TELE-TECH

A Caldwell-Clements Publication

MARCH, 1953

FRONT COVER: STELLAR ELECTRONIC EVENTS AHEAD—Pictured here are the emblems of the principal engineering, professional, and commercial organizations serving the Electronic Industries. Where possible the dates for forthcoming main annual events for each of these groups has been indicated under the symbol. For a complete listings of organizations (from top to bottom) and coming events see page 155.

DEPARTMENTS

TELE-TECH*, Vol. 12, No. 3. 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. 75 cents 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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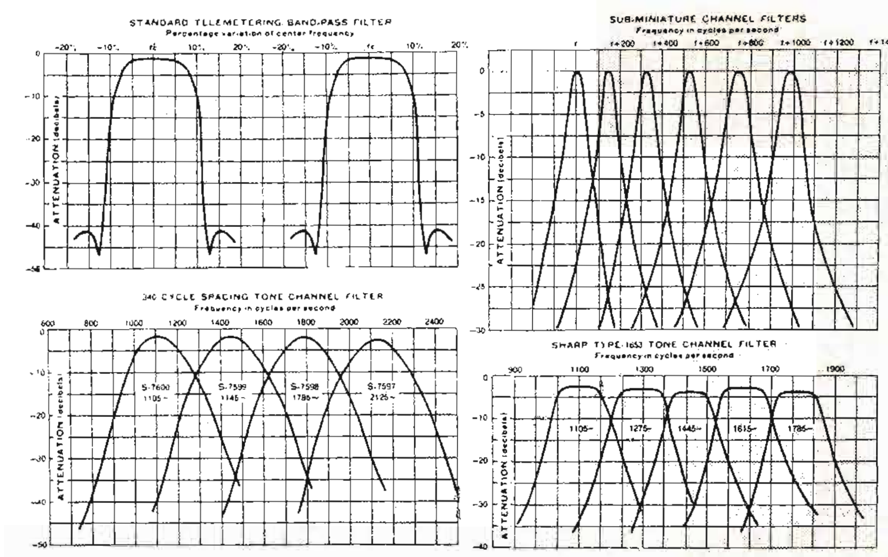
*Reg. U. S. Pat. Off.

TELE-TECH'S GUARANTEED 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 the summer of 1954. Meanwhile, sworn statements and post office receipts will be furnished covering the guaranteed 21,000 circulation.

EXPANDING PRODUCTION

in Toroids & Filters

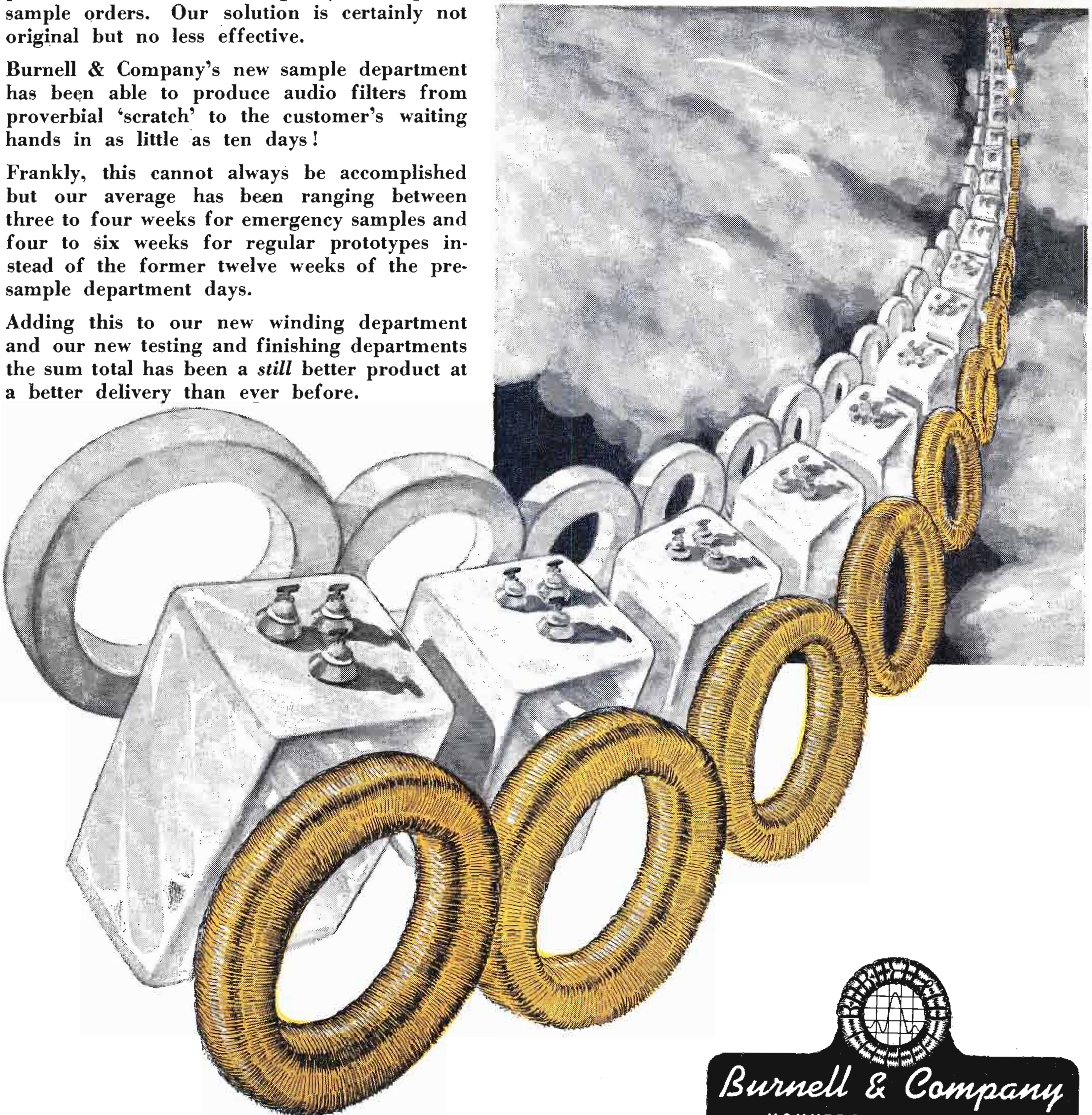


At every management meeting in Burnell & Company there is an unseen but highly respected visitor. He is the spectre of all our customers and his opinions carry weight. Recently he suggested that in addition to our other expansion measures that we must find a way to improve deliveries for emergency and special sample orders. Our solution is certainly not original but no less effective.

Burnell & Company's new sample department has been able to produce audio filters from proverbial 'scratch' to the customer's waiting hands in as little as ten days!

Frankly, this cannot always be accomplished but our average has been ranging between three to four weeks for emergency samples and four to six weeks for regular prototypes instead of the former twelve weeks of the pre-sample department days.

Adding this to our new winding department and our new testing and finishing departments the sum total has been a *still* better product at a better delivery than ever before.



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TELE-TECH* 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 and 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.

* Reg. U. S. Pat. Off.

TELE-TIPS

(Continued from page 29)

CABLE RADAR—Electric light, phone and telegraph companies have a new method for locating distant breaks in their lines. It employs the radar technique and consists in sending a wave impulse into the open-ended conductor and then measuring the time taken for the reflected impulse to return. Knowing the characteristics of the line by comparison with an unbroken conductor, the distance to the break can be readily computed.

ADJACENT CHANNEL COLOR-TV—NTSC (National Television System Committee) has appointed a group to look into Paul Raiburn's (Paramount Pictures) recent suggestion, as voiced in the pamphlet entitled "Color Television Without Problems," that we use adjacent channels for color-TV transmissions. For further details on this suggestion see page 74 in *Tele-Tech*, January 1953.

COCKROACHES IN TV sets are almost entirely harmless. At least that is the official assurance given to the public by the Director of Rodent Control for the District of Columbia after several complaints of infestation prompted a studied investigation of the subject. The brown-banded cockroach only eats a little excess glue off connections and does not meddle with actual receiver operation.

PROCEEDINGS of the Iceland Parliament at Reykjavik will now be preserved for future generations of Icelanders via tape-recording equipment. Eleven Stancil-Hoffman (Hollywood) tape-recording units were recently installed in Iceland's two main chambers of parliament. Thus, the oldest legislative body in the world, created in 930, becomes one of the first with completely modern recording facilities. This enlightened republic of 141,000 people, where illiteracy is virtually unknown and where more books, newspapers and magazines per capita are published than any other country in the world, will record the entire proceedings of its General Assembly's continuous debate for the edification of its entire population. Taxpayers can now tab each Krona spent by the Iceland government.

"OUT OF CRISIS comes opportunity!"—Don G. Mitchell, President Sylvania Electric Products, Inc.

(Continued on page 60)

keeping communications ON THE BEAM

JK PRODUCTS

the JK FD-12

FREQUENCY AND MONITOR MODULATION

Monitors any four frequencies anywhere between 25 mc and 175 mc, checking both frequency deviation and amount of modulation. Keeps the "Beam" on allocation: guarantees more solid coverage, too!

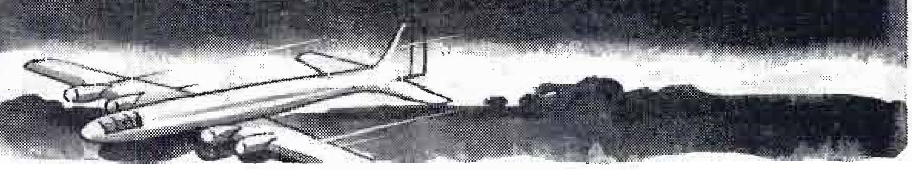
JK STABILIZED H-17 CRYSTAL

CRYSTALS FOR THE CRITICAL

The JK H-17 Crystal meets rigid airline requirements for compactness, light weight, rugged dependability. A Military type, it is hermetically sealed—dust and moisture proof—plated, quartz plate is shock mounted. One of many JK Crystals made to serve every need.

Ceiling Zero... Communications 100%

"Pea soup" over the field . . . and still the giants of air travel come in "on the beam". When visibility is poor, commercial pilots must rely on radio-radar equipment to bring their ship in safely. JK Crystals play an important role in this every day drama of keeping airlines communications "on the beam" in the air and on the ground.



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First to provide Tubes and Transistors that are correctly designed for quick, efficient printed circuit assembly. For the ultimate in portable performance, combine Raytheon's high-efficiency, filamentary Subminiature Tubes with Raytheon's Junction Transistors.

Subminiatures		Filament Volts	Filament Ma.	Plate Volts	Screen Volts	Grid Volts	Plate Ma.	Screen Ma.	Mutual Cond. Umhos.	Voltage Gain	Plate Resis. Meg.
1AG4	Output Pentode	1.25	40	41.4	41.4	−3.6	2.4	0.6	1000	35†	0.18
1AH4	RF Pentode	1.25	40	45.	45.	0	0.75	0.2	750		1.5
1AJ5	Diode-Pentode	1.25	40	45.	45.	0	1.0	0.3	425	50	0.3
1V6*	Mixer-Pentode	1.25	40	45.	45.	0	0.4	0.15	200**		1.0
	Osc.-Triode			45.	—	Rg = 1 meg.	0.4	—	550		
1AK4	RF Pentode	1.25	20	45.	45.	0	0.75	0.2	750		1.5
1AK5	Diode-Pentode	1.25	20	45.	45.	5 meg.	0.5	0.2	280	40	0.4

†Power Output — milliwatts **Conversion Conductance

***Type 1V6 is a high performance, low battery drain converter. Note the comparison with 1R5 using 45 volt supply.**

	1V6	1R5
Total Cathode Current (ua)	960	2750
Conversion Conductance (umhos)	200	235
Plate Resistance (megohms)	1.0	0.6
Conversion Gain (load = 175K)	30	32
Equiv. Noise Resistance (ohms)	70K	180K

PNP JUNCTION TRANSISTORS
(Average Characteristics at 30° C)

	CK721	CK722
Collector Voltage (volts)	−1.5	−1.5
Collector Current (ma.)	−0.5	−0.5
Base Current* (ua.)	−6	−20
Current Amplification Factor*	40	12
Power Gain* (db)	38	30
Noise Factor* (1,000 cycles) (db)	22	22

*Grounded Emitter connection

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TELE-TIPS

(Continued from page 49)

SENSE APPEAL—Predictions made years before "Cinerama" foresaw the development of three-dimensional TV and the "smellies"—devices which are now patented inventions. During moments of idle speculation, the imaginative have been focusing their attention on the subtle implications and design problems of the ultimate form of communication which will appeal to all the five senses. As an example of this trend of thought, Aldous Huxley's futuristic book *Brave New World* described an entertainment medium called the "feelies." An excerpt states, "'Going to the Feelies this evening, Henry?' enquired the Assistant Predestinator. 'I hear the new one at the Alhambra is first-rate. There's a love scene on a bearskin rug; they say it's marvellous. Every hair of the bear reproduced. The most amazing tactual effects.'"

PROGNOSTICATION has been further presented in Al Capp's comic strip *Li'l Abner.* A system called "feelavision" showed little solid men jumping out of the receiver. However, not all of these concepts lie within the realm of humorous writing. One inventor has actually made a drawing board design of a "telebiovision" system which boasts an odor organ, smoke unit, vibrator arrangement for shaking the living-room floor, heat emitter, and to make the sense appeal complete, a multimetal grid which creates the illusion of different tastes when pressed against the tongue!

ON GETTING AHEAD—"You Don't Have To Be Brilliant To Make A Greater Success Of Your Life," says Sam Himmell, practical philosopher who occasionally visits TELE-TECH's offices. "You May Not Always Be Better Than Others, But You Can Always Be Better Than Yourself . . . Every Artist Was First An Amateur, And the Most Difficult Part Of Getting To The Top Of The Ladder Is Getting Thru The Crowd At The Bottom . . . It Takes Just A Little More Than The Ordinary To Move Out Ahead Of The Herd, And If You Cannot Overwhelm Them With Your Quality, Overwhelm Them With Your Quantity . . . The Faster You Go, The More Chance There Is Of Stubbing Your Toe, But The More Chance You Have Of Getting Somewhere." . . . *Said Ovid, The Philosopher,* in the Year 1400, "Chance Is Powerful. Let Your Hook Always Be Cast. In The Pool Where You Least Expect It, Will Be a Fish."

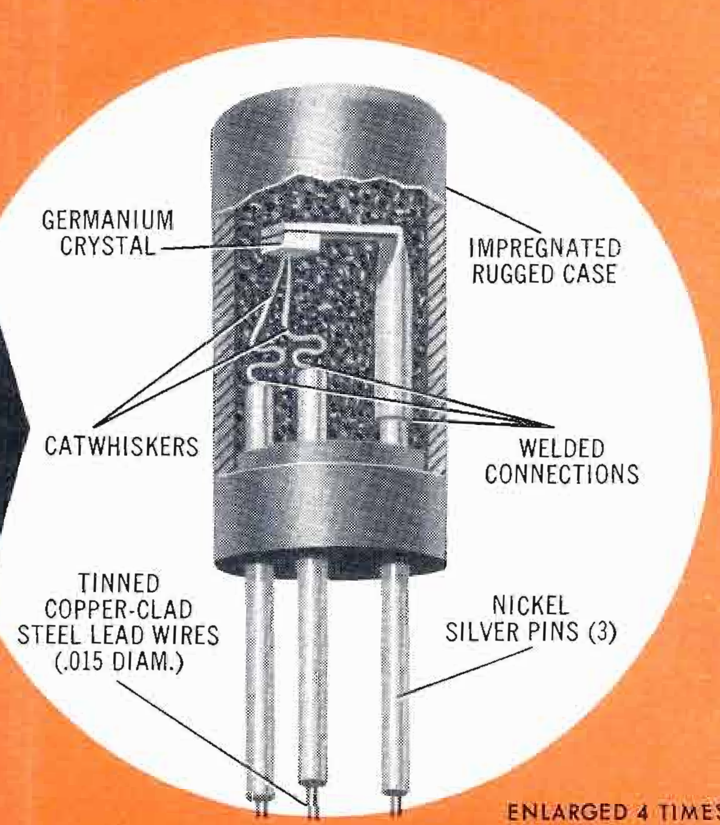
CBS-HYTRON TRANSISTORS

CBS-HYTRON
PT-2A

ACTUAL SIZE

CBS-HYTRON
PT-2S

- Moisture-resistant
- Plug-in or solder-in
- Sturdy triangular basing
- Polarized base connections
- Auto-electronically formed
- Thoroughly stabilized
- Operate up to 55° C



ENLARGED 4 TIMES

AND YOU CAN BUY THEM NOW!

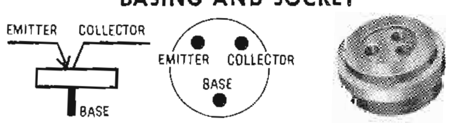
Already a major producer of germanium diodes, CBS-Hytron now offers you prompt delivery of transistors: Point-contact CBS-Hytron PT-2A (for amplifying) and PT-2S (for switching). Both have stable characteristics and are guaranteed moisture-resistant. Note flexible leads welded to base pins. You may solder flexible leads into circuit. Or snip them to use stiff base pins in CBS-Hytron type T-2 socket.

Triangular arrangement of base pins is stronger . . . avoids bent pins. Easy-to-remember basing layout simulates basing symbol (see diagram). Polarization makes socket connections foolproof. You are assured of uniformly optimum characteristics by electronic control of pulse forming. Thorough aging achieves maximum stability. You may operate these transistors up to 55°C. And you can order both CBS-Hytron PT-2A and PT-2S for immediate delivery.

MECHANICAL FEATURES

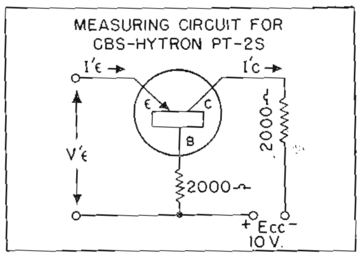
1. Single-ended construction gives maximum mechanical stability.
2. Rugged triangular basing design resists shock and vibration.
3. Dual-purpose connections permit use of flexible leads or stiff plug-in base pins.
4. Direct soldering of germanium wafer to base support guarantees positive contact, avoids flaking.
5. Glass-filled plastic case and high-temperature impregnating wax assure moisture-resistant, trouble-free operation.

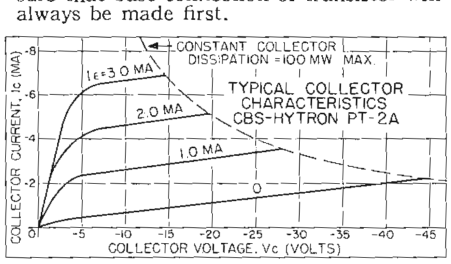
BASING AND SOCKET

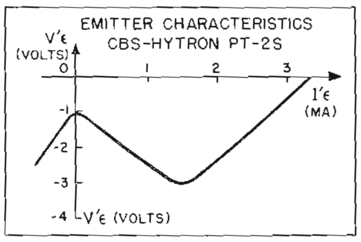


Transistor Symbol | **Basing Diagram (bottom view)** | **CBS-Hytron T-2 socket**

Note similarity of pin layout to that of transistor symbol. CBS-Hytron type T-2 transistor socket features groove to guide pins into socket. Also anti-burn-out design to insure that base connection of transistor will always be made first.



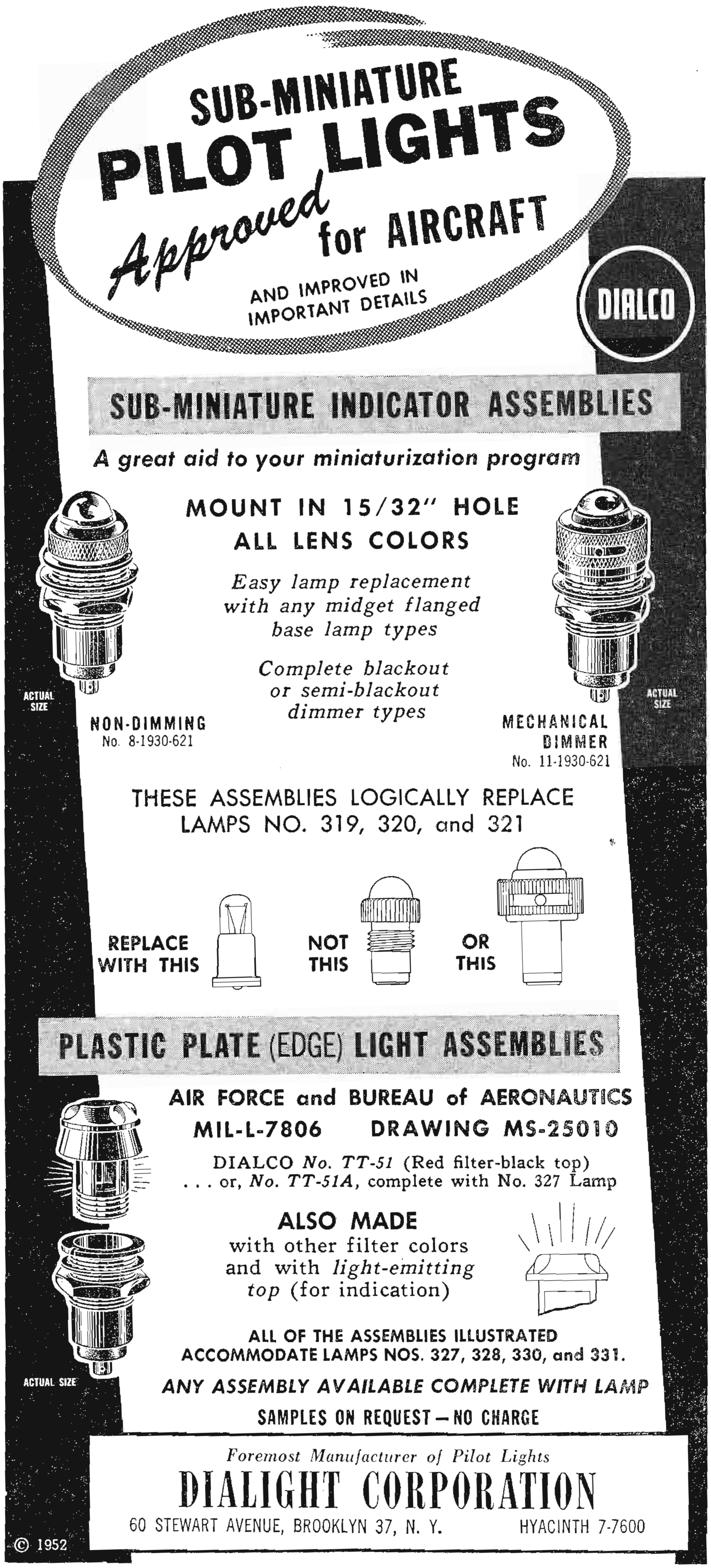




MANUFACTURERS OF RECEIVING TUBES SINCE 1921
HYTRON RADIO AND ELECTRONICS CO.
A Division of Columbia Broadcasting System, Inc.
Main Office: Danvers, Massachusetts

WRITE FOR DATA. Complete free data on CBS-Hytron PT-2A and PT-2S . . . and the T-2 socket . . . are yours for the asking.

RECEIVING . . . TRANSMITTING . . . SPECIAL-PURPOSE AND TV PICTURE TUBES • GERMANIUM DIODES AND TRANSISTORS



LETTERS . . .

Q-Meters

Editors, TELE-TECH

The letter printed on page 48 of your February issue regarding Q-Meter states that the originator of the method is not known. While I cannot answer that question for sure, I believe that the first reference was published in the magazine *Electronic Industries* on page 88, July, 1943. The latter report was published several years before Q-Meters were provided with inductance scales.

While I am about it, the reference to small diameter necks on cathode ray tubes that recently appeared in your columns was of interest. I had such a tube built in 1931. This tube was pictured in the magazine *Instruments,* as Fig. 8 in my article of October, 1935. Tubes with small necks were in common use well before 1917, however, and in the German literature especially many of these tubes were described.

RALPH R. BATCHER
Chief Engineer, RTMA
489 Fifth Ave.,
New York 17, N. Y.

Trans-Atlantic TV in 1930!

Editors, TELE-TECH:

I was most interested to read the discussion on "Transatlantic Television" in your recent issue.

You may be interested to hear that on September 17, 1930, I received a TV programme direct from the General Electric station at Schenectady, N.Y. and I have in my possession a cable sent to me by G.E. which fully confirms my reception. This was undoubtedly the first time that American television crossed the Atlantic and to the best of my knowledge it has not been repeated.

I am bound to admit, however, that the frequency used for this three-days test transmission to Germany (where it was not received, I understand) was favourable for trans-Atlantic communication—it was around 15 megacycles. (1930 was very early in the comparatively short history of television for such long distance reception.) The Jenkins Co. wrote to me soon afterwards and said they were calling me on TV specially on Wednesdays, but as far as I remember this was on approximately 145 metres, which was hardly suitable for the occasion.

I am convinced that a permanent transAtlantic relay circuit whether by the NARCOM Plan, ionospheric scatter or any other method would be of inestimable value to our two countries.

—DOUGLAS WALTERS,
Manager Radio Laboratory.
186, High Holborn,
London WCI, England

TELE-TECH

& ELECTRONIC INDUSTRIES—RADIO-TELEVISION

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

THE NEED FOR
Advance Engineering Planning

The general approach in dealing with radio communication problems has undergone considerable transition in the past decade or more. Before that the engineer was concerned more with equipment evolution than with advance methods planning.

When the pressure of demand faced the infant industry there was little time for the fundamental niceties of research and also litttle financial encouragement therefor, so that effort gravitated towards the assembling of specific apparatus. The builders of growing enterprises exhibited impatience towards the efforts of the abstract technician and did not seriously visualize the future or try to understand the actual mechanics of how the results they were getting were being achieved or how they could be improved through the development of fundamentals. In the mad rush of making this instrumentality useful to mankind the demand for consistent practical technical planning, which we call engineeering, became somewhat smothered.

Systems and Methods

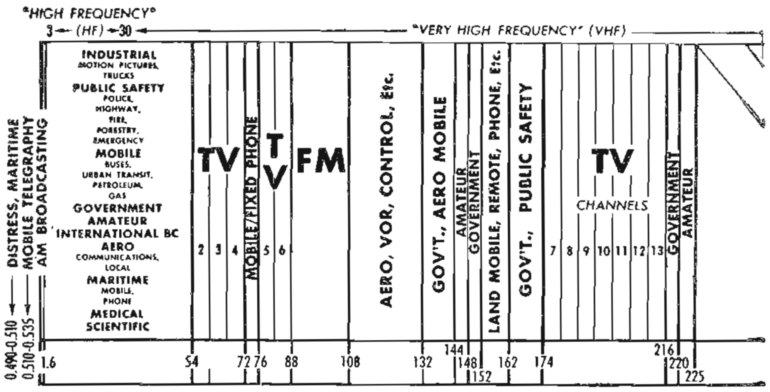
Today much more emphasis is given to system and methods aspects. The technique of equipment and gadget production is currently such that the methods engineer can generally get the apparatus made up that he needs to fit a planned system instead of being confronted with a system made up of such building blocks as could be picked up on the market. This is particularly true for those higher frequency bands that have come into use in recent years where impediments because of previously long established services with vested rights were minor or absent. The field in which many engineers work is susceptible to this approach, and more and more engineers will develop interest in methods and utilization planning. Business men and administrators have acquired a greater awareness of this trend and are reaching the viewpoint that technical solutions to meet specific objectives are just a matter of time and effort.

Fullest Use of Facilities

Another transition can be discerned. Before some of these frequency bands became uniformly overcrowded it was largely taken for granted that, when the need arose, more use could be developed by seeking out those hidden frequency spaces which would be disclosed by applying improved technical processes such as better frequency stability, confining radiation bands to those widths essential for passing the required intelligence, etc. Being uninterested in salesmanship as such and not pressed by an urgent demand, engineers did not aggressively publicize at the outset how future growth and prosperity could be promoted by a universal understanding that technical attainments must be used to their fullest. Recent convention addresses give testimony that the importance of this has become paramount.

And now for the future. The trends that I have pointed out will continue. The ability to create technical means to meet specified objectives will improve. The engineer will concern himself more and more with the end product of the communication service. This will put him in closer touch with the economic and social phases of human endeavor and broaden his area of interest and operations. His training of using perceptive thought and critical planning combined with discipline and patience will clear ways to further accomplishments.

A guest editorial by Haraden Pratt, Telecommunications Advisor to the President of the United States, and Secretary IRE, adapted from his recent address to the Professional Group on Vehicular Communications, IRE.



RADARSCOPE

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

GOVERNMENT

IRAC—In these columns attention has frequently been called to the fact that the Washington Interdepartment Radio Advisory Committee has long actually controlled about one-half of the available radio spectrum, having first choice of all radio frequencies—with the FCC getting only the "left overs" for assignment to commercial, educational and public use. After two changes of name, IRAC still functions, but with a chairman (Lt. Col. W. M. Lauterbach), reporting to the Telecommunications Advisor to the President, and sharing his White House Extension offices. Representing the various departments IRAC's members now are: Air Force, J. D. Corley; State Dept., John S. Cross; Justice, M. W. Kuhrtz; Navy, Capt. T. P. Lowndes, USN; Interior, S. L. Windes; Army, Maj. E. R. Reynolds; Coast Guard, Capt. E. K. Rhodes; Civil Aeronautics, Lloyd H. Simson; Forest Service, E. C. Wagner. IRAC's executive secretary is C. W. Loeber, Room 2024, T-5 Building, 16th and Constitution Ave., N. W., Washington 25, D. C.

COLOR—TV

NTSC has now agreed on the technical characteristics of a new horizontal sync signal for the all-industry compatible color-TV system. Arrangements for field tests using the new signal are now being made. Upon successful completion of these tests, the system will be ready for presentation to the FCC,—probably in the Fall of this year. Uncertainty over the technical characteristics of the horizontal sync signal has been credited as a reason for the reluctance of some manufacturers to build experimental receivers. Now that this problem has been resolved even greater manufacturer participation is expected.

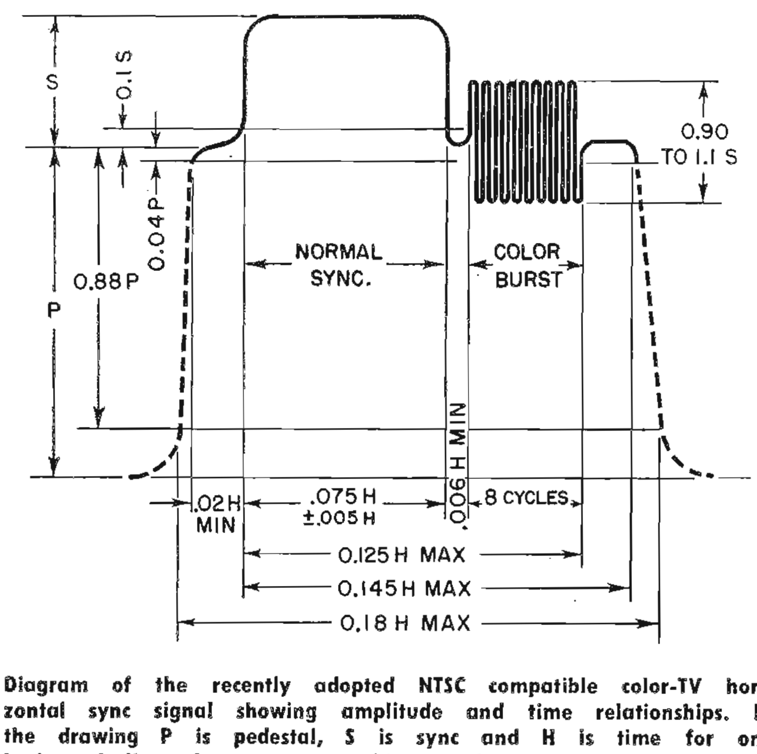


Diagram of the recently adopted NTSC compatible color-TV horizontal sync signal showing amplitude and time relationships. In the drawing P is pedestal, S is sync and H is time for one horizontal line. Agreement on this waveform now opens way for full field testing of NTSC color-Tv system, after which, probably in late fall, a formal presentation will be made to FCC.

INTERNATIONAL BROADCASTING

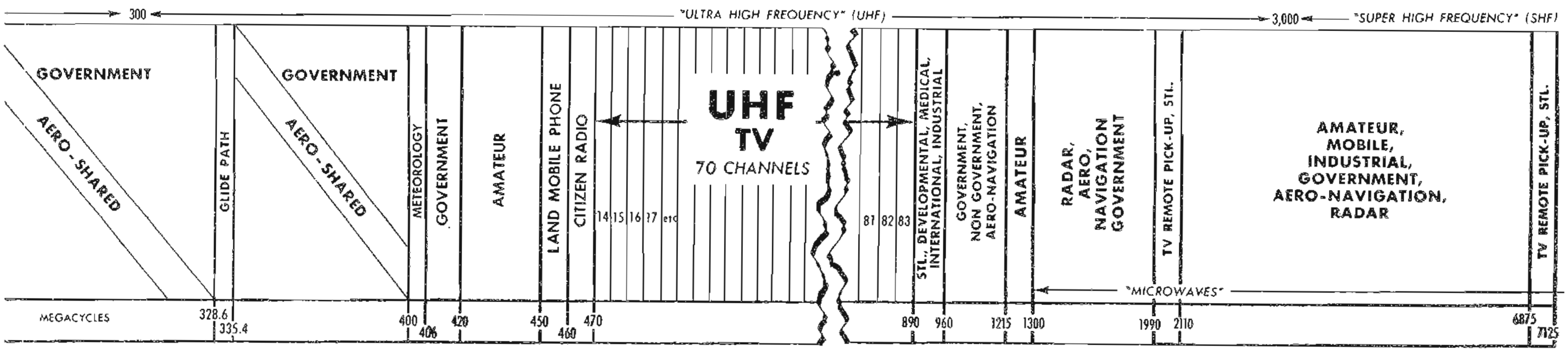
CROSS-MODULATION interaction studies in Australia and Europe are providing valuable theoretical information which may be used for measuring the magnetic field in the E-layer of the ionosphere. The presence of certain electric currents in the ionosphere has been postulated to account for numerous terrestrial magnetic variations. A very interesting secondary result of these investigations which concerns skyway reception is the observation that conditions due to this type of interference are present much more than is commonly supposed. However, our European observers state that ether conditions in Europe now preclude skyway reception. Apparently very few people there attempt to receive stations which are not within ground wave range due to the absence of clear channels for wide area coverage.

INTERFERENCE

SPURIOUS EMISSIONS—Commending the Joint Technical Advisory Committee on its admirable report on "Radio Spectrum Conservation," the FCC now asks JTAC for further study of "spurious radiation." Comments Chairman Walker:

"In providing for the maximum use of the radio spectrum, the Commission has been confronted with the necessity for controlling the radiation of radio frequency energy which does not make constructive use of the spectrum. Such radiation results in interference which is not only wastful but may be also dangerous where the safety radio services are involved. The spurious radiation from transmitters, receivers and other equipment, coupled with the inadequate selectivity of receivers, presents a problem of spectrum engineering which has greatly increased in importance and difficulty in recent years.

"With manual operation and aural reception, interference is rapidly noted and prompt corrective measures are generally feasible. However, with the trend toward automatic operation, interference cannot readily be detected and remedial measures are not easy. The wider bandwidths used in many new applications increases the vulnerability to interference. The situation is further aggravated by the development of high powered transmitters and the parallel development of receivers having low inherent noise, and the tendency towards the geographical concentration of many types of services."



AUDIO

SEVERAL LARGER TV AND RADIO set manufacturers are reported as now looking to the high fidelity market with considerable interest. The annual "Hi-Fi" business volume has been increasing steadily in recent years and these manufacturers are weighing thoughts of perhaps including "Hi-Fi" models in their receiver lines. The audio equipment manufacturers are noticeably concerned over this possibility. They feel that "Hi-Fi" on a mass production basis would be mediocre at best from a performance standpoint, that it would force down unit selling prices, that it would cause a lowering of quality standards throughout the industry to meet competitive prices and that any lowering of quality standards might in turn sour the public on the purchase of "Hi-Fi" equipment.

TEST EQUIPMENT

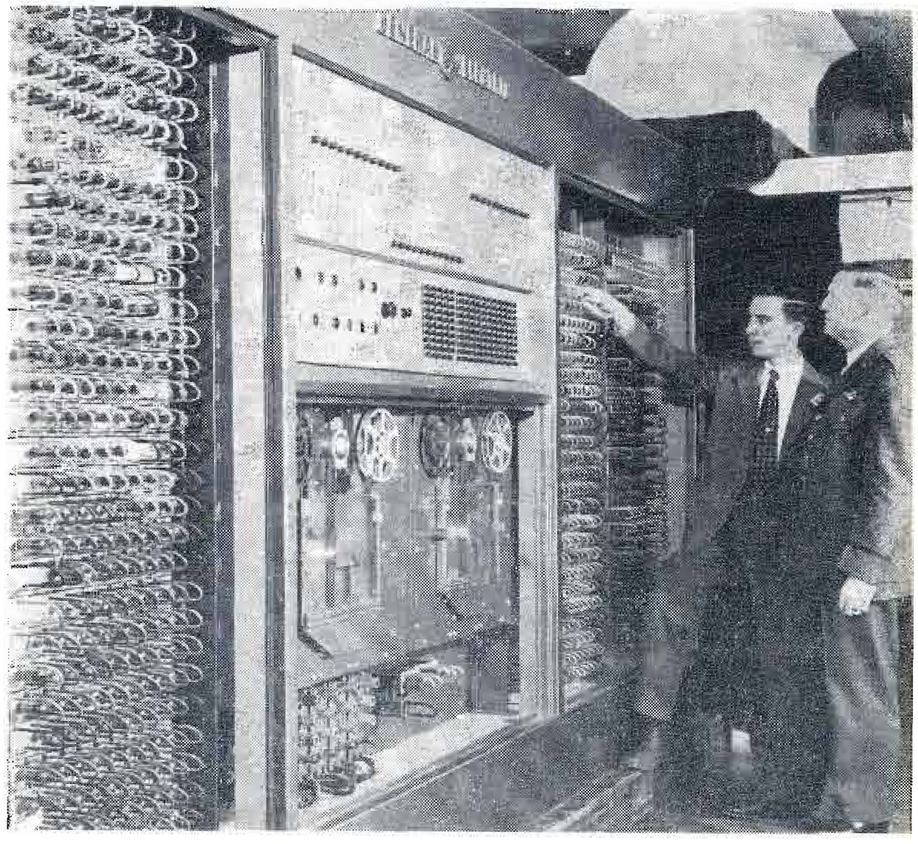
STANDARDIZE INSTRUMENT CONTROLS? The cathode ray working group of AIEE is reported to be considering the establishment of standards for the placement of controls on cathode ray oscilloscopes. This same thought might also be advantageously employed on other types of test equipment. The idea certainly has considerable merit when one considers the time lost by engineers now in having to familiarize themselves with the control operation of each item of test equipment that they plan to use. Clutch and brake pedals have standard locations in all automobiles and learning to drive one enables you to drive all. Standardizing the control locations on various test equipment items would be likewise effective.

ELECTRONIC PRINTING

PHOTOELECTRIC TYPESETTING—What electronic tubes have done for other forms of communication, may now revolutionize typesetting and printing. In the newest Photon system, the keyboard characters are "memorized" electronically, as in a computer circuit, and are then expanded or "justified" to fill the line. This completed, the characters are printed on film from a whirling disc, by light flashes controlled at the proper instant. A simple disc suffices for any size of type of the same font, by varying the lens position. Speeds up to 12,000 characters per hour, have been obtained,—three times the operating speed of conventional typesetting machines. The finished composition is a film negative from which the printed page will be reproduced.

MANPOWER

WARNING!—"The manpower situation is becoming so critical that before long contracts will either have to be extended or cancelled," observed Maynard M. Boring, personnel manager of General Electric, at a recent armed forces conference. He attributed the reason for this precarious position to the shortage of engineering graduates—a shortage which is being made increasingly critical by the growing drain of the Reserve Officers Training Corps. The percent of engineering students in the ROTC has been increasing although total enrollment has been falling. In 1952, 16% of 29,000 engineers graduated from 196 colleges were in the ROTC. They have been called to active duty for two to three years. In 1953, 21,000 graduates will include 22% ROTC. The figure will rise to 46% of 17,500 in 1954, and 52% of 21,000 in 1955. The preliminary count for 1956 is 65% of 25,000 graduates. Under normal conditions a substantial number drop from ROTC at the end of the sophomore year. Today this drop apparently is only 3%. Considering that a shortage of 40,000 engineers exists, it would be a good idea for the armed services to ease up and permit more technical men to enter industry.



Brig. Gen. L. I. Davis, armament director at Baltimore Air Force Air Research & Development Command, and B. Geyer, GE engineer, inspect OARAC, a new digital computer for the Flight Research Lab., Wright Air Development Center, Dayton, Ohio. Center section contains operations panel and high speed input and output tape mechanisms. 1400 tubes and 7000 diodes are employed by equipment. Additional technical details are described elsewhere in this issue.

Casting Resins for Electronic

Methods of applying embedding techniques to circuit components and assemblies, for aircraft. Advantages over conventional coatings are improved dissipation, moisture

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THE use of casting resins and embedment techniques as applied to electronic equipment has increased greatly during the past five years. The early use of these materials was confined to the embedment of complete circuit assemblies. The use today is of much larger scope. Casting resins, or, more properly, formulations based on casting resins, are used as coatings, impregnants and even molding compositions. These resins are used in processing resistors, capacitors and transformers, as individual circuit elements and even in the construction of electronic hardware.

Advantages & Limitations

It will be worthwhile briefly to review some of the advantages and limitations in the use of casting resins. These refer specifically to the embedment of electronic circuits, where the circuit is placed in a mold and the resin polymerized around it to produce a completely solid structure.

Hermetic Sealings: It is well known that all plastic materials will absorb and transmit moisture. For the required degree of protection, two factors must be considered: (a) the moisture absorption of the resin, and (b) the moisture transmission. Moisture absorption by a resin results in impairment of its electrical properties. Insulation resistance decreases, dielectric constant increases, and dissipation factor increases.

Moisture transmission through the embedment compound will, of course, have a direct effect on the circuit elements. Difficulties in this respect can almost always be corrected by a small increase in thickness of the embedment compound.

It is good practice to test a blank, that is, a casting of the same physical characteristics of the embedded unit, under humidity conditions to determine what the moisture absorption effects will be. For unfilled polyester type resins, ⅛-in. has been found adequate for a moisture seal on most sensitive components. For example, a precision mica capacitor which was very sensitive to high humidity was embedded in a block of plastic so that the coating had a thickness of approximately ⅛ inch. The plastic used was a polyester resin of the rigid type with a moisture transmission coefficient of 150g/100 sq. m./hr. (for 1 mil film) and a moisture absorption of 0.2% in 24 hours at 25° C. After 1,000 hours in 100% relative humidity, the capacitor had not increased in capacitance or dissipation factor.

Problem of Moisture

When embedding circuits or components, there is always the problem of moisture tunneling into the embedment at the interface between the plastic material and the metal lead. It is, therefore, good practice to use solid bare single conductor leads at the entry point. It is also good practice to locate leads so that the plastic material in polymerization shrinks on to the surface at which a seal is desired. This difficulty can usually be overcome by the use of a priming coat of good adhesion. Small molded connectors are sometimes made a part of the casting and are effective in prevention of moisture tunneling.

Ruggedization and Shockproofing: Delicate electronic assemblies are made rigid solid structures through casting techniques with no opportunity for relative movement of components. By controlling the damping characteristic of the cured resin, it is possible to control transmission of vibrations.

Acceleration tests made on embedded circuits for guided missile use have indicated that there is no damage to the embedment resin or to properly embedded components. Difficulties are more likely to occur within vacuum tubes or other circuit elements.

Elimination of Mountings: Mountings, terminal strips and other hardware are minimized or eliminated in embedded circuits. Often bare point-to-point wiring may be used for rapid circuit assembly. Insulation is adequately supplied by the resin.

Miniaturization: Three dimensional packing of components permits miniaturization. For example, on some well designed embedments it has been possible to utilize over 60% of the volume of the embedment in components.

There are a number of limitations on the use of casting resins to embed circuits. A few of the more important are presented.

Repair: The repair of embedded circuits is very difficult and in most cases impractical. The use of solvents to dissolve the resin is time-consuming and often results in destroying circuit elements. It is possible, however, to recover certain valuable components by this method. Drilling into an embedment, making the repair and recasting is sometimes used, but is a rather expensive procedure. Moreover, this requires the use of a transparent casting resin. One approach is to embed assemblies as units which are to be discarded if trouble appears.

Heat Dissipation: The dissipation of heat from within an embedded circuit is a problem which must be considered carefully during physical design phases. Tests on subminiature vacuum tubes, operating under rated conditions, indicate that the surface temperature of a tube embedded in a one-inch cube of polyester resin will be approximately 85° C above ambient, whereas the surface of the tube in air under free convection conditions will be 70° C above ambient. The thermal conductivity of the resin in this instance was 1.5 BTU/ft^2/hr/°F/in.

Surface Temperature

Surface temperature of the embedded tube increased at the rate of 30° C per watt of dissipation. The surface of a ½ watt carbon resistor at rated dissipation was 30° C above ambient, whereas the surface temperature of a 1 watt resistor at ½ watt dissipation was 23° C above ambient. Both were embedded in the center of a one-inch cube. This indicates some advantage in the use of over-rated heat dissipation components.

Under conditions where components are closely packed and where assemblies are in confined spaces so that there is no appreciable air flow,

Equipment

including shockproof units and corona properties

circuits run at approximately the same temperature whether embedded or not. This is due, of course, to the poor heat transmission through still air.

Many components will operate at much higher temperatures within an embedment than they will in air. Two reasons for this are the elimination of attack by oxygen and the prevention of escape of volatile constituents.

There is, of course, an effect on circuit constants when an assembly is embedded. It is usually necessary, therefore, to make preliminary embedments of a circuit or component to determine what these effects are and to then take them into account on the final design.

In some instances it has been found desirable to allow for screw driver adjustment within an embedment. A small void is left, adjustment made, and the void is then filled.

Core of Embedment

A series of Q meter coils which ranged in frequency from 5 to 60 MC and in which the Q's were from 140 to 170 were embedded in a resin with a dissipation factor of approximately 2% and a dielectric constant of approximately 3.0. The winding mandrel for the coils was polystyrene. This material remained as the core of the embedment. It was found that embedment in a large mass of resin caused a 5% decrease in Q and an increase in distributed capacitance of the order of 1 μμf.

The embedment of precision components presents several problems. The embedment compound may have an effect on the material from which the component is constructed. This may be due to solvent action by the resin or pressure due to shrinkage on polymerization. The effect is not always reproducible to the degree required.

Weight addition due to potting equipment is a design consideration. The specific gravities of most casting resin compositions range from 1 to 1.5. When embedment is used on a physically well designed unitized assembly, weight is increased roughly

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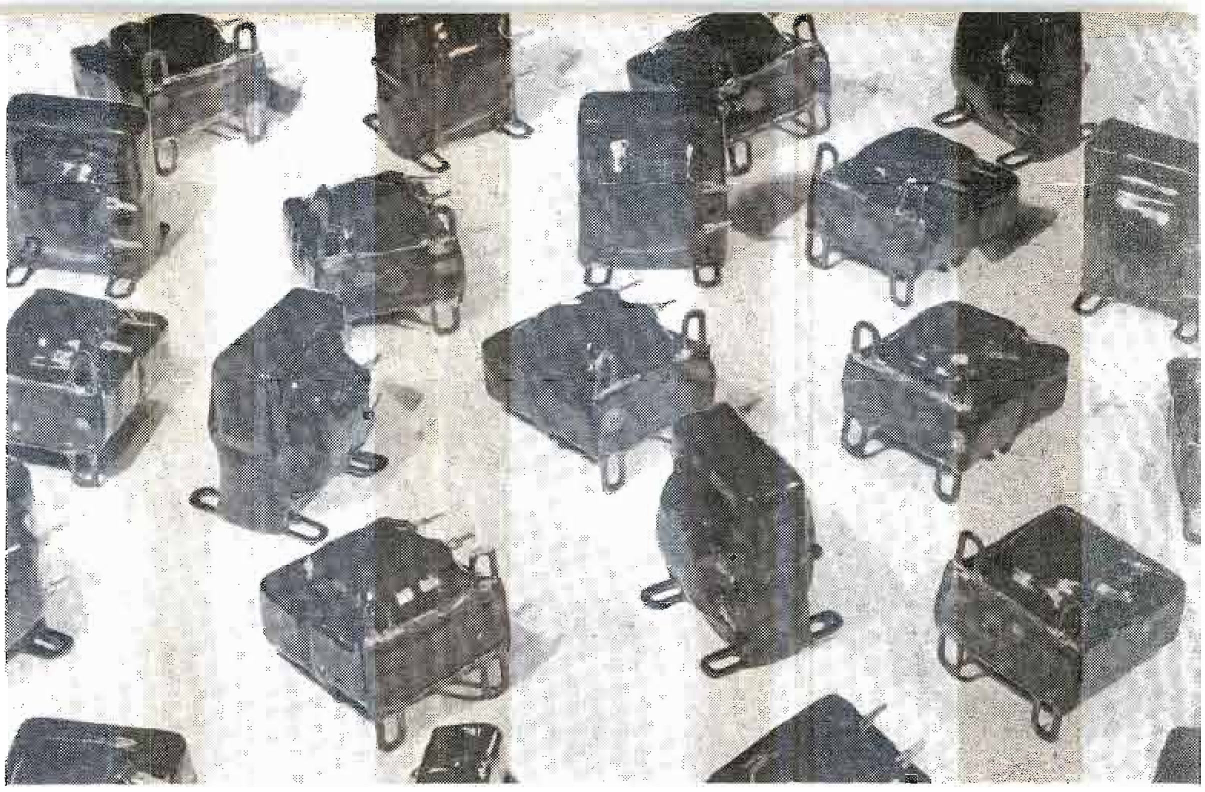


Fig 1: Dip-coated transformers show improved moisture sealing and heat dissipation properties

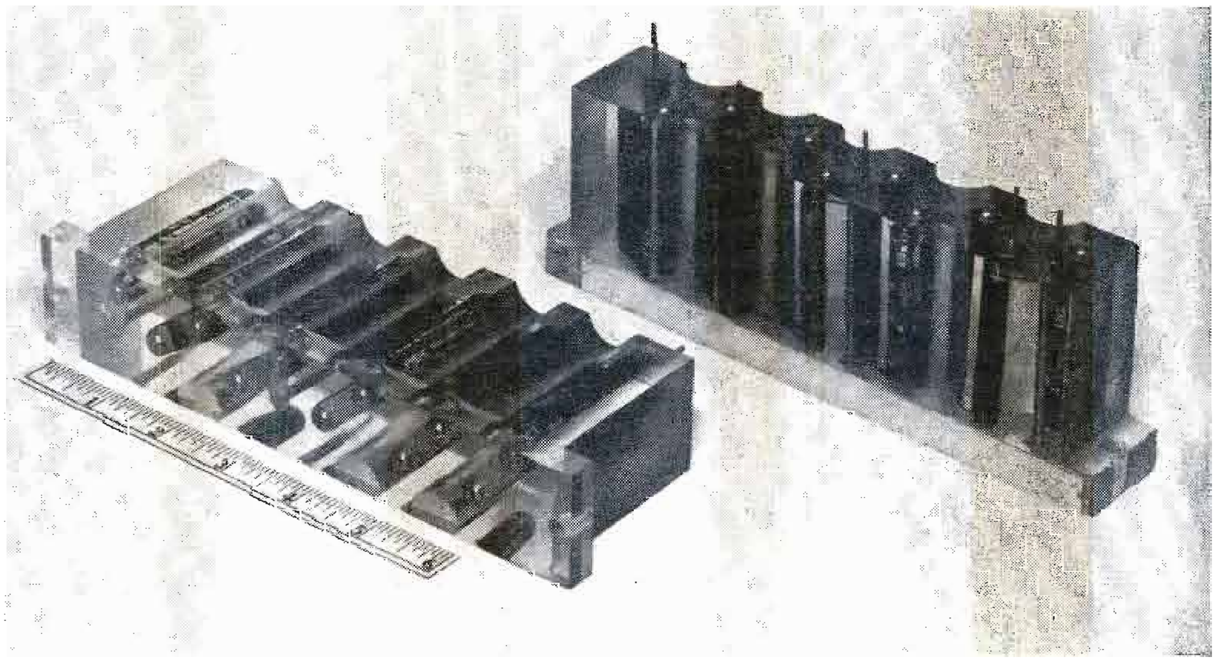


Fig. 2: Compact bleeder embedments for CRT supplies comprise eleven 4-meg, 2-watt resistors

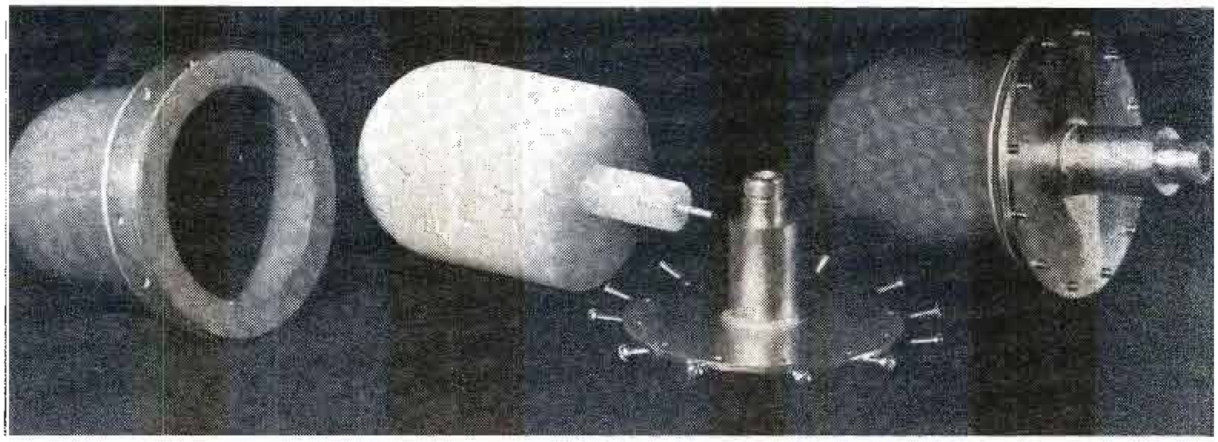
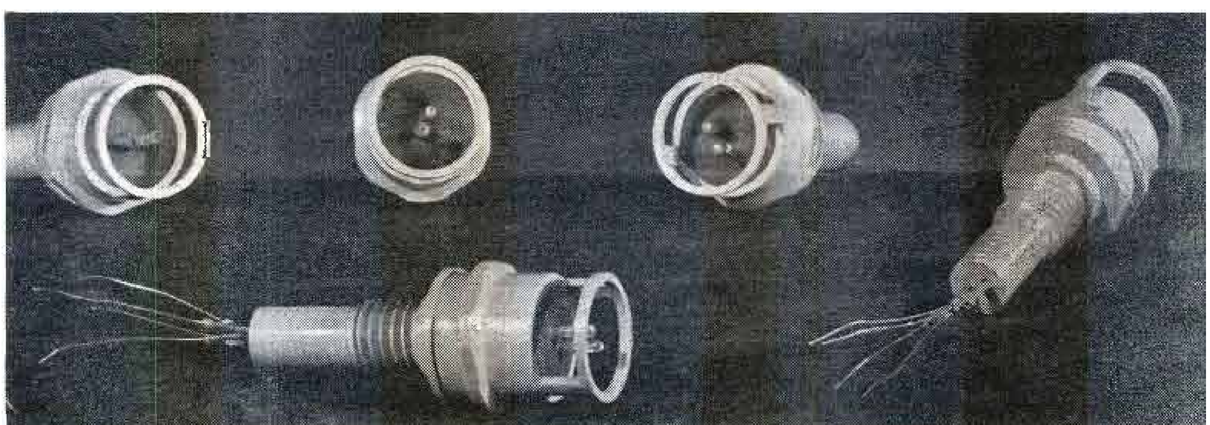


Fig. 3: Helical antenna embedded in rugged polythylene casting fits into radome housing

Fig. 4: Thermistor assemblies for measuring underwater temperatures are sealed against 300 psi



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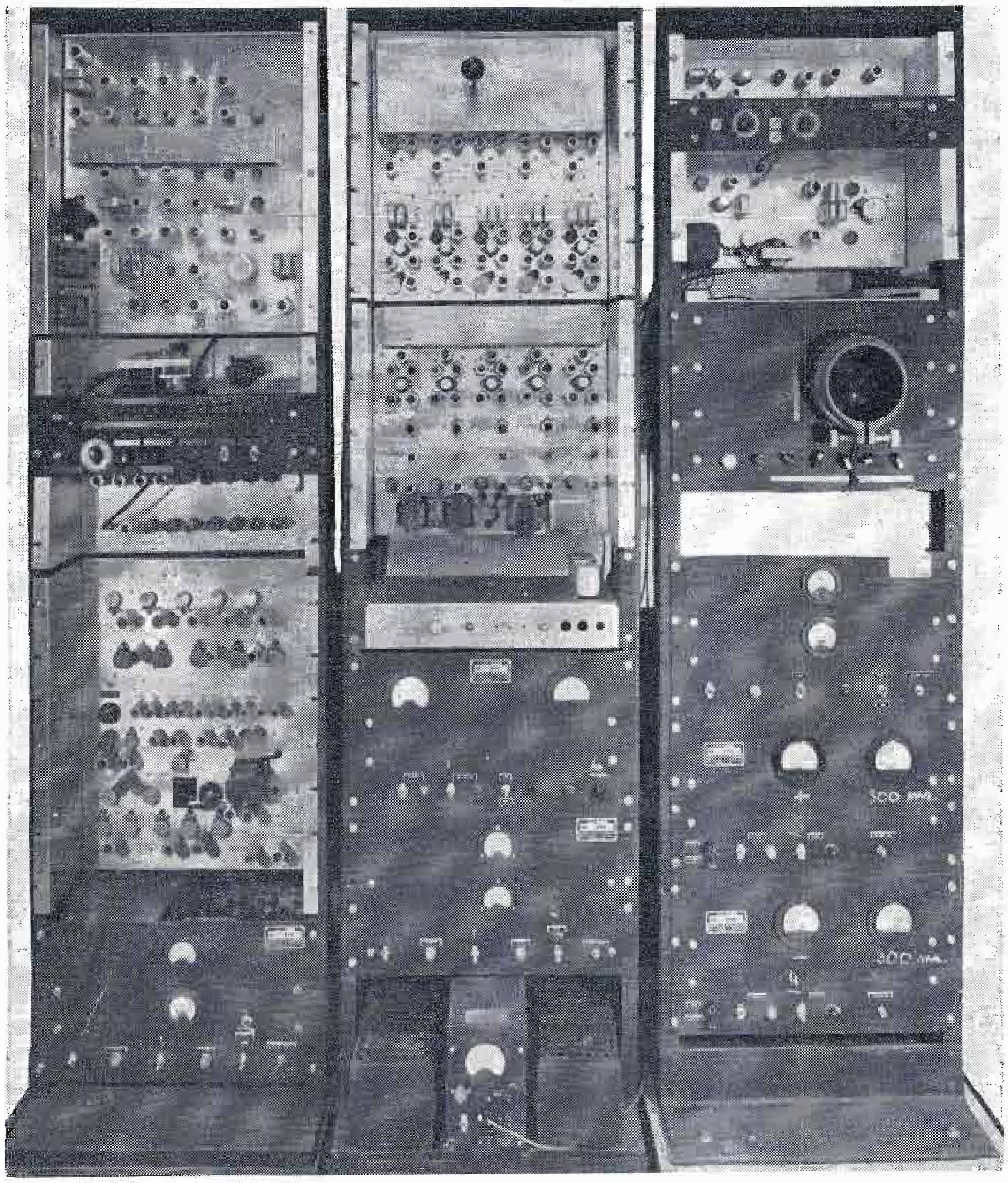

Fig. 1: Five-channel correlator provides rapid evaluation of correlation functions

Recently developed device extends application of statistical theory to communication problems by rapid simultaneous computation of five points of a correlation curve

By ***M. J. LEVIN & J. F. REINTJES***

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THE application of statistical techniques and probability theory to the field of communications has provided electrical engineers with new and valuable tools for understanding and handling problems arising in this field. Of great importance to these techniques are the correlation functions of the time series involved in the problems under consideration. As is well known, the crosscorrelation function of $f_A(t)$ and $f_B(t)$ is defined as

$$\phi_{AB}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} f_A(t) f_B(t+\tau)\, dt \qquad (1)$$

The autocorrelation function of $f_A(t)$ is defined as

$$\phi_{AA}(\tau) = \lim_{T\to\infty} \int_{-T}^{T} f_A(t) f_A(t+\tau)\, dt. \qquad (2)$$

Here $f_A(t)$ and $f_B(t)$ represent time series such as signals or noise and τ represents a displacement in time. The crosscorrelation function is, then, a curve plotted against τ. Each point on the curve represents the average value of the product of $f_A(t)$, and $f_B(t)$ delayed by τ. The autocorrelation function can be described in a similar manner. These functions are especially useful, since they can be computed from the actual time series under consideration by means of electronic correlators where analytic calculations would be difficult or impossible.

The evaluation of a correlation function in its exact analytic form by electronic equipment would require continuous multiplication and integration over an infinite time interval for each value of τ desired. This would be inconvenient; but fortunately it can be shown that a close approximation to the correlation function can be obtained which is suitable for electronic computation. For the crosscorrelation function it takes the form,

$$\phi_{AB}(\tau) \simeq \frac{1}{N} \sum_{n=1}^{N} a_n b_n \qquad (3)$$

An analogous expression is valid for the autocorrelation function. Here a_n is a sample (instantaneous value) of $f_A(t)$ obtained at time t, and b_n is a sample of $f_B(t)$ obtained at time $(t+\tau)$. The approximate value of the correlation function for each value of τ is obtained by suming N products of sample pairs. The error involved in this process can be calculated, and it is found that when N is of the order of magnitude of 10,000, the accuracy is adequate for most purposes.

Correlators for obtaining this approximation can be constructed by utilizing pulse-circuit techniques. To obtain each point on a curve the following operations are needed: First, two samples of the input time series separated by the time τ are obtained. The two sample values are multiplied and the resulting product

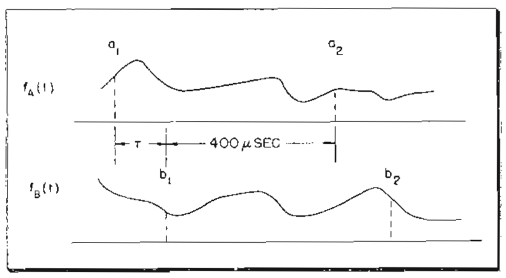


Fig. 2: Sampling sequence, single channel unit

stored. This process is repeated for N different pairs of samples. Then the N products are added and the resulting value displayed as one point on the curve. The entire process is repeated for each different value of τ desired. The increment in τ between successive points on the curve is referred to as $\Delta\tau$.

The multiplication and addition can be done by either digital or analog techniques. Experience has shown that digital equipment is inherently more accurate and flexible,

Channel Analog Correlator

but that analog equipment operates more rapidly and requires much simple circuitry. For example, the digital single-channel correlator [1] at the Research Laboratory of Electronics at M. I. T. contains 400 vacuum tubes; the single-channel analog correlator[2] there requires only 60. When $\Delta\tau$ is 1 μsec and 8000 sample pairs are taken, the digital correlator requires 20 seconds to compute one point on a curve; the analog correlator, ten seconds. For the computation of a complete curve of 110 points, the analog correlator needs 18 minutes, while a curve of five points takes 50 seconds.

