new phasor was then operated for several hours on each pattern (during the experimental period) to check for difficulties such as arcing, component heating, or instability.

Removing the Old Phasor

Once it had been determined that the new phasor was operating correctly, the old unit was removed and

• *Please turn to page 48*

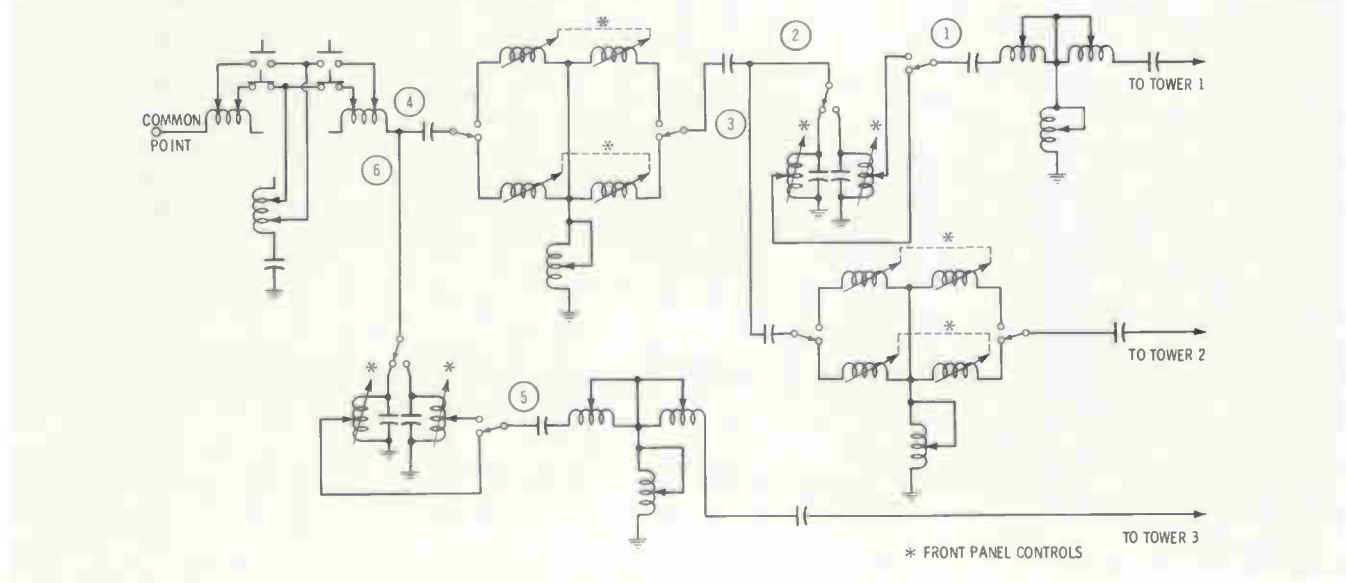
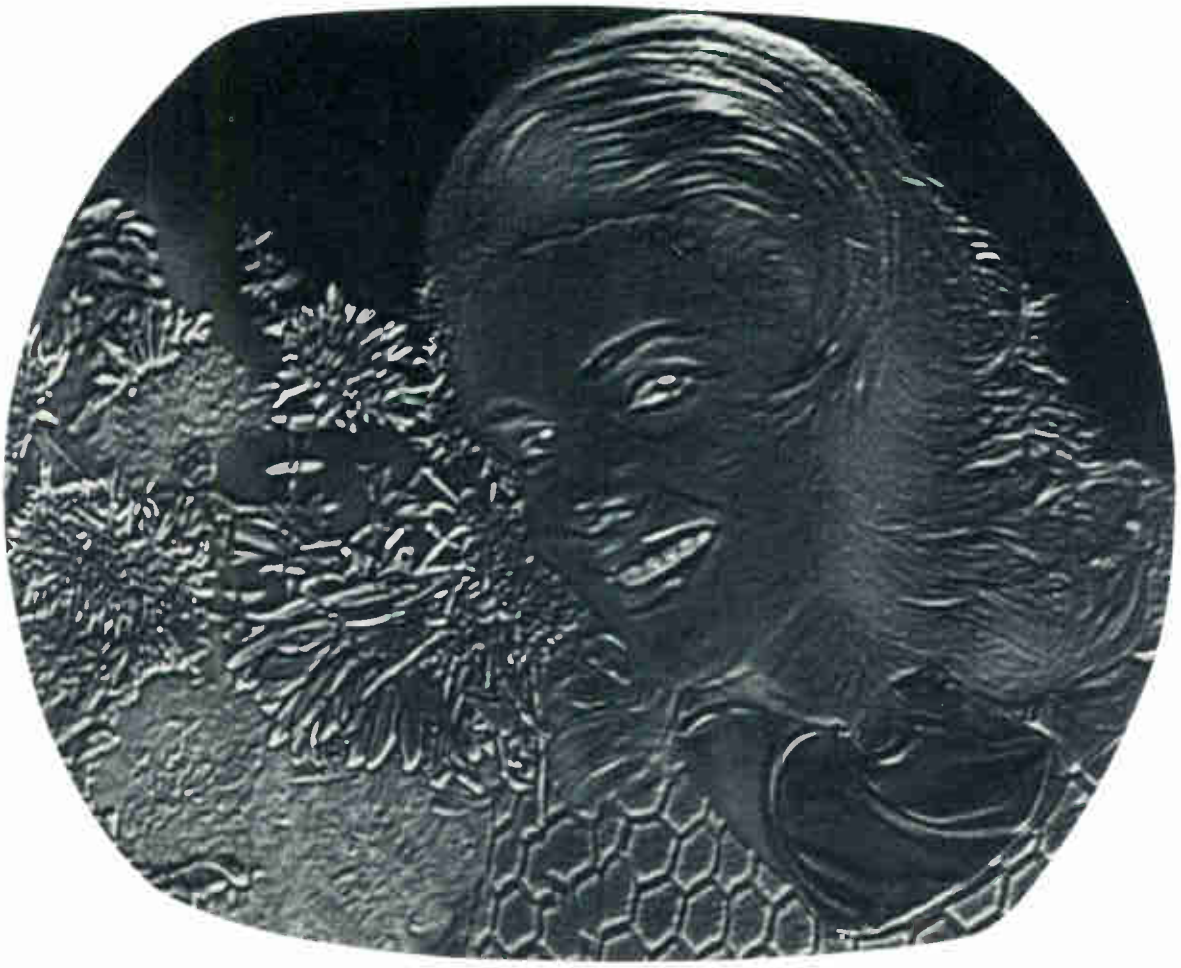


Fig. 2. Controls for the second pattern were brought to the front of the new phasor, facilitating tuning adjustment.



These unretouched photographs, taken directly from monitors, tell the story:

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SILICON RECTIFIER PROTECTION

by A. G. Swan— The causes of silicon rectifier failure are discussed, and methods to prevent their occurrence are presented.

Solid-state rectifiers have given broadcasters unusual advantages in efficiency, space-saving, and heat dissipation. Reliability has been amazing in most cases, but disappointing in some. There is sometimes a longing to revert to the vacuum-tube rectifier, where visual inspection can often spot the failure, and where replacement is quick and easy. But the solid-state era is here, and the rapid advances of manufacturing techniques and design are fast shaking out the bugs.

Although most of this progress has been in the past few years, the semiconductor field is not new. As early as 1835, the property of asymmetric conduction in certain solids was known. From this have cascaded many devices, including the old galena crystal detector, vacuum-tube diodes, and transistors.

Causes of Failure

There are three basic causes of failure in silicon rectifiers. These are temperature and thermal excursion, current overloads, and voltage transients.

Temperature and Thermal Excursion

Heat at a constant value is not a great problem, because silicon junctions can withstand temperatures up to 200° C, and sufficient cooling in the form of heat sinks and convection is not difficult to provide. More serious is thermal excursion. Here, the changes in temperature cause stress between the parts of the silicon cell, and may eventually cause crystallization. The forward resistance of the cell increases, dissipation rises, and the cell fails.

Current Overloads

Current overloads can quickly destroy silicon junctions. The junction is very small and has a normal current capability of a relatively high magnitude. Currents in the overload region, however, can rapidly heat the junction to a point of failure. Fortunately, overload-protection devices can be found which will act fast enough to prevent this.

Inrush currents occur when the rectifier sees a large capacitance at the input of a filter. These currents increase very rapidly as the applied voltage increases. This is because the forward resistance of the diode decreases as the voltage across it increases, and when this voltage reaches a peak of about 180 volts, the diode has virtually zero resistance. Hence, when the circuit is closed, the initial inrush current may be very large. These currents, where power dissipation permits, may be limited by series resistance. Where too large a dissipation would occur, a reactance can be used.

For broadcast reliability, the safest back-up precaution for both overload and inrush currents is to provide extravagent safety factors. The initial cost of this, although prohibitive for mass-produced commodities, is low when compared to the revenue losses of broadcast down-time.

Voltage Transients

Voltage transients are probably the most bothersome of the three main causes of diode failure. Transients are hard to predict and relatively hard to detect. They can occur as kick-backs from inductive loads and switching, but line-voltage surges—especially from lightning—are entirely unpredictable. Here again, economy should not be a factor in broadcast design, and more than adequate inverse peak-voltage ratings should be used. In spite of this, heavy direct lightning hits on AC power lines can produce voltage transients and forward currents of tremendous values.

Protection Devices

There are several surge-protection devices available, but the success of these is dependent upon the speed at which they act. It takes an almost immeasurably short length of time for a transient to destroy a junction, and the protecting device must act more quickly.

