TELE-TECH

A Caldwell-Clements Publication

JULY, 1953

FRONT COVER—"MULTICON"—A NEW STORAGE-TYPE CAMERA TUBE. Developed by engineers at Philips in Eindhoven, Holland, this new tube is the heart of the camera in Standard Electronics' new general purpose TV camera chain equipment which was first introduced at the recent NARTB convention in Los Angeles, Calif. Operating on principles similar to those employed in the iconoscope-type pickup tube, this design stresses improved sensitivity, smaller size and lower cost. See page 57 this issue for additional details.

DEPARTMENTS

TELE-TECH*, Vol. 12, No. 7. Published monthly by Caldwell-Clements, Inc. M. Clements, President; Orestes H. Caldwell, Treasurer. Acceptance under Section 34.64 Postal Laws and Regulations authorized at Bristol, Conn., February 8, 1952 with additional entry at New York, N. Y. 75c a copy. Annual Subscription Rates: United States and Possessions: $7.00; Canada: $8.00; All Other Countries: $10.00. Please give title, position and company connection when subscribing.

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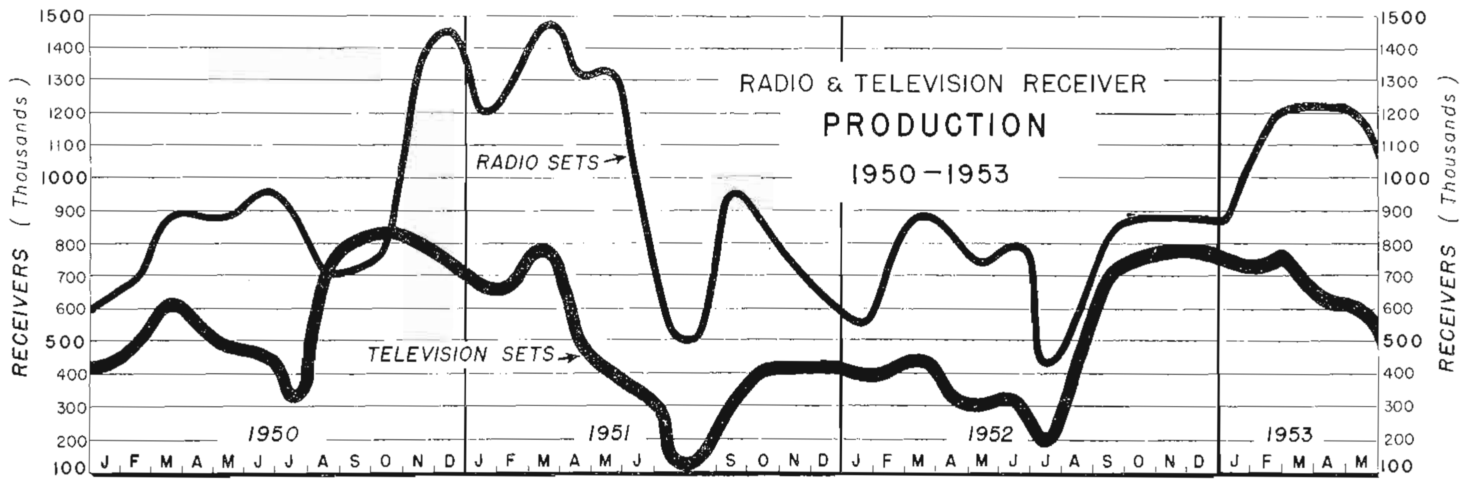
Publishers also of TELEVISION RETAILING

* Reg. U. S. Pat. Off.

TELE-TECH'S CIRCULATION, 21,000

Because of the lag in auditing, never catching up with current circulation in an expanding industry, an audit for the calendar year 1953 will not be made until after the end of the year. Meanwhile, sworn statements and post office receipts will be furnished covering the guaranteed circulation



Broadcast Stations in U.S.

	AM	FM	TV
Stations on Air	2368	590	146 VHF 35 UHF
Under Construction (CPs)	145	65	123 VHF 224 UHF 18 Educational
Application Pending	230	8	404 VHF 221 UHF

Radio and TV Receiver Production

	TV		Radio
May, 1953		Home	275,000
		Battery	142,000
		Auto	525,000
		Clock	142,000
Total	530,000		1,084,000
Five months (Jan.-May, '53)	3,495,400		6,376,640

Electronic Industries' Manufacturing Capacity

Estimates of possible monthly output of existing factory equipment if pushed to full production, compiled by J. E. Hobson, director Stanford Research Institute, Stanford, Calif.

Electron tubes (1200 different types)	30,000,000
Television sets	500,000
Home radios	500,000
Portable radios	100,000
Automobile radios	300,000
Germanium diodes, transistors	Several hundred thousand

BREAKDOWN OF TUBE SIZES AND TYPES

DISTRIBUTION OF TUBE TYPES SPECIFIED (NOT SOLD) IN TV RECEIVERS: Circuit analysis of different makes and models of new receivers published in Caldwell-Clements' *TV-Electronic Technician* during past six months shows that average set contains 17.5 tubes, exclusive of rectifiers and picture tubes. The 15 most popular types noted above (percents add up to 100%) account for 84.6% of the total. The five most specified picture tube types are 21FP4A, 17HP4, 17LP4, 17YP4 and 20HP4A.

PICTURE TUBE SIZES

1949-1950

7"	10"	12"	15"	16"	20"	PROJECTION
3.5%	22.5%	30%	7%	29%	2%	6%

1952-1953

16"	17"	20"	21"	24"	27"	30"
3.6%	36%	10.7%	36%	7.1%	3.3%	3.3%

TUBE TYPES MOST SPECIFIED

1949-1950

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6AG5	6AU6	6AL5	6SN7GT	6J6	6BA6	6K6GT	5U4G	1B3G	12AU7	6BG6G	6V6GT	5V4G	6AC7	6W4GT

1952-1953

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6CB6	6AU6	6AL5	6SN7GT	5UAG	6BQ6GT	1B3GT	12AU7	6W4GT	6J6	6AV6	6W6GT	6V6GT	12BH7	6AH6
20.7%	12.7%	11.4%	8.8%	7.5%	5.9%	5.9	5.3	4.4	4.0	3.0	2.9	2.5	2.5	2.5

Television-Set Shipments to Retailers during 1952

A total of 5,712,150 television receivers are estimated to have been shipped to retail radio-TV dealers during the last calendar year, according to preliminary figures prepared by the Editors of Television Retailing & Mart, the Caldwell-Clements dealer magazine which reaches 32,000 dealers each month. This 1952 total shows an increase of about 18% above total TV-set shipments to dealers in 1951.

Following are the 1952 figures by states:

Alabama	70,700
Arizona	22,600
Arkansas	14,700
California	544,000
Colorado	82,500
Connecticut	121,000
Delaware	19,400
District of Columbia	56,700
Florida	93,600
Georgia	104,500
Idaho	600
Illinois	322,000
Indiana	212,600
Iowa	98,450
Kansas	36,300
Kentucky	78,600
Louisiana	60,000
Maine	10,100
Maryland	105,000
Massachusetts	233,000
Michigan	259,000
Minnesota	83,500
Mississippi	19,800
Missouri	150,700
Montana	500
Nebraska	49,000
Nevada	100
New Hampshire	21,000
New Jersey	227,000
New Mexico	8,300
New York	668,000
North Carolina	114,600
North Dakota	500
Ohio	430,000
Oklahoma	95,300
Oregon	30,300
Pennsylvania	489,000
Rhode Island	35,300
South Carolina	28,600
South Dakota	1,200
Tennessee	72,600
Texas	253,000
Utah	30,800
Vermont	7,000
Virginia	103,400
Washington	93,900
West Virginia	62,700
Wisconsin	88,300
Wyoming	2,400
Grand Total	5,712,150

See also Caldwell-Clements Statistics in World Almanac, Encyclopaedia Britannica, National Conference Board Economic Almanac, and "Information Please" Almanac

Westinghouse Microwave Letter

WESTINGHOUSE ELECTRIC CORPORATION, ELECTRONICS DIVISION, 2519 WILKENS AVE., BALT. 3, MD.

30 Independent Channels Give Maximum Communications Capacity...Reliability

Many critical communications and control requirements are solved by microwave—the newest complete system of communications. When you compare the practical advantages of presently available microwave systems, consider these facts about the new Westinghouse 2000 MC Microwave.

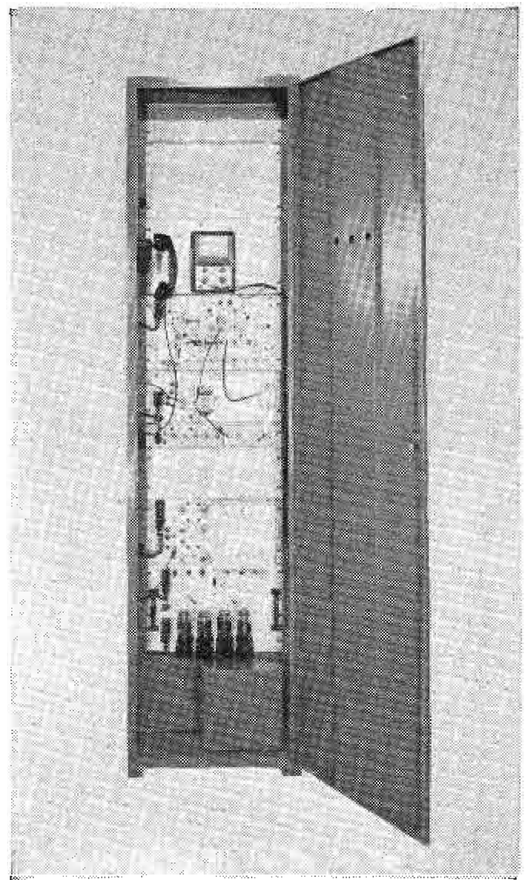
This Westinghouse system is based on (1) an extensive field and laboratory study of user requirements, and (2) years of valuable manufacturing and application experience with all types of end-use equipment. Selection of the 2000 MC band is one important result. This band provides more capacity than lower frequencies . . . gives less fading than higher frequencies.

Another important result is capacity: Westinghouse 2000 MC Microwave supplies 30 voice channels—more than enough for most present needs and capable of accommodating future needs. An independent 31st channel supplies service communications.

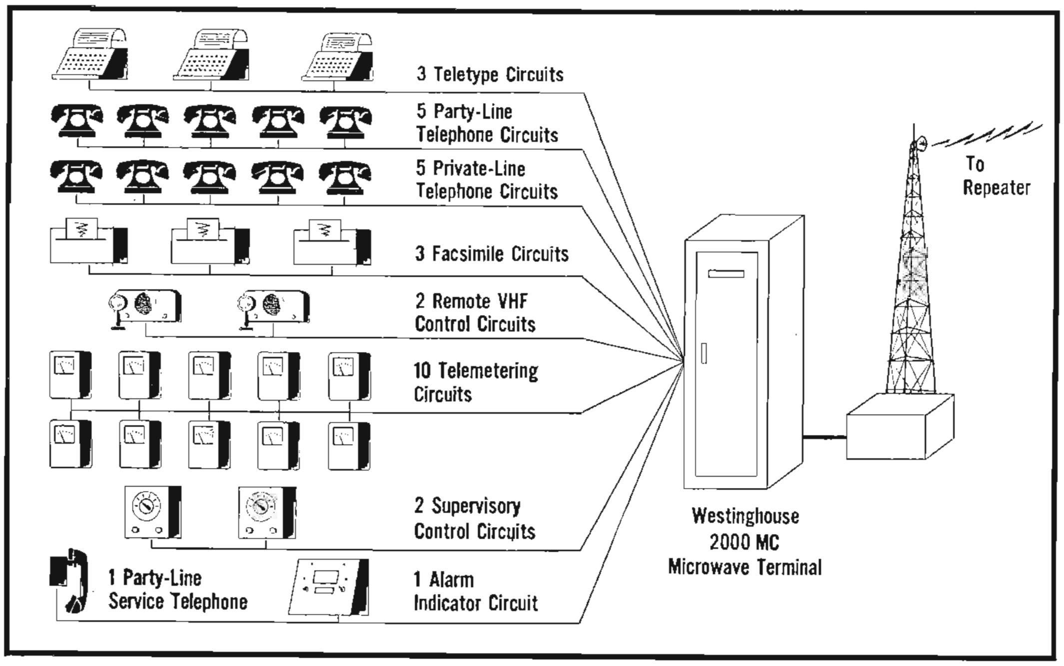
Each of these 30 voice channels can handle up to 15 telegraphic circuits. At full telegraphic capacity, 450 circuits are available for teletype, telemetering, VHF control, supervisory control, relaying, load control, and other functions. See illustration below for a typical arrangement.

These functions of Westinghouse microwave are based on a simple, flexible system of utmost reliability. Its two streamlined assemblies – Type FR Microwave Radio (illustrated) and Type FJ Multiplexing Equipment – have only four basic units each. Type FR Radio units can be assembled as either terminal or repeater stations. Type FJ Multiplex panels are entirely self-contained . . . each panel is provided with an individual power supply . . . and for high multiplex channel stability each channel has individual crystal control.

Strict channel independence like this means multiplexing reliability. If one channel develops a fault, all other channels continue to operate without interruption. That's why Westinghouse multiplex equipment, using frequency division, is your greatest guarantee of service continuity.



Westinghouse Type FR Microwave Radio assembly. Service channel and alarm panel are included for safe, efficient operation.



One of the many combinations of services that can be operated simultaneously over one microwave radio beam in Westinghouse 2000 MC Microwave radio.

Westinghouse has called upon its years of practical experience in microwave communications to suggest other beneficial design features for the new 2000 MC equipment. Call your Westinghouse representative or write: Westinghouse Electric Corporation, Electronics Division, Microwave Section, 2519 Wilkens Ave., Baltimore 3, Maryland.

Ask for our Microwave Booklet.

YOU CAN BE SURE...IF IT'S Westinghouse

J-02274

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Is the Heart of the Famous Collins Navigation System

The Collins 51R-3 Navigation Receiver is typical of the outstanding developments of the Collins Radio Company for aviation, navigation, and communication. It is in wide use among airlines, private, and military planes. With accessories, it is the heart of the Collins navigation system to which is entrusted the efficient and safe operation of every type aircraft.

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TELE-TECH* & ELECTRONIC INDUSTRIES is edited for top-level engineers and executives throughout the electronic industries. It gives the busy engineering executive authoritative information and interpretation of the latest developments and new products, with emphasis on subjects of engineering import and timeliness. Special attention is given to:

MANUFACTURING

- **Electronic equipment, communications, broadcasting, microwave relay, instrumentation, telemetering, computing.**
- **Military equipment including radar, sonar, guided missiles, fire controls.**
- **TV-FM-AM receivers, phonographs, recorders, reproducers, amplifiers.**

OPERATION

- **Fixed, mobile and airborne communications in commercial, municipal, aviation and government services.**
- **Broadcasting, video and audio recording, records, audio and sound systems, motion picture production.**
- **Military, civilian and scientific electronic computing and control systems.**

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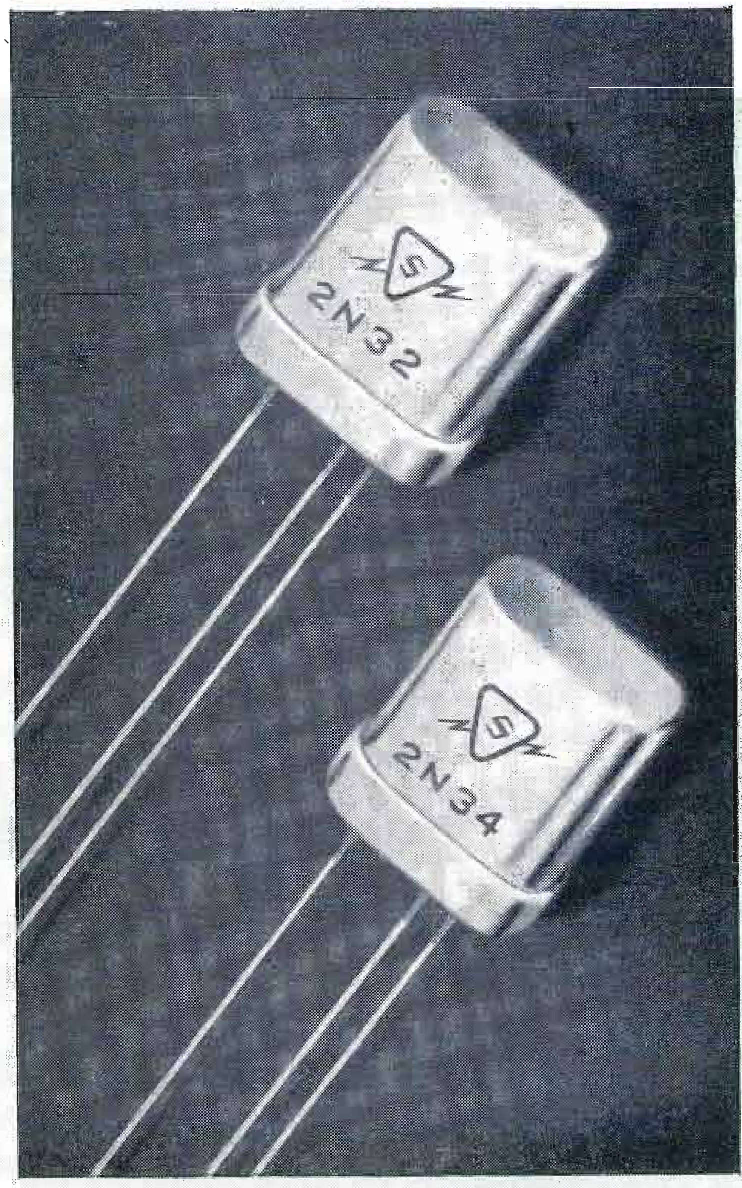

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TELE-TIPS

GI RECOLLECTIONS should be stirred by the name of GE's new Ordinal Memory Inspecting Binary Automatic Computer—OMIBAC. A hearty welcome to another member of the computer fraternity which boasts such "be-bop" names as MANIAC, WAC, SWAC, ACE, ERA, RAYDAC, XRAC, OARAC, EDVAC, REAC, ENIAC, UNIVAC and ELECOM. Oh, my back!

"ATOMIC ENERGY & SEX have much in common. Both are relevant to survival, yet neither should go unharnessed. By some strange social agreement, both are eschewed in polite conversation. Youngsters seem to know more about both than do their elders. And atomic energy, like sex, is surrounded by curious taboos. Both are featured, and about equally now, in the 'comics,'—although atomic energy does less well in the paper-backs, since it lends itself less naturally to front-cover use"—Robert R. Wilson, director, Laboratory of Nuclear Studies, Cornell.

JET vs TV—At Belmar, N. J., a jet plane zooming over rooftops sucked a television antenna off the roof of the home of Raymond Crowther, he reported to the police. Mr. Crowther said that the nose intake of the plane, flying 150 feet above his home at 1620 M Street, pulled a twenty-eight-foot aerial and directional tuning motor right off the roof as it sped by. The antenna, which landed on an open back porch, "was torn up, guide wires and all," he reported.

DEEP AMPLIFIER TESTS—The cold high-pressure depths nearly two miles down in the North Atlantic, where no diver would dare to penetrate, are reproduced artificially by Western Union Telegraph Company engineers in a downtown New York skyscraper. An approximation of the ocean depths, chilled by 3,300 pounds of ice, is produced periodically inside a five-ton tank at Western Union's headquarters at 60 Hudson Street. The novel five-foot-high pressure chamber plays an important role in testing amplifiers being installed on the company's cables on the ocean bottom.

RADIO CLUB'S 43rd anniversary gathering was told that within the next ten years atomic reactors will be able to compete with coal-burning electric plants. Dr. Lloyd V. Berkner, President of Associated Universities, Inc., which operates the Brookhaven reactor, said that a pound of uranium when burned completely in a reactor, produces the heat equivalent of a million pounds of coal, so that 200 tons of uranium would supply the entire fuel requirements of the United States for a year. When it is realized how rapidly our fuel reserves of coal and oil are being depleted, the prospect of atomic power becomes of utmost importance. This important discussion of energy requirements and sources is now available in printed form as Vol. 30, No. 1, of the Proceedings of The Radio Club of America, Inc., 11 West 42nd St., New York City, at 50 cents per copy.

THE LONG VIEW—"Every age has believed itself at the last peak of human achievement and every age has been wrong. Throughout the history of invention and discovery wise men have declared that we were only straining our imaginations."

"We are all upset now. Everybody is pretty well willing to sell out and discount the world. I am not, because if you will just read a little bit of history, you will find out the troubles we are in today are just ordinary picnics compared to what we have had, so I am not willing to sell out."

—Charles F. Kettering

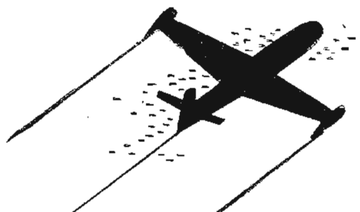
Major Armstrong on "The Spirit of Discovery"

Dr. Edwin H. ("Major") Armstrong, professor of electrical engineering at Columbia University, and discoverer of fundamental radio principles, was scheduled to be the guest speaker at the summer general meeting of the American Institute of Electrical Engineers at Atlantic City, June 15, responding to the topic "The Spirit of Discovery," and stressing the importance of the inventor and scientific explorer in the modern world.

During the session, Professor Armstrong was presented with a certificate of honorary membership in the Institute, voted him by the Board of Directors on April 23. Dr. Armstrong was awarded the 1942 Edison Medal by the AIEE and in 1951 he won the Washington Award, given by the Washington Award Commission composed

(*Continued on page 24*)

Field Engineers



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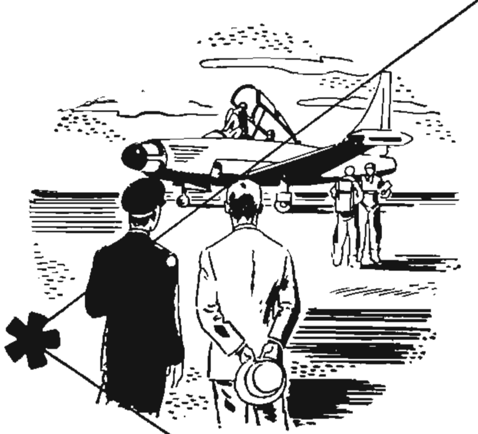

Here is an unparalleled opportunity for men with a College or Technical Institute Training and a sound background in electronic engineering. The training and experience provided will open up increasing opportunities for earnings and advancement in the fast approaching age of jet air transportation.

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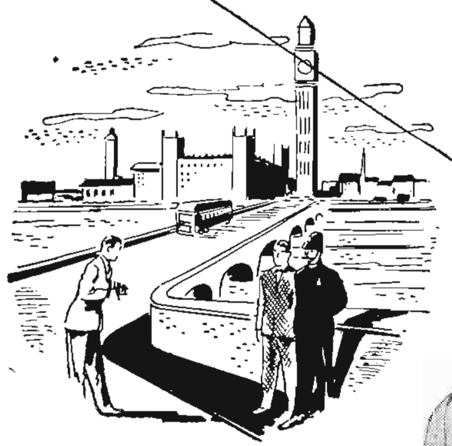

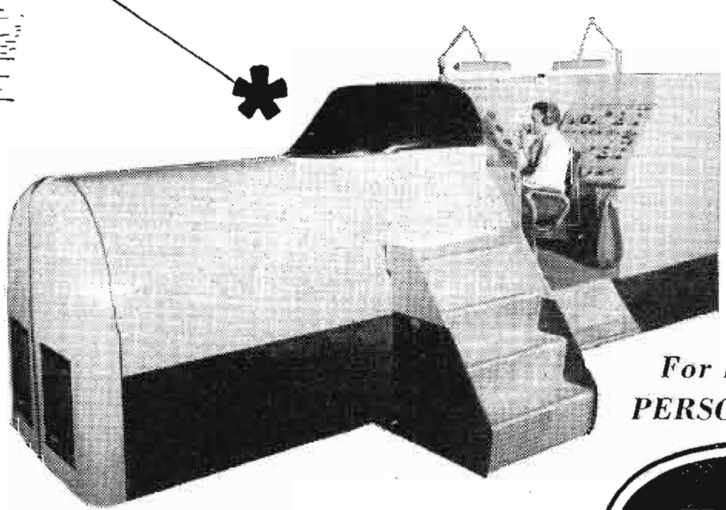

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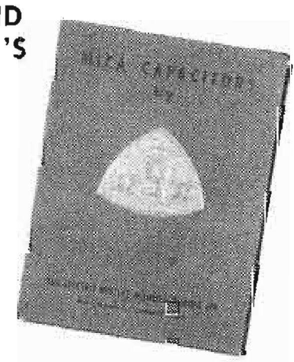

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THE ELECTRO MOTIVE MFG. CO., INC. WILLIMANTIC, CONNECTICUT

Major E. H. Armstrong

(*Continued from page 11*)

of members of the Western Society of Engineers and the four founding engineering Societies.

Often accredited as "The greatest American inventor since Edison" and the "most important of all radio inventors, including Marconi," "Major" Armstrong made four basic discoveries that have revolutionized radio, both AM and FM. These are: The regenerative circuit, which took radio out of the crystal-detector headset stage; the superhetrodyne circuit, the basic circuit of today's standard radio; the superregenerative circuit, used in military, forestry and other ultra high frequency communications, and frequency modulation, or static-free high-fidelity radio.

As a Boy Inventor

Professor Armstrong's interest in radio dates back to 1904 when his father, John Armstrong, brought him two books from England, "The Boy's Book of Invention" and "Stories of Inventors." The Armstrongs then lived in Yonkers, N. Y., and soon the attic of their house was filled with homemade radio devices and he was picking up signals from wireless sets in New York, and once in 1908 he picked up signals from the Navy Station at Key West.

When he entered Columbia in 1909, his interest in radio was heightened. In 1912 while studying Lee De Forest's audion tube, he discovered the regenerative circuit, but his father refused to loan him $150 to patent it and he had his paper notarized Jan. 13, 1913 and filed them away.

Forty Years at Columbia

Upon graduation in 1913, he took a $50 a month job as an assistant professor in electrical engineering at Columbia in order to use the university laboratory facilities. He was associated with the research physicist, Michael I. Pupin at the Marcellus Hartley Research Laboratory at Columbia from 1914 until Pupin's death in 1935.

Professor Armstrong has been professor of electrical engineering at Columbia since 1934.

During the first world war he served as a captain and major in the U. S. Army Signal Corps and was made a Chevalier, Legion d'honneur in 1919.

Besides the Edison Medal and the Washington Award, Professor Armstrong has won may other honors. They include the 1917 Institute of Radio Engineers Medal of Honor; the 1939 Egleston Medal, Columbia University; the Modern Pioneer Plaque of the National Association of Manufacturers in 1940; the Holley Medal, American Society of Mechanical Engineers, 1940; the Franklin Medal, Franklin Institute, 1941; the John Scott Medal, Board of City Trusts, City of Philadelphia, 1941; the Armstrong Medal, established in 1943 by the Institute of Radio Engineers.

TELE-TECH

& ELECTRONIC INDUSTRIES—RADIO-TELEVISION

O. H. CALDWELL, Editorial Director ★ M. CLEMENTS, Publisher ★ 480 Lexington Ave., New York (17) N. Y.

The Five Touchstones of

ENGINEERING-EXECUTIVE SUCCESS

Five special attributes appear to mark engineers who have successfully turned business executives and risen to the top in some fifty leading American corporations:

1. **An ability to express themselves clearly and well.**
2. **Normal curiosity regarding economics, finance, law, psychology, and other non-engineering subjects.**
3. **A willingness to make the logical and reasonable compromise with perfection which day-to-day business requires.**
4. **A ready understanding that income must exceed outlay, and—**
5. **Above all, an ability to get along with contemporaries and to understand, at least, competitors.**

Unless one can express his views and opinions to others, he is of little worth as an engineer or as an administrator. Today's executives must maintain a constant contact with financiers, who provide their plants and credits; suppliers, who provide raw materials; engineers, who design their products; labor, which builds the products; the sales force; and finally the customer to whom they must look for the profit which enables them to continue in business. Unless their contacts with each of these groups are in mutually understandable language, their jobs are not well done.

BROAD KNOWLEDGE IS BASIC

Broad collateral knowledge is essential to any engineer who aspires to management posts. He must learn why people buy one product and ignore another; understand the market trends and analyses; know the whys and wherefores of finance; become familiar with elementary business law; observe labor trends and management reaction.

Engineers are inclined by nature to be perfectionists. Every engineer is sure that his fine handiwork of today can be made even finer tomorrow. And it is amazing how often he is right. If our predecessors had been content with their first early models of the steamboat, or the airplane, progress would have bogged down before science had an opportunity to produce its greatest marvels.

But the wise business executive recognizes that industry must produce goods—not just design them—if it is to prosper, and production is impossible if designs are changed from day to day. Thus, he realizes that practical operation must make the logical reasonable compromises with perfection which make possible continuous profitable operation. The successful engineer-turned-executive realizes that there is a sharp and irreconcilable difference between competitive production demands and the creation of a single model-shop unit.

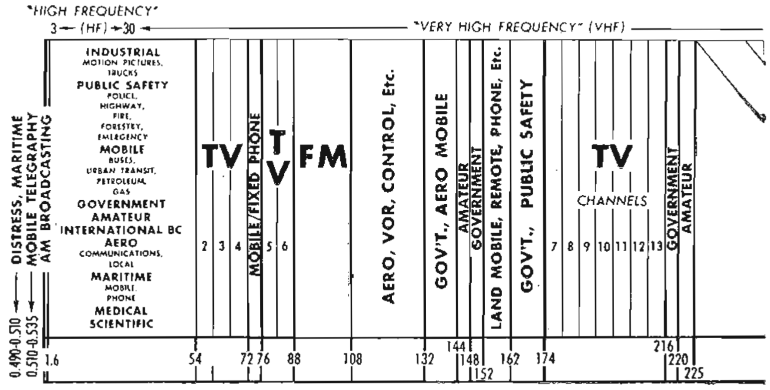
FACTS OF COMPETITIVE LIFE

Production requires, for example, a design which can be made at the lowest cost consistent with satisfactory quality. It calls for connections and adjustments easy to get at and simple to operate. It requires the fewest possible parts and the simplest assembly plan. It is this "know-how" which frequently means the difference between red or black ink.

It is the basic "facts of competitive life" which the practical administrator never overlooks.

Each of the foregoing characteristics is essential to management success, but there is another without which all others are lost. This magic key to successful administration is ability to get along with people. This ability to cooperate with one's contemporaries influences every human relationship and is responsible more than anything else for the success or failure of a business executive.

A guest editorial by the late Walter C. Evans, vice-president of Westinghouse Electric Corporation in charge of radio, TV, and electronic operations. Mr. Evans was a radio pioneer and experimenter whose activities continually broadened until he carried a heavy top-executive load in the rapid expansion of the Westinghouse company's electronic developments and applications.



RADARSCOPE

Revealing Important Advances Throughout the Spectrum of Radio, TV and Tele Communications

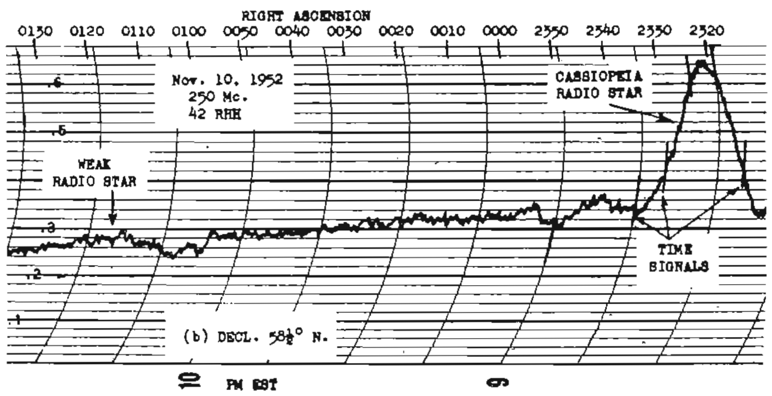
VIDEO RECORDING

MAGNETIC-TAPE TV in recent years has been receiving increasing mention in both newspapers and periodicals. Several methods of accomplishing this have been suggested and include: (a) Dividing the video bandpass required into discrete sections, and beating the frequencies in each of these sections against a fixed frequency oscillator so as to obtain a recordable beat frequency. (b) Determine frequencies having maximum energy concentrations in the video spectrum and arrange the recording system facilities to accommodate these. (c) Establish a recording system which will record only the difference video signals appearing in successive frames (change in picture elements, not entire picture). Researchers are hard at work on this problem and there are indications now that a practical system may be proposed before years end. The impact that such a development will have on the television, color television and motion picture industries will be tremendous. It's conceivable that the recording of images on motion-picture film might be obsoleted as the result.

COLOR TELEVISION

CAMERA TUBES are still a most troublesome item in the compatible color television system. Equipment clumsiness and the electrical difficulties encountered in lining up the three individual pickup tubes used with the dichroic mirror arrangement are great annoyances to all concerned. RCA recently demonstrated a new pickup tube which enables taking off the three color signals simultaneously, but this is still several years away from commercial reality. A newer approach has been to use vidicon camera tubes in conjunction with an orthicon camera tube. Here the latter picks up the monochrome detail and the former are employed for color information only. The fact of the matter is though, that we do not have the color-TV camera tubes we shall soon be needing. And prospects for getting them in the near future are not too bright.

ATOMIC-ENERGY RADIO TRANSMITTER



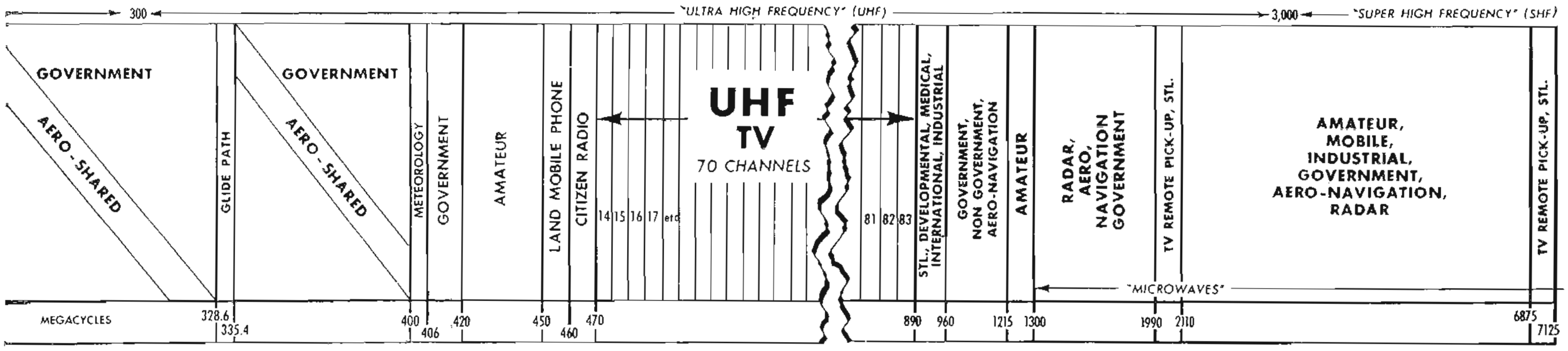
The biggest atomic explosion in all human history was that observed in the 16th century when a nova or "new star" broke out in the northern sky in the constellation Cassiopeia,—a star which could be seen in bright daylight for many weeks! That nova, centuries ago, flickered out of sight to even our largest telescopes, but now with the new radio detectors, a tremendous radio signal is continuously coming from that point in the sky where the stellar atomic blast occurred nearly 400 years ago. Does this imply that the last stages of an atomic explosion, after producing intolerable light and heat, finally run down the frequency spectrum and serve as a source of radio waves?

ELECTRONIC CUTTER

ULTRASONIC SOUND WAVES now drive a new kind of machine tool that carves fancy shapes, drills holes, and does other such work in hard steel, glass, ceramics, or even precious stones. The 27,000-cycle machine was developed by Raytheon of Waltham, Mass., and was first used for mixing so-called immiscible liquids. Now the device, which employs "magnetostrictive" principles, has been developed into a machine tool which is expected to have widespread applications in many metalworking industries. Present form of the machine is most nearly like that of a conventional drill press, but Raytheon engineers are working on other models that may enable it to perform the functions of a lathe, milling machine, boring mill, shaper, planer, saw and router. One of the most amazing features of the machine is that the cutting tool can be made of relatively soft material—such as cold rolled steel, or brass—and yet, such a tool, cutting through only a few atoms at a time, will penetrate hard steel, stone, cast iron, or even sapphire!

BASIC PHENOMENA

ELECTRON FLOW—An electronic conductor is a lattice of atoms pervaded by free electrons forming an electron-atmosphere defines Karl K. Darrow of Bell Labs. When an electric field is applied, the electron-atmosphere blows through the lattice like a wind. There are experiments that give the product of the wind-speed and the density of the electron-atmosphere, and there are other experiments that give either factor by itself. Normally the wind-speed declines with increase of temperature, the electron-density rises with rising temperature. In metals it is the former factor that dominates the dependence of resistance on temperature, in semi-conductors it is the latter. Theory says that the wind-speed depends on the vibrations of the atoms and on other irregularities in the lattice, and the electron-density on the work required to transform a bound electron into a free one.



"PROMISED LAND"

WEST VS. EAST—Why has the electronic industry grown so fast on the West Coast? Is it because excellent men, trained in the East, prefer to live in the West? Does the climate cause them to do better work than they could in the East? What about facilities? Equipment in labs. still is below the scale generally found in the East. Raw materials for manufacturing are not always at hand, transportation costs are greater because of long haul, both ways,; because principal markets for goods are usually not found in the West. There should be advantages in guided-missile work on Coast because of nearness to aircraft companies and test fields. Outdoor tasks, such as testing antenna patterns, etc., can go forward many more days in the year than in the East. What are chances for post-graduate work in universities? Better recreation facilities? Good schools for children? Better health? Outdoors more?

Answers to all of the latter questions appear to be in the affirmative. But to find out to what degree; to learn more of the situations and conditions, watch for next month's TELE-TECH. The whole issue is focused on the activities of the West Coast Electronic Industries.

NEW HORIZONS

DIELECTRIC AMPLIFIERS may someday take a place of industry prominence, along with the magnetic amplifiers about which we have heard so much in recent years. Dielectric amplifiers are powerful yet amazingly simple and minute sheets, approximately 1/8-inch square and 7/1000 of an inch thick. When used in simple circuits roughly similar to those employed with electronic tubes, they amplify weak electrical currents to produce more powerful currents. Made of ferro-electric materials coated on each side with silver, they can best be described as resembling ordinary little pieces of paper.

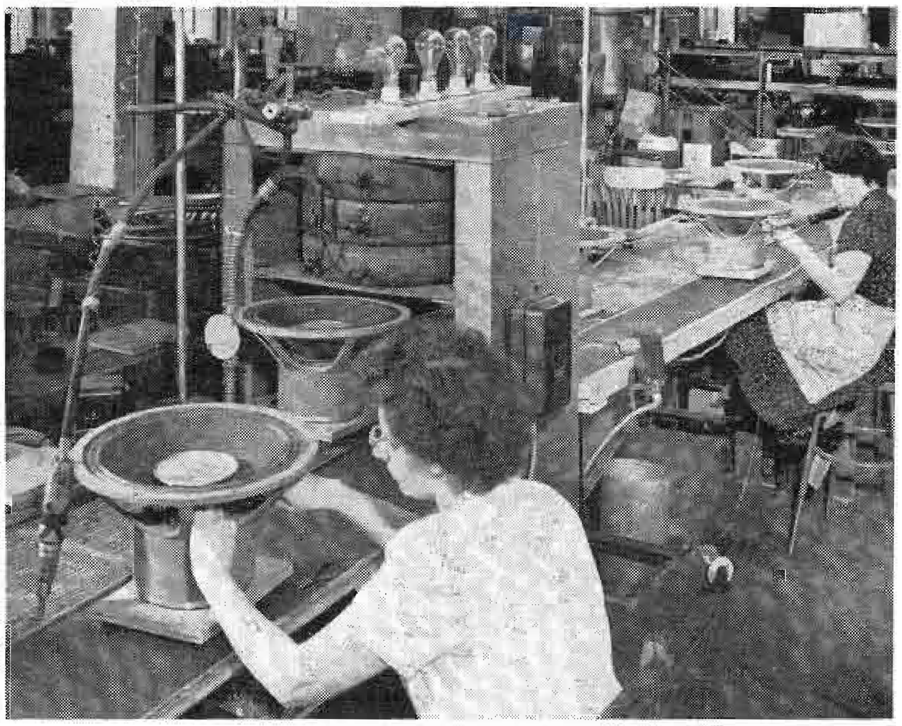
As far as present research can determine, these rugged little particles will last indefinitely and appear to have great promise for replacement of fragile vacuum tubes in military equipment. They may also find their way into industry where automatic control equipment such as photo-electric counting and high speed servo-mechanisms are used. For radios and TV sets, the amplifiers may not be of practical use because of the elaborate auxiliary equipment that goes along with them.

Research on dielectric amplifiers has been under way for the last three years with such participating units as General Electric, Bell Telephone, Glenco Co., Radiation Inc., Massachusetts Institute of Technology and Carnegie Tech.

TELEVISION FILMS

UHF STATIONS—The possibility has been suggested that the new UHF television stations will use different methods of film production from those used by VHF TV stations. All the available information points to the fact that there will be no difference in either film or live pick-up in UHF TV operations. Even the magnetic sound on films system is not, as far as is presently known, being proposed for TV operations. It is probably due to the fact that few if any TV film projectors have been modified to use this new system and even fewer release films, or library films have been duplicated using magnetic sound on film. Therefore the supremacy of the old optical system appears to be unchallenged.

10,000 to 14,000 GAUSS!



New 2.5-ton magnetizing unit goes into operation in Stromberg-Carlson's Sound Division plant, Rochester, N. Y. Photoelectrically controlled, unit consists of steel yoke supporting two pole-pieces each one foot in diameter. Each of the three coils on each pole-piece has 1450 turns of No. 12 cotton-enamel copper wire. (700 lbs. copper, total) In operation, 50 amps at 300 v. produces 10,000 gauss in air-gap. When magnetizing 10.5 lb. Alnico V polepiece in 15-in. speaker, the flux density rises to 14,000 gauss. Bulbs and heating coils are wired in parallel with magnet's coils to absorb power surges resulting from "on-off" operation.

Magnetic Amplifiers for

Special designs provide control power for instrument type ment. Careful attention to design problems permit high reli-

By J. K. McKENDRY
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IN the present state of magnetic-amplifier development, one of the most attractive applications is in the output stages of instrument servo-amplifiers, particularly for use in airborne equipments.

Under an Air Force contract, several positioning servomechanisms were required, having general similarities but differing widely in some details and specifications. The motor used in all instances is the 2 phase, 400 CPS, Mark 7 (Bureau of Ordnance designation). It is rated at 6 watts input per phase, has a stalled torque of 1.5 oz. in., and a free-running speed of 5000 RPM. Ranges of variation in other important servo perimeters are:

	Maximum	Minimum
Gear Ratio	3200	533
Control Signal Sensitivity	0.39 volts/degree	0.022 volts/degree
Permissible Error	15 min.	3 min.

In the interests of production economy and in consideration of the spares stocking problem, it was desirable to have a single amplifier design for all these applications. In addition, no factory or field adjustment of the amplifiers was to be required. Fixed attenuators are provided in the system to equalize the variations in control signal sensitivity and gear ratio.

One feature common to all the servos is the assumed presence of coulomb friction in the mechanical loading. A maximum value, based on previous experience with similar mechanisms, was assumed to apply in all cases. Each servo is then required to have a sufficiently high torque-error constant to reduce error to acceptable limits in the presence of this value of load friction. Unfortunately, since the friction term is not controllable except as to its maximum value, it is not possible to rely on it as a stabilizing influence.

Primary Function

The primary system function is that of an analog computer having slowly varying inputs. Velocity and acceleration errors are accordingly of little significance, and the frequency pass bands of the servomechanisms can be correspondingly restricted. This consideration is of course favorable to the use of magnetic amplifiers which are relatively low-pass elements.

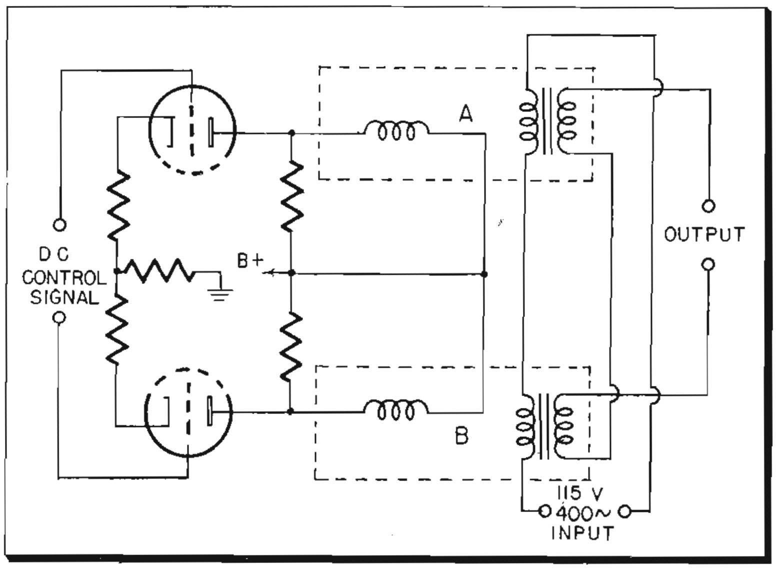
It was initially decided that an all-magnetic amplifier would not be feasible, in view of limitations on gain per stage and the anticipated difficulty in stabilizing a servo loop incorporating more than one stage of magnetic amplification. The amplifier, as finally produced, consists of a magnetic amplifier output stage and three dual-triode vacuum tubes of the voltage amplifier class.

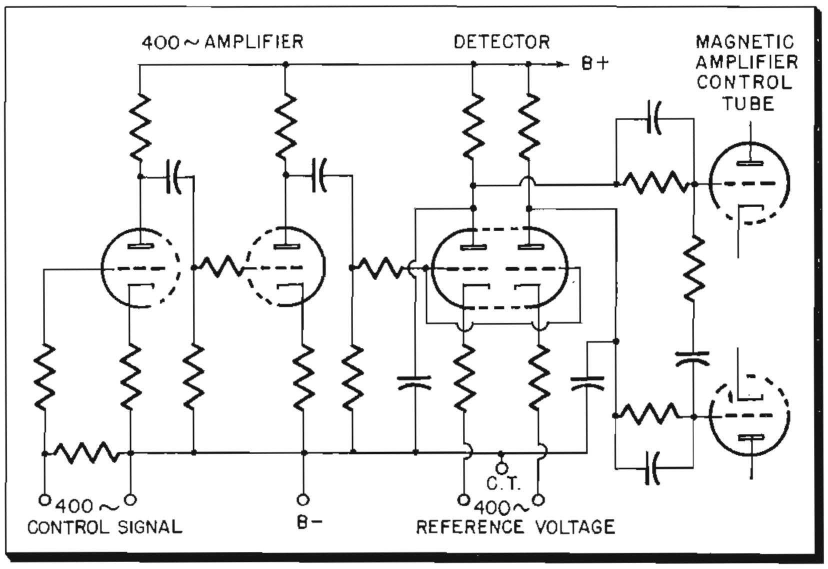
The magnetic amplifier, shown schematically in Fig. 1, with its associated control tube, is of a conventional type, consisting essentially of two identical saturable core transformers. The primary coils are connected in series across the 115 volt, 400 CPS line. The secondary coils are also connected in series, with opposing polarity. With equal currents flowing in the two control windings, the transformer voltages are equal and there is no net output voltage. If the control current of transformer A is increased and/or the control current of transformer B is decreased, the primary impedance of transformer A is reduced relative to that of B, and the primary and secondary voltages of B will be correspondingly greater than those of A. A net voltage of 'B' polarity then appears across the output terminals. Obviously a positive current increment in the control winding of B will reverse the operation and yield an output of 'A' polarity.

The physical dimensions of the magnetic amplifier are 1-5/8 x 2 x 2-1/8 in. Its weight is 13½ oz. in a hermetically sealed case. The cores are stacked E-I laminations of audio transformer grade steel. Coils are of class "A" construction.

Economical design of the magnetic amplifier requires that its internal impedance, as seen at the output terminals, represent a significant fraction of the total load circuit impedance. The voltage delivered to the load is accordingly affected in magnitude and phase by the nature of the load impedance. This effect is usefully applied in the servo-ampli-

Fig. 1: (l) Magnetic amplifier with its asscoiated control tube. Fig. 2: (r) RC network following phase detector improves torque-erro constant





Airborne Applications

servomechanisms used in military equip-
ability without sacrifice of performance

fier by trimming the load so that it effectively consists of a resistance in parallel with a capacitor which resonates with the magnetic amplifier inductance at 400 CPS. Under these conditions the load voltage is in exact quadrature with the primary line voltage, which is the desired condition for control of a 2-phase motor. This phase relation holds reasonably constant over the full range of output voltage providing the average of the two control currents is maintained constant.

A secondary benefit derived from the load tuning capacitor is the marked improvement in load voltage waveform due to harmonic attenuation. Other, less favorable, aspects of the tuned load circuit will be discussed later.

The preceding electronic stages of the servo-amplifier are shown in the circuit diagram, Fig. 2. They consist of an initial two stage, resistance coupled, ac amplifier, followed by a phase sensitive detector. The detector output is coupled to the grids of the magnetic-amplifier control tube through a resistance-capacitance network which performs the necessary shaping of the amplifier's frequency response.

Energy Storage Effects

The necessity for frequency response shaping in this application is largely due to the energy storage effects contributed by the magnetic amplifier, and by the interacting motor and magnetic amplifier. To demonstrate the validity of this statement it is necessary first to examine the frequency dependent transfer function of the motor alone.

The Mark 7 motor, in addition to the characteristics already cited, has a rated rotor inertia of approximately 0.017 oz. in.[2] The effective damping coefficient, computed from the rated stalled torque and the rated free running speed is 0.0029 in. oz./radian/sec. The ratio of these two quantities in the order given and after conversion to equivalent units, is approximately 0.014 sec. This is, by definition, the motor time constant. The inverse ratio, sometimes referred to as the motor natural frequency or corner frequency, is approximately 70 radians or 11 CPS.

This computed value is somewhat optimistic since the damping coefficient at low control voltages is markedly smaller than at full rated voltage. While the generated motor torque is a reasonably linear function of control voltage, the free-running motor speed at low control voltage levels is considerably higher than proportional. Tests with hard-tube proportional amplifiers, having

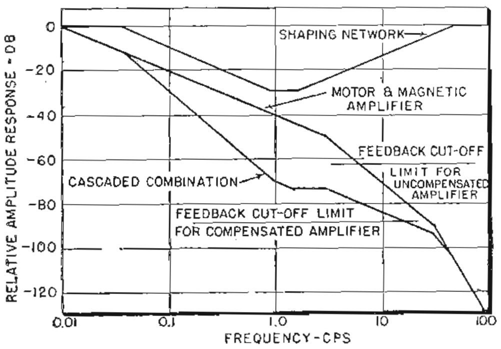


Fig. 3: Position servo transfer functions

no energy storage elements effective in the servo frequency range, indicate that the actual corner frequency for low signal levels is approximately 7 CPS. With such an amplifier it is possible to achieve a closed loop gain corresponding to a velocity-error constant of approximately 300 radian/sec/radian, a torque-error constant of 0.5 in. oz./radian, and a resonant peak at approximately 20 CPS. Such a servo is not well damped but is acceptable for many applications.

Phase Lag Network

The magnetic amplifier has an obvious energy storage mechanism in the inductance of the control windings. In the circuit configuration of Fig. 1, using a 12AU7 dual-triode as a control tube, the effect is that of a phase lag network with a corner frequency in the vicinity of 30 CPS. This is adjustable, to some extent, by variation of the effective control tube resistance, but practically cannot be increased much above the frequency mentioned.

There is also a second, less obvious, energy storage mechanism associated with the magnetic amplifier load circuit. As previously indicated, the control winding of the motor is paralleled with a condenser which, at 400 CPS, creates a condition of parallel resonance with the motor winding effective inductance, plus series resonance with the magnetic amplifier load circuit inductance. When a modulated 400 CPS carrier is impressed on this circuit, by the control action of the magnetic amplifier, the higher frequency modulation component lags in phase behind the low frequency component. The net effect is the production of a phase lag in the modulation envelope. In the region of interest this can be satisfactorily represented as a simple phase lag element, operating on the modulation frequency, and having a corner frequency at approximately 30 CPS.

Servo Motor Blocked

The two preceding effects are observable with the servo motor blocked. There is also a third deleterious effect which becomes apparent only when the motor is running free, and results from an interaction between the motor and magnetic amplifier. The stalled motor can be satisfactorily represented (at fixed frequency) by paralleled resistance and inductance. Free running, the motor has an induced internal voltage, which is essentially in series with its equivalent resistive component. The external impedance presented at the motor terminals to this back e.m.f. is essentially that of two parallel resonant circuits of quite high "Q". For a fixed value of control signal fed into the magnetic amplifier there will be, then, a considerably higher voltage across the terminals of the freerunning motor than across the stalled motor. This increase in voltage with increasing speed constitutes an effective reduction in the motor damping coefficient.

In the closed loop servo equations, reduction of the motor damping coefficient can produce varying results, depending on what compensating changes can be made in other loop parameters. In the absence of all time lags except that of the motor, it must entail reduction of the torque-error constant, reduction of the loop damping ratio or a combination of these two effects. The presence of time lags at higher frequencies furthermore places an absolute limit on the amount of reduction in damping ratio which can be accepted in lieu of reduced torque-error constant.

The back e.m.f. of the servo-motor is proportionally larger at low control voltages. It therefore not only reduces the average motor damping coefficient but also enlarges the range of variation of this parameter, to such an extent that it is impossible to compensate the effect adequately by any simple means such as a phase lead network.

It has been found possible, by means of inverse feedback around the magnetic amplifier, to minimize the back e.m.f. effect to a considerable extent. In this particular application use of feedback would have required a large number of additional components, and would have placed some undesirable limits on system functioning. A more acceptable solution was found to be the use of load-damping resistors across the motor terminals. This of course reduced the maximum useful power output of the magnetic amplifier but not to an intolerable extent. The effective motor corner frequency is, by this means, restricted to a range of variation of approximately 3 to 5 CPS. With this modification, the composite open loop transfer function of the motor and magnetic-amplifier can be adequately represented algebraically as a fractional expression having a gain-constant in the numerator and a fourth degree polynomial in $j\omega$ in the denominator. A graphical plot of the amplitude of the transfer function in decibels against log of frequency can be approximated by three straight-line asymptotes; the first extending from zero to 3 CPS with a slope of −6 db per octave, the second extending from 3 CPS to 30 CPS with a slope of −12 db per octave, and the third above 30 CPS with a slope of −24 db per octave.

Closed Loop Stability

The phase shift associated with the transfer function reaches 180° (lagging) at approximately 6 CPS. For closed loop stability the gain constant must accordingly be adjusted to produce feedback cut-off at or below this frequency. The corresponding velocity-error constant is approximately 75 radians/sec/radian and the torque-error content is approximately 0.06 in. oz. radian or about one tenth as large as that which can be realized with an uncompensated hard-tube amplifier.

The re-shaping of the transfer function to improve the torque-error constant to a usable level is performed in the resistor-capacitor network shown following the phase detector in the circuit diagram of Fig. 2. This is a composite lead-lag network of a common variety sometimes descriptively titled a "notch" network. The straight-line asymptotes of its amplitude response curve on a decibel-log frequency graph are as follows:

1. A straight line of zero slope below 0.035 CPS.
2. A straigh line of −6 db/octave slope from 0.035 CPS to 1.0 CPS.
3. A straight line of zero slope from 1.0 CPS to 1.7 CPS.
4. A straight line of plus 6 db/octave slope from 1.7 CPS to 48 CPS.
5. A straight line of zero slope above 48 CPS.

