ELECTRONIC INDUSTRIES

TELE-TECH

A Caldwell-Clements Publication

MAY, 1953

FRONT COVER: GUIDED MISSILE AND AIRCRAFT progress hinge on radio and electronic developments. That's the feeling in military circles. According to Major General Donald L. Putt of the Air Force Research and Development Command, "the scheduled introduction of guided missiles into operational units depends primarily on the accuracy and reliability of guidance and control systems." So far, two missile types are known to be in production. These are believed to be Nike and Corporal E. A significant trend in airborne control systems is the use of digital computers for launching and directing pilotless craft. Although hampered by the size and complexity of program and memory units, the digital computer is getting the nod over the analog type because of lower accuracy deterioration in succeeding stages, greater flexibility for a variety of applications, and adaptability to simpler production techniques.

DEPARTMENTS

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CALDWELL-CLEMENTS, Inc.

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Publishers also of TELEVISION RETAILING

* Reg. U. S. Pat. Off.

TELE-TECH'S CIRCULATION, 21,000

Because of the lag in auditing, never catching up with current circulation in an expanding industry, an audit for the calendar year 1953 will not be made until the summer of 1954. Meanwhile, sworn statements and post office receipts will be furnished covering the guaranteed 21,000 circulation.

YOUR FILTER NETWORK PROBLEMS ... *Solved in Jigtime*

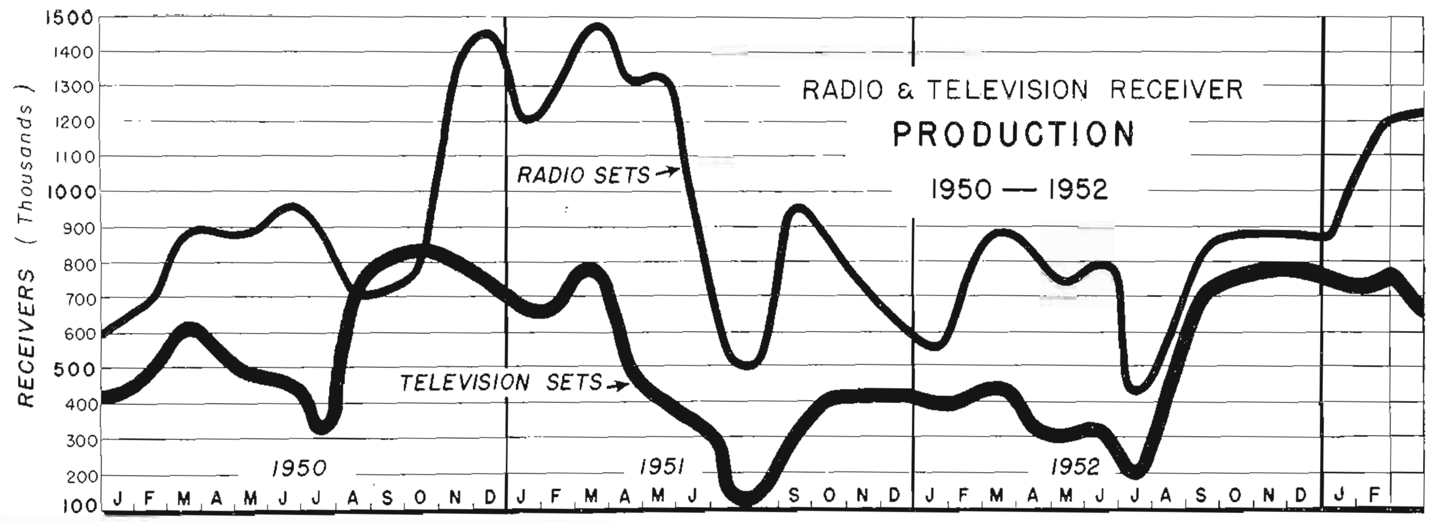
Selecting the proper filter network component for a critical electronic application is not exactly comparable to fitting a piece to a puzzle. In filter networks the criteria are not quite as superficial as proper size, shape, etc. Even compliance with attenuation requirements is not usually sufficient. There are a multitude of hidden factors in the manufacture of an audio filter that go much deeper than these qualifications.

Here in Burnell & Co. we concern ourselves with all the phases in the design of a filter of superior quality. To maintain our high standard we manufacture our toroids with the most modern facilities and quality controlled methods. The capacitor components employed are either the finest silver mica type or are wound with plastic dielectric material employing no impregnants that may affect the life or long term stability. All other components are just as carefully selected and controlled.

This policy of incorporating only the best ingredients coupled with our advanced design method insure our customers that not only will our filters meet the **basic** requirements but that they will also maintain **all** of their characteristics under all the service conditions of equipment in which they are used.

Burnell & Company
YONKERS 2, NEW YORK
CABLE ADDRESS "BURNELL"

EXCLUSIVE MANUFACTURERS OF COMMUNICATIONS NETWORK COMPONENTS



Broadcast Stations in U.S.

	AM	FM	TV
Stations on Air	2364	590	138 VHF 19 UHF
Under Construction (CPs)	149	66	109 VHF 211 UHF 14 Educational
Application Pending	221	10	441 VHF 250 UHF

Radio and TV Receiver Production

	TV		Radio
March, 1953		Home	354,000
		Battery	124,000
		Auto	510,000
		Clock	236,000
Total	667,000		1,224,000
Three months (Jan.-March '53)	2,086,000		
Three months 1952	1,324,000		

Transitor Expansion

The new Western Electric Co. plant at Laureldale, Pa., will have capacity to produce a million tranisistors a month, all to be used by Armed Forces and Bell System. Meanwhile, Bell Laboratories have 300 of their 2300 researchers working on solid-state devices. Nearly 100 at RCA's Princeton laboratory are assigned to similar projects.

The Signal Corps has applied $13,000,000 to financing the Laureldale plant and pilot production lines at General Electric, Raytheon, RCA and Sylvania, declares *Fortune* writer, Francis Bello.

Electronic Aids to Aviation

Already, 365 omniranges are operating out of a program of 414, according to Civil Aeronautics Administrator Charles F. Horne. Approximately 45,00 miles of airways have been established for aircraft with omnirange equipment, while 70,000 miles of low-frequency airways still are in operation. "As soon as sufficient aircraft are equipped with omnirange receivers and our VOR airways coverage is adequate, we expect to turn off most low-frequency ranges," he said. Mr. Horne reports the new Distance Measuring Equipment has been installed and tested along the very-high-frequency airway between New York and Chicago. In the next 18 months, more than 400 additional omniranges will be equipped with DME.

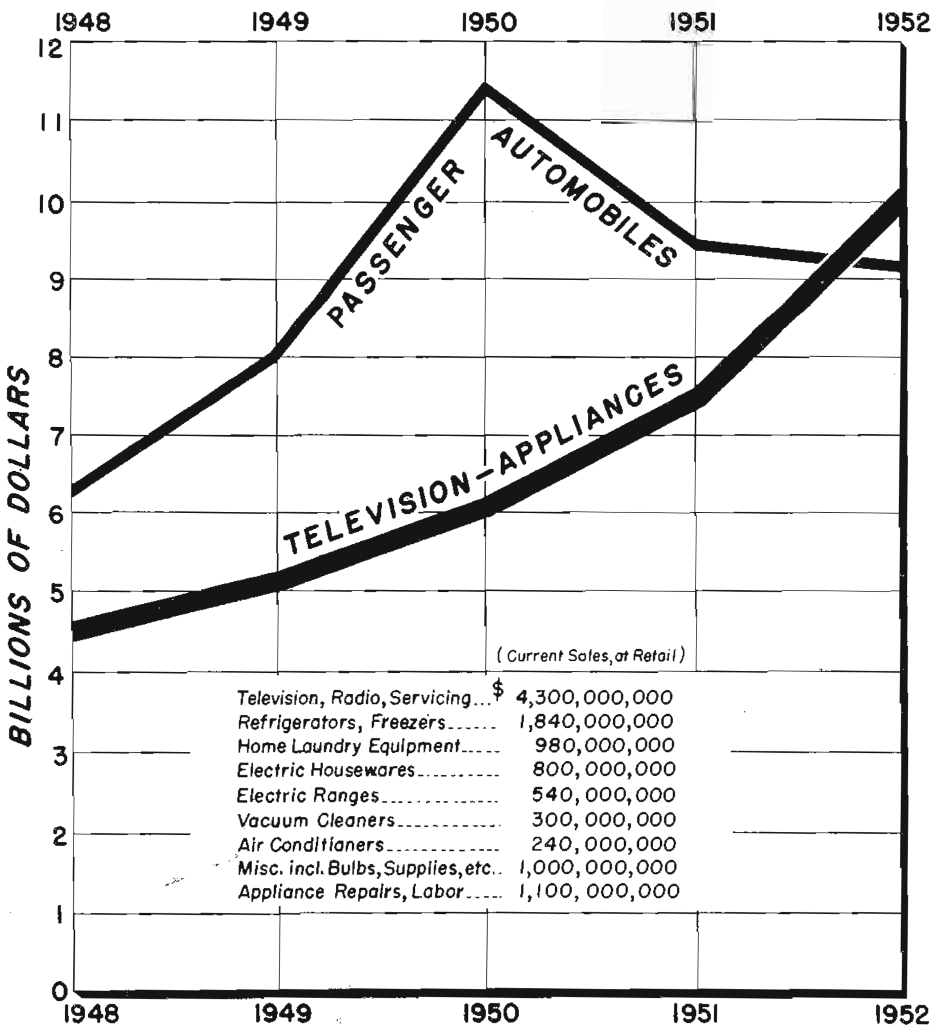
TELEVISION-APPLIANCE SALES NOW EXCEED AUTOS

Under the impact of swelling television output, total annual retail television-appliance sales to American homes have now, for the first time, passed yearly dollar sales of passenger automobiles.

Figures compiled by Caldwell-Clements' *Mart & Television Retailing* show that TV-appliance merchandise is now going into U. S. households at the rate of $10 billions annually, as compared with the latest official yearly total of 4,130,000 passenger cars for which purchasers paid $9.1 billions.

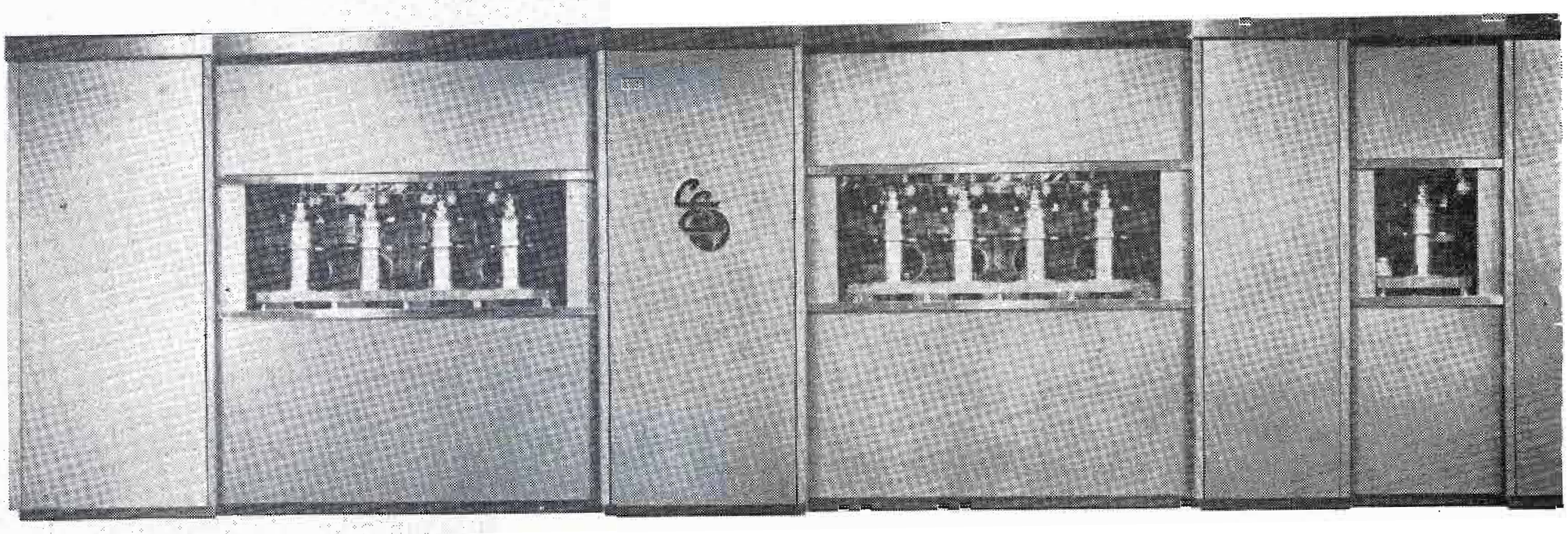
And if the tremendous television-appliance servicing and repair business is included, the present annual volume of the TV-appliance industry exceeds $11 billions.

Television, radio and associated products and servicing make up the largest single category, comprising nearly 40% of the $11 billion total of "plug-in" home equipment.



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

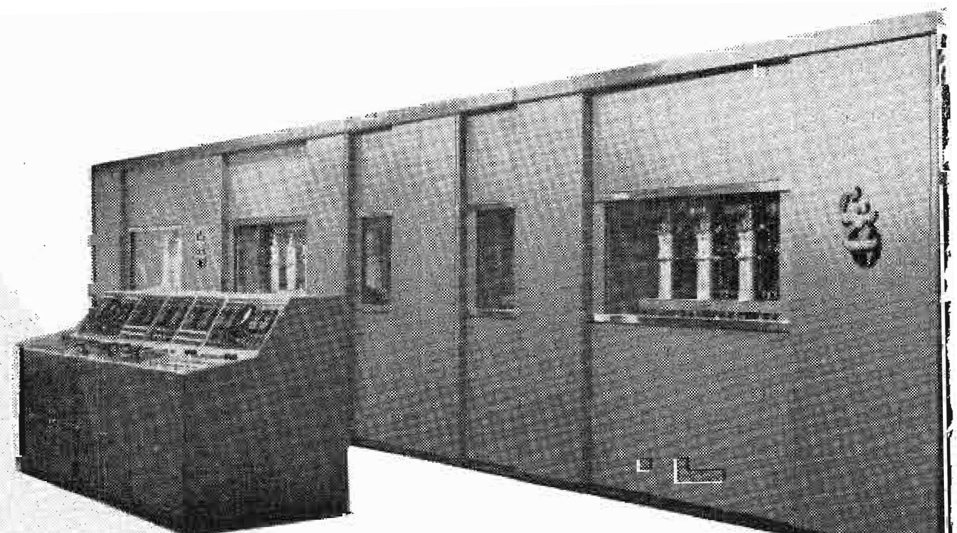
BROADCASTING EQUIPMENT ABOVE



...this gigantic new *Continental* Transmitter develops F

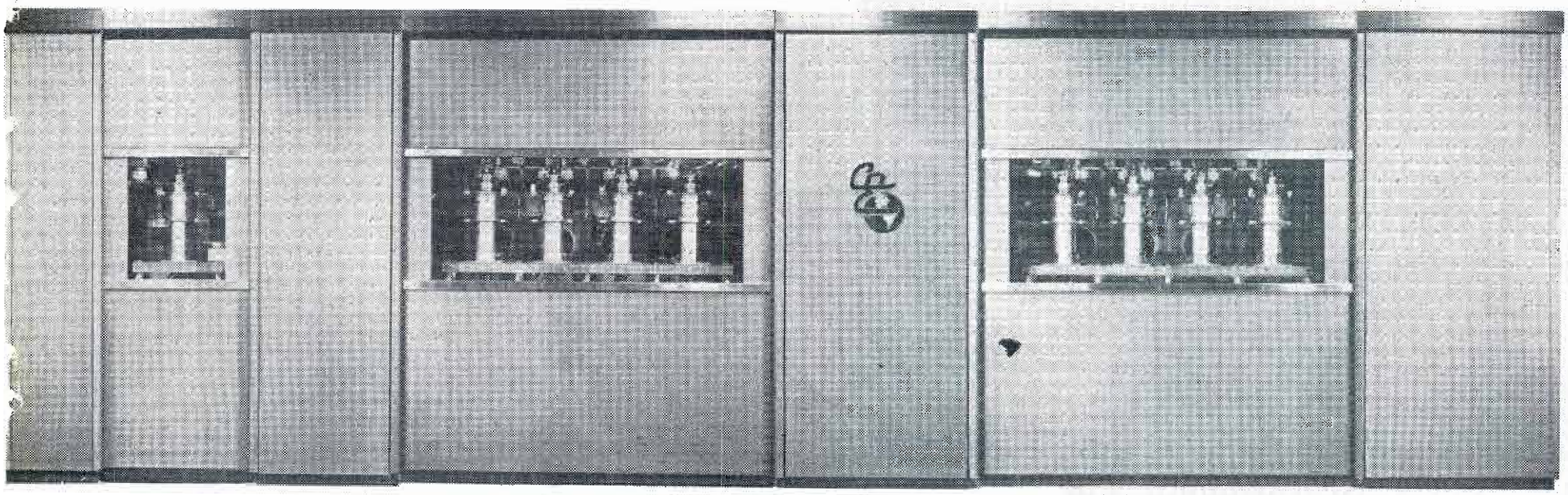
Now it can be told. Continental Electronics of Dallas is busy at work helping to keep the Voice of America loud and clear around the globe. Continental engineering skill is working hand in hand with the Department of State to bring unprecedented power and clarity to international broadcasting.

In spreading the word of freedom, the Continental Type 105-B Super Power 1,000 kw AM Transmitter is America's bold, dramatic answer to the problems of geographic difficulties and Communist jamming operations. This electronic Goliath is the first Megawatt AM Transmitter ever built in the world. Photographs are of the transmitter proper and do not include other



20 times as powerful as the largest AM Broadcast Radio Station operating in the U.S.A.!

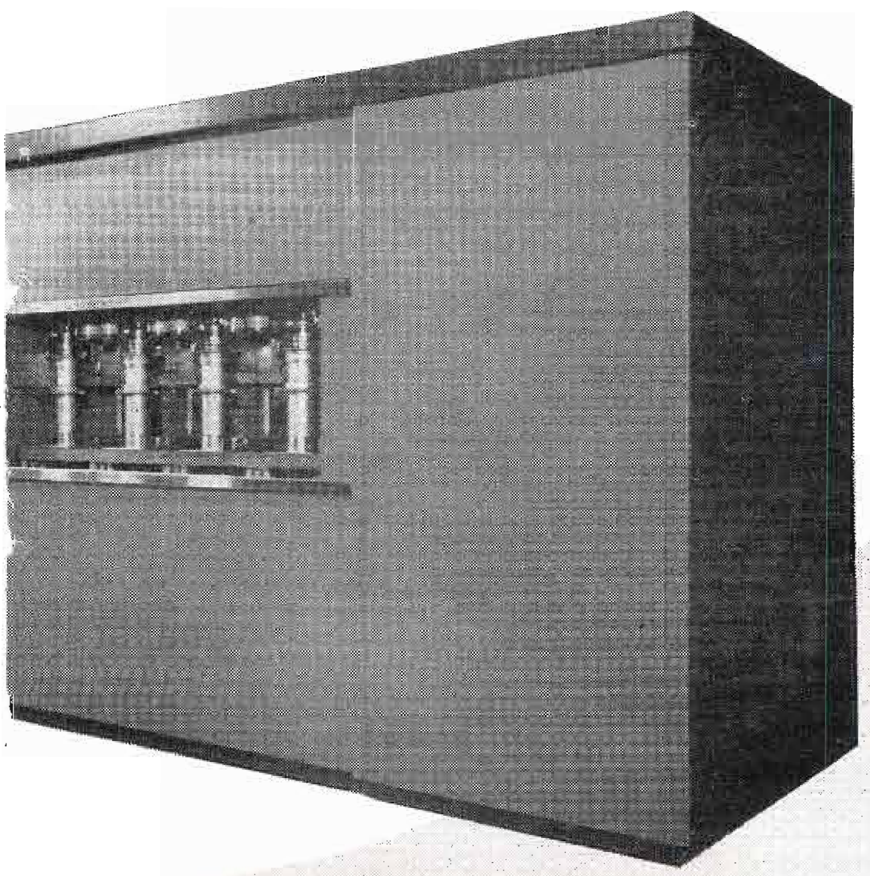
ND BEYOND THE USUAL STANDARDS



UR Million Watts peak power for VOICE OF AMERICA Broadcasts

items such as low power drivers, cooling equipment and power supplies.

Continental is proud to take part in this vital American operation, being currently conducted by the Department of State and its International Information Administration, to bring hope and enlightenment to peoples of Communist dominated lands . . . to assure that the Voice of America is not drowned out in an electronic maze of din and discord.



Features of the Transmitter

★ Unmodulated carrier — 1,000,000 watts. Peak power 100% modulation — 4,000,000 watts.

★ Performance characteristics far surpass FCC requirements for standard broadcast transmitters.

★ High efficiency linear power amplifiers utilizing high gain tubes and most modern techniques in circuitry.

★ Overall efficiency, from power mains to radiated power, better than 50%.

★ All of the metering, tuning controls and power control have been centralized on a console type of control and tuning unit.

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MANUFACTURING COMPANY
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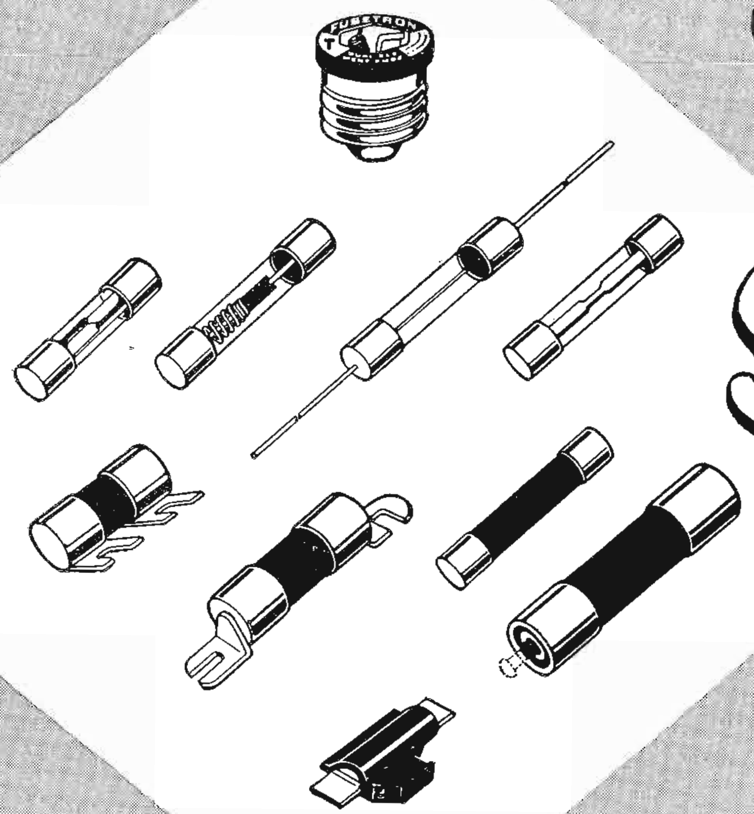
MANUFACTURING

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

OPERATION

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

* Reg. U. S. Pat. Off.

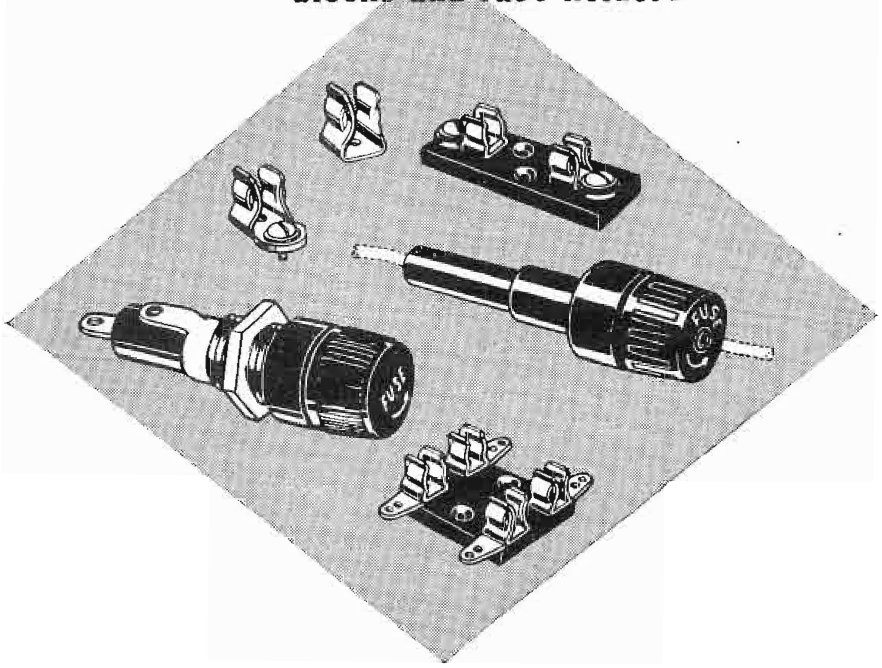


Simplify
Your Search for the Right Protection

Standardize
on BUSS Fuses..

the complete line for Television • Radio • Radar Instruments • Controls and Avionics

***Plus* a complete line of fuse clips, blocks and fuse holders**



Whatever your protection requirements, you'll find the right fuse faster when you look first to BUSS. All types and sizes, from 1/500 ampere up, are included in the complete BUSS line. This can simplify your purchasing and stock handling.

To assure protection to both the product and your good name, every BUSS fuse is tested on a sensitive, electronic device for correct construction, calibration and physical dimensions.

TO HELP YOU GET STARTED THE RIGHT WAY

BUSS Fuse Engineers will gladly assist you in selecting the fuse to suit your needs best... a fuse that if possible will be available in local wholesalers stocks.

BUSSMANN Mfg. CO., Division of McGraw Electric Co.
University at Jefferson, St. Louis 7, Missouri

BUSSMANN Mfg. Co. (Division of McGraw Electric Co.)
University at Jefferson, St. Louis 7, Mo.

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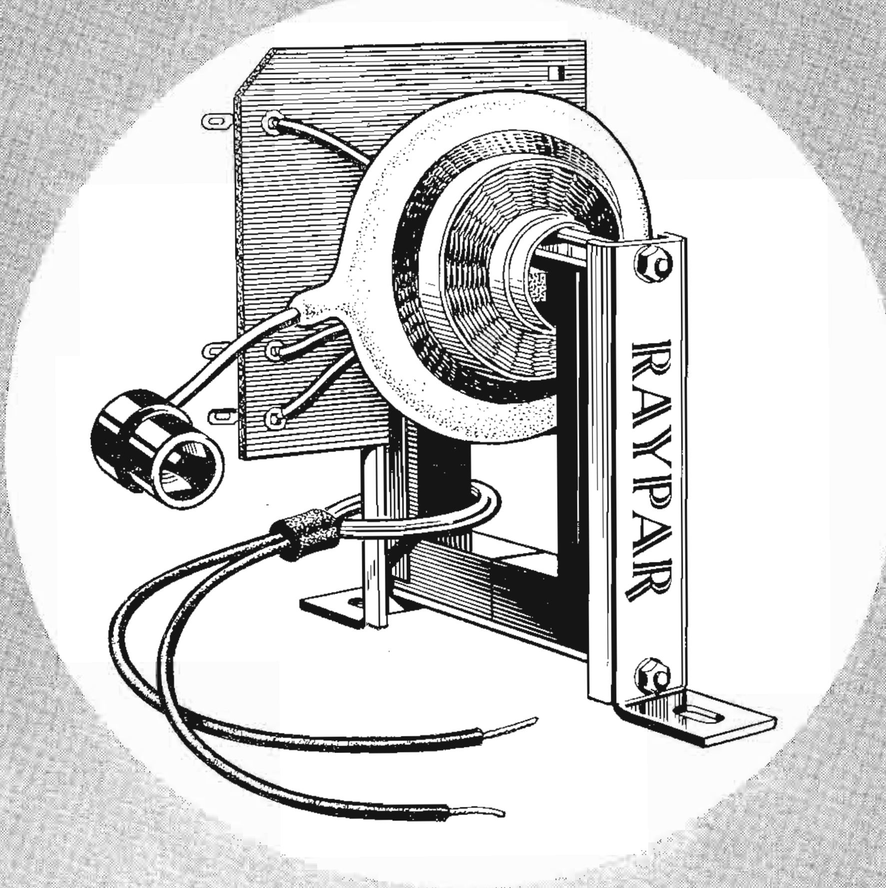


TELE-TIPS

CORONATION TELECASTS will be shown in the U. S. a few short hours after the ceremony takes place in London on June 2, 1953. An important time-saving factor is that films of Queen Elizabeth's Coronation will be edited and prepared while en route by plane. CBS, for example, has removed 12 seats from a Stratocruiser, and installed 3000 lbs. of electrical and other special equipment, including editing tables, viewers, cue markers, and sound readers.

COLOR-TV SETS—NTSC has advised the Congressional Committee on Interstate Commerce that the following TV-Color receivers will be available for testing the new NTSC standards:

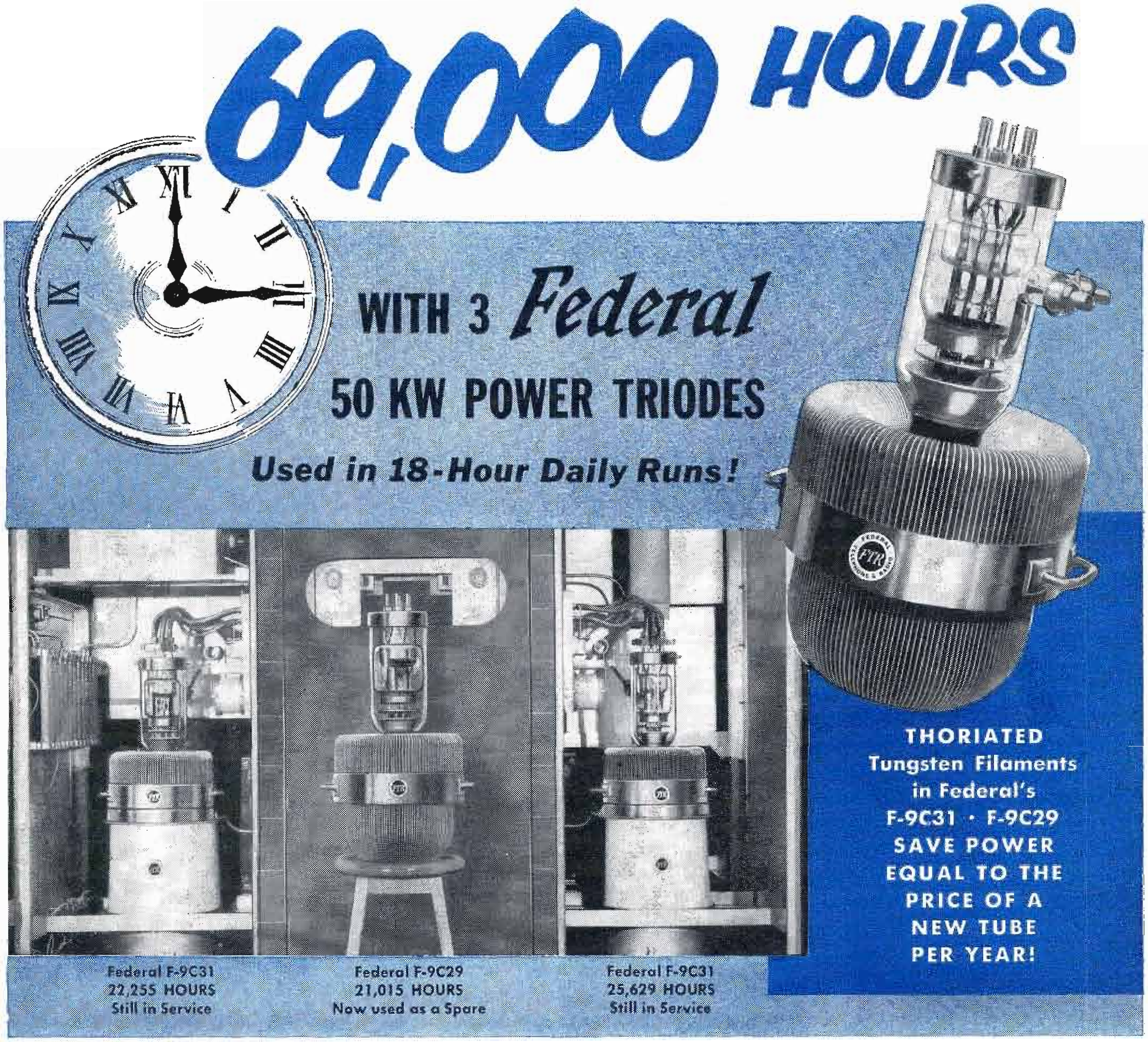
Sylvania three receivers.
RCA eight receivers.
Westinghouse two receivers.
Emerson was to have one late in April.
Tele-King was to have one late in April or early May.
Crosley was to have one receiver March 15th.
General Electric two receivers.
Admiral two receivers.
Hazeltine two receivers.
Zenith one receiver.
Motorola two receivers.
Philco two receivers.

DIAGNOSIS via long distance telephone may be practised someday by brain specialists, obviating personal visits to out-of-town patients. Recent tests involving the transmission of electroencephalograms (brain waves) over the facilities of the Northwestern Bell Telephone Co. by Univ. of Nebraska medical college scientists have been described as "quite encouraging" but technique is said to be still in development stage.

LOOK TO THE OCEAN to supply the increasing demand for magnesium in military, aircraft, structural and automotive applications. The lightweight metal is expected to find wide use in batteries because it can supply electrical energy without polarization. The President's Materials Policy Commission predicts that 1,100,000,000 lbs. will be used by 1975—an 1845% increase over 1950. Most plentiful source of supply to be exploited is the ocean, which contains 320,000,000 cubic miles. Each cubic mile of sea water contains 12,000,000,000 lbs. of magnesium.

(*Continued on page* 54)

CANADIAN BROADCASTING CORPORATION NOW AT...



THIS is the life story of 3 of numerous Federal power triodes used by the Canadian Broadcasting Corporation at station CBX, Lacombe, Alberta: Since October, 1948, to recent date, these tubes have served for 69,000 hours. Both F-9C31's appear to have full emission and capability of many more hours. The F-9C29 – used in modulator unit – is on standby after 21,015 hours.

Behind the long performance of these 3 tubes is Federal's pioneering in the *multi-strand thoriated tungsten filament,* which permits hairpins to expand *individually* . . . eliminates stresses which might be conducive to filament warping.

Cathodes of this type provide lower operating temperatures . . . keep components cooler, more durable. Because *less* filament power is consumed, tube life is *longer* . . . operating costs are *lower.* The power saved per-tube-per-year equals the price of a *new* tube!

For full information on Federal's F-9C31 and F-9C29, or Federal quality-controlled tubes of any power output, write Dept. K-166.

Federal always has made better tubes"

FEDERAL TELEPHONE & RADIO — FTR — AN IT&T ASSOCIATE

Federal Telephone and Radio Corporation

VACUUM TUBE DIVISION — **100 KINGSLAND ROAD, CLIFTON, N. J.**

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp., 67 Broad St., N. Y.

TELE-TIPS

(Continued from page 52)

"IF FLYING SAUCERS flew around as thick and fast as flying saucer rumors, they'd be as plentiful as mosquitoes after a rain," commented one observer. Nevertheless, latest report is that A. V. Roe, Ltd., Malton, Ontario, Canada, has a new aircraft in the works which will rise vertically from the ground and travel at 1500 mph. Rumor's description is that the projected craft is shaped like a saucer, with the pilot's bubble in the middle of a jet-driven rim.

SUBSONIC PUMPS promise to revolutionize the oil industry by eliminating the "sucker rod" on plunger pumps. Considering that plunger pumps are used in 75% of the nation's 450,000 oil wells, and that the rods run to depths as great as 15,000 feet, the new pump should cut oil production costs significantly. In operation, the subsonic pump vibrates the oil well casing, causing the oil to move slowly upward. Check valves in the well prevent the oil from falling back. At least one of these pumps is now operating.

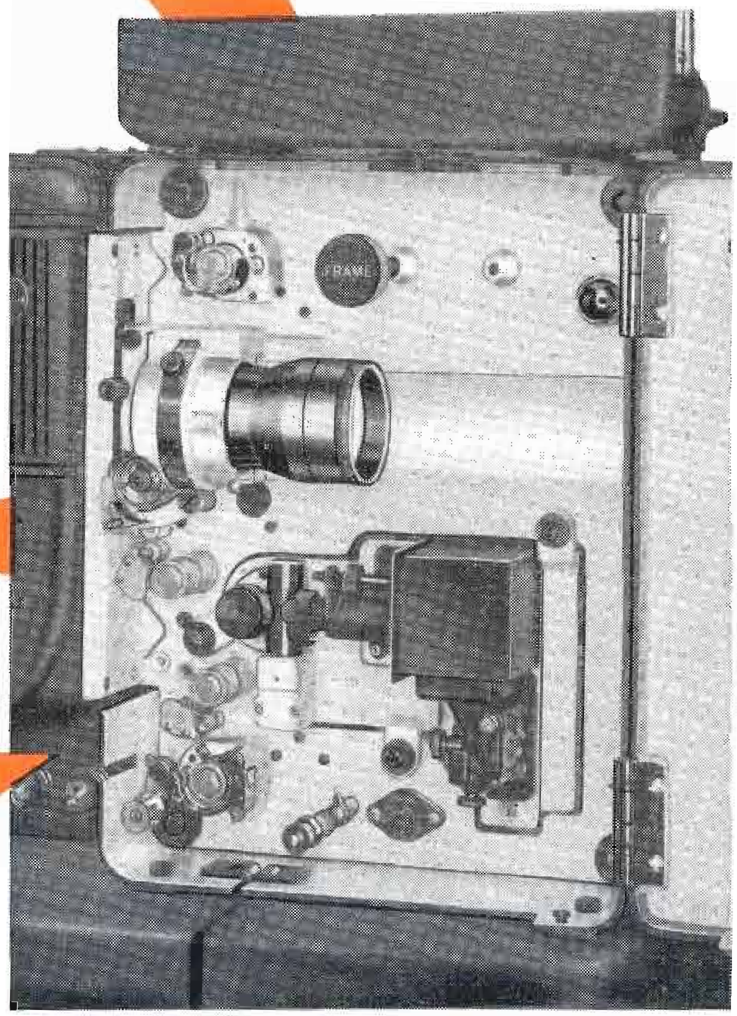
RCA's TV ON TAPE—"I was surprised at the demonstration I saw of a television program coming from New York and being simultaneously recorded on tape in the Princeton Laboratories 45 miles away." comments Gen'l. David Sarnoff "The recording was played back instantly. The quality of the recorded picture still needs improvement—but even its present performance convinced me that we will have the television tape recorder before the time (1956) specified.

"Tape recordings will obsolete the use of film for television and reduce over-all costs. Small degradations which mark the various steps in the production of a film, creating a cumulative effect in the final print, will be eliminated. This new method will revolutionize the entire art. As a simpler and cheaper process, it will extend into color television. And it may extend into the motion-picture industry as well.

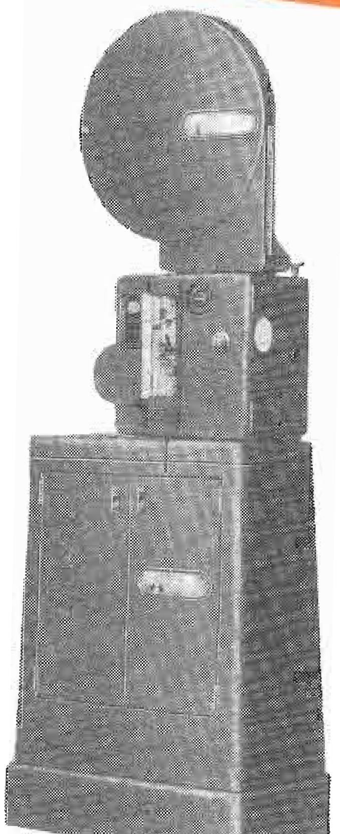
"As you all know, the recording of sound on magnetic tape already has reached a high degree of perfection. When recorded sound has served its purpose it can be wiped off and the tape used over again. I believe that we now stand on the threshold of the same service for sight."

(Continued on page 56)

Look into this
PROFESSIONAL
Telecast Projector
and see years of Dependable Service



The GPL Model PA-100A 16-mm Studio Projector with the basic features and performance reliability of the famous Simplex 35-mm Theatre Projectors.



The Model PA-100A is a 16-mm projector consistent with the professional character of television station operation. Its enclosed 4,000-foot film magazine provides for 2 hours of projection — an entire feature.

Sharper Pictures . . . Finer Sound From Any Film in Your Studio

The importance of 16-mm film in television programming has called for new standards of projection quality and dependability. The GPL Model PA-100A is designed and built specifically for television studio use. It is a heavy-duty film chain projector for operation with any full-storage type film pick-up, as well as with the image orthicon camera.

The professional, sprocket-type intermittent, similar to that used in the finest 35-mm equipment, is quiet and trouble-free. It provides a vertical stability of better than 0.2% over years of service.

Optical system has dynamic resolution and flatness of field that provide resolution exceeding 600 lines in center and all four corners simultaneously. Screen image uniformly bright—corner illumination is at least 85% of that at center. With a 1,000 watt light source, the projector delivers 100 foot-candles to the camera tube. The sound system provides a frequency response truly flat to 7,000 cps, with flutter less than 0.2%.

GPL has a full line of 16-mm television and theatre projectors, built to highest standards of 35-mm construction.

For full details, write, wire or phone

General Precision Laboratory GPL

INCORPORATED

PLEASANTVILLE NEW YORK

Cable address: Prelab

Export Department:
13 East 40th St., New York City
Cable address: Arlab

TV Camera Chains • TV Film Chains • TV Field and Studio Equipment • Theatre TV Equipment

TELE-TIPS

(*Continued from page* 54)

LIGHTNING is simulated with a 75-lb. synchrograph developed by James M. Clayton and Dr. E. L. Harder to facilitate the study of lightning effects on broadcast stations and power lines. The device makes the simulated bolts "stand still" to allow rapid calculations. It costs a few hundred dollars, and performs many of the jobs done by the $200,000 high-voltage surge generator.

HOUSEWIVES aren't the only people plagued by the dust problem. In experiments to determine why various insulation materials break down, the test electrodes must be perfectly smooth and dust-free. According to General Electric's Dr. A. Harry Sharbaugh, one tiny speck of dust may cause the breakdown voltage to vary as much as 10,000 volts on successive tests. In order to get the smoothest solid surface possible, researchers are turning to glass, coated with vaporized gold.

BANK TV—The New York Savings Bank has introduced a new system for speeding up depositors, transactions through a coordination of television and IBM machines. Styled "bankavision," the system performs banking operations in a fraction of the time formerly required. Television is used on withdrawal transactions.

The signature card and balance is sent on private television lines directly to the teller on a screen built into the teller's counter. In the new Rockefeller Center office, which will be opened soon, all record keeping will be done at the main office through the use of television and telautograph.

TOWER JUMPER—A television sound-effects man called off his threat to jump 300 ft. off the Canadian Broadcasting Co. TV tower in downtown Toronto after police showed up with the man's pretty girl friend. Despondent because he had lost his job with CBLT, Toronto TV station for CBC, the man climbed 300 ft. up the 460-ft. tower and stayed for two hours. More than 1000 persons assembled as floodlights played on him. Detective Robert Miller got the would-be jumper to talking about his girl friend and how much he loved her. "Can you imagine how upset she'll be if you jump?" Miller asked.

The sound man agreed to come down if his girl friend was waiting at the foot of the tower for him. She was, and he did.

(*Continued on page* 59)

(*Continued from page 56*)

COST OF GOVERNMENT sponsored research and development for the 1953 fiscal year is estimated at $2,189,000,000 by the National Science Foundation. In 1952, the bill came to $1,839,000,000, of which the Dept. of Defense administered 72%, and the AEC 14%.

"PUMPERATING" — A new means of rating television programs —the water use method—is described in *Public Works* by George J. Van Dorp, Water Commissioner of Toledo, Ohio. It is based on experiences of operators of that city's water works. In recent years the operators have had difficulty in satisfying the varying demands for water at suitable pressures during the evening hours. Repeatedly the pumpage load on the plant would increase as much as 25 to 30 per cent within a few minutes. Because of their construction, the pumping units in service sometimes were unable to handle the load. More units would then be added but as soon as they were put in use the load would drop. After considerable study, says Mr. Van Dorp, it was discovered that the extreme fluctuations were a direct result of television. During popular TV programs little water is consumed, but large quantities are drawn all at one time as soon as the commercial goes on or the program ends.

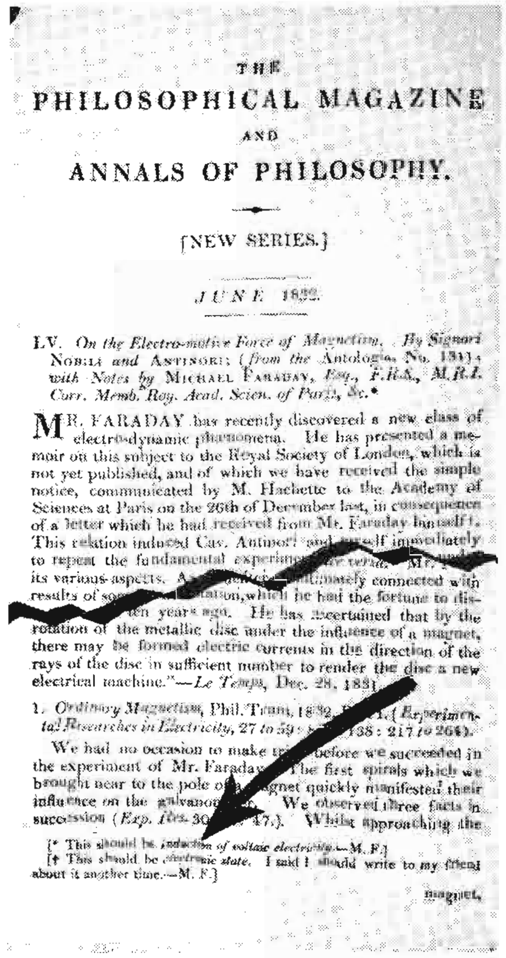
A BUSINESS, Like An Automobile, Has To Be Driven, In Order To Get Results, says Salesman Sam. And keeping a little ahead of conditions is one of the secrets of business . . . . To Know How Little You Know Is The First Step To Knowing More: the difference between a man who reaches a high position of power and influence and one who does not rise above mediocrity is largely due to the fact that one studies and the other does not . . . . You Can't Do Today's Job With Yesterday's Methods, And Be In Business Tomorrow: Many people are very open-minded about new things, so long as they're exactly like the old ones . . . . Small Opportunities Are Often The Beginning Of Big Business; but opportunity looks so much like hard work that most people never recognize it . . . . Nothing Great Was Ever Achieved Without Enthusiasm; and Promptness Is The Soul Of Business . . . . *Said Napoleon:* "The Reason I Beat The Austrians is, they didn't know the value of 5 minutes."

"ELECTRONIC"

First uses in 1832 and 1929

OLD archives again reveal an earlier use of the word "electronic", now fixing its origin 97 years before any commercial usage and associating the term with the immortal scientist, Michael Faraday.

This discovery is highly interesting. It not only helps to trace the name of what is now a multi-billion



THE
PHILOSOPHICAL MAGAZINE
AND
ANNALS OF PHILOSOPHY.

[NEW SERIES.]

JUNE 1832.

LV. *On the Electro-motive Force of Magnetism. By Signori* NOBILI *and* ANTINORI; (*from the Antologia, No.* 131); *with Notes by* MICHAEL FARADAY, *Esq., F.R.S., M.R.I. Corr. Memb. Roy. Acad. Scien. of Paris, &c.**

MR. FARADAY has recently discovered a new class of electro-dynamic phænomena. He has presented a memoir on this subject to the Royal Society of London, which is not yet published, and of which we have received the simple notice, communicated by M. Hachette to the Academy of Sciences at Paris on the 26th of December last, in consequence of a letter which he had received from Mr. Faraday himself†. This relation induced Cav. Antinori and myself immediately to repeat the fundamental experiment [illegible] Mr. [illegible] its various aspects. A [illegible] intimately connected with results of so[illegible]tation, which he had the fortune to dis[illegible]en years ago. He has ascertained that by the rotation of the metallic disc under the influence of a magnet, there may be formed electric currents in the direction of the rays of the disc in sufficient number to render the disc a new electrical machine."—*Le Temps*, Dec. 28, 1831.

1. *Ordinary Magnetism*, Phil. Trans. 1832, [illegible] (*Experimental Researches in Electricity*, 27 to 59 [illegible] 138 : 217 *to* 264).

We had no occasion to make [illegible] before we succeeded in the experiment of Mr. Farada[illegible] The first spirals which we brought near to the pole o[illegible]gnet quickly manifested their influence on the galvano[illegible] We observed three facts in succession (*Exp. Res.* 30 [illegible] 47.). While approaching the

[* This should be *induction of voltaic electricity*.—M. F.]
[† This should be *electronic state*. I said I should write to my friend about it another time.—M. F.]

magnet,

dollar industry, but it clarifies the confusion attending early commercial uses of the word.

Thanks to the indefatigable researcher, Lloyd Espenschied, of Bell Telephone Laboratories, who brings this newest development to our attention, his continuing investigation of early uses of the word "electronic" has led to the discovery of the printing of the word "electronic" in 1832 as part of a letter signed by Faraday, appearing in the London "Philosophical Magazine & Annals of Philosophy", Vol. XI, June, 1832, bearing on Faraday's 1831 Royal Society paper on electromagnetic induction. In other letters written at the time, Faraday refers to a magnetic "electrotonic state", and Espenschied suggests that the 1832 word "eléctronic"—however prophetic—may have been a printer's error.

At various times in recent years, TELE-TECH has published excerpts from the work of early scientists showing use of the word "electron" and "electronic". In December, 1949, for example, TELE-TECH stated:

"In 1891 Dr. G. Johnstone Stoney coined the word "electron" and gave the ultimate particle of electricity its now familiar name."

In the same article, was another authentic record:

"Also, in 1919, Lloyd Espenschied reminds us, the term "electronic" appeared in reference to a vacuum table category, in the Gherardi-Jewett paper on "Telephone Repeaters" in Proceedings A.I.E.E., November, 1919."

The first suggestion of a technical publication in the field of the electronic industries was made July 2, 1929 in a memorandum entitled "New Magazine Opportunity" written by M. Clements, then manager of McGraw-Hill's "Radio Retailing", for Malcolm Muir, and Edgar Kobak, the two senior officers of McGraw-Hill.

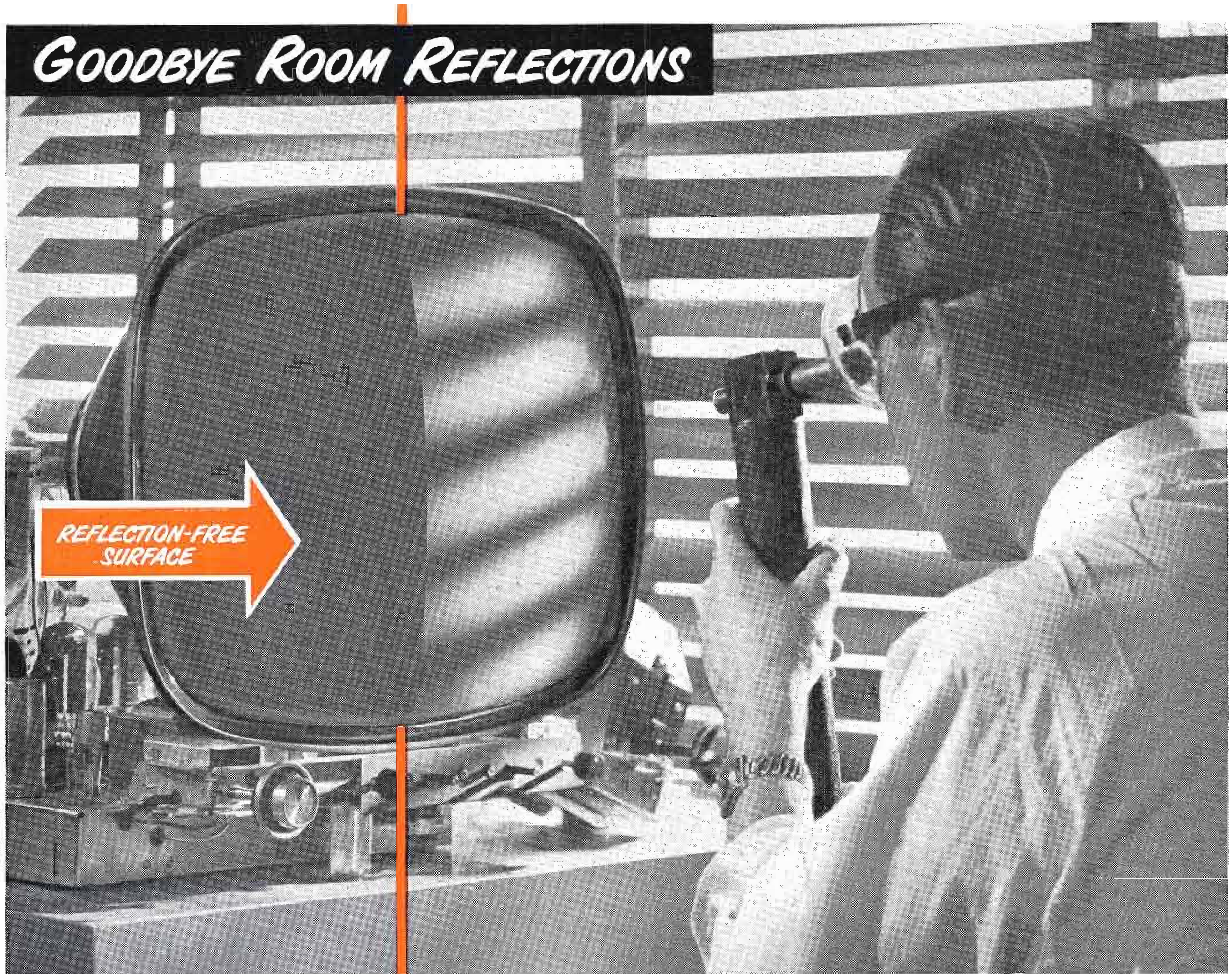
This eight-page memorandum outlined a publishing plan by Mr. Clements as follows:

"The magazine I am proposing will serve the engineering and manufacturing functions in the industries based on the thermionic tube. This, the radio tube, is the common denominator of these and other industries: radio apparatus, broadcasting, sound pictures, "wired wireless", high frequency telephony, television, etc. You cannot interest the radio engineer in a broad-gauged electrical engineering publication. His world revolves around the application of the thermionic valve to all industries."

During the magazine's development period, Mr. Clements tentatively used "Electrons" as the name of the proposed publication. Later, Mr. Clements and Dr. Caldwell, who was then editor of the McGraw-Hill magazine, "Radio Retailing", and subsequently first editor of "Electronics", had visited authorities in the field, and one of them, Dr. John Mills of Bell Telephone Laboratories, made the suggestion that the name "Electrons" be expanded to "Electronics", the name finally used.

Recognition of Mr. Clements' contribution to the founding and naming of the magazine appeared in an official McGraw-Hill Executive Order No. 142, dated January 15, 1930 and signed by Malcolm Muir, President, which reads as follows:

"M. Clements has been appointed Sales Manager of 'Electronics'. This increase in Mr. Clements' responsibilities gives recognition to his excellent record on 'Radio Retailing' and to the *thorough job he has done in developing the plan for the new publication 'Electronics'*".



Proved by the 50/50 faceplate test

● Why do the light reflections disappear—at the midway point of the faceplate?

It's because the left half of the faceplate surface is etched—while the other half is smooth and glossy like an ordinary faceplate.

Built specifically for reflection studies, the experimental "50/50" metal-shell picture tube shown in this photograph clearly illustrates how an untreated faceplate (right half) "mirrors" light reflections, while a treated faceplate "kills" them. *No change in picture detail, either.*

Take advantage of this simple answer to an old problem—and make YOUR TV line "reflection-free." Use RCA Metal-Shell Kinescopes which feature specially treated reflection-free faceplates. They will give your sets new, extra sales appeal.

For technical data or design help, write RCA, Commercial Engineering, Section 57ER, Harrison, N. J. Or just call your nearest RCA Field Office:

(EAST) Humboldt 5-3900, 415 S. 5th St., Harrison, N. J.

(MIDWEST) Whitehall 4-2900, 589 E. Illinois St., Chicago, Ill.

(WEST) Madison 9-3671, 420 S. San Pedro St., Los Angeles, Cal.

RCA Metal-Shell Kinescopes

RCA-21AP4	RCA-21MP4
(magnetic-focus type)	(electrostatic-focus type)

All RCA metal-shell kinescopes feature faceplates which suppress annoying room reflections.

RADIO CORPORATION of AMERICA

ELECTRON TUBES — HARRISON, N. J.

TELE-TECH

& ELECTRONIC INDUSTRIES—RADIO-TELEVISION

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

Military Gear Must Work in Battle

The introduction of radically new and complex electronic equipment for the Armed Forces has brought about a host of design and operational problems which require concerted corrective attention by top level government and industry engineers.

The $64 question is: Have we gone too far in the development of complex equipment? At the present time, the answer is an unfortunate *yes*. However, with proper planning this situation can be changed. Here is how:

First, let's define two types of complexity. There is "operational complexity," which refers to the operator's confusion in manipulating many controls and observing numerous functions. Considering the turbulence of battle conditions, any device overly susceptible to operational complexity is intolerable. One curative approach is the incorporation of automatic functions in the design, thereby relieving the operator of activities prone to human error. Besides the inherent nature of the equipment, this is a major factor in "circuit complexity."

The good sense, or lack of it, in favoring automaticity with resultant circuit complexity has been hotly debated. The fact is that operational accuracy has been rising, and therefore *the decision in favor of circuit complexity was a sound one*. Nevertheless, production and operation factors related to circuit complexity have not kept apace with the performance capabilities of the systems developed. These associated factors are amenable to correction, and when they are resolved we will realize the benefits of which the equipment is capable.

Increased circuit complexity highlights the already troublesome problem of reliability. It would indicate that an extension of the reliability program already instituted is in order, particularly where vacuum tubes are concerned. Fully 50% of electronic equipment failures are attributed to tubes. The Army's current purchases of about 1,500,000 reliable tubes at an average of $4.50 each is a heartening sign.

Much has been done to increase reliability and reduce complexity where possible. A great deal is still to be done, particularly in setting up a more effective overall plan. Here is a 5-point program which should contribute materially to effecting such a plan.

1. Liason: A more closely coordinated program between the Armed Forces and the electronic industries will result in more orderly development and production. All too often a new system has been hurried into production before it has been adequately evaluated. By restricting systems to do no more than required by the military, industry can turn out equipment unencumbered by complex gadgets. A more carefully thought out specification and procurement program by the Armed Forces would eliminate non-essentials and duplication.

2. Application: Variations of the rate of vacuum tube failures in different pieces of equipment cover a 10:1 range, indicating that a refined study of the application of different tube types would be highly desirable. By careful circuit engineering, followed by field use only for the equipment's intended purpose, performance reliability can be raised considerably.

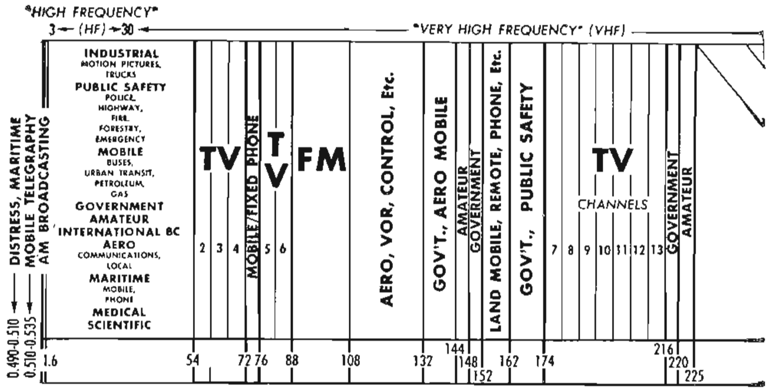
3. Production: The refinement of automatic production techniques will improve reliability by eliminating errors caused by human judgment on the assembly line. It will also demand the simplification of parts construction to permit automatic assembly. An exhaustive investigation of those components which exhibit high rejection rates during production would point up shortcomings either in the manufacturing process or in the basic design.

4. Monitoring: A comprehensive program to monitor all equipment during development, production and field use would function as an information channel to pinpoint trouble at the various stages. Correlating failures with their associated circumstances would provide the practical information which could be fed back to an earlier stage to modify an unreliable or excessively complex design.

5. Maintenance: The effectiveness with which maintenance personnel can repair out-of-order equipment has not kept abreast of growing circuit complexity. A critical need exists not only for more technicians, but for highly trained technical people capable of maintaining devices in operating order. To this end, a more comprehensive training program is proposed.

The above steps are not independent from one another. On the contrary, they are integrally related as part of a unified program to improve reliability and decrease complexity without loss of important functions. The application of these proposals, along with the commendable programs presently in effect, is urged—always with the uppermost thought: Military Gear Must Work in Battle.

RADARSCOPE



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

VIDEO TAPE RECORDING

NEARLY A DOZEN laboratories are now carrying on work on recording TV signals on magnetic tape,—half of these under Government contracts. The Armed Forces are interested in such recordings for military photography. Replacing a light-sensitive film, such a tape record would be immune to radio-active fogging from nuclear-bomb sources, would be immediately available for reproduction without "developing" or other processing, and could be edited and spliced like sound-tape clips. Already Signal Corps and Navy laboratories are at work on "wide-band recording" as the official term is. And recent reports of work on video recording have been heard from Bing Crosby Enterprises, General Electric, RCA, Webster-Chicago, Magnecord, Freed Radio, and Alan Shoup laboratory. In fact, public demonstrations of TV-on-tape may be forthcoming before the end of May.

MANPOWER

ENGINEER SHORTAGE—Right now, there is a need for 40,000 new engineering graduates for industrial and civilian-governmental needs alone, without considering the needs of military services or education. Yet the grim facts on the supply of engineering graduates for the next four years are estimated, for 1953 at 23,000; 1954 at 19,000; 1955 at 22,000; and 1956 at 29,000. Meanwhile engineers' campaigns to enroll high school students in engineering classes are producing results. The U. S. Office of Education reports that freshman enrollment of 127 schools, which last year included 85% of the total engineering enrollment of the country, was up 29%. If reports from the remaining schools show the same increase, it will mean that 4.6% of the 1952 high school graduates have enrolled as engineering freshmen as compared with the usual 2.9% characteristics of pre-war years. On this basis, the entering freshman class in engineering will total 52,000 out of which it is estimated 29,000 will graduate, if not withdrawn earlier by Selective Service.

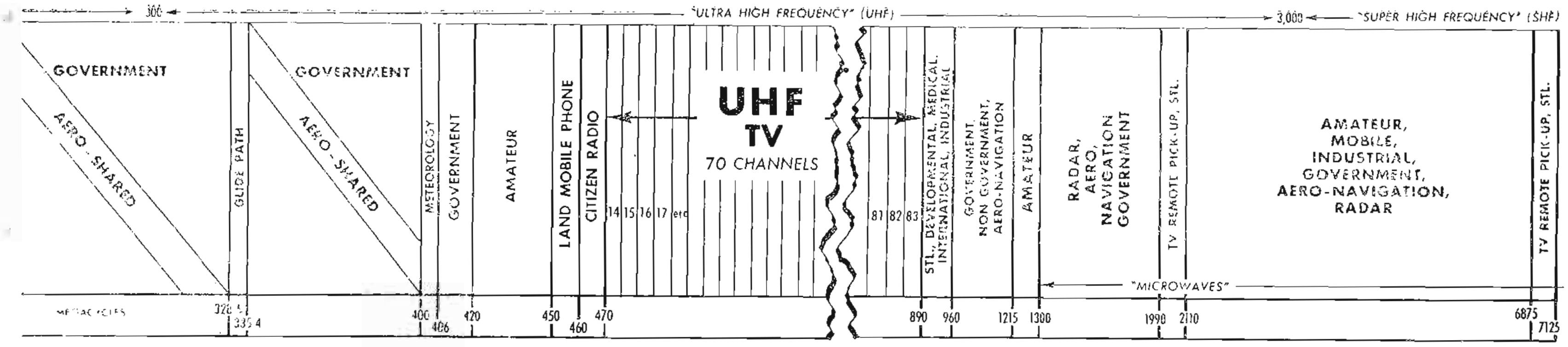
Membership luncheon of the Technical Products Division, RTMA. Left to right: James D. McLean, Philco Corp., Chairman, Committee on Arrangements; Major General C. S. Irvine, Deputy Commander for Production of the Air Materiel Command, Wright-Patterson Field; C. W. Miller, Westinghouse Electric Corp., Chairman of the Technical Products Division; RTMA Director H. J. Hoffman, Machlett Laboratories, Inc., and James D. Secrest, RTMA Executive Vice President.

COLOR TV

STARTING DATE for color video is still the subject of considerable difference of industry opinion. Dr. E. W. Engstrom, RCA, told the House Committee that NBC is ready to begin color-broadcasts at once and to expedite the sale of color receivers to the public. Dr. W. R. G. Baker, GE, and chairman NTSC, estimated six months more of field testing of color receivers operating on NTSC standards, and six to 18 months FCC procedure before official adoption, followed by a tooling-up period for mass production. Dr. A. B. DuMont thinks color TV is five-to-ten years off, declaring that it will be at least a year before an acceptable system could be submitted to the FCC and it would take that agency about three years to act on the proposed system. After this, it would take the industry about a year to tool up and go into production, Dr. DuMont added that in his opinion neither his company nor any other company has developed a satisfactory color system. He was emphatic that he would not go into production with sets on the basis of any present system.