Correlation Functions

The long-time intervals required to obtain complete correlation functions with this present equipment, in addition to being time consuming, limits the use of correlation techniques in many of their present applications. For example, the use of correlation functions makes it possible to detect the presence of a periodic signal obscured by noise. This suggests the possibility of an application to radar, but clearly, the periodic signal must be detected more rapidly than the correlators described above are capable of doing for any practical use to be made of this property. An additional difficulty presented by long-time intervals of computation is that the characteristics of the time series may change during the period of observation. Then, each point on the curve is obtained under different conditions, providing erratic results.

Equipment for the more rapid evaluation of correlation functions is, then, highly desirable. This paper describes a correlator[3] which has been designed with the primary objective of presenting rapidly the approximate form of a correlation curve, rather than obtaining a high degree of accuracy. Five points on the correlation function of a time series are obtained simultaneously. Because of this, and other time-saving features, a curve of five points is computed and presented in only four seconds for the same value of $\Delta\tau$ and number of sample pairs mentioned above. The correlator can be set to obtain any one of eight groups of five points along a curve. It was constructed for use as a practical laboratory tool and also to test the practicability of multi-channel correlators. Important characteristics of this equipment are given in Table I. A picture of the complete unit is shown in Fig. 1.

To aid in explaining the operation of the five-channel correlator, the operation of a single-channel correlator of the same type will first be described. As previously indicated, the evaluation of a crosscorrelation function involves the sampling of two time series, $f_A(t)$ and $f_B(t)$, at a time τ apart. This is shown in Fig. 2. The first two sample values, a_1 and b_1, are multiplied and the product stored. The circuits in this equipment require 400 μsec to complete this multiplication. After the 400 μsec a second pair of samples, a_2 and b_2, is obtained, multiplied and the product stored. This continues until a predetermined number of sample pairs has been obtained, at which time the process is stopped and the resulting sum of all the prod-

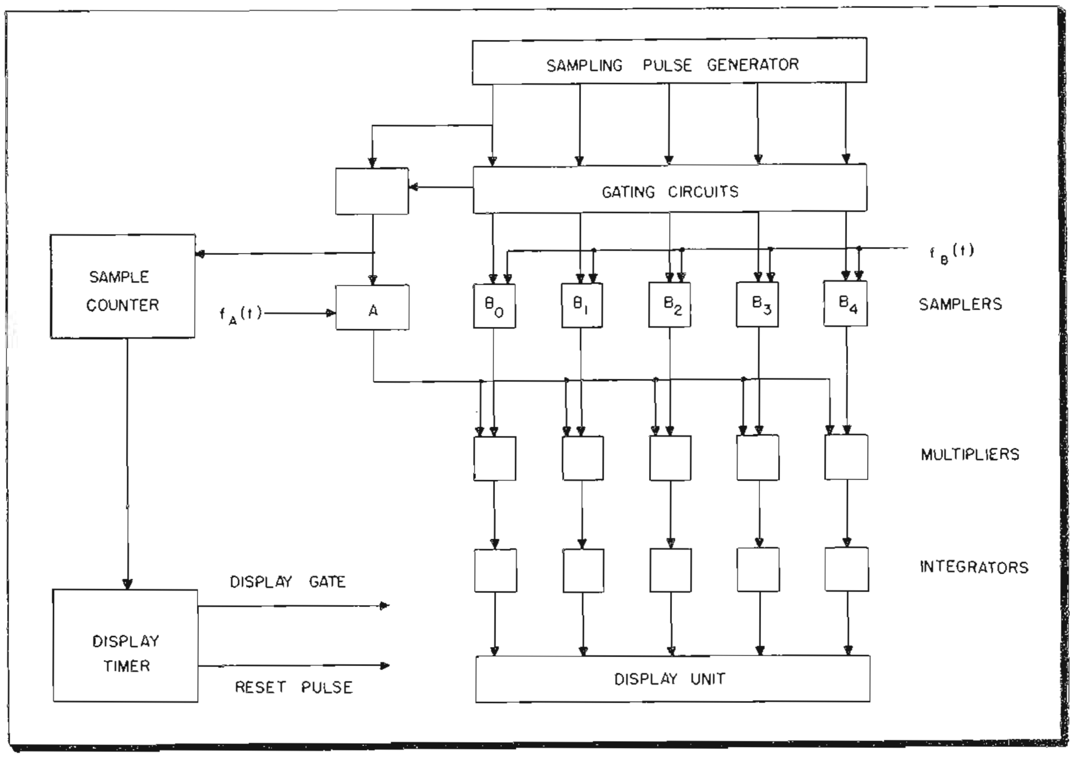
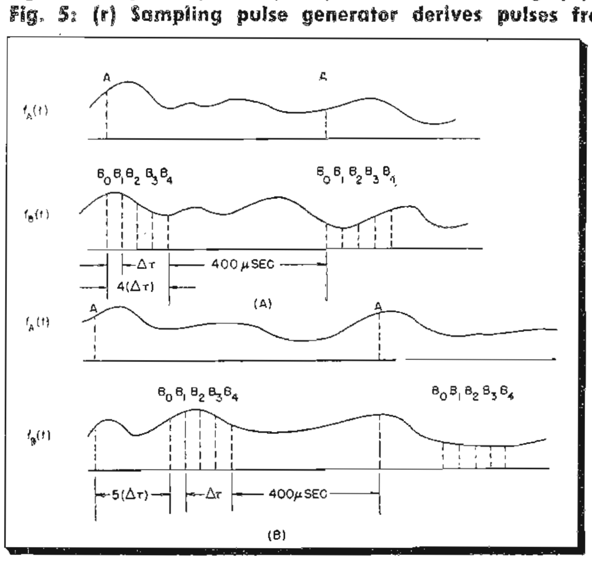
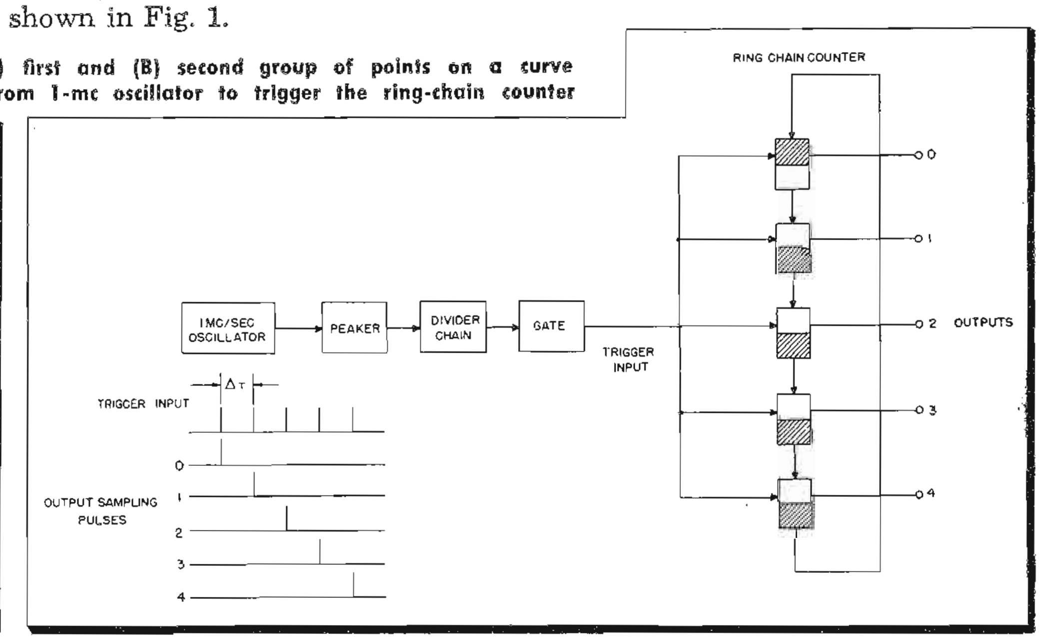


Fig. 3: Block diagram of the five-channel correlator shows arrangement for sampling time series

Fig. 4: Sampler operating sequence for obtaining (A) first and (B) second group of points on a curve

Fig. 5: (r) Sampling pulse generator derives pulses from 1-mc oscillator to trigger the ring-chain counter





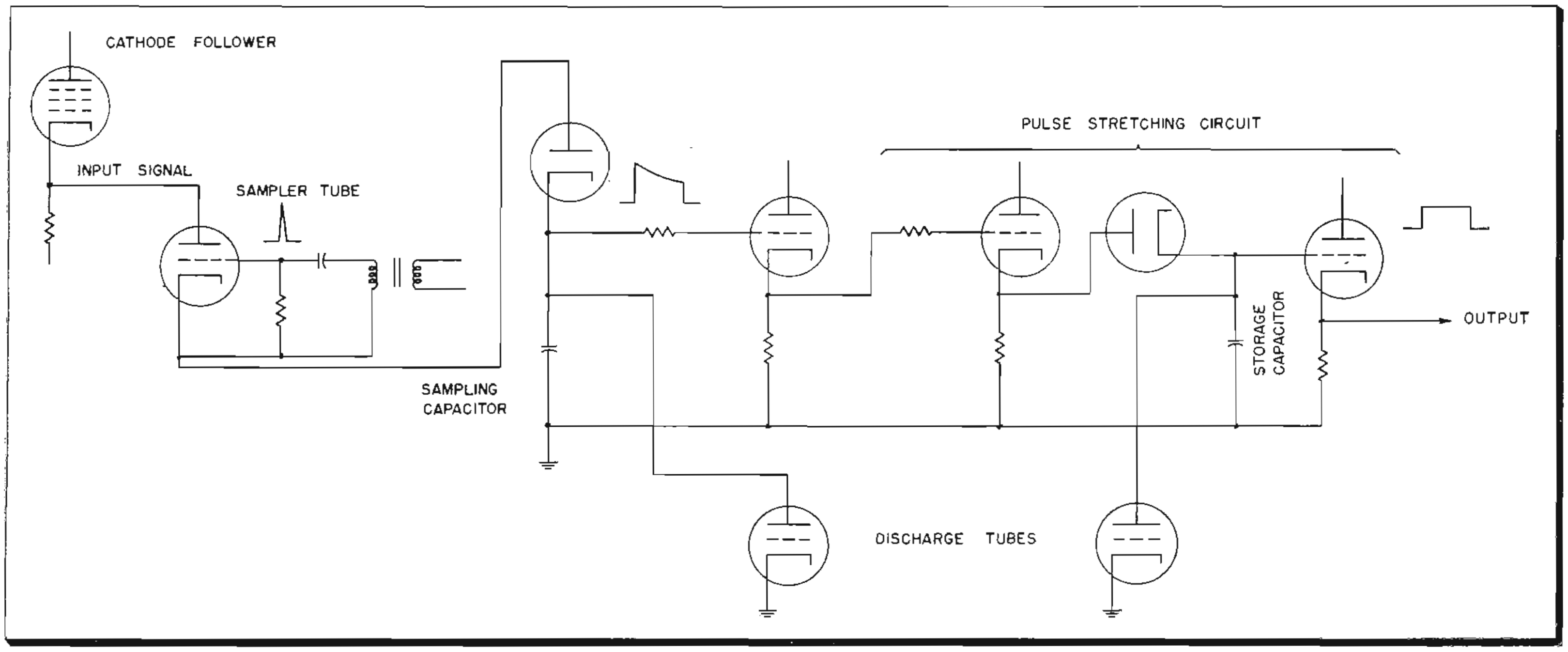


Fig. 6 Sampling circuit samples input signal during 0.2 μsec period and stores resulting value for 5000 μsec with less than 1 % decay

ucts displayed as a point on the correlation curve for the particular value of τ used. The adder is then reset and the next point on the curve computed with the value of τ increased by the amount $\Delta\tau$.

The five-channel correlator operates in an analogous manner. A block diagram of this correlator is provided in Fig. 3. The time series $f_A(t)$ is sampled by the A channel sampler. Then $f_B(t)$ is sampled by the five B-channel samplers at five different times, the timing between the A sampling pulse and each B sampling pulse being correct so as to provide the desired value of τ. The sequence in which the samplers operate when obtaining the first group of points on a curve is indicated in Fig. 4(A) and for the second group of points on a curve in Fig. 4(B). The value of $\Delta\tau$ is set by the rate at which the sampling pulse generator is triggered. The proper timing between the A channel sampling pulse and the B_0 channel sampling pulse is obtained with the gating circuits. These gating circuits can be set so that any one of eight groups of points along the curve can be obtained.

After the B-channel samples have been taken, each B-channel multiplies its sample value by the A-channel sample value and transfers the product to its adder (the integrator). When the sample counter indicates that the proper number of sample pairs has been collected, the flow of products to the adders is stopped and the resulting values for the five different points on the curve displayed. The adders are reset after the display period, which is adjustable between seven and twenty seconds. The reset operation requires two seconds. The correlator can be set so that the entire process is then automatically repeated, or so that the next group of points along the curve is computed.

Circuitry

Some of the special circuits which were developed for this correlator will be described. Attempts were made to achieve simplicity in the circuitry in order to limit the correlator to a reasonable size. The component circuits were designed to be applicable to a larger correlator containing 50 channels, but the construction of this correlator has not yet been started.

A. Sampling-Pulse Generator: This circuit[4] generates sampling pulses at intervals of from one to 400 μsec depending on the desired value of $\Delta\tau$. These sampling pulses must be distributed to the five B-channels. Requirements of accuracy and wide frequency range led to the choice of a ring chain counter distributor circuit for this purpose.

Fig. 5 is the block diagram of the sampling pulse generator. A one megacycle oscillator, peaker and pulse-divider chain provide a train of pulses occurring at the desired interval of $\Delta\tau$. The pulses pass through a gate circuit which interrupts the pulse train during the 400-μsec periods which are required for the multiplication circuits to operate. The pulses which pass through the gate are applied to the ring-chain counter. The double blocks each represent one flip-flop (bistable multivibrator) stage, the shaded half representing the conducting tube in that stage. Positive triggering pulses are applied simultaneously to the cathodes of the upper tube in each stage; the plate of the lower tube is connected to the plate of the upper tube in the next stage. Thus the conventional scale-of-two counter is modified to provide triggering pulses applied simultaneously to each flip-flop stage. A flip-flop will not change state when the positive pulse is applied to the cathode of the tube already in the non-conducting state. The counter in Fig. 5 is in the zero position, the condition that stage 0 will be reset by the next trigger pulse. Thus, when the next trigger is applied, stage 0 will be reset which will trigger stage 1. No other stage will change state. A subsequent input pulse will reset stage 1, which in

(*Continued on page* 120)

TABLE I: CHARACTERISTICS OF 5-CHANNEL CORRELATOR

Input signal frequency range	200 CPS to 500 KC
Available values of $\Delta\tau$	1,2,4,20,80 or 400 μsec
Number of sample products obtained for each point on a curve	4000, 8000 or 16,000
Number of sample products obtained per second	2500 for $\Delta\tau$= 1 μsec 500 for $\Delta\tau$=400 μsec
Number of tubes excluding power supplies	215

Strain-Gage Remote Metering

AN/AKT-8 instrument incorporates multivibrator circuit in FM/FM system covering 215 to 230 MC range. Subcarrier oscillators packaged in miniature plug-in units

STRAIN gages are universally used for the measurement of airframe stresses and as the basic sensing element in many accelerometers, pressure gages and other measuring instruments. They can be made to have an accuracy of better than 1% of full scale, excellent linearity and temperature stability.

However, they are one of the most difficult types of instruments to incorporate into FM/FM telemetering systems. The main reason for this is the low ratio of output to input voltage. A full scale, open circuit output of 2.5 mv/v. input may be considered typical for many strain gage instruments. The resistance of the gages is between 120 and 1000 ohms, although we understand that at least one manufacturer now offers a gage of considerably higher resistance. Heat dissipation in the bridge arms limits the power input to approximately 0.25 watt for unbonded and one watt for bonded gages so that the maximum voltage that may be applied to a 120 ohm gage of either type is 5 and 10 volts, respectively. At full output, the bridge delivers 12.5 for the unbonded, and 25 mv for the bonded type into a high impedance load.

We now concern ourselves with the problem of converting the bridge output voltage to a variable frequency—constant amplitude voltage for FM/FM telemetering. One method which has been used extensively since about 1946 consists of a phase shift oscillator containing the strain gage bridge as a phase shift element. The frequency of the oscillator is dependent on the phase shift in the loop and therefore is a function of the bridge unbalance.


Stastny


Butts

By G. F. STASTNY & R. S. BUTTS
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A block diagram of this arrangement is shown in Fig 1a. One arm of the bridge is shunted by a capacitor so that a nearly 90° voltage, E_{xc}, exists at the bridge output when the arms are balanced. When the bridge is unbalanced a voltage of variable magnitude and either leading or lagging E_{xc} is added. The resultant is a vector voltage, E_o having a loci as shown in Fig. 1b. The frequency of the oscillator is dependent on the phase shift in the loop and therefore is a function of the bridge unbalance.

At bridge unbalance the oscillator operates at the frequency for which the phase shift in the RC network is approximately 90°.

For a frequency deviation of ± 7.5% of center frequency, which is usual for FM/FM systems, the corresponding phase shift in the RC network will need be approximately ± 4.3° (Fig. 1c). The magnitude of the quadrapture voltage E_{xc} is adjusted by selecting the value of C so that the resultant bridge output voltage phase swings the same amount at maximum bridge unbalance.

Fairly good linearity of control is possible since the cotangent of the low pass filter phase angle deviates from a straight line approximately 3.9% over a total variation of ± 4.3°. The loop gain variation as frequency changes may have a secondary effect on frequency of oscillation so as to possibly effect linearity. This has not been computed and experimental results show linearity of 2% may be obtained.

Determining Gain

The gain required in the amplifiers may be determined as follows. If the commonly used 120-ohm strain gage bridge is considered we would use a 9 to 1 turns ratio step down transformer between the driver tube and the bridge for proper impedance matching. The quadrature voltage should be 14 times the unbalance voltage, E_R, or 1/28 of the bridge input voltage for ± 4.3° phase deviation. The loss in the two stage RC phase shifter will be approximately 2. Therefore, the minimum gain required from the bridge output to the plate of the driver stage is approximately 500. The use of three stages provides a sufficient additional gain to permit negative feedback stabili-

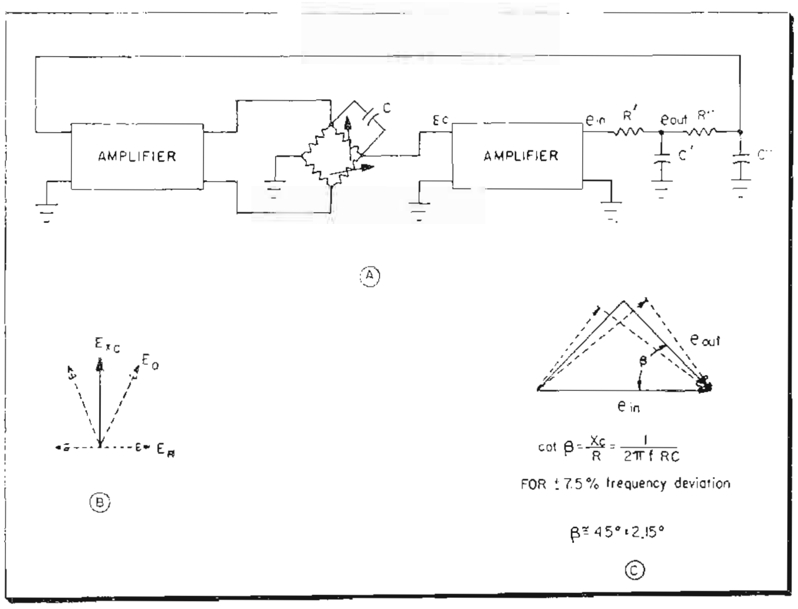
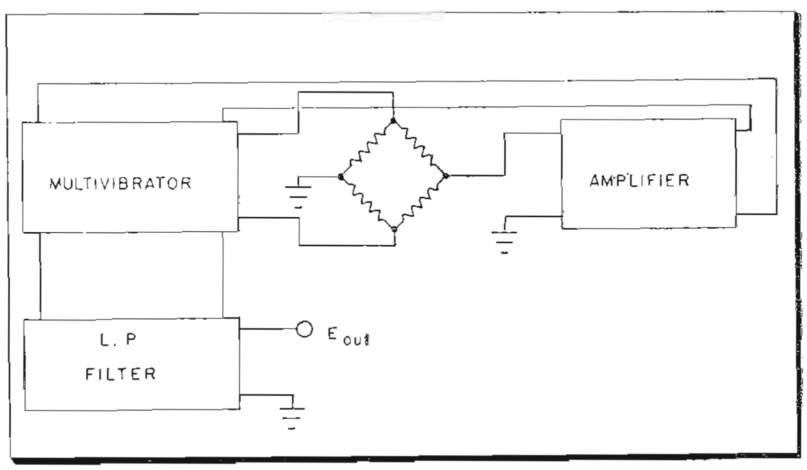


Fig. 1: (l) Phase shift circuit. Fig. 2: (r) Block diagram of the multivibrator circuit



zation in the amplifier. An additional stage would be required to isolate a desirable low impedance output circuit from the high impedance oscillator circuits.

The output voltage is found to vary about 5% over the frequency range. A low pass filter is needed in the output to reduce the harmonic distortion to 1% or less.

Another circuit we have recently employed might be called a multivibrator bootstrap circuit. A block diagram is shown in Fig. 2. In this arrangement the bridge is driven with a square wave from the two cathodes of the multivibrator. The multivibrator grids are returned to a positive bias voltage. The frequency of the multivibrator is a linear function of the bias voltage over a considerable range.

The scheme is to superimpose the amplified bridge square wave output voltage onto the positive bias so as to make the instantaneous bias and, hence, frequency a function of the magnitude of the bridge output voltage. Remember that the grid of the tube which is not conducting in any half cycle is the only one to be affected by the instantaneous value of the external bias. If the bridge output voltage is not changing, both grids are exposed to the same value of bias since the polarity of the bridge output voltage switches as the multivibrator reverses. The circuit employs five triode sections.

Fig. 3 is a curve of multivibrator frequency as a function of positive bias and shows the control range for ± 7½% frequency deviation. A bias voltage change of ± 5 volts is required. A practical value of bridge driving voltage for this arrangement is 1 volt peak to peak. For a maximum 2.5 millivolt bridge output an amplifier gain of 2000 is required. This can be obtained with transformer coupling and three triode stages with sufficient additional gain for negative feedback stabilization. A schematic of this circuit is shown in Fig. 4.

Regulated Plate Supply

It is desirable to use a regulated plate voltage supply for this multivibrator type subcarrier oscillator wherever possible since it is quite voltage sensitive. However, where battery operation is required, a circuit has been developed which greatly reduces the effect of plate voltage variation. The frequency of the multivibrator decreases with increasing plate voltage as shown in Fig. 7. By adjusting the dc positive bias applied to the grid returns of the multivibrator, the frequency may be readjusted to the nominal value for any given change in plate supply voltage. However, a nonlinear compensation is required. This is provided by using a 9002 triode tube as a nonlinear resistance element in a voltage divider circuit. The same compensating curve is applicable to all six subcarrier oscillators so that one compensator may be used to

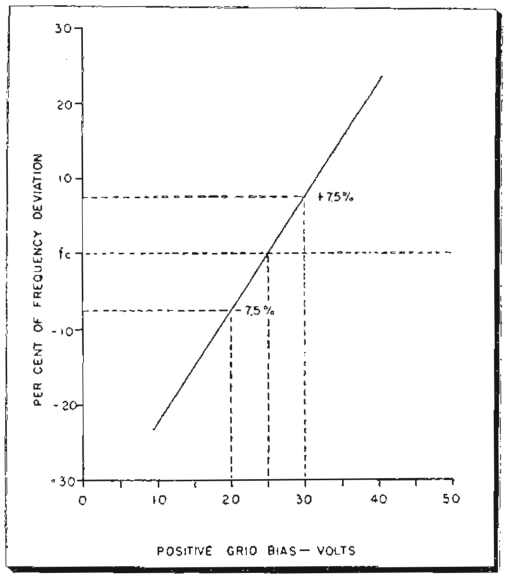
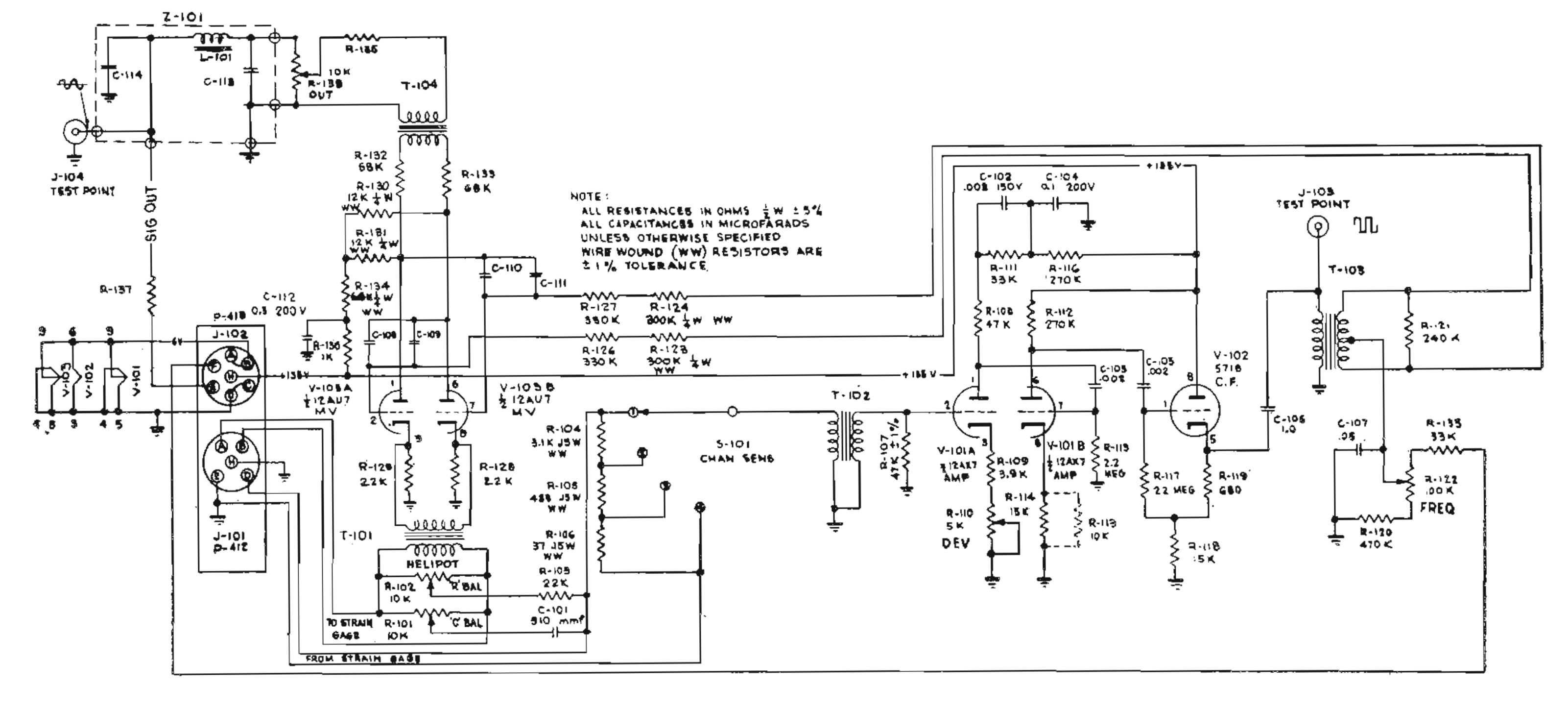


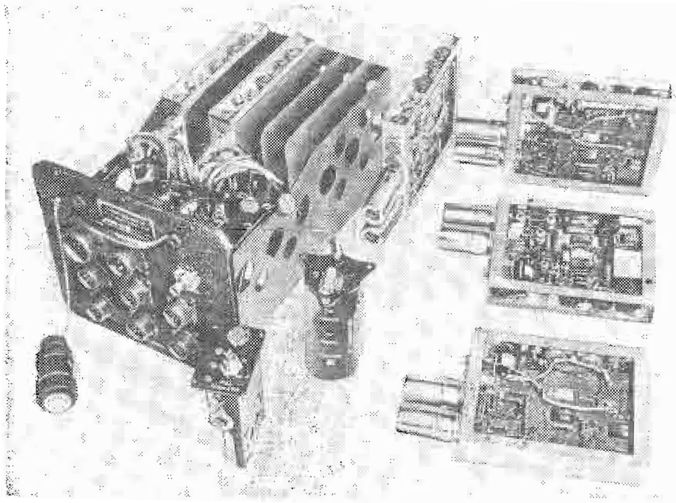
Fig. 3: Bias control characteristic for multivibrator shows range for a deviation of 7.5%

Fig. 4: Circuit of multivibrator subcarrier oscillator employs triode stages with gain sufficient for negative feedback stabilization

CHANNEL	1	2	3	4	5	6
Frequency	2300	3000	3900	5400	7350	12,300
C-108 & C-110	330µµf	330µµf	220µµf	180µµf	120µµf	82µµf
C-109 & C-111	100µµf	---	33 µµf	10µµf	22µµf	---
C-113 & C-114	0.01µf	0.0056 µf	0.0056 µf	0.0027 µf	0.0027 µf	0.00082 µf

CHANNEL	1	2	3	4	5	6
Frequency	2300	3000	3900	5400	7350	12,300
L-101	550mh	550mh	320mh	320mh	190mh	190mh
R-137	18K	15K	15K	15K	15K	10K
R-135	3.3K	4.7K	4.7K	4.7K	4.7K	3.9K





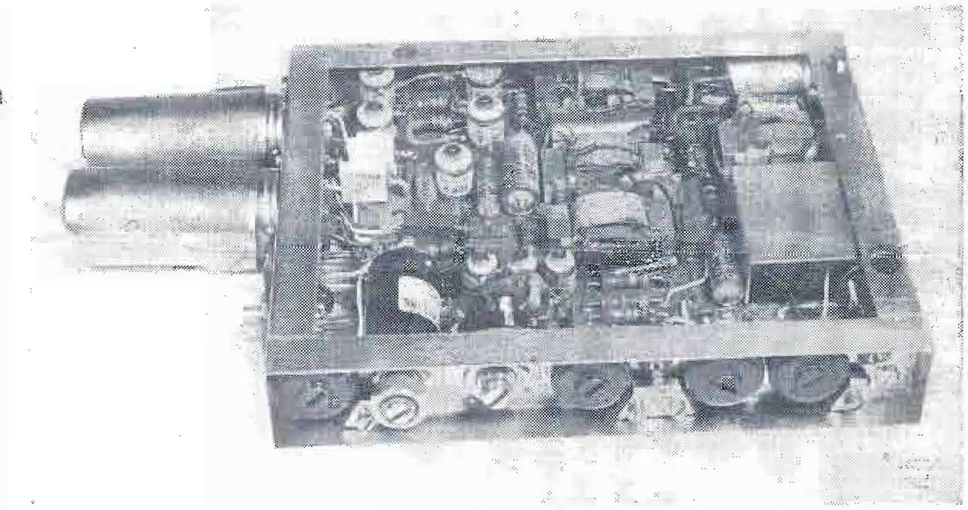


Fig. 5: (l) Exploded view of AN/AKT-8 FM/FM telemetering transmitter. Fig. 6: (r) One of six miniature plug-in subcarrier oscillators in AN/AKT-8

regulate all six oscillators simultaneously.

To maintain reasonable accuracy under varying temperature conditions, the RC combination in the grid circuit of the multivibrator is designed to remain nearly constant under varying temperature conditions.

Temperature Coefficient

The capacitors used in the grid plate coupling circuits of the multivibrator are vitreous enamel dielectric type having a temperature coefficient of +120 parts per million per degree C. This coefficient is quite

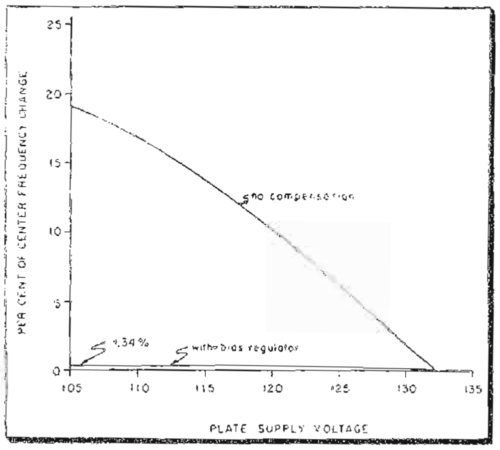


Fig. 7: Plate voltage compensation curve

stable and apparently reproducible in production quantities. In fact, the tolerance on the temperature coefficient is stated by the manufacturer to be ± 5 ppm/°C. If this positive temperature coefficient can be matched with a stable resistor having a negative coefficient of the same value, a constant RC product with respect to temperature will result. This condition is approached by the use of a series combination consisting of a wirewound resistor having a negative coefficient of 10 to 30 ppm/°C and a deposited film resistor having a negative coefficient of 280 to 420 ppm/°C. The resistance values of the two resistors are proportioned so that the resultant temperature coefficient of the combination is —120 ppm/°C.

Resistors and capacitors having standard production tolerances of temperature coefficient have been used in a limited number of oscillators with a fairly low rejection rate of completed oscillators due to excessive temperature drift. The latter can be held to a value less than ±.75% of center frequency over a temperature range of —17 to +40°C.

This multivibrator type circuit has been incorporated into a six channel FM/FM telemetering transmitter which bears the nomenclature AN/AKT-8. This is shown in Fig. 5. The six subcarrier oscillators are packaged as individual plug-in units, miniature construction being used. Fig. 6 is a photograph of one of these units. The overall dimensions of each of the subcarrier oscillators are 8.5 x 5 x 1 inches and the weight is 1.5 lbs. The use of an etched foil conductor process results in a readily serviceable unit with access to all components. With the exception of the capacitors in the multivibrator and the components in the output circuit, all six channels use the same parts.

Resistance and capacitance bridge balance controls have been incorporated into each of the subcarrier chassis so that no external bridge

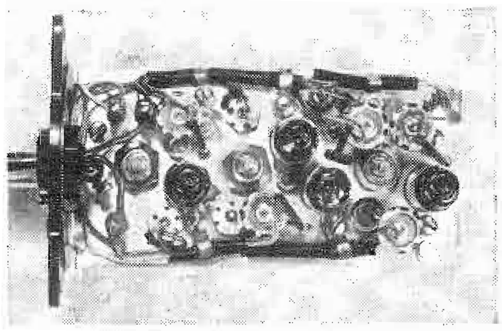


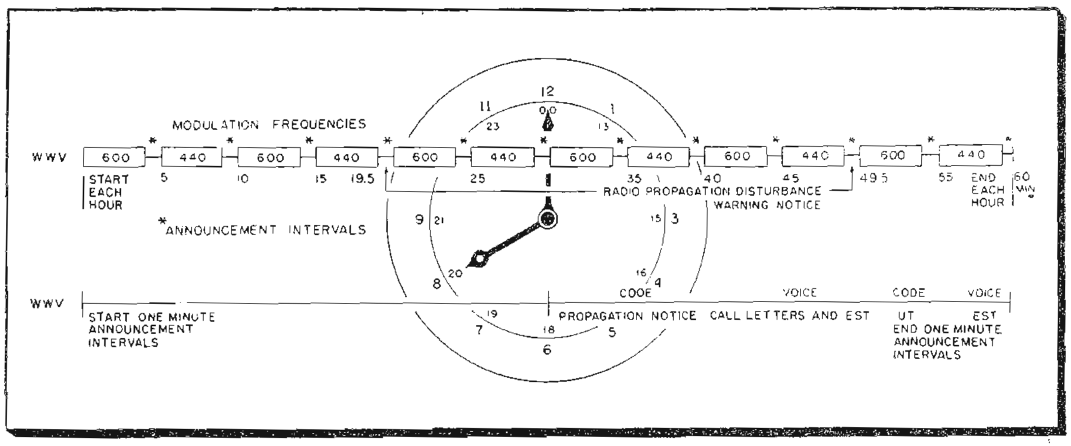
Fig. 8: R-F transmitter covers 215-230 MC

balancing components are required in the installation.

The AN/AKT-8 employs an r-f transmitter having a diameter of 2 in. and a length of 4 in. It is shown in Fig. 8. The weight of the r-f transmitter is 1 lb. The transmitter

(*Continued on page* 176)

NBS RADIO SERVICES



Schematic diagram showing services offered by NBS Radio Broadcasting Station WWV. At start of each hour, a 600-cycle tone is heard for four minutes. This is interrupted by a 1-minute announcement period in which Eastern Standard Time is announced in voice and Universal Time in code. At conclusion of announcement period, a 440-cycle tone is transmitted for four minutes. Announcements are repeated for new time and then followed by 4-minute 600-cycle tone. A pulse of 0.005-second duration at intervals of one second is broadcast simultaneously with audio notes. At 19½ and 49½ minutes past the hour, radio propagation disturbance warnings are transmitted in code.

Preview of the 1953

Record-breaking meeting to hear 220 technical dustries. Turnout of 30,000 engineers expected

Once again New York City plays host to the IRE's National Convention, March 23-26, 1953. Some 220 technical papers will be presented at 43 sessions held in the Waldorf-Astoria Hotel, Belmont Plaza, and Grand Central Palace. A record attendance of 30,000 radio engineers from all over the world is expected to view the 400 exhibits which will fill the four floors of Grand Central Palace. Exhibits on the third and fourth floors will be grouped according to such subjects as audio, components, instruments, mobile equipment, military radio and computers. Several theaters will be provided for audio and TV demonstrations. The comprehensive display of radio-electronic aparatus is valued at $10 million.

Convention Highlights

Other highlights of this impressive 1953 Convention will include the presentation of the gavel of office to IRE president J. W. McRae by his predecessor D. B. Sinclair, and the principal address by William R. Hewlett of Hewlett Packard Co. at the March 23 opening meeting at 10:30 AM in the Waldorf-Astoria Grand Ballroom. A get-together cocktail party will be held the evening of March 23. On March 25, the Annual IRE Banquet will feature an address by David Sarnoff.

Since Grand Central Palace is not expected to be available next year, plans are under way to hold the 1954 Convention in the Kingsbridge Armory, Bronx, N. Y., one of the largest in the world.

The technical program includes the following papers:

Monday, March 23

ANTENNAS I—GENERAL

"The Measurement of Highly Directive Antenna Patterns and Over-All Sensitivity of a Receiving System by Solar and Cosmic Noise"—J. Aarons, Air Force Cambridge Research Center.
"Radiation Patterns for Aperture Antennas with Non-Linear Phase Distributions"—C. Allen, General Electric.
"Factors Affecting Radiation Patterns of Corrugated Surface Antennas"—M. Ehrlich and L. Newkirk, Hughes Aircraft.
"A Microwave Anechoic Chamber for Antenna Pattern Measurements"—A. H. Simmons, Naval Research Lab.
"Wide-Frequency-Range Tuned Circuits and Antennas"—A. G. Kandoian and Sichak, Federal Telecommunication Labs.

TELEVISION I

"Theory of Synchronization Applied to NTSC Television"—D. Richman, Hazeltine.
"Color Synchronization in the NTSC Color Television Receiver by Means of the Crystal Filter"—W. E. Good, General Electric.
"Automatic-Phase-Control Color Synchronization for NTSC Color Television"—D. Richman, Hazeltine.
"Transient Response In a Color Carrier Channel With Vestigial Side Band Transmission"—J. S. S. Kerr, General Electric.
"Transients in Color Television"—P. W. Howells, General Electric.

CIRCUITS I—NETWORK THEORY

"A General RLC Synthesis Procedure"—L. Weinberg, Hughes Aircraft.
"A General Theory of Wide-band Matching"—H. J. Carlin and R. LaRosa, Polytechnic Institute of Brooklyn.
"Synthesis of Electric Filters With Arbitrary Phase Characteristics"—B. J. Bennett, Stanford U.
"Wide-Band Filter Amplifiers at Ultra-High-Frequencies"—J. M. Pettit, W. A. Christopherson and D. O. Pederson, Stanford U.
"Network Analysis With the Aid of Generating Polynomials"—H. Kurss, Polytechnic Institute of Brooklyn.
"Two New Equations for the Design of Filters"—M. Dishal, Federal Telecommunication Labs.

ELECTRONIC COMPUTERS I

"Multichannel Analog Input-Output Conversion System for Digital Computer"—P. A. Adamson and M. L. MacKnight, Hughes Aircraft.
"An Analog to Digital Converter With an Improved Linear Sweep Generator"—D. W. Slaughter, Calif. Institute of Technology.
"Dynamic Binary Counter With Analog Read-Out"—L. Packer, Columbia U.
"Life and Reliability Experience With Transistors in a High Speed Digital Computer"—J. J. Scanlon, Bell Tel. Labs.
"Engineering Experience in the Design and Operation of a Large Scale Electrostatic Memory"—J. Logue, A. Brennemann and A. Koelsch, IBM.

SYMPOSIUM: INSTRUMENTATION I—AUTOMATIC

"A New Method for Measuring Noise Figure and Gain of a Radar Receiver"—R. J. Parent and V. C. Rideout, U. of Wisconsin.
"Automatic Instrumentation for Continuous Monitoring of Systems Performance"—M. V. Ratynski, M. Kant and H. Webb, Rome Air Development Center.
"Automatic One-Shot Methods for Bandwidth Measurement"—J. B. Woodford, Jr. and E. M. Williams, Carnegie Institute of Technology.
"Microwave Power Meter with Automatic Zero Setting and Telemetering"—L. A. Rosenthal and G. M. Badoyannis, Rutgers U.
"Monitoring of Errors in Synchro Servo Systems"—G. Quazza, Polytechnic Institute of Brooklyn.

RADIO LOCATION, NAVIGATION AND AIRBORNE ELECTRONICS

"The Technique of Monopulse Radar"—W. Hausz, General Electric.
"Reducing Sky Wave Errors in CW Tracking Systems"—M. S. Friedland, Patrick Air Force Base, and N. Marchand, Electronics Lab.
"An Application of Integrator Type Signal Enhancer to Direction Finding Equipments"—C. A. Strom and J. A. Fantoni, Rome Air Development Center.
"A Theory of Target Glint or Angular Scintillation in Radar Tracking"—H. Delano, Hughes Aircraft.
"Automatic Dead Reckoning Navigation Computers for Aircraft"—J. L. Dennis, Wright Air Development Center.

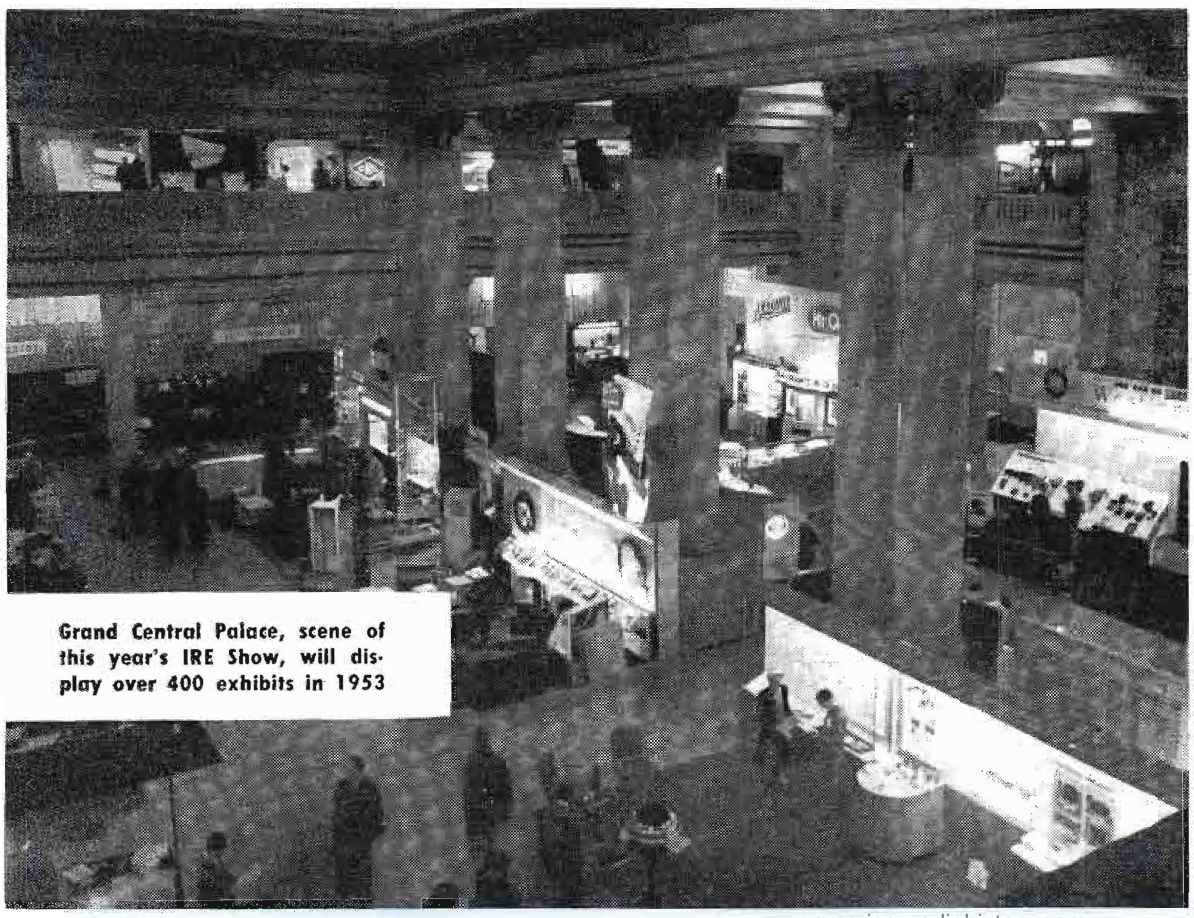
Tuesday, March 24

ANTENNAS II—MICROWAVE

"Arrays of Flush Mounted Travelling Wave Antennas"—J. N. Hines, V. H. Rumsey and T. E. Tice, Ohio State U.
"Transient Build-Up of the Antenna Pattern in End-Fed Linear Arrays"—N. H. Enenstein, Hughes Aircraft.
"A New Microwave Reflector"—K. S. Kelleher, Naval Research Lab.
"Crosstalk in Radio Relay Systems Caused by Foreground Reflections"—H. W. Evans Bell Tel. Labs.
"Low Side Lobes in Pencil-Beam Antennas"—E. M. T. Jones, Stanford Research Institute.

TELEVISION II

"Probability Distribution Measurements of Television Signals"—W. F. Schreiber, Cruft Lab., Harvard U.
"Colorimetric Properties of Gamma-Corrected Color Television Systems"—D. C. Livingston, Sylvania.



Grand Central Palace, scene of this year's IRE Show, will display over 400 exhibits in 1953

IRE Convention

papers covering all phases of the electronic in-
to view 400 exhibits valued at $10 million

"**Phase Measurements at Subcarrier Frequency in Color Television**"—A. P. Stern, General Electric.
"**A Precision Line Selector for Television Use**"—I. C. Abrahams and R. C. Thor, General Electric.
"**A Monitoring System for NTSC Color Television Signals**"—C. E. Page, Hazeltine.

CIRCUITS II—SYMPOSIUM: PANEL DISCUSSION ON WIDEBAND AMPLIFIERS

"**Conventional Amplifiers**"—W. Bradley, Philco.
"**Feedback Amplifiers**"—H. N. Beveridge, Raytheon.
"**Transistor Amplifiers**"—R. L. Wallace, Bell Tel. Labs.
"**Distributed Amplifiers**"—W. G. Tuller and E. H. Bradley, Melpar Electronics.
"**Traveling Wave Tube Amplifiers**"—L. Field, Stanford U.

ELECTRONIC COMPUTERS II

"**Analog Computing with Magnetic Amplifiers Using Multi-Phase A-C Voltages**"—J. E. Richardson, Hughes Aircraft.
"**Some Recent Developments in Logical 'Or-and-Or' Pyramids for Digital Computers**"—C. Leondes, U. of Pennsylvania.
"**Magnetic Core Switches as Logical Elements in Computers**"—E. A. Sands, Magnetics Research.
"**Magnetic Shift Register Using One Core Per Bit**"—R. D. Kodis, S. Ruhman and W. D. Woo, Raytheon.
"**Simple Computer for Automatically Plotting Correlation Functions**"—A. H. Schooley, Naval Research Lab.

(Continued on page 135)

Dr. James W. McRae
President of the IRE for 1953

TECHNICAL PAPER TOPICS, SYMPOSIA, and THEIR LOCATIONS for 1953 IRE CONVENTION

	BELMONT-PLAZA	WALDORF-ASTORIA			GRAND CENTRAL PALACE	
	Moderne Room	Grand Ballroom	Astor Gallery	Jade Room	Gold Hall	Blue Hall
Mon. P.M. 2:30	Antennas I - General Session 1	Television I Session 2	Circuits I - Network Theory Session 3	Electronic Computers I Session 4	Symposium: Instrumentation I - Automatic Session 5	Radio Location, Navigation and Airborne Electronics Session 6
Tues. A.M. 10:00	Antennas II - Microwave Session 7	Television II Session 8	Circuits II - Symposium: Panel Discussion on Wideband Amplifiers Session 9	Electronic Computers II Session 10	Instrumentation II - Symposium: Transistor Measurements Session 11	Significant Trends in Airborne Equipment Session 12
Tues. P.M. 2:30	Antennas III - Propagation Session 13	Symposium: Diagnostic Programs and Marginal Checking for Large Scale Digital Computers Session 14	Circuits III - Time Domain Networks - Delay Lines Session 15	Electron Devices I - Transistors Session 16	Instrumentation III - Electronics Session 17	Symposium: Trends in Mobile Communications Session 18
Tues. Eve. 8:30		Session 19 (to be announced)				
Wed. A.M. 10:00	Electron Devices II - Electron Tubes Session 20	Circuits IV - Active Networks - Transistors Session 21	Noise and Modulation Session 22	Symposium: Television Broadcasting Session 23	Quality Control Methods Applied to Electron Tube and Electronic Equipment Design Session 24	Seminar: Acoustics for the Radio Engineer - I Session 25
Wed. P.M. 2:30	Electron Devices III - Microwave Tubes Session 26	Information Theory I - Recent Advances Session 27	Communications Systems Session 28	Symposium: Television Broadcasting and UHF Session 29	Microwaves I - Symposium: Manufacture of Microwave Equipment Session 30	Seminar: Acoustics for the Radio Engineer II Session 31
	Moderne Room	Grand Ballroom	Starlight Roof	Sert Room	Gold Hall	Blue Hall
Thurs. A.M. 10:00	Symposium: Nucleonics Session 32	Information Theory II - Theoretical Session 33	Medical Electronics Session 34	Broadcast and Television Receivers - I Session 35	Microwaves II - Discontinuities and Transitions Session 36	Radio Telemetry Session 37
Thurs. P.M. 2:30	Audio Session 38	Engineering Management Session 39	Information Theory III - Coding Session 40	Broadcast and Television Receivers - II Session 41	Microwaves III - Ferrites and Detectors Session 42	Remote Control Systems Session 43

RELIABILITY OF

Filamentary Subminiature Tubes

Performance records show over 50,000 hours of satisfactory operation for each failure. Rugged construction withstands extreme shock and vibration

By ROSS WOOD
Raytheon Manufacturing Co.,
55 Chapel St., Newton 58, Mass.

ONE of the requirements of reliable tubes is uniformity of characteristics, not only from tube to tube, but as shown by stability of characteristics throughout the expected or intended operating life. For one application reliability might be achieved by long life under normal conditions of operation. In another application a short operating life of a few hundred hours or perhaps even a few hours might be acceptable in exchange for greater freedom from early failures under severe operating conditions. Still another might require a high probability of successful operation for at least an extremely short time immediately after a long period of inactivity.

Different Environments

Another important requirement of a reliable tube is its ability to operate satisfactorily in a wide range of different environments. In various applications, extremes of ambient temperature are encountered. In some cases shock and vibration may constitute the principal hazard. Perhaps a short period of severe shock or vibration might cause permanent damage to the structure thus leaving the tube in an inoperative condition after the environment had changed to a more flavorable one. Operation might be required during shock and vibration in which case the resulting electrical output would be the principal cause of concern.

A third requirement is the ability to function satisfactorily over a wide range of electrical operating conditions. A single tube type may be expected in one application to afford reliable operation in conservative Class A amplifier service, in another the demand will be for high peak current in a Class C circuit, and in still another freedom from grid emission may be the outstanding requirement. At the same time each of these applications may require the tube to deliver its own peculiar kind of service while the voltages supplied to it are varying.

Design Factors

In view of these requirements it is worthwhile to outline briefly the design factors which are common to both filamentary cathodes and indirectly heated cathodes before proceeding with a more detailed discussion of the filamentary subminiature tube. Of course, good workmanship and adequate processing are prerequisites to reliability in a tube of any size, shape or construction. Uniformity of characteristics from tube to tube requires, in addition, that the mechanical design should provide precise control of the critical spacings between elements. Under conditions of shock and vibration it is necessary to limit the relative motion between elements. This motion can originate at the supports, for example from a loose fit between the grid siderods and the micas, or from the bending of the element. In either case, in order to minimize the electrical output it is quite important to maintain symmetry with respect to the plane through the grid siderods and the cathode.

Let us now compare the factors affecting reliability in indirectly heated cathode tubes which differ from those affecting reliability in filamentary types. First we have the possibility of failure of the heater structure. This is most likely to happen in one of three ways: heater-cathode shorts may result from the mechanical failure of the insulating heater coating or from inadequate spacing between uncoated portions of the heater and the cathode, heater-cathode leakage may develop, or open heaters might result from damage done to the heater wire while it was being formed or from portions of the heater with low thermal inertia overheating when the power is first applied. In the filamentary type tube, since there is no separate heater and cathode, the hazard of heater-cathode shorts or leakage is non-existent. The reduction in the number of parts by the elimination of the heater-cathode assembly and the reduced number of welds further reduce the hazard of mechanical failure in the filamentary tube. The hazard of the open filament as compared with the open heater is somewhat reduced because of the greater structural simplicity of the filament and its lower operating temperature.

Spacing of Elements

Another significant difference between the cathode-type and the filamentary-type lies in the relative spacings from cathode to grid. The need for improved characteristics has forced the designer of the cathode-type tubes to resort to extremely close spacings of approximately two thousandths of an inch between the cathode coating and the inner surface of the grid winding. The closest corresponding spacing found in the filamentary types is about twice this distance or 0.004 in.

TABLE I: Life Tests Representing 13,500,000 Tube-Hours

Nature of Failure	Number of Tubes Failing	% of Tubes Failing	Tube-Hours Per Failure
Glass	9	0.03	1,500,000
Mechanical	48	0.18	284,000
Characteristic	197	0.72	69,000
All	254	0.93	54,000

TABLE II: Life Tests Representing 47,000,000 Tube-Hours

Nature of Failure	Number of Tubes Failing	Tube-Hours Per Failure
Glass	16	3,000,000
Mechanical	120	397,000
Characteristic	685	69,000
All	821	58,000

This greater spacing in the filamentary tube is brought about not so much from the desire for greater reliability at the expense of characteristics as from the fact that we do not know how to make the tube in production quantities with the closer spacing.

Emission Efficiencies

Still another difference between the two types of cathode is shown by a comparison of thermionic emission efficiencies. In the cathode-type CK6148, which is the reliable subminiature counterpart of the 6AK5, we use in normal operation a space current of 10 ma or 8 ma/watt of heater power, whereas in the filamentary subminiature type 1AD4 the corresponding figure is 3 ma or 24 ma/watt. If we make the comparison on the basis of the ratio of mutual conductance to total power input, we find that the CK6148 provides 2,000 micromhos per watt while the 1AD4 shows 8,000 micromhos per watt. Thus for applications where the heat introduced by the tube is important to reliability the filamentary type has the advantage.

The filamentary subminiature has much to offer in its ability to withstand severe shock and vibration without suffering permanent damage. In both types of subminiature the factors of small size, low mass, and short spans both lengthwise and laterally contribute greatly toward improved strength. The effect of short spans is of particular importance since, under a given acceleration, the deflection of a beam is directly proportional to the fourth power of the length. Thus a 1% decrease in the length of an element results in about a four percent decrease in the deflection. Since the bending moment varies as the square of the length, a 1% reduction length will accommodate a 2% increase in acceleration before permanent deformation results. In addition the filamentary type offers a very much smaller cathode mass than does the heater-cathode combination with consequent reduction of the hazard of mica damage as a result of shock. Again comparing the 6AK5 with the 1AD4, the ratio of cathode assembly masses is about 100:1.

Shock and Vibration

In many of the applications which have developed in recent years a highly important, and frequently absolutely essential, requirement for reliability is that the electrical output during shock and vibration should be so low as to approach the inherent thermal noise level of the system. In order to minimize the electrical output during vibration, two important factors must be considered. One is the reduction of relative motion between the tube elements, the other is the attainment of both electrical and mechanical symmetry with respect to the two working faces of the cathode.

Motion Between Elements

Several methods have been employed successfully with both filamentary and cathode types to reduce the motion between the tube elements and the supporting mica spacers. These include the use of tight grid-holes and cathode-holes in the micas, the use of double mica spacers both top and bottom, and in some cases the more positive anchorage of the grids by means of straps or stakes riveted to the mica.

The next factor requiring attention in the reduction of relative motion is the bending of the elements under conditions of shock and vibration. This manifests itself in two ways: as excitation of mechanical resonances within the structure, and as forced vibration of the elements at frequencies far removed from the natural resonant frequencies.

(*Continued on page* 112)

Navy Releases Authorized Reliable Tube List

THE Department of the Navy has issued a reliable tube list describing tube types, lower quality counterparts, approved supply sources, and factors affecting interchangeability. They are divided into two groups: Group A, production types; and Group B, development-production types. The pertinent specifications and interchangeability factors (where present) are described in the footnotes below the main listing, which supersedes listings prior to Nov. 13, 1952.

GROUP A PRODUCTION TYPES

Spec. No.	Reliable Tube Type	Lower Quality Counterpart	Approved Source
2	5Y3WGTA	5Y3GT	Hytron
4	6AU6WA	6AU6	G.E.
4	6SK7WA	6SK7, 6SK7W	G.E.
4	5654	6AK5, 6AK5W	Raytheon, G.E., RCA Sylvania, Tung-Sol
4	5670[a]	2C51	G.E., Bendix, Raytheon
1	5686	———	G.E., Raytheon
4	5725	6AS6, 6AS6W	Raytheon, G.E.
4	5726	6AL5, 6AL5W	Raytheon, G.E., Tung-Sol, Hytron, Sylvania, RCA G.E.
3	5727	2D21, 2D21W	G.E., Sylvania,
4	5749	6BA6	Raytheon, Tung-Sol G.E.
4	5750	6BE6	G.E.
4	5751[a,c]	12AX7	G.E., Raytheon,
4	5814[a]	12AU7	Hytron, Sylvania
4	6005	6AQ5, 6AQ5W	G.E.
4	6072[a]	12AY7	G.E.
4	6135[a]	6C4, 6C4W	G.E.

GROUP B DEVELOPMENT-PRODUCTION TYPES

Spec. No.	Reliable Tube Type	Lower Quality Counterpart	Approved Source
11	OA2WA	OA2, 6073	Hytron
11	OB2WA	OB2, 6074	Hytron
11	5R4WGYA[b]	5R4GY, 5R4WGY	Chatham
5	5Y3WGTB	5Y3GT	G.E.
6	6AC7WA	6AC7, 6AC7W	G.E.
11	6AK6WA	6AK6	National Union
11	6AN5WA	6AN5	Raytheon
9	6C4WA[b]	6C4, 6C4W	Raytheon
7	6J4WA	6J4	RCA, Sylvania
8	6J6WA	6J6, 6J6W	Raytheon, Sonotone, Westinghouse
11	6SN7WGTA	6SN7GT, 6SN7WGT	Sylvania
6	12AT7WA	12AT7	G.E.
11	807WA[b]	5933, 807W, 807	Sylvania
9	5651WA	5651	Chatham, Raytheon
11	5687WA	5687	Tung-Sol
10	6080WA[b,d]	6080, 6AS7G	RCA

1. MIL 28 Feb. 1952
2. MIL 25 June 1952
3. MIL 27 Aug. 1952
4. MIL 28 Oct. 1952
5. BuShips 20 Jan. 1952
6. BuShips 28 Jan. 1952
7. BuShips 4 Feb. 1952
8. BuShips 21 Feb. 1952
9. BuShips 4 Mar. 1952
10. BuShips 5 Mar. 1952
11. BuShips 13 Mar. 952

a. Reliable tube draws 1/6 more heater current than counterpart
b. Reliable tube bulb shape different than counterpart
c. Reliable tube mu is 70 instead of 100
d. Reliable tube base different than counterpart

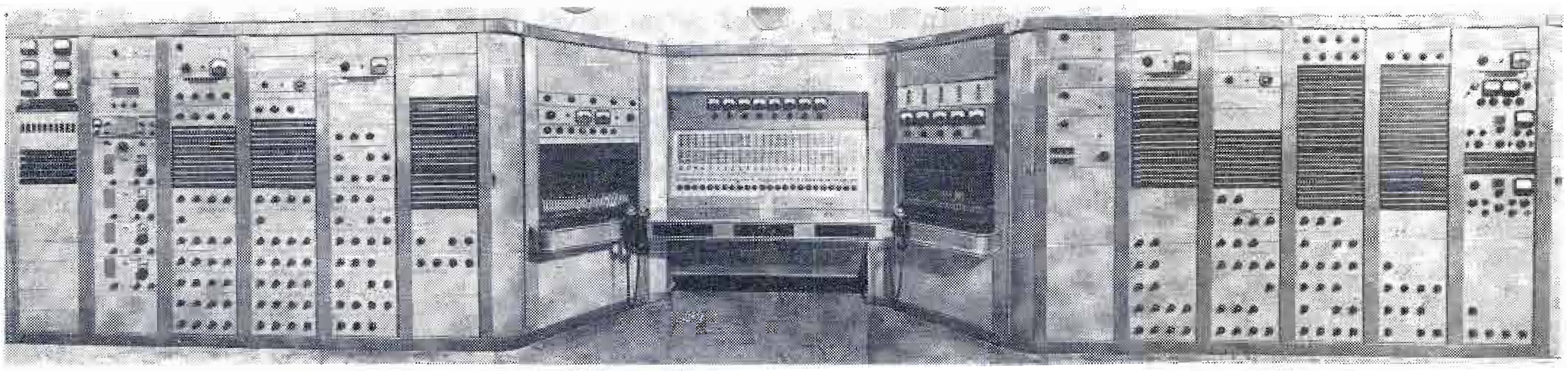
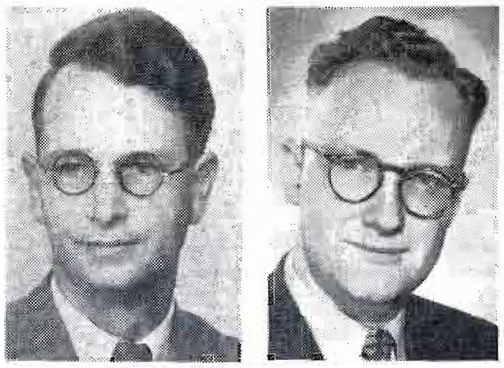


Fig. 1: Canadian Broadcasting Corporation's master control installation at Montreal feeds the outputs of 24 studios to eight network lines

Avoidance of Crosstalk in Large Audio Distribution Systems

Master control at Canadian Broadcasting Corp., one of world's largest, uses unshielded wire to interconnect 180 program amplifiers



Tanner Thompson

By R. H. TANNER and G. B. THOMPSON

Northern Electric Co., Ltd. Belleville, Ontario, Canada

FOR more than a year, the new Master Control equipment at the Montreal headquarters of the Canadian Broadcasting Corporation has been in full operation. This system is one of the largest in the North American continent, and mainly in order to save space and installation labor, nearly all the wiring is carried out in unshielded telephone cable. In spite of this, the performance of the equipment, especially as regards noise and crosstalk, is of a very high order.