Thyrite Devices

Thyrite devices can handle large surges. The thyrite unit shunts the line, and its resistance decreases as the voltage increases. It is active, however, only at about 600 volts minimum, and a diode may be destroyed before this voltage is reached.

Krypton Tubes

A faster device, and one which operates at about 300 volts, is the krypton tube. Although faster than the thyrite devices, it cannot handle as heavy a current.

Selenium Suppressor

The fastest device is the selenium suppressor. These protection devices are available in sizes capable of handling considerable current, and are the basis of some commercially available protection devices.

Controlled-Avalanche Diode

The most significant step in transient protection is the development of the controlled-avalanche diode. Although the ordinary diode rectifier can dissipate considerable peak energy in its forward direction, it

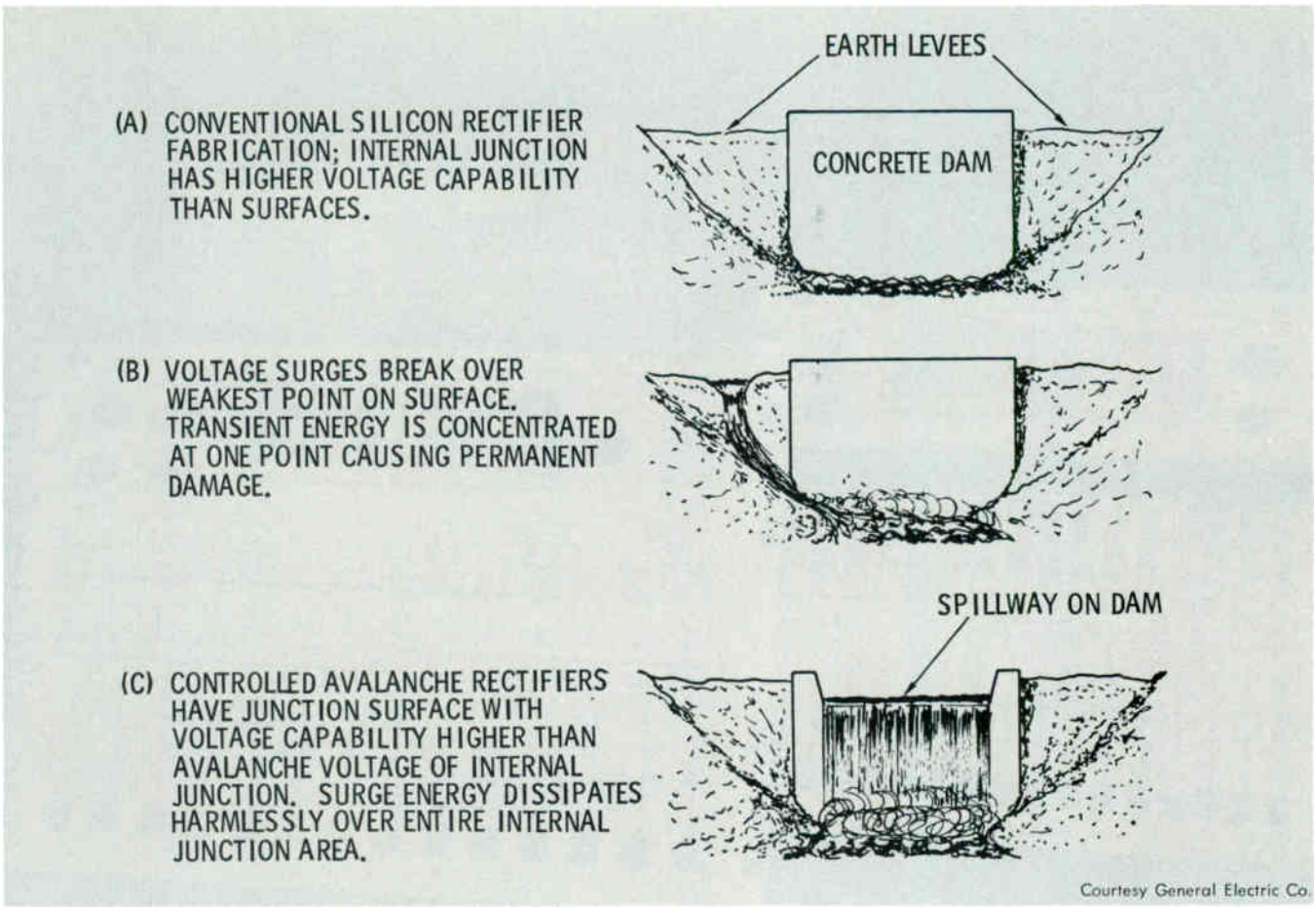


Fig. 1. Analogy to hydraulic operation shows how controlled-avalanche rectifiers dissipate surge energy harmlessly.

cannot do this in its reverse direction. When high voltage transients occur, the reverse current tends to seek out one tiny spot in the junction and pass through it. The result is a sudden very high dissipation, and the heat from this can destroy the entire junction. Diodes, however, possess a characteristic known as the "zener breakdown"; when a certain reverse voltage is reached, the diode suddenly passes a reverse current of large magnitude without damage to the junction. During this large reverse, or "avalanche," current, the voltage across the diode remains constant. It is this property which is used in zener voltage regulators. If the ordinary diode rectifier could be made to avalanche before the reverse voltage reached the value which would destroy the junction, it could handle many times the reverse currents set up by the voltage transients. This can now be done by careful control of the physical characteristics of the junction and the impurities injected into the materials. The result is the "controlled avalanche diode." A hydraulic analogy of this is shown in Fig. 1. So long as the described condition is satisfied, and the avalanche current causes a heat dissipation within the thermal capability of the diode, the diode will not fail.

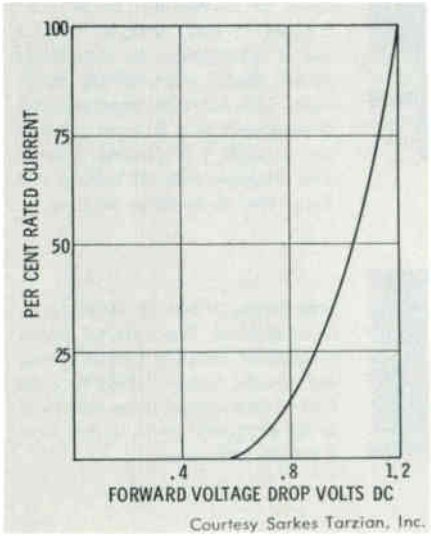


Fig. 2. Forward current rises rapidly.

Shunt Resistors

It is customary to shunt each diode of a series string with a resistance of high value. This is to equalize the voltage gradients across the string. Shunt capacitors also help absorb unequal effects of transients. These two precautions are not always necessary where controlled-avalanche rectifiers are used.

Preventive Maintenance

Preventive maintenance can catch some failures before they happen. If rectifier stacks are built so that individual diodes are accessible, a check across each diode with an ohmmeter will help locate bad ones before catastrophe strikes. This should be done about once a month. It should be emphasized that this is only a quick and approximate check of a rectifier. The forward current through a rectifier increases very rapidly in relation to the forward voltage drop (Fig. 2), and approaches a point where the internal resistance of the ohmmeter is great compared to the forward resistance of the diode. For accurate checks on a diode, the manufacturer's techniques for measurements should be followed.

Old rules for cleanliness still stand. Dust likes high voltages, and even if transient protection is provided, arcs across dust paths can overload the rectifier stack in its forward direction. Sufficient series resistance, fast overload relays, and routine cleaning are wise protection against this condition. ▲

RACK MOUNTED ASSEMBLY

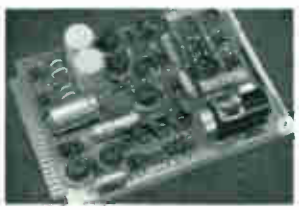
212T 2

212T 1

Photocell Operation. The photocell lamp completely isolates control voltage from the audio circuits for audio switching and level control. Small physical size enables the photocell to be located in active audio circuitry, thus keeping audio leads to a minimum. Switching time constant eliminates transients such as pops and clicks.

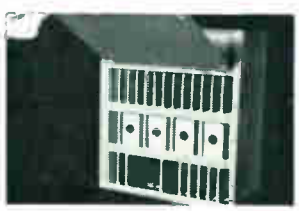
Remote Capability. Remote photocell location allows all audio and power supply components to be contained in a rack-mounted assembly. Because a photocell can be remotely controlled, it is suitable for distant audio switching and level control functions. Remoting active audio and power supply components in an area adjacent to the control room frees audio leads from video and sync signals present in the TV control room.

New Fader Design. New fader design eliminates problems associated with slide contact arrangements. The design provides smooth drive, free of backlash. Repair, if ever required, is very simple.



Solid-State Amplifiers. Solid-state amplifiers using silicon transistors are built on high quality, etched epoxy boards. Photocell operation provides switching and level control functions on the amplifier cards, not on the control panel. A selection of amplifier cards is available to meet all common input levels and impedances.

Illuminated Pushbutton Switching. Status is indicated either by two levels of illumination or by color changes in push buttons. Variable overall illumination is controllable to suit control room lighting conditions. Each panel has engraved push buttons with A or B input selection and Channel 1 or Channel 2 selection. Push-on, push-off buttons turn each fader on or off as required.



Easy Access. Access for maintenance is no problem. There are no hidden components. Straight forward wiring and remote control capability allow routine maintenance to be performed in an equipment room, rather than a control room area.

You don't have to order (and pay extra for) a Custom Control Console.

Check the features in Collins' new Audio Control System and see why.