INTERNATIONAL TELEVISION

WE THOUGHT we had troubles when the FCC authorized non-compatible color television, but the Belgians really do have something to complain about! The decision of the Belgian Administration to commence broadcast television services in that country has to take into account the varying standards used in Europe, i.e. adjacent countries. Not only are two languages used in Belgium but the adjacent countries of The Netherlands and Germany use 625 lines and 7 megacycle channels, and France uses 819 lines and 14 megacycle channels. It is even possible that the ability to receive the British transmissions on 405 lines may also be a feature of some of the Belgian receivers. Here indeed is a strong case for television standardization in Europe.



NAMES

FROM TIME TO TIME we hear rumblings of efforts to rechristen our industry and industry associations with electronic titles. Such moves usually come from extraneous or newcomer sources—for the glamour of electronic mystery continues to impress stock-market tipsters, advertising-copy writers, and non-technical executives in search of a new punch to add to the basic radio-TV story. And so it happens that the newspapers continue to tout the six-billion-dollar "electronics industry"! In contrast, the facts are that in a peacetime economy, the total electronic output *has never exceeded 3 to 5% of the radio-TV total.* And during a preparedness period like the present, even the vast "military electronic" output is *two-thirds radio.* Thus as recent charts in these columns have shown, radio-TV totals $4.7 billions, while the actual electronic total is $1.3 billions. Summing it up, socalled "electronics" is a minority of say 5% in peacetime, and possibly up to 22% during rearmament activity. So, in thinking of this $6 billion industry of ours—radio, television and electronics—and in calling ourselves by the right name, let's not let the minor electronic tail wag the six-billion-dollar dog!

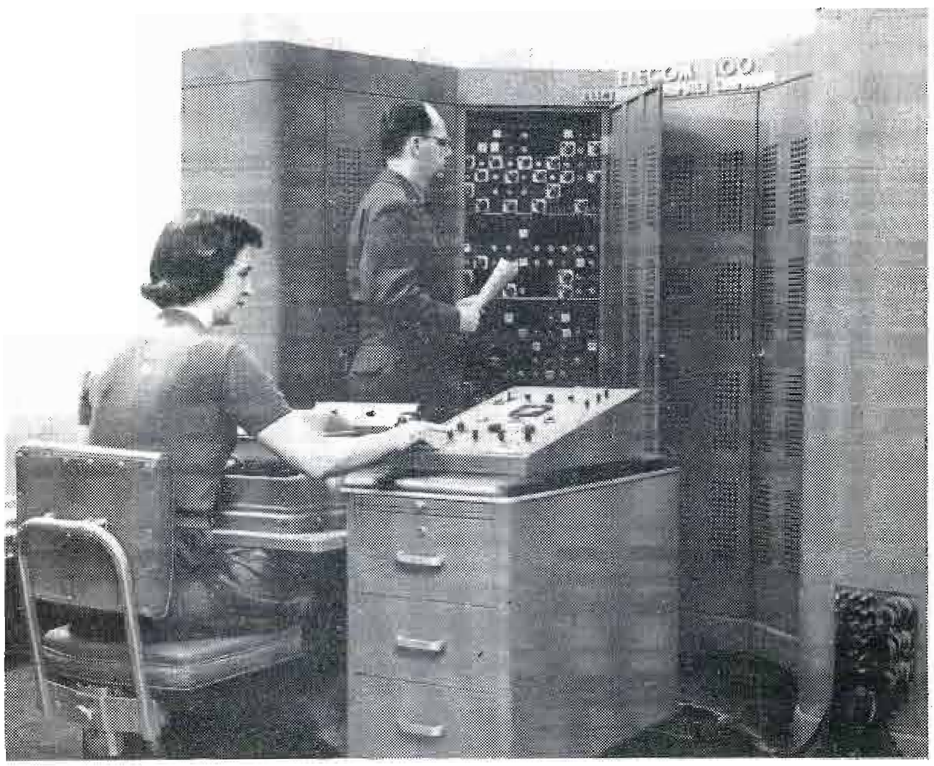
ELECTRONIC TYPE-SETTING

PHOTON is the name of a new electronic typer, employing electronic-computer techniques, and promised by Dr. Vannevar Bush to revolutionize printing. Developed in the Cambridge, Mass., laboratory of the Graphic Arts Research Foundation, the Photon is operated from a typewriter keyboard. From this, the keyed impulses flow into a complex of selectivity relays, are stored momentarily in a "memory bank" while the typed line is being completed, and then pass into a binary code mathematical system like a monstrous calculating machine. The calculator justifies the line—adds the space between letters and words so the line will exactly fill the column or page. A decoding and control system then takes over, and delivers the line to the photo unit. There is a glass matrix carrying 1400 letter characters, spinning steadily ten times a second. As the proper letter arrives at a tiny opening, a light flashes brilliantly for a millionth of a second, photographing the letter. The film is developed, ready for makeup proofs or for engraving on the metal plates which will print the page.

One of the biggest cost-saving factors is in the glass matrix with its 1400 characters. This simple eight-inch disk contains the equivalent of $25,000 worth of the matrices needed for a standard type-setting machine. It never wears out—and it weighs just 1½ pounds. The same variety of material in standard matrices would weigh more than two tons and take up more than 90 cubic feet of space. With it the operator can select quickly and easily from 16 complete sets of type, of every size and style, and even mix them in a line.

ATOMIC ENERGY

APPLICATIONS of nuclear energy to radio and electronics have been difficult to find, but recent astronomical discoveries in connection with "radio stars" suggest that it may some day be possible to use earthly atomic sources as transmitters of radio frequencies. In fact this seems already to be taking place in the remains of exploded stars or "novas." First these nuclear explosions in the far off heavens give off brilliant floods of light. Then as the nuclear processes wane and slow down, the emitted frequencies drift lower and pass through the radio spectrum. Already more than 100 of these radio stars have been located. One particularly strong source of radio transmissions is in the now-dark portion in Casseopeia where Tycho's great nova blazed out hundreds of years ago. Radio emanations from the Great Crab Nebula, the Loop Nebula in Cygnus detected with the new radio telescopes, confirm this theory that today's radio impulses are coming from the "ghosts" of dying stellar explosions, now nearly exhausted.



This first low-cost "robot brain" electronic computer available commercially for general use has been accepted by Army Ordnance officials at Aberdeen Proving Ground after it successfully completed sixty hours of grueling nonstop tests. Making errorless computations at the rate of 1700 a minute, this compact Underwood computer established a record unmatched in accuracy.

How 3-D Motion Picture

Nation-wide surge of interest in three-dimensional movies highlights approach. Stereophonic sound finding increasing use to heighten

A DELUGE of new terminology has accompanied the recently renewed interest in three-dimensional motion pictures, TV, and sound. Particularly confusing are the host of 3-D movie trade-names which have been thrust on the public and engineering fraternity—Cinerama, Cinemascope, Metrovision, Paravision, Natural Vision, Todd-AO, Vectograph—and more to come. An examination of how these systems work, and the differences between them, will cut through the multiplicity of names and show that 3-D is not essentially complicated.

Basically, 3-D films are divided into two types. First, there is the stereoscopic film, which presents a slightly different picture to each eye to produce the depth perspective similar to the way our eyes would view the original scene. The second type employs a wide, curved screen to present a panoramic display which gives the illusion of depth.

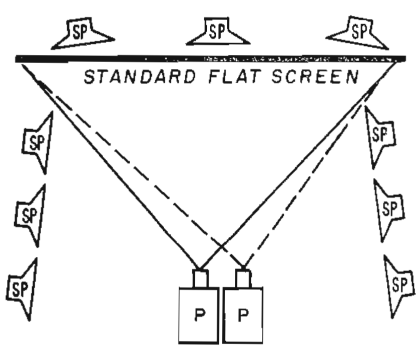
Stereoscopy has developed considerably since 1832 when Sir Charles Wheatstone laid down the basic principles. In 1891, L. D. du Hauron began using anaglyphs, which consisted of red and green filters to separate the two images viewed through red and green glasses. Although this system was improved by Lumiere, commercial use in the 1930's demonstrated its technical inadequacy. Of course, anaglyphs could not be used for color. In addition, a retinal rivalry is set up by the different colors for each eye.

Mechanical System

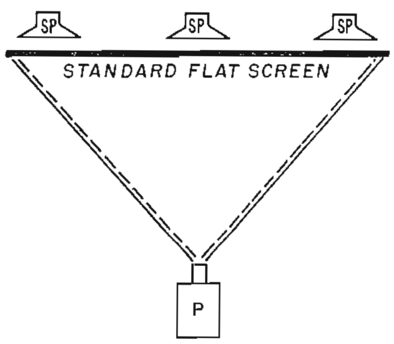
A mechanical system for producing stereo pictures consists of a shutter mounted in a viewing device held by the observer, which alternately covers and uncovers each eye in synchronism with alternating left- and right-eye pictures projected on the screen. Technical and commercial limitations prevent this method from gaining widespread use.

It was not until 1932 that Edwin H. Land announced the first practical polarizer in sheet form, to be followed four years later by public showings of Polaroid's large-screen, full color stereo films at the New York Museum of Science and Industry. The same kind of system is used today in Warner Brothers' Natural Vision, and stereo systems being studied by MGM and Paramount. The current method requires the linking together of two projectors in the theatre projection booth for the simultaneous projection of two separate films, the left one through a filter polarized at 90° to the right film. The observer views the screen through glasses which are correspondingly polarized for the left and right eyes. The pictures can be either in color or black-and-white.

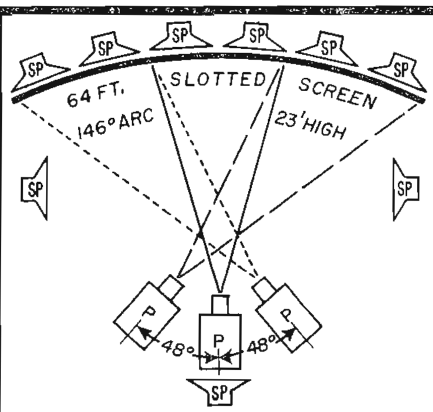
Although this twin projector system is highly workable, it presents



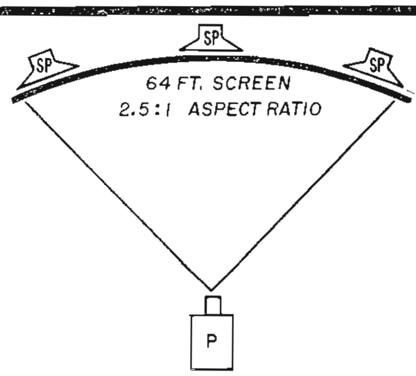
POLAROID
Natural vision (Warner), MGM & Paramount
Polarized glasses for viewing
Uses: 2 standard synchronized projectors
2 polarized light filters
2 35-mm films
4 sound tracks, 25 speakers (Warner)



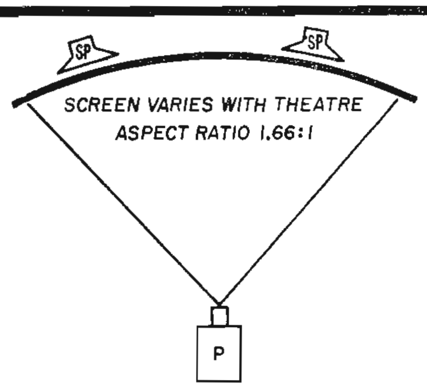
VECTROGRAPH (Polaroid, experimental)
Polarized glasses for viewing
Uses: 1 standard projector
1 35-mm film with polarized images on front and rear surfaces



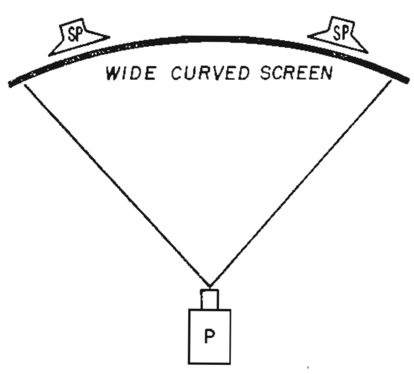
CINERAMA
No glasses for viewing
Uses: 3 synchronized projectors
3 35-mm films
6 magnetic sound tracks on film
8 speakers



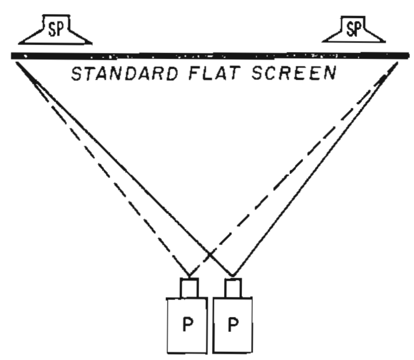
CINEMASCOPE (20th Century-Fox)
No glasses for viewing
Uses: 1 standard projector
1 anamorphoser lens
1 35-mm film (laterally compressed image)
3 sound tracks on film
3 speakers



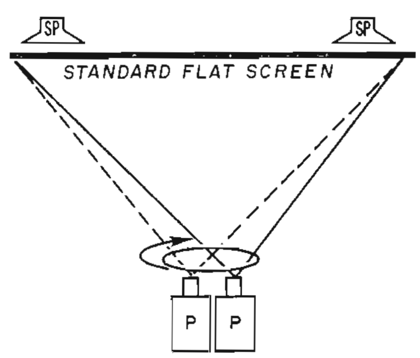
PARAMOUNT
No glasses for viewing
Uses: 1 standard projector
1 wide-angle lens
1 35-mm standard 2-D film
1 sound track
Speakers vary



TODD-AO (Magna Theatres)
No glasses for viewing
Uses: 1 projector
1 wide-angle lens
1 65-mm film
Speakers vary



ANAGLYPH (obsolete)
Red-and-green glasses for viewing
Uses: 2 standard synchronized projectors
1 red light filter
1 green light filter
2 35-mm films
Cannot show color films



SYNCHRONIZED SHUTTER WHEEL (obsolete)
Rotating shutter viewer
Uses: 2 standard synchronized projectors
1 rotating shutter in sync with viewer
2 35-mm films

and TV Systems Operate

two basic techniques: polarized dual-image method and wide curved screen realism. 3-D TV being developed for industrial and broadcasting applications

several problems which indicate its replacement by a simpler method in the near future. Among the prime problems are the heavy burden placed on exhibitors for initial equipment and for assuring correct projection. Also, the insertion of new reels causes occasional interruption unless four projectors are in the booth. One solution is the Vectograph film, first announced by Polaroid Corp. in 1940, and soon to be available for commercial applications. It uses only one film, a single standard projector, and requires no filters or special equipment at the projector. Vectograph carries one image on the back surface of the film and the other on the front of the same film. Since the images are themselves polarized, no filters are needed at the projector. Color or black-and-white may be viewed with polarized spectacles.

Several non-stereoscopic 3-D motion picture systems have come to the fore. This second type of three-dimensional movies presents a large picture projected on a very wide, concave curved screen. Since a single "flat" picture is projected, these systems are not truly three-dimensional. Nevertheless, the panoramic display achieves the depth effect by occupying a large part of the normal field of vision, stimulating peripheral observation. That is, part of the picture is seen out of the "corner of the eye" similar to the way the eye usually sees objects off to the side of its central focus. Since a single image is shown, no glasses are required to view the wide-angle pictures, which may be in color or black-and-white.

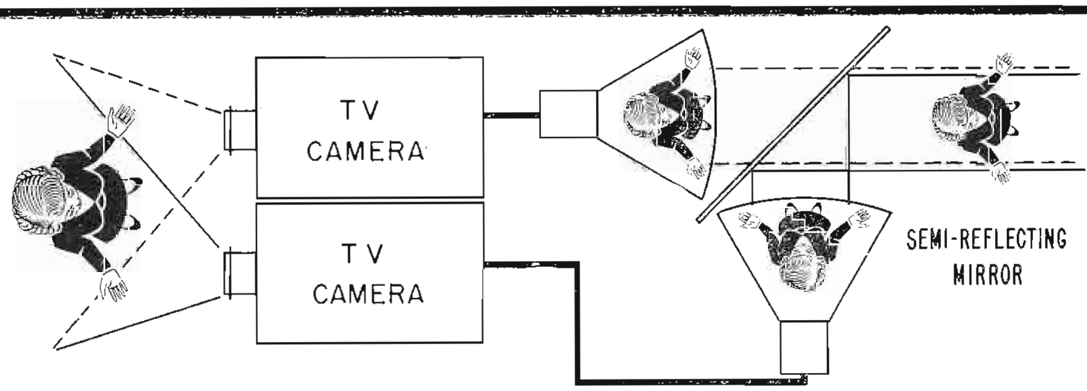
Tri Panel Picture

Cinerama (TELE-TECH & ELECTRONIC INDUSTRIES, Nov. 1952, p. 84), developed by Fred Waller, is the one wide-angle system which employs three separately located 35-mm projectors 48° apart. The projectors are synchronized to throw a tri-panel picture on a 64 x 23 ft. curved screen made of 1100 strips of perforated tape. The screen covers 49 ft. across the front of the theatre, and subtends a visual arc of 146° horizontally, and 55° vertically. Each projector covers about one third of the screen area, which is six times larger than a standard screen.

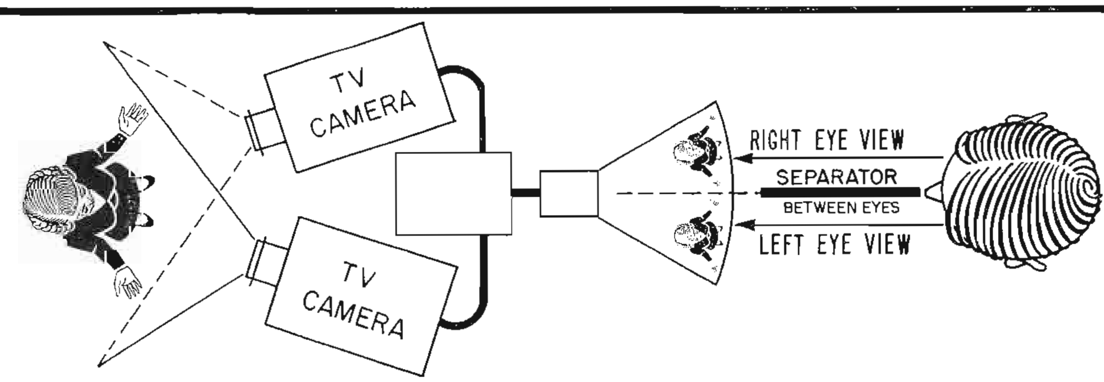
Cinemascope is the 20th Century-Fox contribution to the wide-angle field. It employs a device perfected by Henri Chretien in 1931 called an anamorphoser. The anamorphoser is essentially a curved lens which squeezes a wide picture onto ordinary 35-mm film. A similar unit unsqueezes the laterally compressed image from a standard projector, flashing the picture on a curved screen some 64 ft. wide, or 2.66 times as wide as a standard screen. Fox is

(*Continued on page* 144)

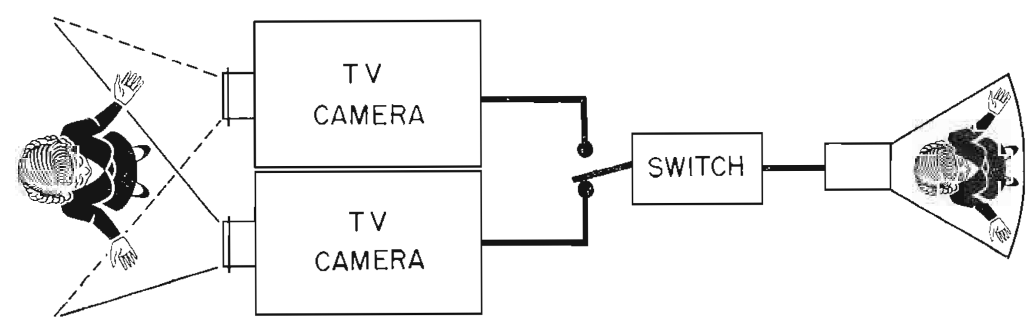
STEREO TV (RCA & DuMont)
Polarized glasses for viewing
Uses: 2 TV cameras
2 polarized picture tubes
1 semi-reflecting mirror



SPLIT IMAGE TV
Opaque separator for viewing
Uses: 2 TV cameras
1 picture tube



SYNCHRONIZED SHUTTER TV (American TV)
Rotating shutter viewer
Uses: 2 TV cameras
1 picture tube
1 electronic switch in sync with viewer



Magnetic Amplifiers

Circuits, general characteristics and applications of magnetic amplifiers reviewed and compared to electronic amplifiers

By SIEGFRIED R. HOH
Components & Systems Laboratory
Weapons Components Division
Wright Air Development Center
Dayton, Ohio

PART ONE OF TWO PARTS

THE advantages which may be realized from using the magnetic amplifier in certain fields of applications are becoming more and more apparent. As compared to the electronic amplifier, the magnetic amplifier offers the following distinct advantages:

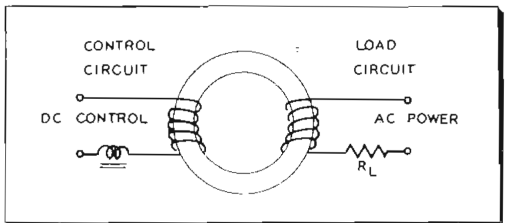


Fig. 1: Simple controlled saturable reactor

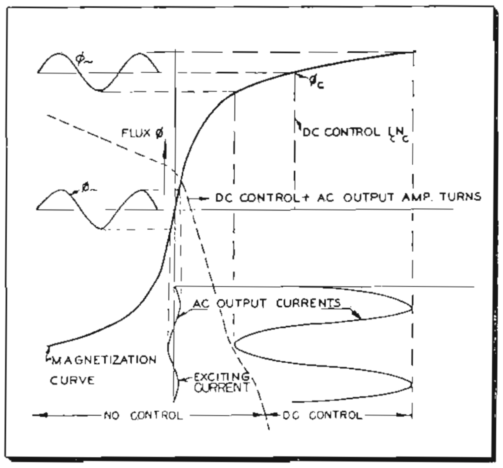
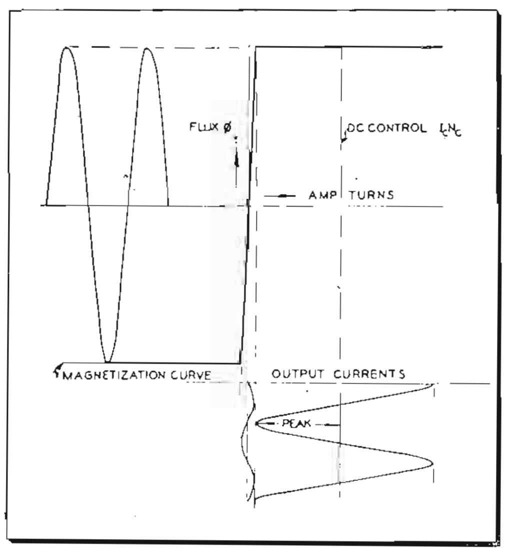


Fig. 2: Operation of controlled reactor

Fig. 3: Curves depicting conditions when saturable reactor is more efficiently controlled



1. It is more rugged and less subject to wear. As a result, there are fewer failures, and less servicing is required.
2. Since no filaments need to be warmed, it is ready for immediate operation.
3. Because of higher efficiency, the required operating power and heat dissipation are reduced.
4. The dc amplification is more stable.
5. High power output can be achieved at low voltage level, thus reducing insulation and corona problems.
6. With a small amount of equipment, complete amplifiers can be built as easily as transformers.
7. The magnetic amplifier, without any modification, can provide stable amplification of both dc and ac.
8. Input and output impedances can be varied widely to meet operational requirements.
9. The input circuit can be completely isolated from the amplifier and can operate at a different voltage level. Input signals at different voltage levels can be mixed conveniently.

Such qualities as those mentioned in 1, 2, and 3 above make magnetic amplifiers particularly suitable for military applications. This was proved in German World War II equipment.

The magnetic amplifier field of application is definitely smaller, however, than that of vacuum tube amplifiers. These limitations and shortcomings are brought out later.

In various publications, the magnetic amplifier has been called a transductor, direct current transformer, amplistat, saturable reactor, and by other designations. For the purposes of this article, "saturable reactor" shall be understood to be the basic component of a magnetic amplifier. However, the same clear distinction between a saturable reactor and a magnetic amplifier cannot be made as with vacuum tubes and electronic amplifiers.

A saturable reactor can be described as an inductor with a saturable core. It utilizes the nonlinear

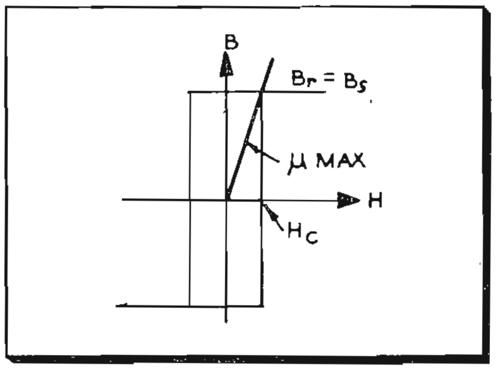


Fig. 4: Rectangular hysteresis loop

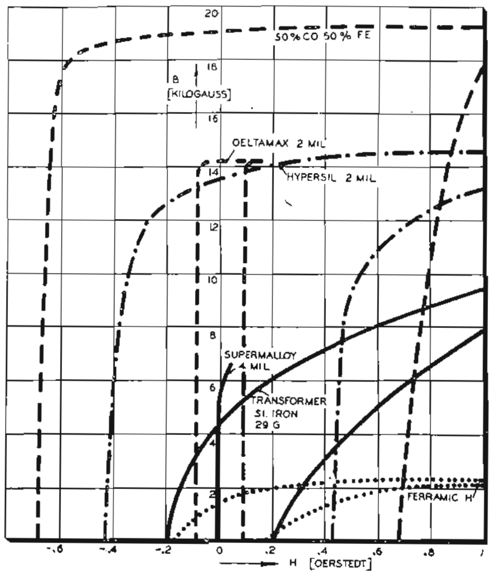


Fig. 5: Half DC hysteresis loops of typical saturable reactor core materials

magnetization curve of ferromagnetic cores. Applications of saturable reactors are found in voltage and current regulators, harmonic generators, mechanical rectifier chokes, etc.[1]

A controlled saturable reactor has two windings as shown in Fig. 1. There is a close resemblance between this device and a transformer. Although transformers could actually be used as saturable reactors, the operation of a controlled saturable reactor is different.

The control or input winding is to carry a control current of a frequency which is lower than the power frequency. For simplification, a dc control is assumed. To suppress the transformer action of the device a choke is used in the control circuit. The resulting high impedance will not draw a substantial induced ac in the control circuit.

The operation of the controlled saturable reactor is to be described in three steps with the aid of Fig. 2.

First, only a direct control current is applied to the reactor. This magnetomotive force, expressed in ampere turns, sets up a magnetic flux ϕ in the core. The resultant curve conforms with the well-known magnetization curve of the core material. The hysteresis is neglected since it would not basically affect the operation.

Sinusoidal Voltage

As a second step, a sinusoidal ac voltage is applied to the power or load winding. The resulting flux swing $\phi\sim$ will be sinusoidal also, as shown. The corresponding small "exciting" current flowing in the ac or load circuit is shown at the bottom of Fig. 2. This is the output current of the saturable reactor at zero control.

In a third step, both the ac voltage and a dc control Ic Nc are applied This is a normal operating condition. The dc control will set up a continuous flux ϕ_C on which the alternating flux is superimposed. The alternating flux swing in the core has to be the same as it was without control because the same ac voltage is applied (see Eq. 5). The voltage drop in the load circuit resistance R_L is neglected here for simplification reasons. Fig. 2 shows that a much higher alternating current is required to cause the same alternating flux swing as occurs without control.

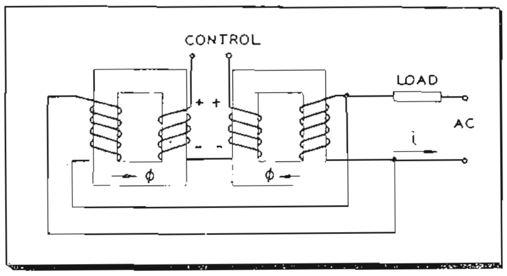


Fig. 6: Mag. Amp., parallel type, 2 cores

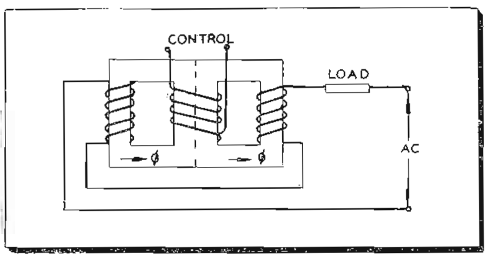
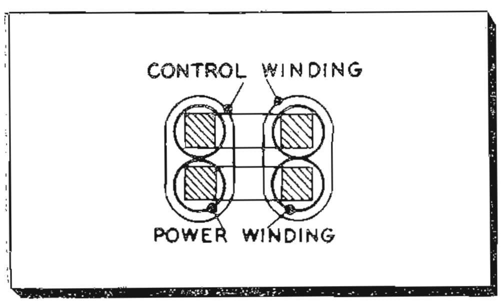


Fig. 7: Mag. Amp., series type, single core

Fig. 8: Diagram illustrates sectional view of another combination of two cores



If still higher control currents are applied, the magnetization curve will be horizontal, indicating "saturation" of the core material. It is obvious that, in this case, the applied voltage could not be absorbed by the reactor. The reactor would lose its inductance, and the resulting ac would be limited only by the load circuit resistance.

This principle is included in a more practical controlled saturable reactor as seen in Fig. 3. The reactor of Fig. 2 has practical significance only where low power wave shape distortion is desired.

A core material with a more rectangular magnetization curve is used in Fig. 3. Better use of the core is made by initially magnetizing the core up to the knee of the magnetization curve. A much higher power supply voltage can be applied, as indicated by the higher alternating flux swing. The exciting currents in Figs. 2 and 3 are made equal to emphasize the advantage gained in Fig. 3.

Output Current

A higher output current will be achieved because of the higher applied voltage and because saturation (horizontal portion of magnetization curve) is achieved at low magnetizing currents. The horizontal portion of the magnetization curve indicates that the reactor has no appreciable impedance, and the total applied power voltage has to be absorbed by the load. Load currents and voltages for intermediate control values are highly distorted as are those obtained with thyratrons. Neglecting the relatively small magnetomotive force which is required to achieve saturation, Fig. 3 shows that, for maximum output, the peak values of the load ampere turns equal the dc control ampere turns. This can be written:

$$I_{L\ (Peak)}\ N = I_C\ N_C \qquad (1)$$

This equation does not mean that no gain could be obtained from this controlled saturable reactor. By relating the output current I_L to the input current I_C, the current gain in this particular case is:

$$I_{L\ (Peak)}/I_C = N_C/N_L \qquad (2)$$

It can be seen that a current gain can be achieved if the number of control winding turns is made substantially higher than the number of turns in the load winding. The power gain can be very high if, in addition, the load resistance is much higher than the control circuit resistance.

A brief comparison between the

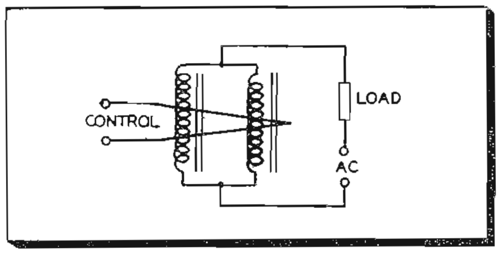


Fig. 9: Circuit diagram of simple magnetic amplifier as illustrated in Fig. 6.

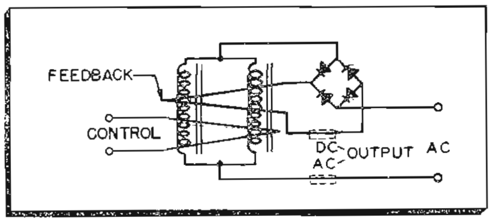


Fig. 10: Amp. with feedback, dc or ac output

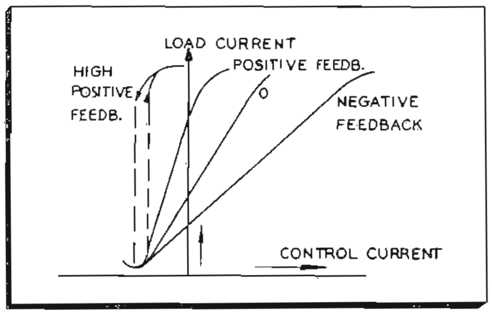


Fig. 11: Amp. characteristics, varying feedback

amplifying saturable reactor, vacuum tube, and transistor, which illustrates some major functional differences, is as follows:

1. Saturable reactors are controlled inductances; therefore such reactors have to operate on ac power. Vacuum tubes and transistors are controlled resistances and, generally, they operate on dc power.

2. Saturable reactors and transistors are essentially controlled by currents, and, as a result, have relatively lower input impedances than vacuum tubes, which are controlled by an electric field or control voltage.

A few fundamental relations of the saturable reactor are presented here for two reasons: (1) They allow a rough design analysis; (2) they form an introduction into the theory.

The basic relation in an inductor like the load circuit of Fig. 1 can be expressed as:

$$e = iR + N\frac{d\phi}{dt} = iR + L\frac{di}{dt} \qquad (3)$$

where:

e = instantaneous value of applied ac voltage
i = instantaneous value of current
R = circuit resistance
N = number of turns in winding
ϕ = magnetic flux in core
$\frac{d\phi}{dt}$ = rate of change of flux over time
L = inductance

MAGNETIC AMPLIFIERS (Continued)

It should be noted that no commitments are made here as to the system of units, hence no numerical constants appear in the equations.

If the flux swing remains in the steep linear portion of the magnetization curve (Fig. 3), the voltage drop is mainly inductive and iR can be neglected. Eq. 3 then reduces to:

$$e = N\frac{d\phi}{dt} \qquad (4)$$

Assuming sinusoidal voltage and flux alternations, Eq. 4 can be written as:

$$E = N2\pi f\phi \qquad (5)$$

where E and ϕ can be taken as maximum, rms, or average values. It should be kept in mind, however, that voltage and flux are still 90° out of phase as indicated in Eq. 3 and 4. The power supply frequency is denoted by f. Since the total core flux can be expressed as flux density B times core sectional area A, Eq. 5 can be rewritten as:

$$E = N2\pi fAB \qquad (6)$$

This equation represents a suitable design formula linking electrical and core dimensional quantities. Loss and heat dissipation considerations have to be made in addition.

In the saturable reactor illustrated in Fig. 3, B has to be taken as the flux density where the knee in the magnetization curve occurs. The voltage that has to be applied will then be obtained in maximum values.

The exciting current derived graphically from Fig. 3 can also be derived from Eq. 6 by recalling that the magnetization curve is exprcssed by the relation $B = \mu H$, where μ is the permeability, and H is the magnetizing force which can be approximated by the ampere turns IN per core length l. Hence,

$$B = \mu\frac{IN}{l} \qquad (7)$$

where B is the flux density at the knee, and IN are the ampere turns of the exciting current.

Substituting B (of Eq. 7) in Eq. 6 yields.

$$E = I2\pi f\frac{N^2\mu A}{l} \qquad (8)$$

This equation governs the operation of the saturable reactor in Fig. 2 where μ is being varied by the control current. I is the output current. This equation (8) also gives an expression for the inductance. Since, according to Ohms law,

$$E = I2\pi fL \qquad (9)$$

we obtain from comparison of Eqs. 8 and 9 the following:

$$L = \frac{N^2\mu A}{l} \qquad (10)$$

According to the method of operation, the amplifying saturable reactor operates essentially as a modulator. The modulating characteristic is emphasized here in order to further illustrate the method of operation. The output current of saturable reactors, unlike that of vacuum tubes and resistors, will always be ac unless rectified. The signal appears as the envelope of the amplitude modulated power frequency. Inherent limitations of the magnetic amplifier derive from its modulating characteristic.

Particular qualities of the saturable reactor which are desirable in some applications also stem from the modulating characteristics. Saturable reactors can be used advantageously in the input stage of low level dc amplifiers. Here the main objective is the conversion of the dc signal into ac, which can be amplified more conveniently.[2]

TABLE I: DC CHARACTERISTICS of SATURABLE REACTOR CORE MATERIALS

COMP. (REST IRON)	TRADE NAME	SPECIAL TREATMENT	MAXIMUM PERMEABILITY	SATUR. B-H (K GAUSS)	RESIDUAL FLUX D. (K GAUSS)	B RES / B SAT APPR.	COERCIVE FORCE (OERSTEDT)	RESIST'S MICR. CM
3-4% Si	TRANSFORMER STEEL	NONE	5,000 – 10,000	20	12	0.6	APPR. 0.5	60
3-4% Si	HYPERSIL TRANCOR 3X SILECTRON	GRAIN ORIENTED	20,000 – 40,000	20	14	0.7	0.1 – 0.3	
45-50% Ni	VARIOUS DESIGNATIONS	NONE	20,000 – 50,000	16	6-8	0.45	0.2 - 0.3	40 – 50
45-50% Ni	DELTAMAX PERMENORM 5000Z HYPERNIK V ORTHONIK ORTHONOL	GRAIN ORIENTED	20,000 — 200,000	16	13 – 15	0.9	0.1 – 0.4	50
65% Ni	65 PERMALLOY	MAGN. ANNEAL	300,000 - 600,000	14	→ 14	→ 1	0.01 - 0.2	
77Ni 80%Ni 79Ni4Mo	MU METAL HYMU 80 4-79 Mo - PERMALLOY	NONE NONE NONE	40,000 – 100,000	8	4 - 5	0.5	0.05-0.15	55
79Ni5Mo	SUPERMALLOY	NONE	100,000 — 500,000	7.8	4 - 5.5	0.6	0.002-0.06	65
50%Co	NONE	MAGN. ANNEAL	10,000 — 30,000	22.4	19	0.85	0.7	
FERRITES (BIVALENT METAL OXIDES)	FERRAMIC MF 1118		700	2.35	2.13	0.91	1.6	
FERRITES (BIVALENT METAL OXIDES)	FERRAMIC MF 666		250	1.66	1.37	0.83	2.6	
FERRITES (BIVALENT METAL OXIDES)	CERAMAG 7 (AT 60 CPS)		4600	2.46	1.74	0.71	0.2	1.8×10^{10}

TABLE II: IDEALIZED RELATIONS of MAGNETIC AMPLIFIERS in OPERATING RANGE

CIRCUITS	SIMPLE AMPLIFIER		FEEDBACK AMPLIFIER *	
	SERIES	PARALLEL	SERIES	PARALLEL
AMPERE TURNS RELATION	$I_L N_L = I_C N_C$	$I_L N_L = 2 I_C N_C$	$I_L N_L = I_C N_C \pm I_L N_F$	$I_L N_L = 2(I_C N_C \pm I_L N_F)$
CURRENT GAIN $\frac{I_L}{I_C}$	$= \frac{N_C}{N_L}$	$= 2\frac{N_C}{N_L}$	$= \frac{N_C}{N_L \mp N_F}$	$= \frac{2N_C}{N_C \mp 2N_F}$
VOLTAGE GAIN $\frac{E_L}{E_C}$ = CURRENT GAIN x $\frac{R_{LT}}{R_C}$	$= \frac{N_C R_{LT}}{N_L R_C}$	$= \frac{2N_C R_{LT}}{N_L R_C}$	$= \frac{R_{LT} N_C}{R_C(N_L \mp N_F)}$	$= \frac{2R_{LT} N_C}{R_C(N_L \mp 2N_F)}$
POWER GAIN (AV. OUTPUT) = (CURRENT GAIN)^2 x $\frac{R_{LT}}{R_C}$	$= \left(\frac{N_C}{N_L}\right)^2 \frac{R_{LT}}{R_C}$	$= 4\left(\frac{N_C}{N_L}\right)^2 \frac{R_{LT}}{R_C}$	$= \frac{R_{LT}}{R_C}\frac{N_C^2}{(N_L \mp N_F)^2}$	$= \frac{R_{LT}}{R_C}\frac{4N_C^2}{(N_L \mp 2N_F)^2}$
TIME CONSTANT IN CYCLES OF POWER FREQUENCY	$= \frac{1}{4}\frac{R_{LT}}{R_C}\frac{N_C^2}{N_L^2}$	$= \frac{R_{LT}}{N_L^2}\left(\frac{N_C^2}{R_C} + \frac{N_L^2}{2R_w}\right)$	$= \frac{R_{LT}}{4N_L(N_L-N_F)}\left(\frac{N_C^2}{R_C} + \frac{N_F^2}{R_F}\right)$	$= \frac{R_{LT}}{N_L(N_L-N_F)}\left(\frac{N_C^2}{R_C} + \frac{N_F^2}{R_F} + \frac{N_L^2}{2R_w}\right)$

SYMBOLS

I = average current
N = number of turns in one reactor winding
R = resistance
R_{LT} = total load circuit resistance

SUBSCRIPTS

L = load circuit
C = control circuit
W = ac winding of one reactor
F = feedback circuit

* UPPER SIGN IN SUM REFERS TO POSITIVE FEEDBACK.
LOWER SIGN IN SUM REFERS TO NEGATIVE FEEDBACK.

Core Materials

A comparison of the saturable reactor of Fig. 2 with that of Fig. 3 reveals that magnetization curves composed of vertical and horizontal portions are desirable for high gain. A vertical magnetization curve

(*Continued on page* 135)

Simple Computer Automatically Plots Correlation Functions

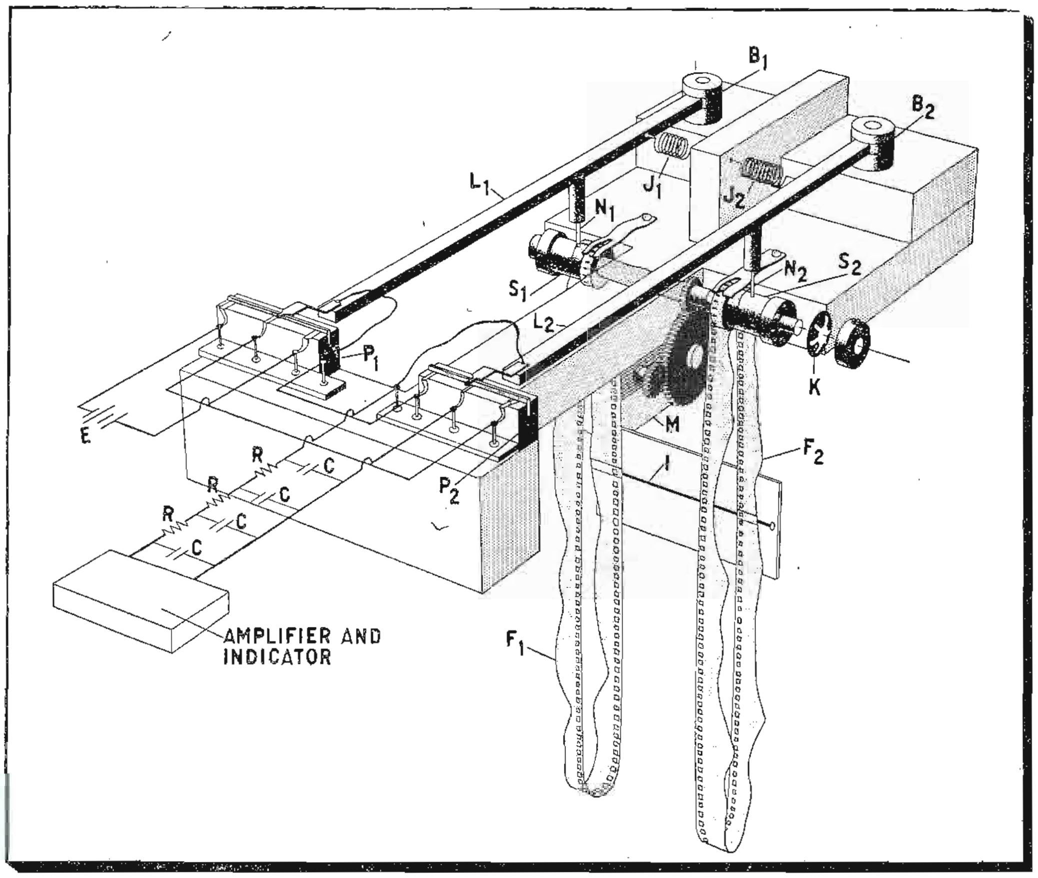


Fig. 1: Sketch showing the basic method of Simcor operation

"Simcor," a simple analog device, takes input information on motion picture film tapes and automatically provides answer on paper strip. Immediate applications include radar noise, ship deck motion, and hearing perception studies. Important time savings for scientists promised

By ALLEN H. SCHOOLEY

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In recent years the correlation function has found application in the electronic field for the detection of periodic signals in noise. Lee, Cheatham, and Wiesner[1,2] have exploited this approach. Correlation analysis has also been used to some extent in the study of ocean waves by Seiwell and Wadsworth.[3] Wilson[4] has even examined the correlation function of Ayres' index of business activity in the hope that he might be able to predict the boom and bust periods of commerce.

The autocorrelation function was first set forth by Wiener[5] in 1930. It is defined as

$$\phi(\Upsilon) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} f(t)\, f(t+\tau)\, dt \quad (1)$$

where f(t) is a time function,

$f(t+\tau)$ is a time function identical to f(t) except displaced τ time-units, and

T gives the integration time limits.

Eq. (1) involves the following basic operations. First, the given time function f(t) is displaced by the time τ. Second, the time function and its displaced form are multiplied together. Third, the average of the integral of the product is obtained over a complete period of $-T$ to $+T$. This process generates a new function, $\phi(\tau)$, which may be plotted as a correlogram with displacement τ as the independent variable. For obvious reasons, the integration limits of time ($-\infty$ to $+\infty$) are not rigorously used in practical applications. Judgment must be used in selecting the length of the time function sample, since it must be sufficiently long to give a reasonably correct correlogram without involving an impractically long integration time. The crosscorrelation function is defined by an equation similar to Eq. (1), except that f(t) and $f(t+\tau)$ are expressed as $f_1(t)$ and $f_2(t+\tau)$ because two different time functions are correlated.

There have been several successful attempts to mechanize the operations indicated by Eq. (1). A rather complex electronic digital correlator was built by Singleton.[6] Hastings and Meade[7] have built a relatively elaborate correlation-function computer utilizing magnetic tape.

In pursuing an electronic research problem, it was found desirable to devise a simple analog computer for use in evaluating the autocorrelation and crosscorrelation functions of analytical and experimental time functions. A simple correlator, called "Simcor," has been constructed at the Naval Research Laboratory. It has proved to be quite useful for the problem for which it was devised and, in addition, is being used for correlation analysis in other fields.

Principle of Operation

Fig. 1 is a schematic sketch showing the basic method of Simcor operation. A small constant-speed motor (M) is used to drive two 35-mm motion-picture sprockets (S_1 and S_2) at the same speed, through gearing to a common shaft. On each sprocket is one side of a loop of 35-mm motion-picture film, designated as F_1 and F_2. The film width of each loop represents the dependent variable of the time func-

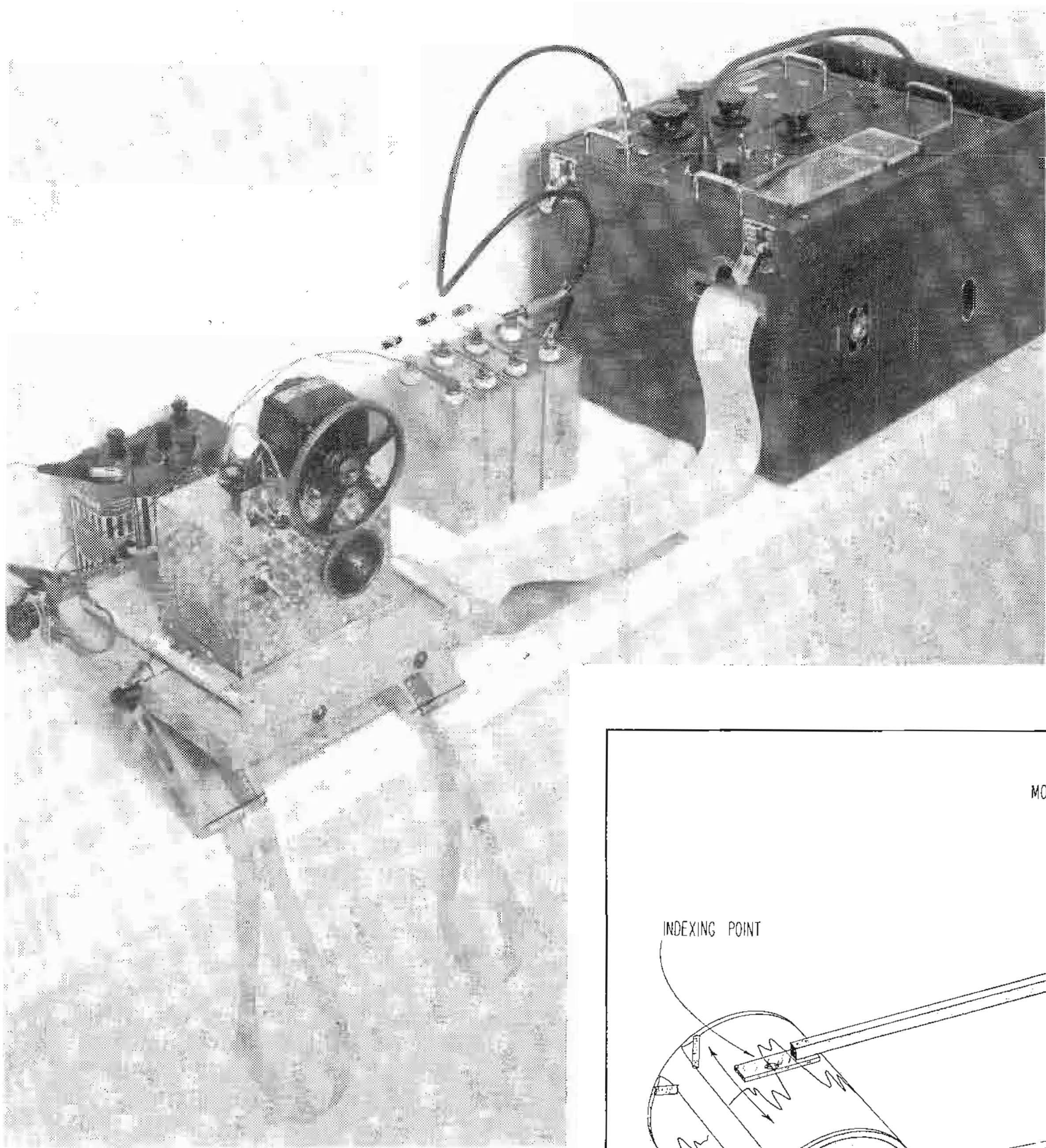


Fig. 2: (Above) The automatic Simcor

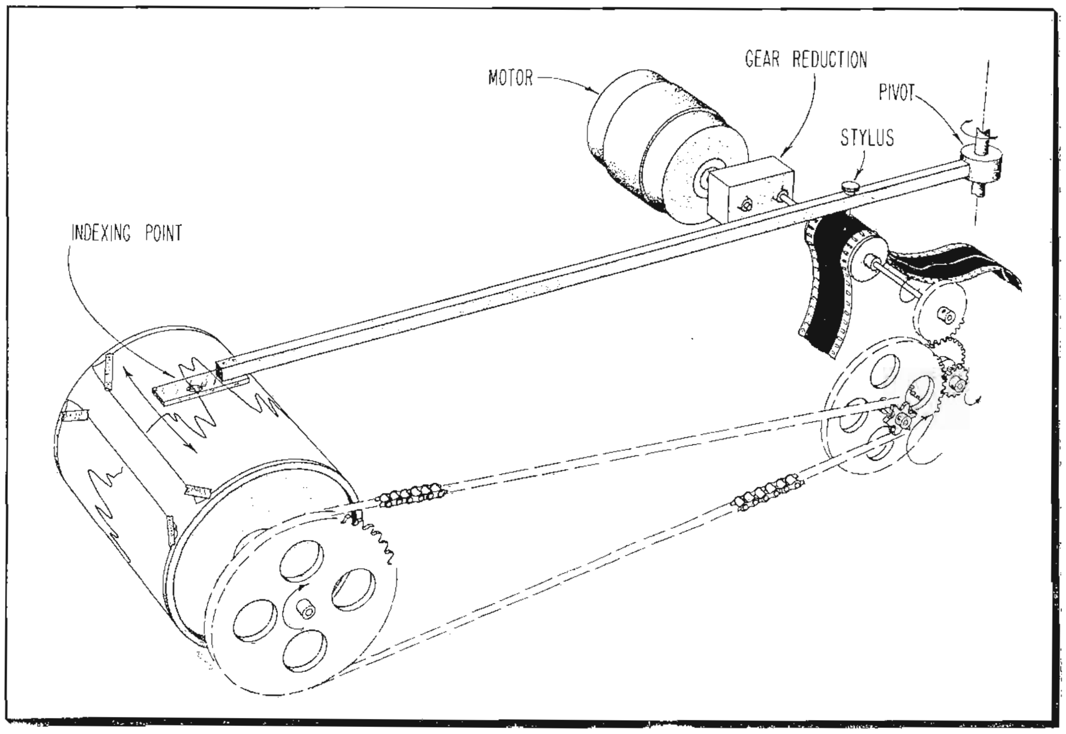


Fig. 3: (Right) Embossing apparatus devised for convenience in preparing film tapes

tions f(t) and f(t) or $f_1(t)$ and $f_2(t)$. The sprocket holes provide a convenient unit of measure for the independent variable t. Riding against the opposite edge of the film-loops at the sprocket position are steel pins N_1 and N_2 that are attached to the center portions of levers L_1 and L_2. The far ends of L_1 and L_2 have bearings B_1 and B_2 which allow movement in the lateral direction. The near ends of L_1 and L_2 form the moving arms on linear potentiometers P_1 and P_2. The position of each potentiometer arm is closely proportional to the instantaneous position of the dependent variable, provided that the steel pins N_1 and N_2 always are held in contact with the edges of F_1 and F_2 by the springs J_1 and J_2.

In evaluating the autocorrelation function of a given time function, the two loops of film are made to be similar by scribing the time function on a suitable length of 35-mm film and then cutting along the scribed mark. The two resulting sections of film are then spliced to form two loops and placed on the sprockets, as shown in Fig. 1. The sketch shows both loops synchronized, corresponding to $\tau = 0$. This is evident because F_1 and F_2 are shown stationary with their splices at the fixed index mark (I). Under this condition, when the tapes are rotated, the moving arms of both linear potentiometers will move in unison as the sprockets drive the film.

As shown in Fig. 1, the potentiometer P_1 is supplied with a fixed dc voltage by the battery E. The potential between the fixed center connection and sliding contact of P_1 is then applied across potentiometer P_2. The potential across the fixed center connection and the sliding contact of P_2 is then connected to a dc amplifier and indicator through an integrating RC filter. The input resistance of the filter and amplifier is much greater than the resistance of P_2, and the resistance of P_2 is much greater than the resistance of P_1. Thus, with the connections shown, the voltage applied to the filter is proportional to the instantaneous product of the two functions represented by the two loops of film. The RC filter performs the integrating and averaging process and its output is finally applied to the indicator. In this way, the basic operations for evaluating the autocorrelation function $\phi(\tau)$ as given by Equation (1) is mechanized for $\tau = 0$.

To determine $\phi(\tau)$ for other values of τ, it is necessary to stop the motor and, using the loop splices as an index, shift one loop with respect to the other by the number of sprocket holes representing the desired value of τ. This shift may be accomplished by a friction clutch (K) built into one of the sprockets (shown in exploded view in Fig. 1). After τ has been properly set, the motor is allowed to run long enough for the input to the indicator to stabilize. The deflection of the indicator then gives the value of $\phi(\tau)$ for the value of τ that was selected. The same process is repeated for sufficient values of τ so that the autocorrelation function can be plotted as a correlogram.

It is obvious that the arrangement shown in Fig. 1 is not suitable for automatically plotting correlation functions. The automatic feature has been accomplished by two modifications. First, a differential gear arrangement was constructed to replace the friction clutch, making it possible to change τ while the film strips are in motion. Second, the indicator was replaced by a paper recorder. The automatic Simcor is shown in Fig. 2. Within the metal box are a small synchronous motor and gearing for driving the two sprockets at a rate equivalent to a film speed of 2 ½ in./sec. A second synchronous motor and gearing which can be seen on the metal box operate through differential gearing within the box to shift one film tape with respect to the other at a continuous rate of one sprocket hole every 15 seconds. Since the film tapes are about 30 in. long, they make approximately one round trip for each differential tape movement of one sprocket hole. This meets the requirement of slow scanning of τ as compared to the necessary integrating time, which must be on the order of one round-trip time for the tapes.

Linear Potentiometers

The linear potentiometers consist of wirewound resistance cards mounted in slots in insulating blocks. The knob shown on the left of the visible potentiometer block provides lateral adjust of the potentiometer center-tap to the mean-value point of the time function being correlated.

Visible in the left rear of Fig. 2 is the battery source of direct current. The RC filter is in the center and consists of three ½-megohm resistors and four 12-μf capacitors. The amplifier and recorder are contained in the wooden box on the right; the paper speed is ½ cm per minute.

Preparation of Function Tapes

Before showing the results from Simcor, a few remarks regarding the preparation of the time-function loops should be made. It is possible to lay out the time function directly on 35-mm film, but usually it is more convenient to start with a time function plotted to a larger amplitude than would be allowed by a 35-mm film. Furthermore, it is desirable to have the time scale more expanded on the film loop than is usual when the same curve is plotted for visual inspection. For convenience in preparing film tapes, the embossing apparatus shown schematically in Fig. 3 was devised. In this equipment a person keeps the index point in coincidence with the time function that has been drawn on a sheet of paper and attached to the large drum. The drum is rotated slowly by the motor acting through two gear trains. The 35-mm film sprocket is rotated to give a higher linear rate for the film than for the graph. A suitable length of film is threaded on the sprocket and passed beneath a phonograph-needle stylus mounted on the tracking lever near the pivot point. The stylus thus embosses the time function on the film at reduced amplitude and lengthened time scale, as compared to the original time function. The amplitude compression ratio used is about 4.5/1 and the time scale expansion about 4/1. A film cutter also has been built to cut time-function tapes directly from magnetic tape recordings of the time functions.

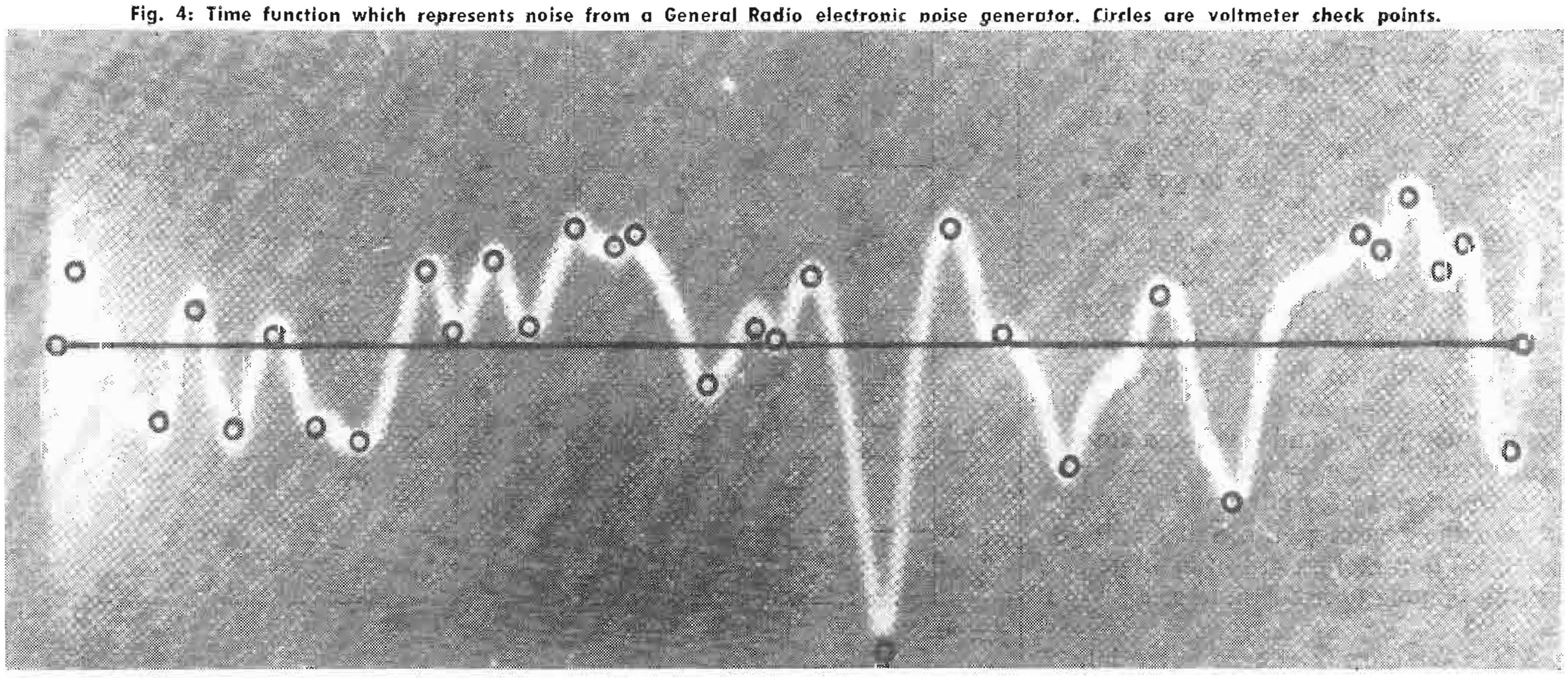
The question arises as to the accuracy of scribing a time function on film, cutting the film apart, and then reproducing the time function on the Simcor potentiometers. Fig. 4 shows a time function representing noise from a General Radio Co. electronic noise generator.[8] This function was put through the embosser, and the resulting film was cut apart with scissors, made into loops, and put on the correlator. A high-resistance voltmeter was then connected to the output of P_1 (Fig. 1) the film was advanced by hand, and the voltmeter was read point-by-point along the loop of the film. The small circles seen at the maximum and minimum points were indicated by the voltmeter after care was taken to establish the proper scale factor. It is evident that, in general, the errors are less than 10%.

Correlation Analysis

It can be shown analytically that the autocorrelation function of a square-wave time function is of triangular shape. Thus a square wave provides perhaps the simplest method for checking the over-all performance of a correlator. Fig. 5a shows the autocorrelation function of a symmetrical square-wave time function, as plotted by Simcor. Inspection reveals that, due to inaccuracies in the mechanization, the peaks of the triangular autocorrelation function are rounded off. Probably the principal contributing cause to this rounding off is the finite rise time required for the square-wave input to Simcor when, actually, this rise time should be infinitesimal. This type of error, though present, does not preclude

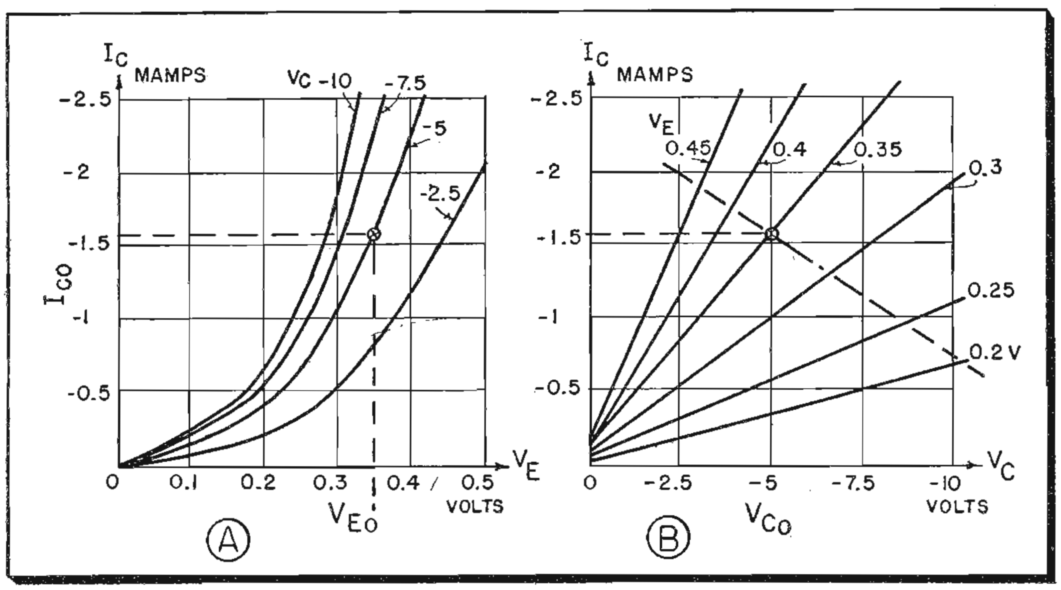
(*Continued on page* 156)

Fig. 4: Time function which represents noise from a General Radio electronic noise generator. Circles are voltmeter check points.



Transistors in Terms of Vacuum

Constant-voltage parameter analysis reveals philosophy of transistor terminology. Technical details of the "Transistorbridge," a new



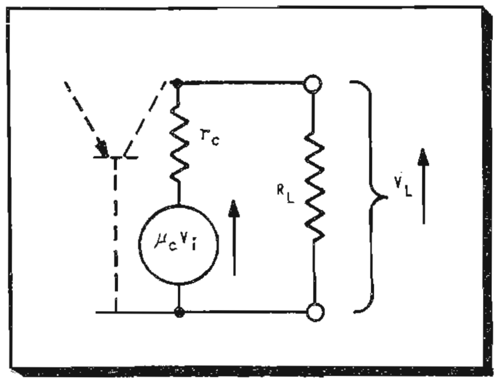


Fig. 2: Equivalent collector circuit

Fig. 1: (Left) Collector characteristics (A); (B) transfer curves for constant voltages

By Dr. HANS E. HOLLMANN

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ANY two-, three-, or four-pole element is characterized by its current-voltage characteristics. The form in which these curves are plotted is a matter of taste and convenience, that means the dependent and independent variables can be selected in different combinations. Following the old-fashioned trend of vacuum tubes, the starting point for our considerations is the family of collector characteristics showing the collector current versus the collector voltage with the emitter voltage as parameter (Fig. 1 b). Interchanging the independent variables yields the transfer characteristics, Fig. 1 a. It is well known that both families are similar because they represent only two aspects of the same three-dimensional surface.