The installation, is pictured in Fig. 1. The center section comprises the preset switching system, connecting as required the outputs of 24 studios to eight outgoing network lines, together with input and output gain controls and output volume indicators. The right hand wing houses the order wire switchboard and the volume indicators and switching associated with five local transmitter lines. In the left hand wing are the control panel for an elaborate monitoring selector and a device for feeding various cue programs back to the studios. The remainder of the bays carry the 180 program amplifiers and their associated jackfields, as well as such accessories as receivers, test equipment, and power distribution panels.

More Wire Needed

At the request of the C.B.C., and in order to facilitate any changes in circuitry which future operations require, the inputs and outputs of every amplifier are connected to their corresponding jacks by way of a large telephone type distribution frame (Fig. 2), located on the floor below, on which the cross jumpering may readily be changed. While this is obviously a very valuable feature from the point of view of the user, it results in a very considerable increase in the amount of wire required. For example, an incoming network program may be taken from the distribution frame to the main panel or down again thirteen times before it reaches an outgoing line. The possibilities of picking up crosstalk and noise are obvious. Fig. 3 shows the rear of a portion of the equipment, and illustrates the size of cables necessary even with unshielded wire. It is obvious that the use of shielded pairs would have been virtually impossible.

We may now turn to the precautions taken in the original design to avoid crosstalk and to the remedies which had to be applied to cure the crosstalk which manifested itself when the equipment had been built and installed. The first requirement, of course, is good well paired and balanced cable. Good telephone cable, now available in both lead and plastic sheaths, has a very high inherent attenuation from pair to pair provided that considerable care is exercised in the installation and wiring. For example, the lay of the twisted pairs should never be disturbed except at the very ends where, of course, the wires have to be fanned out for connections. In particular, the accidental use of "split pairs," which in a large multi-conductor cable is sometimes only too easy, must be avoided at all costs, since it will inevitably introduce a large amount of crosstalk and yet may be extremely difficult to locate.

Cost Factors

As far as the amplifier design is concerned, the additional cost of well shielded input transformers, which may be used in systems in which the balance of the interconnecting circuits is none too good, must be weighed against the cost of improving this balance so as to allow the use of lower quality transformers. In a large system such as we are dealing with, it is probable that the saving effected through the use of unshielded transformers more than pays for the additional precautions needed in the cabling. It is also important that, where several amplifiers are to be fed from a common power supply, the distortion should be kept to a very low figure (less than 1%), as otherwise any common coupling in the power leads can cause crosstalk during passages of heavy program. For the same reason, the use of amplifiers other than Class A should be avoided. In our case, considerable trouble was caused by the inclusion of a 1 ohm metering resistor in the common B-return of each nest of four amplifiers. The power supplies should be of the voltage regulating type in order to ensure the lowest possible output impedance.

Grounding Arrangements

In any large system, the grounding arrangements are always important. In particular, care must be taken to keep shielding and current carrying grounds separate, except for a single connection, the location of which may sometimes have to be determined experimentally. The main building ground must be adequate and, if possible, leakage from any item of equipment to this point should be prevented. For example, it may sometimes be necessary to insulate the racks from a floor in which steelwork is present. Originally, the C.B.C. installation was equipped with a heavy conductor connecting the common B- of all the power supplies to the building ground: it was found necessary to cut this, and ground the B- to the equipment frame at a point adjacent to the meter panel.

As far as the grounding of the program circuits themselves is concerned, two different systems are practicable. The first is to ground all the available center taps (such as transformers, balanced potentiometers, pads, etc.); the second is to ground as few as possible, normally one on each circuit loop. The latter is usually preferable as it eliminates the possibility of longitudinal magnetic pickup in the cables.

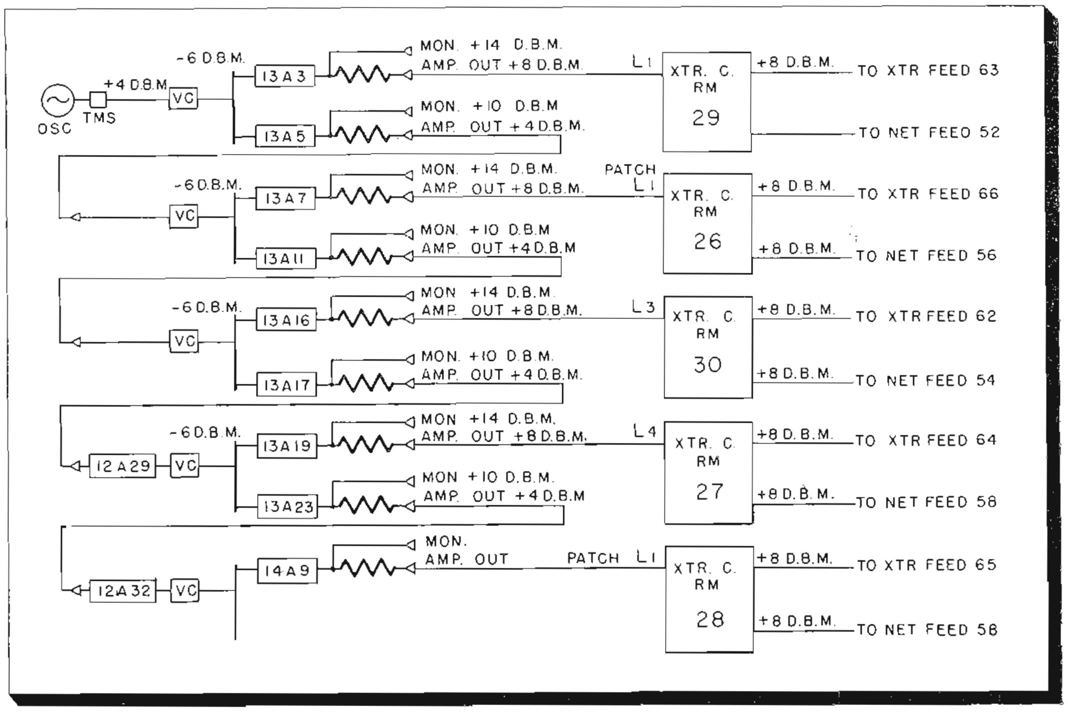


Fig. 4: Set-up for measuring crosstalk employs tone fed into five inputs, energizing 105 amplifiers

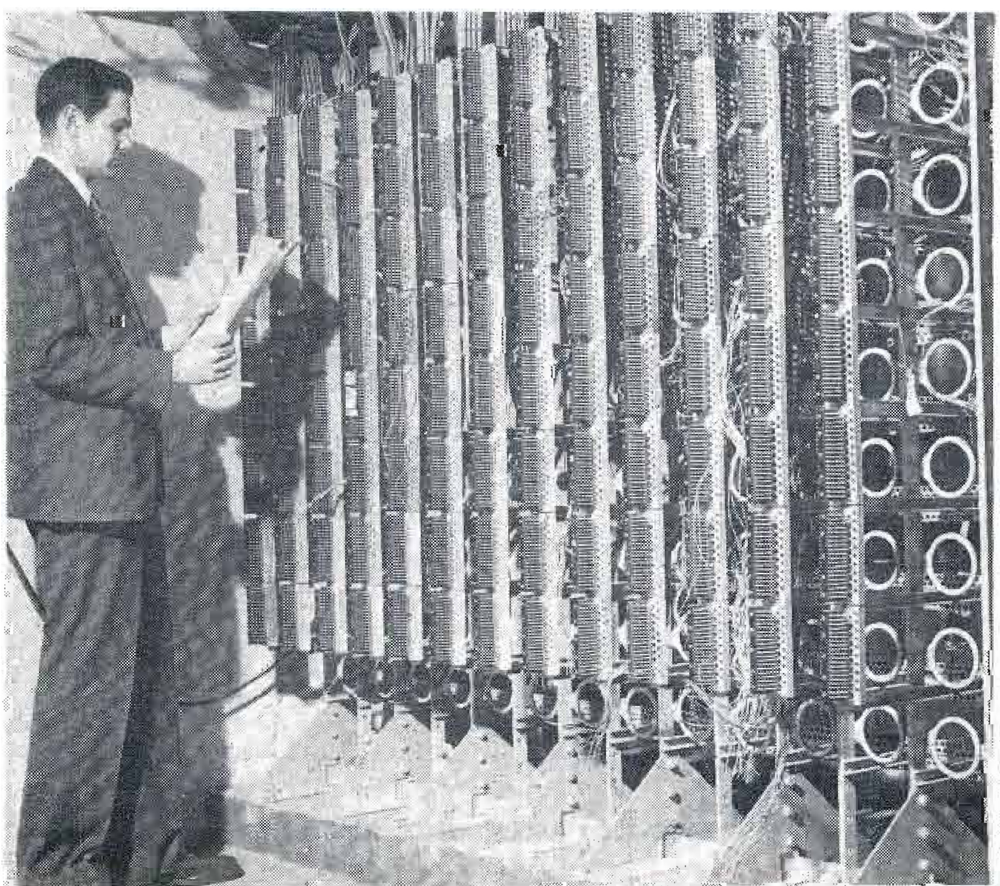
Differential Ohmmeter

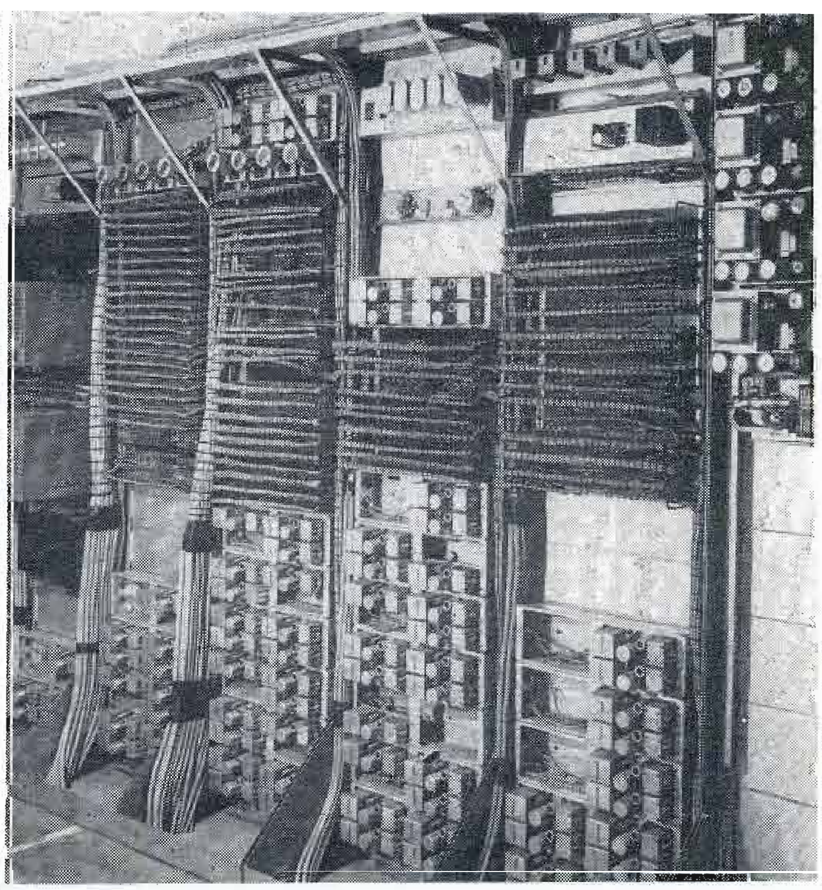
Stray and unintentional grounds are of course quite fatal and must be discovered and eliminated at the earliest possible stage. For this purpose, we used a home made gadget called a differential ohmmeter (or more familiarly, a "whiffledink") which is shown in Figure 5. The device consists of a dc selsyn of the aircraft fuel gauge type, a battery and a jack. When patched to a circuit, it detects a grounded conductor and identifies it. Similarly, by deliberately grounding one end of a pair, the other end may readily be found.

In general, throughout a system of this kind, all circuits of any length should be balanced to ground with reasonable accuracy. In the apparatus under discussion this is done with all the busbars across which amplifiers are bridged, either by the use of balanced attenuators, the center points of which are grounded, or by two equal resistors from each side to ground. Of course in cases where the circuit is fed from or terminated in a center tapped transformer, the connection of this tap to ground often provides the simplest and most accurate means of balancing. In practice, it is sometimes pos-

(*Continued on page* 147)

Fig. 2: (l) Front view of distribution frame shows flexible jumper-jack arrangement for changing amplifier connections. Fig. 3: (r) rear view





Frequency Range for Air-Dielectric

RTMA standards now being established for rigid, gas-filled coaxial lines set up frequency limits for various sizes. Results of calculations for 50-ohm and 75-ohm lines

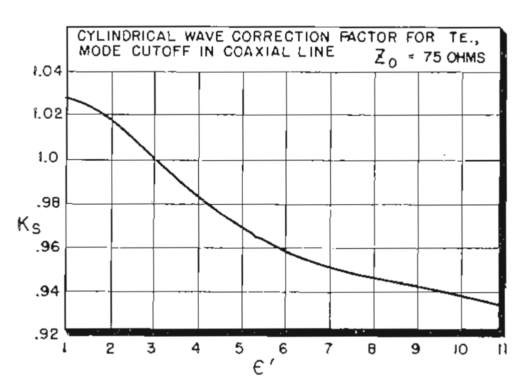


Fig. 1a: Wave correction factor for 75-ohm line

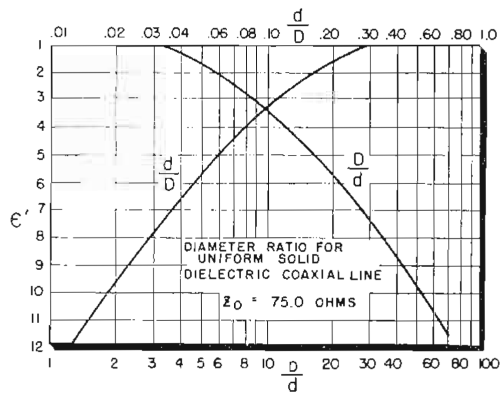


Fig. 2a: Diameter ratios 75-ohm coaxial line

By OWEN FIET
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The RTMA Subcommittee on Air Dielectric Coaxial Transmission Lines (TR 9.11.2) is engaged in setting up a standard for tubing dimensions and tolerances for coaxial transmission lines of the rigid, gas filled type. These lines are to have electrically transparent supporting structures with a nominal iterative impedance of 50 ohms. See Table I. In the course of these activities it appeared desirable to specify frequency limits for the various sizes of coaxial transmission lines to be included in the standard. The problem of establishing frequency limits was turned over to the authors of this paper for their consideration. The problems considered were two-fold.

1. The determination of a set of criteria from which could be derived the frequency limits for the various sizes of transmission line.
2. Establishment of the actual frequency limits.

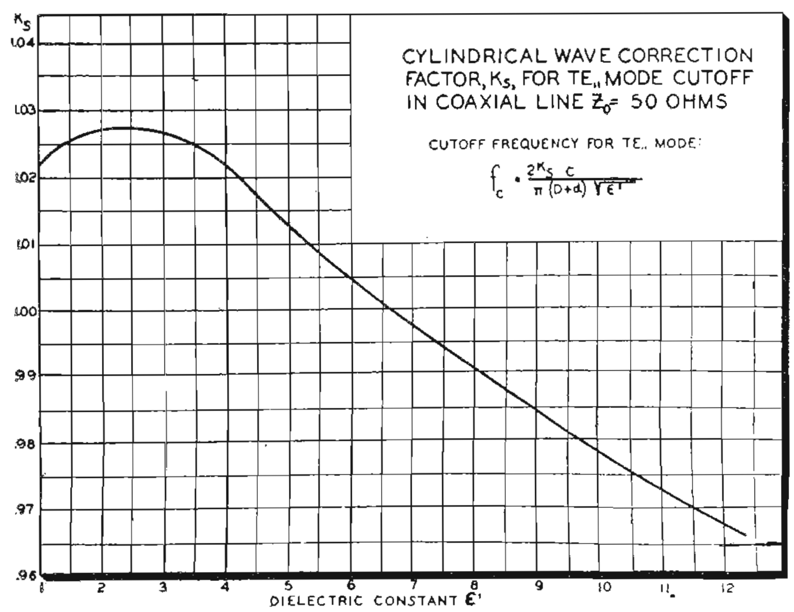
Criteria for Frequency Range

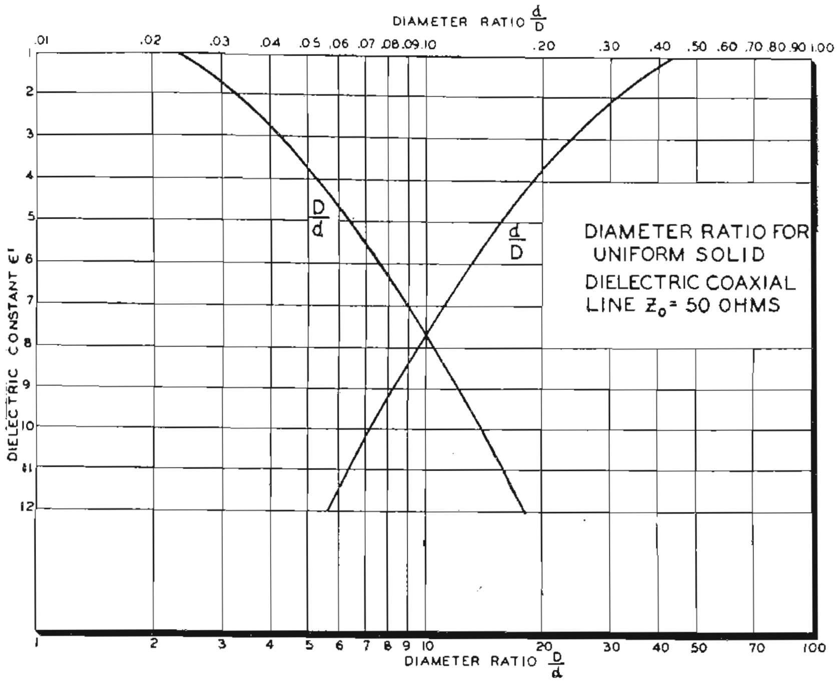
A uniform coaxial transmission line will transmit in the fundamental transverse electromagnetic (TEM) mode all frequencies. At the lower frequencies the characteristic impedance of the coaxial transmission line is no longer a function only of the inside diameter of the outer conductor and the outside diameter of the inner conductor.

From a constant impedance point of view, it must be considered that the lower frequency limit falls somewhere in the very low radio frequency band and is determined by the deviation of the impedance of a finite length of the transmission line from the specified tolerance on the iterative impedance.

At the high frequency end the existence of higher order (waveguide) modes will produce apparent changes in the iterative impedance and will result in reflections of undesirable magnitude. For a uniform coaxial transmission line without any discontinuities or supporting structures, it would be possible to transmit the fundamental TEM mode at frequencies above the cutoff of the TE and TM waveguide modes. In this type of transmission line, if a pure TEM mode is excited at the input; it would be the only mode propagating as long as the transmission line had no perturbations which could excite the higher order waveguide modes. In actual practice, it is extremely difficult, if not improbable, to achieve a perfectly uniform transmission line. Accordingly, it is the desirable practice to set the upper frequency limit for TEM mode propagation at a frequency where all higher order modes are below cutoff, at least in the gas filled portion of the coaxial lines. The upper frequency limit of a coaxial transmission line is de-

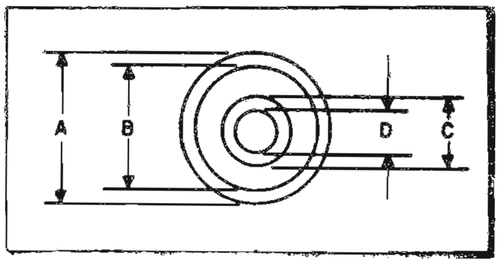
Fig. 1: (l) Wave correction factor for 50-ohm line
Fig. 2: (r) Diameter ratios for 50-ohm coaxial line





Coaxial Lines

termined by the cutoff frequency of the higher order waveguide modes of propagation since their existence will affect the impedance of the line and the transmission characteristics of the normally propagated TEM coaxial mode. The waveguide mode which has the lowest cutoff frequency is the TE_{11} mode; and, for most practical applications this cutoff frequency is the upper limit of operation of the coaxial transmission line. The presence of dielectric supporting structures requires that the



Cross-sectional coaxial line dimensions

dimensions of the inner and/or outer conductor be modified to maintain the impedance. Thus, the cutoff frequencies in the supporting structure will differ from that for the uniform air dielectric coaxial line. The cutoff frequency in the dielectric supporting structure will always be lower than that in the uniform gas filled region, since the known solid dielectrics have in general a relative dielectric constant much larger than that of air.

TABLE 1—Dimensions, Tolerances, Iterative Impedance and Cutoff Frequencies for Rigid Air Dielectric Coaxial Transmission Lines

	OUTER CONDUCTOR				INNER CONDUCTOR				Z_0= 50 OHMS	
Line Size	A Dia.	B Dia.	Wall Thickness Nominal	Maximum Deviation From Average	C Dia.	D Dia.	Wall Thickness Nominal	Maximum Deviation From Average	Iterative Impedance (ohms) Nominal	Max. Min.
6-1/8	6.125 ±.008	5.981 ±.008	0.072	.012	2.600 ±.004	2.520 ±.004	0.040	.0075	50	50.15 49.82
3-1/8	3.125 ±.005	3.027 ±.005	0.049	.0075	1.315 ±.003	1.231 ±.003	0.042	.005	50	50.26 49.73
1-5/8	1.625 ±.003	1.527 ±.003	0.049	.005	0.664 ±.0025	0.588 ±.0025	0.038	.005	50	50.31 49.64
7/8	0.875 ±.0025	0.785 ±.0025	0.045	.005	0.431 ±.002	0.291 ±.002	0.025	.003	50	50.57 49.48
3/8	0.375 ±.002	0.285 ±.002	0.045	.0045	0.125 ±.002	----	Rod	----	50	50.83 48.07

TABLE 1A—Dimensions, Tolerances, Iterative Impedance and Cutoff Frequencies for Rigid Air Dielectric Coaxial Transmission Lines

	OUTER CONDUCTOR				INNER CONDUCTOR				Z_0=75 OHMS	
Line Size	A Dia.	B Dia.	Wall Thickness Nominal	Maximum Deviation From Average	C Dia.	D Dia.	Wall Thickness Nominal	Maximum Deviation From Average	Iterative Impedance (ohms) Nominal	Max. Min.
6-1/8	6.125 ±.008	5.981 ±.008	0.072	.012	1.716 ±.004	1.636 ±.004	0.040	.0075	75	75.14 74.70
3-1/8	3.125 ±.005	3.027 ±.005	0.049	.0075	.869 ±.003	.789 ±.003	0.040	.005	75	75.20 74.59
1-5/8	1.625 ±.003	1.527 ±.003	0.049	.005	.438 ±.002	.362 ±.002	0.038	.005	75	75.27 74.49
7/8	0.875 ±.0025	0.785 ±.0025	0.045	.005	.226 ±.002	.176 ±.002	0.025	.003	75	75.53 74.09
3/8	0.375 ±.002	0.285 ±.002	0.045	.0045	.082 ±.001	-----	Rod	-----	75	75.74 73.43

Cutoff Frequency

The TE_{11} mode cutoff frequency can be readily estimated from the mean circumference calculated from the outer conductor inside diameter and the inner conductor outside diameter by setting this value equal to one wavelength at the cutoff frequency. This will be in error by less than 3% for 50 ohm coaxial transmission line with insulating materials ordinarily utilized in high frequency operation. A small correction factor K_s, (see Fig. 1) applied to the cutoff frequency will give a result corresponding to the exact solution using cylindrical waves. The equations are given for the general case and for 50 ohm transmission lines. Figs. 1 and 2 will aid in the calculation of the cutoff frequency for most supporting structure dielectric materials.

For any uniform coaxial transmission line the cutoff frequency of the TE_{11} mode is given by:

$$f_o = \frac{2cK_s}{\sqrt{\epsilon'}\,\pi\,(D + d)} = \frac{7514\ K_s}{\sqrt{\epsilon'}\,(D + d)} \qquad (1)$$

and the impedance for air dielectric is:

$$Z_o = 138.16 \log_{10} (D + d) \qquad (2)$$

For a uniform air line as a func-

Symbols Used in Mathematical Formulae

- f — Operating frequency, mc
- f_o — Cutoff frequency for TE_{11} mode, mc
- c — Velocity of light in vacuum $(2.99796/2.54) \times 10^4$ in./μsec.
- ϵ' — Dielectric constant relative to vacuum
- μ_o — Permeability of free space 4×10^{-7} h/m
- D — Inside diameter of outer conductor of air (vacuum) line, in.
- d — Outside diameter of inner conductor of air (vacuum) line, in.
- K_s — Correction factor accounting for cylindrical wave boundary condition (based on Schelkunoff "Electromagnetic Waves," D. Van Nostrand Co., Inc. 1943, Fig. 8.51, P. 327 and Text, page 391)
- D' — Inside diameter of overcut outer conductor, in.
- d' — Outside diameter of undercut inner conductor, in.
- δ — Depth of penetration, cm
- ρ — Resistivity, ohm-cm
- V — Voltage on transmission line
- I — Current in transmission line
- s — Distance along transmission line
- Z — Series impedance per unit lengh
- Y — Shunt admittance per unit length
- γ — Propagation constant
- Z_o — Characteristic or iterative impedance
- Z_o' — Low frequency modified characteristic impedance
- L_o — Inductance per unit length, h/cm
- $H\Theta$ — Angularly directed component of magnetic field in the metal
- H_o — Angularly directed component of magnetic field at the surface of the metal
- r_o — Radius to an internal surface of the transmission line
- Rs — Skin effect resistance in ohms (the d.c. resistance between the edges of a square plate of thickness equal to the depth of penetration)
- r — A radius inside the metal having a value close to r_o
- η_m — Intrinsic impedance of metal
- v' — Velocity of propagation at very low radio frequencies

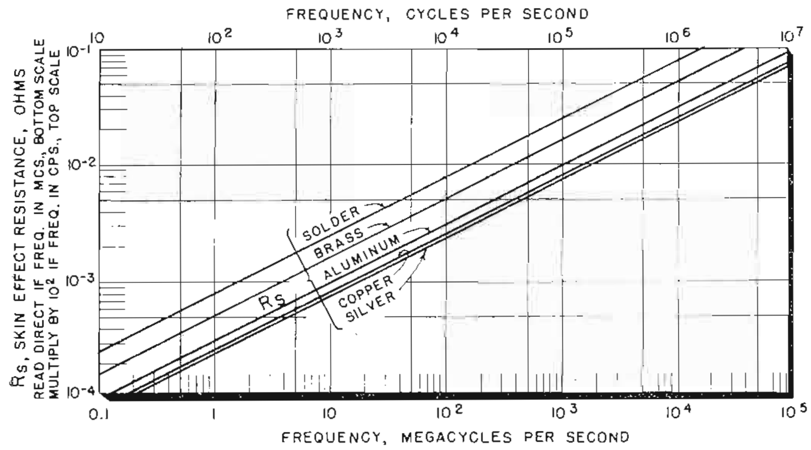


Fig. 3: Skin effect resistance-frequency characteristic

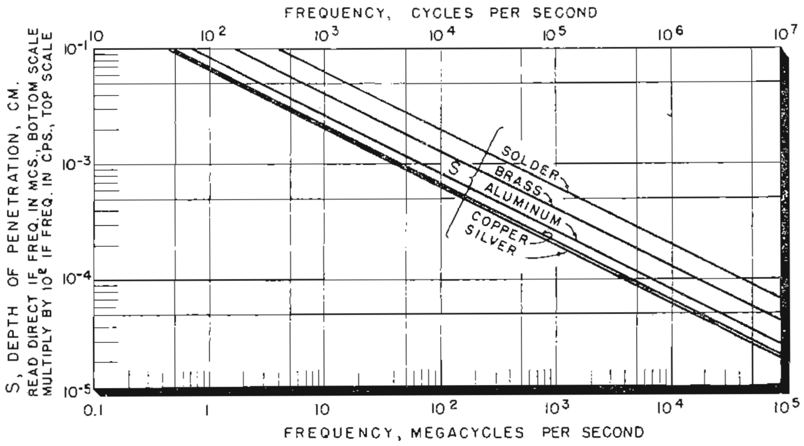


Fig. 4: Depth of penetration-frequency characteristic

tion of the outer conductor diameter and the impedance, Eq. (1) becomes:

$$f_o = \frac{2cK_s}{\pi D\,[1 + \log_{10}^{-1}(-Z_o/138)]} \quad (3)$$

$$= \frac{7514\ K_s}{D\,[1 + \log_{10}^{-1}(-Z_o/138)]}$$

For a uniform air line as a function of the inner conductor and the impedance Eq. (1) becomes:

$$f_o = \frac{2cK_s}{\pi d\,[1 + \log_{10}^{-1}(Z_o/138)]} \quad (4)$$

$$= \frac{7514\ K_s}{d\,[1 + \log_{10}^{-1}(Z_o/138)]}$$

For a constant impedance transmission line where the supporting structure is to be electrically transparent, it becomes necessary to modify the inner or outer conductor diameter to retain the nominal iterative impedance in the solid dielectric portion. The two most prevalent practices are either to enlarge the inner diameter of the outer conductor or to decrease the outer diameter of the inner conductor so that the impedance computed by the relationship given in Eq. (2) will remain constant. The first type is designated overcut transmission line and the latter is known as undercut transmission line. For these two specific cases the general relationships for the cutoff frequency can be obtained by proper manipulation of Eq. (1) and (2).

For the overcut transmission line the inner conductor remains fixed and the resultant inner diameter of the outer conductor, D', is obtained from the relationship:

$$D' = [\log_{10}^{-1}(Z_o\sqrt{\epsilon'}/138)]d \quad (5)$$

which gives the general equation for determining the cutoff frequency in terms of the inside diameter of the outer conductor of the air line:

$${}_{oc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\,D\left[\log_{10}^{-1}\frac{Z_o}{138}(\sqrt{\epsilon'} - 1) + \log_{10}^{-1}\left(-\frac{Z_o}{138}\right)\right]} \quad (6)$$

In terms of the outside diameter of the inner conductor of the air line, the cutoff frequency is given by:

(*Continued on page 162*)

TABLE II—Low Frequency Impedances and Cutoff Frequencies for TE_{11} Mode in Various Size Coaxial Lines and Insulator Supports; for Copper Conductors; Z_o 50 ohms

Line Size	Inner d OD"	Outer D ID"	D/d	TE_{11} MC Cutoff (Air Line)	TE_{11} MC Cutoff Undercut Teflon	TE_{11} MC Cutoff Overcut Teflon	TE_{11} MC Cutoff Undercut Poly-styrene	TE_{11} MC Cutoff Overcut Poly-styrene	Z'o		v'/C	
									0.1 mc	1.0 mc	0.1 mc	1.0 mc
3/8	.125	.285	2.28	18,800	14,387	9,895	13,422	8,175	52.80	50.90	0.9470	0.9827
7/8	.341	.785	2.302	6,818	5,223	3,593	4,873	2,968	51.05	50.33	0.9798	0.9935
1-5/8	.664	1.527	2.300	3,505	2,686	1,847	2,506	1,526	50.53	50.17	0.9895	0.9936
3-1/8	1.315	3.027	2.302	1,768	1,355	932	1,264	770	50.27	50.09	0.9947	0.9983
6-1/8	2.600	5.981	2.300	895	686	472	640	390	50.14	50.05	0.9973	0.9991

TABLE IIA—Low Frequency Impedances and Cutoff Frequencies for TE_{11} Mode in Various Size Coaxial Lines and Insulator Supports; for Copper Conductors; Z_o 75 ohms

Line Size	Inner d OD"	Outer D ID"	D/d	TE_{11} MC Cutoff (Air Line)	TE_{11} MC Cutoff Undercut Teflon	TE_{11} MC Cutoff Overcut Teflon	TE_{11} MC Cutoff Undercut Poly-styrene	TE_{11} MC Cutoff Overcut Poly-styrene	Z'o		v'/C	
									0.1 mc	1.0 mc	0.1 mc	1.0 mc
3/8	.082	.285	3.485	21,051	15,881	9,048	14,655	6,970	78.81	76.20	.9517	.9842
7/8	.226	.785	3.483	7,643	5,766	3,285	5,324	2,531	76.41	75.45	.9815	.9940
1-5/8	.438	1.527	3.486	3,929	2,964	1,689	2,737	1,301	75.72	75.225	.9904	.9970
3-1/8	.869	3.027	3.473	1,982	1,495	852	1,381	656	75.37	75.15	.9950	.9980
6-1/8	1.716	5.981	3.476	1,003	757	431	699	332	75.187	75.06	.9975	.9992

CONELRAD

FCC and Air Force plan controls station operation to prevent use of signals as navigational aid to enemy aircraft

THE FCC has formulated plans for the Control of Electromagnetic Radiation (CONELRAD) in the event of attack by enemy forces. Primary object of the plans, which have been approved by the Chairman of the National Security Resources Board and the Secretary of Defense, is to prevent the utilization of signals from broadcast stations in the U.S. as a navigational aid to enemy aircraft. Plan No. 1 covers the alerting of broadcast stations, and Plan No. 2 encompasses the controlled operation of these stations.

Under Plan No. 1, the U.S. is divided by the Air Defense Command (ADC) into three large areas known as Eastern, Central and Western Air Defense Forces. Each of these is broken down into smaller areas called Air Divisions, each Division, having an Air Defense Control Center (ADCC). See Fig. 1. Operationally, the plan is built around the various ADCC's.

Certain broadcast stations are designated as Basic Key Stations and Key Relay Stations. When conditions exist which justify the announcement of warning YELLOW or RED, at the discretion of the ADC, alerts will be issued by the ADCC's to all Basic Key Stations. The notifications will be passed on to the transmitter locations of Relay and other stations by telephone or, in certain instances, by radio broadcast, and will normally consist of prepared recordings. All stations subject to this plan must install and keep in readiness the equipment necessary to receive alerts and all clears.

Minimize Signals

The object of Plan No. 2 is to minimize the use of broadcast signals as navigational aids, and at the same time permit stations to be operated. Broadcast stations notified of an alert will be required, during the alert period, either to observe radio silence or follow operational procedures prescribed in Plan No. 2.

Under this plan, all FM and TV stations notified will be required to observe radio silence. Whether standard AM broadcast stations will be required to observe radio silence or will be permitted to operate in accordance with the prescribed procedures, will initially depend on the wishes of the station licensees. So far as practicable, the FCC will agree to these decisions. However, once these decisions are made, they are binding upon the stations, and stations participating in the CONELRAD operation may withdraw only upon 30 days' advance notice to the FCC.

Procedure During Alert

From the time of alert notification until the alert is ended, no broadcast station of any type will be permitted to make an on-air identification, unless specially authorized by the FCC. Those required to observe radio silence must leave the air immediately, except that before leaving the air they may broadcast an approved sign-off or civil defense message.

All stations permitted operation under Plan No. 2 will be on one or both of two frequencies, 640 KC and 1240 KC, during the alert period. The power ERP) allowed will not in any case exceed 10 kw, and usually will not be over 5 kw. Four different modes of operation are prescribed in the plan, one of which will be assigned by the FCC to each operating station. These are: sequential, on-off, pulsating and synchronous operation. See Fig. 2.

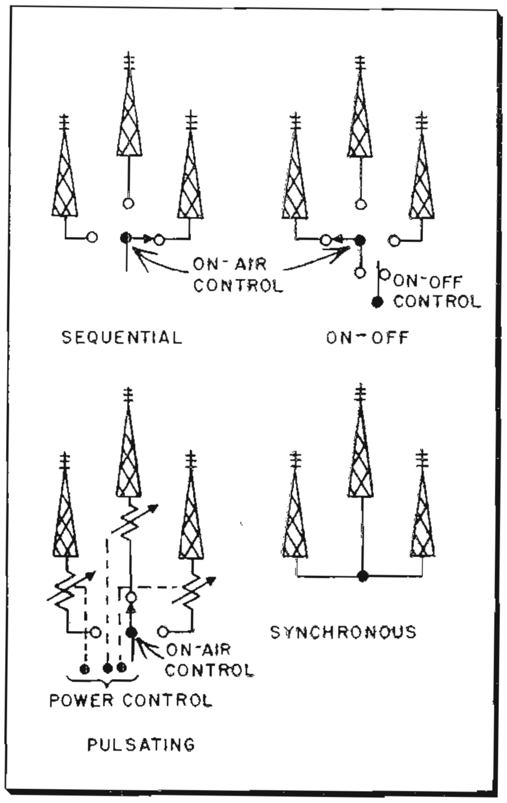
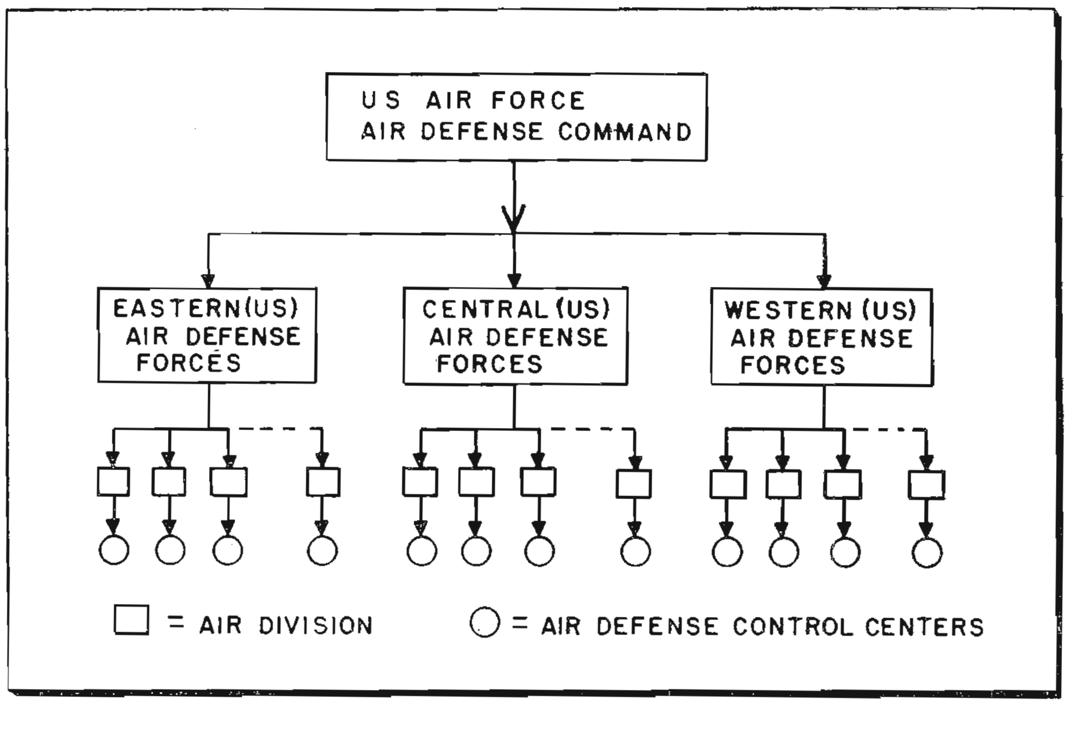


Fig. 2: Four modes of operating broadcast stations prevent guidance to enemy aircraft

Sequential Mode: In the sequential mode of operation, the FCC arranges two or more stations into a group, all using the same frequency, 640 KC or 1240 KC, or both. Power is

(*Continued on page* 160)

Fig. 1: Organizational structure of CONELRAD command plan from national to regional areas



CUES for BROADCASTERS

Practical ways of improving station operation and efficiency

Making Electrical Conductors in the Field

G. W. LEE, Consulting Engineer, 46 Roxborough St., Toronto, Canada

BROADCAST, television and communications equipment utilize soft-drawn copper tubing for electrical conductor paths whenever an appreciable amount of high frequency energy is transferred. During installation of such equipment the engineer must bend and shape conductors of various length and diameter. As new installation ideas evolve, the building housing the equipment is changed and unit modifications are undertaken in the field.

However, properly bending tubing which is larger than ¼ in. in diameter is impossible unless special methods are employed to avoid buckling and cracking. Applying heat is not the answer. Smooth bends require the tubing to be kept at such high temperature that handling becomes impractical. On a job requiring a large number of conductors different ways of tube shaping were tried until a successful one developed. This method consists of filling the tubing with fine, dry sand, capping it then bending same to requirements.

1) Take measurements between the terminals that the still-to-be made conductor will connect. Cut from a roll of tubing, a piece slightly longer than measurements to make sure of adequate length.

2) Fill the tubing with fine, dry sand. The sand must be quite dry and fine textured (screened) so that it will flow easily and also pack well.

3) Cap the ends of the tubing with wooden plugs, (terminal lugs will do if crimped on tightly.)

4) Bend the tubing to the required shape.

5) Empty out the sand which may be used again. Fit the conductor into place—trimming off the ends with a pipe cutter. Terminal lugs may be soldered on the ends if desired.

6) Polish and install the conductor in its proper place.

This method can be applied to ¼ in. to ¾ in. tubing; above ¾ in. diameter buckling is liable to occur. As most high frequency conductors fall within these limits, the method is generally applicable to all electronic equipment installations.

$$$ 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.

Under-Modulation Indicator

RONALD T. MIYAHIRA, Chief Engineer, KULA, Honolulu, T.H.

WE have a device that may help others faced with a problem similar to ours—that of maintaining a high percentage of modulation at all times.

We operate the highest powered station in Hawaii, and everyone expects us to be pounding into their receivers, although we are only a few db's above our competitors in actual power. Therefore our problem was to maintain the highest percentage of modulation possible at all times so that we actually sounded much louder than our competitors.

The easiest and best solution would be to have the operator keep a constant vigil on the modulation meter and ride gain on the program from the studios and tape machines, but this was impractical as the operator is constantly occupied with tape and disc recording jobs.

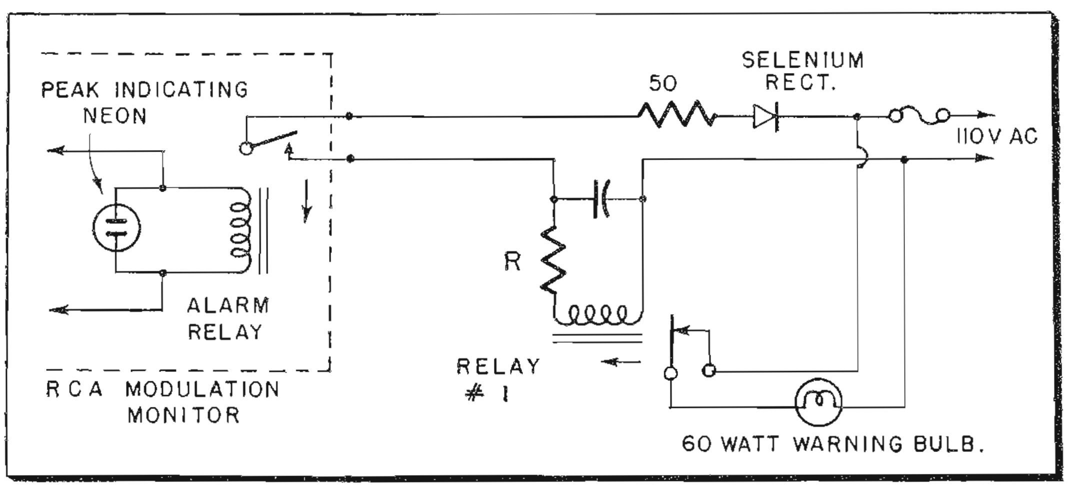
Furthermore even if the studio did send us a constant level, we would occasionally have a speaker with a stronger negative peak, and although the compressor would be compressing very hard due to the negative peaks, the actual output of the limiter would have a weak positive peak and our modulation meter would register about 50% when it should have been hitting 95 to 100%.

Our problem was to have an under-modulation indicator that would warn the operator when modulation peaks drop below 85% for more than ten seconds. (ten seconds is the interval between two successive peaks). Also, the system must be quiet and be able to warn the operator no matter where he was in the control room or how busy he was.

The first problem was solved by using a time delay relay in the warning circuit and the second by employing a 60-watt bulb. The bulb would light up the whole room, and the operator could not fail to miss the warning. To detect the undermodulation condition we employed the overmodulation alarm relay in our RCA modulation meter. We set the peak indicator on the front panel of the modulation meter to 85% so that it would indicate all peaks over 85%. By setting a high compression level in our limiting amplifier we had no difficulty with over-modulation.

When the modulation is below 85%, the alarm relay will not operate and relay 1 will be in a closed state. The bulb lights up and indicates an undermodulation condition. When a peak of 85% or higher is reached, the alarm relay closes and charges up the condensor. As the condensor charges almost instantly, relay 1 will be actuated and the bulb extinguished to indicate high percentage of modulation. The next peak may not reach 85% but the relay will remain in the energized con-

Under modulation meter utilizes peak indicating circuit of RCA modulation monitor



dition for 10 seconds during which time another peak will come by to recharge the condensor. The condensor will discharge slowly through resistor R and the relay to maintain the 10 seconds delay.

Under normal conditions the lamp will always be out except in certain types of music where the low passages are longer than the 10 seconds delay. Normal pauses in speech do not affect the relay. We found that too large a condensor was impractical as it took several consecutive peaks to charge it up to a point where it could actuate the relay and maintain the necessary delay.

A small capacitor with a large resistor works best but this in turn means that a very sensitive relay must be used. We used a 90 µf condensor and found that triggering was almost instantaneous. Since the installation of this device, we have found that our program level has been at a consistently high level of modulation.

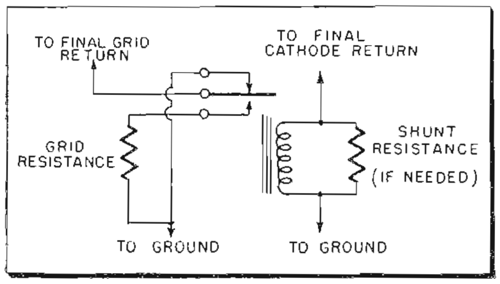
Static Arc Discharges

ROBERT R. BREEDING, Chief Engineer, KGAR, Garden City, Kan.

BROADCASTERS in dry, dusty, and windy climates often have trouble with arcing in the final and antenna tuning units. This is caused by static charges that gather on the antenna, and are not properly discharged due to the dry conditions of the ground. The accompanying diagram shows a unit that will kill these r-f arcs without interrupting the normal broadcast.

The relay is a 6v. dc relay, shunted so that it operates at twice the normal plate current. The grid resistance is 200 times the grid leak resistance of the final amplifier of the transmitter.

This resistance need not be of high wattage since it is in the circuit less than a second. This unit does not affect the normal operation of the overload relay when it is needed. I have watched this unit in operation over a period of 3 months, and it has proved satisfactory. The only effect on broadcast quality is a slight bloop when the relay operates.



Static arcs controlled by plate damper

Battery-Operated Broadcast Loop Tester

LLEWELLYN JONES, Chief Engineer, WSBA, York, Pa.

IN an earlier issue (TELE-TECH, Jan. '51, page 38) I described an ac powered tone oscillator WSBA used for continuous monitoring of remote broadcast loops throughout the city. Since the ac units have been in operation, I have constructed simple, battery operated relaxation oscillators using NE-2 Neons and two Eveready, No. 467 67½-vs. radio batteries. The complete unit can be mounted in a small box, 5 x 4 x 4, with only the terminals and switch (optional) externally mounted. Using the values listed, the units have been operating for 8 months, 24 hours a day and still going strong. The circuit drain is about 50 µamps from the batteries.

The battery operated oscillator is ideal because it can be mounted close to the loop—no need to worry that ac power will be turned off or interrupted at any time. The engineer at WSBA studios can dial any remote line and, in a moment, know the condition of the loop. If tone isn't heard he calls the phone company for a loop check.

I have also used this generator for tracing audio lines on new patch board installations with great success. No external power is required.

Remote Mike Switch for Consoles

R. S. HOUSTON, 2921 North Woodstock, Philadelphia 32, Pa.

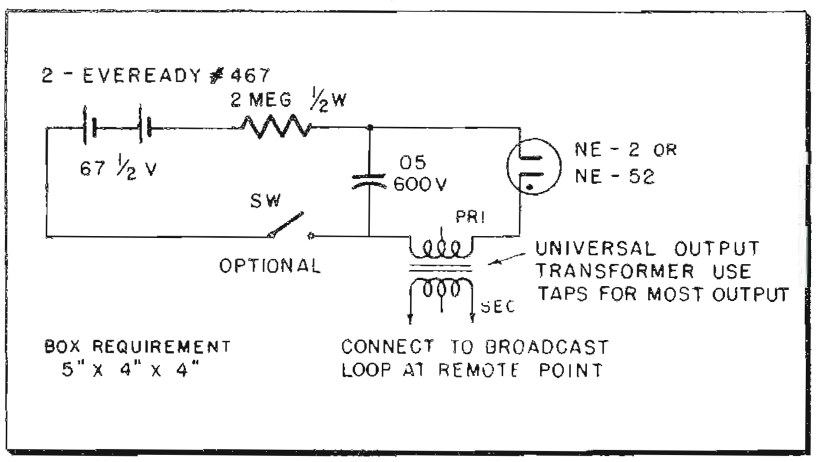
DESPITE the many advantages of having the announcer control his own mike, there are no consoles commercially built today that have the feature of a remote mike switch that may be extended into the studio where the announcer does not operate his own board. Such a switch was installed in one station without mutilating the internal wiring of the console, and gave, in addition to the mike control a talkback facility. The talk back was independent of any console control, so it permitted the announcer to talk to the operator at any time for emergency instructions without first having to signal the operator to put his mike on audition.

The air muting circuit consisted simply of a shorting arrangement connected across the mike socket, or the console input. Operation of the switch took the short off the mike to make it "live." There was an additional contact on the control switch connected in the speaker muting relay and cue light circuit to control these functions. For talk back, the mike input was connected to a high gain amplifier, which could be the audition amplifier. Any other talkbacks from other studios can be connected in parallel with this input. It is necessary only to insert a small resistance in series with the mike input to the console. This will upset the impedance match slightly, and if desired, the input impedance of the transformer in the console may be changed to accomodate this. The resistance recommended for the input circuit should be equal to the mike impedance. This will drop the level about three db, which is easily compensated.

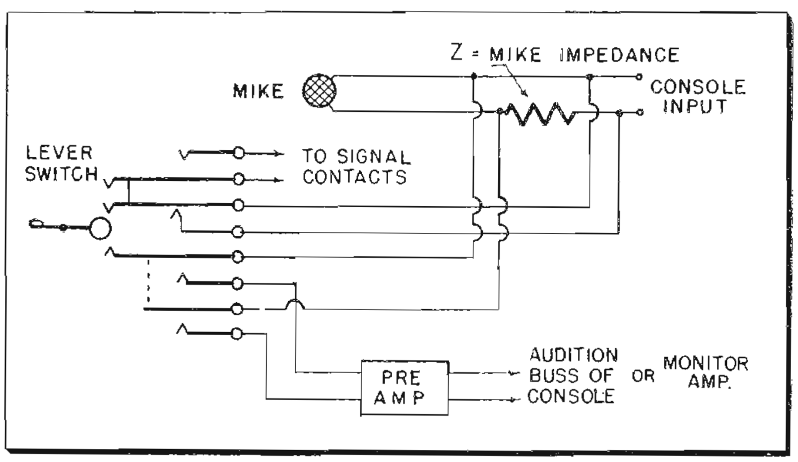
In some stations where an audition amplifier is used in connection with the audition mixer on a console,

(*Continued on page* 110)

Neon relaxation oscillator for testing broadcast loops, or any other circuit requiring simple audio source



Simple remote microphone control switch for announcer also handles "talk back" circuit



Quality Factor for Radar

Universally applicable criterion evaluates effectiveness of radar display systems. ception time now possible with proper consideration of functions of contrast ratio

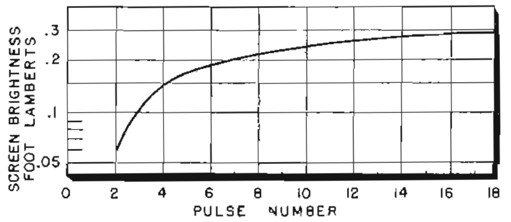


Fig. 1: Intensity buildup for successive pulses

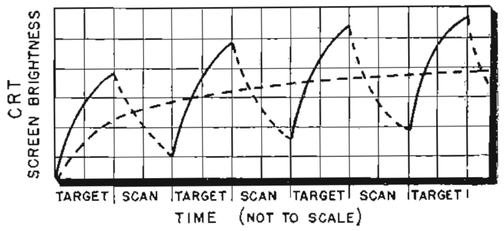


Fig. 2: Long time average brightness buildup

By A. F. BISCHOFF, Central Engineering Laboratory General Electric Co., Schenectady, N. Y.

THE radar operator or pilot of an aircraft is generally interested in obtaining three-dimensional intelligence from the radar cathode-ray display; namely, target range, elevation and azimuth. In addition he may be interested in obtaining other specialized information such as range rate and closure time. The importance of presenting this information in an optical form which can be readily interpreted into desired action, cannot be over emphasized.

The ultimate value of any radar system is determined by its ability to furnish accurate information in a readily usable form. At the present state of the art, this information is presented to the pilot or radar operator on a CRT. The information presented may be used either for operational or supervisory purposes, but in either case the CRT forms a vital link. What can be seen on the tube, the length of time required to see, and the precision of the data derived from the observation, is to a large part determined by the particular radar system and the method of presentation. In designing new radar systems it is therefore well to consider the relative effectiveness of the CRT display as a function of the proposed system.

Relative Display Effectiveness

Up to the present time there has been no direct means for integrating the major radar system parameters into a quantitative expression of the relative display effectiveness. It was with the intent of establishing a formula which would provide a quality factor for radar CRT presentations that this investigation was undertaken. To arrive at such an expression it is necessary to consider those factors which determine what we see, and to derive corresponding radar systems parameters which express those factors quantitatively. Since the correlation between mechanical optical measurements and measurements on cathode-ray tubes has been well established by Williams, Bartlett, King[1] and others, much effort can be saved by taking advantage of the many thousands of measurements made in the mechanical optical field.

Mechanical Optics

In the field of mechanical optics Luckiesh[2] pointed out the four factors which determine what we see:

1. Actual brightness level of the object and its surroundings, particularly the background.
2. Contrast in brightness between the object and its background.
3. Size of object and distinguishing characteristics.
4. Time available for seeing.

In applying Luckiesh's four factors to radar CRT displays, it is necessary to investigate the specific display function which influences the parameters of the four factors. The following major display functions influence the ability to see and time required to obtain visual information from the display:

1. Pip brightness.
2. Background brightness.
3. Size of presentation area and size of pip.

Assigning values to the above three factors will determine the time required for perception and, ultimately, whether or not the pip or spot can be seen at all. Since in airborne radar, time is of the essence, it is desirable to evaluate the relative effects of the three variables on perception time so that time can be reduced to a minimum by the most advantageous design of radar indicator displays. Each of the three time determining factors will be treated separately in an effort to consolidate the contributing parameters and to derive an expression for the factor which can be incorporated in an equation expressing the display quality factor of a radar system.

Excitation Duty Cycle

Since the CRT phosphor is only energized when the antenna beam is on the target, the excitation duty cycle varies with the scan or frame time of the radar. The average brightness of the CRT or visual effect depends not only upon the number of hits per target but also upon the length of time elapsing between excitation periods and the decay characteristic of the particular phosphor used.

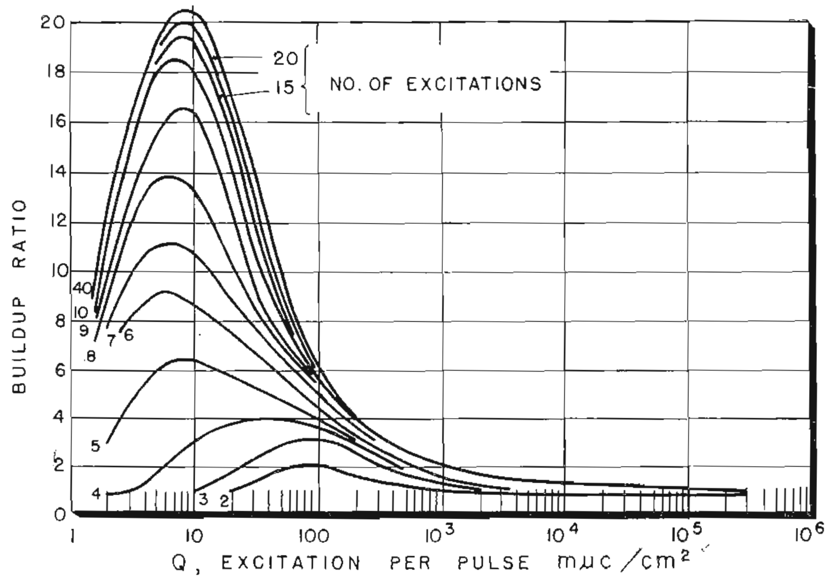
For an intermittent light source the Bunson-Roscoe law of optics states that if the product of light intensity and duration is held constant that the visual effect will be constant. Blondel and Rey found that this law held true over a range of light durations of 0.001 to 3 seconds. Baumgardt[3] showed that the relationship held for flash durations as short as 4 μsec. George E. Long[4] investigated the effect of duration time of onset and cessation of a light flash as it effects the optical signal received. He found that changes in the waveform of a light flash, within the limits of waveshape rectangular to triangular, do not affect the total amount of light energy required to produce an optical impression. The intensity variation of a CRT pip is essentially triangular in intensity waveform and pip repetition rate in radar systems is generally included in the range 4 μsec to 3 seconds. It can therefore be concluded that the visual effect or optical signal to the brain is proportional to the product of the intensity of the cathode-ray tube pip multiplied by the length of time it persists.

Cathode-Ray Tube Presentations

Improvement in per- and presentation size

Fig. 1 shows a typical intensity buildup curve for successive pulses on a P7 phosphor. Brightness was measured just before each excitation period. It will be noted that the screen brightness reaches a constant level after a finite number of excitations and that integration of subsequent pulses does not increase the intensity. This maximum brightness will be greater than that shown in Fig. 1 if the pulse repetition rate is increased or if the excitation is applied for a longer period of time, until saturation value for the CRT screen material is reached.

Fig. 6: Buildup gain as function of phosphor excitation per pulse (milli-micro-coulombs) for groups of pulses from 2 to 40, derived from empirical data. Note that little gain in buildup ratio is obtained between 20 and 40 pulses.



During the search period of a radar, target pulses are received in groups at pulse repetition rate, the groups being spaced by a scan period. Fig. 2 illustrates the increase in CRT average brightness with time. In the illustration four pulses excite the CRT during the "target" time, each increasing the brightness. During the scan period, the brightness decays until the next "target" period and succession of four exciting pulses which increases the average brightness to a new level. The successive groups of exciting pulses have a brightness buildup effect which becomes asymptotic to a constant value. Long time average brightness buildup is shown by the dashed line in Fig. 2.

The brightness of the CRT at any instant is equal to the summation of the exponentially changing brightnesses of all preceding excitation periods. The area under the brightness curve, Fig. 2, is the average light energy emitted by the phosphor.

Decay Characteristic

Fig. 3 shows a typical decay characteristic for a P7 phosphor screen. This is the decay characteristic from screen saturation at 4000 volts accelerating potential and 3.0 μa of screen current per sq. cm. This curve has been approximated by four exponentials having the slopes of α_5, α_6, α_7, and α_8. The x's indicate the summation of these exponential curves at various points. The summation points closely approximate the decay curve.

The equations of the exponential curves have the form

$$Ae^{-\alpha t}$$

where A is the "Y" axis intercept or peak brightness and t is time after peak brightness.

Summing up the light contained under the four exponential curves of Fig. 3 shows that 66 foot-lambert-seconds of light is emitted during the first 120 seconds of phosphor decay and that, of this 58 F.L.S., or 88% is emitted during the first three seconds. Of the total three second energy, 98% is contained under the the single exponential curve, α_8, of Fig. 3.

For slow pulse repetition rates, of the order of two minutes, the maximum error involved when a single exponential approximation is used, is about 10%. For normal repetition

Fig. 3: Decay characteristic for P7 phosphor

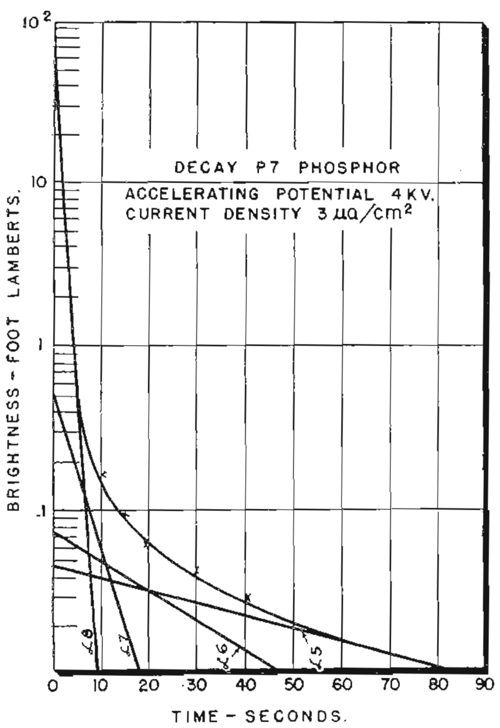


Fig. 4: Current density relative to brightness

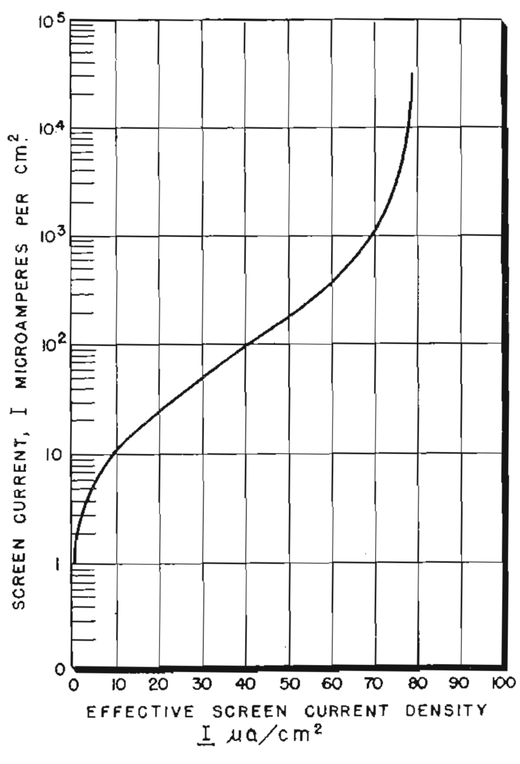
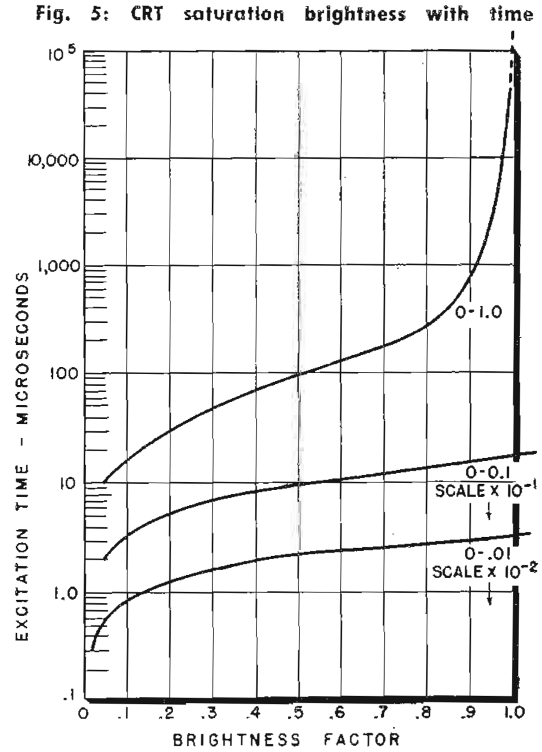


Fig. 5: CRT saturation brightness with time



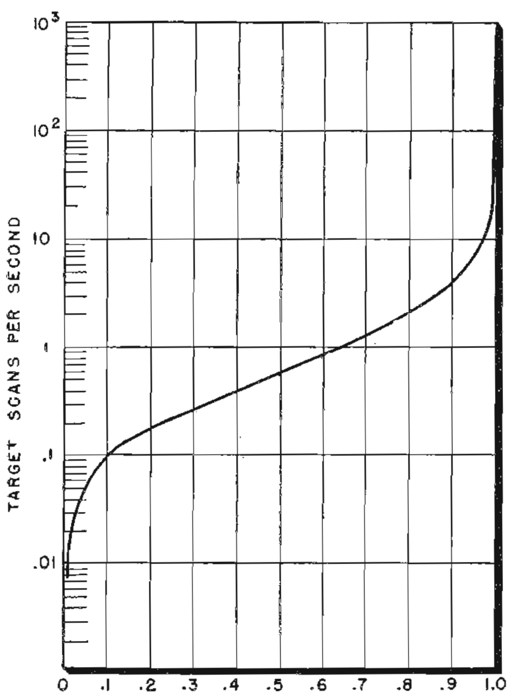


Fig. 7: Scan-light output characteristic

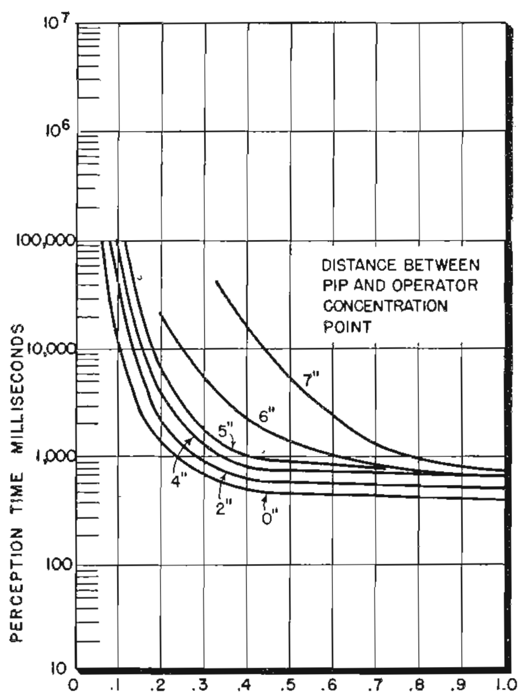


Fig. 8: Contrast-perception characteristic

rates, greater than one pulse every three seconds, the approximation introduces an error of only about 2%. It seems reasonable, therefore, to use the single exponential approximation.