Collins' new series of audio control systems is designed especially for television, large AM facilities and recording studios. The two systems making up the 212T Series are designated the 212T-1 and 212T-2 Audio Control Consoles. Both consist of three basic units: a control panel, a rack-mounted assembly containing the amplifiers and I/O terminals, and rack-mounted power supplies. The latter two units are common to both the 212T-1 and 212T-2.

Both systems have many features in common. The primary difference between the two systems is control panel configuration. Two different panel designs provide for a variation in the number of controls available and for flexibility in panel mounting.

The 212T-1 provides 28 inputs to 14 faders, two program output channels, two auxiliary program outputs, two 10-watt monitor outputs, and a built-in cueing speaker. The overall panel dimensions of the 212T-1 are 15¾" high x 24" wide.

The 212T-2 provides 32 inputs to 16 faders. The control panel is divided into two separate functional sections. A 5¼" high x 19" wide section contains the VU meters and monitoring controls. The other section containing faders and cue switches is 10½" high x 19" wide. Both sections may be rack-mounted. The two panels are interconnected by plug-in cable assembly. When desired, the VU meter panel may be mounted at a different angle or location than that of the fader panel.

Rack-mounted Assembly is common to both the 212T-1 and 212T-2. The assembly can be located in an equipment room and linked by cable to the audio control panel in the studio. Sensitive audio wiring is concentrated in a card cage away from interference. All rack-mounted assembly wiring is readily accessible. Audio input and outputs are connected to terminal strips. Rugged connectors are used to couple cables to the front panel. Cable lengths can be supplied as required for any installation.

For a new descriptive brochure on the 212T Series, contact Broadcast Marketing, Collins Radio Company, Dallas, Texas 75207. Phone: (214) AD 5-9511.

COMMUNICATION/COMPUTATION/CONTROL

COLLINS

COLLINS RADIO COMPANY / DALLAS, TEXAS • CEDAR RAPIDS, IOWA • NEWPORT BEACH, CALIFORNIA • TORONTO, ONTARIO

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Circle Item 16 on Tech Data Card

NEW STUDIO ON A SHOESTRING

by Robert M. Costello

By making use of existing facilities, this installation was made with minimum cost.

A new radio studio and control room for a total outlay of $500? The transmitter staff of KOAP-TV stayed within this limit by making use of existing facilities and a little imagination. And the new facilities seem to work; in the two months of operation there have been no complaints from production personnel.

KOAP is one of the stations of the state-owned Oregon Educational Broadcasters network. Until the summer of 1966, the 10-kilowatt FM transmitter and control room of this station were located in a small building in the hills overlooking Portland; nearby was a second building containing all the engineering and production facilities for the television station. The TV installation consisted of a small studio (which was lovingly dubbed "the largest telephone booth in the world"), a control room, a film room, and a transmitter room. These facilities were barely adequate, and when a second film chain and VTR were moved in at Christmas 1965, the building became badly overcrowded.

To alleviate this situation, the entire television production operation was moved during the summer of 1966 to a larger building closer to downtown Portland. This left the former control room and studio unused. So it was decided by the management to move the FM production equipment to the former TV control room. Not only would the environment be quieter, but large musical groups could be accommodated in the studio.

A control-room layout was worked out by the engineering staff (working with the FM production personnel) to assure that all the equipment would be in the best position. It was decided that all the equipment in the old control room could be transferred to the new location. A horseshoe configuration was used so that the operator could see through the existing double glass windows into the studio, and so the wiring would fall into the existing trenches.

Because there was a new air-cooled 10-kilowatt television transmitter at the other end of the building, it was considered desirable to enclose the radio working area with a soundproof wall. This also would allow part of the former control room to be used for storage. The wall has a frame of two-by-fours covered on the outside by ⅜-inch plywood and on the inside by ½-inch plywood and acoustical tile. It has a double glass window and a solid-core door with another double glass window and a soundproof threshold. This wall encloses a space 9 by 13 feet. Record-storage shelves with a built-in monitor speaker were attached to the wall next to the operator, and a duct was built from the new room to an existing fan.

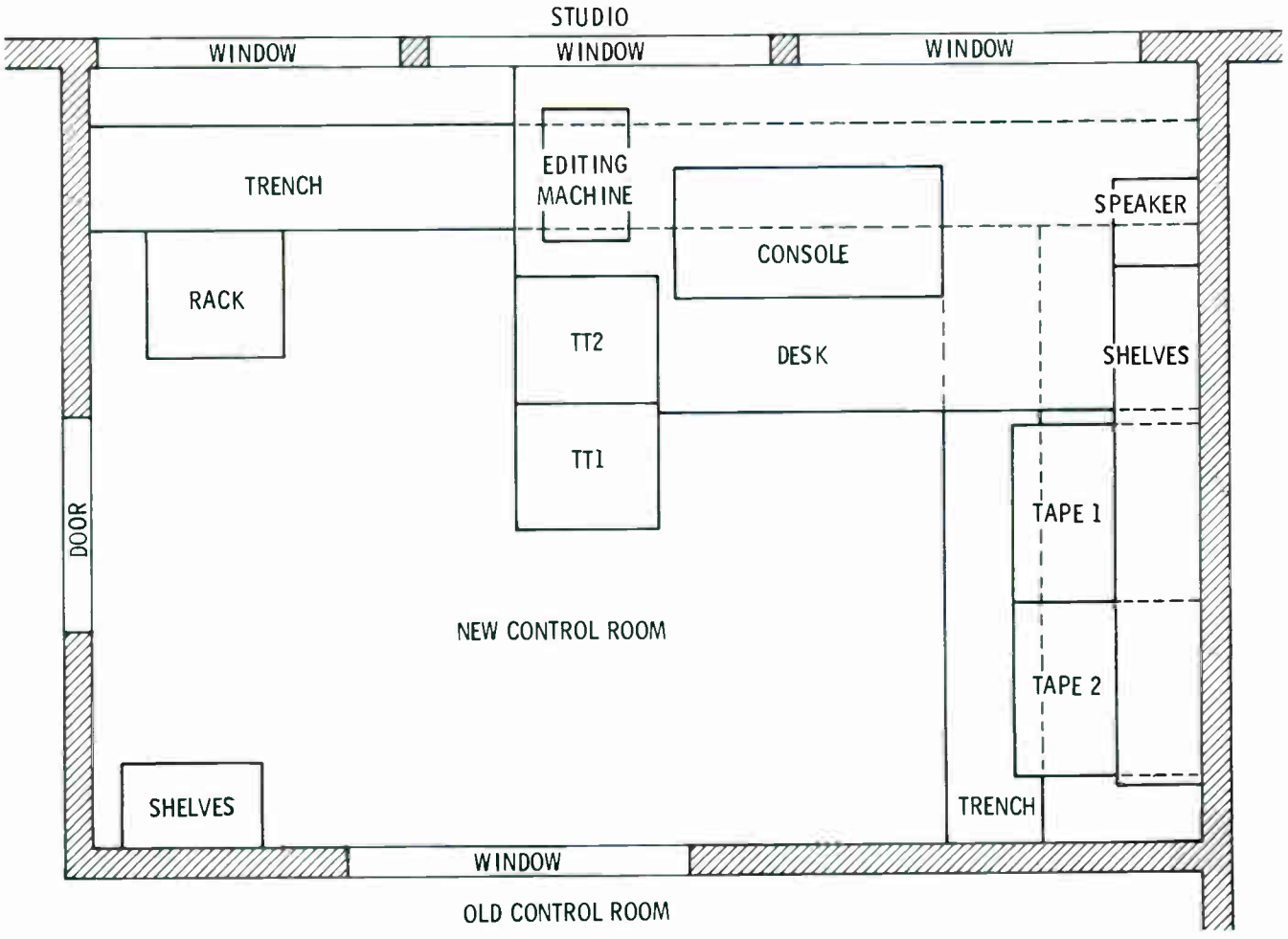
In order to acquire enough desk space for the audio console, the remote controls for the two on-air tape machines, the two turntables, and a tape machine for editing, it was decided to construct the desk from a single sheet of ¾-inch plywood. Not only would this allow sufficient space, but it would be more than strong enough. The plywood was stained and finished with several coats of plastic varnish for the sake of appearance. This finish has proven to be as tough as any of the linoleum-type coverings and is, in our opinion, more attractive.