In Fig. 3 are shown the amplitude response asymptotes for the composite motor-magnetic amplifier and for the notch network, together with the asymptotes of the curve representing their cascaded response. This overall response curve has a section of −6 db per octave slope between the frequencies of 1 CPS and 30 CPS (with minor irregularities near the low frequency end). The phase shift corresponding to this amplitude curve reaches 180° at approximately 20 CPS. At lower frequencies it remains in the quadrant between 90° and 180° with a maximum lag of 160° in the region of 0.2 CPS.

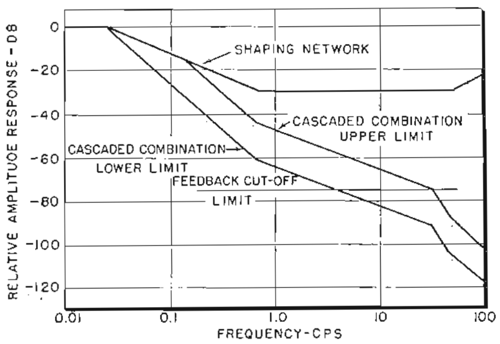


Fig. 4: Transfer functions of rate servo

If the loop gain is adjusted to produce feedback cut-off anywhere in the region of 1 to nearly 15 CPS, the servo operation will be stable and acceptably damped. With cut-off at 15 CPS, the velocity error constant of the servo is approximately 1900 radians/sec/radian. The torque error constant is 1.4 in. oz./radian for this same gain level.

Gain Variation

Computed maximum variation in overall amplifier gain, due to arithmetic addition of all component variations affecting gain, amounts to a range of approximately 5 to 1. In each individual loop a fixed attenuator is included such that the loop gain, with an amplifier having maximum computed gain, will reach cut-off at 15 CPS. A minimum gain amplifier will accordingly produce a torque-error constant of 0.28 oz. in./radian. This is sufficient in all cases to meet the static accuracy requirements of the system.

Rate Servo

The servo-motors used for this application are a 2-phase 400 CPS type, similar to Naval Ordnance Mark 8 except that they have 4 poles per phase, yielding a synchronous speed of 12,000 rpm. The stalled torque is 2.5 oz. in. and the free running speed is 10,000 rpm. The motor damping coefficient, computed from these values is 0.0024 oz. in./radian/sec. Rotor inertia is 0.019 oz. in.^{2} and that of the direct-coupled precision tachometer is 0.57 oz. in.^{2} The effective motor time constant is then 0.64 sec, and the corner frequency is 1.56 radians or 0.25 cycles/sec. As in the previous case, this value is reduced at low signal levels, to approximately 0.15 CPS.

The amplifier used is identical in configuration with that of the positioning servo. Differences are in the magnetic amplifier which is slightly larger, as required to furnish the rated motor input power of 16 watts, and in the shaping network values.

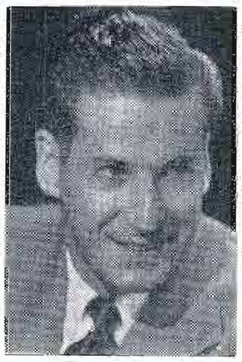
The requirements placed on the shaping network are again determined almost entirely by the nature of the transfer function of the composite motor-magnetic amplifier. As in the positioning servo, the phase lag effects due to the control winding inductance of the magnetic amplifier and to the resonant load circuit become effective in the vacinity of 30 CPS. There is also a substantial and variable reduction of the effective motor damping coefficient. In the case of the rate servo it was found possible to tolerate this varying effect without direct compensation.

With the varying motor time constant it is not possible to define an exact transfer function in linear terms. However it is possible to define the limits of the transfer function and determine loop stability for all intervening fixed values. In the lower limit the transfer function can be approximated on a db-log frequency graph by a straight line of zero slope below 0.025 CPS, a straight line of −6 db per octave slope from 0.025 to 30 CPS and a straight line of −18 db per octave slope above 30 CPS. In the upper limit the low frequency asymptote extends to approximately 0,15 CPS, the upper cor-

(*Continued on page* 123)

Battery-Operated Remote Amplifier

Extremely simple to construct and operate, self-powered portable unit provides remote audio pick-up where ac line is not conveniently at hand



By
JEFF EVANS
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WLDY
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MOST radio stations can make use of an extra remote amplifier, especially when the amplifier has good fidelity and is self-contained. Sometimes it is necessary to run a couple hundred feet of ac line, and sometimes no ac whatsoever is available. In the smaller stations, a single man quite often carries the remote broadcasts, and a battery-operated amplifier, simple to operate, maintain, carry and cheap to build, is a boon.

The following battery-operated remote amplifier (see Fig. 1), weighing only a few pounds, has only one switch to turn on and one volume control which is usually opened to maximum and left there. If preferred, the volume control can be omitted entirely. As an additional aid, a surplus visual indicator was added. If the operator wishes, there is room inside for spare batteries but we prefer to pack the microphone, spare batteries, spare tubes, screwdriver, headphones, etc., in a companion box about 8 in. square. The operator can broadcast conveniently from any place the phone company will string a loop.

Mounting Arrangement

The amplifier is contained in an 8 by 12 in. metal box obtained from a hardware store at a cost of $2.59. The amplifier is mounted in the left third of the bottom about 1.5 in. from the bottom to allow for wiring, on shelf brackets made from two pieces of scrap aluminum bolted to the front and back to give support to the amplifier chassis.

Basically, the chassis is an old GE pre-amplifier 4BA1B (any pre-amplifier will probably fit). The transformers were left in the pre-amplifier and the four octal sockets adapted themselves readily to the two tubes and two plug-in capacitors. The circuit is a standard audio amplifier utilizing a 1H5 input and a 1D8 output tube with one half of the 1D8 used as an intermediate amplifying stage. See Fig. 2. To help keep the amplifier non-microphonic, the input stage tube is shock mounted on rubber grommets, as are the input stages of most pre-amplifiers. The input 1H5 is shielded and wiring is kept as short as possible.

When first built, the amplifier did not have visual indication, but we obtained a few army surplus indicators with black, green and red scale. A check with a VU meter showed them to be perfectly color coded for −10, 0 and plus 3 VU positions. This meter will take a lot of abuse, and gives an indication of movement and signal output. It is recommended that if loud sounds are picked up the gain be cut down to give an indication of full scale reading. Under these conditions the normal male voice during a sports event will continually kick the meter and under yelling circumstances will hit full scale or peg lightly.

The drain on the batteries is extremely light and the batteries will last for a year. WLDY uses this amplifier for all sports. As the station uses 250-ohm microphones with three-prong Cannon connectors, the female wall-mounting Cannon socket was mounted on the front of the amplifier with the gain control, headphone jack and VU meter. The off-on switch, S-1, however, is mounted just inside the amplifier to forestall accidental switching. The case can be locked so that the operator does not have to be immediately on hand to make sure the amplifier remains on. The switch merely turns on the filaments and the amplifier is immediately ready for use—no warmup is necessary. The input and output transformers are Thordarson shielded case transformers, but any good audio transformer could be used, and, if using a high impedance microphone, the input transformer could be omitted and the necessary resistor installed for high impedance input to the 1H5. The output transformer can be any impedance desired. WLDY uses a 600-ohm output impedance to match the tele-

(*Continued on page* 130)

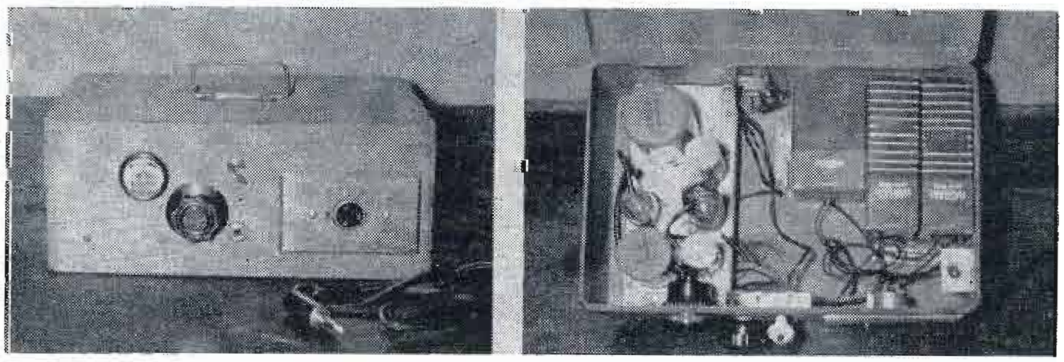

Fig. 1: Simply constructed remote amplifier is housed in 8 x 12 in. box, weighs only a few pounds

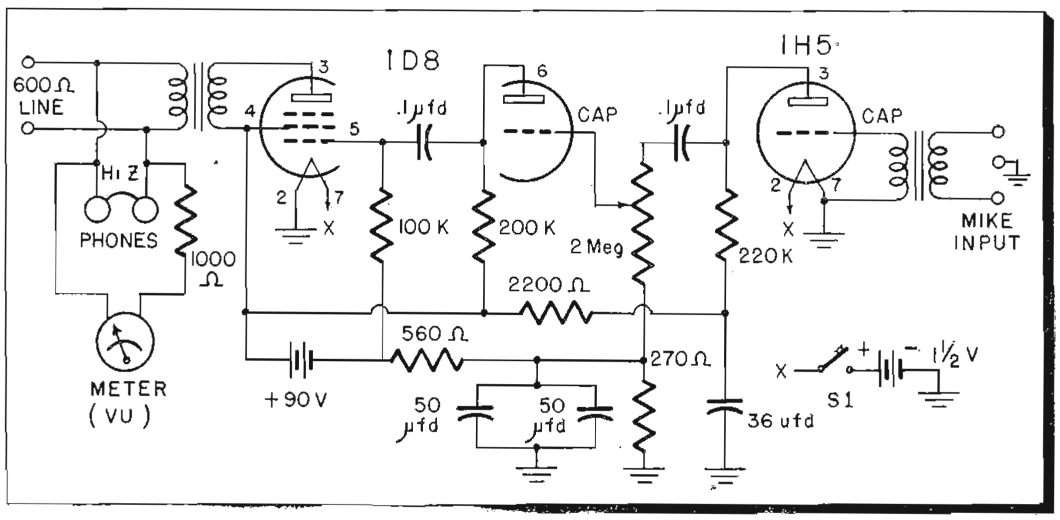

Fig. 2: Circuit of battery-operated unit employs surplus meter as visual modulation indicator

Printed Circuit

Practical photo-resist method for small quantity production of circuit boards permits engineers to experiment with simply operated low-cost equipment

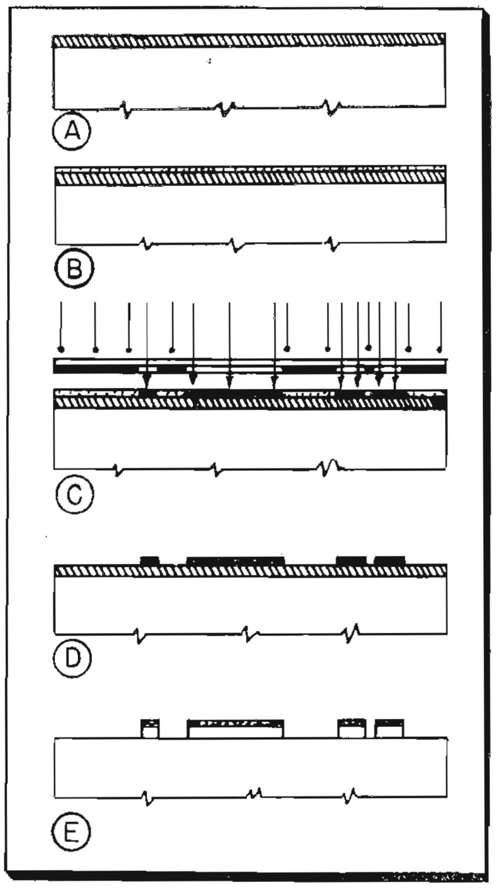

Fig. 1: To produce printed circuit, copper laminate plate (A) is sensitized (B), and exposed to light through negative (C). Unexposed enamel is dissolved (D). Copper areas unprotected by hard enamel are etched away (E)

By
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In the field of electronic manufacturing and development, printed circuits are attracting an increasing interest as the solution to many engineering problems. With stimulated activity in both the development of new equipment and the conversion of existing circuits utilizing the printed circuit techniques, it is self-evident that facilities for producing samples in the laboratory are highly desirable, if not essential.

Quantity Production

A number of practical methods have been evolved for the quantity production of printed circuits each having its own merits with regard to electrical and mechanical properties, cost, and speed of production. While somewhat slow and costly from the production standpoint, the photo-etch process is capable of producing circuit boards of the highest accuracy. For this reason, the photo-etch technique has been chosen for laboratory use. The initial expense can be kept to a minimum and the relative simplicity of the method allows corrections and modifications, both temporary and permanent, to be applied at any stage in the process.

Photo-Resist Technique

Briefly, the photo-resist technique is as follows:

1. The required layout is drawn, usually to an enlarged scale.
2. A high contrast printing negative is produced photographically in a process camera.
3. A copper-clad plastic laminate plate is coated with a light sensitive enamel (Fig. 1a, b).
4. Masked by the negative, the sensitized plate is exposed to light (Fig. 1c).
5. The exposed plate is developed. washed, and dried leaving an enamel resist image on the surface of the copper (Fig. 1d).
6. The copper area not protected by the enamel resist is dissolved away by immersion in ferric chloride etching solution (Fig. 1e).
7. The remaining enamel is removed, the plate cleaned, dried, and trimmed to size.

Good photographic reproduction requires a high contrast ink drawing on a clean white background; medium weight, white bristol board is commonly used for this purpose. High dimensional stability especially in excessively humid conditions may require the use of glass drawing cloth or vinyl film to maintain tolerances. Drawings for photographic reproduction are usually scaled up two to five times required size; the actual degree of enlargement being dictated by the desired accuracy. Minimum line widths and spacings should be kept to 0.010 in. since one or two mils may be lost in the etching process. Large areas of bristol board to which india ink is applied may warp due to excessive moisture absorption. To avoid this condition the area is outlined in india ink and filled in with a non-aqueous black opaque such as Dietzgen scratch 2704 opaque, a suspension of colloidal graphite in butyl protection is obtained by covering the completed drawing with one of the acrylic plastic sprays supplied in small spray containers (Krylon, Quick Spray, Spray Art).

Vinyl Film

A versatile drawing medium recently investigated is a vinyl film coated with a photographically opaque lacquer more commonly used in making silk screens. The drawing is made by cutting through the lacquer overlay with an etching knife and carefully peeling off the unwanted coating. Replacing the drawing lead with a steel cutting blade adapts conventional drafting instruments to this technique. The very sharp lines produced by the cutting action allows the circuit to be drawn in reversed negative form; thus the circuit board may be printed directly from the drawing without the need of photographic reversal.

The Negative

Where photographic equipment is available and tolerances are not too strict, the drawing may be reduced to required size in the laboratory. Generally, however, these facilities are not common to electronic laboratories so that a more convenient procedure is to employ the services of a photoengraving shop; their experience in the production of negatives and plates for the printing and lithographic trade is directly adaptable to the technique of printed circuits. Some preliminary checks must be made on the accuracy of their process camera; it is advisable to include at least one dimension on the drawing so that corrections, if necessary, can be made to the camera calibration. Ordinarily the photoengraver will use an acetate or nitrate base film in his work; for greater precision a non-shrinking vinyl base film is available, while for maximum stability, glass plates are necessary.

It is often desirable, where a number of small circuit boards are to be made, to make use of the full capacity of the equipment by printing with a multiple negative. Where available, a step and repeat camera is capable of producing a number of negative images of one drawing on a single piece of film, each image accurately spaced for ease of final trimming. An alternative method is to mount the required number of negatives on a sheet of clear film by means of cellulose tape; this may be used as the printing negative or a contact copy can be made for the purpose.

Most manufacturers of laminated plastics are actively producing copper-clad sheet stock for photo-etch circuits. Complete data on mechanical and electrical properties is available from the manufacturers; generally, the variety of materials ranges from phenolics to teflon in thicknesses from 0.005 to 0.5 in. with copper foil from 0.00135 to 0.005 in. on one or both sides.

Roughening Copper Surface

The material having been chosen, the plate is cut approximately ½ to 2 in. larger in each dimension than the required circuit board. Thorough cleaning and a slight roughening of the copper surface is essential and may be accomplished in the following way: Fine pumice powder is sprinkled over the dry plate, a wad of cotton or a small hand scrubbing brush moistened in a 3% sulfuric acid solution is used to rub the pumice over the plate. After scrubbing, the plate is rinsed under a stream of water and swabbed to remove any acid or pumice residue. As a test of proper cleaning, the plate should be capable of maintaining an unbroken film of water on its surface.

Several sensitizing solutions are on the market, commonly known in the photoengraving trade as cold top enamel. The two most desirable qualities are first the ability to resist the etching solution and second their resistance to humid atmospheric conditions. Several products should be tested to assure absence of fog in the form of scum on the developed plate under adverse humidity conditions. Cold top enamels may be obtained from photoengraving supply houses.

Fig. 2: 78-rpm phono motor in whirler spins circuit board to obtain uniform light-sensitive coating

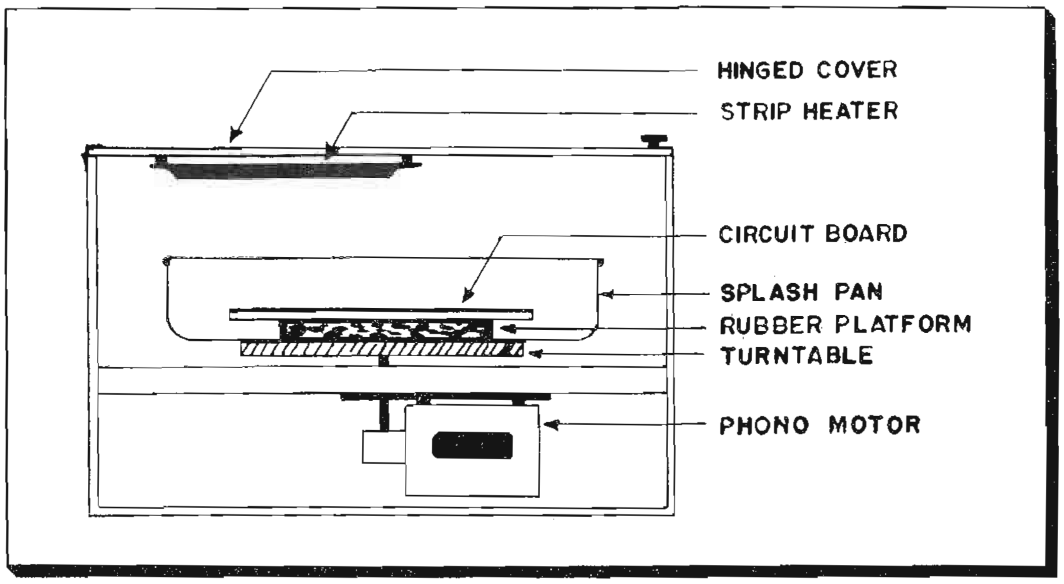
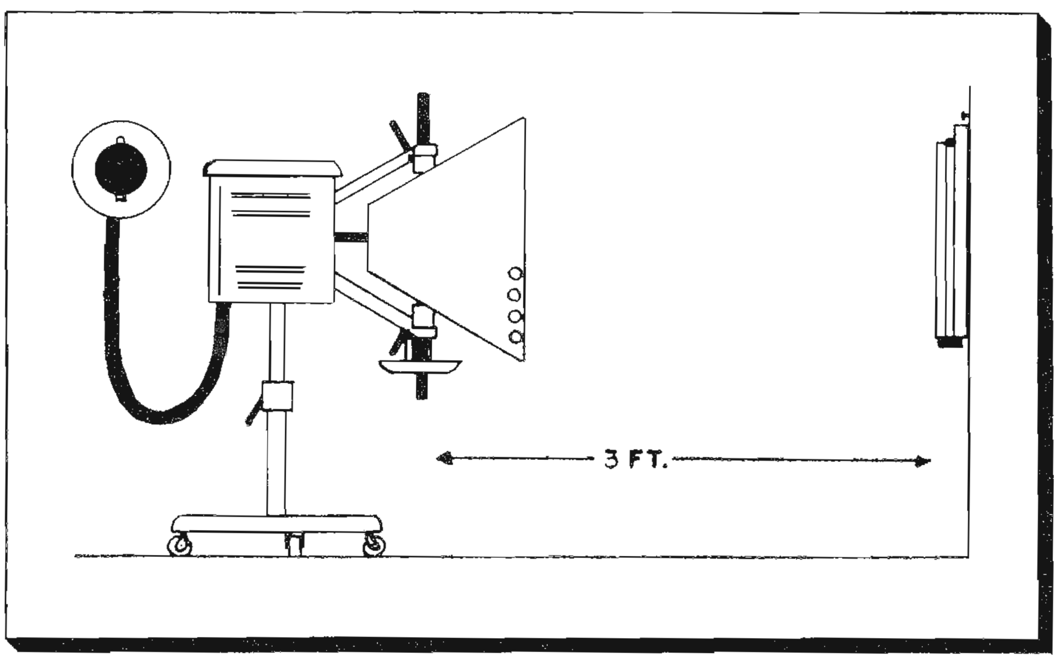


Fig. 3: Sensitized copper surface and negative are exposed to 40-amp arc light for 2-5 minutes



Enamel Application

Following the cleaning procedure and while still wet, a quantity of enamel, sufficient to cover the plate, is poured on, flowed to each corner and drained off. A second coating, applied in the same way is allowed to remain while the plate is transferred to the whirler where final drying takes place. To obtain a uniform coating it is necessary to whirl the plate horizontally at approximately 80 r.p.m. in a whirling machine. See Fig. 2. This type of equipment is standard with photoengravers and many models are available for both upright and inverted whirling. The speed may be increased to 100 r.p.m. in later drying stages in order to throw off enamel which may collect in the corners. Where economy is essential, an acceptable sustitute can be made from a 78 r.p.m. record player turntable. Application of mild heat hastens the drying cycle, but the plate must not be allowed to exceed 120° F. A small strip heater or an inverted hot plate element mounted 4 to 6 in. above the plate provides sufficient heat for this operation. Since the dry enamel is light sensitive, the whirling equipment should be housed in a wooden or metal enclosure to exclude excessive light. The turntable should be easily removable for cleaning.

With the negative, emulsion (dull) side down, in tight contact with the sensitized copper surface, the exposure to a high intensity light source is given for several minutes. Uniformly intimate contact must be maintained between negative and plate, particularly where fine detail must be reproduced and for this purpose two types of printing frames are available. For circuit boards in excess of 1 or 2 sq. ft., a vacuum frame is necessary; for smaller work, a pressure type frame in which the negative and sensitized plate are sandwiched under pressure between a sheet of plate glass and a sponge rubber padded back plate.

High Intensity Light

For reasonably short exposure times, a high intensity light source is necessary. Where any quantity of work is anticipated, an arc lamp of 20 to 40 ampere capacity is a wise investment. Alternatively, a battery of 4 to 6 reflector photofloods, suitably mounted on a stand, may be used although the excessive heat may require the use of a cooling fan directed at the printing frame. Exposure time to a 40 ampere arc light, 3 feet from the contact frame, varies between 2 and 5 minutes depending on the type of enamel used. See Fig. 3.

The action of light through the clear areas of the negative results in a hardening of the enamel; the action of the developer is to dissolve the unhardened emulsion to expose the underlying copper. The developer commonly used is methyl alcohol containing a quantity of dissolved blue dye. The dye present in the solution stains the remaining enamel so that defects in the image can be easily detected. The developer is usually stored in a vertical tank large enough so that by suspending the plate from the top edge it hangs completely submerged in the solution; the width of the tank need only be 2 or 3 in. It is convenient to mount the tank near the sink and be equipped with a tight fitting cover to prevent evaporation of the developer when not in use.

The exposed plate is suspended in the developer for approximately two minutes, removed, and quickly flooded with a heavy stream of water to wash away the alcohol and dissolved enamel; a short length of hose attached to the water faucet allows the water stream to be directed quickly to all areas of the plate. At this point the image should appear sharply outlined in blue against a clean copper background. In damp weather, particularly, the copper areas may be fogged with a light blue scum, which, with great care, may be removed by very light swabbing with a water soaked wad of cotton. The image is very soft at this point and after draining and shaking off the surface water it is thoroughly dried and hardened by exposure to infra-red lamps. Drying may be accelerated by directing the air stream from an electric fan towards the plate. Upon drying, the circuit board may be inspected for pinholes and breaks in the enamel resist pattern. Blue lacquer such as is used in sheet metal layout work is recommended for repairing defects when applied with a fine sable or camel hair retouching brush. A small etching knife or razor blade is of value in removing unwanted resist.

Etching

The purpose of the etching process is to remove chemically all copper areas not protected by the enamel resist; prime requirement are speed and uniformity of etching action. Etching machines as used by photoengravers fulfill these requirements by the use of a motor driven paddle wheel which throws the ferric chloride etching solution uniformly and with considerable force against the vertically mounted plate. Although etching takes place at the rate of about 2 minutes per mil, the cost of such equipment is often prohibitive and in such cases one of the following alternative methods may be used.

1. *Still bath etch:* This type is simply a tray slightly larger than the circuit board containing 2 or 3 in. of ferric chloride solution. The plate is first swabbed lightly with a piece of cotton saturated with etch solution to break down any oil or grease film that may have accumulated on the copper. Being careful to avoid trapping air bubbles underneath, the plate is slid face down into the solution. Small non-metallic blocks support the plate at each corner just below the surface of the solution, additional blocks being placed on top to weight it down. Etching takes place at the rate of about 15 minutes per mil. Unetched areas resulting from air bubbles or grease spots can be locally etched by light rubbing with etch soaked cotton.

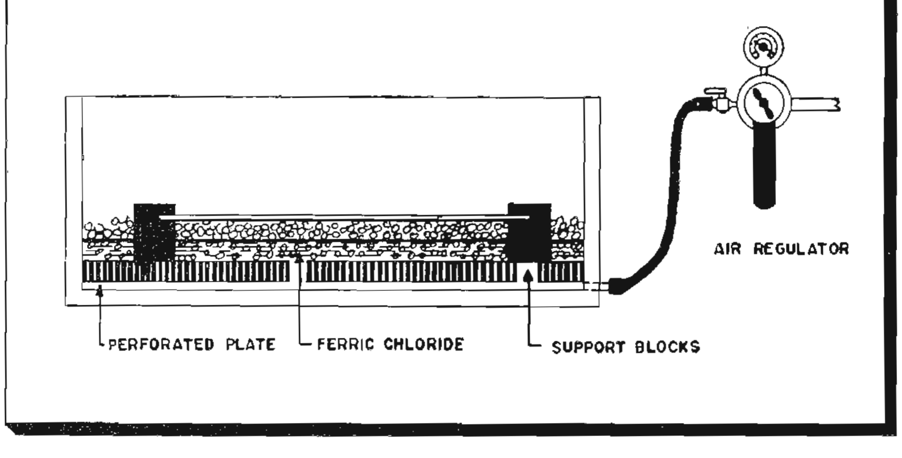
2. An improved version of the still bath can be made by installing an air bubbler in the bottom of the tank. See Fig. 4. A perforated plate is placed in the tank spaced about ½ in. from the bottom, ½ in. of etch solution is used and the inverted plate is mounted approximately ½ in. above the surface. Compressed air is blown through the perforated plate sufficient to raise bubbles to the level of the circuit board. Preliminary swabbing is not usually required although as an after treatment, it is useful in cleaning up any unetched areas. The action takes place at an 8 minute per mil rate.

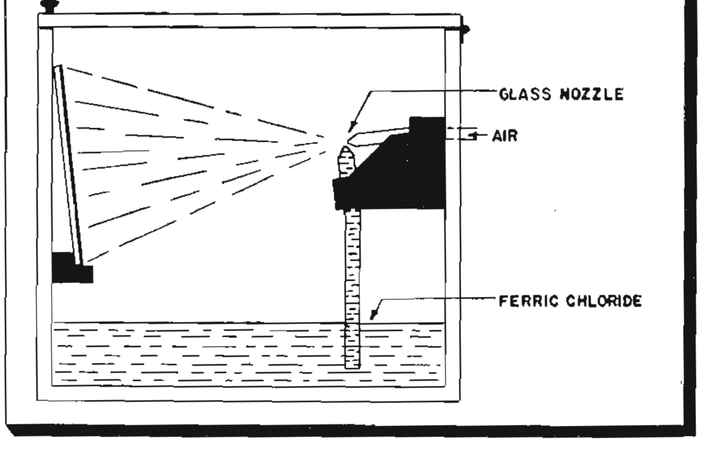
3. A spray etcher has been used in which the ferric chloride solution is sprayed from a glass nozzle which draws its supply from the bottom of the tank. The circuit board in this case is mounted vertically. See Fig. 5.

The etching solution in each case is a 42° Baume solution of ferric chloride, and is obtainable in prepared form from photoengraving

(*Continued on page* 111)

Fig. 4: (l) Exposed board is placed face down above etching bath. Bubbles carry ferric chloride to surface. Fig. 5: (r) Spray etcher





Perforated-Tape Reader

High reliability is featured in vacuum-actuated tape system for feeding input information into digital circuitry

By SIDNEY WALD
Glenn L. Martin Co.
Baltimore 3, Md.

PERFORATED paper tapes, because of their many advantages, have continued to enjoy wide popularity as a means of supplying input information to various kinds of electronic equipment. Such punched tapes employing a variety of paper widths and hole codes have been used for the control of automatic looms, simulated road testing, teletype transmission, automatic message accounting for telephone service, and as input data for digital computers.

As a means for converting coded data into accurately timed electrical pulses these tapes may be punched manually at a relatively slow rate and later decoded by a suitable tape reader at the high speeds acceptable to the rest of the machine.

The particular principle employed to actuate any given tape reader depends of course on the requirements of the machine it is to control.

THIS TAPE READER was developed under Signal Corps contract to provide a means for feeding input information into digital circuitry. It features:
- High reliability and ruggedness
- No tubes or auxiliary amplifiers
- Negligible wear on tape

These principles may be classified as follows:

1. Mechanical "pin-sensing"
2. Brush contact
3. Photoelectric
4. Pneumatic or vacuum actuated

The pneumatic pin-sensing tape reading principle is used more widely than any of the others because of the high degree of reliability and ruggedness which is thereby attained. This method is employed for teletype transmission, typewritten letter duplicators and automatic telephone message accounting.

The tape is pulled intermittently through a gate where a series of spring-loaded steel pins (whose diameters are slightly less than those of the holes in the paper) repeatedly try to push their way through. When one or more of the pins encounter holes, they travel further than those which meet with the resistance of the unpunched paper. Those pins which pass through holes permit contact making levers to operate.

Such devices operate at a maximum speed of about 10 holes per second and pose a serious problem for the tape if it is desired to read the same information repeatedly. The average life of a typical paper tape 0.003 in. thick in such a reader is about 10 to 15 passes before the pins succeed in pushing new holes through the paper.

Brush Contact Readers

Brush contact readers attempt to make and break circuit right through the holes by means of light pressure electrical contacts. While higher speeds are readily obtainable with such devices, their reliability is extremely low since with heavy brush pressure the tape or the brush wears out rapidly depending on the relative abrasion resistance of the two. Light brush pressures result in unreliable operation. Such devices have not been generally employed in the past for these reasons.

Photoelectric tape readers have been used to a large extent in connection with digital computers because of the very high operating speeds obtainable. However, where many tapes must be read simultaneously, a great deal of auxiliary amplifying equipment is required, thus neutralizing to a large extent both the simplicity and reliability of the method.

Pneumatic means for decoding punched tape have been used since the early 1900's in "player-pianos" when musical compositions were encoded on a wide paper tape, in combinations of some 90 holes. Reduced air pressure from a vacuum pump caused the proper piano keys to be struck when the corresponding holes in a reading bar were opened by the passing perforations. These devices were rugged, highly reliable and permitted innumerable readings of the paper tape to take place at moderate speeds. In spite of the rather crude components available during that period, key striking rates up to 8 per second could be attained.

In this article is described a mod-

(*Continued on page* 108)

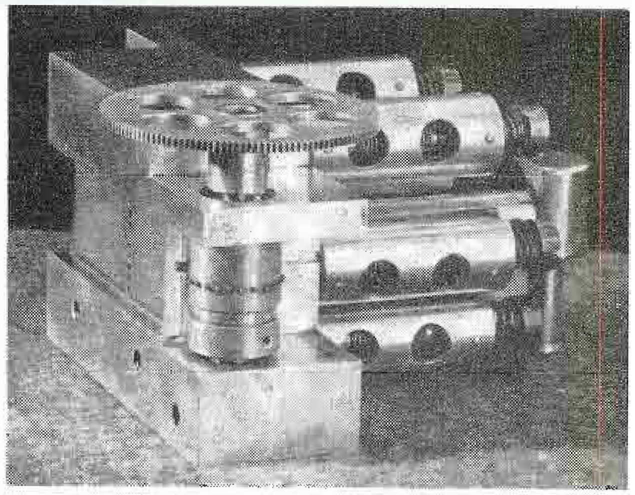


Fig. 1: Pneumatic tape reading head

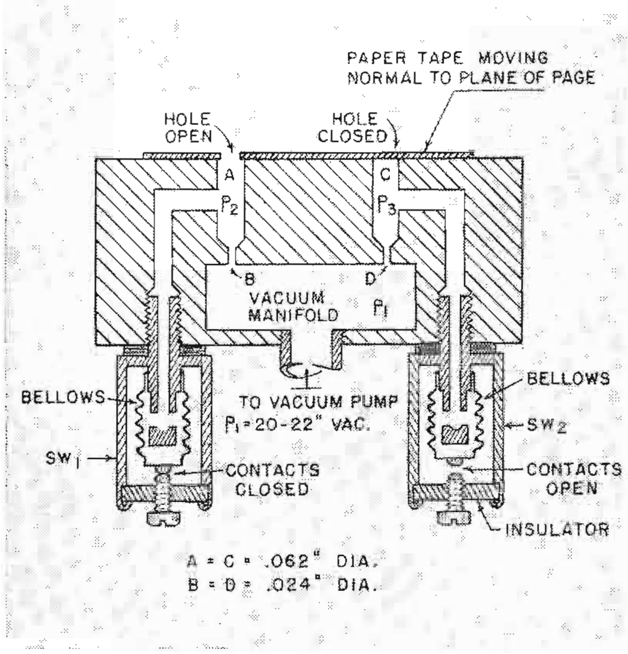


Fig. 2: Atmospheric pressure through "A" keeps SW_1 closed. Closed hole "C" permits vacuum to actuate bellows which opens contacts of SW_2

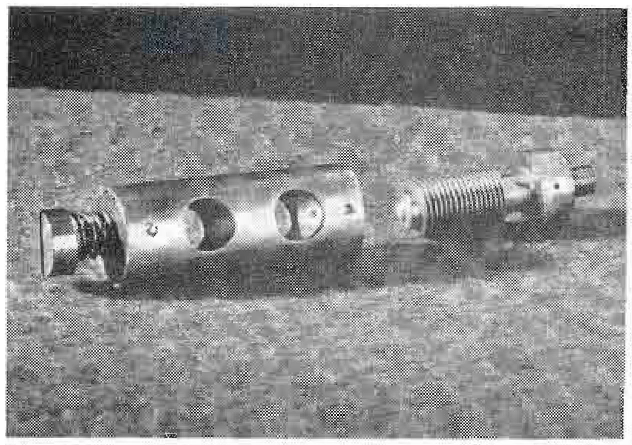


Fig. 3: Construction of individual bellows unit

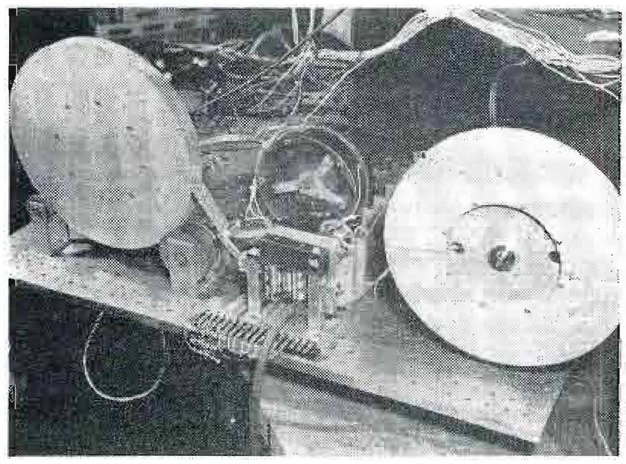


Fig. 4: Experimental lab set-up. Paper tape is pulled at 2.5 ips, equivalent to 25 pulses/sec

ABC Audio Installation

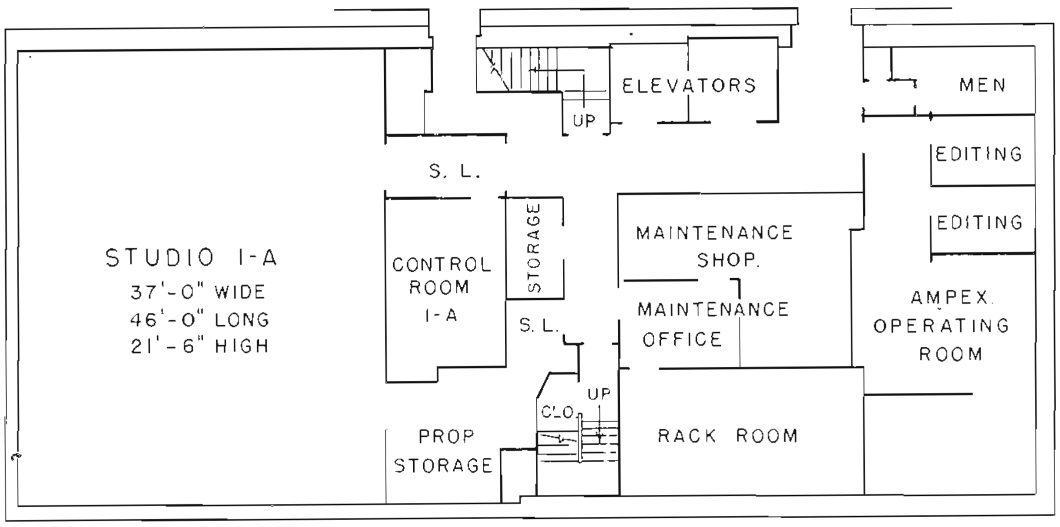


Fig. 1: Basement floor plan of American Broadcasting Co. building in New York City

Network move to new facilities in New York, Chicago and Los Angeles affords opportunity to standardize studio equipment. Novel switching system in master control

By:
E. P. VINCENT, American Broadcasting Co., 7 West 66th St., New York, N. Y.
and
A. C. ANGUS, Broadcast Studio Sect., General Electric Co., Syracuse, N. Y.

THE American Broadcasting Co. move to new radio network quarters in New York, Chicago and Los Angeles, necessitated complete AM broadcast studio construction and audio equipment installation. In as much as all three locations are represented by similar design let us consider the New York ABC-WJZ Broadcast studios.

The building, six stories and a basement, contains 11 studios, master control, news room, recording room, maintenance and field shop and operations offices. These functions were apportioned as follows: In the basement (floor plan shown in Fig. 1) are located the Ampex tape recording room, maintenance shop, equipment room and Studio 1A. Studio 1A is one of the four largest studios measuring 37 x 46 x 35 feet high, and serves the purpose of the show case studio with an isolated gallery for about 100 persons, and a clients booth, both on the upper level and viewing downward.

On the main floor, shown in Fig. 2, the lobby is located with a gold fish bowl arrangement for the master control room which is of a size designed to accommodate only operating control equipment. Also located on this main floor is the announce booth used for local station breaks and announcements.

On the second floor, space is allocated to operations offices and Studio 2A and control room—approximately the same size as 1A. The entire third floor (Fig. 3) is devoted to news operations. The control room houses all equipment necessary for any special events pickups.

The fourth, fifth and sixth floors contain only studios (see Fig. 4), two more A or large studios, three B or medium studios, and three C or small studios. The Studio 1A control room below the observation gallery (Fig. 5), provides for two audio racks, console and turntables, these to be used immediately. Studio 1A control room, as well as the three other A studio control rooms, is oversized purposely for the future installation of TV equipment. The studios were treated acoustically such that the "A" studios would have a reverberation time of 0.75 second, at 512 CPS, with the smaller studios at shorter times proportionate to their size.

Design Modified

These design principles were extended to Chicago and Los Angeles, with their six studios apiece, all modified slightly to meet existing local conditions. To facilitate installation of the audio equipment, no interconnecting terminal blocks were used. In order to accomplish this, ample conduits were installed with six 4 x 4 duct risers run directly through the building from basement to ceiling, with two left unused, these for future television use. Each studio was then connected with four 2-in. conduits, to these risers. With this scheme, audio pairs and control wires were run straight through from studio to master control, with the longest, 120 ft., from 6A to the master control racks.

Taking all three locations, New York, WJZ, Los Angeles, KECA, and Chicago. WENR, let us summarize the requirements for equipment that was to be placed before

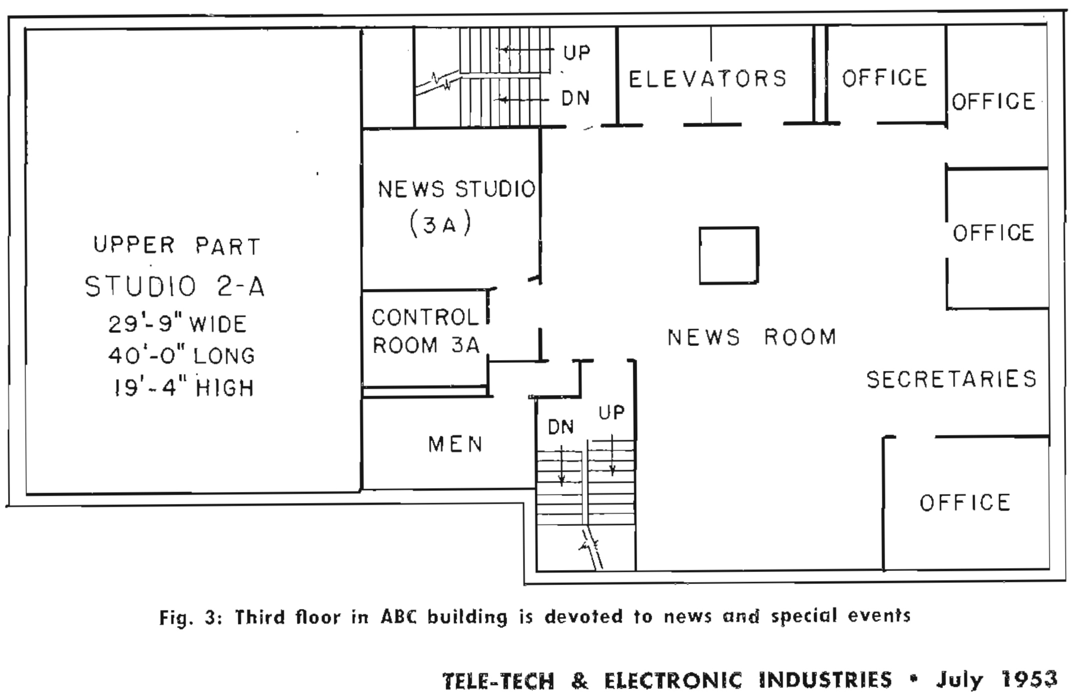


Fig. 3: Third floor in ABC building is devoted to news and special events

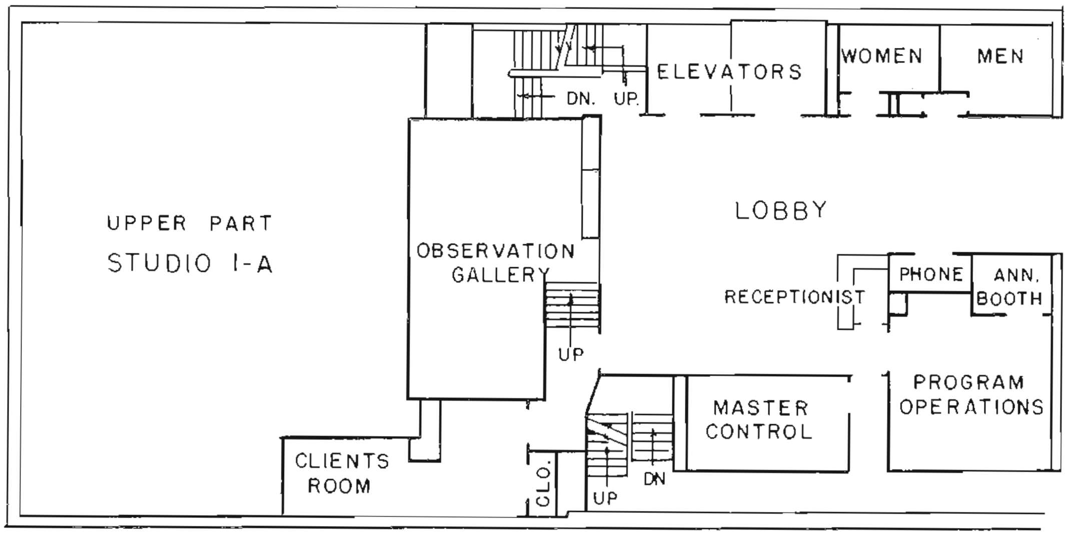


Fig. 2: First floor plan of American Broadcasting Co. building in New York City

manufacturers for their submittal of proposals. The fact that three stations of the ABC radio network were to be newly equipped, afforded us an opportunity to realize the dream of standardization. To do this a master control that could accommodate any possible combination of inputs and outputs in any one of three locations, was necessary. It must be remembered that although the three outlets are part of one network, the individual functions are quite different. New York's function being mainly that of origination of shows for network use, production of shows on tape, etc. Chicago, with its different time zone, concentrates on delayed broadcasts through the medium of tape and in addition will feed perhaps as many as four regional networks. Los Angeles is a combination of both New York and Chicago.

Inputs in New York

New York's requirement is for the maximum number of studio and remote inputs to a master control switching system. A figure of 20 equipped and four non-equipped inputs was arrived at as being optimum. This easily handles New York's 11 studios and would actually be more than enough for the other two locations. The matter of output channels is determined by the maximum any one of the three would require. This would be Chicago, with about six active and two spare channels making a total of eight. We, therefore, required a master control switching system with 24 inputs and eight outputs. Each output channel must be equipped to feed two parallel radio lines, properly isolated for regular and emergency purposes.

As an absolute minimum the following items must be included:

1. Output channel amplifier and studio switcher input amplifiers, loudspeaker monitoring of all outputs and inputs, with VU metering of output channels.
2. Facilities to accommodate office and control room monitoring of all inputs and outputs. (This would also be necessary in the future when an automatic monitoring system is installed.)
3. Control of output level on all channels.
4. Complete facilities for handling remote pickups including equalizers, VU metering and loudspeaker monitoring.
5. Three echo chamber facilities.
6. Complete jack field arrangement so that any part of the system is available on a patching basis. This includes enough jacks space for all remotes, normally as many as 60.

In addition to the aforementioned requirements, the switching system must be one whereby studios or inputs can be preset and put on air either at master control or from the on-air studio at master control's direction.

In order to effect local station breaks easily, some means for access to the output channel is necessary from any studio control room and announce booth. With all these controls a comprehensive tally light system is essential. The physical layout of the master control room in New York was such as to accommodate eight standard audio racks with one being allocated for telephone company private line equipment. Thus all switching and jack panel equipment would be included in seven racks. Additional racks containing the bulk of the amplifiers would be installed in the equipment room located directly beneath the master control room and immediately adjacent to the maintenance shop.

Basically that summarized the master control problem. For the studio facilities, we should like to have basic consoles and racks to satisfy all operational problems in AM broadcasting, plus the control circuit keys and preset and on-air indicators necessary to operate the master control switching system.

Microphone Positions

To begin with, the size of the studio would determine the number of microphone positions and faders with the largest requiring seven inputs plus an announce position separate from the studio mixer bus.

This announce position is to be included on all consoles large and small. The studio mixer bus is to be controlled by a sub-master fader to permit fading from a studio set-up to announce, nemo, or turntable without disturbing the studio mixer balance. On the console, in addition to microphone inputs, there must be a turntable mixer and a nemo mixer with four sources at a —16 VU level operated by a pushbutton switch.

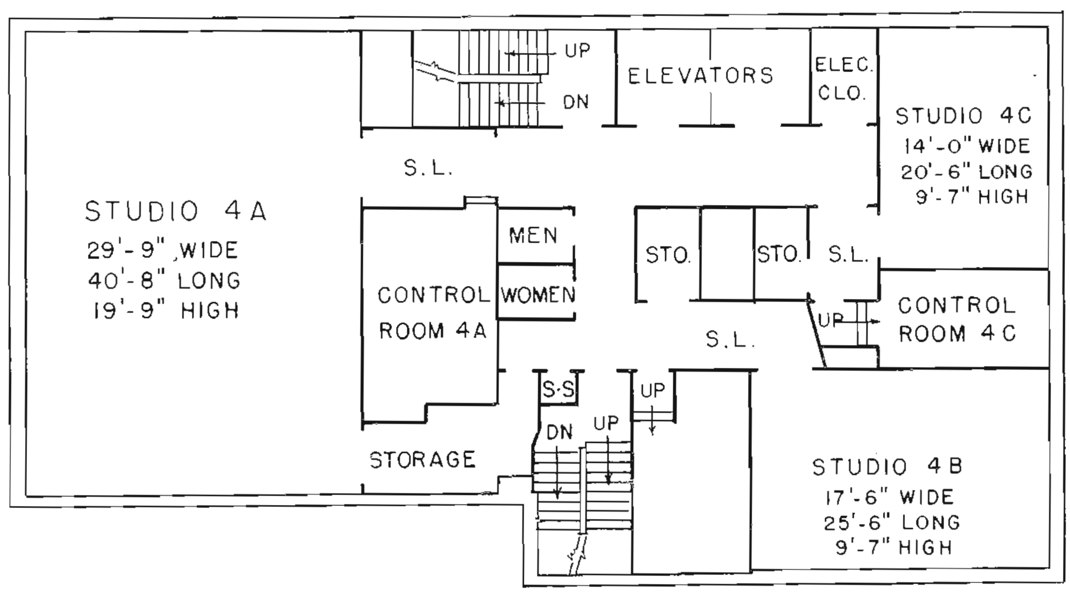


Fig. 4: Fourth floor contains three studios. Control rooms are oversize for future TV equipment

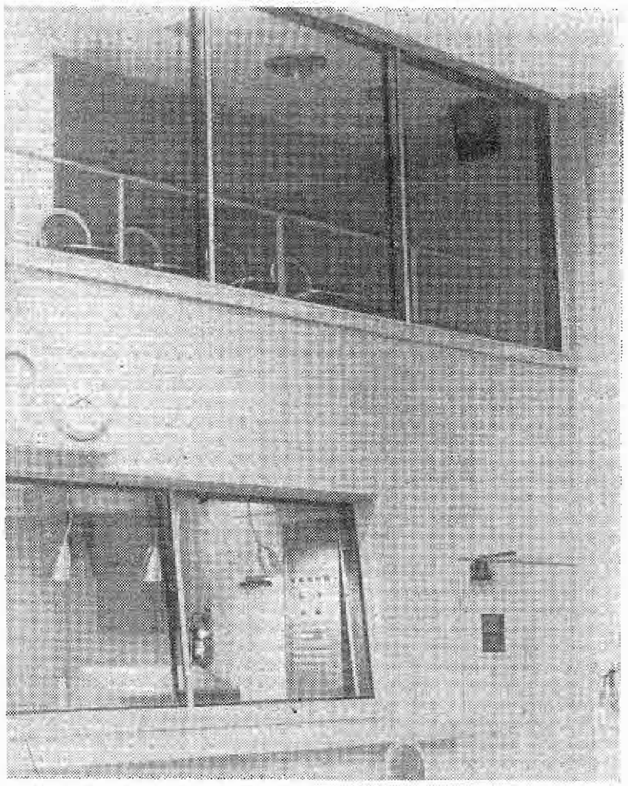


Fig. 5: Studio 1A control room below gallery

For the Los Angeles consoles, a separate mixer for control of Ampex tape machine outputs was required, much the same as the turntable output is controlled.

The other necessary items are monitor loudspeaker gain control, the master fader or main gain control, and a cue selector switch for listening to local or network program cues. These items are all those absolutely necessary for the production of any program. Then, in addition, are those special effects facilities inherent to the production of the more elaborate shows. These are: 1. The echo facility which in the studio consists only of the echo fader or mixer on the console, and patching jacks for insertion of echo to either one microphone output or on the overall program. 2. A filter for telephone effects and the like again used on a patching basis with the key for "filter in" and "filter out" on the console. 3. A utility key with three inputs and one output also located in the console.

Console Components

Physically, therefore, the console consists of operating mixer controls, special effects controls, master control switching functions, and the VU level meter. The remaining studio equipment is to be installed in the rack, including all the necessary patching jacks so that all parts of the circuit can be made readily available.

The final item was the equipment for use in two announce booths, the first a regularly used booth for insertion of local station break announcements, and the other to be available on a flash basis located in the news room for flash news events use.

To fill ABC's Studio Audio requirements, six models of a custom console design were built. These custom built consoles were used in the New York and Hollywood installation. The Chicago requirements were met by modifications to General Electric's type BC-11-A console. The general design of the Studio Audio systems were such that only the necessary operating controls were mounted on the console with all necessary amplifiers, power supplies, and jack fields, etc., mounted in a cabinet rack.

All amplifiers and power supplies used in the Studio Audio systems were General Electric broadcast plug-in types and required no special engineering. The custom consoles of which six different variations were built, were designed to fill our express needs. The major difference in the various models was the extent of mixing facilities. These varied from four mixer positions on the smaller consoles to twelve positions with sub-master controls on the large consoles. In addition to the mixer and gain controls, each console included all the special features desired by ABC. Each console also included a program output key which permits feeding the audio output to Master Control by either the normal program bus circuits or by the "break-in" circuit. In addition, both "Preset" and "On Air" lamps and a Release Key were provided which operate in conjunction with the Master Control Switching System.

14 Rack Cabinets

With these requirements in mind, the design of the Master Control System was undertaken by GE. It was felt that a system designed around their stock broadcast items would be desirable, reducing the required engineering time. It would also help expedite delivery of the system. A system was arrived at which would be contained in 14 rack cabinets; of these, eight cabinets would be located in the control room proper and the balance of the equipment would be installed in an adjacent equipment room.