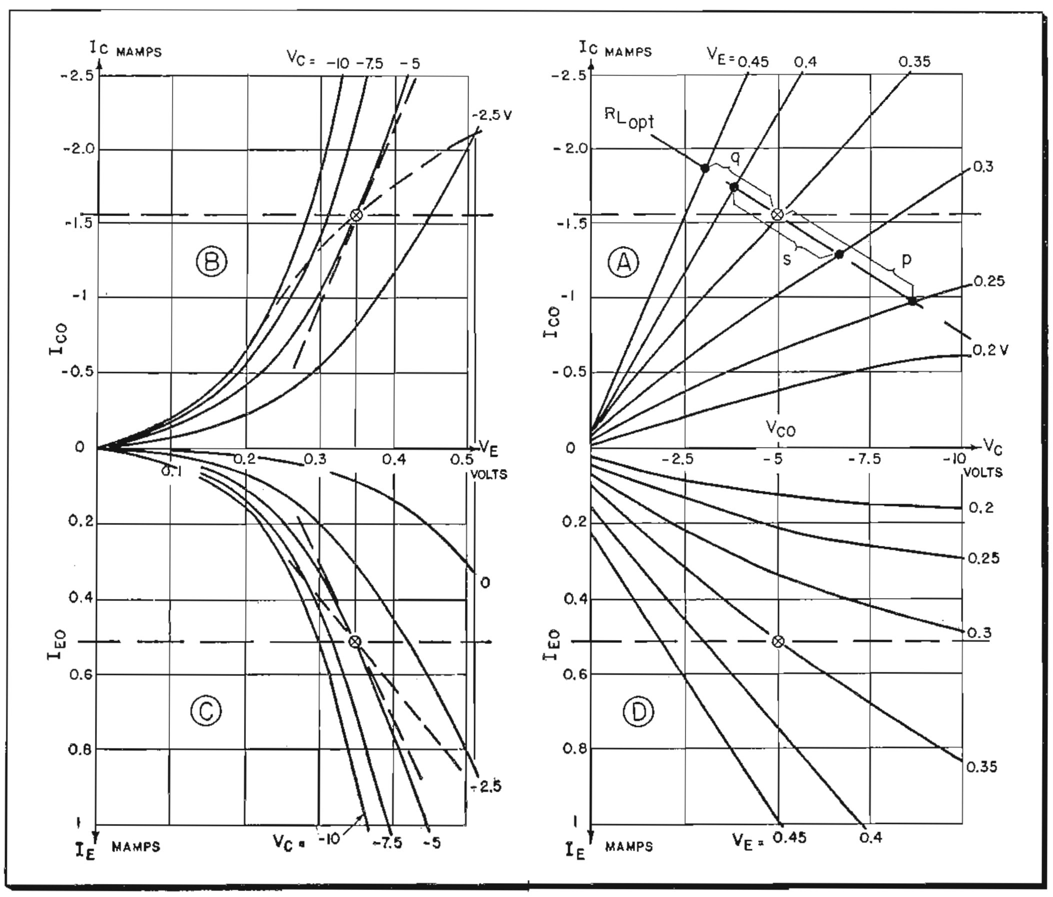
For a moment, let us forget that we are dealing with transistors and let us analyze the curves in terms and symbols of vacuum tubes. We then derive an internal collector resistance $r_c = (dV_c/dI_c)$ for $V_E =$ const., a collector transconductance $g_{mc} = (dI_C/dV_E)$ for a constant collecter voltage V_C, and a voltage amplification factor $\mu_c = (dV_C/dV_E)$ for a constant collector current I_c. With reasonable accuracy, these three differential parameters are interrelated by the famous tube formula $r_c\, g_{mc} = \mu_c$.

Since the base is at zero potential, the factor μ_c is the voltage amplification of a grounded-base transistor at open collector circuit. The equivalent network (Fig. 2) contains a collector generator producing the e.m.f. $\mu_c V_i$, exhibiting the internal impedance r_c, and being loaded with the external resistance R_L. The action of the load is characterized by a loadline. At the same time, the intersections between this line and the collector curves permit the evaluation of harmonic distortions. As for vacuum-tube amplifiers, the voltage gain can easily be seen to be

$$A_V = \mu_c / (1 + r_c/R_L)$$

Up to this point, our considerations do not differ from customary tube

Fig. 3: Collector and emitter characteristics



Tubes

circuitry in vacuum tube simple tester, described

philosophy. The picture must be completed, however, by taking care of the emitter circuit. For this purpose, we supplement the collector characteristics by two families of emitter curves (Fig. 3 c and d). The opposite polarity between the collector and emitter supply voltages result in opposite direct currents so that the emitter curves represent an image-inverted picture of the collector curves.

These new curves suggest the definition of three additional transistor parameters, namely an internal emitter impedance $r_e = (dV_E/dI_E)$ for constant collector voltages, an emitter tranconductance $g_{me} = (dI_E/dV_C)$ for V_E = constant, and, seen from the collector, a voltage attenuation factor $\mu_e = (dV_E/dV_C)$ for a constant emitter current. Again, the three additional parameters are interrelated by the formula $r_e g_{me} = \mu_e$.

Emitter Circuit

The equivalent emitter circuit in Fig. 4 incorporates an emitter generator in synchronism with the collector generator producing the counter e.m.f. $\mu_e V_L$ where $V_L = A_V V_i$ denotes the output voltage across the load resistor.

In addition to the four parameters μ_c, r_c, μ_e, and r_e, it is convenient to introduce the current amplification factor $\alpha = (dI_C/dI_E)V_C$ in the forward direction and an associated current attenuation factor $\beta = (dI_E/dI_C)V_E$ in the reverse direction. Whereas the voltage amplification factors for both directions equal the products of impedances and transconductances with the same subscripts, the current amplification and attenuation factors equal the impedance and transconductances products with interchanged subscripts, i.e.

$$\alpha = g_{mc} \cdot r_e = \mu_c r_e / r_c \text{ and}$$

$$\beta = g_{me} \cdot r_c = \mu_e r_c / r_e.$$

They may be found with the aid of the previous parameters but also can be derived as the slopes of the I_C-I_E curves shown in Fig. 5 and plotted for V_C and V_E = constant, respectively.

There exists a significant relationship between the voltage and current

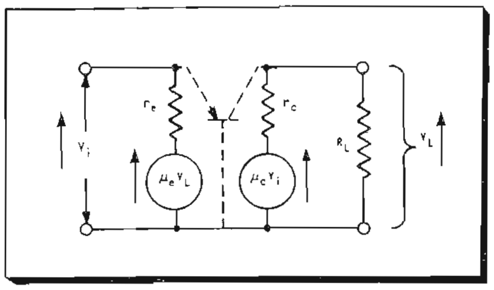


Fig. 4: Two-generator circuit of a transistor in a grounded-base connection

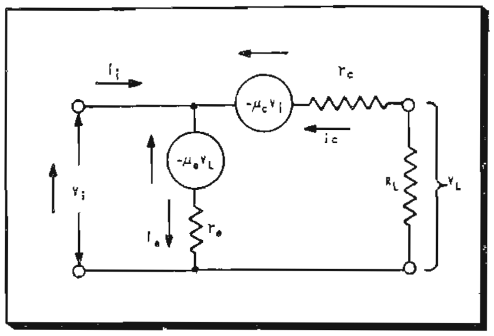


Fig. 6: Diagram showing the grounded-emitter circuit having two generators

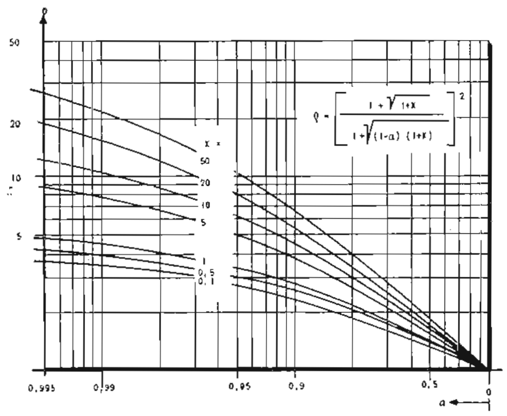


Fig. 7: Curves showing ratio between maximum available power gains of a grounded-emitter and grounded-base transistor

gains on the one hand and the voltage and current attenuation factors on the other hand, namely

$$\alpha \cdot \beta = \mu_e \cdot \mu_c = \delta.$$

As a rule of thumb, we may state that a transistor is more efficient, the closer δ approaches unity. Excellent transistors are characterized by a number δ which deviates from one only by a few per cent. In order to avoid the corresponding decimal points, the introduction of a general figure of merit

$$K = \delta/(1-\delta)$$

is convenient. Excellent transistors exhibit figures of merit between 1 and 10.

The tube expert is satisfied with the voltage amplification factor because the power gain of a vacuum tube is infinitely high—as long as the electron inertia does not enter the picture. In the transistor field, however, the power dissipation in the emitter becomes a decisive factor. The maximum available power gain of a transistor in a grounded-

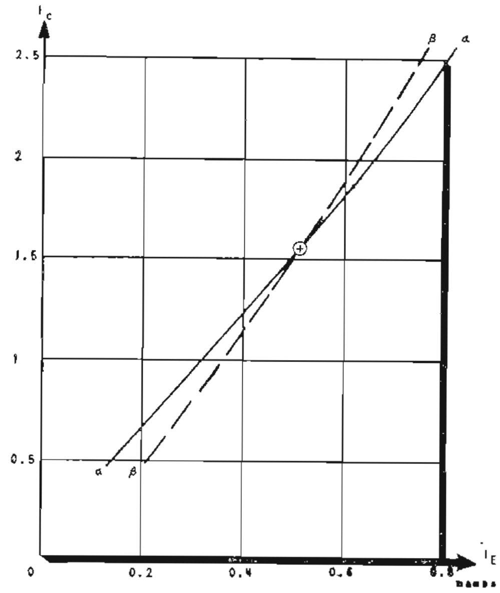


Fig. 5: Collector and emitter current characteristics for constant voltages

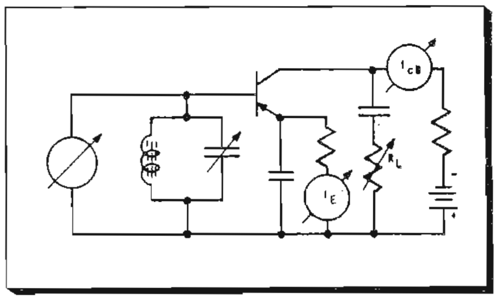


Fig. 8 Schematic of dynatron-transistor

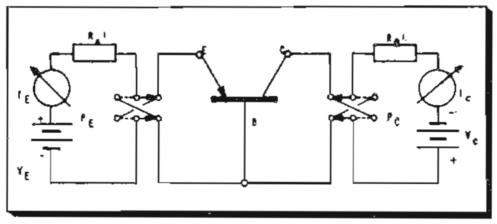


Fig. 9: DC circuitry of transistorbridge

base connection, expressed in terms of the constant-voltage parameters, is

$$A_{P\,max} = \frac{\alpha \mu_c}{(1+\sqrt{1-\delta})^2} = \alpha \mu_c \frac{1+K}{(1+\sqrt{1+K})^2}.$$

The optimum available power gain equals the product of the current and voltage amplification factors multiplied by a simple function of the figure of merit. For great values of K, the expression assumes the simple form $\alpha\mu_c$ = amplification-product Inversely, when K approaches the extremely low value of zero, the power gain is only one fourth of the amplification product. As an aid for memory, the maximum available gain may be visualized to be one half of the amplification-product accurately as ac power equals half the product of the peak values of current and voltage.

A second transistor connection which has been found to be very practical is the grounded-emitter stage (Fig. 6). In this case, the emitter generator may balance the input voltage so that no input current is drawn. The transistor then operates similar to a vacuum tube. On the other hand, if the emitter-generator voltage remains below the input voltage, in other words, if there is no balance, the input impedance remains positive but is much greater than the emitter impedance r_e.

Instead of evaluating the power gain of the grounded-emitter connection, let us consider the improvement of the latter over the grounded-base stage, more accurately, the ratio between the maximum available power gains in both circuits. The ratio Q can be expressed in terms of α and δ or of α and K as follows:

$$Q = \left[\frac{1 + \sqrt{1-\delta}}{\sqrt{1-\alpha} + \sqrt{1-\delta}}\right]^2 = \left[\frac{1 + \sqrt{1+K}}{1 + \sqrt{(1+K)\,(1-\alpha)}}\right]^2.$$

Fig. 7 shows this ratio versus α for various figures of merit. Once the current amplification factor and the figure of merit is known, the superiority of the grounded-emitter stage over the grounded-base transistor can easily be read off.

The other extreme is the case in which the emitter generator overcomes the input voltage so that the input impedance becomes negative. Since the e.m.f. of the emitter generator depends on the loadresistor, the negative base impedance can be adjusted by means of R_L. Based on this principle, the "Dynatron-Transistor" may be utilized as a Q-meter (Fig. 8). The schematic shows the base loaded with a tank circuit. At a definite value of R_L, the negative base impedance equals the resonant resistance of the tank circuit and generates oscillations which are observed by means of a vacuum tube voltmeter or an oscilloscope. The transistor Q-meter is calibrated by replacing the tank circuit with different standard resistors and by adjusting R_L until the system becomes unstable and starts relaxation oscillations. In this way, the load resistor R_L can be calibrated in terms of negative resistances accurately as the negative plate resistance of a dynatron tube is calibrated in terms of grid voltage.

Automatic Plotters

The evaluation of the differential transistor parameters by means of the static current-voltage characteristics—regardless of whether they are plotted for constant voltages or constant currents—is very cumbersome and time consuming. The task is facilitated by automatic plotters which trace the characteristics either on the screen of an oscilloscope or directly on paper by means of a recording potentiometer. More convenient is the measurement of the incremental parameters with ac. For this purpose, we transfer the well-established methods for measuring the small-signal behavior of vacuum tubes into the transistor field. The result is a simple tester, called the "Transistorbridge."

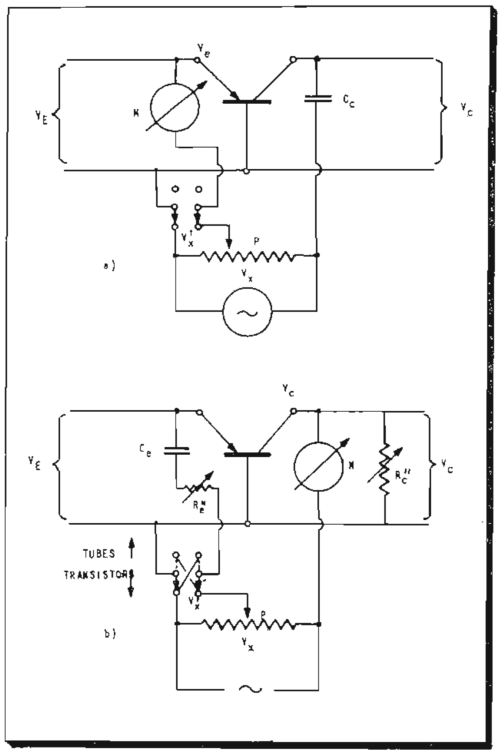


Fig. 10: AC circuitry of transistorbridge

In order to facilitate the explanation of the circuitry, the various bridge circuits are discussed in the same sequence as they are actuated by a main selector switch whose four positions are labeled μ_e, μ_c, r_c, and r_e,

Separate dc and ac circuits permit the balancing of the bridge without affecting the quiescent points of operation. In the schematic (Fig. 9), the transistor currents adjust themselves via the preresistors R'_e and R'_c. Since these resistors should be much larger than the emitter and collector impedances, saturated vacuum tubes are more efficient. The polarity of the two power supplies or batteries can be reversed thus

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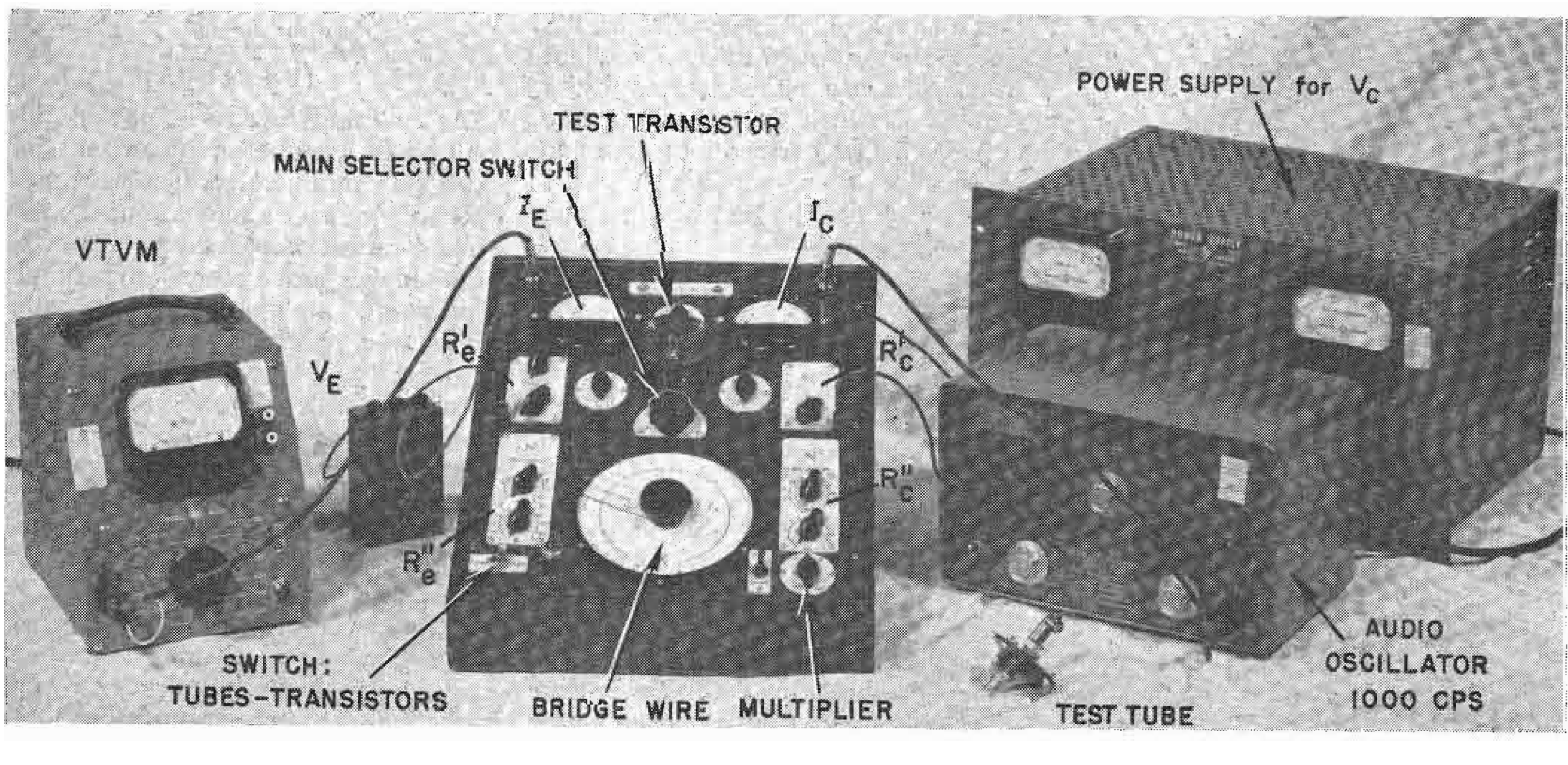
Fig. 11: A laboratory model of the test set



New Antenna Fittings Reduce P-Static Interference

Insulated antenna fittings materially reduce precipitation interference in all kinds of weather. Three year program has ultimately developed commercial sources capable of supplying military and non-military needs. More development needed at supersonic speeds

By CHARLES DE VORE
Naval Research Laboratory, Washington 25, D.C.

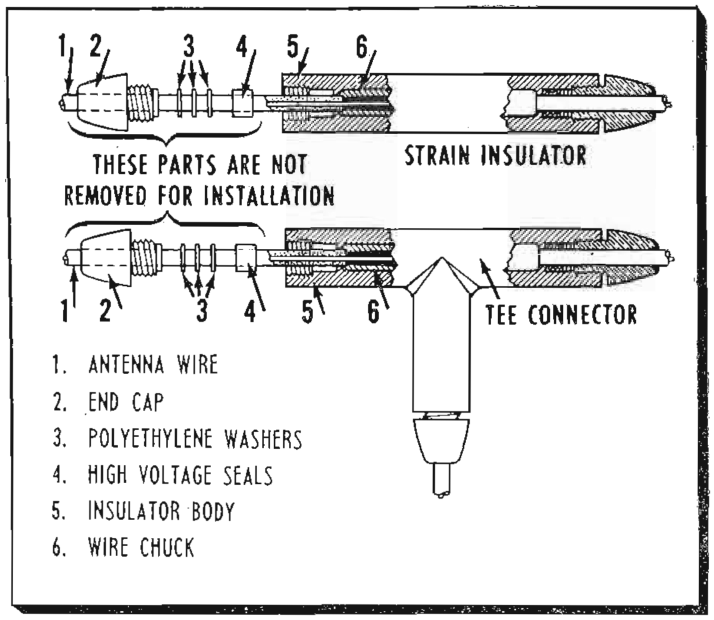


Fig. 1: Strain insulator IL-7/U and tee connector U-67/U

Ten years of research, development, test and production at the Naval Research Laboratory have resulted in antenna fittings that effectively reduce aircraft radio interference caused by precipitation static, and are easy to install and cheap to maintain.

After three years of unsuccessful attempts to secure a satisfactory commercial supplier of the entire line of fittings, the Laboratory has not only produced sufficient quantities of the new fittings to supply the most critical needs of the Navy, but in addition has developed commercial sources for components of the fittings which should be capable of supplying the future needs not only of the military services, but of commercial airlines as well. Fig. 3 shows the complete line of antenna fittings developed by NRL. The achievement is of particular significance, incidentally, because several of the recent military air crashes, particularly in the Arctic regions, have been authoritatively attributed to precipitation static.

Precipitation static is no new phenomenon. Back in 1906, a ground radio station in Denver, Colorado, reported interference caused by atmospheric static. Two kinds of such static were experienced: (1) short, intermittent crashes due to lightning, and (2) a continuous type which might blanket reception for hours and was characterized by a combination of noises, which might be either intermittent or regular, but consisted of crackling, "screaming" or "crying" sounds. This second class of static was termed precipitation static in 1937. It was usually experienced in an airplane radio receiver when flying through rain, snow, hail, ice crystals, or even dust clouds.

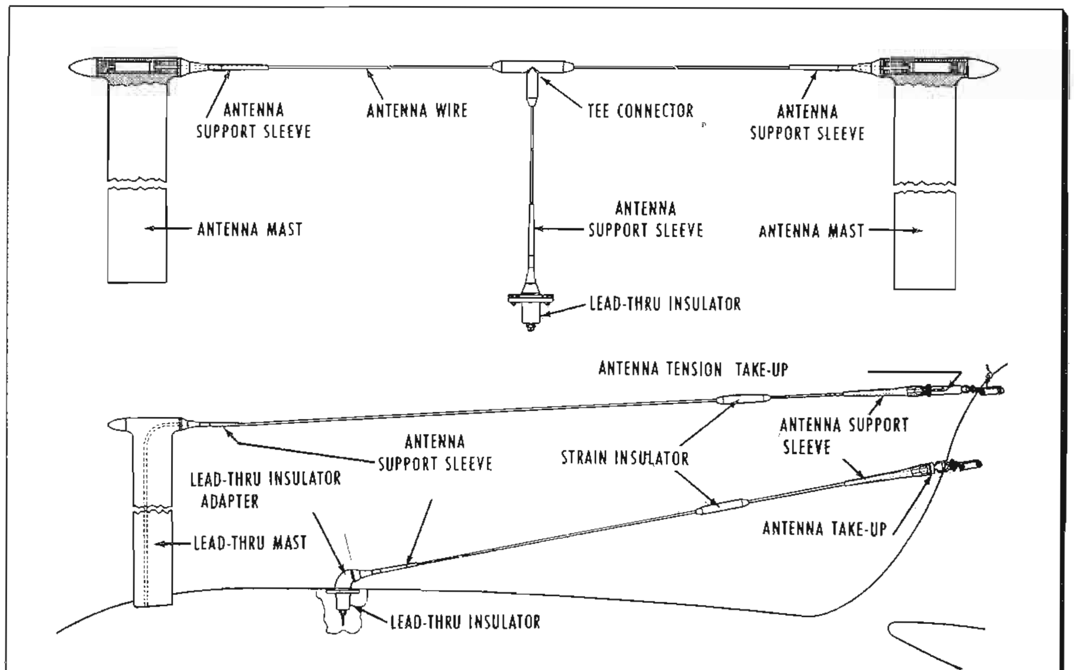


Fig. 2: Diagram showing two typical installations using new anti-precipitation-static fittings

Early Preventives

Between 1928 and 1934 transport aircrafts were equipped with radio. In trying to solve the precipitation static problem, commercial planes tested radio antennas covered with tape, or thick rubber covering. There were also developed trailing steel wire dischargers used either at stabilizer tips or at aircraft tails. Shielded loops, mounted under the nose of an airplane, also proved effective.

Although the seriousness of precipitation static was well recognized by 1935 when all-weather flying was the order of the day, there was no general agreement on the causes of this source of radio interference. Shortly after the beginning of the war, the military services, stimulated by the loss of many aircraft and personnel as a direct result of such interference, determined to set up a research project to investigate its causes and devise a cure. A joint Army-Navy Precipitation-Static Project Committee was therefore organized in May, 1943, to carry on this investigation (at that time, the Air Force still was part of the Army). Because the Navy was already working on the research aspects of the problem, the provision of research facilities and technical direction was made the responsibility of the superintendent of the mechanics and electricity division of the Naval Research Laboratory, who at that time was Ross Gunn. To expedite the work, the Navy's Bureau of Aeronautics built a giant hangar at Minneapolis, in which special experiments could be performed. Extensive laboratory as well as flying experiments were conducted over the next few years.

By 1946, the Minneapolis Project, as it became known, could report these findings:

(1) an airplane flying in precipitation of various sorts is charged to a high electrical potential, with more or less intense corona evident on sharp projections;

(2) precipitation static is caused by that corona;

(3) suppression of corona on the antenna itself and elimination of sharp projections near the antenna does away with most of the radio interferences caused by the charged condition of the airplane;

(4) the charge on the airplane can be reduced to some extent by means of dry-wick dischargers mounted on the wing and vertical stabilizer tips.

Taping the Fittings

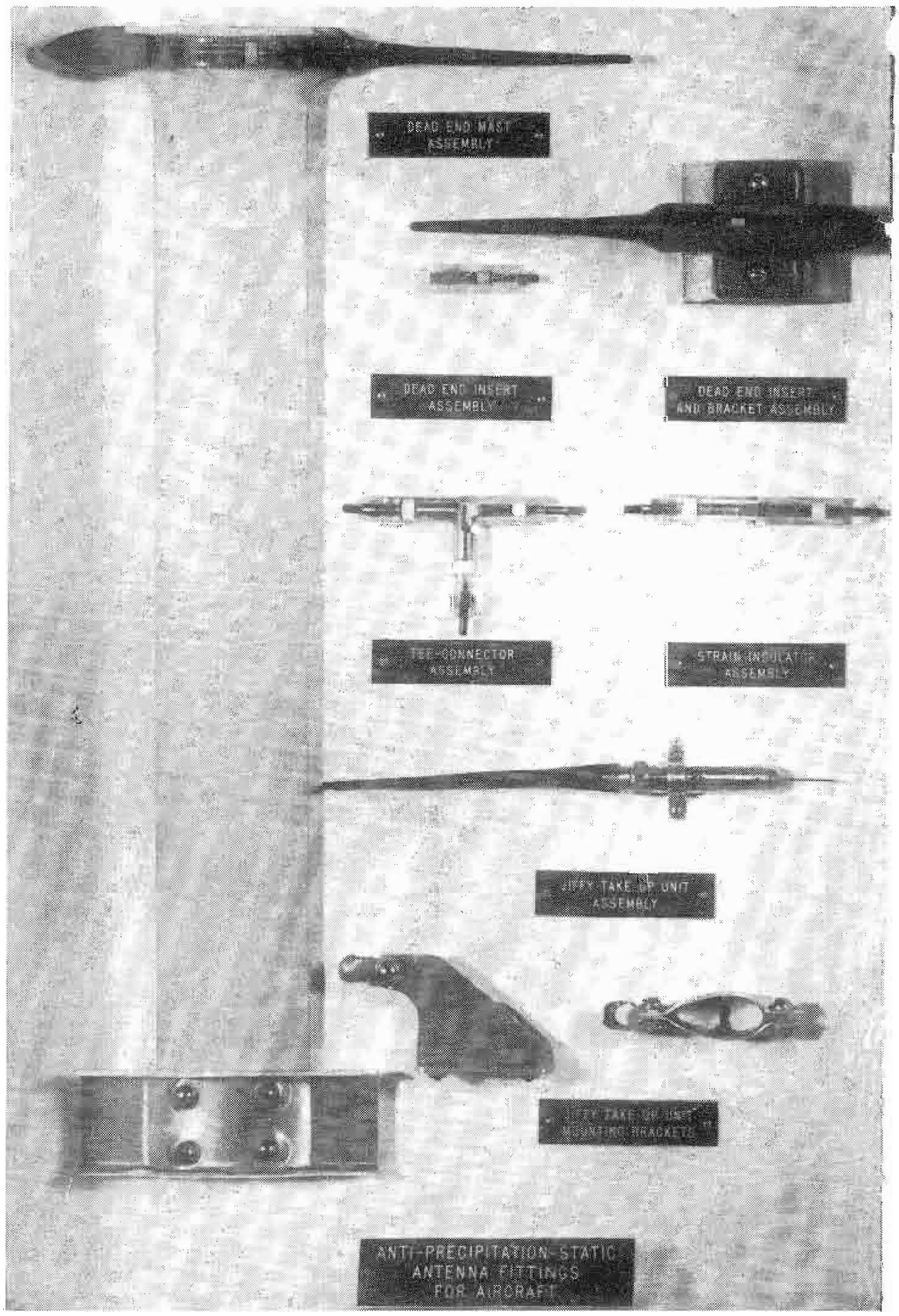
The Project also developed a polyethylene-covered wire and a technique of taping the fittings with polyethylene tape in such a manner, that, with extreme care, fair suppression of antenna corona could be achieved. Polyethylene-covered antenna fittings were also developed by the Project, but these fittings were inadequate because of the lack of a high-voltage seal where the insulated wire terminated in a fitting.

The Project was terminated as a "joint" activity in 1947, but development work on the antenna fittings was continued at the Naval Research Laboratory, under the technical direction of W. A. Von Wald, Jr., of the mechanics division. It was found that the slightest pinhole or minute break in the antenna coverings would make the entire covering useless. Simply stated, the problem was to lick this difficulty.

By 1948, a suitable packing-gland type of high-voltage seal had been developed. This seal consists of a silicone rubber sleeve, a series of polyethylene thrust washers and a molded lucite cap which, when screwed into the end of the fitting, forces the rubber sleeve tightly against the wire covering and the inside of the molded covering of the fitting. The thrust washers prevent cutting of the soft silicone rubber by the cap and also serve to protect the sealing sleeve from any liquids which might otherwise become absorbed in the rubber and damage the seal or the entire fitting.

The end of the wire is anchored in the fitting by a wire-holding chuck. This chuck consists of a pair of spring-loaded jaws which are assembled in a tapered housing. On installation, the wire is pushed into the fitting thus forcing its way between the jaws and compressing the spring somewhat. When an outward pull is exerted on the wire, the wire

Fig. 3: The complete line of anti-precipitation-static fittings



pulls the jaws down into the taper, forcing them to grip the wire ever tighter as the pull increases. All insert assemblies are fastened together with a rolled or swaged joint.

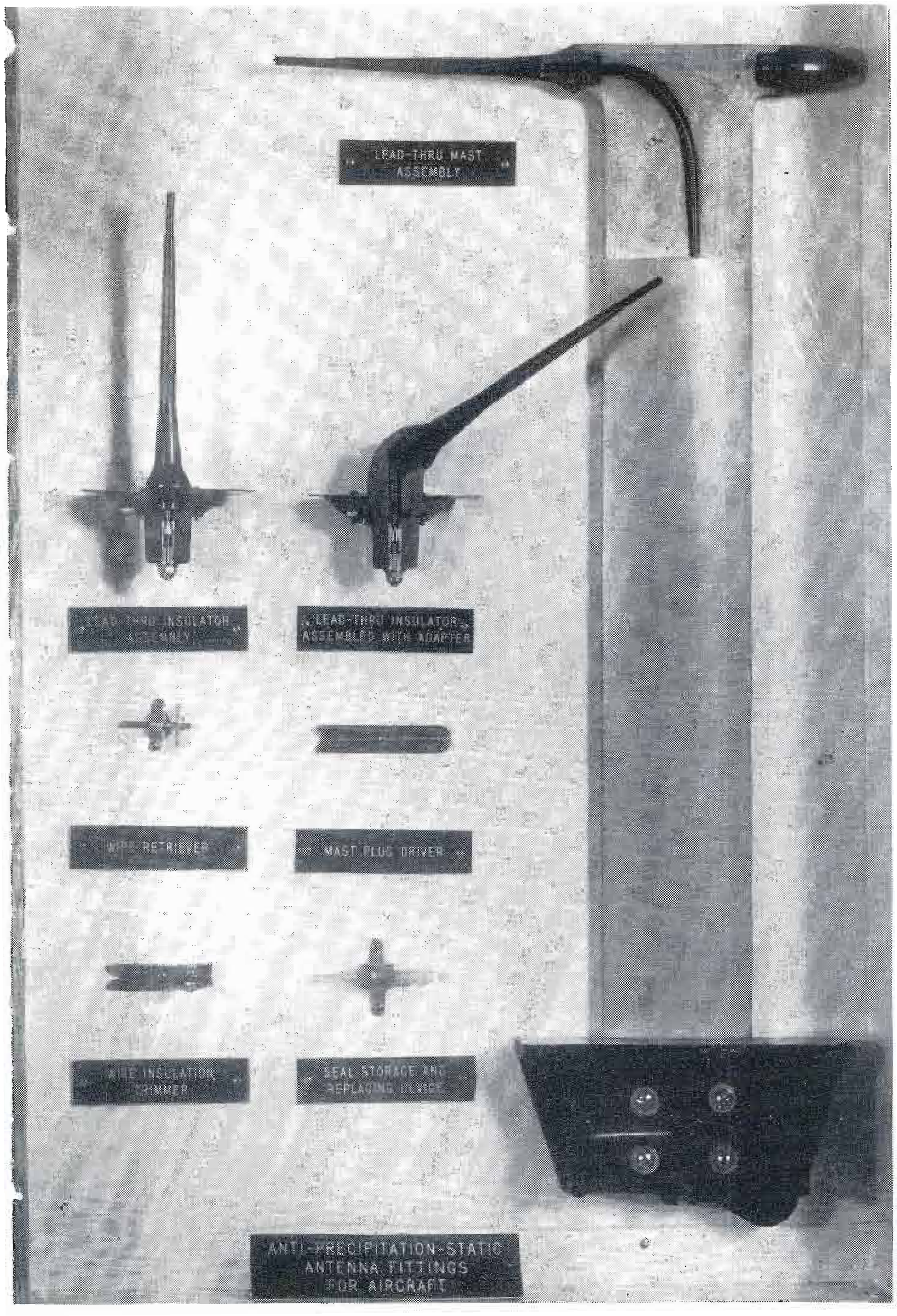
Strain Insulator

Three of the fittings which were developed are worthy of special mention. One of these, a strain insulator, consists of an insert assembly composed of two wire-holding chucks separated by an r-f insulator. This assembly is encased in a molded lucite sheath with a sealing cavity and threaded cap on each end. See Fig. 1. A teesplice is made up of three wire holding chucks fastened to a metal tee spacer which provides mechanical support and electrical connection between them. This assembly is molded into an insulating covering similar to the strain insulator described.

A dead-end mast is a streamlined plastic unit, 24 in. long, with an adjustable insert in its head for terminating an antenna. This insert is a wireholding chuck encased in a molded insulating covering. The inside of the mast head is threaded and, by means of a plastic nut at each end of the insert, a certain amount of "take-up" is provided.

Naturally, these developments did not come easily. For one thing, the NRL scientists had to build molding facilities as well as learn molding techniques, including the molding of lucite around metal inserts, for which there was no existing guide. In general, materials were selected for low-loss electrical characteristics, combined with high mechanical strength, but some compromise was necessary in view of such considerations as availability and, particularly ease of fabrication. Finally, however, satisfactory fittings were developed which met electrical tests of 240,000 volts dc, and mechanical tests of 900 lbs. for the mast and mast fittings and 500 lbs. for all other fittings. What is more important, the fittings retained these performance characteristics after a temperature-cycle test which simulated actual service conditions.

developed and produced by the Naval Research Laboratory



Enough experience was gained by NRL in pilot-plant manufacturing processes to warrant a Navy contract in 1949 for production quantities. The prime contractor subcontracted for various component parts and the Laboratory continued to furnish advice and guidance. But the contractor was unsuccessful; a second contractor had no better luck.

Large-Scale Production

Von Wald and his associates still were convinced that the manufacturing procedures they had developed in the laboratory for pilot-plant operation were adaptable to large-scale production. So NRL made a break with tradition and undertook a straightforward manufacturing approach to the problem, rather than developing any new scientific techniques.

It soon appeared that the contractors' problems had been those of quality control. For example, cleanliness—similar to that common to food-handling operations—was necessary in handling the silicone packing washers; molding cycle temperatures and rates had to be carefully observed and then held at chosen settings, not just taken for granted or varied at the whim of the machine operator. (Simple things in most cases; the kind that appear natural to a research man but seemed finicky and time-wasting to the contractors.) In confirmation of their belief that the job was a practicable one, the NRL crew turned out 1,500 pieces in the two days preceding Christmas, 1952! Within nine months after undertaking the production problem which had stymied two contractors for three years, the

(*Continued on page* 142)

Conductance Curves Speed Triode R-C Amplifier Design

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

By KEATS A. PULLEN, *Ordnance Dept., Ballistic Research Labs. Aberdeen Proving Grounds, Md.*

DESIGN of circuits for reliable operation of electron tubes is a problem of determination of both the preferred static operating conditions and the preferred dynamic conditions for the tube. Since recent developments have emphasized the importance of adequacy and reliability of circuit operation, the ability to design and optimize the operation of a tube circuit is of greatly increased importance.

The characteristic curves normally provided for use with tubes offer reasonably adequate information on static operation of tubes. The use of these curves to obtain dynamic information, however, proves rather unsatisfactory because of the difficulty in obtaining small signal tube parameters from static type curves.

The problem of information transmission is closely interwoven with design data requirements in the planning of tube characteristics curves. The forms of curves used should provide in as simple a form as possible all the principle data needed in a circuit design. The curve types should permit design over as wide a range of operating conditions as possible and should give a design which when built in the laboratory or shop would conform with design requirements. The curves should provide information which would permit the designer to verify that for a range of dynamic parameters about the mean, or bogie, the circuit using the tube would have adequate reserve to make certain that proper operation of the stage could be obtained with production run tubes. In addition, the curves provided should permit the designer to redesign his stage for minimum element power dissipations in order to provide maximum life and reliability.

Fortunately, the conductance type curves which were recently announced appear to meet most of these requirements. See Fig. 1. Considerable experience collected in use of this type of curves on several tube types and a wide variety of circuits has disclosed no circuit failures traceable to the new type tube characteristic curves. Amplifications of the designed stages checked within normal tube tolerances, distortion characteristics have been approximately the same as the values calculated, power output capacities proved to be available, and even circuits such as multivibrators can be designed within reasonable limits.

Sample Tubes

The conductance characteristics curves which have been published (see reference articles) and also in this article are not to be considered as sets of bogie curves on the tube type in question. They were taken on one or two sample tubes available. In spite of the fact the curves cannot be considered to be those of a bogie tube, no difficulties have been encountered so far in assuming the curves to approximate those of a bogie tube. The reason satisfactory designs result in spite of the fact the curves are not bogie appears to be that the effect of tube variation appears to be one of scale instead of one of curve pattern.

This article examines the application of the conductance design techniques to the design of resistance coupled triode amplifiers. Further articles discussing other applications of the conductance technique to a variety of the more commonly used circuit and tube types are in preparation.

Derivation of the voltage amplification equation in the best form for use of conductance data is based on the small signal plate current equation of the electron tube. For the triode this equation is

$$i_p = G_M e_c + G_P e_p \qquad (1)$$

where i_p is the plate current change, G_M is the transconductance, e_c is the grid voltage change, G_P is the plate conductance, and e_P is the plate voltage change. Since the supply voltage is normally constant, the sum of the plate voltage change and the load voltage change is zero. Substituting

$$e_p = -e_L = -i_p R_L$$

in (1), rearranging, and multiplying the value of i_p by $-R_L$ gives

$$e_p = -G_M R_L e_c / (1 + G_P R_L) \qquad (2)$$

The ratio of e_p to e_c gives the voltage amplification, VA, of the stage. It is

$$VA = -G_M R_L / (1 + G_P R_L) \qquad (3)$$

The amplification given by (3) is actually the small signal, or dynamic amplification. This amplification varies as a function of the load resistance, the bias, and the plate voltage.

Determination of the actual amplification requires one first to estimate the values of transconductance and plate conductance at the load line—grid contour intersection where the value of the amplification is desired. The values of the transconductance and the plate conductance, and the resistance value of the plate load resistor then are insterted in (3). When (3) is solved, it gives the required amplification.

Distortion Equation

Determination of the distortion of the amplifier stage is based on the values of amplification at several values of bias as calculated by (3). Because the amplification determined by (3) is small signal, rather than average, amplification, the distortion equation applying is slightly different than the usual equation. In cases where the second harmonic component of distortion predominates, the distortion equation is

$$\%\ \text{Distortion} = \frac{25(VA_1 - VA_2)}{(VA_1 + VA_2)} \qquad (4)$$

The VA_1 and VA_2 in (4) are the amplifications at the most positive grid bias and the most negative grid bias respectively.

Where push-pull amplifier operation is used, a more complex equation applies. Since in push-pull operation second harmonic distortion is assumed to cancel out, the distortion would be

$$\% \text{ Distortion} = (100/3) \frac{(VA_1 - 2VA_2 + VA_3)}{(VA_1 + 6VA_2 + VA_3)} \quad (5)$$

where VA_1, VA_2, and VA_3 are the amplifications at the most positive bias, mean bias, and most negative bias respectively (the assumption of cancellation of the second harmonic distortion may not be valid).

Evaluating Distortion

The technique for evaluating the distortion as in (4) and (5) requires first the selection of a number of typical points over the range of bias to be used which is numerically equal to the highest order harmonic to be determined. Two of the points should be chosen at the most positive and the most negative biases respectively, with the remaining points spaced to provide uniform bias increments. A power expansion of the amplification as a function of bias may be equated to the actual point by point amplifications to obtain the coefficients of the power expansion. Integration of the amplification power series to provide output voltage as a function of input voltage followed by the application of a sine wave inputvoltage gives the amplitude of the harmonics in terms of the point-by-point amplifications of the amplifier. The two most important cases are (4) and (5).

Determination of allowed operating range is based largely on the data on distortion. Care must be used where the dynamic load impedance of the stage is different than the static load impedance. The technique for handling changes of load impedance resulting from dynamic loading is indicated in the examples. The available output power from the R-C amplifier stage can be determined by use of the data collected in stage design. Use of the data for obtaining the available power is indicated in the second example.

As the first example of calculation of amplifier design, assume that an R-C amplifier using a 6J5 tube were desired which would, with a peak grid voltage change of plus or minus three volts, provide an output voltage of ±45 volts with less than 4% dis-

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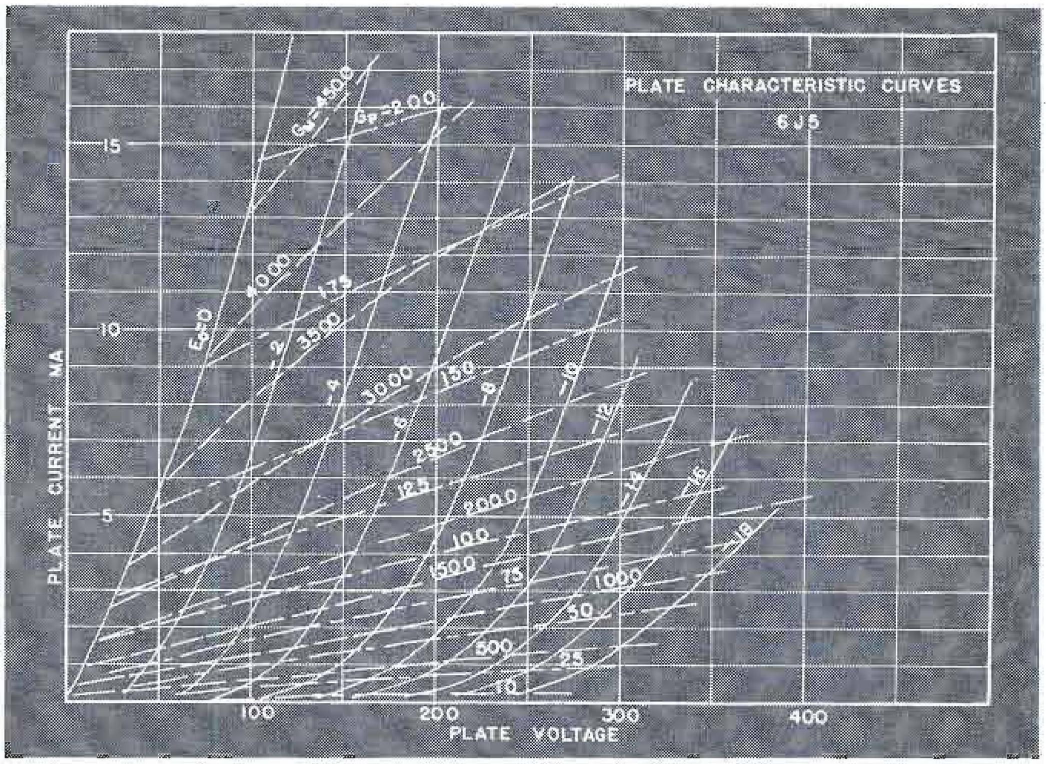
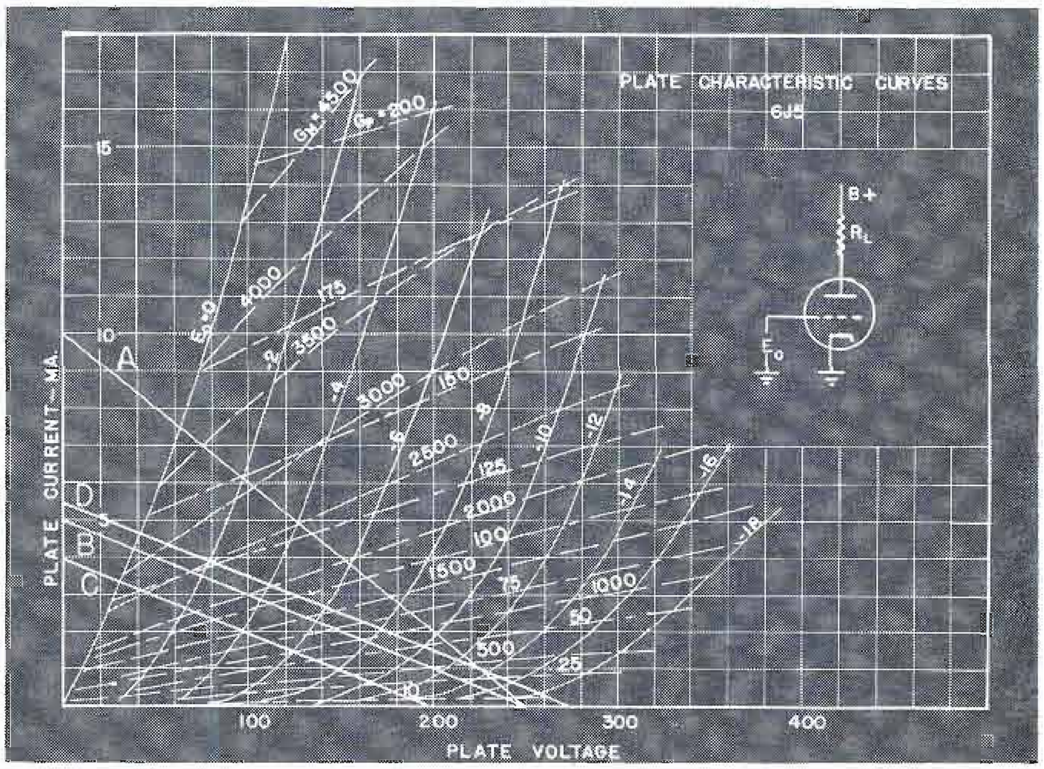
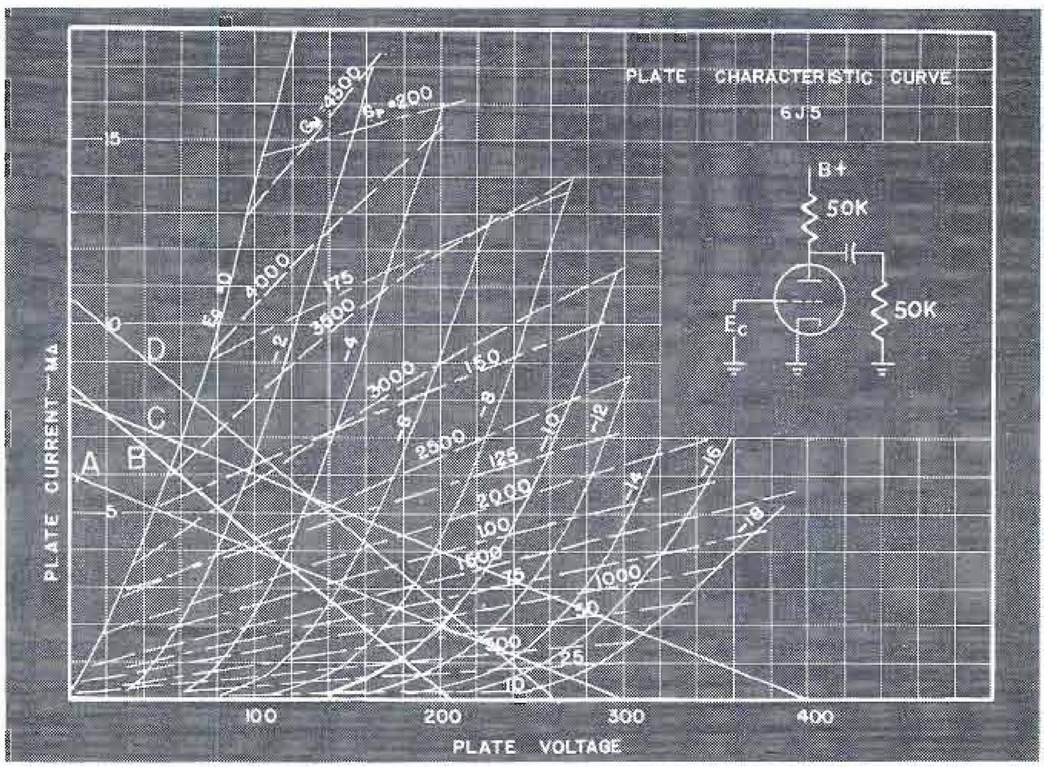






Figs. 1, 2 and 3 (top to bottom): Conductance curves of sample 6J5 vacuum tube facilitate determination of voltage amplification, distortion, and other operating characteristics

Fig. 1: Multimeter developed by Signal Corps Engineering Labs., with probes and cover removed

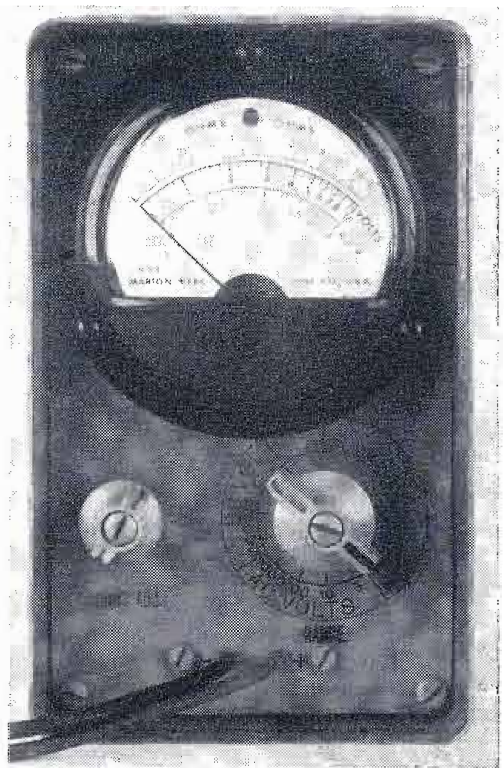


Fig. 2: Front view shows operating controls

New Pocket-Size

Rugged test instrument developed by Signal Corps automatic assembly. Simple design requires only 21

By
HERBERT CAHN
Signal Corps Engineering Labs.
Fort Monmouth, N.J.

DEVELOPMENT of a new general utility test instrument by the Signal Corps Engineering Laboratories (SCEL) at Fort Monmouth, N. J., is expected to result in a modernized and fully militarized version of that most fundamental and widely employed measuring instrument of the communications and electronics technicians, the multimeter. The newly developed test instrument shown in Fig. 1 consists fundamentally of a conventional type of combination ac and dc voltmeter and dc ohm meter designed around a d'Arsonval type indicating microammeter. Novel features incorporated in the design, however, have made possible a rugged, lightweight, pocket size test instrument, of high sensitivity and versatility in a form which has been planned for utilization of the most modern printed circuit techniques, and which is adaptable to production by automatic assembly methods. Reduction of both the materials and the labor cost factors has been stressed throughout the development as will be seen from the detailed description of design which follows.

The multimeter, which has been assigned the military nomenclature designation "Multimeter ME-77 ( )," has been developed under the current military program aimed at modernization and cost reduction of communications and electronics equipment.

Unlike most new equipments, which are being provided for the military establishment through development contracts with private industry, wherein administration of development activity is accomplished by government engineers representing the contracting officers, this development has been accomplished entirely within SCEL at Fort Monmouth. Although the facilities of SCEL have evolved into a multiplicity of extremely specialized units for planning and administering research and development contracts, as well as for test and evaluation of the end products of these contracts, it is felt that the fullest advantage of the specialized talents available within SCEL was taken by means of the close coordination with these specialists during each phase of the development.

It has thus been practicable to select each electrical component as well as the material for every mechanical part under the direct guidance of one or more experts whose major job assignments are concerned primarily with military application of that type of part or material. The decision to develop the new test instrument without benefit of a development contractor's facilities was made after consideration of the scope of the project in terms of the time required for engineering and supporting personnel, the cost of processing and administering a contract and the advantages which accrue from close control of design of the end product by engineers who are in frequent contact with the final user of that end product; namely the military repairman who is a member of a tactical field organization.

Design Criteria

As for the design of the multimeter, the major criteria of versatility, reliability and low cost were held paramount in arriving at the details of circuit design and construction. Since the multimeter is intended primarily for general purpose use by military repair and maintenance personnel in forward tactical units, the types of fundamental measurements to be made were first considered in the light of

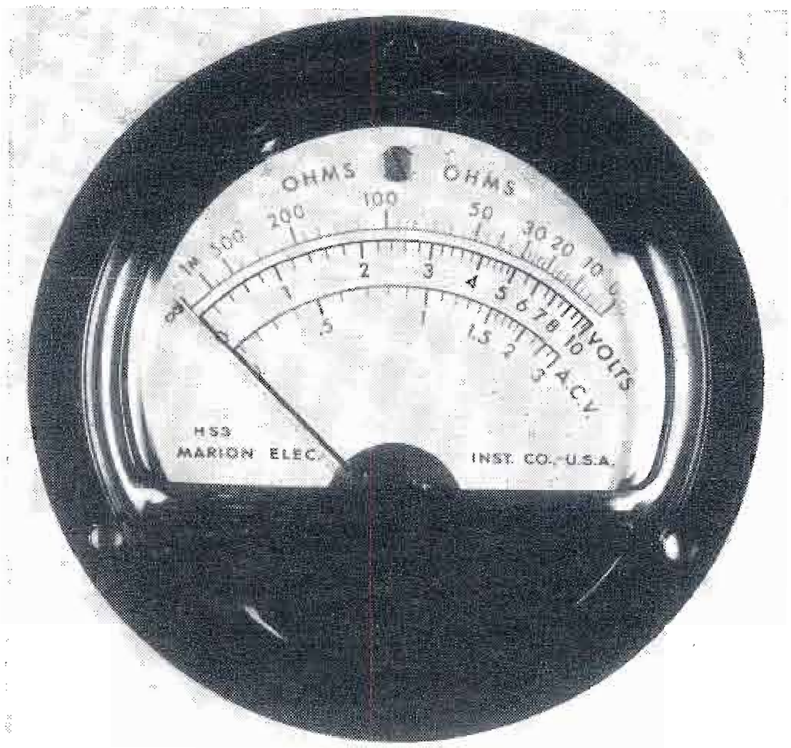


Fig. 3: Specially developed nonlinear meter for Multimeter ME-77

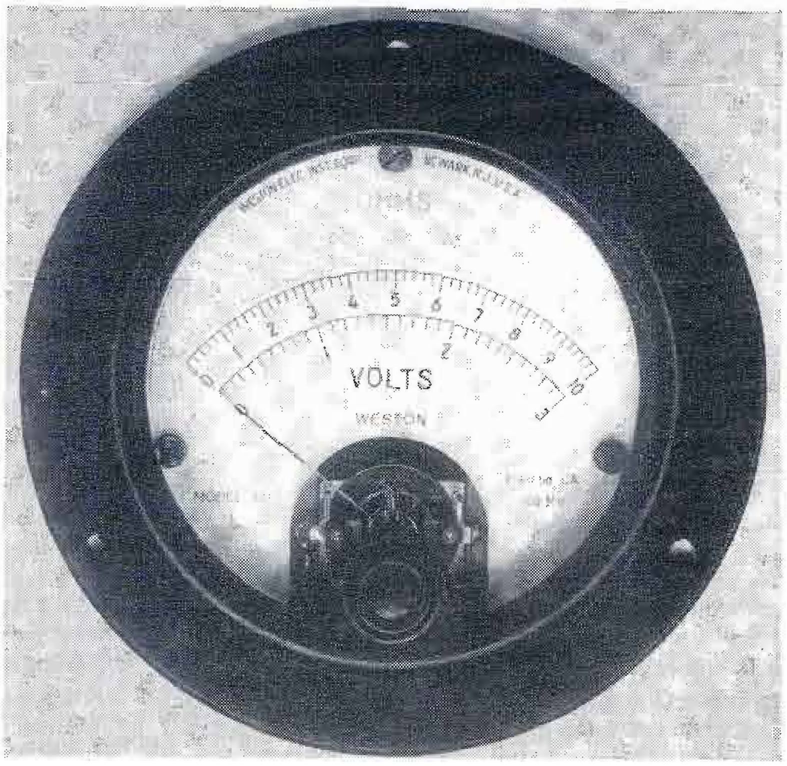


Fig. 4: Conventional linear meter has compressed high ohms scale

Military Multimeter

uses latest printed circuit methods, adaptable to fixed resistors. Nonlinear scale aids readability

the possibilities offered by conventional circuitry and in the order of their probable frequency as well as convenience of measurement. These considerations channelled the initial effort to an investigation of a suitable circuit for the wide range measurement of dc voltage, dc resistance and ac voltage, respectively listed in order of importance to the military repairmen.

Meter Selection

A survey of existing measurement circuitry of the simple and reliable type required led to the selection of a sensitive (50 μa) indicating meter with conventional associated circuitry to provide desired measurement capabilities. Additive series multiplier resistors provide the dc voltmeter circuit employing the full sensitivity of the indicating meter, 20,000 ohms/v, in continuous ranges from the lowest permitted by the particular microammeter selected, 100 mv, to the maximum value allowed by Joint Services maintenance policy, 1000 volts. The ac voltmeter circuit also employs additive series multiplier resistors, but in a 1000 ohms/v system.

The use of a copper oxide meter rectifier becomes most practical at this sensitivity, and in this case it is used in conjunction with a second rectifier unit which serves to limit to a safe value voltages appearing across the first during those half cycles of current flow in the high impedance direction. The particular half wave circuit used was selected for its simplicity, its linearity at relatively low voltages, its good frequency response and its relative insensitivity to temperature changes over the extremely wide range encountered by the prospective military users. The optimum lower limit established as the full scale value is three volts. Even though the rectifier efficiency is nearly as constant over the lowest range of 0 to 3 volts, as it is on higher ranges, an independent dial calibration has been provided for this range. This calibration, which conforms to the mean response of a representative sampling of rectifiers, allows full advantage to be taken of the inherent accuracy, sensitivity and stability of the circuit.

For simplicity of operation as well as reliability, it is highly advantageous to hold the number of measurement ranges and their associated calibration scales to the practical minimum. This has been accomplished quite effectively by exploitation of the possibilities offered by a specially developed microammeter having an unusual nonlinear response. It will be seen from Fig. 2 that the middle dial scale, which is directly proportional to the response of the indicating meter to direct current, is essentially linear for the first 10 μa, and approaches a logarithmic distribution thereafter from 10 to 50 μa. Thus, a scale with essentially constant accuracy of readability over most of its length has been obtained. By establishing the lowest range for the dc voltmeter at 100 mv and increasing each of the five steps respectively by a factor of 10, a simple scale with a single set of numerals is sufficient to achieve the usual order of accuracy for sensitive multimeters using linear scales; that is, within ± 3% of full scale values. This has been achieved without the usual overlapping ranges and multiple sets of scale numerals with their attendant reading difficulties. It is notable that only five steps are required to achieve the overall range from the lowest calibrated value of 2mv, to 1000 volts, the full scale value of the highest range.

Similar Ranges

Very conveniently, the essentially linear response of the ac voltmeter circuit employed makes it possible to establish ranges of the same magnitude as those of the dc voltmeter provided that the previously mentioned minimum full scale value of three volts is not overlooked.