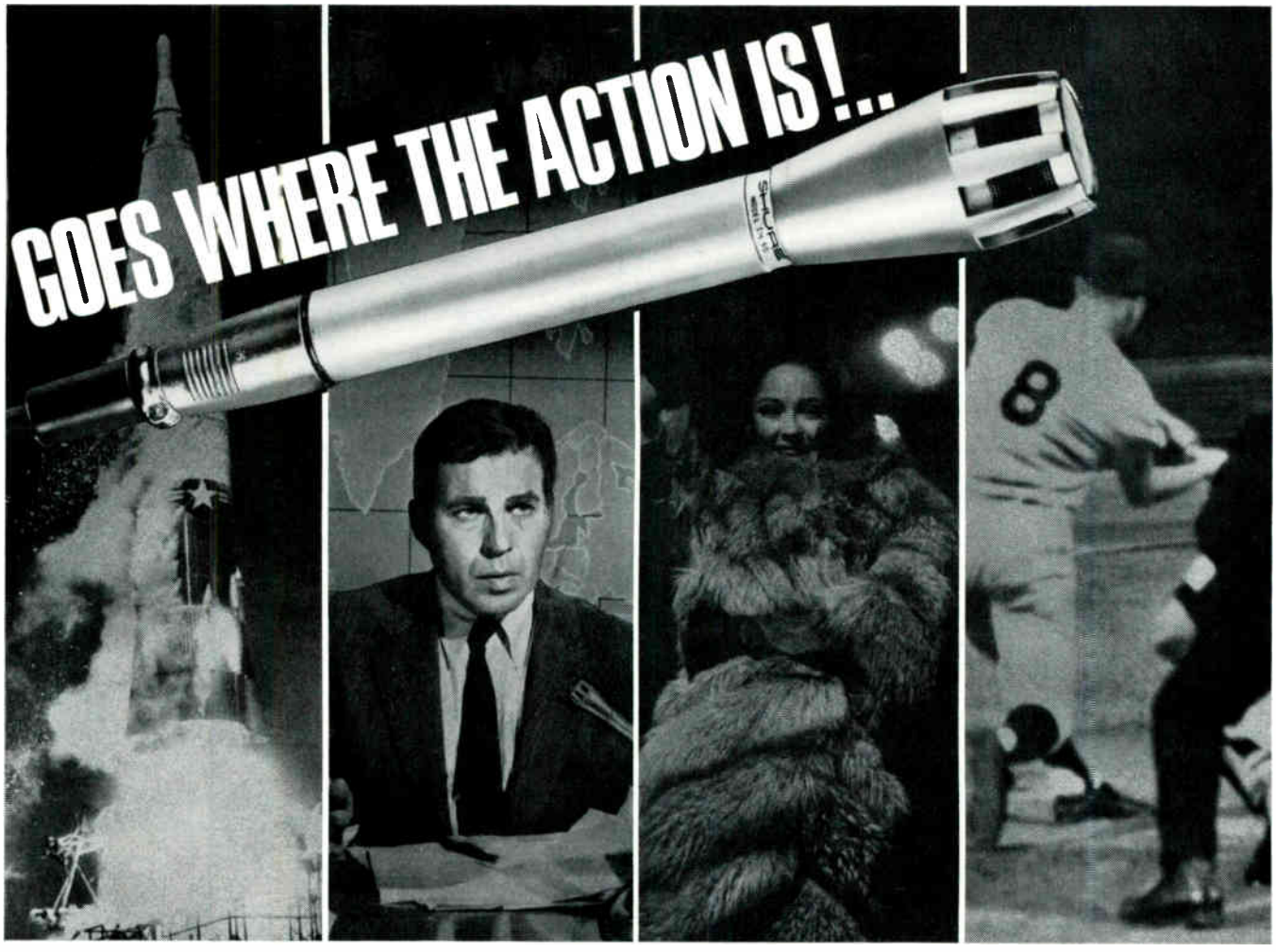
A six-foot rack was placed over the existing trench to hold a patch panel, the power supplies for the console and muting relays, and a test oscillator. Plenty of space remains for future expansion.

The carpentry was fairly simple and was well within the abilities of transmitter operators, who completed the wall and control desk in their spare time within a month. The power wiring was arranged so that the lights and ventilating fan are on one breaker and the electronics are on another. This reduces the possibility of shock while working on the equipment.

The old television studio was adapted easily to its new use. The lighting grid and cyclorama track remained from the former layout and were used to hang sound deadening material. Although it was much too small as a television studio, as a radio studio there is room for a large chorus or orchestra.

The entire move was accomplished for a cost of less than $500 for materials and a few weeks of spare time. It has been well worth the investment in terms of improved sound and improved morale because of the quiet and pleasant surroundings. ▲





The SM60 cannot be stereotyped—is equally at home in the studio or in the field—stand-mounted or hand-held—in uses as diverse as outdoor sporting events and elaborate variety shows. Small wonder that audio engineers have called it one of the most versatile omnidirectional dynamics they've ever encountered, for the SM60 is a unique combination of good-looks, strength, performance and economy.

The smooth, wide-range response provides cleanest, natural reproduction of both speech and music. A very effective built-in wind and "pop" filter protects against undesirable effects of close-talking.

Lustrous, non-glare metallic finish and tailored-to-the-hand dimensions provide striking on-camera appearance and superior handability. Specially reinforced machined-steel case front is designed to take abuse that would ruin other microphones—you can drop it on its nose without damage to the internal structure! Efficient windscreen and front end are *quickly* and *easily* removable for cleaning.

Best of all, it is priced competitively with conventional "workhorse" microphones. Why not check out an SM60 now? See your Shure Professional Products Distributor, or contact Mr. Robert Carr, Manager of Professional Products Division, Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill. 60204—Phone 312 - 328-9000.

SHURE SM60

VERSATILE OMNIDIRECTIONAL DYNAMIC MICROPHONE

THE LAST WORD IN WEARABLE LAVALIER MICROPHONES . . . BY SHURE

Specifically designed for radio, TV, motion pictures . . . matches well in sound with stand or desk mounted units. Smoothly-contoured, machined-steel case and recessed grille for minimum clothing noise. Exclusive snap-in mounting of microphone for greater convenience, security. "Positive Lock" lavalier goes on in an instant—provides simple, noiseless position adjustment. Extra-flexible, kink-free rubber cable is easily replaceable.

MODEL SM51 DYNAMIC LAVALIER

August 1967

We interrupt this magazine to bring you. . .

Late Bulletin from Washington

by Howard T. Head

Antenna Farm Rules Adopted

The Commission has adopted its proposal to establish "antenna farm areas" where tall FM and television towers are to be grouped (see July 1965 Bulletin). Under the new Rules, these areas may be established by the Commission on its own motion, or at the request of the FAA or any interested party. In any event, FAA concurrence will be required.

Once an antenna farm area has been established, the Commission will not accept applications proposing structures higher than 1000 feet above ground outside of the farm area unless the applicant has received prior FAA approval. Where a location in an established antenna farm area would not meet the Commission's mileage separation requirements, operation at substandard mileages may be permitted; "equivalent protection" of existing stations would be required.

Established stations will be permitted, but not required, to move into antenna farm areas.

Presunrise Operation of AM Stations

New rules have been adopted by the Commission governing the operation of standard broadcast (AM) stations prior to sunrise. Under the new rules, Class III and many Class II stations may request permission to sign on as early as 6:00 AM with 500 watts power. The new rules apply to both daytime and unlimited-time stations.

Stations wishing to take advantage of the new rules must file a request with the Commission for a Presunrise Service Authority (PSA), including a required engineering showing. Existing presunrise authority for stations which have not filed for a PSA by August 31, 1967, will terminate on October 28, 1967, when Daylight Saving time ends.

The new rules were made possible by an agreement between the U.S. and Canada (see December 1966 Bulletin).

FM Interference to Television Reception

The expansion of FM broadcasting is bringing about an increasing number of complaints of FM interference to the reception of television signals. In addition to FM second-harmonic problems (see March 1966 Bulletin), reports of interference have also been traced to TV-receiver cross-modulation products caused when the sum of two strong FM signals falls within the television band. In one case, interference was caused by the combination of a strong FM carrier and a strong low-band television carrier.

The problem appears to be aggravated by poor performance of RF traps, both internal and external to the TV set. Some traps are relatively ineffective, while others produce excessive attenuation of the desired signal.

Some Commission staffers have suggested that one solution would be to locate FM transmitters sufficiently far from built-up areas to avoid the overloading associated with strong FM signals. One drawback to this approach, however, has been the lack of a meaningful definition of FM blanketing interference (Section 73.315(e) of the Rules). In a recent California case, the Commission refused to require an FM applicant proposing a power increase to locate outside of a residential area because the rule does not establish an FM blanketing standard.

Television Translator Inquiry Under Way

The Commission has instituted an inquiry to examine problems encountered in television translator operation, and to explore the possibility of greatly expanding the use of both VHF and UHF translators. In announcing the inquiry, the Commission notes the competitive problems which have been generated by the development and spread of CATV systems.

Among measures being considered are power increases up to 10 watts input for VHF translators west of the Mississippi River and in Alaska and Hawaii. Proposed rule changes would permit television broadcast station licensees to operate VHF translators outside their Grade B contours and to contribute financially to established VHF translators. Program origination by translators, including local commercial announcements, also would be permitted.

Short Circuits

A Commission frequency-measuring program for microwave transmitters is finding up to one-third outside of frequency tolerance -- in some instances, frequencies are completely outside of the assigned band. . .The Commission has ruled that when an application is filed to move a broadcast station from one city to another, any other applicant may file for operation in the same or nearby cities . . .RCA is testing equipment to provide four channels of facsimile transmission in regular television broadcast channels, using the vertical blanking interval for the facsimile signals -- present regulations provide for facsimile transmission only in the FM broadcast band. . .NAB has formed a Committee to advise on preparation of the new Sixth Edition of the NAB Engineering Handbook (see February 1966 Bulletin). . .UHF television stations within 250 miles of the Canadian border are limited to one megawatt ERP; however, the Canadians appear ready to accept the U.S. limit of 5 megawatts, and it's likely our agreement with Canada will be so modified. . .In a California CATV case, the Commission has ruled that only the calculated Grade A contour may be used in defining the areas included in the "top 100" markets (see June 1966 Broadcast Engineering, page 32) -- field-strength measurements taken in the case were specifically ruled out. . .The Commission has withdrawn its proposal to increase the minimum required ERP for Class C FM stations from 25 kw to 50 kw.

Howard T. Head. . .in Washington

Phasor

(Continued from page 35)

the new one slid into its place. All necessary modifications for the permanent connection of the new unit had been completed previously by the station chief engineer. Therefore, the physical replacement required only a short period of time. Each common-point circuit was rechecked and adjusted as necessary to compensate for the absence of the jumpers. The new phasor was then operated during regular programming hours for final touch-up adjustments.