The eight racks located in Master Control contained the Output Switching System, all the patching facilities, equalizers, and the necessary program amplifiers. The necessary monitoring amplifiers, echo chamber amplifiers and "Break-in"

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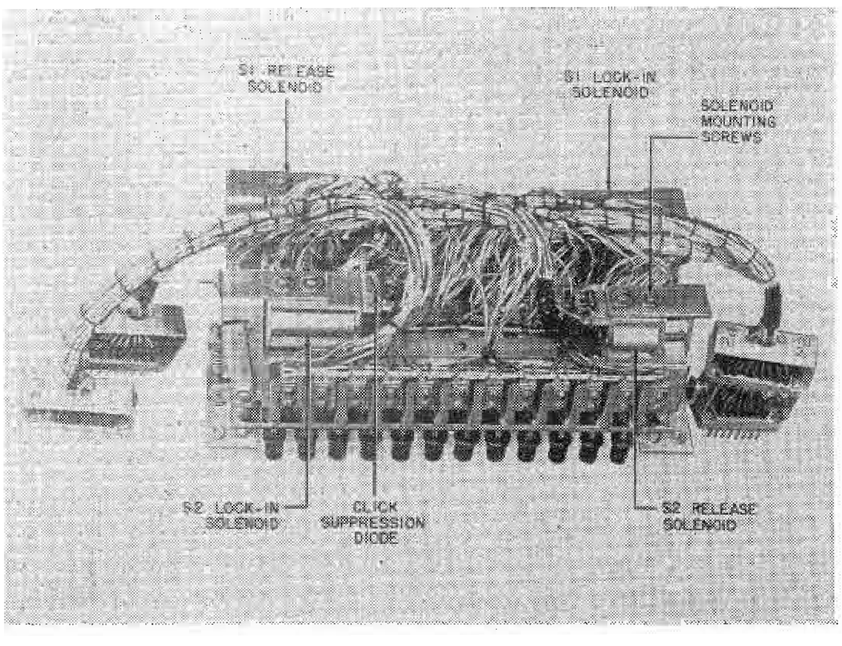
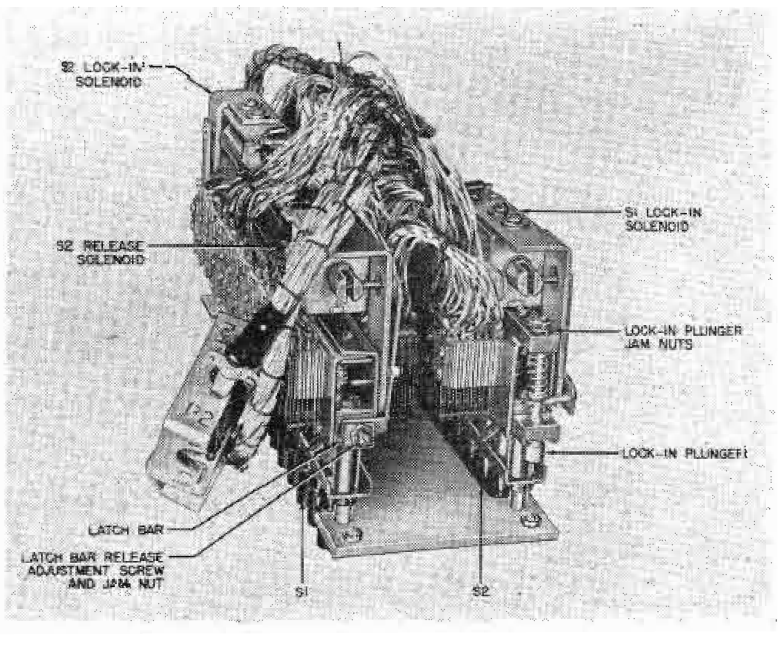
Fig. 6: (l) Rear view of 12-station push-button switch. Fig. 7: (r) End view of master control switch. Lock-in solenoids prevent accidental release





Page from an Engineer's Notebook

No. 21 — Design Boners: II

By JOHN H. WYMAN, Chief Project Engineer
Bendix Aviation Corp., Eatontown, N. J.

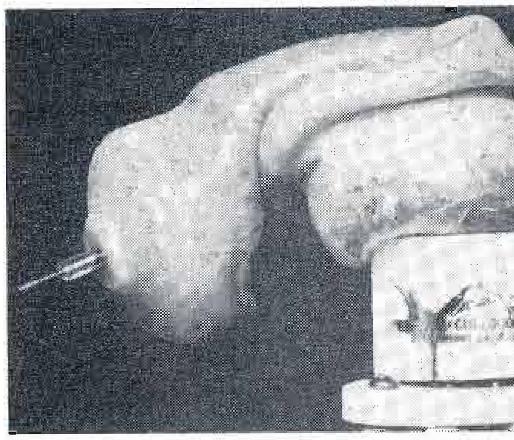
BEAM TUBES IN DC PLATE CIRCUITS: Beam power tubes are frequently used in servo circuits as shown in Fig. 1. Under conditions of heavy grid drive the instantaneous value of the voltage at the plate varies as in Fig. 2, with respect to the constant screen voltage. Under these conditions the peak screen current can attain a very high value which often damages the screen by overheating. While the tube is used in the circuit exactly as in an audio amplifier, the condition of continuous drive over rather long periods of time will cause damage to the screen where the intermittent signals encountered in audio work will not. The cure here is simple—a screen resistor should be added as in Fig. 3.

The value of resistance should be chosen so that under maximum conditions with full drive the maximum allowable screen dissipation is not exceeded. Depending on voltage on the screen between 2,000 to 10,000 ohms for R_s should suffice.

BEAM TUBES IN AC PLATE CIRCUITS: A similar difficulty is often experienced when using a beam tube in a phase discriminator circuit similar to that shown in Fig. 1, except that ac is used on the plate and screen.

The condition shown in Fig. 4 then obtains. Under this condition the screen grid is heated sufficiently to emit electrons by the heavy currents during the positive half cycle and then during the negative half cycle when the control grid is positive with respect to the screen these emitted electrons flow to the grid and return through the external grid circuit to the cathode. In so doing they are of such a polarity as to further increase the bias on the tube and reduce the useful output of the tube.

Phase shift in the inductance in the plate circuit which, for clarity, has been disregarded almost always complicated the picture further. The cure or cures here are to use a screen resistor as in Fig. 3, and to keep the grid #1 Resistance R_G as low as possible; preferably under 100,000 ohms.



THIS COULD HAPPEN TO YOU!
Courtesy Eitel-McCullough

Dependance upon special characteristics of a tube which are not closely controlled is another frequent misapplication. Circuits designed to be critical as to cut off conditions should be avoided or allowances made for the wider variation that occurs in this area.

THYRATRONS: Small thyratrons like the 2050 are practically zero impedance devices which will attempt to pass any current that the external circuit will admit. But these tubes only have a finite safe cathode current. Many applications of thyratrons to operate relays in ac circuits ignore this as in Fig. 5. Here the capacitor impedance is essentially zero at the beginning of each cycle and a very high peak current flows damaging the cathode. A tube in this curcuit might well fail in 100 to 200 hours. A cure is a resistor (shown dotted in Fig. 5) of sufficient value to reduce this peak current to well under the maximum noted.

For the sake of clarity, some minor second order effects have been ignored in the accompanying illustrations.

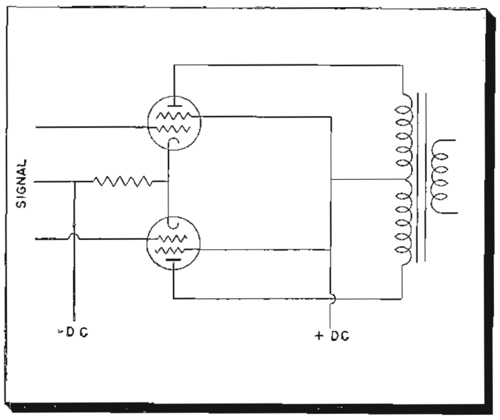


Fig. 1: Beam power tube in servo circuit

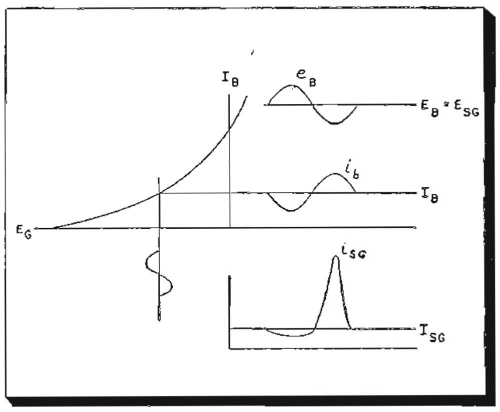


Fig. 2: Beam power conditions under heavy drive

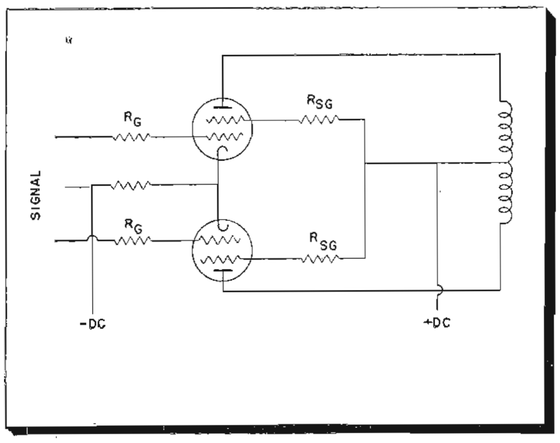


Fig. 3: Resistor RSG prevents damage when grid drive is heavy. Low RG reduces phase shift

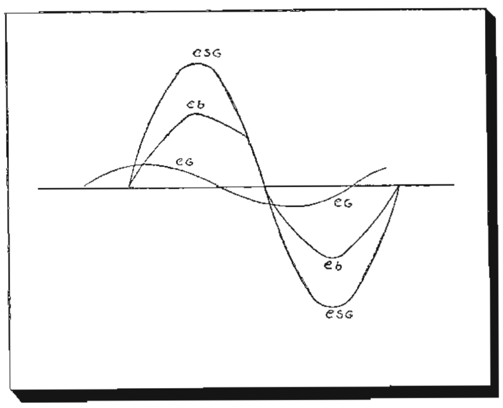


Fig. 4: Conditions from use of beam tube in phase discriminator with ac on plate and screen

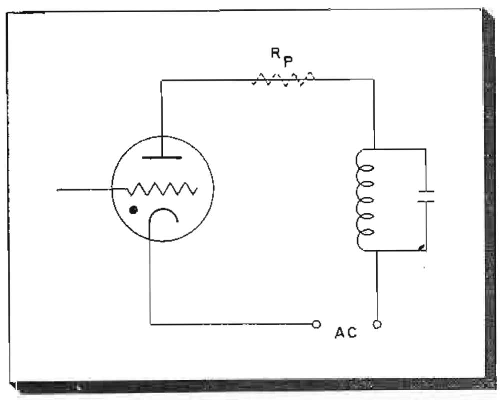


Fig. 5: Resistor RP prevents damage to thyratron cathode by reducing very high peak current

Conductance Curves Speed

Flexible circuit design technique gaining widespread use. Dynamic information more readily available with conductance curves than characteristics normally provided with vacuum tubes

By
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Ordnance Dept.
Ballistic Research Labs.
Aberdeen Proving Grounds, Md.

THE design of pentode amplifiers differs from the design of triode amplifiers in two major respects. The first of these is the availability of an additional parameter, the screen voltage. The second is the reduced effect of plate conductance which results from the presence of the screen grid in the tube.

Examination of the conventional plate characteristic curves for pentode tubes shows that over the normally used range the constant bias contours are nearly horizontal (Fig. 1). This nearly horizontal part of the contour presents relatively little information on the tube beyond that contained in any one point on the horizontal portion of the contour. The variations of the plate current and also the transconductance, although slow as a function of the plate voltage, are rapid with respect to the screen voltage. Consequently a plot of the bias contours and transconductance contours as a function of plate current and screen voltage makes available design information over a much wider range of parameters than is available in the conventional pentode plate characteristics curves. A set of screen characteristic curves is shown in Fig. 2.

Basic Design Technique

The plate current equation for the pentode electron tube may have two more terms than the equation for the triode. These terms involve the mutual effect of the screen and suppressor on the plate current.

$$i_p = G_{M1}\, e_{c1} + G_{M2}\, e_{c2} + G_{M3}\, e_{c3} + G_P\, e_p \qquad (1)$$

In cases where the voltages on the screen and suppressor are held fixed with respect to the cathode, the screen and suppressor terms may be disregarded. The pentode amplification equation then reduces to the same equation as for the triode.

$$VA = -\,G_M R_L \,/\, (1 + G_P R_L) \qquad (2)$$

The area of the plate characteristics curves normally used in pentode circuit design is the area where the grid contours are nearly horizontal. If the design is such that the slope of the dynamic load line is appreciably greater in magnitude than the slope of the bias contours on the plate characteristics curves, then the $G_P R_L$ term in the denominator of Eq. (2) may be neglected. In most design problems encountered in practice, this condition exists. The assumption that $G_P R_L$ may be neglected usually is a preliminary step in the design calculation.

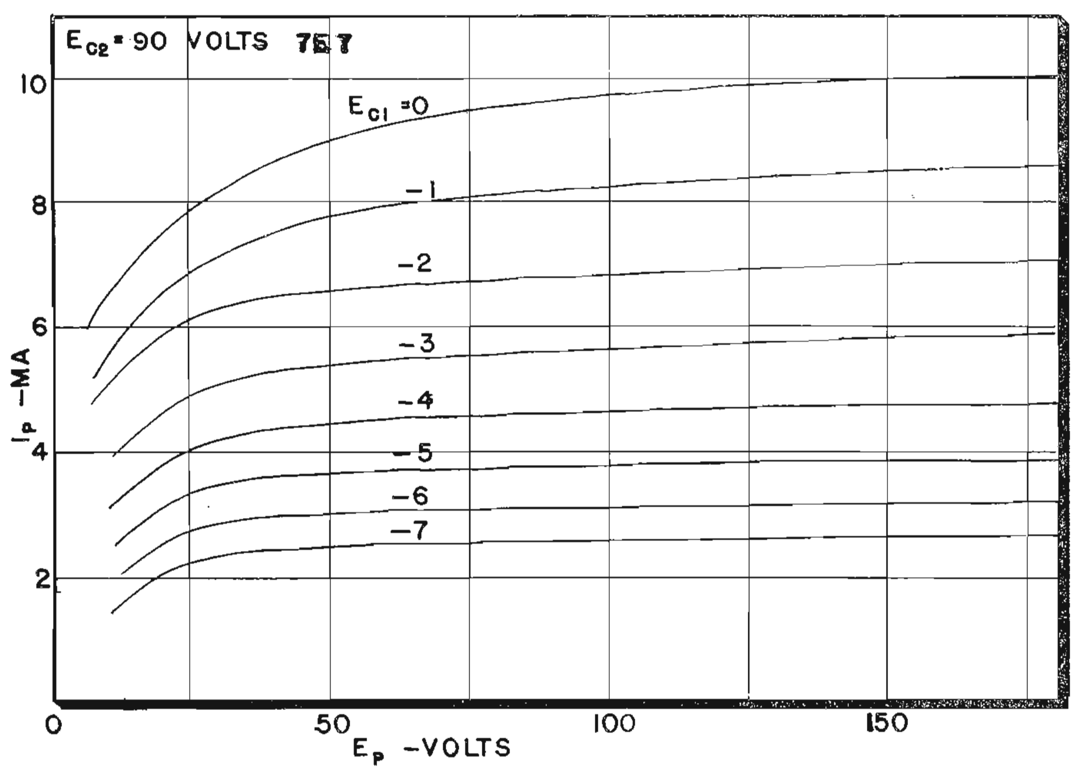
The equivalent circuit of an electron tube usually is used in the explanation of operation and the derivation of operating equations of both triode and pentode amplifiers. Use of an equivalent circuit has two major drawbacks. The first of these is the failure to impart to the student or user a clear physical picture of tube operation. The second is the need for different equivalent circuits for triode circuits and pentode circuits, rendering the interrelation of the equations for the two types of circuits somewhat unsatisfactory.

Reference in derivation to the plate current stream and to the factors directly influencing the plate current provides a readily understandable picture of tube functioning. Eq. (2), which is based on the plate current stream approach, is in a form that is applicable to both triodes and to pentodes, whether the mode of operation approaches a constant voltage, a constant current, or an intermediate condition.

Design Procedure

Because of the availability of the screen voltage of the pentode as an additional active parameter, the pentode circuit design procedure differs from the triode design procedure. The first step in pentode circuit design is to determine the range of bias over which the grid must vary in the problem in question. Since the tube only recognizes a change in bias with respect to its cathode, the grid voltage change with respect to the cathode is the one of interest. The second step is to set a limit upon the amount of distortion which may be tolerated in the tube. The third step is to select the screen voltage required to provide amplification of the

Fig. 1: Conventional plate characteristic curves for a typical pentode tube



Pentode R-C Amplifier Design

desired signal voltage within the chosen limits on distortion.

Design experience indicates that in the design of any pentode amplifier, the screen voltage for the tube should be chosen at as low a value as is consistent with distortion, frequency response, and/or power output requirements. Depending on the intended application of the amplifier, any one or group of these requirements may prove to be the controlling factors. Verification of this principle is an interesting exercise which requires one to set up a series of typical designs at different screen voltages.

The load line required with the screen characteristics curves of Fig. 2 is normally a vertical line drawn at the chosen screen voltage. Values of transconductance at the different bias contours on this vertical load line may be interpolated at each desired bias point.

Distortion may be determined from the values of transconductance read at the various bias lines. For the case of predominate second harmonic, the equation takes the form

$$D = 25\,(G_{M\text{-}max} - G_{M\text{-}min}) \,/\, (G_{M\text{-}max} + G_{M\text{-}min}) \qquad (3)$$

FOR A DESCRIPTION of the application of the conductance curve technique to the design of triode R-C amplifiers, see the May 1953 issue of TELE-TECH & ELECTRONIC INDUSTRIES, page 80. Also, "Using G Curves in Tube Circuit Design," July-August 1949; "The Use of Conductance Curves for Pentode Circuit Design," Nov. 1950; and "Notes on UHF Oscillator Design," Feb. 1953.

Actually distortion in a pentode amplifier is less than the value given by Eq. (3). The effect of the small slope of the plate characteristics curves is to reduce the actual distortion to possibly three-quarters of the calculated value. Consequently, Eq. (3) will normally provide an adequate safety margin.

The choice of the proper pentode plate voltage for an R-C amplifier is based on the load voltage developed at zero bias and the selected screen voltage. The plate voltage of the tube at zero bias should not be less than four-fifths of the screen voltage chosen. The total voltage developed across the load resistance may be added to the minimum allowed plate voltage to obtain the supply voltage. Where the supply voltage is excessive, the voltage may be reduced by a decoupling network consisting of the proper size voltage reduction resistor and a bypass capacitor.

Correction curves may be provided for making adjustments for the small variation of plate current and transconductance which result from variations of plate voltage with fixed screen voltage. The screen characteristics curves included in Fig. 2 are based on a plate voltage which is twice the screen voltage. The variation of plate and screen current and transconductance as a function of E_p/E_{c2} is indicated on Fig. 2 in the upper left hand corner. If the value of X_p at the plate-screen voltage ratio required is multiplied by the transconductance or the plate current at the screen voltage and bias under consideration, the corrected values of transconductance or plate current will be obtained.

The curve for X_{g2} against E_p/E_{c2} also plotted on Fig. 2 gives the correction factor required to convert the plate current into the corresponding value of screen current at any desired plate-screen voltage ratio. This parameter is useful in estimating the screen current when choosing the proper voltage reducing resistor for the screen circuit.

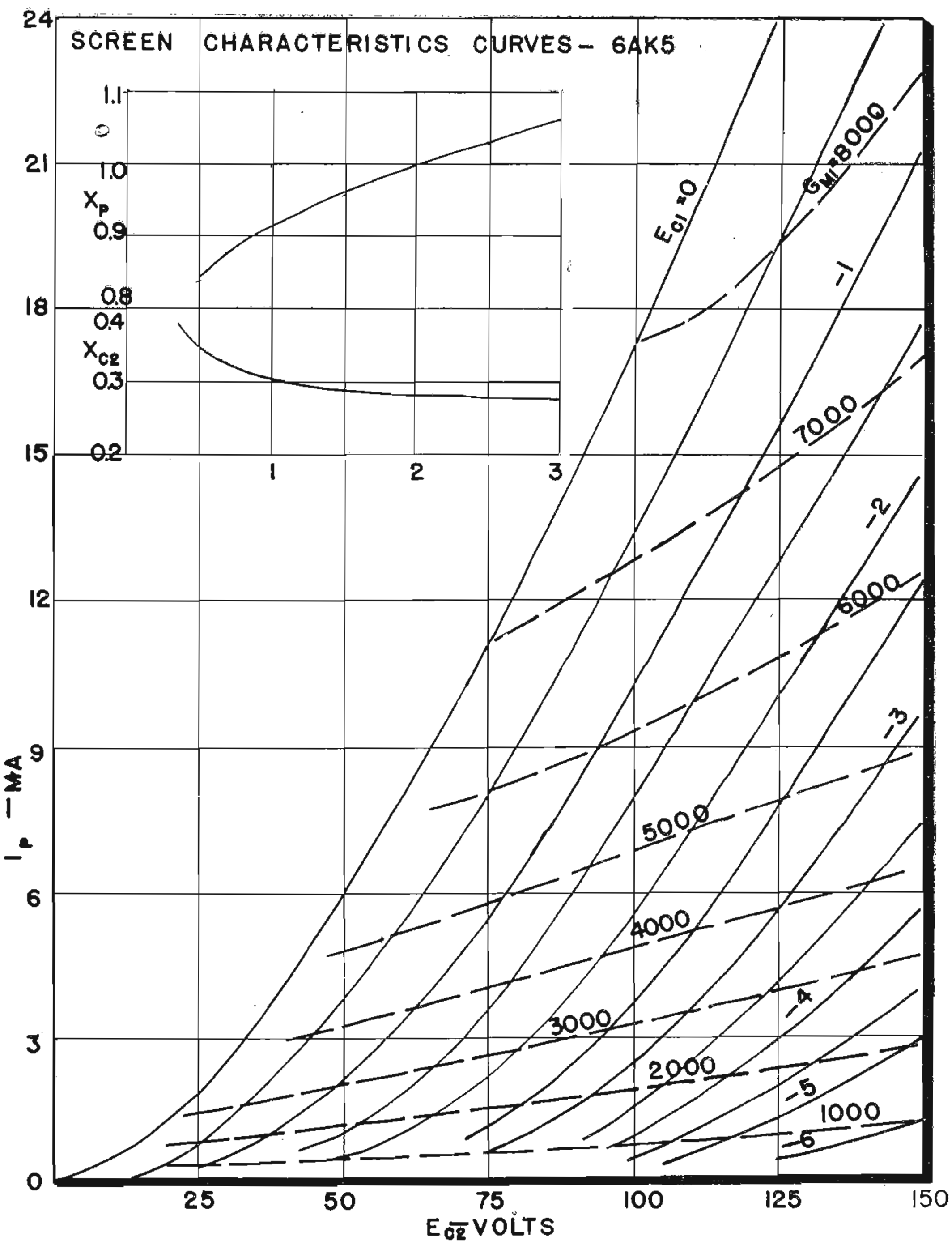


Fig. 2: Screen characteristic curves for 6AK5. Corrector for current and G_m variations at upper left

Examples

As an example of pentode design, assume that a resistance coupled pentode amplifier is desired which will amplify a signal of ±1 v. with not more than 10% distortion. The available plate supply voltage is 300 v. The 6AK5 tube has been

Conductance Curves (Continued)

chosen as the pentode to be used (curves in Fig. 2). Distortion as a function of screen voltage for the 6AK5 tube with a one volt signal is tabulated in Table I.

TABLE I

Screen voltage:	50	75	85	90	100	125
Distortion—%:	17.2	11.5	9.5	8.6	7.5	7.3

At the 125-v. screen voltage, a minimum fixed bias of 2 v. is required. For the other screen voltage values the minimum fixed bias is 1 v.

Examination of Table I shows that the minimum screen voltage which meets distortion requirements is about 85 v. An adequate margin of safety should be available at either $E_{c2} = 85$ v. or $E_{c2} = 90$ v.

Since experience indicates that the use of the lowest screen voltage which will meet design requirements with a tolerance margin is the best screen voltage choice, either 85 or 90 volts might be chosen in this problem. Choosing 90 v. for the screen, the lowest allowed plate voltage would be about 75 v. Thus, 225 v. must be developed at 15 ma across the plate load resistance at zero bias. The required plate load resistance of 15,000 ohms produces a stage amplification of about 85. Since the 6AK5 screen current is approximately three-tenths of the plate current, the screen voltage reducing resistor has approximately 82,000 ohms resistance (voltage loss divided by static screen current). The total average cathode current would be slightly more than 10.4 ma. Consequently, a 100-ohm cathode resistor would produce the required volt bias.

Minimum Screen Voltage

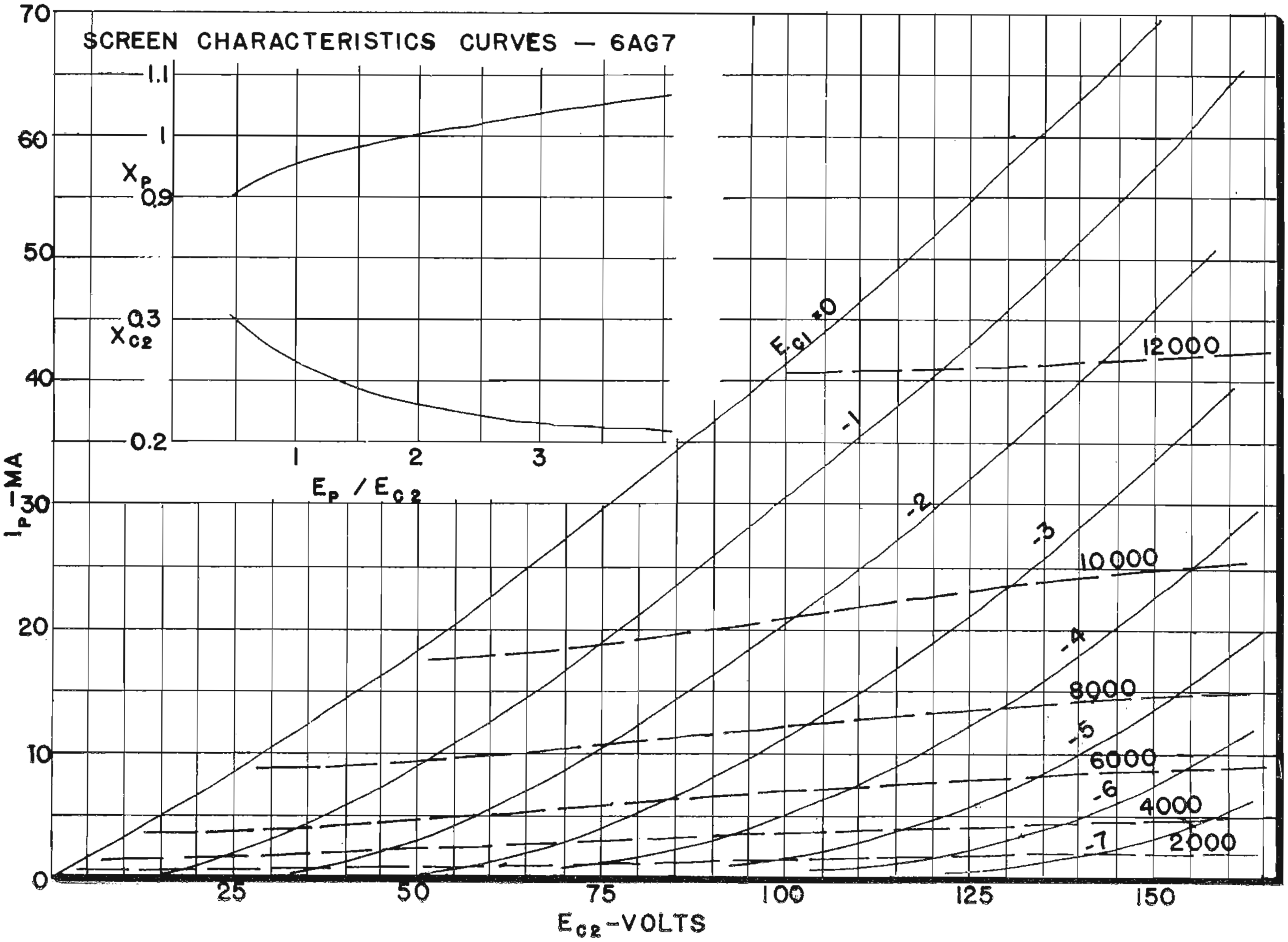
The advantage of use of minimum possible screen voltage for an amplifier becomes apparent very quickly if one makes a series of amplifier designs at different screen voltages. The voltage amplification, the element power dissipations, and the power output should all be calculated. The available output voltage is greatest with minimum screen voltage in audio type resistance coupled amplifiers. Power output may rise slowly at first, but quickly reaches a maximum and begins to decrease as the screen voltage is raised from the minimum satisfactory value. A set of calculations of corresponding designs at a series of screen voltages gives one an excellent feel for the characteristics of a given tube. Such a set of calculations gives one in but a few minutes a feel of a tube's characteristics which can be duplicated only by many hours of experimental testing.

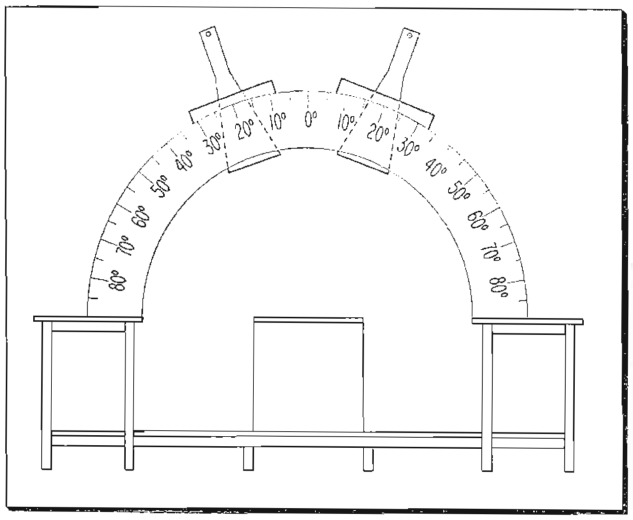
The design of a video amplifier presents a somewhat different problem than the design of a conventional audio amplifier. Basically, the difference results from the limitation on the load resistance which is caused by frequency response requirements. The primary result of the reduced load resistance is the comparatively small plate supply voltage required. As in the standard pentode amplifier, the lowest screen voltage which will meet distortion and power requirements is chosen. Then the plate supply voltage is chosen so that the zero bias plate voltage is approximately 80% of the screen voltage.

Assume, for the video amplifier problem, that the input grid voltage available is ±1 v., and the maximum permitted distortion is 8%. Frequency response requirements may be assumed to limit the plate load resistance value to 2,000 ohms. Under the conditions just listed, a video

(*Continued on page* 86)

Fig. 3: Screen characteristic curves for 6AG7. Curves at upper left correct for variations of plate and screen current and G_m as function of E_p/E_{c2}





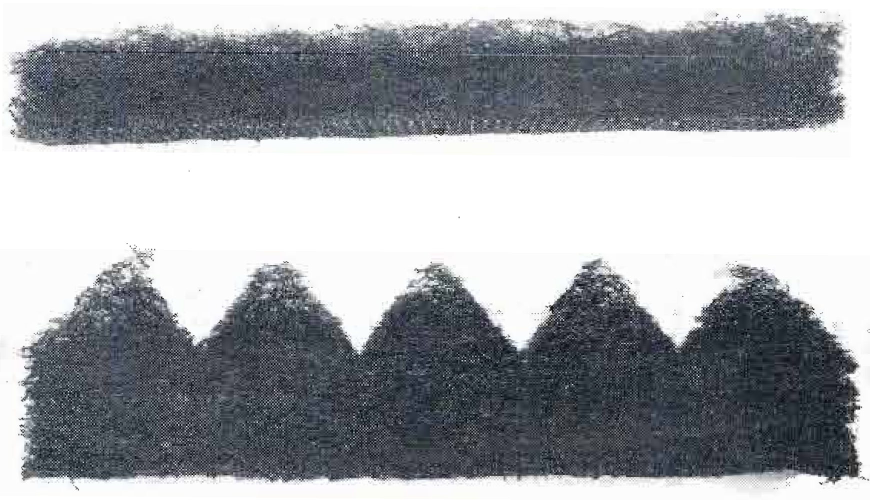


Fig. 1: (l) Arch apparatus for free-space measurements in the 2,500 to 25,000 MC range. Fig. 2: (r) Flat and pyramid type absorbing materials

Anechoic Chamber for Microwaves

New broadband absorbing material proves valuable measurement aid in recording antenna radiation patterns in 2,500 to 25,000 MC region

By ALAN J. SIMMONS & WILLIAM H. EMERSON
Naval Research Laboratory, Washington 25, D. C.

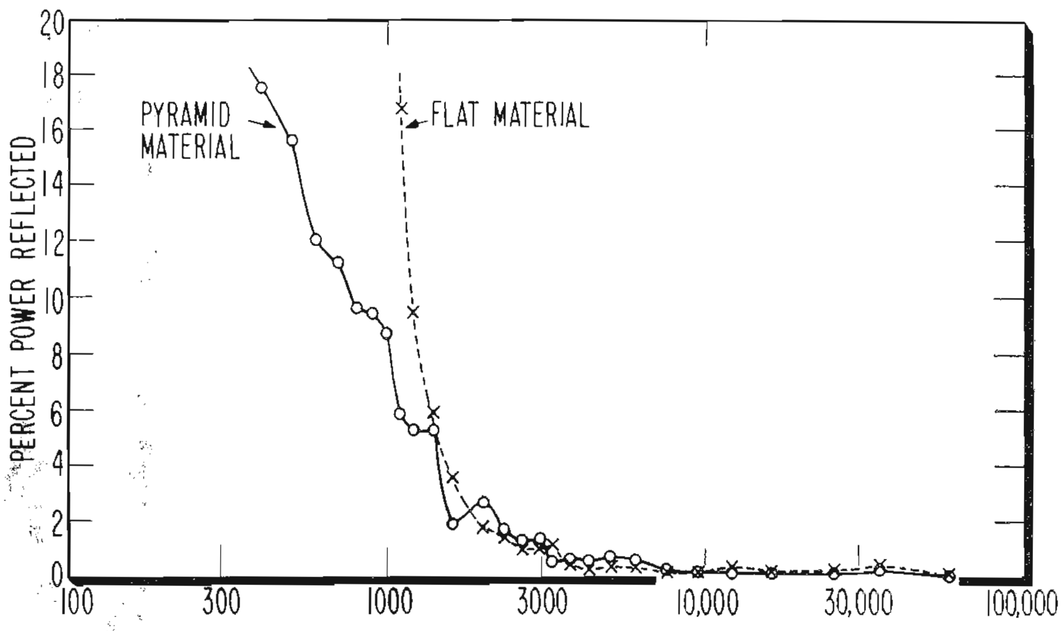
IN the study of antennas, a characteristic of prime interest is the radiation pattern measured when the antenna is radiating into free space. With many small microwave antennas it is feasible to measure "far-field" patterns at fairly short distances and therefore it is convenient to work indoors. This is only possible if reflections from walls, floor and ceiling do not appreciably disturb the free space conditions. Thus it is desirable to construct a special chamber whose inside surfaces are coated with non-reflecting material and which contains a minimum of antenna mounting structure.

The construction of such an anechoic chamber or darkroom has been held up by the lack of suitable absorbing material. A good material should reflect only a small percentage of the incident power over a wide range of frequency and of angle of incidence for any polarization. In addition, it should be lightweight, easily mounted, and relatively low in cost. A material with these characteristics has been designed at the Naval Research Laboratory and is now being manufactured commercially. Using this material, an anechoic chamber has been built and has proven very useful over the entire microwave region.

Design and Development: Radio frequency energy propagating in free space may be effectively absorbed by passing it into a dissipative medium so designed as to reflect only a small amount of the incident energy. This medium should have relatively low dielectric constant to facilitate impedance matching to free space and yet have as high a value of attenuation as is consistent with the low dielectric constant in order to reduce the required thickness of the medium. These characteristics suggest the use of a resistive expanded material for this purpose. In the course of development, various types were evaluated.

On the basis of cost and performance the material chosen for a practical absorber was one made by impregnating a commercially available mat of curled animal hair with a mixture of conducting carbon black in neoprene to provide conduction loss. The hair material is widely used for packing and upholstering purposes because of its resiliency and light weight. It is also well suited for use as an expanded framework for supporting the dissipative material because of its large percentage volume of air (approximately 96%) and the relatively large total surface area provided by the great quantity of hairs. The lossy rubber is applied by either spraying or dipping. This process coats the

Fig. 3: Specular reflection-frequency characteristic for flat and pyramid materials



individual hairs with a thin film of lossy material. Measurements showed that this conducting layer has a resistivity of approximately 8 ohm-cm and at 3000 MC a dielectric constant of about 50, with a loss tangent of about 1.4.

Reflections from the air-material interface may be minimized over a wide frequency range by either geometrical shaping of the front surface or by distributing the loss with depth. In using the first method, the top surface of the treated hair material was cut into a series of pyramids of equal height. While it was shown experimentally that other shapes such as cones and wedges were similarly effective, these were less desirable from the standpoint of fabrication. In using the second method, the top surface was left flat and the amount of conducting rubber applied to the hair was increased gradually with depth in the material from a low value at the front face to a large amount at the back. The air-to-material transition was also aided here by the rough, uneven nature of the hair surface. Both these methods may be considered as utilizing lossy tapered sections to transform impedance from that of free space to that of the medium. As frequency is increased, both methods were found experimentally to start reducing reflection in the region where the length of taper is a quarter wavelength long in air and to continue to improve in effectiveness as the electrical length of taper increases.

Experimental Results

Experiments were performed to determine empirically the influence of factors such as density of hair, type of carbon black, amount of distribution of loss, and size and shape of pyramids. Application of the results of these experiments demonstrated that it was possible to design both flat and pyramid types of absorbers which would meet the requirements for the anechoic chamber.

Experimental development and small scale production of these absorber types was carried out at the Naval Research Lab pilot plant under the direction of H. A. Tanner of the Chemistry Div.

Measurement Techniques: Fig. 1 shows a diagram of the apparatus used to make free space measurements in the frequency range of 2,500 to 25,000 MC. The arch allows convenient variation of the angle of incidence and polarization of the radiation. Transmitted energy is reflected from a metal plate to a receiving horn. A comparison of the amount of energy reflected from the metal plate with that detected when the plate is covered by an absorber allows a determination of the percentage of incident power reflected by the material.

Enclosed System

At frequencies below 3000 MC a completely enclosed system is used to measure the performance. In this case a sample of the material to be evaluated is mounted at the end of a shorted section of special coaxial transmission line. A measurement of VSWR in the line is used to determine the ratio of reflected to incident power.

There is reasonable agreement between these two methods of measurement in the frequency range of overlap.

Characteristics of Commercial Materials: Since Jan. 1952 the Sponge Rubber Products Co. of Shelton, Conn. has manufactured considerable quantities of both flat and pyramid materials. Fig. 2 shows a cross-section view of both types. The commercial pyramid material which was used in the Naval Research Lab. darkroom is about 3-¾

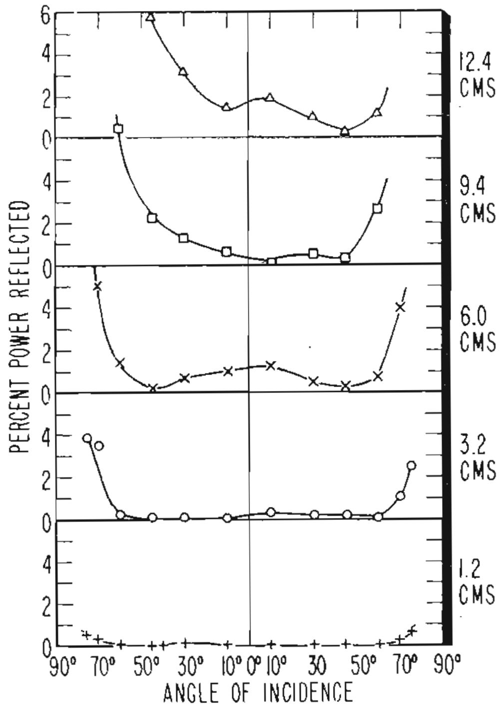
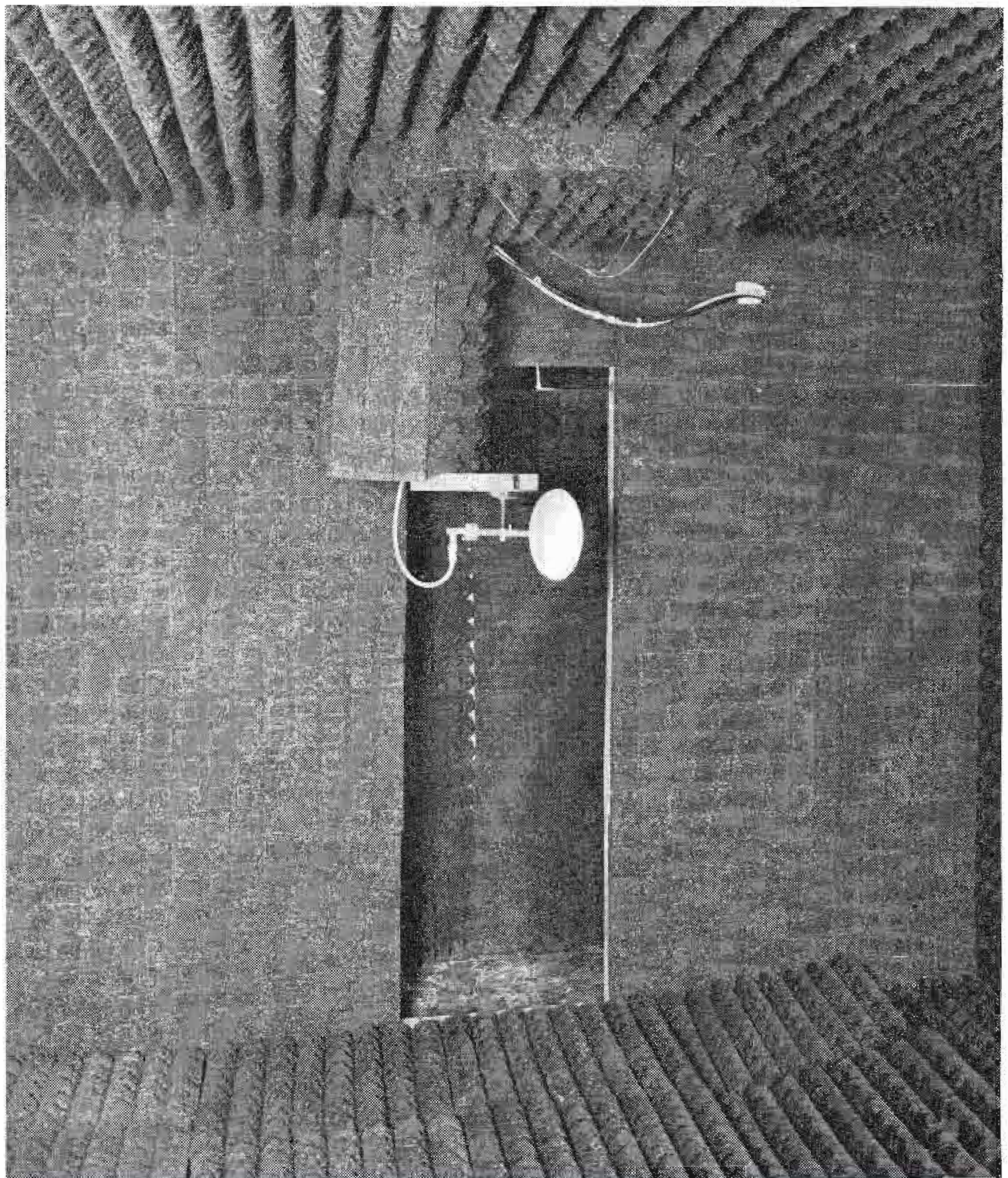


Fig. 4: Performance-incidence characteristics

Fig. 5: Rotating antenna mount installed in anechoic chamber. Klystron rotates with antenna



in. thick, including the pyramids which are 2-½ in. high and 3 in. wide. It weighs approximately 1.4 lbs./sq. ft. The flat material is somewhat thinner and more flexible than the pyramid type. It is about 2 in. thick and weighs about 0.4 lbs./sq. ft.

Fig. 3 is a plot of specular reflection vs. frequency at angles near normal incidence for both types of materials. It is seen that performance is similar for both types at frequencies above 1500 MC, but as a result of greater thickness and dissipation, the pyramid material is somewhat better at lower frequencies. The energy reflected from these materials as compared to incident energy is about 20 db down at 10 cm, 25 db down at 3.2 cm, and 30 db down at 1.2 cm for radiation at normal incidence. The high frequency limit of effectiveness has not been determined on these materials. Measurements made at a wavelength of 5 mm indicates that the performance of these materials is still continuing to improve. Above 2500 MC the reflection from both materials is essentially the same whether they are backed by a conducting sheet or left open circuited.

Fig. 4 shows how performance varies with angle of incidence and polarization for specular reflection. It is seen that the reflection is somewhat similar for both polarizations and that these materials are effective over a wider range of angles of incidence at smaller wavelengths. Both flat and pyramid types are similar in respect to performance at various angles for the wavelengths shown.

Low Reflection

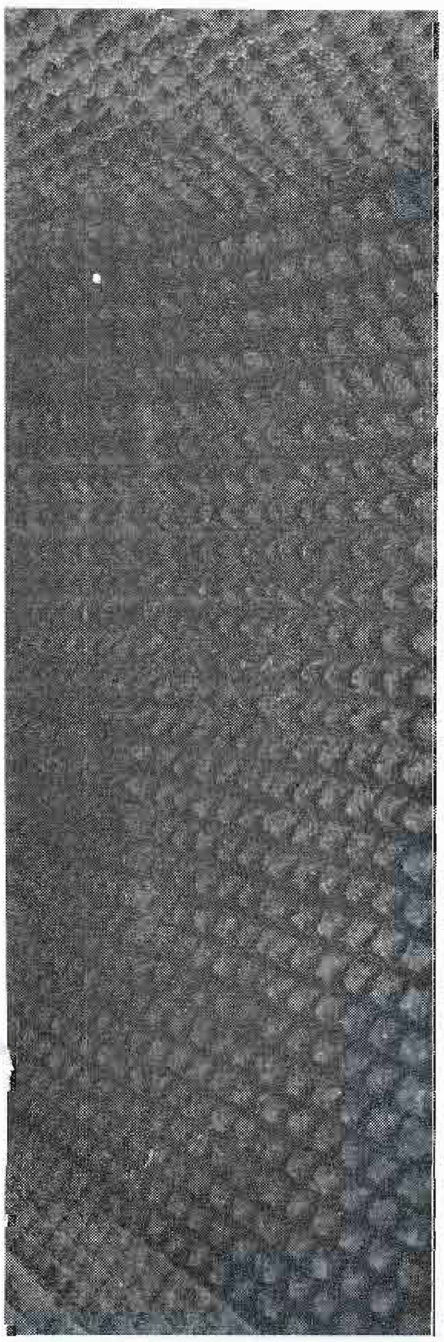
It has been established that it is the intrinsic absorbing property of the material, rather than the scattering of the incident energy over a wide solid angle, that leads to the low reflection which is observed. This was determined by comparing free space measurements where only the specularly reflected energy is detected with those made with the material in a closed horn where scattered energy is added to that directly reflected. No increase in reflected energy was found in the latter case.

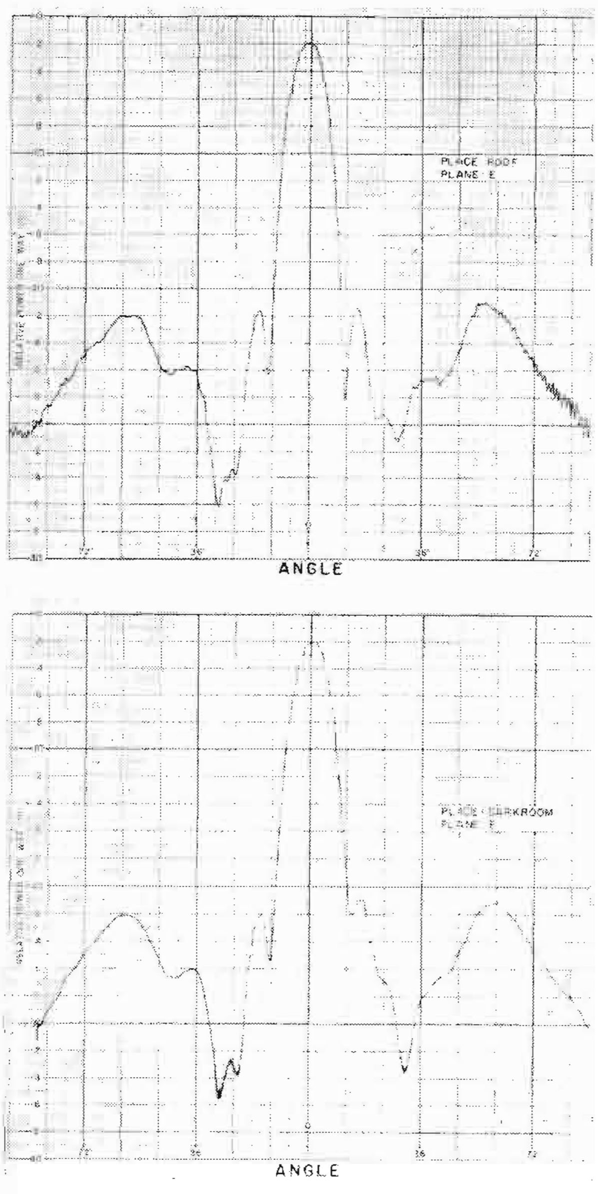
Measurements were also made to determine the upper limit of power-handling ability of these materials. It was found at 1300 MC that both flat and pyramidal types could dissipate as much as one watt per square inch, and that at this power level the temperature of the hair is around 200°F.

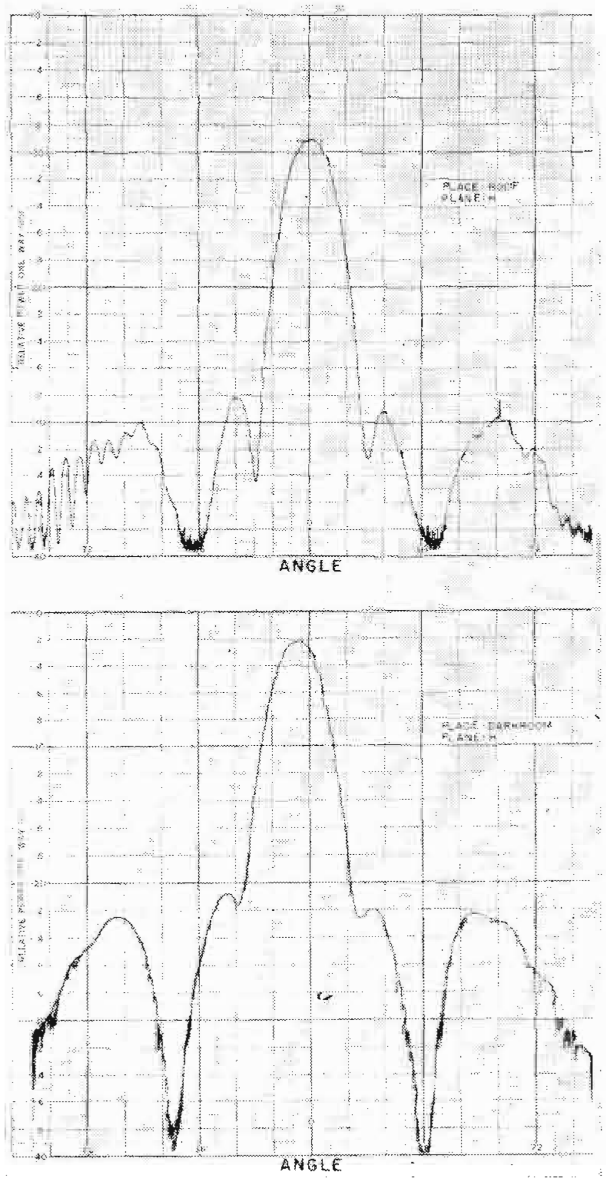
While these materials were designed primarily for indoor use, they have been found to have sufficiently stable charactcristics to withstand considerable exposure to rain and sun. This stability was well demonstrated by one sample which was kept under water in the Potomac River for 10 weeks. Upon removal and drying, the reflection from it was found to have changed by less than 3 db at 5 test frequencies above 2500 MC. Other samples which were left exposed to the weather for 11 weeks showed less than 4 db variation in reflection above 2500 MC. Samples of both types were also measured directly after withdrawal from a tank of water to determine the effects of wetness. Here the pyramid material was found to return to within 3 db of original performance within 30 seconds whereas the flat material continued to show considerable reflection until natural drainage and evaporation removed large drops of

(*Continued on page* 100)

Fig. 6: (l) Patterns of 8-inch paraboloid, $\lambda = 3.2$ cm. Fig. 7: (r) Patterns of 17.5-inch paraboloid, $\lambda = 10$ cm







CUES for BROADCASTERS

Practical ways of improving station operation and efficiency

Amplifier Modification

GEORGE F. SPRAGUE,
WIOD, Miami, Fla.

STATIONS using the Langevin 119-A Progar amplifier may be interested in the following modification. We have used this equipment for some time and find it extremely satisfactory. Occasionally, however, a heavy transient peak will operate the guardian circuit to such a degree that the audio level will be reduced 20 or 25 db below normal, where it will remain for the duration of the "guardian action wait time" (in our case, 6 seconds). This can occur when the microphone is hit accidently, when someone coughs, or during the presence of heavy transient program line noise such as would occur during electrical storms. This same effect can also result from short power failures. If the power stays off long enough for the dc power supply voltage to fall below a certain value, the guardian circuit drops the audio level to an extremely low value, after the power returns, and remains there for the duration of the "guardian action wait time."

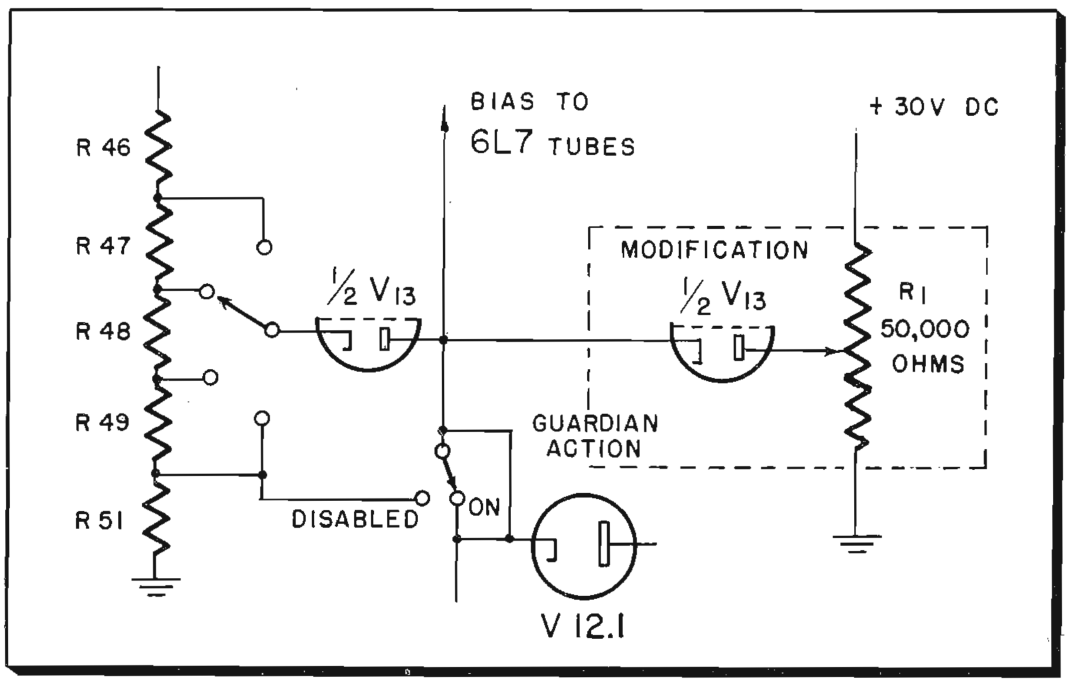
To minimize effect of this action, the circuit was modified as shown in the diagram. In the normal circuit, the two diodes of V13 are connected in parallel. It was found that disconnecting one of the diodes had no noticeable effect on the "guardian increase limit" action. This spare diode was connected in a clamp circuit giving us, in effect, a "guardian decrease limit" control. Instead of clamping the guardian voltage only at a positive value, it is also clamped at a negative limit with this modification. RI becomes the "guardian decrease" control. It is a midget type control and is mounted below the input attenuator so that it can be adjusted from the rear of the amplifier unit. We have set R1 so that the maximum "guardian decrease limit" is −5 db and the "guardian increase limit" control has been set at +5 db. This results in a net range of 10 db which, we have found, is more than sufficient for our operating conditions.

Operation is as follows. In the case of a heavy peak, the guardian circuit is reduced to the predetermined level of −5 db instead of to a subnormally low level, and the peak is suppressed by the limiter circuit. In the event of a power failure of short duration, the guardian circuit returns to a level of −5 db, as soon as the power supply voltage returns to a normal value, instead of returning to a value of −20 or −25 db which previously occurred. Thus, the level is only 5 db below normal for the duration of the "guardian action wait time" instead of the subnormally low levels previously encountered.

$$$ FOR YOUR IDEAS

Readers are invited to contribute their own suggestions which should be short and include photographs or rough sketches. Typewritten, double-spaced text is requested. Our usual rates will be paid for material used.