Using this approximation and assuming a CRT anode potential of 4 kv and a screen current density of 3 μa/sq.cm., an equation for CRT brightness as a function of time, can be written.

$$\text{Brightness} = 60\, e^{-1.0t} \text{ foot lamberts (approx.)}$$

where t is the time after excitation was removed.

The integral of this equation between $t = 0$ and $t = \infty$ is 60 foot-lambert-seconds. This total light is for decay from CRT screen saturation value. Actually the screen will reach saturation value only under certain conditions and hence the maximum brightness will depend upon these conditions. The peak value of light output is determined by the CRT screen current density and the length of the excitation time. However the relationship between screen current density and brightness is far from linear and it is necessary to study this relationship in detail.

To obtain good target resolution most radar displays utilize the unmodified receiver signal for CRT intensification. Because of the resulting smaller pip size, short pulse lengths provide superior target resolution. Commonly used pulse lengths of the order of 0.5 μsec do not provide sufficient time for the delivery of enough energy to the CRT phosphor to obtain good phosphor excitation even at the high CRT screen current densities that can be obtained.

Increasing the CRT screen current density to compensate for extremely short excitation periods will not produce a linear increase in brightness. The linear relationship between CRT screen current density and brightness does not continue as the screen current becomes very large. Fig. 4 shows the actual CRT current density in μa/sq.cm. plotted against the effectiveness of this screen current density in producing CRT brightness. The curve is fairly linear between the limits of 1 and 10 μa/sq.cm., but above 10 μa it requires a thousand fold increase in screen current density to obtain an eight fold increase in brightness.

Saturation Brightness

Fig. 5 shows the relationship between excitation time in microseconds and the degree of CRT saturation brightness that is obtained. The curve showing this relationship has been broken up into three parts with different abscissa scales to allow for accurate readings at short excitation times. From Curve C it can be seen that the brightness factor for long excitation periods approaches unity. Unity Corresponds to saturation brightness. The brightness obtained from excitation periods less than that required for saturation can be obtained by multiplying the saturation brightness by the brightness factor, F, derived from the curves. It will be noted that for pulse lengths of less than 2 μsec that the decrease in brightness factor is more rapid than the decrease in excitation time. This lack of linearity is due to the fact that the CRT phosphor has a threshold value of energy needed for excitation, brightness is meager until this threshold is exceeded and then brightness increases superproportionally.

Soller, Starr, and Valley[5] working at MIT were the first to publish data indicating that the energy of successive excitations had a cumulative effect on brightness. They termed the brightness increase due to a succession of excitations over that for a single excitation, "buildup ratio." Because of the threshold characteristics of the phosphor, it becomes obvious that the buildup ratio is a function of the amount of energy per excitation. The amount of energy per excitation, or charge, Q, placed upon the phosphor can be expressed quantitatively in units of milli-micro-coulombs per sq. cm. The amount of energy per excitation, expressed in these units, can be found by multiplying the CRT screen current density expressed in ma/sq. cm., I, by the duration of the exciting pulse in microsecond t_e.

Family of Curves

To show the relationship that exists between charge per excitation and buildup ratio the curves in Fig. 6 were drawn from empirical data. This family of curves shows the buildup gain obtained as a function of the phosphor excitation per pulse, expressed in milli-micro-coulombs per sq. cm., for groups of pulses from 2 to 40. It will be noted that little gain in buildup ratio is obtained between 20 and 40 pulses, and that 40 pulses represents the saturation level for pulse buildup for pulses occurring at normal radar rates. Actually the crests of the curves will occur at slightly different values of Q as the pulse repetition rate is varied. The curves do, however, give good results in the range of repetition rates that are commonly encountered in radar equipments. Using this family of curves it is possible to derive a brightness buildup factor, B, by which the single pip intensity can be multiplied to give the cumulative brightness of the pip as the result of a pulse group occurring at radar pulse repetition rate. Normally this pulse group would correspond to a single scan of the target.

CRT peak brightness, exclusive of phosphor buildup and excitation time, is also proportional to an exponential power of the effective final anode voltage. This exponent varies

(*Continued on page* 142)

Frequency Feedback

A dynamic concept applied to ac circuitry. How to use saturable r-f reactors and ferroelectric capacitors in resonance systems having amplitude-frequency relationships

By *HANS E. HOLLMANN*
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AS a rule, feedback is applied to currents or voltages in order to make an electric network unstable or to render it more stable and more linear by means of positive or negative feedback, respectively. The concept of feedback, however, may be extended to other electrical parameters, the most immediate being frequency, to produce a positive or negative frequency feedback.

Frequency feedback may be achieved either by means of an external feedback channel or by internal feedback in a nonharmonic resonant system, that is a system wherein the energy reservoirs are not constant but vary in time. Consequently, frequency feedback manifests itself in the form of nonharmonic resonance curves.

External Feedback Channel

As an introduction, the principle of frequency feedback may be illustrated by an external feedback channel as shown in Fig. 1. A parallel resonant circuit consisting of the inductance L_o and the capacitance C_o is excited by a signal generator with constant current and variable frequency. In addition, the tank circuit is paralleled by the frequency modulator M, e.g., a reactance tube. Moreover, an envelope detector D rectifies the induced r-f voltage $\hat{V}\sim$ and thus produces the control voltage V_c. The feedback loop is closed in that V_c is impressed upon the input terminals of M.

For simplicity, let us assume that the modulator capacity C_m increases proportionally to V_c and that the diode may have 100% efficiency, i.e., V_c may be equal to the peak values $\hat{V}\sim$. We therefore write $C_m = KV_c = 1K\hat{V}\sim$ where K denotes the sensitivity of the modulator. The angular frequency of the tank circuit is $\omega = \omega_o/\sqrt{1+C_m/C_o}$ where ω_o is the resonant frequency of the original tank circuit without the modulator, or at $V_c = \hat{V}\sim \rightarrow 0$. The combined equations then give

$$\omega = \frac{\omega_o}{\sqrt{1 + (K\hat{V}\sim/C_o)}} \qquad (1)$$

so that the frequency deviation from ω_o, the detuning owing to the feedback becomes

$$x_f = (\omega/\omega_o)^2 - 1 = -K\hat{V}\sim/C_o \qquad (2a)$$

or multiplied with the quality factor Q

$$Qx_f = -A\hat{V}\sim \qquad (2b)$$

where A stands for QK/C_o. Even though Q depends on the frequency and therefore on the detuning, no great error occurs if the quality factor is considered to be constant, particularly when we confine ourselves to $x_f >> 1$.

Under the influence of an increasing feedback voltage V_c, the modulator capacity increases and the entire resonant curve shifts toward lower frequencies. Consequently, if the oscillator frequency f_{gen} is increased so that it approaches resonance, the resonant curve shifts toward f_{gen} that means, the resonance of the tank circuit automatically approaches the generator frequency and a positive frequency feedback may be recognized. Inversely, if the generator frequency approaches the tank resonance in the direction from higher to lower values, the resonant curve runs away and the frequency feedback is negative.

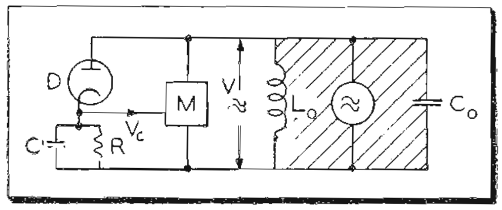


Fig. 1: External frequency feedback channel

The feedback action is explained in detail by means of Fig. 2. The dotted lines are the feedback lines originating at various independent variables Qx and having the slope —1/A. The resonant curve of a harmonic resonant circuit is expressed in terms of

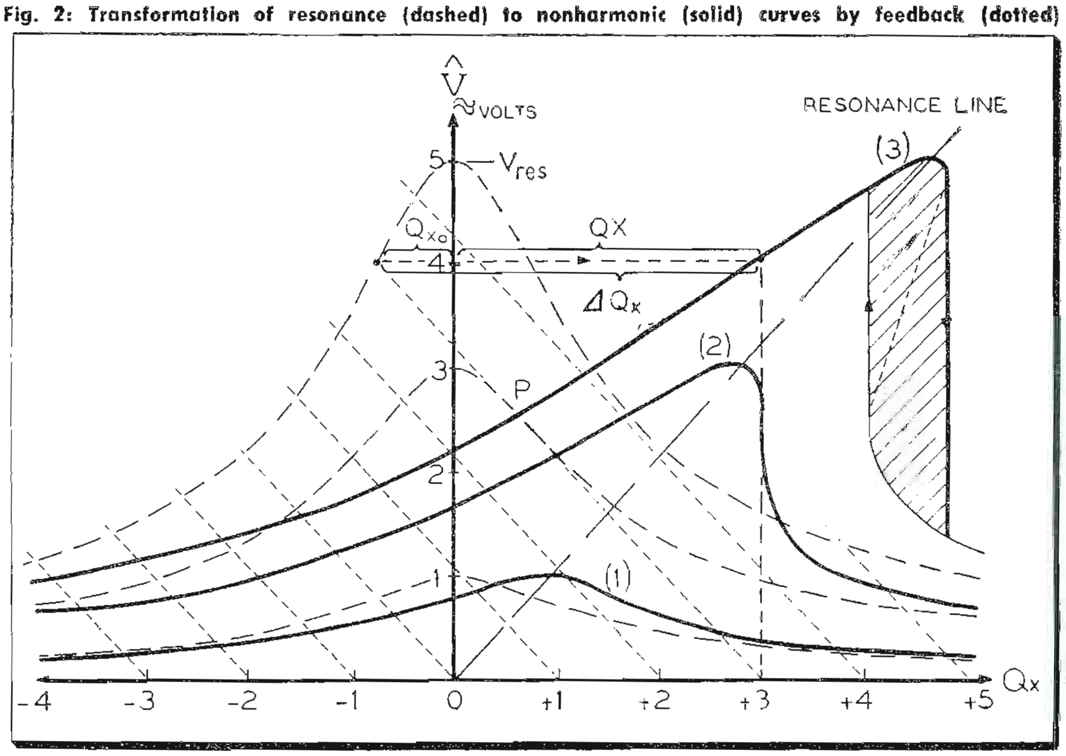
$$V\sim = V_{res}/\sqrt{1+(Qx_o)^2} \qquad (3)$$

yielding, for three values of the r-f excitation characterized by three resonance voltages V_{res}, the three dashed curves. The feedback lines intersect these resonance curves at the values $Qx_o = Qx - \Delta Qx$, where ΔQx denotes the shifting of the new curves. Because the explicit evaluation of these new resonance curves in terms of $V\sim = f(Qx)$ results in an equation of higher order, it is simpler to evaluate $Qx = f(V\sim)$ so that we obtain

$$Qx = A\hat{V}\sim + \sqrt{(V_{res}/V\sim)^2 - 1} \qquad (4)$$

There are three important phe-

Fig. 2: Transformation of resonance (dashed) to nonharmonic (solid) curves by feedback (dotted)



nomena that can be seen at a glance.

First, the resonance maximum, under the influence of frequency feedback, shifts from the original value zero to $Qx_{res} = AV_{res}$, and therefore follows the resonant line. Because of $V_{\sim} \rightarrow 0$, the lower portions of the new resonance curves coincide with the harmonic curves, consequently the "nonharmonic" resonance curves are unsymmetrically deformed. The "higher" branches, more accurately the branches over $Qx > Qx_{res}$, become increasingly steep at the expense of the opposite branches over $Qx < Qx_{res}$. In terms of feedback terminology, we may say that the frequency feedback is positive above resonance and negative below.

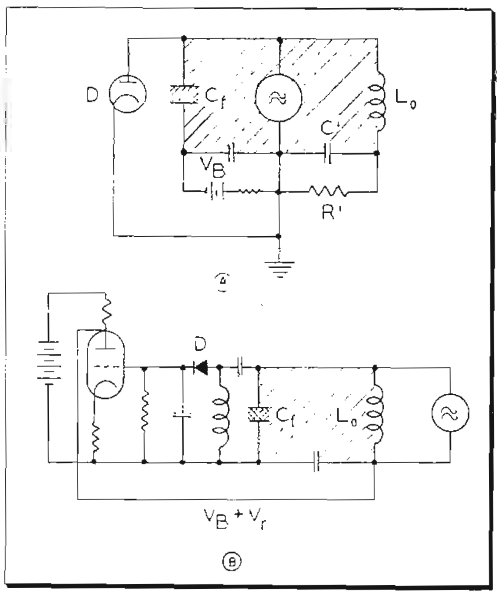
Critical Case

Second, Fig. 2 reveals a critical case at which a small section of the higher branch becomes vertical. This critical case is characterized by the fact that the slope of the feedback line equals the maximum slope of a resonant curve at its point of inflection, in the present example of the dashed curve at $V_{res} = 3$ volts. Because the maximum slope of the standardized resonance curves amounts to $0.385\ V_{res}$, the critical case occurs at the resonant voltage $V_{res} = 2.6/A$.

Third, at higher resonance voltages the higher branch assumes a negative slope (curve 3). The system becomes unstable in that the r-f voltage describes a tuning loop.

Without any further explanation, it can easily be seen that the picture reverses when the slope of the feedback line reverses its sign which is, when the modulator capacity decreases with increasing feedback voltage, for example, if the polarity of the diode D in Fig. 1 is reversed. The frequency feedback then is positive at frequencies below and negative at frequencies above resonance.

Fig. 3: Frequency feedback by ferroelectric capacitor (a) and dc voltage amplification (b)



The external modulator in Fig. 1 may be replaced with an internal modulator in that the tank circuit contains either a saturable r-f reactor or a ferroelectric capacitor. In both cases, the dynamic reactance and therefore the tank frequency depends on the magnetization or polarization, in other words, on a control current or a control voltage, respectively. The ferroelectric condenser C_f in Fig. 3(a) is charged directly by the diode D whereas the voltage V_B acts as bias. The degree of frequency feedback can be increased by introducing a multistage amplifier into the feedback loop. Thus, the circuit diagrammed in Fig. 3(b) exhibits a sensitive frequency feedback because a vacuum tube amplifies the detector voltage while the plate battery, at the same time, produces the necessary bias.

Fig. 4 illustrates examples of nonharmonic resonance curves taken with the aid of a sweep generator and a barium strontium titanate condenser. At low r-f excitation, resonance occurs at ω_0 (oscillogram a). The following two oscillograms show not only the shifting of the resonance maximum toward higher frequencies but also reveal (b) the critical condition of operation and (c) the instability.

Internal Frequency Feedback

The external frequency-feedback channel is to be taken primarily as a means of explaining the principle. A disadvantage of external feedback is the time constant of the filtering network in the detector circuit. Internal frequency feedback avoids such a limitation because it operates solely under the influence of r-f.

Internal frequency feedback occurs in any nonharmonic resonant system at strong excitation, regardless whether the nonlinearity is caused by a saturable reactor (Fig. 5a), a ferroelectric capacitor (Fig. 5b), or both in proper combination, and regardless of whether or not the nonlinear elements are subjected to a bias. In order to gain an insight into the phenomenon of internal frequency feedback, it will be helpful to review some pecularities of ferromagnetics, and ferroelectrics under various conditions of operation.

The philosophy of ferromagnetics is very complex and that of ferroelectrics is not even fully developed. Therefore we can improve our knowledge only through the analogy between ferroelectricity and ferromagnetism. Nevertheless, the complexities become evident if we recall the various types of permeability such as the initial, the reversible, the incremental, the apparent or effective, and even the complex permeability which lead to similar types of permitivity. The discussion, under a common point of view, is facilitated if we combine both terms

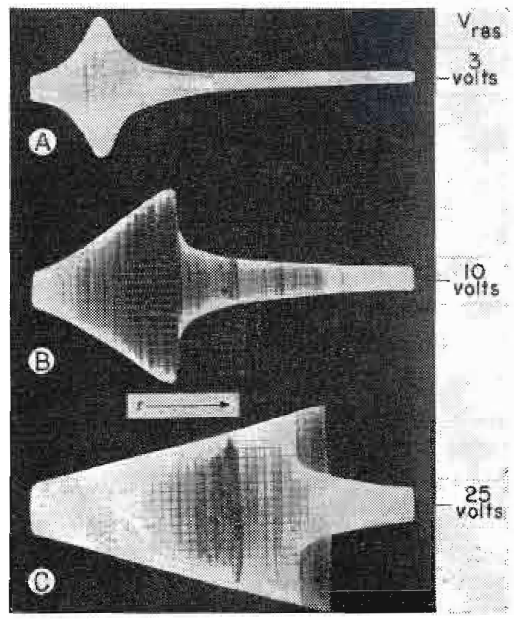


Fig. 4: With increasing r-f excitation, harmonic curve (a) assumes the critical form (b) and then becomes unstable as is shown by (c)

in speaking of "permeativity" (μ,ε) whereby we keep in mind that we mean $\mu = B/H$ or $\Delta B/\Delta H$ as well as D/E or $\Delta D/\Delta E$ where B and D is the magnetic or electric flux, respectively, and H or E the magnetic or electric polarization.

The philosophy of our permeativity, under the influence of biasing and superimposed alternating fields, may be derived from magnetic as well as dielectric hysteretic loops. Right from the start, we confine ourselves to an average or dynamic permeativity that means to a permeativity only for the fundamental frequency but we neglect the hysteretic losses as well as the harmonic distortions.

Polarization Characteristic

With these restrictions in mind, let us consider Figs. 6(a) and (b). Fig. (a) shows a polarization characteristic with various minor hysteretic loops resulting from an ac field superimposed upon different biasing polarizations. In other words, the test specimen is driven at various quiescent points of operation. The slope of the major axis denotes the incremental permeativity $(\mu, \varepsilon)\Delta$. It can easily be seen that this value not only decreases with increasing bias but, at the same time, increases with increasing ac amplitudes. As a result, the dynamic inductance of a saturable reactor and the dynamic capacitance of a ferroelectric capacitor changes when the elements are subjected to different biasing as well as ac polarizations.

R-F Reduction Effects

When the r-f excitation is reduced, the incremental permeativity asymptotically approaches the reversible values $(\mu,\varepsilon)_r$. Note that variations of the bias and varying r-f amplitudes produce opposite effects.

Numerous tests with nonlinear specimens of both types confirmed these results to a certain degree. At large ac fields, the incremental permeativity decreases because it suffers a peculiar rectification. An extreme, namely a specimen excited by increasing r-f fields with no bias present, is depicted in Fig. 6(b). Recalling the definition of the dynamic permeativity, we see the slope of the major axis of the different hysteresis loops first increase a little but then decrease as soon as the peaks run into the regions of saturation. An alternate explanation is that the permeativity suffers saturation during part of the cycle thus reducing the effective value. Fig. 6(c) illustrates the case wherein the specimen

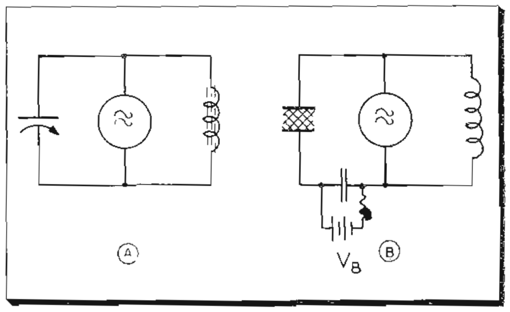


Fig. 5: Nonharmonic resonance circuits using iron-core inductance (a) and capacitor (b)

is subjected to a constant bias with increasing r-f polarization superposed. Without going into details, the small increase of the permeativity and the subsequent decrease of the dynamic value can easily be seen by combining the Figs. 6 (a) and (b).

(Continued on page 126)

PRECISION TRANSISTOR OSCILLATOR

Peter G. Sulzer at the National Bureau of Standards has recently developed a crystal oscillator that is small, portable, dependable, and accurate over long periods of time. The new unit, utilizes a junction transistor as the source of driving power for a high-stability quartz crystal unit. All components of the circuit, including the power supply, fit into a metal tube less than 2 in. in diameter and about 7 in. long. At an operating frequency of 100 KC, the long-period drift in the first model was about 3 parts in 10^9 per day.

The major components of the transistor oscillator are a type 2517 junction transistor, a high-precision 100 KC GT-cut quartz crystal unit,[1] and a long-life mercury cell. The dry cell supplies power to the whole unit (1.35 volts at 100 microamperes), and has an active life, under these conditions, of five or more years.

Two of the requirements that must be met in developing a high-stability crystal oscillator are constancy of phase shift in the feedback loop associated with the crystal and constancy of the amplitude of oscillation. A constant phase shift is obtained by using large, stable "swamping" capacitors at both crystal connections and by using highly stable components in the remainder of the circuit. Excellent amplitude stability is achieved by operating the transistor in such a manner that collector-voltage limiting is produced.

The transistor is used in the grounded-emitter connection. It produces an output of 0.8 volt across a tuned circuit connected to the collector electrode. The tank circuit, composed of a 350 μμf capacitor and a 6 mh coil, is designed to oscillate at 100 KC; however, the magnitude of the voltage is too high to be applied directly to the crystal unit. Consequently, the voltage is reduced by means of an attenuator, which consists of a 40 μμf and a 0.01 μf capacitor in series from the collector electrode to ground. The driving current (less than 100 microamperes) for the crystal is taken from the junction between these capacitors. The crystal voltage is coupled to the output through a 100 μμf capacitor.

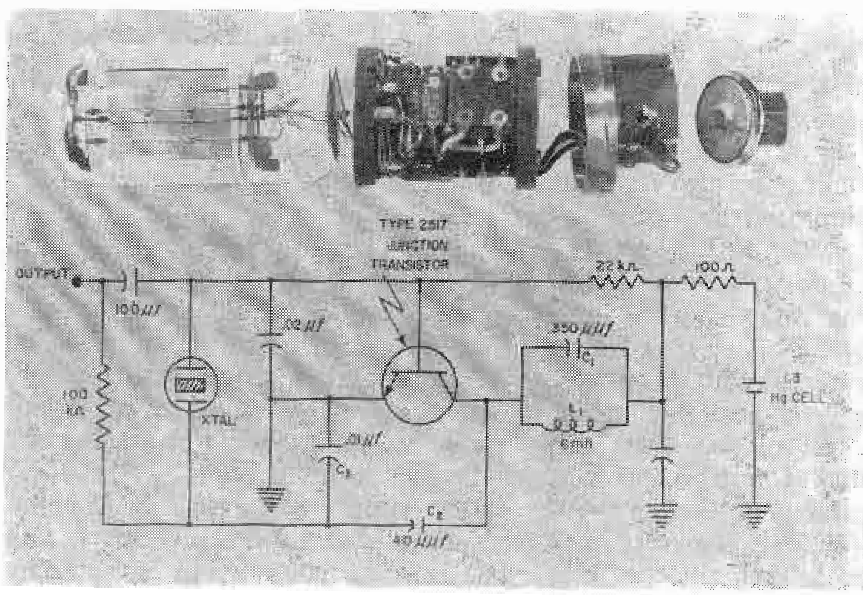
Crystal Mounting

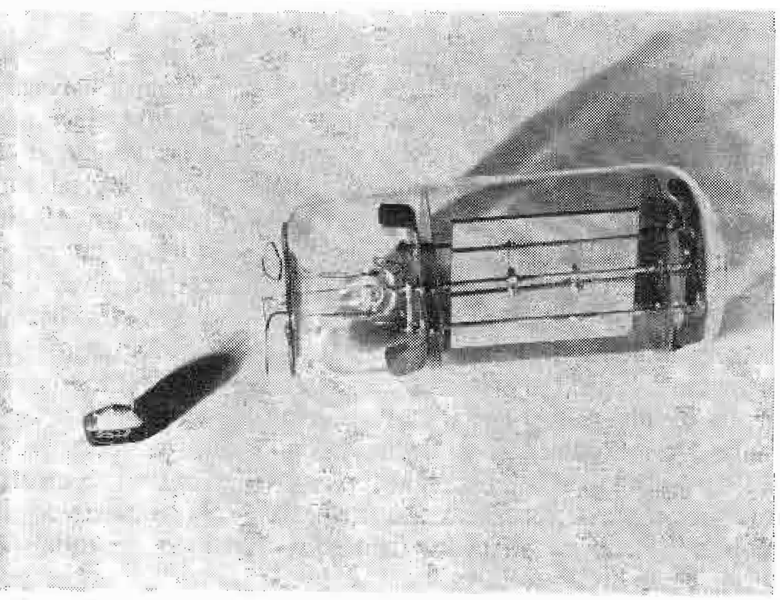
Over half of the space in the 1¾-in. diameter by 7-in. metal tube is consumed by the crystal, which is mounted in an evacuated glass envelope. The transistor, coil, capacitors, and resistors are supported on a bakelite frame that may be "potted" in casting resin to add to the rigidity of the section. The mercury cell, only about one-half inch deep, is at the base of the assembly and is insulated from the metal "can" by a bakelite shield.

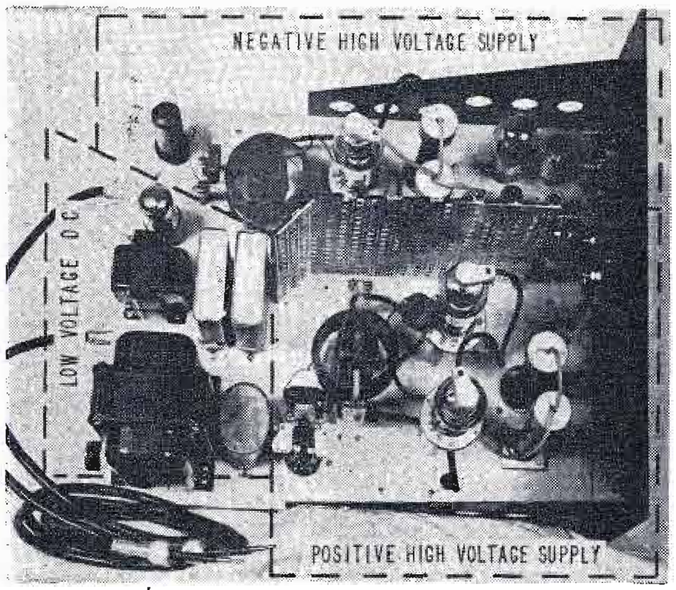
(Continued on page 145)

Fig. 1: (below left) Exploded view and circuit diagram of the new transistor oscillator developed by the National Bureau of Standards. This new oscillator fits into a metal tube less than 2 inches in diameter and about 7 inches long. A Mercury cell (right), with a life of about 5 years, supplies all the power to the unit—1.35 volts at 100 microamperes. The circuit components, including the transistor, are lumped together in a bakelite form (center), which may be "potted" in a casting resin for greater rigidity'. The GT-cut quartz unit is placed in an evacuated envelope (left). The new oscillator has a short-time stability of about 3 parts in 10^{10} and a long-time accuracy (per 24 hour day) of 3 parts in 10^9. The schematic diagram below the exploded view shows the various resistor, capacitor, and inductive components of the transistor oscillator.

Fig. 2: (below right) Basic components of the new transistor oscillator developed by the National Bureau of Standards. The driving power for the unit is obtained from a type 2517 junction transistor (left). This power is applied to a precise GT-cut quartz crystal unit, which is enclosed in an evacuated glass envelope (right). The new oscillator has a short-time stability of about 3 parts in 10^{10}. The complete unit is enclosed in a tube 1-¾ inches in diameter and 7 inches long, which includes the power supply for all the components.







Positive and Negative

Dual r-f power supplies mounted on single chassis provide 20 to 30 kv and −4 to −10 kv for oscilloscope crt. Excellent ±0.5% dc regulation as ac line varies from 90-130 volts

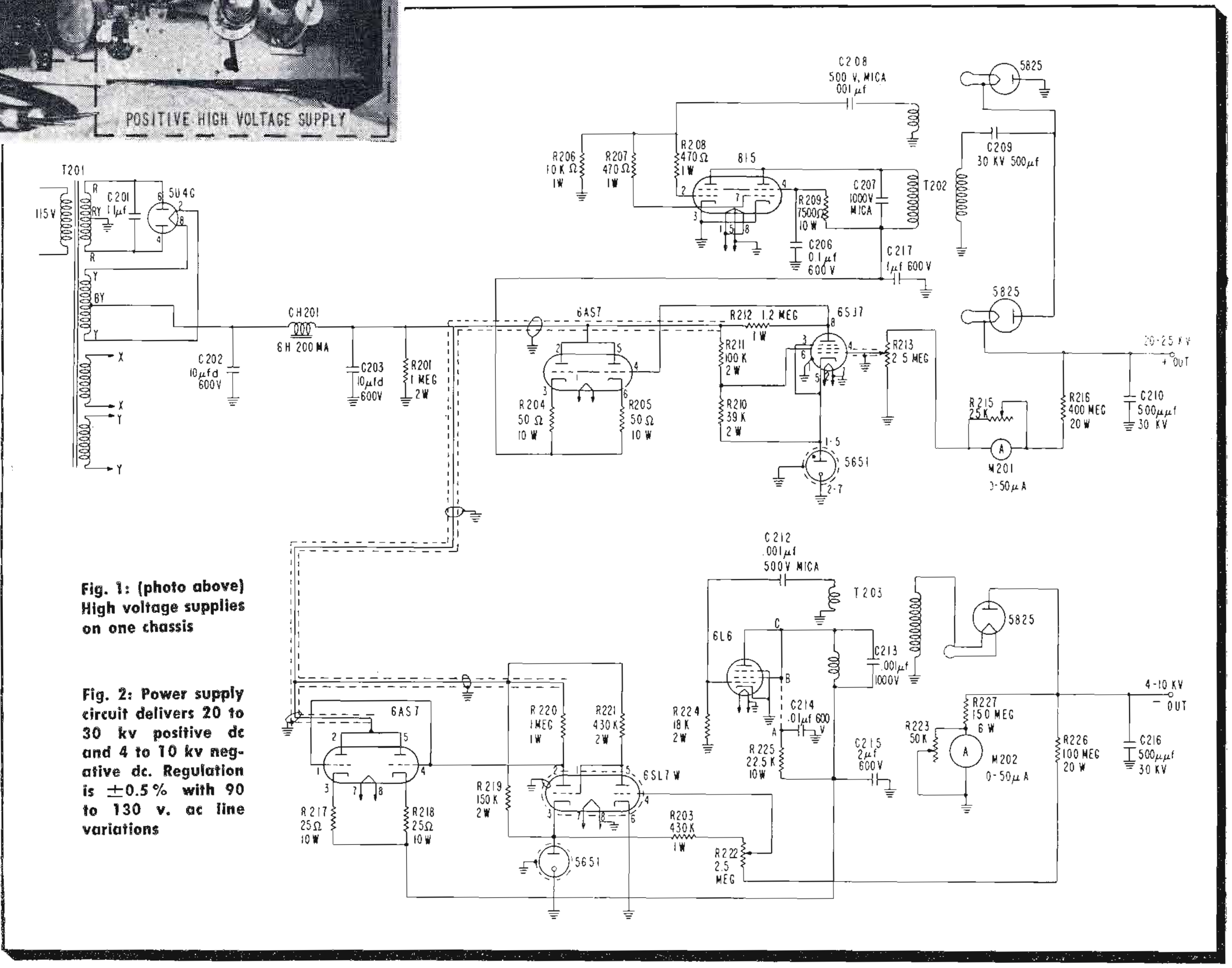


Fig. 1: (photo above) High voltage supplies on one chassis

Fig. 2: Power supply circuit delivers 20 to 30 kv positive dc and 4 to 10 kv negative dc. Regulation is ±0.5% with 90 to 130 v. ac line variations

THE chassis pictured in Fig. 1 contains both a positive and negative regulated r-f power supply using a common dc power source. The dual unit was developed to provide accelerating and cathode potentials for the cathode-ray tube of an oscilloscope. Remote installation of the oscilloscope required that it be operated for days without maintenance or attention. An installation of this type demanded extreme reliability of the oscilloscope and its associated components. The need for high dependability suggests for first solution, that high voltage be obtained directly from a 60-cycle voltage source by a transformer-rectifier circuit. However, the problem was complicated further by the rigorous requirements imposed on the high-voltage supplies. The installation required that the dc voltage be regulated to better than ±0.5% and ripple content be 0.5% or less. These two factors alone rule out the feasibility of 60-cycle supplies when space and weight of the units are limited. Another requirement that both positive and negative dc voltages be independently variable over wide ranges prohibited the use of a single power supply. Considering the requirements imposed, a r-f power supply was selected as being most practical for this application.

Circuit

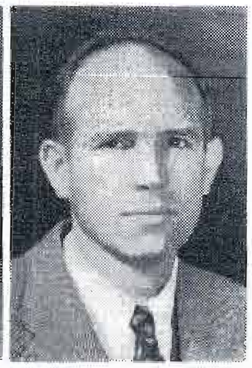
Fig. 2 is a schematic diagram of the complete power supply. To aid in maintaining good regulation with varying input voltage, both the positive and negative radio-frequency supplies were driven by a 500-volt plate supply using a Sola Constant Voltage transformer. Using a Sola power transformer in conjunction

High Voltage Supply

with a voltage-regulating network made it possible to maintain ±0.5% dc voltage regulation with ac line voltages from 90 to 130v. The positive HV supply provides an output range of 20 to 30 kv dc. This supply consists of a type 815 tube, both sections operated in parallel as a reverse feedback oscillator, and a r-f step-up transformer with voltage-doubler rectifiers. Oscillator plate voltage is regulated by controlling a type 6AS7 tube in series with the oscillator power supply. A type 5651 voltage-reference tube provides a fixed voltage reference to a type 6SJ7 control amplifier tube. The 5651 is an excellent voltage reference if its current is maintained between rather close limits. This tube exhibits much less hysteresis than the conventional voltage regulator, such as, the type OC3/VR105. This means that the actual voltage across the tube varies a minimum between successive on and off operations.

The negative power supply has an oscillator and r-f transformer similar to the positive supply except that here a type 6L6 tube is used as the oscillator and a half-wave rectifier provides negative voltage from −4 to −10 kv in two ranges. Connecting the 6L6 as a pentode covers a range of −5 to −10 kv and by connecting the 6L6 as a triode, the regulation range is shifted to −4 to −6 kv. Plate voltage of the oscillator is regulated with a type 6AS7 tube in series with the plate-supply voltage. Two stages of amplification through a type 6SL7 tube provides the correct polarity for regulation of the 6AS7 with high sensitivity. A type 5651 voltage-reference tube serves a dual purpose: to raise the gain of the error voltage as well as to provide a reference voltage, by connecting the ground end of the negative supply to this tube. This connection permits sampling the error voltage at a higher potential above ground and hence, samples a larger percentage of the error voltage which appears across the dc output. The high gain resulting from cascading the two halves of the 6SL7 requires that extra care be taken in shielding and positioning of wiring to prevent oscillation in the control circuit.

Robinson



Van Allen

By GEORGE ROBINSON & ROLAND VAN ALLEN

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Performance

Load regulation curves for the two supplies are shown in Fig. 3. Regulation of the negative supply was made considerably better than that of the positive supply, since the former provided the potentials for the gun structure of the CRT. The extent of control on regulation is shown by the "plateau" or flat portion of the curves. The width of this "plateau" is limited by the range of plate voltage available to the oscillator tubes. Increasing or decreasing the input ac voltage has the effect of increasing or decreasing the width of the "plateau." Using a Sola transformer in the oscillator plate power supply minimized this effect.

A test of regulation under conditions of 120°F and 90% relative humidity showed that ±0.5% regulation could be maintained under constant conditions. However, the positive voltage changed +1.3% and the negative voltage changed +0.5% in raising the ambient temperature from 75°F to 120°F since no attempt was made to make the circuit temperature compensating.

Design

Mautner and Schade[1] have outlined the procedure for the design of r-f transformers used in r-f power supplies. This paper is very valuable in view of the fact that most available literature on coupled-circuits theory is not readily adaptable to an application of this kind.

The secondary high-voltage coil design for the positive power supply was also used in the negative supply with satisfactory results; the production problem was simplified by using a single type. Although the same secondary coil was used in both supplies, the resonant frequencies of the two oscillators were not the same since the capacitance presented by the rectifying circuit was different in each case. The resonant frequency of the negative-supply oscillator was approximately 220 KC while that of the positive-supply oscillator was approximately 190 KC. The difference in the resonant frequencies of the two oscillators, plus the placement of a metal screen between the units, prevented any interaction due to the proximity of the two tank circuits on a single chassis. In this particular design the type 5825 rectifier tubes were used to achieve good reliability. The 5825 has a peak inverse voltage rating that is twice that of the type 1B3GT so that rectifier tube failure was

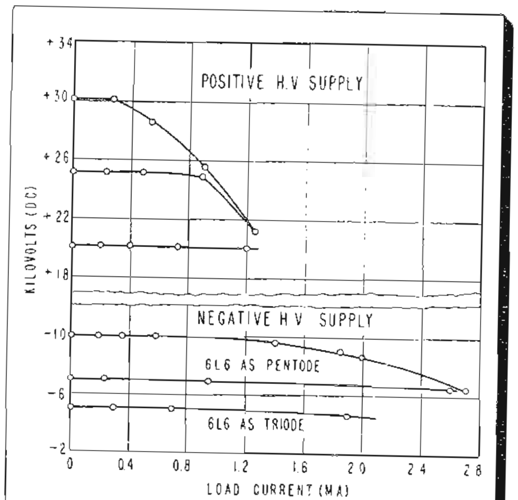
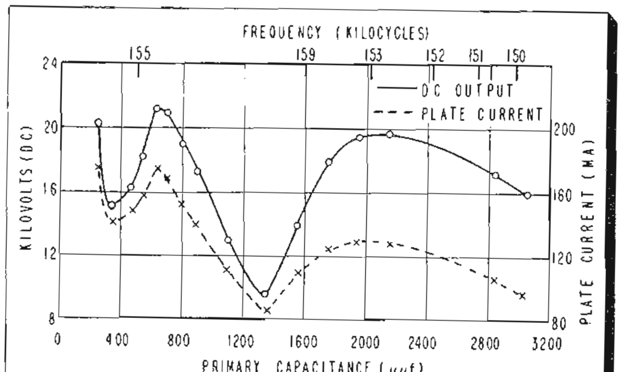
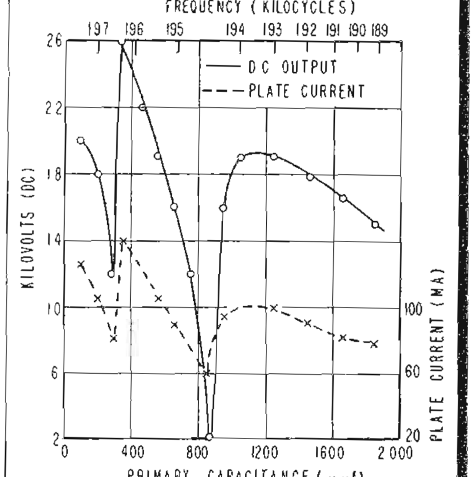


Fig. 3: (1) Load regulation of pos. & neg. supplies Fig. 4: (c) Output at L_{pri}=0.21 mh; L_{sec}=44.4 mh; K=0.265; E_{osc}=350 v; 125 meg load. Fig. 5: Output with r-f transformer, L_{sec}=31 mh; others same as 4





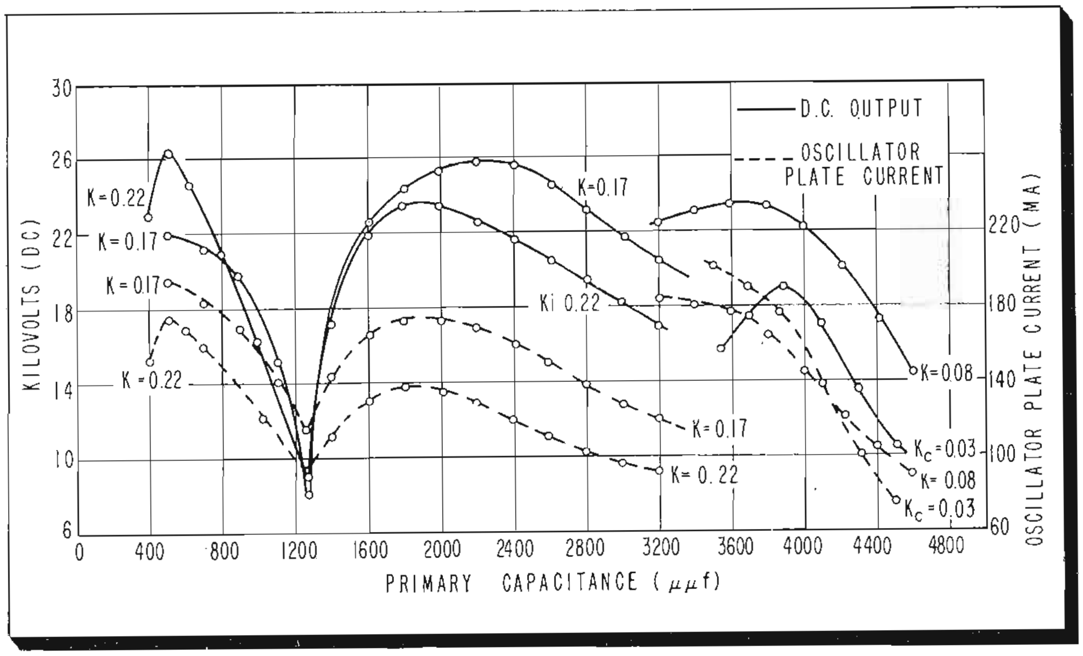


Fig. 6: Output characteristics using different coefficients of coupling, L_{pri}=0.13 mh, L_{sec}=31.1 mh. Oscillator plate voltage is 350 volts, and the dc load is 125 megohms

reduced to a minimum. Experience with the 1B3GT rectifiers showed that they would frequently become gaseous and unduly increase the r-f transformer loading. There have been no failures other than filament breakage due to handling, when using the 5825's, even though 150 type 5825 tubes have been in service for several hundred hours for each tube.

Secondary Coil

The secondary coil of the r-f transformer was designed to deliver 15,000 v. peak as a maximum with the range of operation from 10,000 to 12,500 v. peak. Designing a secondary coil to withstand such high voltages poses the problem of prevention of corona and excessive heating. Such problems are particularly difficult where the physical size of the coil must be kept small. Factors influencing the design of the secondary coil are listed in order of descending importance:

1. Absence of corona at 15 kv peak.
2. Absence of breakdown from heating.
3. Small physical size.
4. High unloaded Q.
5. High inductance.
6. Low distributed capacitance.
7. Low loaded Q.

Considering these design parameters, several factors are seen to be incompatible so that it becomes necessary to make compromises. For example, to insure freedom from corona, this wire size must be large; but this precludes maximum inductance for a given space. To reduce coil heating, the winding must be distributed to give adequate heat dissipation and ventilation, whereas the inductance would be higher for a more compact coil. The result is that anything done to reduce coil heating, which at the same time, reduces the tuned impedance of the tank circuit, may result in a net increase in coil loss and coil heating instead. Therefore, increasing wire size and turns distribution must be done judiciously so that the tuned impedance will be kept sufficiently high to prevent excessive secondary coil losses.

An attempt was made to use an available commercial r-f transformer which has the following dimensions:

	Secondary	Primary
Number of Turns	1400	40
Form of diameter	1.25 in.	3.25 in.
Number of pies	7	2
Wire Size	3/41 Litz	50/38 Litz
Inductance	44.4 mh	0.21 mh
Coil height	1.55 in.	0.55 in.
Q	250	330

This secondary coil was not practical for operating above 10 KV peak; arc-over and corona caused failures at 12.5 KV under conditions of high humidity and long continuous operation. The compact 7-pie construction of this coil did not allow sufficient radiation of heat and since the primary r-f coil was mounted coaxially with the secondary r-f coil, the high voltage end of the secondary was close to the primary windings and arc-over occurred. The small wire size and configuration of this secondary r-f coil limited the maximum operating voltage to 10 KV peak. It was found that the allowable maximum operating voltage could be raised by addition of forced-draft cooling; however, for this application the addition of a blower unit was not practical. Fig. 4 shows the output characteristic of the voltage doubler using this commercial coil.

Using the experimental data for the performance of the commercial coil in addition to design techniques set forth by Mautner and Schade[1], a r-f transformer was designed having the following dimensions:

	Secondary	Primary
Number of turns	1400	32
Form diameter	1.25 in.	3.25 in.
Number of pies	10	2
Wire size	7/41 Litz	50/38 Litz
Inductance	31.1 mh	0.13 mh
Coil height	2.35 in.	0.55 in.
Unloaded Q	260	360

This secondary coil proved quite satisfactory operating at voltages as high as 17.5 KV peak without evidence of corona or excessive heating. It is evident that reducing the inductance of the secondary coil would lower its impedance at resonance which would in turn raise the coil losses due to increased secondary current. However, the additional pies, increased wire size, and the overall increase in radiating surface tended to reduce the operating temperature of the coil. The actual measured temperature rise was found to be slightly lower than that of the commercial coil, even though calculations indicated that coil losses were increased about 30%. Both coils were wound on thin impregnated forms that were slotted between each pie winding to give as much ventilation as possible and still provide adequate support for the windings.

Output Characteristics

Output characteristics for the new secondary coil, with two different primary coils, are shown in Figs. 5 and 6. Plotting dc voltage output versus primary tank capacitance gives a better representation of output characteristics than the conventional plot of voltage output versus frequency. The change in frequency that results from variations in primary capacitance is small, in the order of 5 to 8 KC, and is not as convenient to obtain as values of primary capacitance over the same range. Another reason for plotting the value of primary capacitance as abscissa, is its importance as a variable in determining the r-f transformer output. In maximizing the output of a r-f power supply, the most important adjustments are (1) degree of coupling in the r-f transformer and (2) primary tuning capacitance, each adjustment made with a constant dc oscillator plate voltage and load. Since the secondary of the r-f transformer is tuned by its distributed capacitance and the parallel capacitance of the high-voltage rectifying circuit, tuning ad-

(Continued on page 117)

Transistor Characteristics at Low and Medium Frequencies

How properties of junction types modify circuit performance. Use of vacuum tube analogy and admittance parameters lead to simplified design approach

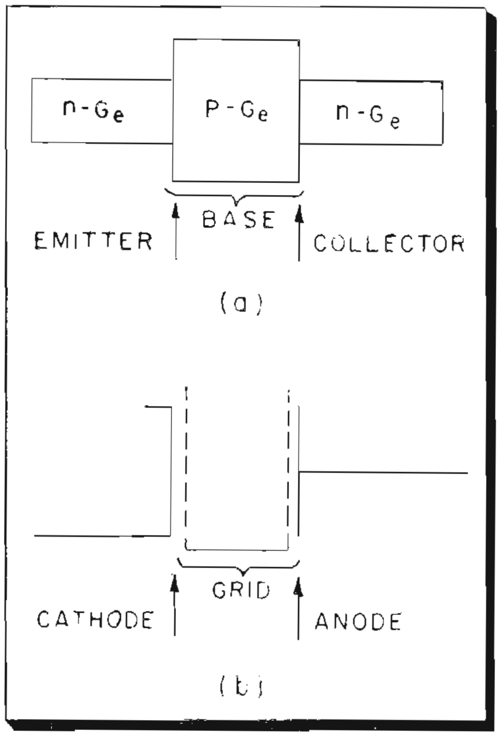


Fig. 1: N-P-N- transistor and analogous tube

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The performance of a junction transistor changes rapidly when the operating frequency is increased. To obtain a better understanding of the factors that determine the low and medium frequency performance, the transistor parameters that are of importance must first be understood, and next, suitable methods of parameter measurement must be devised. This article will be concerned with these two aspects.

In order that the terminology and symbology to be employed in this presentation are well understood, it is necessary that a preliminary development of the transistor subject

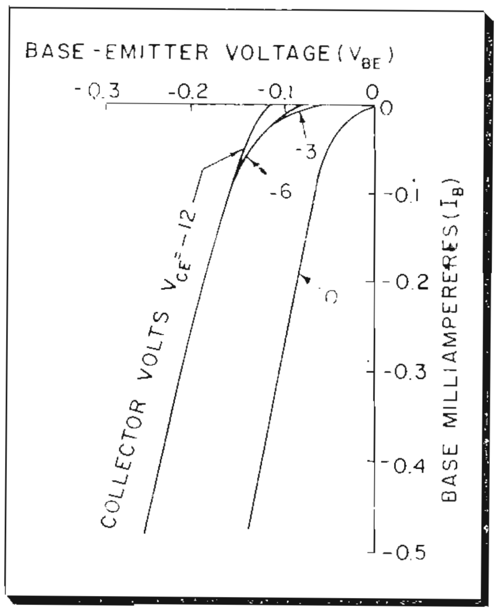


Fig. 2: Base characteristics of p-n-p type

be undertaken. The starting point for this development is a vacuum tube analogy[1] as shown in Fig. 1. Here an n-p-n junction transistor is compared directly with a three-element vacuum tube. The emitter corresponds to the cathode and the collector to the anode. In the transistor, the active region is the p-type germanium base. The corresponding active region in the vacuum tube is the space included between the cathode and anode. In order that the vacuum tube active region be field-free, as is approximately the case in the transistor, the vacuum tube active space is enclosed between two grids connected together to form a grid structure which is now comparable with the transistor base element.

A direct comparison between the two devices is particularly useful to those who are making a transition from vacuum tube art to transistor

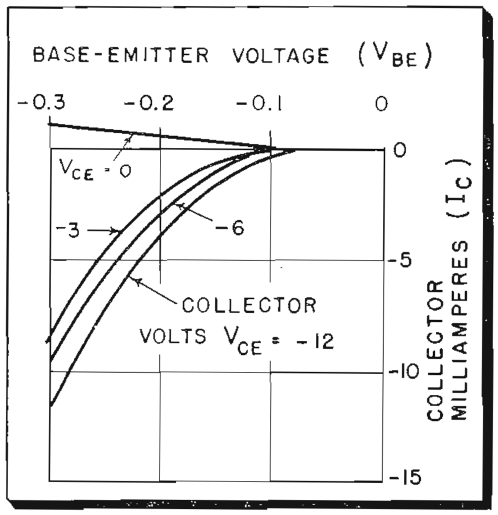


Fig. 3: Transfer characteristics of p-n-p unit

Table I: (l) Common-Emitter Nodal Equations and Parameters

Table II: (r) Definitions of Transistor Amplification Factors

$$\begin{cases} I_b = y_{bbe} V_{be} + y_{bce} V_{ce} \\ I_c = y_{cbe} V_{be} + y_{cce} V_{ce} \end{cases}$$

$y_{bbe} = g_{bbe} + jb_{bbe}$ = INPUT ADMITTANCE WITH OUTPUT SHORT-CIRCUITED

$y_{bce} = g_{bce} + jb_{bce}$ = REVERSE TRANSFER (FEEDBACK) ADMITTANCE WITH INPUT SHORT-CIRCUITED.

$y_{cbe} = g_{cbe} + jb_{cbe}$ = FORWARD TRANSFER ADMITTANCE WITH OUTPUT SHORT-CIRCUITED.

$y_{cce} = g_{cce} + jb_{cce}$ = OUTPUT ADMITTANCE WITH INPUT SHORT-CIRCUITED

a_{cb} = FORWARD COLLECTOR-TO-BASE CURRENT AMPLIFICATION FACTOR $= -\left.\frac{\delta I_c}{\delta I_b}\right|_{V_{ce}=cons.} = -\frac{y_{cbe}}{y_{bbe}}$

a_{bc} = REVERSE BASE-TO-COLLECTOR CURRENT AMPLIFICATION FACTOR $= -\left.\frac{\delta I_b}{\delta I_c}\right|_{V_{be}=cons.} = -\frac{y_{bce}}{y_{cce}}$

μ_{cb} = FORWARD COLLECTOR-TO-BASE VOLTAGE AMPLIFICATION FACTOR $= \left.\frac{\delta V_{ce}}{\delta V_{be}}\right|_{I_c=cons.} = -\frac{y_{cbe}}{y_{cce}}$

μ_{bc} = REVERSE BASE-TO-COLLECTOR VOLTAGE AMPLIFICATION FACTOR $= \left.\frac{\delta V_{be}}{\delta V_{ce}}\right|_{I_b=cons.} = -\frac{y_{bce}}{y_{bbe}}$

ϕ_{cb} = FORWARD COLLECTOR-TO-BASE POWER AMPLIFICATION FACTOR $= \frac{|y_{cbe}|^2}{4g_{bbe}\, g_{cce}}$

ϕ_{bc} = REVERSE BASE-TO-COLLECTOR POWER AMPLIFICATION FACTOR $= \frac{|y_{bce}|^2}{4g_{bbe}\, g_{cce}}$

CONJUGATE ADMITTANCE MATCH EQUATIONS:

LET

$$G_E = \frac{g_{bce}g_{cbe} - b_{bce}b_{cbe}}{g_{bbe}\ g_{cce}}$$

$$B_E = \frac{b_{cbe}g_{cbe} - b_{cbe}\ g_{bce}}{2g_{bbe}\ g_{cce}}$$

THEN

$$g_{i-cm} = g_{bbe}\sqrt{1 - G_E - B_E^2} \qquad b_{i-cm} = b_{bbe} - g_{bbe}B_E$$

$$g_{o-cm} = g_{cce}\sqrt{1 - G_E - B_E^2} \qquad b_{o-cm} = b_{cce} - g_{cce}B_E$$

$$\text{FORWARD POWER AMPLIFICATION} = \frac{4\phi_{cb}}{\left[2 + 2\sqrt{1 - G_E - B_E^2} - G_E\right]}$$

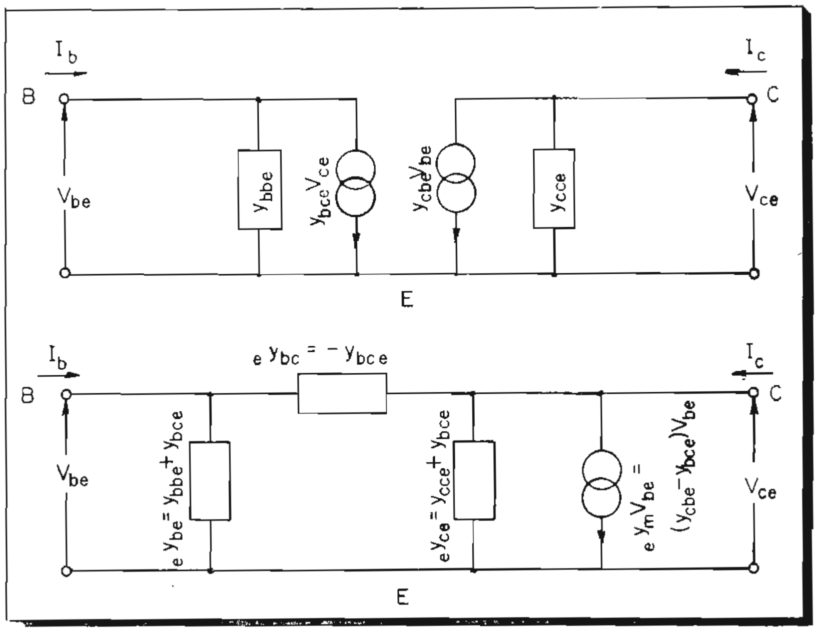


Fig. 5: (r) Two- and one-generator common-emitter equivalent circuits

Table III: (l) Conditions for Maximum Power Amplification in Transistors

art. Both transistor and vacuum tube require a positive voltage on the base and grid respectively in order to get significant output current. For this mode of biasing, both devices exhibit "pentode" output characteristics with the collector or anode current being essentially independent of the collector or anode voltage except at low voltages where the collection of electrons is limited by space-charge conditions. Thus, the base-to-emitter voltage in the transistor determines the number of electrons entering the base wafer. Most of these electrons flow to the collector to produce a saturated collector current. It is seen then, that there is a close correspondence between transistor collector characteristics and vacuum tube anode characteristics.

The preceding discussion has centered about an n-p-n junction transistor. The data to be presented here are for a p-n-p junction transistor which can be considered analogous to a vacuum tube provided the cathode emits positrons. The charge carrier for either device is now positive so that all voltage polarities must be reversed.

The dc characteristics of a junction transistor can be presented in several different ways. A set of characteristics that appears to be particularly useful includes the base characteristics, transfer characteristics, and collector characteristics. This set of characteristics follows closely the data usually presented for a vacuum tube. Following vacuum tube practice, the transistor voltages are measured with the emitter as the reference point. Thus, the base characteristics for a p-n-p junction transistor are depicted in Fig. 2. The following comments are applicable to this as well as the following figures. The axis directions have been chosen to be algebraically consistent with the quantities being measured. Upper-case letter subscripts are used to denote dc values and lower-case letter subscripts will be used to denote ac values. Finally, all data to be presented are for the same transistor, an experimental p-n-p junction transistor made by alloying indium into opposite faces of an n-type germanium wafer.[2] The transfer characteristics of the transistor are shown in Fig. 3, and the collector characteristics in Fig. 4. Collector characteristics have, in the past, been published with

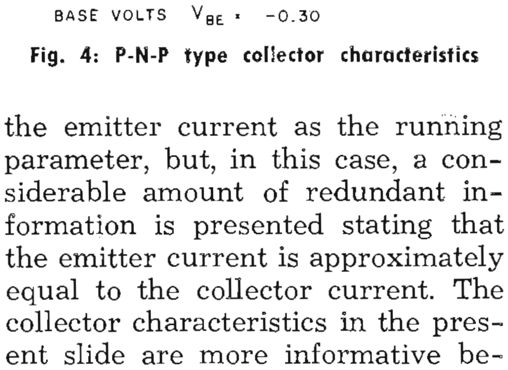


Fig. 4: P-N-P type collector characteristics

the emitter current as the running parameter, but, in this case, a considerable amount of redundant information is presented stating that the emitter current is approximately equal to the collector current. The collector characteristics in the present slide are more informative because the parameter is the base-to-emitter voltage. Among other things, it is apparent, as was also indicated in the preceding transfer characteristics, that the transistor exhibits nonlinear control characteristics similar to a vacuum tube. The problem of obtaining linear operation is therefore very similar for both devices.

Small-Signal Representation

There are many amplifier applications for which the operation of the transistor is accurately specified on a small-signal basis. Accordingly, a small-signal representation of the transistor is very useful. Any four independent parameters are sufficient to specify the small-signal and therefore the linear) operation of the transistor. The parameters most often employed are the four coefficients associated with the input and output terminal equations. Since these terminal equations can be written in either a nodal or a loop form, there is a choice of using either admittances or impedances as the parameters. Most of the literature that has been published has employed the impedance parameters. It is the author's belief that the nodal equations together with the admittance parameters are somewhat more suitable for the following reasons:

(1) The emitter current is approximately continuous through the device so that current equations appear more appropriate;

(2) The nodal equations lead easily to a π equivalent circuit which has been used extensively in connection with vacuum tubes because of greater ease of circuit adaptability. In contrast, the loop equations lead easily to a T equivalent circuit with an inaccessible neutral point;

(3) One of the most compelling reasons is the existence of commercial equipment for the measurement of the real part of the admittance parameters.

There are three possible transitor

connections depending upon which of the three transitor elements is is chosen as common. In order to maintain the comparison with the vacuum tube and because this will probably be the most frequently used connection, the common-emitter circuit is singled out for detailed attention. Accordingly, this article will be devoted exclusively to the admittance parameters associated with the common-emitter circuit. It is well to note that this choice imposes no serious restrictions as, knowing one set of independent parameters the appropriate parameters associated with any other circuit including the loop-derived parameters can be easily determined. In order that the notation to be employed be understood, the nodal equations and the definition of the admittance parameters for a common-emitter transistor circuit are shown in Table 1.

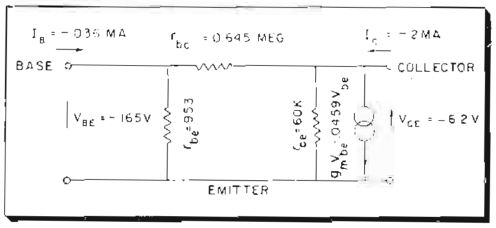


Fig. 6: Nodal derived circuit of p-n-p unit

A few words concerning the notation employed may be appropriate. The first two subscripts are chosen to coincide with the numerical notation often used in connection with a general four-terminal network. The last subscript designates the common element of the circuit connection.

The nodal equations are depicted most directly by means of a two-generator equivalent circuit shown on the top of Fig. 5. The one-generator equivalent circuit shown on the bottom of Fig. 5 is the π equivalent circuit that is doubtlessly familiar to all who have studied vacuum tube operation particularly at high frequencies. The parameters of the π equivalent circuit employ a pre-subscript to designate the common element and have been designated in a unique manner so that there will be no ambiguity with the two-generator parameters. It is well to point out that ${}_{e}y_{m}$ is a parameter somewhat comparable to the complex transconductance of a vacuum tube and therefore is of considerable importance. The nodal parameters can be used to define certain amplification factors as shown in Table II. Of these factors, the forward current amplification factor has been greatly overworked in connection with transitor operation. Equally as important is the forward voltage amplification factor which has so often been overworked in connection with vacuum tube operation. The power amplification factors were conceived by the speaker in order to have a single factor that might be used as an index of the transitor performance. It is noted that the power amplification factors are essentially the product of the appropriate voltage and current amplification factors with suitable modifications so that the final result is always a real quantity.

With the aid of the four nodal parameters, the actual circuit amplification, the input and output match conditions, as well as other operating data can be determined. These quantities will not be considered except as they enter into the subsequent considerations of the transistor performance.