The physical replacement and associated adjustments were completed in just one night during the experimental hours. This allowed the station to operate during its normal broadcast day without interruption, and with its licensed directional patterns at all times. After all adjustments were completed, a final check on the common point was performed.

Pattern Check

The final step was to recheck all monitor points and conduct a skeleton proof of performance on each pattern. The skeleton proofs were performed by taking three or four field-intensity readings on each bearing along which measurements had been made previously; the readings were made at points employed in the last complete directional proofs of performance. The readings were then compared statistically with previous data to determine the radiation in each given direction. These proofs were necessary to verify the shapes and efficiencies of both patterns.

Conclusion

The steps followed in this equipment change were simple and straightforward; such a procedure should result in minimum difficulty when any phasor is replaced. No "off-the-air" time or disruption to service was involved, and the station's audience was never aware of the change. (Of course, this wouldn't be true for a 24-hour station.) The most important feature of the procedure used at WITY was that the station made the complete phasor change without once deviating from licensed parameters during normal operating hours. ▲

NEWS OF THE INDUSTRY

INTERNATIONAL

License Agreement

Fernseh GMBH of Germany and the **General Electric Co.** have entered into a license agreement under which Fernseh will manufacture a live color television camera system using the basic design of the PC-19-A camera head of the General Electric PE-250. The camera heads, to be manufactured by General Electric in Syracuse, will be modified to a European version in Darmstadt, Germany, in order to meet the special requirements of European broadcasters.

NATIONAL

New Plant

The Telex Corp. has announced construction of a new 50,000-square-foot manufacturing plant in Blue Earth, Minnesota. The plant will house the assembly of Viking Tape Recorders, currently made in Bloomington, Minnesota. In-plant production is scheduled to start September 1.

The Bloomington plant will be converted to serve as headquarters for the Minneapolis-based Telex divisions to accommodate general offices, sales, and engineering departments.

Microwave System for NY ETV

The five educational television stations in the state of New York will be interconnected into a single ETV network via microwave links. The state has awarded the prime contract for the network to the **New York Telephone Co.** N.Y. Telephone has in turn purchased the microwave equipment from **Raytheon Company's Communications and Data Processing Operation.**

Seventeen microwave stations will be located on a route extending north from New York City to Albany and then roughly following the turnpike west to Buffalo. The network will have a total of 449 route miles of microwave connecting links. The system will provide two-way transmission with one channel each for video and audio.

New CATV Equipment Manufacturer

A Florida electronics manufacturer, **Electra-Tronics, Inc.,** has formed an **Automated CA-TV Products Division** and entered the community television industry to manufacture specialized public-service programming equipment. A principal product is equipment to telecast the complete New York Stock Exchange ticker. Other products being marketed include an automatic programmer which lists the programs being presented on the closed circuit at the time of observation, and a continuously moving public-service announcement machine.

1549-Foot Tower

WTVT, Tampa-St. Petersburg, has begun telecasting from its new 1549-foot tower. The tower, located near Balm, Florida, is the tallest structure in Florida and is taller than the Empire State Building in New York City. Nearly twice the height of the former WTVT tower, the new structure will substantially extend the WTVT coverage area and improve reception in the area already served.

Talk-Back ETV

A closed-circuit educational television system with a "talk-back" circuit has been installed between a private industry and a private university by **Southwestern Bell Telephone Co.** The system includes a microwave relay supplied by **Lenkurt Electric Co., Inc.** The system, which went into opera-

Ball Brothers Research Corporation has acquired Miratel Electronics Company. Our reasons are easily defined. At Ball Brothers Research, we make special effects generators, waveform monitors, video and pulse distribution amplifiers, and automatic gain control equipment. But no monitors.
Miratel Electronics makes a complete line of black-and-white monitors, as well as color monitors and transistorized display devices. By combining our collective experience, we can establish BBRC/Miratel as a major provider to the broadcast television industry. So that's what we're going to do.

Miratel

Ball

BROADCAST TELEVISION EQUIPMENT • BALL BROTHERS RESEARCH CORPORATION • BOULDER, COLORADO

Circle Item 21 on Tech Data Card

tion this year, was installed between **Southern Methodist University** and **LTV Electro-systems, Inc.,** a subsidiary of **Ling-Temco-Vought, Inc.** The facility is being utilized to transmit graduate engineering courses to LTV engineers who are taking advanced college work.

Speech Bandwidth Halved

A new method of compressing the frequency spectrum of speech to half its normal bandwidth has been devised at **Bell Telephone Laboratories.** Such a reduction offers the possibility of increasing the number of voice circuits that can be carried on a path. Feasibility of the method was tested by simulating the system on a computer without building actual equipment.

The speech compression method was described at an IEEE International Convention in New York in a paper by M. R. Schroeder, J. L. Flanagan, and E. A. Lundry of Bell Labs. Known as analytic signal rooting, the method promises simpler equipment and better speech fidelity than older bandwidth-compression schemes. In the new process, the speech spectrum is first divided into four contiguous bands spanning the telephone frequency range. Each band nominally contains no more than one speech formant or vocal tract resonance. Two operations are then performed simultaneously on each band. The instantaneous frequency (or phase) of the signal is divided in half, and the amplitude of the signal envelope is reduced in value to its square root. The new signal occupies approximately one half the bandwidth of the original signal—but retains formant structure and pitch information. After the signal is transmitted, the signal-rooting process is reversed by an analytic squaring operation, and the original signal is reconstructed.

Emmy Award

An Emmy award from the **National Academy of Television Arts and Sciences** has been presented to the **Ampex Corp.** for the company's development of high-band color video-tape recording. Thomas E. Davis, Ampex vice president - general manager, audio/video communications division, accepted the award in Hollywood on the

nationally televised 19th annual television Academy Awards program. The award was presented for Achievement in Engineering Development.

ORGANIZATIONS

NAB

Eleven broadcast engineers have been appointed members of the National Association of Broadcasters' 1967-68 Engineering Advisory Committee.

Malcolm M. Burleson, vice-president for engineering, Metromedia, Inc., was named chairman of the group. Appointed to serve with him were: J. B. Epperson, vice-president – engineering, Scripps-Howard Broadcasting Co., Cleveland; Clyde M. Hunt, vice-president for engineering, Post-Newsweek Stations, Washington; Leslie S. Learned, vice-president for engineering, Mutual Broadcasting System, New York; Clure H. Owen, manager of allocations, American Broadcasting Co., New York; James D. Parker, director, transmission engineering, CBS Television Network, New York; Russell B. Pope, director of engineering, Golden Empire Broadcasting Co., Chico, Calif.; Henry E. Rhea, director of engineering, Triangle Stations, Philadelphia, Pa.; Daniel H. Smith, vice president and director of engineering, Capital Cities Broadcasting Corp., Albany, N. Y.; William H. Trevarthen, vice-president, operations and engineering, National Broadcasting Co., New York; and Eugene R. Hill, director of engineering, Kaiser Broadcasting Corp., Boston, Mass.

NAEB

"Extending Educational Opportunities Through Educational Broadcasting" has been selected as the theme for the 43rd annual convention of the National Association of Educational Broadcasters which will be held November 5-8 at the Denver Hilton Hotel, Denver, Colo.

Meetings will be held at the hotel and at the Denver Auditorium, where the convention exhibit area will be located. One hundred thirty-five booths will be used by manufacturers of broadcast equipment for demonstration and display of their products.

The 8th Armed Forces Television Conference also will be held in Denver at Lowry Air Force Base concurrent with the NAEB convention.

SMPTE

Arrangements Chairmen for the 102nd Technical Conference of the Society of Motion Picture and Television Engineers have been appointed by SMPTE conference vice-president E. B. (Mike) McGreal, Producers Service Corp., Glendale, Calif. The semi-annual conference is set for Chicago's Edgewater Beach Hotel, September 17-22.

General arrangements chairman is Allen F. Hilliard, Geo. W. Colburn Laboratory, Inc., Chicago. Arrangements vice-chairman is William A. Koch, Eastman Kodak Co., Chicago.

Topics for the Conference Papers Program were announced by Program Chairman Hans C. Wohlrab, Bell & Howell Co., Chicago. According to Mr. Wohlrab, papers will be presented in Cinematography, Medicine, Laboratory Practices, Education, Aerospace, Theater, Studio Techniques, International, Television, Sound, and Instrumentation and High-Speed Photography.

In addition to the papers program, the Conference will feature an equipment exhibit in which some 80 booths of equipment will be on display. Exhibit Chairman is Denis H. G. Howe, Wilding, Inc., Chicago.

PERSONALITIES

Helmut Dieter and **Ray M. Wood** were named vice-presidents at a recent **Ameco** board meeting. Mr. Wood, vice-president, manufacturing, has been director of Ameco's production facility since last September. Mr. Dieter, vice-president, contracting, first joined the **Merrill CATV Systems** as manager of Decatur, Ala., Cable TV.

Another Ameco appointment is

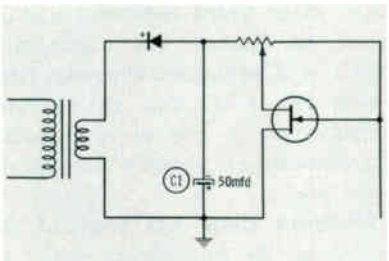
Charles M. Rice as national sales manager at Phoenix headquarters. He is in charge of the newly consolidated CATV product and contract sales forces.

The promotion of **William L. Robinson** to director of engineering at **Capitol Records** has been announced. In his new assignment, Mr. Robinson will be responsible for all electronic engineering activities of Capitol in the three factories and two recording studios located in the United States and the ten operations in Europe and Latin America.