Spare diode in "Progar" provides guardian decrease limit control



Economical and Accurate Tape Editing Device

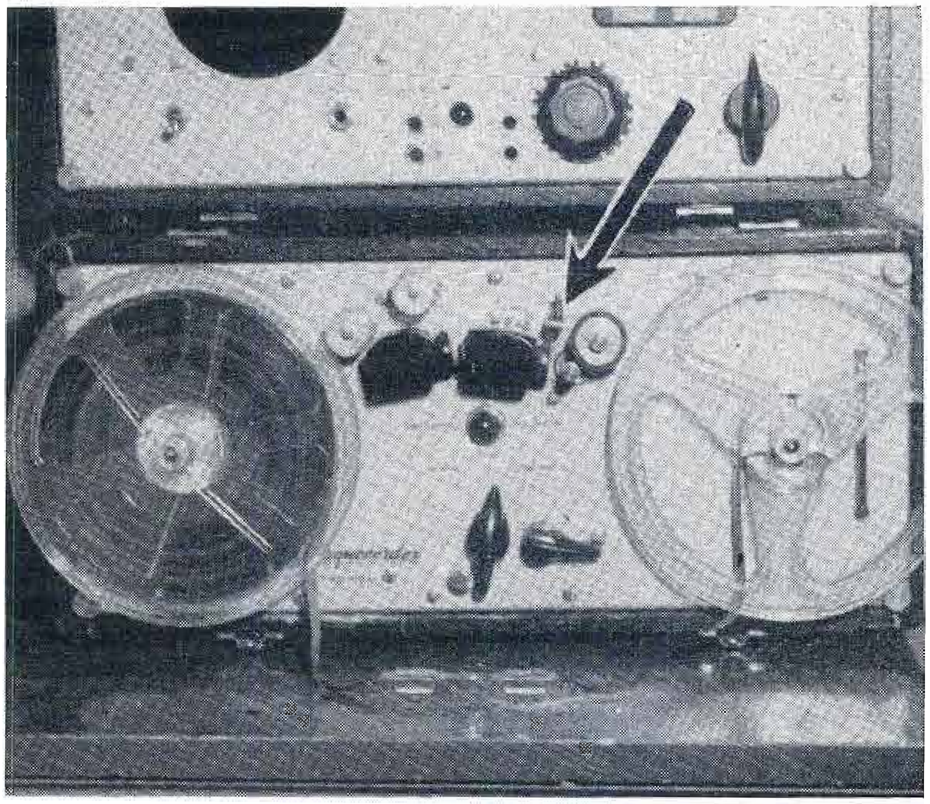
GEORGE PYLE, Engineering
Supervisor, WMBD, Peoria, Ill.

CUTTING tape at the correct point when editing can be difficult. This is especially true when the spacing between desired and undesired portions is very short. The tape can be marked with a grease pencil, but this method is awkward and time consuming. Since the cost of professional equipment designed for editing is generally beyond the means of the average small station, the writer designed and constructed a simple device which has proved useful in improving both speed and accuracy in editing work.

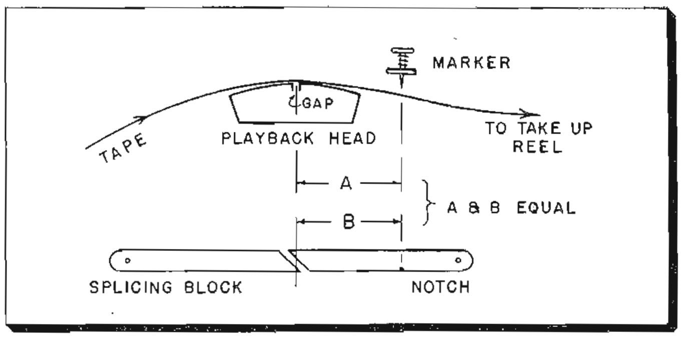
Although this unit was designed for use on a Magnecorder, it can be adapted for use on other machines. The photo shows the device attached to a machine setup for editing work. Construction details are shown in the drawing.

In operation, the idea is to run the tape until you hear the spot where a cut is desired. Keep tension on the tape by grasping the supply reel to stop tape motion and press the plunger to punch a small marking hole in the tape. Stop the machine and break the tape an inch or so to the left of the mark. Then run the tape to the next pickup point and mark it again. The distance between the punch mark in the tape and the center of the playback head will always be the same. Take any standard splicing block and file a small notch to the right of the cutting slot the same distance as that between the center of the playback head and the mark on the tape.

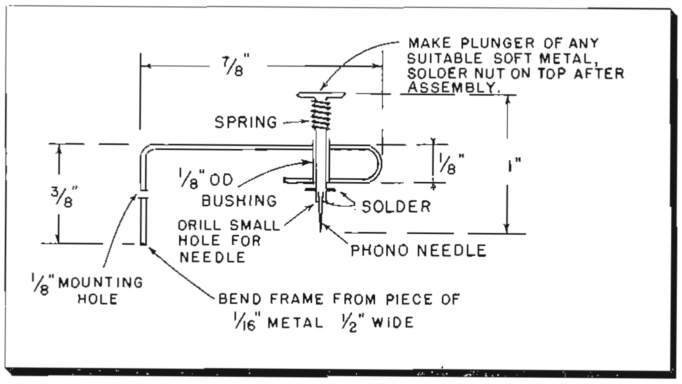
Now, lay the two tape ends on the splicing block, line up the two punch marks with the notch, cut, splice and trim in the usual manner. The important thing to remem-



Arrow points to tape marker plunger mounted on Magnecorder



Construction details of tape marker



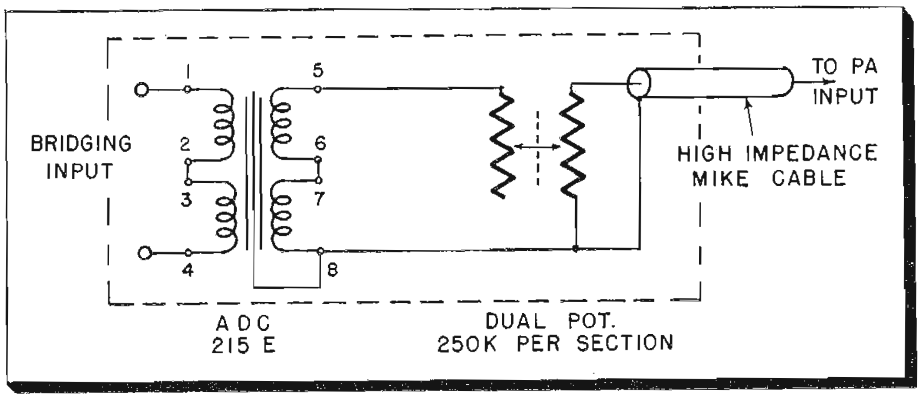
Needle in brass plunger cues tape for cuts

ber is to press the marker immediately after hearing the last word or musical note that you desire to save, then punch it again just before the next desired portion crosses the playback head or just after the last word of an undesired portion crosses the head. After a little practice, the entire operation can be performed with ease.

Feeding P. A. Amplifier from Remote Amplifier

OLAF N. GABRIELSON, Chief Engineer, KFGO, Fargo, N. D.

ON occasion, it is necessary to use a high impedance input public address system in conjunction with a remote broadcast. To eliminate the need for extra mikes and riding gain on both PA and the remote amplifier, a small unit can be used to bridge the output of the remote amplifier and provide remote control of the PA gain. This can be plugged into either the microphone or turntable input on the PA. It can also be used in the studio for emergency monitoring or tape recording with a high impedance input amplifier.



Adapter unit for using high impedance input PA with remote amplifier

Increasing Flexibility of Remote Amplifier

R. S. HOUSTON, E. C. Page Consultants, 600 Bond Bldg., Wash. 5, D. C.

THERE are today several makes of remote amplifiers having provisions for feeding an external P.A. amplifier from the mixer bus of the broadcast amplifier. However, there arise occasions when mikes are needed on the P.A. system independent of the air microphones for announcements to the crowds.

To handle any contingency that might arise in this direction, the mixer of a commercial remote amplifier was modified with the following changes. The amplifier was of the high level mixing type, and had four preamplifier channels. To accomplish this change, the mixing circuit was made high impedance by removing the output transformers from the pre-amps and substituting a resistance coupled circuit. The input transformer was removed from the program amplifier also, and it was coupled directly to the mixer as shown in the diagram. The four low impedance faders were replaced with 20,000 ohm faders with 3 db steps. The input contact on these four faders was paralleled to the input on four similar faders which comprise the P.A. mixer. The output of all faders goes through a ½ meg resistor for isolation. This prevents any fader which is in the "off" position from shorting out the mixer bus.

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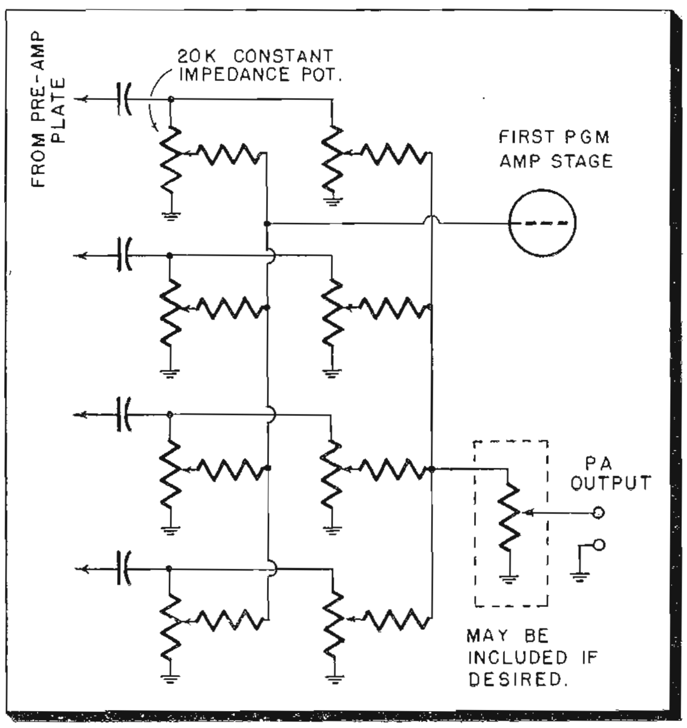


Independent PA and remote microphone high level mixer amplifier

Design of Cathode Followers

Here's how to design this type of circuit with minimum of effort. Take advantage of the cathode-loaded amplifier's high input and low output impedances

By ROBERT L. WHITTLE
Georgia Institute of Technology, Atlanta, Ga.

IN recent years the cathode-loaded amplifier, or cathode follower, has been frequently used in electronic circuit designs because of its convenient characteristics. The basic cathode follower circuit shown in Fig. 1 is characterized by its high input impedance (up to several megohms), and its relatively low output impedance (100 to 1,000 ohms for typical tubes).

The input impedance is equal to R, in parallel with the input capacity of the tube. This input capacity is less than for a conventional amplifier using the same tube, being:

$$C_{in} = C_{gp} + C_{gk}\ (1 - A)$$

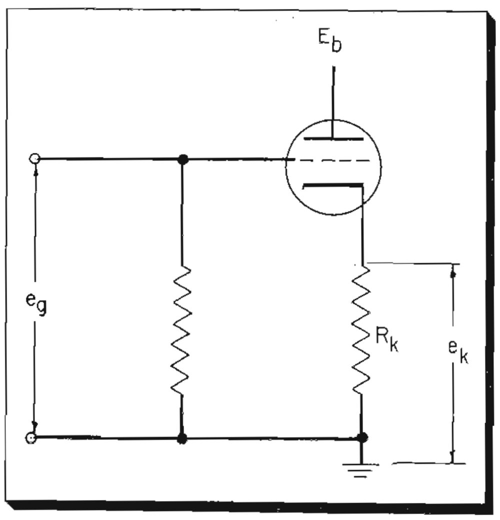
where A is the ratio e_k/e_g.

The voltage gain is approximately given by:

$$A = \frac{G_m R_k}{G_m R_k + 1}$$

For a tube having a μ of 10 or greater the approximation is very close.

The output impedance is $r_p/(\mu+1)$,



Fi. 1: Cathode follower circuit is characterized by high input and low output impedances

where $\mu >> 1$ this impedance is very nearly equal to $1/G_m$. The equivalent circuit is therefore that of a generator of internal impedance, $r_p/(\mu+1)$, working into a load impedance R_k. The open circuit voltage is $e_g \cdot \mu/(\mu+1)$, and therefore no voltage gain can be realized. A power gain is realized, however, due to the difference of impedance levels at the input and output.

$$G_{Power} = 10 \log_{10} A^2\ R_g/R_k \text{ db.}$$

The maximum power gain is realized when $R_k = r_p/(\mu+1)$.

It should be pointed out that the output impedance of the generator is independent of the value of R_k except for the normal change of G_m as the bias voltage on the tube is changed. Thus wide-band frequency response may be obtained with large values of R_k provided certain precautions are not overlooked. In pulse work, when the grid is driven in a positive direction the capacity shunting R_k (heater to cathode capacity, strays, plus any capacity due to the following stage, etc.) is charged through the internal impedance of the cathode follower, i.e., $1/G_m$.

Cathode Load Rise

Since the G_m of the tube generally increases as the grid is driven in a positive direction the rise across the cathode load is very fast. When the grid voltage is changing in a negative direction, however, as on the trailing edge of positive pulse, the effective internal impedance of the generator increases because the voltage at the cathode is held by the capacitance of the circuit. If the decay in voltage at the grid is fast enough the tube may be completely cut off, in which case the voltage at the cathode is exponential in form having a time constant of $R_k\ C_k$. This is the limiting factor which restricts the value of R_k that can be used and becomes of increasing importance of very fast waveforms. A variation of the basic circuit that is sometimes used is shown in Fig. 2.

The circuit has the same general characteristics as the basic circuit but the input impedance is not equal to R_g in this case. An effective input impedance very much greater than R_g can be realized if a value of R_L is chosen such that A is near unity. The value of this impedance is

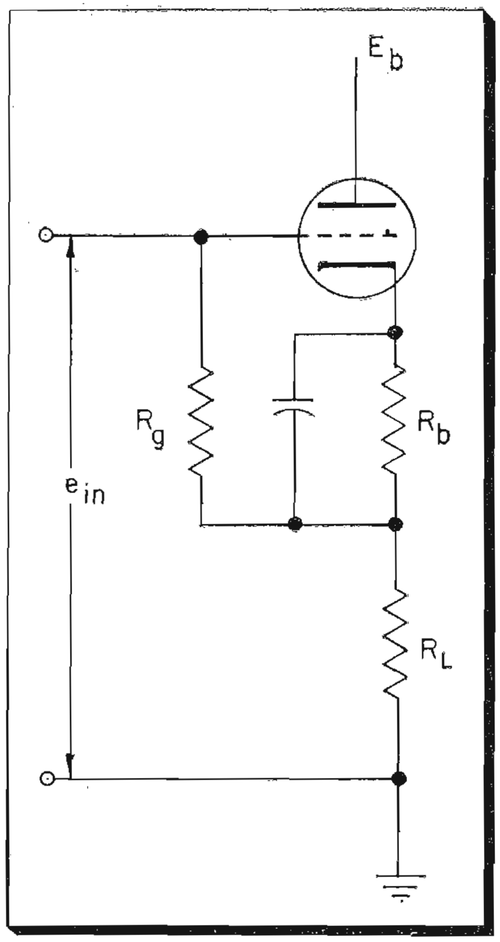


Fig. 2: Modified cathode follower has very high input impedance and is useful where long time constant is necessary in the coupling circuit

$R_{in} = R_g/(1-A)$, or approximately

$$\frac{R_g}{1 - \dfrac{G_m R_L}{G_m R_L + 1}}$$

When the bias resistor, R_b, is not bypassed the effective input impedance is approximately

$$\frac{R_g}{1 - \dfrac{G_m R_L}{G_m (R_L + R_b) + 1}}$$

If the output is taken directly from the cathode the output impedance is still $r_p/(\mu + 1)$. When the output is taken only across R_L, the impedance is then $r_p/(\mu + 1) + R_b$. The gain is also reduced by the factor $R_L/(R_b + R_L)$, being approximately

$$\frac{G_m R_L}{G_m (R_L + R_b) + 1}$$

The very high input impedance of the circuit of Fig. 2 is useful where a long time constant is necessary in the coupling circuit. The value of the coupling capacitor may be much smaller than for the circuit of Fig. 1. This circuit may be used to obtain a larger voltage swing at the output than can be obtained where the grid is at dc ground potential.

Prediction of the performance of a

cathode follower may be assisted by the construction of a set of curves similar to the $E_b - I_b$ curves given in most tube manuals. The data given in the $E_b - I_b$ curves may be used for this construction.[1]

Cathode Follower Curves

For the cathode follower curves, voltages are taken from grid to plate and from cathode to plate since the plate is held at a constant potential with respect to ground. An example of such a set of curves is given in Fig. 3, plotted for a parallel connected 6J6. The slope of each curve in this case is G_m instead of $1/r_p$ as is the case for the conventional tube characteristic. The load line is constructed in the usual manner with a slope of $-1/R$. For the example given the value of R_k is 10,000 ohms and a plate supply of 200 volts is taken. The point *A* represents the quiescent operating point for the circuit of Fig. 1. This represents a dc voltage at the cathode of 6 volts and a quiescent current of 0.6 ma. Maximum positive permissible output is at the point *B* where grid current starts to flow. This represents a maximum positive swing of 194 – 60 = 134 volts. Maximum negative swing is 6 volts. This would be satisfactory for a positive going pulse, but would be unsatisfactory for a negative pulse or sinusoid having a peak amplitude greater than 6 volts. To accommodate these waveforms adequately, the operating point should be shifted to the left by placing a positive potential (with respect to ground) on the grid, thus reducing the grid to plate voltage. Equal positive and negative swings could be obtained by placing the operating point at C. By interpolation the grid to plate voltage is found to be 133 volts. This represents a grid to ground voltage of 200 – 133 = 67 volts. The cathode voltage to ground is then 200 – 130 = 70 volts and an output of 70 volts peak in either a positive or negative direction may be obtained. The positive voltage for the grid may be obtained by returning the grid to a point on the cathode resistor as in Fig. 2. In this case the ratio $R_b/(R_b + R_L) = 3/70$. Since $R_b + R_L = R_k = 10{,}000$ ohms, $R_b = 429$ ohms.

The same result could be achieved by returning R_g in Fig. 1 to a source of + 67 volts, a high impedance voltage divider connected to the plate supply is satisfactory.

The points found graphically in this manner can be computed to a close approximation by using the approximate line of grid current

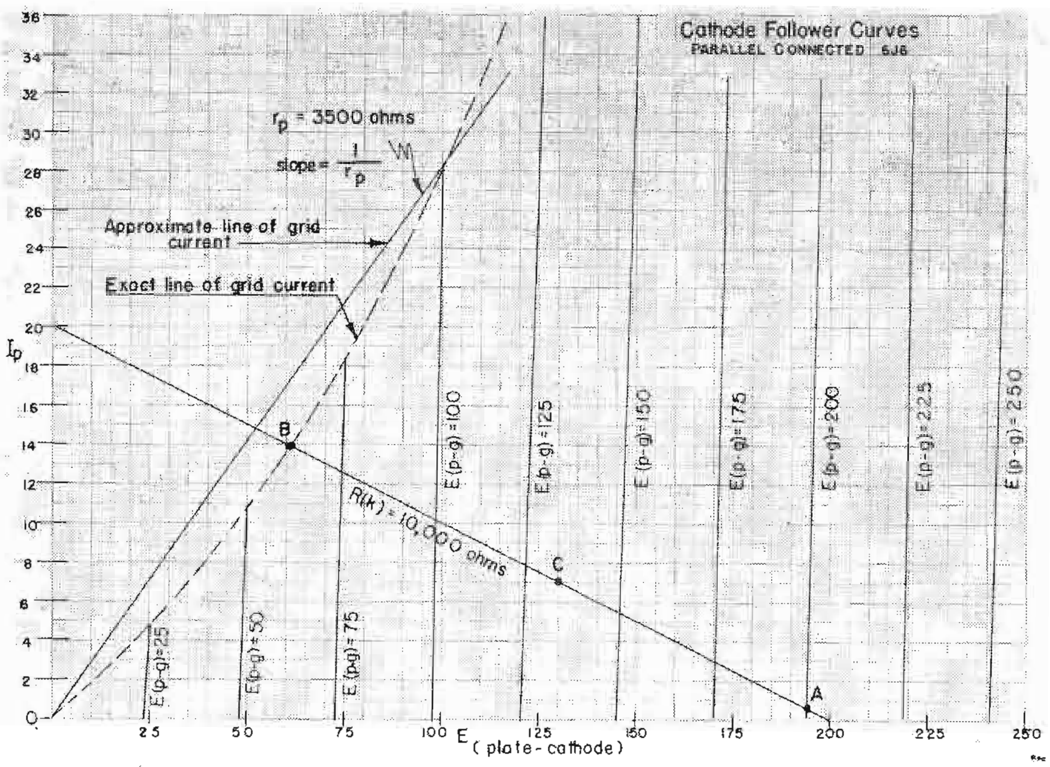


Fig. 3: Cathode follower curves for parallel connected 6J6. Slope of each is G_m

which is a line drawn from the origin with a slope of $1/r_p$. The approximation results from the fact that r_p changes with the operating point and an average value is used in the computation.

Plate-to-Cathode Voltage

Since the slope of the line connecting the points at which grid current starts to flow is $1/r_p$, the plate-to-cathode voltage at which this occurs is given by: E_{pk} (for grid current flow) $= r_p E_b/(r_p + R_k)$, where E_b is the plate supply voltage. The maximum peak-to-peak output that may be obtained for a given tube and R_k is then:

$$E_{p-p} = E_b - \frac{r_p + E_b}{r_p + R_k}$$

$$= E_b \left(1 - \frac{r_p}{r_p + R_k}\right)$$

For example given r_p is approximately 3,500 ohms, the maximum peak-to-peak voltage available is therefore:

$$E_{(p-p)} = 200 - \frac{3{,}500 \times 200}{3{,}500 + 10{,}000} =$$

$$200 - 52 = 148 \text{ volts}$$

From this the peak positive or negative swing is 148/2 or 74 volts. The operating plate to cathode voltage for equal positive or negative output is $E_b - 74$ or 126 volts.

This plate-cathode voltage represents a point mid-way between the grid current point and cut-off. At cut-off the grid-cathode voltage is – 6, and at the grid-current point this voltage is zero. If linearity is assumed, the mid-point bias on the tube is 3 volts. This represents a grid-plate voltage of 126 + 3 = 129 volts. The grid-ground voltage is then 200 – 129 = 71 volts.

In many cases the ease of computation makes this method preferable to the graphical solution, and the results are close enough for practical use.

1. Shapiro, David L. "The Graphical Design of Cathode-output Amplifiers," *Proc. I.R.E.*, May 1944.

RTMA Fall Meeting

The preliminary technical program of the RTMA-sponsored Radio Fall Meeting has been announced by Chairman Virgil M. Graham. It will be held on Oct. 26-28, 1953, at the King Edward Hotel, Toronto, Canada. Following is the tentative program outline:

Monday Morning, **Television Interference** Symposium (Sponsored by the RTMA Engineering Department); Monday Afternoon, **Quality Control** Session—J. R. Steen, Presiding (Sponsored by the IRE Professional Group on Quality Control).

Tuesday Morning, **Television** Session—I. J. Kaar, Presiding (Sponsored by the IRE Professional Group on Broadcast & Television Receivers); Tuesday Evening, Radio Fall Meeting Dinner (Sponsored by the RTMA of Canada).

Wednesday Morning, **Electron Devices** Session—L. S. Nergaard, Presiding (Sponsored by the IRE Professional Group on Electron Devices); Wednesday Afternoon, **Electron Devices** Session—George A. Esperson, Presiding (Sponsored by the IRE Professional Group on Electron Devices).

Color Television—Its Status Today

Dr. W. R. G. BAKER'S RECENT ADDRESS to the 45th Annual Convention of the National Association of Electrical Distributors contained probably the outstanding summary of the past, present and future of compatible color television, presented to date. Dr. Baker is vice president of the General Electric Co. and Chairman of the National Television System Committee and the RTMA Television Committee. Technical information describing the operation of the NTSC compatible color-TV system has been excerpted from this address and is presented herewith.

In 1950, the FCC approved a field sequential system of color television. The principal objection to this system lay in the fact that it was not compatible to the system under which black and white television was operating, which meant that the 8,000,000 black and white receivers then in American homes could not receive color broadcasts either in color or black and white, without extensive alterations and expense to the owner.

The importance of that major shortcoming is evidenced and magnified by the fact that, today, the public has invested over $7-billion in some 25-million black and white receivers, that would not be able to receive such color broadcasts in black and white without such expensive alterations.

Obviously, the solution of the problem lay in the possibility of developing an all electronic system that would be "compatible"—that is, a system that would make it possible for any and every black and white receiver in the home to receive future color broadcasts in black and white, without any alteration or expense.

National Television System Committee

The development of this system was the task undertaken by the National Television System Committee, formed under the auspices of the Radio-Television Manufacturers Association.

It should be appreciated that in the development of the standards for a compatible color system the NTSC had the full and complete cooperation of the companies comprising our industry. The source of an idea was completely disregarded. The only question was—Is this the best idea—Is this the best way to do the job?

Ninety-one companies in the industry contributed the skill and services of over 200 of its leading scientists and engineers toward the color assignment. One of the first actions of the NTSC was the naming of a five-man Ad Hoc Committee to determine whether a compatible Color television system could be evolved within the standard 6 M.C. band. While RCA in 1950 proposed and demonstrated a compatible system which would operate within the standard band, it was thought desirable to initiate a comprehensive analysis of the entire field to review existing material and thoroughly explore new approaches to the problem.

After considering all the developments to date and the possible new solutions to the problems, the Ad Hoc Committee reported in the affirmative and laid down the framework and philosophy for the proposed system. The system was broken down into its major components and 10 Panels of the NTSC were established to undertake the solution of the many and complex problems.

Monochrome TV

The standard black and white television transmitter sends out two signals, one carrying the picture, the other the sound. The picture signal, is produced in the television camera which views the scene in full color and transforms it into a representation in shades of gray. In so doing, the camera removes the "color" aspect of the image. In the monochrome television image, it is not possible, for example, to tell whether an object is red or green, nor to tell whether the colors are deep and intense or are displayed in pastel shades. The monochrome system thus omits any reference to the spectral quality of the color itself (known to artists as "hue" or its visual depth of color known as "saturation").

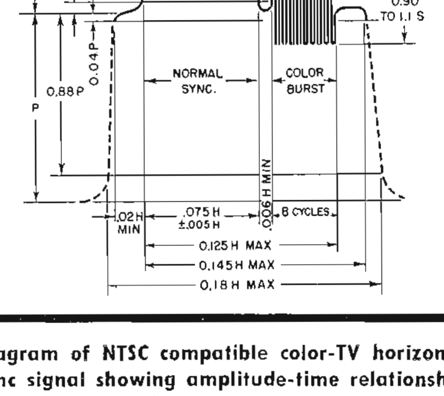


Diagram of NTSC compatible color-TV horizontal sync signal showing amplitude-time relationship. P is pedestal, S is sync and H is time for one horizontal line. Note location of color burst

In transmitting a full-color image, then, it is necessary to take into account the missing elements of hue and saturation. In the NTSC system, these are transmitted by a third signal, known as the color carrier, which is fitted into the channel between the picture signal and the sound signal.

How NTSC Color-TV Works

The NTSC color system is thus founded on the principle that a color image may be reproduced from two signals, one of which carries a monochrome version of the image in shades of gray, while the second superimposes on the monochrome image the missing hues and saturations. This principle is well suited to compatible operation of monochrome receivers. It is merely necessary so to arrange the transmissions that monochrome receivers respond only to the monochrome signal, ignoring the color signal. Color receivers, on the other hand, are designed to accept and make use of both signals.

Simple as this principle appears, it was a major task to develop a system based on it. The principal problems were two:

1) How to fit all the information of both monochrome values and hue and saturation values into the standard television channel without overcrowding, and

2) How to assure that monochrome receivers would ignore the color information for which they have no use.

The first problem was solved by the NTSC with the discovery that the monochrome aspect carries the essential pictorial detail of a full-color image. Once the monochrome portion is available in full detail, the hues and saturation can be superimposed in a relatively coarse manner, "painted with a broad brush," so to speak. Hence, the color carrier need not occupy as much channel space as the picture carrier, and overcrowding of the channel is avoided.

The second problem was solved by the NTSC when the color signal carrier frequency was assigned a precise numerical value relative to the picture signal carrier frequency.

and a Look into the Future

When this exact frequency relationship is maintained, the monochrome receiver retains its full sensitivity for the picture signal, but finds itself virtually blind to the color signal. Mutual interference between the signals is thereby avoided.

In summary, the NTSC system achieves compatible color transmissions by building on the existing monochrome system. No basic changes are required in the existing FCC regulations governing black and white broadcasting beyond tightening of tolerances which has the effect of improving the performance of receivers now in the hands of the public and making a minor addition to the synchronizing pulse. To these regulations must be added a group of supplementary standards, which set up the color signal, specify its frequency, and outline the techniques by which the hue and saturation values are transmitted.

On April 14, 1953, this NTSC system was formally demonstrated by RCA to the Wolverton Committee and to the Industry on April 16, 1953. It was acclaimed as highly successful. It is now undergoing final and extensive field tests, preparatory to formal submission to FCC for consideration.

A television transmitter broadcasting a monochrome signal will accommodate the color signal without change. Precautions necessary to insure satisfactory monochrome transmission are, in general, the only precautions necessary to insure proper color transmission, although misadjustment will be more objectionable in the picture when transmitting color.

Transmitters which will take color signals from the network will probably be required to utilize an additional piece of equipment known as a "synchlock" to insure the adequacy of the received synchronizing pulse. This, fortunately, is a rather simple and inexpensive piece of equipment and could be supplied quickly to any station then on the air with black and white.

The Networks

Signals have been satisfactorily transmitted over the telephone company's networks. The telephone company's engineers have taken a very active part in the affairs of the NTSC, and are thoroughly familiar with the NTSC proposal. The development of the telephone company's facilities has kept pace with the development of the system generally.

These two factors mean that a color program originated at a network key station and put on the network, could, for a minor capital investment and at practically no extra operating expense, be taken off the network and rebroadcast by any local station.

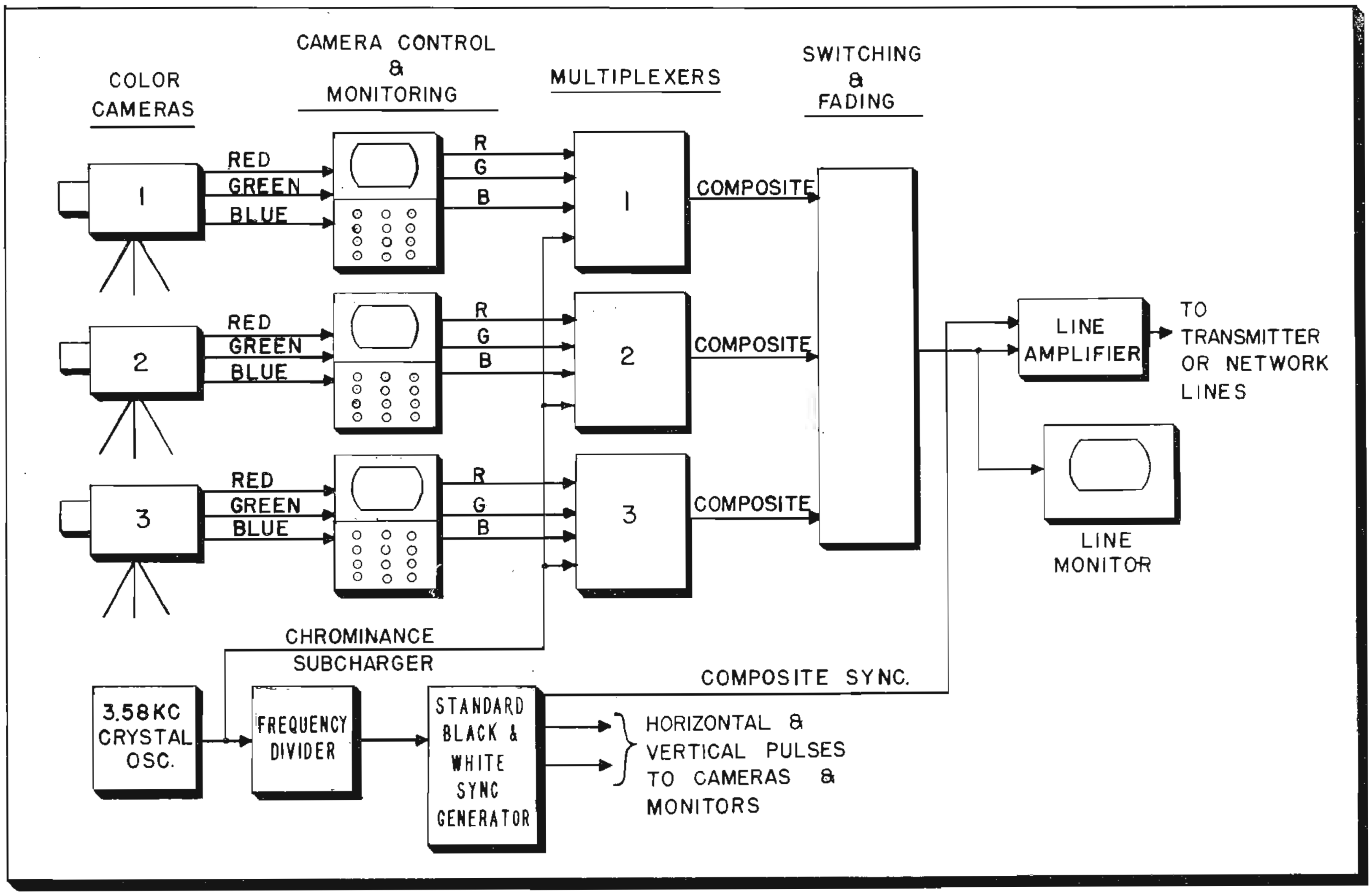
Thus, color programs on a national basis could be available a few months after the system is approved.

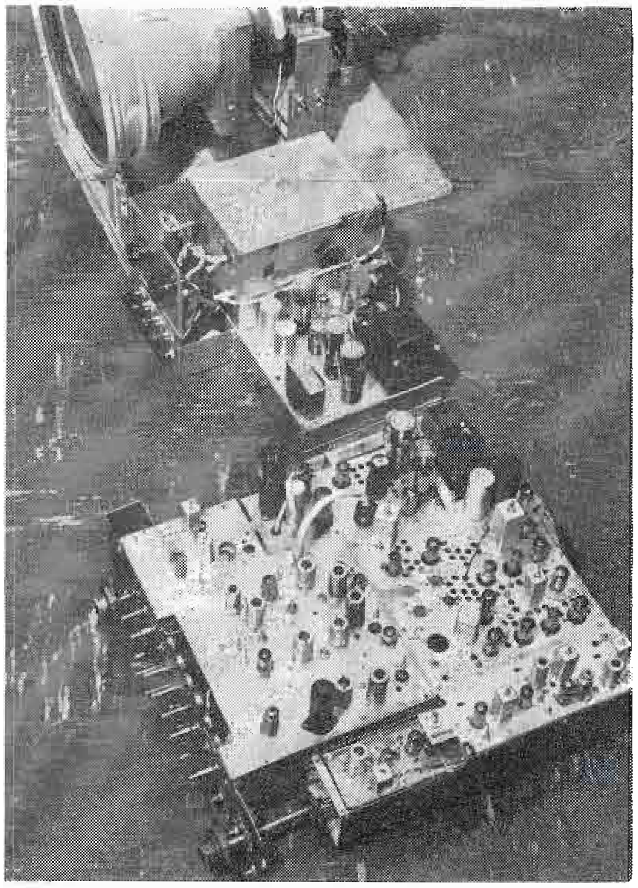
Studio Equipment

It is in the color television studio that the most extensive changes will be required. A three-tube camera initially will be used, although development now intensively underway, may result in a single camera tube which, if successful, will materially reduce the bulk and complexity of the color camera.

The signal from the camera is directed to a system of rack mounted equipment, where the signal is dis-

Simplified block diagram illustrating equipment interconnections within typical color-TV studio.





Close-up showing present day experimental General Electric NTSC color-TV receiver.

sected and each of the signal components is then optimized and dealt with individually. At this point, also, the special synchronizing pulse is generated. From this equipment then, there is delivered a complete signal which is ready to modulate a standard transmitter or to be fed to the networks.

Providing the necessary studio equipment for hundreds of stations across the country is a very substantial technical and production job. But, this need not necessarily preclude the possibility of originating a national color television signal quickly, as above. Enough studio gear, much of it now only in prototype stages, is available to equip at least several key network stations. This equipment, however, could be used to put small percentage of color programs through the networks in parallel with the standard black and white programs.

Color Television Receivers

One of the three important elements of the NTSC color television signal is that it employs the same monochrome signal as used for present day black and white television. This, of course, is the feature of the system which makes it fully compatible. This feature in the NTSC system does simplify to some degree the design of color television receivers. The fact remains, however, that to incorporate in one chassis and in one picture tube, the ability to receive either color programs or black and white, at the turn of a switch, is a complex problem in engineering and costly in production.

The first sets must be "good" if color is to be given its proper chance to prove its desirability and win the approval of the public. Nothing could retard color quicker than the advent of "compromise" color receivers that would offer less than the maximum performance. Cost reduction can come later as a logical development, but the first units must be "tops" and that means that they will be expensive in comparison to present black and white receivers. Industry estimates indicate they will be at least double the price and may run three times the cost of comparable picture-size monochrome sets.

It has been estimated that somewhere in the neighborhood of 100 color receivers have been built to date. These have been kept "up to date" with the latest NTSC developments and, by and large, have been successful after the expected "prototype" bugs have been eliminated.

Receiver Availability

Actual commercial designs, however, cannot be completely frozen until final specifications have been determined and the system receives final approval by FCC. Much design work, however, can be anticipated, which will materially reduce the time cycle required for final designing, tooling and getting color receivers into production. In spite of this, it may well develop that the receivers will be the bottleneck and that color programs will be on the air months before any reasonable supply of receivers is available.

The major remaining problem in color television lies in the picture tube. One industry leader has made the statement "We do not have a picture tube." This is not actually true, but the severity of this problem should not be minimized.

All tri-color tubes have in common the requirements that the phosphor surface utilize not a homogeneous deposit, as is the case in monochrome, but three separate phosphors for red, green and blue, deposited as hundreds of thousands of dots, or, as fine vertical or horizontal stripes. Here the similarity ends and development is progressing in two general directions:

1) Using a single electron beam with a change in beam direction at the front of the tube to provide color selection. Such approaches are exemplified by the Lawrence tube of Chromatic Laboratories, and by the Lafferty tube of General Electric. Such tubes, in general, are simpler and cheaper than the ones next to be described, but depend upon complicated chassis and require greater circuit precision in order to insure color fidelity. Furthermore, the beam bending operation requires an appreciable amount of power at high frequency, which raises the problem of interference radiation.

2) The second general category of tubes comprises those utilizing three separate electron beams whose possible paths are restricted physically so that the green gun, for instance, can only reproduce green, etc. These tubes are exemplified most familiarly by the one introduced by RCA. The use of these tubes permits a reduction in chassis and circuit precision and complication, but the tube complexity and cost is increased. The radiation problem, of course, does not exist. Several laboratories are known to be working in this direction.

In summary, then, as regards the picture tube, the Industry seems to have two choices:

a) Build the precision in the tube, thus permitting simpler chassis circuits with the assurance that when a given color is called for, only that color can be reproduced. The radiation problem does not exist.

b) Build the precision into the chassis. This alternative possibly will result in lower cost tubes. It involves the hazard of radiation and probably puts more of the responsibility for reliable operation into the hands of the customer.

Color Receiver Costs

The picture tube holds, not only the key as to how the chassis is to be designed, but also in a great measure, the cost of the finished end product—the complete color television receiver.

If the three-gun type, such as this RCA tube is used, and if current price estimates of $150 to $200 prevail, it is obvious that the picture tube component alone in the receiver might add $325 to $350 to the list price. Just adding this difference in picture tube price to the price of an average good quality 21" console would bring the total cost to $750 or more. Further, a color receiver will probably use 45 to 50 receiving tubes, more than twice that of a black and white set. Add the

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Multicon—A New TV Camera Tube

By HARRY SMITH
Standard Electronics Corp.
285-289 Emmett St.
Newark, N. J.

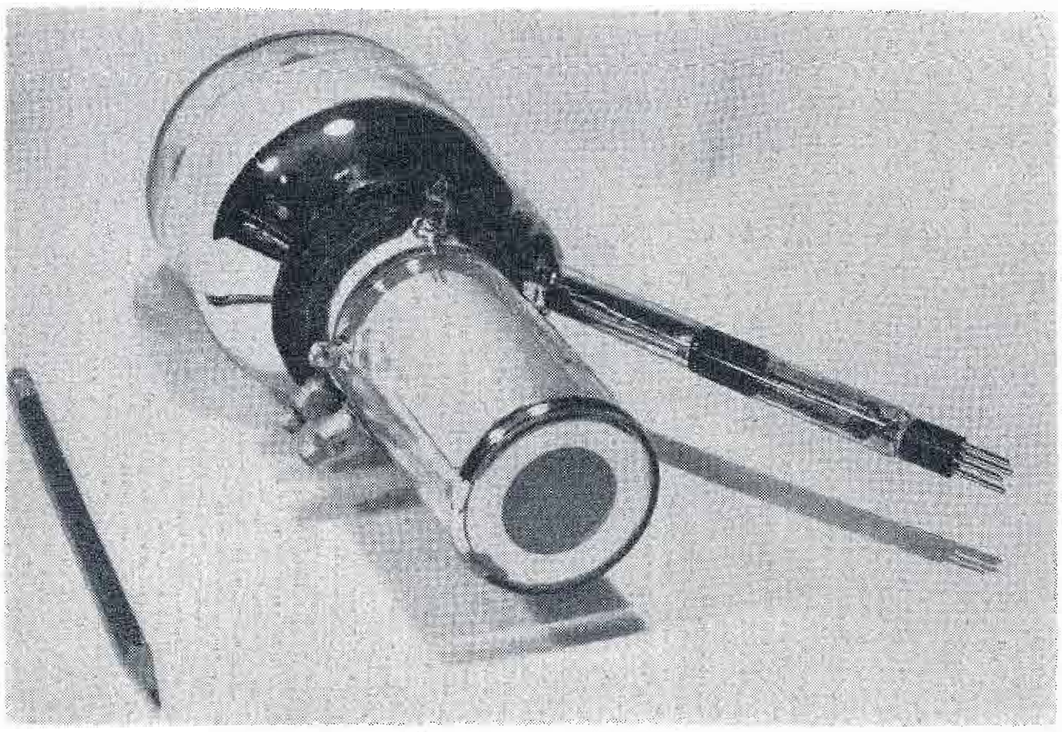


Fig. 1: Photograph of the new "multicon" TV camera tube. Operation is similar to image iconoscope

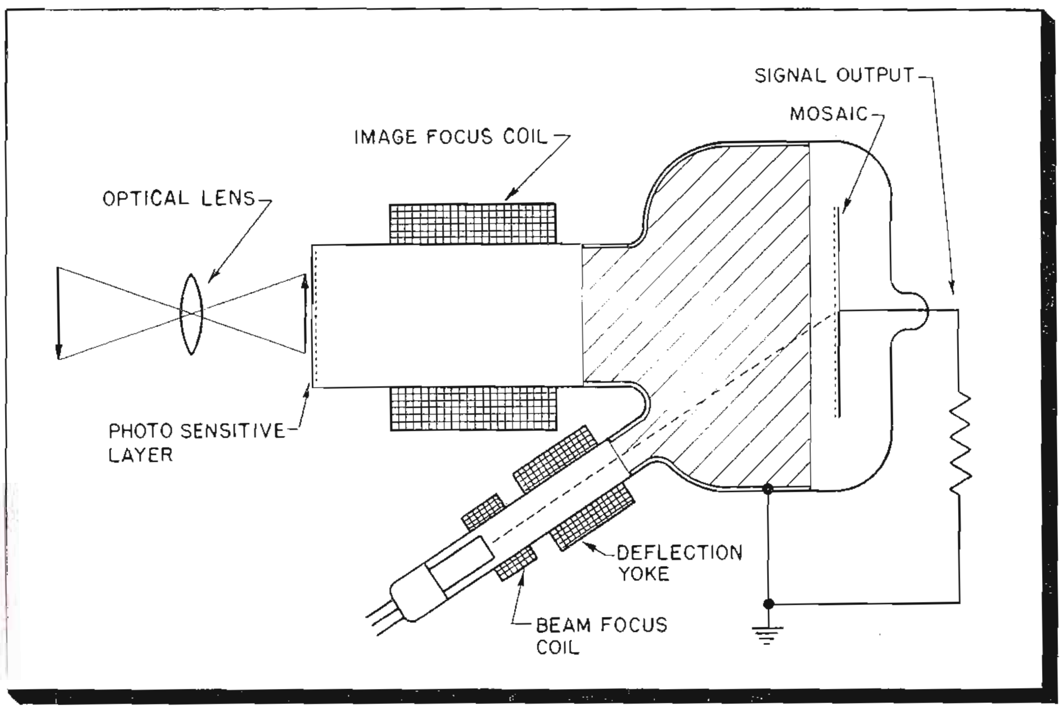
Heart of recently announced low-cost camera is 9-inch long image iconoscope, not used previously in U. S. commercial stations. Unit features high sensitivity, eliminates need for blowers and heaters

THE "multicon" is a new television camera tube having operating characteristics similar to those employed in the image iconoscope. Tubes falling into this general category have not been used heretofor in the United States for commercial broadcasting but are currently being used rather extensively in Europe for studio work. The "multicon" is manufactured by Philips, in Eindhoven, Holland. (See Fig. 1.)

The principle of operation for this type tube very briefly is as follows: The optical image is focused on a photosensitive layer which is deposited on the inner surface of the flat face plate of the tube. (See Fig. 2.) Photo-electrons emitted from this surface are accelerated toward the mosaic by a suitable electric field established within the tube envelope. The photo-electron streams are focused by means of the image focus coil on the surface of the mosaic. The mosaic surface is made up of a vast number of microscopic particles deposited on an insulating plate. The particles are insulated from one another and consist of material which is a good secondary emitter. The photo-electron streams cause a charge image to be formed on the mosaic surface by virtue of secondary emission.

The charge image is scanned by an electron beam produced by an electron gun, magnetic focus coil, and magnetic deflection yoke. As the beam passes over the charge image on the mosaic, a variation in net charge on its surface takes place, the amount of variation depending upon the charge condition of the elements being scanned. (i.e. the number of secondary electrons released from the mosaic by the photo-electrons.) As was mentioned, the mosaic surface consists of isolated microscopic particles deposited on an insulating plate. The opposite side of the insulating medium is covered with a conductive layer known as the signal plate. Each particle in the mosaic can be considered to be "capacitively coupled" to the signal plate. The variation in net charge on the mosaic is transferred via capacity to the signal plate which in turn is connected through a suitable glass seal to an external load resistance. The resulting current variations in this load resistance produce the video output voltage.

Fig. 2: In operation, light striking photo-sensitive layer causes photo-electrons to be emitted and accelerated toward mosaic. Secondary emission from mosaic forms charge image, which is scanned



The principle by which the video signal is obtained from the mosaic will be recognized as being similar to that of the iconoscope tube. The iconoscope tube is currently used as the pickup device in almost every film system now in commercial use. Its ability to give high definition pictures with no tendency to "burn in" or stick are well known. The multicon retains these good qualities and the addition of an image section leads to several advantages which war-

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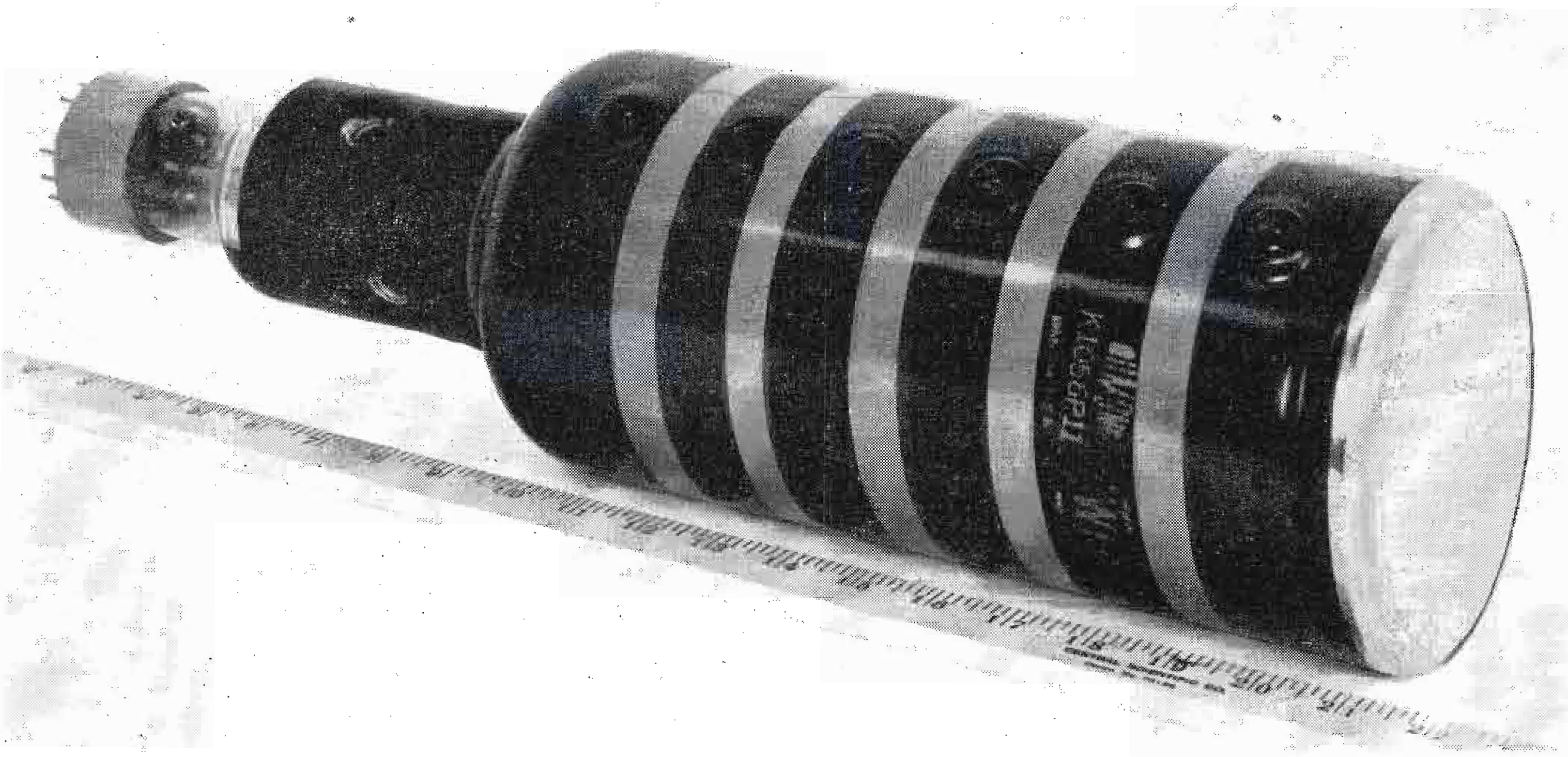


Fig. 1: Type K1056 cathode-ray tube, built by DuMont under Office of Naval Research contract, provides high writing speed and improved resolution

A New High-Speed Cathode-Ray Tube

Particularly suited for recording transient-voltage waveforms, type K1056 provides improved resolution and minimum distortion. Spot velocities as high as 13,000 inches/microsecond recorded

By HAROLD J. PEAKE & ROBERT W. ROCHELLE
Naval Research Laboratory, Washington 25, D.C.

As the electronic art progresses, the need constantly arises for obtaining permanent records of transient-voltage waveforms. Furthermore, the demand is for a means of recording waveforms with increased rates of rise or decay, thus requiring increased writing-speed capability of the recording set-up. To satisfy this demand, recent improvements have been made both in cathode-ray tubes and in photographic techniques. The CRT's developed in recent years for the display of high-speed traces are exemplified by the Du Mont types 5RP-A[1], K1017, K1032, and finally the tube described here, K1056, which was built by Du Mont under Office of Naval Research contract. The type K1056, when compared with its predecessors, provides improved resolution, greater useful screen area, and minimum distortion and background illumination, in addition to the increased writing-speed capability. A sample production tube is shown in Fig. 1.

During the development of the K1056 CRT, a total of 48 experimental tubes were fabricated for testing and evaluation. An analysis of the results obtained with each experimental model was used to establish the next line of attack. At the start of the investigation the 5-in. screen diameter was chosen from purely practical considerations. It was also clear that the multiband postdeflection-accelerating electrode arrangement would be required in order to use a high overall tube voltage and yet maintain a reasonable deflection factor (volts per inch). Owing to previous difficulties that resulted from non-uniform screen charge distribution on uncoated screens, it was initially decided that the screen would have an aluminized backing connected to the full tube potential.

Length of Envelope

From the standpoint of application as well as that of manufacture it is desirable to minimize the length of a CRT envelope. Consequently the first four experimental models had an overall length of 17 in., and the throw from the deflection plates to the screen was 11 in. Owing to the required greater beam-deflection angle as compared with that of a tube having a longer plate-to-screen throw, these first tubes had several deficiencies: (1) excessive trace distortion (deflection nonlinearity),

(2) insufficient usable screen area, and (3) defocusing of the spot when deflected from the center of the screen. On deflection from the axial position the electrons in a beam Cross-sections do not all experience the same net accelerating force. The electrons nearer to a deflection plate travel through the deflecting field along a path shorter than that followed by electrons diametrically opposite. This means that the deflected beam is focused at a point considerably short of the screen. Hence, if the undeflected beam is focused on the screen, focusing occurs at deflected positions. Subsequent models therefore had greater bulb lengths, the final design having a nominal 21-in. overall length and 15-in. throw. The first experimental tubes had a new feature that was retained in the final model: the intensity-grid and cathode leads were brought directly out through the glass neck of the tube. This lead arrangement effects a reduction in the grid-cathode capacitance and the associated lead inductances—important considerations in the application of fast blanking or unblanking signals.

Deflection Linearity

In an attempt to increase deflection linearity with unbalanced signals, a deflection-plate design called the "box plate" was incorporated in several sample tubes. One of a pair of plates was a plane surface; the other plate had a parallel planar section. In addition, the two edges parallel to the electron-beam axis were folded inward at 90°. This box-plate configuration was used in an attempt to maintain deflection linearity with an unbalanced-to-ground deflection signal. Tubes utilizing this plate structure showed severe distortion of the trace near maximum deflection and exhibited an aggravation of the defocusing with deflection. In view of these results it was decided that a symmetrical plate structure would be used. This provides a balanced-signal display with minimum distortion as well as good reproduction of unbalanced signals.

Because of the deterioration of spot focus when the beam was deflected from the center portion of the tube, an investigation of the use of curved faceplates was undertaken. The use of a fluorescent screen surface that is convex outward would, at least partly, correct for field curvature of camera lenses. (Edgerton, Germeshausen & Grier type 3114 camera with a Wray f/1.0, 2-in., 4:1 copyratio lens, used in developing K1056.) However, this study showed that, as far as the electron optics are concerned, essentially no improvement accrues in using other than a flat screen area on a CRT having a multiband postdeflection acceleration. The electron beam of such tubes must follow a doubly inflected path such that, on arrival at the screen, parallelism is maintained regardless of beam deflection. The K1056 has an optically flate glass face plate.