Low-Frequency Measurements

In the preceding formulation of small signal representation, admittances rather than conductances have been used because the junction transitor exhibits rather pronounced reactive effects even at relatively low frequencies. At low enough frequencies, all admittances are essentially conductances, and it is these conductance parameters that are of interest for the low-frequency operation of the transitor. Although the

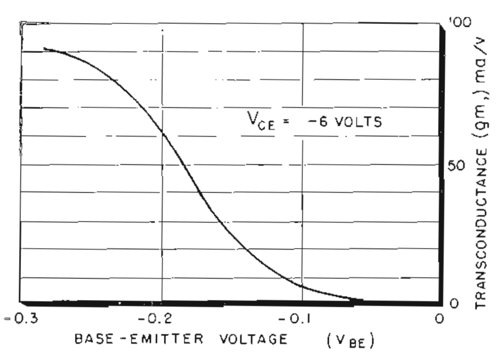


Fig. 7: P-N-P transconductance characteristics

conductance parameters can be measured by voltmeter-ammeter methods a much better method is the use of a bridge circuit. The General Radio Co. Type 561 vacuum tube bridge can be readily used for this purpose with the junction transitor being connected as though it were a vacuum tube triode. A suitable collector-to-emitter voltage is connected to the bridge plate terminals and a suitable base-to-emitter voltage is connected to the bridge grid terminals. This will permit the measurement of two parameters, the output conductance, g_{cce}, and the forward transfer conductance, g_{cbe}, and their ratio, the forward voltage amplification factor, μ_{cb}. The collector and base connections together with their associated supplies are then interchanged and the input conductance, g_{bbe}, the reverse transfer conductance, g_{bce}, and the reverse voltage amplification factor, μ_{bc}, measured.

Bridge Measurements

The bridge measurements are made at 1,000 CPS, and since reactive components are also balanced, the real components of the admittances at 1,000 CPS are obtained. The bridge balance for the measurements made on the collector side are obscured to some extent by transistor noise, but with some care and the usual precautions, measurements on the collector side as well as on the base side can be made to three significant figures. The measurement of the voltage amplification factors can be used to check the self-consistency of the data which is generally within a few percent.

The 1,000 CPS equivalent circuit for the p-n-p junction transistor is shown in Fig. 6 with components other than trans-conductance specified in terms of resistance rather than conductance. The dc operating point chosen was a collector-to-emitter voltage of −6.2 volts and a collector current of −2 ma. There are a few items of interest in connection with this equivalent circuit. First, it is noted that the feedback resistor between the input and output, although not infinite as is the case for a vacuum tube, is large enough that it is sometimes permissable to consider the input and output circuits independently. Next, it is interesting to note that the transconductance, 45.9 ma/volt, of the transistor is considerably larger than transconductances of vacuum tubes. Of greater importance, is the fact that the transconductance-to-emitter current ratio, g_m/I_E, should have the theoretical value of $e/kT = 38.6$. The actual

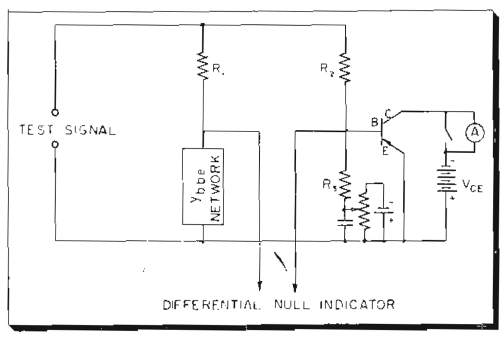


Fig. 8: Input admittance bridge test set

value of this ratio does not differ greatly from this theoretical value. Thus for the transistor under consideration this ratio is 23, that is,

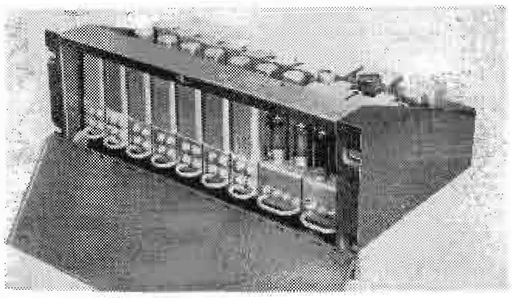
(*Continued on page 150*)

New Equipment and Components

Preview of products to be displayed at 1953 IRE Convention

Mounting Assembly

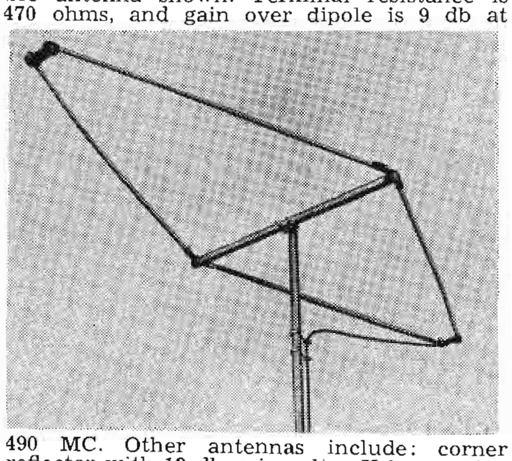
The 11338 assembly is a relay rack mounting frame designed to hold combinations of the 11301 cover tray which is the mounting base for the Altec Lansing A-428B amplifier and the 11302 cover tray which is the



mounting base used with the A-429B amplifier, P-522A and P-523B power supplies. The 11338 assembly will hold a maximum of nine 11301 trays or a maximum of six 11302 trays. These trays are mounted permanently in the 11338 assembly in the quantity which may be required and the amplifiers or power supplies are mated into them since they contain the mating part of the Cannon connector to which permanent wiring is attached. Wiring gutters are provided in this frame, as well as heavy-duty terminals for connecting 60 cycle power leads. All wiring connections are made in the rear. The assembly provides easy access to the equipment contained therein and facilitates testing and metering of the various units.—**Altec Lansing Corp., 9356 Santa Monica Blvd., Beverly Hills, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Antennas

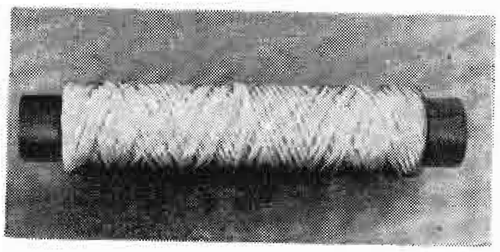
A complete line of UHF and VHF receiving antennas include Model UHF 200 rhombic antenna shown. Terminal resistance is 470 ohms, and gain over dipole is 9 db at



490 MC. Other antennas include: corner reflector with 13 db gain; ultra V-beam; six-element Yagi for 10 UHF channels; broadband UHF bowtie and reflector with 7.3 db gain; double-vee; and the Model Jet 283 VHF-UHF combination combining a bowtie and conical antenna.—**JFD Mfg. Co., Inc., 6101 Sixteenth Ave., Brooklyn 4, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES.

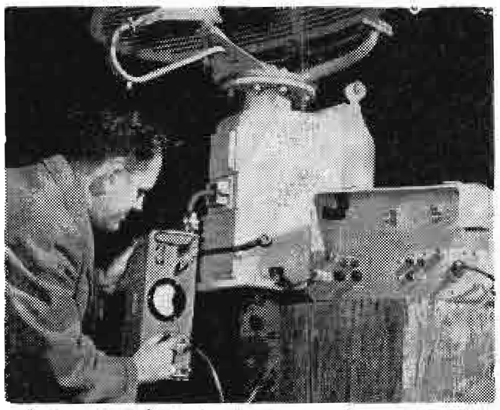
Fungus-Proof Nylon Lacing Cord

A new Nylon Lacing Cord and Flat Braided Tape resists deterioration due to the growth of mold and micro-organisms. The special synthetic resin coating on the cord and tape causes the life to be considerably lengthened. They are said to have a high abrasion resistance and low moisture absorption. A further advantage is that they have the desirable malleability of wax and are non-toxic to humans.—**Heminway & Bartlett Mfg. Co., 500 Fifth Ave., New York 36, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES



X-Band VSWR Meter

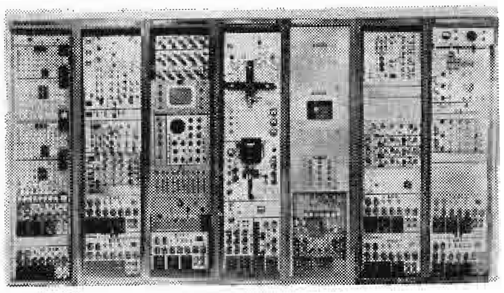
Simplified, direct measurement of VSWR in the 8.5 to 9.6 KMC range is accomplished with the Model 539 test set. One application shown is checking the transmission efficiency of a radar scanner's waveguide feed system. This portable X-band unit contains modulated source, microwave bridge, de-



tector, amplifier, indicator and power supplies. VSWR range is 1.05 to 3.0 in three calibrated scales, and 3 to 10 uncalibrated. Accuracy is from 5 to 10%. Size of the 35-lb. set is 17.75 x 11.25 x 10 in. In addition, other equipments on display include: Model 538 direct-reading X-band power meter; thermistor mounts for measuring power in four bands between 5 and 25 KMC; and the SRX-52 Klystron local oscillator.—**Sperry Gyroscope Co., Great Neck, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Color TV Equipment

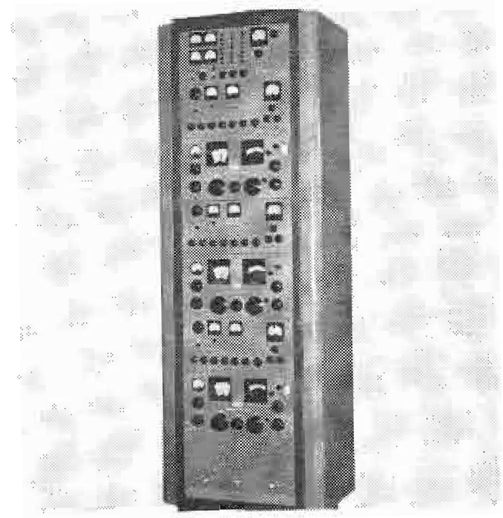
An integrated assembly of seven racks comprise the equipment for the generation and test of color and monochrome TV sig-



nals. The units include color scanning gear, NTSC color transmitter and NTSC color receiver employing a three-tube dichroic monitor. Automatic pushbuttons control the transmission and reception of existing color signals. Also on display are monochrome scanning equipment, an economy type TV picture generator, and UHF noise generator. —**Telechrome, Inc., 88 Merrick Rd., Amityville, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Single-Sideband Receiver

Model 155 triple-diversity single-sideband receiver is said to provide the optimum in reception of all forms of modulation used in HF (3 to 30 MC) communication. This includes reception of reduced carrier single-



sideband transmission, and double-sideband transmission (either AM or PM) by exalted-carrier reception. It is available with either Hammarlund type SP600JX or Collins type 51J communication receivers in triple-diversity, dual-diversity, or single receiver arrangements.—**Crosby Laboratories, Inc., Box 233, Robbins Lane, Hicksville, N.Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

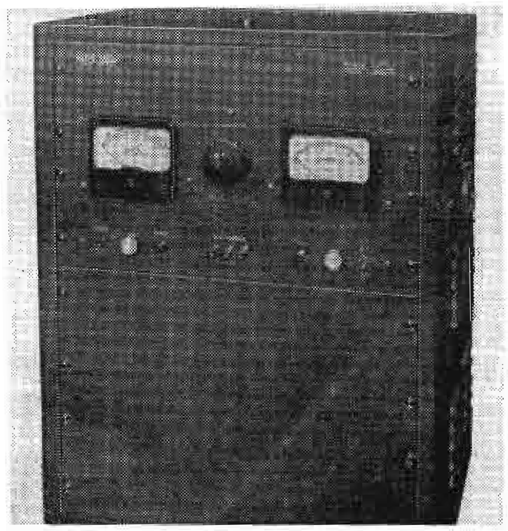
Additional IRE Equipment Previews will appear in the April issue of TELE-TECH & ELECTRONIC INIDUSTRIES

Portable Scaler

Self-contained portable scaler Model 2080 is a Geiger-Mueller scaler which provides count indication with an electronic scale-of-eight and a mechanical register. Unit includes input amplifier, scale-of-eight with interpolation meter, register and drive, and battery-vibrator supply. Maximum counting rate is 6000 counts per minute, with a paired pulse resolution of 0.1 millisecond. Input sensitivity is 0.5 v., and the vibrator supplies 900 v. A 700-v. type is also available. Battery complement includes three "little six" 1.5-v. cells, three D cells, and one 45-v. B battery, with a battery life of 60 hours intermittent operation. The 11-lb. device measures 11 x 6.25 x 8 in. Other equipment to be on display are the Series 1550 digital recorder and Model 558 events-per-unit-time meter.—**Berkeley Scientific, 2200 Wright Ave., Richmond, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Power Supply

Model 750 power supply features one regulated dc voltage supply with excellent regulation, low ripple content and low output



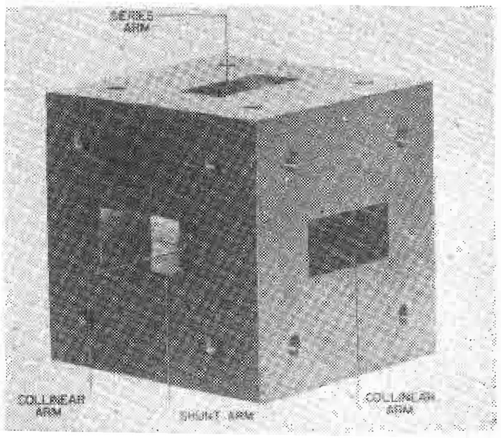
impedance. It is continuously variable from 0-600 v. and delivers from 0-750 ma. In the range 30-600 v. the output voltage variation is less than ½% for both line fluctuations from 105-125 v. and load variation from minimum to maximum current. The ripple voltage is less than 10 mv peak to peak.—**Kepco Laboratories, 131-38 Sanford Ave., Flushing, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

for Engineers and Designers

Exhibitors' products reveal many new developments

Precision "Magic Tee"

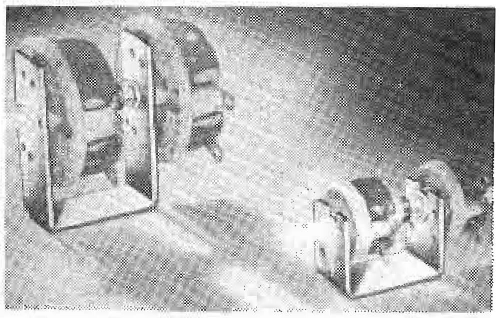
A precision "X" band hybrid junction uses a new type of construction assuring isolation of −50 db or better as well as low VSWR



over a broad frequency range. Stub and septum matching is employed to provide a nominal VSWR of 1.05 at the design center, and 1.185 at the 10% band extremes, using any arm as input terminal. Better VSWR's can be provided on special order. In addition to its function as a Magic Tee, it can be used as a highly accurate power divider, in the configuration of a shunt or series tee, by blocking the appropriate arms. It is supplied with plain flange faces, in .4 x .9 inch waveguide size in brass or aluminum. Other sizes can be supplied on special order.—**General Precision Laboratory, Inc., 63 Bedford Road, Pleasantville, New York.**—TELE-TECH & ELECTRONIC INDUSTRIES

Tandem Coupling Kits

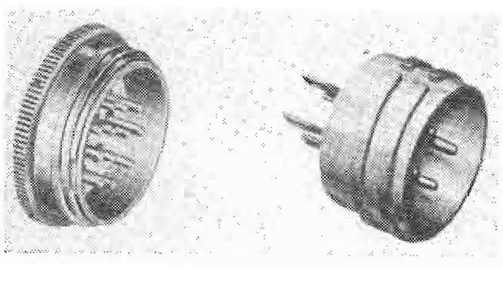
Two new rheostat coupling kits facilitate the mounting of certain standard Ohmite rheostats in tandem. Each kit consists of a



steel "U" frame, mica washer, coupling, Allen wrench, and assembly instructions. The large frame is designed for use with Ohmite Model G, K, or L rheostats. The small frame is designed for use with Ohmite Model H or J rheostats.—**Ohmite Manufacturing Co., 4835 Flournoy St., Chicago, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

New Hermetically-Sealed Series

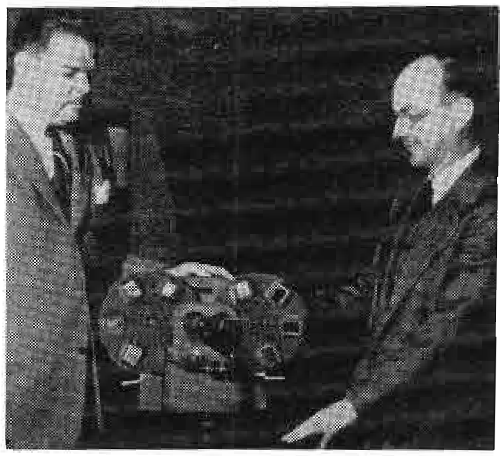
The KH and RKH connector series have been added to Cannon's heremetically-sealed lines. The new plugs and receptacles are similar in construction to the GSO2 and GSO6 (AN type). Chief features of the steel shell common to the Cannon Electric K and RK types, is the heavy duty special Acme thread. KH receptacles mate with standard K



plugs and RKH plugs with RK receptacles. The true hermetic seal is achieved by the special vitreous insulation around the steel contacts and fused to the shell. The KH connectors will withstand 200 to 900 psi, depending on size and contact complement. −320°F to +600°F, emergencies to 1,000°F if mating fitting and finish are expendable. All MIL-C-5015 vibration and thermal shock tests are met.—**Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Projector for TV

A lightweight projector for TV stations provides automatic, remote or local control "lapping" of an unlimited number of 2"x 2" transparent sildes. In operation, projection alternates from one lens system to the other, and the "turrets" which hold the slides alternately revolve one slide space as they are actuated by a solenoid mechanism. One loading of the two turrets gives a sequence of twelve slides. Additional loaded slide turrets, which can be substituted for used turrets in a matter of seconds, provide an unlimited sequence. Tolerances on the projection mechanism are such that the variation in positioning of successive images is well within the 1/32 in. width image on mosaic at approximately 36 in. from



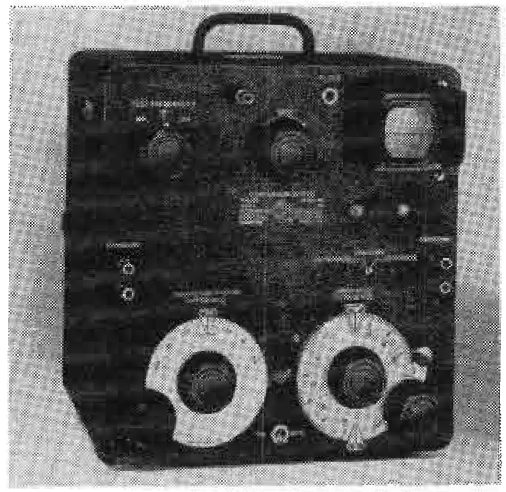
the slide. Other lenses may be used to provide longer focusing distances. The equipment includes infra red filters to give optimum contrast with the iconoscope film camera.—**Gray Research and Development Co., Inc., 521 Fifth Ave., New York, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Capacitors

A line of high voltage disc ceramicon capacitors is said to provide the smallest unit available for a given voltage and capacitance. The standard sizes in the new lines are 3/8 in., 13/32 in. and 3/4 in. maximum diameter. They have phenolic dipped, vacuum wax impregnated case insulation. Leads are #22 tinned copper wire. Standard dc working voltage ratings are 1000, 1500, 2000, 3000, 5000, and 6000, with a dielectric strength test of twice the rated working voltage.—**Erie Resistor Corp., 644 W. 12 St., Erie, Pa.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Comparison Bridge

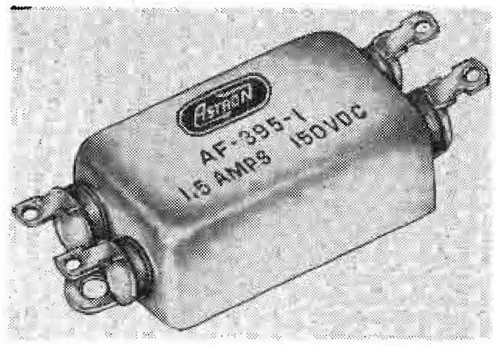
Accurate and simple production tests can be performed on the new general-purpose type 1604-A Comparison Bridge. With a basic accuracy of 0.1%, the bridge can be used for direct comparison of resistors, capacitors and inductors over the wide impedance range of about 2 ohms to 20 megohms. Two impedance-deviation ranges, ±5% and ±20% are provided. Dissipation-factor (or storage-factor) differences are also indicated. The bridge is completely self-contained with a cathode-ray visual detector and an oscillator operating at either 1 kc or 5 kc. Operation is from the ac line. The point at which the bridge is grounded can be switched, so that measurements can be



made with the unknown either grounded or ungrounded. Primary application is that of sorting components to a given tolerance. The standard to be used need not be a precision standard but can be a component which has been independently measured. An offset zero is provided within the bridge so that an accurate standard is not necessary. The bridge is also useful for measuring center-tapped windings to be sure that the tap is correctly center; for checking ganged potentiometers and capacitors; and for measuring small capacitors of a few $\mu\mu$f by placing them in parallel with, say, 100 $\mu\mu$f.—**General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Filter Subminiaturization

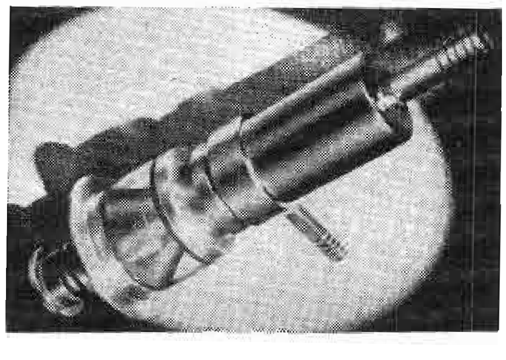
Reductions of from 40 to 50% in the size of r-f interference filters through the use of metallized paper capacitor elements and inductances made with special windings on high permeability core materials are



currently being effected. Standard or specially designed filters are available in single or multiple filter section for suppressing conducted and radiated noise on one or more power lines and for noise attenuation from 14 kc to 1,000 mc. Subminiature filters conform to all existing government specifications.—**Astron Corporation, 255 Grant Ave., E. Newark, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Coaxial Terminal Triode

A water-cooled ring seal triode incorporating an integral anode water jacket, the ML-6257, is designed specifically for r-f

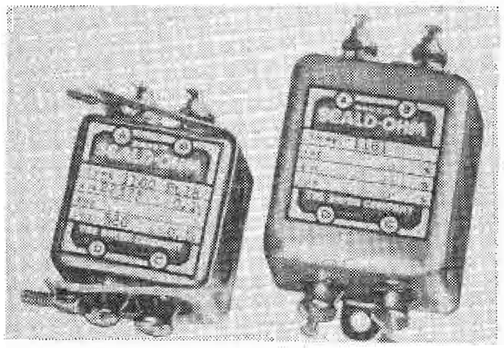


NEW EQUIPMENT & COMPONENTS (Continued)

heating application in the 2-3 kw range, but is well adapted to AM, FM and TV transmission. The tube has plate input and dissipation ratings of 7 kw and 5 kw, respectively; stress-free thoriated tungsten filament operates at 12.6 v., 27 amps. Maximum ratings apply to 110 MC. It is also available in forced-air cooled model and in a version designed for use with Machlett quick-change automatic seal water jacket.—**Machlett Labs., Inc., Springdale, Conn.**—TELE-TECH & ELECTRONIC INDUSTRIES

Resistors

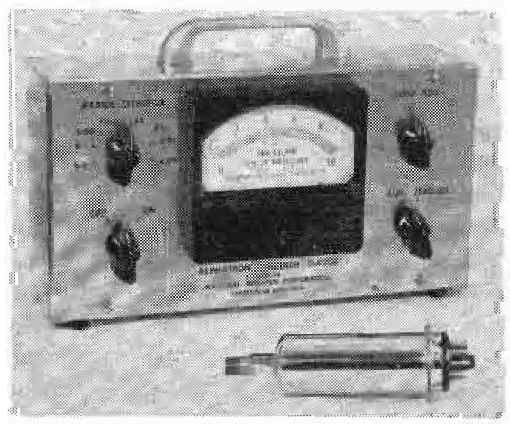
Hermetically sealed resistor series 1160 and 1161 features rugged, shock-resistant construction provides complete protection from corrosion, fungus and other harmful effects



of extreme humidity and temperature. These resistors are intended for use as secondary standards, resistor elements in bridge networks, in voltage divider circuits, in attenuation networks, etc. Resistor windings, either spool or card type, are supplied with various types of wire, depending upon the resistance and temperature characteristics required for the specific application. Temperature coefficients as low as 20 parts per million are available. All windings are artificially aged to insure stability and may be obtained with accuracies as close as ±0.05%. The high stability achieved assures no appreciable variation in resistance or accuracy with long use. Spool-type resistors are non-inductively wound and for most applications, there is no appreciable effect over the audio range. Where card-type windings are employed, the frequency range is limited by the particular design; the usual range is from 0 to 10 MC.—**The Daven Co., Dept. HR, 191 Central Ave., Newark 4, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Vacuum Gauge

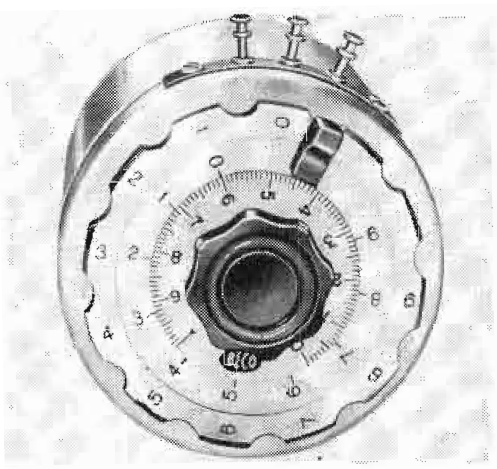
Type 511 Alphatron (R) vacuum gauge employs a shielded radioactive source instead of a hot filament. Alpha particles ionize the gas. Ionization current produced is measured



by a dc amplifier which is calibrated to give absolute pressure in millimeters of mercury. The sensing element and first stage amplifier are housed in a steel envelope which weighs only four ounces. Attachment to the vacuum system is made by a ⅛ in. standard pipe thread tubulation. The power supply, high stage amplifier, range selector, and output meter are incorporated in a compact stainless steel housing weighing 7 lbs. Dependence on outside power supply which is subject to fluctuation is eliminated by the use of readily available batteries. The use of batteries eliminates an expensive regulated direct current power supply and substantially reduces the cost of the gauge.—**National Research Corp., 70 Memorial Drive, Cambridge, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

Potentiometers

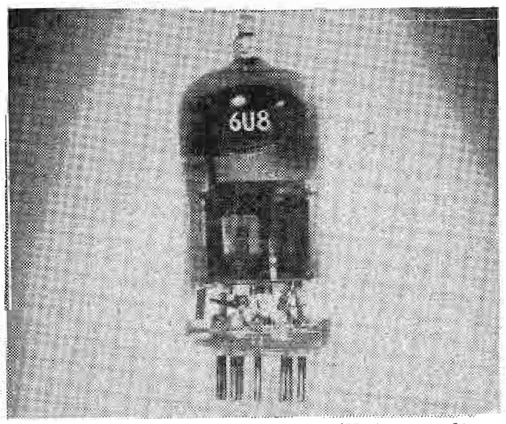
A new series of panel mounting precision potentiometers, Dekapot model DP-211, achieve a linearity that is better than ±0.01% and total resistance that is better



than ±0.05%. The Dekapot has two decades of fixed resistors and an interpolating slide-wire to accomplish the voltage division. The dial arrangement gives an effective scale length of 390 in. The resistance wire used has a temperature coefficient of less than ±0.002% C°. These units are now available in total resistances of 10,000 ohms. Other values are available on special order.—**Brown Electro-Measurement Corp., 4635 S. E. Hawthorne Blvd., Portland 15, Oregon.**—TELE-TECH & ELECTRONIC INDUSTRIES

Triode-Pentode

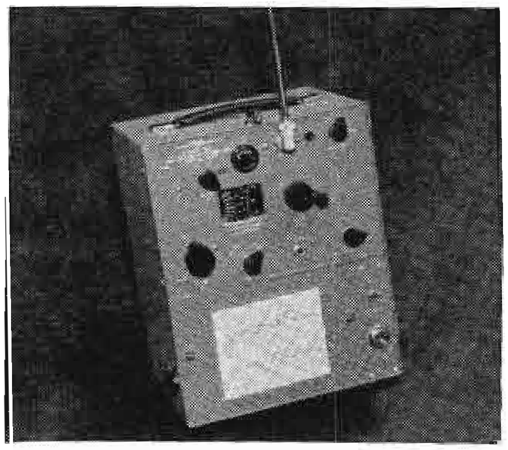
Both sections of a new miniature nine-pin, triode-pentode receiving tube are electrically independent and adequately shielded. The pentode section is said to provide excellent



gain with a low local oscillator voltage which minimizes oscillator radiation. The pentode section may also be used as an i-f amplifier, video amplifier, sound limiter or sync separator. The triode performs satisfactorily as a horizontal or vertical oscillator, or sync clipper.—**Sylvania Electric Products Inc., Radio Tube Division, Emporium, Pa.**—TELE-TECH & ELECTRONIC INDUSTRIES

UHF Frequency Meter

A direct reading UHF frequency meter (model FM-3) has a resetability which is ±0.0005% and stability which is ±0.001%. Accuracy is ±0.001% and range is 20-640



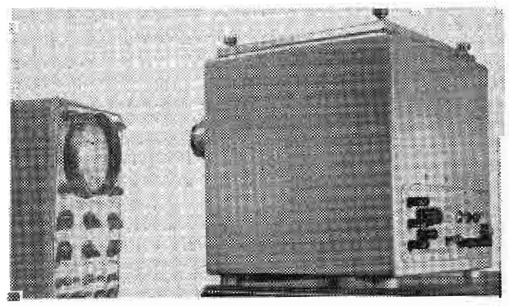
MC. Under certain conditions it can be used to 1,000 MC. The multiple oscillator method of frequency method is utilized. It is supplied with carrying case and removable cover and can be used with batteries for portable use. Provision is made for attaching an external power supply for fixed station use.—**Gertsch Products, Inc., 11846 Mississippi Ave., Los Angeles, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Magnetic Tape

A new magnetic tape for critical recording applications employs a new magnetic coating material with increased magnetic remnance. Designated "Scotch" No. 120 "High Output" (trade mark) magnetic tape, it is designed especially for use in radio, television and recording studios, in computer work, and in other critical applications. The new tape is stated by the manufacturer to produce at least 8 db more output at a given distortion level than any other magnetic tape over the entire range of the audio spectrum. It has a cellulose acetate backing of the same grade and thickness as standard "Scotch" No. 111 magnetic tape. Limp and easily handled, the new tape has a strong and flexible coating, "dry lubricated" by a special process to prevent squealing on critical machines. No. 120 tape has the same coercivity, frequency response erasability and print ratio as No. 111 tape, and no change in bias is necessary to obtain maximum results from the new tape on machines now set for optimum bias for No. 111 tape. Output uniformity at 1 KC is guaranteed not to exceed ±¼ db within a reel, and ±½ db from reel to reel. The No. 120 tape is available in lengths of 2400 ft. on the NARTB reel or hub, and in 1200-ft. lengths on the 7-in. professional plastic reel with the special 2¾ in. hub only. All lengths are guaranteed splice-free. List price is $7.00 for the 1200-ft. length, $13.00 for the 2400-ft. length on the NARTB hub, and $15.85 on the NARTB reel.—**Minnesota Mining and Manufacturing Co., 900 Fauquier Street, St. Paul 6, Minn.**—TELE-TECH & ELECTRONIC INDUSTRIES

Oscilloscope Camera

A new cathode-ray oscilloscope recording camera provides still, continuously moving film, and drum photography. These three modes of operation, each having its own special advantages, provide records for measurement of electrical and physical phenomena that may be displayed on a cathode ray tube. This camera is manufactured by Southern Instruments Ltd., Surrey, England. A continuous feed mechanism provides for the movement of 25 ft. of sensitized material at rates of from 0.4 to 100 in. per second. The drum attachment, carrying 20 in. of sensitized material, provides linear speeds from 4 to 1200 in. per second. Performated or unperforated film or paper of either 35mm or 70mm width may be accommodated. The drive motor operates on



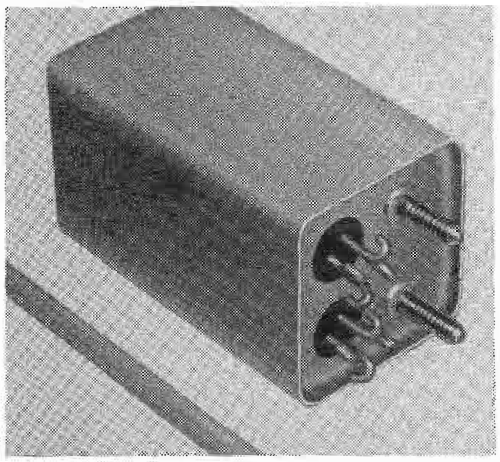
6 to 12 V approximately, drawing 6 amps maximum. An f/1.9 lens is furnished as standard.—**J. A. Maurer, Inc., Photographic Instrumentation Div., 37-01 31 St., Long Island City 1, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Batteries

A new line of low-voltage, tiny mercury batteries will meet the specific requirements and characteristics of transistor operations, such as increased energy per unit volume, long service life, constant discharge characteristics and long, corrosion-free shelf life. All Mallory transistor power supplies incorporate new contact features for better, corrosion-free service, and the Power-Pak batteries are coated with a "shrink-on" plastic to provide a tight, leakproof seal between cells. They maintain a substantially constant voltage and energy output level over wide temperature ranges at current drains from 10μa to 10 ma.—**P. R. Mallory & Co., Inc., Battery Division, N. Tarrytown, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Relay

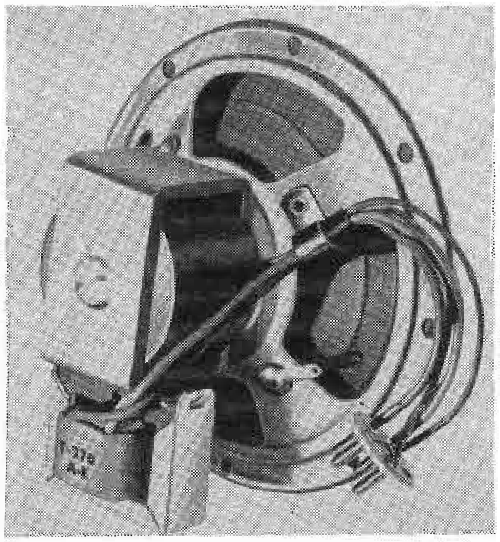
A miniature, hermetically sealed, double pole, double throw relay, weighing only 3½ ounces, is designed to operate through a wide range of environment. Due to its well



counter-balanced features this relay will withstand high acceleration, vibration, shock and tumbling. It meets the shock requirements of MIL-E-5400 and will withstand continuous acceleration of 50 G without malfunctioning. Certain contact combinations can be furnished with a required coil power as low as 20 mw and any relay in this series can be obtained with a coil resistance as high as 15,000 ohms.—**Phaostron Co., 151 Pasadena Ave., S. Pasadena, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Speakers

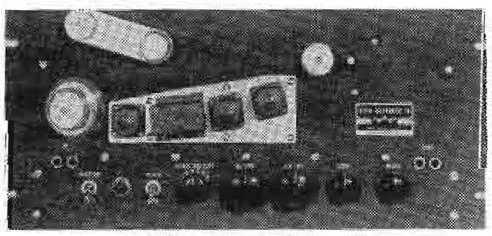
Each field coil in a new line of electrodynamic speakers is guaranteed to contain the given number of turns within the standard tolerance. There are no wire-stretching



or other quality-reducing shortcuts to cause deviation from the resistance and wire size specified by the customer. The second important feature is the use of the same perfectly round "No-Rub" Voice Coil which is used on the Heppner P.M. speaker line. This coil (an exclusive Heppner feature) is installed perfectly round by means of a Heppner developed process which eliminates all egg-shaped coils that cause rubs. The electro-dynamic speakers are available in 3, 4, 5, 6½, 10 and 12 in. sizes with or without bucking coils, plugs, transformers and/or brackets as specified.—**Heppner Manufacturing Co., Round Lake, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Reverberation Unit

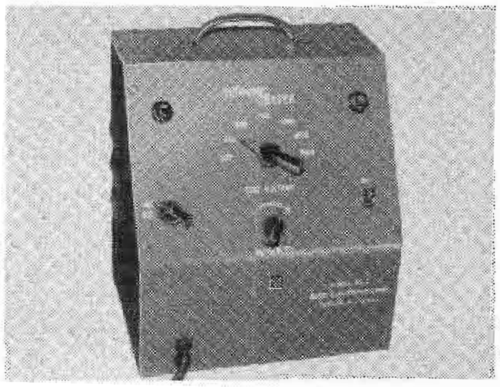
An improved form of the Goodfriend—Audio Facilities magnetic tape loop system comprises the seven-head model 42 reverberation unit improving recorded music and special effects. The signal is recorded, then reproduced by several magnetic heads at different times. The reproduced signals are returned to the recording head, and passed around the recirculation loop again with



diminished amplitude. Three major controls on the 8.75 x 19 in. panel determine head arrangement, reverberation time, and reverant-to-direct sound ratio. The unit contains a zero-loss straight-through channel, as well as the tape-loop reverberation channel, so that no audio system circuit changes are necessary. The unit may be patched directly between studio-console preamplifier output and mixer-input, or between a tape reproducer output and a disc recorder input. Controlled input and output levels are −30 or +40 VU. Impedances are 600 ohms input, 600 ohms output. Frequency response for direct channel is ±1 db, 50-15,000 CPS; and for reverberation channel is ±1 db, 200-8,000 CPS, and shaped from 50 to 200 CPS, and from 8,000 to 15,000 CPS. Power requirements are 117 v., 60 CPS, 125 watts. Reverberation time is adjustable up to 10 seconds. Also, five-head model 40 is available with adjustable reverberation time up to 6 seconds.—**Audio Instrument Co., Inc., 133 W. 14 St., New York 11, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Hipot Tester

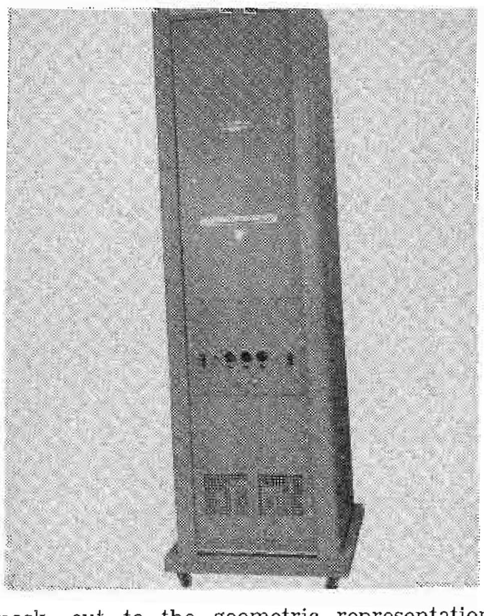
Model 55c Hipot tester has a range up to 1500 volts in steps of 250 volts with a sensitivity control that gives exact sensitivity desired for detection of faulty insulation or



surface leakage. Features include: ac or dc output; sensitivity up to one megohm/100 v; guaranteed shockproof to operator; audible alarm signal; no surface arcs.—**Bliss Electronic Corp., Box 123, Sussex, New Jersey.**—TELE-TECH & ELECTRONIC INDUSTRIES

DC Calibrator

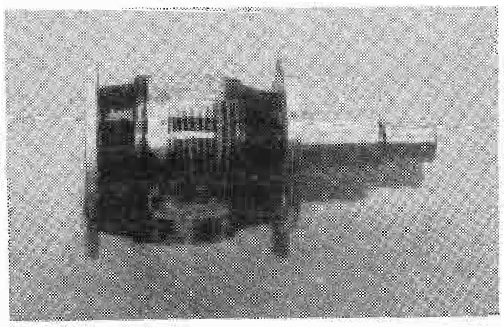
An electronic dc calibrator has been developed to correct automatically, in true time, the non-linearities present in telemetry systems. By the use of a paper calibration



mask, cut to the geometric representation of the desired function, both transducer nonlinearities as well as errors inherent in ground receiving equipment can be corrected, thus furnishing an immediate calibrated output for display or recording purposes. It operates on input signals from dc to one KC with an overall accuracy of approximately 1% of full scale. The unit is constructed on a standard relay rack mounting and measures approximately 88 x 25 x 25 in. It is designed around a 16-in. cathode ray tube, so that masks can be cut directly, without need for a reproduction process. It can also be used as an arbitrary function generator for laboratory purposes or applications involving electronic analog computers.—**Benson-Lehner Corp., 2340 Sawtelle St., Los Angeles 64, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Vacuum Capacitors

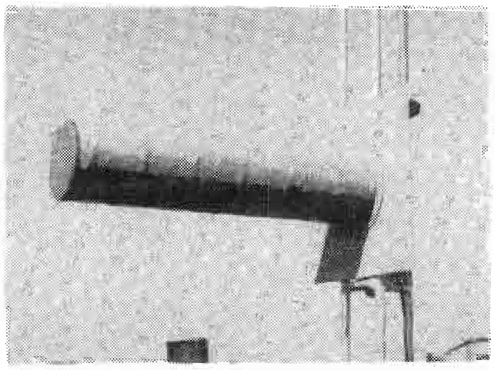
A full line of miniature vacuum capacitors in fixed and variable types, rated at 3 KV and 5 KV, are characterized by their small physical size, their negligible power factor,



and their extremely wide capacity ranges. For example, one variable unit has a capacity range of 5½μμf to 1000μμf. Another unit has a range of 4μμf to 250μμf and is only 4 in. long. The fixed JCSL Series and the variable UCSL Series are both sold in capacities ranging up to 2000μμf.—**Jennings Radio Mfg. Co., P. O. Box 1278, 970 McLaughlin Ave., San Jose 8, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Helical Beam Antennas

The helix conductor in a new line of helical beam antennas for unidirectional applications in the 450-470 MC region is molded integrally into a Fiberglas-polyester



resin radome housing. The Fiberglas molded helix is rigidly mounted to a 16 in. square ground plate which terminates the coaxial cable connector and provides for convenient mount to the support tower. This electrical design affords 12 to 14 db gain in point-to-point service and provides certain advantages of circular polarization propagation over conventional linear polarized propagation. Until the techniques of molding the helix conductor into the Fiberglas housing were perfected it was almost impossible to realize the advantages of the helical beam antenna in a commercially acceptable structure. All helical units are designed to withstand 100 mph wind velocity with ½ in. radial ice load. Either right-hand or left-hand units are available as standard production items.—**Mark Products Co., 3547-49 Montrose Ave., Chicago 18, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

X-Band ATR

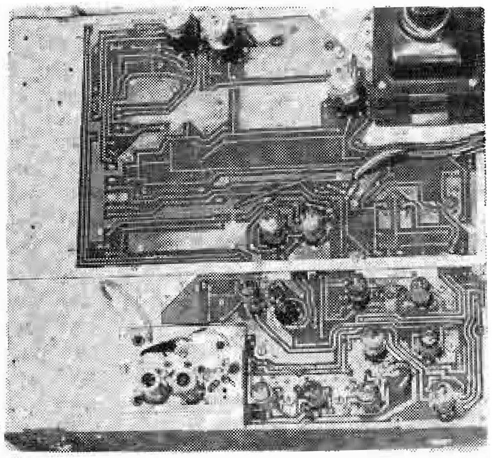
Type 6276 X-Band ATR is designed for operation in the X-band at a frequency of 9280 MC. It is electrically but not mechanically interchangeable with such types as the 1B35 and 1B35A. A braid gasket flange type of mounting is located near the window instead of a resonant choke mounted seat. Because of this, lower values of normalized equivalent conductance and freedom from arcing at high power operation are said to be achieved. The tube is completely silver brazed and has an overall length of one in. The tubulation is located on the narrow side of the waveguide body. The mount for

NEW EQUIPMENT & COMPONENTS (Continued)

the 6276 is of the flange contacting type and may be procured from Airtron, Inc., under part number 47855. The electrical equivalent of the type 1B37 is also available. This tube, the 6284, is mechanically interchangeable with the type 6276 and may be used in the same mount. It is designed for operation at a frequency of 8750 MC—**Microwave Associates, Inc., 22 Cummington St., Boston, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Printed Circuit

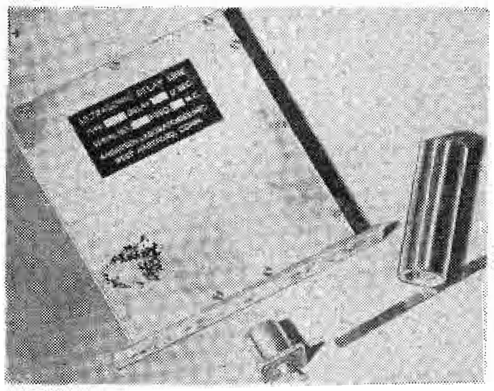
The Circuitron is a printed circuit which uses a different method of bonding the pattern to the insulating base. The conductive pattern can be run from one side of the base



material to the other by plating through holes maintaining circuit continuity without the need for eyelets or other hardware. This permits crossovers, greater design flexibility, and easy adaptation to single-dip soldering. Copper, silver and other metals, in any specified thickness can be used for the conductive circuit. The pattern can be overplated with nickel, silver, rhodium or gold.—**Circuitron, Inc., 400 Ninth Street, Hoboken, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Ultrasonic Delay Lines

A series of fused quartz ultrasonic delay lines for radar and electronic computer applications are available in bandwidths of 12 MC or greater, and feature an extremely low



ratio of spurious to designed signals. This can be held as low as −50 db for special requirements. Insertion losses are also kept to a minimum, 34 to 50 db being characteristic depending on the terminating impedance necessary.—**Anderson Labs., Inc., W. Hartford, Conn.**—TELE-TECH & ELECTRONIC INDUSTRIES.

New High-Power Klystrons

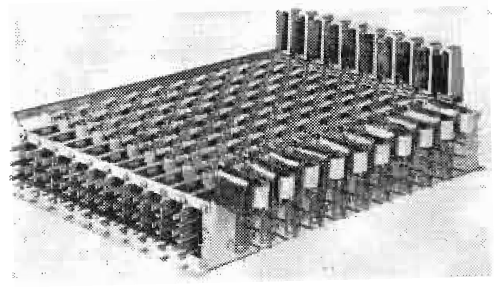
Six high-power klystron tubes have been added to the present transmitting tube line and will be in production soon. Developed for UHF telecasting at San Carlos, Calif., by Varian Associates, Inc., the tubes are rated for a maximum power output of 15 KW with a synchronizing peak level of 12 KW. Each of the six tubes is rated for a specific UHF range and together they cover all UHF channels, from 470 to 890 MC. The type numbers, frequency ranges, and channel ranges for the six tubes:

Tube type	Frequency range	Channel range
GL-6237	47-530 mc.	14-23
GL-6238	530-590 mc.	24-33
GL-6239	590-656 mc.	34-44
GL-6240	656-728 mc.	45-56
GL-6241	728-806 mc.	57-69
GL-6242	806-890 mc.	70-83

—**Tube Department, General Electric Co., Syracuse, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Crossbar Switch

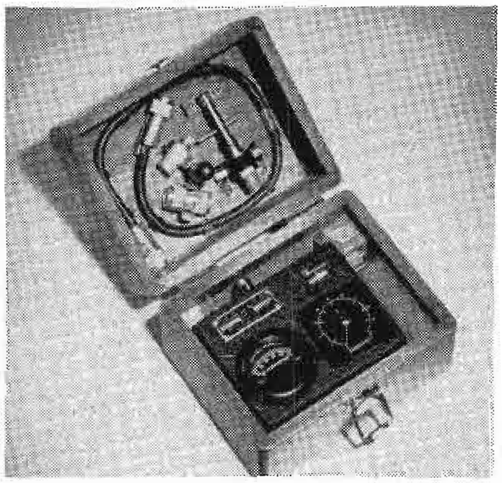
Multiple switching of audio, video, computer and other circuits is effected by crossbar switch employing palladium twin contacts. Available in up to 25 horizontal levels and 10 vertical levels, the unit switches up



to 10 MC. Plug-in connections are used, and strap wiring is eliminated. Contacts are made by successive operation of select and hold magnets, each requiring 200 ampere turns equivalent to 2.5 watts. Release and operating time is 0.0005 sec. For 10 x 10 switch shown, crosstalk is more than 60 db down at 10 MC, bridging capacity between adjacent conductors is 15$\mu\mu$f, and size is 8 x 11 x 3.5 in.—**James Cunningham, Son & Co., Rochester 8, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Wavemeter

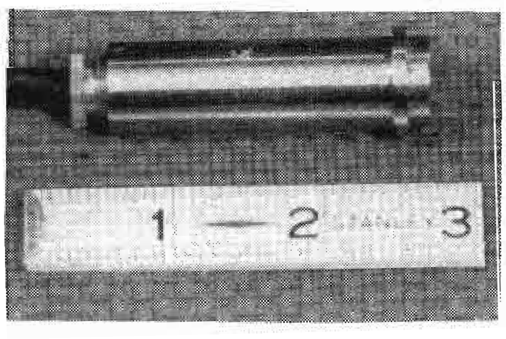
A wavemeter test set consists of a portable indicating instrument of the resonant cavity type and other auxiliary apparatus contained in a wooden carrying case. It measures the frequency and relative strength



of signals from 2400 to 3400 MC, each test set combining two methods for making such measurements; namely, the transmission method and the absorption method. Maximum powers required to produce full scale deflection are: absorption, 2 mw; transmission, 3 mw. Accuracy is ±0.1%, and "Q" loaded is over 1000. Size is 5¾ x 5¼ x 3⅜ in., and weight is approximately 6 lbs., 9 ozs. The American Wavemeter is being supplied also as TS-117/GP.—**American Encaustic Tiling Co., 924 Kenilworth Ave., Lansdale, Pa.**—TELE-TECH & ELECTRONIC INDUSTRIES

Standard Microphone and Blast Gage

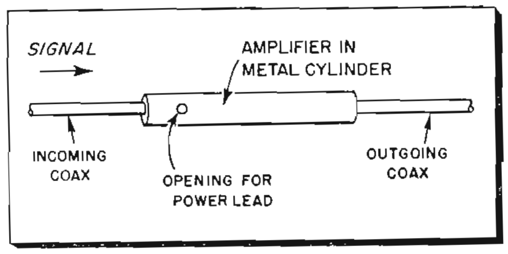
Model M-141A wide range microphone and blast gage will make absolute sound pressure measurements over the frequency range 20 cps to 30,000 cps and covers a dynamic range from a few dynes/cm² to several million dynes/cm². The new standard is in the form of a ⅝ in. diameter cylinder



with a small flange near the pressure sensitive end to permit its flush mounting into a pipe or chamber when desired. A 20-ft. cable is provided as an integral part of the microphone and the sensitivity is accurately adjusted so that 5 μv/dyne/cm² sound pressure appears at the open circuit terminals of the cable plug. The microphone employs ADP crystals in its construction and may be used up to temperatures of 160°F. Total electrical capacity is approximately 500$\mu\mu$f. Adjustment of the absolute sensitivity of the instrument has been chosen so that if the cable plug is connected to the input terminals of a Ballantine model 310A VTVM, or its equivalent, the voltmeter becomes a calibrated sound pressure level indicator giving direct readings of sound levels from 100 db to 221 db. If the voltmeter is used with a times 10 preamplifier, sound levels from 80 db may be accurately measured.—**Massa Laboratories, Inc., 5 Fottler Road, Hingham, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Smallest Broadband Coaxial Repeater

Coaxial cables, carrying television signals from city to city, require amplifiers at intervals of 5 or 10 miles. These are housed in boxes large enough to contain several vacuum tubes and associated equipment. But the advent of transistors promises to change this situation. W. H. Doherty, Bell Labs., during his testimony in the Theatre Television hearing in Washington showed the FCC an experimental coax amplifier compressed to the almost unbelievable dimensions of a metal tube ⅛ in. in diam-



Coax tetrode transistor amplifier is housed in metal tube measuring ⅛-in. wide and 1½ in. long. In volume this is equivalent to a stack of about four paper clips.

eter and 1½ in. long, equal in volume to a stack of four paper clips!

A tetrode (4-electrode) transistor was used to secure the following excellent performance: gain 22 db; response flat to within 0.1 db from 0.4 MC to 11 MC. Coax having an outside diameter of 100 mils can be cut at ⅓-mile intervals and one of these midget repeaters can be inserted by pushing the coax into the input and output ends respectively of the little metal cylinder which houses: a transistor, an input and an output transformer, diode-type voltage stabilizers, two terminal boards, resistors, capacitors and provision for negative feedback!

From an operating point some miles away can be fed the only power required, 22½ v., 5 ma. This is supplied by a single insulated wire lying alongside the coax, the sheath of which forms the battery return circuit. The insulated wire enters the amplifier through a small hole in the side of its tiny cylindrical housing.

New TV Station Timetable

Geographical listing of new outlets for which "post-freeze" FCC grants and construction permits have been issued through February 9, 1953

State and City	Call Letters	Channel No.	Date On Air
ALABAMA			
Birmingham	WJLD-TV	48	*
Birmingham	WSGN-TV	42	*
Gadsden	WTVS	21	4/53
Montgomery	WCOV-TV	20	3/53
ARIZONA			
Tucson	KVOA-TV	4	2/53
Tucson	KCNA-TV	9	*
ARKANSAS			
Ft. Smith	KFSA-TV	22	5/53
Little Rock	KRTV	17	4/53
Little Rock	KETV	23	*
CALIFORNIA			
Bakersfield	KAFY-TV	29	4/53
Fresno	KMJ-TV	24	5/53
Los Angeles	KPIK	22	5/53
Los Angeles (NCE)	KUSC-TV	28	*
Salinas	*	28	*
San Bernardino	KITO-TV	18	10/53
Santa Barbara	KEYT	3	5/53
Stockton	KTVU (TV)	36	9/53
COLORADO			
Colorado Springs	KRDO-TV	13	4/53
Denver	KDEN	26	Spring
Denver	KIRV	20	*
Pueblo	KCSJ-TV	5	3/53
Pueblo	KDZA-TV	3	2/53
CONNECTICUT			
Bridgeport	WICC-TV	43	2/53
Bridgeport	WSJL	49	2/53
Bridgeport (NCE)	*	71	*
Hartford (NCE)	*		*
New Britain	WKNB-TV	30	*
New London	WNLC-TV	26	8/53
Norwich (NCE)	*	*	*
Waterbury	WATR-TV	53	3/53
FLORIDA			
Ft. Lauderdale	WITV	17	*
Ft. Lauderdale	WFTL-TV	23	4/53
Lakeland	WONN-TV	16	*
Pensacola	WPFA	15	6/53
St. Petersburg	WSUN-TV	38	5/53
West Palm Beach	WIRK-TV	21	6/53
IDAHO			
Boise	KIDO-TV	7	7/53
Boise	KGEM-TV	9	Fall
ILLINOIS			
Belleville	WTVI	54	5/53
Chicago	WHFC-TV	26	*
Danville	WDAN-TV	24	12/53
Decatur	WTVP	17	7/53
Peoria	WTVH-TV	19	*
Rockford	WTVO	39	4/53
INDIANA			
Lafayette	WFAM-TV	59	5/53
Muncie	WLBC-TV	49	3/53
IOWA			
Fort Dodge	*	21	*
Sioux City	KWTV	36	*
Sioux City	KVTV	9	4/53
KANSAS			
Hutchinson	*	12	*
Manhattan (NCE)	KSAC-TV	8	*
KENTUCKY			
Ashland	WPTV	59	7/53
Henderson	WSON-TV	50	5/53
Louisville	WKLD-TV	21	Spring
Louisville	WLOU-TV	41	*
LOUISIANA			
Baton Rouge	KHTV	40	*
Lake Charles	WTAG (TV)	25	6/53
Monroe	KNOE-TV	8	4/53
Monroe	KFAZ-TV	43	5/53
MARYLAND			
Baltimore	WITH-TV	60	*
Frederick	WFMD-TV	62	*
MASSACHUSETTS			
Fall River	WSEE-TV	46	5/53
New Bedford	WNBH-TV	28	2/53
Northampton	WACE-TV	36	*
Springfield-Holyoke	WWLP	61	2/53
Springfield-Holyoke	WHYN-TV	55	3/53
MICHIGAN			
Ann Arbor	WPAG-TV	20	3/53
Battle Creek	WBKZ-TV	64	5/53
Battle Creek	WBCK-TV	58	8/53
East Lansing	WKAR-TV	60	8/53
Flint	WCTV	28	Spring
Flint	WTAC-TV	16	*
Jackson	WBIM-TV	48	*
Kalamazoo	WKMI-TV	36	*
Muskegon	WTVM	35	*
Saginaw	WKNX-TV	57	3/53
MINNESOTA			
Duluth	KFTV	38	3/53
Rochester	KROC-TV	10	4/53
St. Cloud	WJON-TV	7	*
MISSISSIPPI			
Jackson	WJTV	25	*
Meridian	WCOC-TV	30	*
MISSOURI			
Columbia (NCE)		8	*
Festus	KACY-TV	14	6/53
Kansas City	KCTY	25	7/53
St. Joseph	KFEQ-TV	2	4/53
St. Louis	KSTL-TV	36	*
Springfield	KTTS-TV	10	3/53
Springfield	*	3	*
MONTANA			
Billings	*	8	*
Butte	KOPR-TV	4	*
Great Falls	KFBB-TV	5	*
NEBRASKA			
Lincoln	KOLN-TV	12	2/53
Lincoln	KFOR-TV	10	4/53
NEVADA			
Reno	KZTV	8	3/53
NEW JERSEY			
Asbury Park	WCEE-TV	58	Late '53
Atlantic City	*	52	*
New Brunswick (NCE)	WTLV	19	*
NEW MEXICO			
Roswell	*	8	*
Santa Fe	*	2	*
NEW YORK			
Albany (NCE)	WRTV	17	*
Binghamton (NCE)	WQTV	46	*
Buffalo (NCE)	WTVF	23	*
Buffalo	WBUF	17	4/53
Buffalo	WBES-TV	59	9/53
Elmira	WTVE	24	3/53
Ithaca (NCE)	*	14	*
Ithaca	WHCU-TV	20	11/53
Jamestown	WJTN-TV	58	*
Kingston	WKNY-TV	66	*
N. Y. City (NCE)	WGTV	25	*
Poughkeepsie	WEOK-TV	21	12/53
Rochester (NCE)	WROH	21	*
Syracuse (NCE)	WHTV	43	*
Watertown	WWNY-TV	48	*
NORTH CAROLINA			
Asheville	WISE-TV	62	4/53
Greensboro	WCOG-TV	57	*
Raleigh	WETV	28	4/53
NORTH DAKOTA			
Fargo	WDAY-TV	6	*
OHIO			
Akron	WAKR-TV	49	Winter
Dayton	WIFE	22	7/53
Lima	WLOK-TV	73	3/53
Lima	WIMA	35	Summer
Massillon	WMAC-TV	23	3/53
Sandusky	WLEC-TV	42	12/53
Warren	WHHH	67	*
Youngstown	WUTV	21	7/53
Youngstown	WFMJ-TV	73	Early '53
Youngstown	WKBN-TV	27	*
Zanesville	WHIZ-TV	50	4/53
OKLAHOMA			
Lawton	KSWO-TV	7	3/53
OREGON			
Salem	*	24	*
PENNSYLVANIA			
Altoona	WFBG-TV	10	2/53
Bethlehem	WLEV-TV	51	*
Easton	WEEX-TV	57	Spring
Harrisburg	WHP-TV	55	4/53
Harrisburg	WTPA (TV)	71	*
Hazelton	WAZL-TV	63	*
Johnstown	WARD-TV	56	*
New Castle	WKST-TV	45	2/53
Philadelphia	WIP-TV	29	*
Pittsburgh	WENS	16	8/53
Pittsburgh	WTVQ	47	8/53
Pittsburgh	WKJF-TV	53	5/53
Reading	WEEU-TV	33	5/53
Scranton	WTVU	73	3/53
Scranton	WGBI-TV	22	4/53
Wilkes-Barre	WILK-TV	34	*
Williamsport	WRAK-TV	36	*
York	WNOW-TV	67	4/53
SOUTH CAROLINA			
Charleston	WCSC-TV	5	4/53
Columbia	WNOK-TV	49	4/53
Columbia	WCOS-TV	25	Spring
Greenville	*	23	*
SOUTH DAKOTA			
Sioux Falls	KELO-TV	11	3/53
TENNESSEE			
Chattanooga	WTVT	43	3/53
Chattanooga	WOUC	49	*
Johnson City	*	11	*
Memphis	*	13	*
TEXAS			
Amarillo	KGNC-TV	4	3/53
Amarillo	KFDA-TV	10	3/53
Austin	KCTV	18	*
Austin	KTVA	24	*
Beaumont	KBMT	31	5/53
Dallas	*	23	*
El Paso	KEPO-TV	13	4/53
Galveston	KGUL	11	3/53
Galveston	KTVR	41	*
Houston (NCE)	KUHT	8	5/53
Houston	*	23	*
Houston	KNUZ-TV	39	7/53
Lubbock	KCBD-TV	11	4/53
San Angelo	KTXL-TV	8	*
San Angelo	KGKL-TV	3	*
Temple	*	6	*
Tyler	*	19	*
Waco	KANG-TV	34	6/53
Wichita Falls	KTVW	22	4/53
Wichita Falls	KFDX-TV	3	3/53
Wichita Falls	KWFT-TV	6	3/53
VIRGINIA			
Charlottesville	*	64	*
Danville	WBTM-TV	24	*
Lynchburg	WWOD-TV	16	*
Roanoke	WROV-TV	27	*
WASHINGTON			
Bellingham	KVOS-TV	12	5/53
Spokane	KXLY-TV	4	*
Tacoma	KTNT-TV	11	*
Tacoma	KMO-TV	13	5/53
Yakima	KIMA-TV	29	3/53
Yakima	KIT-TV	23	7/53
WISCONSIN			
Appleton	WNAM-TV	42	9/53
Green Bay	WBAY-TV	2	*
Madison	WKOW-TV	27	6/53
Madison	*	33	6/53
Neenah	WNAM-TV	42	Fall
Oshkosh	WOSH-TV	48	4/53
WYOMING			
Cheyenne	KFBC-TV	5	*
HAWAII			
Honolulu	KAMI	11	Early '53
PUERTO RICO			
San Juan	WKAQ-TV	2	Late '53

* Information not available at press time.
(NCE) Noncommercial educational station

NEW TV STATIONS on the AIR

State and City	Call Letters	Channel No.	Date On Air
ALABAMA			
Mobile	WKAB-TV	48	12/52
Mobile	WALA-TV	10	1/53
ARIZONA			
Tucson	KOPO-TV	13	2/53
COLORADO			
Colorado Springs	KKTV	11	12/52
Denver	KBTV	9	10/52
Denver	KFEL-TV	2	7/52
ILLINOIS			
Peoria	WEEK-TV	43	1/53
INDIANA			
South Bend	WSBT-TV	34	12/52
LOUISIANA			
Baton Rouge	WAFB-TV	28	1/53
MAINE			
Bangor	WABI-TV	5	2/53
NEW JERSEY			
Atlantic City	WFPG-TV	46	12/52
OREGON			
Portland	KPTV	27	9/52
PENNSYLVANIA			
Reading	WHUM-TV	61	2/53
Wilkes-Barre	WBRE-TV	28	1/53
York	WSBA-TV	43	12/52
TEXAS			
Austin	KTBC-TV	7	11/52
El Paso	KROD-TV	4	12/52
El Paso	KTSM-TV	9	1/53
Lubbock	KDUB-TV	13	11/52
VIRGINIA			
Lynchburg	WLVA-TV	13	2/53
Roanoke	WSLS-TV	10	12/52
WASHINGTON			
Spokane	KHQ-TV	6	12/52
HAWAII			
Honolulu	KGMB-TV	9	12/52
Honolulu	KONA	11	11/52

WASHINGTON
News Letter

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

FRANK PLANS—As had already been forecast in this column, the FCC in its future proceedings on major policy determinations will not allow time-consuming presentations of testimony and self-serving blue-printing of plans by proponents for new communications and television services such as prolonged interminably the color television case. This new FCC procedure was exemplified in the theater television issue when the Commission ordered the motion picture industry to answer eight questions to give the specific plans for their establishment of the theater TV service. The FCC ordered the answers so the regulatory agency could decide "whether to proceed further with this hearing" and whether the continuance of the proceeding with the rather nebulous plans of the film industry "would serve any useful purpose."