Norman E. Hall has been named engineering manager of **KERO-TV**, Bakersfield, California. He succeeds Ward Bledsoe who has resigned to assume ownership of the Muzak franchise in Kern County, California.

Richard A. Quodomine has been appointed manager of technical operations for **WOR-TV** in New York City.

Erratum



In the diagram accompanying the "Engineers' Exchange" item "Audio Dropout Alarm" (BROADCAST ENGINEERING, December 1966, page 38, and March 1967, page 10), a further correction is necessary. The polarity of C1 should be reversed as shown in this partial schematic diagram.

In his new position, he will direct studio, remote, film, and video-tape operations.

WOR has also announced the promotions of **Francis Garufy** and **Robert O. Norris.** Mr. Garufy will be manager of transmitter engineering and operations, and Mr. Norris will be supervisor of video-tape operations.

TRANSACTIONS

Radio Station **WLAP,** licensed to Lexington, Kentucky and owned by **Thoroughbred Broadcasters, Inc.,** has been sold to **Illinois Broadcasting Co.,** operator of WSOY-AM-FM, Decatur, and WVLN and WSEI-FM, Olney, Illinois. The purchase price was $326,000 plus assumption of other considerations. The sale is subject to FCC approval.

Zoomar, Inc. has announced the successful conclusion of negotiations for the acquisition of the **Kilfitt Optischewerke,** West German optical company. The firm will now be operated by the newly formed **Zoomar GMBH** in Munich, and the products will be sold throughout the U.S., Canada, and South America by Zoomar, Inc.

Rheem Manufacturing Co. has acquired all the outstanding stock of **J. M. Nelson Electronics Ltd.,** Vancouver, B. C., a company marketing tape recorders and related equipment throughout Canada. As a wholly owned subsidiary of Rheem, Nelson Electronics will operate as the Canadian marketing arm of the Califone-Roberts Electronics Division of Rheem. Included in the transaction is a wholly owned subsidiary of Nelson Electronics, **Yves Courville Distribution Ltd.,** of Montreal.

An agreement has been signed in which **Riker Video Industries** has an option to acquire the outstanding shares of **Continuous Progress Education, Inc.** CPE, Inc. designs and manufactures a line of audio-video communications systems for educational use.

Memorex Corp. has acquired the balance of the outstanding equity of **Disc Pack Corp.** Previously, Memorex had owned 40% of Disc Pack Corp. Memorex manufactures magnetic tapes for computer, instrumentation, and television recorders. Disc Pack is presently engaged in the development of memory disc packs for use as information storage devices for computers. ▲

NEW PRODUCTS

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

Instant Color Replay System

(45)

A high-band video recording system capable of providing color instant replays in slow motion and stop action has been developed by **Ampex Corp.** The system records on metal disks instead of conventional magnetic tape. Called the HS-100, the new system records and plays back 30 seconds of action in high-band color; for replay of significant action, any part of the 30-second recording may be cued for on-the-air use in four seconds. System capabilities include reverse action playback at either normal or slow-motion, and frame-by-frame advance. Slow-motion speeds down to stop frame may be chosen.

Solid-State Video Switcher-Fader

(46)

A solid-state video switcher-fader, designed for the small studio by **Dynair Electronics, Inc.,** is available in both standard and remote-controlled configurations. The Model VS-121B (or remote-controlled Model VS-121B-R) is primarily for broadcast applications but is also suitable for educational and industrial usage.

Features include controls for fade-in, fade-out, lap dissolve, and superimposition. Six of twelve video inputs are for use with noncomposite video, and the other six can be switched independently for either noncomposite or composite video inputs.

Image-Orthicon Tube
(47)

A long-life, 3-inch broadcast-type image-orthicon tube with a second-generation, electron-conducting glass target is now available from the **General Electric Co.** In manufacturer's tests, the new IO exhibited no degradation of initial parameters after 8760 hours of continuous camera operation. Stated signal-to-noise ratio is in the range of 70:1 and 80:1, and normal resolution is given as 650 to 750 lines in an 8.5-MHz band.

GE Tube Type Z-7888, with field mesh, or Type Z-7899, without field mesh, is available either for monochrome service or "matched for color."

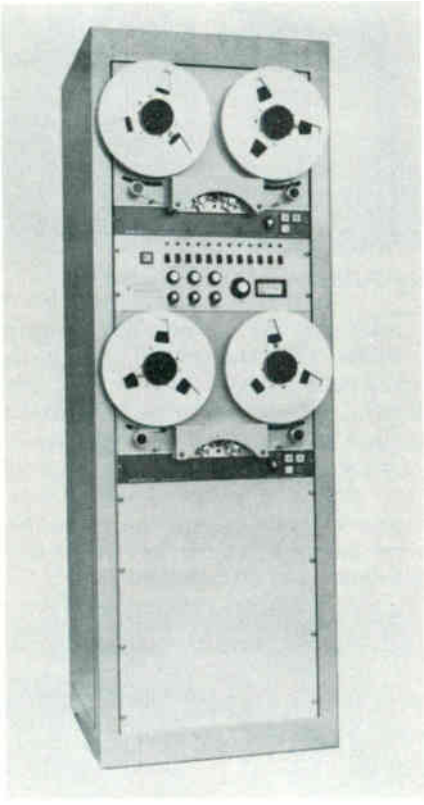
3-kw FM Transmitter
(48)

A new 3000-watt FM transmitter has been introduced by **Bauer Electronics,** a subsidiary of **Granger Associates.** The transmitter, Model 603, is intended to meet the needs of the Class-A station which wants to transmit full power with both horizontal and vertical polarization. The circuit design calls for the lowest possible investment in tubes and includes a direct FM exciter.

Basically designed for a 3-phase power supply, the Model 603 can be furnished in a single-phase version when 3-phase power is not available

or is too costly to obtain. Stereo and SCA facilities can be added at any time. The cabinet measures 30" × 25½" × 75" and is built with both front and back door openings for maximum accessibility.

The same transmitter is available for 5000-watt operation. A 3-kw station can boost power to 5 kw by a plate-transformer change. The 5-kw unit is designated Model 603-5.

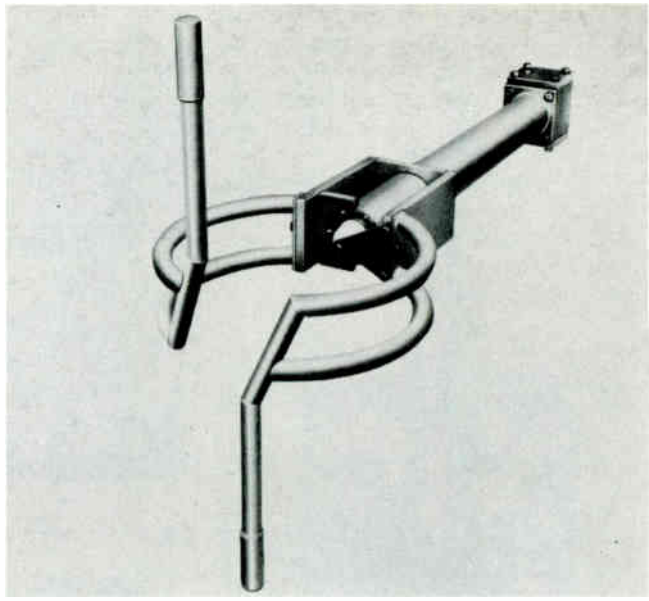


Music System
(49)

Alternate versions of the new 3000 Series Music Systems, by **Metrotech Inc.**, provide for "main-channel" radio-station programming and for background-music distribution via SCA, leased telephone lines, or CATV.

The main-channel systems are available for mono or stereo operation. These systems are built around an intersperser control unit, which switches the integral transports in a predetermined, switch selected sequence. The basic system includes two bidirectional transports with provision for a third source (cartridge machine, etc.) Four-transport and custom systems also are available.

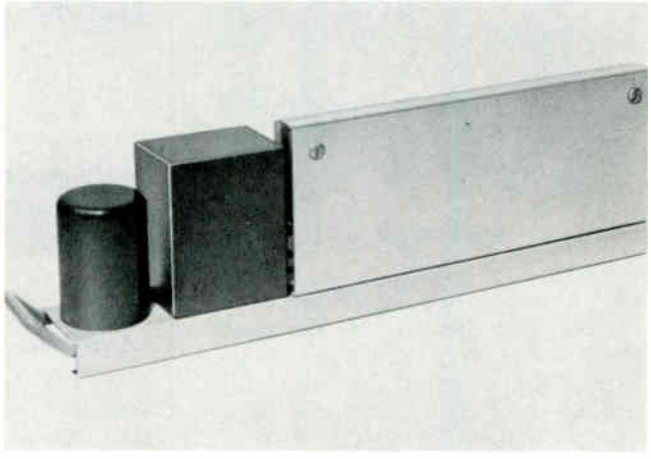
The background-music systems are similar to the "main-channel" systems, except that switching is initiated by a silence-sensing circuit rather than by a tone-operated device. An optional feature is provision for programmed periods of silence, and a third source may be added for such applications as "storecasting."



Circularly Polarized FM Antenna

(50)

A new circularly polarized FM antenna has been developed by **Gates Radio Co.** Designated the "Dual-Cycloid," the antenna is built to provide low VSWR over a bandwidth of 200 kHz. By combining both horizontal and vertical elements into one funtional unit which radiates a circularly polarized signal, the need for separate radiating bays and the associated power divider is eliminated. From one to sixteen Dual-Cycloids can be stacked in an array. Maximum power input per bay is 10 kilowatts, and arrays will handle up to 40 kilowatts.