To determine the effect of the type and thickness of the screen phosphor, tubes with different thickness of P7

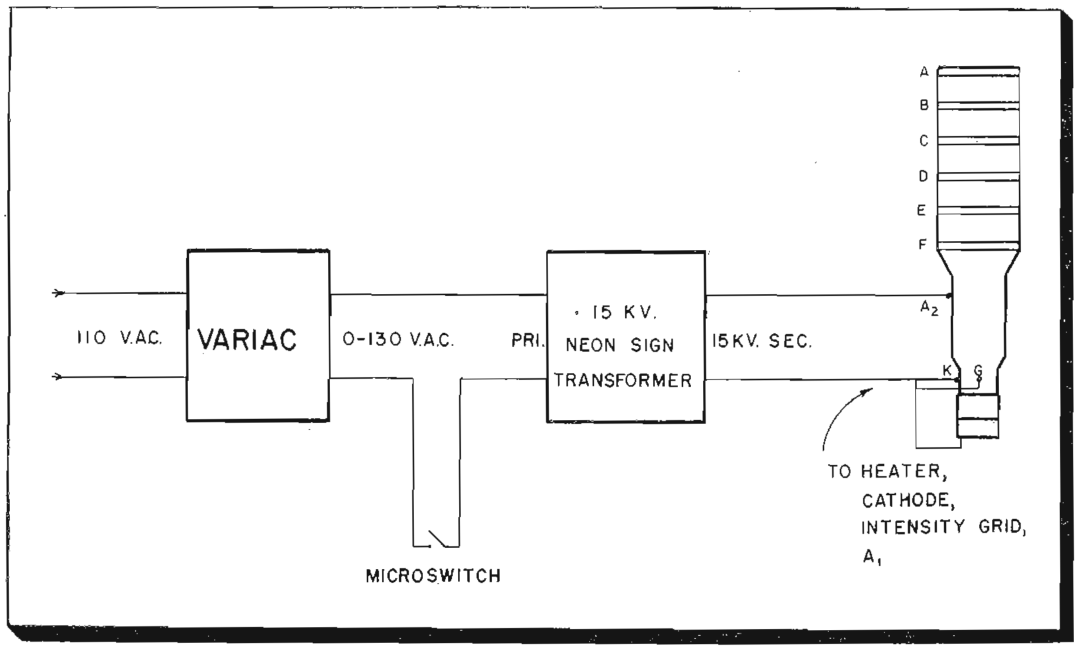


Fig. 2: Circuit for "sparking" process applies high-voltage transient to gun structure region

TABLE 1: GENERAL CHARACTERISTICS OF TYPE K1056 TUBE

Electrical	
Heater	
Voltage, ac or dc	6.3 v.
Current	0.6 amp.
Deflection	Electrostatic
Focus	Electrostatic
Screen	
Phosphor	P11
Fluorescence	Blue
Persistence	Short
Direct Interelectrode Capacitances, Nominal-Cathode to all other electrodes (including filament)	4.6 μμf
Grid 1 to all other electrodes	3.7 μμf
D_1 to D_2	1.0 μμf
D_3 to D_4	1.0 μμf
D_1 to all other electrodes except D_2	1.3 μμf
D_2 to all other electrodes except D_1	1.3 μμf
D_3 to all other electrodes except D_4	1.3 μμf
D_4 to all other electrodes except D_3	1.3 μμf
Mechanical	
Over-all length	21 ± 3/8 in.
Greatest diameter of bulb	5 1/4 ± 3/32 in.
Minimum useful screen diameter	4 1/4 in.
Bulb contacts (A_3bands)	Snap terminal ball contacts
Neck contacts (cathode and grid)	Special lateral contacts
Deflection-plate connections	Coaxial (fit Ucinite J-1357 plug)
Base	Medium 12-pin diheptal
Maximum Ratings*	
Anode-3 voltage (postdeflection accelerator)	35,000 v. dc
Anode-2 voltage	10,000 v. dc
Ratio of anode-3 voltage to anode-2 voltage	5
Anode-1 voltage	5,000 v. dc
Grid-1 voltage	
Negative bias	400 v. dc
Negative peak	<0 v.
Typical Operating Conditions	
Anode-3 voltage**	30,000 v.
Anode-2 voltage	7,500 v.
Anode-1 voltage for focus	2,500 to 2,600 v.
Grid-1 peak voltage	<-20 v.
Grid 1 bias voltage (for visual extinction)	—100 to —150 v.
Deflection factor (D_1-D_2 and D_3-D_4)	210 to 250 dc v./in.
Spot position (undeflected)	Within 15-mm sq.

* All voltages are with respect to the cathode

** A_2-A_3 voltage equally divided between the five accelerator bands i.e., (30—7.5)/5=22.5/5=4.5 kv per band

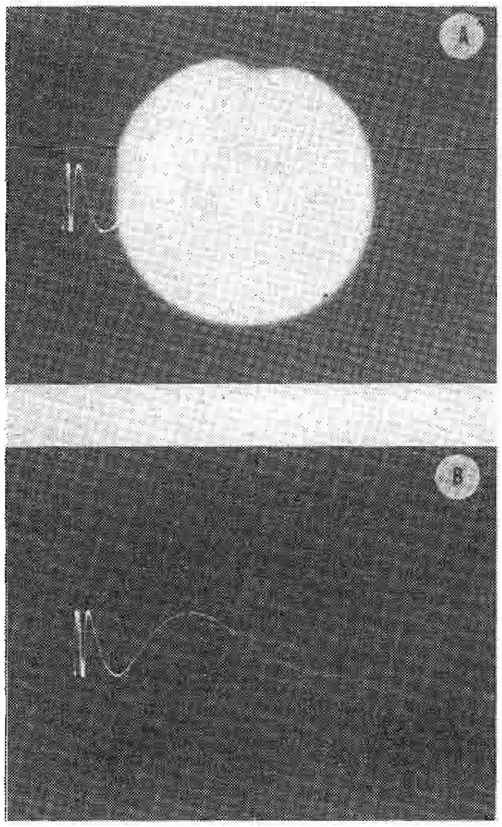


Fig. 3: (a) Trace with spurious screen illumination. (b) Same trace after sparking applied

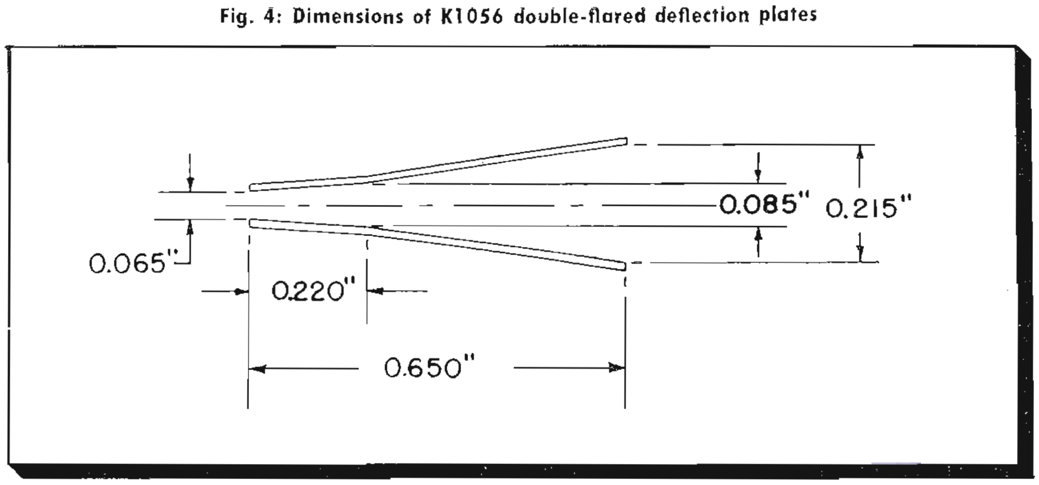
and P11 screen materials were tested. Only the short-persistence portion of the P7 screen was used. The thickness, as measured by the transmission of light from an incandescent source through the screen, was varied from 40 to 60% in 5% increments. The P11 material was generally superior, and the optimum thickness was found to be that corresponding to a light transmission of 53%.

Spurious Screen Illumination

Trouble has been encountered, both in previous tubes and in experimental K1056's with regard to spurious screen illumination. Such illumination falls into two categories: steady illumination ("stray emission"), and illumination under control of the intensity grid ("bloom"). Much effort has been expended toward the elimination of these two effects, since any background screen illumination seriously affects the maximum recordable or observable writing speed. Possible sources of undesired electrons are flecks of material from the getter, cathode, screen, electron gun, and accelerator bands. Since it is practically impossible to fabricate a "clean" CRT, some operation on the finished tube is required. The most useful technique is that of "sparking" by means of a high-voltage transient applied between the second anode and the combination of grid, cathode, heater, and focus anode. A current-limiting 15-kv neon sign transformed will supply the necessary pulses if a variac and spring-return switch are used to control the voltage (Fig. 2). Momentarily closing the switch then applies a high-voltage transient to the gun-structure region, burning off the offending particles deposited in the vicinity. This process is carried out in a very dim light so that the progress made may be followed by noting the incandescence excited at points inside the tube: the brilliance and frequency of the light flashes diminish as the cleaning-up process is continued. Sparking between adjacent accelerator bands, at reduced voltage, is also performed. Since stray emission or bloom may reappear in a tube that has been handled in shipping, the users of such tubes should consider applying the above techniques. Fig. 3a shows a trace largely obscured by spurious illumination, and Fig. 3b shows the same trace after sparking has been applied. If sparking a tube is not completely successful in eliminating background illumination, the application of a negative (with respect to the second anode) dc voltage of about 50 to 300 v. on the first accelerator band is very effective.

Several changes were made in the basic K1032 electron-gun structure that was used as a starting point for the K1056 development. The size of the intensity-grid aperture was reduced, the focus anode was increased in length, and the spacing between the intensity grid and the preaccelerator portion of anode two was decreased. The combined effect of these changes was to produce a higher beam-current density and a smaller spot size.

Fig. 4: Dimensions of K1056 double-flared deflection plates



Deflection Plate Design

In addition to the box-plate design other variations in deflection-plate size and shape were tried, including different-sized plane-parallel, flared, and doubly flared plates. This last type was adopted for the K1056 design (Fig. 4) in view of its superior transit-time and frequency-response characteristics as well as its relative freedom from defocusing effects when the beam is deflected. For plane-parallel deflection plates the transit time of the "first kind" (i.e., through one pair of plates) can be measured by determining the period

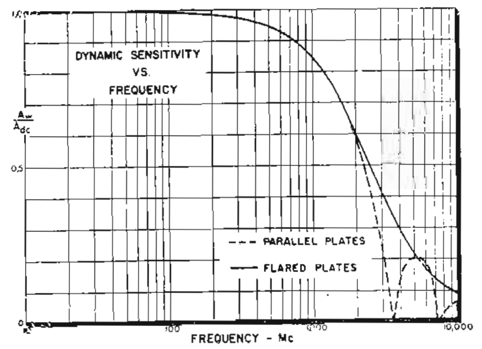


Fig. 5: Parallel and flared plates performance

of the lowest frequency signal that produces zero deflection of the beam.[2] This is shown by the dashed line in Fig. 5. The solid curve shows how the experimentally determined sensitivity of the K1056 tube varies with excitation frequency. There is no frequency at which the deflection falls to zero for the doubly flared plate structure. Hence, transit time of the "first kind" for the K1056 CRT has been taken as the period of the frequency at which the dynamic and static (dc) deflection factors are in the ratio of ε (2.718). The transit time thus defined through a set of plates is 2.8×10^{-10} seconds (corresponding to a frequency of 3,600 MC) with an anode-two potential of 7.5 kv. Transit time through a set of plates was actually determined by applying a fixed-frequency signal, varying the accelerating potential, and noting the potential at which the deflection (corrected for beam velocity) falls to $1/\varepsilon$ of the dcdeflection. The transit time for any beam voltage may then be obtained from the voltage-velocity relation for the electron.

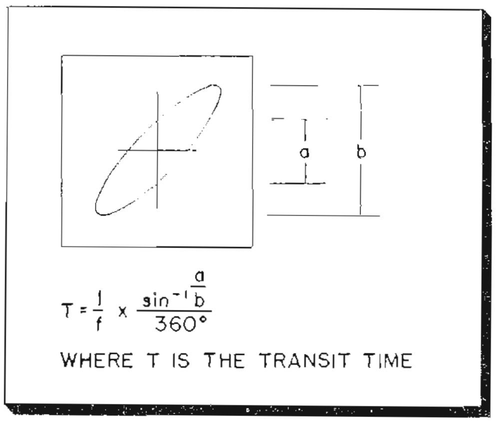


Fig. 6: Measuring transit time of "second kind"

Transit time between the two pairs of deflection plates (transit time of the "second kind") is an important consideration for CR tubes used in high-frequency or high-speed transient work. The centers of the two pairs of plates in the K1056 deflection structure are axially spaced ¾ in. apart, and a metal shield with a rectangular aperture is interposed between the two deflection-plate pairs to minimize cross-talk. Both by calculation and by measurement the transit time between sets of plates is $10.2 \times 10^{-10}/\sqrt{E_{KV}}$ sec., where E_{KV} is the second-anode voltage in kilovolts. This gives a value of 3.73×10^{-10} sec. at 7.5 kv. Fig. 6 shows the method used for measuring the transit time of the "second kind." Balanced in-phase 200-MC excitation was applied to both pairs of deflection plates, and a photograph of the resulting ellipse and its axes was made. The phase rotation between the two deflection fields is the angle whose sine is the axial distance across the ellipse divided by the total deflection parallel to that axis.

"Static" Tests

A finished K1056 tube is subjected to various "static" tests, including measurements of beam current, orthogonality deviation of the two deflection directions, visual-cutoff grid voltage, dc deflection factor, examination of cathode surface, and inspection for spurious electron emission, screen imperfections, and astigmatism. In addition, each tube was tested "dynamically" by operation in an oscilloscope set-up. A transient-voltage signal was applied to check for maximum writing-speed capability as well as the ability to display a trace involving a wide range of writing speeds.

The K1056 tube characteristics are given in Table 1. Operating without applying astigmatism voltages to the deflection-plate system is satisfactory for many purposes. However, to obtain minimum line width for highest resolution traces, the vertical-deflection plates should be at about −10 v., and the horizontal-deflection plates should be at about +100 v., both voltages being with respect to the nominal anode-two voltage.

Fig. 7a shows a photographic recording made with a K1056 tube displaying a 200-MC timing wave vertically and the rise of an electronic pulse-generator output horizontally. The spot speed varies from zero at the start of the sweep to 1,500 in./μ sec. near the end of the trace. The trace width varies from 0.018 in. at a spot speed of 50 in./μ sec. to 0.010 in. at a spot speed of 1,500 in./μ sec. Hence, the trace speed reckoned in trace widths per second varies from 2.78×10^{9} to 1.50×10^{14}. The sensibility of the tube lies in the range of 2 to 4 v. per trace width, the actual value depending on the spot speed at which the trace width is measured. Fig. 7b shows a recording of a magnetron output at 6,500 MC. The comparative ease with which such traces can be observed and/or recorded by use of the K1056 CRT should be of tremendous aid in the exploration of fast transient phenomena.

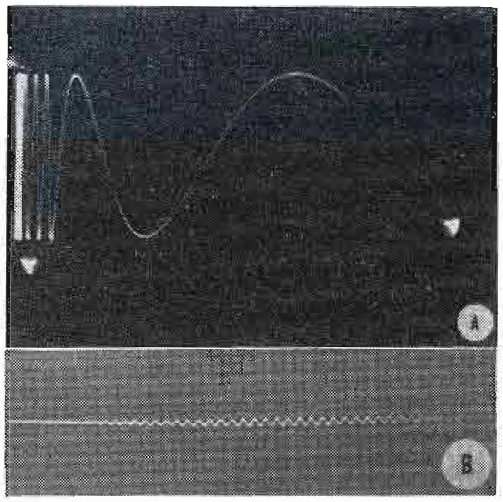


Fig. 7: K1056 cathode-ray displays when vertical deflection is (a) 200 MC, and (b) 6500 MC

In one sample of high spot velocity recording, the vertical deflection is furnished by a 6500-MC magnetron; the horizontal deflection is by means of a coaxial breakdown gap fired by the output of an electronic pulser. The spot velocity is about 7,000 in./μ sec. A spot velocity of 13,000 in./μ sec. is the highest recorded thus far with the K1056. This is well above the free-space velocity of light (12,000 in./μ sec.). The recorded rate of change of voltage from the 13,000 in./μ sec. is 3×10^{12} volts/sec.

The deflection linearity of the K1056 tube is shown in Fig. 8, a typical calibration raster.[3] The deflection-voltage increment between adjacent lines of the raster is 40 v. Maximum deflection nonlinearity occurs near maximum deflection, where the distortion is about 4%.

To judge the performance of a CRT, a figure of merit has been devised as follows:

$$FM = E/2DS$$

where FM is the figure of merit; E is the peak signal voltage available, equal to or less than the full-screen deflection voltage; D is the deflection factor in v./in.; and S is the spot size in inches. This figure of merit is numerically equal to the resolution of the tube display in terms of the trace width. Since the trace width varies with the trace speed, a choice must be made as to where to measure the trace width. For example, on the trace in Fig. 7a, if the width were taken at 50 in./μ sec., a somewhat low figure of merit would be obtained, since the line width at higher speeds may be reduced by a half. Nevertheless, on this basis, the average K1056 tube, having an average 0.019-in. line width at 50 in./μ sec., has a figure of merit of

$$FM = 940/(2 \times 235 \times 0.019) = 105$$

for full-screen (4-in.) deflection. The figure of merit for the highest speed portion of the trace (or the figure for any trace with a small range of speeds) would be 200 or more.

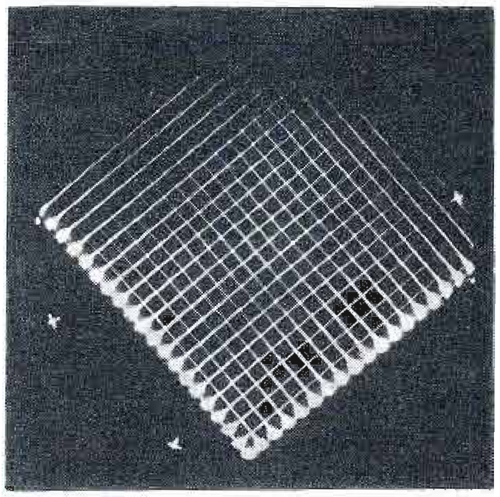


Fig. 8: Calibration raster measures linearity

Acknowledgments

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Practical Analysis of Vertical

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Nonlinear tubes and transformers prove eco- design produces more effective vertical output

THE commercial development of television has brought about a high degree of refinement in the design of many circuits which are fundamentally not at all unique. The vertical-deflection circuit, for example, is basically a power-output stage driven by a sawtooth voltage. This article will discuss the often overlooked fundamentals of vertical-deflection-circuit design. In addition, the operating principles of vertical-deflection circuits will be compared with those of more familiar power-output circuits, and an effort will be made to dispel some common misconceptions which have hindered a true understanding of their functioning.

Current-Waveform Requirements

The vertical-deflection circuit of a television receiver is required to send current through the deflecting coil in such a manner that the vertical deflection of the electron beam is suitable for use with a standard television signal. This current should be sawtooth in waveform; that is, the rate of change of current during the trace must be constant and the retrace must be quite fast. The blanking standards require that retrace be accomplished in less than 5% of the 1/60 sec. scanning cycle. Fig. 1 illustrates the desired current waveform, and also shows the voltage waveforms which appear across the deflecting coils when such a current is passed through them. Examination of the voltage waveforms indicates that some assumptions can be made to simplify the circuit analysis. The deflecting coils may be considered as a series resistance and inductance; for the initial analysis, the small amount of distributed capacitance in the coils may be neglected. Typical values of resistance and inductance for a modern deflecting yoke, RCA-211D1, are 47 ohms and 42 millihenries, respectively. The voltage across the resistive component, iR, is sawtooth in waveform and the voltage across the inductance, L(di/dt), is rectangular in waveform. During trace, approximately 16,000 microseconds, the inductive component of the voltage is much smaller than the resistive component. In this portion of the cycle, therefore, the vertical-deflecting coils appear to be essentially a resistance and the inductance may be neglected, at least in the first approximation. During retrace, however, the inductive component of the voltage is of the same order of magnitude as the resistive component and both must be considered. In view of these considerations, analysis of circuit operation can be simplified by examination of the trace and retrace portions of the scanning cycle separately.

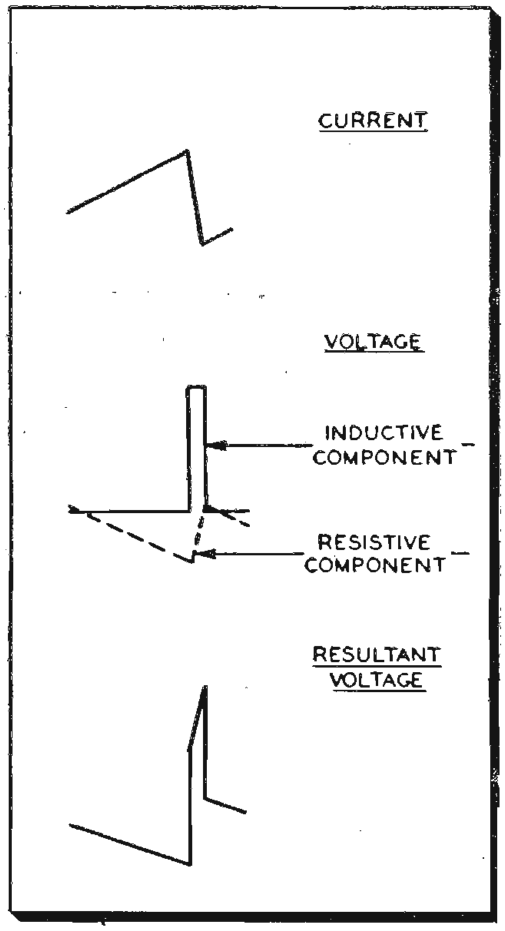


Fig. 1: Voltage and current waveforms in vertical deflecting coils (linear traces assumed)

Trace Portion of Cycle

Because the deflecting coils can be considered a resistance during trace, the deflection current may be produced, as in audio circuits, by a class A amplifier driven by a sawtooth grid voltage. Practical deflecting-yoke design requires that the current through the coils be relatively high and the voltage relatively low, or, in other words, that the coils have low impedance. It is expedient, therefore, to use a stepdown transformer from the amplifier tube to the yoke, a method which is again analagous to audio power-amplifier practice. A basic vertical-deflection output circuit suitable for use in analysis of the trace portion of the scanning cycle is shown in Fig. 2. A straightforward way to produce linear deflection is to minimize distortion in the circuit components by using a transformer having negligible distortion, a tube having good linearity of characteristics over its operating range, and a linear sawtooth grid signal. It will be shown, however, that some deviations from these ideal conditions often are required in practice. First, tube operation during trace will be considered with the assumptions that an ideal transformer is used to couple the tube to a resistive load and that the grid voltage is a linear sawtooth.

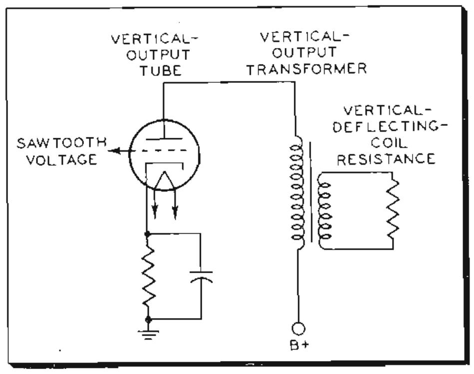


Fig. 2: Basic vertical deflection output circuit used in analysis of trace portion of cycle

Load Impedance

The choice of load impedance for the vertical-output tube is based on the same factors used in audio amplifiers, the major considerations being power output, efficiency, and distortion. A common erroneous assumption is that the load must be matched to the plate resistance, r_p, of the tube. The concept of a tube as a voltage generator with an internal impedance equal to its plate resistance may be useful after the load impedance has been determined if the tube operates in a linear portion of its characteristics. The output of a power amplifier, however, is

Deflection Circuits

nomically expedient. Proper circuit with adequate damping and peaking

limited by distortion caused when the tube is operated in the region of non-linear characteristics, and the characteristic curves of the tube should be used to determine the load impedance. Triodes have been used most commonly as vertical-deflection output tubes in this country because of their inherently good linearity of characteristics and because of other reasons which will be mentioned later. In addition, these amplifier tubes have been operated class A_1 because of the economy and convenience of generating the grid signal in high-impedance circuits.

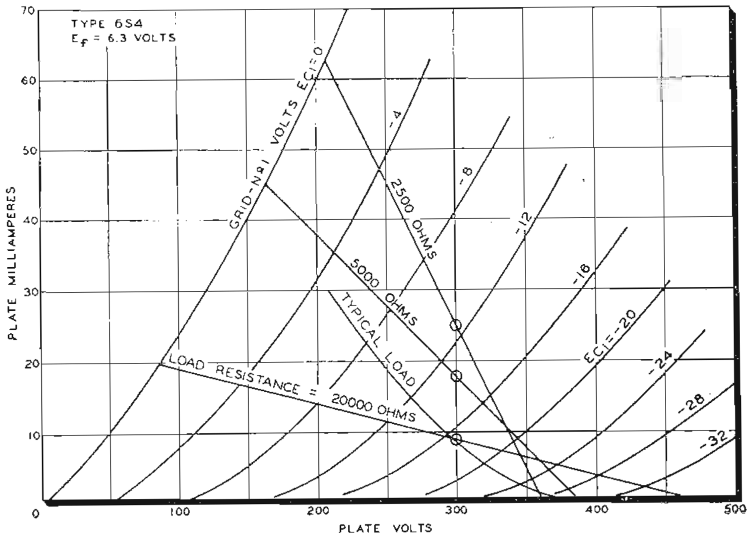


Fig. 3: 6S4 plate characteristics. "Typical load line" is for 6000-ohm resistance in parallel with a 60-henry inductance and a sawtooth current of 30 ma peak-to-peak in the resistance. Three other resistance load lines also shown

Plate Characteristics

Some effects of the choice of load impedance can be examined with the aid of Fig. 3, which shows the plate characteristics of type 6S4 and three load lines. A plate voltage of 300 volts is assumed and load lines are drawn for load resistances of 2500, 5000, and 20,000 ohms. The operating bias, indicated by a circle on each load line, was selected by inspection of the curves so that approximately equal grid-voltage swing above and below the operating point would reach zero bias and cutoff respectively. The value of load impedance has a relatively small effect on power output (picture height), but has a considerable effect on power input, plate dissipation, and plate efficiency. It is good design practice to select the output-transformer ratio giving a load impedance which permits adequate picture height with maximum efficiency and minimum tube dissipation rather than to seek the ratio which provides the most output. The choice of load resistance, therefore, may depend more upon the B voltage and the deflection power required than upon the tube type used for vertical output. Of course, some reserve deflection must be allowed so that variations in line voltage, tubes, and components can be accommodated and the tube is not driven to zero bias under normal operating conditions.

Choice of Tube Type

The maximum theoretical efficiency of an amplifier delivering a sawtooth current waveform into a resistive load is 33⅓%, as compared to 50% for a sine wave and 100% for a rectangular wave. A necessary condition for obtaining plate efficiency approaching the maximum theoretical efficiency with any power amplifier is that the minimum plate voltage, at zero bias on the appropriate load line, should be a relatively small fraction of the plate supply voltage. Good efficiency is most easily obtained, therefore, with high plate supply voltages. The 6S4, for example, has been used in commercial circuits having an ample reserve of deflection with better than 20% plate efficiency from a 500-volt plate supply. The 6S4 is well suited for such an application because its relatively high mu makes it easy to drive and because it requires only a small part of the B supply voltage for cathode bias. If a 300-volt supply were used for the 6S4, the efficiency would be much lower and output adequate for most modern deflection requirements would be impossible to obtain. The output which must be supplied to the vertical-deflecting coils to scan kinescopes having deflection angles of 66° to 70° and operating at anode voltages of 14 to 16 kv is in the order of one watt. For applications in which plate-supply voltages are relatively low, better efficiency is obtained with other high-transconductance tubes having lower mu, such as the 6AQ5 triode-connected. A triode-connected 25L6-GT or 6W6-GT will provide even more output if the application permits operation within tube ratings.

Output Tube

Because high plate current at low plate voltage is required for vertical deflection in receivers having a low B voltage, it may seem that a pentode would be better than a triode for the output tube. Pentodes do have the advantage of being capable of higher efficiency, but most designers have avoided their use because the value of load impedance is more critical and the attainment of proper deflection linearity requires special design considerations, as will be discussed in the next section.

Up to this point, it has been assumed that an ideal vertical-output transformer is used in the circuit of Fig. 2. Actually, transformers depart from the ideal in many respects. The chief difficulty encountered in the design of vertical-output transformers is that of making the primary impedance high enough so that it has no appreciable effect on the circuit. A transformer with such hight primary impedance would have disadvantages with respect to size, weight,

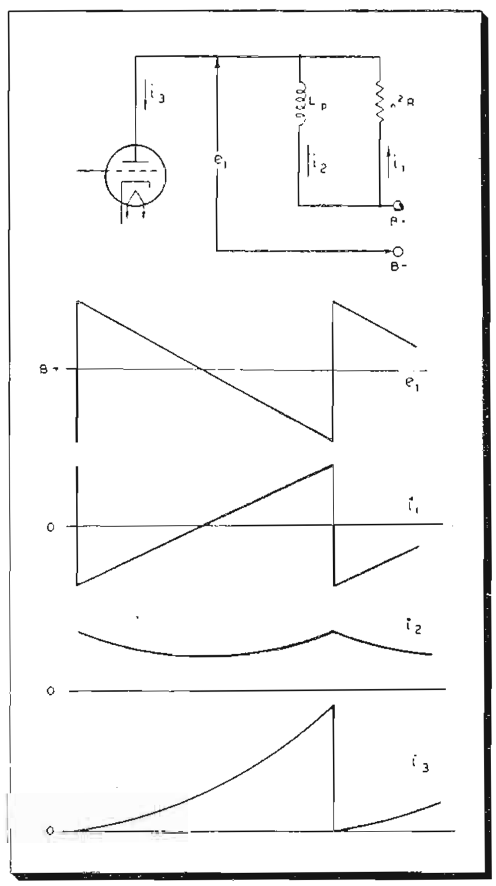


Fig. 4: Equivalent circuit for vertical deflection output; voltage and current waveforms

VERTICAL DEFLECTION (Continued)

and cost, and would also cause an undesirable increase in leakage reactance and distributed capacitance.

Leakage Reactance

The leakage reactance of commercial transformers currently in use

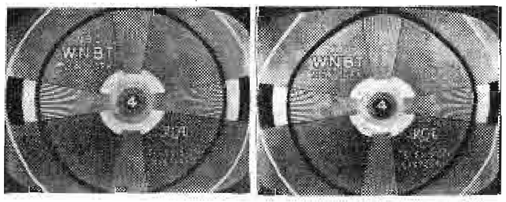


Fig. 5: (a) Normal test pattern at left. (b) Nonlinear patern resulting from reducing primary inductances of vertical output transformer

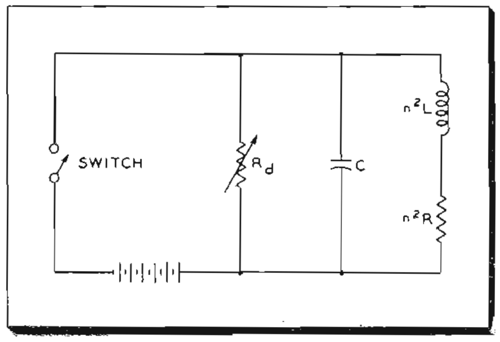


Fig. 6: Approximate equivalent for vertical output circuit during retrace part of cycle

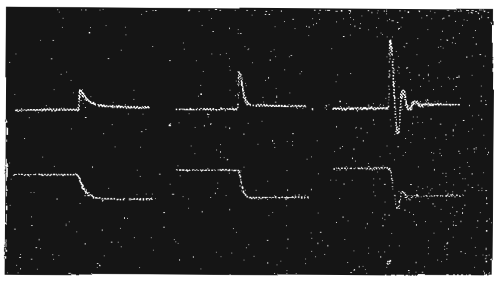


Fig. 7: Transient voltage (top) across capacitor C, and current (bottom) through inductance n^2L, switch open in Fig. 6 (a—left) Overdamped, R_d small; (b—center) R_d adjusted for critical damping; (c—right) R_d large, oscillatory

can usually be neglected; the primary inductance, however, should be considered. These transformers can be represented with reasonable approximation by the equivalent circuit shown in Fig. 4. In this circuit, retrace is still disregarded, and the deflecting coils are represented by the resistance n^2R, where n is the transformer ratio and R is the resistance of the coils. The current waveform through the deflecting coils, i_1, is a sawtooth as indicated. The voltage across the resistance, e_1, must also be a sawtooth. If the primary inductance of the transformer is assumed to be linear (that is, if the effect of the iron core which causes the inductance to be somewhat dependent upon the current is neglected), the current through the inductance, i_2 is of the waveshape shown in Fig. 4. This waveform is, mathematically, the sum of a section of a parabola and a straight line having a negative slope. The plate current of the tube, i_3, is the sum of the currents i_1, and i_2, and, with the ratio of R to L_p found in most commercial transformers, the waveform is nearly parabolic as shown. If numerical calculations are made, a typical load line can be constructed on tube characteristic curves. Such a construction has been made on Fig. 3 (typical load line) for the voltage and current waveforms of Fig. 4. The near-parabolic current waveform, i_3, can be obtained either by driving the tube with a similar grid voltage waveform or by having some nonlinearity in its plate characteristics. The characteristic curves of Fig. 3 show that the 6S4 has such non-linearity of characteristics. This type of nonlinearity, which is inherent in triodes, permits the use of a nearly-linear grid signal to produce the plate current waveform required by an economical transformer. The nonlinearity of characteristics is sometimes deliberately accentuated in the design of vertical output tubes. A tube having more linear characteristics could be used with a properly shaped grid signal, but the circuitry required to produce such a grid signal is cumbersome and costly, at least at the present state of the art. We mentioned previously that the most straightforward way to obtain linear deflection is to avoid distortion in each part of the circuit; however, the use of nonlinear tubes and transformers having complementary characteristics which provide linear deflection has proved economically expedient in commercial receivers. In addition to the economies in tube and transformer, a more detailed analysis shows that the addition of a suitable inductance in parallel with the load resistance increases the theoretical plate efficiency from 33⅓% to as high as 50% when the ratio of R/L_p is equal to 120.

Optimum Deflection Linearity

For the best deflection linearity, the tube and transformer must be designed to complement each other. Variation in either can be at least partially compensated by adjustment of bias on the vertical-output tube. This bias adjustment is usually made by means of a variable cathode resistor—the "vertical-linearity control." Only a certain amount of compensation is possible, however, and objectionable distortion can result from improper pairing of the tube and transformer. Fig. 5a is a photograph of a test pattern illustrating the good linearity produced with typical commercial deflection components (6S4 tube, RCA-226T1 vertical-output transformer, and RCA-211D1 deflecting yoke). Fig. 5b shows the impaired linearity which resulted in the same circuit by reducing the primary inductance of the transformer to about 55% of the original value. Considerable adjustments of the height and vertical-linearity controls were necessary to make the linearity even as good as that of Fig. 5b. No adjustment of the controls, however, could produce satisfactory linearity.

Because of its nonlinear characteristics, a triode tends to stretch the bottom of the picture, which is coincident with maximum plate current, and thereby to correct for the

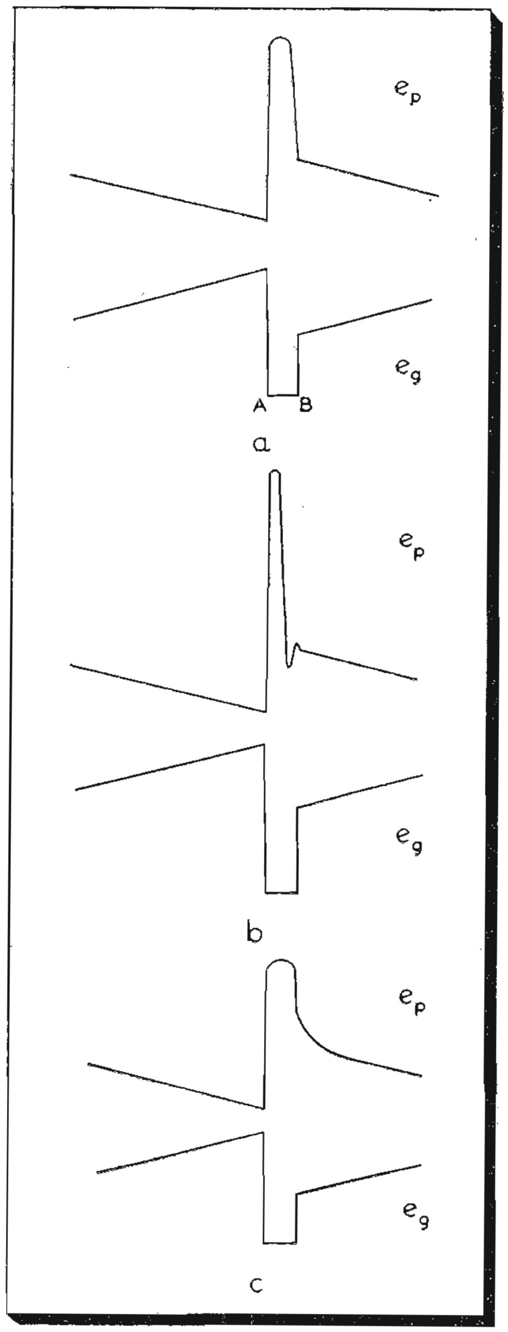


Fig. 8: Vertical output tube voltages. (a) Correct peaking; (b) too much; (c) too little

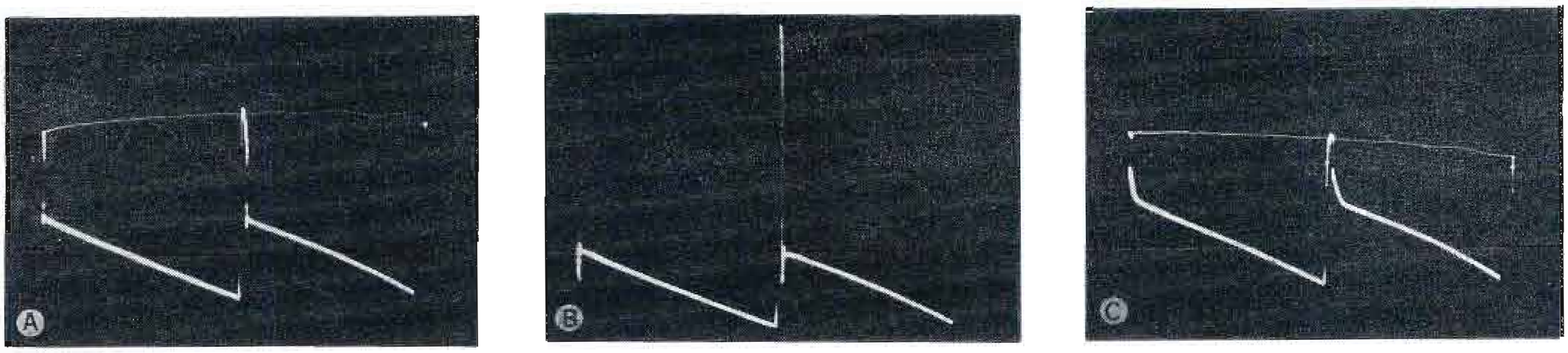


Fig. 9: Actual plate voltage waveforms for the vertical output tube illustrating the conditions of Fig. 8

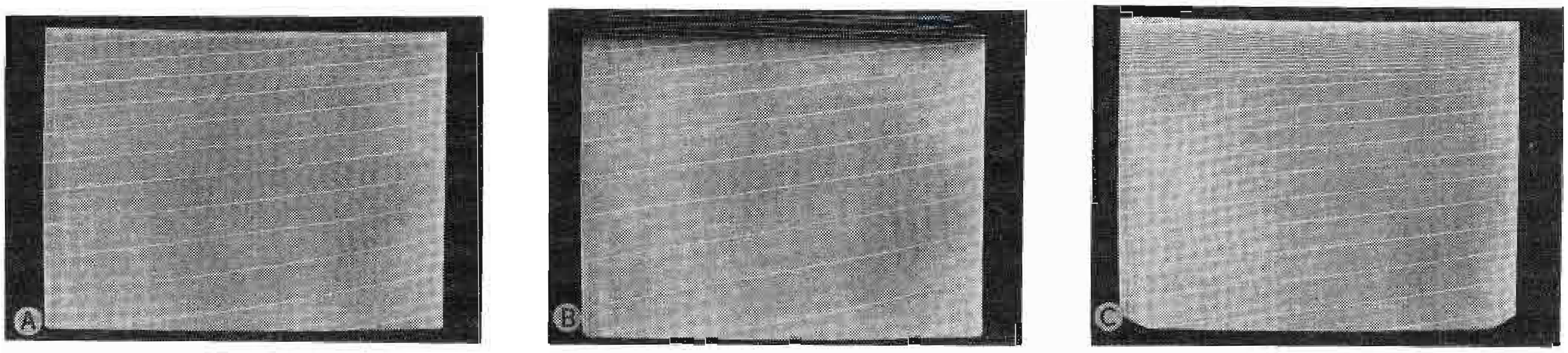


Fig. 10: Peaking effect on raster retrace. (a) Correct peaking; (b) too much, linearity disturbance at top; (c) too little peaking, excessive retrace time

effect of the transformer primary inductance. Pentodes can be used in a similar manner, provided the load impedance is chosen so that the load line does not approach the "knee" of the tube plate characteristics. Neither tube type has a clear-cut advantage in such operation, as evidenced by the fact that triodes have been more popular in this country while pentodes have been used extensively in Europe. Operation of pentodes in this manner, however, does not take advantage of their high-efficiency capabilities. If the high efficiency of the pentode is required, the grid-signal waveform must be modified and a suitable load resistance chosen. Degenerative feedback circuits provide a practical means of modifying the grid signal. In such circuits, the increase in driving signal required by feedback is compensated for by the high power sensitivity of pentodes. Approximately the same amplitude of grid signal is required, therefore, with either triodes or pentodes.

Cathode Bias

It was mentioned earlier that cathode-resistor bias is ordinarily used for the vertical-output tube even though some power output is sacrificed because of the reduction in effective plate voltage. An important reason for the use of cathode bias is that large values of grid resistors are necessitated by the high-impedance driving circuits and by practical values of coupling capacitors. Reverse grid current from gas or grid emission in the amplifier tube may cause a significant reduction in effective grid bias when a large value of grid resistance is used, and cathode-resistor bias is required to minimize the possibility of excessive plate current.

Retrace Portion of Cycle

The retrace portion of the scanning cycle is probably best explained in terms of transient phenomena. A complete discussion of transients would require treatment of differential equations, but adequate familiarity with the subject can be obtained through consideration of some voltage and current waveforms and a brief explanation of what happens. The circuit of Fig. 6 is an approximate equivalent circuit for a vertical-deflection circuit; R and L are the resistance and inductance of the vertical deflecting coils, n is the transformer ratio of primary to secondary turns, C is the distributed capacitance of the transformer and yoke, and R_d is an external damping resistor. Fig. 7 shows a series of oscillograms of voltage and current waveforms obtained with the three different values of R_d when the switch is opened in such a circuit. This circuit could be made a more nearly exact equivalent if the equivalent resistance of the transformer windings were included in the value R. In a well designed transformer, the resistance of the windings is about 20% of the yoke resistance. Larger values of transformer-winding resistance usually cause an objectionable reduction in transformer efficiency.

Commerical vertical-deflection circuits include such values of R, L, and C (Fig. 6) that, without external damping, the oscillatory transient condition is encountered. Circuit resistance, however, is such that the oscillations die out after a few cycles. Such oscillations can be objectionable because they may continue beyound the blanking period and upset the deflection linearity at the top of the picture. Furthermore, the "frequency" of oscillation is quite high compared to the vertical scanning frequency, and the high peak voltages developed may cause arcing in the transformer, tube, and socket. Commercial practice has been to damp the circuit in such a way that the retrace time is lengthened and the oscillations are not permitted. It should be noted, however, that the resistors which are commonly placed across each vertical deflecting coil are primarily for the elimination of another undesired effect in the yoke, and additional damping is required for the purpose discussed above.

Pentode Output Tube

When a pentode output tube is used, it operates very much like the switch in Fig. 6. When the tube is cut off at the end of the trace, it remains substantially cut off during retrace despite the high plate voltage developed because the plate current of a pentode is relatively independent of the plate voltage. Damping is usually accomplished through the use of a series resistor and capacitor across the primary of the vertical output transformer. The capacitor contributes both to increased retrace time and to reduced loading due to the resistor during the trace portion of the cycle. The value of resistance is chosen so that there are no oscillations but the retrace time is not excessively long. The values of these components are selected empirically.

Vertical Output for Damping

When a triode output tube is used, the tube plate current is usually controlled during retrace in such a manner that the tube does the damping. The use of the tube rather than fixed components for damping has some minor advantages. First, the damping "resistance" is present only during retrace and no power is wasted in a damping resistor. Second, the value of the effective damping resistance can be varied during retrace and the value of peak voltage developed can be kept smaller for a given retrace time than if fixed components were used.

The action of the tube in damping the circuit may be explained with the aid of the grid-voltage and plate-voltage waveforms shown in Fig. 8. The grid-voltage waveform for a triode output tube cannot be a simple sawtooth because the high plate voltage developed during retrace would cause considerable tube conduction and the excessive damping would cause long retrace time. During retrace, when the plate voltage is high, it is necessary to add a negative pulse, the "'peaking" pulse, to the grid voltage to keep the tube near cutoff. Fig. 8a shows the waveform, e_g, of the sawtooth grid voltage with the peaking pluse added.

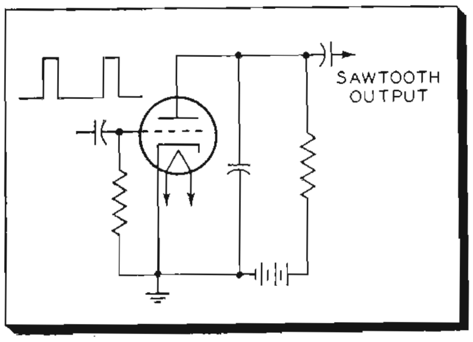


Fig. 11: Discharge-tube circuit for the generation of a sawtooth voltage waveform

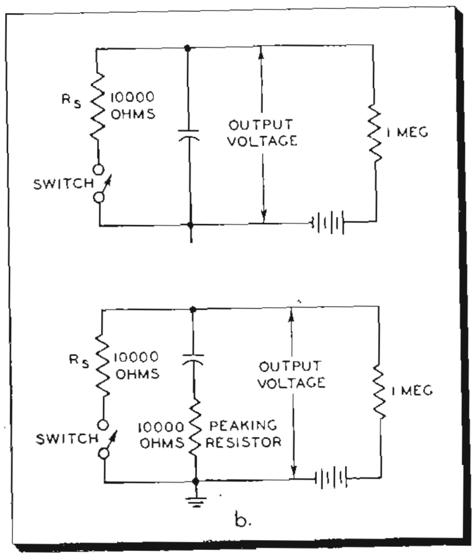


Fig. 12: Equivalents for Fig. 11. (a) Simple discharge circuit; (b) with peaking resistor

In Fig. 8a, the trace ends at the point indicated A. At this point, which corresponds to the bottom of the picture, the plate voltage is low and the grid voltage is at its highest value. The application of a high negative grid voltage practically cuts off the plate current and thus causes the transient condition of rapidly decreasing current in the deflecting coils and a resultant high value of plate voltage. The plate voltage might rise to a value of 3000 volts or more, but the peaking amplitude is adjusted so that at some lower value—say 1500 volts—appreciable plate current flows, damping the circuit or slowing the rate of change of current in the deflecting coils. As the deflecting-coil current decreases, the plate voltage drops to a lower value at the point indicated B. The peaking pulse should end at point B to coincide with the end of retrace as shown in Fig. 8a. When the trace begins again at B, the grid and plate voltages are at the approximate values indicated by the analysis used earlier in this article, in which the deflecting coils were assumed to be a resistance and retrace was disregarded. The effective damping resistance can be varied during retrace by suitable control of the waveform of the peaking pulse.

Action During Retrace

One point should be emphasized in this discussion; the vertical output tube does not act like a conventional voltage amplifier during retrace even though its grid-voltage and plate-voltage waveforms may be similar. The departure from amplifier action is more obvious when the circuit performance with incorrect adjustments of the peaking amplitude is examined.

Fig. 8b illustrates the effect of too large a peaking pulse. Because of the large negative grid voltage during retrace, there is little damping by the tube. Retrace is completed

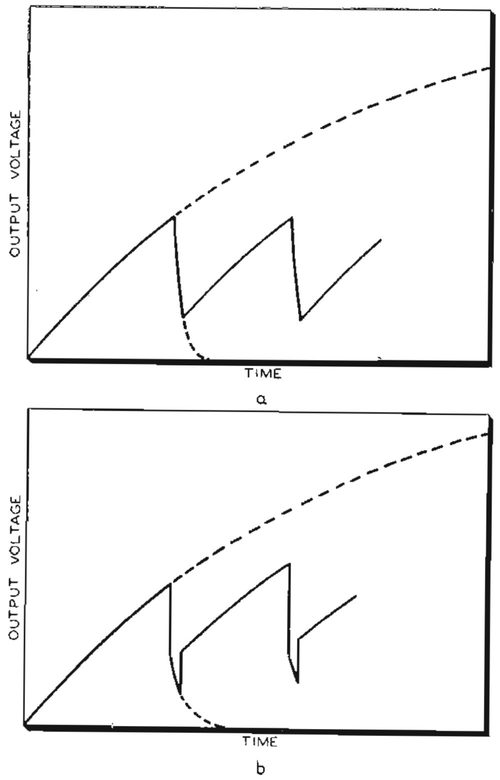


Fig. 13: (a) Sawtooth formed with circuit of Fig. 12a; (b) voltage with peaking, Fig. 12b

rapidly and the current in the "under-damped" circuit continues to oscillate while the tube is cut off. When the peaking pulse ends, the oscillations are damped out quickly by the tube. The disadvantages of too much peaking are the higher peak voltages developed and the linearity disturbance at the top of the picture.

Fig. 8c illustrates the effect of too small a peaking pulse. The relatively small negative grid voltage during retrace causes the tube to damp the circuit excessively. In fact, the peaking pulse ends before the retrace is completed and the resultant increase in damping causes a further increase in retrace time. Insufficient peaking may cause foldover at the top of the picture because of the long retrace time.

For the sake of clarity the retrace time was shown disproportionately large in the waveforms of Fig. 8. Actual plate-voltage waveforms observed in a practical vertical deflection circuit with corresponding adjustments of peaking amplitude are shown in Fig. 9.