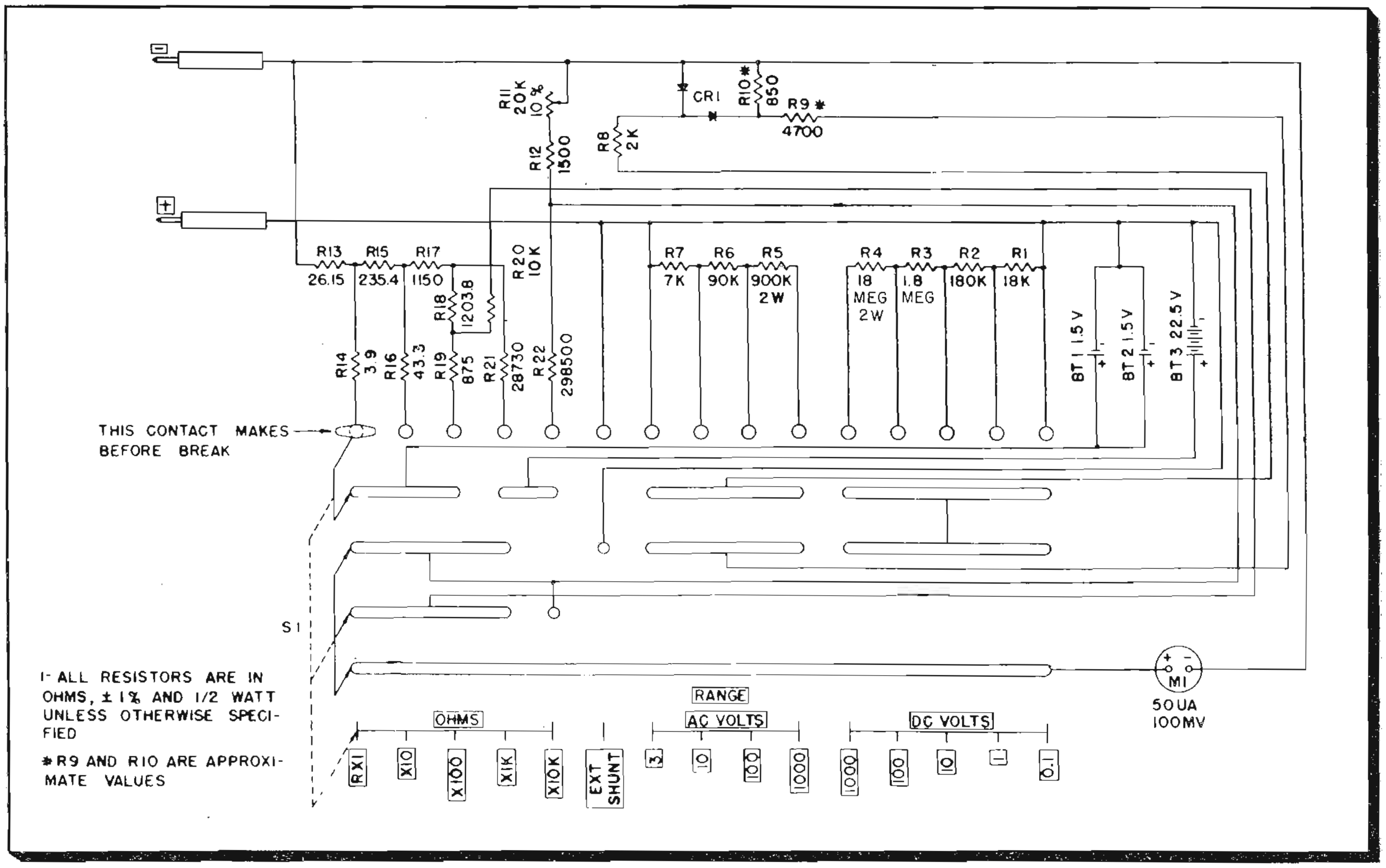


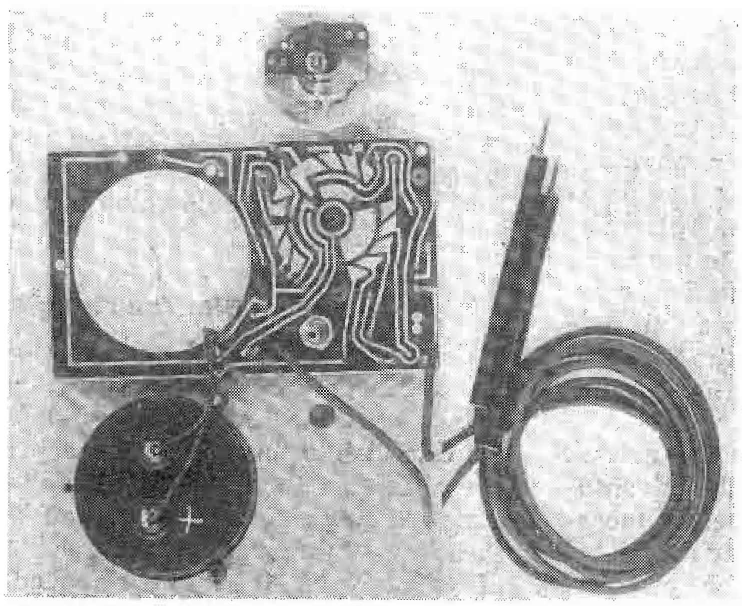
Fig. 5: Simple design of multimeter requires only 21 accurate fixed resistors

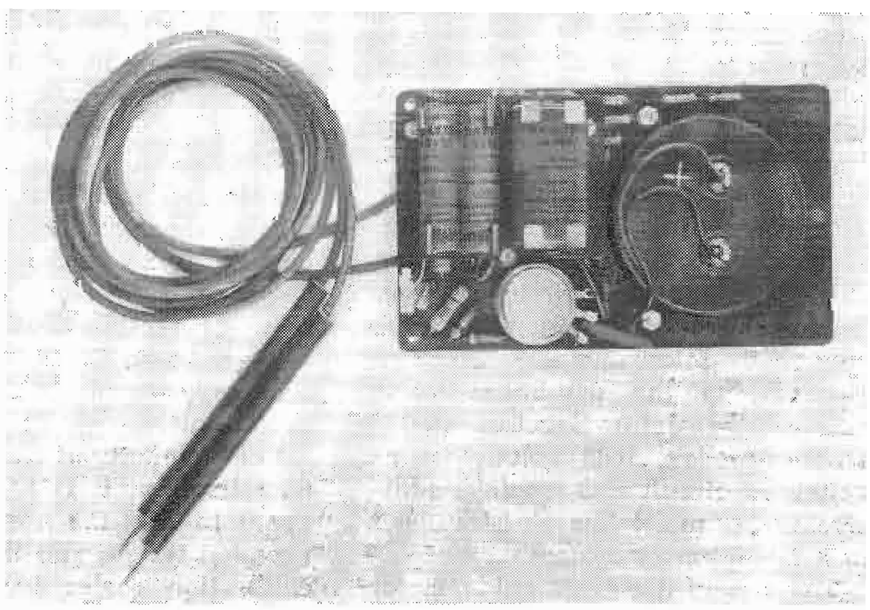
Hence, the ranges of 0 to 10, 0 to 100 and 0 to 1000 volts ac were obviously established. It is now apparent that all voltage indications, save those of ac below three volts can be read on a single calibrated scale by means of a single set of numerals. There is little likelihood of confusion between the 0 to 10 scale and the 0 to 3 scale because of the distinctive color correlation feature employed in marking both the scales on the meter dial and the markings on the control panel, and also because of the obvious direct relationship of the 30 division scale to the 0 to 3 volt ac range and of the 0 to 10 scale to all other voltage measurement ranges.

As for the dc resistance measuring circuit, a conventional adaptation of the series type ohmmeter has been designed. A five step arrangement provides overall measurement capabilities from one ohm to 20 megohms. It is interesting to note the advantages in the scale distribution which are gained from the non-linear response of the indicating meter employed by comparison of Fig. 3 with Fig. 4, the former being the meter under discussion and the latter a conventional linear meter employed in an equivalent ohmmeter circuit. The usually congested left hand portion of the scale has been relieved considerably. Simultaneously, compression of the normally more than adequate right hand portion has taken place. Battery voltages of 1.5 and 22.5 serve respectively for the lower three and

(*Continued on page* 146)

Fig. 6: (l) Interior view shows rotor disassembled from printed switch stator. Fig. 7: (r) Rear interior view shows batteries installed in place





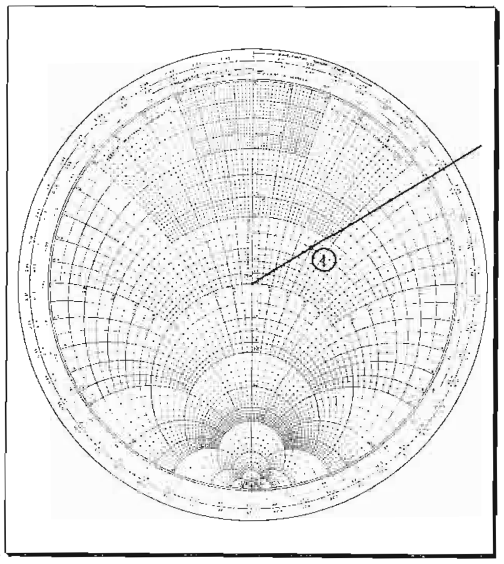


Fig. 1: Finding the reflection coefficient

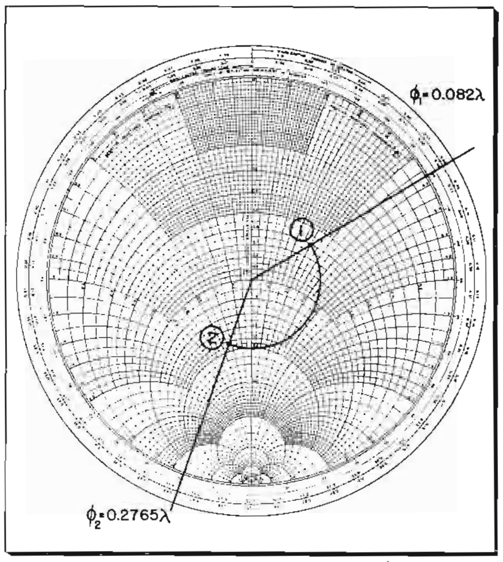


Fig. 2: Finding Z_s given Z_L, θ, Z_o

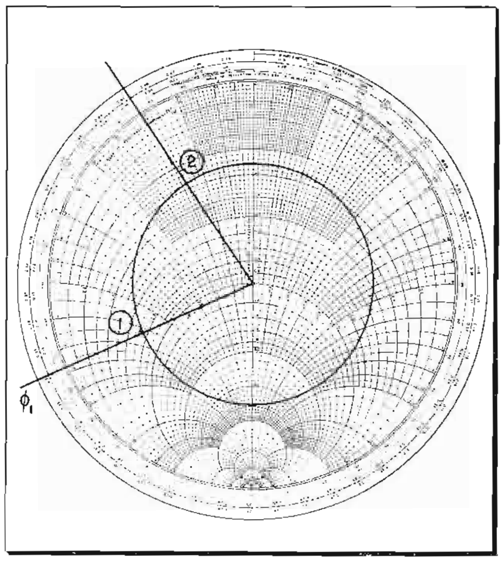


Fig. 3: Finding Y_s given Y_L, Z_o, and θ

Smith Chart Applications

Use of Smith Charts enable quick calculation of impedance relations in transmission lines, waveguides and other circuitry at VHF and UHF. Examples and explanations for typical problems given

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The Smith chart has become a useful tool in quick calculation of impedance relations in transmission lines, waveguides and other circuitry at VHF and UHF. It also aids immensely in visualizing and analyzing circuit behavior at these frequencies.

PERTINENT TRANSMISSION LINE BEHAVIOR (ASSUMING NO LOSS)

1. Impedances repeat every half wavelength.

2. At a voltage maximum the line input impedance $Z_s = \rho Z_o$ and is resistive, ρ being the standing wave ratio and Z_o the line characteristic impedance. Conversely, when $Z_{in} = \rho Z_o$ and is resistive, the voltage is a maximum.

3. At a voltage minimum, $Z_s = Z_o/\rho$ and is resistive. Conversely, when $Z_s = Z_o/\rho$ and is resistive, the voltage is a minimum.

4. $$Z_s = Z_o \frac{Z_L + jZ_o \tan\theta}{Z_o + jZ_L \tan\theta}$$

where Z_L = load impedance. Z_s = input impedance and θ = angular distance from load to input point.

LOCATING POINTS on CHART

1. All values are normalized or expressed per unit of characteristic impedance. Thus a load impedance of 30 + j20 ohms on a 50 ohm line is expressed as 0.6 + j0.4 before being located on the chart.

Admittances similarly are divided by their characteristic conductance. The characteristic conductance is the reciprocal of the characteristic impedance. As an example, a load admittance of 0.015 — j0.025 on a 50 ohm line is expressed as (0.015 — j0.025) / (1/50) = 0.75 — j1.25 for purposes of the chart.

2. Resistance or conductance coordinates are located on circles tangent to the bottom of the chart. The largest circles have the smallest resistance coordinates. The $r_1 = 1$ circle passes through the center of the chart.

3. Reactance or susceptance coordinates are located on circles that pass through the bottom of the chart. The largest reactance values are the smallest circles. Positive values are on the right hand side, negative on the left. The $X_1 = 0$ circle is the main vertical axis and is also called the axis of reals.

4. The two outermost scales are called the wavelength or ϕ scales. Values taken on them correspond to the distance in wavelengths between two points on a line. The scale to be used depends on which impedance is known. If, for example, the load impedance is known and the line length is given, to find the input impedance one may think of moving away from the load or toward the generator, whereupon the outermost scale, "WAVELENGTHS TOWARD GENERATOR" should be used.

FINDING MAGNITUDE and ANGLE OF REFLECTION COEFFICIENT, Γ

Locate a point on the chart. Now draw a radius from the chart center to the point and extend the radius until it intersects the scale called "ANGLE OF REFLECTION COEFFICIENT IN DEGREES." The distance from the chart center to the point is the absolute value of Γ where the radius of the $r_1 = 0$ circle is considered unity. The angle of the reflection coefficient is read directly off the reflection coefficient scale.

EXAMPLE 1: (See Fig. 1.) An impedance of 30 + j20 ohms on a 50 ohm line, when entered as 0.6 + j0.4 on the chart has a radius, r_1, or 1 in. as against a radius of 2 15/16 in. for the $r_1 = 0$ circle. $|\Gamma| = \frac{1}{2\ 15/16} = 0.3405$. The reflection coefficient angle is read as 120.8°.

FINDING INPUT IMPEDANCE, GIVEN LOAD IMPEDANCE, LINE LENGTH and CHARACTERISTIC IMPEDANCE

1. Locate Z_{1L} (point #1) on the chart.

2. Draw a circle whose center is the chart center and whose radius, M_1, is determined by the distance from the chart center to point #1. This circle, called the Γ circle, is the locus of all per unit input impedance values of Z_s as θ increases. Careful consideration of this circle will show that.

a. It is generated in a clockwise rotation because Z_s is closer to the generator as θ increases.

b. It must cross the axis of reals twice, once above the chart center, when $r_1 < 1$ and once underneath the chart center, when, $r_1 > 1$.

c. Its values repeat every half wavelength.

3. Draw a ray from the chart center through point #1 and continue it until intersecting the outermost "Wave Lengths Toward Gen." scale.

4. Read ϕ_1 the wavelength angle on this scale.

5. Find $\phi_2 = \phi_1 + \theta$ on the outermost scale, where θ is the line length expressed in fractions of a wavelength.

6. Draw a new ray from the chart center to ϕ_2.

7. The intersection of this ray with the Γ circle will determine $\mathbf{Z_{1s}}$ (point 2). Read Z_{1s}.

8. $Z_s = Z_{1s}\ Z_o$

9. After some practice it will be seen that it is not necessary to draw the complete Γ circle in each case or each complete ray.

10. a) The significance of the Γ circle intersection with the axis of reals lies in the fact that here the input impedance has no reactive component and is therefore a pure resistance.

b) If this pure resistance works out to less than Z_o which will be the case when the intersection is with the upper axis of reals, the voltage, at that point in the line will be at a minimum. The per unit input impedance value at this point,

$$r_{1\,min} = \frac{Z_o/\rho}{Z_o} = \frac{1}{\rho}$$

c) An intersection with the lower axis of reals indicates a voltage maximum. The per units value

$$r_{1\,max} = \frac{\rho Z_o}{Z_o} = \rho$$

Thus it is seen that for a given load and line impedance the standing wave ratio may be read directly by noting the value of the point at which the Γ circle intersects the lower axis of reals.

EXAMPLE 2: (See Fig. 2.) A 50 ohm line, 70° long is terminated in 30 + j20 ohms. Find the input impedance.

$\phi_1 = 0.082\lambda$ on the "WAVE LENGTHS TOWARD GENERATOR" scale. A length of 70° converts to $^{70}/_{360} = 0.1945\lambda$

$\phi_2 = \phi_1 + \theta = 0.082 + 0.1945 = 0.2765$

$Z_{1L} = 1.88 - j0.49$

$Z_L = Z_o\ Z_{1L} = 50\ (1.88 - j0.49)$

$= 94 - j24.5$

$\rho = 2.04$

A reverse procedure will give Z_L where Z_S, Z_O and θ are known.

Similar procedure is used in finding Y_S, given Y_L, θ and Z_O.

Where Z_L and Z_S are both specified it should either be possible to find unique values of θ and Z_o that satisfy these conditions or show that there is no possible solution. However, to the author's knowledge, there is no such graphical solution although an analytical solution is simple enough.

EXAMPLE 3: (See Fig. 3.) A 50 ohm line 220° long is terminated in an admittance of 0.015 - j0.025 mhos. Find the input admittance.

$y_{1L} = 0.75 - j1.25$

$\phi = 0.3413\lambda$ — 0.3413

$\theta = 220° = 220/360$ — 0.611

$= 0.611\lambda$ — 0.9523

$\phi_2 = \phi_1 + \theta = 0.342 + 0.611 = 0.953\lambda$ — 0.5, 0.4523

The scale repeats every 0.5λ so ϕ_2 may be taken as $0.953 - 0.5 = 0.453\lambda$.

$y_{1S} = 0.27 - j0.286$

$Y_S = (5.4 - j5.7)10^3$ mhos

$\rho = 4$

Lines terminated in an open or short circuit are handled by the same procedure, the open circuit being considered a load impedance of ∞ ohms or zero mhos, the short being considered as 0 ohms or ∞ mhos. In either case the radius of the Γ circle is that of the $r_1 = 0$ circle, which is the largest Γ circle on the chart. The standing wave ratio, $\rho = \infty$.

EXAMPLE 4: (See Fig. 4.) A 50 ohm line 24° long is open circuited. Find the input impedance.

$Z_{1L} = \infty / Z_O = \infty$

$\phi_1 = 0.25\lambda$

$\theta = 24° = 0.167\lambda$

$\phi_2 = \phi_1 + \theta = 0.25 + 0.167 = 0.417\lambda$

$Z_{1S} = 0 - j0.575$

$Z_S = Z_{1S}\,Z_o = (0 - j0.575)\ 50 = -j28.75$ ohms.

EXAMPLE 5: (See Fig. 4.) A 300 ohm shorted line is to have an input susceptance of + j.012 mhos. How long should the line be?

$y_{1L} = \infty / G_o = \infty\ (300) = \infty$

$\phi_1 = .25\lambda$

$Y_S = 0 + j.012$

$y_{1S} = Y_S/G_o = Y_S Z_o = (0 + j.012)\ (300) = 0 + j3.6$

$\phi_2 = .2065\lambda$

The wavelength distance, θ, from ϕ_1, to ϕ_2 is from 0.25λ to 0.5λ (0λ) and thence to 0.2065λ, a total of 0.4565λ.

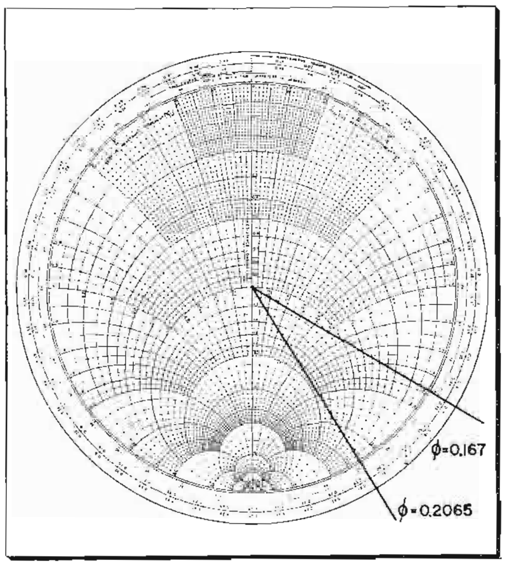

Fig. 4: Finding Z_s for open or shorted line

FINDING Z_L GIVEN Z_o, DISTANCE to a VOLTAGE MINIMUM and STANDING WAVE RATIO:

It is often most convenient to determine the load impedance using values easily found on a slotted line, such as the standing wave ratio and the distance to a voltage minimum.

A typical setup has the UHF signal generator feeding into an attenuator (6 to 10 DB) for proper termination of the generator, (usually 50 ohms). A slotted line and the load impedance follow the generator.

1. With Z_L in place note ρ and a convenient E min.

2. Now short out Z_L and note the new minimum voltage position, E' min, choosing that which is closest to E min.

3. a) The ρ of step (1) gives us the radius of the Γ circle. Locate the point at which this Γ circle intersects the upper axis of reals. We now have located z_{1s} the per unit impedance at the voltage minimum.

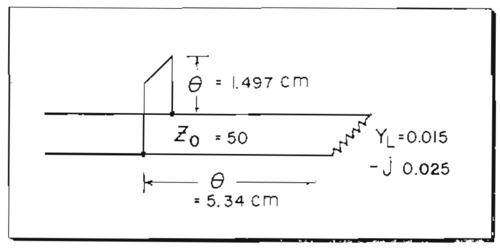

Fig. 6: Single stub impedance match (Fig. 7)

b) E' min is due to a short at the end of the line. Since impedances repeat every $\lambda/2$, wherever there is an E' min may be considered the end of the line for purposes of calculation.

c) If E' min is on the load side move counterclockwise the distance θ = E' min — E min. If E' min is on the generator side move clockwise.

d) z_{1L} is that point on the Γ circle which is θ wavelengths from the upper axis of reals.

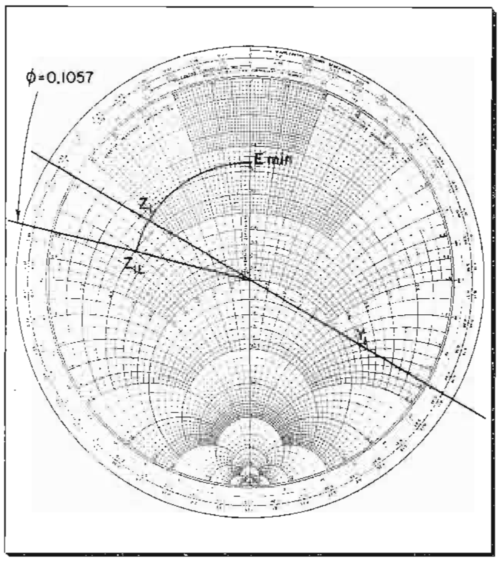

Fig. 5: Z_L when given Z_o, ρ, distance to E_{min}

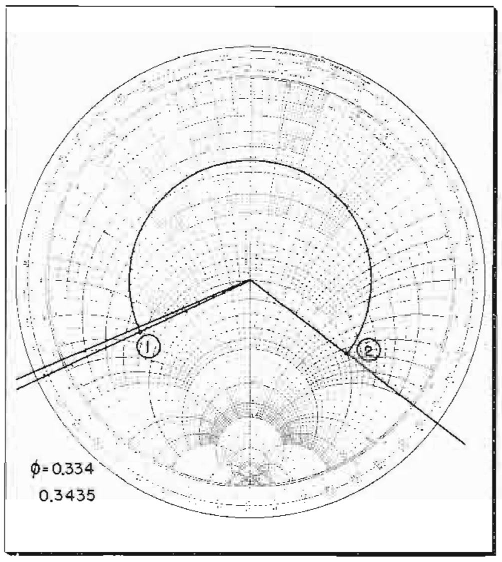

Fig. 7: Single stub impedance match (Fig. 6)

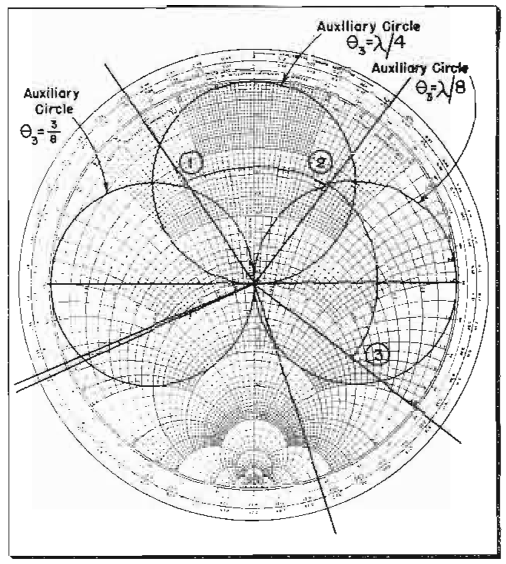

Fig. 9: Double stub impedance match (Fig. 8)

4. As a general check on the above calculations:

a) If E′ min moves away from the load, Z_L is partly inductive.

b) If E′ min moves toward the load, Z_L is partly capacitive.

c) The higher ρ is, the greater is the divergence of R_L from Z_o.

d) If E′ min does not move, Z_L is resistive and $<Z_o$.

e) If E′ min moves λ/4, Z_L is resistive and $>Z_o$.

EXAMPLE 6: (See Fig. 5.) An unknown impedance, Z_L, placed at the end of a 50 ohm slotted line (whose cm. scale zero is on the generator side) causes a voltage minimum at 6.27 cm. and a ρ of 3.7. When the impedance is shorted, voltage minima occur at 7.96 and 15.96 cm. Find Z_L.

$\lambda/2 = 15.96 - 7.96 = 8.0$ cm

$\lambda = 16$ cm

E′ min has shifted towards the load. Therefore Z_L should have a capacitive component.

$$\theta = \frac{7.96 - 6.27}{16} = \frac{1.69}{16} = 0.157\lambda.$$

θ should move counterclockwise, toward the load, so $\phi_1 = .1057$ on the scale marked "WAVE LENGTHS TOWARD LOAD."

$z_{1L} = 0.415 - j0.685$

$Z_L = z_{1L}\ Z_o = 50\ (0.415 - j0.685)$
$= 20.75 - j34.25$

QUARTER WAVE TRANSFORMER. CONVERSION from IMPEDANCE to ADMITTANCE and REVERSE:

For $\theta = \lambda/4$, $Z_S = Z_o^2/Z_L$. Where Z_s and Z_L are both resistive or one is the conjugate of the other, a properly chosen Z_o can transform Z_L into Z_S.

Going further, if $Y_L = 1/Z_L$ and and $Y_o = 1/Z_o$,

$$\frac{Y_L}{Y_o} = \frac{1}{Y_o Z_L} = \frac{Z_o}{Z_L}$$

But, for $\theta = 90°$, $\frac{Z_o}{Z_L} = \frac{Z_s}{Z_o}$

so $\frac{Y_L}{Y_o} = \frac{Z_s}{Z_o}$ or $y_{1L} = Z_{1s}$.

If Z_{1s} can be thought of not as the per unit value of input impedance for a λ/4 transformer but as the per unit value of load admittance then we can use the chart to change from an impedance to an admittance and vice versa. The choice of Y_o or Z_o is not important as long as each remains fixed and the inverse of the other through one problem.

EXAMPLE 7: Given $Z_L = 29 - j53$, find Y_L.

Let $Z_o = 100$ ohms and $\theta = 90°$.

$z_{1L} = 0.29 - j0.53$

$y_{1L} = 0.79 + j1.42$

$$Y_L = Y_o\, y_{1L} = \frac{y_{1L}}{Z_o}$$

$= (7.9 + j14.2)\ 10^{-3}$ mho

SINGLE STUB IMPEDANCE MATCH

In example 3 which concerns the finding of the input admittance the Γ circle that is drawn must not only intersect the top and bottom of the axis of seals but also the $g_1 = 1$ circle, once on the positive and once on the negative side. If θ is taken to the $g_1 = 1$ intersection and a parallel matching stub is connected at this point such that it will have a susceptance equal in amplitude and opposite in sign to that of the line itself, all that remains is a per unit conductance of 1, which will cause Y_s to equal Y_o. But a line terminated in its characteristic conductance (or impedance) is flat (and has max. pow. transfer). Thus from the matching stub back to the generator there should be no voltage minima or maxima. Mechanically, the slotted line feeds to a T joint from which come the matching stub (a shorted telescoping coaxial line) and the line stretcher (another telescoping line) placed in series with the load. By adjusting the length of the line stretcher the stub is placed at the correct point so that a proper adjustment of the stub length will give minimum standing wave ratio.

EXAMPLE 8: (See Figs. 6 and 7.) A 50 ohm line 220° long is terminated in an admittance of 0.015 — j0.025 mho. Find the length and position of a shorted stub which, when placed as close to the load as possible, will cause the line to be flat or nonresonant, from the stub back to the generator.

$y_{1L} = 0.75 - j1.25$ (point 1)

$\phi_1 = 0.342$

Moving clockwise from y_{1L}, intersection with the $g_1 = 1$ circle is at $1 + j1.5$ or at $1 - j1.5$. Of the two $1 + j1.5$ is closer to the load and is therefore chosen as the point at which the stub is to be placed.

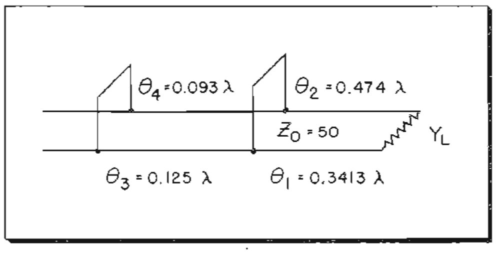

Fig. 8: Double stub impedance match (Fig. 9)

ϕ_2 at $1 + j1.5$ is 0.176 so $\theta = (0.5 - 0.342) + 0.176 = 0.334\lambda$

The shorted stub must have an input susceptance of $-j1.5$.

Using the procedure of example 5, $\phi_1' = 0.25$ and ϕ_2' is found to be 0.3435λ.

$\theta' = 0.3435 - 0.25 = 0.0935\lambda$.

If the wave length is 16 cm., $\theta = (0.334)\ (16) = 5.34$ cm and $\theta' = (.0935)\ (16) = 1.497$ cm.

If the stub length and position and the line characteristic impedance were given it should be possible to find Y_L or Z_L. This will be left as an

(Continued on page 116)

Maintenance Problems in

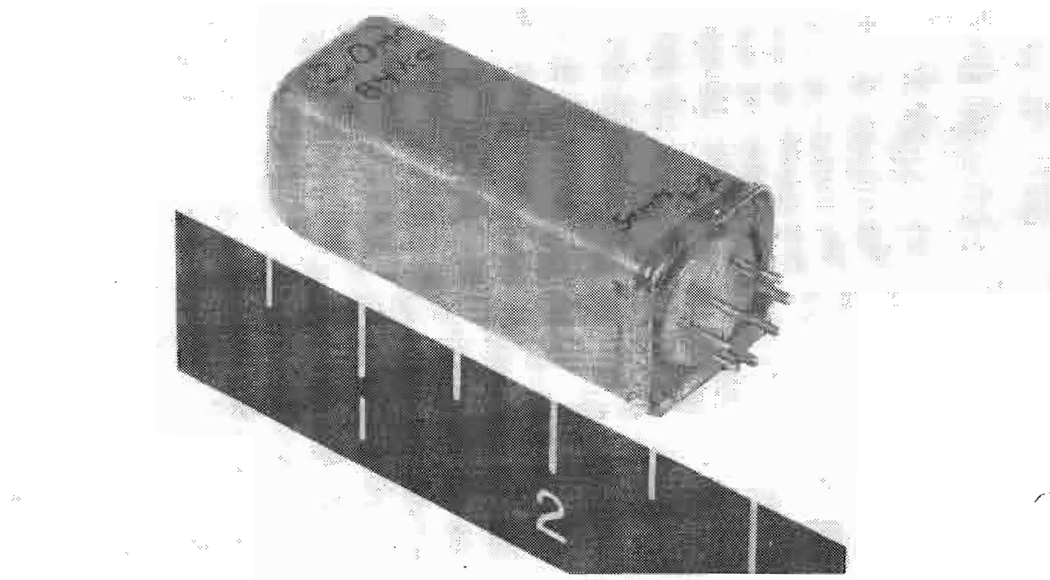

Fig. 1: Typical hermetically sealed amplifier stage

Vastly increased complexity of modern designs have made sectionalization and subminiaturization of equipment mandatory. Maintenance, in turn, has become more difficult but plug-in throw-away units aid. Achieving goal of 2000-hour completely reliable operation may make discarding of entire equipment economically feasible

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A COMMUNICATION set out of commission means a grounded combat aircraft until the radio set is repaired and made serviceable. Sometimes a complete radio equipment exchange is possible but, sooner or later, defective radio sets must be repaired, since spare radio sets are far too costly to buy in great quantities, and such expedients are not necessary when front line maintenance is as simplified as it can be even for the most complicated equipments.

In the past five years, the complexity of military airborne radio communications equipments has increased by leaps and bounds. It has been the result of many factors such as: the use of synthesizers for obtaining frequency control (crystal saving circuitry) to eliminate the necessity for the tremendous stockpile of plug-in quartz crystal units which was necessary during the last war; greater equipment automaticity brought about by the necessity for direct pilot or co-pilot operation, particularly on medium and high frequency equipments formerly operated by a trained radio operator; automatic antenna tuning and loading over many frequency octaves; inclusion of the UHF band in military communications with attendant complicated antenna-radio set coupling circuitry; higher frequency stability for more effective use of the radio frequency spectrum; added functions which eliminate the necessity for carrying other separate equipments.

Small Units Discarded

Subminiaturization, exemplified in many of the equipments, has added somewhat to complexity during manufacture, but this is offset by the fact that, in maintenance operations, it has led to the possibility of discarding small units instead of repairing them. Also, such expedients as printed wiring have simplified the manufacturing aspects somewhat.

The added complexity in newer equipments has been the outgrowth of advances in the state of the art which permit doing more things better, and changing military requirements and, while it is a recognized drawback, the penalty is accepted to obtain the facilities and performance now possible and available. Efforts have been made with some success, to reduce complexity, but the fact remains that little more can be done since airborne radio communications sets now in use not only must actually "remember," but must "think" as well. Efforts to further reduce complexity as the demands on the

Fig. 2: Typical test receptacles

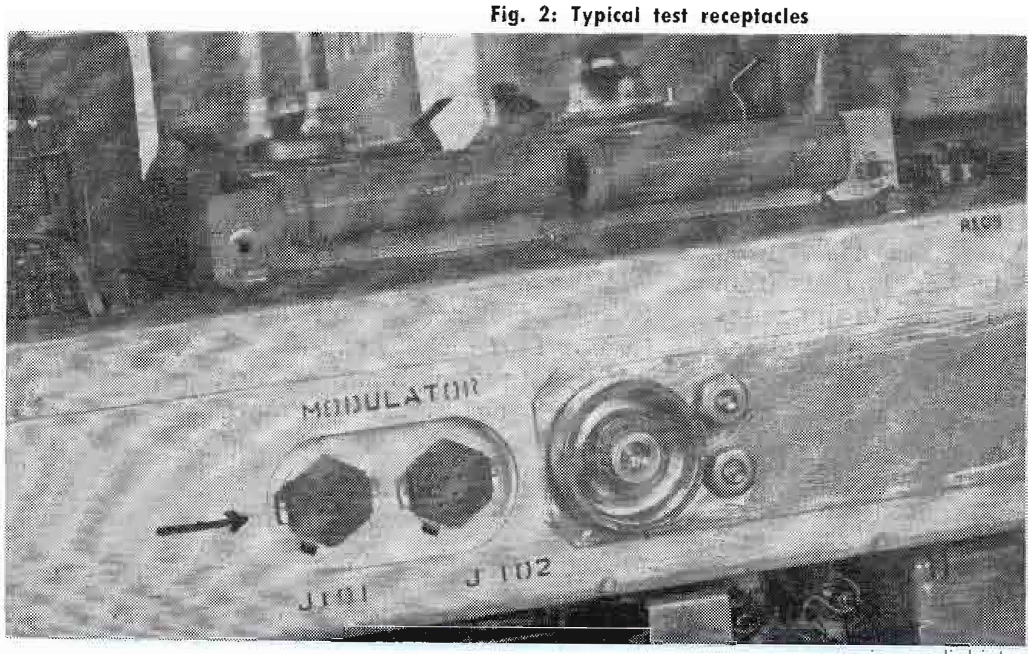
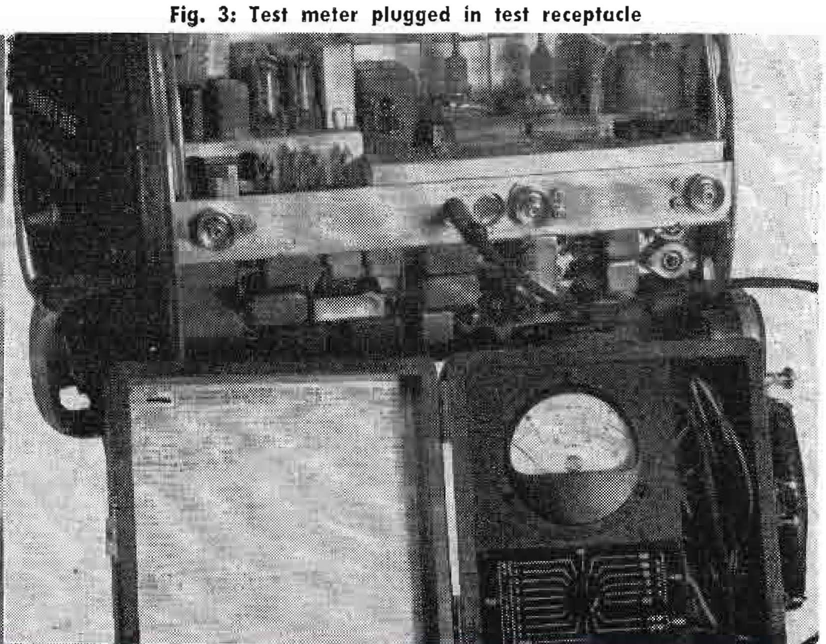


Fig. 3: Test meter plugged in test receptacle



New Airborne Radio Equipment

equipments grow, in general have reached the point of diminishing returns.

The real problems are those which are introduced by complexity, that is, maintenance and repair of the equipments. Since even engineers have some difficulty in "debugging" the radio sets they design, the plight of the technician who maintains the equipment in the field becomes an acute problem. The logical attack is to give the repairman the necessary means for quickly analyzing and locating the faulty subassembly, and spare subassemblies for quick and easy substitution.

Civilian vs Military Problems

If the military services procured equipments manufactured using the usual techniques employed by commercial concerns in building television or broadcast receivers, we should end up in a hopeless mess of wires and components to any but highly-trained personnel. This is no reflection on the industry because civilian and military problems bear no resemblance to each other. The military services do not have the counterpart of the radio and television serviceman and his shop at the front line. Equipments must be completely sectionalized and each section must be of the plug-in type for easy removal and replacement. Such subassemblies are small enough to handle easily, even in the largest of equipments. Some of the portions of a subassembly or the subassembly itself, if it is small enough, may be discarded rather than repaired. This idea of "throwaway" units is a relatively new concept in the military services, but is gaining ground as subminiaturization provides more and more small, hermetically-sealed, minor subassemblies and parts. Such parts are exemplified by intermediate frequency amplifier stages (Fig. 1) which are solder sealed and include glass insulated terminals.

Sectionalization in itself does not aid in fault finding, but does help in the return of the complete equipment to service after the fault is located. In order to localize a faulty subassembly, a test receptacle is mounted on every subassembly, accessible when the radio set is completely assembled (Fig. 2). Some complex subassemblies may require more than one receptacle. To identify one receptacle from another, they may be color coded. An external, portable multimeter, simple and inexpensive, is utilized on a "go—no go" basis (Fig. 3). A selector switch permits sampling the currents and voltages of all critical circuits and the meter readings are compared with limits printed in the upper lid of the multimeter. No training is required for this operation. The subassembly exhibiting out-of-limits readings is the defective subassembly. Thus isolated, it only is removed and replaced by another, similar unit. The remainder of the radio set is left undisturbed.

Adjustment Unnecessary

In most advanced equipments, no adjustment is required when a subassembly is replaced by a similar one. To further simplify the manual labor involved, subassemblies are fastened to the main frame with from two to not more than four captive screws. The few radio frequency connections are made by means of small, easily manipulated connectors. There are no leads to unsolder and, generally, no gears to align or shafts to position, in removing a faulty subassembly and replacing it with a good one.

If a questionable subassembly is to be investigated further, a patch cord, with similar male and female connectors, may be used to connect the unit to the plug receptacle in the main chassis where the subassembly is located normally (Fig. 4). With the unit patched into the radio set, the entire equipment may be operated in the normal manner. While so connected, the "go—no go" meter may be used, or other test equipment may be employed (Fig. 5). The foregoing procedure normally takes place at an echelon of maintenance higher than the first level, about which we are most concerned.

Costs and Time

The choice of repair or discard depends almost entirely upon the costs involved and, of course, the repair time required is converted into dollars. If the cost of repair is about as much or more than the cost of a minor subassembly or small unit, it is discarded. If not, it is sent to higher echelon maintenance for repair where adequate facilities and trained personnel are available. With the reliability of ruggedized, subminiature tubes reportedly approaching that of such circuit elements as resistors and capacitors, it is economically feasible to include a complete stage, vacuum tube and all, in a solder-sealed assembly (Fig.1). When transistors are in common usage, this type of construction will become very commonplace.

In those cases where a complete equipment must be pressurized or at least maintain near sea-level pres-

(*Continued on page* 148)

Fig. 4: (left) Subassembly patched to main frame

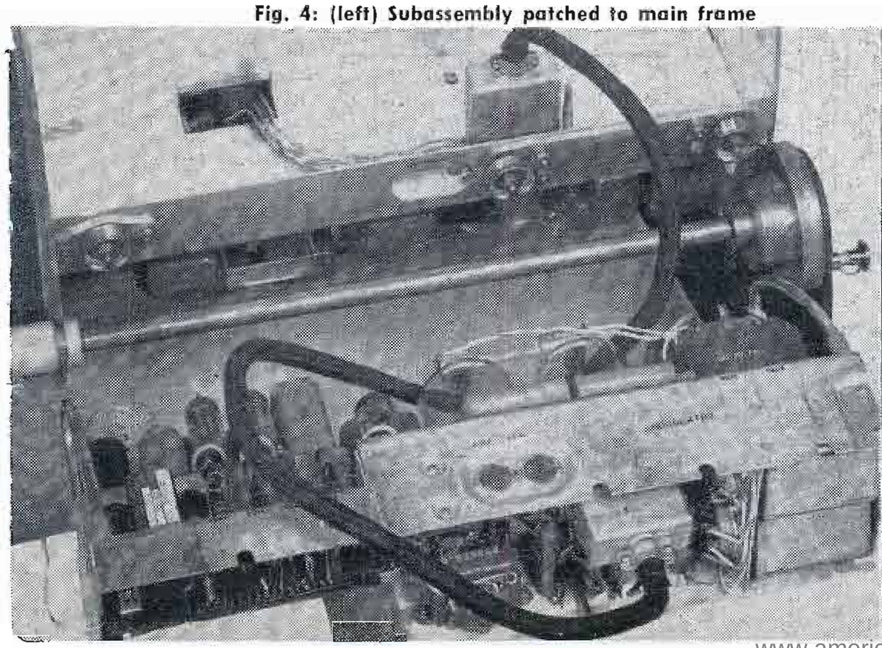
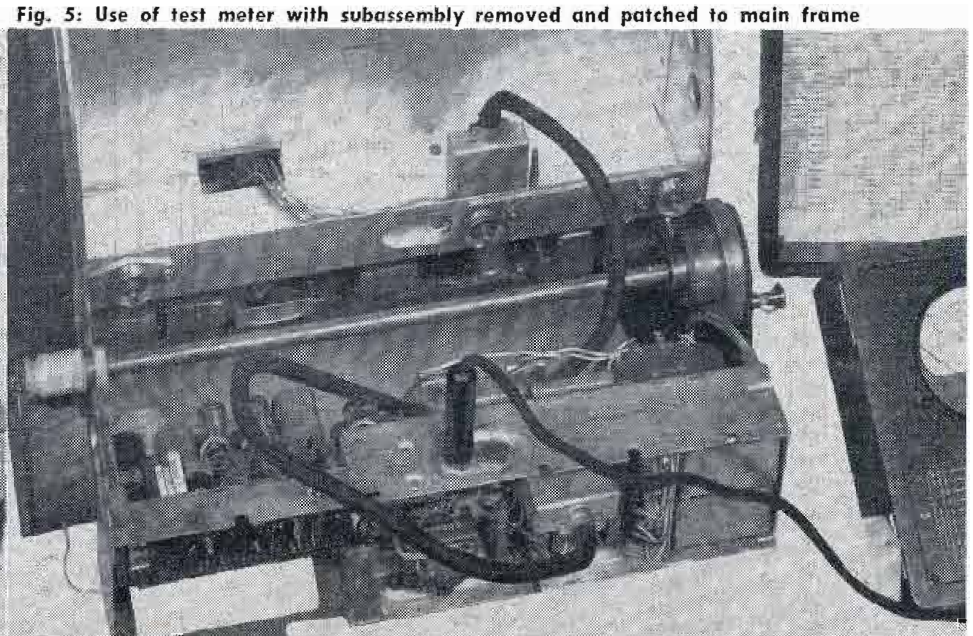


Fig. 5: Use of test meter with subassembly removed and patched to main frame



CUES for BROADCASTERS

Practical ways of improving station operation and efficiency

All-Electronic Beacon Flasher

LOUIS N. SELTZER, Chief Engineer, WCOJ, Coatesville, Pa.

WE use an out-of-the-ordinary method for flashing our tower beacon which, in our opinion, is far superior to available mechanical techniques.

We had been continually bothered by having to readjust our mechanical flasher unit. Also, we found that the mercury switch in our unit failed quite frequently and required replacement.

We built a small electronic unit consisting of a power supply, an adjustable multivibrator, and an amplifier stage. The unit is constructed on a small standard-size chassis mounted on the wall of the transmitter house so that the controls and on-off switch are accessible.

CAA specifications call for a range of 20 to 40 flashes per minute, with the "on" time twice the "off" time. Two potentiometers in the multivibrator circuit help to fulfill this requirement. The multivibrator puts out an adjustable rectangular wave one side of which is twice the other. It is easy to set the "multi" anywhere between 20 and 40 flashes per minute. The desired rectangular wave feeds the amplifier stage which keys a sensitive relay in its plate circuit. We use a single #14 line and ground to the tower, to key a heavy-duty Adlake sealed mercury relay originally designed for heavy-duty sign-flashing service, which we have found far superior to anything else available. (It is Adams and Westlake's code 4601, Part #100001—net $14.00—available from Elkhart, Indiana.) We removed the "innards" from our mechanical unit at the tower and installed the Adlake relay in the weather-proof box.

The circuit is designed so that the beacon will be on continuously should either relay stop operating. Vacuum tubes rather than thyratrons were used in its design because of their availability, and we started with the premise that we would use only common parts which could be found at the transmitter. This unit has now been in operation for two years without a single failure.

$$$ 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.

Taped Tones

ANSON CLARK, Chief Engineer, KNBY, Newport, Ark.

THIS station and another in the vicinity are owned by the same person. Equipment is shuttled between the two stations when needed. Consequently we are sometimes caught without an audio oscillator. We, therefore, recorded 30 minutes of tone on a tape. 10 minutes of 400 cycle, 10 minutes of 600 cycle, and 10 minutes of 1000 cycle. When it becomes necessary to check some of the monitor equipment we can play back the tones through the console from the Magnecorders used at the station.

Four-Channel Mixer Amplifier

HAROLD SCHAAF, Chief Engineer, WRFD, Worthington, Ohio

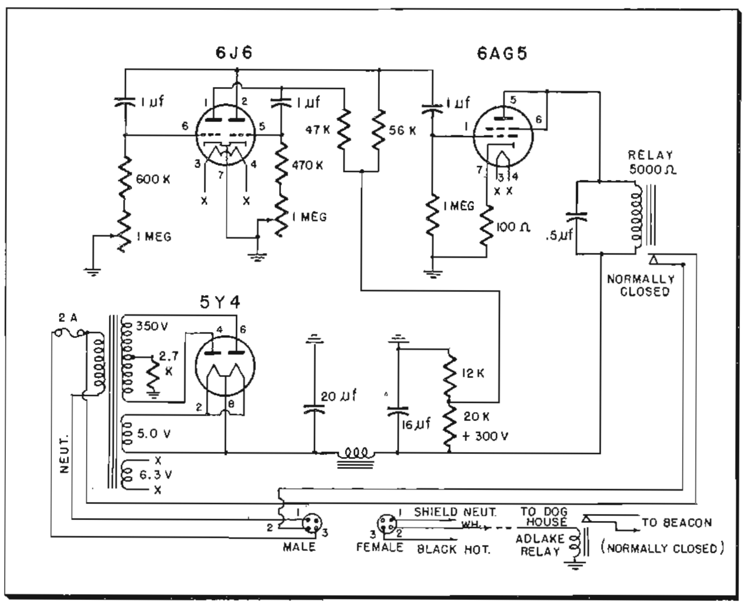
WE were faced with the problem of quickly providing a low cost four-channel mixer-amplifier for use in a local church. We had in stock a UTC HP122 shielded power transformer, some shielded surplus input and output transformers, a case from a discarded wire recorder and of course capacitors and resistors.

Since attenuators are expensive, regular potentiometers were used as channel and master gain controls. Allen Bradley Type AB pots were used in the mixer channels and operated quietly. An amplifier that would have sufficient gain to overcome the loss of the mixer section and still provide up to plus 8 VU without excessive noise was needed. The tube lineup settled upon was a 1620 feeding a 6SJ7 which in turn feeds a parallel connected 6SN7.

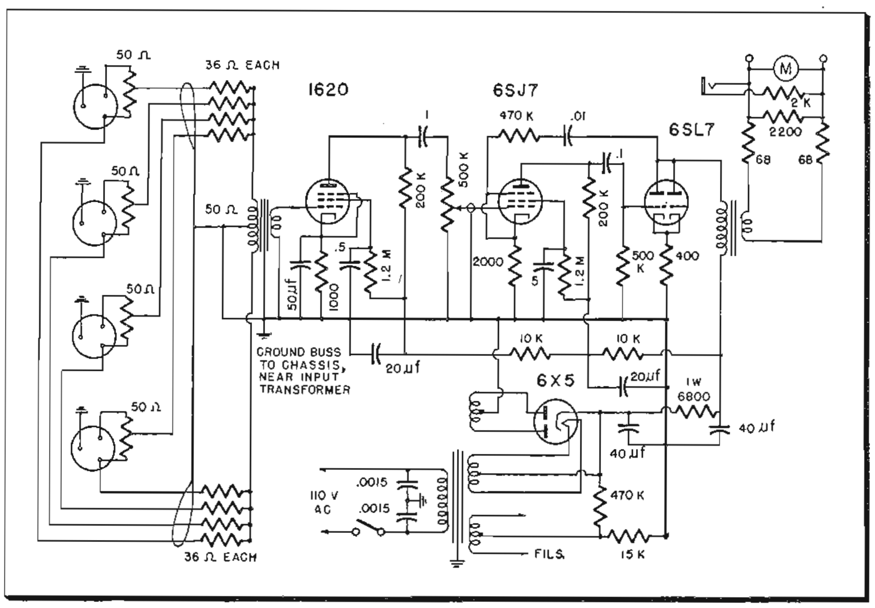
The amplifier section and the power supply were built at opposite sides of the case, care being used in orienting both the power transformer and the input transformer for minimum hum pickup. Shielded filament wiring was also used.

We use 50 ohm microphones; how-

Multivibrator controls flasher on tower. In case of failure beacon remains alight until circuit is restored

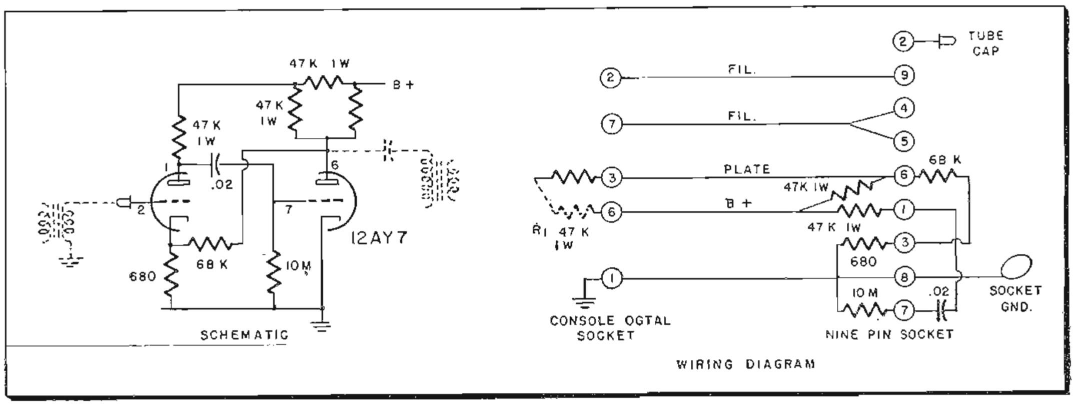


Low cost four input mixer amplifier uses low-level mixing and features low noise level through careful layout and shielding



ever different input impedances can be provided by changing the values of the input potentiometers and resistors.

Interaction between channels is not noticeable. Since this was a rush job we were unable to make noise and distortion measurements. However, the unit has been operating for some time and compares quite favorably with other remotes using commercially built mixer amplifiers. Cost was approximately $55.00 for parts plus the labor.



Preamplifier provides increased gain for use with reluctance type pickups and standard studio console

Locating Gas Leaks in Coaxial Lines

G. W. LEE, 565 Duplex Ave. Toronto, Ont., Canada

THE growth of microwave and television communications using nitrogen filled coaxial transmission lines has created a necessity for an accurate method of locating gas leaks in this type of line. In the past, the method of detecting leaks was to cover all areas likely to leak with a solution of soapy water. A soap bubble formed by the escaping gas indicated the leak which could then be repaired. This method is unsatisfactory for the following reasons:

(1) The rate of gas escape is often so slow that the soap solution dries up before a bubble large enough to be observed can be found.

(2) The area suspected of leaking must be exceptionally free from grease and dust, otherwise the soap solution will not form a film over it. This necessitates a laborious cleaning process.

(3) Leaks are often situated in areas that cannot be observed.

The author has found the above method described slow, unreliable and costly.

The following method was evolved and has since been used successfully on broadcast, television and microwave installations:

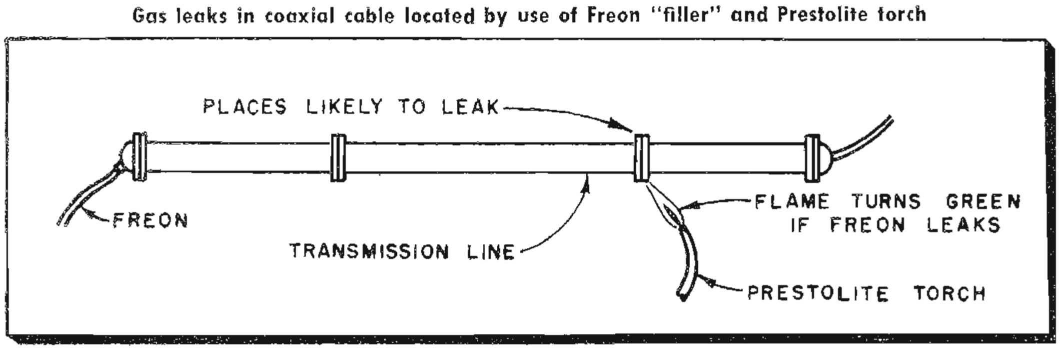
(1) After the transmission line is installed, connect a bottle of freon gas and fill line to about 15 PSI with freon.

(2) Play a low flame from a Prestolite torch over the line. Pay particular attention to all mechanical joints and fittings. If any freon is escaping and comes in contact with the flame, a characteristic *green* flame will result. Thus, the leak may be recognized and corrected.

(3) Gas leaks in Nitrogen-filled capacitors may be detected as well as in the transmission line. It is first necessary to purge the capacitor of nitrogen, then fill with freon to about 15 PSI, and detect by the above method.

(Editor's note: the presence of copper in a flame will also produce a green flame since coaxial cables are made of copper. Do not be misled.)

Gas leaks in coaxial cable located by use of Freon "filler" and Prestolite torch



More T.T. Preamp Gain

ALLEN BELL, Chief Engineer, WCLI, Corning, N. Y.

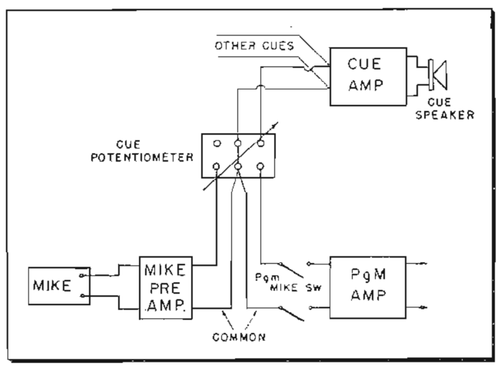
WHEN we wished to change over to reluctance type pickups for recorders and microgrooves we found that the triode connected 6J7 preamps in our Raytheon console did not have sufficient gain for the low level output of these pickups after equalization. It was desired to alter the original console wiring as little as possible. Turret type adaptors were built using an octal plug to fit the 6J7 preamp socket in the console. Approximately 1½ in. above the octal plug a nine-pin socket was supported by #14 leads soldered to the plug. The 12AY7 tube used had more than sufficient gain in spite of the inverse feedback used and the plate voltage had to be reduced below the original by connecting a 47K 1 watt resistor from the B plus to the unused #6 pin of the octal socket. B plus was picked up from the high side of the original 100K plate load resistor in the console. That resistor was not removed, thus the only change made to the console was soldering in a resistor at each TT preamp socket.

Parts for the modification run about $4.50, the major item being the 12AY7 tube. Frequency response is limited only by the console input and output transformers T6, T7, T15 and T16 which are broadcast quality UTC units. As a routine check on the emission of the 12AY7's without removing them, the B plus drop can be measured at pin #6 of the console sockets during maintenance. Nine-pin sockets used were supplied with shields. All resistors ½ watt unless marked.

Order Circuit

SAM DUDAS, Staff Engineer, WBRD, Ft. Lauderdale, Fla.

THIS circuit will be of use to the busy control-room engineer when the announcer wants to give



Order circuit for use with cue circuit

instructions to him and will save him motions and time. It is normally used for turntables, to cue up records, and is invaluable when incorporated in the studio control board.

Clean Tapes for Recording

GILBERT HANZLICEK, KVGB, Great Bend, Kan.

HERE is an easy way to assure clean tapes when recording. Insert a dc erase head (discarded brush) ahead of the ac head as used on the Magnecorder. Used programs may be erased on "rewind" by

(*Continued on page* 114)

High-Powered Microwave Dummy

Units for standard military waveguide sizes cover 2600 to 12,400 MC range. Use wedges in waveguide walls gives constant power loss per length; enables uniform

By TORE N. ANDERSON,
Chief Engineer,
Airtron Inc., Linden, N. J.

TABLE I

Freq. MC	Waveguide Size, in.	Metallic Skin Depth in.	Metallic Attenuation db/in.	Desired Dissipative Att. db/in.	Dissipative Wall Skin Depth in. (Approx.)
3000	2.840 x 1.340	7.5 x 10-5	0.0066	1.0	0.0112
5000	1.872 x 0.872	5.1 x 10-5	0.013	1.5	0.0056
7000	1.372 x 0.622	4.3 x 10-5	0.027	1.9	0.0047
8500	1.122 x 0.497	3.5 x 10-5	0.027	2.1	0.0027
11000	0.900 x 0.400	3.2 x 10-5	0.038	3.0	0.0023

In modern waveguide systems, there has been a need for high powered dry loads which would allow the absorption of the high peak and average powers which are presently being employed in modern radar sets. For indoor testing of radar transmitters and for a number of other practical applications, it is necessary to be able to absorb the power emitted from the radar transmitter during test and operation.

This paper describes the development of a series of waveguide dummy loads which have a peak power rating equal to that of rigid waveguide as a result of their inherent design, and an average power far in excess of that heretofore achieved in standard dry type microwave dummy loads without auxiliary cooling means.

As a design objective to insure a component part which would not become rapidly obsolete, an initial goal of a minimum peak power breakdown equivalent to that of rigid waveguide was established. Thus, a definite safety factor is allowed since, in any practical radar system or high powered transmitter, the power limiting device is generally something in the system less than that of the rigid waveguide, duplexers, rotary joints, transitions, etc., which prohibit developing the full peak power rating of the rigid guide.

Aircraft Tests

Since, in a number of these test positions especially when systems are located in aircraft, aboard ship, etc., it is very inconvenient to provide forced air cooling or liquid cooling, it was desired that these dummy loads be capable of being operated without any additional auxiliary cooling equipment and still carry average powers which are representative of the most high powered systems in use today.

Fig. 2: Smith chart plot of dummy load having 40-60 mix as a function of frequency

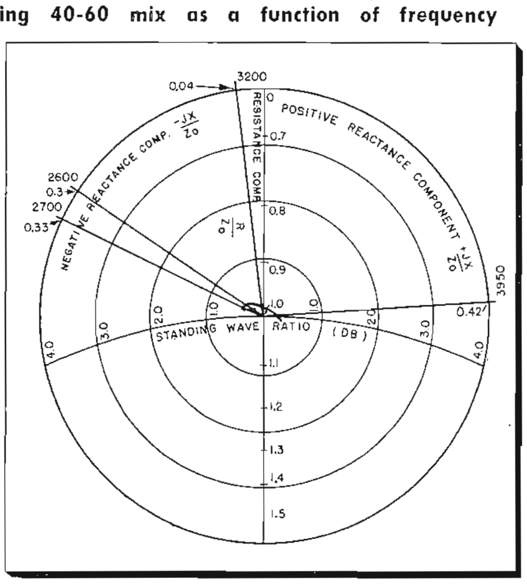
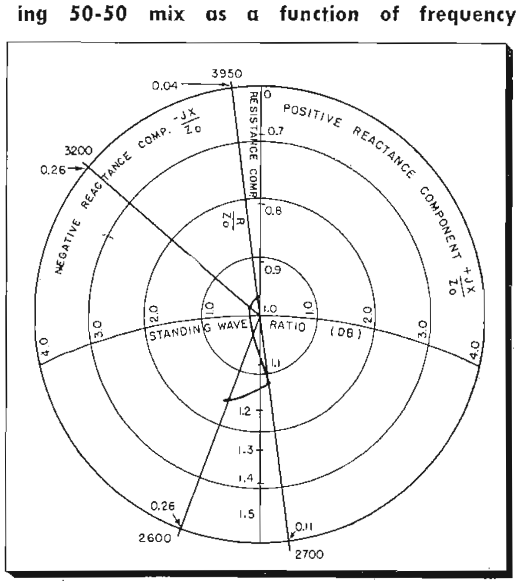


Fig. 3: Smith chart plot of dummy load having 50-50 mix as a function of frequency



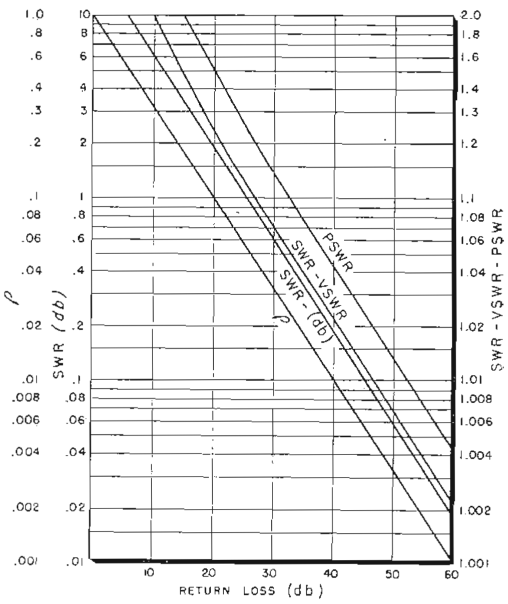


Fig. 1: Return loss (db) versus VSWR

In the microwave region, the most straightforward and perhaps the most satisfactory method of making a waveguide high power termination is to use waveguide walls which are poor conductors instead of using attenuating material which fills the waveguide. Such a construction facilitates more effective removal of the heat generated in the loads, provides conditions for maximum power breakdown since the smallest dimensions can be made equal to that of rigid guide and provides a junction which is essentially reflectionless.

The junction of two waveguide sections will give rise to a mismatch given by the familiar expression:

$$\gamma = \frac{Z_1}{Z_0} = \frac{b_1 a_0}{b_0 a_1} \sqrt{\frac{\mu_1 \varepsilon_0}{\mu_0 \varepsilon_1}} \times \frac{\sqrt{1-\left(\frac{\lambda_1}{2a_0}\right)^2}}{\sqrt{1-\left(\frac{\lambda_1}{2a_1}\right)^2}} \qquad (1)$$

where:

$a_0 b_0$ are dimensions of standard waveguide,

$a_1 b_1$ are dimensions of dummy load section

μ is dielectric permeability

ε is dielectric permittivity

γ = VSWR

for small discontinuities less than $\gamma = 1.20$ then approximately

$$\gamma = \frac{b_1 a_0}{b_0 a_1}$$

Loads

of tapered metallic overall heating

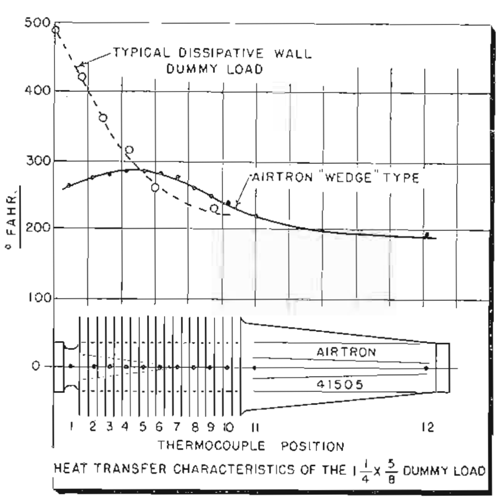
In a dissipative wall section the skin depth in the lossy wall sections will determine the discontinuity and, in general, be the biggest contribution to any mismatch.

Thermal Limitations

The length of a dummy load for a particular waveguide size is dictated in large measure by the amount of power dissipation which the unit is to handle without excessive overheating. For practical considerations, the maximum external temperatures for conventional style dummy load dissipative wall materials is 450° F. Thus, for a dummy load in the 3 x 1½ waveguide size designed for 2000 watts average power, the maximum length is fixed by the finned area for suitable heat dissipation and results in a dummy load which is approximately 30 in. long for a starting point design. To provide a satisfactory attenuating termination, the attenuation of the dummy load must be designed for 30 db one way total loss. Although somewhat less loss could be tolerated since any reflections from the peak of the load would be doubly attenuated, it has been found from practical experience that the 30 db design value is a more satisfactory starting point and will allow a reasonable mechanical tolerance for the actual construction of the load. Fig. 1 gives the relation between return loss (the ratio expressed in db between the reflected and incident power) and the VSWR. From this curve, a total attenuation of 30 db would result in theoretically a VSWR of 1.05. Since the two way attenuation will be considerably higher than this, the actual VSWR should be considerably lower; but in practice, will not generally be obtainable due to variations in the mix material, dimensional tolerances and by the fact that the mismatch above in eq. 1 is only approximate for lossy wall structions.