Transistorized Plug-In Line Amplifier

(51)

A new solid-state line amplifier has been designed by **Aerovox Corp.** to feed a line or distribution system, or to be useable as a microphone preamplifier or booster amplifier. The new amplifier, designated Model 102-SS, is built to have a high input impedance with respect to source impedance. Except for the input and output transformers, all components and transistors are mounted on a glass-epoxy based, etched wiring board. Only two types of transistors are used.

Specifications include: source impedances, 50, 250, and 600 ohms; load impedances, 150 and 600 ohms balanced; maximum levels, −24 dBm input and +30 dBm output; gain, 53 dB ±1 dB with input terminated and 58 dB ±1 dB with input unterminated; noise level, −67 dBm at output with input and output terminated; frequency response, ±0.5 dB from 30 to 15,000 Hz; harmonic distortion, less than 0.25% rms at 24 dBm output and less than 1% rms at 30 dBm output.

Mobile Microwave Antenna System

(52)

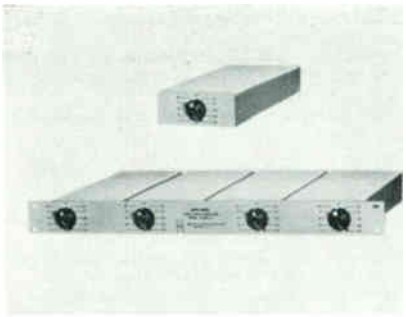
A complete trailer-mounted microwave antenna system, designed to be placed in operation by four men in eight hours, has been produced by **Andrew Corporation.** The two-wheel, 1½-ton trailer unit includes a 100-foot pneumatic telescoping mast, 6-foot microwave antenna, azimuth/elevation antenna positioner with remote-control system, 140 feet of Heliax elliptical waveguide, automatic dehydrator, and a gasoline-operated compressor. The telescoping mast provides for a top load of 600 pounds with a windload of 125 mph. The antenna positioner offers elevation adjustment of ±15° and azimuth adjustment of ±45°. Beam deflection of the antenna unit meets EIA Specification RS 222.

Connector for Low-Voltage Wiring

(53)

A solderless electrical connector designed for use in control systems, sound installations, and other electrical applications of 30 volts or less has been announced by the **3M Co.** The "Scotchlok" brand connector No. 560 features a self-stripping "U-type" element encased in white polypropolyne. Connections are made by driving the "U-type" element down over the conductors with pliers. The

spring compression reserve in the U-type element supplies holding power and electrical contact. A hinged cover attached to the connector case then is snapped into place for additional protection. The connector is designed for use on No. 14-18 solid or stranded copper wire.



Video-Cable Simulator
(54)

The KAPPA SUPER-n Video Cable Simulator, for simulation of from 25 to 250 feet of video cable in decade steps, is available in two models from Kappa Networks, Inc. Model KR-250 is an individual module, and Model KR-250-4 is an assembly of four separate rack-mounted Model KR-250's.

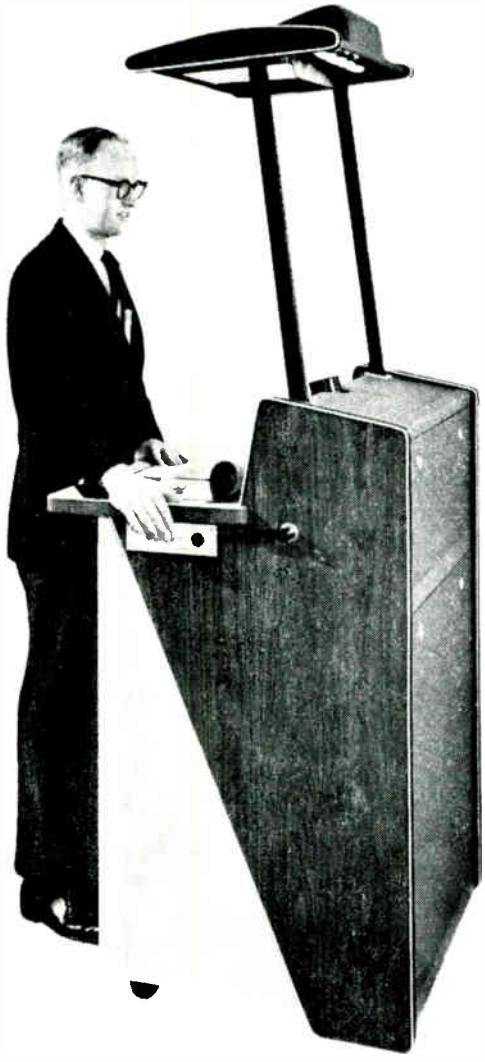
Specifications of Model KR-250 include: amplitude response, within ±.05 dB to 12MHz; ripple, less than ±.05 dB; group delay, ±0.5% to 12 MHz; delay, 360 nsec (250 ft.); resolution, 36 nsec (25 ft.); impedance, 75 ohms; insertion loss, 3dB at all settings; "K" factor, .25% for 125 nsec $\sin^2$ pulse.

The price for each single Model KR-250 is $350. The four-unit Model KR-250-4 is $1100.

UHF Antenna Catalog

A new catalog of UHF Zig-Zag antennas has been published by the **Jampro Antenna Co.** The 60-page book covers the history and theory of operation of the Zig-Zag antenna and shows the theory and need for beam tilt, null fill, and pattern shaping. Hundreds of possible pattern combinations are shown, both for horizontal and vertical polarization. Construction methods showing how these antennas can be fitted to an existing tower or built on a new tower are included. Weights and windloads are also shown. The catalog presents information regarding line losses in various transmission lines as well as graphs showing tilt *vs* distance at various elevations.

The catalog is free to consulting engineers or those planning a UHF station. Write to Jampro Antenna Co., 6939 Power Inn Road, Sacramento, California 95828. ▲



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3 in 1 VERSATILITY!

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- **Overhead Camera Television System**

TeleMation's newly restyled TELECTERN* overhead camera system is designed to facilitate the art of television instruction. Simple, convenient controls allow the instructor to select video source, lighting mode and lens focal length (10:1 zoom range). A built-in 2" x 2" slide projector is also available.

The handsome, portable lectern console is sturdily constructed with walnut-finished side panels, a durable laminate work surface, and fiberglass video monitor panel.
The TELECTERN* is available in several different configurations, ranging from a basic, closed-circuit industrial model to a complete EIA broadcast system with camera chain.

*Trademark, TeleMation

Write for details

TELEMATION, INC.
2275 South West Temple
Salt Lake City, Utah 84115
Telephone (801) 486-7564

Circle Item 38 on Tech Data Card

ENGINEERS' TECH DATA

ANTENNAS, TOWERS, & TRANSMISSION LINES

57. DELHI—12-page catalog presents information regarding new line of receiving-type towers and masts for TV, amateur, and CB, etc., usage.
58. FINNEY—Covered in form No. 20-413, a 6-page color brochure, are new FINCO color spectrum antennas for VHF-UHF-FM, VHF-FM, and UHF.
59. FORT WORTH TOWER—Subjects of literature are towers, passive reflectors, and equipment buildings.
60. GATES—Material describes the new Dual-Cycloid FM antenna with circular polarization, the KD-20A portable audio console, and the Dualux—a nine-mixer dual-channel console.
61. RF SYSTEMS—New brochure has photographs and descriptions of various antennas and towers.

AUDIO EQUIPMENT

62. ACOUSTIC RESEARCH—Offered are frequency-response and distortion curves for all AR speaker systems, the AR-turntable instruction manual, and plans for building equipment shelves.
63. ATLAS SOUND—Catalog 567 lists speakers; horns; microphone stands, booms, and accessories; and line transformers.
64. DUOTONE—Brochure is about phonograph and tape accessories.
65. FAIRCHILD RECORDING—New bulletin describes Model 658A and new Model 658B compact reverberation systems.
66. INT'L NUCLEAR—Publications are for the Model TAA1 audio line amplifier, and the Model TPA1 regulated 24-volt power supply.
67. STANFORD INT'L—MB microphones and headphones are illustrated, and technical data are discussed in 6-page flyer.
68. SWITCHCRAFT—Bulletin 172 describes a new, battery-operated, four-channel mixer, Model 307TR.
69. UNITED RADIO—Catalog sheet gives specifications for the "Kustom Electronics Broadcast Console."
70. VEGA ELECTRONICS—The Vega/Syncron S-10 cardioid condenser microphone and the Vega-Mike wireless microphone systems are subjects of literature.

CATV EQUIPMENT

71. BENCO—Spec sheets detail information about the "Benavac" headend control unit, M-9A transistorized CATV amplifier, "Benpre" solid-state preamplifiers, "Benex-22" line extenders, and CATV line splitters and asymmetrical splitters.

COMPONENTS & MATERIALS

72. BOSTON INSULATED WIRE & CABLE—Tech data sheet is about

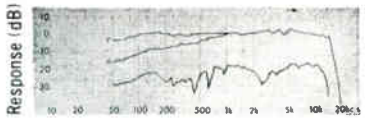
Primo

NEW!
CARDIOID DYNAMIC MICROPHONE
(Slim, Pop-out Type)

Provided with
★ TONE CONTROLLER
★ WIND SCREEN
★ SWITCH

UD-857A

Designed specifically for stage, broadcast applications.