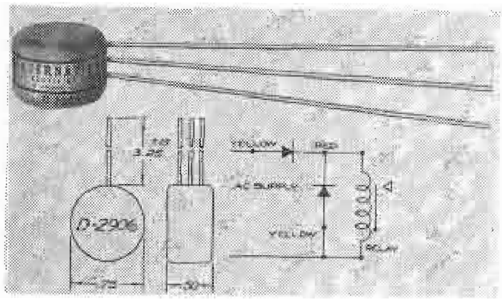
The adjustment of peaking amplitude may also be made with the aid of observation of vertical-retrace lines in the raster. The raster must be de-centered on the kinescope so that the top of the raster is visible. Because the adjustments of height, vertical linearity, vertical frequency, and peaking are interdependent, the adjustment of peaking should be made with normal picture height and linearity, and with the picture synchronized. Fig. 10 shows three photographs of synchronized,

(*Continued on page* 88)

NEW EQUIPMENT for Designers and Engineers

Relay Rectifier-Suppressor

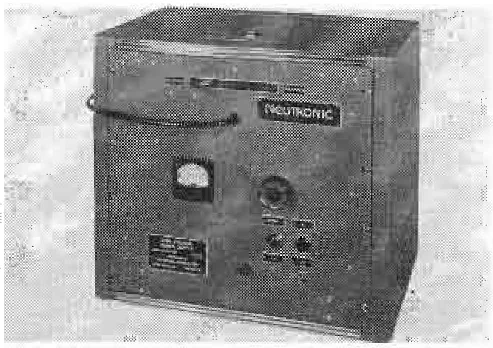
Type D-2906 rectifier suppressor for use with dc relays is encapsulated within a thermosetting plastic material



which offers complete protection from moisture, fungus, salt spray, and corrosive vapors. The unit has two elements: one provides half-wave rectification of the ac input, the other provides a path for current resulting from the collapse of the relay coil magnetic field during the non-conducting half-cycle. The unit is rated 48 v. max. input and 5 µa output at 100° C. It is provided with three pigtails, and measure ¾ in. in dia. and is 1 in. long.—**International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

RF Power Supplies

Two new regulated and two new unregulated bench-type high-voltage rf power supplies, models R-22C, R-22CR,



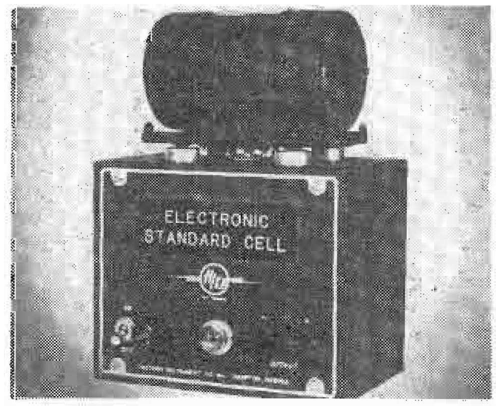
R-22M, and 22MR, are unusual in that they can be reversed in polarity by a front panel lever. A further advantage is that they provide both positive and negative output from a single power supply. The R-22 shown is rated 5-30 kv, 2 µa at 18 kv, regulated to 0.5%.—**Neutronic Associates, 83-56 Vietor Ave., Elmhurst 73, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Volt-Ohm-Microammeter

Model 269 volt-ohm-microammeter has an ultra-sensitivity of 100,000 ohms per volt. Each of its 33 ranges has been "customized" to meet the needs of the electronic and electrical industries. Its measurement accuracy is 3% dc and 5% ac of full scale deflection. To save time and assure accuracy, the model 269 makes use of only a setting range control and an ohms adjustment control. A pair of removable alligator clips and a 4,000 v. dc probe extension are furnished. Encased in a molded bakelite case, the unit is 6 in. long, 2$^{15}/_{16}$ in. deep, and 7$^{15}/_{16}$ in. wide.—**Simpson Electric Co., 5200 W. Kinzie Street, Chicago 44, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Electronic Standard Cell

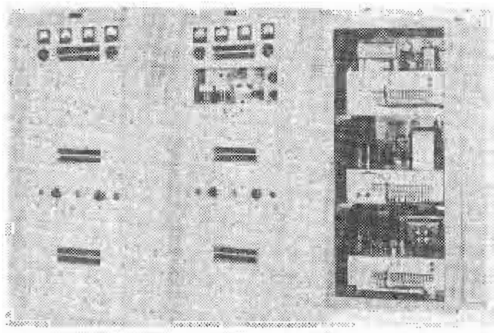
An electronic standard cell which furnishes a stable power supply from a 28 v. dc input has less than ±0.15% change in output when used intermittently; and when used continuously, shows less than 0.1% total output change. Its ac ripple is less than 1 mv, therefore, the cell can be used with all types of recording oscillographs; and it will meet the requirements of other applications that require a stable output in the ranges 0—100 v and 0—30



ma. The unit is well adapted to laboratory use, but it is small enough to use as a built-in power supply for larger instruments.—**Hastings Instrument Co., Inc., Hampton, Va.**—TELE-TECH & ELECTRONIC INDUSTRIES

Standby Transmitter

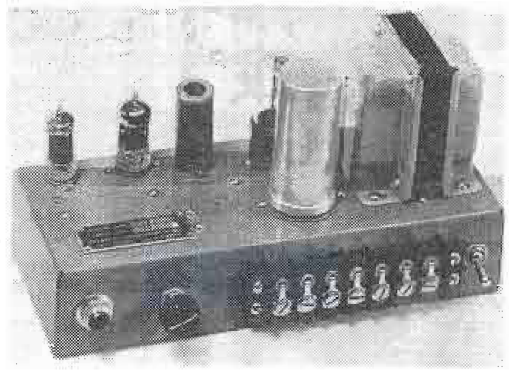
General characteristics of the BCA 250-watt standby transmitter, which is expected to find wide use in AM stations because of its low cost and com-



pactness, are: frequency range, 540-1700 KC; noise, equal to or greater than -40 db below 100% modulation; distortion, equal to or less than 5% from 150-5000 CPS, 0-100% modulation; response, equal to or less than ± 2db from 150-5000 CPS, from zero to 100% modulation; R-F load, will match loads from 30-300 ohms. Frequency and load specified by customer. Second harmonic is lower than 40 db below fundamental. Cabinet size is 50 in. high, 23 in. wide, 26 in. deep. Primary power for the transmitter requires 1400 va at 115 v, single phase, 60 CPS for average program leads.—**Gates Radio Co., Quincy, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Electronic Thermostat

The electronic thermostat shown was designed to control the Kay-Lab Logaten at 100°F. within 0.2°. A Western



Electric type 7A thermistor with a nominal 500 ohm resistance at 100°F., built into the Logaten, comprises the sensing element. Three 500 ohm arms, with one adjustable ±50 ohms, enable exact temperature adjustment. Normally 1 mv. of unbalance signal applied to the phase-sensitive amplifier input operates the relay of the system. In operation, the bridge is driven by a 4 v. winding and the relay applies 6 v. at 0.5 amp. to the heater.—**Kalbfell Laboratories, Inc., 1090 Morena Blvd., San Diego 10, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

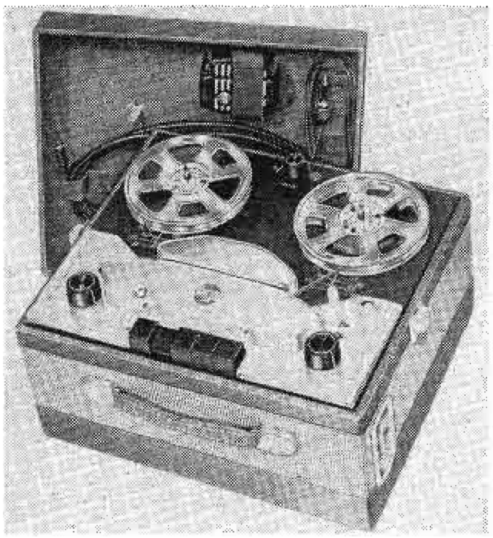
Portable Galvanometer

According to GE engineers, alnico magnets used in a redesigned line of high-sensitivity galvanometers give a field of more than twice the strength that was obtainable with chrome steel magnets used before. The instruments are designed so that the entire coil and suspension element can be removed from the magnetic assembly and replaced by a different sensitivity system without disturbing the external connections or remagnetizing. The galvanometer element and optical system are in a light-weight, shock-mounted metal case that is approximately 6½ x 8 x 16 in. The instrument scale, tilted 15° for the convenience of a standing user, is marked 50-0-50 and 0-100 in 1 mm divisions. The zero ad-

justing knob enables rolling back the hairline to give an effective scale of 280 mm.—**General Electric Co., Schenectady 5, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Tape Recorder

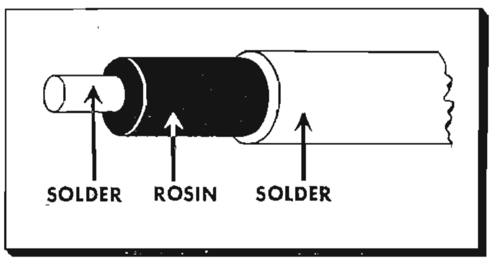
A new portable tape recorder weighs 25 lbs. and is packaged in a 14 x 12 x 9 in. aviation type luggage case. Using any size reel up to 7 in., the dual-speed ma-



chine records or plays back for two hours max., and rewinds in approx. 2¾ min. Tape threading takes only a few seconds. The recorder is operated by pushbutton controls and has a jack with which to attach a phonograph, radio receiver, public address system. The unit has a 4-tube built-in amplifier. Its external speaker impedance is 3.2 ohms, and it operates 105 to 125 v., 60 CPS, ac current.—**RCA Victor Div. Radio Corp. of America, Camden, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Rosin-filled Solder

The new sequence-action, rosin-filled solder is a solder wire coated with rosin over which the outer solder-sleeve is formed, thereby eliminating the pos-



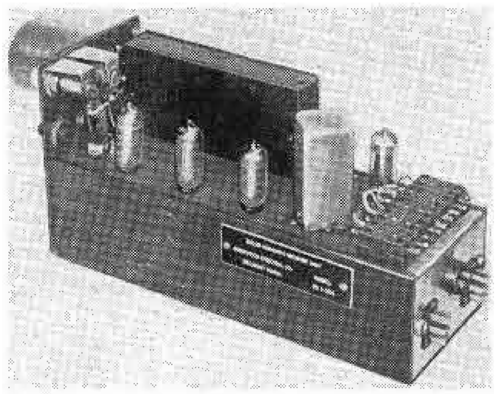
sibility of a rosin void. The energized rosin flux in "Cen-Tri-Core" flows ahead of the molten solder and reduces waste. The new construction is non-corrosive and electrically non-conductive. Beyond its conformity to Federal Spec QQS-571b, Par. E-2a, the new product has withstood 250 v dc cycled humidity at high temperatures for 42 days without evidence of corrosion or rosin breakdown. "Cen-Tri-Cor" is available in all alloys, diameters, and flux core percentages.—**Alpha Metals, Inc., 56 Waters St., P. O. Box 34, Bergen Sta., Jersey City 4, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Molded Tubular Capacitor

A highly moisture-resistant, tubular molded-paper capacitor uses a new molding compound ("Humiditite") and a new stable impregnant that provides additional strength and holds the unit to rated capacity. It is said to be the only capacitor to have the molded tubular construction that can meet the minimum requirements of NIL-C91A (Proposed). Engineering data sheet TEL contains additional information.—**Sangamo Electric Co., Marion, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Memory Unit

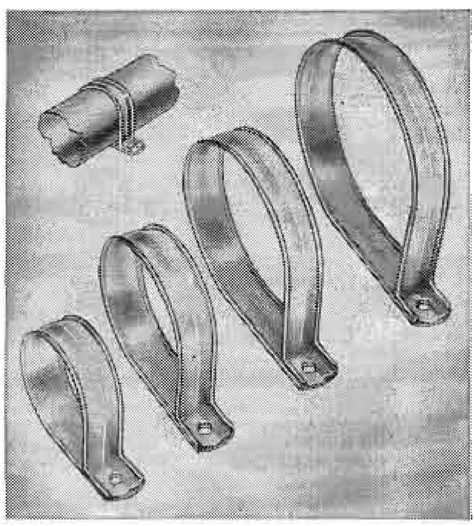
Model 3C1-384 includes a solid acoustic delay line and the entire memory circuit packaged in one plug-in type chassis ready for installation in a com-



puter. The unit stores 384 bits at a pulse rate of 1 mc. All five germanium diodes are grouped in a plug-in type sub-unit. Input voltage in write-erase gate is 10 v. The reshaped output signal level is 15 v in a 100 ohm impedance load. All circuits are degenerated, with reserve gain in the wide band if amplifier. Tuning is unnecessary. Temperature coefficient of the quartz delay line is-123 parts per million per degree C. —**Computer Control Company, 106 Concord Ave., Belmont 78, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

Cable Clips

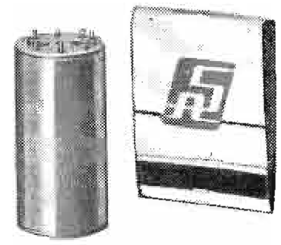
Type 7R "Etholoc" plastic cable clips are made wider and heavier to hold cable or wire from 1½ in. through 3 in.



diameters in such electrical components as batteries, capacitors, etc. The clips are fabricated from "Ethocel," a tough, ethyl cellulose material made by Dow Chemical Co. Information concerning the electrical properties of the clips is available.—**Weckesser Co., 5261 N. Avondale Ave., Chicago 30, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Subminiature Rate Gyroscope

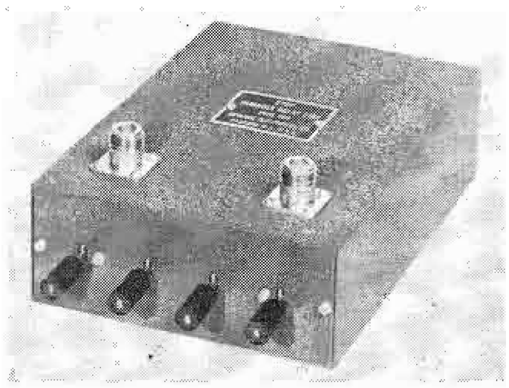
Model 7 subminiature rate gyroscope is 1 in. in dia., less than 2 in. long, and weighs 3 oz. The maximum linear output of the hermetically-sealed and temperature-compensated unit occurs at an input of 420° per sec. and its out-



put resolution is better than 0.05° per sec. Its sensitivity is 14 mv output per degree per sec. The rotor speed is 24,000 rpm requiring 6.3 v 400 cps, 3 w. With an ac output, the gyro is applicable to aircraft instruments, guided missiles, radar antenna stabilization, and fire control system.—**Sanders Associates, Inc., 137 Canal St., Nashua, N.H.** —TELE-TECH & ELECTRONIC INDUSTRIES

Step Variable Delay Line

Type 702 step variable delay line produces variable time delay up to 10 μsec and has an equal input and output im-



pedance. The line consists of 55 sections of lump-parameter L-C filter networks, each of which is designed to give linear phase-shift to 70% of cutoff frequency, and a Gausian shape response curve. As a result, the unit produces an essentially zero over-shoot and has a very rapid rise time. The in step time delay is variable from 1 to 10 μsec. Characteristic impedance is 190 ohms nominal input and output. Rise time is less than 0.45 μsec per step. Cutoff frequency is 1.27 MC; max. applied voltage is 500 v. peak. Its dimensions are 2 x 5½ x 8 in.—**Advance Electronics Co., P. O. Box 394, Passaic, N.J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Modification Kit

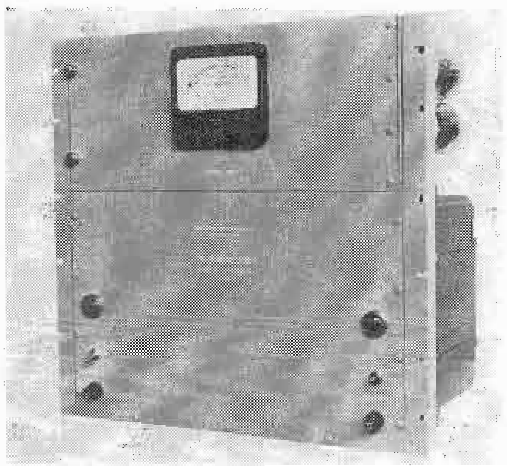
A new modification kit includes circuits that are necessary to change the NTSC signal to the 3.58 MCIQ specification. It is comprised of delay circuits, matrix units for I′, and Q′, and Y phase-corrected band-width limiting, and rematrix circuits for use with Telechrome Model 609-AR Encoder or Colorplexer.—**Telechrome, Inc., 84 Merrick Rd., Amityville, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

FM Signal Generator

The FM signal generator 100C, represents a new departure in signal generator design. A novel circuit with a single tube is used in the rf compartment instead of the usual three or four. As no reactance is used, drift, which otherwise might result from variations in transconductance, is minimized. Since no mixing or multiplication is used, and the oscillator frequency is the output frequency, there are very few low spurious out puts. Low modulation distortion, low A-M, and low hum are also consequent results. Leakage is minimized by a heavy, silver-plated, cast bronze cavity to enclose the rf compartment. A single tuning range covers the 25-216 MC range. An incremental dial permits precise carrier change.—**New London Instrument Co., New London, Conn.**—TELE-TECH & ELECTRONIC INDUSTRIES

Variable Frequency Power Supply

Model D-50 variable frequency power supply is capable of supplying 500 watts power at 115 v. ac. A level control adjusts output voltage from 0 to 125 v. ac. Frequency can be supplied by a tuning fork, or by a variable frequency audio oscillator capable of supplying 3 v. RMS. The unit can be employed for continuous duty cycles, or for applications such as servo-spin tables, or "G" tables. All circuitry and the level control are accessible via the hinged top panel.—**International Research Assoc., Div. of Iresco, Inc., 2221 Warwick Ave., Santa Monica, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

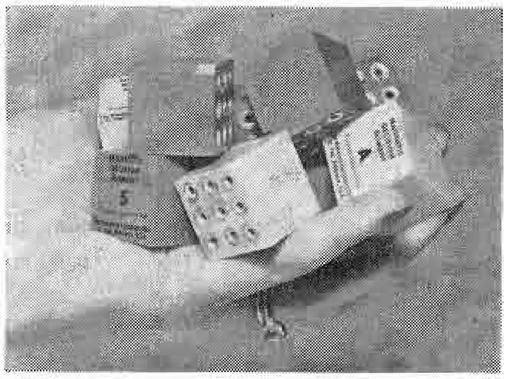


Pulse Transformers

A new line of miniaturized pulse transformers for blocking oscillator applications suitable for commercial and government equipments are available in three styles: a plug-in octal base construction; a hermetically sealed MIL-T-27 construction; and, an encapsulated version with a built-in solder seal for chassis mounting.—**Raytheon Manufacturing Co., Waltham 54, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

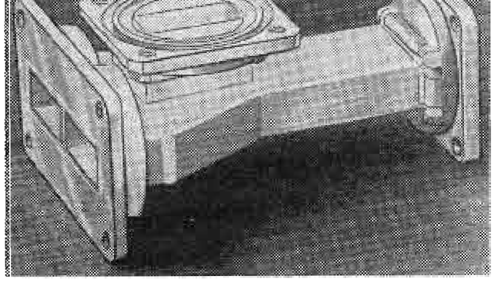
Magnetic Decision Elements

Two new building blocks, termed "S" and "A," occupy only one cu. in., nevertheless, they are completely basic, flexible elements with which it is possible to build the entire arithmetic, program, control, and memory sections of any digital computor. This whether it is a serial or parallel system, or whether the computer is a simple flip-flop or binary, a large-scale general purpose instrument, or a digital differential analyzer. Magnetic Decision Elements contain no electron tubes or transistors. Synchronization and power drive is derived from a central 200 CPS, two phase, clock pulse generator. The information flow rate is 100 CPS. Static storage in each element makes it possible to switch off power completely and retain all information indefinitely, including the operations of dynamic arithmetic. Therefore, the "S" and "A" elements can be used as the complete foundation for digital computing systems.—**The Minnesota Electronics Corp., St. Paul 1, Minn.**—TELE-TECH & ELECTRONIC INDUSTRIES



Folded Hybrid

A new folded hybrid that can be used in balanced mixer applications has the following properties in a frequency range from 8,500 to 9,600 MC; VSWR into either arm is less than 1.2; isolation is greater than 40 db; power split better than 0.05 db. A series of new plumbing resigns are in course to enable use of the new folded hybrid in duplexer circuits.—**Airtron, Inc., East Elizabeth Ave., Linden, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

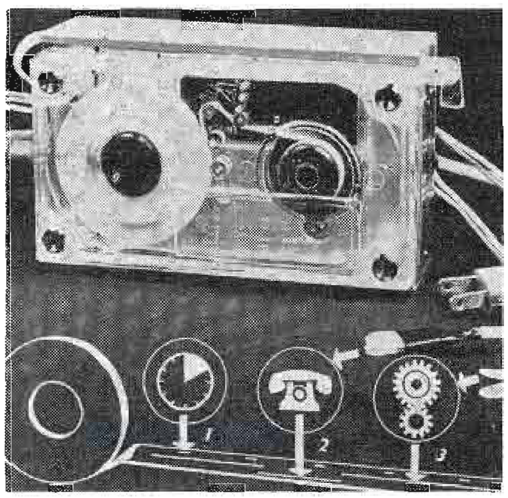


Mobile Power Generator

A new light and power generator is driven by a 2 cylinder, 4 cycle type air-cooled engine. The unit consists of a 5 kw ac generator which develops 60 cycle current at standard voltages of 110/220, single phase, or 3 phase, 220/440, 1800 rpm. It is available with or without automatic voltage regulator or standard 6 v automatic type starting. Auxiliary hookup equipment is available to provide full automatic standby.—**Katolight Corp., 624 N. Front Street, Mankato, Minn.**—TELE-TECH ELECTRONICS INDUSTRIES

Magazine Recorder

Designed primarily to simplify the collection of a number of actions over a period of time, this monitoring recorder fits into the palm of a hand. Nevertheless, it prints and stores a tape record of two separate data traces plus a timing trace. The 1/4 in. electrosensitive tape is uneffected by extreme temperature or humidity changes, and positively records actions separated by as little as 1/16 sec. One magazine loading will run for 8 days, or minutely detailed data may be run through in a few hours. All that is necessary to place the recorder in operation is to attach either a normally-open or a normally-closed switch to the phenomena source, plug connecting wires into the unit and plug the power line into a 110 v. outlet which provides power to drive the reels and mark the tape.—**Alden Electronic & Impulse Recording Equipment Co., Westboro, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

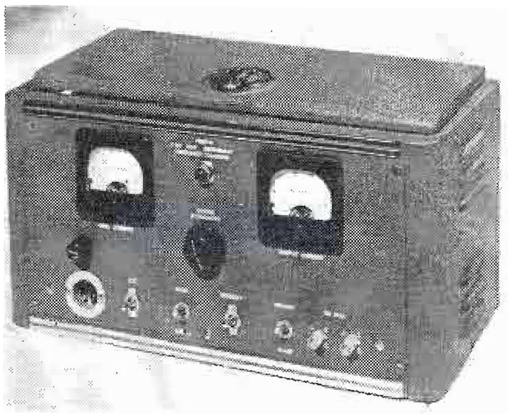


Electronic Liquid Level Control

An electronic liquid level control eliminates hot tube failure and does not require floats, bellows, or other moving parts. Its accuracy is independent of pressure and temperature. The new Haledy TT-1 triode used needs no filament, plate transformer, or circuitry, hence, requires no warm-up or standby current. Its unusually accurate level detection results from its 2½ million amplification factor. Less than two μa flow through the electrodes at low voltage, the system, therefore, is safe for a wide range of liquids and electrode corrosion is negligible.—**Haledy Electronics Co., 57 William St., New York 5, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Microwave Standard

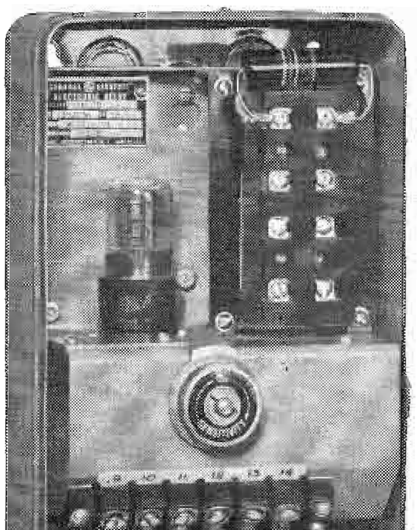
The Model 100 Microwave Secondary Frequency Standard provides a versatile and relatively inexpensive instrument to generate accurate test signals over



the extremely wide range of 200 to approximately 11,000 MC without any frequency tuning. It delivers to the 50 ohm input of a typical microwave receiver an uninterrupted series of CW signals paced every 100 and 200 MC over the complete frequency range, and 50 MC marker output useful up to approximately 9000 MC. These signals are all delivered simultaneously without any frequency tuning. Frequency accuracy is ±0.005%. Tube complement includes 12AU7, 6AK5, 5763, 5Y3GT and 1N23B. Dimensions of 16-lb. unit are 8 x 8 x 16 in.—**Presto Recording Corp., P. O. Box 500, Paramus, N. J.**—TELE TECH & ELECTRONICS INDUSTRIES

Electronic Relay

An electronic relay which is highly sensitive to resistance changes and can be varied by a stepless dial, may be used to start or stop a fractional horse-



power motor directly when a contact-making meter reaches a required reading. Other uses include liquid-level and sorting controls, solenoids, and contractors wherever there is sufficient change in the resistance of a circuit. Two single-pole double-throw contacts permit control of independent systems, and simple jumper change sets the relay for normal or reversed operation. Power requirements are 115/230 volts ac, 50/60 cycles, and should not exceed 10 volt-amperes. The time delay, depending somewhat on the dial setting and the external resistance value, is rated at 5 milliseconds minimum. The relay enclosure is weather resistant and measures approximately 10 x 6¼ x 4⅞ in. —**General Electric Co., Schenectady 5, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

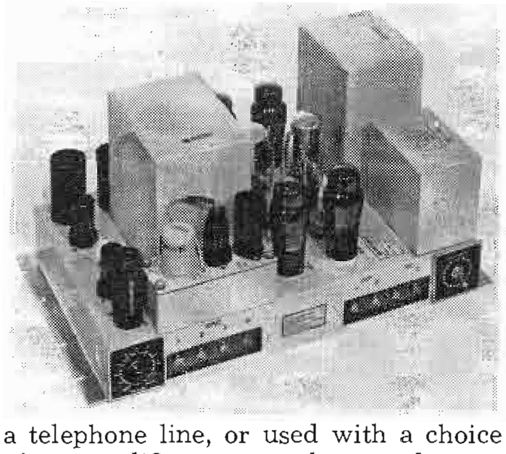
Precision Potentiometers

Linearity of 0.01% is a feature of the Series 3500 ten-turn Potentiometer, now available in production quantities. Resistance range is 2000 ohms to 300,000

ohms with a standard resistance tolerance of ±1%. Lower resistance values, down to 500 ohms, are available at reduced linearity (0.02%). Electrical and mechanical rotation may be specified to any value between 360° and 3780 ±½° (linearity tolerance of 0.01% is based on 3600° rotation). A built-in traveling nut type limit stop is a standard feature. This unit may be servo or panel mounted. Its torque and inertia characteristics are adapted to servo requirements. The case is accurately concentric with the shaft so that the unit may be cradle-mounted and driven differentially.—**Birklan Corp., 200 E. Third St., Mt. Vernon, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Audio Frequency Amplifier

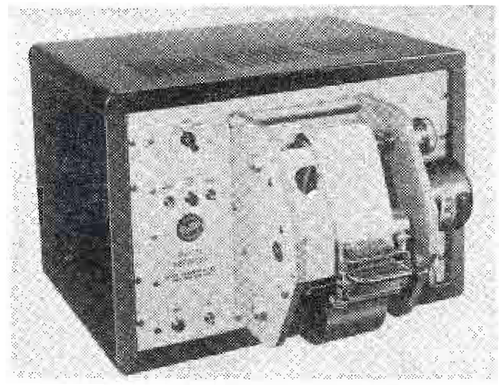
Heavy-duty audio frequency amplifier type 101-D will provide long service with a minimum of maintenance in railroad yard, warehouse, and depot paging systems. The unit delivers 50 watts of power with less than 3% total RMS harmonic distortion from 100 to 8,000 CPS; and its frequency response is flat within 1 db from 30 to 15,000 CPS. A filter restricts output to the voice band range when required. Also, provision is made for working load impedances within 1 to 1000 ohms. The load may be balanced or one-side grounded, as load windings are fully grounded. The type 101-D can be stacked, and matched or bridged across



a telephone line, or used with a choice of preamplifiers to match several types of microphones, or phonograph or tape reproducers.—**Langevin Manufacturing Co., 37 W. 65th St., New York 23, N.Y.** —TELE-TECH & ELECTRONIC INDUSTRIES

Digital Recorder

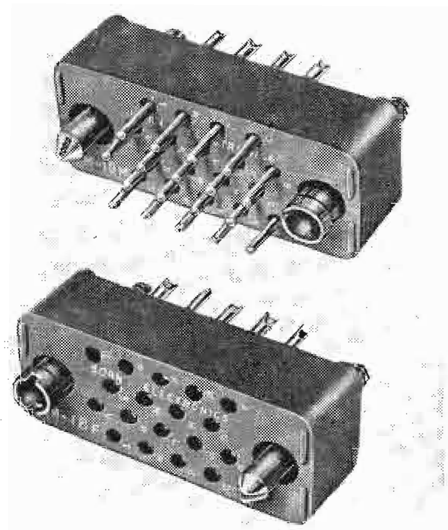
Digital recorder, model 960, records up to eight digit numbers per sec. and is designed for use with any equipment which provides a binary coded decimal



indication. Data is recorded on electrosensitive paper by groups of four styli. An intermittent drive system provides data input paper advance control at recording speeds below 10 per sec. Intermittent motion automatically merges into continuous drive above 10 records per sec. Continuous drive can be also independent of input data. Paper speed is adjustable from 2.5 to 20 in. per sec. Paper rolls, 4¼ in. x 400 ft., enable 50,000 recordings without reloading. Standard unit incorporate 20, 26, or 32 styli. Dimensions are 17⅛ x 12½ x 16¾ in. Power input is approx. 300 watts.—**Potter Instrument Co., 115 Cutter Mill Road, Great Neck, N. Y.**—TELE-TECH & ELECTRONICS INDUSTRIES

Precision Miniature Connectors

Light weight connectors are available in a newly-developed line which have from one to 100 contacts. To assure



maximum conductivity, the contacts are gold plated over silver, and a floating feature of their design facilitates engagement and disengagement. Precision molded melamine bodies with raised barriers resist arcing and heat and provide longer creeping paths. Male and female guides assure positive polarization. The new connectors are especially suited to installations where high voltages are required and compactness and light weight are essential. —**Gorn Electronics, Div. of Gorn Electric Co., 875 Main St., Stamford, Conn.** —TELE-TECH & ELECTRONIC INDUSTRIES

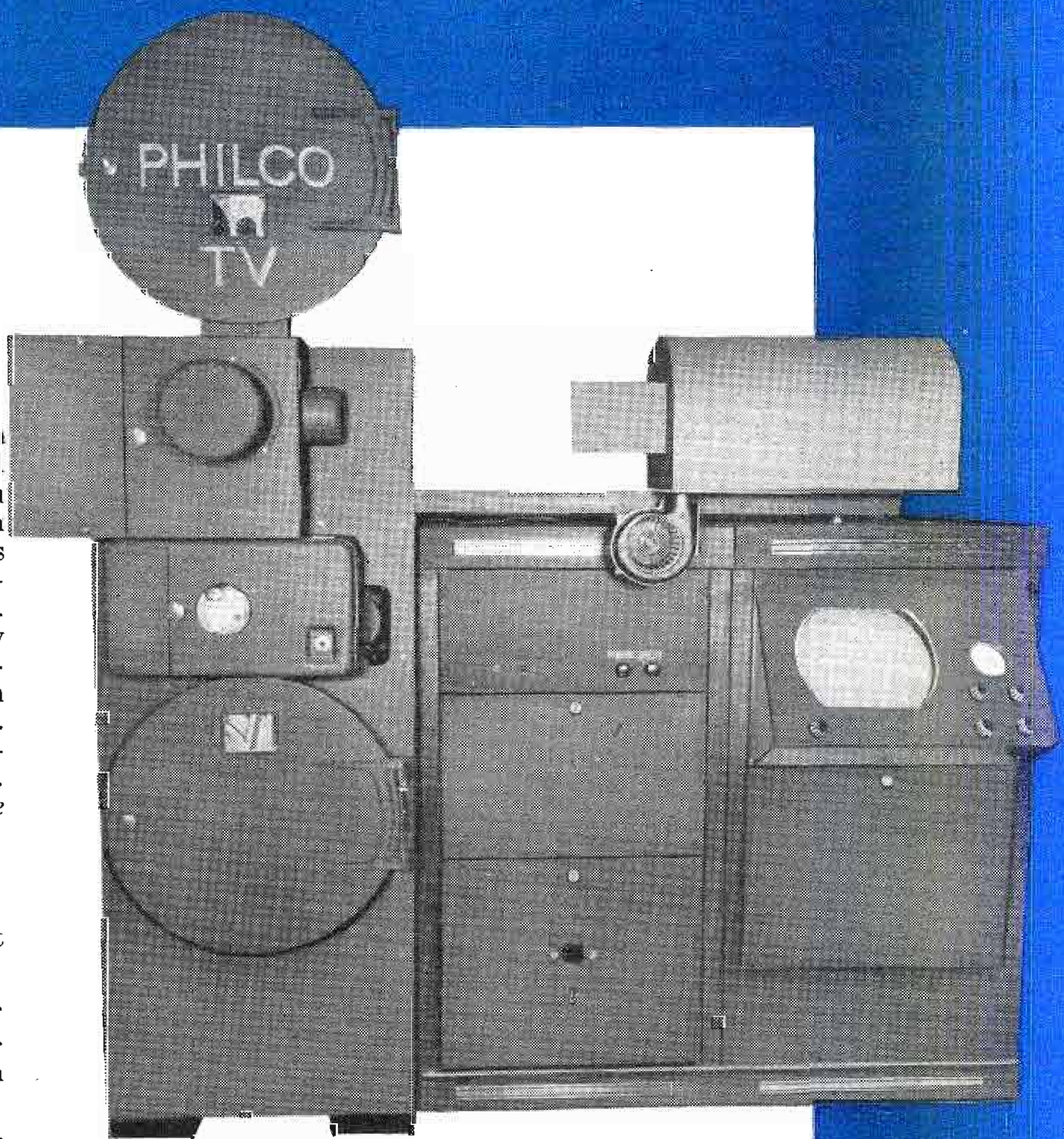
Two Sensational Developments for TV BROADCASTING

A REVOLUTIONARY NEW FILM PROGRAMMING SYSTEM

This new Philco TV Film Scanner will put realism and life into your film programs . . . It will build audience acceptance surpassing anything you have ever experienced with conventional film projection systems. Developed by Philco, this unique Film Scanner is a complete, yet inexpensive program source for both film and slides. It is quiet, compact and easy-to-operate. New design principles employing continuous film motion and flying-spot scanning techniques result in superb film reproduction and greatest reliability. Film motion is continuous and smooth . . . resulting in greater film life and utmost dependability. Moreover, this Philco Film Scanner *is adaptable to any color system or any TV standard.*

CHECK THESE PHILCO FEATURES:

- Operates at any Film Speed . . . Can Project Stationary Frames.
- Cold Illumination Source—No Film Burning.
- Smooth Film Movement . . . Reduces Film Wear.
- Distortionless Optical Compensation for Film Shrinkage.
- Automatic Film Registration and Extreme Picture Steadiness.
- Shading Adjustments Eliminated by Flying-Spot Scanner.



Philco 35 mm Film Scanner.

GOVERNMENT & INDUSTRIAL DIVISION • PHILADELPHIA 44, PA.

WASHINGTON
News Letter

Latest Radio and Communications News Developments Summarized by TELE-TECH's Washington Bureau

BETTER TV STATIONS—Television stations to be approved in future by FCC will be headed by leading substantial members of the communities involved under the new processing program of the Commission. "Strike" applicants who interposed last-minute applications to delay authorizations of stations will not gain the right of consideration. This should definitely result, in the opinion of competent observers of the growth of television, in the television stations, sponsored by the more qualified applicants, being approved by the FCC. This also will mean future television stations will be stronger financially and will render excellent video service to their communities.

SPEEDIER GRANT PLAN—Merger between competitors for TV stations on a time-sharing basis under the new FCC processing rules has already produced prompt action by the FCC in the authorization of television stations to get on the air in a swift fashion. The FCC approval of a new "merged" TV station application has come in the matter of a few days, generally a total of three working days, instead of months of delay. In the case of applications of competing stations where one or more drop out and leave a single applicant, which had gone to hearings, the FCC in another medium of expediting station authorizations now permits the examiner to certify the hearing record directly to the Commission for its immediate action.

STANDARDS SOON—The FCC with the support of leading members of Congress is slated in July to formulate the engineering standards for color television on a compatible all-electronic basis. RCA has prepared for experimental FCC authorization for the transmission of color TV programs on networks to obtain the reaction of viewers to color pictures as seen on black-and-white screens. While mass production and sales to the public may not come for a year, color television definitely has reached a stage of progress where it will become a major facet of telecasting in the immediate future.

DEFENSE DEPARTMENT—Responsible sources have discounted rumors circulating in Washington that the Defense Department reorganization will go so far as to consolidate communications operations of the three branches of the armed forces in one service. Some speculation has it that the Army Signal Corps, for example, would take over operating responsibilities of the Air Force and Navy, as well as the Army. These sources say that such a proposal has been considered in the past and then discarded.

COMMUNICATIONS POLICY—Government officials have gradually been getting down to cases on policy and personnel, but many critical matters remain unsettled. With several plans under study, the coming six months are seen as the most significant since the war. Study of such agencies as the Defense Department, FCC and Rural Electrification Administration shows a relative lack of concrete developments in recent months, with specific actions awaiting staff changes and policy determinations.

ESSENTIALITY RECOGNIZED—The armed services were felt to recognize the essentiality of the uses of radio and radar by the petroleum industry so that "it is unlikely that this use would be disturbed by the military even in a national emergency." This was emphasized in a report of a special committee of the National Petroleum Council which was recently submitted to the Defense Department and the Department of the Interior. However, the committee brought out that except for limited use of three Shoran frequencies all of the radio frequencies now used by the petroleum industry are non-military frequencies. Since continued expansion of existing petroleum radio and radar systems as well as installation of new systems can be expected, the petroleum industry group warned channel-splitting and time-sharing must be used.

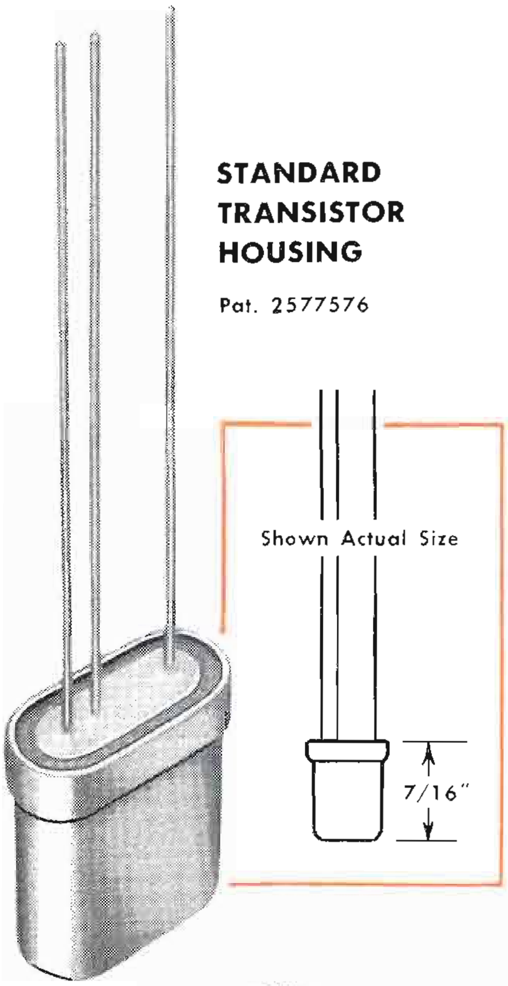
MANUFACTURERS RADIO SERVICE—Establishment of a separate manufacturers radio service in the mobile and microwave fields has been proposed to the FCC by a group of 65 major manufacturers in the United States. The committee, headed by Chairman Herbert E. Markley of the Timken Roller Bearing Co. of Canton, O., stressed that the present special industrial radio service is inadequate in the provision of frequencies for the needs of the manufacturers. This is particularly applicable, the committee cited, with respect to free and uninterrupted use of existing mobile systems, the availability of microwave frequencies for point-to-point communications, and multiple-frequency use. The FCC plan of one frequency to a special industrial user, unless a special showing of need is made, also introduces a factor of inflexibility in the planning of radio systems by the larger departmentalized manufacturers.

National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington, Editor

Let Hermetic Show You How to Achieve a True Hermetic Seal for Transistor and Diode Housings

HERMETIC offers the following enclosures selected from a wide variety of available designs:



STANDARD TRANSISTOR HOUSING

Pat. 2577576

DIODE HOUSING

It is axiomatic that the only true hermetic seal is a glass-metal seal. This has been demonstrated in vacuum tube design and operation.

In the development of transistor and diode housings, HERMETIC has employed the same principles as those proven in the manufacture of vacuum tubes and has eliminated the necessity of using the high sealing temperatures so detrimental to the performance of semi-conductors.

HERMETIC's long years of experience in the design and production of hermetic seals have enabled its staff of specialist-engineers to create glass-metal housings to meet the most demanding requirements of the semi-conductor industry. HERMETIC's Transistor and Diode Housings have received wide acceptance and usage in the field.

HERMETIC's glass-metal seals of compression or standard design are known to be vacuum tight, moisture proof and contaminant proof by mass spectrometer tests and by virtue of years of successful operation.

Because the production pace of the semi-conductor industry is a swift one, **HERMETIC** has geared itself to produce and deliver in accordance with its customers' schedules.

Contact **HERMETIC** today!

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HERMETIC SEAL PRODUCTS CO., 33 South Sixth St., Newark 7, N. J.

THE EXPERIENCED SOURCE for TRANSISTOR and DIODE HOUSINGS

CONTRACT AWARDS

This list comprises electronic contracts awarded by the government during May and June, 1953

Headquarters, Air Material Command, Wright-Patterson Air Force Base, Ohio

Control Panels	$128,400	The Vendo Co.
Power Supply	$ 28,110	Hoffman Labs. Inc.
Relay Resistor Boxes	$238,508	Scintilla Magneto Div., Bendix Aviation Corp.
Machmeters, Spare	$256,283	Kollsman Instrument Corp.
Regulators, Aerno	$794,861	Westinghouse Electric Corp.
Computer & Transmitters	$266,625	Kollsman Instrument Corp.

Navy Department, Bureau of Aeronautics, Washington, D. C.

Turn & Bank Indicators	$ 65,641	Bendix Aviation Corp. Eclipse-Pioneer Div.
Manifold Pressure Transmitters	$ 32,846	Bendix Aviation Corp. Eclipse-Pioneer Div.
Control Amplifiers, Indicators	$1,482,215	General Electric Co.
Generators	$ 25,636	General Electric Co.
Wind Velocity Indicators	$108,193	Bendix Aviation Corp., Friez Instrument Div.
Frequency Converters	$ 60,165	American Electric Motors, Inc.
Altimeters	$179,040	Kollsman Instrument Corp.
Controls	$8,715,049	General Electric Co.
Accelerometers	$95,550	The Tackner Co.

Office of the Contracting Officer, Air Force Missile Test Center, Patrick Air Force Base, Florida

Recorders	$ 34,950	Audio & Video Products

Gentile Air Force Depot, Dayton, Ohio

Computers	$122,544	Hewlett Packard Co.
Computer Calibrators	$177,700	Telectro Industries Corp.

Oakland QM Procurement Agency, U. S. Army, 124 Grand Ave., Oakland, Calif.

Solder,soft	$ 42,543	Bow Solder Prod. Co.
Electron Diffraction Investigation	$ 29,500	University of Michigan

Contracting Branch, Holloman Air Development Center, New Mexico

Computers, analog	$103,000	Goodyear Aircraft Corp.
Multiplier units	$ 42,500	Goodyear Aircraft Corp.
Function generators	$ 18,000	Goodyear Aircraft Corp.

Electronic Supply Office, Building 2-B, Great Lakes, Ill.

Tubes	$176,400	Raytheon Mfg. Co.
Relays	$ 32,503	Guardian Electric Mfg. Co.

Bureau of Ordnance, Washington, D. C.

Synchro Controls	$256,100	Bendix Aviation Corp., Montrose Division

Rome Air Force Depot, Griffiss Air Force Base, Rome, N. Y.

Plug-in Coil Drawers	$ 94,571	Technical Material Corp.
Wire	$2,547,000	American Insulated Wire Corp.
Amplifier Couplers	$ 75,867	New London Instrument Co.
Spectrum Analyzers	$ 25,470	Polarad Electronics Corp.

Supply Office, Portsmouth Naval Shipyard, Portsmouth, N. H.

Switches, rotary selector	$ 37,843	U. S. Instrument Corp.
Switches, rotary selector	$187,688	Federal ProductsCo.
Switches, rotary selector	$ 40,049	Lovell-Dressel Co., Inc.

Aviation Supply Office, 700 Robbins Avenue, Philadelphia 11, Pennsylvania

Cable	$2,726,429	General Cable Corp.
Actuators	$187,562	Breeze Corp. Inc.
Detectors	$ 42,020	Safe Flight Instrument Corp.
Switch & Transmitters	$ 28,368	Eclipse Pioneer Div., Bendix Aviation Corp.
Indicators	$ 63,503	Eclipse Pioneer Div., Bendix Aviation Corp.
Frequency Meters	$105,049	Radio City Products Co., Inc.
Indicators for aircraft	$ 40,513	Kollsman Instrument Corp.
Crystal Units	$ 41,390	Collins Radio Co.
Generators	$ 40,447	Hewlett-PackardCo.
Relays	$ 84,739	The Hartman Electric Mfg. Co.
Radar Test Sets	$121,594	Garod Radio Corp.
Actuators for Aircraft	$125,320	Gilfilian Bros., Inc.
Recorder-Reproducers	$ 41,851	Pierce Wire Recorder Corp.
Plug-Receptacles	$ 46,020	American Phenolic Co.
Plug-Receptacles	$ 28,147	General Electric Co.
Test Oscillators	$ 26,595	Hewlett-PackardCo.
Antennas	$ 34,329	N.S.T. Corp.
Microphones	$ 47,535	The Roflan Co.
Amplifiers, calibrators	$ 34,425	Simmonds Aerocessories, Inc.
High voltage insulation	$ 40,577	Transitron, Inc.
Meters	$ 54,012	Hewlett-PackardCo.
Generators	$ 96,654	General Electric Co.
Generator & Exciter Controls	$649,189	General Electric Co.
Amplifier Assembly	$ 35,730	Engineering & Research Corp.
Cell Type Screen Rooms	$ 46,652	Shielding, Inc.
Relays	$ 32,518	The Hartman Electric Mfg. Co.
Voltmeters	$ 77,585	Millivac Instrument Corp.
Indicators, transmitters	$ 75,729	The Liquidometer Co.
Alternators	$172,171	Bendix Aviation Corp., Red Bank Div.
Signal Generators	$ 29,352	Aircraft Radio Corp.
Regulators	$ 29,579	Bendix Aviation Corp., Red Bank Div.
Regulators	$ 39,283	Eclipse-Pioneer Div. Bendix Aviation Corp., Teterboro, N.J.

Bureau of Ships, Washington, D. C.

Accessories set Acoustic	$ 32,328	J. R. Feeney
Accessories set Magnetic	$174,911	Needham Manuf. Co.
Computer-Indicators	$743,821	Specialty Assembling and Packing Co., Inc.

TAPE DUPLICATION GOES INTO "MASS PRODUCTION"

with the NEW AMPEX Tape Duplicator

Whether you need thousands — or just a few at a time, high fidelity duplicate tapes can now be produced at a cost comparable to disc recordings. The extraordinary fidelity inherent in a good master tape is retained in the duplicates to as high a degree as a sensitive ear can discern. The AMPEX Tape Duplicator is easy to set up, simple to operate and produces up to 80 hours of duplicate performance in 15 minutes operating time.

Duplicate tapes open new opportunities

RADIO BROADCASTING — "Tape networks" and programming services become practical supplements or alternatives to line networks.

BACKGROUND MUSIC — Tape becomes the best medium for background music in that it provides higher fidelity, longer playing and lower attendance costs.

RECORD MANUFACTURE — With mass duplication of tapes now feasible, all performances currently sold on Lp records can also be offered on tape.

EDUCATION — Systemwide duplication and distribution of educational tapes, music and outstanding school performances becomes practical.

COMMERCIAL DUPLICATING SERVICES — With this efficient equipment now available, excellent business opportunities exist in setting up tape duplication services.

Features of the AMPEX Tape Duplicator

- One to ten simultaneous duplicates (slave recorders can be purchased one at a time as needed)
- Time saving speedup during duplication (as much as 32 to 1)
- *15,000 cycle response on 7½ in/sec. duplicates
- *45 to 50 db signal-to-noise ratio
- Duplicate tapes of any standard speed from any master
- Single or double track duplicates in one pass
- Any standard reel sizes up to 14-inch
- Centralized pushbutton controls

*From master tapes of suitable quality.

Write Today
for further information; Dept. U-1204A

AMPEX
MAGNETIC RECORDERS

AMPEX ELECTRIC CORPORATION • 934 Charter Street • REDWOOD CITY, CALIFORNIA
Distributors in principal cities

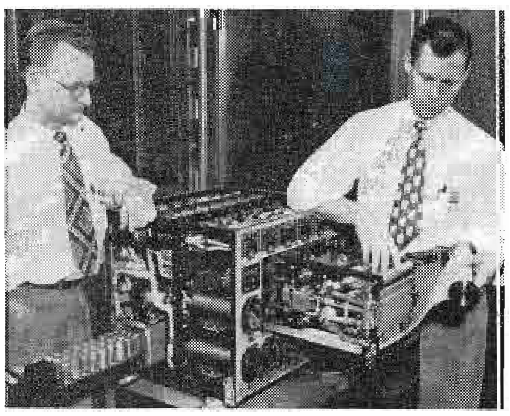
TELE-TECH's NEWSCAST

Automatic Flight Control with Air Force Device

A new device developed for the United States Air Force which enables an aircraft to take off, fly on a prescribed course to a given destination and then land—all without a human hand touching the plane's controls—was announced by Minneapolis-Honeywell Regulator Company and Air Research and Development Command Headquarters. The device, called an Automatic Master Sequence Selector (AMSS), operates on the familiar punched-tape principle to program the functions of the autopilot and the air-speed control. When used with this other electronic equipment, the "brain" forms a robot "pilot" which practically places the human pilot in a monitoring role throughout an entire flight.

The "brain" takes over many of the duties normally performed by a human pilot by "memorizing" a flight plan from punched tape, and then converting information from a myriad of instruments, sensors, computers and navigational aids into electrical impulses that go to the plane's autopilot and airspeed systems to carry out the plan.

Here's how the robot works: A flight plan is made out in advance. The plan is divided into sequences; that is, one sequence for taxiing down the runway, another for takeoff, a third for climbing after the plane is airborne, and so on. This flight plan then is punched into tape by means of a special coding device developed by Honeywell for use with the AMSS. In operation, the punched tape is fed through the AMSS in much the same manner that music rolls were run through the old fashioned player piano, except that the motion is intermittent—one sequence at a time.



Keith Bulleyment (l) and Ray Michel, Honeywell engineers, examine automatic sequence selector which employs punched tape for flight control

The robot's mechanism is housed inside a cabinet about the size and shape of a large table-model television set. Among the parts are 430 metal pins located in the sensing element. As the tape moves through the AMSS, these metal pins drop down on it and search out the punched holes. Where there are holes, the pins make electrical contacts, and these in turn are converted into signals that operate the plane's controls.

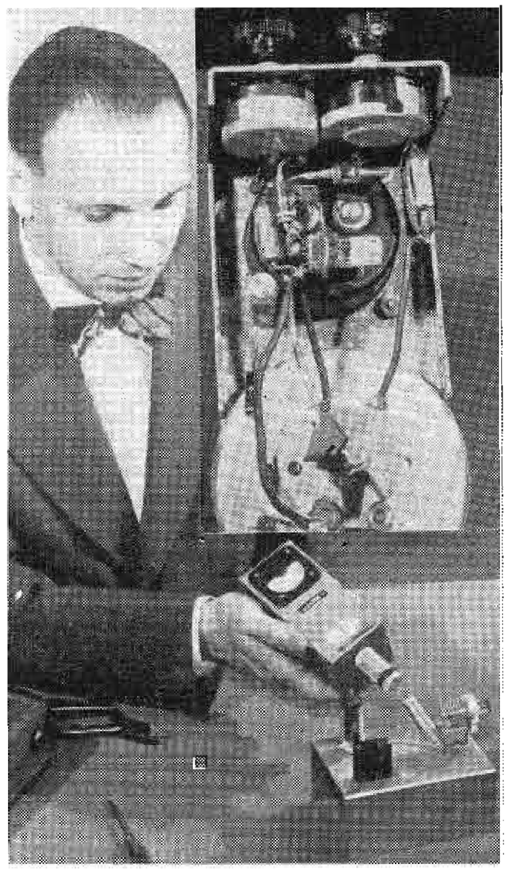
The device is designed so that a human pilot aboard can keep tab on the over-all progress of the flight at all times. It is also designed so that he can take over manual control instantly, should he desire to because of an emergency, such as mechanical failure or unforeseen obstacles in the flight path. Thus, if the plane ran into an unexpected storm, the human pilot would be able to take control, fly around the storm, return to the original course, and turn control back to the robot.

An engineering model of the AMSS already has been delivered to the Flight and All-Weather Testing Directorate at the Air Research and Development Command's Wright Air Development Center, Dayton, Ohio, for whom it was built, and is now awaiting flight test. It was this United States Air Force unit which made flight history in 1947 by flying a C-54 across the Atlantic without human hands touching the controls.

Theatre TV

The technical paper, "Engineering Plans for Theatre TV," was presented by Albert J. Forman, assistant editor of TELE-TECH & ELECTRONIC INDUSTRIES, on June 16 at the AIEE Summer General meeting held in Atlantic City, N. J. The development of the medium was traced from initial research in 1928 to the existing installations valued at $2.5 million, with another $1 million of equipment now on order. Around the early part of the year there were 108 theatres equipped in 56 cities in 32 states, in addition to installations in the Pentagon, U. S. Naval Academy and several manufacturing firms. Included among the companies reported to be producing theatre TV equipment are Air Marshall Corp., General Precision Labs., Paramount Pictures, RCA Victor, Skiatron, Telechrome, Trad Television, and 20th Century-Fox. The technical specifications for a complete theatre TV network presently under consideration by the FCC, was described. These include the following standards: a 735-line picture; 10-MC video bandwidth; frequency modulation for the picture carrier; and transmission of sound by a pulse-width-modulated pulse on the back porch of the horizontal sync signal.

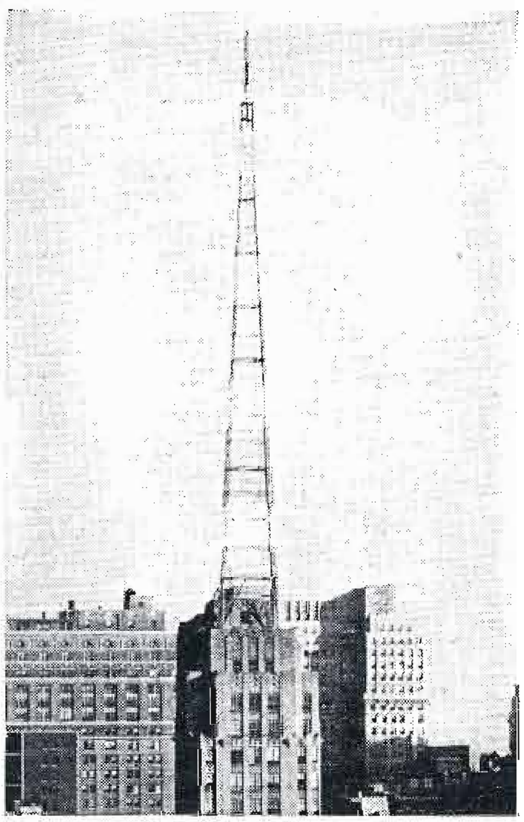
Note: A limited number of reprints of "Engineering Plans for Theatre TV" are available to readers upon written request on company letterhead.

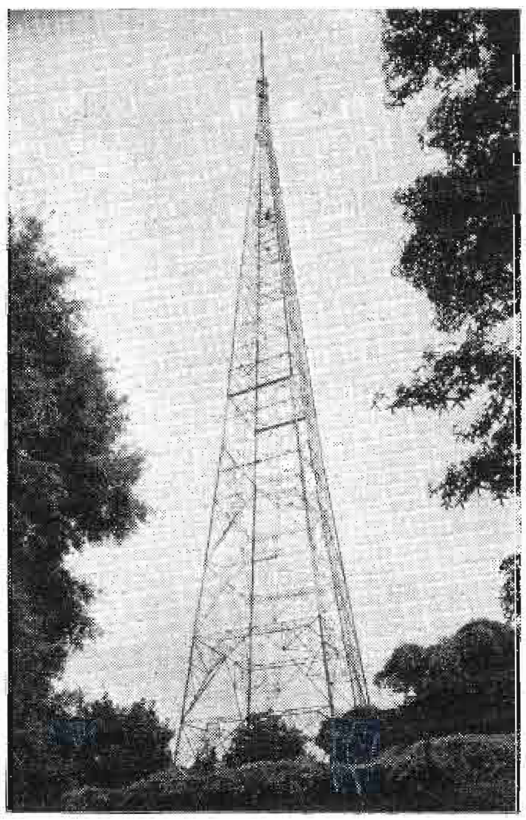


Clarence A. West, an RCA engineer, holds the transistorized grid-dip oscillator developed as a private project. Unit, shown in inset, measure 5 x 2¼ x 2¼ in., consumes only 25 mw

Transistor-Grid-Dip Oscillator

Development of what is believed the first grid-dip oscillator using a transistor and covering the five major amateur radio bands was reported by the Tube Dept. of RCA Victor. This experimental electronic test instrument is built around a single RCA-2N33 point-contact transistor and is powered by a miniature 22½-volt hearing aid battery. The device was developed as a private project by Clarence A. West, an amateur experimenter who operates amateur radio station W21YG. The complete unit, together with power supply, is contained within a metal case measuring only 5 in. high, 2¼ in. wide, and 2¼ in. deep. The instrument's power consumption is only 25 mw.





PERSONAL

Eugene M. Keys has been named president of the Edwin I. Guthman Co., Chicago, Ill. Mr. Keys joined the company in 1942. In 1945, he was made sales manager; then elevated to the salesmanagership in 1947. In 1951, he became vice president in charge of sales. He was made executive vice president of the company in 1951.

W. Walter Watts, former vice president in charge of the Engineering Products Department, was recently elected vice president in charge of Technical Products of the RCA Victor Div. of Radio Corporation of America.


W. Walter Watts

Mr. Watts, who joined RCA after wartime service with the Signal Corps Distribution Agency, will supervise the Engineering Products Department and the Tube Department. **Theodore A. Smith** was concurrently elected vice president in charge of the Engineering Products Department. Mr. Smith, previously assistant manager of this department joined RCA's Technical and Test Laboratories at Van Cortland Park, New York in 1925.

Dr. Constantin S. Szegho was recently appointed vice president in charge of research by the board of directors of The Rauland Corp., Chicago, Ill. Dr. Szegho has been director of research since he joined the Rauland staff in 1942. Before his arrival in America in 1940, he was chief of the vacuum laboratory for Baird Television, Ltd., London, following several years research under Prof. W. Rogowski, the German electrophysicist.

Rodney D. Chipp, director of engineering for the Du Mont Television Network, succeeds T. Ralph Leadbeater, director of safety for Todd Shipyards, as president of the Technical Societies Council of New York, Inc. whose 25,000 engineering and scientific societies in members represent virtually all the

(*Continued on page* 84)

INDUSTRIAL CONTROL

ACTUAL SIZE

MAXIMUM RATINGS #

Relay and Grid-Controlled Rectifier Service (for anode supply frequency of 60 cps)

PEAK ANODE VOLTAGE:	
Forward	650 max. volts
Inverse	1300 max. volts
GRID-NO. 2 (SHIELD-GRID) VOLTAGE:	
Peak, before anode conduction	−100 max. volts
Average*, during anode conduction	−10 max. volts
GRID-NO. 1 (CONTROL-GRID) VOLTAGE:	
Peak, before anode conduction	−200 max. volts
Average*, during anode conduction	−10 max. volts
CATHODE CURRENT:	
Peak	5 max. amp
Average*	0.5 max. amp
Fault, for duration of 0.1 sec. max.	20 max. amp
GRID-NO. 2 CURRENT:	
Average*	0.05 max. amp
GRID-NO. 1 CURRENT:	
Average*	0.05 max. amp
PEAK HEATER-CATHODE VOLTAGE:	
Heater negative with respect to cathode	100 max. volts
Heater positive with respect to cathode	25 max. volts
AMBIENT TEMPERATURE RANGE	−75 to +90° C
Maximum Circuit Values:	
Grid-No. 1—Circuit Resistance	2 max. megohms

*Averaged over any interval of 30 seconds maximum.
#Absolute values

NOW—precise electronic control at lower cost with the new RCA-6012 gas thyratron

Expressly designed for industrial control applications, the new RCA-6012 gas tetrode features the ruggedness necessary to withstand rough industrial usage. It has the additional advantages of low cost and nation-wide renewal distribution...both of importance to the end user.