With the total attenuation established, the actual attenuation constant at the entrance section of the dummy load must be considered. Since the finned area is to dissipate

Fig. 4: Temperature distribution along a 1¼ x ⅝ dummy load compared to a typical uniform dissipative wall dummy load



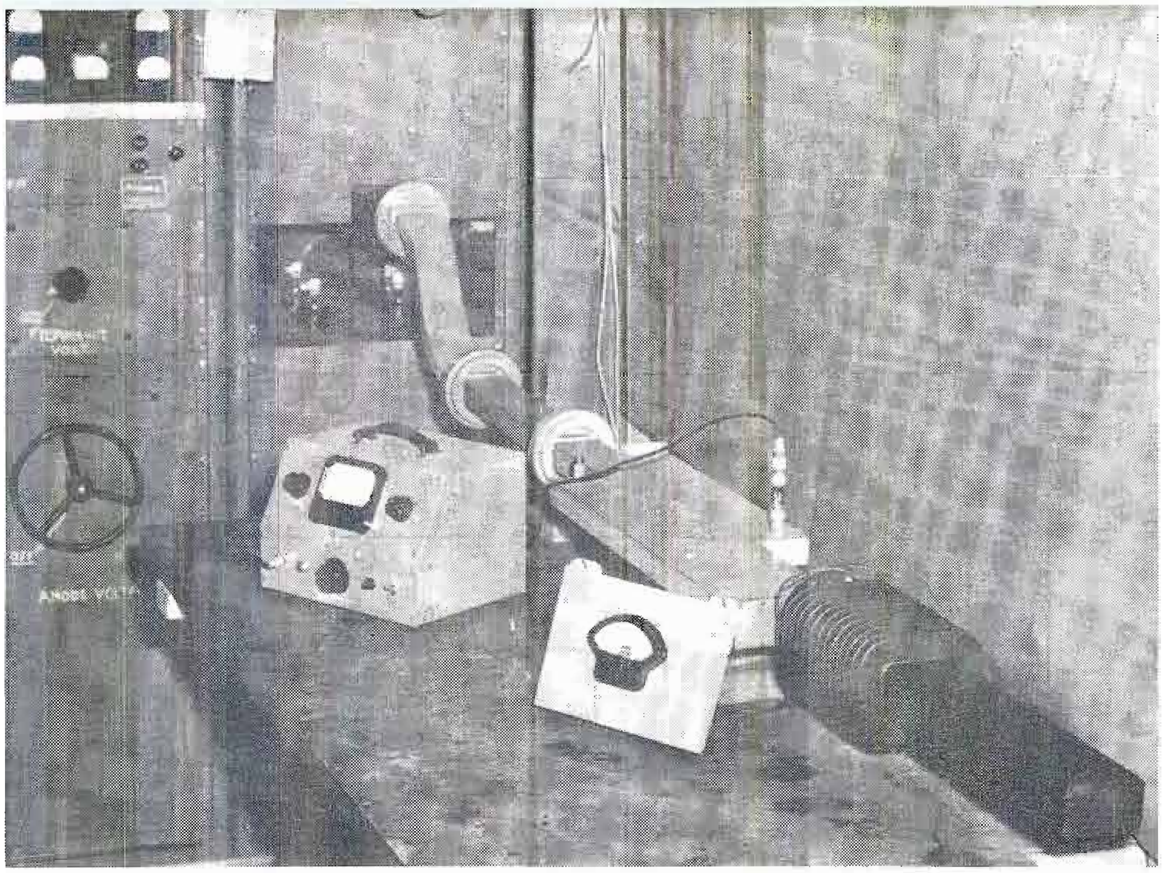


Fig. 5: High power CW magnetron test set for 3 x 1½ waveguide systems

TABLE II

Sample	Freq. MC	Pos. of Min. #1	Pos. of Min. #2	Diff.	VSWR	Pos. of Min.
No. 1	2600	15.40	25.01	9.61	1.195	21.91
50-50%	2700	13.73	22.43	8.70	1.145	19.51
Mix.	3200	14.93	21.10	6.17	1.03	18.06
By Weight	3950	14.28	18.75	4.47	1.04	20.12
No. 2	2600	15.40	25.01	9.61	1.03	23.26
40-60%	2700	13.73	22.43	8.70	1.055	20.97
Mix.	3200	14.93	21.10	6.17	1.02	18.48
By Weight	3950	14.28	18.75	4.47	1.025	20.66

TABLE III

Low Power VSWR

Frequency	VSWR (Limit 1.10) Before High Power	After High Power
2600 MC.	1.07	1.045
3200 MC.	1.05	1.055
3950 MC.	1.03	1.03

High Power Test (2000 Watts Average)

Elapsed Time Minutes	Incident Power Meter * (MW)	Incident Power Actual Watts	Reflected Power Meter ** (MW)	Reflected Power Actual Watts	Return Loss (db)	VSWR	Temperature at Point 13
0	1.43	2000	0.014	0.14	41.5	1.017	290
15	1.43	2000	0.025	0.25	39.0	1.023	407
30	1.43	2000	0.014	0.14	41.5	1.017	465
45	1.43	2000	0.014	0.14	41.5	1.017	495
60	1.43	2000	0.018	0.18	40.5	1.020	512
75	1.43	2000	0.023	0.23	39.4	1.021	500
90	1.43	2000	0.023	0.23	39.4	1.021	515
105	1.43	2000	0.023	0.23	39.4	1.021	515

* Incident power is measured 63 db below power in main guide.
** Reflected power is measured 40 db below power in main guide.

NOTE. 1. Interior of dummy load free of water and signs of deterioration.
2. Interior of isolating section of waveguide *DRY*.

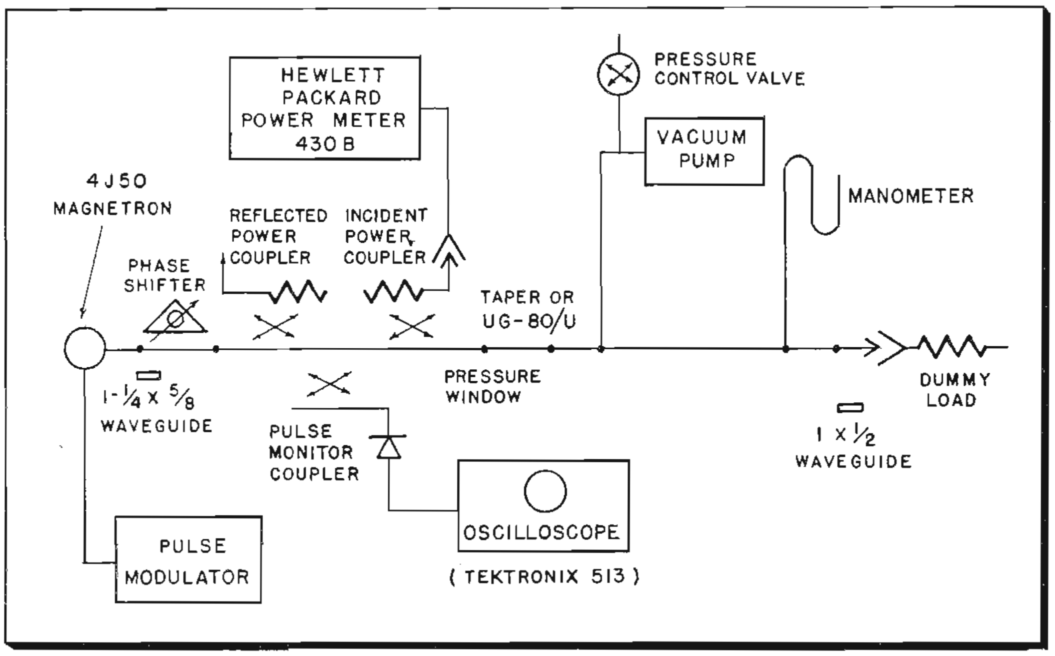


Fig. 6: High power breakdown block diagram

the heating, a good design value is to allow 10 db attenuation to occur in the finned section. Thus, 90% of the heat will be dissipative in this section and reduce overall hot spots. This means then, that for a "S" band dummy load, the attenuation constant at the entrance section should be approximately 1 db per inch. Table I gives an approximate evaluation of the dissipative skin depth compared to normal skin depth for aluminum waveguide components.

As a function of frequency, this table has been extended to include standard military waveguide sizes and the approximate dimensions chosen for the high power series of dummy loads which have been designed using these techniques. From the skin depth, it is apparent that the higher frequency dummy load series shows a relatively noncritical range of attenuation in order to provide a good low VSWR since even taking attnuation constant of twice the required value from thermal considerations will result in skin depths which would not be especially serious from a mismatch point of view.

VSWR Critical

It is indicated that the VSWR for dissipative wall dummy loads of this type would be more critical in the lower frequencies insofar as the characteristics of the mix with higher attenuation constants are concerned. The VSWR would become appreciable due to the relatively large skin depth. Table II shows the results of too high an attenuation constant for a 3 x 1½ dummy load as a function of frequency.

The two dummy load samples No. 1 and No. 2 described above were made from a special high temperature cement (Lumnite) and graphite (Dixon No. 2) mixture, silicon resin impregnated, and the ratio of cement to graphite was varied as shown in the table. Figs. 2 and 3 show Smith Chart Plots for samples No. 1 and No. 2.

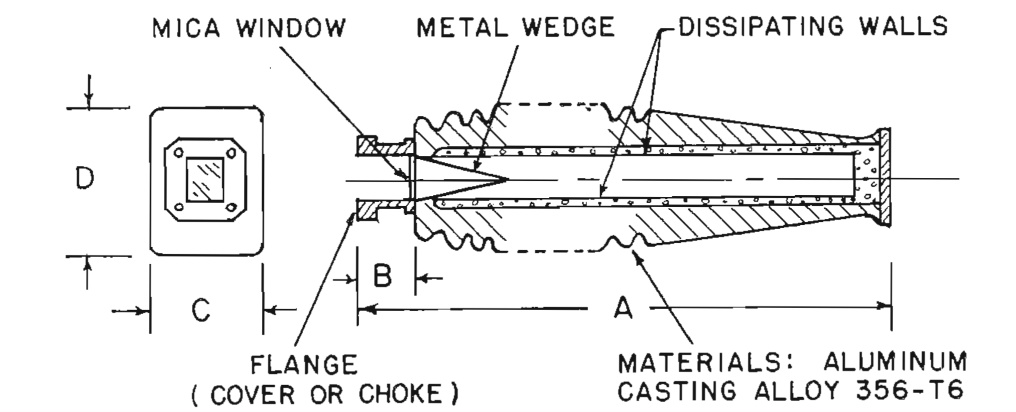
It can be seen from the Smith Chart Plots that the sample with the lower attenuation constant has an admittance component which is greater than unity and practically pure resistance. It would indicate that the approximate analysis for the waveguide mismatch is essentially correct. Decreasing the attenuation constant of the mixture results in a very satisfactory VSWR as can be seen from Fig. 2.

Power Distribution

Once the attenuation constant has been established by suitable experimentation and a mix material arrived at, generally by purely empirical means, the matter of distributing the power through the finned section is of prime importance in a design of a satisfactory dummy load, since, as all four walls are filled with the same dissipative material, the attenuation constant will be linear with length and will result in excessive heating in the first sections of the finned area. For example, with 1 db/in. the first 3 db will be dissipated in the first 3 in. or 50% of the power, and with a finned area of some 20 in. long, only the first few fins will

(*Continued on page* 159)

Fig. 7: Dimensions and test characteristics of waveguide dummy loads



Waveguide I.D.	Flange (1)	Gov't. Type Ref.	A	B	C	D	Frequency Range KMC (2)	Maximum Average Power (Watts)
0.900 x 0.400	Cover (UG-135/U / Choke (UG-136A/U	DA-22/U / –	10$\frac{15}{16}$	1$\frac{1}{2}$	2$\frac{1}{8}$	2$\frac{7}{8}$	8.20 to 12.4	300
1.122 x 0.497	Cover (UG-138/U) / Choke (UG-137A/U)	DA-21/U / –	16$\frac{1}{4}$	1$\frac{9}{16}$	2$\frac{9}{16}$	3$\frac{1}{2}$	7.05 to 10.0	350
1.372 x 0.622	Cover (UG-441/U) / Choke (UG-440A/U)	DA-20/U / –	15$\frac{9}{16}$	2$\frac{1}{16}$	3	4	5.85 to 8.20	500
1.872 x 0.872	Cover (UG-407/U) / Choke (UG-406A/U)	DA-19/U / –	21$\frac{1}{16}$	2$\frac{1}{4}$	3$\frac{1}{2}$	4$\frac{7}{8}$	3.95 to 5.58	1500
2.840 x 1.340	Cover (UG-439/U) / Choke (UG-438A/U)	DA-18/U / –	32$\frac{13}{16}$	3$\frac{1}{16}$	5$\frac{1}{8}$	6$\frac{1}{4}$	2.60 to 3.95	2000

Servomechanism Theory Applied to AFC Circuit Design

A practical approach to the development of automatic frequency control systems for TV picture synchronization

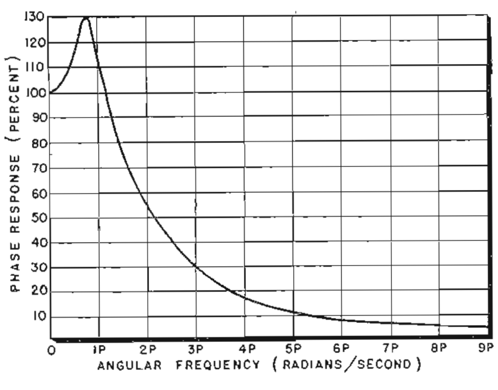
By
G. D. DOLAND
Research Div.
Philco Corp.
Tioga & C Sts.
Philadelphia
34, Pa.

The problem of automatic frequency control (AFC) in TV has always been an important consideration. When dot systems and multiplex operation were being considered, the problem became even more complicated. Although these two systems have since given way to others, they provided the stimulus for the design of the AFC circuit described herein.

Although the matter of noise is important in AFC, the prime considerations are the hold-in and the pull-out ranges. If a small drift of the local oscillator causes the AFC circuit to lose control or to have a static phase error so large as to cause fold-over in the picture, the circuit is unacceptable. Moreover, the AFC circuit must be able to pull itself into synchronization when stations are changed and when noise or loss of signal causes the system to fall out of synchronism.

A third consideration in the design of an AFC circuit is its transient response. At the time the vertical information is sent, the horizontal information is upset because (if for no other reason) there is an extra set of pulses between the pulses of desired information. With some of the original AFC circuits used in commercial black-and-white TV, this resulted in the appearance of an undesirable hook at the top of the picture. When the dot system was used, the transient response could be observed by looking at the dots on the retrace line. Thus, a poor transient response in an AFC circuit is undesirable because it distorts the picture and reduces the performance in the presence of noise.

Fig. 1: Steady-state frequency-phase response relates servo output to input phase



In addition to satisfying the above conditions of hold-in range, pull-in range, and transient response, the AFC circuit must be capable of working in the presence of a reasonable amount of noise. To achieve this, an adequate and effective sync separator is required which will prevent excessive amounts of noise from reaching the AFC circuit. Considered in the light of dot and multiplex systems, as well as of present requirements, the horizontal AFC must be free from video, dot, and vertical sync information and as free as possible from noise. If video information enters the sync circuit, the picture may lose synchronism on picture peaks; with smaller amounts of video, the horizontal oscillator phase may change with the picture content, thus distorting the picture. Dot information entering the sync circuit may cause the picture to lose the dot interlace and result in a two-to-one loss in resolution. As mentioned before, vertical information entering the sync circuit will cause a hook at the top of the picture.

Although the purpose of an AFC circuit is to permit operation in the presence of noise and with a temporary loss of sync, a poorly designed sync separator may pass an excessive amount of noise which could cause a complete lack of sync information for unduly long periods. One of the aims in the design of a sync separator is to maintain some sync information at all times and not to let noise spikes block any stage.

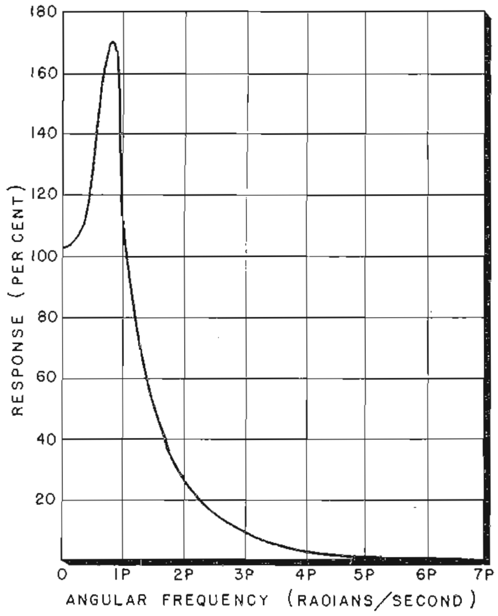


Fig. 2: Square of steady-state frequency response determines the effect of noise

After an adequate sync separator has been designed, there are still other points to be considered before designing the AFC circuit. For maximum pull-in and hold-in range and minimum static phase error, the local oscillator should operate as closely as possible to the transmitter frequency; this requires a balanced phase detector. It will also require that the sync information be presented to the phase detector at the correct time. The time delay and frequency response of the sync separator must be considered to make sure the sync pulses do appear at the correct time.

Circuit Analysis

The AFC circuit performs as a servomechanism and can be analyzed as such. The phase detector is the error-measuring device. The filter represents the characteristics of the regulator. The phase of the oscillator is the regulated variable. The oscillator is the regulated system and must be considered in the servo loop. The sync information is the unregulated variable, reference, or input.

From servomechanism theory, the error response may be found from the following formula:

$$u = v/(1 + fgh) \qquad (1)$$

where

u is the error response,

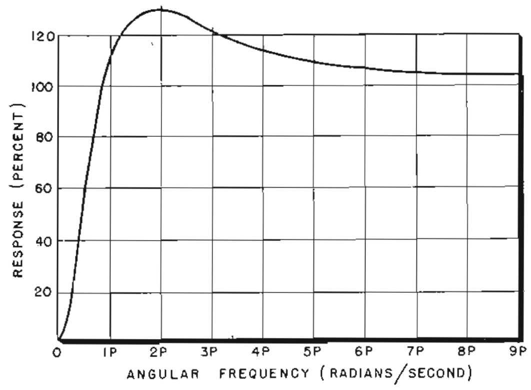


Fig. 3: Steady-state error response indicates error between sync and oscillator

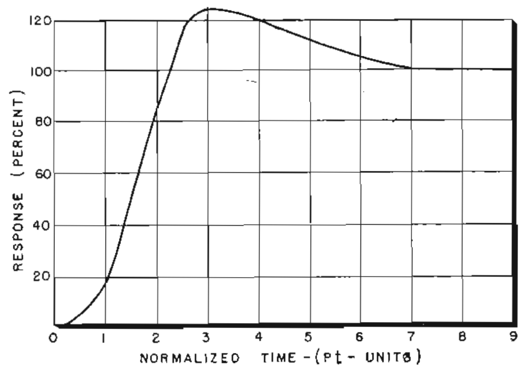


Fig. 4: Unit step phase response curve

v is the variation of the input,
f represents the phase-detector characteristics,
g represents the filter characteristics,
h represents the oscillator characteristics, and
fgh represents the characteristics of the complete open-circuit servo loop.

Likewise, the over-all response of the system, r, can be written as follows:

$$r = fgh\ v/(1 + fgh) \qquad (2)$$

The derivation of Eq. (2) for the AFC system will be discussed later in this paper.

Phase Detector

The phase detector will produce either a voltage or a current which is proportional to the phase error in microseconds. For this paper, it will be assumed that the output is a voltage. Also associated with the phase detector is a time constant, which will be considered here as a part of the filter. The filter will be a four-terminal network having a transfer function. The time constants of this filter will be considered large enough to smooth out the sync pulses and cause the circuit to act as if it were supplied with continuous information. For the required range of operation, the frequency change of the oscillator will be proportional to the voltage from the filter. The variable used is phase, and therefore its rate of change in microseconds per second will be proportional to the voltage output from the filter. These three characteristics can be represented by the following equations:

$$E_i = k_1(\phi_i - \phi_0) \qquad (3)$$

$$E_0 = Z_t E_i \qquad (4)$$

$$d\phi_0/dt = k_2 E_0 \qquad (5)$$

where

E_i is the voltage into the filter,
E_0 is the voltage out of the filter,
ϕ_i is the phase change of the input,
ϕ_0 is the phase change of the controlled oscillator,
Z_t is the transfer function of the filter,
k_1 is the proportionality or sensitivity constant of the detector.
k_2 is the proportionality or sensitivity constant of the oscillator.

These three equations may easily be solved for ϕ_0, or fgh may be determined and substituted for the response. Further analysis will require Laplace transforms; therefore, the equations will be written in that form. To be complete,

$$fgh = k_1 k_2 Z_t (1/s) \qquad (6)$$

and

$$\phi_0 = \frac{k_1 k_2 (Z_t/s)}{1 + k_1 k_2 (Z_t/s)} \phi_i \qquad (7)$$

where

s is the Laplace transform operator.

Since k_1 and k_2 are constants, the real problem is to find the filter which gives the desired response. At first, one might think there are an infinite number of filters which would fulfill this requirement. However, for practical purposes, there are only a few types of filters which need be considered.

Determination of Filter Type

The type of servo system required can be determined directly from the theory of servomechanisms and from the requirements of the system. The fact that there is a (1/s) factor in fgh makes it a Type I, or zero-position-error, servo. This means that there will be no static phase error for a step-of-phase change in the phase of the sync information if the uncontrolled frequency of the oscillator and the incoming sync are the same.

Actually, the type of servo required by the system is a Type II, or zero-velocity-error, servo so that the oscillator may tend to change frequency and still have no phase error. This may be achieved by using a (1/s) factor in the filter or may be approximated by using a 1/(s + A) factor in the filter and a very large gain. Because a (1/s) factor is difficult to obtain, the approximation is used.

This, however, is not the only factor to be considered in determining the filter. Unless compensating sections are used, the servo will be greatly under-damped. One type of compensating section which might be used contains a single pole and single zero and has the form (s + z)/(s + A).

Instead of going directly to a servo system having the final form, several filters which will lead to the same end results will be considered. The first will have a single pole, the second two poles and no zeros, and the third two poles and a single zero, which is the required form. The poles and zeros at infinity are not counted.

The first filter will have the form

$$Z_t = k_0 A/(s + A) \qquad (8)$$

where

k_0 is the dc gain of the filter and
A is the pole location.

For convenience,

$$K = k_0 k_1 k_2. \qquad (9)$$

Substituting in Eq. (7) and simplifying,

$$\phi_0 = \frac{KA}{s(s + A) + KA} \phi_i. \qquad (10)$$

For critical damping, the poles of the servo loop will be located at

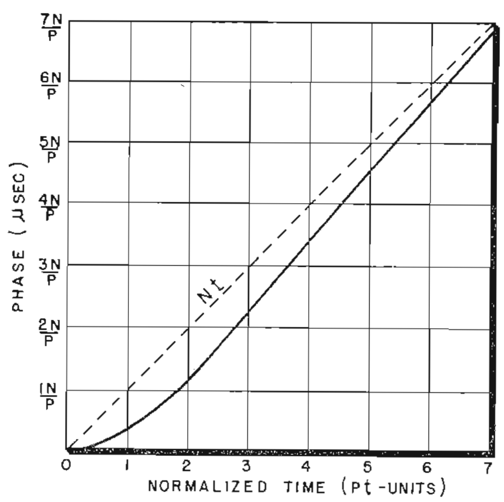


Fig. 5: Linear phase transient response

the same point. The location of the poles can be found by factoring the denominator of Eq. (10) or by solving its characteristic equation; that is,

$$s^2 + As + KA = 0. \qquad (11)$$

Eq. (11) is then solved by the quadratic formula and the radical is set to zero. For critical damping,

$$4K = A. \quad (12)$$

A similar derivation has been described by T. S. George.[1]

There is a direct relationship between the bandwidth and the gain of the servo loop. Increasing the gain will cause the servo loop to be under-damped unless the bandwidth is also increased.

For direct current, the gain of the filter is k_0. Therefore, the static phase error can be found by solving Eq. (3), (4), and (5) to obtain (13) at dc,

$$d\phi_0/dt = K(\phi_i - \phi_0). \quad (13)$$

This equation holds regardless of the type of filter. By setting the maximum static phase error with a particular uncorrected frequency error in the local oscillator, the minimum value of K can be calculated from Eq. (13). The required bandwidth may then be calculated from Eq. (12). Numerical computation will show at once that the value of A is so large for a small static phase error that the filter is worthless in the presence of noise, or that the

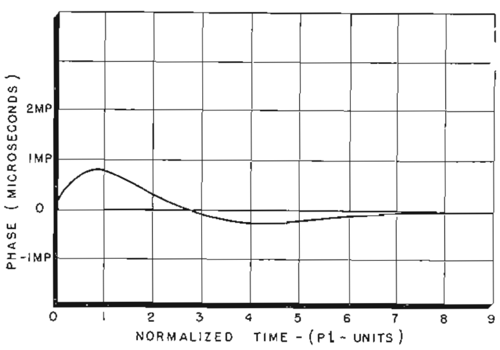


Fig. 6: Servo response to spike input

static phase error is so large for a small bandwidth that the circuit is worthless if any oscillator drift is present. Thus it is seen that this first type of filter does not approximate a zero-velocity-error system. Although the gain can be increased and the servo loop operated in an under-damped condition, this method of operation is not recommended because transients will set up oscillations that last for unduly long periods.

The second filter, the one having only two poles, will have the form

$$Z_t = k_0AB/(s + A)(s + B). \quad (14)$$

Then,

$$\phi_0 = \frac{KAB}{s(s+A)(s+B)+KAB}\phi_i \quad (15)$$

With RC filters, it is not possible to find values for the filter which locate the three poles of the servo loop at the same point. However, two poles of the closed loop may be placed at one point, even with filters having both poles at one point or at widely separated points, if the proper gain is used. If one pole of the filter is moved toward infinity, the single pole of the servo also moves toward infinity, and the circuit operates as a servo having a filter with a single pole. The frequency response of the two-pole filter is nearly like that of the single-pole filter, but a major difference exists between the two filter types. A system with only one pole in the filter cannot oscillate, regardless of the gain. With a two-pole filter, the servo will oscillate when the numerical value for the gain is greater

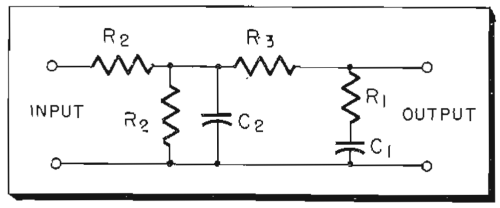


Fig. 7: Filter network with large R_3

than the sum of the poles of the filter.

The single-pole filter is not satisfactory because of the limitation on gain for a particular bandwidth of the closed servo loop. The two-pole filter has the same limitation with a tendency toward oscillation if the gain is too high. The tendency toward oscillation increases as the number of poles is increased because of the additional phase shift of the filter.

The third filter to be considered, the one having two poles and one zero, will have the form

$$Z_t = \frac{k_0AB(s+z)}{z(s+A)(s+B)} \quad (16)$$

and

$$\phi_0 = \frac{(KAB/z)(s+z)\phi_i}{s^3 + (A+B)s^2 + AB(1+K/z)s + KAB}. \quad (17)$$

With the proper choice of components for the filter, the servo may be designed so that the three poles will all lie at the same point. The denominator of Eq. (17) will be a perfect cube, and, by equating the coefficients of s with the coefficients of a perfect cube, the required relationships can be determined. The resulting equations are as follows:

$$3P = A + B, \quad (18)$$

$$3P^2 = AB(1 + K/z), \text{ and} \quad (19)$$

$$P^3 = KAB \quad (20)$$

where

P is the triple pole of the servo.

Since the gain is to be very large, K/z is very large and Eq. (19) can be approximated by Eq. (21),

$$3P^2 = AB(K/z). \quad (21)$$

Eq. (20) is substituted for KAB in Eq. (21) to obtain

$$3z = P. \quad (22)$$

The values of A, B, and z for any K and P can be determined from

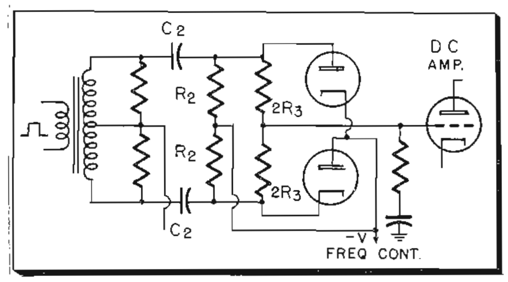


Fig. 8: Phase detector is nonlinear device

Eq. (18), (20), and (22). This means that the gain of the servo loop can be chosen to obtain the desired static phase error and then the location of the triple pole chosen to get the proper filtering action to eliminate noise. Satisfactory operation can be had with this type of filter, and more complicated types need not be considered.

The resulting equation for the servo may be written as follows:

$$\phi_0 = \frac{(3P^2)(s+P/3)}{(s+P)^3}\phi_i \quad (23)$$

The steady-state output or frequency response can be found by replacing s with $j\omega$, rationalizing, and also taking the ratio of output to input.

$$R = \frac{P^2(9\omega^2 + P^2)^{1/2}}{(\omega^2 + P^2)^{3/2}} \quad (24)$$

where

R is the steady-state frequency response and

ω is the frequency in radians per second.

Steady-State Response

A portion of the curve is shown in Fig. 1. The steady-state frequency response relates the output of the servo to a continuous sine-wave variation of phase of the input signal. This curve is useful if there is a low-frequency modulation of the phase of the synchronizing information.

A more useful curve is the square of the steady-state frequency response shown in Fig. 2. This curve is used in determining the effect of noise by comparison on a power basis. The area under the curve in-

(*Continued on page 149*)

TV Station Planning

Technical and equipment considerations involved in establishing any one of four different sized television stations having "combined" studio-transmitter operations

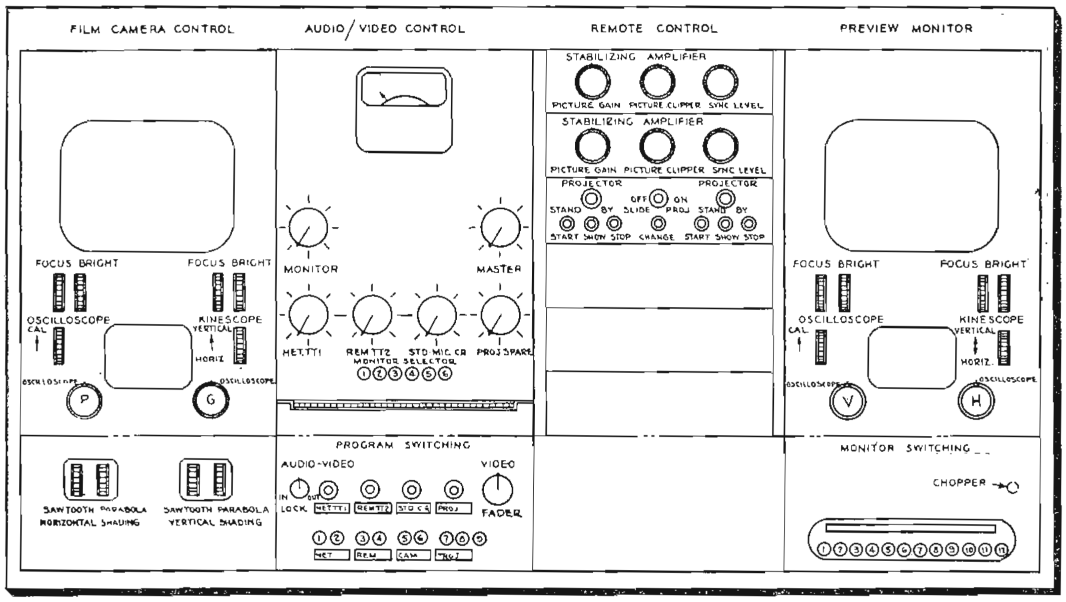


Fig. 1: Detailed panel layout showing the controls, meters and pushbuttons provided by the four basic console sections. Additional studio camera control and film camera control sections are added as plans and programming scope increase

By L. E. ANDERSON & W. O. HADLOCK

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PART ONE of TWO PARTS

HAND-in-hand with station building design and construction goes the proper selection and layout of technical equipment to satisfy contemplated programming requirements. Programming requirements however vary widely and range from simple to complex. As a solution to this situation four general equipment plans were selected to represent well-equipped TV stations for four specific categories of operation.

The need for building and companion equipment plans that may grow logically at minimum cost was considered essential in selecting the following equipment groupings:

STATION GROUP	TRANSMITTER POWER	PROGRAM SOURCES
★ "A"	TTU-1B, 1-KW UHF TT-2AL/AH, 2-KW VHF TT-500, 500 watt	Film, Slides and network
★ "A-Prime"	TTU-1B, 1-KW UHF TT-2AL/AH, 2-KW VHF	Same as above, plus "Single-Camera" Live Studio
* "B"	TTU-10B, 10-KW UHF TT-10AL/AH, 10-KW VHF	Same as above, but "2-Camera" Live Studio
* "C"	TTU-10B, 10-KW UHF TT-25 BL/BH, 25-KW VHF TT-50 AL/AH, 50-KW, VHF	Same as above, with "2-Studio" Live and Remote

Plan "A," "A-Prime" and "B" are versatile and permit expansion of both the building and equipment at minimum cost. Plan "C" represents a larger type of operation and is not a direct outgrowth of any of the other plans. Although individual station requirements, budget appropriations, and scope of operations are seldom alike—the four plans are considered adequate to satisfy a majority of cases. The four distinct groupings of equipment or classes of operation range from Plan "A" (a film and network station only) to Plan "C" (a fairly large "two-studio" station with remote facilities). TV stations with more complex arrangements of program sources than Plan "C" will fall into the "custom" planning category requiring special consideration and investigation.

Mandatory objectives

In arriving at these four TV station equipment layouts, consulting authorities established the following objectives as mandatory: (a) Building plans that would minimize TV planning errors. (b) Provide prospective operator with practical plans and information to develop adequate facilities during early stages of operation; (c) Provide plans that permit suitable expansion with a minimum of obsolesence.

It will be noted from the floor plans that wherever economically feasible, some space allowance has been made for incorporating transmitters of several different power ratings. Plans "A," "A-Prime," and "B" employ transmitters of 500-watts VHF, 1-KW UHF, and 10-KW VHF or UHF.

Conserving Floor Space

It is assumed that sideband filters or diplexers can be ceiling-mounted to conserve floor space, and that the engineer's desk can be conveniently moved to general office areas to provide space for accommodating 10-KW transmitters. When employing the 10-KW VHF transmitter, aural and visual plate transformers are floor-mounted behind the transmitter, as are the plate transformer and regulator for the 10-KW UHF Transmitter.

Since the scales used and resultant room sizes are only approximate, the planner should be cautioned to consider carefully both his present and future space needs and balance this with his planned expenditure. For example, Plan "B" would not be suitable for accommodating a 25-KW or 50-KW Transmitter, unless associated rectifier, control and power equipment could be located on a basement floor or elsewhere. It is suggested that the planner compare proposed doorway sizes with individual components to assure entrance of such items as transmitter cubicles and Filterplexers.

Plans "A," "A-Prime" and "B" are all based on modest, "combination" transmitter/master control facilities and include only the associated console and rack equipment to suit this type of operation. Where separate transmitter supervisory consoles or additional racks are contemplated, greater space should be provided. In general, the provision of a little extra space will be more than repaid by the ease with which later expansion can be made.

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* Transmitters of lower power are equally applicable to these plans.
★ Transmitters of higher power are equally applicable where space permits.

Plan "C" accommodates a 25-KW or 50-KW Transmitter and a Supervisory Console. Since this is a master control point, space for multiple rack equipment is also provided.

General Considerations

All TV installations, large or small, are alike in many respects. The difference in size, for instance, is mostly a matter of the number of cameras and studios involved. The single studio of a small station and its associated control room may be almost identical to one of the studios and associated control rooms of a larger station. Thus, the general arrangements of the equipment for the control room may also be quite similar. Moreover, the equipment for all stations is made up from the same basic units. And finally, the basic control system used in all of them performs the same functions.

However, this article would be incomplete if it failed to point out that there are various deviations in arrangement of studio and control room facilities to suit special conditions and personal tastes. For example, it is not necessary that video control operators be able to see into the studio since their primary function is to maintain control of the picture signals emanating from a camera. It is more important that the program director be able to see the production. It would be possible to place a program director's console directly in front of the studio window, and locate the camera controls at one side or even in a different room. In some large stations, all of the camera controls have been placed in master control. This, of course, centralizes all the operational equipment in one spot but requires remote video relay switching and fading to be effective in saving personnel and avoiding many long cable runs. The program director also has control of switching either directly or indirectly. The audio operator should also be able to see the studio action to be able to ride gain properly.

On the other hand, for economic reasons primarily, some stations may require that the camera controls must be located in front of the studio window in order that the program director in the back of the control room, who is located on a raised platform, may see both the studio action and the associated monitors at a glance. This arrangement requires fewer monitors but causes the view of the Program Director to be restricted by the presence of the Video Operator.

In smaller installations, all controls may be located where a veiw of the transmitter, projection room, announce booth, and even a small studio is possible. Such operating conditions are satisfied by the "A" and "A-Prime" plans.

The TV studio should be large enough to provide for as many sets as possible which may be successive scenes in a play or advertising program; while control rooms should be made large enough to admit additional equipment as the station grows. As a matter of fact, the floor plan of "A" can serve as a basic building block for plans "A-Prime" and "B." At least one announce booth is essential in any TV Station layout. Such a booth is provided with the necessary audio facilities and a picture monitor. It enables a commentator, for example, to see the picture upon which he is commenting. If this announce booth is to serve also for station identification, it is advisable to locate the booth so that visual "cue" may be given from the studio control console. It may be desirable on some occasions to point a camera at the announcer through the announce booth window, and this possibility has been taken into consideration in the plans of "A-Prime," "B," and "C." This has been accomplished by existing TV stations with varying degrees of success. To overcome the problem of reflections, some stations have found that the use of inclined windows contributed to improved performance, while others use non-reflective glass.

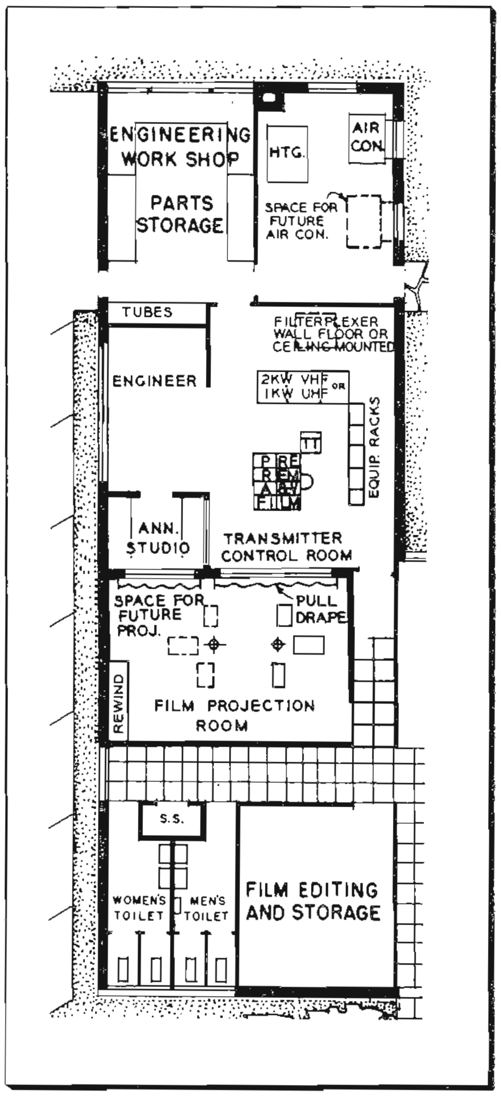


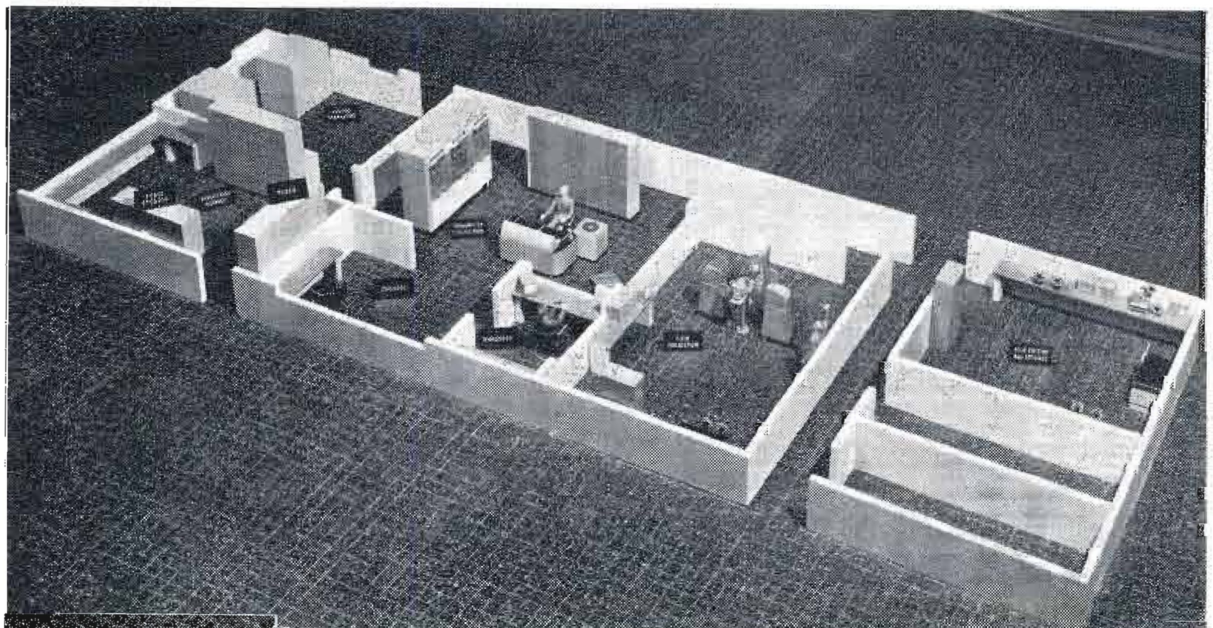
Fig. 2: Plan "A" technical facilities

Basic Studio Equipment

TV Equipment units, in addition to the familiar studio and film camera, include video control consoles which are made up of standard sections referred to as camera control units. There is one of these control units for each studio camera and one for each film camera. Each unit contains a picture monitor showing at all times the picture picked up by the associated camera. It also contains an oscilloscope for "waveform" monitoring and the necessary controls for adjusting brightness, contrast and electrical focus. The video operator uses these controls to keep the several camera pictures in optimum adjustment at all times. Thus, the technical director, or switching operator is free to concentrate on the action without being concerned about the camera adjustments.

In the layouts of plan "A" and plan "A-Prime," a single combina-

Fig. 3: Corresponding model layout photo of Plan "A" station of Fig. 2. In this photo a 1-KW transmitter is employed in central transmitter/video/audio control room



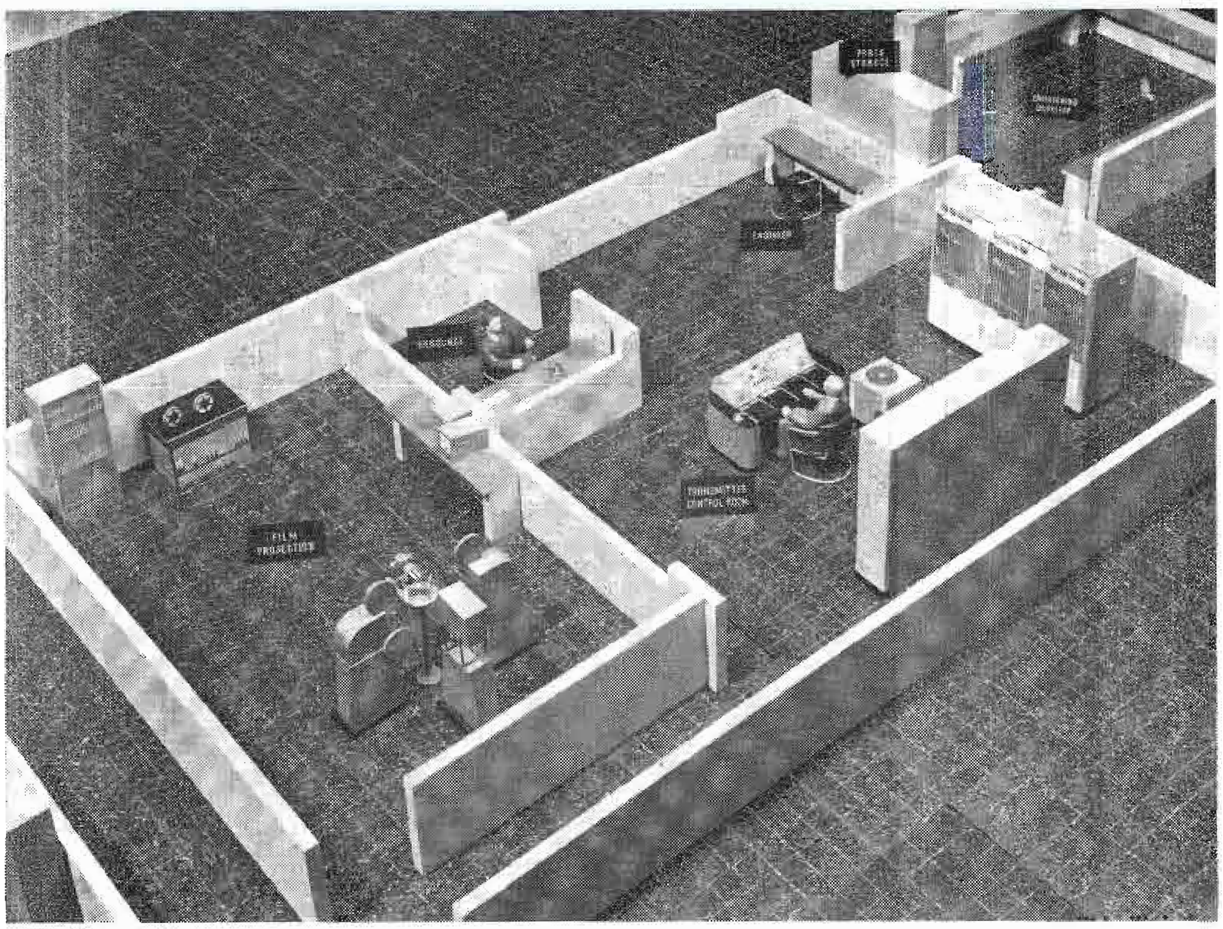


Fig. 4: Closeup of Plan "A" film projection room and transmitter control room

tion Audio/Video console is located in the transmitter room and provides all switching, camera control, monitoring and previewing facilities. Additional monitoring sections and camera controls may be added for future expansion. In plans "B" and "C," separate studio control consoles are employed. However, regardless of the location of individual sections, the output of each studio or film camera is fed into one of the input positions on the TS-10A Video Switching and Fading Console. At this console position, the video signals from the cameras are mixed (or switched) in the same manner as microphone and transcription inputs are mixed at the audio console. From the video switching console, the picture signal is fed either directly to the transmitter line or to a master control room together with signals from other studios, network line, or outside points.

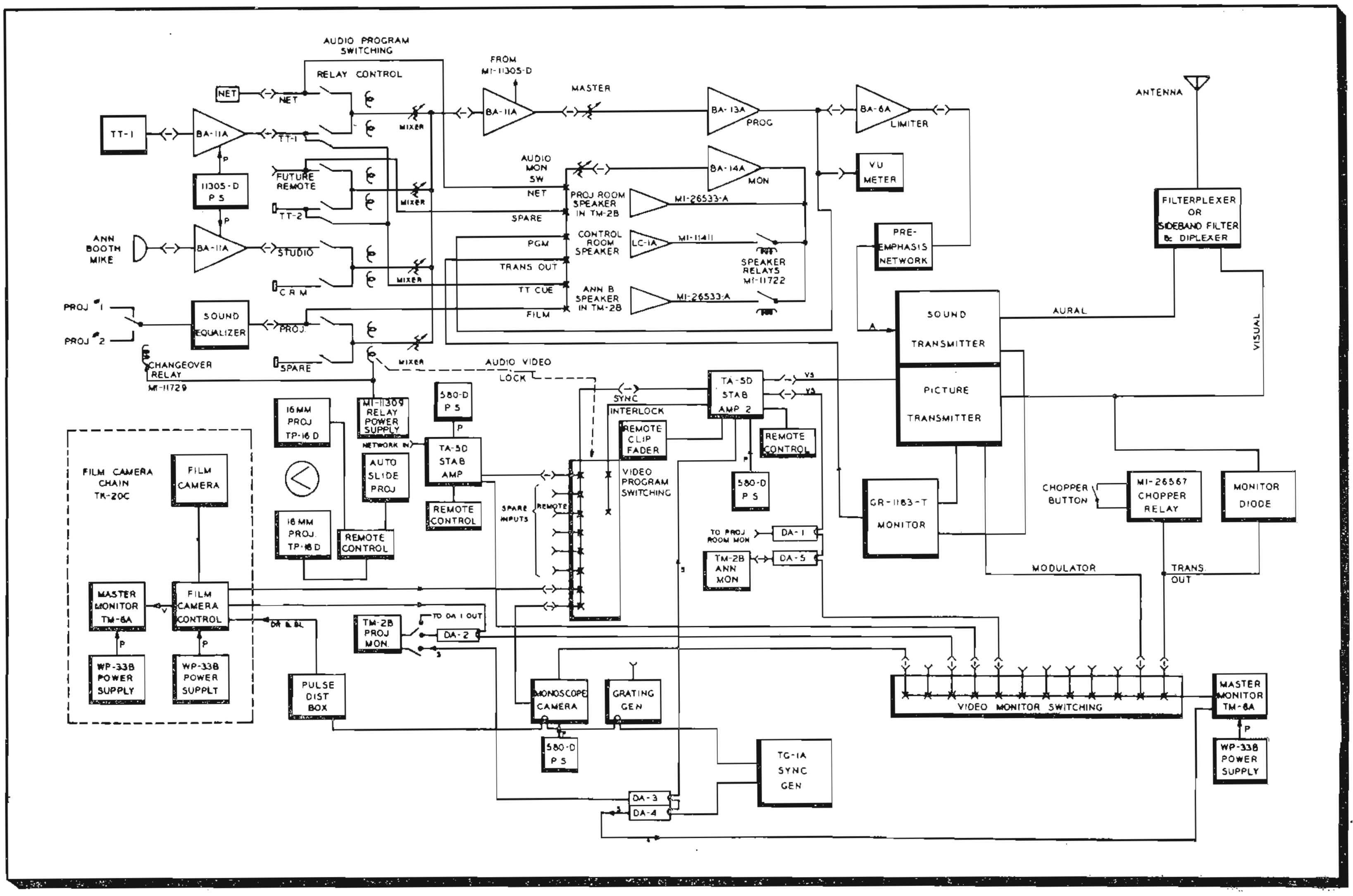
The audio equipment used in a television station has several minor differences compared to that used in a standard broadcast station. One is occasioned by the fact that microphones are usually kept out of sight and that performers must work farther from them. This usually requires more microphones or the use of elaborate boom mounts.

Audio switching is normally "tied-in" or interlocked with video switching. However, provision can be made to divorce the two functions, if necessary. The TV audio control operator, in addition to performing his normal job of riding gain, must maintain close following of the overall program and generally keep step with video control.

The location and arrangement of facilities for video switching varies widely. In medium-sized stations (Plan "B"), a simple but effective arrangement consists of adding to the video console two additional monitor sections. One of these acts

(*Continued on page* 120)

Fig. 5: Overall block system digram showing the arrangement of "Plan "A" technical equipment.



WASHINGTON

News Letter

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

FCC TRANSITION—During the transition period from the 20-year Democratic administration to the Eisenhower administration, the FCC has been functioning in rather a "neutral" gear position as far as making determinations and formulating policies in its spheres of broadcasting and television and communications. The installation of one new commissioner as a Republican member, former Chairman John C. Doerfer of the Wisconsin Public Service Commission, in the second week in April helped somewhat in accelerating the FCC activities. But until another Republican is named by President Eisenhower for the upcoming retirement of Oklahoma Democrat Chairman Paul A. Walker whose term expires at the end of June the Commission will not operate at full effectiveness. Nomination of Commissioner Walker's successor might well come from the President during May.

PRIVATE ENTERPRISE BACKER—New FCC Commissioner Doerfer in his former Wisconsin commission chairmanship of the past six years has had his experience solely in the regulation of utilities, including the telephone companies, and motor bus and truck transportation so that he has had no direct knowledge in the work of supervising broadcasting and television which constitutes around 80 percent of the FCC's activities. Commissioner Doerfer, however, has come to the FCC with a very excellent record of integrity and ability and is known to support completely private enterprise and to have a fundamental belief in its benefits to the nation. As chieftain of the Wisconsin commission he gained a high reputation for his administrative capabilities and was instrumental in the reorganization of that commission's staff—a situation which gained his immediate attention when he was inducted into the FCC. He is a lawyer and has six years experiience in the accounting profession.

COLOR TV ROADBLOCK—Until the FCC has its full complement of commissioners after the retirement of Chairman Walker, the FCC approval of the future public service color television system will not be forthcoming and the final sanction will in all probability not be made until late this summer at the earliest. While the FCC through Chairman Walker defended its position in the controversy, there was no question in the views expressed at the recent House Interstate Commerce Committee hearings that a compatible all-electronic color television system will be one to be sanctioned by the FCC. The Radio Corporation of America with its position and exposition of its huge efforts in this field expressed by RCA Laboratories Vice President E. W. Engstrom and the report on the accomplishments of the National Television Systems Committee by General Electric Vice President W. R. G. Baker demonstrated to the Congressional committee that the radio-television industry is pushing ahead with sincere effort to achieve a solution of color television.

DEFENSE STATUS—With intensified analysis of the 1954 fiscal year budget of the Defense Department aimed towards elimination of non-essential expenditures being the major task of the three armed services there will undoubtedly be a cutback in funds available for radio-electronics procurement during the fiscal period starting next July 1. But there is every indication that the current fiscal year appropriation for research and development in the electronics field of more than one half billion dollars will be maintained and possibly increased. Procurement contracts where radio-electronic equipment has not been delivered over a two-year period are most likely to be canceled with compensation for the work already accomplished. In practically all such cases the originally ordered equipment is now regarded as obsolete. It is also most certain that there will be a reduction in funds approved by Congress for new procurement, but this reduction in the radio-electronics field will in all probability not be as large percentage-wise as in other spheres of military equipment.

MICROWAVE FUTURE—The future of microwave radio operations, involving a new approach in the assignment of microwave frequencies, was discussed by FCC Safety & Special Radio Services Bureau Chief Edwin L. White at the recent annual meeting of the Petroleum Industry Electrical Association at Houston, Texas. He explained a theory of geometrically "engineering in" microwave systems which would greatly increase the potential use of microwave bands.

UTILITIES RADIO—Like the petroleum industry, the power and gas utilities of the nation are the two most important segments in the mobile radio and microwave fields of operation. At the annual meeting of the National Committee for Utilities Radio during mid-May in New Orleans that organization is considering a ten-point program on both a possible reorganization of the committee's structure and of the major operating problems. NCUR Chairman Jonh G. McKinley, electronics manager for the West Penn Power System, had scheduled among the subjects for consideration at the meeting the position of the power radio service in regard to the use of 450 megacycle frequencies and study of the Bell System's broadband multiplex system proposed for this band. The NCUR is expected to take a firm position on the proposal of the FCC to establish a new policy governing the assignment of 72-76 mc frequencies to operational fixed stations on the ground that this band should be retained for point-to-point communications.

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Personnel, Addresses, and Equipment for VHF & UHF Stations Now Operating

TELE-TECH & ELECTRONIC INDUSTRIES

State	City	Call Letters	Channel Number	Business Address	Principal Studio Address	Transmitter Address	Manager	Chief Engineer	Network Facility[1]	Power (KW) Video[4]	Power (KW) Audio[4]	Power (KW) Trans.	Ant. Height[2]	No. TV Cameras	No. Micro-wave Relays	Sets in Area[3]
ALA.	Birmingham	WAFM-TV	13	Protective Life Bldg.	Vulcan Park	Vulcan Park	C. P. Persons Jr.	J. L. Evans	ACD	26	13	5	875	3	1	151
		WBRC-TV	6	1727½—2nd Ave. N.	1727—2nd Ave. N.	Red Mountain	Jerry Hamann	Jerry Hamoan	NBC	35	17.5	5	898	3	0	175
	Montgomery	WCOV-TV	20	Adrian Lane	Adrian Lane	Adrian Lane	H. M. Smith	W. D. Weatherly	CD	17.9		1	425	1	0	8
ARIZ.	Phoenix	KPHO-TV	5	631 N. 1st Ave.	631 N. 1st Ave.	618 N. Central Ave.	R. B. Rawls	G. L. McClanathan	ACDN	17.5	8.7	5	400	4	1	
	Tucson	KOPO-TV	13	115 Drachman	115 Drachman	115 Drachman	E. S. Mittendorf	Walter Stiles	CD	33.5	16.75	5	165	3	1	10
CALIF.	Hollywood	KHJ-TV	9	1313 N. Vine St.	1313 N. Vine St.	Mt. Wilson	W. H. Brown	Robert Arne		30.5	15.7	5	3,100	8	2	1,500
	Los Angeles	KECA-TV	7	4151 Prospect Ave.	4151 Prospect Ave.	Mt. Wilson	Phil Hoffman	C. G. Pierce	A	29.5	14.5	5	3,040	13	3	1,400
		KNBH	4	Sunset and Vine	Sunset and Vine	Mt. Wilson	D. A. Norman	A. H. Saxton	N	47	23.5	24	3,130	31	4	1,300
		KNXT	2	1313 N. Vine St.	1313 N. Vine St.	Mt. Wilson	J. T. Aubrey, Jr.	L. H. Bowman	C	25	12.5	5	2,840	36	3	1,375
		KPIK	22	6540 Sunset Blvd.	Los Angeles, Cal.	Mt. Wilson	John Poole		O	60	35	12	2,975			
		KTTV	11	5746 Sunset Blvd.	5746 Sunset Blvd.	Mt. Wilson	R. A. Moore	E. E. Benham	D	30.9	15.6	5	2,345	19	5	
	San Diego	KFMB-TV	8	1405—5th Ave.	1405—5th Ave.	Mt. Soledad	H. L. Chernoff	T. W. Chew	ACDN	27	13.7	5	750	6	2	177
	San Francisco	KRON-TV	4	901 Mission St.	901 Mission St.	San Bruno Mt.	H. P. See	J. L. Berryhill	N	100	50	25	1,441	8	2	540
		KGO-TV	7	421 Taylor St.	ABC TV Center	ABC TV Center	Vincent Francis	A. E. Evans	A	25.4	12.6	5	1,261	9	1	
		KPIX	5	2655 Van Ness Ave.	2655 Van Ness Ave.	Mt. Sutro	P. G. Lasky	A. E. Towne	C	17	8.5	5	1,140	6	1	650
COLO.	Colo. Springs	KKTV	11	Exchange Natl. Bk. Bldg.	115 E. Mill St.	Cheyenne Mt.	James Russell	M. R. Norton	ACD	46	23	5		3	1	16
	Denver	KFEL-TV	2	550 Lincoln St.	550 Lincoln St.	Golden, Colo.	Gene O'Fallon	Rhean Cunningham	DN	15.9	9.4	5	680	4	0	117
	Pueblo	KCSJ-TV	5	211 W. 5th St.	2200—7th Ave.	2200—7th Ave.	Douglas Kahle	R. J. Tryon	N	17	10	5	400	3	0	13
CONN.	New Britain	WKNB-TV	30	213 Main St.		Farmington, Conn.	P. B. Kenney	John Shipley	CD	20	10	1	970	1		225
	New Haven	WNHC-TV	6/8	1110 Chapel St.	1110 Chapel St.	Hamden, Conn.	Edward Obrist	Vincent DeLaurentis	ACDN	15.1	7.55	5	510	4	1	349
D. C.	Washington	WMAL-TV	7	4461 Conn. Ave. N.W.	4461 Conn. Ave. N.W.	Nebr. & Mass. Ave. N.W.	K. H. Berkeley	Frank Harvey	A	22	12		515	6	2	436
		WNBW	4	Wardman Park Hotel	Wardman Pk. Hotel	Wardman Pk. Hotel	C. D. Smith	J. G. Rogers	N	100	10.5	20	330	6		438
		WTOP-TV	9	13th & E. Sts. N.W.	40th & Brandywine	40th & Brandywine	John Hayes	Granville Klink	C	27.3	14.2	5	460	8	2	436
		WTTG	5	12th & Penn. Ave. N.W.	12th & Penn. Ave. N.W.	5217—19th Rd. N. Arlington, Va.	Walter Compton	M. M. Burleson	D	17.5	10.5	5	587	11	3	417
FLA.	Ft. Lauderdale	WFTL-TV	23		SE 1st St.	1785 SE 15th	N. E. Kersta	Richard Northey	N	20	10	1	5	2	1	50
	Jacksonville	WMBR-TV	4	605 S. Main St.	605 S. Main St.	Vine St.	Glenn Marshall, Jr.	Ernest Vordermark	ACDN	100	60	40	478	5	1	102
	Miami	WTVJ	4	17 N. W. 3rd St.	316 N. Miami Ave.	Everglades Hotel	Lee Ruwitch	Earl Lewis		16.5	8.25		291			
	West Palm Beach	WIRK-TV	21	711 S. Flagler Dr.	Datura St.	Datura St.	J. S. Field	W. P. Heitzman		24	12	1	262			5
GA.	Atlanta	WAGA-TV	5	1018 W. Peachtree St.	1018 W. Peachtree	1018 W. Peachtree	G. C. Jackson	H. A. Bondy	C	28	14	5	530	4	1	215
		WLW-A	8	15 Forsyth St. S.W.	15 Forsyth St. S.W.	1601 W. Peachtree St. NE	W. T. Lane	H. J. Aderhold	A	23.8	12.5		579	3	0	250
		WSB-TV	2	Biltmore Hotel	1601 W. Peachtree	N.W. 780 Willoughby Way, N.E.	Marcus Bartlett	C. F. Daugherty	N	50	25	5	932	6	2	215
ILL.	Belleville	WTVI	54	Boatmen's Bank Bldg. St. Louis, Mo.	10,200 W. Main St.	10,200 W. Main St.	B. T. Wilson	R. J. Trompeter	D	207	103.5	10	635	0	4	160
	Chicago	WBKB	7	20 N. Wacker Dr.	20 N. Wacker Dr.	20 N. Wacker Dr.	John Mitchell	E. C. Horstman	A	28.3	15	5	670	23	2	
		WGN-TV	9	441 N. Michigan Ave.	441 N. Michigan Ave.	435 N. Michigan Ave.	F. P. Schreiber	C. J. Meyers	CD	29.0	14.5	5	585	22	2	1,400
		WNBQ	5	Merchandise Mart Plaza	Merchandise Mart Plaza	20 N. Wacker Dr.	H. C. Kopf	H. C. Luttgens	N	23	12	5	595	20	1	1,342
		WBBM-TV	4	410 N. Michigan Ave.	190 N. State St.	33 N. LaSalle St.	H. L. Atlass	J. F. Novy	C	25.2	12.6	5	390	16	2	
	Peoria	WEEK-TV	43	Box 144, E. Peoria	2907 Springfield Rd.	2907 Springfield	F. C. Mueller	W. F. Lovely	ACDN	1.7	.85	100	1,150	2	0	22
	Rockford	WTVO	39	N. Merridan Rd.	N. Merridan Rd.	N. Merridan Rd.	Harold Froelich	Herb Eckstien	CDN	19.6	9.8	1	690	1	0	27
	Rock Island	WHBF-TV	4	231—18th St.	231—18th St.	231—18th St.	L. C. Johnson	R. J. Sinnett	ACD	23.4	11.7	5	370	3		200
IND.	Bloomington	WTTV	10	Hillside Dr.	Hillside Dr.	Hillside Dr.	Robert Lemon	Mort Weigel	ACDN	26.9	13	5	715	3	4	221
	Indianapolis	WFBM-TV	6	1330 N. Meridian	1330 N. Meridian	Wash. & Meridian	Harry Bitner, Jr.	Harold Holland	ACDN	30.8	18.1	5	400	7	0	327
	South Bend	WSBT-TV	34	225 W. Colfax Ave.	225 W. Colfax Ave.	Ironwood Rd.	N. B. Welch	Arthur O'Neil	CDN	17.5	8.75	1	540	4	1	27
IOWA	Ames	WOI-TV	4	Osborn Dr.	Bissell Rd.	R.F.D. No. 3	R. B. Hull	Keith Ketcham	ACDN	15.7	8	5	560	4	2	120
	Davenport	WOC-TV	5	805 Brady St.	805 Brady St.	R.R. 1, Bettendorf	E. C. Sanders	Paul Arvidson	N	22.9	12.5	5	350	4	2	200
	Sioux City	KVTV	9	614 Pierce St.	614 Pierce St.	41st & Howard	R. R. Tincher	Clifton Todd	CD	28	15.6	5	705	2	0	40
KY.	Louisville	WAVE-TV	3	334 E. Broadway	334 E. Broadway	New Albany	Nathan Lord	W. E. Hudson	ADN	100	50	25	914	6	2	229
		WHAS-TV	11	525 W. Broadway	525 W. Broadway	525 W. Broadway	Neil Cline	O. W. Towner	C	31.6	15.8	28	495	6	1	190
		WKLO-TV	21		Henry Clay Hotel	New Albany	Joe Eaton	D. C. Summerford		23	11.5	12				135
LA.	Baton Rouge	WAFB-TV	28	P. O. Box 1566	844 Gant St.	844 Gant St.	T. E. Gibbens	D. K. Allan	ACDN	17.5	8.75	1	500	2	0	18
	New Orleans	WDSU-TV	6	520 Royal St.	520 Royal St.	Hibernia Bk. Bldg.	R. D. Swezey	L. G. Riddle	ACDN	31	15	5	395	5	1	175
	Bangor	WABI-TV	5	159 State St.	Holden	Holden	Murray Carpenter	W. L. Dickson	ACDN	2	1	5	673	1	0	120