BED-ROCK FUNDAMENTALS—There are three choices for the FCC, it is regarded, for the continuance of its deliberations on the theater TV issue. The Commission could dismiss the motion picture industry petition, or continue the hearing in its present form, or—the most likely course—the hearing procedure should be recast into the delineation of its bed-rock fundamentals. The FCC directed the counsel for the motion picture industry and the film theaters to submit their intentions on why if common carrier facilities like those of the Bell System were used it was not feasible to operate on the already allocated common carrier frequencies instead of sharing the industrial services spectrum space; under what concept the theater TV service would be established as an industrial service; the extent of the frequencies sought by the theater industry; the entire costs of the theater TV service so as to determine the ultimate cost of admission to the film theater patron; the percentage of time on a day-by-day basis of the proposed service; and if programs of only live interest will be provided over theater TV.

SLOW APPOINTMENT—Because of the more urgent national and international problems, together with the selection of the major appointments, President Eisenhower had not designated the new FCC Commissioner to replace appointee Eugene H. Merrill up to the press deadline of TELE-TECH. In fact there had been no appointments of commissioners to any of the administrative or regulatory agencies such as the Interstate Commerce Commission, Federal Power Commission, Securities and Exchange Commission and similar governmental units since the selections for the higher level posts in the departments and agencies were being carefully scrutinized for the best possible choices and President Eisenhower has taken on the added duty of interviewing each appointee personally. Commissioner Rosel H. Hyde still was out in the front as the President's probable choice for the FCC Chairmanship, because of the overwhelming support from all segments of the communications, broadcasting-television and electronics industries.

MAY BE DROPPED—The revocation of the grand jury authorization in the criminal anti-trust allegations against twenty radio-television-electronics manufacturing companies which was the final official act of the Truman Administration's Attorney General McGranery was felt to augur the dropping of the entire anti-trust suit even under civil litigation. Launched mainly because of the color television controversy with implications that some manufacturers had banded together in concerted action against the FCC-proposed color video equipment standards, the suit had been a rather definite deterrent in the full production by the electronics industry for the defense mobilization program. It also was a hurdle for progress in the goal of public color television and with the litigation out of the way color TV can now progress rapidly. Like similar rather useless anti-trust litigation the case had caused the manufacturers and the Radio-Television Manufacturers Association to make substantial expenditures of funds and personnel working time to compile data and reports, particularly on patent practices, sought by the Department of Justice attorneys. The Radio Corporation of America particularly had been called upon to furnish voluminous reports on its patent practices and policies.

INDUSTRIAL RADIO GROUP—Between 1100 and 1200 licensees in the rapidly-growing special industrial mobile radio services were called upon to establish an organization in that field at a meeting Feb. 18-19 at St. Louis. The association is to work to prevent any possible encroachment by other radio users upon the presently allocated frequencies for the special industrial radio services. In addition, the newly-formed association plans to coordinate the assignment of present frequencies allocated to the service to insure equitable distribution and minimum interference.

National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington, Editor

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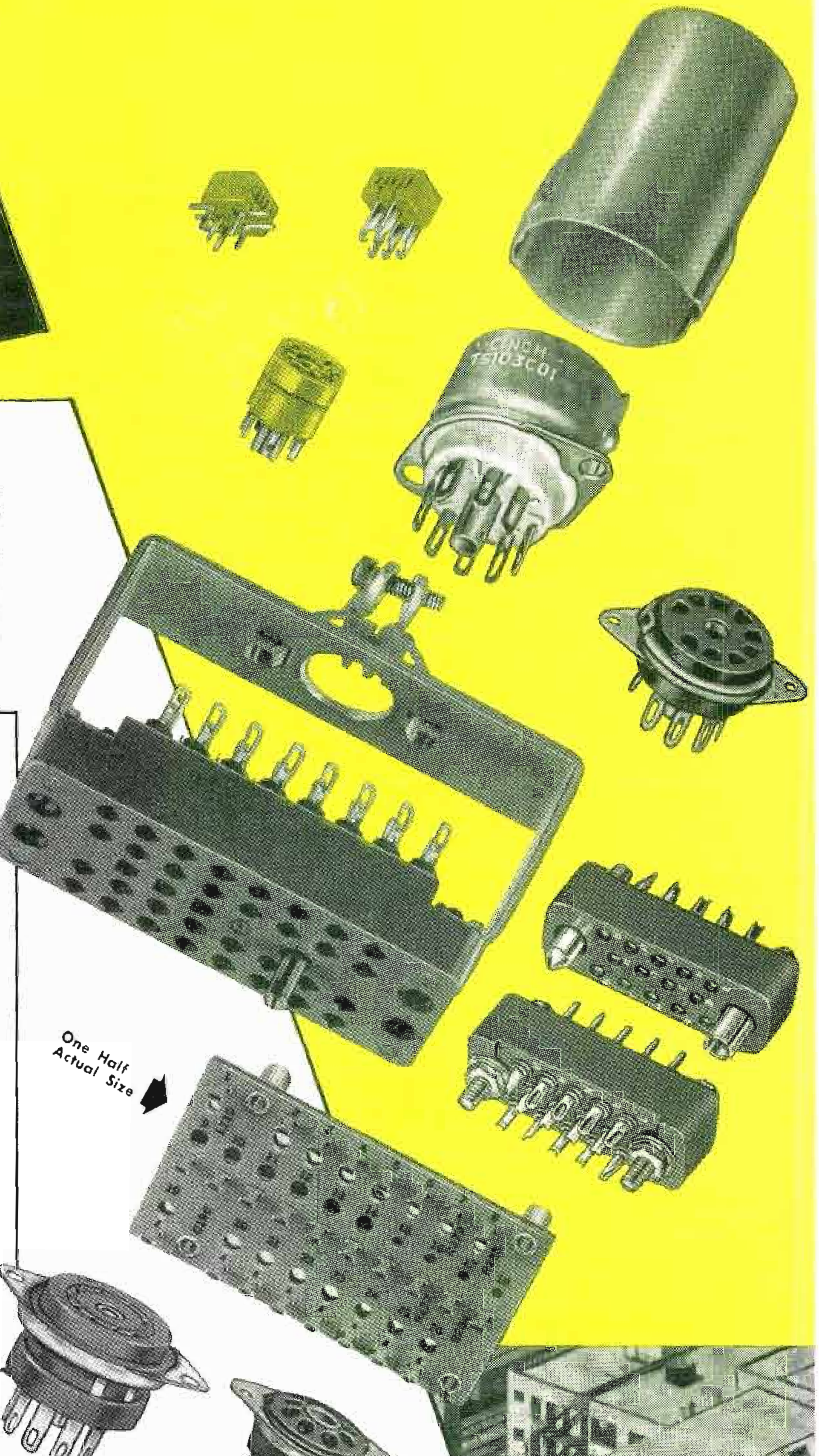

METAL PLASTIC ASSEMBLIES

To produce the intricate assemblies of metal and plastic so essential in gear of all kinds, facilities include a combination of metal stamping and plastic production. A highly trained staff is available for any military or commercial requirement.

The list below comprises the products of both Cinch and Howard B. Jones Division. They are indicative of their wide scope and also indicate the myriad of variations and redesigning that are possible with this background of production experience.

SOCKETS: Tube (Receiver, Transmitter and Special): Battery, all types • C-R Tube • Crystal • Electrolytic • Glass Type; 4 to 7 prong laminated • Infra-red Ray Tube • High Altitude Airborne Types • Kinescope; Magnal, Duodecal, Diheptal • Loktal-Miniature-Multiplug-Noval-Octal (Molded bakelite, steatite, teflon, Kel-F and laminated) • Plexicon • Printed Circuit • Special Sockets to Specs • Sub-Miniature; Hearing Aid Types • TV; 110V Circuit Breakaway • Vibrator • Pencil Tube Transistor • Diode

- ANTENNA JACKS
- BANANA PINS AND JACKS
- BARRIER TERMINAL STRIPS
- FANNING STRIPS
- BATTERY PLUGS & SOCKETS
- BINDING POSTS
- DIODE SOCKET
- CONNECTORS, MULTI CONTACT
- FUSE STRIPS, BLOCKS & BOARDS
- GRID CAPS
- GRID CAP SHIELDS
- HERMETICALLY SEALED TUBE SOCKETS
- METAL STAMPINGS
- MICRO-CONNECTORS
- MOUNTING DEVICES
- PHONO TIP JACKS
- PRINTED CIRCUIT, CONNECTORS
- SHIELDS, TUBE-MINIATURE & NOVAL & BASES SOLDERING LUGS—200 VARIATIONS
- STRAP NUTS
- TRANSISTOR SOCKET
- TUBE HOLDERS—SPRING TYPE
- VIBRATOR PLUGS AND SOCKETS

TERMINAL ASSEMBLIES: Blocks, boards in laminated and molded, assembled with lugs, pins, screw terminals, contacts, clips, turret lugs and other hardware to specifications.

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BOOTH No. 505 & 506

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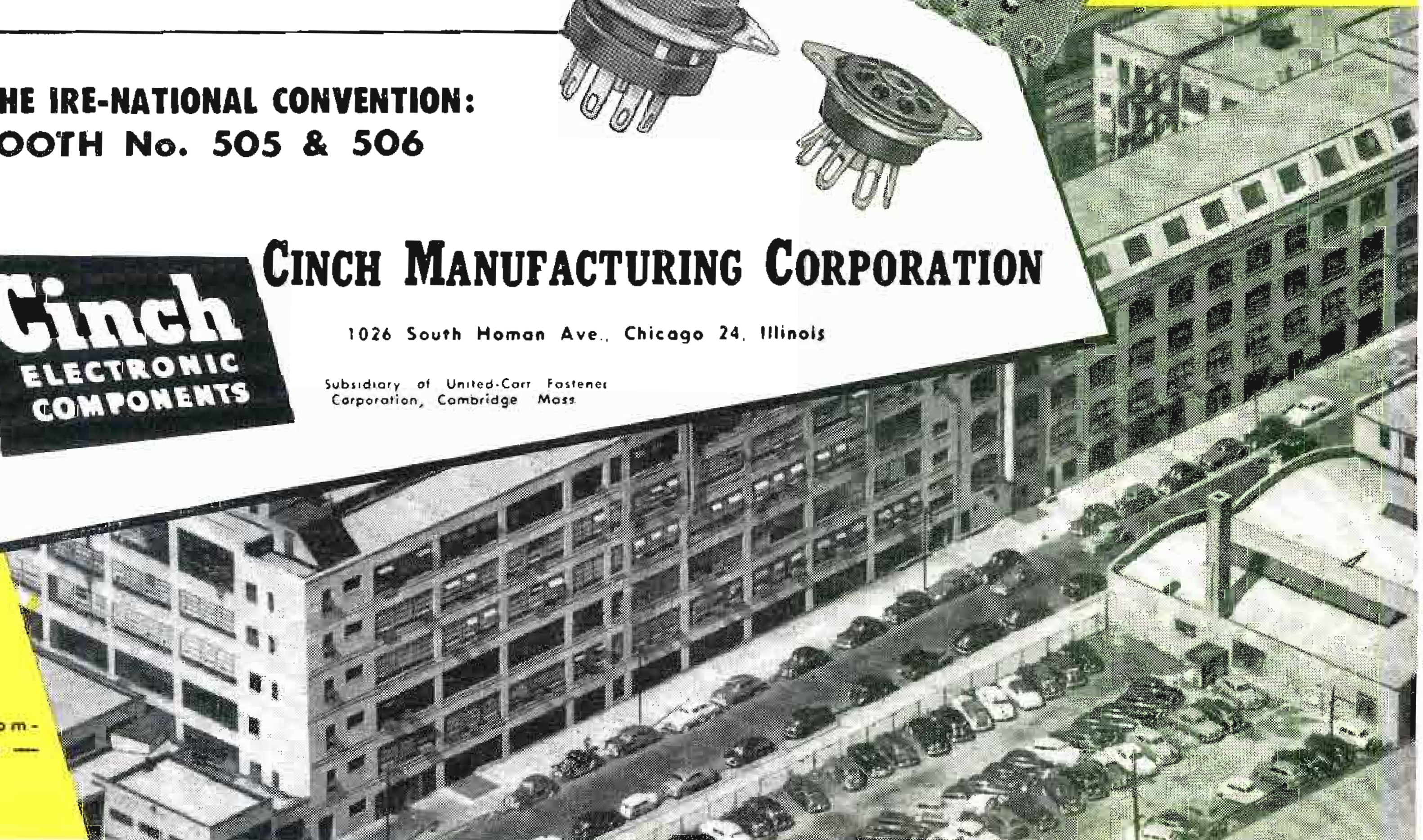


At electronic component jobbers — everywhere.

TELE-TECH's NEWSCAST

OARAC Computer Solves Air Force Problems

The OARAC (Office of Air Research Automatic Computer) is a serial, decimal, single address machine built by General Electric for use at Wright-Patterson Air Force Base for solving problems in aircraft design, guided missiles and ballistics. It has a magnetic tape input and output, and magnetic drum internal memory.

The computer has a 10,000-word memory, one of the largest in use. A single magnetic head per track is used both for recording and playing back. There are 50 sets of four parallel tracks with 200 words on each set. A word consists of a 10-decimal digit number, plus sign, or of a two-digit operation code and five-digit address. The arithmetic unit contains a serial adder and three vacuum tube storage registers.

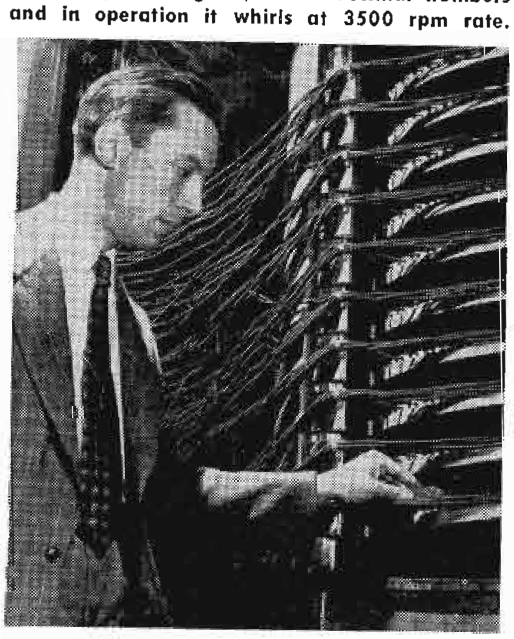
The control unit consists of two address registers, one containing the address of the instruction being performed, and other containing the address of the number being recorded into or played back from the memory. Serial addition time is 83 sec. Maximum access time, however, is 17 milliseconds and because this is a single address machine, it cannot be programmed to perform faster than 8.5 milliseconds or 110 operations per second. Basic repetition rate is 150 KC.

Information is fed into and out of the computer on magnetic tape. A piece of information on tape consists of a word plus its address in the internal memory. The tape preparation unit has a standard electric typewriter.

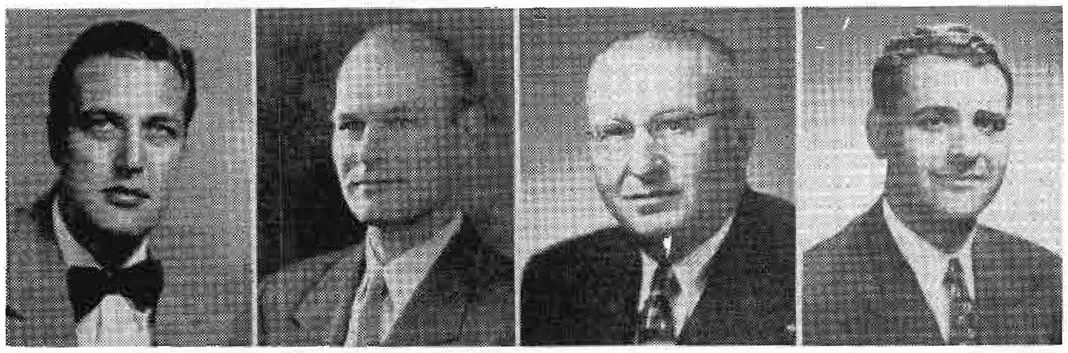
Errors due to faulty programming, or a single transient failure, can be detected by the feature of rollback built into the machine. At any point the programmer can perform a check either by programming by two different methods and comparing results or by leading to some known result. If the check is satisfactory, the computer proceeds to the next operation; otherwise it returns to the preceding check point and performs all operations over again. This can happen two times at any check point, the third time the computer gives up and rings an alarm.

For all of its complexity, components have kept to a minimum. The main part of the computer, made up of most of the standard plug-in units, is housed in a single cabinet approximately 16 x 2.5 x 7 ft. It contains approximately 1,400 tubes, 1,000 plug-in turrets, and 7,000 germanium diodes. Excluding inscriber-outscriber, OARAC requires 100 sq. ft. of floor space. Power required is 20 kw.

"OARAC's" memory drum is capable of holding pulses representing 10,000 10-decimal numbers and in operation it whirls at 3500 rpm rate.



WESCON CHAIRMANSHIPS ANNOUNCED



Four project committee chairmen for the 1953 Western Electronic Show and Convention (Aug. 29-31) have been selected. Bernard Oliver (upper left), research director of Hewlett-Packard Co., will head the papers committee. Wilson Pritchett, (2nd from left) will head the arrangements committee. Les Hogan (3rd from left) is chairman of the Hotels Committee and David Ross (extreme right) heads visitor's service.

Sound Recording Contest

Audio Devices, Inc., manufacturers of Audiodiscs and Audiotape, have announced the opening of a cash prize contest, with awards totaling over $1,000.00, for the fourteen best articles on the use of tape and disc recording in the modern radio station, TV station or recording studio. The following prizes are offered:

One First Prize $250.00
Three Second Prizes ... 100.00 each
Ten Third Prizes ...... 50.00 each

In addition, $25.00 will be given to the author of any other contest article published in whole or in part in Audio Record or any other Audio Devices publication.

Entries should be addressed to: Sound Recording Contest Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y. To be eligible for the contest, entries must be postmarked not later than midnight, May 1, 1953.

IRE Appointments

The Board of Directors of the IRE has appointed six officers and directors for the year 1953. Haraden Pratt, telecommunications advisor to the President, was reappointed Secretary of the Institute, a post he has held since 1943. W. R. G. Baker, vice president of GE, was appointed Treasurer for the third successive year. Alfred N. Goldsmith was appointed Editor, an office he has held since the IRE was founded in 1912. Appointed as directors for 1953 were Ralph D. Bennett, Naval Ordnance Lab.; William R. Hewlett, Hewlett Packard Co.; and Arthur V. Loughren, Hazeltine Electronics Corp.

First Commercial Application of Transistors

After one year of pilot production, Raytheon Manufacturing Co., Waltham, Mass. now reports that it has swung into large-scale production of junction transistors and is presently shipping tens of thousands of the units each month to more than 15 hearing aid manufacturers. These germanium transistors, selling to the hearing aid firms for about $8 each, are expected to replace vacuum tubes, thereby improving performance, permitting smaller designs, and eliminating the expense of repeated battery replacements by about 90%. The compact junction transistors are only 0.035 cu. in. in volume and weigh 0.033 oz. According to Norman B. Krim, Vice President and General Manager of Raytheon's Receiving Tube Div., since 1939 Raytheon has produced 75% of the vacuum tubes used in hearing aids. With 10,000 of its 21,000 employees (including 3,500 engineers) in this division which produces transistors, the firm is stepping up production of thousands of engineering samples for other commercial and military accounts.

CUES for BROADCASTERS

(*Continued from page 87*)

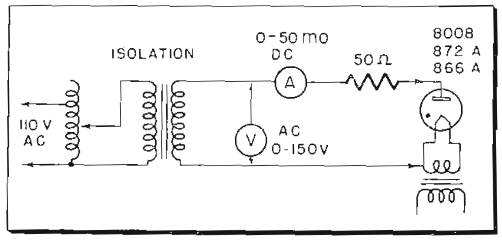
it may be possible to use the audition bus for the talk back in connection with a high gain preamplifier inserted between the talk back input, and the audition mixer bus. Or it can be used to over-ride the program on the normal monitoring amplifier if amplifiers are at a premium.

Checking Rectifiers

LEO WILSON, Chief Engineer, WHOP, Hopkinsville, Ky.

LOSS of program time due to rectifier arc-back can be minimized by making a monthly check of each rectifier tube and recording the results. A tube which is deteriorating will require progressively higher voltage for breakdown and will fire later in the conducting half-cycle. A simple test circuit can check each rectifier tube.

An isolation transformer, and a variable auto transformer, which will give an output adjustable from 0 to 75 v., are needed. Connect a voltmeter across this winding. In series with this winding, connect a 50 ohm current-limiting resistor, a 50 ma. dc meter, and the tube to be tested. To test the tube, slowly increase the applied voltage from zero to the point where dc current just begins to flow. The peak value of the RMS voltage read by the voltmeter at this point is the initial breakdown voltage. The peak breakdown voltage for a good tube will average 10 to 15v. When the



peak breakdown voltage reaches 30 v., the tube should be tested at more frequent intervals. A value of 50 v. will generally indicate that it should be replaced.

Reel Identification

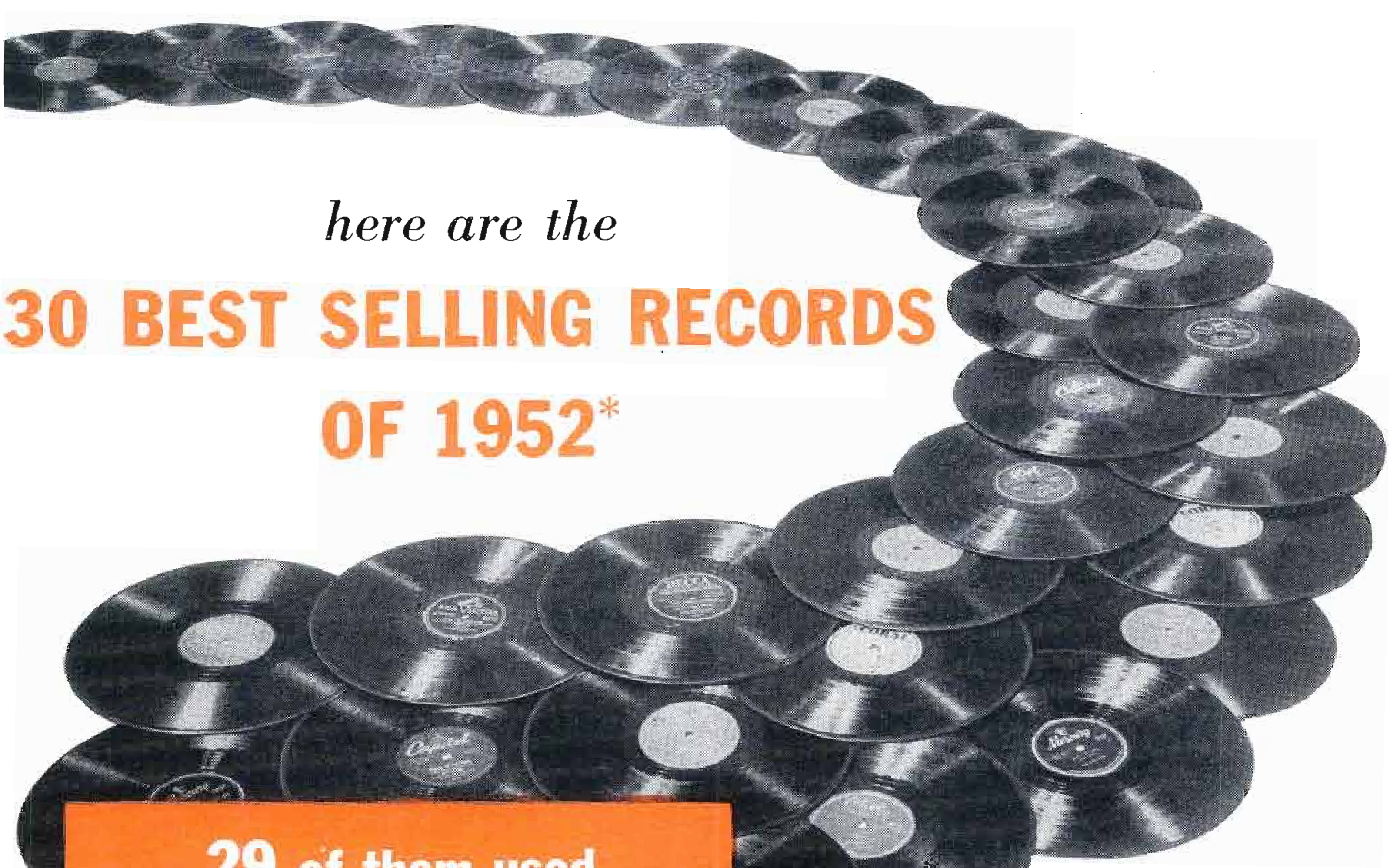
ERWIN P. SCHOENY, Chief Engineer, WGBF-WMLL. Evansville, Ind.

RECENTLY at WGBF-WMLL we purchased the large hub type of recording tape. Having several dozen reels of the small diameter tape in use, we were faced with the problem of keeping the two types of tape separated.

We solved this problem by marking the newer reels. This was accomplished by painting a red stripe on each of the spokes on both sides of the reel. We used red nail polish, diluted to the proper consistency for easy application with nail polish remover.

We carry one of each size take-up reel with the equipment and personnel are instructed to match the supply and take-up reel as to color of spokes, thus avoiding intermixing of tapes.

Tape delay system allowing fifteen minute delay on a two-hour program, designed by William McDonald, Chief Engineer, CKRM, Regina, Saskatchewan, Canada.



here are the

30 BEST SELLING RECORDS OF 1952*

29 of them used audiodiscs® for the master recording

Record, Artist & Label	Made from Audiodisc Master
BLUE TANGO *(Leroy Anderson—Decca)*	✓
WHEEL OF FORTUNE *(Kay Starr—Capitol)*	✓
CRY *(Johnnie Ray—Okeh)*	✓
YOU BELONG TO ME *(Jo Stafford—Columbia)*	✓
AUF WIEDERSEH'N, SWEETHEART *(Vera Lynn—London)*	
I WENT TO YOUR WEDDING *(Patti Page—Mercury)*	✓
HALF AS MUCH *(Rosemary Clooney—Columbia)*	✓
WISH YOU WERE HERE *(Eddie Fisher—Hugo Winterhalter—Victor)*	✓
HERE IN MY HEART *(Al Martino—BBS)*	✓
DELICADO *(Percy Faith—Columbia)*	✓
KISS OF FIRE *(Georgia Gibbs—Mercury)*	✓
ANY TIME *(Eddie Fisher—Hugo Winterhalter—Victor)*	✓
TELL ME WHY *(Four Aces—Decca)*	✓
BLACKSMITH BLUES *(Ella Mae Morse—Capitol)*	✓
JAMBALAYA *(Jo Stafford—Columbia)*	✓
BOTCH-A-ME *(Rosemary Clooney—Columbia)*	✓
GUY IS A GUY *(Doris Day—Columbia)*	✓
LITTLE WHITE CLOUD THAT CRIED *(Johnnie Ray—Okeh)*	✓
HIGH NOON *(Frankie Laine—Columbia)*	✓
I'M YOURS *(Eddie Fisher—Hugo Winterhalter—Victor)*	✓
GLOW WORM *(Mills Brothers—Decca)*	✓
IT'S IN THE BOOK *(Johnny Standley—Capitol)*	✓
SLOW POKE *(Pee Wee King—Victor)*	✓
WALKIN' MY BABY BACK HOME *(Johnnie Ray—Columbia)*	✓
MEET MR. CALLAGHAN *(Les Paul—Capitol)*	✓
I'M YOURS *(Don Cornell—Coral)*	✓
I'LL WALK ALONE *(Don Cornell—Coral)*	✓
TELL ME WHY *(Eddie Fisher—Hugo Winterhalter—Victor)*	✓
TRYING *(Hilltoppers—Dot)*	✓
PLEASE, MR. SUN *(Johnnie Ray—Columbia)*	✓

**According to Retail Sales, as listed in THE BILLBOARD.*

. . . and over 43% used **audiotape**† *for the original sound!*

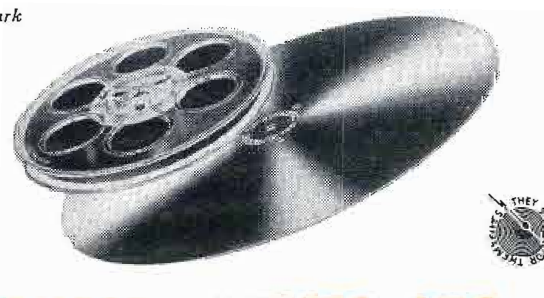
Like Audiodiscs and Audiotape, this record speaks for itself.

Of the thirty top hit records of the year, all but one were made from Audiodisc masters! And that *one* — a London Record — was made abroad.

It is significant, too, that the original recordings for over 43 per cent of these records were first made on Audiotape, then transferred to the master discs. This marks a growing trend toward the use of Audiotape for the original sound in the manufacture of fine phonograph records.

Yes — Audiodiscs and Audiotape are truly a record-making combination—in a field where there can be no compromise with Quality!

†Trade Mark



AUDIO DEVICES, INC.

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Export Dept.: 13 East 40th St., New York 16, N. Y., Cables "ARLAB"

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Tube Reliability

(Continued from page 79)

Resonant excitation of the grid structure as a whole, or of parts of a grid, may take place with either filamentary or cathode-type tubes. The frequency of these resonant modes for the grids of subminiature tubes goes from a few thousand cycles per second on into the supersonic range. Reduction of the troublesome electrical output can be obtained by raising the resonant frequency of the grid or by increasing the mechanical damping. Fortunately we gain in two ways by raising the resonant frequency; the amplitude of vibration, and consequently the electrical output, is reduced for the same excitation, and at the same time the frequency is shifting to a less objectionable portion of the spectrum for many applications.

Resonant excitation of the filamentary cathode is more pronounced than for the indirectly heated cathode. In the exchange, however, we have lost the vexing problem of adequate anchorage of the cathode to the mica without excessive heat loss. As with the grid structure, the best methods of reducing the resonant motion of the filament are by increased damping and higher resonant frequency. In the early days of filamentary tubes the recourse to high frequency resonance of the filament was not available because of the use of filaments having inherently low strength. With the successful production of many millions of subminiature tubes with oxide coated tungsten filaments, this limitation no longer exists. It is perfectly feasible with high production tubes such as the CK534AX and CK549DX to achieve filament resonant frequencies of 8,000 CPS and higher.

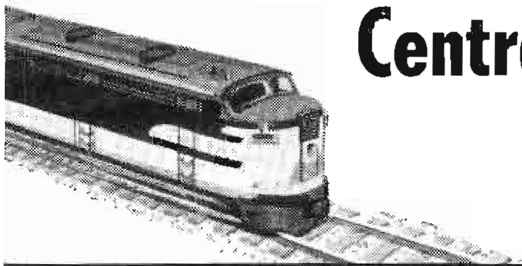
With forced vibration, such as the bending or flexing of the grid or filament at frequencies below resonance, the indicated corrective measures are adequate anchorage to the mica spacers and raising of the resonant frequency. As was noted previously, when a tube element is subjected to acceleration the resulting deflection is proportional to the fourth power of the length. This statement can be made even more general by saying that the resulting deflection, or the amplitude of the forced vibration, will be directly proportional to the acceleration and inversely proportional to the square of the resonant frequency. This is true regardless of whether the frequency is determined by the stiffness of the member itself, as with a grid, or by applied tension as with the filament. The constant of proportionality will, however, vary with the constraints.

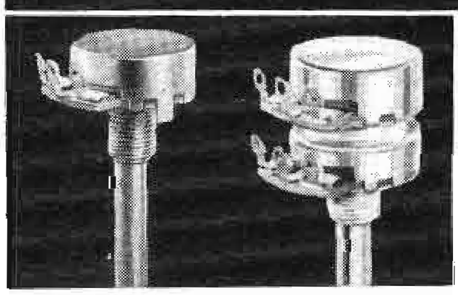
Next to reduction of relative motion, the controlling factor in the reduction of vibration output is symmetry. Consider a tube with perfect symmetry with respect to the plane through the grid side-rods. The plate current to the right of this plane would be the same as the plate current to the left. If now, under conditions of vibration, the grid moves to the right with respect to the cathode, the grid-cathode spacing will increase for the right-hand side of the structure and the plate current to this side will ordinarily decrease. Simultaneously for the left-hand side of the structure the grid-cathode spacing will decrease and the plate current will increase. If the changes in the two halves of the plate current were exactly equal, the total plate current would be unchanged and hence the vibration output would be zero. The situation is the same as that of two identical vacuum tubes in a circuit with push-pull input and parallel output. In such a circuit, with a signal applied to the grids, if the two tubes had identical characteristics the fundamental and odd harmonic components of plate current would be zero. The output would be composed entirely of the even harmonic components introduced by the nonlinearity of the individual tubes. As the two tubes become unbalanced, corresponding to lack of symmetry in our vibration case, the fundamental component of plate current would soon become larger than all the harmonics. A like situation exists in our tube when vibrating, with symmetry between the two halves, the vibration output is very small and is made up entirely of even harmonics of the vibrating frequency. As we depart from symmetry the cancellation becomes less effective and the electrical output at fundamental vibrating frequency soon predominates. Through this mechanism, symmetry with respect to the central plane plays an important part in determining the magnitude of the vibration output of a tube whether vibrated at the resonant frequency of an electrode or under forced conditions below the resonant frequency of any of the elements.

For many years filamentary subminiature tubes were made with nickel filaments. For the past ten years, the trend has been toward the use of tungsten filaments so that now practically all the subminia-

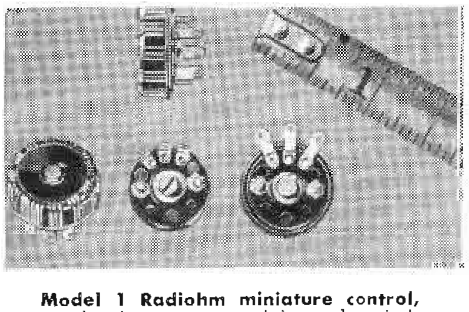
(Continued on page 114)

Centralab Model 2 EXPRESS keeps you ahead on AM-FM-TV

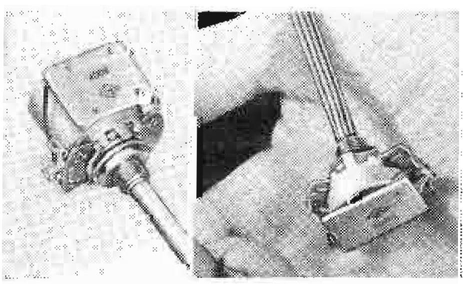




Typical Model 2 Radiohm control — only 15/16″ dia., rated at ⅓ watt. Three basic switch ratings available 5, 8 and 1 amp, plus 8 switch combinations for real flexibility in application and design. Check No. 42-85 in coupon for more data.



Model 1 Radiohm miniature control, rated 1/10 watt — plain and switch types. World's smallest volume control! Ideal for hearing aids, other miniature uses. New high-torque control now available — stands vibration to 3.0 ounce-inches. Check No. 42-158.



Newly announced Compentrol combines volume control and Printed Electronic Circuit. Equalizes bass and treble response at low volume. Furnished in ½ or 1 meg—plain or switch types. Check No. 42-182 in coupon for more details.

You can always count on Centralab's wide variety of standard and custom controls to meet commercial and government requirements

CENTRALAB'S newest — the Model 2 Express — is ideal for the manufacturer needing controls on extremely short notice. Unique time-saving feature simplifies shaft assembly requirements — control shaft fits all standard RTMA split-knurled and certain spring-type push-in knobs.

Shafts and controls are carried in stock at our plant. When your order is received, desired shafts are staked directly to controls. Control assembly arrives in *your* plant in just a few days! To help you plan, Centralab will even tell you approximate delivery *time in hours,* from the date your order is received.

The new Express is available in two values: ½ megohm and 1 megohm, audio taper (C2) with SPST a-c line switch. These two values meet 75% of requirements for switch-type controls. Flat shafts are stocked separately in 14 lengths ranging from ⅞″ from mounting surface to 2½″ fms in increments of ⅛″. For complete details check No. 42-163 in coupon.

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Other famous Centralab plain or switch-type controls — standard or custom designs — with plain or dual concentric shafts are shown at left. They meet today's demand for smaller size, extra quality. Check coupon for more details. Manufacturer's samples on *all* controls on request.

MILITARY TYPES. If you use types RV2A or RV2B, Model 2 variable resistors on your next military order — there's no contractual approval or waiver required. They meet JAN-R-94, characteristic U requirements.

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☐ No. 42-85; ☐ 42-158; ☐ 42-182; ☐ 42-163. Please send the bulletins I've checked. ☐ I'd also like a copy of Centralab's new Catalog No. 28, listing more than 470 *new* items for the fast-changing electronic field.

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tures are using the oxide coated tungsten filament. The increased strength of the tungsten permits much higher filament tension to be used. This results in much higher resonant frequencies with the consequent reduction in microphonic output. The modern subminiature also uses shorter filaments and improved methods of controlling symmetry. All these factors contribute to the tremendous improvement that has taken place in the filamentary subminiature within the past few years. The over-all result is that several of the filamentary subminiatures now compare favorably with the cathode-type tubes. For example, when vibrated at 40 CPS with an acceleration of 15 times gravity, tube types CK534AX and CK549DX give an output equivalent to a signal of only 200 µv at the grid.

Life Test Data

The performance of the filamentary subminiature on life test is well worth consideration. At Raytheon we have accumulated data on more than 27,000 filamentary subminiatures which were life-tested for periods ranging from 500 hours to 10,000 hours. Most of these tubes were operated for 500 hours and over 2,500 tubes were carried beyond 10,000 hours. To simplify the analysis the rejects have been arranged in three groups: glass failures, mechanical failures, and characteristic failures.

The results are shown in Tables I and II. Table I is the result of life tests on 27,260 tubes representing 13,500,000 hours of satisfactory operation. Table II represents 27,000 tubes carried to 500 hours, with some to 10,000 hours, totaling 47,000,000 tube hours of satisfactory operation.

This performance record, showing more than 50,000 hours of satisfactory operation for each failure shows that we already have a rather high degree of reliability with filamentary subminiature tubes as they are today. These tests were made, of course, under controlled operating conditions and limited environment. Normal voltages were maintained at all times, the ambient temperature covered the ordinary range of room temperature, neither shock nor vibration influenced the results. The scoring was carried out with respect to the particular performance for which the tube was intended, namely: voltage gain and power output with freedom from gas and leakage under normal operating conditions.

The electric motor is often cited

as an example of reliability. It certainly deserves this reputation when operated under appropriate conditions. Many motors are equipped with thermal overload devices to prevent sustained operation under improper conditions. We would hardly expect a motor to provide reliable operation under conditions of improper ventilation, overloading, and in particular operation at reduced line voltage while delivering full load.

Likewise with the vacuum tube, either filamentary or cathode-type, in order to obtain maximum reliability it is imperative that it be given the advantage of appropriate environment and electrical operating conditions. The life test record shows that the filamentary subminiature tubes of today provide reliability when given appropriate environment and electrical operating conditions. These tubes were handled many times in removal from the racks for repeated testing during the life test period. The filamentary subminiature tubes are notable for their ability to withstand severe shock. Surprisingly few changes were required to enable them to operate satisfactorily after undergoing an acceleration of 20,000 times gravity in the proximity fuse.

Future Problem

The problem for the future is to retain the reliability we now have and still meet additional requirements imposed by operation under conditions of shock, vibration, high ambient temperature, and abnormal electrical conditions. The solution to this problem will require progressive changes in tube design, materials, and processing. At the same time abnormal electrical operating conditions must either be avoided or the tube must be processed and tested with the abnormal condition in mind. Tubes are being improved constantly, particularly with respect to their ability to perform under conditions of severe vibration. In the meantime, for applications where either the environment or the operating conditions are unfavorable to the tubes as they are now made, a closer relationship between the user and the maker of tubes can be of utmost importance. Reliability can be best realized through the cooperative efforts of the tube design, process, and circuit engineers. The reliability of a system requires the proper tube for the application and the proper application for the tube.

This paper was first presented at the National Electronics Conference held in Chicago, Sept. 29-Oct. 1, 1952.

Another Machlett Contribution Toward Better, More Reliable Tubes for Industrial Service

ML-6257 is the latest addition to Machlett's line of tubes specially designed and processed for use in electronic heating equipment. It fulfills a long standing requirement for a long life tube which can safely provide 3 kw of heater output with reliability and economy.

ML-6257—with its companion tubes ML-6256 and ML-6258—makes available design and performance characteristics which provide a higher standard of value for all applications—including AM, FM & TV broadcasting.

ML-6257 is rated 5 kw plate dissipation with cooling provided through an integral anode water jacket. Type ML-6256 with the same ratings uses the Machlett automatic seal water jacket. Type ML-6258 designed for forced-air cooling is rated at 3 kw plate dissipation.

Phone, wire or write for more information—Machlett Field Engineers will be glad to assist in any tube application problem.

RATINGS AND CHARACTERISTICS

Electrical Data—General

Filament voltage	12.6 Volts
Filament current	27 Amps
Amplification Factor	21
Interelectrode Capacitances:	
Grid-Plate	20 uuf
Grid-Filament	22 uuf
Plate-Filament	0.7 uuf

Maximum Ratings—Class C Telegraphy

(Key down conditions per tube without modulation)

D-C Plate Voltage	5500 Volts
D-C Grid Voltage	—1500 Volts
D-C Plate Current	1.5 Amps
D-C Grid Current	.22 Amp
Plate Input	7 kW
Plate Dissipation	5 kW

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H V Supply

(*Continued from page 96*)

justment is restricted to the primary tank circuit.

Fig. 6 shows the output characteristic for several different coefficients of coupling, including critical coupling. The dc output characteristic for critical coupling corresponds to the curve labeled $K_c = 0.03$. The other values of coupling in this plot are greater than K_c. Oscillator plate current is plotted to indicate the overall efficiency of the system as the parameter of coupling is varied. Examination of Fig. 6 shows that efficiency increases with increased coefficient of coupling, but the maximum dc output voltage shows little increase for K greater than 0.17. From the curves in Fig. 6, we are able to choose the optimum coupling for a particular value of L_{Pri} and L_{Sec}. Since the maximum output obtained is approximately equal for all values of K from 0.08 to 0.22, we can choose the output characteristic which is the most efficient and has the most desirable shape.

The maximum dc voltage output obtained at a coefficient of coupling greater than $K_c = 0.03$ corresponds to the lower-frequency resonant peak of an overcoupled circuit. This resonant peak occurs at a frequency below f_0, where f_0 is the resonant frequency of the secondary circuit in isolation. Operation at the lower-frequency resonant peak is more desirable than at the higher-frequency peak. This has been pointed out by several others who have investigated r-f type power supplies.[1,2]

Output Characteristics

The output characteristics in Figs. 4, 5, and 6 show some marked discontinuities which should not be confused with double-resonant phenomena of over-coupled circuits. As a matter of fact, the sharp dips in the curves are a function of the resonant frequency of the primary and harmonics present in the oscillator. For example, in Fig. 5, the first dip, at $C_{Pri} = 900$ μμf, is due to the presence of the second harmonic and at $C_{Pri} = 300$ μμf is due to the presence of the third harmonic. For these values of primary capacitance the primary tank is tuned to a frequency $2 \times f_0$ and $3 \times f_0$, respectively, in the absence of the secondary circuit. Since the tickler coil is coupled closely to the secondary the r-f oscillation frequency is very nearly f_0 (the resonant frequency circuit). However, there is some coupling be-

(*Continued on page 118*)

tween the primary tank and the tickler coil. Consequently, when the value of C_{Pri} is such that L_{Pri} and C_{Pri} tune to a frequency 2 x f_0, the r-f voltage developed across the primary is predominantly at this higher frequency. This is similar to a class-C amplifier tuned to operate as a harmonic generator. Since the secondary tank is tuned to f_0 and is very selective, the output from the secondary is reduced at the points where the primary tank is resonant to a harmonic. Therefore, dips in the dc voltage output occur, corresponding to the second and third harmonics of f_0. When the primary is tuned to $2f_0$, an oscilloscope connected across the primary tank shows the magnitude of the second-harmonic voltage is greater than the voltage of the fundamental frequency. This is explainable from a viewpoint of a frequency-selective load.

Further Investigation

Further investigation of these dips in dc output was made by driving the r-f circuit of the power supply as a class-C amplifier from a separate class-C oscillator. This was done by disconnecting the tickler coil and introducing r-f directly to the grids of the type 815 tube and an adjustable bias arranged to similate normal operation of the oscillator. Output characteristics then were obtained by tuning C_{Pri} for maximum output after making small changes in the driving frequency. The output characteristics of the power supply were found to be quite similar, including second and third harmonic dips, to those obtained with the r-f circuit connected normally.

An oscillator which obtains feedback voltage from the primary tank instead of the secondary can produce poor power-supply starting characteristics. This is due to a tendency for oscillations to build up at a frequency determined by the primary tank constants alone. When this occurs secondary loading is negligible and so is secondary output. To avoid this difficulty, the tickler coil must be coupled much more tightly to the secondary than to the primary. The oscillator grid-bias resistor should be kept small so that only the secondary tank circuit can provide sufficient feedback voltage to sustain oscillation.

1. R. S. Mautner and O. H. Schade, "Television High Voltage R-F Supplies," RCA Review, vol. VIII, no. 1, p. 43.

2. G. W. C. Mathers, "Some Additions to the Theory of Radio-Frequency High Voltage Supplies," Proc. IRE, vol. 37, no. 2, p. 199.

ANALOG CORRELATOR

(*Continued from page 72*)

turn will trigger stage 2. Resetting of stage 4 by the fifth pulse will trigger stage 0 and the cycle will be repeated.

The output from each stage as it is reset triggers a blocking oscillator in each channel which provides the sampling pulse output for that channel.

B. Sampling Circuit: The sampling circuit[5] is designed to sample the input signal accurately during a 0.2 μsec period and to store the resulting value for 5000 μsec with less than 1% decay. This has been achieved by the circuit of Fig. 6.

The grid of the sampling tube (both sections of a type 5687 in parallel) is held cut off except during the occurrence of the 0.2-μsec sampling pulse, when the grid is driven positive. During this period the resistance offered by the tube is low enough to allow the cathode follower to charge the sampling capacitor to the voltage of the input signal. The sampling capacitor is charged through a 6AL5 diode because it has been found that this arrangement greatly reduces the leakage of the sampling capacitor to ground. The

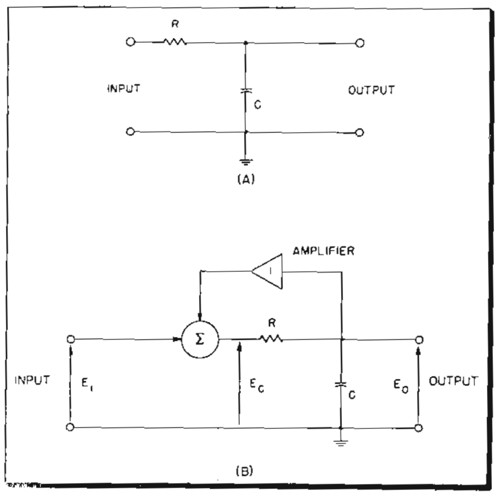

Fig. 7: (A) Basic RC integrator circuit and (B) integrator with amp and summing circuit

major factor responsible for this reduction is the larger cathode to heater resistance of the 6AL5 compared with the 5687.

To preserve the sample voltage it is necessary to charge a larger storage capacitor by means of a pulse stretching circuit. Two cathode followers in cascade are necessary in the pulse stretching circuit to prevent grid current flow from discharging the sampling capacitor. The resulting circuit then meets the required storage time specifications.

After the sample value has been used by the multiplying circuits, it is necessary to discharge the capacitors to prepare for obtaining the next sample. This is accomplished by connecting the ungrounded side of each capacitor to the plate of one section of a 12AU7 triode. The grids of these discharge tubes are held cut off except when it is desired to discharge the sampler. Then the grids are driven positive by a pulse for 30 μsec and the capacitors discharge through the low tube resistance to ground. The grids of the discharge tubes are then cut off and the circuit is ready to obtain the next sample.

C. Multiplier: Multiplication is performed in each B-channel by modulating the amplitude of a rectangular pulse in proportion to the value of the A-channel sample, while the width of the pulse is modulated in proportion to the B-channel sample. The area of the pulse is then proportional to the product of the sample values plus a constant which is later subtracted. Integration of these pulses provides an output voltage proportional to the value of the desired point of the correlation function.

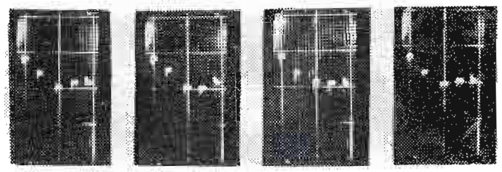

Fig. 8: Autocorrelation functions of 6D4 gas tube noise passed through low-pass RC filter

D. Integrator: A bootstrap type integrator circuit was developed to provide the long-time constant, freedom from drift and wide bandwidth necessary for accurate operation of this correlator. The theory of operation of this circuit is discussed in reference 6 where it is shown that if an amplifier having a gain K of nearly unity is supplied across the resistor of an RC integrating circuit, the resultant time constant is approximately RC/(1-K).

The operation of this circuit can be explained briefly as follows: The simple RC circuit of Fig. 7(A) would function as an integrator if its time constant could be made long enough. This cannot be done in practice since for accurate correlation a time constant of at least 200 seconds is required, whereas the maximum RC product realizable economically is about five seconds. The effect of having too small a time constant can be thought of in the following manner: As positive pulses are integrated, the voltage across the capacitor increases and effectively subtracts from the true voltage of the pulses. In addition, as the voltage across the capacitor increases the capacitor tends to discharge through the resistor R and the source resistance. These effects could be removed if the voltage level of the pulses at the input terminal of the integrator could be raised by the same amount as the output voltage across the capacitor. Then the effective voltage across resistor R would be the voltage of the input pulses, as it should be. This can be done with a unity gain amplifier and a summing circuit as indicated in Fig. 7(B). Since pulses are being integrated this summing can be effectively accomplished by using a diode clamping circuit. The RC time constant is entirely adequate to integrate accurately one individual pulse which averages only 200 microseconds in length. When the pulse ends, the clamping circuit makes E_c equal to E_o. This raises the input voltage level by the required amount.

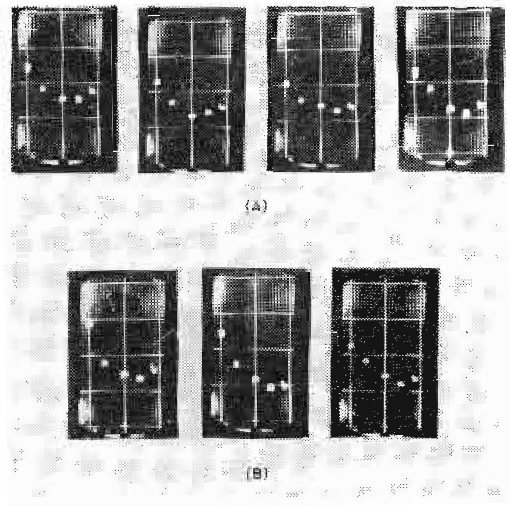

Fig. 9: Autocorrelations of (A) male and (B) female speech covering high frequency components show same general shape for same voice

Unity Gain Amplifier

The unity gain amplifier is realized by comparing E_o and E_c and using the difference as the input to a high gain, direct-coupled amplifier. The output of the amplifier is connected with the proper polarity to reduce this difference. This arrangement is equivalent to a high gain amplifier with unity-negative feedback. The resultant circuit has a gain of nearly unity when K is large. In this correlator an RC product of approximately 1 megohm times 1 μf is employed together with an amplifier gain of about 0.995 providing an overall time constant of 200 seconds.

It should be noted that this circuit is much less subject to drift than the conventional means of multiplying RC products with a Miller integrator. The reason is that the Miller circuit requires a high gain direct-coupled amplifier which does not have direct-coupled negative feed-

(*Continued on page 123*)

back. The high-gain amplifier associated with this bootstrap circuit does have direct-coupled negative feedback which reduces its gain to approximately unity. The resulting circuit is much less subject to drift at its output than the high-gain amplifier associated with the Miller integrator.

E. Display Circuit: During the display period the output voltage of each integrator appears in the form of a vertical spot displacement above a baseline on the face of a cathode-ray tube[6]. These displays are photographed with a Polaroid Land camera if a permanent record is desired.

To obtain this display, a conventional, continuous sawtooth sweep is applied to the horizontal plates of the CRT. At each of five points along the sweep the output voltage of one of the B-channel integrators appears as a vertical spot displacement. This requires a switching circuit to connect the output of each integrator in turn to the vertical deflection system of the CRT at the time when the CRT beam is in the position corresponding

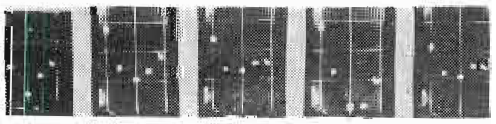

Fig. 10: Autocorrelation functions of music (Mozart E Flat Piano Concerto, end 3rd move.)

to that integrator. A mechanical switching circuit was tried, but an electronic system was found to be more reliable.

This switching circuit contains a five-stage, ring-chain counter, each cycle of which is started in synchronism with the horizontal sweep. Each of the five output pulses opens briefly, in turn, one of five gate circuits. The input of each gate is connected to a B-channel integrator; the outputs are tied to a common wire. The waveform upon this common wire appears as a group of five rectangular pulses of varying heights. An ac amplifier with suitable clamping circuits applies this waveform to the vertical deflection plates of the cathode-ray tube.

A multichannel correlator such as this is especially valuable for investigating nonstationary time series; that is, those time series whose statistical characteristics change with time. With a single channel correlator, which computes only one point on the curve at a time, each point is obtained under different conditions. The five-channel correlator obtains an entire group of five points at one time. By obtaining successive correlation functions of a nonstationary time series, the manner in which the

(*Continued on page* 125)

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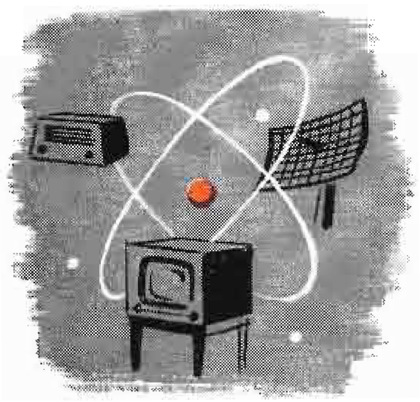

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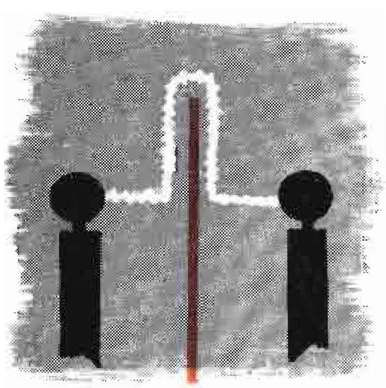

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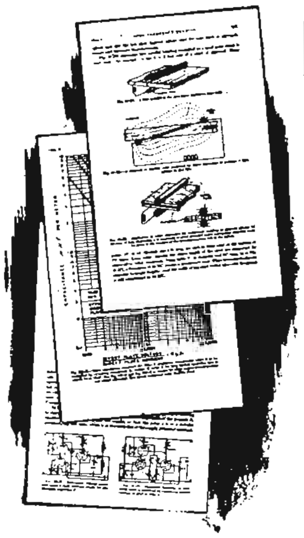

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(This offer good only within the boundaries of the United States) correlation function is changing is indicated.

Figs. 8-10 show how the correlation functions of certain time series do vary. Each figure shows several correlation functions obtained from the same time series at different times. The first group of five points along the curve is shown in each instance. The data was obtained for the following conditions:

- Value of τ increases from left to right
- $\Delta\tau = 400$ µsec
- Number of sample pairs=4,000
- Time interval covered by each curve equals 8 seconds
- Time between successive curves equals about 20 seconds

In each case the input was passed through a clipper to make certain that large peaks did not cause large errors by overloading the multipliers. The clipping was slight, and it was verified by listening to the output of the clipper through headphones that the actual sound was not more than slightly affected.

The curves obtained for gas tube noise (Fig. 8) show very little difference among themselves. This is to be expected since there is no apparent reason for the output of the noise generator to be nonstationary over the short interval of time during which the curves were obtained. The slight fluctuations that do occur are probably random fluctuations (sampling noise) caused by the limited number of sample pairs taken.

Since these curves have a maximum τ value of only 1.6 milliseconds, the curves obtained for speech (Fig. 9) cover only the high frequency components. Successive curves differ noticeably, yet all have the same general shape for the same voice.

Fig. 10 shows curves that have been obtained for music. Here the rapidly varying character of the time series is clearly evident.

Appreciation is expressed to Professor Y. W. Lee for suggesting the construction of the five-channel correlator and to H. Levick, F. L. Petree and D. E. Ullery for their contributions to this work.
This work has been supported in part by the Signal Corps, the Air Materiel Command, and the Office of Naval Research.

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2. J. F. Reintjes, "An Analogue Electronic Correlator," Proc. N.E.C., vol. 7, 1952.
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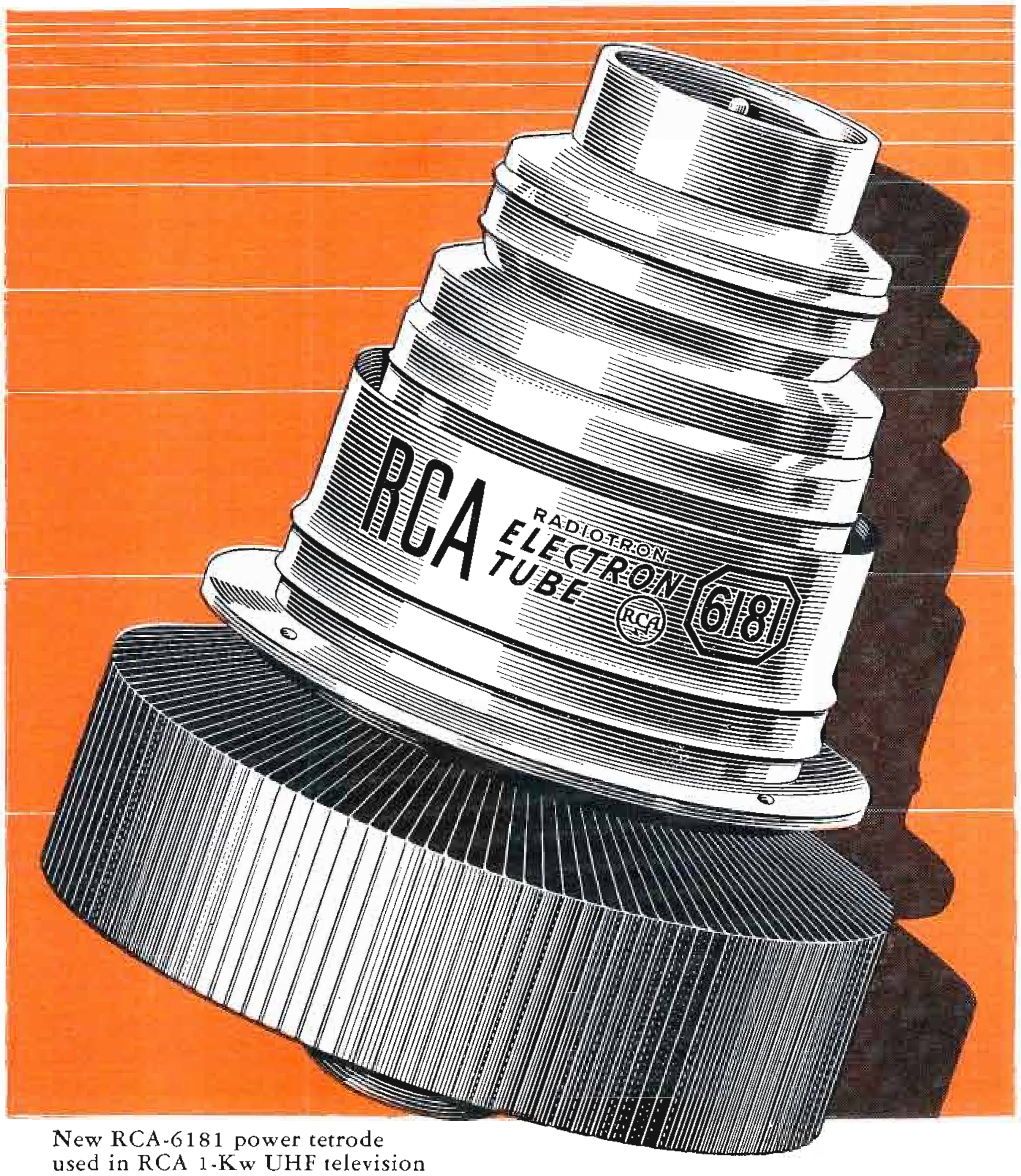


New RCA-6181 power tetrode used in RCA 1-Kw UHF television transmitter type TTU-1B.

FREQUENCY FEEDBACK

(*Continued from page 93*)

Because the biasing permeativity $(\mu,\varepsilon)_B$ corresponds to the center points of the various chords, the relationship between $(\mu,\varepsilon)_B$ and the amplitudes of the polarizing field becomes evident as a result of flux rectification.

Although this philosophy may not be fully conclusive, the illustrated phenomena reveal the relationship between dynamic permeativity on one hand and bias as well as superimposed ac polarization on the other hand. At any rate, the dynamic permeativity manifests itself in equivalent changes of the dynamic inductance of an iron-cored coil and the dynamic capacitance of a ferroelectric condenser, respectively. In fact, variations as large as 10 : 1 have been measured for inductors with Ferramic cores and as large as 4 : 1 for barium strontium titanate capacitors, whereby the lower ratio of the capacitor must be attributed to breakdown voltage, dielectric losses, and temperature effects.

If we now turn back to frequency feedback, we may easily see that the relationship between dynamic reactance and r-f amplitude takes the place of the feedback line in Fig. 2. Hence, the resonance curves of a nonharmonic resonant system are unsymmetrically deformed in the same manner as when caused by an external feedback channel. This has been corroborated by numerous experiments which evidenced the nonharmonic resonance curves depicted in Fig. 7 and produced by a nonlinear coil (a) as well as a barium strontium titanate capacitor (b), except that the limited dielectric strength of the latter prevents the instability.

Instead of oscillographing the nonharmonic resonance characteristics with the aid of a sweep generator, it is also possible to sweep the test circuit by means of its nonlinear reactance. As shown in the diagram of Fig. 8 a sweep voltage is impressed upon the ferroelectric capacitor and, at the same time, provides the X-deflection of the oscilloscope. The two oscillograms shown in Fig. 9 illustrate the resonance shifting with increasing r-f excitation from oscillogram (a) to oscillogram (b), in other words: The tank circuit is retuned by a higher biasing voltage.

Nonharmonic Resonance

A resonant system also becomes nonharmonic if it contains a nonlinear resistor such as a crystal diode, a Thyrite, or a Polaristor,[1,4] provided it operates in combination with a fixed reactance. For this purpose) the nonlinear resistor forms part of a network, the simplest circuit containing both in series. The resulting RX-modulators have been utilized for FM[2] but, at the same time, make a resonant system nonharmonic.

Fig. 10(a) shows the nonlinear resistor R_S in series with the constant reactance X_s paralleling the shaded tank circuit. If we convert the series network into the equivalent parallel network shown in Fig. 10(b) wherein the equivalent reactance X_p and the equivalent damping resistor R_p shunt the tank circuit, the nonlinearity of R_S is transformed into X_p so that the RX-modulator is equivalent to a nonlinear reactance.