SPECIFICATIONS
- Cartridge: DM-33
- Frequency Response: 50～15,000c/s ± 5dB
- Impedance: 600ohm
- Sensitivity: —72dB/dyne /cm.cm (0.25mV)
- Net Weight: 430g
- Finish: Chrome hair lined

* For catalog write to
PRIMO COMPANY LTD.
Chicago Illinois Office: A.P.T. No.204 530 W.Surf. St. Chicago Illinois 60657 U.S.A. Tel. 312-472-61421
Head Office: 2043 MURE, MITAKASHI, TOKYO, JAPAN TEL 0422-43-3121-6 CABLES: "Primo Musashino Mitaka" TELEX 2822-326 PRIMO MUS

Circle Item 39 on Tech Data Card

TV-85C connector for 79- and 81-conductor data. Also included is camera cable catalog.

73. HOLLAND ELECTRONICS—Epoxy molded coaxial patch cords and adapters for using connectors and test probes with jack fields are described in literature.
74. INT'L ELECTRONIC RESEARCH—New 8-page short-form catalog gives information regarding shields for tubes and heat dissipators for semiconductor devices.
75. SHALLCROSS—Specifications and other data are listed in catalogs for precision, wire-wound resistors and resistance decades.
76. THOMAS & BETTS—Catalogs for Ty-Rap cable ties, Connecto-Blok terminal blocks, and Shield-Kon shielded cable connectors are offered.
77. TROMPETER—Catalog M-4 gives information on line of coax, twinax, and triax matrix and multipole, multithrow switches.
78. UNIMAX SWITCH—Colorful 12-page Catalog 50 provides dimensions, ratings, and other information about LPB Series 9 illuminated push-button controls.

FILM EQUIPMENT

79. HOUSTON FEARLESS—Brochure outlines capabilities of motion-picture film processors, Labmaster for black and white and Colormaster for color.

MISCELLANEOUS

80. AIR SPACE DEVICES—Eight-page Catalog No. STC-3-67(R)-15M has photographs of various installations and information about safety device for climbing.
81. TERADO—"Lite-Saver," a device for extending bulb life, is covered by material.

RECORDING & PLAYBACK EQUIPMENT

82. CONCORD—Sixteen-page brochure outlines features and operation of Model VTR-600 video tape recording system. Literature is also available on TCM-20 monitor/viewfinder TV camera.
83. MEMOREX—New 79 Series helical-scan video tape is subject of brochure.
84. MINNEAPOLIS MAGNETICS—Printed matter on replacement heads for professional tape equipment is available.
85. 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 MATERIALS & SCHOOLS

86. 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

87. BALL BROS.—Spec sheet has technical data and descriptive information about the Mark VI-A and VI-AR special effects generators.
88. CLEVELAND ELECTRONICS—A 52-page quick-reference step-down die-cut catalog gives complete information on vidicon, **Plumbicon,** and image-orthicon deflection components.
89. COHU—Four-page "A Guide to Lens Selection for Cohu Television Cameras" (Data Sheet 6-322) is offered.
90. COLORADO VIDEO—Data sheet describes CVI Model 220-A video converter for changing "slow-scan" TV signals to 525-line standards for viewing on conventional monitors.
91. GENARCO—Form 430 is about dual-head slide projector for a rear-projection system.
92. KALART—Several Kalart/Victor 16-mm sound projectors (some with built-in screens) and large-screen TV projectors are covered by material. A booklet, "How Industry Profits from the use of Sound Films," is part of offer.
93. RAYTHEON LEARNING SYSTEMS—The Type 520 camera chain for commercial and educational TV is detailed and illustrated in 8-page brochure.
94. TELEMATION—Price list for the **TELECTERN** overhead camera system for instructional TV is offered.
95. TELEVISION ZOOMAR—Information covers the NEWSBREAKER 400 color film processor, TV COLORGARD meter for balancing of color TV monitors, and HTS studio equipment.
96. VITAL—Model VI-500 AGC amplifier combined with mono- or color-stabilizing amplifier, Model VI-20A pulse-distribution amplifier, and Model VI-10A video distribution amplifier are described in publications.

TEST & MEASURING EQUIPMENT

97. BENRUS—25-page catalog is on CRT display modules, monitor scopes, oscillators, voltmeters, and laboratory oscilloscopes.
98. DELTA ELECTRONICS—The RG-1 receiver/generator for use with impedance bridges to measure antenna impedances is outlined in data sheet.
99. ROHDE & SCHWARZ—Material is news and reports from laboratories, test departments, and sales offices.
100. SECO—Operating manual for the Model 107C tube tester is offered.
101. SIMPSON—16-page catalog 2076 lists specifications for 15 different VOM's and other types of test equipment.
102. TRIPLETT—Literature describes the new Model 600 transistorized volt-ohmmeter which has FET circuitry and 11 megohms/volt input impedance.

TRANSMITTERS & ASSOCIATED EQUIPMENT

103. BAUER—Catalog sheet shows the model FB-5V 5000-watt AM broadcast transmitter.
104. METRON—Spec sheet covers the solid-state Model 506B-1 AM modulation monitor.

Advertisers' Index

August, 1967

Professional Services

Professional Services

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. Eldson Electronic Co., Box 96, Temple, Texas 76501, Phone 817 773-3901. 2-67-tf

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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

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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

Trimm 504 Audio Patch cords $4.00. Audio jack panels for 19" racks, 10 pair $8.95. Repeat coils 500-500 ohm flat to 20kc $4.00 —Relay racks and equipment cabinets. Write for list. Gulf Electro Sales, Inc., 7031 Burkett, Houston, Texas. 4-66-tf

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

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

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

New Spotmaster cartridge equipment, QRK turntables, all models available, will take in any trade regardless age or condition. Audiovox, 4310 S. W. 75 Ave., Miami, Fla. 3-67-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

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(301)942-1224 3-67-12t

For sale: three GE 4PE4C1—3" IO portable camera chains; new IO tubes under 30 hours each, various lenses—if desired. $5,000 each including monitoring and cable. Contact William Woods, Director-Engineering, WTTW-TV, 5400 N St. Louis Ave., Chicago, Ill. PH: 312/583-5000. 6-67-tf

FM frequency and modulation monitor. Western Electric 5A monitor operating, with crystals on 106.7 mc plus manual for $200.00. Contact Harold Counts, Chief Engineer, WSRW Hillsboro, Ohio. 8-67-1t

Large selection used equipment at attractive prices. 1-kw transmitters; Schafer automation system; Magnecorder & Crown reel-to-reel machines; Schafer, RCA, Spartamatic cartridge machines; ribbon mikes. Write Broadcast Services Inc., 2877 Kalakaua Avenue, Honolulu, Hawaii 96815. 8-67-1t

RCA TS 30D Field Switcher. Like New, $600. Vital Industries, 3614 SW Archer Road, Gainesville, Florida 32601. 8-67-2t

Three Model 1005 MaCarTa cartridge playbacks— $150.00 each. One Model 450 MaCarTa cartridge recorder— $75.00. Ray Bevenour, WAIK, Galesburg, Illinois. 8-67-1t

Gates Dynamote M-4880E Console. Modified; 8 inputs, cueing, etc. More information: Gabrielsen, P. O. Box 3175, Scottsdale, Arizona. 8-67-1t

Two modified RCA TK-40A Color Camera Chains in working condition. Exceptional value. $16,000 each chain, or $29,500 for both. Inspection invited. Immediate delivery. Write P. O. Box 18151, Tampa, Florida, 33609, or phone area 813, 253-0447, Tampa. 8-67-1t

Equipment Wanted

We need used 250, 500, 5K & 10K Watts AM Transmitters. No Junk. Broadcast Equipment and Supply Co. 1314 Iturbide St., Laredo, Texas 78040. 3-66-tf

INSTRUCTION BOOK WANTED
Urgently require manual and parts list (accurate duplicate) for RCA BTF-5A FM transmitter and exciter. Radian Associates, 2 Arden Thorpe Road, Scarborough, Ontario, Canada. 8-67-1t

NEED TWO Lapp base antenna insulators No. 5537. Pat Uliano, WICC, Bridgeport, Conn. 8-67-1t

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

CATV and Broadcast Engineers needed immediately for systems, manufacturers and broadcasting stations for all positions. Send well prepared resume to Nationwide Broadcast Personnel Consultants, 615 North Michigan Avenue, Chicago, Illinois, 60611. We have openings for all qualified applicants and the employer pays our fee. 6-67-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.
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Our rapidly expanding volume of business has created openings for systems engineers familiar with vertical interval switching equipment. Responsibilities include provision of wiring information on rack and control panel equipment for custom switchers. Some station experience and familiarity with audio preferred. Please send resume of experience or call Mr. R. J. Rainey, 201-382-3700.

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Please send Resume/or call Mr. Leo Darrigo, (212) 736-5840 in New York City.

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A leading manufacturer of broadcast equipment is presently forming a new TV Equipment Development Department. Opportunities exist for engineers with strong solid-state circuit backgrounds in TV transmitting equipment and related communications equipment.

Specific design and development assignments exist in:

Transistor circuits in the audio and video range associated with TV transmitters.

Filter and compensating networks.

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This is an opportunity to become associated with the development of new products within a well established and rapidly growing electronic communications equipment manufacturer. Persons applying must have a B.S.E.E. and be capable of accepting responsibility ranging from initial design concept through pilot production. You will be working in a new facility and in an atmosphere where creative contribution is encouraged.

Located in a medium size mid-west city oriented towards the finest of family living and progressive civic pride.

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You've heard of the panic button. International Nuclear has invented the calm button. They use it on their custom-built switchers. When you push it, whatever is supposed to happen will happen. You want camera three, you get camera three . . . no shorting . . . no gap . . . no flop. The major networks use International Nuclear switchers. And networks, as you know, can be very fussy.

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Circle Item 43 on Tech Data Card

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