MD.	Baltimore	WAAM	13	3725 Malden Ave.	3725 Malden Ave.	3725 Malden Ave.	Ken Carter	Benjamin Wolfe	AD	26	14	5	530	5	1	460
		WBAL-TV	11	2610 N. Charles St.	2610 N. Charles	Cottage & Violet Ave.	L. H. Peard, Jr.	W. C. Bareham	N	27	13.5	5	540	10	2	460
		WMAR-TV	2	Charles & Redwood St.	Charles & Redwood St.	10 Light St.	E. K. Jett	C. G. Hopper	C	25	12.5	5		7	3	460
MASS.	Boston	WBZ-TV	4	1170 Soldiers Field Rd.	1170 Soldiers Field Rd.	1170 Soldiers Field Rd.	W. C. Swartley	W. H. Hauser	N	100	50	18.96	529	7	2	1
	Holyoke	WHYN-TV	55	180 High St.	Atop Mt. Tom	Atop Mt. Tom	Charles DeRose	Harold Schumacher	CD	182	91	12	989	2	0	60
	Springfield	WWLP	61	61 Chestnut St.	Agawam	Agawam	A. C. Tindal	G. R. Townsend	AN	150	75		704	2		
MICH.	Ann Arbor	WOAC-TV	20	Hutzel Bldg.	Hutzel Bldg.	Maple Rd.	E. F. Baughn	Donald Boudish	D	1.9	1	100	343			
	Detroit	WJBK-TV	2	500 Temple	500 Temple	8009 Lyndon	G. J. Grubb	P. O. Frincke	CD	16.5	8.3	5	485	7	3	880
		WXYZ-TV	7	Mutual Bldg.	5057 Woodward Ave.	5057 Woodward Ave.	John Pival	C. F. Kocher	A	27.9	13.9	5	483	13	2	850
		WWJ-TV	4	615 W. Lafayette	615 W. Lafayette	Penobscot Bldg.	E. K. Wheeler	E. J. Love	N	20.5	10.2	5	658	14	3	850
	East Lansing	WKAR-TV	60	E. E. Bldg.	E. E. Bldg.	Okemus	Dr. A. L. Hunter	L. P. Towsley		240	120	12	976	3	2	
	Grand Rapids	WOOD-TV	7	National Bank Bldg.	Natl. Bank Bldg.	230 E. 92nd St.	Willard Schroeder	L. C. Bergenroth	ACDN	28.5	14.5	5	490	3	3	225
	Kalamazoo	WKZO-TV	3	124 W. Michigan Ave.	124 W. Michigan Ave.	AB Ave. & 24th St.	J. E. Fetzer	C. E. Lee	ACDN	16	8	5	525	2	3	267
	Lansing	WJIM-TV	6	Bank of Lansing Bldg.	Bank of Lansing Bldg.	Howard & Saginaw	W. E. Walbridge	C. E. Wallace	ACDN	18.7	9.3	5	350	2	0	171
MINN.	Duluth	WFTV	38	Hotel Duluth	4th Ave. & 10 St.	4th Ave. & 10 St.	J. C. Cole	Norman Gill	ADN			1	624	3	1	7
	Minneapolis	WCCO-TV	4	50 S. 9th St.	50 S. 9th St.	Foshay Tower Bldg.	F. Van Konynenburg	J. M. Sherman	ACD	100	50	17.5	540	7	2	354
MISS.	Jackson	WJTV	25	Van Winkle Rd.	Van Winkle Rd.	Van Winkle Rd.	John Rossiter	J. R. Whitworth	ACDN	17.7		1	750	3	2	14
MO.	Kansas City	WDAF-TV	4	3030 Summit St.	3030 Summit St.	3030 Summit St.	William Bates	J. A. Flaherty	ACDN	100	50	22	755	7	1	275
	Springfield	KTTS-TV	10	Chamber of Commerce Bldg.	Chamber of Commerce Bldg.	Chamber of Commerce Bldg.	G. P. Ward	W. F. Curry	CD	13	6.5	2		1	0	17
	St. Louis	KSD-TV	5	1111 Olive St.	1111 Olive St.	1111 Olive St.	G. M. Burbach	J. E. Risk	ACDN	100	60	16	510	5	1	490
		KSTM-TV	36	6 N. 7th St.	6100 Berthold	6100 Berthold	W. E. Ware	E. L. Favlrs	A	275		12	600	2	0	490
NEBR.	Lincoln	KOLN-TV	12	40th & W. St.	40th & W. St.	40th & W. St.	H. E. Anderson	Stan Seivers	D	26.9	13.5	5	362	2	0	31
	Omaha	KMTV	3	2615 Farnam St.	2615 Farnam St.	2615 Farnam St.	O. L. Saddler	R. J. Schroeder	ACD	100	50	18	591	5	0	177
		WOW-TV	6	Insurance Bldg.	3509 Farnam St.	3509 Farnam St.	F. P. Fogarty	W. J. Kotera	DN	100	50	17.6	580	4	2	170
N. J.	Atlantic City	WFPG-TV	46	Steel Pier	Murray & Ohio Aves.	Murray & Ohio Aves.	Fred Weber	B. K. Thron	ACDN	19.5	9.75	1	445			47
	Newark	WATV	13	1020 Broad St.	1020 Broad St.	Empire State Bldg. New York, N. Y.	I. R. Rosenhaus	F. V. Bremer		180	107	50	1,200	8	5	13,500
N. MEX.	Albuquerque	KOB-TV	4	234—5th St. S.W.	905 Buena Vista S.E.	905 Buena Vista S.E.	G. S. Johnson	G. S. Johnson	ACDN	5	2.5	5	69	3	1	24
N.Y.	Binghamton	WNBF-TV	12	Arlington Hotel	Arlington Hotel	Ingraham Hill	C. D. Mastin	L. H. Stantz	ACDN	50	25	5	820	2	0	
	Buffalo	WBEN-TV	4	Hotel Statler	Hotel Statler	East Aurora	G. R. Torge	R. J. Kingsley	ACDN	50	25	5	1,206	6	3	336
	Elmira	WTVE	24	366 N. Main St.	Elmira	Comfort Hill	T. K. Cassel		D	15.5	7.75	1	800			24
	New York	WABC-TV	7	7 W. 66th St.	7 W. 66th St.	Empire State Bldg.	Paul Mowrey	Frank Marx	A	110	55	36	1,380	50	2	
		WABD	5	515 Madison Ave.	205 E. 67th St.	34th & 5th Ave.	R. E. Jones	R. D. Chipp	D	16.7	8.3	5	1,339	30	3	3,350
		WCBS-TV	2	485 Madison Ave.	15 Vanderbilt Ave.	34th & 5th Ave.	Craig Lawrence	R. G. Thompson	C	42	21	15	1,300	72	3	3,389
		WNBT	4	30 Rockefeller Plaza	101 W. 67th St.	Empire State Bldg.	T. J. Buzalski		N	14	7	5	1,450			3,300
		WOR-TV	9	1440 Broadway	1440 Broadway		Warren Wade	William DaCosta		88			1,087			3,290
		WPIX	11	220 E. 42nd St.	News Bldg.	Empire State Bldg.	G. B. Larson	T. E. Howard		100	51	23	1,408	15	3	
	Rochester	WHAM-TV	6	201 Humboldt St.	201 Humboldt St.	Pinnacle Hill	William Fay	Kenneth Gardner	ACDN	23.4	11.7	5	497	6	3	177
	Schenectady	WRGB	6	1 River Rd.	60 Washington Ave.	New Salem	R. B. Hanna, Jr.	W. J. Purcell	N	98	49	26.5	1,010	5	1	256
	Syracuse	WHEN	8	101 Court St.	101 Court St.	Jamesville	Paul Adanti	Gene Crow	ACD	190	100	20	514	4	2	211
		WSYR-TV	5	224 Harrison St.	224 Harrison St.	Onondaga	E. R. Vadeboncoeur	A. G. Belle Isle	N	26	12.8	5	1,636	2	0	214
	Utica	WKTV	13	P. O. Box 386	Smith Hill Rd.	Smith Hill Rd.	M. C. Fuseo	D. T. Layton, Jr.	ACDN	25	12.5	4.3	830	4	0	90
N. CAR.	Charlotte	WBTV	3	Wilder Bldg.	Wilder Bldg.	Spencer Mountain	C. H. Crutchfield	M. J. Minor	ACDN	50	30	12.2	1,111	6	2	299
	Greensboro	WFMY-TV	2	212 N. Davie St.	212 N. Davie St.	212 N. Davie St.	Gaines Kelley	W. E. Niell	ACDN	16.7	820	5	481	2	0	155
		WCOG-TV	57	Greene St.	Mairs Chapel Rd.	Mairs Chapel Rd.	Virgil Evans	Herman Holl		150		5	770	2	0	150
	Raleigh	WNAD-TV	28	219 S. McDowell	219 S. McDowell	Asbury	Sam Dodd	Pete Miller	C	17.5	8.75	1	463	2	1	18
OHIO	Akron	WAKR-TV	49	First National Tower	853 Copley Rd.	First National Tower	R. G. Berk	I. L. Knopp		19	9.5	1	366	3	0	300
	Cincinnati	WCPO-TV	9	2345 Symmes St.	2345 Symmes St.	2345 Symmes St.	Horry LeBrun	Paul Adams	AD	316	160	50	665	4	2	402
		WKRC-TV	12	800 Broadway	800 Broadway	1932 Highland Ave.	U. A. Latham	George Wilson	C	250	125	25	610	6	1	405
		WLW-T	4	140 W. 9th St.	140 W. 9th St.	Chickasaw & Warner St.	J. T. Murphy	Howard Lepple	N	23.1	14	5	670	8	2	350
	Cleveland	WEWS	5	1816 E. 13th St.	1816 E. 13th St.	Parma	J. C. Hanrahan	J. B. Epperson	C	16	8	5	640	9	3	140
		WXEL	9	1630 Euclid Ave.	1630 Euclid Ave.	4501 Pleasant Valley Rd. Parma	Franklin Snyder	H. A. Brinkman	AD	25.6	13.4	5	725	14	1	740
		WNBK	4	815 Superior Ave.	815 Superior Ave.	Breeksville	Hamilton Shea	S. E. Leonard	N	39.22	20.26	5	620	10	2	750
	Columbus	WBNS-TV	10	33 N. High St.	495 Olentangy Blvd.	495 Olentangy Blvd.	R. A. Borel	L. H. Nafzger	C	24.3	12.15	5	485	4	0	279
		WLW-C	3	3165 Olentangy River Rd.	3165 Olentangy River Rd.	3165 Olentangy River Rd.	James Leonard	C. B. Sloan	N	15.25	7.6	5	455	3	1	279
		WTVN	6	753 Harmon Ave.	753 Harmon Ave.	50 W. Broad	J. W. McGough	J. P. Gill	AD	19.8	10	5	545	3		279
	Dayton	WHIO-TV	7	45 S. Ludlow St.	1414 Wilmington Ave.	1414 Wilmington Ave.	R. H. Moody	E. L. Adams	ACD	24	12	5	570	4	3	269
		WIFE	22	5 S. Jefferson		Dayton				200	100	11	500	2	1	
		WLW-D	5	4595 S. Dixie Hwy.	4595 S. Dixie Hwy.	Frytown & W. Carrollton Road	H. P. Lasker	L. G. Sturgill	N	16	8	3	490	5	2	613
	Toledo	WSPD-TV	13	136 Huron St.	136 Huron St.	117 S. Superior St.	Allan Hard	W. M. Stringfellow	ACDN	24.5	12.3	5	524	6	1	220
	Youngstown	WKBN-TV	27	3930 Sunset Blvd.	3930 Sunset Blvd.	3930 Sunset Blvd.	J. L. Bowden	B. T. Wilkins	ACD	15.8	9.5	1	580	3	0	85
		WFMJ-TV	73	101 W. Boardman St.	101 W. Boardman St.		W. F. Maag, Jr.	F. A. Dieringer	N	175	89	10	960	4	0	
	Zanesville	WHIZ-TV	50	N. 5th St.	Downard Rd.	Downard Rd.	V. A. Nolte	W. A. Hunt		92.1	52.1	5	535	1	1	73

TV STATION DATA (Continued)

State	City	Call Letters	Channel Number	Business Address	Principal Studio Address	Transmitter Address	Manager	Chief Engineer	Network Facility[1]	Power (Kw) Video[4]	Power (Kw) Audio[4]	Power (Kw) Trans.	Ant. Height[2]	No. TV Cameras	No. Micro-wave Relays	Sets in Area[3]
OKLA.	Lawton	KSWO-TV	7	Lawton	Lawton	Lawton	P. N. Goode	William Buford		9.6	4.8	2	540	1	0	10
	Oklahoma City	WKY-TV	4		500 E. Britton Rd.	500 E. Britton Rd	P. A. Sugg	H. J. Lovell	ACDN	16.9	8.9	5	935	7	3	193
ORE.	Portland	KPTV	27	735 S.W. 20th Pl.	735 S.W. 20th Pl.	3405 Council Crest Dr.	R. K. Olsen	R. K. Olsen	ACDN	17.6	8.8	1	1,023	3	0	72
PA.	Altoona	WFBG-TV	10	1320—11th Ave.	Altoona	Altoona	J. M. Snyder	G. R. Burgoon	DN	75	37.5	5	990	1	0	75
	Bethlehem	WLEV-TV	51	801 Hamilton St. Allentown, Pa.	Savercool Ave.	Savercool Ave.	T. R. Nunan, Jr.	J. E. Mathiot	N	2.25	2.25		1,095	2		
	Easton	WGLV	57	48 N. 4th St.	Gaffney Hill	Gaffney Hill	N. S. Rounsley	C. R. Thon	AD	100	66	5	1,093	2	1	
	Erie	WICU	12	3514 State St.	3514 State St.	3514 State St.	Ben McLaughlin	Michael Csop	ACDN	30	15	5	110	2	0	194
	Harrisburg	WHP-TV	55	216 Locust St.	216 Locust St.	Blue Mt.	A. K. Redmond	E. D. Leibensperger	C	253	126	10	920	4	2	40
	Johnstown	WJAC-TV	6	329 Main St.		Laurel Hill Mt.	A. D. Schrott	Theodore Campbell	ACDN	70	35	25	1,120	0	0	600
	Lancaster	WGAL-TV	8	8 W. King St.	24 S. Queen St.	8 W. King St.	H. E. Miller	J. E. Mathiot	ACDN	7.2	3.6	3.6	290	3	0	212
	New Castle	WKST-TV	45	Cathedral Bldg.	New Castle	New Castle	A. W. Graham	Donald Dout	D	20	10	1	1,608	0	0	27
	Philadelphia	WCAU-TV	10	City Line & Monument Rd.	City Line & Monument Rd.	12 S. 12th St.	D. W. Thornburgh	J. G. Leitch	C	27.0	14.0	5	670	14	3	1,200
		WFIL-TV	6	4532 Market St.	4532 Market St.	Roxboro	R. W. Clipp	H. E. Rhea	AD	27.7	13.8	5	650	12	3	1,100
		WIP-TV	29	35 S. 9th St.	35 S. 9th St.	Waverly Rd.	Benedict Gimbel, Jr.	C. C. Harris		275	135	12	800			
		WPTZ	3	17th & Sansom Sts.	1619 Walnut St.	Wyndmoor	E. B. Loveman	R. J. Bowley	N	16	8	5	720	14	4	1,215
	Pittsburgh	WDTV	2	Chamber of Commerce Bldg.	Chamber of Commerce Bldg.	4101 Grizella St.	H. C. Lund	R. W. Rodgers	ACDN	16.6	8.3	5	818	5	1	570
		WKJF-TV	53	1715 Grandview Ave.	1715 Grandview Ave.	1715 Grandview Ave.	F. G. Raese	P. E. Pappas		20	10	1	420	2	0	500
	Reading	WEEV-TV	33	433 Penn. St.	433 Penn. St.	Skyline Dr.	T. E. Martin	David Miller, Jr.	AN	227.7	113	12	1,200	2	0	50
		WHUM-TV	61	Skyline Dr.	Skyline Dr.	Summit Station	H. J. Greig	J. E. McCormack	C	260	135	12	1,766	4	2	84
	Scranton	WGBI-TV	22	1000 Wyoming Ave.	1000 Wyoming Ave.	Bald Mount	R. E. McDowell	K. R. Cooke	C	285	150	12	1,163	2	1	
		WTVU-TV	73	First Natl. Bk. Bldg.	Television Hill	Television Hill	Jan King	C. F. Halle		22.94	11.5	1	1,281	3	0	.40
	Wilkes-Barre	WBRE-TV	28	62 S. Franklin St.	62 S. Franklin St.	Wilkes-Barre	D. M. Baltimore	Charles Sohoshi, Sr.	CN	1,000	500	50	1,224	2	2	50
	York	WSBA-TV	43	RD. No. 5	South Queen St.	South Queen St.	Walter Rothensies	Llewellyn Jones	AD	20	10	1.2	500	2	0	50
R. I.	Providence	WJAR-TV	11	176 Weybosset St.	176 Weybosset St.	Pine St., Rehoboth, Mass.	Norman Gittleson	T. C. J. Prior	ACDN							405
S. CAR.	Columbia	WCOS-TV	25	Cornel Arms Apt. Bldg.	2 Notch Rd. & Wisteria St.	2 Notch Rd. & Wisteria St.	Stewart Spencer	Robert Lambert	A	15.7	7.9	1	650	3	0	10
S. DAK.	Sioux Falls	KELO-TV	11	8th & Phillips Ave.	8th & Phillips Ave.	Sioux Falls	Evans Nord	L. C. Froke		55	33	5	528	0	0	
TENN.	Memphis	WMCT	5	165 Madison Ave.	165 Madison Ave.	Memphis	H. W. Slavick	E. C. Frase, Jr.	ACDN	60	30	25	650	4	3	195
	Nashville	WSM-TV	4	301—7th Ave. N.	15th & Compton	15th & Compton	Shelton Weaver	Aaron Shelton	ACDN	23.8	11.9	5	680	4	7	107
TEX.	Amarillo	KFDA-TV	10	Box 1400	Cherry & Broadway	Cherry & Broadway	John Hopkins	Bill Spiller	AC	56.5	30.4	5	550	3	0	13
	Austin	KTBC-TV	7	Driskill Hotel	Driskill Hotel	Austin	J. C. Kellam	Ben Hearn	ACDN	102.9	51.45	10	737	2	1	23
	Dallas	KRLD-TV	4	Herald Square	Herald Square	Camp & Griffin Sts.	R. M. Flynn	B. B. Honeycutt	C	27.3	13.6	5	465	4	1	250
		WFAA-TV	8	3000 Harry Hines Blvd.	3000 Harry Hines Blvd.	3000 Harry Hines Blvd.	R. W. Nimmons	Bill Ellis	ADN	27.1	13.5	5	350	5	1	240
	El Paso	KROD-TV	4	2201 Wyoming	2201 Wyoming	Mt. Franklin	Val Lawrence	E. V. Talbott	CD	56	28	10	1,550	3	1	17
	Ft. Worth	WBAP-TV	5	3900 Barnett St.	3900 Barnett St.	3900 Barnett St.	George Cranston	R. C. Stinson	AN	16.4	8.2	5	490	8	2	233
	Lubbock	KDUB-TV	13	7400 College Ave.	7400 College Ave.	7400 College Ave.	W. D. Rogers, Jr.	T. W. Kirksey	CDP	35	17.5	5	852	4	1	20
	San Antonio	KEYL	5	Transit Tower Bldg.	Transit Tower Bldg.	Transit Tower Bldg.	G. B. Storer, Jr.	W. J. Jackson	ACD	100	50.1	15.5	447	7	1	131
		WOAI-TV	4	1031 Navarro St.	1031 Navarro St.	1031 Navarro St.	A. X. Pangborn	C. L. Jeffers	N	100	50	22	480	6	1	132
UTAH	Salt Lake City	KDYL-TV	4	143 S. Main St.	68 Regent St.	Mt. Vision	J. M. Baldwin	Allen Gunderson	N	30	15	5	3,083	7	3	120
		KSL-TV	5	145 Motor Ave.	145 Motor Ave.	Tooele	D. L. Murdoch	V. E. Clayton	ACD	19.6	9.4	5	4,400	6	1	118
VA.	Lynchburg	WLVA-TV	13	Church St.	Church St.	Lynchburg	P. P. Allen	John Orth	CD	28	14	5	2,050	1	1	40
	Norfolk	WTAR-TV	4	720 Boush St.	720 Boush St.	720 Boush St.	Campbell Arnoux	R. L. Lindell	ACDN	24	12	4.9	400	6	1	162
	Richmond	WTVR	6	3301 W. Broad St.	3301 W. Broad St.	Staples Mill Rd.	W. M. Havens	J. W. Kyle	N	20	10	5	434	3	1	162
	Roanoke	WROV-TV	27	P. O. Box 1110	Mt. Trust Bk. Bldg.	2080 Prospect Ave. S.	F. E. Koehler	J. W. Robertson	A	104.7	62.5	18	674	1		25
		WSLS-TV	10	Shenandoah Bldg.	Shenandoah Bldg.	Poor Mt.	J. H. Moore	J. P. Briggs	CN	252	126	20	1,973	3	1	60
WASH.	Seattle	KING-TV	5	Seattle	320 Aurora Ave.	301 Galer St.	O. P. Brandt	J. L. Middlebrooks	AN	19	10	5	410	4	2	232
	Spokane	KHQ-TV	6	Radio Central Bldg.	4102 S. Regal	4102 S. Regal	R. O. Dunning	Al. Sparling	AN	100	50	35	826	2	1	18
		KXLY-TV	4	315 W. Sprague	315 W. Sprague	Mt. Spokane	Norm Hawkins	Jack Provis	CD	48	27		3,078	2	1	24
	Tacoma	KTNT-TV	11	948 S. Grant St.	1701 S. 11th St.	1701 S. 11th St.	L. H. Higgins	M. H. Bice	CD	29.5	15	5	450	2	0	275
W. VA.	Huntington	WSAZ-TV	3	Box 2115	9th St. & 2nd Ave.	8th St. Rd.	L. H. Rogers	L. E. Kilpatrick	ACDN	100	42	25	600	5	10	185
WISC.	Milwaukee	WTMJ-TV	3	333 W. State St.	720 E. Capitol Dr.	720 E. Capitol Dr.	W. J. Damm	P. B. Laeser	ACDN	16.1	10.3	5	325	11	3	
	Oshkosh	WOSH-TV	48	1235 Bowen St. Rd.	1235 Bowen St. Rd.	1235 Bowen St. Rd.	William Johns, Jr.	D. R. Zuehalke	A	1.3	0.7	1	313	2	0	5

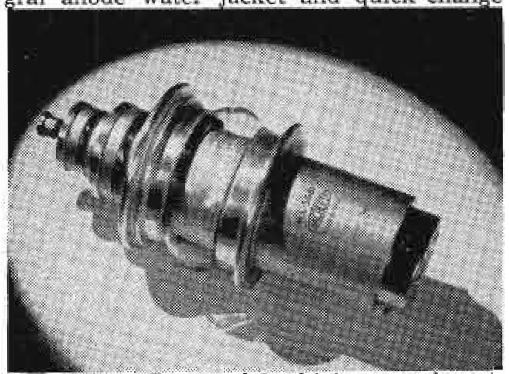
NOTES: 1. A—ABC Network, C—CBS Network, D—DuMont Network, N—NBC Network, P—Paramount Network.
2. Above average terrain in ft.
3. Estimated by station and listed in thousands.
4. Effective Radiated Power.

NARTB Equipment Displays

Previews of latest equipments to be shown at 7th Annual Broadcast Engineering Conference, Los Angeles, Calif.

Coaxial Triode

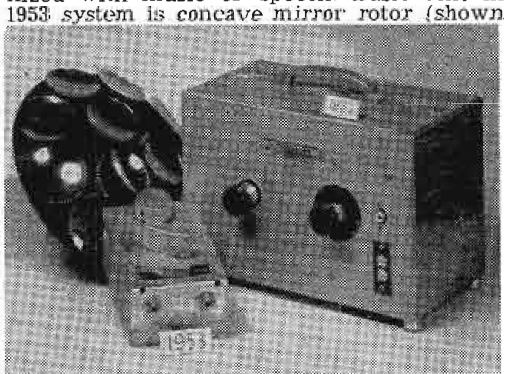
The ML-5681 coaxial terminal triode, suitable for cavity circuitry, features an integral anode water jacket and quick-change



connections. Designed for high power broadcasting applications, the tube makes available 35 kw on low-band TV, 50 kw on FM, and 50 kw on AM.—**Machlett Laboratories, Springdale, Conn.**—TELE-TECH & ELECTRONIC INDUSTRIES

Synchronized Light

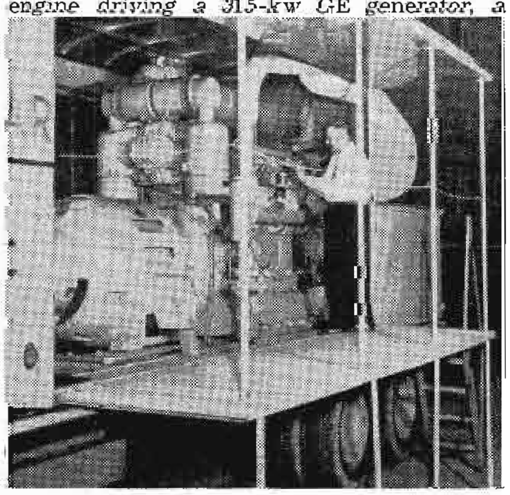
"The Light That Dances" is the name of a decorative illuminating device for TV which creates mobile light abstractions synchronized with music or speech. Basic unit in 1953 system is concave mirror rotor (shown



at left) and transistorized synchrometer in 4x3x2 in. aluminum box. 1952 model using tubes is 9x6x5 in. Sounds cause synchrometer to feed impulses to reversible motors in projector unit so that db changes control mirror assemblies to project color images. TV camera is focused on special 20x16 in. translucent screen or on standard rear-projection screen up to 20x16 ft. Equipment is leased and serviced on one year contract basis.—**Musicolor, Inc., 840 N. Michigan Ave., Chicago 11, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Mobile Power Plant

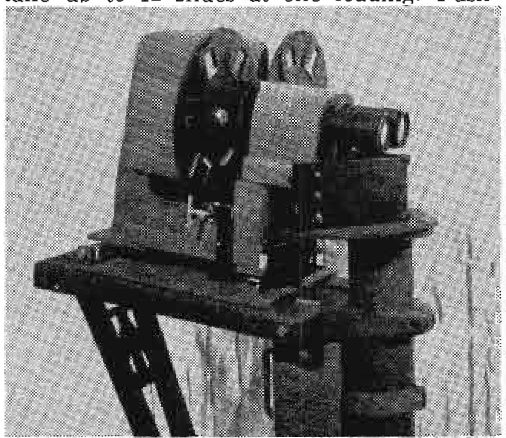
A mobile electric power unit, reported to be the largest yet developed, is mounted in a van-type trailer to provide emergency power at any required location. The road-borne power plant contains a 500-hp Diesel engine driving a 315-kw GE generator, a



Western Electric radio-telephone, and dual-range meters to read 2400 or 4160 volts. 150 feet of cable permit unit to be hooked up in parallel with existing sources to carry part of load within 15 minutes after arrival. 32-ft. trailer weighs 56,000 lbs. or less than 18,000 lbs./axle, which is within road load limits.—**Caterpillar Tractor Co., Peoria 8, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Dual Turret Slide Projector

Dual turret Telojector Model 3A projects 2x2 in. transparencies in uninterrupted sequence. The two easily substituted turrets take up to 12 slides at one loading. Push-



button control permits tripping of one slide only at a time, each slide automatically lapping to the next. Projection alternates between two 6-in. lenses, each providing a 4.5-in. wide image on a mosaic 36 in. from slide. Infra-red filter provides optimum contrast with iconoscope film camera. Unit weighs 35 lbs., measures 14.5x18.5x16 in., and operates from 115 volts, 60 CPS.—**Gray Research and Development Co., Hilliard St., Manchester, Conn.**—TELE-TECH & ELECTRONIC INDUSTRIES

Tape Programming

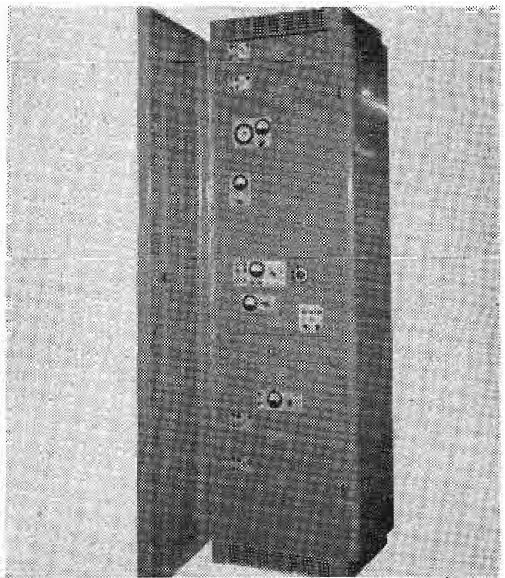
Based on the model 450 tape player which permits 8 hrs. of play from a single tape, system would permit automatic broadcast of day's complete programs. If three players are employed, one could have music and the others announcements and station breaks. A 25-cycle tone at the conclusion of each musical selection stops the music machine and starts the announcement. Station breaks on third machine is controlled by clock mechanism. Transcription services can produce 8-hr. tapes economically with duplication system which permits production of 1200 hours of program material in one working day.—**Ampex Electric Corp., Redwood City, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

UHF-TV Station

Fully equipped TV broadcast station features UHF equipment, including high-level modulated transmitters, slotted pylon antennas, as well as audio equipment and TV cameras. Scale models illustrate station planning for stations of varying size. Also on display are new studio monitoring device called Monitran, dual disc slide projector, miniature vidicon camera, and special effects amplifier with versatile wipe. Also 5-kw AM transmitter and associated units.—**Radio Corp. of America, Camden, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

TV Microwave Relay

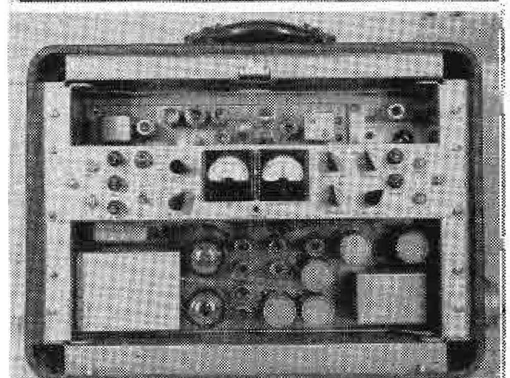
Designed for point-to-point composite video transmission in the 5925-6425 MC or 6875-7125 MC bands, the TLR-2A utilizes FM and heterodyne remodulation for low distortion. Modulated sideband output from repeater klystron mixer is 1 watt. R-F bandwidth is 20 MC, and FM is used with a dc mean carrier swing of 12 MC. First i-f centered at 75 MC has 20 MC bandwidth, second i-f at 115 MC is also 20 MC wide. Video band is flat ±1 db from 60 CPS to 5 MC. Peak-to-peak video levels across 75 ohms are: Input, 1.0 to 2.5 v.; output, 1.0 to ±25%. Stability of r-f oscillator determined by invar



wavemeter cavity is better than 0.02%. Overall i-f carrier-to-noise-ratio for average hop is 45 db. Power consumption is 1 kw at 115 v., 60 CPS. Also on display are TLR-2B portable TV microwave relay, CLR-6 radio relay, CMT-4 multiplex equipment, and a new TV film scanner.—**Philco Corp., Philadelphia 34, Pa.**—TELE-TECH & ELECTRONIC INDUSTRIES

Portable Microwave Relay for TV

A portable microwave relay for relaying in-the-field TV pickups, the KTR-100, has a 25-mi. range. Carrier is 6380-7425 MC, i-f is



130 MC, and transmitter power output is 0.1 watt. R-F head mounted on parabola tripod (top) weighs 43 lbs., may be removed in 10 sec. Weatherproof control unit (below) weighs 43 lbs., measures 21x16x9 in. Maximum frequency deviation is 9.6 MC peak-to-peak video plus 2.4 MC peak-to-peak subcarrier. Video input impedance is 40-170 ohms, and input level is 0.4 v. at 9.6 MC deviation. Video output impedance is 75 ohms, level is 0.5 to 3 v. Audio channel distortion in 1%, S/N is 55 db below swing ±25 KC. Telescopic sight for antenna alignment. 4-ft. dish weighs only 22 lbs.—**Raytheon Mfg. Co., 138 River St., Waltham, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

TV Camera Chains

An image orthicon camera chain with remote control of all operations, plus a new TV film chain mark the first showing on the West Coast for both of these developments. The full-sized image orthicon is mounted on a special pan-and tilt pedestal. From a control box as much as 1000 ft. away, the camera operator may pan through 280°, tilt through 63°, switch to any one of four lenses, adjust the focus and iris setting. The new film chain camera will be combined with the

Additional Previews
of NARTB Equipment Displays
are provided on page 112

GPL PA-100A 16 mm projector. Two sync generators with change-over panel will be mounted in standard rack for maximum utility and saving of studio space as well as field convenience.—**General Precision Lab., Inc., Pleasantville, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

AM and FM Remote Control

A new remote control system for AM and FM transmitters enables placing the transmitter under ideal conditions where real estate costs are low. No personnel are required at the transmitter, only a small building to

house the equipment. Staff members released from the transmitter can be used more effectively at a convenient studio location. The remote control system consists of a studio unit and a transmitter unit connected by two telephone lines. Up to nine meter readings can be made and up to nine operations controlled by simply dialing desired functions. Adjustment is made remotely while simultaneously observing readings of appropriate meter. Additionally, the unit can be used to control a number of other activities at the transmitter location. The system meets all FCC requirements and was tested in AM and FM broadcast stations for several years prior to its introduction to the market. **Rust Industrial Co., Manchester, N. H.**—TELE-TECH & ELECTRONIC INDUSTRIES

Transcription Table

Model 530 3-speed synchronous transcription table has integrally built 3-speed direct drive unit, any speed, 33-1/3, 45 or 78 rpm,

may be selected at will by the flip of a switch whether the table is running or still. This is a direct gear drive transcription table synchronous at all three speeds. Synchronous operation is important to radio stations to insure transcribed programs ending on the second exactly as planned. Synchronous operation is important to the TV station for synchronizing sound with motion picture material.—**Fairchild Recording Equip. Corp., 154th St. and Powells Cove Blvd., Whitestone 57, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

1953 National Airborne Conference

Following the general pattern of last year's successful meeting, the 1953 National Conference on Airborne Electronics is being held in Dayton, Ohio, May 11-13.

Sponsors are the Dayton Section IRE and Professional Group on Airborne Electronics. Exhibits of military and commercial equipment by 59 companies are being displayed at the Biltmore Hotel.

A wide selection of technical papers, presented at the Biltmore and the Dayton Engineers Club, cover components, propagation, instruments, antennas, tubes, microwaves, production, servos, dielectrics, circuits, communications, computers, transistors, and navigation.

Tape Recorder

The RT-11A broadcast tape recorder is being displayed along with the industrial TV chain and 16 mm magnetic projector. Miniaturized equipment and transistors illustrate latest designs.—**Radio Corp. of America, Camden 2, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

Radar Beacon

Of particular interest to guided missile engineers, the new Model MP-2006 high performance S-band superheterodyne radar beacon is being exhibited. **Melpar, Inc., 452 Swann Ave., Alexandria, Va.**—TELE-TECH & ELECTRONIC INDUSTRIES

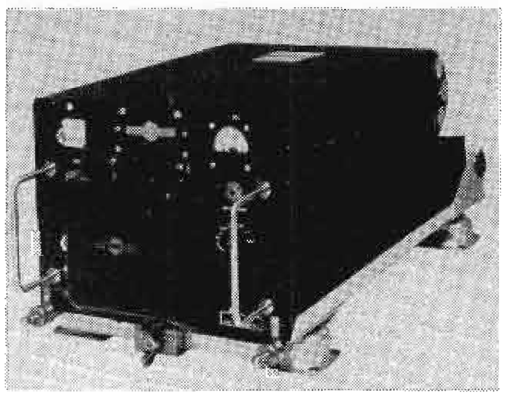
Junction Transistors and Rectifiers

Hermetically-sealed junction transmitter, part of subminiature radio transmitter, is submerged in boiling water to show efficient operation under adverse temperature and humidity conditions (1). Diffused junction rectifier Type 1N94 (r) handles 130 v. RMS input, 380 v. peak inverse, 1.57 amp peak forward, 500 ma dc output, at 50 KC. Also

on display are Types 1N91, 1N92 and 1N93. —**General Electric Co., Syracuse, N. Y.**— TELE-TECH & ELECTRONIC INDUSTRIES

VHF Aircraft Transmitter

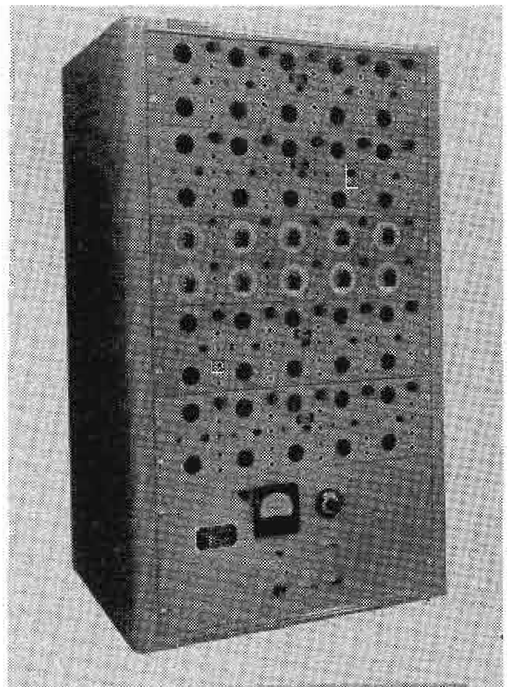
Covering the frequency range 118-135.95 MC, the Model 17M VHF aircraft transmitter provides 360 channels, phone transmission. Power output is 50 watts, and the power source is 27.5 v. dc. Frequency stability is

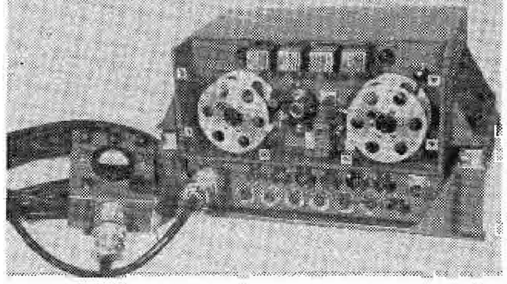


0.005% in ambient temperature -40° to 70°C. Weight with shockmount is 43.4 lbs. Also shown are the 51R-3 navigation receiver, 51V-2 glide slope receiver, omni-range test equipment, and the 618S-1 airline transceiver.—**Collins Radio Co., Cedar Rapids, Iowa.**—TELE-TECH & ELECTRONIC INDUSTRIES

Computer and Recorder

The analog simulator and computer, ANSER, consists basically of four amplifier chassis, each containing five operational amplifiers, 10 coefficient potentiometers and a power supply (top). Simplicity of design brings about low cost and easy operation, although it can handle simultaneous differential equations up to the 12th order. Amplifier gain is over 10,000; phase shift at 10 KC is about 1°; drift after 30-min. warm-up is less than 5 mv/hr.; and input imped-





ance is 50,000 ohms or greater. Input power requirements are 105-125 v., 60 CPS, 300 watts. Basic computer sells for under $2000. Also being shown is the Model 502 magnetic playback system, which is used in aircraft vibration studies with the 501 tape recorder (bottom) which records 14 channels on a 1.75-in. tape.—**Davies Labs., Inc., 4705 Queensbury Rd., Riverdale, Md.**—TELE-TECH & ELECTRONIC INDUSTRIES

TV and 3-D Featured at SMPTE Meet

The 73rd semi-annual convention of the Society of Motion Picture and Television Engineers is being held at the Hotel Statler in Los Angeles, April 27 through May 1, 1953. Partly because of the growing interest in three-dimensional movies (see page 66 in this issue), a record attendance is expected. TV and stereophonic sound are also an important focus of attention.

Listed below is the technical program for the five-day meeting.

Monday, April 27

Stereophonic Sound Session

Basic Principles of Stereophonic Sound Recording, Dr. Harvey Fletcher, Brigham Young University, Provo, Utah.

Demonstration of Stereophonic Sound, Ross Snyder, Ampex Electric Corp., Redwood City, Calif.

Stereoscopic Motion Picture Session

Human Vision and 3-D Motion Pictures, R. A. Sherman, Bausch & Lomb Optical Co., Rochester, N. Y.

Descriptions of current stereo production techniques by Paramount Pictures Corp., Warner Bros. Pictures, M-G-M Studios and RKO Radio Pictures. These talks will be illustrated with demonstration film.

Tuesday, April 28

Television Session, CBS Television City

Increasing the Efficiencyof Television Station Film Operations, R. A. Isberg, Consulting Television Engineer, Palo Alto, Calif.

Low-Cost Versatile Kinerecording Camera, John H. Battison, National Radio Institute, Washington, D. C.

Description and Tour of the CBS Television City Studios, Richard O'Brien and Les Bowman, CBS Television, New York & Hollywood.

Symposium on Stereoscopic Motion Pictures

A Slide Demonstration of Stereoscopic Principles, Motion Picture Research Council, Hollywood, Calif.

Stereoscopic Motion Pictures Committee Report, John A. Norling, Committee Chairman

Stereo Camera Design Problems, John A. Norling, Loucks and Norling Studios, New York

Space Control and the Use of the Stereo Window, Raymond J. Spottiswoode, Stereo

(*Continued on page* 128)

i-m-f* Outmodes all others

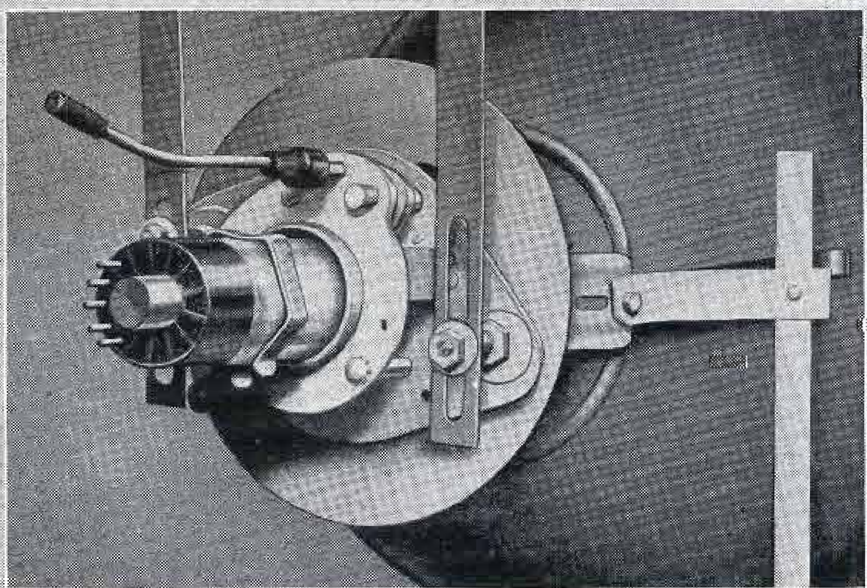
PICTURE TUBE

***with Internal Magnetic Focus**

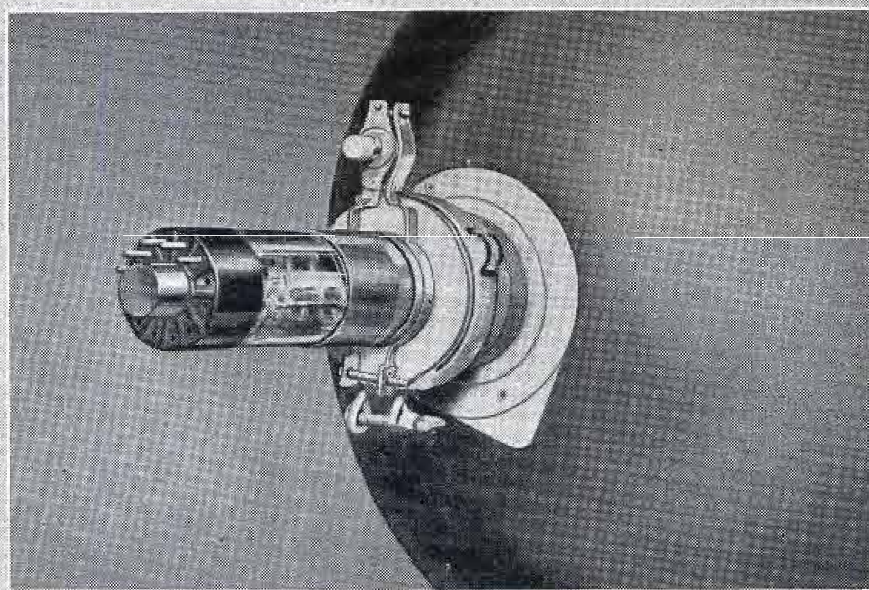
75 YEARS OF ELECTRICAL PROGRESS

- **Saves parts, circuitry, labor in set manufacture!**
- **Gives needle-sharp over-all image!**
- **Permanently pre-focussed for best viewing!**

COMPARE (left) the bulky parts needed for a standard tube with (right) the clean simplicity of an *i-m-f* tube ready to install!



The external ion-trap magnet on this standard tube, is an extra cost item for the TV manufacturer and requires special adjustment. The focus coil and complicated mounting also mean extra cost. They take up space, add weight, consume assembly and adjustment time. Get rid of all three parts with G. E.'s new *i-m-f* tube!



Now, no hard-to-adjust external ion-trap magnet! No focus coil, or external focus magnet, with cumbersome bracket! Instead, an *i-m-f* tube calls for just two parts when installed, both of them compact: (1) a close-fitting steel shunt band that is easily slipped on and (2) a small centering device to position the picture.

ON this 75th anniversary year, General Electric takes pride in announcing its *i-m-f* picture tube as the latest in a long series of significant G-E "firsts". To the many advantages given by internal, factory-adjusted ion-trap and focus magnets, can be added radically improved design in important tube details. One example of this is the new, precision-made metal "lens" that greatly narrows the electron beam, assuring clean, sharp picture definition over the entire TV screen area. Now 90°-sweep tubes can have good detail across the whole face! You can expect production soon in 21" size. Other *i-m-f* types will be added rapidly. Television manufacturers and television designers will be sent full information on request. *Tube Department, General Electric Company, Schenectady 5, New York.*

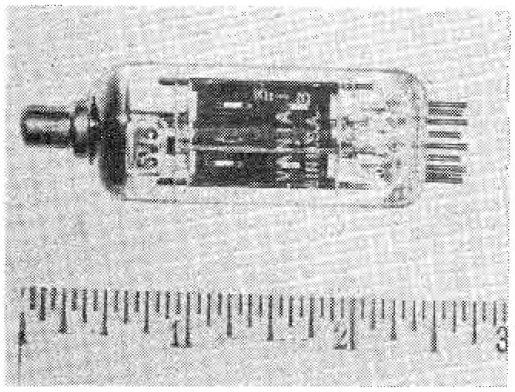
GENERAL ELECTRIC

162-1A2

NEW EQUIPMENT for Designers and Engineers

Damping Diode

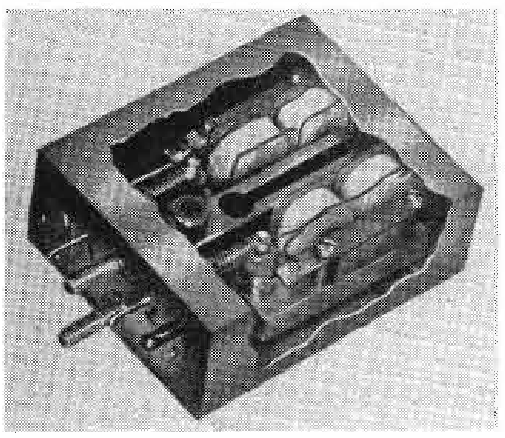
A miniature high voltage, half wave, cathode type rectifier, contained in a miniature T-6½ envelope, Type 6V3, is being



produced by the Radio Tube Division of Sylvania Electric Products Inc., Emporium, Pa. The unit has a coated unipotential cathode connected to the top cap and is designed for use as a damping diode in TV receivers. When used within its maximum ratings in new equipment applications, the Type 6V3 is capable of withstanding a peak inverse voltage of 6000 v. and a steady state peak current of 600 ma. Heater characteristics are: heater voltage, 6.3 v.; heater current, 1.75 amps. Ratings (absolute max. values) are: peak inverse voltage, 6000 v.; steady state peak current, 600 ma; heater-cathode voltage (heater negative), 750 v.; peak heater - cathode voltage, 6750 v.; dc output current, 135 ma. **—Radio Tube Div., Sylvania Electric Products, Inc., Emporium, Pa.**—TELE-TECH & ELECTRONIC INDUSTRIES

Tuning Fork Resonator

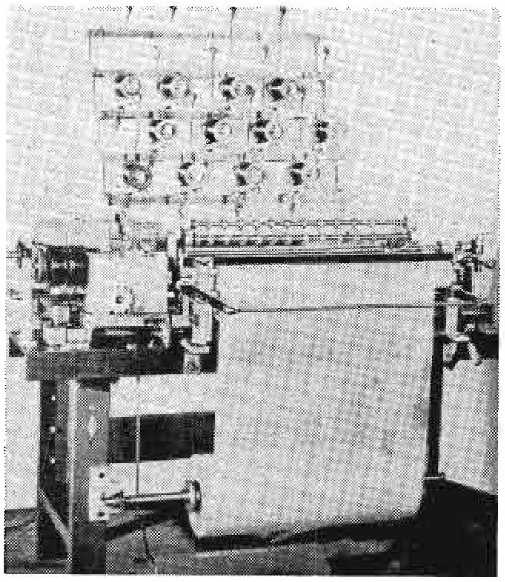
The new Model J miniaturized 8 oz. tuning fork resonator contained in a case only 1x2$\frac{3}{16}$x2$\frac{11}{16}$ in. high is available in any frequency



from 400 to 2,000 cps. The instrument has an accuracy rating of either 1 part in 10,000 or 1 part in 2,000 for operation from -40°C to +85°C. The unit is completely temperature-compensated, solder-sealed, and evacuated. Its silicone rubber internal and external mountings provide excellent shock and vibration isolation. The high effective working Q, approx. 10,000, assures generation of accurate fixed audio frequencies.**—Philamon Laboratories Inc., 5717 Third Ave., Brooklyn 20, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Transformer Winder

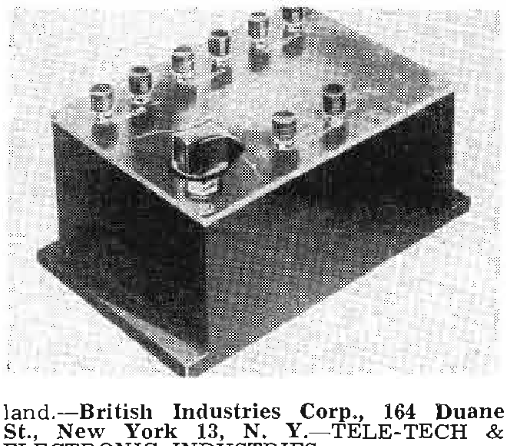
An improved multiple transformer winder, model 37-SA, with a positive stopping magnetic clutch-brake and automatic resetting counter eliminates coil rejection by winding accurately to turns and stopping automatically. Braking power is increased or decreased by turning a dial. Turns are added or taken off the coil by a current-releasing switch. There are no brushes or collector rings to wear out. The equipment multiple-winds paper section, power, audio, fluorescent ballast and types of transformer coils; also, bobbin coils. Coil sizes are up to 6 in. long and to 9 in. o.d. On rectangular coils there is a 4½ in. clearance. A winding traverse up to 8 in. can be supplied on special order. Mandrels up to 28 in. long can be used. Twelve tensions with rack support wire gauges 18 to 42 and spools up to 6 in. in dia. Tension for wire gauges 36 to 46 is available. Winding speeds up to 2000 r.p.m. Winding ranges are from 10 to 500 turns/m. Winding length is determined by reversing mechanism. ½ H.P. 115/230 v. 60 cps single phase uniform tongue motor operates the unit. Speed varies from 0-2000 r.p.m. Job change-over takes 30 minutes. Wire size change or spacing requires 5-10 minutes. A turns/in. gear chart is furnished. Accurate coil cutting is assured by manually operated marking knives mounted on the machine. Rigidity and permanent alignment is assured by a precision-ground, heavy steel channel base. The roll paper feed (illustrated) is available at slight extra cost. A tilting table for pre-cut paper is supplied. A spiral attachment with $\frac{3}{32}$



in., ⅛ in. or $\frac{3}{16}$ in. spacing is available at extra cost for space winding start and finish layers of high voltage coils. This attachment speeds up coil tapping. The machine is shipped bench-mounted.**—Geo. M. Stevens Mfg. Co., Inc., Pulaski Rd. at Peterson, Chicago 30, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

Three-Way Crossover Network

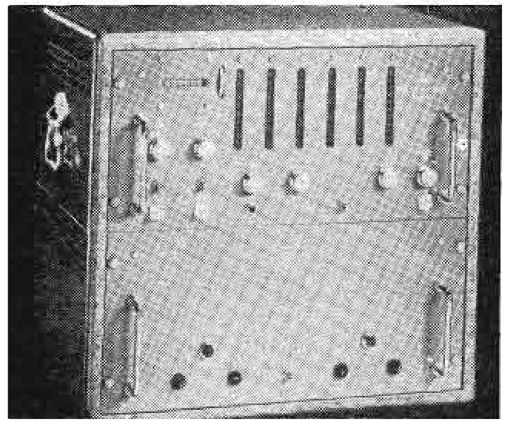
A new three-way crossover network, Model HS/CR/3, is designed of three-speaker sound systems, and its purpose is to divide and separate frequencies between the low end (woofer), mid-range speaker, and high-end (tweeter). The network requires that three loud speakers be similar in sensitivity and that the middle speaker be 8 in. - 10 in. dia., and the treble speaker 5 in. - 8 in. dia., or a small, horn-loaded pressure unit. The crossover points are at 800 and 5,000 cps; and the network is of constant resistance, half-section construction. Max. input is 30 w. Fitted with a volume control across the high-end output terminals, the unit is able to suit upper frequencies to the listeners' individual tastes or to cope with scratch from old records. It can be used as a two-way crossover by ignoring the treble terminal. As the box is wax-filled to keep out moisture, it is suitable for tropical use. The new three-way network unit is built in Eng-



land.**—British Industries Corp., 164 Duane St., New York 13, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Time Interval Meter

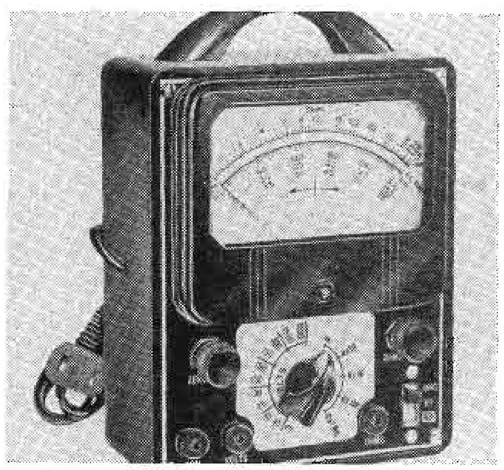
The Model 5120 time interval meter provides a direct reading of elapsed time between any two events, in 1μsec increments,



to a max. of 1 sec. with an accuracy of +1μsec, +xtal drift. Any occurrence that can be translated into changing voltages may be so timed and timing may be started and stopped by independent voltages. The unit may be started and stopped by either positive or negative pulses by means of polarity selecting toggle sw. Attenuators permit selection of amplitude of start and stop voltages at optimum level for elimination of interference. Power is available from the "accessory socket" to operate various transducers. The time that digital reading is displayed can be controlled either manually or automatically up to a max. of 5 sec. The unit consists of a megc xtal osc, input circuits, an electronic gate, and six Berkeley decimal counting units. The first event or voltage opens the electronic gate and passes the 1 megc time base signal to the first cascaded decimal counting unit. The second event closes gate and the time interval between the two is then displayed in decimal form in increments of 1μsec. Interpolation is unnecessary as the total number is read directly. Each digit of that number is indicated by the illumination of a single figure on each decimal counting unit.**—Berkeley Scientific Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Voltmeter

Model 940 vacuum tube voltmeter has a frequency response of 25 to 100,000 cycles at peak to peak or RMS voltages. Circuit



overload is prevented by high input resistance of 16.5 megohms, ac voltage ranges are 3, 15, 30, 150, 300, and 1,500 v. dc voltage ranges are 3, 15, 30, 150, 300, 1,500 v. Resistance ranges are from 0-1,000, 10,000, 1 megohm, 10 megohms, 1,000 megohm. Included decibel ranges are from -24 to -1.5, -8, -15, +12 to +35, +21.5 to +44.5, +32 to +55 db. Model 940 utilizes a dual triode balanced bridge circuit, and has a center position for discriminator alignment. The unit has a durable 4½ in. 350 microamp. D'Arsonoval type meter and is housed in a round cornered bakelite case that measures 5¼x6⅞x2¼ in.**—Elliott Labs., 50-34 201 St., Bayside, L. I., N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

News of MANUFACTURERS' REPS

United Technical Laboratories, Morristown, N. J. has appointed two new sales representatives for North and South Carolina, Tennessee, Georgia, Alabama, Mississippi and Florida. They are John T. Butters, 4924 Oleander Drive, Wilmington, N. C. and Harry A. Cole, Box 852, Jacksonville, Fla.

R. T. Bozak Co., Manhattan-Pacific Bldg., Stamford, Conn., manufacturers of loudspeakers, and **Sound Workshop**, 75 N. 11 St., Brooklyn, N. Y., producers of packaged sound and radio systems, have appointed Frederick I. Kantor as exclusive representative in the metropolitan New York-New Jersey area. Mr. Kantor's offices are located at 4010 Saxon Ave., New York 63, N. Y.

Robert Sargent and Paul Nichols of Land-C-Air Sales Co., manufacturers representatives, Tuckahoe, N. Y. have increased their sales engineering staff to six men by the addition of Lew Forrest who will cover the state of New Jersey.

Gerber Sales Co., manufacturers' representatives with headquarters in Boston and a New Haven branch office, announce another appointment to their growing staff, James Murray, in their coverage of industrial and jobber accounts in the New England area.

Bittan-Shafer Sales Co., New York, national sales representatives for the Short-O-Matic circuit breaker made by Aldane Industries, have appointed the following representatives: J. W. Lehner Co., Columbus, Ohio, for Kentucky, Ohio, West Virginia and western Pennsylvania; Henry W. Burwell Co., Atlanta, Ga., for the Carolinas, Florida, Georgia, Alabama, Mississippi and Tennessee; Jack Jacobs, Brooklyn, N. Y., for eastern Pennsylvania, southern New Jersey, Delaware, Maryland and Washington, D. C.; Dick Hyde Co., Denver, for Colorado, Montana, eastern Idaho, Wyoming, western Nebraska, Utah, Arizona and New Mexico.

SAFTLER RECEIVES AWARD

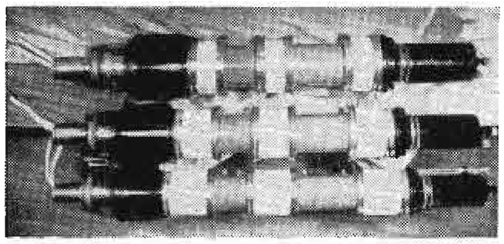
Perry Saftler, well known N.Y. Rep., receiving gold watch for 20 years of service in personally arranging Industry's yearly radio & TV special train to May Parts Show in Chicago. (l to r) Special committee making presentation include M. Berns, H. Finkelstein, (Saftler), and D. Wagman

Klystrons

The cascade type Eimac 3K20,000L 5kw clystrons for UHF-TV transmitters come in a series of three that will cover the entire UHF TV spectrum from 470 to 890 MC as follows:

Type No.	Frequency Range	UHF Channels
3K20,000LA	470-580 MC	14-32
3K20,000LF	580-720 MC	33-55
3K20,000LK	720-890 MC	56-83

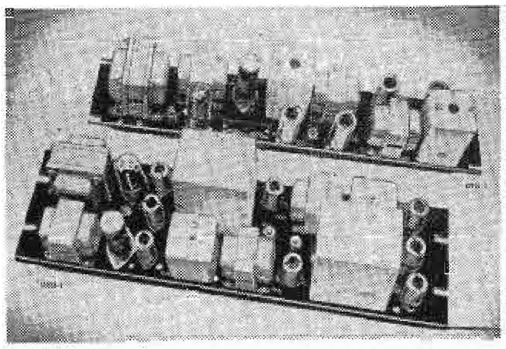
The size, weight (45 lbs.), and versatility of these practical klystrons minimize stockpiling, mass production, and equipment design. Typically these units operate at a peak sync power output of 515 kw with a power gain of 20 to 25 db and collector dissipation



of 14 kw. All types have low-loss, externally tuned ceramic cavities and metal-to-ceramic seals. Cavities are readily cooled by a small amount of forced air; the balance of the tube is water-cooled.—**Eitel-McCullough, Inc., Application Engineering Dept., San Bruno, Calif.**—TELE-TECH & ELECTRONIC INDUSTRIES

Single Direction Service

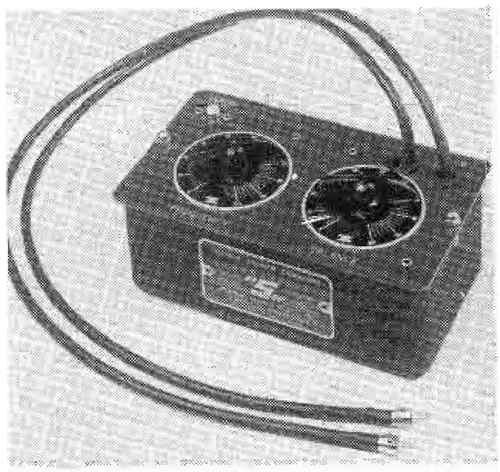
Separate transmitters and receivers to provide maximum design flexibility for signaling, dialing, slow speed telemetering, or supervisory control are in production. Two independent operations may be transmitted in one direction by one dual transmitter unit DTU-1 and one dual receiver unit DRU-1 over wire lines, telephone or power line carrier and radio or microwave communications circuits. The equipment includes the same basic features as the duplex signaling unit, except that operations may be carried on in one direction only. Each unit has its own power supply. The DTU-1 incorporates a pair of transmitters, each consisting of a



stable tone generator and an amplifier designed to bridge across a 600-ohm circuit, mounted on a 3½ in. standard relay rack panel. Harmonic distortion is negligible, frequency stability is excellent, and a total of 36 frequency channels are available between 2000 and 6475 cycles. The DRU-1 incorporates a pair of receivers, each consisting of two stages of amplification, a signal rectifier, relay tube and relay, and a sharply selective band-pass filter unit, mounted on a 5¼ in. relay rack panel. Either a continuous or a keyed tone can be used and the units can be installed in multiple and with Hammarlund 2-way signaling units (DSU-2's) as installation requires.—**Hammarlund Mfg. Co., Inc., 460 W. 34 St., New York 1, N. Y.**—TELE-TECH & ELECTRONIC INDUSTRIES

Variable Speaker Crossover

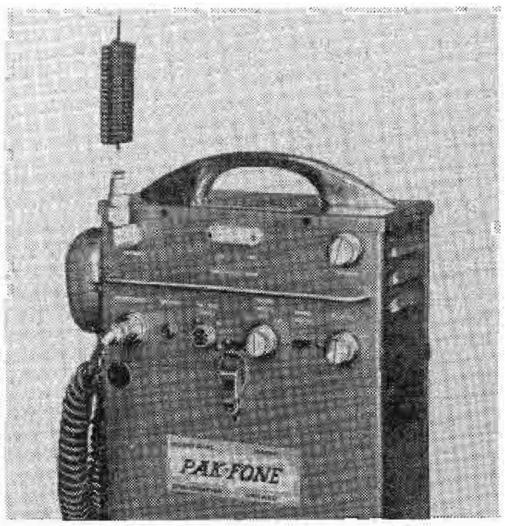
With the new type 214-X8 variable speaker crossover, speaker "woofers" and "tweeters" can operate under the best conditions of speaker damping, relative output balance, and without the undesirable effects of L-C crossover networks. The most important advantage is that speakers can be connected directly to the amplifiers with optimum damping and without interposition of resonant L-C networks. The type 214-X8 is entirely resistive-capacitive, hence, all effects of resonant under-damping are eliminated. This avoids L-C filter effects that are critical to terminating impedances from low source such as the outputs of the better amplifiers. The unit has two controls; one provides continuous adjustment of crossover frequency from 175 to 3000 cps; the other allows continuous adjustment of acoustical balance between "woofer" and "tweeter" to compensate for different speaker efficiencies. The 214-X8 is designed for use with the type 120-A



equalizer-preamplifier and two type 220-A power amplifiers produced by the manufacturer.—**Hermon Hosmer Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass.**—TELE-TECH & ELECTRONIC INDUSTRIES

Two-Way Radio

A portable 2-way radio packset for industrial, police, fire, utility and conservation department applications has recently been introduced to provide dependable 2-way radio telephone communication between other portable stations, mobile, or fixed stations. The completely self-powered "Pak-Fone" consists of a powerful 8 tube transmitter and a sensitive 15 tube receiver that conforms with FCC licensing regulations. Optional power supplies enable the packset to be used also as a mobile station with a 6 v. automobile battery as the power source or as a fixed station using 115 V.A.C. Special features prolong battery life. When on "stand-by," a relay type squelch shuts off the filaments of several tubes. An incoming signal automatically switches the tubes into operation. An on-off indicator light shows battery condition. The unit is shipped with a weather-resistant carrying case, microphone, crystals, antenna, and batteries as standard



equipment, and is designed to operate in either to 25 to 50 MC or the 152 to 174 MC bands.—**Industrial Radio Corp., 428 N. Parkside Ave., Chicago 44, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES.