Whereas FM is produced by controlling the series resistor by means of an external modulating voltage, nonharmonic resonance occurs under the influence of r-f in that the dynamic resistance is altered. Let the nonlinear resistor be characterized by the symmetrical I-V characteristic $I = \pm K V_r^2$ depicted in Fig. 11(a). If we recall the dynamic permeativity, the dynamic resistance may be set equal to the inverse slope of the dashed chord

$$R_d = 1/K\hat{V}_r \qquad (5)$$

where $\hat{V}_r$ denotes the peak value of the r-f voltage across R_S. By means of this analogy, it can easily be seen that the dynamic resistance decreases with increasing r-f amplitudes as illustrated in Fig. 11(b).

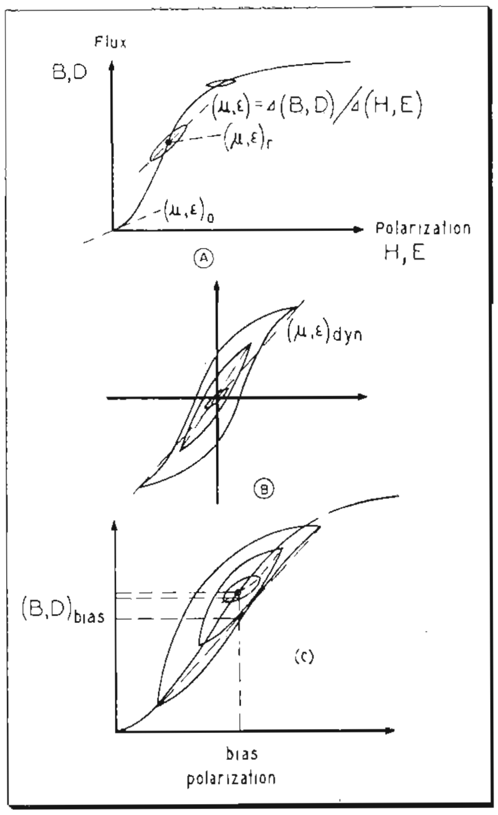


Fig. 6: Various hysteresis loops caused by using different ac and bias polarizations

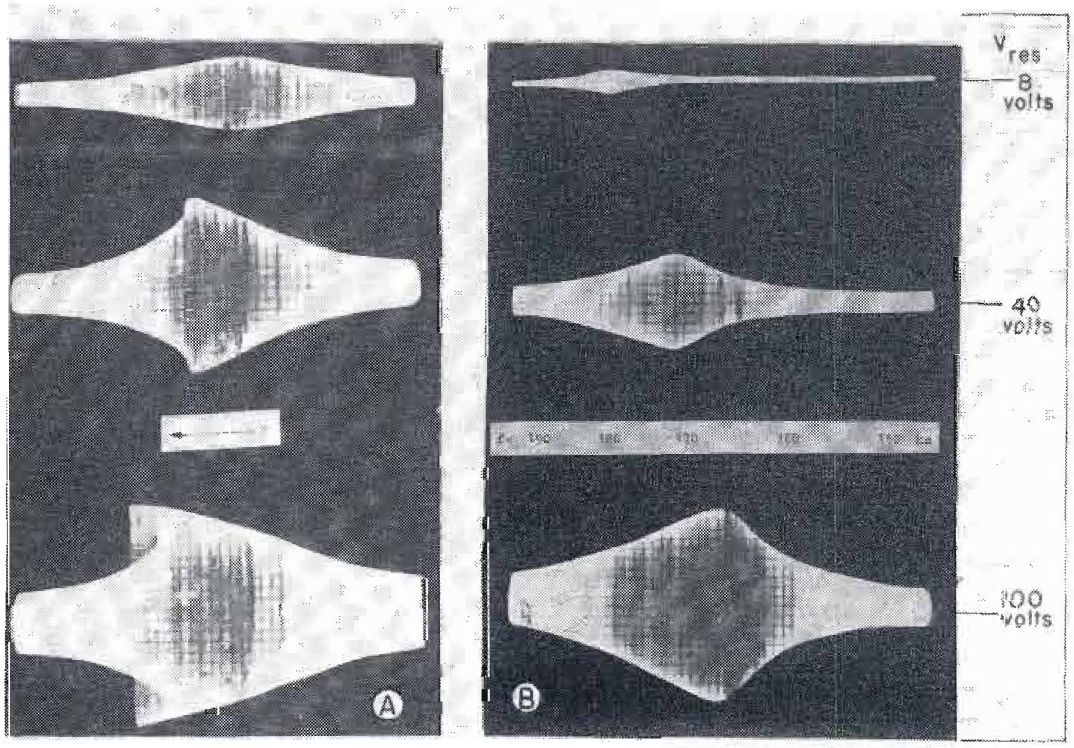


Fig. 7: Nonharmonic resonance due to saturable reactor (a) and nonlinear capacitor (b)

RX-Modulator

The frequency feedback caused by an RX-modulator may be explained by a first order analysis. Let the series reactance X_s be a capacitance $1/\omega C_s$. The voltage drop V_r then follows from the r-f voltage $V\sim$ induced in the tank circuit as

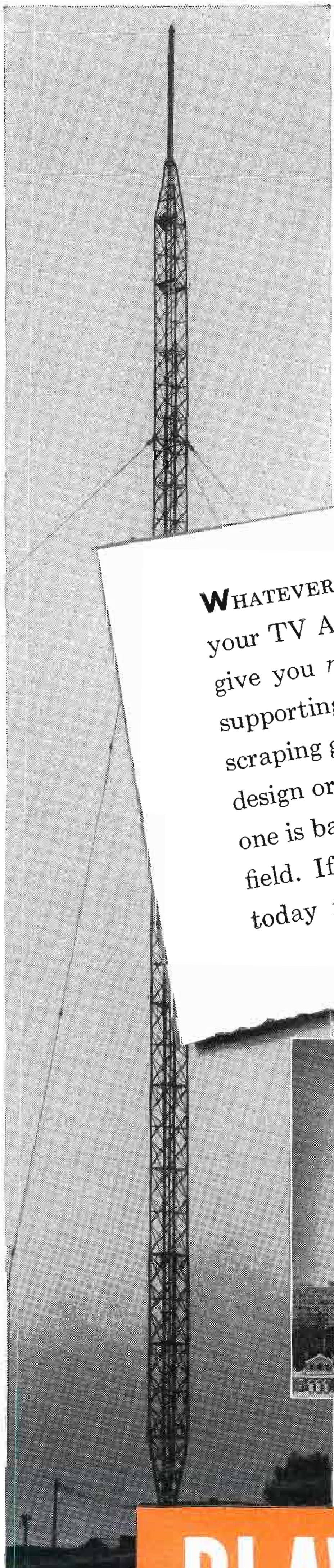
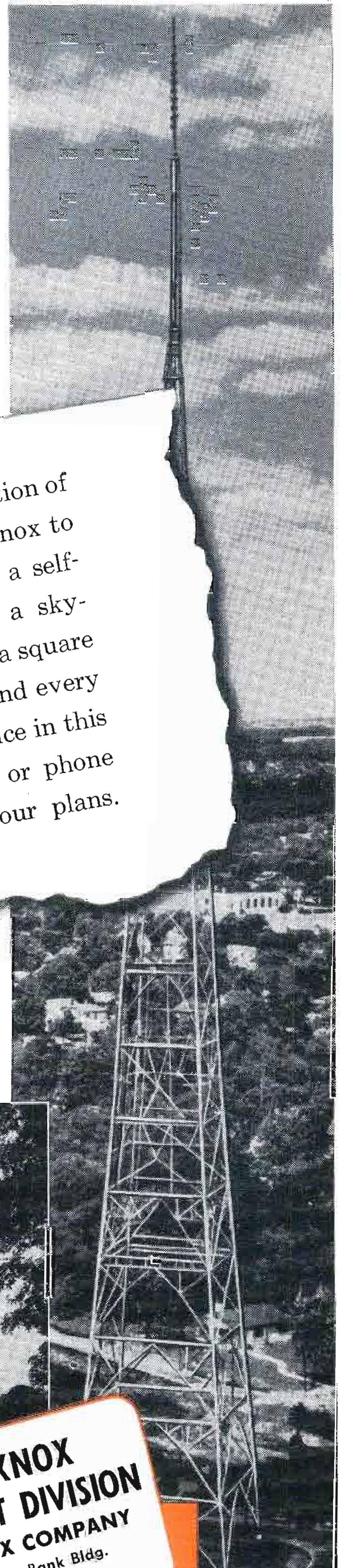
$$V_r = V\sim/\sqrt{1+PV_r^2} \qquad (6a)$$

where $P = (K/\omega C_s^2)$. The equation has the solution

$$V_r^2 = (\sqrt{1+4PV^2\sim}-1)/2P \qquad (6b)$$

Now, the series combination must be converted into the equivalent

(*Continued on page 128*)

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$$\frac{1}{R_d+1/j\,\omega\,C_s} = \frac{1}{R_p} + j\,\omega\,C_p \qquad (7)$$

gives

$$C_p = \frac{C_s}{1+(\omega C_s R_d)^2} \qquad (7a)$$

and

$$R_p = R_d\left[1 - \frac{1}{(\omega C_s R_d)^2}\right]. \qquad (7b)$$

If we introduce Eqs. (5) and (6b), both formulas assume the forms

$$C_p = C_s\,\frac{\sqrt{1+4PV^2\sim}-1}{\sqrt{1+4PV^2\sim}+1} \qquad (8a)$$

and

$$R_p = \frac{\sqrt{1+4PV^2\sim}+1}{\sqrt{2}\,\omega C_s\sqrt{\sqrt{1+4PV^2\sim}-1}}. \qquad (8b)$$

Fig. 8: Schematic of an arrangement for making oscillograph curves of nonharmonic resonance

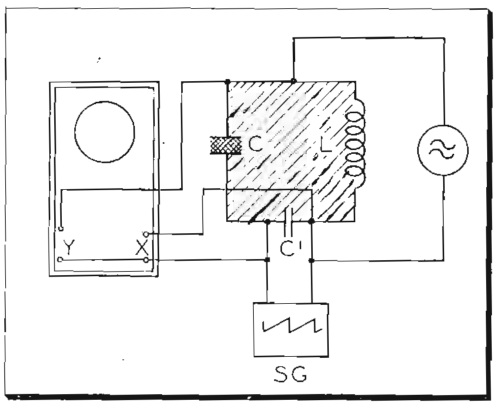
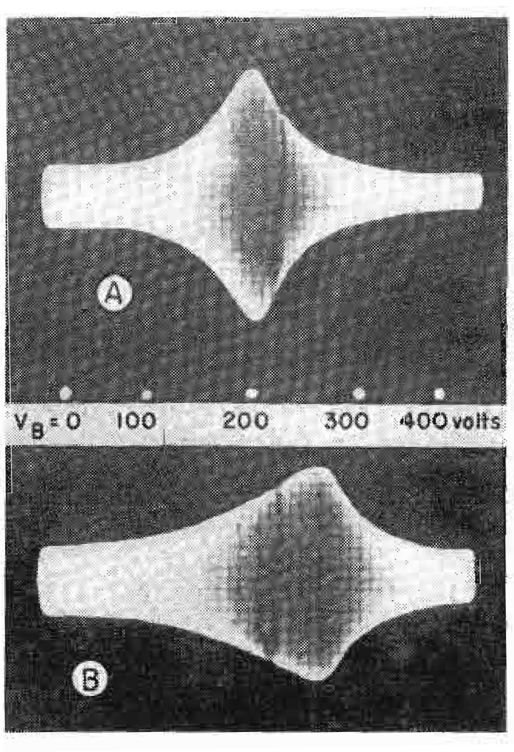


Fig. 9: Curves made by circuit shown in Fig. 8



Finally, we evaluate the detuning of the nonharmonic tank circuit by means of

$$x = \frac{\omega}{\omega_o} - \frac{\omega_o}{\omega} = -\frac{C_p}{C_o}\,\frac{1}{\sqrt{1+C_p/C_o}} \qquad (9)$$

$$= -\frac{C_s}{C_o}\sqrt{\frac{1+2PV^2\sim - \sqrt{1+4PV^2\sim}}{1+2PV^2\sim\left(1+\frac{C_s}{C_o}\right)+\sqrt{1+4PV^2\sim}}}$$

The accuracy of Eq. (9) has been checked by the investigation of a test circuit shunted by an RX-modulator with $C_o = 2{,}400$ μμf; $C_s = 1{,}000$ μμf; $\omega_o = 1.27 \cdot 10^6$ whereas two germanium diodes in back-to-back connection are characterized by $K = 10^{-2}$. The solid characteristic in Fig. 12 shows the measured detuning versus increasing r-f excitation. The dashed curve is evaluated and agrees with the experiment as well as can be expected. The sensitive diodes produce a strong frequency feedback: An induced voltage as low as 0.4 volts approaches the short-circuit detuning $x_s = -0.35$ for $R_d \to 0$.

Eq. (8b) shows that the equivalent parallel resistor R_p becomes infinitely high for $R_d = 0$ as well as ∞ because both extremes cause no additional damping. Between these extremes, R_p passes a minimum. This is corroborated by the dotted characteristic in Fig. 12 disclosing the quality factor $\sqrt{Q}$. At low r-f excitation, Q decreases rapidly from its initial value $Q_o = 86$ and, after passing a minimum of only 5, increases again and asymptotically approaches Q_o. Such a heavy damping can be avoided by smaller capacitors C_s or less sensitive resistors at the expense of detuning sensitivity.

Impedance of Nonharmonic Systems

Up to now, the result of frequency feedback has been discussed at varying frequencies with the driving power as parameter. The philosophy of frequency feedback, however, is not complete as long as we do not change the parameters, in other words: The nonharmonic system is excited at a constant generator frequency and fed by the r-f current I~ with the constant frequency ω_{gen}. A preresistor r in Fig. 13(a) stabilizes the feeding current and may represent the internal impedance of the generator.

Let the dynamic capacity be related with the induced voltage V~ by the formula

$$C_d = C_b(1 - A\ V\sim) \qquad (10)$$

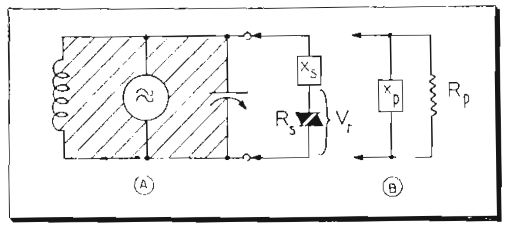


Fig. 10: RX-modulator (a) and equivalent (b)

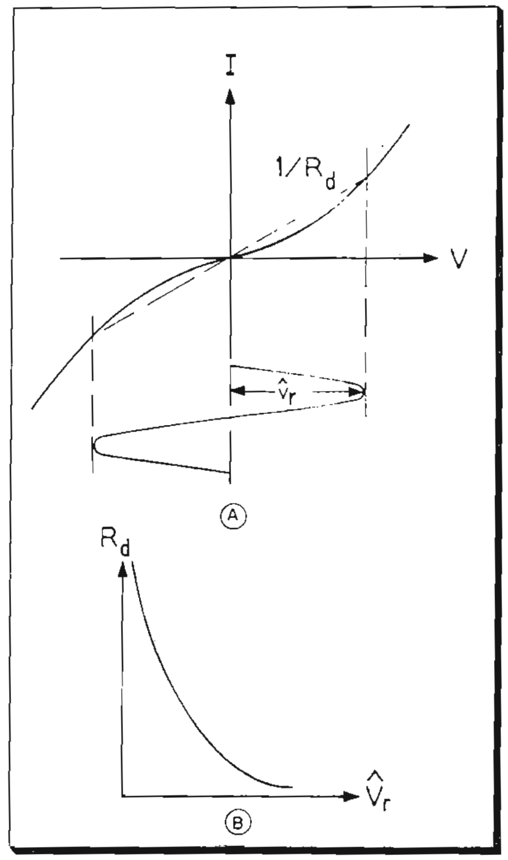


Fig. 11: I-V characteristic of nonlinear resistor (a) and resistance characteristic (b)

where C_b is the bias capacity and A the dynamic sensitivity taking care of the change in incremental permittivity as well as of the ferroelectric rectification at given conditions of operation. The admittance of the tank circuit then becomes (11a)

$$G = \left|\omega_{gen}\,C_b\,(1 - AV\sim) - \frac{1}{\omega_{gen}\,L}\right|.$$

After introducing the resonant frequency $\omega_B = 1/\sqrt{IC_B}$ and after several rearrangements it assumes the form (11b)

$$G = \sqrt{\frac{C_b}{L}}\left|\frac{\omega_{gen}}{\omega_b}(1 - AV\sim) - \frac{\omega_b}{\omega_{gen}}\right|.$$

The formula reveals as a function of the induced r-f voltage at constant frequencies. Consequently, the driving current I~ and the induced voltage V~ are related by (12)

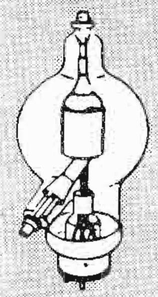
$$I\sim = V\sim G$$

$$= V\sim\sqrt{\frac{C_b}{L}}\left|\frac{\omega_{gen}}{\omega_b}(1 - AV\sim) - \frac{\omega_b}{\omega_{gen}}\right|$$

with the frequency ratio as parameter.

The simplest condition of opera-

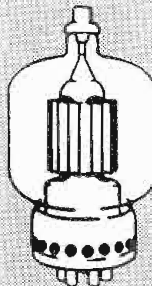
(Continued on page 132)



TRIODES

2C39A, 3W5000A3, 3W5000F3, 3W10000A3, 3X2500A3, 3X2500F3, 3X3000A1, 3X3000F1, 6C21, 25T, 35T, 35TG, 75TH, 75TL, 100TH, 100TL, 152TH, 152TL, 250TH, 250TL, 304TH, 304TL, 450TH, 450TL, 592/3-200A3, 750TL, 1000T, 1500T, 2000T

follow the leaders to EIMAC TUBES!

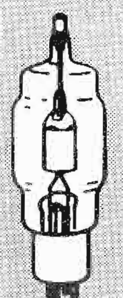


TETRODES

4-65A, 4-125A, 4-250A, 4-400A, 4-1000A, 4PR60A, 4W20000A, 4X150A, 4X150D, 4X150G, 4X500A, 4X500F

PENTODE

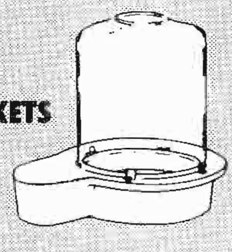
4E27A/5-125B



RECTIFIERS

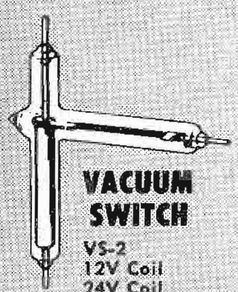
2-01C, 2-25A, 2-50A, 2-150D, 2-240A, 2-2000A, KY21A, RX21A, 250R, 253, 866A, 872A, 8020 (100R)

AIR SYSTEM SOCKETS



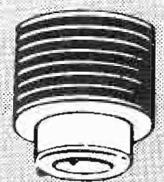
4-400A/4000
4-400A/4006*
4-1000A/4000
4-1000A/4006*
4X150A/4000
4X150A/4006*

*Replacement Chimneys



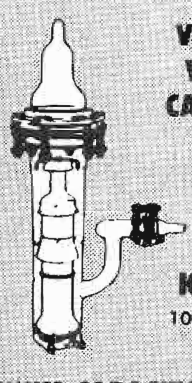
VACUUM SWITCH

VS-2
12V Coil
24V Coil



ACCESSORIES

HR Heat dissipating connectors
Preformed Contact Finger Stock



VACUUM PUMP

HV-1
OIL DIFFUSION PUMP

Type A
Pump Oil
HV-1
Pump Parts

VARIABLE VACUUM CAPACITORS

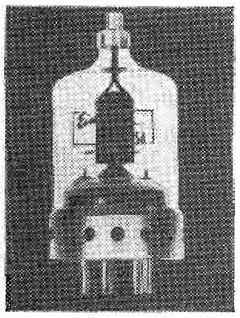
VVC60-20
VVC2-60-20
VVC4-60-20

ION GAUGE

100 IG ion gauge

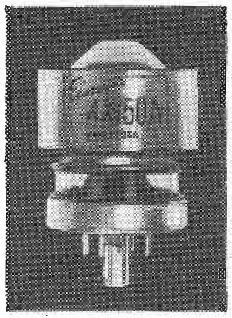
VACUUM CAPACITORS

VC6-20, VC6-32, VC12-20, VC12-32, VC25-20, VC25-32, VC50-20, VC50-32



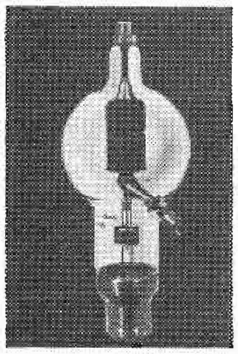
4-125A

The radial-beam power tetrode that made transmitting screen-grid tubes popular. This tube will take a plate input of 500 watts for CW or 380 watts for fone. Driving power is less than two watts. A pair of these tetrodes make an ideal high power fone or CW final for the amateur.



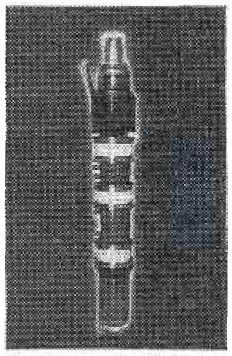
4X150A

This small external anode radial-beam power tetrode operates efficiently at all frequencies into the UHF range with a driving power of only a few watts. Its small size and ruggedness make it ideal for compact equipment such as mobile.



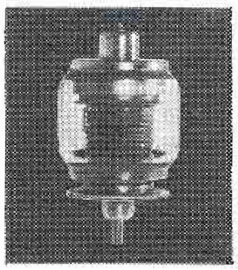
450T

Often referred to as the workhorse of modern communication systems, this dependable triode has a plate dissipation rating of 450 watts. It is widely used as an amplifier, oscillator or modulator.



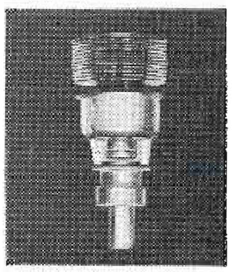
3K20000L (A-F-K)

These Klystrons, the latest development in UHF television transmitting, have a power output of 5000 watts. The three versions of the Klystron will cover the entire UHF range —470-890 mc. These water and air cooled Klystrons have a power gain of 20 db.



VVC60-20

This is but one type in the Eimac line of variable and fixed vacuum capacitors for plate tank circuits. It is variable over a range of 10 mmfd to 60 mmfd. Maximum rf voltage is 20 kv. at 40 amperes.



2C39A

This small, rugged triode is designed for use as a power amplifier, oscillator or frequency multiplier to frequencies above 2500 mc. It is particularly suitable for compact fixed or mobile equipment.

Eimac TUBES

● Complete technical data available on request.

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

EXPORT AGENTS: FRAZAR & HANSEN • 301 CLAY STREET • SAN FRANCISCO 11, CALIFORNIA tion is characterized by $\omega_{gen} = \omega_b$ which means the tank circuit, at low r-f excitation, is in resonance with the generator frequency. The driving current then increases proportionally to the second power of V~. For $\omega_{gen} > \omega_b$ however, the I~ — V~ characteristic shown in Fig. 13 (b) is obtained. The negative slope shows a negative impedance resulting from the fact that the frequency feedback causes the tank circuit to run into resonance. At resonance, the current passes a minimum at a critical excitation

$$V_{crit} = \frac{1}{A}\left[1 - \left(\frac{\omega_b}{\omega_{gen}}\right)^2\right]. \quad (13)$$

When this critical value is exceeded, the tank circuit runs out of resonance and the I~ — V~ curve approaches a parabola.

Negative Impedance

The negative impedance is not to be confused with a negative resistance because it is confined to rms values of currents and voltages but the sign does not denote an inductive or capacitive component. Another implication is the important fact that a negative impedance cannot convert dc energy into ac energy as does a negative resistance. On the other hand, a negative impedance, in combination with a fixed preresistor, becomes bistable as illustrated in Fig. 13 (b).

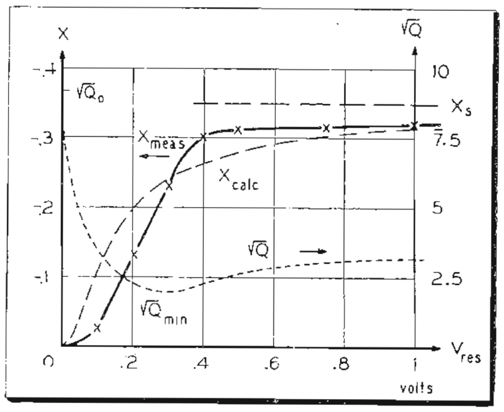


Fig. 12: Detuning and quality factors of a nonharmonic circuit vs. resonant voltage

Only in this respect, a negative impedance cannot convert dc energy alent to a negative resistance. The nonlinear I~ — V~ characteristic is intersected by the dashed loadline having the slope 1/r and originating at the generator voltage V_{gen}. Only the two points O′ and O″ of intersection are stable so that the driving current, under the influence of fluctuating generator voltages, jumps between the values I′ and I″. The similarity between a negative impedance and a negative resistance, both in series with a constant resistor, is obvious. Hence we may say that the concept of a negative resistance is transferred from the field of dc into the ac field.

Practical Applications

Although the purpose of this paper is the explanation of the basic problem of frequency feedback rather than the description of practical applications, some examples may be given.

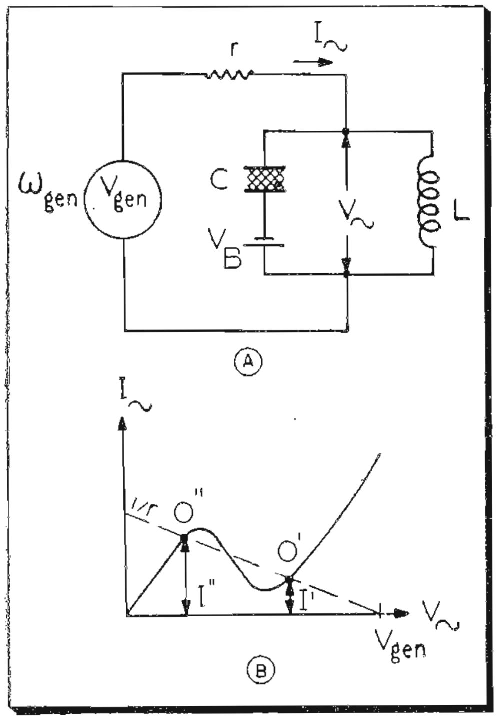


Fig. 13: Excited nonharmonic tank circuit (a) and the associated I~-V~ characteristic (b)

The simplest application is the conversion of AM into FM. For this purpose, the tank circuit of an oscillator is made nonharmonic by providing it with an iron-cored coil, a ferroelectric capacitor, or an RX-modulator. As soon as the amplitude of such an nonharmonic oscillator is modulated in any conventional way, the AM is accompanied by FM. This phenomenon may be utilized for neutralizing the parasitic FM of signal generators. Experiments have shown that a one per cent AM of 10 MC carrier frequency produces a frequency swing of 2 KC *without* unreasonable damping.

Frequency Shift Reception

Another example makes use of the opposite effect for the conversion of FM into AM for frequency-shift reception. Frequency-shift keyed transmission alternates between two discrete frequencies termed mark and space, respectively. The receiver is tuned to the transmitter's center frequency, often termed the phantom carrier. The discriminator

(*Continued on page* 134)

of the frequency-shift receiver then is driven by the output of the limiter stage and comprises two nonharmonic tank circuits which perform minute tuning loops on both sides of the phantom carrier. For this purpose, one of the discriminator's tank circuits shown in Fig. 14 (a) contains a ferroelectric capacitor and the other an iron-cored coil. Their r-f voltages are rectified by two detectors which produce the

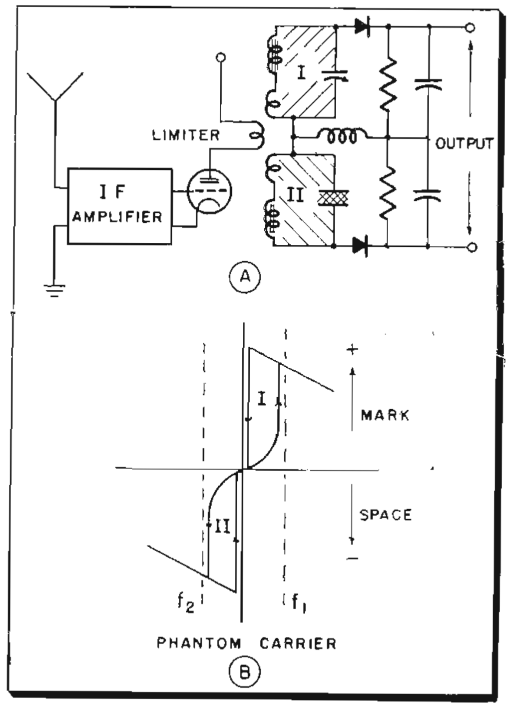


Fig. 14: Nonharmonic discriminator for frequency-shift reception (a) and tuning loops (b)

output voltage across a common load resistor. As a result, the output voltage versus transmitter frequency follows the curve shown in Fig. 14 (b). Mark and space produce equal potentials of opposite polarity.

A third example of application is a flip-flop gating device adapted to a parallel-gated binary-computing system and based on the explained bistability. Such a trigger device—which differs from the described circuitry only by series resonance circuits instead of parallel circuits—has been described previously.[3]

The description of additional applications is beyond the scope of this paper. Following the developed principle, the expert may develop other applications according to his own requirements.

REFERENCES

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2) H. E. Hollmann, "Nonlinear Elements and Some Applications in AF and RF Circuits," *Proc. Nat. E. Conf.,* vol. 7, pp. 130-140; Feb., 1952; *Tele-Tech,* Apr. '52.
3) C. Isborn, "Ferroresonant Flip-Flops," *Electronics,* vol. 25, pp. 121-123; Apr. '52.
4) H.E. Hollmann, "Dielectric & Semiconductive Suspensions," *Tele-Tech,* Sept. '52.

This paper was first presented at the National Electronics Conference held in Chicago, Sept. 29-Oct. 1, 1952

IRE Program

(Continued from page 77)

INSTRUMENTATION II—SYMPOSIUM: TRANSISTOR MEASUREMENTS

"**Transistor Metrology**"—D. A. Alsberg, Bell Tel. Labs.
"**Measurement of Transistor Parameters by CRO and Other Methods**"—W. E. Morrow, Jr., MIT.
"**Transistor Static Characteristics Obtained by Pulse Techniques**"—D. R. Fewer, Bell Tel. Labs.
"**Bridges for Measuring Junction Transistor Admittance Parameters**"—L. J. Giacoletto, RCA Labs.
"**A Transistor Alpha Sweeper**"—H. G. Follingstad, Bell Tel. Labs.
"**Rapid Tracing of Transistor Characteristics by Oscillographic Methods**"—V. Mathis, General Electric.

SIGNIFICANT TRENDS IN AIRBORNE EQUIPMENT

"**Some Systems Considerations in Flight Control Servomechanism Design**"—R. J. Bibbero and R. Grandgent, Republic Aviation.
"**Faired-In ADF Antennas**"—L. E. Raburn, Electronics Research.
"**Magnetic Amplifiers for Airborne Applications**"—J. K. McKendry, General Precision Labs.
"**Aircraft Electrical Power**"—J. C. Dieffenderfer and G. W. Sherman, Wright Air Development Center.
"**The Effects of Electronic Equipment Standardization on Aircraft Performance**" G. C. Sumner, Consolidated Vultee.

ANTENNAS III—PROPAGATION

"**Notes on Propagation**"—L. A. Byam, Jr., Western Union.
"**Tropospheric Propagation in Horizontally Stratified Media over Rough Terrain**"—H. M. Swarm, R. N. Ghose, G. H. Keitel, U. of Washington.
"**Radio Wave Scattering in Tropospheric Propagation**"—J. W. Herbstreit, K. A. Norton, P. L. Rice and G. E. Schafer, National Bureau of Standards.
"**Extended-Range Radio Transmission by Oblique Reflection from Meteoric Ionization**"—O. G. Villard, Jr., A. M. Peterson, L. A. Manning and Von R. Eshleman, Stanford U.
"**An Interpretation of Vertical Incidence Equivalent Height versus Time Recordings on 150 Kc/s**"—R. Lindquist, Pennsylvania State College.

CIRCUITS III—TIME DOMAIN NETWORKS—DELAY LINES

"**Continuously Variable Delay Line**"—C. Berkely, Du Mont Labs.
"**General Transmission Theory of Distributed Helical Delay Lines with Bridging Capacitance**"—M. J. DiToro, Du Mont Labs.
"**Distributed Constant Delay Lines with Characteristic Impedances Higher Than 5000 Ohms**"—W. S. Carley, U. S. Naval Ordnance Lab.
"**Helical Winding Exponential-Line Pulse Transformers for Millimicrosecond Service**"—J. Kukel and E. M. Williams, Carnegie Institute of Technology.
"**Time Domain Approximation by Use of Pade Approximants**"—R. D. Teasdale, RCA.
"**Frequency Transients in Idealized Linear Systems**"—B. Gold, Hughes Aircraft.

ELECTRON DEVICES I—TRANSISTORS

"**The Negative Resistance Diode**"—I. A. Lesk and V. P. Mathis, General Electric.
"**Reliability of Transistors**"—W. R. Sittner and R. M. Ryder, Bell Tel. Labs.
"**Characteristics of the M-1768 Transistor**"—L. B. Valdes, Bell Tel. Labs.
"**Development High Frequency Alloy Transistors**"—C. W. Mueller and J. I. Pankove, RCA Labs.
"**Behavior of Germanium Junction Transistors at Elevated Temperatures and Power Transistors Design**"—L. D. Armstrong, RCA Labs.

INSTRUMENTATION III—ELECTRONICS

"**The Response of a Panoramic Receiver to CW and Pulse Signals**"—H. W. Batten, R. A. Jorgensen, A. B. Macnee and W. W. Peterson, U. of Michigan.
"**A VHF Impedance Meter**"—J. H. Mennie, Boonton Radio.
"**Simplified Measurement of Incremental Pulse Time Jitter**"—W. T. Pope, Griffiss Air Force Base.

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"Wide-Band Wave Analyzer"—O. Kummer, Bell Tel. Labs.

"Ultra-Low Frequency, Three-Phase Oscillator"—G. Smiley, General Radio.

SYMPOSIUM: TRENDS IN MOBILE COMMUNICATIONS

"The Effects of Selectivity, Sensitivity and Linearity in Radio Circuits on Communications Reliability and Coverage"—J. G. Schermerhorn, Rome Air Development Center.

"Single Sideband for Mobile Communications"—A. Brown and R. H. Levine, Coles Signal Lab.

"Major Factors in Mobile Equipment Design with Emphasis on 460 MC Mobile Equipment Characteristics"—John Byrne and A. A. Macdonald, Motorola.

"Field Experience with 450 MC Mobile Systems"—P. H. Bellingham and J. Q. Montrese, Bell-Mont Communications Service.

Wednesday, March 25

ELECTRON DEVICES II—ELECTRON TUBES

"Gas Pressure Effects on Ionization Phenomena in High-Speed Hydrogen Thyratrons"—W. C. Dean, Odessa, Texas and G. W. Penney and J. B. Woodford, Jr., Carnegie Institute of Technology.

"Low Noise, Hot Cathode, Gas Tubes"—E. O. Johnson, W. M. Webster and J. B. Zirker, RCA Labs.

"New Dispenser Type Thermionic Cathode"—R. Levi.

"Multi Output Beam Switching Tubes for Computers and General Purpose Use"—S. Kuchinsky, Burroughs Adding Machine.

"An Equivalence Principle in High Frequency Tubes"—Robert Adler, Zenith.

CIRCUITS IV—ACTIVE NETWORKS—TRANSISTORS

"Transient Analysis of Junction Transistor Amplifiers"—J. J. Suran and W. F. Chow, General Electric.

"The Grounded-Collector Transistor Amplifier at Carrier Frequencies"—F. R. Stansel, Bell Tel. Labs.

"Symmetrical Properties of Transistors and Their Application"—G. C. Sziklai, RCA Labs.

"A Study of Transistor Circuits for Television"—G. C. Sziklai, R. D. Lohman and G. B. Herzog, RCA Labs.

"Conductance Curve Design of Relaxation Circuits"—K. A. Pullen, Aberdeen Proving Ground.

"Transistor Relaxation Oscillators"—S. I. Kramer, Fairchild Guided Missiles.

NOISE AND MODULATION

"Noise Problems of Theoretical and Practical Interest"—B. Gold, Hughes Aircraft.

"A Note on Receivers for Use in Studies of Signal Statistics"—R. Deutsch and H. V. Hance, Hughes Aicraft.

"Amplitude Modulation by Plate Modulation of CW Magnetrons"—J. S. Donal, Jr., and K. K. N. Chang, RCA Labs.

"Comparison of Modulation Methods"—R. M. Page, Naval Research Lab.

"A Technique of Intermodulation Interference Determination"—A. J. Beauchamp, Rome Air Development Center.

SYMPOSIUM: TELEVISION BROADCASTING

"The Design of Speech Input Consoles for Television"—R. H. Tanner, Northern Electric.

"Building TV Broadcast Facilities for Growth, Flexibility and Economy"—A. R. Kramer and E. R. Kramer, Kramer, Winner and Kramer.

"Fashions in TV Transmitting Antennas"—F. G. Kear, Kear and Kennedy, and J. G. Preston, American Broadcasting Co.

"High Gain Amplifiers for High Power Television Transmitters"—J. Ruston, DuMont Labs.

"Optimum Utilization of the Radio Frequency Channel for Color TV"—R. D. Kell and A. C. Schroeder, RCA Labs.

QUALITY CONTROL METHODS APPLIED TO ELECTRON TUBE AND ELECTRONIC EQUIPMENT DESIGN

"Use of Statistical Tolerances to Obtain Wider Limits on Tube Component Dimensions"—E. V. Space, RCA.

"Tolerance Considerations in Electronic Product Design"—R. C. Miles, Airborne Instruments Lab.

"Distribution Patterns for the Attributes of Electronic Circuitry"—R. F. Rollman and E. D. Karmiol, DuMont Labs.

"The Application of Statistics to Field Sur-

Professional Groups

A warm reception has been accorded to the Professional Groups operating within the framework of the IRE. Group membership, and the number of Groups, has grown significantly since the plan's inception in 1948. The formation of three additional Groups since last year brings the total up to 19. In line with the trend toward scientific specialization, nine Professional Groups are planning 11 special symposia on subjects of timely interest in their respective fields.

veillance of Product Performance"—R. Herd, Aeronautical Radio.
"Reliability of Electron Tubes in Military Applications"—E. F. Jahr, Aeronautical Radio.
"Dynamic Environment Testing"—D. T. Geiser, Boeing Airplane.

SEMINAR: ACCOUSTICS FOR THE RADIO ENGINEER—I

"Fundamental Theory"—L. L. Beranek, MIT.
"Microphones"—H. F. Olson, RCA.
"Loudspeakers"—H. S. Knowles, Industrial Research Products.

ELECTRON DEVICES III—MICROWAVE TUBES

"High Power Traveling Wave Tube Amplifiers"—M. Ettenberg, Sperry Gyroscope.
"Operation of the Traveling-Wave Tube in the Dispersive Region"—L. A. Roberts and S. F. Kaisel, Stanford U.
"A Traveling-Wave Electron Buncher"—R. B. Neal, Stanford U.
"Some Properties of Periodically Loaded Structures Suitable for Pulsed Traveling Wave Tube Operation"—M. Chodorow and E. J. Nalos, Stanford U.
"Experiments on Millimeter Wave and Light Generation"—H. Motz, W. Thon and R. N. Whitehurst, Stanford U.

INFORMATION THEORY I—RECENT ADVANCES

"Recent Advances in Information Theory"—L. DeRosa, Federal Telecommunication Labs.
"Radar Problems and Information Theory"—H. Davis, Airmateriel Command.
"Analysis of Multiplexing and Signal Detection by Function Theory"—N. Marchand, Marchand Electronic Labs.
"Optimum Nonlinear Filters for the Extraction and Detection of Signals"—L. A. Zadeh, Columbia U.
"Detection of Information by Moments"—J. J. Slade, Jr., S. Fich, D. A. Molony, Rutgers U.

COMMUNICATIONS SYSTEMS

"Automatic-Tuning Communications Transmitter"—M. C. Dettman, Federal Telecommunication Labs.
"Doubling of Channel Capacity of Single Sideband Systems"—C. D. May, Office of Chief Signal Officer.
"Performance of Space and Frequency Diversity Receiving Systems"—R. E. Lacy and M. Acker, Fort Monmouth; and J. L. Glaser, Bell Tel. Labs.
"Effect of Hits in Telephotography"—P. Mertz and K. W. Pfleger, Bell Tel. Labs.
"Reliability of Military Electronic Equipment and Our Ability to Maintain it for War"—A. S. Brown, Stanford Research Institute.

SYMPOSIUM: TELEVISION BROADCASTING AND UHF

"A Flexible TV Studio Intercommunication System"—R. D. Chipp and R. F. Bigwood, DuMont TV Network.
"CBS Television's Hollywood TV City: Video, Audio and Intercommunication Facilities"—R. O'Brien, R. Monroe and P. Fish, Columbia Broadcasting System.
"An Experimental Study of Wave Propagation at 850-MC"—J. Epstein and D. W. Peterson, RCA Labs.
"A Typical UHF Installation"—W. H. Sayer, Jr., DuMont Labs.
"High Power UHF Klystron Application"—A. E. Rankin, General Electric.
"High Power UHF Klystron Amplifier Design"—N. P. Hiestand, Varian Associates.

(*Continued on page* 138)

"High Power UHF Television Broadcasting Systems"—H. M. Crosby, General Electric.

MICROWAVES I—SYMPOSIUM: MANUFACTURE OF MICROWAVE EQUIPMENT

"How to Design Microwave Components for Ease of Assembly"—F. Neukirch, N.R.K. Mfg.

"The Design of Microwave Components for Production"—H. J. Riblet, Microwave Development Labs.

"Fabrication of Microwave Components Employing the Dip Brazing Process"—J. Rudolph, Glenn L. Martin.

"Electroforming with Copper, Nickel and Other Metals"—C. L. Duncan.

"Manufacturing 'Microstrip' Printed Circuit Components"—H. F. Engelman (probable speaker), Federal Telecommunication Labs.

SEMINAR: ACOUSTICS FOR THE RADIO ENGINEER—II

"Phonograph Reproducers"—B. B. Bauer, Shure Brothers.

"Tape Recording"—M. Camras, Armour Research.

"Studio Acoustics"—H. J. Sabine, Celotex.

Thursday, March 26

INFORMATION THEORY II—THEORETICAL

"Error Probabilities of Binary Data Transmission Systems in the Presence of Random Noise"—S. H. Reiger, Air Force Cambridge Research Center.

"Statistical Properties of the Output of Certain Frequency Sensitive Devices"—G. R. Arthur, Sperry Gyroscope.

"Cross-Correlation Applied to Automatic Frequency Control"—M. J. Stateman, Sylvania.

"Approximate Probability Density Function of First Level Crossing for Linearly Increasing Signal Plus Noise"—G. Preston and R. Gardner, Philco.

"A Design Criteria for the Optimum Demodulation of Generalized Modulated Signals"—F. W. Lehan, Calif. Institute of Technology.

BROADCAST AND TELEVISION RECEIVERS—I

"Gain Stable Mixers and Amplifiers with Current Feedback"—G. E. Boggs, National Bureau of Standards.

"Video Amplifiers with Instantaneous Automatic Gain Control"—W. E. Ayer, Stanford U.

"An Automatic Level-Setting Sync and ACC System"—E. O. Keizer, RCA Labs., and M. G. Kroger, Motorola.

"Packaged Adjacent Channel Attenuation for Television Receivers"—J. P. Van Duyne, DuMont Labs.

"Methods of Matrixing in an NTSC Color Television Receiver"—W. M. Quinn, General Electric

MICROWAVES II—DISTINCONTINUITIES AND TRANSITIONS

"R-F Measurements on Metallic Delay Media"—S. B. Cohn, Sperry Gyroscope.

"Impedance Measurement in a Circular Waveguide with TE_{01} Excitation"—L. S. Sheingold, Sylvania.

"Experimental Determination of the Properties of Microstrip Components"—M. Arditi Federal Telecommunication Labs.

"A Wideband Transition Between Waveguide and Coaxial Line"—N. A. Spencer and H. A. Wheeler, Wheeler Labs.

"A Contribution to the Ridge Guide Problem"—B. A. Lengyel, Hughes Aircraft.

RADIO TELEMETRY

"Telemetering Requirements for Upper Air Rocket Research Experiments"—M. O'Day, Air Force Cambridge Research Center.

"Telemetering—Broad Band on Short Order"—T. F. Jones, Jr., General Electronic Labs.

"Flutter Compensation for FM/FM Telemetering Recorder"—J. T. Mullin, Bing Crosby Enterprises.

"A Magnetic Tape Recording System for Precision Data"—L. L. Fisher, Ampex Electric.

"An Improved FM/FM Decommutator Ground Station"—F. N. Reynolds, Ralph M. Parsons Co.

"Some Industrial Applications of Telemetry" —F. N. Stephens, Midwest Research Institute, and L. Bergren, Great Lakes Pipe Line Co.

AUDIO

"Sound Reinforcement System, General As-

sembly, United Nations"—L. L. Beranek, MIT, and C. W. Goyder, United Nations.
"A Variable Time Delay"—K. Goff, MIT.
"A Flux Sensitive Head for Magnetic Recording Play Back"—D. E. Wiegand, Armour Research.
"Uniaxial Microphone"—H. F. Olson, J. Preston and J. C. Bleazey, RCA Labs.
"Sound Pressure Measurement Between 50 and 220 BD"—J. K. Hilliard, Altec Lansing.

ENGINEERING MANAGEMENT

"Report of Year's Activities by the Chairman of the Professional Group on Engineering Management"—R. I. Cole, Rome Air Development Center.
"General Problems of Engineering Management Facing the Electronics Industry"—H. Pratt, Telecommunications Advisor to the President.
"Research and Development Problems of Engineering Management in the Electronics Industry"—M. J. Kelly, Bell Tel. Labs.
"Production Aspects of Engineering Management in the Electronics Industry"—W. A. McDonald, Hazeltine.
"What the Military Services Expect from Engineering Management of the Electronics Industry"—D. L. Putt, Air Research and Development Command.

INFORMATION THEORY III—CODING

"A Necessary and Sufficient Condition for Unique Decomposition of Coded Messages"—A. A. Sardinas and G. W. Patterson, Burroughs Adding Machine.
"A Systematic Survey of Coders and Decoders"—B. Lippel, Fort Monmouth.
"Method for Time or Frequency Compression-Expansion of Speech"—G. Fairbanks, W. L. Everitt and R. P. Jaeger, U. of Illinois.
"A New Coding System for Pulse Code Modulation"—A. G. Fitzpatrick, Burroughs Adding Machine.
"Coincidence Detectors for Binary Pulses"—C. Gates, Calif. Institute of Technology.

BROADCAST AND TELEVISION RECEIVERS—II

"Factors Affecting the Design of VHF-UHF Tuners"—E. H. Boden, Sylvania.
"Theory of A. F. C. Synchronization"—W. J. Gruen, General Electric.
"Standardization of Printed Circuit Materials for Mechanized Radio Assembly"—W. Hannahs, J. Caffiaux and N. Stein, Sylvania.
"A Color TV Receiver for the NTSC System"—K. E. Farr, Westinghouse.
"A Simple Pickup Camera Attachment for Television Receivers"—V. K. Zworykin, L. E. Flory and W. S. Pike, RCA Labs.

MICROWAVES III—FERRITES AND DETECTORS

"Space Charge Detector for Microwaves"—A. B. Bronwell, J. May, C. Nitz, T. C. Wang, and H. Wachowski, American Society for Engineering Education.
"Low Level Synchronous Mixing"—M. E. Brodwin, C. M. Johnson, Johns Hopkins U., and W. M. Waters, Bendix Radio.
"Guided Wave Propagation Through Ferrites and Electron Gases in Magnetic Fields"—L. Goldstein, M. Gilden, and J. Etter, U. of Illinois.
"Cavities with Complex Media"—A. D. Berk and B. Lax, MIT.
"Resonance in Cavities with Complex Media"—B. Lax and A. D. Berk, MIT.

REMOTE CONTROL SYSTEMS

"The Organization of a Digital Real Time Simulator"—H. J. Gray, Jr., U. of Pennsylvania.
"Control System Engineering Applied to Suspension Systems"—C. J. Martin, R. Jeska and E. B. Therkelsen, U. of Michigan.
"Experimental Evaluation of Control Systems by Random-Signal Measurements"—W. W. Seifert, MIT.
"Extension of Conventional Techniques to the Design of Sampled-Data Systems"—W. K. Linvill and R. W. Sittler, MIT.
"Generalized Servomechanism Evaluation"—W. P. Caywood and W. Kaufman, Carnegie Institute of Technology.
"Method for Reducing the Forced Dynamic Error of Closed-Loop Systems"—L. H. King, MIT.

BOOKS

Filter Design Data for Communication Engineers

By J. H. Mole. Published 1952 by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. 252 pages. Price $7.50.

It would be surprising if this handbook on filter design did not receive a warm reception from engineers engaged in circuit design. This is a practical book, no effort being made to explain theoretical principles. As such, it should relieve the practical engineer of much of the labor that is often spent on routine calculations. The volume contains 127 drawings and charts, and 56 tables, many giving specific design examples. Chapters 1 through 7 cover the familiar symmetrical and dissymmetrical filters, impedance transformation, losses and terminal sections. Chapter 8, on Tchebycheff behavior of stop-band attenuation, is of notable interest. Chapters 9 through 12 include the effects of dissipation, tolerances, tables of useful functions, and simpler filters. AJF

Dictionary of Conformal Representations

By H. Kober. Published 1952 by Dover Publications, Inc., 1780 Broadway, New York 19, N.Y. 224 pages. Price $3.95.

The use of conformal transformations is a significant aid in simplifying the analysis of two-dimensional electric and magnetic fields. Difficult problems become more amenable to solution because the actual coordinates are represented by an equivalent system which permits the field's characteristics to be compared with familiar geometries.

This handy reference should be of inestimable aid, not only to the electrical engineer, but to the aerodynamicist and physicist as well. Incorporating 447 diagrams, the book contains a large number of transformations which are classified according to their analytic functions. These time-saving setups should eliminate much of the laborious work involved in deriving a particular configuration. Of notable value are the linear, bilinear and Schwartz-Christophel transformations. This unique volume, originally prepared for the British Admiralty, effectively fills the need for an aid in solving Laplace's equation in two dimensions, and is highly recommended. AJF

Advanced Antenna Theory

By Sergei A. Schelkunoff. Published 1952 by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. 216 pages. Price $6.50.

The engineer and mathematician engaged in antenna work should find this authoritative work a valuable addition to their collections of technical books. Of necessity, this is a somewhat sophisticated book, the problems of advanced antenna theory often being of an inherently complex nature. The primary contribution of this work is the concise presentation of mathematical methods for solving antenna problems, including material which has not been published previously. Where possible, the author stresses the resemblance and compatibility with established circuit theory.

The book is divided into six main sections. Part 1, discussing spherical waves, covers Maxwell's equations, transmission lines and other "groundwork" material. Part 2, covering mode theory of antennas, is the core of the work and makes up one-third of the volume. Included are the author's theory of conical antennas and thin antennas of arbitrary shape. The remaining sections encompass spheroidal antennas, integral equations, cylindrical antennas, and natural oscillations. Inserted between the main text and appendixes are 44 interesting problems and their answers, rounding out a highly instructive and reasonably comprehensive volume. AJF

BOOKS RECEIVED

Television Factbook No. 16

Edited by Martin Codel and staff. Published 1953 by Television Digest, Wyatt Bldg., Washington 5, D. C. 268 pages. Price $3. Compilation contains directory of post-freeze TV stations and applications, markets, statistics, manufacturers, personnel, trade associations, publications, and map of network interconnections.

Proceedings of the National Electronics Conference—1952

Vol. 8, National Electronics Conference, 852 E. 83rd Street, Chicago 19, Illinois. 835 pages, Charts, Diagrams, Tables, 9¼ by 6¼ inches, case bound, $5.00. This book contains all of the 97 technical papers presented at the 1952 conference covering electronic research, development, and application in antennas, the assembly and measurement of components, audio, circuits, coding and recording techniques, computers, delay lines and HF test equipment, electronic instruments, engineering management, industrial measurements, magnetic amplifiers, memory tubes, radar, radio navigation, reliability of components and equipment, semiconductors, servomechanism, television, transistors, and waveguides. Volumes 2, 4, 5, 6 and 7 for previous conferences may also be obtained for $5.00 per copy.

Radioactivity Measures Semiconductor Impurities

The use of radioactivity methods has greatly accelerated research in semiconductor materials used in transistors, according to Dr. George H. Morrison of Sylvania Electric Products Inc. It is possible to measure impurities of one part in 100 million by radioactivity methods in germanium. Conventional chemical methods of measurements are ineffective at these extremely low concentrations.

Containers, called boats or crucibles, made of the purest available graphite, are irradiated with neutrons in the nuclear reactor at the Brookhaven National Lab. The containers are then used in the melting of the germanium metal. The small amounts of radioactive impurities in the container are transferred to the germanium during the melting process. The amounts transferred may be determined by the standard methods of measuring the intensity and rate of decay of the radioactive emission.

CR Tube Presentations

(*Continued from page 90*)

from 1.4 to 3.0 for various P7 phosphor screen compositions and processing. For RCA screen material having a ZnS to CdS composition ratio of 82 to 18, the accelerating voltage exponent was determined experimentally as 2.5 for accelerating potentials in the range 1.5 to 6.0 kv. This figure will be used.

Having calibrated the various nonlinearities which limit the peak brightness of the pip it is now possible to calculate peak brightness. However, the mere multiplication of the light per excitation by the number of excitations per second will not give the amount of light emitted per second nor average brightness. It is necessary to modify an expression which defines saturation brightness for conditions of repetitive pulse excitation. The peak brightness reached during one target scan can be obtained by multiplying CRT brightness by the buildup factor obtained from Fig. 6, but during the remainder of the frame time no more pulses will be received to excite the same spot on the CRT phosphor and the brightness will decay according to the curve of Fig. 3. Since the major part of the light energy is contained under the exponential curve having an α of -1, this approximation was used to calculate the curve of Fig. 7 which shows the relationship between target scans per second and the total light output. The total light output can be obtained by multiplying the peak brightness by the Scans per Second Factor, S, derived from Fig. 7. This factor varies from a very low value at low scan or frame rates to near unity at ten or more scans per second.

The total light energy and hence the visual stimulation of a radar presentation as a function of time and radar parameters can now be written. Since this expression is a measure of the visual stimulation derived from a radar system CRT presentation, it can also be considered as a radar system presentation quality factor for comparison with other radar systems.

$$\text{Effective Pip Brightness} = 19.8(10^{-9})\ IE^{2.5}FBS \text{ Foot Lamberts Effective}$$

where $19.8(10^{-9})$ is a constant characteristic of the P7 phosphor

I is effective CRT screen current density in $\mu a/cm^2$ derived from Fig. 4.

E is CRT final anode accelerating voltage, volts

F is the Excitation Time Brightness Factor, from Fig. 5

B is Brightness Buildup Ratio from Fig. 6

S is the Scans per Second Factor from Fig. 7

Having arrived at the effective brightness of the radar presentation it is now necessary to consider those factors which degrade the ability of the observer to see the pip, namely, receiver noise, background light and size of the pip and presentation.

Subjective tests indicate noise level, from whatever source, adversely affects perception time in two ways. It increases the average field brightness of the CRT, thus decreasing contrast ratio, and it clutters up the presentation resulting in considerable confusion to the operator. Under conditions of low ambient light, noise brightness about two-thirds pip brightness, and noise pips the same physical size as signal pips, perception time with noise increases by a factor of two on a 1-in. presentation and by a factor of more than seven on a 6-in. presentation. Since the resultant deterioration of CRT intelligence perception due to noise is considerably dependent upon a particular radar system and upon the method of utilizing the receiver signal for the CRT display, it is not possible to take noise into consideration in a general formula for perception time. Needless to say, its effects should be reduced to a minimum by the best techniques available.

The light reflected from the CRT phosphor is equal to the brightness of the ambient light, A, times the coefficient of reflectivity of the CRT phosphor. In optics, contrast ratio is expressed as the difference between the brightness of the object and the brightness of the background, divided by the brightness of the object. On the CRT the "object" is a pip whose intensity is equal to the phosphor brightness, P. plus the reflected ambient light brightness, Ar where r is the coefficient of reflectivity of the phosphor. When incident light falls on the CRT face plate at an angle, θ, then the effective incident light is A sin θ, and the reflected light is Ar sin θ and

$$\text{Contrast Ratio} = \frac{P}{P + Ar \sin\theta}.$$

Contrast ratio is a major factor in determining what can be seen and the time necessary to see it. Although it is recognized that the ability to see also depends upon the absolute brightness of the pip and its background, in radar displays the range of brightness of the pip encountered in normal displays is not very great and hence as a close approximation it is possible to use

(*Continued on page* 144)

contrast ratio as a single criterion and plot a series of empirical curves as shown in Fig. 8. In this figure, perception time in seconds is plotted as a function of contrast ratio. The figures on the curves 1, 2, 4, etc. indicate the distance in inches between the spot where the operator is concentrating his attention and the spot where the pip appears. In the extreme case this distance is the display size. It will be noted that perception time, at low contrast ratios, increases very rapidly as the display size increases. Since perception time, in itself, is difficult to measure, the perception times of Fig. 8 also contain an average reaction time of 400 milliseconds.

The relative ability of the observer to see pips of various sizes was investigated and it was found that, at viewing distances of 14 in. and at constant brightness, pip size in the range 0.06 to 0.50 in. had no appreciable effect on seeing time or the ability to see. This situation held for viewing distances of 14 in. or less, whereas at viewing distances greater than 20 in. the optical "visual angle" effect became prominent.

Using the method of display evaluation described in this study, the brightness and perception time of several modern radar equipments was calculated and then measured. In all cases, for both search and track mode, the calculated results agreed with the measurements within a maximum error of 25% provided care was taken to obtain accurate radar system characteristics. Typical values for pip brightness were: in search mode—1.5FL; in track mode—9 FL. Since the radar systems used to check the formula had widely different characteristics, it is assumed that good results will be obtained on present and contemplated radar systems in general.

The work described in this paper was performed on Air Force Contract AF33 (038) 23309. The author wishes to express his appreciation to his colleague, H. S. Jackson[6], who was responsible for much of the subjective testing.

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5. Soller, Starr, and Valley, *Cathode-Ray Tube Displays*, Radiation Laboratory Series, McGraw-Hill Book Co., 1948.
6. Jackson, H. S., "Investigation of the Effect on Seeing Time of Brightness, Pip Spacing and Noise on CRT Displays," Contract AF33(038) 23309.

This paper was first presented at the National Electronics Conference held in Chicago, Sept. 29-Oct. 1, 1952.

Transistor Oscillator

(*Continued from page* 93)

Determinations of the frequency stability with changes in temperature and supply voltage have indicated that the frequency varies approximately 1 part in 10^8 per degree C, and 1 part in 10^8 per 0.10 volt. The transistor oscillator was also compared with the standard oscillators controlling the transmissions of WWV. Short time variations were about ± 3 parts in 10^{10} and the long interval drift—in days—indicated changes of about 3 parts in 10^9 per 24 hours. These figures are comparable to those obtained from vacuum tube standard oscillators, particularly at the time of their initial installation. Fortunately, frequency drift in the quartz-crystal unit of a conventional type standard oscillator normally decreases with age. It should also be noted that because the transistor oscillator has just recently been developed, no data exist in regard to long-time stability in terms of years.

The compactness of the transistor oscillator lends itself to more convenient and portable temperature control measures. Heretofore standard quartz oscillators[1] or quartz clocks have required relatively complex temperature control apparatus (operating at temperatures up to 60°C) and special high-reliability power sources.

Tests were conducted on the new transistor oscillator with the complete unit operating at 0°C. Reasonable temperature stability was achieved by merely placing the oscillator in a Dewar flask containing crushed clear ice. Among the results was an indication that the reduced temperatures were responsible for reducing drift and increasing the Q of the quartz crystal unit. Thus, it now becomes possible to make available a readily-portable continuously-oscillating frequency standard.

[1] High stability quartz crystal unit for frequency standards, J. P. Griffin, *Bell Lab. Record 30*, No. 11 (1952).

New NARTB Seal

New NARTB Seal of Good Television Practice contains address of Television Code Board to enable viewers to write in comments on those programs they consider objectionable.

News of MANUFACTURERS' REPS

I. R. Ross, president of Credda, Inc., national distributors of electronic and aeronautical equipment, has formed a new company, Ross Associates, 19 W. 26 Street, New York, N. Y., which is representing manufacturers of electronic equipment nationally.

Staver Co., Inc., Bay Shore, L. I., N. Y., manufacturer of tube shields and other electronic components, has announced the appointment of The Frank A. Emmet Co., 2837 W. Pico Boulevard, Los Angeles, Calif. as the company's west coast rep.

Helipot Corp., South Pasadena, Calif., has appointed J. S. Root, 290 Lawrence Ave. West, Toronto 12, Ont., Canada, as its factory representative for the Dominion. Bivens and Caldwell, Security Bank Building, High Point, N. C., has also been appointed Helipot representative for Tennessee, North and South Carolina, Kentucky, Georgia and Alabama.

Bittan-Shafer Sales Co., manufacturers' representatives of electronic parts, television and radio has been formed by Harry Bittan and Peter Shafer with offices and showroom at 120 Liberty St., New York, N. Y. Sales activities will cover the metropolitan New York and northern New Jersey area.

Dan J. Connor Co. is now occupying new and larger offices at 1346 Suburban Station Building, Philadelphia 3, Pa.

Ram Electronics Sales Co., producer of test-pattern tested flybacks, deflection yokes, width and linearity coils, and other components for television, has announced the appointment of Stan Cluphf & Assoc., 4265 Santa Fe Drive, Littleton, Col., as sales reps for the territory of Colorado, Utah, Wyoming, Montana, New Mexico.

Pinkney & Hine, 522 Plymouth Building, Minneapolis, Minn., is the new selling agency for technical products of Allen B. DuMont Laboratories, Inc. in North and South Dakota, Minnesota, Northern Wisconsin and the Michigan Peninsula area.

Harold A. Moyer, formerly assistant sales manager of the Astatic Corp., has announced his entry into the manufacturer's representative field. He will handle several accounts from the late Ray Schottenberg and will cover the middle Atlantic area. Present address is P. O. Box 14, Haddonfield, N. J.

Samuel C. Hooker, 397 Highland Ave., Winchester, Mass., has been appointed sales representative in the New England States for the Hammarlund Manufacturing Co., Inc., of New York City.

Stanley K. Wallace Sales Agency of Lutz, Fla., whose activities cover the states of Alabama, Florida, Georgia, Mississippi, North & South Carolina, Tennessee and Virginia, have relinquished all automotive lines. Henceforth, all sales activities will be concentrated on electronic lines.