For motor-control, electronic-inverter, and general relay service at power supply frequencies, the RCA-6012 is rated to withstand a maximum peak inverse anode voltage of 1300 volts, a maximum peak cathode current of 5 amperes, and a maximum average cathode current of 0.5 ampere.

Operating features of the RCA-6012 include a negative-control characteristic which is essentially independent of the ambient temperature over the range from −75° to +90° C, low preconduction currents, low control-grid-to-anode capacitance, and low control-grid current.

The RCA-6012 is compactly designed, and employs a structure that increases its resistance to both shock and vibration. A button stem is used to strengthen the mount structure and to provide wide inter-lead spacing as a means of reducing susceptibility to electrolysis and leakage.

For complete technical data on the RCA-6012, write RCA, Commercial Engineering, Section 57GR, Harrison, N. J. . . . or contact your nearest RCA field office.

FIELD OFFICES: *(East)* Humboldt 5-3900, 415 S. 5th St., Harrison, N. J. *(Midwest)* Whitehall 4-2900, 589 E. Illinois St., Chicago, Ill. *(West)* Madison 9-3671, 420 S. San Pedro St., Los Angeles, Calif. Tmks. ®

Another **new RCA tube**

RCA-6080 is a current-regulator tube for use in regulated dc power supplies. Similar to the 6AS7-G, it features a button-stem construction for improved resistance to shock and vibration. The 6082 is a similar tube for aircraft power supplies.

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ELECTRON TUBES — HARRISON, N. J.

engineering and scientific societies in the Greater New York area. Other officers elected were J.V.N. Dorr of the Dorr Co., vice president; John B. Hewett, of the John B. Hewett Co., secretary; and Robert M. Edmiston, of the American Optical Co., treasurer.

Dr. Michael J. DiToro has become head of electronic development in the Fairchild Guided Missiles Division engineering department. Dr. DiToro has been an associate director of the Microwave Research Institute of Brooklyn Polytechnic Institute, and he has held several important engineering posts in leading electronics firms.

Lloyd A. Hammarlund, president of the Hammarlund Mfg. Co., Inc., has been elected to join the executive board of the Electronic Manufacturers Association, an organization that comprises most of the electronic manufacturers in the New York-New Jersey area. One of its programs is to obtain the best possible union contracts for the manufacturers. Last December he was elected to the position of Employer-Trustee of the District 4 Welfare Plan, a plan developed by the members of the IUE-CIO groups in the New York and New Jersey area. Its major goal is to obtain maximum welfare benefits for union members. As a member of both groups Hammarlund reported that he believed he now was in the position to help provide for the best of contracts for both electronic manufacturers and employees in the area.

TV Camera Contest

William Zillger, vice president of Standard Electronics Corp., has announced the winner of the "Mystery Camera Contest." He is A. J. Mosby of Missoula, Montana. Award of the first prize, a Philco air conditioner, was decided by three judges, including Dr. Orestes H. Caldwell, Editorial Director of TELE-TECH & ELECTRONIC INDUSTRIES, based on the answers to 10 questions. Some of the questions are: How many tubes? (32 including pick-up and viewfinder) Lens price? ($250) Weight? (72 lbs.) For more information see the June 1953 issue of TELE-TECH & ELECTRONIC INDUSTRIES, page 186. The heart of this camera is the multicon pick-up tube on this month's cover, story on page 57.

Broadcast Symposium

The IRE Professional Group on Broadcast Transmission Systems is planning to hold their annual broadcast symposium in late October at the Franklin Institute in Phila. Emphasis this year will be on color TV and UHF-TV. Readers wishing to contribute papers should mark same for the attention of L. Winner or Scott Helt, IRE headquarters, East 79th St., N. Y.

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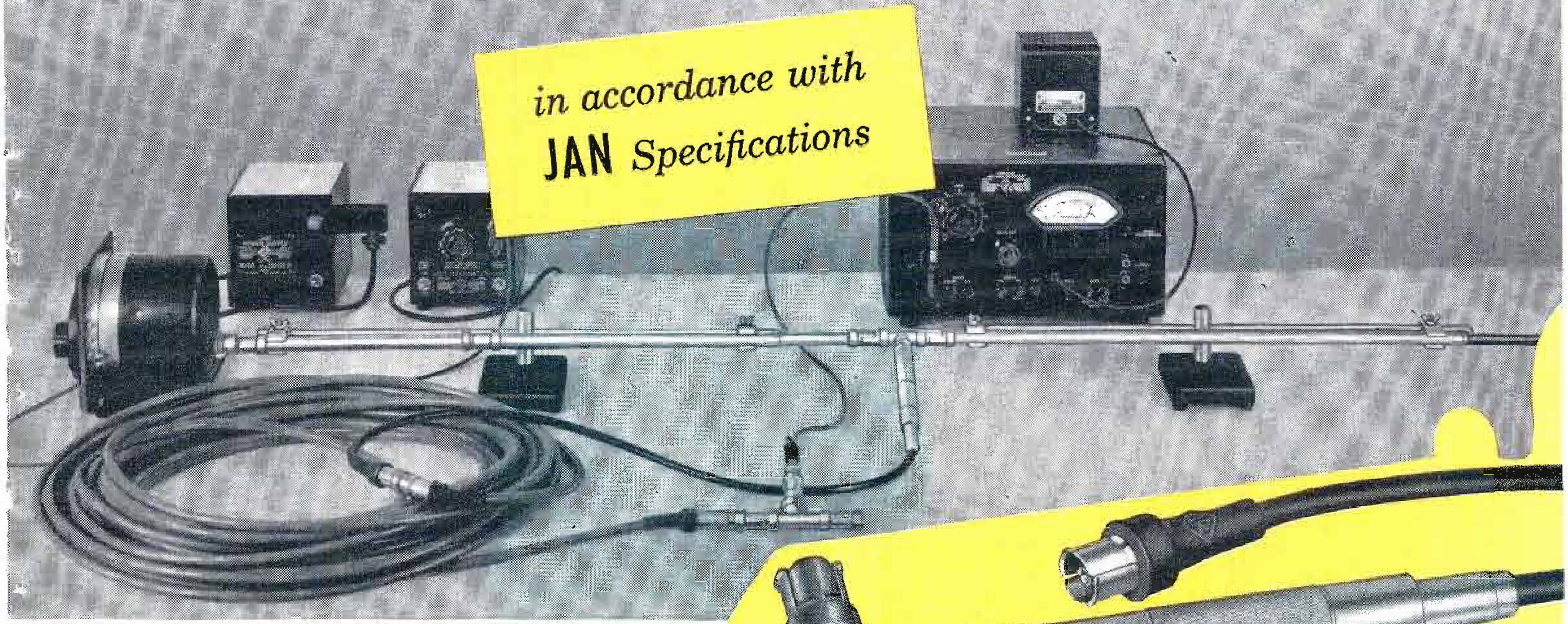

Complete Setup for attenuation measurements at the JAN specified frequency of 400 Mc. Equipment includes the G-R Type 1208-A Unit Oscillator, the 1231-B Amplifier and Null Detector and various coaxial components. With appropriate high-frequency oscillators, measurements may be made at any frequency from 200 Mc to 4000 Mc.

Key Element is the Type 874-GA Adjustable Attenuator operating on the wave-guide-below-cutoff principle. It is an accurate, continuously adjustable *primary* standard whose ultimate accuracy depends only on mechanical dimensions; specifically, the inside diameter of the attenuator tube and the accuracy of two screw threads. **Price $55**

For Designers, Manufacturers and Users of r-f cables . . .

GR offers a well integrated group of instruments and components for highly accurate measurements of . . .
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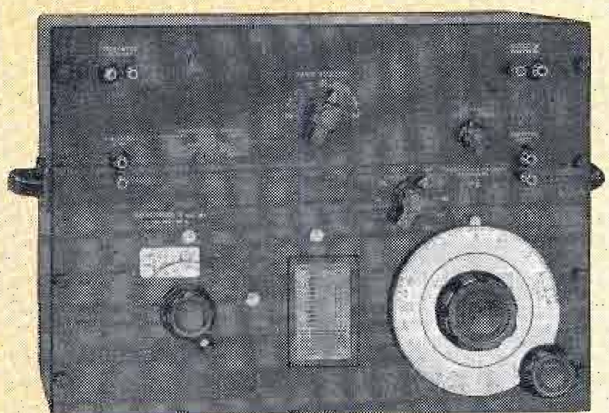
Capacitance . . . *Insulation Resistance.*

Manufacturers of coaxial and dual-coaxial cables, t-v twin-lead and shielded twin-lead are now using G-R equipment with highly satisfactory results. In the insertion-loss method illustrated above, attenuation measurements are made with an accuracy of better than 1% + 0.2 db. Accuracy is independent of crystal-detector calibration. Well-designed G-R Type 874 coaxial connectors eliminate troubles from leakage and bad contacts. The equipment is readily assembled and easy to operate.

Insulation Resistance is measured directly by the Type 1862-A Megohmeter at the commonly accepted ASTM potential of 500 volts.

The instrument range is 0.5 to 2,000,000 megohms — accuracy is 3% to 50,000 megohms, decreasing at higher resistances. Guard and ground terminals are provided for measurements of three-terminal samples. A panel switch removes voltage from the unknown terminals permitting connections without danger of shock.

Type 1862-A Megohmeter $225



Cable Capacitance and Capacitance Unbalance are measurable to a high degree of accuracy with the Type 716-C Capacitance Bridge — an instrument used the world over for capacitance standardization.

In substitution measurements, accuracies obtainable are ±0.1% or ±0.5 μμf, whichever is greater, for values up to 1000 μμf — frequency range is 30 cycles to 300 kc. With appropriate techniques, this bridge will also measure inductance and resistance as well as capacitance and conductance.

Type 716-C Capacitance Bridge (mounted in walnut cabinet) . . $545

Velocity of propagation is measured, to an accuracy of within ±0.5%, with the same equipment in another configuration. Characteristic impedance is readily calculated from the values for velocity of propagation and capacitance per foot of cable.

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CUES for BROADCASTERS

(Continued from page 51)

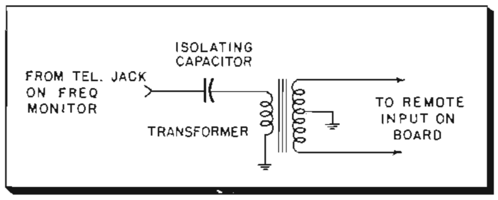
With this arrangement it is possible to use any mike for P.A. broadcast, or both, depending on the situation. And, needing only one mike for a given pickup, it eliminates the clutter of cables and stands, as well as the problem of the performer favoring one mike. With all the faders mounted on one convenient panel, it allows much more careful control over mixing levels, and the operator is more easily able to control feedback on the P.A. system. If desired, a master fader for the P.A. could be mounted on the control panel. With the type of P.A. system used, this system of mixing worked admirably since the mixer was high level, and allowed connection to a high impedance phonograph input, with plenty of output and reserve gain.

Economical 1000 cps Tone Unit

CHARLIE H. PARISH, Chief Engineer, WFPM, Ft. Valley, Ga.

MANY times in radio station operation it is desirable to have a steady tone of some frequency for testing and other purposes. At WFPM we use a steady 1,000 cycle tone for both test purposes and as a time signal. I constructed a generator at no cost with the use of one condenser and a transformer from the junk box. The source used was the station frequency monitor. We use the General Radio monitor, Type 1181-A which has an outlet marked (Tel.) on the front panel. (Also obtainable with monitors of other makes)

This is the outlet of the beat frequency which is 1,000 cycles. A regular phone jack was used to



carry the 1,000 cycle signal through an isolating condenser to the transformer primary. The secondary was center tapped to ground and the output wired to one of the remote inputs of the board. Therefore, at any time desired, the 1,000 cycle tone can be obtained directly from the board. By leaving the remote pot "up," convenient tone beeps can be had by closing the remote on-off switch. There's no limit to the ways it can be used . . . code for newscasts, steady tone for frequency checks, modulation for MTR, and countless others.

CONDUCTANCE CURVES

(Continued from page 46)

amplifier using a 6AK5 tube would require a screen voltage of 100 v. The minimum plate voltage at zero bias is 80 v. The zero bias plate current on the 6AK5 with 100 v. on its screen being 17 ma, the voltage developed across the load resistor is 34 v., making the total required supply voltage 114 v. The amplification is about 12.6 times.

Where the available supply voltage exceeds the required plate supply voltage, a series resistor may be used which will provide the required voltage loss at the static plate current. An 18,000-ohm five-watt resistor would be adequate to reduce 300 v. to the 114 v. required for the 6AK5 tube. A bypass capacitor is required to maintain the voltage constant at the supply end of the plate load resistor. This capacitor should keep the voltage variation at the supply end of the plate load resistor less than a tenth of the maximum output voltage change at the lowest frequency which the amplifier must pass. Choosing a one-volt variation limit at twenty cycles, the capacitance may be determined from

$$Q = CE = \Delta i \cdot t \qquad (3)$$

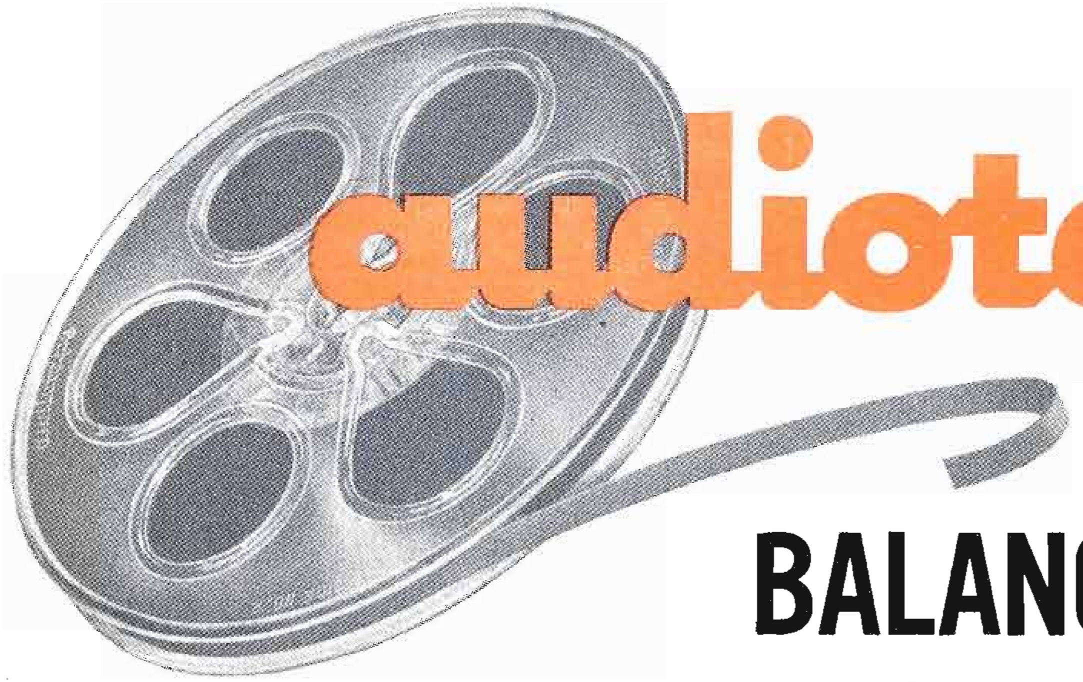
The current change is 17 — 10.5 ma equals 6.5 ma. The time is approximately the reciprocal of the angular frequency, or 0.008 seconds. Substituting gives a capacitance of about 50 µf.

Series Resistor

The series resistor in the screen circuit must provide a voltage loss of 200 volts at approximately 3.2 ma. A 62,000-ohm one-watt resistor will be satisfactory. The screen voltage variation should also be held to not more than a volt. Eq. (3) may be used to determine the proper size capacitor for bypassing the screen grid. Twenty microfarads is ample.

The size of cathode resistor required to provide the one-volt bias to the 6AK5 tube is determined by dividing the sum of the plate and the screen currents into the required bias. Seventy-five ohms is ample for the cathode circuit. The cathode by-

(Continued on page 92)



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Complete Interchangeability — Since Audiotape requires no special equalization adjustments, Audiotape recordings can be interchanged freely between radio stations and studios — played back perfectly on any machine.

Highest Coating Adhesion — keeps the magnetic oxide coating from rubbing or flaking off. No danger of fouling heads and guides.

Guaranteed Splice-Free — Plastic base Audiotape, in both 1200 and 2500 ft reels, is positively guaranteed to be free from splices.

Low-Tension Reel Design — with 2¾″ hub now standard for all 1200 foot, 7″ reels. By eliminating the high tension zone encountered at smaller hub diameters, this reel assures more accurate timing, more constant pitch, slower maximum reel speeds and reduced wear on heads and tape.

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Vertical Deflection

(*Continued from page 66*)

blank rasters which illustrate the appearance of the vertical-retrace lines with various peaking adjustments. The picture size was greatly reduced for the purpose of these photographs so that almost the entire raster would be visible on the kinescope.

The preferred procedure for designing the width and amplitude of the peaking pulse is to adjust the width of the pulse to the desired retrace time and then to adjust the amplitude of the pulse so that retrace is completed at the same time the peaking pulse ends. These adjustments may be made by observation of the raster or with the aid of an oscilloscope.

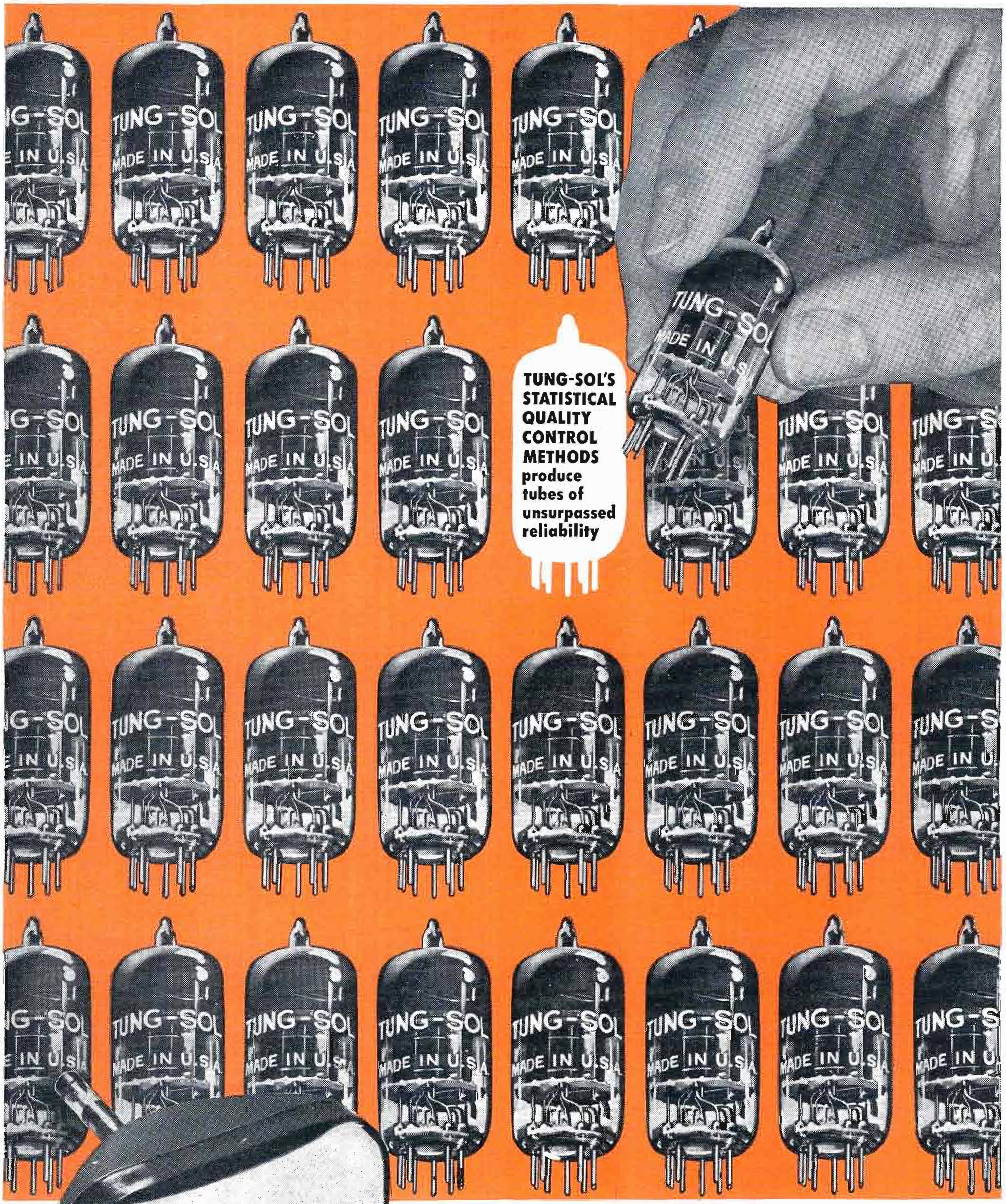
Because proper operation of vertical-deflection circuits depends on sawtooth voltages with peaking pulses, a brief discussion of the method of generating such voltage waveforms, which is basically quite simple, will be given below.

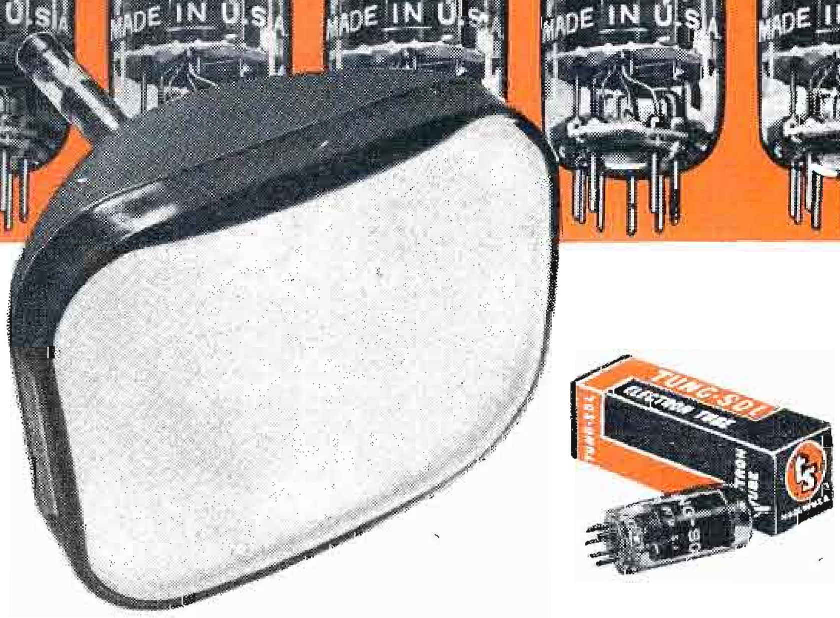
Sawtooth Voltage Generators

The circuits which generate the sawtooth voltage waveform operate by charging a capacitor through a resistance and discharging the capacitor through a tube. The tube is cut off while the capacitor is being charged and an appropriate voltage is then applied to the grid to cause the conduction required to discharge the capacitor. Such a "discharge-tube" circuit is shown in Fig. 11. The pulse at the grid may be derived from a separate source, such as a blocking oscillator, or from more complex circuitry in which the discharge tube is part of the oscillating circuit. The latter type of oscillator-discharge circuits include blocking oscillators, conventional multivibrators, and feedback circuits in which the grid pulse is obtained from the plate of the vertical output tube. All of these circuits have been used in commercial receivers. Sync pulses are not used directly to drive the discharge tube in receivers because the noise immunity would be poor and because vertical deflection would fail in the absence of a television signal.

The functioning of any of the discharge circuits is basically like that of the circuit shown in Fig. 11. The approximate equivalent circuit of Fig. 12a may be used to show the details of sawtooth formation. The inaccuracy of this equivalent circuit lies in assigning a fixed internal resistance, R_s, to the discharge tube. Even though the grid voltage may

(*Continued on page 90*)





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remain at zero during the entire discharge period (i.e., while the "switch" is closed), the effective tube resistance is a function of the plate voltage and varies during discharge.

The component values indicated in Fig. 12 are of the order of magnitude found in practical circuits. When the switch is open and the capacitor is being charged, the voltage across the capacitor follows an exponential curve, as shown in Fig. 13a. When the switch is closed, the capacitor discharges rapidly; the capacitor voltage during discharge follows another exponential curve until the switch is opened and the charge begins again. If the RC time constant of the charging circuit is fairly large compared to the vertical-scanning period, the portion of the exponential curve used is substantially linear and the desired sawtooth voltage is obtained.

"Peaking" Resistor

Fig. 12b shows the addition of a "peaking" resistor in the circuit; the result on the output-voltage waveform is shown in Fig. 13b. Because the value of the peaking resistor is small compared to the one-megohm charging resistor, it has practically no effect on the circuit during charging of the capacitor. When the switch is closed, however, the capacitor voltage is instantly divided between the peaking resistor and the switch resistance. Because the switch resistance is of the same order of magnitude as the peaking resistor, the output voltage drops to a low value. Because of the longer time constant, the rate of discharge is slower than when no peaking resistor was used. When the switch is opened, the capacitor has not completely discharged; the output voltage jumps instantly to the approximate voltage still remaining across the capacitor, and the charging of the capacitor begins again.

Two important points may be noted from this simplified discussion. First, the amplitude of the peaking pulse is easily adjusted by varying the value of the peaking resistor. Second, the width of the peaking pulse depends solely upon the time the switch is closed (i.e., the width of the pulse applied to the grid of the discharge tube) and may be adjusted in the oscillator circuit, the specific method of adjustment being dependent upon the type of circuit used.

The shape of the peaking pulse is not exactly like that of Fig. 13b in practice. The change of effective resistance of the tube during dis-

(Continued on page 92)

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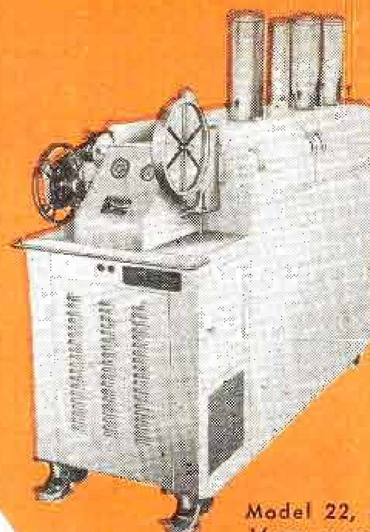

Model 22, H-F developer for 16mm reversal films. It is self-contained, easy to operate, entirely automatic, daylight operating. Adaptable to negative, positive or 35mm films.

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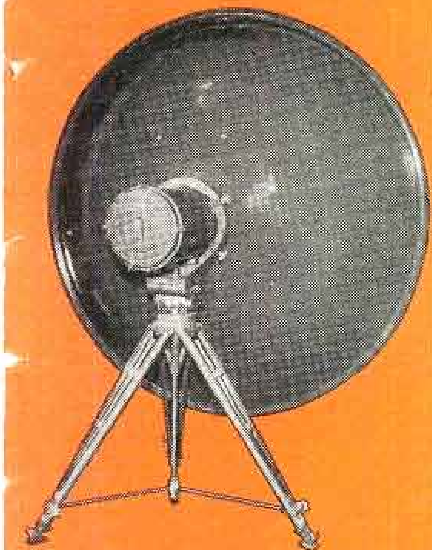

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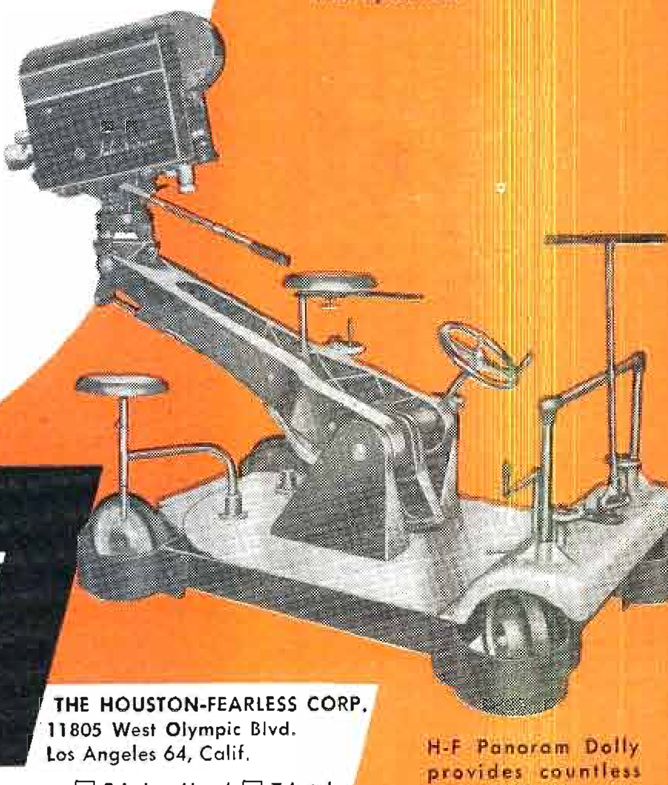

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charge tends to change the downward slope at the bottom of the pulse, making it nearly flat or even producing an upward slope. Furthermore, the waveform of the pulse driving the discharge tube influences the effective tube resistance and, as a result, affects the shape of the peaking pulse. The shape of the peaking pulse may be important in receiver design because of its influence on the peak voltage developed at the plate of the vertical output tube.

Conductance Curves

(*Continued from page* 86)

pass capacitor size may be determined, for a square-wave response to a frequency f_1 by the equation

$$C_k = 1 / (0.2\pi f_1 R_k) \qquad (4)$$

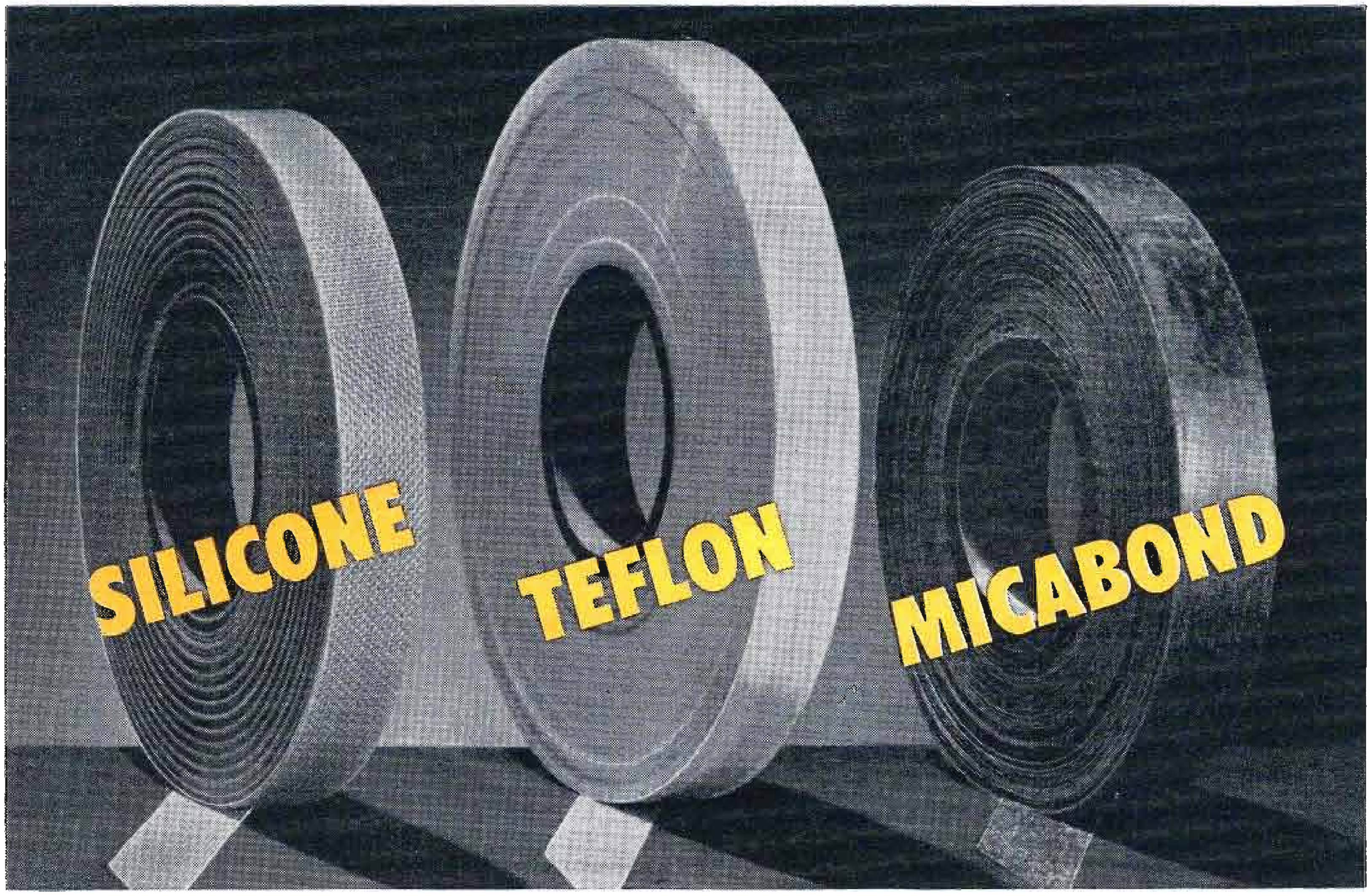
Approximately 1000 µf is required for the 6AK5.

The power dissipation in the screen of the tube is 0.32 watt, and the plate dissipation is 1.2 watts. Since the screen and plate dissipation limits are 0.5 and 1.7 watts respectively, the tube will not be overloaded.

This same video amplifier design might be based on the use of a 6AG7 tube (curves in Fig. 3). For 8% distortion and a bias range of ±1 v. from minus 1 v. static bias, a screen voltage of about 58 v. is required. The mean voltage amplification of the stage with the 6AG7 tube is about 16.4 to one. The required supply voltage is 98 v. The output voltage from the 6AG7 tube is ±16.4 v. compared to 12.4 v. for the 6AK5 tube.

The 6AK5 tube is being operated rather near the limit of its capability in this video amplifier. The 6AG7 tube, however, has considerable reserve. If the screen voltage were increased to 125 v., and the balance of the design completed, a signal having a peak amplitude of ±2.25 v. could be amplified with less than 8% distortion. The voltage amplification is 19.5, and the available output voltage is now ±43 v. The cathode bias resistor must have 64 ohms resistance. The tube plate dissipation is 5 watts, and the screen dissipation is 0.9 watts.

Design of pentode circuits to provide required operational characteristics with minimum dissipation can best be accomplished with curves providing both dynamic and static characteristics throughout the range of voltages in which the tube can be caused to function as an amplifier. The curves and techniques herein described appear to provide a very satisfactory solution to the design problem.



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BOOKS

Simplified Drafting Practice

By Healy & Rau. Published 1953 by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 156 pages, $5.00.

This is not a textbook on engineering drafting. Its purpose, rather, is to arouse the interest of engineering and drafting organizations everywhere in the substantial savings in time and money that can be attained by the adoption and extension of simplified practices.

As applied to the design and manufacture of industrial products, drafting has contributed much to the material wealth of the present era. But paradoxically, while it helped to improve manufacturing and promote progress, drafting itself remained relatively unchanged. It still employs today virtually the same amount of time-consuming elaboration of detail as it did at the time of its inception. Engrossed with the responsibility for product design and development, drafting organizations appear not to have realized that their practices are still quite extensively shackled to the past.

Here are a few chapter headings of interest: Eliminating Unnecessary Work; Arrowless Dimensioning; Examples of Simplified Drafting; Legible Lettering: and Reproduction Processes.

Radiotron Designer's Handbook

Fourth edition, edited by F. Langford-Smith. Printed in U. S. A. (1953) by Radio Corp. of America, Harrison, New Jersey. 1522 pages, $7.00.

This new fourth edition thoroughly covers the design of radio and audio circuits and discusses in detail, from the viewpoints of theory and practice, the design considerations necessary for the proper use of electron tubes and circuit components. It includes 1000 illustrations, bibliographies and references totaling more than 2500 items, and an extensive 50-page index containing 7000 entries.

Circuit design and applications are discussed not only from the theoretical and mathematical approach but also from a practical standpoint.

Topics covered: Part 1, Radio Tubes; Part 2, General Theory and Components; Part 3, Audio Frequencies; Part 4, Radio Frequencies; Part 5, Rectification, Regulation; Part 6, Complete Receivers; Part 7, Sundry data in the form of tables, graphs and charts.

BOOKS RECEIVED

Television Receiver Design I—IF Stages by A. G. Uitjens. 188 pages, 6" x 9"; 123 illus. This is volume VIIIA in the "Philips" Television Design Monograph Series and deals with the application of the pentode in superheterodyne IFs and RF amplifiers. Price in USA is $4.50. Copies available from Elsevier Press Inc., 155 East 82 St., New York 28, N.Y.

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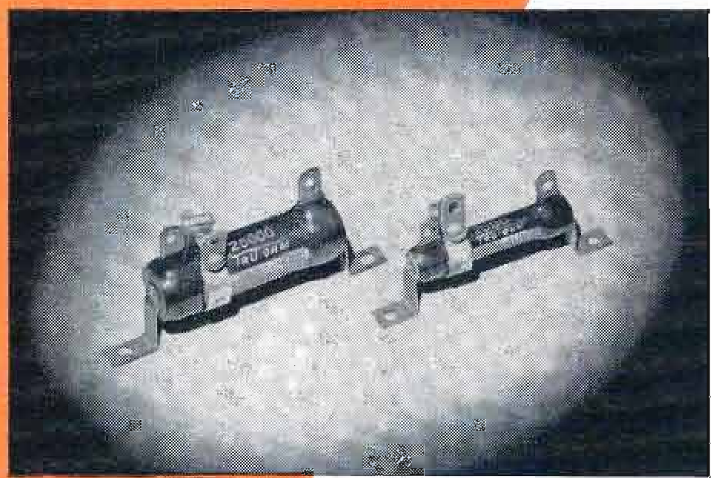

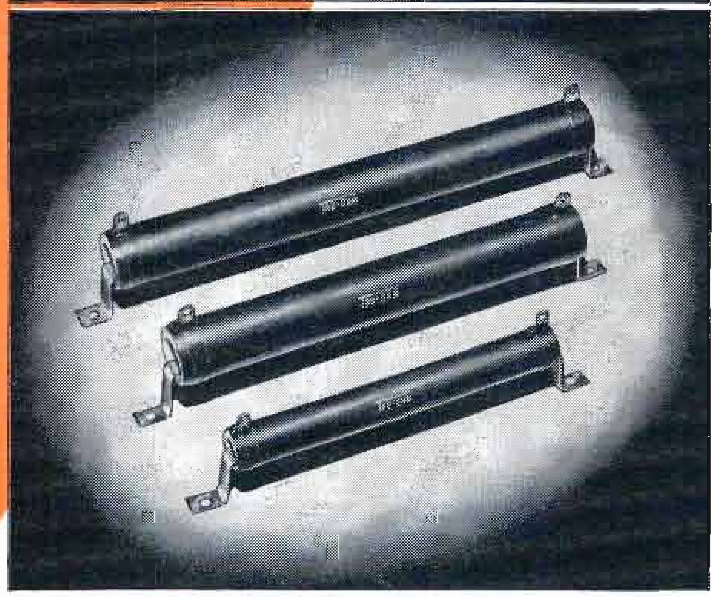

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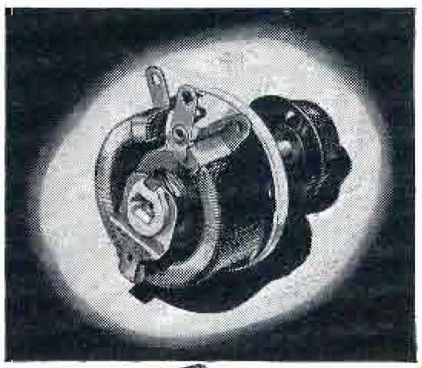

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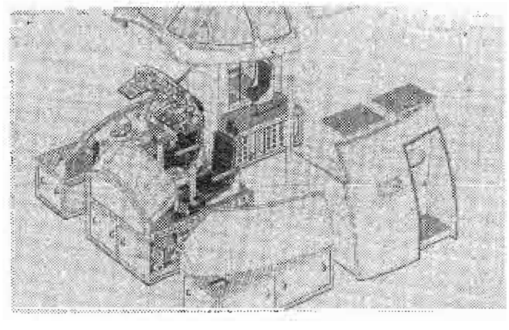
Electronic Aircraft Simulator

An all-electronic simulator for the 200-passenger Douglas C-124A Globemaster, one of the world's largest military transports, has been completed by the Electronics Division of the Curtiss-Wright Corp. and accepted by the Air Force. Representing the latest advances in the field of synthetic crew training, the new simulator is a complete duplicate of the cockpit of the 175,000-lb. Globemaster. It will be installed at the Air Force training base at Morrison Field, West Palm Beach, Fla.

The newest in the line of Curtiss-Wright Dehmel flight simulators, the C-124A unit introduces for the first time these features:

1. Completely electronic control loadings designed to meet USAF specifications for quick and realistic aircraft response.
2. The most modern and complete radio aids unit, designed to provide all instrumentation required for air navigation instruction.
3. Precise cockpit duplication that activates through electronic means every control, instrument, and switch found in the aircraft itself.
4. New designs for cabinets and interconnecting cables that provide easy accessibility to all components of the equipment.
5. Advanced fabricating techniques have been developed so that repair time can be kept to a minimum. Experience on earlier simulators has shown that down-time averages 2% or less, even when the equipment is being used as much as 18 hours per day.

The cockpit never leaves the ground, nor does it move or gyrate. So complete is the simulation effect, however, that crews in training have a perfect sensation of actual flight. Partly this is the result of realistic sound effects, which permit the crew to hear the noises of engines and propellers—and the sound of wheels hitting the runway as the simulator is brought in for a "landing." All sound effects, including those resulting from failure to synchronize propellers accurately in a two or four-engined aircraft, are produced electronically.



Exploded drawing of cockpit assembly of the C-124A electronic aircraft flight simulator

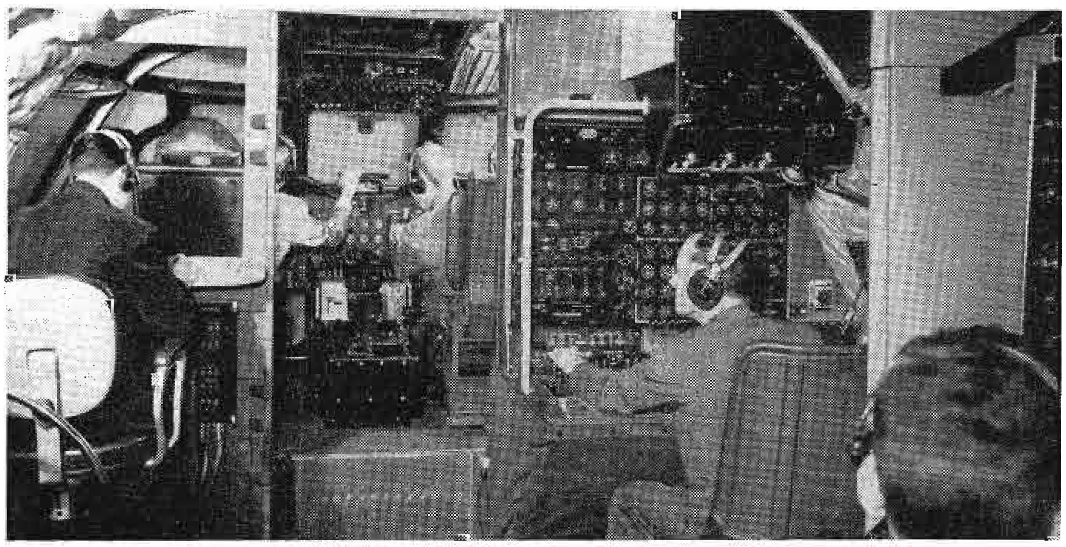
Just back of the cockpit and separated from it by a curtain is the instructor's compartment which contains all radio aids equipment and a trouble console.

Radio aids devices, to which are connected course and glide path recorders, provide a means of accurately reproducing radio range signals and such other navigational signals as VOR and DME. In addition, ILS and GCA are included.

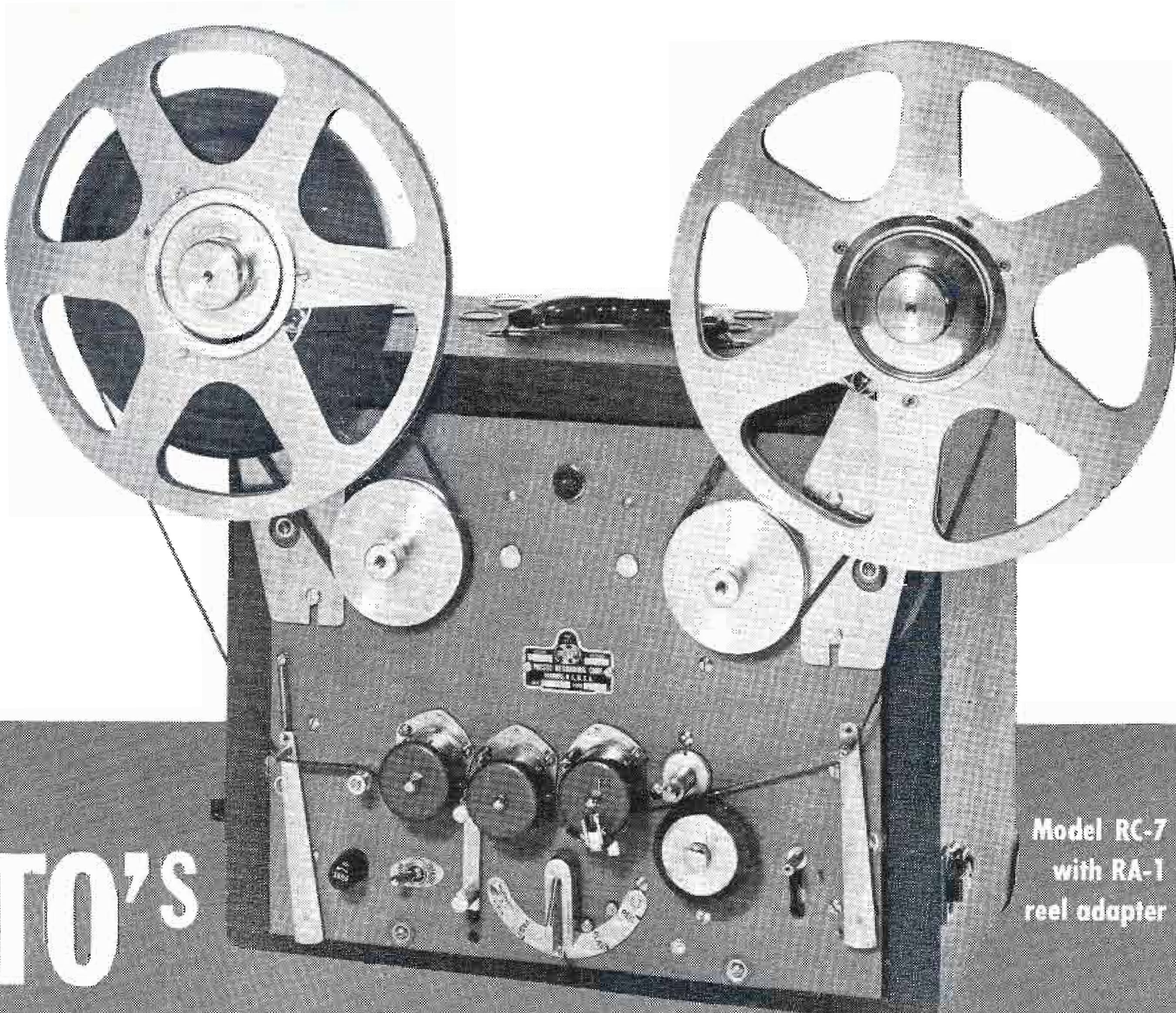
The trouble console permits the instructor at will to add emergencies to any flight routine. These can include fires, mechanical failures, icing, propeller and engine troubles, landing gear failures, and the like.

In the Curtiss-Wright Dehmel simulator, engine operation is simulated by four analog computers—one for each power plant. It is through this means that all engine performance variables are related to provide exact simulation. Loss of one or more engines reflects in thrust and aerodynamic computations. Engine instruments automatically reflect any condition which affects engine power and efficiency. By means of computers the effects of aerodynamics and power are translated into instrument readings as in the aircraft itself.

The electronic control loadings reflect in the feel of the "stick" changes in wind, velocity, angle of attack, and trim. The control force system receives signals from each of the many sources which affect it in actual flight. These are resolved by electronic devices and translated into simulated forces by sensitive and accurate servo systems.



Looking over shoulder of an instructor (lower right) at trouble console toward (l to r) check pilot, pilot, co-pilot and engineer in simulator. In use, curtain is drawn between crew and instructors



Model RC-7
with RA-1
reel adapter

PRESTO'S "LONG PLAYING" PORTABLE TAPE RECORDER

The PRESTO RC-7 has already been acclaimed "the finest tape recorder of its size available." Although portable in size, the RC-7 embodies features and heavy duty construction found only in larger, more expensive, studio-type machines.

Now, with the new RA-1 reel adapter, this precision recording instrument becomes an indispensable piece of equipment for every station and recording studio. With this adapter, the RC-7 accommodates reels up to 10½" diameter, providing continuous long-period recording or playback.

If you are contemplating a portable tape recorder, don't buy any—until you see the PRESTO RC-7 with 10½" reel adapter (RA-1). Without a doubt, it's the *best buy in professional tape equipment!*

Present PRESTO RC-7 owners may convert their machines with this adapter for just $39.00. Write today for details!

Compare the RC-7 with any studio-type recorder

- Instantaneous speed accuracy
- Dynamic range better than 50 db. at 3% distortion
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- No friction clutch or friction brakes
- Heavy duty construction throughout
- Separate erase-recording-playback heads
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Anechoic Chamber

(*Continued from page* 49)

water trapped near the front surface. In view of these experiments it is considered likely that, at least in dry weather, these materials can also be used effectively to reduce reflections from obstacles near outdoor antenna test ranges.

Design of Chamber

Physical Description: The framework of the chamber was built of 2 x 4 in. lumber inside an available room, and is 20 ft. long, 10 ft. wide and 7 ft. 8 in. high. The absorbing mats are tied to the walls and ceiling with string and laid on the floor where necessary. Two access doorways at either end are masked by screens of absorbing material on a portable framework.

The transmitting antenna under test is mounted on an L-shaped arm (Fig. 5) which extends down into the chamber from a rotating mount on the roof of the chamber. The klystron oscillator is mounted on this arm and rotates with the antenna. The receiving antenna is on a rolling mount which is guided by a track down the middle of the floor. This mount contains a motor for rotating a linearly polarized antenna about its axis for automatic recording of antenna polarization characteristics.

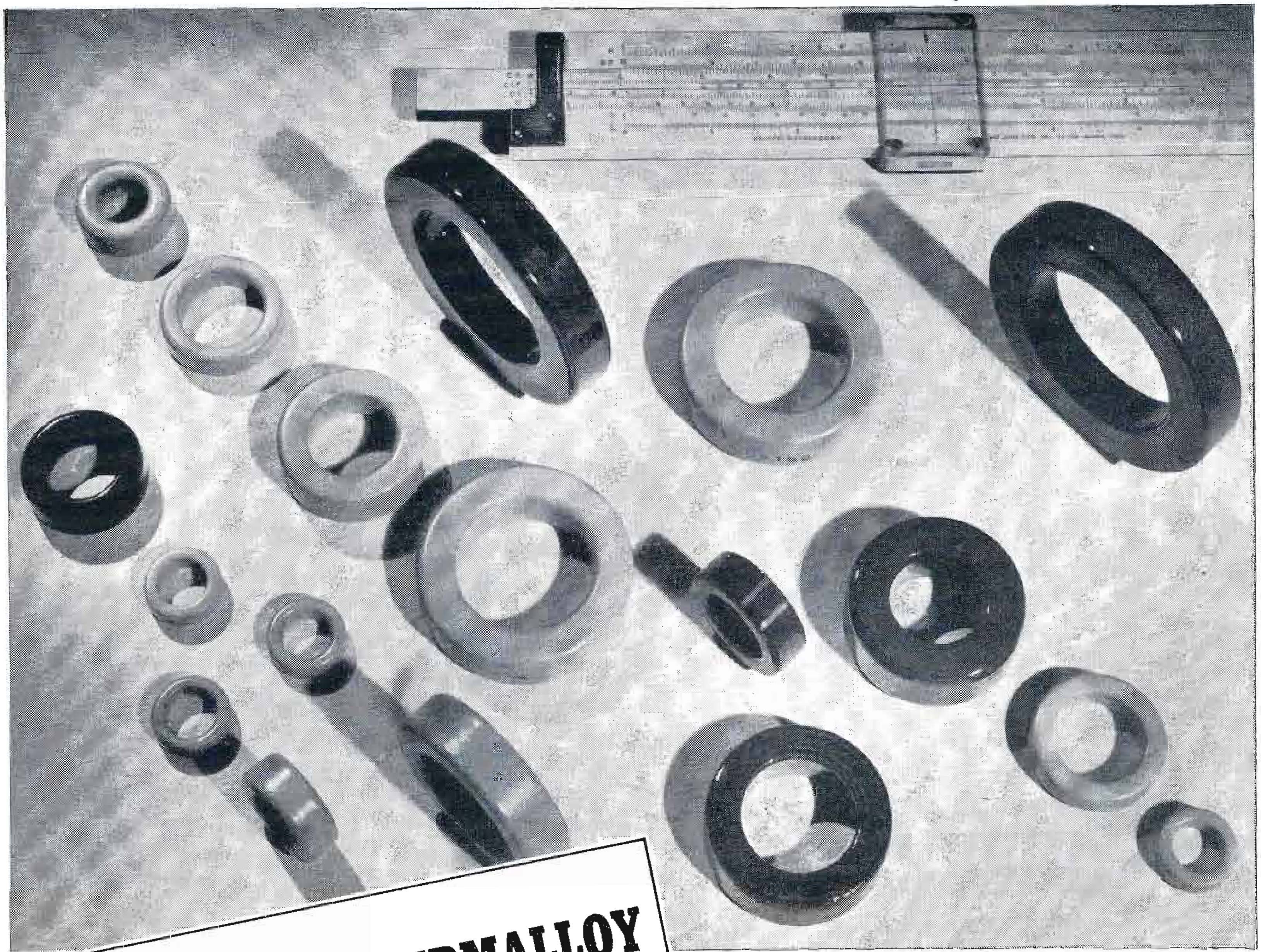
Maximum separation between receiving and transmitting antennas is about 13 ft. making possible the study of antennas up to 10 in. in diameter at X-band (around 3.2 cm) and 18 in. at S-band (around 10.0 cm), using the criterion $R_{min} = 2D^2/\lambda$, where D is the maximum linear dimension of the larger of the two antennas.[1]

Theoretical Considerations: In the measurement of directive antennas, the greatest error in pattern occurs when the transmitting antenna, whose pattern is being measured, has rotated so that it points at a spot on the wall midway between the receiving and transmitting antennas. At this angle, energy is transmitted from one antenna to the other by specular reflection off the wall. If the angle of rotation is θ_r and the effect of the reflection is represented by an image antenna behind the wall, then the ratio of undesired to desired signal strength is

$$\left|\frac{E_u}{E_d}\right| = \frac{R_1}{R_2}\sqrt{\frac{P_I\, G_T(\theta)\, G_R(\theta_r)}{P_T\, G_T(\theta_r)\, G_R(\theta)}},$$

where R_1 is the distance between transmitting and receiving antennas,

(*Continued on page* 102)



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*Manufactured under license arrangements with Western Electric Company

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R_2 is the distance between image and receiving antennas,

P_T is the total power radiated by the transmitting antenna,

P_I is the total power radiated by the image antenna,

$G_T(\theta)$ is the gain of the transmitting antenna,

$G_R(\theta)$ is the gain of the receiving antenna.