Capacitor Molding Compound

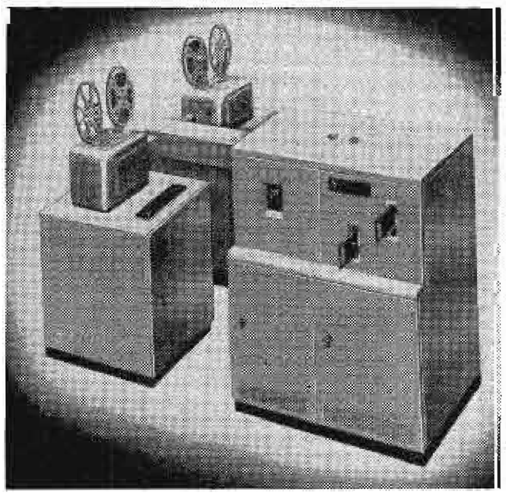
Humiditite, a new molding compound for capacitors has been developed for use where high moisture resistance is required. All Sangamo wire lead mica capacitors are now molded in Humiditite, and the new compound will be used in molded paper tubulars as soon as changes in company facilities are made. The standard moisture resistance test described in MIL-C-5A (Proposed) Specification requires mica capacitors to offer at least 100 megohms of insulation resistance after ten 24-hour cycles in a humidity chamber at 90% to 95% relative humidity. The new Humiditite micas tested in excess of 50,000 megohms of insulation resistance. Continued tests proved the smallest sizes to the largest able to withstand from 20 to 52 cycles before failure to measure 100 megohms. Engineering Bulletin TS-111 contains complete information—**Sangamo Electric Co., Capacitor Div., Marion, Ill.**—TELE-TECH & ELECTRONIC INDUSTRIES

NARTB DISPLAYS

(Continued from page 107)

TV Film Scanner

Combined film, opaque and slide pickup permits simple video switching from 16-mm movie to 4 x 5 in. print. In operation, small spot traces unmodulated raster of highlight intensity, which is directed to mirror which switches light to film or opaque pickup. For



film: Light passes through objective lens and is subsequently focused on film after passing through optical immobilizer which holds raster stationary on each frame of passing film. Light modulated by film falls on multiplier phototube, whose output is fed to gamma correction amplifier which corrects for optimum grey scale reproduction and adds blanking. It provides video from two identical signals, one for monitor, one for program. For opaque: When light from flying spot is switched by mirror to opaque, it passes through a semi-mirror, 50% going to opaque slide. Other 50% goes to another opaque. Two multiplier tubes pick up each opaque, the output going to the gamma amplifier as with film. Alternate system provides lapping and fading between two opaques. Film scanner is now ready for production.—**Allen B. DuMont Labs., Inc., Clifton, N. J.**—TELE-TECH & ELECTRONIC INDUSTRIES

AM Transmitters

Low intermodulation distortion is featured in Type 315 (5 kw) and Type 316 (10 kw) AM transmitters. Frequency stability is ± 5 cps; audio response within ± 1.5 db from 50 to 10,000 CPS; distortion less than 3% between 50 and 7500 CPS; and grid bias modulation is used. Dimensions of the 8000-lb. transmitters are 132 x 58 x 83 in. Also on display is the 250-watt Type 312 transmitter, which is well adapted for remote operation. Versatile remote control equipment is available.—**Continental Electronics Mfg. Co., 4212 S. Buckner Blvd., Dallas 10, Texas.**—TELE-TECH & ELECTRONIC INDUSTRIES

Other Products of Interest

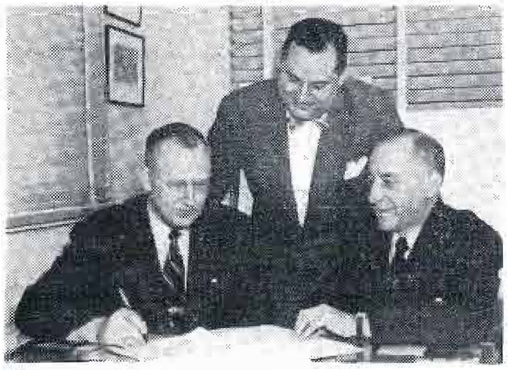
Andrew Corp., 363 E. 75 St., Chicago 19, Ill, features equipment for UHF-TV applications. Included are 3-⅛ in. and 6-⅛ in. coaxial transmission line, copper-clad steel waveguide and accessories.

Federal Telecommunication Labs., Nutley, N. J., an IT&T associate, is displaying a typical operating TV station. Among the products included are the microwave TV link, sync generator, picture monitors, Poly-Efex scanner, audio and control equipment. A new UHF antenna and UHF transmitter console are being shown.

Houston-Fearless Corp., 11801 W. Olympic Blvd., Los Angeles 64, Calif., is showing a new reversal film processing machine for TV. Other items of studio equipment is also being exhibited.

Standard Electronics Corp., 285 Emmet St., Newark 5, N. J., features the S-E 20 kw TV amplifier and a 1 kw UHF transmitter, incorporating "add-a-unit" design which permits installation without obsoleting initial equipment.

New Equipment for WOR



E. M. Johnson (l) WOR-TV vice president in charge of Station Relations and Engineers, signs contract for the purchase of Standard Electronics AM-FM and TV transmitting equipment. William Zillger, vice president of Standard Electronics and Charles Singer, chief engineer of WOR witness the signing. Standard Electronics Corp. is also providing WAFM-TV Birmingham, Ala., with Channel 13 20-kw amplifier.

Coming Events

May 11-13—IRE, National Conference on Airborne Electronics, Dayton Biltmore Hotel, Dayton, Ohio.

May 14-16—AFCA, 7th Annual Convention, Dayton, Ohio.

May 18-21—Electronic Parts Show, Conrad Hilton Hotel, Chicago, Ill.

May 24-28—SAMA, Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

May 27-29—ASQC, 7th Annual Convention, Convention Hall, Philadelphia, Pa.

June 9-11—2nd International Aviation Trade Show, Hotel Statler, New York, N. Y.

June 15-19—Exposition of Basic Materials for Industry, Grand Central Palace, New York, N. Y.

June 16-24—International Electro-Acoustics Congress, The Netherlands.

June 20-Oct. 11—German Communication and Transport Exhibition, Munich, Germany.

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

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

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

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.

AFCA: Armed Forces Communications Assoc.
APCO: Associated Police Communication Officers
AIEE: American Institute of Electrical Engineers
ASQC: American Society for Quality Control
IRE: Institute of Radio Engineers
ISA: Instrument Society of America
MPA: Metal Power Assoc.
NARTB: National Association Radio and Television Broadcasters
NEMA: National Electrical Manufacturers Assoc.
RDB: Research and Development Board
SAMA: Scientific Apparatus Makers Assoc.
SMPTE: Soc. of Motion Picture and TV Engineers

CUES for BROADCASTERS

(Continued from page 91)

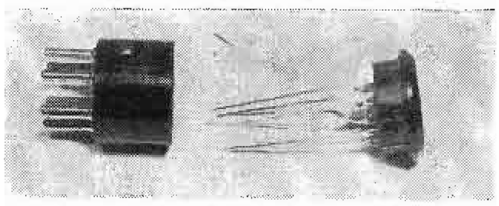
leaving the tape on the dc head and clearing all other mechanism. If tape is to be delayed for broadcast *be sure* to remove the tape from the dc head on the rewind!

Console Tube Conversion

ROLAND JORDAN, JR., Chief Engineer, WSBB, New Smyrna Beach, Fla.

LIKE many small radio stations we have a Western Electric 23C consolette. This unit uses type 1603 tubes and we have experienced considerable trouble with them. These cost $7.25 each so we decided to use a different type of tube.

The logical thought was to change tube sockets but these are spring mounted to minimize microphonics and it was decided that this feature should be retained, if possible, which left an adapter as the most practical



Noval tube socket made into adapter for console to enable use of different tube.

way to solve the problem. The new nine pin *Noval* adapter sockets for modernizing old equipment looked good and allowed the use of the new 5879 tube, developed especially for low-level audio input service.

When one of these sockets was obtained, it was found that it would not fit either the large size used for the 42 or the small size used for the 6C6 or 1603. In order to make the socket fit in the small base it was put in a metal working lathe and the bottom shoulder below the spring retaining groove turned down so that it would be a snug fit in the tube base.

This may sound like a delicate operation but it was much simpler than anticipated. Fig. 1 shows the socket with the turned down shoulder and with the wires attached, ready to be inserted into the tube base. The physical arrangement of the pins lends itself to easy wireing with only two of the wires having to be crossed. The others go directly from socket pin to tube base prong. As shown in Fig. 1 these two wires are insulated where they cross as well as the one that comes out through the side for the grid cap connection. The small hole for the grid lead should be drilled close to the bottom of the tube base wall, and between prongs four and five,

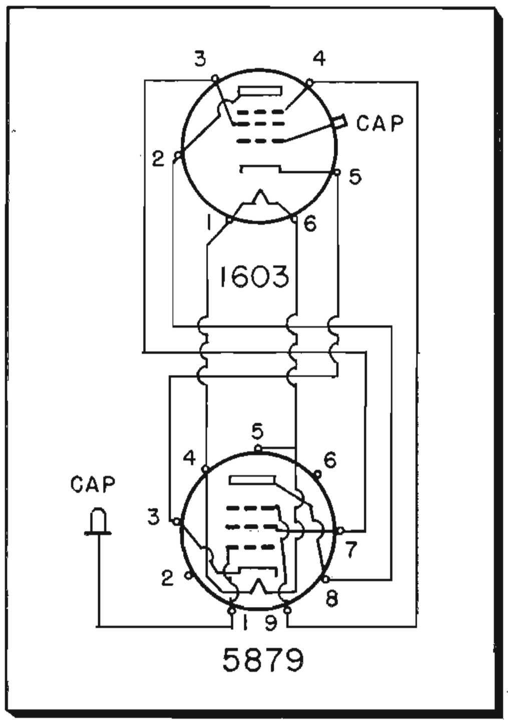
Appearance of 5879 tube mounted in adapter

since the socket goes well into the base.

After the leads have been pulled down through the prongs they should be checked for shorts and continuity before soldering. A few drops of cement around the upper edge of the tube base wall will secure the socket and remove any strain from the leads when the 5879 has to be removed from the socket.

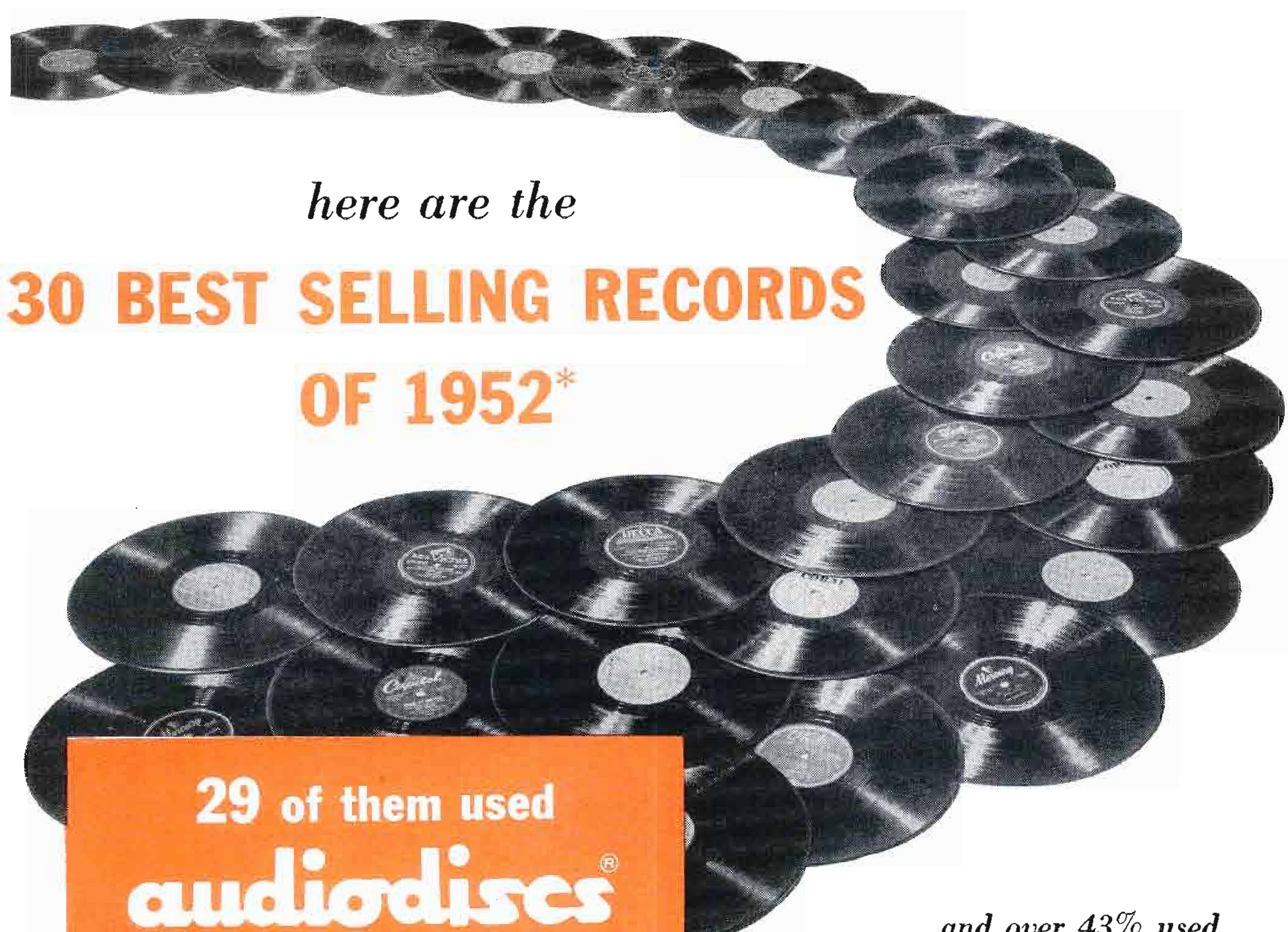
Fig. 2 shows the complete unit with the tube in place and the grid cap from a discarded tube soldered to the grid lead.

This adapter with the 5879 tube is directly interchangeable with the 1603 and has been in use in our con-



Conversion connections from type 1603 tube to type 5879 with top cap grid connection

sole for over three months now. Its use has brought about a marked reduction of hum and noise, as well as affecting a very considerable saving tube cost. Also, the unit is so small that the tube shield used with the 1603 is no longer necessary.



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.

444 MADISON AVE., NEW YORK 22, N. Y.
Export Dept.: 13 East 40th St., New York 16, N. Y., Cables "ARLAB"

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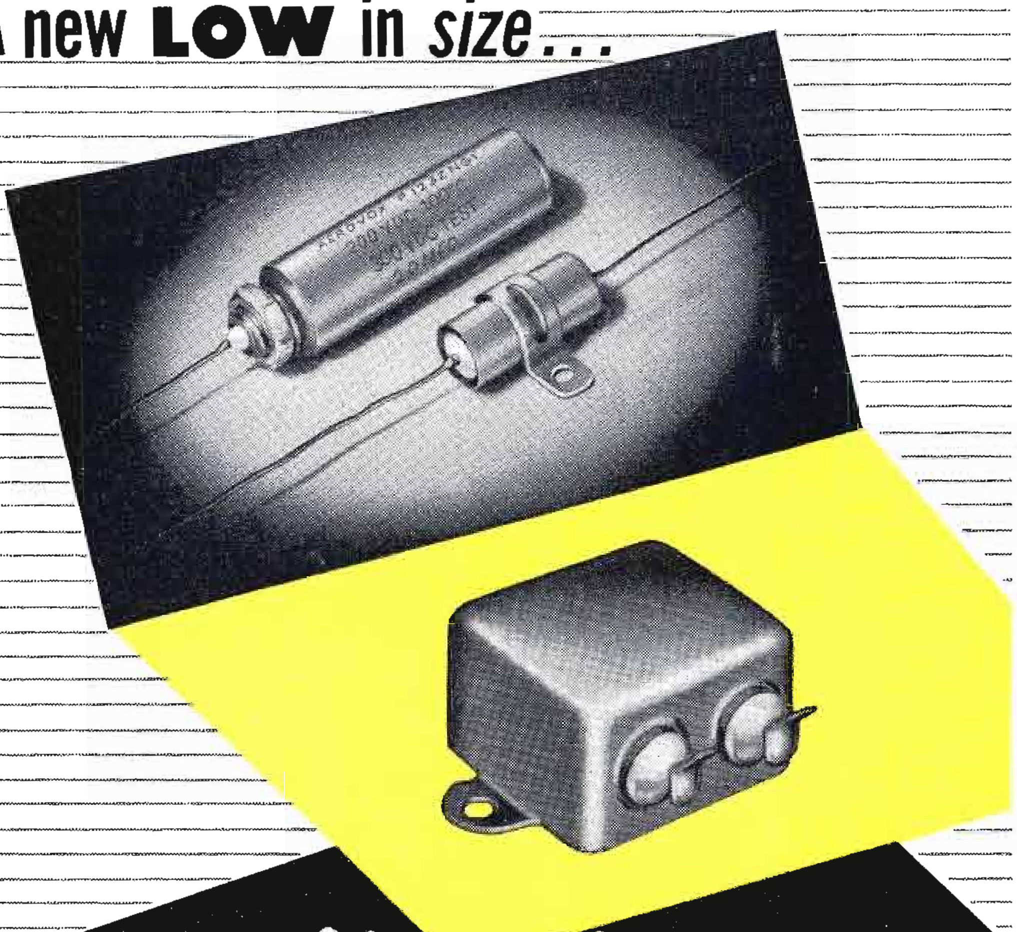

Smith Charts

(*Continued from page 87*)

exercise and as a tribute to the perseverance of the reader.

Double Stub Impedance Match

It may be inconvenient to change a stub position as in the single stub match, and so a double stub match in which the distance between two stubs is fixed but the stub lengths are variable, may be preferable. See Fig. 8.

An auxiliary circle must be drawn whose diameter is equal to that of the $g_1 = 1$ circle and whose location is such that it passes through the chart center and is tangent to the $g_1 = 0$ circle at a point determined by the spacing between the stubs. For zero spacing between stubs the point of tangency is at $\phi = .25$ on the scale "WAVE LENGTH TOWARD LOAD". As spacing increases, the point of tangency moves counter-clockwise. When the spacing is $\lambda/8$, the auxiliary circle diameter is horizontal and all circle values are positive. For a spacing of $\lambda/4$ the auxiliary circle diameter is vertical and coincides with the upper axis of reals. A spacing of $\lambda/8$ and $3/8\lambda$ are best for handling the greatest variety of impedance loads.

Length Adjustment

An interesting property of the auxiliary circle is that if the stub closest to the load is properly adjusted so that the input admittance is then caused to fall on the auxiliary circle, the impedance transformation caused by the length of line between stubs is such that at the second stub the per unit conductance value of the input admittance is unity. Proper length adjustment of the second stub will cancel out any susceptance present and once again as in the single stub match make the admittance into the network equal the characteristic line admittance.

1. Using the procedure of example 3, find y_{1s} (point 1) at the point where the first stub will be placed.

2. Holding g_{1s} constant, rotate along the g_{1s} circle until intersection with the auxiliary circle (point 2). In certain cases the g_{1s} circle will not intersect the auxiliary circle. This indicates a double stub match is not possible. In that case either the spacing between stubs θ_3, or the distance to the first stub, θ_1, will have to be changed. If y_{1s} is at a voltage max. a match will always be possible for the g_1 value will then be <1, and any g_1 circle of value less than 1 has a radius large enough so that it intersects any and all of the auxiliary circles.

3. The difference between the b_1

value at the intersection point and the b_1 value of step 1 indicates the necessary input susceptance and, therefore, length of the first stub. Note that the Γ radius of point (2) is not the same as that of point (1).

4. Using the Γ radius of point (2) rotate θ_3 wavelengths (distance between stubs) toward the generator. If there has been no mistake this new point (point 3) will fall on the $g_1 = 1$ circle. Note the per unit susceptance at this point.

5. As for the single stub match, choose the second stub length such that its input susceptance will be the negative of that found for point (3).

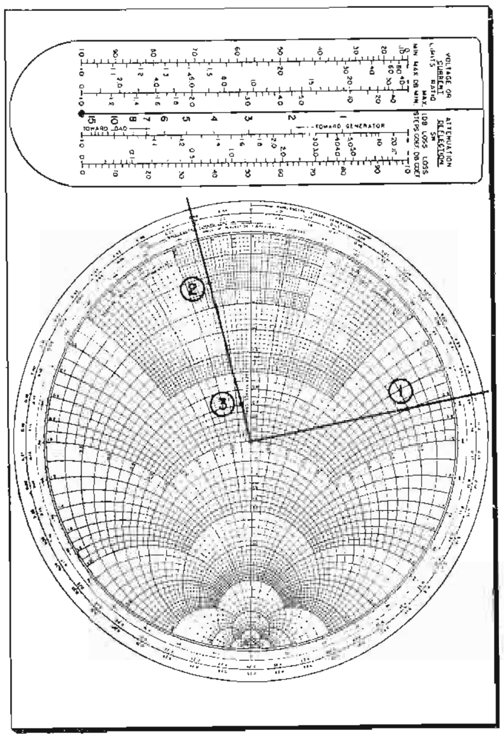

Fig. 10. Lines with attenuation

EXAMPLE 9: (See Fig. 9.) A 50 ohm line 220° long is terminated in an admittance of 0.015 — j0.025 mhs. A double stub match is to be designed, the stubs being λ/8 apart and short circuited, the first stub 220° from the load.

The per unit admittance 220° from Y_L is 0.27 — j0.286 from example 3.

Going along the $g_1 = 0.27$ circle we intersect the auxiliary $\theta_3 = \lambda/8$ circle at 0.27 + j0.318.

The necessary input susceptance for the first stub (θ_2) is j0.318 — (—j0.286) = + j0.604. Using the procedure of example 5 θ_2 is found to be 0.224λ + 0.25λ = 0.474λ.

Using the new Γ radius of point (2) (which is close to the Γ radius of point (1) (by coincidence) and with $\theta_2 = 0.0515$, rotate 0.125λ toward generator. Note that point (3) so determined is on the $g_1 = 1$ circle. The coordinates of point (3) are 1 + j1.51.

The second stub must then have a

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per unit input susceptance of − j1.51, which means it will have to be 0.343 − 0.25 = 0.093λ long.

LINES WITH ATTENUATION

All procedures are the same except that the Γ radius is not constant in length, but decreases on going toward the generator, and increases going toward the load. The amount of radius increase or decrease is given by the auxiliary scale "1 DB STEPS".

EXAMPLE 10. (See Fig. 10.) A load of 10 + j40 ohms terminates a 50 ohm line whose loss is 4 DB/meter. The line length is 1.537 meters. The wavelength is 10 cm. What is the input impedance, the standing wave ratio near the load and near the input end?

Enter the chart with $z_{1L} = \frac{10 + j40}{50}$ $= 0.2 + j0.8$

$\phi_1 = 0.1092\lambda$ and $\rho = 8.5$

With $\theta = \frac{153.7}{10} = 15.37\lambda$, subtract largest no. of half wave lengths and take $\theta = 0.37\lambda$. Then $\theta_2 = \phi_1 + \theta = 0.1092 + 0.37 = 0.4792\lambda$.

If there were no attenuation z_{1s} would be $0.12 - j0.13$. Due to attenuation the Γ radius must be decreased.

Unfortunately the "1 DB STEPS" scale is not numbered. Assigning the number 0 to the mark just under the scale designation, the marks are numbered out to 15 DB. Then the radius for z_{1L} comes to 1.15 DB.

With a length of 1.537 meters and 4 DB/meter, the total attenuation is (1.537) 4 = 6.15 DB, which comes to 1.15 + 6.15 = 7.3 DB on the scale. This shortens the radius very considerably. The new ρ becomes 1.46 and z_{1s} becomes $0.69 - j0.07$.

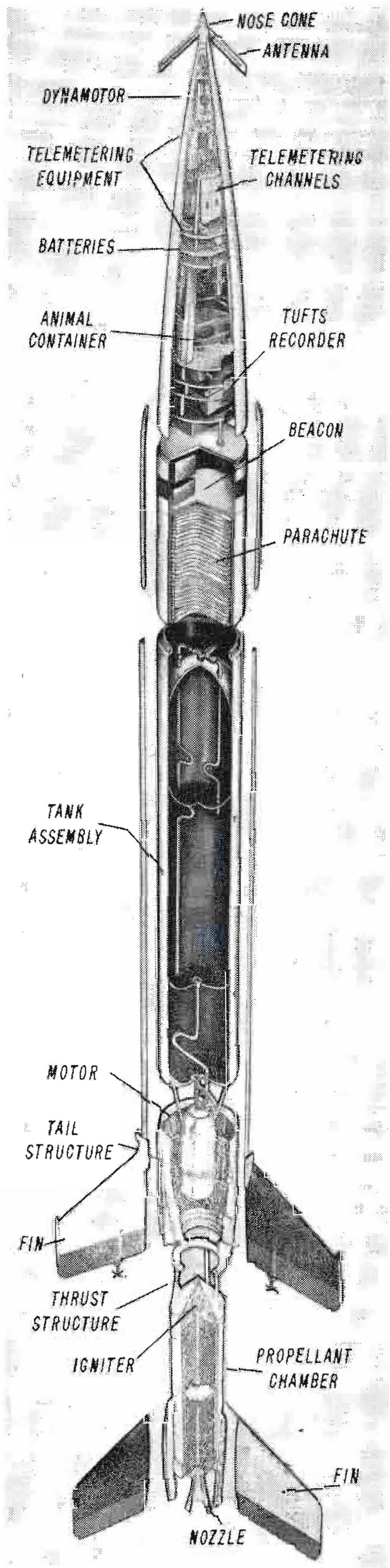
$Z_s = 50\ (0.69 - j0.07) = 34.5 + j3.5$

Waveguides may be handled just as transmission lines but with the caution that the characteristic impedance and phase wavelength must be determined for each frequency.

Antennas, filters, tuners, VHF tubes and magnetrons are among the circuit elements whose input impedances vary significantly with frequency. A graph of these input impedances on the Smith chart will often clarify the problem, which is usually that of keeping the standing wave ratio underneath certain limits.

Transistor Oscillator

Owing to a printer's error, the drift of the precision transistor oscillator, described on page 93 in the March issue of TELE-TECH & ELECTRONIC INDUSTRIES, was erroneously indicated as 3 parts in 109 per day. The correct figure is 3 parts in 10^9 (ten to the ninth) per day.



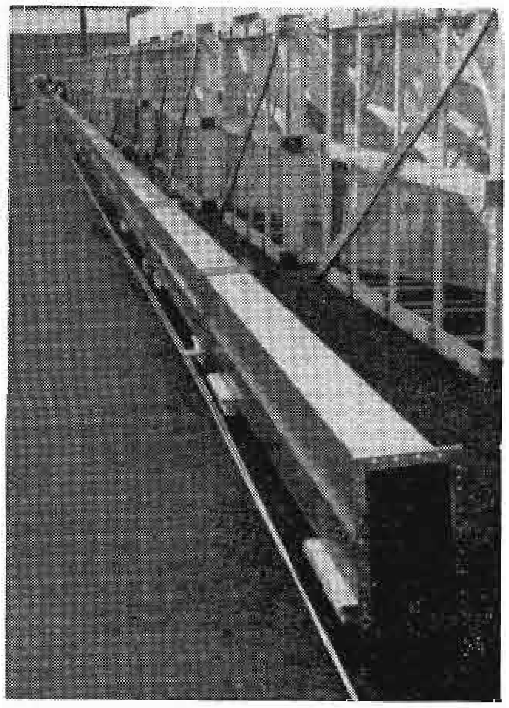
Cutaway view of Aero Jet Aerobee Sounding Rocket shows pressurized nose cone which carries animals and telemetering equipment into the upper atmosphere. During flight, data on physiological reactions are transmitted to ground station recorders. Important result is that animals were recovered in good condition, and were able to orient and control their bodies, indicating that a properly secured man in an aircraft can function normally during periods of zero gravity.

Waveguide and Coax Line Combinations for UHF-TV

The use of combinations of waveguide and coaxial line are dictated by considerations such as wind loading,

CHANNEL	14	49	83
FREQ. (MC.)	470	680	890
ATTENUATION (GUIDE & 3-1/8" COAX)	0.77	1.03	1.36
ATTENUATION (3-1/8" COAX)	1.16	1.78	2.25
ATTENUATION (WAVEGUIDE)	0.35	0.22	0.31
GUIDE SYSTEM VSWR	1.05 NOMINAL		

tower costs, and terrain conditions, as well as transmission line attenuation at UHF. The chart, furnished by Product Development Co., Kearny, N.J., lists nominal attenuation values of 3-1/8 in. coax and copper clad waveguide,



Series of waveguide sections being assembled

and measured attenuation of coax. It is a basis for comparison, considering a typical system about 540 ft. long. In the combination, 250 ft. are waveguide.

Tarzian Expands TV and Manufacturing Operations

Sarkes Tarzian, electronic manufacturer and founder-owner of WTTS and WTTV, Bloomington, Ind. was elected President of the Bloomington Chamber of Commerce early in April. The Armenian born, Pennsylvania-educated engineer now employs more than 2,000 people in his Bloomington plants and stations. Under construction now is a new 250,000 square foot tuner assembly plant in Bloomington with completion by mid-summer expected. WTTV will undergo more than a half million dollars of improvements this summer. Tower height will be increased to 1,000 feet, with ERP of 100 KW on Channel 4 instead of Channel 10.

STATION PLANNING

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as a master (or program) monitor. On its screen appears at all times the picture output of the control room. There is a space in this console for a panel containing pushbutton switches with lap-dissolve levers, signal lights, etc. The technical director uses these controls to select the picture for transmission. The second monitor is used as a "preview" monitor. The technical or program director uses a set of pushbuttons to select any of the camera input he proposes to use. This monitor may also be used to take visual "cue" from a preceding program.

Remote Signals

The average TV program consists of a succession of camera pick-ups, plus the occasional inclusion of signals from remote points or other studios. A simple example of the latter is the insertion, into the program, of a station identification slide or short picture sequence originating in the film projection room. Another is the occasional (although less frequent) insertion of outdoor scenes or sporting events picked up by field equipment and fed to the station by line or microwave relay. Thus, even though the major part of any one program will originate in one studio, with control of the program centered in its control room, some provision must be made for coordinated control of the remote signals, as well as control of the signals emanating from the projection room.

In almost any television station, it is desirable to be able to switch from local to remote and network signals in master control. A feature of the layouts described here is that remote and network signals as well as signals from other studios may also be brought into any of the camera switching systems by means of a video patch panel, thereby allowing control of all program source material within any studio control room.

Plan "A" is especially suited to the small TV Station involving minimum investment. Requirements for this class of operation include only the technical equipment necessary for handling the following programs: (1) network (2) local film programs from 16 mm projectors (3) local slide projection programs and (4) test pattern from a monoscope. The advertising or commercial function can be of either local or network origin.

Overall housing facilities of Plan "A" include Sales, Administrative, program offices and storage space, in addition to the space provided for the technical operation (see Fig. 2). Floor space for technical equipment is separated into: a combined transmitter and video control room, announce booth, film projection room, film editing and storage, engineering workshop and parts storage, and heating and ventilating.

Major items of the equipment required to perform programming operations consist essentially of a film camera chain, master monitor, two 16 mm film projectors, an automatic dual-disc slide projector, multiplexer, film editing equipment, monoscope camera, studio synchronizing generator, audio/video switching console, two stabilizing amplifiers, one turntable, microphones, transmitter, antenna, audio equipment and miscellaneous accessories such as rack mounted power supplies, etc. A block diagram illustrates the major equipments incorporated in Plan "A," and accompanying floor plans and "exact-scale" model photos show their approximate location. Video power supplies, distribution amplifier, stabilizing amplifiers, monitoring equipment, sync generator, audio equipment and test equipment are housed in five standard cabinet racks located near the console (See Fig. 4).

In Plan "A," the transmitter is located in the central control room at the right of audio/video control console. Transmitter test and monitoring equipment required to fulfill FCC requirements are mounted in equipment racks behind the control console. The "Filterplexer" (a combination sideband filter/diplexer) is ceiling-mounted to conserve floor space. Plan "A" indicates the use of a 1 or 2 KW transmitter. However, Broadcasters planning to increase to 10-KW later with "add-on" amplifiers may do so by moving the engineer's desk into another office, thus providing the extra space.

Plan "A" Centralized Console

Smooth and successful performance of this console is made possible to a large extent by the proper grouping of important controls to make them easily accessible to the operator. This is accomplished by using the audio/video switching console (which consists of two console sections) plus one film camera and one switchable master monitor also mounted in standard console sections. These four standard sections are arranged "in-line" to form the simple unified console of Plan "A." This console is coupled with a film camera control and forms the nucleus of a complete TV operation. The section at the extreme left of the console houses the film camera control unit. In the upper part of this console section is a master monitor which has a 10-in. picture tube and a 5-in. CRO tube. In the lower portion of the housing is the film camera control chassis. It supplies the blanking and driving signals to the film camera and reproduces a picture generated by the film camera. Controls for the adjustment of picture levels and shading are located on the sloping desk panel of this console section. The film camera control is located at the left end of the Console for convenience of operation. However, the unit may be removed from this position if desired, and placed at another location without disturbing the functions of the remainder of this switching console (See Fig. 4)

The audio and video switching equipment is composed of the two center sections of the operating console and provides audio and video controls and audio monitoring facilities.

The two center console sections comprise (left to right, see Figs. 1 and 5) 1. Audio control with combined Audio Video program switching. 2. Remote control section. On the sloping portion of the audio/video section (second from left) are located the program switching controls composed of one row of key switches for audio control, one row of pushbuttons for video control, a video clip-fader control and a tie-switch for combining audio and video switching, controlled from the video pushbuttons. The combined audio/video switching is obtained by using relays. This system provides for eight inputs of audio and eight of video with one output for each. Audio may be switched separately, if desired.

Plan "A" Audio Control

The audio portion provides for eight inputs to four mixer positions. Audio key switches provide means of selecting any input such as turntable, projector, studio, remote or network. The inputs are relay operated so they can be controlled by the video selector switch when desired, simplyfying the audio/video combination switching (actual circuits are kept apart thereby preventing crosstalk). The relays are also interlocked to prevent accidental doubling of the circuits. A selector switch allows a monitor amplifier and speaker to check most of the audio circuits including transmitter input and output, and

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turntable cueing. It is visualized that a separate cueing amplifier and speaker may be used in most applications.

One rack of equipment is needed in addition to the control panel. This houses the preamplifiers; program monitor, and limiting amplifiers; and power supplies. Jacks are provided for all amplifier inputs and outputs.

The video pushbuttons also provide a means of selecting any one of eight signals, such as film, studio, monoscope, remotes or network for transmission. In addition, by using the "lock-in" switch on the left side of the panel, certain audio and video signals may be switched simultaneously by means of the video pushbuttons. When switching from local to remote or network signal, contacts on the switches provide automatic removal of the local synchronizing signal.

On the right side of the switching panel is a remote "clip-fade" control. By means of this control, the signal may be faded to black, at which time an instantaneous switch may be made to a new signal, and then the new signal faded up, thus letting "roll over" occur during the black period, when switching from local to remote or network.

Remote Controls

The other section of the audio and video switching equipment (third from left) houses all the remote controls that are necessary to provide finger tip operation of those equipments necessary for simple basic programming.

The two top panels control the stabilizing amplifiers. One of these amplifiers is for network or remote signals and the second is for controlling any signal to the transmitter. The second stabilizing amplifier is also used for mixing the "sync" and local video signals, since some form of local signal is necessary for advertising purposes. The third panel in this section is the projector switching control. Three groups of pushbuttons and tally lights are located on this panel. The groups at either end composed of three buttons and a separate lamp are identical while one pushbutton and toggle switch are located in the center. The center toggle switch is for turning the power on and off a slide projector. The pushbutton directly under the switch has a tally light built in and may be used to switch slides in the slide projector.

The tally light at the top of the panel at either end indicates when control has been transferred from the film projector to this remote operating position. The pushbutton on the left of the group is used to start the projector and has a built-in tally light to indicate that the machine is running. The center button of the group with built-in tally light is for transferring sound and picture from one machine to the other, when two film projectors are used. The third button is for stopping the projector, and does not have a built-in light. Another group of buttons at the other end of the panel is identical and performs the same functions for a second projector.

Master Monitor

The fourth section at the extreme right-hand end of the console contains a Master Monitor, and on the sloping desk surface are located the pushbutton switches for monitor selection. Each switch is mechanically interlocked. Provision is made for twelve inputs and one output. This unit may be used to monitor all the necessary transmitter signals in addition to serving as a preview monitor for remotes and networks. In the normal operation, this monitor will register the line signal. The output of the switch is fed from a cathode follower, which receives its power from the master monitor associated with it. Located in the monitor switching panel, a pushbutton for chopper control is provided to select a calibrating signal for indicating percentage of picture modulation to the transmitter.

Film Projection Room

As shown in the layout photos and "A" floor plan, the film projection facilities include a film camera, two 16-mm projectors, a slide projector and a Utility Monitor.

Control of the projectors is extended by use of a projector control panel located at the centralized "transmitter room" console. Complete provision is made for station breaks and spots during network hours. Windows provide visibility into the transmitter control room and announce booth, in the event visual cue is desired. Pull drapes are shown so that "darkened room" operation may also be accomplished, since the operator at the central console has program switching control and complete film monitoring and talkback facilities.

Space is provided for a rewind bench and storage cabinet in the projection room. Since film programming will make up a large part of the station activity, space is provided for the future addition of a duplicate film projection setup. This would also require the addition of a second film camera control section to the main console in the transmitter room. Some planners may elect to start with a dual setup. Another possibility is the addition of a "Telop" projector and a second film camera for the handling of "opaques" and other program material mentioned later.

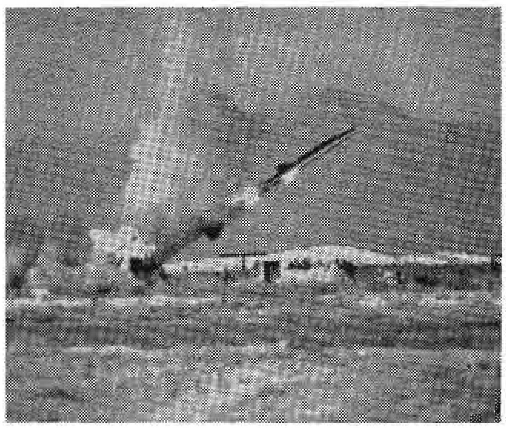
Film Editing & Storage

A separate room provides space for film accessory equipment to accommodate film handling, editing and storage needs. Some stations, because of expanded film programming, may find a need to enlarge these facilities. As previously mentioned, part of this equipment is installed in the film projection room for convenience in handling daily shows. Space requirements for handling film may vary; however, room should be provided for editing, splicing, rewinding, commercial insertion and storage for both "daily and upcoming" shows that are to be aired. The editing area will also be needed to accommodate last minute "hurry-up" changes so frequently encountered in the preparation of film for airing. (See Fig. 3)

Telemetering Conference

The annual National Telemetering Conference will be held on May 20th through 22nd at the Edgewater Beach Hotel in Chicago. Registration fee for W. H. Wickham, Registration Chairman the entire proceedings will be $3.00. may be reached at the Commonwealth Edison Company, 2233 S. Throop Street, Chicago, Ill. J. E. Hobson, Director of the Stanford Research Institute, will be the principal speaker at a banquet to be held on Wednesday evening, May 20th.

BOMBER-DEFENSE MISSILE



Boeing's "GAPA" supersonic research missile just after leaving launching rack at Alamogordo, N. M. Developed as a bomber defense vehicle under an Air Force sponsored project, "GAPA" was never placed into production. 1500 mph missile is now providing valuable research information in a new, advanced missile program

Triode RC

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tortion. The assumption is made that amplifier loading may be neglected if the amplifier load resistance, R_L, is less than 0.1 megohm. The problem is to pick the lowest plate supply voltage and a satisfactory amplifier load resistance, R_L, to provide the amplification with the distortion within the specified value.

One must select some supply voltage and load resistance as a starting point. One might choose, for example, a supply voltage of 250 volts and a load resistance of 25,000 ohms (Line A on Fig. 2). The amplification of the tube at zero bias with this supply voltage and load resistance is (Load line A)

$$VA = \frac{-0.0037 \times 25{,}000}{1 + 0.000105 \times 25{,}000} = \frac{-92.5}{5.125} = -18.04$$

Note that the transconductance and the plate conductance values are those estimated at zero bias on the load line. The amplification at a negative six volts bias is

$$VA = \frac{-0.0019 \times 25{,}000}{1 + 0.000105 \times 25{,}000} = \frac{-47.5}{3.625} = -13.1$$

The transconductance and plate conductance values in this case are for a negative six volts bias on the grid. The distortion then is

$$D = \frac{18.04 - 13.1}{18.04 + 13.1} \times 25 = \frac{4.96}{31.14} \times 25 = 3.95\%$$

The chosen design might prove satisfactory. It is too close, however, to accept. Consequently, one might try doubling the load resistance, leaving the plate supply voltage unchanged. The voltage amplification at zero bias now is (Load line B)

$$VA = \frac{-0.0031 \times 50{,}000}{1 + 0.00014 \times 50{,}000} = \frac{-155}{8} = -19.4$$

At a bias of negative six volts,

$$VA = \frac{-0.00145 \times 50{,}000}{1 + 0.00008 \times 50{,}000} = \frac{-72.5}{5} = -14.5$$

The percentage distortion is

$$D = \frac{19.4 - 14.5}{19.4 + 14.5} \times 25 = \frac{4.9}{33.9} \times 25 = 3.63\%$$

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adapting the bridge to N- or P-transistors, and even to vacuum tubes.

Combined with this supply circuit are the various ac circuits. First, we measure the voltage attenuation in the reverse direction by impressing an ac voltage upon the collector and by measuring the induced emitter voltage. In the circuit shown in Fig. 10 a, the induced emitter voltage is compensated by the voltage drop V'_x across the bridge wire so that the VTVM operates as a null indicator. The bridge wire is calibrated in values of $X = V_x/V'_x$ so that the voltage attenuation factor becomes $\mu_e = 1/X_e$.

The second step is the measurement of the voltage amplification factor μ_c at open collector circuit (Fig. 10 b). For this purpose, input and ouput voltages are interchanged. Balance occurs directly at $\mu_c = X_c$.

Both values immediately give the characteristic number

$$\delta = X_c/X_e$$

and the associated figure of merit.

$$K = \frac{1}{\frac{X_e}{X_c} - 1}.$$

If we compare the bridge circuitry with the conventional diagram for measuring the amplification factor of a vacuum tube, the only difference is the phase between input and output voltages. Consequently, a simple commutator adapts the transistor-bridge for the testing of vacuum tubes in which case the values of X change to X-1.

Finally, we measure the collector and emitter impedances in the same bridge circuit. First, the collector is loaded with the known loadresistor R''_c and the bridge is balanced for $X' < X_c$. The collector impedance then is

$$r_c = R_c'' \left(\frac{X_c}{X'} - 1 \right).$$

Second, a known preresistor R''_e is inserted into the emitter circuit. The new balance value X″ gives the emitter impedance at open collector circuit as

$$r_e' = \frac{R_e''}{\frac{X_e}{X''} - 1}.$$

This value must be reduced to a short-circuited collector by means of the formula

$$r_e = r_e'/1 + K.$$

More convenient is the balancing of the bridge with the aid of the variable resistors R''_c and R''_e after the bridge wire has been adjusted to $X_c/2$. This manual adjustment can be eliminated by an electrical half-reduction of the voltage attenuation across the bridge potentiometer. For this purpose, the bridge wire lies in series with a preresistor having the same resistance as the bridge potentiometer itself. Turning the main selector switch from its μ- into the r-positions automatically short-circuits the preresistor thus dividing the X-scale by the factor two. At the same time, this half-reduction is combined with different preresistors so as to provide a multiplication of the X-range.

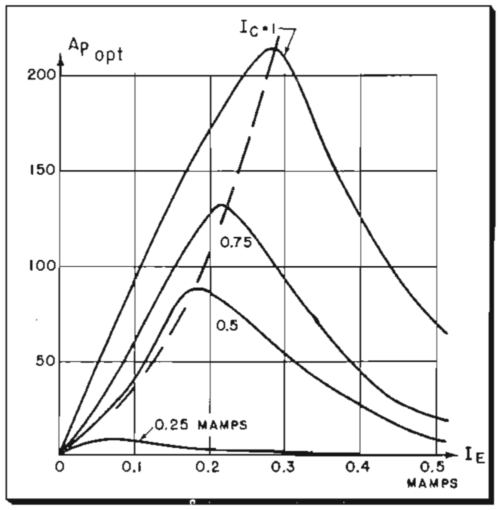


Fig. 12: Curves showing gain characteristics of a point contact transistor.

Experimental Model

Fig. 11 shows an experimental model of the transistor bridge including the supply and measuring devices. With the aid of such an equipment, a transistor can be tested very quickly and conveniently at the actual conditions of operation. Once the four parameters μ_e, μ_c, r_c, and r_e are measured at various pairs of operating currents, the maximum available power gain in the grounded-base connection can easily be evaluated. Fig. 12 illustrates a typical family of gain characteristics. First, it can be seen that a reasonable power gain requires a collector current larger than the emitter current. This prerequisite—with a grain of salt—may be visualized to be the analogue of the negative grid voltage of a vacuum tube. Second, any collector current requires an optimum emitter current and vice versa.

Since the transistor bridge permits the testing of transistors as well as vacuum tubes, the opposite method is applicable, namely the use of a vacuum tube bridge for the testing of transistors. For this purpose, a transistor adapter has been developed which, in combination with the General Radio vacuum-tube bridge 561-D, is the equivalent to the transistor bridge.

It may be interesting to disclose the relationship between the bridge parameters and the constant-current parameters utilized in the customary transistor analysis. In order to avoid confusion, the latter are written with asterisks. The conversion formulas are

$$r_e^* = (r_e - r_c\mu_e) \cdot (1 + K)$$
$$r_b^* = r_c\mu_e \cdot (1 + K)$$
$$r_c^* = r_c(1 - \mu_e) \cdot (1 + K)$$
$$\doteq r_c \cdot (1 + K)$$

$$r_m^* = (r_e\mu_c - r_c\mu_e) \cdot (1 + K)$$

$$\alpha = \mu_c \frac{r_e}{r_c}.$$

These formulas reveal the figure of merit to be the analogue of the quality factor of resonance circuits. The transistor conversion formulas similar to the formulas describing the conversion of series into parallel resonance circuits or from voltage into current resonance according to the principle of quality.

Simpler Equations

The developed terminology and philosophy of transistor circuits lead to simpler equations than those resulting from the constant-current parameters. This is illustrated by the following examples. In terms of constant-current analysis, the voltage amplification of a grounded-base transistor has the form

$$A_V = \frac{\alpha R_L}{r_e^* + r_b^*(1 - \alpha) + \frac{r_e^* + r_b^*}{r_c^* + r_b^*} R_L}$$

The introduction of the conversion formulas changes this complicated expression into the much simpler equation

$$A_V = \frac{\mu_c}{1 + \frac{r_c}{R_L}}.$$

A better illustration is the formula for the maximum available power gain

$$A_{P_{max}}^* = \alpha^2 \times \frac{r_c^* + r_b^*}{r_e^* + r_b^*} \times \frac{1}{\left[1 + \sqrt{\frac{r_e^* + r_b^*(1 - \alpha)}{r_e^* + r_b^*}}\right]^2}$$

which, in terms of the bridge parameters, assumes the form

$$A_{P_{max}} = \alpha\, \mu_c\, F(K) \cdot$$

In the same manner, the optimum load resistor

$$R_{L_{opt}}{}^* = (r_e{}^* + r_b{}^*)\sqrt{\frac{r_e{}^* + r_b{}^*(1-\alpha)}{r_e{}^* + r_b{}^*}}$$

simplifies into

$$R_{L_{opt}} = r_e\sqrt{1+K}$$

and the associated input impedance

$$R_{IN_{opt}}{}^* = r_e{}^* + r_b{}^*$$

$$\times\left[1 - \frac{\alpha}{1 + \frac{r_e{}^* + r_b{}^*}{r_e{}^* + r_b{}^*}\sqrt{1 - \frac{\alpha}{1+\frac{r_e{}^*}{r_b{}^*}}}}\right]$$

into

$$R_{IN_{opt}} = r_e\sqrt{1+K}.$$

Although it is a matter of taste and convenience whether we prefer the constant-voltage or constant-current analysis and expressions, the simplification leads to a simpler tester and an easier understanding of the entire circuitry of transistors.

Remington Rand Announces New Computer

"ERA 1103," produced by Engineering Research Associates Division of Remington Rand Inc. is a "general purpose" digital computer system intended primarily for scientific, mathematical, and control applications.

Developed originally for the United States government, the equipment provides storage capacity up to 17,408 superspeed registers plus unlimited supplementary magnetic tape bulk storage, high operating speed (60 micro-seconds per unit of addition) and wide programming versatility. First commercial models are available for delivery in 1954.

Among the outstanding potential applications of this new computer in addition to automatic process control are: air traffic control and air defense, aircraft simulation, automatic data reduction, general industrial and economic planning, and scientific-mathematical computation.

More than 4500 vacuum tubes are employed by the equipment which is housed in six cabinets measuring approximately 54 ft. in length and 20 ft. wide. It weighs approximately ten tons. The machine is completely sectionalized electronically and relies on programmed checking for reliability. Marginal checking as a preventative maintenance measure is also employed. Here the filament voltages are reduced from 6.3 to 5 volts and the machine is required to operate with 100% accuracy. Using this type of checking, the 1101, forerunner to the 1103, was found to have 87.5% good operating time, 2.5% unscheduled maintenance, and 10% scheduled maintenance.

TRIODE RC

(*Continued from page* 123)

This set of data appears to give the desired design. A check with a reduced supply voltage (200 volts) might be made to indicate the reliability of the circuit. The amplification at zero bias is (Load line C)

$$VA = \frac{-0.00295 \times 50{,}000}{1 + 0.000132 \times 50{,}000}$$
$$= \frac{-147.5}{7.6} = -19.42$$

For a negative six volt bias, the amplification is

$$VA = \frac{-0.001 \times 50{,}000}{1 + 0.000062 \times 50{,}000}$$
$$= \frac{-50}{4.1} = -12.2$$

The percentage distortion is

$$D = \frac{(19.4 - 12.2)\ 25}{19.4 + 12.2}$$
$$= \frac{7.2}{31.6} \times 25 = 5.7\%$$

The effect of reduced supply voltage evidently is to make the stage marginal. The average gain at normal supply voltage, 16.9, is a marginal value. A similar check at increased supply voltage (275 volts) gives the following results. At zero bias, the amplification is (Load line D)

$$VA = \frac{-.0033 \times 50{,}000}{1 + .000145 \times 50{,}000}$$
$$= \frac{-165}{8.15} = -20.0$$

At negative six volts bias, the amplification is

$$VA = \frac{-0.00155 \times 50{,}000}{1 + 0.000087 \times 50{,}000}$$
$$= \frac{-77.5}{5.35} = -14.5$$

The distortion is

$$D = \frac{20.0 - 14.5}{20.0 + 14.5} \times 25$$
$$= \frac{5.4}{34.5}\ 25 = 3.9\%$$

Average amplification is 17.2, a value which may be adequate.

As can be seen, the distortion is marginal and the amplification is marginal using a fifty thousand ohm load resistance. The easiest way to improve operation of the stage sufficiently that it is not marginal is to increase the load resistance. An increase to 62,500 ohms, with a 250 volt supply gives an average amplification of 17.4 and a distortion of about three percent.

When a set of tube operating conditions meeting the basic amplification and distortion requirements is found, variation of the B supply voltage will indicate how critical the circuit. The greater the reliability required, the wider the range of plate voltage variation which must provide operation of the circuit within the prescribed limits. The effect of tube tolerances, although better determined by a set of typical curves representing tubes near the upper limits, mean or bogie, and lower limits, can

IBM Installs New Computer

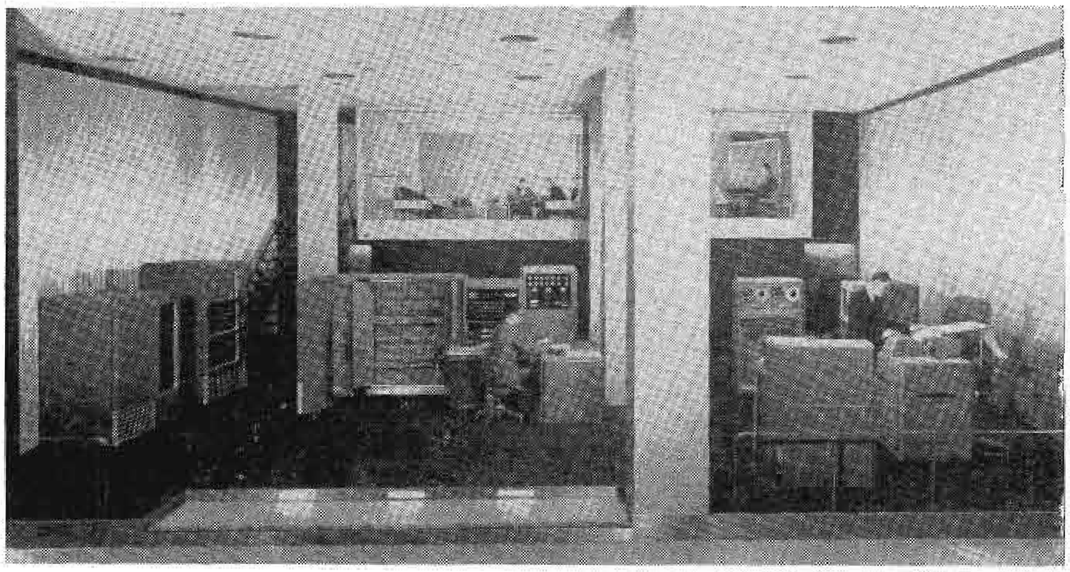
Installation of the first production model of International Business Machines' newest and most powerful high-speed electronic calculator, the "701," has been made at the company's World Headquarters, 590 Madison Avenue, New York City. The "701" is composed of eleven compact and connected units. About a dozen of these equipments will be built this year, all consigned to government agencies or defense industries.

The equipment is capable of performing more than 16,000 addition or subtraction operations a second, and more than 2,000 multiplication or division operations a second. In solving a typical problem, 14,000 mathematical operations a second are performed.

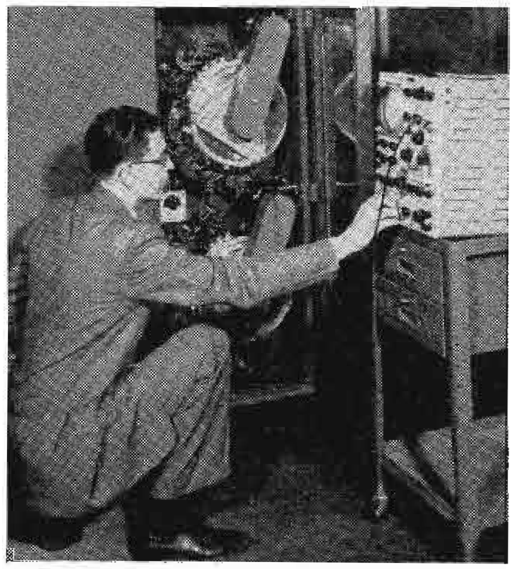
The calculators, which will rent for $11,900 monthly or more, depending upon storage capacity, will be used for the calculation of radiation effects in atomic energy; for aerodynamic computations for planes and guided missiles, including vibration and stress analysis, design and performance computations for jet and rocket engines, propellers, landing gear, radomes, etc.; on studies related to the effectiveness of various weapons, and on steam and gas turbine design calculations. A company which has pioneered the use of high-speed digital computers for cost accounting with the IBM Card-Programmed Electronic Calculator, will use the 701 to speed and simplify the immense task of assembling and interpreting production cost data from its several plants. In government agencies the 701 will be used principally on restricted problems.

The installation at IBM in New York will be operated as a Technical Computing Bureau for organizations having problems involving mathematical computations. These will include problems similar to those listed above, as well as geophysical calculations and commercial studies. Test computations now in progress include a problem relating to the electronic charge distribution in the nitrogen molecule.

IBM Electronic Data Processing Machine 701, comprising 11 units, uses all three electronic storage devices: CR tubes, magnetic drums and magnetic tapes. At center is analytical control unit, card reader at right center. Storage units at left; at right are tape readers, recorders, printer and card punch.



Two drums in magnetic storage unit of the 701 will store more than 80,000 digits. Heads are 0.001 in. from drum which spins at 2929 rpm.



be approximated by a supply voltage variation test. Since amplifier characteristics may be more critically affected by voltage reduction than by voltage increase, the reduced voltage calculation should be made first.

Table I lists the results of applying 200 and 300 volts, as well as the original 250 volts, to the finally selected design developed for Example One.

Table I

Characteristic	E_b=200v.	250v.	300v.
Zero bias gain	18.4	19.5	20.5
—6 bias gain	13.0	15.3	15.2
Distortion	4.4%	3.0%	3.7%
Average gain	15.8	17.4	17.8

Since the supply voltage variation is ±20% of the 250 volt nominal, the design should prove satisfactory. Transconductance variation along the zero bias line is from about 2600 to 3200 microhms for the supply voltage variation from 200 to 300 volts. Variation along the 6-volt bias line is from about 1800 to 1000 microhms. Where a greater freedom of tube characteristics variations is required the use of degeneration is indicated.

Design Problem

As a second example of design, one might wish to find the preferred B supply voltage for an amplifier stage having a static load impedance of 50,000 ohms and a dynamic load impedance of 25,000 ohms. Assume that the input signal was ±4 volts peak.

This problem requires a brief consideration of actual operating conditions. First one notes that the static tube operating characteristics are controlled by a 50,000 ohm load line. The mean operating point will lie on this static load line (line A or line C in Fig. 3). The static operating point will in fact lie at the intersection of the static load line and the 4-volt bias contour. Neglecting the drift resulting from non-linearity, the mean bias point should be chosen at this intersection. A new load line should now be drawn through the mean bias point. This new load line should have the slope of the dynamic load impedance of the amplifier (lines B and D in Fig. 3).

If the static load line for this problem were based on a 250 volt supply voltage, the transconductance variation along the load line would be excessive. The variation is approximately three to one. Consequently, the initial choice of static load line is based on a supply voltage of 300 volts. (A in Fig. 3) The 25,000 ohm

(*Continued on page 128*)

TRIODE RC

(*Continued from page 127*)

load line is line B. Remaining calculations are similar to those in Example One, remembering that the dynamic load impedence should be used in gain calculations. The stage voltage amplifications at zero bias and minus eight volts bias are 18.0 and 9.9 respectively. The mean amplification is approximately 13, and the distortion is 7.25%. If the supply voltage is raised to 400 volts (lines C and D in Fig. 3), the amplifications are 18.6 and 12.0. These amplifications indicate a mean amplification of 15.3 and a distortion of 5.4%.

The power output to the external 50,000 ohm load is determined by

$$P = (VA \cdot e_s)^2 / 2R_L \qquad (6)$$

For the two supply voltages just considered, the outputs are 0.026 watt for the 300 volt case and 0.0375 watt for the 400 volt case. The static tube plate input powers are 0.4 watts and 0.62 watts respectively. The total plate supply input powers are 1.1 and 2.2 watts respectively.

Whenever the dynamic load impedance and the static load impedance are substantially different, the plotting of a pair of load lines is required with triode tubes. The first line plotted is always the static load line, since it controls the actual operating point of the tube. Then the dynamic load line may be plotted to obtain actual operating conditions. In either case, transconductance and plate conductance data may be estimated directly at as many points along the dynamic load line as are required. These conductance data determine the actual operating characteristics of the stage.

Calculation of the effect of coupling capacitors and the effect of the triode grid-plate capacitance in the presence of tube amplification follow the usual technique. The actual calculated voltage amplifications obtained for the stage may be used to improve the accuracy of the calculations somewhat.

Discussion has been limited to the design of the simplest forms of triode amplifiers in this article. As will be seen in later articles of this series, however, the design techniques described are basic to all types of dynamic parameter design of tube circuits.

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"The Use of Conductance Curves for Pentode Circuit Design," *Tele-Tech*, Nov., 1950.

"Notes on UHF Oscillator Design," *Tele-Tech*, Feb., 1953.

"Tube Circuit Design Using the G Curve Technique," Ballistic Research Labs. Memorandum Report No. 489.

A. H. Hodge and K. A. Pullen, "The Use of Conductance Curves for Pentode Circuit Design," Ballistic Research Labs. Memorandum Report No. 499.

"Improved Techniques for Tube Circuit Design," Engineering Edition, *Radio and Television News*, July, 1951.

"Electronic Circuit Design Using Conductance Curves," *Proc. of the National Electronics Conference*, 1950.

As we go to press:
G-Curves for additional popular tube types are now available in the "Conductance Curve Design Book." The introductory price for the volume is $1.00 through Kann-Ellert Electronics 9 So. Howard St., Baltimore 1, Md.

SMPTE CONVENTION

(*Continued from page 108*)

Techniques Ltd., London, England.

Binocular Vision and the Perception of Projected Stereoscopic Pictures, Armin J. Hill, Motion Picture Research Council, Hollywood, Calif.

A Panel Discussion on Projection and Exhibition of Stereoscopic Motion Pictures

Television Session

Fundamental Problems of Subscription Television; The Telemeter System, Louis N. Ridenour and George W. Brown, International Telemeter Corp.

Optical and Electrical Equivalents in Television and Photography, A Progress Report on Applications of Aperture Theory, Otto H. Schade, RCA Victor Div., Harrison, N. J.

Progress Report on NTSC Color, I. J. Kaar, General Electric Co., Syracuse, N. Y.

Closed Circuit Video Recording for a Fine Music Program, W. A. Palmer, W. A. Palmer Films, Inc., San Francisco, Calif.

Wednesday, April 29

Drive-in Theatre and Film Editing Session

Film-Projection Practice Committee Report, Ralph H. Heacock, Committee Chairman

Improved Equipment for Drive-In Theaters, R. H. Heacock, RCA Victor Div., Camden, N. J.

Drive-In Theater Doub'l-Con In-a-Car Speaker, J. R. Hoff, The Ballantyne Co., Omaha, Nebr.

Westrex Film Editor, G. R. Crane, F. Hauser and H. A. Manley, Westrex Corp., Hollywood, Calif.

A Nonintermittent Photomagnetic Sound-Film Editor, Walter H. Hicks, Centaur Products Corp., Manhasset, N. Y.

High-Speed Photograph Field Trip to U.S. Naval Ordnance Test Stations' Morris Dam Test Facility, Azusa, Calif.

Photography for High Velocity Missile Tests at Morris Dam Test Range, Mabry Van Reed. U.S. Naval Ordnance Test Station, Pasadena Annex.

Symposium on Screen Brightness

The Spectra Brightness Spot Meter, Frank F. Crandell, Photo Research Corp., Burbank, Calif.

Recent Developments in Carbons for Motion Picture Projection, F. P. Holloway, R. M. Bushong and W. W. Lozier, National Carbon Co., Fostoria, Ohio

Optimum Screen Brightness for Viewing 16mm Kodachrome Prints, L. A. Armbruster and W. F. Stolle, Eastman Kodak Co., Rochester, N. Y.

Picture Quality of Motion Pictures as a Function of Screen Luminance, Lawrence D. Clark, Eastman Kodak Co., Rochester, N. Y.

The Effects of Stray Light on the Quality of Projected Pictures at Various Levels of Screen Brightness, Raymond L. Estes, Eastman Kodak Co., Rochester, N. Y.

Thursday, April 30

A Self-Blimped Reflex 35mm Motion Picture Camera, Benjamin Berg, Establishments Cinematographiques Eclair, Hollywood, Calif.

Report of Committee on 16mm and 8mm Motion Pictures, M. G. Townsley, Committee Chairman

Recent Development of a Compact High-Output Engine-Generator Set for Lighting Motion Picture and Television Locations, M. A. Hankins and Peter Mole, Mole-Richardson Co., Hollywood, Calif.

Film Dimensions Committee Report, E. K. Carver, Committee Chairman

A New Zoomar Lens for 16mm Motion Pictures, Frank G. Back, Zoomar, Glen Cove, N. Y.

A Transmission Densitometer for Color, K. G. Macleish, Camera Works, Eastman Kodak Co., Rochester, N. Y.

The Magnescope, Rowland L. Miller, Magnescope Corp., Culver City, Calif.

High-Speed Photography Session

A High-Speed Motion Picture System for the Photography of Small Nonluminous Subjects, Albert T. Ellis, California Inst. of Technology, Hydrodynamics Lab., Pasadena, Calif.

High-Speed Motion Picture Photography of Electrical Arcs on a High-Voltage Power System, Everett J. Harrington and Harold C. Ramberg, Bonneville Power Administration.

Applications of High-Speed Photography in Rocket Research Hydraulic Studies, Kurt R. Stehling and Floyd Stratton, Bell Aircraft Corp., Buffalo, N. Y.

Wind Tunnel Illumination by Mercury Vapor Lamp, L. A. Yaggi, Consolidated Vultee Aircraft Corp., Daingerfield, Tex.

Applications of High-Speed Photography at Air Force Flight Test Center, Claude C. Baldridge and Lt. Gene C. Lemmon, Edwards Air Force Base, Edwards, Calif.

Film Processing Session

Processing 16mm Color Film With a Silver Sound Track, John Fritzen, Cinecolor Corp., Burbank, Calif.

Matching Density to Production, Howard T. Raffety, Cinecolor Corp., Burbank, Calif.

Improved Color Films for Motion Picture Production, W. T. Hanson, Jr., and W. I. Kisner, Eastman Kodak Co., Rochester, N. Y.

The Problems of Control of the Color Photographic Processes, Allan M. Koerner, Eastman Kodak Co., Rochester, N. Y.

Eastman Color Prints from Various Sources, Allan Haines and David P. Boyle, Pathe Laboratories, Hollywood, Calif.