Crosstalk

(*Continued from page 81*)

sible to include some unbalanced circuits in the system, provided the level is not too high, although this is always a rather dangerous practice. The main unbalanced circuits in the C.B.C. installation were firstly the main switching system itself, which was equipped with repeating coils on both inputs and outputs so that the area of unbalance could be strictly localized, and secondly, the cueing system in which the unbalanced circuits made the trip down to the distribution frame and back without apparently causing any trouble, but this must be regarded

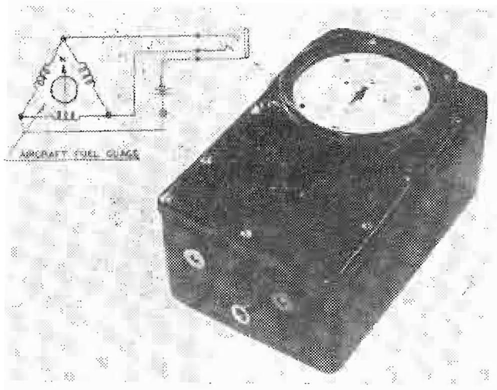


Fig. 5: The "Whiffiedink" is a differential ohmmeter for detecting grounded conductors

more as good luck than good management. In all cases where unbalanced circuits are used, considerable care must be taken in laying out the common ground in order to reduce to a minimum the area of any loops formed. In general, the program and ground leads should be be carried along together wherever possible.

Of the 180 amplifiers in the Master Control Equipment, all but five have bridging inputs, with impedances in the range between 15000 and 20000 ohms. At first, this was attained by the use of series resistors in each leg of the input circuit, feeding a 5000 ohm winding on the input transformer. As this winding was neither center tapped nor shielded, this arrangement caused a great deal of trouble, which was not cured until the wiring had been changed to provide a 20,000 ohm winding, without any series resistors. Another possible source of crosstalk in installations which include several amplifiers is magnetic pickup from the output transformer of one amplifier to the input transformer of another. This can be avoided either by adequate magnetic shielding, or by the adoption of humbucking construction or both.

To conclude this brief survey of ways of avoiding crosstalk, we may indicate the results which were

(*Continued on page 167*)

PERSONAL

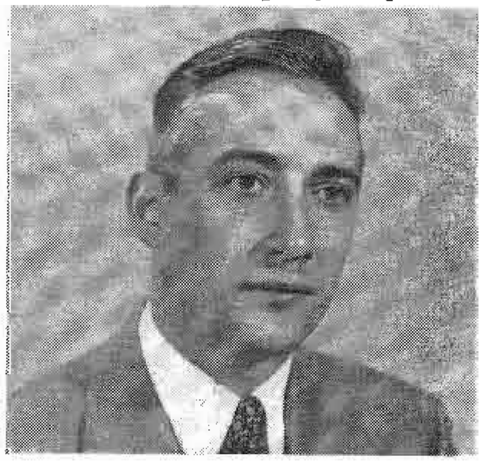
Leslie Norde has joined the Hammarlund Manufacturing Co., Inc. of New York City as chief receiver engineer. He was formerly senior project engineer at Northern Radio Corp.

Arthur L. Chapman has assumed the newly-created post of vice president in charge of electronics operations of Sylvania Electric Products, Inc. He will be responsible for the operations of Sylvania's radio and television, parts, electronics, radio tube and television picture tube divisions.


Arthur L. Chapman

Terrell W. "Tex" Kirksey has been named chief engineer of KDUB-TV, new DuMont equipped station in Lubbock, Texas. He was formerly a sales engineering consultant for Allen B. Du Mont Laboratories, Inc. in the Southwest.

Henry F. McKenney has been named chief engineer of the Ford Instrument Co., division of the Sperry Corp. Formerly he specialized in airborne equipment and holds four patents with eight more pending on magnetic amplifiers, servomechanisms and electronic equipment.


Henry F. McKenney

John Silver, general manager of Motorola's communications and electronics division, has been named vice-president in charge of operations, communications and electronics division. He came to Motorola in 1944 and was appointed general manager of communications and electronics in 1949. Prior affiliations included 12 years in engineering with Crosley Radio Corp., and several years as chief production engineer for Collins Radio Co., Cedar Rapids, Iowa.

Henry Fogel, formerly manager of commercial products division for the Radio Receptor Co., Inc., has been appointed president of Granco Products, Inc., 36-17 20th Ave., Long Island City 5, N. Y. The company was recently organized for the design, manufacture and distribution of converters for ultra high frequency television reception and UHF measuring instruments.

R. W. Clark who has been appointed director of engineering for KONA-TV at Honolulu, has been associated with NBC radio and television networks for the past 22 years. In 1945, he was TV operations supervisor for NBC in New York. In 1948, he was transferred to Hollywood to become manager of NBC's television technical operations and to put KNBH television on the air.

Leonard A. Rooney has been appointed manager of communication equipment sales of Raytheon Manufacturing Co., Waltham, Mass. He will be responsible for all sales of Raytheon communication and television microwave link equipment.

Leonard A. Rooney

Matthew T. Lebenbaum has been appointed supervisor of the newly formed applied electronics section in the research and engineering division of Airborne Instruments Laboratory, Inc., Mineola, L. I., N. Y. Peter D. Strum has been appointed assistant supervising engineer of the new section.

L. E. Ashman has been elected president and a director of Air Associates, Inc., 25-year old firm manufacturing aircraft parts and special purpose electronic equipment. Previously, he was executive vice president of the Rockwell Mfg. Co.

William A. Damerel has been appointed vice president of La Pointe Electronics Inc. **Milby M. Hancock**, formerly general manager of the concern, has been elevated to the position of assistant to the president.

Robert J. Rorden has been appointed chief engineer for Gertsch products, Inc., Los Angeles. Previous affiliations were with Point Mugu government projects and Dalmo Victor Co., San Carlos.

Junction Transistors

(Continued from page 99)

each millampere of emitter current provides 23 ma/volt of control. It is apparent that careful stabilization of the operating point is required in order to utilize the transistor capabilities. For comparison, vacuum tubes have a theoretical transconductance-to-cathode current ratio of 11.6 although in practice this ratio is generally smaller than 1.

The manner in which the transconductance of the transistor varies with base-to-emitter voltage is shown in Fig. 7 which may be compared mentally with vacuum-tube transconductance curves. It is seen

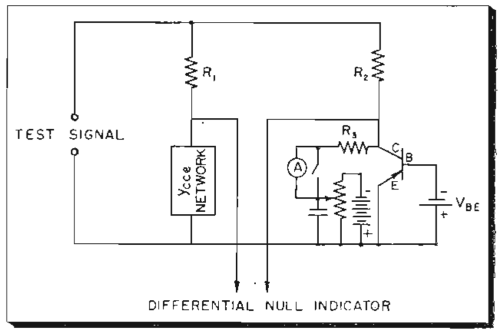


Fig. 9: Output admittance bridge test set

that the transconductance has attractively large values. Returning to Fig. 6, a few other quantities in connection with this transistor are of interest. The forward current amplification factor is −43.6; the forward voltage amplification factor is −2,520; and the forward power amplification factor is 27,600. The reverse current amplification factor is 0.085, the reverse voltage amplification factor is 1.48×10^{-3}, and the reverse power amplification factor is 31.4×10^{-6}. As a matter of interest in so far as the application of this transistor is concerned, if both input and output are matched for maximum power amplification, the input resistance is 438 ohms and the output resistance is 25,300 ohms. The maximum forward power amplification is 40 db.

Medium-Frequencies

As indicated before, the reactive effects of a junction transistor become significant at medium frequencies. It is therefore important to measure the admittance parameters as a function of frequency. This can be done by means of bridge circuits in which both real and reactive components are balanced and measured. For laboratory purposes, it has been convenient to build four separate bridges rather than to build one equipment as was the case for the General Radio Co. vacuum-tube bridge. The general arrangement for the y_{bbe} admittance bridge is shown in Fig. 8. It is seen that this is a conventional bridge arrangement with an unbalanced signal source and a balanced null indicator. R_1 and R_2 need not be equal, but it is generally convenient to make them identical in which case the values of the y_{bbe} network elements will be the same as the transistor values. R_3 can generally be chosen large enough so that it has negligible effect on the bridge measurement. If desired, it too can be balanced out by connecting an identical resistor in the y_{bbe} network. The y_{cce} admittance bridge is similar to the y_{bbe} admittance bridge and is shown in Fig. 9. The same comments made concerning the y_{bbe} admittance bridge apply for the y_{cce} admittance bridge.

The y_{cbe} admittance bridge shown in Fig. 10, since it measures transfer admittance rather than self admittance, is somewhat different from the preceding two bridges. In the y_{cbe} admittance bridge, a test signal is introduced between the base and emitter of the transistor. This signal gives rise to a collector current which produces a signal across R_1. Since there is a phase reversal through the transistor, the signal across R_1 can be balanced out by introducing a current directly from the test signal through a suitably

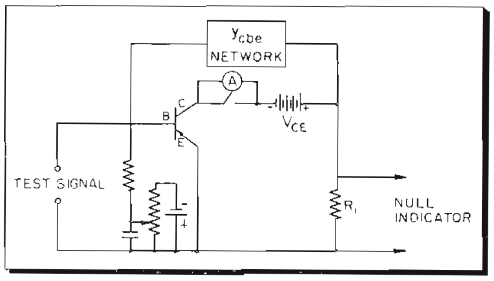


Fig. 10: Forward transfer admittance bridge

y_{cbe} network. The y_{cbe} network is adjusted until no signal appears across R_1 at which time the collector is short-circuited and y_{cbe} is given by the value of the y_{cbe} network elements. The y_{bce} admittance bridge shown in Fig. 11 is similar to the y_{cbe} admittance bridge. The main difference is that the short-circuited base current is in-phase with the collector-to-emitter voltage so that an accurately balanced test signal is required in order to operate the bridge.

The bridge admittance networks can consist of a resistive and a reactive element for point-by-point measurements. It is sometimes possible to have the admittance network approximately duplicate the transistor admittance in which event, the admittance network is a correct representation over a large frequency range. For this type of meas-

(*Continued on page* 157)

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Coming Events

See also "Stellar Events" on opposite page

March 10-11—SPI Annual Conference, Canadian Chapter, General Brock Hotel, Niagara Falls, Canada.

March 18-20—ASTE 21st Annual Meeting, Statler Hotel, Detroit, Mich.

March 19-20—NCIG Conference on Instrumentation, Michigan State College, E. Lansing, Mich.

March 23-26—IRE National Convention, Grand Central Palace & Waldorf-Astoria Hotel, New York, N. Y.

April 12-16—Electrochemical Society, International Meeting, New York, N. Y.

April 18—Cincinnati Section, IRE, Seventh Annual Spring Technical Conference, Cincinnati, Ohio.

April 20-22—MPA, 9th Annual Meeting, Cleveland, Ohio.

April 23-24—IRE Prof. Group on Circuit Theory, International Symposium on Nonlinear Circuit Analysis, Engineering Societies Bldg., New York, N. Y.

April 26-30—SMPTE 73rd Convention, Hotel Statler, Los Angeles, Calif.

April 28-May 1—7th Annual NARTB Broadcast Engineering Conference, Burdette Hall, Philharmonic Auditorium, Los Angeles, Calif.

April 29-May 1—Electronic Components Symposium, Shakespeare Club, Pasadena, Calif.

May 11-13—IRE, National Conference on Airborne Electronics, Dayton Biltmore Hotel, Dayton, Ohio.

May 18-21—Electronic Parts Show, Conrad Hilton Hotel, Chicago, Ill.

June 9-11—2nd International Aviation Trade Show, Hotel Statler, New York, N. Y.

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

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

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

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

AES: Audio Engineering Society
AIEE: American Institute of Electrical Engineers
ASTE: American Society of Tool Engineers
IRE: Institute of Radio Engineers
ISA: Instrument Society of America
MPA: Metal Powder Assoc.
NARTB: National Association Radio and Television Broadcasters
NCIG: National Collegiate-Industry-Government
SMPTE: Soc. of Motion Picture and TV Engineers
SPI: Society of the Plastic Industry

New Special Effects Firm

A new firm for handling TV special effects equipment has been formed. Special Effects & Equipment, Inc., 418 W. 54 St., New York 19, N. Y., will provide products and services to stations, film producers and agencies. SEE formerly constituted the special effects division of Audio & Video Products Corp., but is presently not connected with that company.

Stellar Electronic Events Ahead

The striking graphic display on the front cover might well be called the Constellation of the Electronic Industries, for it represents the numerous organizations whose efforts chart the course of the industry and guide its future growth. As is explained on page one, the following list (tracing the stars on the cover from top to bottom) presents in detail the names, their contractions, and primary meetings scheduled for the stellar groups.

APCO—Associated Police Communication Officers —National Conference, Aug., 1953

PMA—Phonograph Manufacturers Assoc., Inc.—Annual Meeting, July 9, 1953

AES—Audio Engineering Society—5th Annual Convention & Audio Fair, Oct. 13-16, 1953, Hotel New Yorker, New York City

REPS—The Representatives — National Meeting, May, 1953, Conrad Hilton Hotel, Chicago

IAS—Institute of the Aeronautical Sciences, Summer Meeting, July 15-16, 1953, Los Angeles

ASA—American Standards Assoc. — National Meeting, Oct. 19-21, 1953 Waldorf-Astoria Hotel, New York City

ASTM—American Society for Testing Materials—Annual Meeting, June 27-July 3, 1953, Chalfonte-Hadden Hall, Atlantic City, N. J.

RIAA—Record Industry Assoc. of America—Annual Meeting, Feb. 1954

NEC—National Electronics Conference—9th National Conference, Sept. 28-30, 1953, Hotel Sherman, Chicago

RTMA—Radio and Television Manufacturers Assoc. —Annual Convention, June 15-18, 1953, Palmer House, Chicago

AFCA—Armed Forces Communications Assoc.—7th Annual Convention, May 14-16, 1953, Dayton, Ohio

IRE—Institute of Radio Engineers—National Convention and Show, March 23-26, 1953, Waldorf-Astoria Hotel and Grand Central Palace, New York City

ISA—Instrument Society of America—8th National Conference and Exhibit, Sept. 21-25, 1953, Hotel Sherman, Chicago

RCA—Radio Club of America—Annual Banquet, Dec. 1953

WCEMA—West Coast Electronic Manufacturers Assoc.—Western Electronic Show and Convention, Aug. 19-21, 1953, Municipal Acditorium, San Francisco

NEDA—National Electronic Distributors Assoc.—4th Annual Convention, Sept. 14-17, 1953, Chase Hotel, St. Louis, Mo.

NARTB—National Assoc. of Radio and Television Broadcasters—7th Annual Broadcasting Engineering Conference, April 28-May 1, 1953, Philharmonic Auditorium, Los Angeles

AIEE—American Institute of Electrical Engineers—Summer General Meeting, June 15-19, 1953, Atlantic City, N. J.

SMPTE—Society of Motion Picture and Television Engineers—73rd Convention, April 27-May 1, 1953, Hotel Statler, Los Angeles

AFCCE—Association of Federal Communications Consulting Engineers

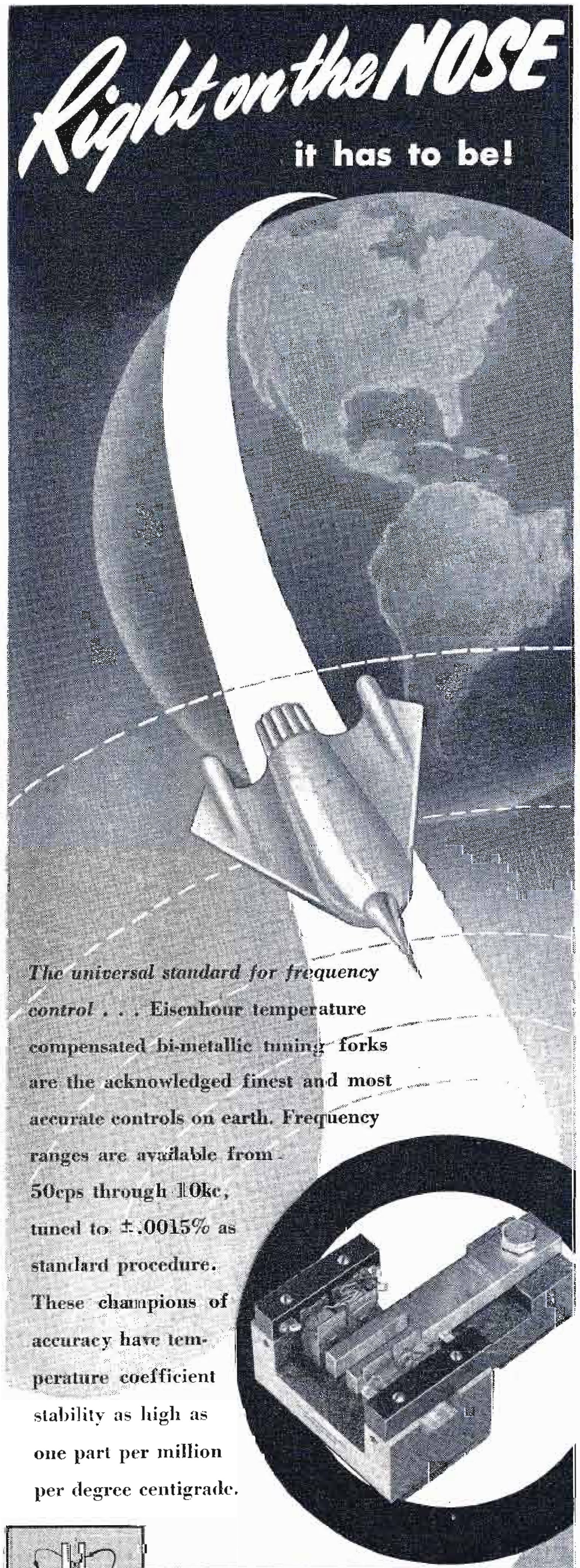
ACM—Assoc. for Computing Machinery—Computer Conference, Dec. 1953

NAED—National Assoc. of Electrical Distributors—45th Annual Convention, May 24-28, 1953, Conrad Hilton Hotel, Chicago

NEMA—National Electrical Manufacturers Assoc.—National Convention, Nov. 9-12, 1953, Haddon Hall Hotel, Atlantic City, N. J.

NSPE—National Society of Professional Engineers —Annual Meeting, June 18-20, 1953, Shearton-Plaza Hotel, Daytona Beach, Fla.

ES—Electrochemical Society—International Meeting, April 12-16, 1953, Statler Hotel, New York City



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Only alphabetical and geographical directory of manufacturers' representatives selling electronic components and engineering equipment. Annual section of regular issues of *Television Retailing* and *Tele-Tech.*

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Junction Transistors

(*Continued from page* 151)

urement, it is convenient to have a square-wave or a swept-frequency test signal so that the correct balance can be easily ascertained.

If desired, bridges can be designed for the determination of the current and voltage amplification factors, but these bridges are not necessary since these quantities can be computed from the nodal admittance parameters.

After the four nodal admittances have been determined the performance of the transistor can be predicted at any frequency desired. In many publications, the frequency performance of the transistor has been cited in terms of the frequency characteristics of the current amplification factor. This is not a good index since as mentioned before, the voltage amplification factor is of equal importance. As a matter of fact, the frequency characteristics of α_{cb} will generally give a pessimistic aspect to the frequency performance of the transistor. On the other hand, the frequency characteristics of α_{ce} will give an overly optimistic aspect of the frequency performance of the transistor.

Power Amplification

The only real criterion of the frequency performance of a transistor is the variation of the power amplification. For maximum power amplification the conjugate admittance match equations are as shown in Table III. The important thing to note in these equations is that the

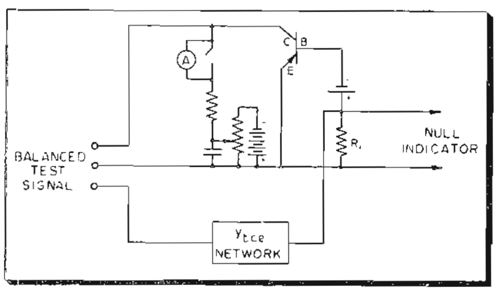


Fig. 11: Reverse transfer admittance bridge

forward power amplification is proportional to the forward power amplification factor. This factor can therefore be used to considerable advantage as a simple single index of the frequency performance of the transistor. The forward power amplification factor in turn is proportional to the square of the magnitude of the forward transfer admittance, y_{cbe}, so that this nodal parameter, the complex transconductance, will play an important part in establishing the performance of the transistor.

Although considerable attention has been focused upon transit-time effects in the junction transistor, at the moment, this is not the limiting factor in its frequency performance. It is relatively easy to construct junction transistors with sufficiently small base dimensions so that transit-time effects are not important up to several megacycles per second. In contrast, unless special precautions are taken, reactive effects in the junction transistor may be quite significant at several kilocycles per second.

By means of detailed measurements of the admittance parameters of junction transistors a clear picture of their operation can be obtained. In particular, these measurements point out the construction factors that now limit frequency performance. By this approach, junction transistors have been made at the RCA Laboratories with improved frequency performance. These improved junction transistors give significant power amplification to over 10 MC.

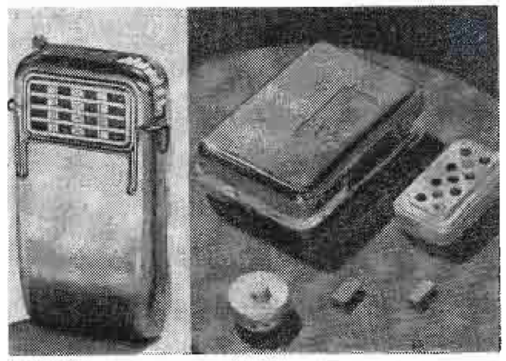
This paper presented at the National Electronics Conference held in Chicago, Sept. 29—Oct. 1, 1952.

[1] For additional details see L. J. Giacoletto, "Junction Transistor Equivalent Circuits and Vacuum Tube Analogy," *Proceedings of I.R.E.*, pp. 1490-1493 November, 1952. N.B. Figs. 1, 2, 3, 4, 6 and 7 are taken from this article.

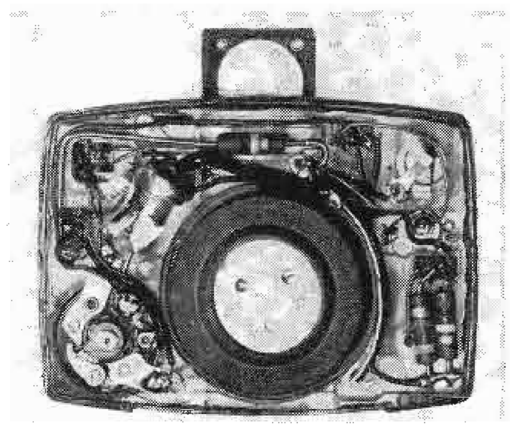
[2] R. R. Law, C. W. Mueller, J. I. Pankove, and L. D. Armstrong, "A Developmental Germanium P-N-P Junction Transistors," *Proceedings of I.R.E.*, pp. 1352-1357, November, 1952.

Hearing Aids Switch to Transistors

The hearing aid industry is turning to transistors to replace vacuum tubes. It is predicted that the aids will increase from 1,000,000 units now in use to several million because of the better performance and economy made possible with transistors. Most important, the "B" battery and excessive drain have been eliminated, bringing annual battery replacement cost from $40 down to $3. Tiny mercury batteries with 2000-hour life are selling for $0.65, or about 30 hours of operation for one cent. Other features include elimination of microphonics, increased gain (63 to 70 db at 1000 CPS), small volume (3.3 cu. in.), light weight (2.8 to 3.75 oz.), high saturation output (122 to 138 db), and low distortion (under 2%). A representative unit, one made by E. A. Myers & Sons, sells for $285.

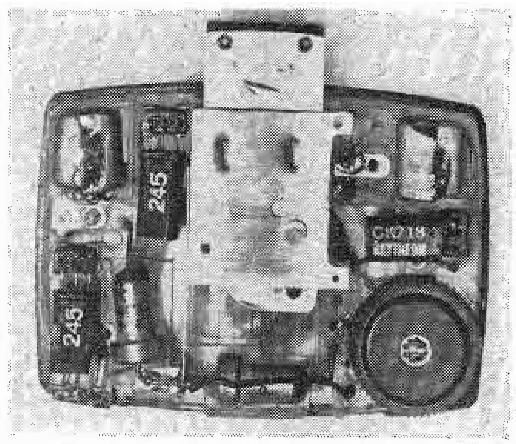


Photos (not to scale) show Sonotone aid (l), first to employ one transistor in circuit. E. A. Myers aid (r) uses three transistors. Parts are magnetic mike, receiver and their magnets



Top view of Maico aid shows partially open battery drawer. At center is magnetic microphone

Underside of Maico aid shows three Raytheon CK718 transistors; is 2.66 x 1.88 x 0.67 in.



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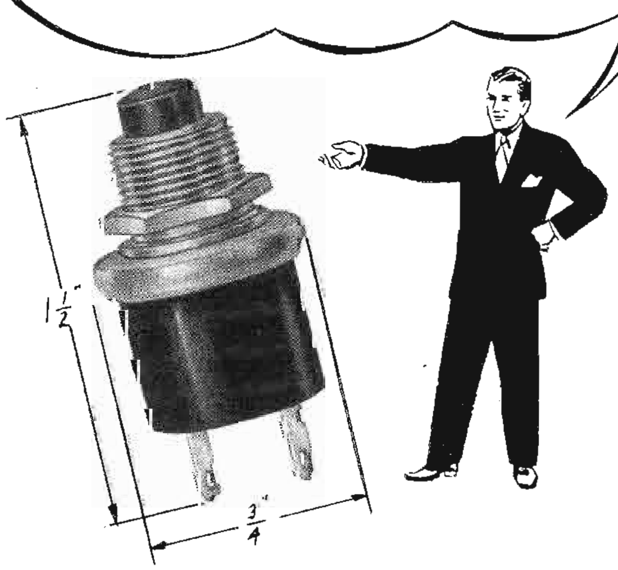

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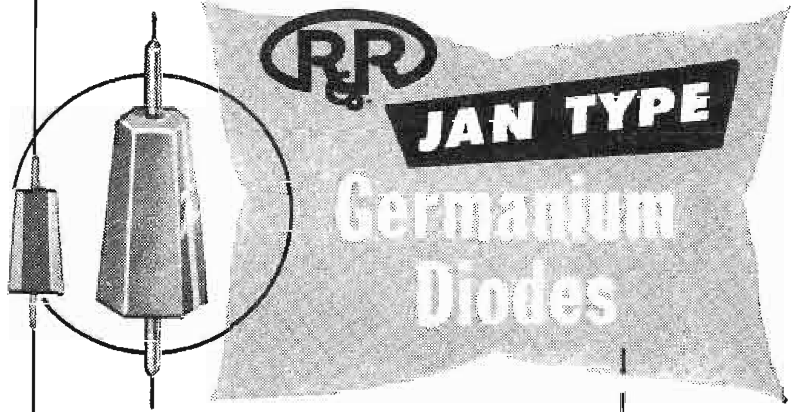

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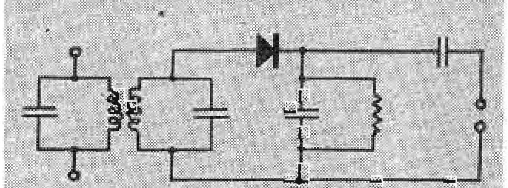

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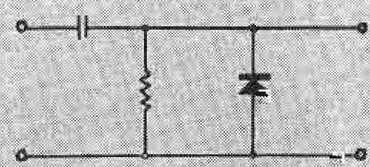
CODE NO.	Min. Forward Current at 1 Volt (MA)	Max. Reverse Current (Micro-Amperes)	*Average Rectified Current (MA Max.)	†Minimum Reverse Volts	Max. Cont. Reverse Operating Volts
1N69	5.0	50 @—10V 850 @—50V	40	75	60
Rectification efficiency: 35% minimum in 100 MC test circuit.					
1N70	3.0	25 @—10V 300 @—50V	30	125	100
1N81	3.0	10 @—10V	30	50	40

*Average half wave rectified current at 60 CPS and 25°C. Consult us for ratings at other conditions.

†For zero dynamic resistance.



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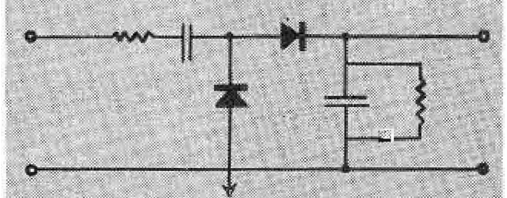

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CONELRAD

(*Continued from page* 85)

properly adjusted throughout the group, and program and sequential control lines are provided for each member station. One at a time, in non-cyclical sequence, each station goes on the air for a random period varying from 5 to 40 seconds. Since one station comes on the air as another goes off, there is no appreciable lost-air time or carrier overlap. Furthermore, because all stations in the group carry the same program, there is no appreciable interruption of program service. The type of equipment to be used for controlling sequential switching and accomplishing self-supervision will be mutually agreed upon by the member station and the FCC.

On-Off Mode: The on-off mode may be applied to individual stations operated by themselves, or to groups being operated in the sequential mode as is illustrated in Fig. 2. For individual stations, the on-air time is about 10 seconds, and the intervening time is of the order of 30 minutes. When applied to groups of stations, this mode will permit the group on-air and off-air times to be from 1 to 30 minutes for each. As in the sequential mode, power is adjusted by the FCC to achieve CONELRAD objectives.

Pulsating Mode: With the pulsating mode, applicable to individual stations or sequential groups, the transmitter power of the station on the air is varied over a 10 db range, at a non-cyclical rate of about 10 to 45 seconds. In a given area such as a city, if several stations are being operated individually, all will carry the same program provided by lines from a common source.

Synchronous Mode: In the synchronous mode, two or more stations in a given area are on the air at the same time, and with the same frequency or frequencies. Power is adjusted so that no one station stands out. If operated with a group of other stations, they are provided with the same program source.

During alert periods, stations allowed to operate may broadcast other programs as they desire, on their own responsibility, when not broadcasting civil defense messages.

Name Changed

The company name of the LaPointe Plascomold Corp. has now been changed to La Pointe Electronics, Inc., it was announced by company president, Jerome E. Respess. The name change will in no way affect the corporate structure of the Rockville, Conn. company and Vee D-X will continue to be the trademark of all its TV antennas.

Air Coaxial

(Continued from page 84)

$$_{oc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\,d\ [1 + \log_{10}^{-1}(Z_o\sqrt{\epsilon'}/138)]} \quad (7)$$

For undercut coaxial transmission line the outer conductor remains fixed and the inner conductor diameter is reduced, with the resultant cutoff frequency given by the following relationship, in terms of the inside diameter of the outer conductor of the air line:

$$_{uc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\,D\ [1 + \log_{10}^{-1}(-Z_o\sqrt{\epsilon'}/138)]} \quad (8)$$

In terms of the outside diameter of the inner conductor of the air line, the cutoff frequency is given by:

$$_{uc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\,d\left[\log_{10}^{-1}\frac{Z_o}{138} + \log_{10}^{-1}\frac{Z_o}{138}(1-\sqrt{\epsilon'})\right]} \quad (9)$$

For transmission lines of 50 ohms iterative or characteristic impedance the cutoff frequencies are given below:

For the uniform air dielectric line:

$$f_c = 5350/D \quad (10)$$

For the overcut coaxial line in the region of the supporting structure:

$$_{oc}f_c = \frac{17{,}290\ K_s}{\sqrt{\epsilon'}\,D\ [1 + \log_{10}^{-1}(0.362\sqrt{\epsilon'})} \quad (11)$$

For the undercut coaxial line in the region of the supporting structure: (12)

$$_{uc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\,D\ [1 + \log_{10}^{-1}(-0.362\sqrt{\epsilon'})]}$$

For the specific cases of Teflon and Polystyrene with relative dielectric constants of 2.1 and 2.544 respectively, the following relationships are used to compute the cutoff frequency:

Overcut line containing Teflon:

$$_{oc}f_c = 2.82 \times 10^3/D \quad (13)$$

Overcut line containing Polystyrene:

$$_{oc}f_c = 2.33 \times 10^3/D \quad (14)$$

Undercut line containing Teflon:

$$_{uc}f_c = 4.10 \times 10^3/D \quad (15)$$

Undercut line containing Polystyrene:

$$_{uc}f_c = 3.83 \times 10^3/D \quad (16)$$

Values of cutoff frequency calculated from Eq. 10, 13 through 16, for the proposed standard sizes of coaxial transmission line are given in Table II.

As the frequency of operation of a coaxial, metallic conductor, transmission line is reduced below several megacycles, the magnetic field energy stored in the metal walls of the transmission line reflects itself in an increase in the series inductance per unit length with a consequent increase in the characteristic impedance and a reduction of the velocity of propagation. In practice, the metal walls are sufficiently thick so that propagation and reflection effects exterior to the outer conductor do not influence the fields which are excited within the coaxial transmission line. The "depth of penetration" for non-ferromagnetic materials is given by the relationship:

$$\delta = 5.033\sqrt{\rho/f} \quad (17)$$

For copper, δ, "the depth of penetration," has a value of 0.021 cm. at a frequency as low at 0.1 MC. Thus, any solid dielectric coaxial conductor having a thickness sufficient for reasonable structural strength and rigidity will have walls thicker than three or four times the "depth of penetration." For the relatively low frequencies being considered the distributed parameter transmission line solution is an excellent approximation for the transverse magnetic wave transmitted in such lines, since the amount of displacement current and the electric field energy associated with the longitudinal electric field at the wall and in the space between conductors is insignificant.

The rate of change of transmission line voltage, V, in the propagation direction, s, is given by:

$$dV/ds = -ZI \quad (18)$$

The series impedance, Z, is the quantity which is affected by energy storage in the walls at low frequency operation. This, in turn, affects the propagation constant:

$$\gamma = \sqrt{ZY} \quad (19)$$

and the characteristic or iterative impedance:

$$Z_o = \sqrt{Z/Y} \quad (20)$$

In the length, ds, the voltage drop, —dV, may be considered to be made up of two parts:

1. The normal TEM transmission line voltage drop per unit length, $j\omega L_0 I$, from the magnetic field between the conductors.

2. The voltage drop per unit length along the magnetic surfaces, $(r_w + j\omega L_w I)$, where both conductors are considered. For a coaxial transmission line having a dielectric with a permeability equal to that of free space, $4\pi \times 10^{-7}$ h/m, the inductance per unit length, L_0, is given by: (21)

$$L_o = Z_o/C = [0.3336 \times 10^{-10}\, Z_o]\ \text{h/cm}$$

The voltage drop at the metal surface is analyzed in terms of mag-

(*Continued on page 164*)

netic and electric fields tangential to the surface of the metal conductor. Within the metal conductor of the transmission line, the magnetic field, angularly directed as in the space between the conductors, is given by:

$$H\theta = H_o \left[\epsilon^{-\left(\frac{1}{\delta} + j\frac{1}{\delta}\right) | \gamma - \gamma_o |} - \epsilon^{+\left(\frac{1}{\delta} + j\frac{1}{\delta}\right) | \gamma - \gamma_o |} \right] \quad (22)$$

The field in the metal decays very rapidly from the place of initiation inside the transmission line, allowing for normal practical diameters, the linear propagation formulas given. Since for any nominal wall thickness as has been previously shown, the attenuation is sufficient to hide any impedance effects, the reflected wave can be set equal to zero. Accordingly, at the internal metal surfaces the intrinsic wave impedance of the conductor is seen. The longitudinal electric field at the metal surface is given by:

$$E_z = \eta_m H_o \quad (23)$$

Where the intrinsic impedance, η_m of the metal is given by:

$$\eta_m = R_s + j\,R_s = \frac{1}{\delta\sigma} + j\frac{1}{\delta\sigma} \quad (24)$$

$$R_s = 0.1987\sqrt{\rho f} \quad (25)$$

The values of R_s, the "skin effect resistance," and the values of δ, the "depth of penetration" for various metals are plotted in Figs. 3 and 4.

For a length, ds, of transmission line, the voltage drop at the inner surface of conductors caused by the intrinsic impedance is then given by:

$$(dV) = (\eta_m\,ds)\,H_o \quad (26)$$

For outer conductor H_0

$$(dV) = (\eta_m\,ds)\,H_o \quad (27)$$

For inner conductor H_0

Where the angular magnetic fields in these surfaces are given by:

$$H_o = I/\pi D \quad (28)$$

For outer conductor

$$H_o = I/\pi d \quad (29)$$

For inner conductor

The series impedances per unit length introduced by the conductors is then:

$$Z = R_s/\pi D + j\,R_s/\pi D \quad (30)$$

For outer conductor

$$Z = R_s/\pi d + j\,R_s/\pi d \quad (31)$$

For inner conductor

The total series impedances introduced by the intrinsic impedances of both conductors and the magnetic field in the gas filled space between them is given by the following relationship:

$$Z = \frac{R_s}{\pi}\left(\frac{1}{D} + \frac{1}{d}\right) + j\,\omega\left[L_o + \frac{R_s}{\omega\,\pi}\left(\frac{1}{D} + \frac{1}{d}\right)\right] \quad (32)$$

$$Z = 0.0249\sqrt{\rho f}\left(\frac{1}{D} + \frac{1}{d}\right) + j\left[2.096 \times 10^{-4} f Z_o + 0.0249\sqrt{\rho f}\left(\frac{1}{D} + \frac{1}{d}\right)\right] \quad (33)$$

For frequencies below several megacycles the primary effect of the real part of the series impedance per unit length is to introduce attenuation. It can be seen from the explanation given that the wall inductance decreases inversely as the size of the transmission line, assuming a constant diameter ratio, that is, a constant inductance associated with the space between the conductors.

For the frequency range under consideration, the real part of the series impedance is very small by comparison to the imaginary portion. From a combination of Eqs. (20) and (33) the low frequency characteristic impedance is obtained:

$$Z_s = \sqrt{Z_o^2 + 118.82\,Z_o\sqrt{\frac{\rho}{f}}\left(\frac{1}{D} + \frac{1}{d}\right)} \cdot \left[1 - \frac{j}{2}\,\frac{0.0249\sqrt{\rho f}\left(\frac{1}{D} + \frac{1}{d}\right)}{Z_o^2 + 118.82\,Z_o\sqrt{\frac{\rho}{f}}\left(\frac{1}{D} + \frac{1}{d}\right)}\right] \quad (34)$$

$$\frac{0.0249\sqrt{\rho f}\left(\frac{1}{D} + \frac{1}{d}\right)}{2\left[Z_o^2 + 118.82\,Z_o\sqrt{\frac{\rho}{f}}\left(\frac{1}{D} + \frac{2}{d}\right)\right]} < 0.0001\,\frac{f}{Z_o} \quad (35)$$

Thus, for all practical impedances, in the frequency range under consideration, the low frequency characteristic impedance is given by:

$$Z_o' = Z_o\sqrt{1 + \frac{118.82}{Z_o}\sqrt{\frac{\rho}{f}}\left(\frac{1}{D} + \frac{1}{d}\right)} \quad (36)$$

The relative velocity of propagation, v'/C, is obtained from the relationship:

$$\frac{v'}{C} = \frac{Z_o}{Z_s} = \frac{1}{\sqrt{1 + \frac{118.82}{Z_o}\sqrt{\frac{\rho}{f}}\left(\frac{1}{D} + \frac{1}{d}\right)}} \quad (37)$$

For 50 ohm transmission line, substituting Eq. (5) into Eq. (36) and (37), the following relationships are obtained:

$$Z_0^1 = 50\sqrt{1 + \frac{7.844}{D}\sqrt{\frac{\rho}{f}}} \quad (38)$$

(*Continued on page 166*)

$$\frac{V'}{C} = \frac{1}{\sqrt{1 + \frac{7.844}{D}\sqrt{\frac{\rho}{f}}}} \qquad (39)$$

The characteristic impedances and relative velocities computed from Eqs. (38) and (39) are given in Table II for the proposed standard coaxial line sizes at frequencies of 0.1 and 1.0 MC.

Appendix A. The 75 Ohm Coaxial Line.

The following covers the essential relationships and tabulated data (see Table Ia) and curves for 75 ohm coaxial, gas filled transmission lines now in the process of standardization. The following formulas have been numbered to correspond to the appropriate 50 ohm relationship given in the original text:

For the cutoff frequency for TE_{11} mode in the uniform air dielectric line (75 ohms):

$$f_c = 5999/D \qquad (10a)$$

For overcut coaxial line (75 ohms) in the region of the supporting structure:

$$_{oc}f_c = \frac{26{,}224\ K_s}{\sqrt{\epsilon'}\ D\ [1 + \log_{10}^{-1}(0.543\ \sqrt{\epsilon'})} \qquad (11a)$$

For the undercut coaxial line (75 ohms) in the region of the supporting structure:

$$_{uc}f_c = \frac{7514\ K_s}{\sqrt{\epsilon'}\ D\ [1 + \log_{10}^{-1}(-0.543\ \sqrt{\epsilon'})} \qquad (12a)$$

Overcut line containing Teflon (ε'=2.1):

$$_{oc}f_c = 2.579 \times 10^3/D \qquad (13a)$$

Overcut line containing Polystyrene (ε'=2.544):

$$_{oc}f_c = 1.986 \times 10^3/D \qquad (14a)$$

Undercut line containing Teflon:

$$_{uc}f_c = 4.526 \times 10^3/D \qquad (15a)$$

Undercut line containing Teflon:

$$_{uc}f_c = 4.179 \times 10^3/D \qquad (16a)$$

For 75 ohm transmission line, substituting Eq. (5) into Eq. (36) and (37), the following relationships are obtained:

Low frequency characteristic impedance:

$$Z_0^1 = 75\sqrt{1 + \frac{7.103}{D}\sqrt{\frac{\rho}{f}}} \qquad (38a)$$

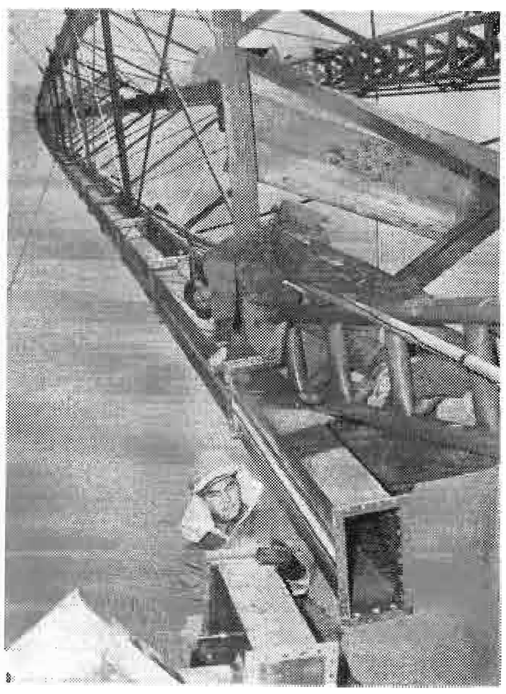
The low frequency relative velocity of propagation:

$$\frac{V'}{C} = \frac{1}{\sqrt{1 + \frac{7.103}{D}\sqrt{\frac{\rho}{f}}}} \qquad (39a)$$

The characteristic impedances and relative velocities together with the TE_{11} mode cutoff frequencies are given in Table IIa for the proposed standard 75 ohm coaxial line sizes.

Curves of K_S and Diameter Ratios versus Dielectric Constant are given in Figs. 1a and 2a, respectively.

WHUM-TV ON AIR



Looking up antenna tower and waveguide transmission line of Reading, Pa.'s UHF WHUM-TV (channel 61). Tower is 1000 ft. high. Station went on air Feb. 10 at 12:12 AM

Crosstalk

(*Continued from page* 147)

achieved in the equipment in Montreal. In order to measure the crosstalk, the set up shown in Fig. 4 was used. Tone from an oscillator was fed into five input networks and thence through the system to a total of ten different outputs. In all some 105 amplifiers and their accompanying circuits were energized. When the correct levels, as shown in Fig. 4 had been achieved, the input to one network was removed and measurements were made of the noise level at the corresponding output as the frequency of interfering tone was varied. The results are shown in Fig. 6 (bottom section) from

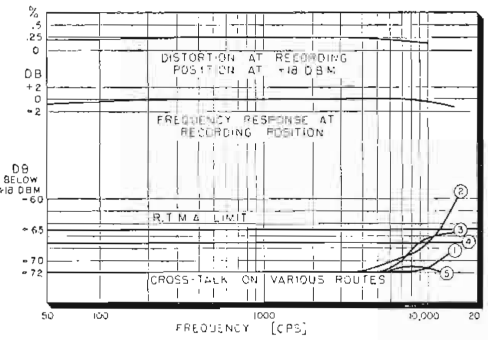


Fig. 6: Measured crosstalk characteristics

which it will be seen that the crosstalk is below the noise level in all cases until the frequency rises above 4000 c/s and that except in the case of one route it remains below the R.T.M.A. signal/noise limit of 65 db up to 15000 c/s. The exception crosses the 65 db line at about 12,000 c/s. Doubtless, if it had been thought necessary, this route could have been brought into line with the others, but we think it will be agreed that the performance as demonstrated by these curves is, to say the least, entirely adequate.

Joint U.S.-British TV Camera Research

General Precision Lab., Inc., and Pye Ltd., Cambridge, England, have signed an agreement providing for an expanded program of joint research and development in the field of industrial and broadcast TV cameras and studio equipment. The two companies have been associated for three years under an agreement which provided for the development of studio equipment currently marketed by GPL. General Precision will manufacture cameras and associated studio items in America, and Pye in England, for independent sale through their respective marketing organizations, but with the combined engineering knowledge of the two firms.

Casting Resins

(Continued from page 81)

by a factor of 3. However, the unitized assemblies are then plugged into a chassis which may be made of metal and thus add significantly to weight. On the basis of the completed equipment the weight contribution due to embedment has run as low as 30%.

Many of the casting resins which are commercially available are not suitable for direct use on a specific application. This is particularly true if they are to be used in connection with components.

Needless to say, the properties of the cured resin are the primary consideration. However, it will be worthwhile to point out a few of the possibilities in formulation of the unpolymerized material.

Some of the changes which are often made consist of the addition to the base resin of fillers, diluents, plasticizers and other resins.

For example, if a polyester resin is to be used as an impregnant for paper capacitors, the viscosity must be adjusted so that complete penetration into the capacitor winding is assured, and at the same time the resin must not flow out of the winding during cure. The addition of monomeric styrene is one method of lowering viscosity. If in addition good low temperature characteristics of the capacitor are required, a plasticizer may be called for.

In the formulation of a dip compound for application of coatings to electrical components, a viscous material is required so that the build-up is sufficient to assure the desired degree of hermetic sealing. Inorganic fillers are often used. These include finely divided mica and talc. Here again, a plasticizer may be needed to improve impact resistance of the coating. Pigments may be incorporated for coloring.

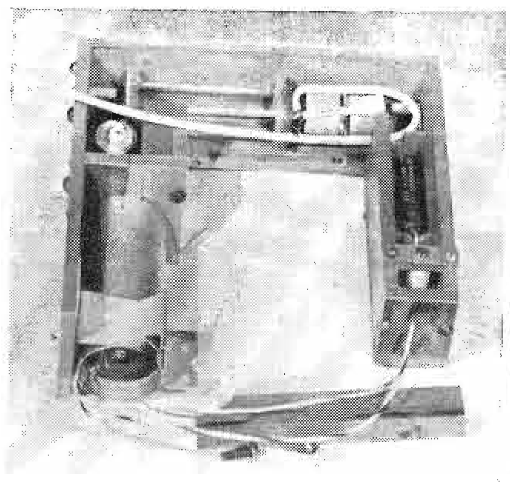


Fig. 5: Amplifier prior to embedment. Glass enclosed HV rectifiers must not be damaged by shrinkage of the resin at —65°C temperature

Conductive plastic materials have been formulated by adding carbon black and/or finely divided metal powders to casting resins.

Another interesting modification of casting resins is the addition of a flocculent material such as chopped glass monofilaments. A relatively small percentage weight addition results in an almost dry molding com-

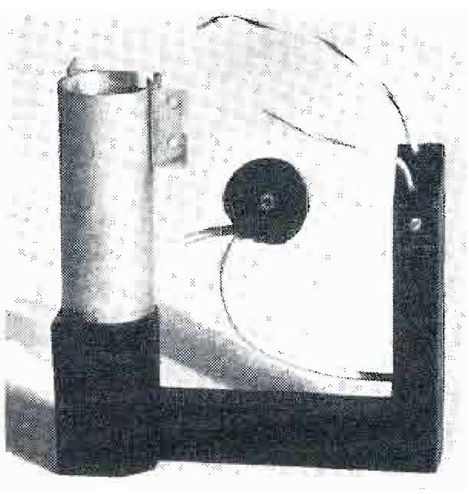


Fig. 6: Irregular shape of embedded amplifier in Fig. 5 is utilized to solve space problems

position. This may be used in a manner similar to that used in phenolic molding. Molding pressures, however, are much lower. Pressures as low as 25 psi have been used successfully.

There is a technique for encapsulation of electronic circuits which overcomes some of the disadvantages inherent in potting and casting. The method consists of the application of a dipped coating to the assembled unit.

A dipping formulation is prepared, and the unit is dipped into it and subsequently placed in an oven to render the coat non-flowing. Other coatings follow until the plastic build-up is sufficient for the degree of sealing required. When properly applied, the coating is completely uniform and is as effective in hermetic sealing as the casting process.

A few of the advantages are elimination of molds, decrease in weight and improved heat dissipation. The final assembly can be made just as rugged as the same circuit embedded.

Casting Resins as Applied to Components:

It will be of value to consider individual electrical components in which casting resins or formulations based on casting resins have been used.

Paper Capacitors: One of the most interesting uses of casting resins is as an impregnant for paper capacitors. The construction of a paper capacitor consists of winding two lengths of metal foil between which are one or

(*Continued on page* 170)

more layers of very fine Kraft paper. To produce the finished capacitors, the winding is carefully dried and impregnated. Common impregnants are oil and wax, which may leak and dry up at high temperatures. Impregnation with a resin which is later polymerized in place has been found to be successful in producing good high temperature paper capacitors. The elimination of the paper and its substitution by plastic dielectric films appears to be logical step.

To illustrate the results which may be achieved, the data on plastic impregnated paper capacitors is presented. Tl ese are for 1 µ f units rated at 400 v. dc. The capacitors are in metal cans, the terminals project through silicone rubber bushings. The capacitors are manufactured by Tobe Deutschmann Corp. of Norwood, Mass.

Variation of capacitance with temperature:

Under 1.5% 20° C to 150° C.

Variation of power factor with temperature:

20° C — 0.35%
85° C — 0.32%
125° C — 0.65%
150° C — 2.5 %

Insulation Resistance:

20° C — 30 K meg.
85° C — 370 meg.
125° C — 30 meg.
150° C — 6 meg.

Life Test:

125° C — 660 v. dc stopped at 2000 hrs
150° C — 400 v. dc 300 to 400 hrs

Low valued paper capacitors are phenolic molded following plastic impregnation and cure. These units have characteristics comparable to those of the canned units. The solid structure of the capacitor permits phenolic molding with less difficulty than is experienced when oil or wax is the impregnant.

Cast housings for capacitors have been used. The mold is machined from metal and the capacitor positioned in it. The casting compound is poured in and cured. Pouring is accomplished at atmospheric pressure or under vacuum. It is applicable to expensive capacitors and those which cannot tolerate pressure molding. At present the casting process cannot compete economically with compression molding of housings around capacitors.

Transformers: There are several processes for the application of polymerizable plastic materials to transformers. The oldest and most widely used is a potting process wherein the impregnated transformer is placed in a mold and the casting resin formulation poured in and subsequently cured. The mold may be a metal can which remains as a part of the completed transformer. The resin merely takes the place of the hot melts and waxes which the transformer industry has used for years.

The use of 100% polymerizable impregnants for transformers has been an improvement over the use of solvent type varnishes. The completely solid structure of the transformer has decreased the possibility of corona, improved moisture sealing, heat dissipation and insulation resistance.

The heat dissipation of the solid transformer structures permits dissipation of up to 30% more heat than a varnish impregnated unit for the same temperature rise. Application of heavy plastic dip coats as a moisture seal is also being used for protection of transformers, as shown in Fig. 1.

Precision Resistors: An investigation has been made by the Rubicon Co. of Phila., Pa. as to the feasibility of embedment of precision resistors in casting resins for hermetic sealing purposes. The investigation is not yet complete.

The resistors used are of 10,000 ohms nominal value, wound on ceramic spools. The resistive element is cloth-covered manganin wire. The resin used was of the unfilled non-rigid polyester type and covered the resistive elements by approximately 1/8 in. The lead in wires were separated by approximately 3/4 in.

Embedments were made in a machined Teflon mold. The embedment compound was in direct contact with the resistive element.

The insulation resistance of the spool with lead in wires attached but with the resistive element removed was 280 K megohms. This blank after embedment measured 110 K megohms. Following subjection to 100% relative humidity for 300 hours, the insulation resistance dropped to 40 K megohms, but recovered to the original value after standing under room conditions for several days.

The change in resistance due to embedment of the 10 K resistors was + 0.06% ± 0.01% or 6 ohms ± 1 ohm. After aging for 1300 hours at room temperature, the resistance change decreased to 2.8 ohms ± 1 ohm. The decrease continued and attempts are being made to accelerate the aging of the units. Present indications are that the resistors will recover to within 1 ohm or 0.01% of their original value.

The temperature coefficient of the embedded resistors is almost exactly that of the manganin wire from which they were wound. Temperature cycling from 100° C to −55° C

(*Continued on page* 173)

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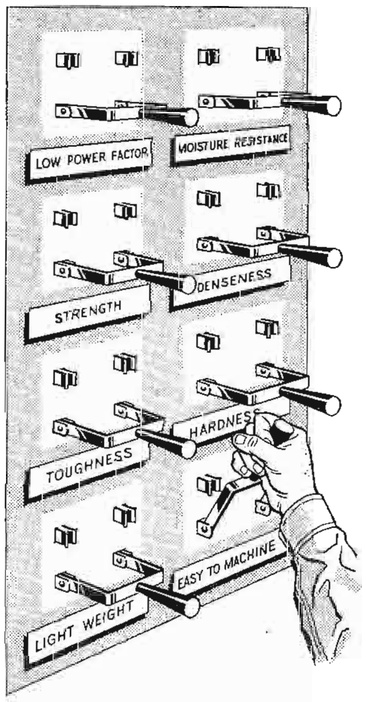

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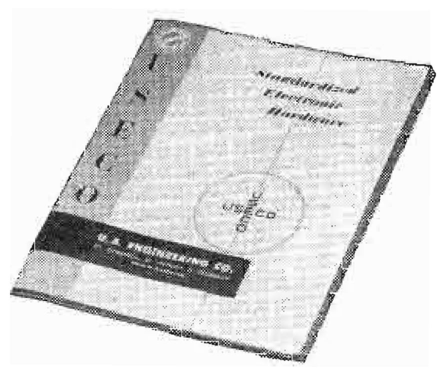

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has no detectable effect on the plastic coating.

Note the bleeder embedments in Fig. 2.

Other embedment methods in which the plastic material does not contact the resistive element are planned for future investigation.

High Frequency Inductors: The techniques outlined previously with respect to capacitors may be applied to high frequency inductors. The wound coil is dried and impregnated with a resin of good electrical properties. Cure of the resin produces a unit of solid structure which then may be enclosed in a housing which is cast, compression molded or dip coated. A polystyrene resin as the impregnant has been used on coils with excellent results.

Electric Motors: Casting resins are used to impregnate the armatures and fields of electric motors. They are generally superior to the varnishes previously used. Void free insulation, avoidance of solvent evaporation and better mechanical anchorage of the windings are given as the advantages.

On small motors and generators for servo applications both rotors and stators have been molded in resin for protection of the very fine wire used. The mold used is machined from Teflon. Teflon is used to eliminate the need for mold release which would upset the close tolerances to which the moldings must be made. The Teflon is carefully treated so that it will remain dimensionally stable. The windings are positioned in the mold and the formulated casting resin run in under vacuum. Curing and removal from the mold follow. The windings have thus applied to them a coating of 0.007 in. uniformly over the surface except at the air gap surface, at which point the coating is 0.005 in. The production rate is one rotor or stator (as the case may be) per mold each 45 minutes.

Teflon is an almost ideal mold material in that casting resins do not adhere to its surface, thus eliminating the need for mold release. Mold release is expensive to apply in a production casting process, and adversely affects the surface finish. Teflon coated metal molds have also proved to be practical for production casting of electrical equipment.

Antennas: Polyethylene has been used to cast around electronic components by a low pressure process. One of the most interesting applications is the embedment of helical antennas. See Fig. 3. It is reported that a one-third size reduction can be made in the size of the antenna

(*Continued on page* 175)

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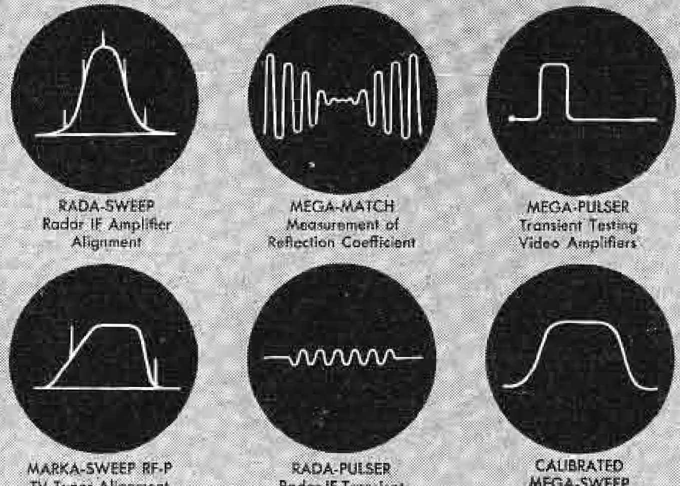

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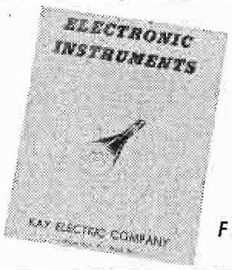

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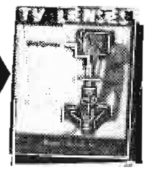

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system. Because of the excellent electrical characteristics of polyethylene there is no impairment in operation.

Polystyrene may also be used but its poor low temperature characteristics have limited its use. Polystyrene casting resin, however, is being used successfully in embedment of the connection between the coaxial cable and antenna elements of the weather-proof antennas made by the Workshop Associates of Needham, Mass.

A method which may be used to make polystyrene castings of extremely large size is to first fill the mold with polystyrene molding granules and under vacuum flow in a properly catalyzed polystyrene casting resin. Upon curing, a perfect bond is formed between the casting resin and the granules. The casting is almost completely strain-free.

Radomes are produced by using casting resin formulations in conjunction with web fillers, such as cloth and glass mat. The cloth or mat is saturated with the catalyzed liquid resin and then introduced between the platens of a press which are shaped to the desired contour of the radome. Low pressures, below 50 psi, and low temperatures 200 to 250° F are used to cure the laminate.

Mechanical Applications: Casting resins have found innumerable uses in electrical equipment wherein the function of the plastic material is primarily mechanical.

A few of these are:

Experimental castings of items which will be injection or compression molded when the final design is frozen.

Production of large plastic pieces which would be impractical to mold. One method which has been used is to injection mold a shell for the casting which serves as the mold. A casting resin which will bond to the shell is poured in and cured.

Casting resin formulations are used as cements and sealants. For example, a pair of thermistors are sealed into an aluminum housing for measurement of underwater temperatures. The seal is of unique design and has been tested against 300 psi water pressure. See Fig. 4.

Electronic Assemblies: Two approaches have been made to the embedment of electronic assemblies and equipment. One has been to embed in one large casting the complete system. This has proved to be successful in only a few instances. The basic difficulty is with component reliability. Until electronic

(*Continued on page* 176)

components can be counted on for long trouble-free life, embedment of large complex assemblies will be impractical for the majority of electronic equipment. With respect to expendable military equipment, complete embedment is practical and should improve overall reliability. Expendable applications include guided missiles, sonobuoys, proximity fuses and controlled torpedoes. Photos of an amplifier assembly before and after embedment are shown in Figs. 5 and 6.

Unitized construction is the other approach. No more than approximately 30 components are contained in a single casting, it is practical for most equipment for the armed services and for many commercial applications.

Polymerizable materials are already seeing large scale use in the electronic industry as impregnants, coatings and potting compounds. At present these uses are mainly with respect to components. Commercial casting of electronic assemblies is limited by lack of knowledge regarding component reliability.

Strain-Gage

(*Continued from page* 75)

provides a power output of 2.0 watts minimum and is tunable over the frequency range 215 to 230 MC. It employs four subminiature triodes and is readily removable as a unit from the main chassis.

The AN/AKT-8 equipment requires 6.3 v. at approximately 5.5 amps and 135 v. at approximately 150 ma.

The six subcarrier oscillators, the voltage regulator unit and the r-f transmitter are contained in a watertight jacket with AN connectors provided on the front panel for strain gage, antenna, and power connec-

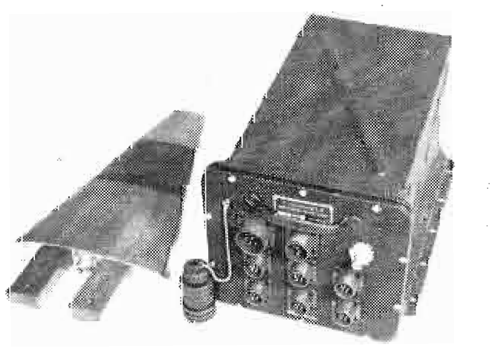

Fig. 9: Complete AN/AKT-8 telemetering unit

tions. If desired, all units may be mounted separately and are capable of operation without shock mounts. The complete AN/AKT-8, with its waterproof jacket, however, is provided with vibration isolation mounts. The assembled AN/AKT-8 is shown in Fig. 9.

TELE-TECH

Advertisers — March, 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.

BULLETINS

Analog Computer

Electronic Associates, Inc., Long Branch & Naberal Avenues, Long Branch, N. J., will forward a copy of their new 17-page bulletin entitled "A Precision Analog Computer" to interested engineers upon written request. Discussions of computer components, elements, and input-output system are included.

Speaker Enclosure

The paper on the R-J speaker enclosure, presented before the Radio Club of America, is now available in printed form and may be purchased by directing inquires to 11 West 42nd St., New York, N. Y. Cost is fifty cents a copy.

TV Transmitters

Specifications and installation information for the series 9000 (low band) and series 12,000 (high band) television transmitters are described in separate bulletins published by Allen B. DuMont Laboratories, Inc., 1500 Main Ave., Clifton, N. J.

Communication Tape Monitor

A fully illustrated eight-page brochure describing an automatic tape monitor system for recording radio and phone communications is available from Magnecord, Inc., 225 W. Ohio St., Chicago 10, Ill. This recorder-reproducer, originally developed for the CAA, permits four simultaneous signal recordings on standard ¼ in. tape.

Microwave and Telephone

The economic aspects of multi-channel operation of telephone and telegraph circuits over microwave radio links are analyzed in bulletin 72A-P16, published by the Lenkurt Electric Co., San Carlos, Calif.

Integrator

The Instron Integrator is the subject of a new bulletin just released by the Instron Engineering Corp., 2 Hancock St., Quincy 71, Mass. Applications, general description, principle of operation, input requirements, and technical specifications are presented.

Bobbin Winder

George Stevens Manufacturing Co., Inc., Pulaski Road at Peterson, Chicago 30, Ill., has released a new catalog sheet illustrating and describing model 119-A bobbin winder (economy box—cam operated) and model T-102 dereeling tension for extremely fine wire.

Power Tetrode

A new technical data sheet on Los Gatos Brand 4D21 power tetrode has been released by Lewis & Kaufman, Ltd., 52 El Rancho Ave., Los Gatos, Calif.

FCC Modifies Operating Rules

The FCC has relaxed its Operator Requirement Rules for many AM and FM stations, permitting remote control of such stations. This has been hailed as major victory for the NARTB, whose petition of Feb. 1, 1952, initiated the Commission's Rule. The amendments to the FCC Rules will permit: (1) Persons holding restricted radiotelephone operator permits or higher class of licenses to stand the required regular transmitter watches at AM and FM stations employing non-directional antennas and operating with powers of 10 kw or less, and (2) Remote Control of such stations. The FCC states, also that operation under the CONELRAD plan for defense measures in case of air raid alerts (see p. 85 of this issue) is possible by operators holding other than first-class radiotelephone authorizations.