If $P_I/P_T = \alpha\ (\theta_r)$, the power reflection coefficient of the absorbing material at the angle θ_r, and if $G_T(\theta) = G_R(\theta)$, i.e., transmitting and receiving antennas are identical, then

$$\left|\frac{E_u}{E_d}\right| = \frac{R_1}{R_2}\sqrt{\alpha\ (\theta_r)}.$$

As a numerical example, if $R_1/R_2 = 1/2$ and $\alpha(\theta_r) = 1\%$, as measured on single mats, then

$$\left|\frac{E_u}{E_d}\right| = 0.05,$$

and the pattern could be in error by $\pm$ 1/2 db at this angle θ_r. An error of this magnitude is usually tolerable.

If

$$\frac{G_R\ (\theta_r)}{G_R\ (0)} > \frac{G_T\ (\theta_r)}{G_R\ (0)},$$

this is, the receiving antenna is less directive than the transmitting antenna, the error becomes larger, so it is obviously advisable to make the receiving antenna as directive as the transmitting antenna, except at frequencies where α is so small as to make this precaution unnecessary. It is not worthwhile, in general, to make the receiving antenna much more directive than the transmitting antenna, since this means increasing the separation, R_1, in accordance with $R_{min} = 2D^2/\lambda$. Increasing R_1 makes θ_r smaller, which makes the factor R_1/R_2 larger, and can make $\alpha\ (\theta_r)$ larger. In addition, with θ_r smaller, the interference occurs at angles closer to the main beam axis where most interest in the pattern is usually centered.

Another case of interest is the non-directive beacon-type antenna. If a directive receiving antenna is used to measure its pattern the only significant reflections come from the back wall, directly behind the omnidirectional antenna, since this is the only spot in the main beam of the receiving antenna. Thus

$$\left|\frac{E_u}{E_d}\right| = \frac{R_1}{R_2}\sqrt{\alpha\ (0)}.$$

This expression is independent of the receiving antenna gain as long as that gain is sufficient to discriminate appreciably against reflections from side walls. Here again if α (0) $\leqq$ 1% and $R_1/R_2 \leqq 1/2$, the pattern is accurate to at least $\pm$ 1/2 db.

Experimental Tests: In the foregoing simple theory, various assumptions have been made including the one that the wall acts as a specular reflector whose reflection coefficient may be measured on a single sample by the two-horn method mentioned previously. In order to see if these assumptions give a reliable guide to the use of the room, and in order to evaluate the room experimentally, three kinds of experiments were performed. The first and most direct was to compare patterns measured in the chamber with those measured on a fairly reliable roof top site. The second was an attempt to measure reflections off the walls directly, similar to the measurements made on individual mats. The third was an attempt to measure standing waves set up in the room by reflection off all the walls.

(a) Comparison patterns for two fairly large antennas at X- and S-band are shown in Figs. 6 and 7. Fig. 6 shows E-plane patterns of an 8-in. double-dipole-fed paraboloid at X-band (λ = 3.2 cm.). Notice that the outdoor patterns are not perfect, showing some fluctuation at wide angles due to reflections off nearby objects. It is felt that the agreement between the two patterns is good. The filling in of the first minima was caused by phase error, not by reflection. The spacing between antennas in the room was slightly too small to measure exactly the true far-field pattern. This perturbation was small enough to affect only the depth of the minima. Fig. 7

(*Continued on page* 105)

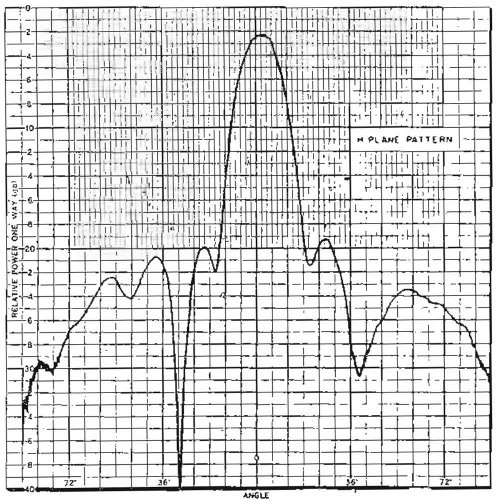

Fig. 8: Pattern of 17.5-inch paraboloid showing effect of wall reflections when small non-directive receiving antenna is employed at S-band

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shows H-plane patterns of an S-band ($\lambda = 10$ cm) dipole-disc-fed paraboloid, and again agreement is good between indoor and outdoor patterns.

To illustrate the effect of wall reflections, the patterns of the S-band antenna were repeated using a small non-directive antenna as a receiving antenna, with results shown in Fig. 8. In this case, θ_r was about 35° and α (θ_r) was several percent, as determined by single-mat measurements, so that in the region around 35° severe pattern distortion may be noted (compare Figs. 8 and 7). It is to be pointed out, however, that this distortion was effectively eliminated by use of a directive receiving antenna as shown in Fig. 7.

(b) Using these same antennas, a direct measurement of wall reflection was made by measuring patterns with the receiving antennas directed at various points on the side wall and noting the apparent increase in side lobe level due to reflection. By far the greatest reflection was found at the angle of specular reflection, indicating that non-specular scattering plays a small part in the perturbation of patterns. Results for this one angle of incidence, 55°, ($\theta_r = 35°$) which was the largest feasible in the room, should represent a worse case, are shown below:

Wavelength	Polarization With Respect to Plane of Incidence	Maximum Power Reflected (At 55°)
3.2 cm	perpendicular	—27 db
3.2 cm	parallel	—35 db
10.0 cm	perpendicular	—13 db
10.0 cm	parallel	—23 db

These measurements are a check on the single-mat measurements. They are obtained by a slightly different method and measure reflections from a whole wall instead of a single mat. The results are in good agreement.

(c) Although in almost all cases, only the reflections from a single wall at a time need be considered when the perturbing effects of the room are taken into account, one experiment was performed which measured the effect of multiple-wall reflections. This was a sort of standing-wave measurement. One omnidirectional antenna, a monopole mounted on a ground plane, was swung in an arc about a similar antenna (see Fig. 9) and the rapid pattern fluctuations were measured to give an indication of reflections adding in random phase to the direct signal. The fluctuations in the neighborhood of the center of the room were converted into percent undesired signal power and the re-

(*Continued on page* 106)

sults for a 4-foot separation of antennas are shown below:

λ	Maximum Undesired Power %
3.2 cm	1%
5 cm	4%
7.5 cm	3%
10 cm	3%
12 cm	2½%
15 cm	5%
20 cm	4%
25 cm	3%
30 cm	5%

These measurements, though somewhat approximate, agree fairly well with what might be calculated using single-sheet reflection coefficient measurements and taking into account multiple-wall reflections in random phase.

Conclusion

The room was designed principally for use in the range from about 3,000 to 10,000 MC. No difficulty should be observed in extending this frequency range upward since the absorbing properties of the material have been shown to remain good, at least through 60,000 MC. A gradual increase in reflection below 3000 MC makes the room less useful, though the results of the standing-wave

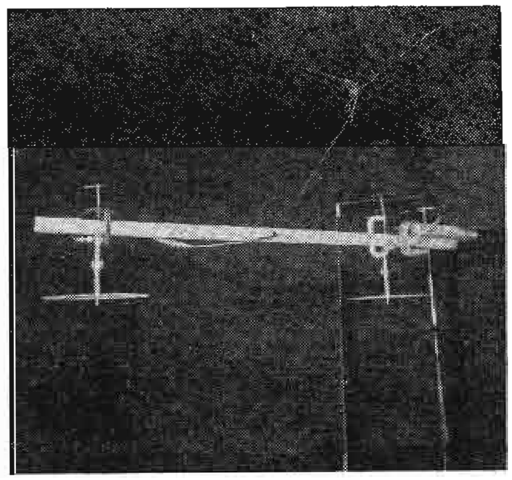


Fig. 9: Standing-wave measurement set-up

test and measurements on single samples indicates that the reflections at frequencies down to 1000 MC have not increased beyond the point of usefulness. When the room was being constructed, some thought was given to building it in some shape other than rectangular. The side walls might be corrugated or the end walls brought in in a wedge. If a fixed setup were used such devices might prove useful in further reducing reflections. In our case, the good results obtained plus the fact that it was difficult to design the room to minimize reflection for all possible setups led us to adhere to the simple rectangular shape.

In conclusion, it seems that the results of measurement on a single sample may be applied by means of a simple image theory to give correct order of magnitude for the perturbing signals due to reflections. In our chamber, though it is relatively small, patterns of X-band antennas up to 10 in. in aperture dimension may be safely measured with results often better than those on an average roof site. The absorbing material is more than adequate at X-band. At S-band, with the precaution of using as directive a receiving antenna as the antenna under test, antennas up to 18 in. may be safely measured to an accuracy of about 1/2 db out to pattern angles where the signal strength is 20 db down. Omnidirectional antenna patterns may be measured to an accuracy of less than ± 1/2 db from 3000 MC up, with slightly reduced accuracy between 1000 and 3000 MC.

[1] S. Silver, *Microwave Antenna Theory and Design*, Rad. Lab. Series, vol. 12, McGraw-Hill 1949, p. 575.

Evacuated Junction Transistor Developed

Bruce A. Coffin, president of CBS-Hytron, Danvers, Massachusetts announces a new *evacuated* junction transistor. Sealing each transistor in a vacuum is a further improvement upon the original hermetic sealing of transistors announced less than two months ago by CBS-Hytron, a division of Columbia Broadcasting System, Inc.

The surfaces of junction transistors, commonly used in electronic hearing aids, are extremely sensitive to moisture. Manufacturers of transistor hearing aids report that for dependable operation, transistors must be sealed against moisture. Ordinary junction transistors encased in molded plastics, they have discovered, are short-lived.

All polar molecules that in time might deposit themselves upon the junction boundary line of these transistors are removed by the evacuation process, unwanted leakage of applied currents and the resultant and gradual break-down of the transistors are eliminated and dependable operation is assured by this new CBS-Hytron evacuation process.

Bellford Plans Move

Bellford Metal Products Co., presently located at 5511 Bellford Ave., Cleveland 27, Ohio will soon move to new and larger quarters in Solon, Ohio. The company manufactures all types of hex head screws by the cold heading process.

S-Band Sweep Generator and Test Set

In the article "S-Band Sweep Generator and Test Set," published in the June 1953 issue of TELE-TECH & ELECTRONIC INDUSTRIES, page 116, credit for the co-authorship of Mr. James H. Kluck of the Naval Research Laboratory was inadvertently omitted. Co-author with Mr. Kluck is Mr. Roy E. Larson.

Tape Reader

(*Continued from page* 35)

ern version of the vacuum reader principle which is capable of reading 8 hole, one-inch wide tape at speeds up to about 25 per second. The reliability is extremely high and tapes may be run and rerun several hundred times without error.

Electrical Contacts

In the pneumatic tape reading head shown in Fig. 1, one pair of electrical contacts per tape hole is provided. These contacts open and close as the perforated tape passes over a reading head. No auxiliary equipment or amplification is necessary except for a vacuum pump. Eight holes corresponding in position to each of the possible hole locations across the tape are either open or stopped as the tape moves. A vacuum manifold which connects with each of the eight sensing holes causes a momentary pressure drop in any of the eight associated air passages when the sensing holes are blocked by the tape. Then when a tape hole passes across a sensing hole, the pressure quickly rises to atmospheric. These pressure pulsations are transmitted to miniature bellows-actuated switches which open or close their respective circuits in accordance with the coded tape information.

Operation

The operation of a typical hole reading pneumatic switch may best be understood by referring to Fig. 2. This is a schematic representation of the pneumatic circuits for two holes. Here we have a solid block in which have been drilled a number of interconnecting passages. The perforated tape is pulled over the holes at uniform speed by means of a driven pin wheel. Let us assume that hole A is open; hole B closed and that a vacuum pump capable of maintaining a vacuum of 20 to 24 in. of mercury is connected to the manifold as shown. The absolute pressure in the vacuum manifold is called P_1.

Outside air at atmospheric pressure will flow into "A", through the small orifice B and into the manifold dropping in pressure to P_1. Bellows operated switch SW_1, being vented to the atmosphere through A, will close due to the spring action of the bellows. Simultaneously, reading hole C being stopped by the tape permits the pressure in the bellows switch SW_2 and its associated connecting passages to drop rapidly to P_1 in the vacuum manifold. All flow through orifice D ceases, P_3 becomes equal to P_1, and SW_2 opens its contacts. The construction of a bellows switch is shown in Fig. 3. The essential parts are a movable, grounded contact fastened to the end of a metallic bellows; a fixed insulated contact mounted on an adjustment screw and an outer housing to maintain all the components in a rigid relationship to one another.

Reducing Air Volume

Not shown in Fig. 3 is a drilled metal plug extending into and almost filling the interior of the bellows. The purpose of this important design feature is to reduce the volume of air included in the bellows to a minimum permitting only the maximum necessary bellows deflection which is of the order of 1/32 in. Thus the effective bellows cross-section may be large to attain sufficient pneumatic actuating force together with minimum operating time.

Fig. 4 shows a laboratory experimental set-up of an 8-hole pneumatic tape reader. The tape is pulled across the reading head by means of a sprocket pin-wheel at a speed of 2.5 in./sec, which with standard hole spacing, is equivalent to 25 pulses per second.

The tape supply and take-up reels are driven in opposite directions through slipping clutches to maintain a light but constant tape tension. To facilitate changing tapes, the supply reel is mounted in a vertical plane and rim driven.

Output Pulses

Tests thus far performed on the Martin Pneumatic Tape Reader indicate that under dynamic-operating conditions with an actual test tape, extremely accurate high amplitude output pulses may be obtained. These pulses when measured at a repetition rate of about 15 per second show an "on" time of 50 milliseconds, "off" time of 20 milliseconds with switch contact forces approximating 4 oz.

Tape threading problems with a pneumatic reader are minimized since atmospheric pressure on the tape over the closed holes is sufficient to maintain the paper in intimate contact with the reading head.

Credit for the success of this project is due to Mr. W. Black who did much of the detailed mechanical design and Mr. C. Herzog who painstakingly constructed the first model.

All the work in the development was performed at The Glenn L. Martin Co. under the sponsorship of the U. S. Army Signal Corps.

Printed Circuit

(*Continued from page 38*)

suppliers. The solvent capacity is approximately 8 ounces of copper per gallon.

On completion of the etching process, the plate is rinsed free of etch and wiped dry. Cold top enamel remover applied by means of a cotton swab wound on the end of a glass rod is effective in removing the remaining resist. Fine steel wool may also be used to clean off the resist especially when the highly corrosive action of the enamel removing solution is to be avoided. As an aid to soldering, the plate may be given a silver flash by immersion in a 10% silver cyanide solution for a few seconds.

Following is a list of equipment together with sources of supply:

Photoengraving Supply Firms:
- Vinyl film and glass plate negative materials.
- Photographic and photoengraving chemicals.
- Darkroom equipment and cameras.
- Cleaning materials (pumice brushes, etc.)
- Cold top enamels, developers and removers.
- Whirlers, sinks, developing tanks.
- Vacuum frames and pumps.
- Arc lamps.
- Etching machines and etching solution.

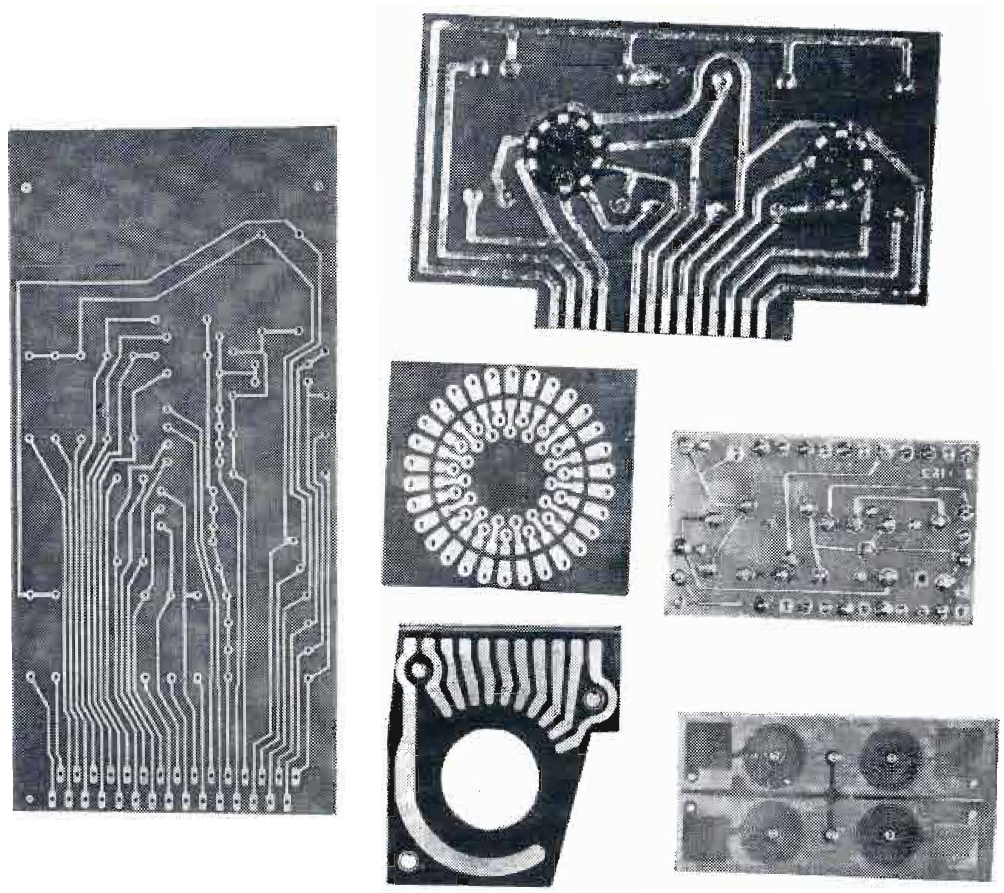
Silk Screen Suppliers:
- Vinyl base cutting film (profilm).
- Acrylic sprays.
- Retouching brushes and knives.
- Printing frames.
- Vinyl film.

Drafting Material Suppliers:
- Glass base drawing cloth.
- Drafting instruments and supplies.

Junction Transistor Price Reduction

The Raytheon Manufacturing Co., Receiving Tube Division has announced a reduced user price of $4.50 for the Raytheon CK722 junction type transistor.

The company believes that this announcement will be of special interest to the experimenters and engineers who intend to enter the Raytheon $10,000 transistor contest which is based on building a piece of electronic equipment incorporating one or more CK722 transistors. Official entry blanks for this contest which closes at midnight, August 31, 1953, may be obtained from any Raytheon Special Purpose Tube distributor.



ABC Audio

(*Continued from page 42*)

amplifiers are mounted in the equipment room racks.

All racks were assemblied and wired in the GE plant. It is worth noting here the wire which was used for all the rack wiring. GE made use of their FA-19-K wire which is a three-conductor shielded cable with an outside diameter of only 0.118 in. The cable is composed of two nylon insulated #22 conductors and one bare #20 conductor. The three conductors are twisted together in a two-inch lay and a shield is spiralled around this assembly (not braided). Over this shield is an extruded nylon outer jacket. The amount of wiring which would normally require a 1.25-in. conduit can be put in a 0.75-in. pipe when this type of cable is used.

Another feature of the wiring of all racks was the use of wiring ducts. These ducts are U-shaped metal channels equipped with readily removable full length covers. The ducts are 77-5⁄16 in. long, 4 in. wide, and 1-7⁄8 in. deep. One side of the duct has forty-two slots, each fitted with a 5⁄8-in. rubber grommet. The duct is designed to be installed in the rear of a cabinet rack with the slotted side of the duct facing the front of the rack. The use of these ducts eliminates the need of lacing and supporting cables and makes wiring changes a simple matter. In some cases as many as 320 FA-19-K cables were carried in two of these wire ducts.

"Break-in" System

To fill the Output Switching requirements, it was necessary to distribute any of 24 program sources to eight outgoing channels with advance preset control. In addition, a "Break-in" system was to be provided for flash announcements, which would by pass the normal switching system without disturbing the "Preset" and "On Air" status of the switching system.

One of the first things which was considered in the design of the switching system was whether or not it should be an all-relay system or a direct switching system. The GE engineers felt that a satisfactory system could be developed around a special spring leaf contact switch, activated by interlocked push-buttons. Such a system, they believed, would result in the following: less wiring in manufacture, lower material costs, and less labor and wiring requirements for installation. It was decided to design the switching system around the special push-button switches.

When the circuit design for the switching system was complete, the requirements in a switch then became known. Since it was required that 24 inputs be switched to an output channel, it was obvious that any mechanically interlocked 24-button switch would be impractical due to mechanical tolerances and effort required to operate such a switch. It was then decided to use two 12-button switch assemblies and work out an electrical interlock between two mechanical switch assemblies.

Push Button Switches

As a source of supply for such a switch, GE turned to the Donald P. Mossman Co., manufacturers of a wide selection of push-button switches which use nickel silver leaf spring with palladium contacts, instead of the customary slide type of contact found on most push-button switch assemblies. This type of contact spring assembly being identical to those used on relays, provides a trouble-free, long-life, self-cleaning switch. The final specifications for the switch called for a 12-station mechanically interlocked push-button switch with electrical "lock-in" and "release" features. Each position of the switch was to have nine form "A" contact combinations and the interlock latch bar was to be so constructed that no two buttons could be depressed simultaneously. Through the efforts of Mr. Donald P. Mossman, Jr., and his company, the switch of Figs. 6 and 7 was designed and manufactured.

In regard to the "release" and "lock-in" features of these switches. In order to operate two 12-station switches as one 24-station unit, a "release" solenoid was mounted on the end of each switch assembly. The solenoid, when energized, exerts a pull on the latch bar which in turn releases any button which has been latched in. These solenoids are operated by series contacts on the switches. The operation is such that when a button on one switch is depressed, any button which was depressed on the other switch will be released.

Since the system was to operate on a "Preset" principle, two 24-station Switch groups had to be provided for each output channel. This allows one switch group to be in an "On-Air" status, and the other group available for "Preset." The changeover from one group to the other is accomplished through the

(*Continued on page* 114)

use of a flip-flop relay. The "lock-in" feature makes use of a second solenoid mounted on the opposite end of the switch from the release solenoid of each switch assembly. This solenoid, when energized, locks the latch bar in position so that it cannot be moved to release a depressed button. These "lock-in" solenoids are energized whenever their associate switches are in an "On-Air" status. This prevents accidental release of a program source when "Presets" are being made.

Maintenance Requirement

This maintenance requirement was met by mounting two switches on a mounting plate. All the necessary wiring of the assembly was cabled out to four 35-pin Cinch connectors. The required cross-wiring between the two switches of an assembly was made with enough slack allowed to permit spreading the switches apart, when they are removed from the mounting plate. This permits easy accessibility to every contact for cleaning and adjustment.

Each output Switching Panel provides facilities for two output channels. Therefore, four of these switch assemblies were required. All assemblies are electrically and mechanically interchangeable.

In addition to the switch assemblies, each switching panel was furnished with "break-in" selector switch, operate key, and VU Meter for each of the two output channels.

The switching system was designed to provide for "Preset" type of operation and included such features as follows: remote release, "Program On" indications and a complete status light system which extended "Preset" and "On Air" lamp indications to all studios.

Flip-Flop Relay

In the operation of this switching system, the changeover from one bank of switches to the other bank is accomplished through the use of a mechanically interlocked flip-flop relay and an associated relay which transferred all indicator and control circuits. The flip-flop relay requires only a short pulse to change its position and requires no holding current while in either position. It is worth mentioning here that this pushbutton switching system, along with its mechanically interlocked flip-flop relay, will not drop or release any program connections in event of a 24-volt power supply failure. Program switching can still be carried on by pushing the buttons of the desired program sources. Only indicator lamp and "lock-in" protection are lost with a relay power failure.

The "Remote Release" feature of the switching system permits the Master Control Operator, at his discretion, to delegate "Release" of an output channel to the studio which is "On-Air." The Master Control Operator can release each channel individually, or collectively, by making use of either one of two group release circuits. This feature permits any or all channels to be switched simultaneously by depressing a single push key.

Germanium diodes were employed for two purposes in the control circuits of these switching panels. One application of these diodes was for click suppression of all solenoid and relay coils. General Electric type 1N48 diodes were used for this purpose. The current and voltage ratings of the 1N48 diodes were found to be adequate for this application on 24-volt control circuits.

A life test on this type of application was run by the GE Components Lab. In this test, twenty 24-volt

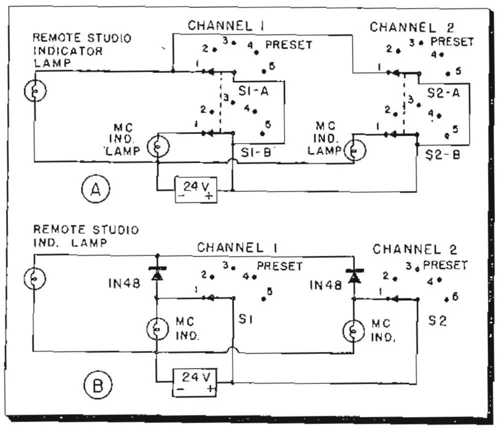


Fig. 8: (a) Wiring for usual switching circuit. (b) Use of diodes cut required wiring by 20%

relays were used. A 1N48 diode was connected in the proper polarity across each relay coil to suppress the induced voltage when the coil circuit was opened. These relays were then operated by an interrupter device for a run of well over 500,000 operations without a diode failure. At specified periods during the test observations were made on an oscilloscope and no spikes were observed.

The advantages of this type of click suppression are two-fold. From an electrical viewpoint, a much better job of click suppression is accomplished than by the usual resistor and capacitor combination. Mechanically, it results in a saving of material and space. This is possible because the small size and

(Continued on page 116)

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weight of the diode permits its mounting by soldering the pigtails directly to the coil leads.

Each complete Master Control System required more than 800 indicator lamps. In addition it was necessary that the "Preset" lamp and the "On-Air" lamp located on each studio console would indicate from any of eight switch circuits in Master Control. Due to the number of circuits involved in such an indicator system, it was felt that efforts to simplify the necessary wiring were in order. Therefore, it was decided that polarized circuits would be a step in the right direction. With this in mind, GE again turned to the germanium diode as a solution to a problem.

Series Feedback Loops

In a circuit where several single indicators must be connected to a common indicator circuit, adequate steps must be taken to eliminate series feedback loops which could give false indications. This necessitates additional switch contacts and wiring. By applying diodes to this problem, it is possible to polarize the lamp circuits and eliminate chances of series loops.

In the design of this switching system, the use of diodes in the lamp circuits eliminates a form "A" contact combination on each position of the Mossman switches. It also cut the required circuit wiring by about 20% which resulted in quite a saving. This application is shown in Fig. 8.

Type 24X switchboard lamps were used throughout the system for indicator purposes. The current requirements of this lamp at 24 volts, runs from 32 to 38 ma. The 1N48 diode will handle up to 50 ma so it was chosen for this application.

The Components Lab. ran some tests on this application. Four 24X lamps, each connected in series with a 1N48 diode, were connected across an interrupted 24-volt source. At the end of 500,000 interruptions, none of the lamps or diodes had failed. In this type of circuit, it was found that a slight reduction in briliancy in the indicator lamps was noted. This has not proven objectionable. We believe that the lamp life will be extended in a circuit of this type due to the effect of diode resistance on the starting current of the lamps.

An overall system test of the equipment before shipping was considered impractical due to production schedules of the different racks which composed a complete system. However, each rack when completed, underwent a complete operational test before being shipped.

The complete overall system test was, therefore, made after the installations were complete, and was entirely successful. The three operating groups of ABC Radio have experienced minimum maintenance after the initial weeks of shakedown.

The authors wish to acknowledge the aid and cooperation of Mr. John Bourcier, ABC New York Engineering Operations Supervisor

Coming Events

July 10-12—6th-Annual National Convention of the ARRL Shamrock Hotel, Houston, Texas.

Aug. 1-5—National Audio-Visual Trade Show, Hotel Sherman, Chicago, Ill.

Aug. 17-18—Symposium on Statistical Methods in Communication Engineering, Berkeley, Calif.

Aug. 19-21—Western Electronic Show and Convention, San Francisco Municipal Auditorium, San Francisco.

Aug. 25-28—APCO, 19th Annual Conference, Sheraton-Cadillac, Detroit, Mich.

Aug. 29-Sept. 6—West German Radio and TV Exhibition, Dusseldorf, Germany.

Sept. 1-3—International Sight and Sound Exposition, Palmer House, Chicago, Ill.

Sept. 1-12—British 20th National Radio & Television Exhibition, Earlscourt, London, England.

Sept. 9-12—NEMA, Haddon Hall Hotel, Atlantic City, N.J.

Sept. 13-16—AICE (Quarterly Meeting) Fairmount and Mark Hopkins Hotels, San Francisco, Calif.

Sept. 21-25—ISA 8th National Instrument Exhibit, Sherman Hotel, Chicago, Ill.

Sept. 28-30—9th Annual National Electronic Conference, Hotel Sherman, Chicago, Ill.

Sept. 30-Oct. 1—Aircraft Electric Equipment Conference, AIEE, New Washington Hotel, Seattle, Wash.

Oct. 5-9—7th Convention of the SMPTE, Hotel Statler, New York, N.Y.

Oct. 6-8—Fractional Horsepower Motors Conference, AIEE, Fort Wayne, Ind.

Oct. 14-16—Machine Tool Conference, AIEE, Hotel Cleveland, Cleveland, Ohio.

Oct. 14-16—Recorder-Controller Section, SAMA, Mid-year Meeting, Seaview Country Club, Absecon, N.J.

Oct. 14-17—Audio Fair, Hotel New Yorker, New York, N.Y.

Oct. 19-21—RTCM Fall Assembly Meeting, Edgewater Beach Hotel, Chicago.

Oct. 30-31 — Semi-Annual Meeting, ASTE, Dayton Biltmore, Dayton, Ohio.

AICE: Amer. Inst. of Chemical Engineers
AIEE: Amer. Inst. of Electrical Engineers
APCO: Assoc. Police Communication Officers
ARRL: American Radio Relay League
ASTE: American Society of Tool Engineers
ISA: Istrument Society of America
NEMA: Nat'l Electrical Mfrs. Assoc.
RTCM: Radio Technical Commission for Marine Services
SAMA: Scientific Apparatus Makers Assoc.
SMPTE: Soc. of Motion Picture and TV Engineers

Color TV

(*Continued from page 56*)

cost of these tubes and necessary circuitry and it becomes evident that a color receiver will have to be priced at $800 or more. There is no doubt that they will be expensive.

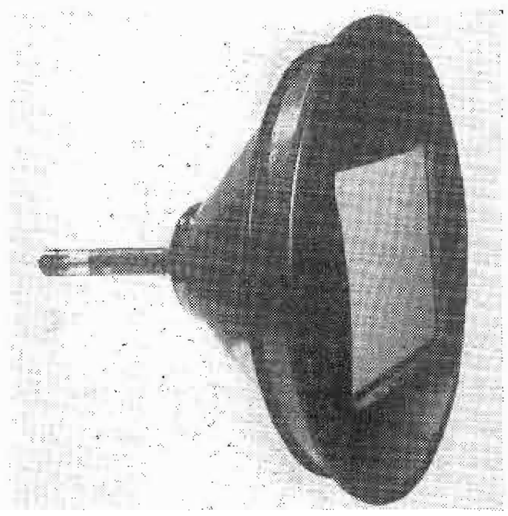
I am presuming in this projection that the color picture size will be equivalent to the 21" black and white picture. Most demonstrations to date have shown smaller size pictures. This problem still lies ahead of the tube industry, but must be resolved if color is to compete successfully with black and white.

Looking forward to picture sizes for color television, it is obvious that sizes must be equal to black and white, probably starting with a 21-in. picture and later including 24 and 27-in. pictures, if and when these sizes are available in monochrome receivers.

Target Dates for Color-TV

It now appears possible that the NTSC can conclude its technical work by September. We might then allow 45 to 60 days for the complete organization of all data to be presented to the FCC.

If such a schedule is met we can assume that the NTSC would petition the FCC for a hearing in October or early November. This could mean that the hearing could be scheduled early in 1954 and the



Chromatic's Lawrence tube, now in pilot production, is 22 in. in diameter, 21.5 in. long, and has rectangular color screen 11 by 15 in.

NTSC system could be approved by March 1, 1954.

If this should happen, I think I can safely predict that some color programs would be available in key city markets shortly thereafter and that color programs, put on the networks might actually be available in many local markets certainly by the middle of 1954.

Also, by March 1, 1954, the color tube output could possiby attain a monthly rate of 2,000 to 4,000 tubes. Assuming that this is accomplished, it may be anticipated that a model or two of color receivers will be included in the Fall line of many manufacturers. Available quantities will be limited, but there should be enough receivers available to permit the public generally to see color television in comparison to black and white in the Fall of 1954.

Conclusions

I mentioned previously that I was convinced that this would be a good thing for the industry. This is an important point of my talk, so let me set forth my reasoning and conclusions in orderly fashion:

1) I believe that color television will come as an evolution and not a revolution.

2) Color will prove to be a supplementary service and will not quickly, or perhaps ever, completely replace the monochrome service.

3) I am confident that the standard black and white receiver will continue to be the back-bone of television sales for at least five years into the future.

4) But, there will be a very critical period in sales while the public appraises the value of color against black and white—becomes educated to the true facts of the actual advantages of color television—the programs that will be available—just how much color adds to the programs and what they would have to pay over and above the cost of a good black and white receiver. The quicker we can give the public the opportunity to make this side by side comparison and appraisal, the shorter will be the period of indecision and hesitancy to buy a black and white receiver.

5) If dealers in all areas are in a position to demonstrate color side by side with monochrome and actually show by direct comparison what each service offers, I am sure that a very high percentage of such prospects would reach the conclusion that a black and white receiver at its lower cost still represents a good sound investment for the future. This would be particularly true if it is shown that such a receiver will, without adjustment or additional cost, receive the color signal in black and white—complete compatibility.

Such a conclusion might be still more obvious by a price comparison, let us say, between well-performing 21-in. monochrome receivers in the price bracket between $250 and $450, as against 17 in. color picture receivers, listing between $750 and $900.

(*Continued on page 120*)

6) Therefore, actual demonstration of the relative value and price of monochrome versus color, would give the dealer a definitely better chance to sell monochrome, than if he attempted to compete with rumor, misunderstanding and public imagination, which would tend to run toward the anticipation of perfection; a general idea that the difference in price would soon be negligible and that it might be smart to withhold purchase of a monochrome set and wait for color.

Acceptance of Color

After this initial period and the rapidity with which color will be accepted by the public will depend on two major factors:

1) The matter of programs.—After all, the "show is the thing." People buy good entertainment. Color alone cannot make a good program out of a poor one. This has been proven in the motion picture industry. It has been 31 years since full color movies have been available, yet today monochrome movies are still the backbone of the business. Many black and white pictures continue to be the box office hits, while many "color" films are among the "flops."

Likewise, I believe that black and white programs will prove to be the "bread and butter" of the television industry for many years to come.

There is a serious matter of economics involved. The cost of programming has already reached staggering proportions that represent a real economic problem to television as an advertising medium. Color will add to these costs—of this, there can be little doubt. How many advertisers will consider that color will add enough "sell" to their programs to justify these extra costs?

Color will add little to the entertainment value of most of the highly popular shows on television today—the situation comedies; the prize fights and wrestling matches; the newscasts and most of the popular plays. True, some programs, like the variety shows, will be greatly enhanced, but will the public pay a big premium in the price of the receiver for this advantage, particularly, when he can get all such programs in excellent black and white on his present set?

2) Another factor also is undeniable—that the cost of the complete color receiver will always be higher than a standard monochrome set. It will always require, not only a more expensive picture tube, but also more receiving tubes and circuitry. I have heard optimistic indications that this difference in price may be

as low as 25%. I am inclined to believe that it may be nearer 50%. In any event, even 25% will prove an important economic factor in the mass markets, which leads me to predict that good standard black and white receivers will represent a comparative value that will attract the major portion of the market for many years to come, perhaps, for all time.

These are the two main reasons that convince me that color television will not be revolutionary but, rather, go through an evolutionary process until it finds its proper level as a supplementary service.

During 1955, the number of hours of color programs will gradually increase. At the same time, perhaps by the Fall of 1955, the price of color receivers will come down somewhat in price as the volume of production increases. We will then be entering the real period of evolution, with color gradually bettering its service and lowering its cost to the consumer. The ratio of color sales to black and white will increase, but I predict that standard sets will still outsell color receivers four to one in 1955.

By that time the industry will be oriented into a pattern where they will be offering the public both types of receivers as a matter of course, and the public will be making their individual choice purely on the basis of what each service offers to them at the price they have to pay. And, I am convinced that under such circumstances and realistic comparison, a high percentage of purchasers will continue to favor the standard black and white receiver. Plain economics will dictate this choice for millions of families, particularly when they know that such a receiver will bring them all the programs on the air in excellent black and white.

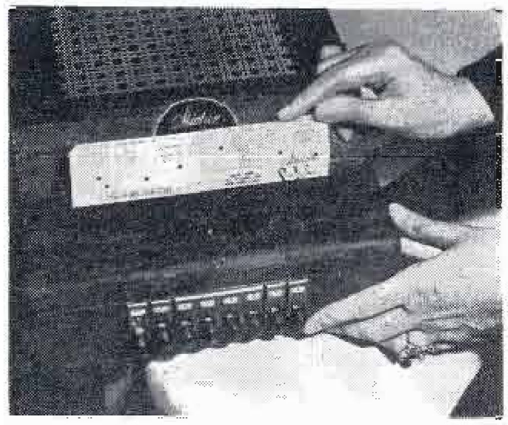
Tricolor kinescope tubes in pilot production are checked at RCA plant in Lancaster, Penna.

First Public Showing Of "Subscriber-Vision"

After 2½ years of tests in cooperation with WOR-TV, Skiatron's Subscriber-Vision has been placed on public display in New York City. Evaluation of technical and market information is in process, and a petition for FCC approval is expected this fall.

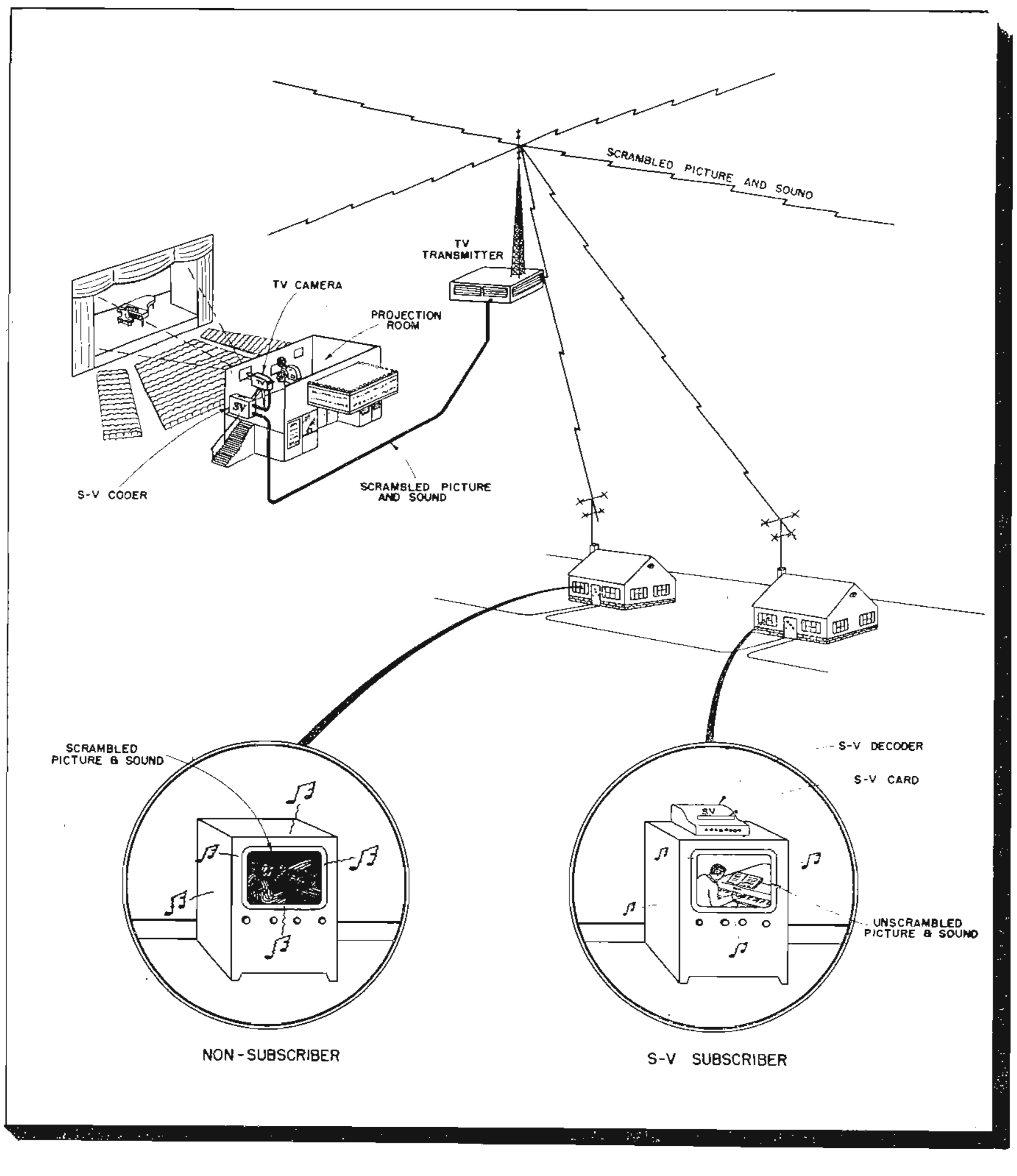
At a preview showing on June 8, Skiatron President Arthur Levey demonstrated how the system operated. Live and film signals were picked up, scrambled by a special coder at WOR's experimental KE2XKC, and transmitted over the air. Those TV sets receiving the broadcast without a special decoder produced a negative picture with double-image horizontal jitter and scrambled sound. Receivers with decoders displayed usual pictures by having a printed circuit punched card inserted into the decoder. For security, a multiplicity of combinations in the circuit allows only the properly designated program to be received undisturbed. For standard broadcasts, the decoder does not affect normal operation.

Initial plans for this pay-as-you-see TV system envision signing up 100,000 subscribers in the New York area. Each will receive a new card in the mail every week. Charges will be made only for those programs seen, with a minimum charge of about $2.50 per week. Billing will be handled by Western Union. Subscriber-Vision will supplement regular programs by buying time on existing stations to bring non-commercial sponsored plays, sports events, current movies and other features not otherwise available to viewers—all contingent on FCC approval.



Skiatron Subscriber-Vision decoder attaches easily to TV set. Program punched card with printed circuit at bottom is shown inserted

Pick-up for Subscriber-Vision employs standard TV and film cameras, whose outputs are scrambled in a special coder and then radiated by a standard station on a regular channel. Non-subscriber receives scrambled picture and sound. S-V subscriber uses decoder to receive clear program



Magnetic Amplifiers

(*Continued from page* 34)

ner frequency remaining at 30 CPS.

With the upper limit transfer function, the maximum stable loop gain would be about 200, increasing to 1200 for a lower limit transfer function. These figures are not acceptable since the integration error permissible is less than one part per thousand.

Transfer Function

Fig. 4 graphically represents the transfer function of the shaping network, the cascaded shaping network and upper limit motor and magnetic amplifier and the cascaded shaping network and lower limit motor and magnetic amplifier. Allowing for an uncontrolled variation of 6 to 1 in amplifier gain, the minimum loop gain expected is approximately 1000.

The foregoing description has intentionally emphasized the servo design problems associated with the use of magnetic amplifiers, as a warning against overoptimistic and indiscriminate specification of magnetic amplifiers for this type of application. However, it seems advisable to point out that an equally detailed analysis of any type of amplifier, meeting equivalent performance specifications, would probably disclose design problems of the same order of complexity.

Primary Objective

The primary objective has been to demonstrate the possibility of using magnetic amplifiers in some types of high performance servo-mechanisms. The acknowledged magnetic amplifier advantages in ruggedness and reliability may accordingly be obtained without sacrifice of performance. Recent magnetic amplifier techniques were not utilized in this application because of some doubt as to their present practicality. Specifically, this equipment is required to withstand ambient temperatures up to 85° C. It is our impression that no dry-disc type rectifier can be expected to have a reliable life much in excess of that of a vacuum tube at these temperatures. Accordingly the self-saturating type of magnetic amplifier, with its associated load circuit rectifiers, cannot be applied to such systems without loss of the reliability, which is one of the chief advantages of magnetic amplifiers.

The possibility of using higher-permeability core materials for these applications was explored tentatively. Their apparent minor ad-

(*Continued on page* 125)

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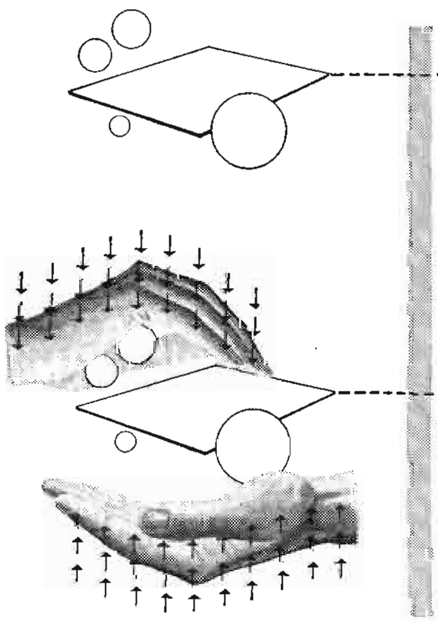

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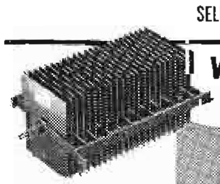

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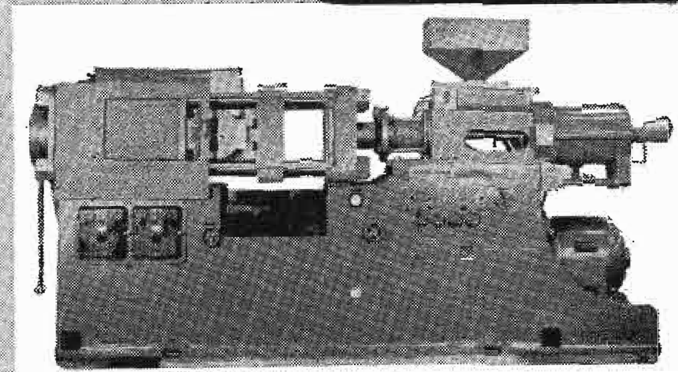

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vantages in efficiency and band width did not seem to justify the additional cost and manufacturing problems which they would entail. It is our impression that these core materials would be justifiable only in the self-saturating type of magnetic amplifier.

Obviously the combination of high-permeability core materials and the self-saturating circuit will greatly reduce the difficulty of the stability problems in magnetic servo-amplifiers. It is to be hoped that such applications will become practical in the near future.

This paper was presented at the 1953 IRE National Convention held in New York City, March 23-26, 1953.

Camera Tube

(*Continued from page* 57)

rant mention. The sensitivity of the tube is increased many fold and the photo-cathode dimensions are reduced. This permits the use of inexpensive (standard 16MM) lenses and enables the tube to operate with excellent signal-to-noise ratio in studio application with the incident light levels now used in television studios. It is possible with the use of an image focus coil of special design, to "enlarge" the charge image on the mosaic by a ratio of approximately 3 to 1 by means of a remotely operated, continuously variable resistance network. The image remains in focus at all times and the video output signal remains constant. The effect is to "dolly in" or "zoom" toward the subject without moving the camera or employing an expensive and heavy optical lens system. This principle permits the camera control operator to change the apparent subject to camera distance by means of a simple control.

Even with the addition of the image section, the tube is considerably smaller than other tubes used in television broadcasting. (See Fig. 2) The overall length measures slightly more than nine inches. The tube operates within wide temperature limits and eliminates the need for blowers and heaters to control the ambient temperature. The moderate tube size, small lenses, and the lack of a need for heaters permit a smaller camera head design.

The multicon is the heart of the new camera in the general purpose TV camera chain developed by Standard Electronics Corp., 285-289 Emmett Street, Newark, N.J. to meet the need for a simple, inexpensive pickup system. The new camera, reportedly, can be used with equal effectiveness on motion picture film, live talent and on still slides or opaques.

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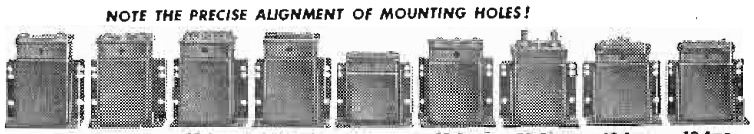

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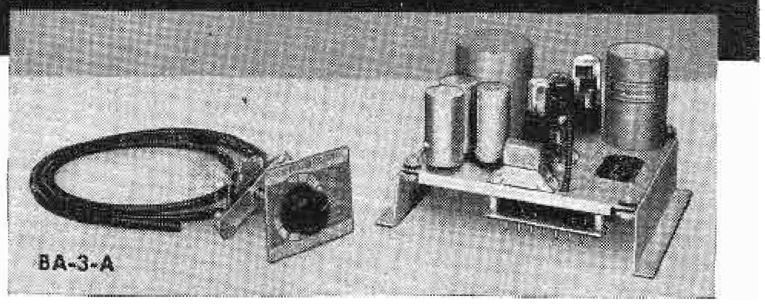

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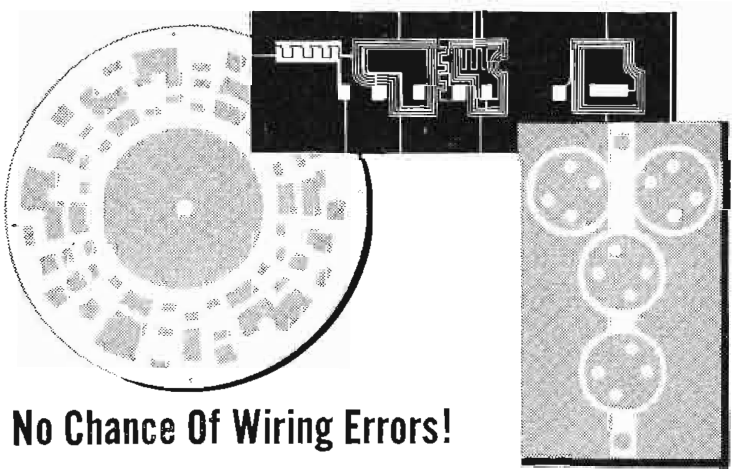

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BULLETINS

Ceramic Capacitors

Radio Ceramics Corp., 109 South Superior St., Angola, Ind., have released an attractive catalog which presents descriptions, characteristics, and performance data covering the three general classifications of ceramic capacitors made by the company.

Temperature-Limited Diodes

An illustrated four-page folder by Thermosen, Inc., 361 West Main St., Stamford, Conn., contains electrical and mechanical specifications and basing diagrams and designations for six temperature-limited diodes that are standard catalog items.

Small Armature Winder

A new catalog sheet describing the Model 36-CA improved small armature winder made by Geo. Stevens Mfg. Co., Pulaski Rd., at Peterson, Chicago, 30, Ill., is now available.

Crystal Diode Chart

An interchangeability chart (No. 1003) for germanium type diode crystals determines which diode can be used as a replacement and which as a substitute. It is issued by the Commercial Enginering Div. of National Union Radio Corp., Hatboro, Pa.

Metallized Paper Capacitors

Complete performance characteristics and test specifications on the new Astron Hy-Mets high-temperature metallized paper capacitors are contained in bulletin AB-19 published by Astron Corp., 255 Grant Ave., East Newark, N. J.

Vacuum Testing Machines

Bulletin TE-52, released by Whittington Pump & Engineering Corp., 1126 Prospect St., Indianapolis 3, Ind., shows ratings of various machines and contains a discussion on vacuum testing by Lawrence E. Sterns, Chief Engineer.

Pipeline Microwave Radio

Features of the Type FR microwave radio and Type FJ multiplexing equipment and their importance to the pipe-line industry are discussed in a new booklet, B-5851, offered by Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Wireless Microphone

Current literature released by Shure Brothers, Inc., 225 West Huron Street, Chicago 10, Ill., describes the company's new cableless microphone, the Vagabond "88".

Color and Color Difference Meter

Bulletin No. 131, just released by Gardner Laboratory, Inc., Bethesda 14, Md., describes the color and color difference meter and various allied accessories, and explains their uses.

Dry Disc Rectifiers

In a folder which discusses vacuum-processed rectifiers and photocells, Bradley Laboratories, Inc., 168 Columbus Ave., New Haven, Conn., present a list of the more important uses of dry disc rectifiers.

Photo Wiring, Forming, and Etching

The Allen D. Cardwell Mfg. Corp., Plainville, Conn., provide examples of printed forms and circuitry in an unusually striking brochure titled, "Design Ideas."

Hermetic Sealing

The "why" and "how" of hermetic sealing for electrical and electronic components and assemblies is presented and explained in a folder by General Hermetic Sealing Corp., 99 East Hawthorne Ave., Valley Stream, L. I., N. Y.

INDUSTRY NEWS

Henry Albaugh has become a member of the sales engineering staff of Radio Condenser Co., Camden, N.J. Before this appointment he was employed in the engineering department of the Philco Corp.

Mal Mobley, Jr., has been appointed assistant business manager of WESCON (Western Electronic Show & Convention, Aug. 19-21). In joining WESCON, Mr. Mobley leaves the post of engineering supervisor at radio station KMPC, Hollywood.

Mal Mobley, Jr.

Ralph R. Shields, who joined the commercial engineering department of Sylvania's tube division as senior engineer in 1948, has been appointed to the newly-created post of product sales manager of television picture tubes.

Louis Hausman, formerly administrative vice president of CBS Radio, has been appointed a director of CBS-Columbia Inc., television and radio receiver manufacturing subsidiary of the Columbia Broadcasting System.

Walter H. Powell has been appointed director of industrial relations by International Resistance Co., Philadelphia, Pa. It will be his responsibility to coordinate and administer all industrial relations arising among the Philadelphia, Downington, Pa., and Asheville, N.C. plants.

Grady L. Roark has been appointed manager of marketing for General Electric's tube dept., Schenectady, N.Y. He was formerly manager of equipment tube sales, after serving as central regional salesmanager in Chicago. Following World War II, after various assignments, he became general superintendent of the receiver department, and later, the electronics division New York district manager.

Lawrence J. Cervone has been promoted to the general sales managership of Gates Radio Company. Since 1947, he was head of the New York office, 51 East 42nd St.

TELE-TECH

Advertisers — July, 1953

While every precaution is taken to insure accuracy, we cannot guarantee against the possibility of an occasional change or omission in the preparation of this index.

Remote Amplifier

(*Continued from page 35*)

phone company broadcast loops. The high impedance phones do not unbalance the line at all nor does the meter (which has its own miniature transformer).

Another good feature of this amplifier is that when the batteries fail (and we have never had that happen during a broadcast—we change them regularly to forestall that occurrence), they do not fail immediately, but there is a noticeable loss of gain—not enough to cause loss of the program, for the control room can boost the remote line gain through the console, but there will be an indication of no pegging when yelling or other loud noises, which would normally peg the meter. Under emergency conditions WLDY continued to use this amplifier with failing batteries through several football games and the amplifier never failed.

If possible, it is recommended that the phone plug have enough extra connections to allow wiring the filament line (ground side) through the phone plug input, so that the amplifier will only work when phones are in place, forestalling the event that the operator may forget to turn the amplifier off after the broadcast. WLDY has had this happen twice and the batteries remained on for hours after the broadcast. Still this did not materially affect their lifetime, the drain is so low.

Recommended Microphones

The fidelity of the amplifier is excellent, but it is recommended that good microphones be used such as RCA 77's or 44BX's. However, when the phone line is such that the fidelity is affected by the line, or when broadcasting a sports event than a cheaper microphone is satisfactory. About 10 ft. of lamp cord is wired into the terminal block on the back inside of the amplifier and is terminated in a male phone plug. Another short length of wire terminated in a female phone plug is wired to the phone company's terminal block and left there for future use. This simplifies hookup operation and the line can be checked hurriedly before the broadcast simply by plugging in a pair of headphones directly to the terminal block.

Simple to operate, good fidelity, sufficient gain and what is as important, extremely cheap to build—all the qualities wanted in a remote amplifier—are now available in that extra amplifier that is so often needed.