Friday, May 1

Sound Recording and Reproduction Session

Motion Picture Sound Installation at the University of California at Los Angeles, Barry Eddy, University of California at Los Angeles.

Push-Pull Negative Track Recording, Murray Dichter and William H. Unger, Dichter Sound Studios, New York

Correction of Frequency-Response Variations Caused by Magnetic Head Wear, Kurt Singer and Michael Rettinger, RCA Victor Div., Hollywood, Calif.

A New Theater Sound System for Multi-Purpose Use, J. E. Volkmann, S. A. Caldwell and A. J. May, RCA Victor Div., Camden, N. J.

A Theater Loudspeaker System with Improved Directional Properties, J. E. Volkmann, S. A. Caldwell, and A. J. May, RCA Victor Div., Camden, N. J.

High Speed Photography Session

The Raptonic High-Speed Camera, Harold E. Edgerton and Kenneth J. Germeshausen, Edgerton, Germehausen and Grier, Inc., Boston, Mass.

A Full-Frame 35mm Fastax Camera, John H. Waddell, Wollensak Optical Co., Rochester, N. Y.

The BRL-NGF Cinetheodolite, Sidney M. Lipton, Aberdeen Proving Ground, Md., and Kenneth Shafter, Naval Gun Factory, Washington, D. C.

A Multipurpose Optical Tracking and Recording Instrument, Sidney M. Lipton, Aberdeen Proving Ground, Md.

The M-45 Tracking Mount, Myron A. Bondelid, U. S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.

Stereophonic Sound Session

Microphones, Loudspeakers and Amplifier for Use with Stereophonic Reproduction in the Theater, John K. Hilliard, Altec Lansing Corp., Beverly Hills, Calif.

Multiple-Track Magnetic Heads, Kurt Singer and Michael Rettinger, RCA Victor Div., Hollywood, Calif.

Westrex Stereophonic Recording and Reproducing Facilities, John G. Frayne and E. W. Templin, Westrex Corp., Hollywood, Calif.

Nomenclature for Motion Pictures and Television in the Society of Motion Picture and Television Engineers, Wm. H. Offenhauser, Jr., Committee Chairman

Wide-Screen Picture and Stereophonic Sound Session

Twentieth Century-Fox Film Corp. will demonstrate CinemaScope complete with stereophonic sound.

BULLETINS

Dials and Pointers

Government approved applications of radioactive and other luminous and non-luminous dials, knobs and pointers is the subject of a new brochure published by Sampson Chemical & Pigment Mfg. Co., 2832 W. Lake St., Chicago 12, Ill.

Portable Radio

Pak-Fone, a portable 2-way radio is described in a bulletin just released by the Industrial Radio Corp., Chicago, Ill.

Magnetic Transient Recorder

Magne-Pulse Corp., 140 Nassau St., New York 38, N. Y., has announced the availability of a new bulletin describing the company's type 103 magnetic transient recorder. This unit was developed recently for recording low frequency, single shot or irregular frequency phenomena.

Indicator Light

"Subminiature Indicator Lights" is the title of a new brochure published by Dialight Corp., 58 Stewart Ave., Brooklyn 37, N. Y. Non-dimming and dimming types are described.

Carrier Terms

Definitions of 150 terms commonly found in telephone and telegraph carrier equipment literature are given in new Lenkurt Bulletin EB-101, "A Dictionary of Carrier Terms." The 16-page booklet also includes a general discussion of carrier equipment theory. Copies of this new publication are available from: Lenkurt Electric Co., 1116 County Road, San Carlos, Calif.

Connectors

A new 16 page catalog of Viking Electric, 1061 Ingraham St., Dept. "B", Los Angeles 17, California, is ready for free distribution. This loose-leaf catalogue gives engineering specifications and templates of miniature connectors, terminal boards, thermocouple connectors and printed circuit hardware.

Coils

J. W. Miller Coil Co., 5917 Main St., Los Angeles, Calif., has announced publication of a new (#54) 32-page catalog.

Recording

A new four-color, 16-page, illustrated booklet entitled "A New Horizon in High Fidelity Recording" has been announced by Minnesota Mining and Manufacturing Co., 900 Fauquier St., St. Paul, Minn. The booklet tells the story of "Scotch" brand "High Output" magnetic tape No. 120. Bias requirements and frequency response characteristics are discussed and illustrated in six graphs.

Bobbin Winder

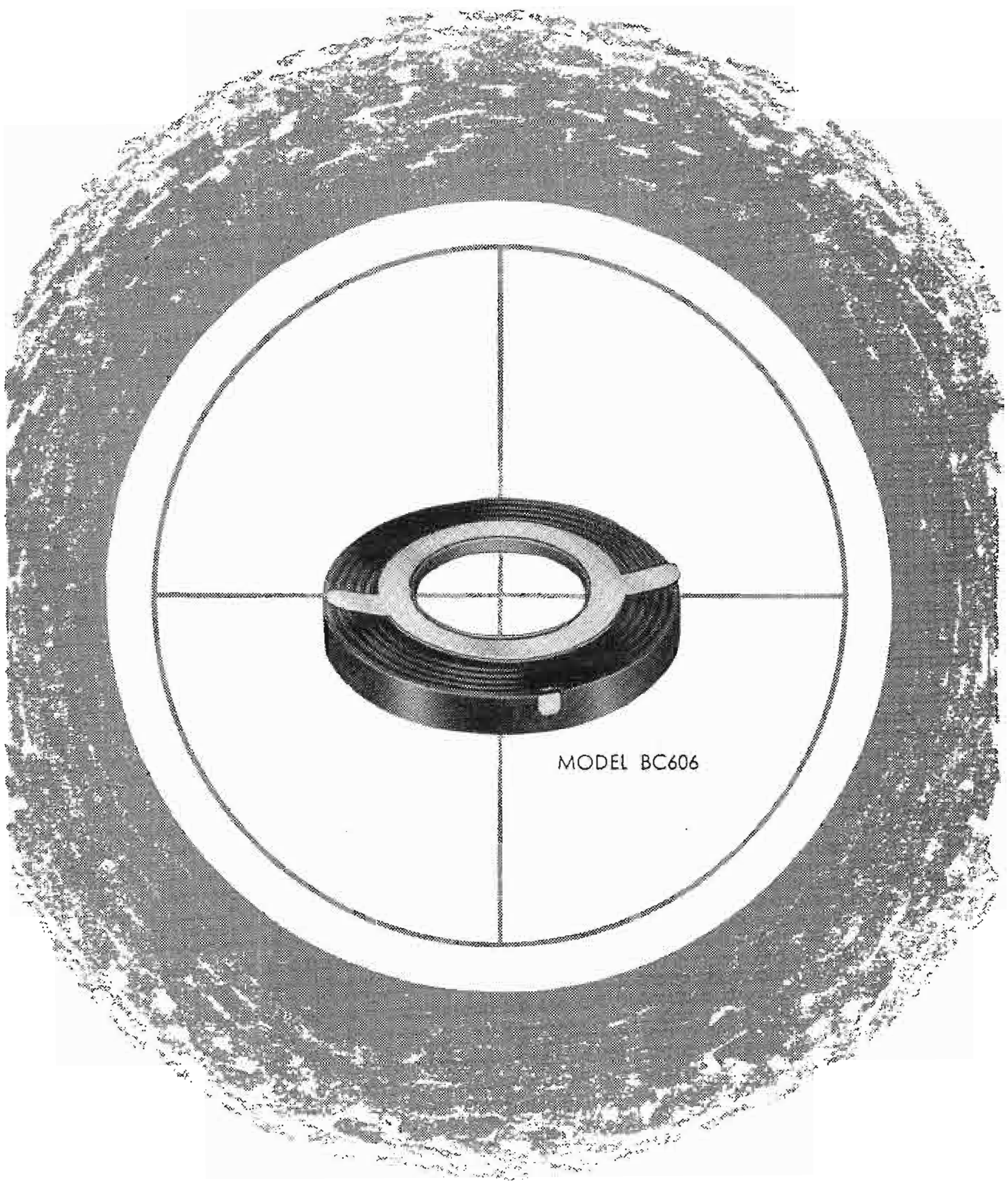
A new catalog sheet illustrating and describing the new Model 38-A miniaturized bobbin winder is now available from Geo. Stevens Mfg. Co., Inc., Pulaski Road at Peterson, Chicago 30, Ill. Of special interest are the slow-start feature which avoids possibility of wire breakage, and the instant re-setting automatic counter which saves time by permitting instant re-setting of the winding cycle by merely touching a lever.

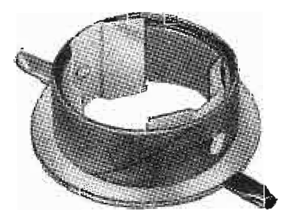
Components

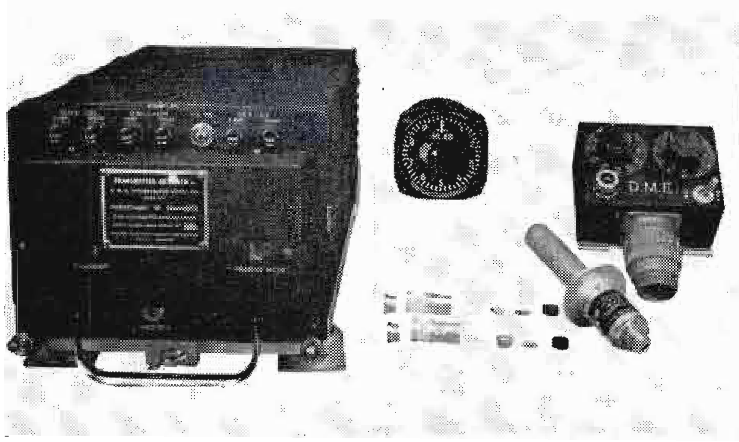
A new eight-page catalog presents the detailed specification, illustrations, typical circuits, and applications of the vibrators, vibrator power supplies, sub-miniature tubes, electrometers, corona regulators, special-purpose tubes, voltage regulators, current regulator tubes, and resistors distributed by Victoreen Instrument Co., Components Div., 3800 Perkins Ave., Cleveland 14, Ohio.

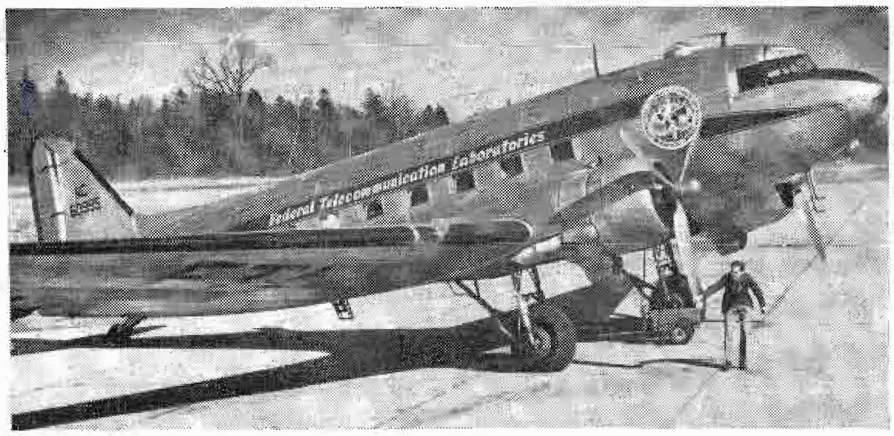
Parts Catalog

A rotogravure sales bulletin announced by Radio Shack Corp., 167 Washington St., Boston 8, Mass., as a part of its 30th Anniversary celebration features the first commercially available junction-type transistors, UHF TV antennas and converters, FM booster, wire, tubes blowers, transformers, condensers, resistors, tuners and amplifiers.









Units of FTL 34-A Airborne DME are (l to r) transmitter-receiver, meter, control box. Federal's DC-3 flying lab tests latest air navigation devices

Flying Laboratory Tests DME

A DC-3 has been converted into an airborne electronic "guinea pig" for flight testing some of the most important developments in aerial navigation—DME (distance measuring equipment), 2-color radar, automatic landing gear, altitude coding, ground-to-plane radio communication of the pulsed-time-modulation type, and many new types of ILS (instrument landing systems). The plane is part of a research and development organization maintained at the Westchester County Airport (Rye Lake, N. Y.) by Federal Telecommunication Labs., Inc., Nutley, N. J., an IT & T associate.

One development—DME—is now being used on the New York to Chicago airway, enabling the pilot to pinpoint his position from a ground station within a fraction of a mile.

In the distance-measuring system, the challenger-responder principle is utilized. Distance is measured by an airborne challenger operating in conjunction with a ground beacon. Both the air borne challenger and the ground beacon have a pulsed transmitter and a receiver. The transmitter in the aircraft starts the measuring process when it sends out a challenging pulse. This is received at the ground beacon and causes its transmitter to respond with a similar pulse. When the response pulse is received in the aircraft, special circuits measure the time elapsed between the transmission of the challenging pulse and the reception of the response pulse. Other circuits then convert the time difference into a mechanical indication of the distance from the aircraft to the beacon. This sequence of operation is repeated frequently enough to give a smooth and continuous indication.

To enable a number of aircraft over a given area to operate with a single ground beacon, a beacon responds to all aircraft within range challenging on its assigned frequency channel. Each airborne challenger, therefore, receives the ground beacon's responses to many other challengers. This method of operation requires that the airborne equipment have some means of finding and abstracting the responses to its own pulses. For this purpose, a random variation is intentionally introduced in the repetition frequency at which each airborne challenger's pulses are emitted. Special circuits in the challenger, called "the strobe," are then employed to examine in a stroboscopic manner all the responses received by the aircraft. Only those response pulses which have the same random variation as the challenging pulses emitted from that aircraft affect its distance indicator.

The following list shows some of the characteristics of equipment already constructed:

(1) Channel separation is 2.37 MC. This allows 51 two-way clear frequency channels within the allocated band 960-1215 MC.

(2) The adjacent-channel rejection is so complete that beacons which are physically adjacent may operate on adjacent channels.

(3) There is no channel ambiguity, therefore multipath echoes do not result in code disturbances.

(4) The narrow bandwidth greatly reduces the possibility of interference from harmonics of lower-frequency transmitters.

(5) A given ground beacon can service more aircraft, for it emits fewer pulses per aircraft.

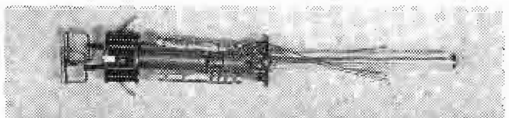
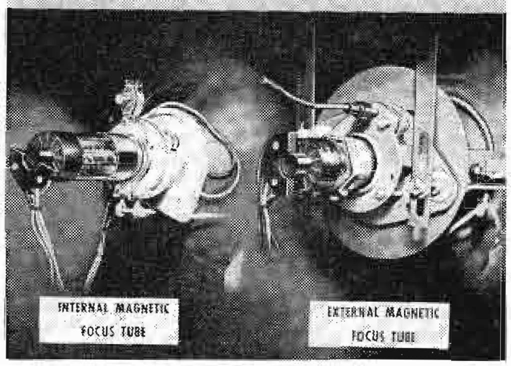
(6) Since pulse combinations or codes are not used for channeling purposes, the use of multiple pulses is reserved for other purposes.

A complete distance-measuring system comprises an airborne challenger and a ground beacon. The challenger operates on all of the 51 channels. Distance information is obtained directly from the rotation of a shaft and can be fed to the computer of an automatic flight control equipment. The distance indicator is a dual-pointer clock-type meter for panel mounting. The calibration is from 0 to 100 nautical miles, with the smallest scale division equal to 0.1 mile.

The receiver is a superheterodyne whose local heterodyning signal is supplied by a crystal oscillator and frequency multiplier. The crystal converter is preceded by pre-selector cavities which, among other things, act as the T/R circuit. The transmitter of the airborne challenger uses a 2C39 "oilcan" tube as a pulsed oscillator. The frequency is determined by a cavity with a movable plunger. The AFC then makes the fine adjustment necessary to bring the frequency to the center of the channel. It is possible to hold the frequency to within ±100 KC of the assigned channel frequency, but a tolerance not exceeding ±200 KC is satisfactory.

GE Shows i.m.f. Tube

Development of an "internal magnetic focus" gun which will permit the elimination of the external focus coil and ion trap magnet on television picture tubes has been announced by General Electric's Tube Department. Use of the gun means a major saving in parts and assembly operations for TV receiver manufacturers. The new gun contains an internal compensating focusing lens which maintains focus over a wide range of operating voltages. A simple soft iron sleeve shunt may be used to increase this range. No external focusing control requiring set owner adjustment is necessary. Clear focus over the entire face of the screen is provided within the rated anode voltage range.

(Above) New internal magnetic focus gun (Below) Comparison of mountings in TV receiver

The focusing and ion trap devices in the new gun employ four tiny Carboloy "Alnico 5" magnets. Three of the Alnico magnets, measuring a quarter of an inch in diameter and five-eighths of an inch in length are used in the focus assembly and the fourth, measuring one-eighth of an inch in diameter and length, is used in the ion trap unit. The 21JP4 is the first G.E. tube type in which the new gun has been incorporated.

PERSONAL

Rinaldo De Cola, chief engineer Admiral Corporation, 3800 Cortland St., Chicago 47, Ill., has been appointed Chairman of Panel 15, NTSC, to replace Dr. D. E. Noble, Motorola, who resigned. **W. O. Swinyard,** Hazeltine Research Inc., 325 Huron Street, West Chicago, Ill., has been appointed vice-chairman of the Panel.

Neal F. Harmon and Roy D. Jordan have received a joint Charles A. Coffin Award, highest honor given by the General Electric Company to its employees. The men were cited "for aggressive efforts in conceiving, developing and promoting an entirely original civil defense communications program, which has materially benefited the General Electric Company and all local, state and federal civil defense organizations."

Kenneth A. Hoagland has been named chief engineer of the cathode-ray tube division of Allen B. Du Mont Laboratories, Inc. He has been with the Du Mont organization for 12 years and is credited with developing the Du Mont "Bent Gun" used in cathode-ray tubes and the Du Mont "Selfocus" picture tube.

Kenneth A. Hoagland

Marvin Hobbs, who recently joined Harvey-Wells Electronics, Inc., Southbridge, Mass., as director of engineering, has been elected vice-president and a member of the board of directors. From 1950 to 1952 Mr. Hobbs was on the staff of the Office of the Secretary of Defense, as Director of the Electronics Division of the Munitions Board and the Defense Dept. member of the Electronics Production Board.

Harry V. Houghton has joined Corson Electric Manufacturing Corp., Union City, N. J., as design engineer, and will expand the company's activities in the pulse-forming network and high-voltage capacitor fields. He was formerly chief equipment engineer at Chatham

Electronics Corp., Newark, N. J., and prior to that was with the American Broadcasting Co.

E. R. Liberg has been named assistant manager, Electronics Sales, of the Graybar Electric Co. He was Manager of the engineering and service group of Audio-Video Products Corp. from 1949 until his Graybar appointment. He was with the terminal facilities division of RCA Laboratories from 1945 to 1949 and was responsible for a number of developments in code converters.

E. R. Liberg

Dr. K. C. Black has joined the executive staff of the Polytechnic Research & Development Co., Inc., Brooklyn 1, N. Y., as business manager. Since 1949, he has been chief scientist of the Naval Air Development Center at Johnsville, Pa. He was, for a number of years, a member of the staff of Bell Laboratories, where he was responsible for the development of repeater equipment of the coaxial system of carrier telephony.

Dr. K. C. Black

Les E. Gradick, WEAS chief engineer, has been appointed technical director of the four-station "Dee" Rivers' radio operations. In his new position, Mr. Gradick has technical supervision over AM stations WJIV, Savannnah; WGOV, Valdosta; KWEM, Memphis; and WEAS, Decatur; as well as all future television stations, including WGOV-TV which has received an FCC grant.

would mean an infinite permeability. However, the loop character of the actual magnetization curve and the existence of a finite coercive force limit the permeability. This can be seen in Fig. 4 where a maximum permeability μ_{max} can be derived as:

$$\mu_{max} = \frac{B_r}{H_C} \qquad (11)$$

where B_r is the residual magnetization which, for a rectangular hysteresis loop, equals saturation, B_s. H_c is the coercive force. Eq. 11 represents a figure of merit for rectangular loop type materials because it links the desired characteristics—high permeability, low coercive force, and high residual magnetization. The significance of a high B_r can be judged from Eq. 6 because it results in a smaller core size.

Rectangular hysteresis loops are obtained by orienting the ferromagnetic domains. This can be done either by suitable orientation of the metallic grains or by proper annealing in a magnetic field.[3,4] Grain oriented materials are often designated as "cold rolled" because cold rolling is an important step in processing.

Comparing Hysteresis Loops

Half hysteresis loops of various materials are compared in Fig. 5, and a list of materials with their characteristics is given in Table 1. Comparison is the best method by which a hysteresis loop can be judged because, by using a small enough scale for the magnetizing force, almost any hysteresis loop can be made to appear rectangular. Also, the differences in coercive forces come out clearer in a comparison.

Saturable Reactors

Originally, ordinary silicon iron of the transformer grade had to be used in saturable reactors. It can still be found in low-cost magnetic amplifiers where gain and weight have no significance. A hysteresis loop of a good grade of transformer core material (USS Transformer 52) is included in Fig. 5 for camparison. The familiar hysteresis loop appears very flat in this representation. Applying grain orientation to this material would result in a hysteresis loop similar to that given for Hypersil, the most popular commercial material among the oriented or cold rolled silicon iron cores. The higher coercive force of this material in Fig. 4 stems from the facts that the Hypersil hysteresis loop goes up to a higher maximum flux density and that the lamination thickness is lower.

The degree of rectangularity can be judged from the expression B_{res}/B_{sat} which is listed in Table I. Highest rectangularity among commercial materials is displayed by oriented materials with 45 to 50% nickel content (the remainder is iron). These materials are sold under the original German designation "Permenorm 5000Z," or as Deltamax, Hypernik V, Orthonik, Orthonol, and others. A combination of grain orientation and magnetic anneal results in almost perfect rectangular hysteresis loops.

Experimental materials with a higher ration B_{res}/B_{sat} such as 65% Permalloy, have not appeared on the market in this country.

Alloys with higher nickel content (77-79%) are known for their high permeabilities and low coercive forces. These alloys are rather important for these qualities in the field of magnetic amplifiers even though the hysteresis loop is not rectangular. The hysteresis loop of Supermalloy, the most advanced material in this class, has condensed into one line in Fig. 5 due to the low coercive force.

Highest flux densities are achieved in cobalt iron alloys.[4] The application of magnetic anneal to this material results in good rectangular hysteresis loops. The higher losses, however, overcome the benefits of the high flux density so that this material will presently be confined to special applications.

Tape-Wound Cores

Cores of high performance material are generally tape wound. This core type is most appropriate because:

1. High permeability is best utilized in gapless cores.
2. Very thin laminations cannot easily be stamped and stacked.
3. Grain oriented materials can be utilized fully only if the rolling and the magnetization direction of the material are identical.

That section of Table I headed "Ferrites" lists materials of an entirely different type. These are ceramic materials with ferromagnetic properties. These "ferrites" are composed of certain bivalent metal oxides including Fe_2O_3. Their nonmetallic, nonconducting properties make these materials suitable for high frequency applications because of the lack of eddy current losses. The hysteresis loop of a ferrite (Feramic H) is depicted in Fig. 5. Even though this loop appears poor in comparison with metallic materials, satisfactory performance of saturable reactors with ferrite cores has been reported at radio frequencies. The low flux density does not result in bulky reactors if the power frequency is high. (See Eq. 6.) Powdered iron materials are not suitable as saturable reactor cores because of a much flatter hysteresis loop.

The simple saturable reactor as shown in Fig. 1 is not practical as a magnetic amplifier because of the induced ac voltage in the control winding. Magnetic amplifiers are built up so that induced ac voltages of the power frequency oppose each other in the control circuit and buck out. This can be achieved by connecting two simple reactors of the type shown in Fig. 1, as shown in Figs. 6 or 7. The individual control windings in both cores have to be connected in series so that for an instantaneous alternating flux direction (indicated by arrows) the induced voltages (indicated by signs + and −) are opposing.

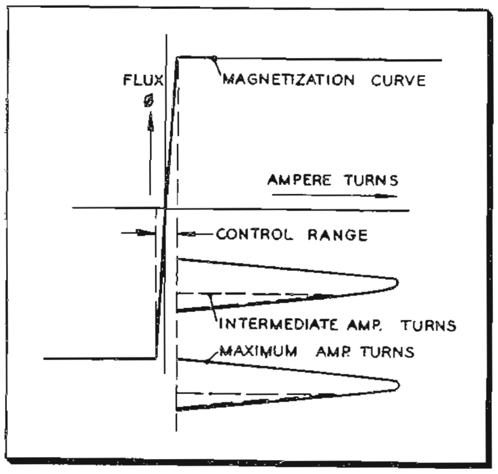


Fig. 12: Self-saturating magnetic amplifier draws maximum load current (half sine wave)

Both individual cores can be connected as in Fig. 7, or a three-legged core can be used. In both cases, only one common control winding is required. Load windings can be connected in parallel (Fig. 6), or in series (Fig. 7), resulting in different performance. The latter connection is preferred because of a lower time constant. Another core combination is shown in Fig. 8. The two cores with individual load windings are arranged one on top of the other instead of side by side. Both cores are then tied together by a common control winding. This core combination is preferred with toroidal cores where the arrangement of Fig. 7 is not practical.

The simple magnetic amplifiers which have been discussed do not give much gain per stage. Under idealized conditions, a simple relation between input and output am-

(*Continued on page* 138)

pere turns in the operating range can be deduced which, for the series-connected type of Fig. 7, reads

$$I_L N_L = I_C N_C \qquad (12)$$

where I_L is the average value of output current, N_L is the number of turns of the load winding, I_c is dc control, and N_c is the number of turns of the control winding.

From this law of equal ampere turns, a relation for the current gain can be derived:

$$\frac{I_L}{I_C} = \frac{N_C}{N_L}. \qquad (13)$$

It is obvious that a substantial current gain can be achieved only by using a relatively high number of control turns. If the load and control circuit resistance is denoted as R_L and R_c respectively, the voltage gain can be written as

$$\frac{E_L}{E_C} = \frac{I_L R_L}{I_C R_C} = \frac{N_C R_L}{N_L R_C}. \qquad (14)$$

The power gain derives as

$$\frac{P_L}{P_C} = \frac{I_L^2 R_L}{I_C^2 R_C} = \left(\frac{N_C}{N_L}\right)^2 \frac{R_L}{R_C}. \qquad (15)$$

$$I_L N_L = 2I_C N_C \qquad (16)$$

For the parallel connected type (Fig. 6) the ampere turn relation reads:

$$I_L N_L = 2I_C N_C \qquad (16)$$

This type appears advantageous because the current and voltage gain are double, and the power gain is four times as high. (See Table II). However, the series-connected amplifier is preferred because of a lower time constant.

In the following paragraphs, simpler diagrams (Fig. 9, 10, 14, 15, 16, 17, 19) shall be used instead of detailed drawings such as Fig. 6. The cores are shown separated even though they may be connected in one or the other way. The control winding, common to both cores, is indicated by one turn even though its number of turns is generally higher than that of the load windings.

The simple magnetic amplifiers, as shown in Figs. 6, 7, or 9, do not require any rectifiers. If a dc output is required, however, the load should be connected to a full wave rectifier.

The equal ampere turn law indicates that the load current is independent of the applied voltage in the operating range. This characteristic has been utilized for current stabilization. Constant alternating reference currents can be obtained if the control is done by a permanent magnet.[5]

Feedback applied to magnetic amplifiers yields results similar to those obtained with other amplifiers. In order to feed a signal back, it has to be demodulated. Hence, feedback magnetic amplifiers have to employ rectifiers. The amplified signal is fed back into an additional feedback winding as shown in Fig. 10. The number of turns and the way of connecting determine degree and sign of feedback. The load can receive either dc or ac power depending on where it is placed in the circuit. With ac output the feedback circuit can also be connected in parallel with the load. Thus, the rectifier will have to carry only a very small current. The effect of feedback on magnetic amplifier characteristics is shown in Fig. 11.

Higher Gain

The characteristic without feedback is that of a simple magnetic amplifier. It can be seen that negative feedback increases linearity while positive feedback increases gain. This higher gain is accompanied, however, by a lower stability and a higher time constant.

The ampere turn relations and current gain due to feedback can be derived from the equations of the non-feedback circuits. The ampere

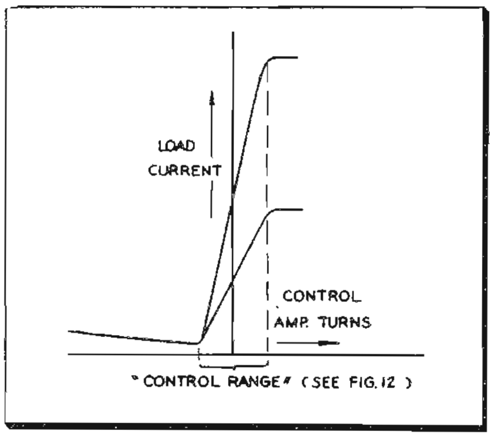


Fig. 13: Response characteristic of magnetic amplifier derived from load curves of Fig. 12

turn relation for the parallel type of Fig. 10 without feedback was

$$I_L N_L = 2 I_C N_C$$

The feedback ampere turns $I_L N_F$ are either added to (+) or subtracted from (−) the control as follows:

$$I_L N_L = 2(I_C N_C \pm I_L N_F) \quad (17)$$

Hence, the current gain is

$$\frac{I_L}{I_C} = 2\frac{N_C}{N_L}\frac{1}{1 \pm 2\frac{N_F}{N_L}} \quad (18)$$

(For more formulas on feedback circuits see Table II.)

With positive feedback increased, the amplifier will become unstable as indicated in Figure 11. The abrupt changes in load current can be uti-

(*Continued on page* 140)

lized. One possible application is a relay which operates without contacts and moving parts. The weight, however, will be substantially greater than that of a conventional relay. This is because the magnetic circuit of a relay is designed for the relatively small control only, while that of the magnetic amplifier is determined by the output.

A simple amplifier circuit (Fig. 10) cannot be made to oscillate by any degree of positive feedback. Self-sustained oscillation can be obtained with other circuits operating like a multivibrator. The oscillating frequency is relatively low, however. High frequency oscillators, employing the principles of magnetic amplifiers and operating from a low frequency power source, are not known. They would be desirable as power supply for high frequency magnetic amplifiers.

Self-Saturating Unit

The self-saturating magnetic amplifier is often referred to as a particular type of a positive or regenerative feedback amplifier. It is termed an internal feedback circuit as contrasted to the circuits described in the preceding paragraphs, which would be external feedback amplifiers. The self-saturating magnetic amplifiers are most widely used because they require no separate feedback winding.

A self-saturating magnetic amplifier is derived from the simple saturable reactor of Fig. 1 by adding an electric valve or half-wave rectifier in series with the load winding. The choke in the control circuit can be omitted because the load current is a pulsating dc only and there is less induced voltage in the control circuit. The same magnetic core characteristic is assumed as in Fig. 3. The maximum load current drawn will be a half sinusoidal wave as shown in Fig. 12 due to the rectifier.

The control required for maximum output will be the small magnetizing force corresponding to the knee in the magnetization curve. This is much less than in the simple saturable reactor of Fig. 3. The designation "self-saturating" indicates that the core is saturated by the load current alone. The average maximum output is the same in both Figs. 3 and 12. Even though the self-saturating amplifier gives only a half sinusoidal current wave, its peaks are twice as high because twice as much voltage can be applied. At zero control, only a half voltage cycle has to be absorbed by the core while the other will be absorbed by the rectifier.

An intermediate load current wave shape is indicated by the dotted line in Fig. 12. At a certain angle of the applied voltage, which is determined by the control current, the amplifier "fires." This jump in load current occurs when the flux reaches the horizontal portion of the magnetization curve.

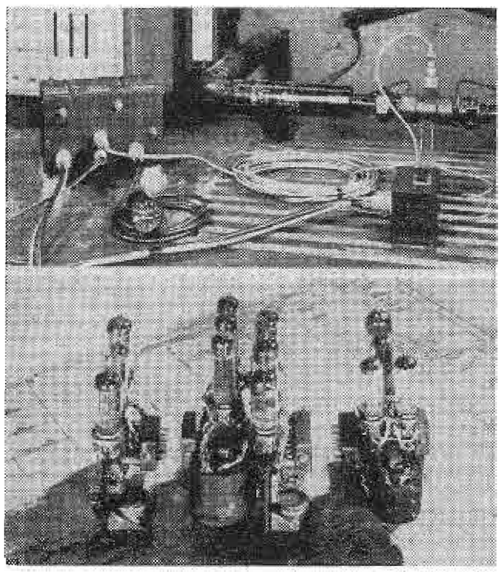
The response characteristics or transfer curves of a self-saturating magnetic amplifier are given in Fig. 13. The operating ranges are represented by the steep linear portions. Two characteristics are presented which result from the same amplifier with load resistances varying in the ratio of approximately 1:2. This load - current - versus - control - current diagram compares with the plate - current - versus - grid - voltage diagram of a triode.

Electronic Mass Flowmeter for Aircraft Developed

Gavco Corp. has recently announced a compact electronic mass flowmeter weighing less than 8 lbs. which is capable of measuring the actual pounds of fuel consumption in aircraft and guided missiles. Industrial applications in product classification, bulk storage, loading, and in research are also expected.

The system consists of a sensing unit fitted into the fuel line that first measures the flow in gallons. A density detector simultaneously weighs samples of the fuel as it passes through the line. Information from both these devices is continuously fed to an electronic integrator that compensates the flow for the true weight of the fluid and sends pulses to a dial indicator showing consumption in lbs./hour. This is important in jet planes since successive fuel loadings may vary in weight by 0.5 lb./gal., and high altitude can change fuel density by 10%. Gavco, a General Aviation Corp. subsidiary, is located at 540 E. 80 St., New York 21, N. Y.

Bench setup (top) of mass flowmeter shows (l to r) electronic assembly, indicator, and density detector. Plug-in units of electronic assembly (below) are (l to r) density compensator, integrator and indicator drive units



Antenna Fittings

(*Continued from page* 79)

Laboratory had produced three to four times the number of fittings the contracts had *specified* over that contractual period. What was more important to the NRL people concerned, the expenditure for this production was less than half the cost of Laboratory consulting service to the contractors, who had not produced any acceptable fittings over the three year period. Keep in mind, too, that 60% of the Laboratory's efforts in this nine-month period went into the design and production of tools and dies to replace those which had been Government-furnished to the contractors. These included multiple-cavity, semi-automatic molds.

Commercial Suppliers

With this additional experience, the time spent in developing qualified commercial suppliers for the components, plus detailed instructions and a motion picture now being completed, the Laboratory now feels there are competent sources for production sufficient to meet the anticipated needs of commercial airlines as well as the military needs.

Although the Naval Research Laboratory took over the Minneapolis Project as a continuing job when the joint activity was disbanded, the Air Force has continued to be of material assistance on the problem. Wright-Patterson Air Force Base, for example, is working on electronic means, which, it is hoped, will effectively reduce other forms of radio interference besides precipitation static. There has been sharing of information, meanwhile, with both the Air Force and the Navy aware of each other's accomplishments.

One Type of Interference

Despite the encouraging success that has been achieved to date in the research, design, and production of the fittings, NRL is quick to point out that these fittings are designed to reduce radio interference of only one type. Other types of interference—faulty magnetos, jamming, lightning, etc.—are not likely to be affected at all by the use either of the antenna fittings or of polyethylene wire.

The fittings have proved out in service, however. Fittings made at the Laboratory and installed on Secretary Forrestall's airplane in 1948 are still in service. Fig. 2 illustrates two typical illustrations.

More recently, the Air Force reported on an "operational suitability test" of these fittings on three B-29 and one C-54 aircraft, in comparison with present-day, standard uninsulated antenna fittings. These, in part, were the findings:

(1) Installation: Provided necessary skin modification is done at the aircraft factory or the air depot, the new fittings can be installed in the field in one-half the time required for the comparable components of the conventional assembly.

(2) Maintenance: B-29s flew from 120 to 170 hours without mechanical failures or maintenance of the insulated fittings. In the same flying time, the uninsulated assemblies all had to be replaced, due to failure of parts.

Use in the B-29

Flight test: "Data obtained from B-29 radio operator logs and through interrogation of radio operators after numerous 'precipitation' flights revealed a marked decrease in the intensity and amount of precipitation static with the new insulated fittings in relation to missions flown in aircraft not equpped with these fittings."

"Insulated antenna systems permitted B-29 radio operators to maintain contact when flying through haze, between cloud layers, and through clouds. These contact improvements are usually not possible on polar flights with the exposed type antenna assembly."

Summing up: "Insulated antenna fittings are easier to install than the present equipment.

"Insulated antenna fittings are of satisfactory design and superior to components of (exposed type) antenna assembly from an installation, maintenance, and operational standpoint.

"Insulated antenna fittings reduce precipitation static an appreciable amount when flying in all kinds of 'weather'."

New Problems

But how about the new flying problems? Flush antennas are being worked on, but may bring their own problems. The effect of static increases as the cube of the speed, at least up to 350 mph. What happens at supersonic speeds? Bubble-type canopies generate precipitation static in much the same way that a comb rubbed on flannel produces an electrostatic effect. What can be done about this?

The solutions to these and other problems remain to be solved. But they are being worked on, at NRL, as well as at other military research laboratories.

3-D SYSTEMS

(Continued from page 67)

preparing to equip 5000 theatres with Cinemascope.

Paramount has come up with a wide-screen lens system which projects standard 2-D films on a screen 1.66 as wide as it is high. The curve is greater than that used with Cinemascope, but its aspect ratio of 1.66 is less than Cinemascope's approximately 2.5. The chief advantage of the Paramount system—an economic one—is that the present inventory of $325,000,000 of standard films could be shown in depth by simply attaching a lens to an ordinary projector, and installing a concave screen.

Another approach is called Todd-AO, being handled by a new firm called Magna Theatres Corp., using a lens produced by American Optical Co. It employs a single 65-mm film to carry the wide pictures, and was conceived by Michael Todd. Years ago a 70-mm strip was used in the original Fox Grandeur technique.

One important problem in all three-dimensional systems is the need for more light. In stereo, the polarized glasses cut observed brightness; in wide-screen, the large projected area is the cause. Several approaches are being explored to raise the standard 15,000 to 18,000 lumens to about 28,000 lumens. One is a new high-current lamp operating at 135 amps, 70 volts. The 10-mm carbon electrodes burn out in about 20 minutes compared to the standard 1 or 2 hours. Other avenues are directive screens coated with thousands of tiny "lenses" which direct light at the audience; larger projector lens openings; infra-red passing mirrors; and better cooling systems.

Three-Dimensional Sound

Recognizing that depth in vision should be combined with depth in sound, 3-D motion picture producers have incorporated stereophonic sound systems in their projection set-ups. Cinerama employs a Reeves sound system with eight speakers mounted around the theatre to permit the sound source to move with the action. These speakers are fed by six sound tracks on a single strip of magnetic film, which was originally recorded by six strategically located microphones. Cinemascope uses three speakers fed by three sound tracks on film. Also, Warner-Phonic sound has come up with a multi-track arrangement that uses 25 speakers and four magnetic sound tracks.

The big rush into 3-D films has been stimulated to some extent by the inroads made by TV in attracting the public's entertainment attention. In what has been described as a counter-counterattack, several TV interests are developing means for getting 3-D on the TV picture screen.

RCA and Dumont Labs. are among the large TV firms who have developed Stereo TV for medical and industrial use. A double TV camera is employed to produce two images on two separate kinescopes. These are polarized in mutually perpendicular planes and superposed optically by a semi-reflecting mirror. When viewed through Polaroid spectacles, the double image produces a stereo picture.

Stereo TV System

In TV broadcasting, American Television, Inc., under the direction of U. A. Sanabria, has come out with a stereo TV system which requires a "synchronous lorgnette" similar to the shutter arrangement described before. The cylindrical viewing device mounted on a stand contains a motor and rotating shutters for each eye that open and close 15 times per second to match the frame rate. At this speed, flicker is encountered. At the studio, an electronic switch alternately selects the outputs of two adjacent TV cameras. More work is required on this system, but the basic idea appears promising.

An extremely simple stereo TV technique was recently introduced on KSL-TV, Salt Lake City, by a photographer who arranged to have his pair of stereoscopic photos picked up by the regular studio TV camera. In their homes, viewers were told to look at the nearly similar side-by-side pictures through two mailing tubes (one for each eye), or to arrange a cardboard separator so that each eye saw only its own side of the screen. About 50% of the viewers were able to obtain satisfactory 3-D effects. Some were able to see stereoscopically even without tubes by paralleling their eyes with distant focus.

Separator Method Variation

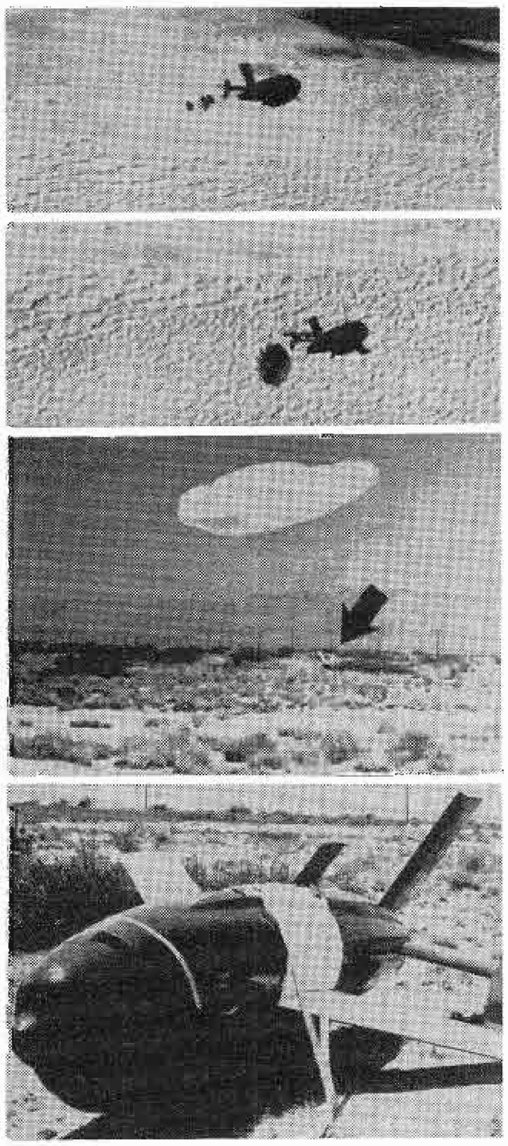
A variation of this separator method for industrial use employs two adjacent TV cameras. Simultaneously, each one produces an image on half of the picture tube.

Milton L. Gunzburg, President of Natural Vision, is working on a 3-D TV system which will not require glasses. He has tried it successfully, but it is fuzzier than systems using Polaroid lenses. Gunzburg, who says that 3-D TV will be here before color, reportedly has a receiver attachment which could sell for about $15, enabling the set owner to obtain the 3-D effect.

And bigger and better things are in the making. Indications are that stereo and wide screen will eventually combine, both in motion pictures and TV, and integrate with stereophonic sound to present realism never before obtained.

Pilotless Jet Plane Parachutes at 600 MPH

Some of the heaviest objects ever dropped at 600 mph are being recovered successfully by parachute at Holloman Air Development Center, Alamogordo, N. M. One example is the Ryan Q-2 pilotless jet target plane, the Firebee (see April 1953 TELE-TECH & ELECTRONIC INDUSTRIES, p. 155). Top photo shows drag chute flaring out of



tail shortly after Q-2 is released from mother craft. Next, main canopy is pulled out. Third photo, drone lands gently, parachute about to disconnect automatically. Bottom, nation's first announced guided missile of its kind rests after 600 mph fall, its electronic equipment undamaged by landing impact.

Military Multimeter

(*Continued from page 84*)

the upper two ranges of resistance measurement.

The simplicity of circuit design is apparent from the schematic diagram shown as Fig. 5. Only 21 accurate fixed resistors are employed, in addition to the indicating meter and its rectifier unit, the ohmmeter adjusting variable resistor, and the batteries.

One of the most interesting features of design of the multimeter is the adaptation of printed circuitry to this type of equipment. As will be seen from Fig. 6, an etched pattern has been produced from a copper foil laminate. This pattern includes not only the conductive pattern which is functionally equivalent to conventional hook-up wiring, but also the stator of the function and range selector switch. The rotor and detent mechanism for the switch is fastened directly to the printed circuit pattern laminate to complete the switch and wiring assembly. In addition the printed circuit pattern laminate serves as a mounting board for all 21 of the fixed resistors, for the variable resistor, for the rectifier unit and for the battery mounting board, as Fig. 7 shows. The test leads are also permanently attached directly to this board. Full advantage of the possibilities offered by the printed wiring technique has been taken in limiting the number of conventional wires to only five flexible leads. Two of these connect the meter to the printed circuit pattern and the remaining three connect the battery terminal contacts to the printed pattern. Battery contact springs are fabricated from beryllium copper strip. Further economy in production of this test set should result from the use of molded thermosetting high impact resistant plastic rather than metals for the control panel, as well as the case and its cover. The entire printed circuit assembly, which contains all circuit elements except the meter, attaches to the rear of the recessed control panel. The meter is fastened directly to the control panel. This entire assembly fits into the box to be retained by machine screws, and the gasketed cover with its two spring latches provides a watertight seal, when in place.

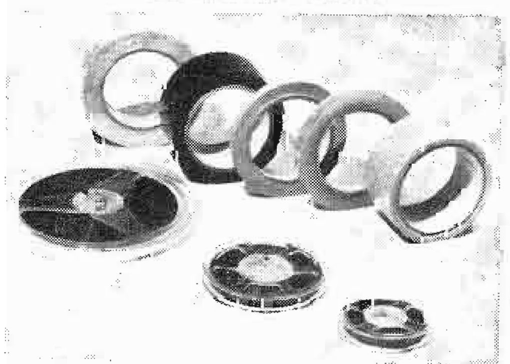
The complete equipment, which weighs about two pounds, is of such rugged design as to enable it to survive being dropped upon hard ground or a floor from a height as great as three feet. Improvement in reliability of the electrical performance over that normally expected of a sensitive multimeter utilizing a ruggedized and sealed meter, can be expected to result from the use of a newly developed overload protection device supplied as an integral part of the indicating meter. An overload which would ordinarily cause permanent damage to the meter is prevented by two tiny circuit breakers at either end of the scale. The force of the pointer striking against this device breaks the meter circuit by opening a pair of contact points in the circuit of the moving coil. These contact points, ordinarily held together by spring pressure, are held open by a tiny permanent magnet after an overload occurs. A turn of 360° on the zero adjust screw of the meter returns the points to the closed circuit position.

Temperature Effect

The effect of temperature on the accuracy of the test set, of great importance to the using service organizations because of intended outdoor use in all climates, has been held to a minimum by use of a carbon composition compensating resistor to correct for the thermal effect on the copper coil in the meter, this coil being the only appreciably temperature sensitive element in the dc circuits. This resistor has been made an integral part of the meter. Design of the ac voltmeter circuit is such that the effect of temperature on the copper oxide rectifiers is of minor importance to overall accuracy, because of the relatively large multiplying resistance value employed on even the lowest range.

It is anticipated that the advantages offered by the new multimeter in operating convenience, in simplified maintenance procedures, and in production economy, will make the new test set a welcome addition to the line of military test equipment now in use, and that a gradual replacement of multimeters of conventional design will take place.

VERSATILE FILM



Du Pont's "Mylar" polyester film is finding an increasing number of tape applications. These include recording, industrial wrapping and electrical insulation. It requires no plasticizer, and has great dimensional stability

Maintenance Problems

(*Continued from page* 89)

sure internally to avoid corona and high-voltage breakdowns, or must be water immersion proof, the manner of sealing is always a problem and must be given very careful consideration. This is true because the seal must be broken during removal of the equipment from its case for servicing and remade again for return of the equipment to active service. Any accidental mechanical disfigurations such as dents occurring on the sealing surfaces while the equipment is out of its case may prevent successful resealing.

The ultimate goal of the military services, brought nearer to realization through the development of the transistor, is an airborne equipment which will operate, say, at least 2000 hours without any maintenance whatsoever. In terms of operational usage, this is a period of at least several years, usually. With such trouble-free performance, it may be economically feasible to discard the whole equipment at the end of its useful life. Such an equipment could be truly hermetically sealed and the seal never broken. Or, at the end of 2000 hours operation, units or parts which are subject to mechanical or electrical wear, deterioration or aging, could be replaced, and the equipment made suitable for another 2000 hours operation without any interim attention.

Such a goal requires higher than present quality in many component items and may be in the rather distant future. However, if higher quality components to meet these requirements were manufacturable, even high cost could not offset the advantages to be gained by eliminating all maintenance requirements. During wartime in particular, reducing the necessity for highly-trained maintenance personnel would be a revolutionary boon to the military services.

Whether or not the goal of no maintenance can be achieved, the military services will continue, through engineering design, to simplify maintenance and servicing, with the greatest emphasis being placed on front line activities where the urgency is greatest and speed is of utmost importance.

Quartz Crystal Polishing

J. H. Tashof, president of Precision Products Inc., 719 Seventh St., N. W., Washington 1, D. C. announces the availability of a new quartz crystal polishing and grinding service. The firm previously specialized in the manufacture of precision optical elements such as lenses, prisms, reticles, etc.

AFC Circuit Design

(*Continued from page* 97)

dicates the sensitivity to noise. The curve must start at unity to track the desired sync signal, but the peak is highly undesirable. This peak is characteristic of servo systems, and designing an over-damped system will have little improvement. The peak indicates the frequency at which noise will have its greatest effect. The noise will cause the phase of the controlled oscillator to jitter at the frequency corresponding to the peak.

The steady-state error response is shown in Fig. 3. It indicates the error between the phase of the sync signal and the controlled oscillator when the phase of the incoming sync signal changes according to a sine wave. The curve is obtained by the same process as used to obtain the steady-state frequency response, except that Eq. (1) is used as the fundamental equatlon instead of Eq. (2).

The curve starts at zero and goes to 110% error at the triple-pole location. This portion can be approximated by a straight line from the origin to 100% at the pole location. This servo system does not attempt to track any but low-frequency changes.

When the synchronizing information changes phase rapidly, this type of servo will not prove satisfactory. A servo that approximates a zero-acceleration-error servo must be used. For TV applications, the zero-velocity-error servo has proved satisfactory, and the zero-acceleration-error servo has not been investigated nor used to date. The latter can only be approximated by adding an additional integrating device (1/s), or possibly by multiple loops. When the zero-velocity-error servo is used, no theoretical improvement can be made by using more complicated filters.

Transient Responses

In the design of the AFC circuit, there are several transient responses which must be investigated. These consist of a step-of-phase and linear change of phase. The step-of-phase response of the system indicates the operation when the circuit is operating normally and drifts out of phase because of a temporary loss of sync signal. The response can be determined from the following equation:

$$\phi_0 = \frac{3P^2(s+P/3)}{s(s+P)^3} \qquad (25)$$

The solution is

$$\phi_0 = 1 + (P^2t^2 - Pt - 1)e^{-Pt}. \qquad (26)$$

(*Continued on page* 150)

The response curve is shown in Fig. 4. The important features of Fig. 4 are the time of the response and the fact that it overshoots.

The second transient response to consider is the response for a step change in frequency or a linear phase change. This transient indicates the response of the system when the frequency of the sync information is suddenly changed. The response is shown in Fig. 5. These curves are accurate provided the phase error does not become greater than one-half of the flyback time; at that point, the phase detector is not linear with the phase error. The maximum rate of change that can be followed is a function of the triple-pole location and can be determined from Fig. 5. This curve was obtained by solving the following equation:

$$\phi_0 = \frac{3NP^2(s+P/3)}{s^2(s+P)^3} \quad (27)$$

where N is a proportionality or sensitivity constant. The result is

$$\phi_0 = Nt - Nt\,(Pt+1)\,e^{-Pt}. \quad (28)$$

The effect of the approximation that the gain is very large becomes apparent in Fig. 5. As shown, the error approaches zero after sufficient time. This is not true in a practical circuit because it does approach a constant fixed error determined by the dc gain. The static phase error has been fixed, and the required dc gain was determined from Eq. (13).

The final transient response to consider is the characteristic response of the servo to a spike input as shown in Fig. 6. The effect is the same as that of a single synchronizing pulse when multiplied by a factor to obtain the correct magnitude. The magnitude is determined as follows:

$$M = (\phi_1 - \phi_0)/F$$

where M is the magnitude factor and F is the repetition frequency. The equation used to obtain the characteristics transient is:

$$\phi_0 = \frac{3MP^2(s+P/3)}{(s+P)^3} \quad (30)$$

and that for the response,

$$\phi_0 = MP^2t(3-Pt)\,e^{-Pt}. \quad (31)$$

The effect of the single spike is to cause the phase to shift, the final result being without error. The graph indicates a slightly oscillatory nature, but Eq. (31) shows that there are no trigonometric terms in the response, and the zero value is caused by the zero in the loop. There is a delay before the main influence of the spike is felt. As the bandwidth of the system is decreased, the delay is increased; however, the magnitude is decreased. This curve can be used to indicate the effect of isolated noise spikes or an error caused by the vertical block in systems using an unbalanced phase detector.

The characteristic transient also affects the pull-in operation. When the system is not in synchronism, the sync pulse will ride up and down on the sawtooth. If both signals (the oscillator and the sync information) remain constant in frequency, the net output over a complete cycle of the beat frequency would be zero. The forces which are to pull the system into synchronism must take effect within a cycle of the beat frequency and leave a residual influence after the cycle.

Pull-In Range

A method for determining the approximate pull-in range of the system can be found by assuming that the system is linear and that the beat frequency between the oscillator and the incoming signal is a phase variation of the incoming signal with the system in synchronism. There is an approximation that the harmonics in the sawtooth waveform have negligible influence. Since the system is considered in synchronism and linear, the equations for the steady-state frequency response are valid. The approximations are of the same order of magnitude as the previous approximations because similar voltages can be developed in the phase detector by variations in phase or by not being in synchronism. The difference between the two signals is the actual position of the pulse on

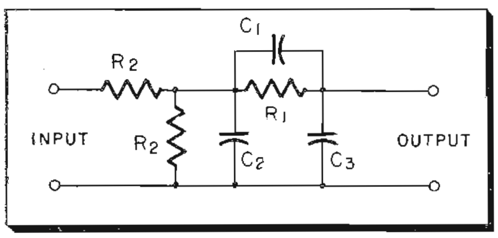


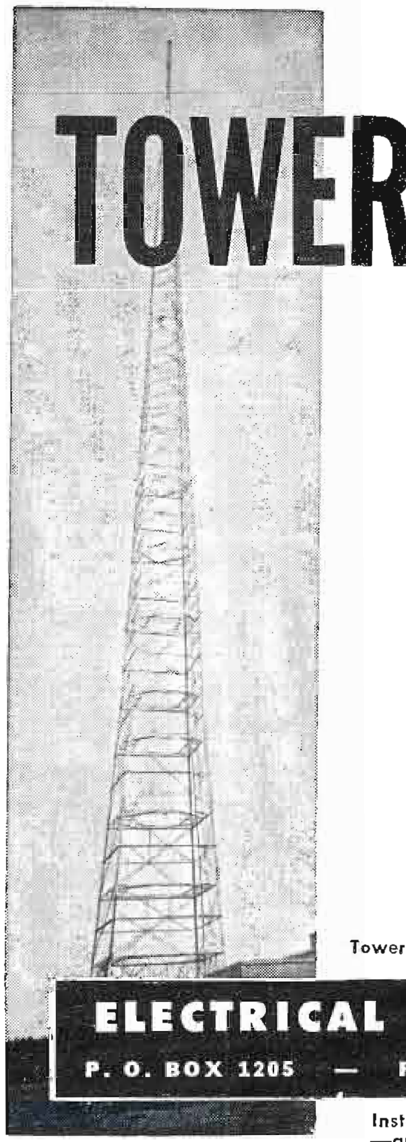
Fig. 9: Circuit of the alternate filter

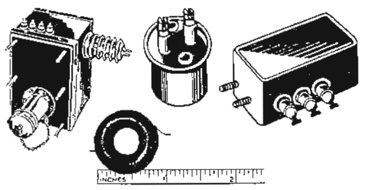
the sawtooth. At one frequency, the output will lag the input by 90°. This frequency can be determined from Eq. (23). The resulting equation is

$$\arc\tan 3\omega/P - 3 \arc\tan \omega/P = 90°. \quad (32)$$

At this frequency, there is no effect upon the operating frequency after one complete cycle in the steady-state condition because there is a 90° shift between the input and output phase. At frequencies higher than this, the phase angle between input and output must be greater than 90° as shown in Eq. (32). After one cycle of the beat frequency, the resulting tendency will be such that the phase angle will increase by

(*Continued on page* 152)





increasing the beat frequency or the frequency difference. This is caused by the synchronizing information being delayed too long in the filter and arriving at the oscillator after a quarter cycle has passed. The result is a negative in-phase component which remains after a complete cycle, thus tending to increase the frequency difference. For frequencies lower than the critical frequency, the tendency will be for the oscillator to be in phase with the beat or, in other words, an in-phase component will remain. This in-phase component will tend to reduce the frequency difference for the next cycle. The result will be cumulative, and the system will pull itself into synchronism. The 90° frequency is the critical frequency for the system to pull itself into synchronism.

At first, it might seem that the pull-in time could be determined by applying the formula for a linear phase change (step of frequency). This is not true because the pull-in operation is over the nonlinear portion of the phase detector and the system may slip a number of cycles. The time calculated would be the minimum. The pull-in time is usually the last consideration because it is important only at transient conditions, and the other factors determine the operation at all times.

Synthesis of the Filter

The next problem is to synthesize a filter having the proper pole and zero locations for use in the system. A network having these characteristics is shown in Fig. 7. The numerical work can be simplified by making R_3 large. Simple analysis will show the following to be correct when R_3 is large.

$$z = 1/R_1C_1, \qquad (33)$$

$$A = 1/R_3C_1, \text{ and} \qquad (34)$$

$$B = 1/R_2C_2. \qquad (35)$$

The pole and zero locations required in the filter can be determined from Eq. (18), (20), and (22). The results are

$$z = P/3 \qquad (36)$$

$$A = P^2/3K, \text{ and} \qquad (37)$$

$$B = 3P. \qquad (38)$$

When this filter was used with a practical phase detector, it had to be modified for two reasons: one was the circuit configuration and the other was the operation of the phase detector. The phase detector is not a linear device and cannot be represented accurately as either a current or a voltage source. Since the diode

(*Continued on page* 154)

conducts for a very short period, its effective impedance is very high. The circuit can thus be best represented as a current source.

The circuit used is shown in Fig. 8. This circuit is only one type of phase detector which may be used. Another basic filter, which is also used in commercial practice, is shown in Fig. 9. The operation of the circuit used was not only satisfactory but

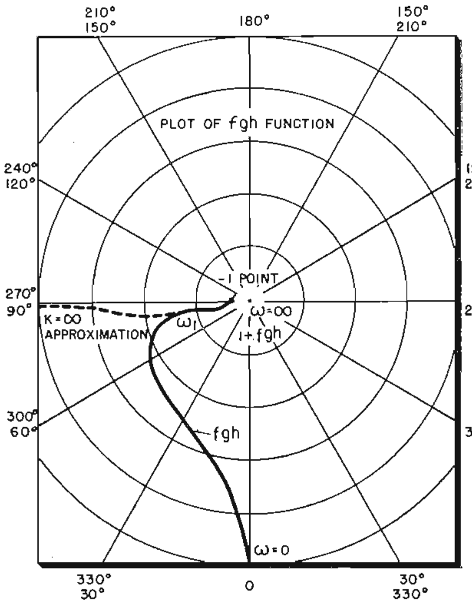


Fig: 10: Open-circuit loop characteristics

performed as predicted from the theory. The main controlling factor in the system is R_1. With R_1 too small, satisfactory operation cannot be achieved.

Design Procedure

The design procedure is first to build and test the oscillator to determine its sensitivity constant. The type of phase comparator should be chosen next, and its sensitivity should be determined by analysis or measurement. The next step is to determine the maximum phase error that can be tolerated with the relative drift existing between the sync source and the controlled oscillator. The dc gain of the system can be determined from the sensitivity constants and the requirements of the system. If there is insufficient dc gain, a direct-coupled amplifier will be required. The triple-pole location of the closed loop is chosen next by assuming the pull-in range or integration to determine the noise performance. Choosing the triple-pole location or any time constant will determine the complete servo system but will not determine the impedance of the network. There is some latitude in choosing the impedance level, but to keep the calculations simple, the value of resistor R_2 should be much less than that of R_3. The values should be calculated and the circuit built.

After construction, the actual gain of the circuit should be calculated from the hold-in range. If there is an appreciable difference between the theoretical and actual values, the design should be repeated and the new values used. Finally, the performance can be tested.

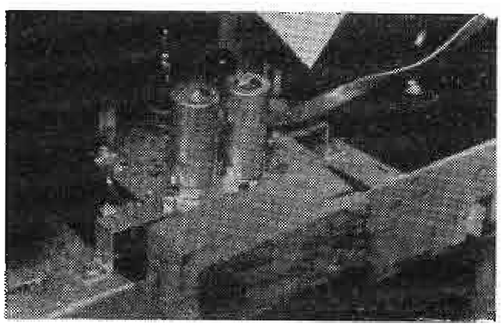
The foregoing completes the theory from the circuit analysis to the design of a complete AFC system. The resulting AFC circuit will be critically damped, and all factors pertaining to its operation (pull-in range, hold-in range, steady-state frequency response, error response, and various transient responses) will have been determined.

The analysis described is completely analytic, although the steady-state frequency response and error response may be determined graphically. The fgh function is plotted on polar-coordinate paper and shows the ratios of the distance from the origin to the curve and from the -1 point to the curve. These distances are used in Eq. (1) and (2). The angle between the input and the output can also be determined from this graph. Furthermore, the graph shows that the system is not critical with respect to the gain in the loop assuring stable operation under varying conditions. An approximate drawing of the fgh function is shown in Fig. 10.

The fact that the AFC circuit may be used in either an AM or a FM television system and that the operation of the sync separator is not linear prevents the numerical calculation of phase variations caused by noise. Therefore, additional information on noise is not given. The system described herein has been tested and has given excellent results. The hold-in and pull-in calculations were found to be correct. Accurate measurements of the signal-to-noise requirements were not made. However, the system remained in synchronism when there was no usable picture and the blanking was almost imperceptible.

[1] T. S. George, "Analysis of Synchronizing Systems for Dot-Interlaced Color Television," *Proceedings of the IRE*, Feb., 1951.

DAMAGE PREVENTION



Insertion of a simple slotted spacer block on television chassis units on CBS-Columbia conveyer lines has minimized damage to sets

Simple Computer

(*Continued from page 73*)

the use of Simcor in many practical correlation analyses.

Fig. 5b shows the autocorrelation function of a sample of the random time function given in Fig. 4. If the time function had been an infinite sample of pure random noise, the autocorrelation function would have been a spike at $\tau = O$, and zero for all other values of τ. In practice such a situation never can be realized. It is interesting to note that any autocorrelation function should be symmetrical around $\tau = O$, and the lack of symmetry may be attributed to imperfections in the method used to calculate the function. Examination of Fig. 5b reveals that symmetry around $\tau = O$ is quite good.

The very-low-amplitude, very-short-period waves noticeable in some parts of the autocorrelation curve are caused by imperfect integration over the period required for the film loops to travel around once. It is desirable that these wiggles appear to a small degree, because they indicate that the $\tau = O$ peak is not appreciably clipped in the τ-scanning process by overintegration. The integrating time can be varied by adjustment of the RC filter.

It is evident from Fig. 5b that the $\tau = O$ point is repeated at the $\tau = -T$ and $\tau = +T$ points. The time represented by the distance $\tau = O$ to $\tau = T$ corresponds to one complete cycle of the τ-scan on Simcor. If Simcor is left running it will continue to repeat the same curve indefinitely as τ is scanned the length of the film loop repeatedly.

Time Function

Fig. 5c shows a time function generated by the pitching of an aircraft carrier as it steams through the irregular waves of the sea. The autocorrelation function of this particular sample shows that underlying the random motion, indicated by the peak at $\tau = O$, there is a major periodic movement having a period of about 8 seconds per cycle. A secondary periodic movement having a period of about 70 seconds per cycle also is evident. Thus we have an example of how the correlation function is helpful in observing a relatively simple harmonic motion that is embedded in random motion. The autocorrelation function is not as helpful if the harmonic motion is relatively complex.

Fig. 5d shows the cross-correlation function of the time function shown in Fig. 4 and of a time func-

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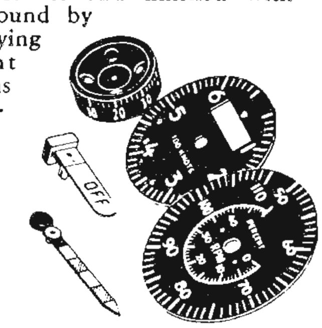

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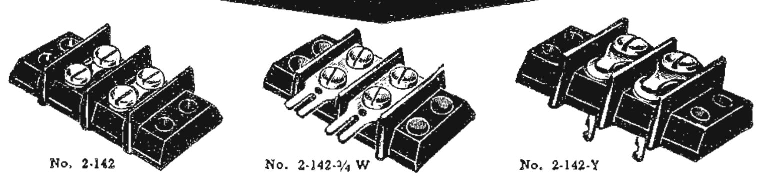

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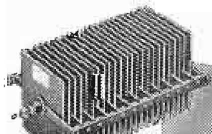

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tion created by adding this time function to itself with a time delay of about ¼ the loop length. The cross-correlation function of these two time functions gives two correlation peaks, as indicated in the figure. In cross correlation, the $\tau = 0$ point depends entirely upon the starting-time relationship of the two functions to be correlated. Unlike auto-

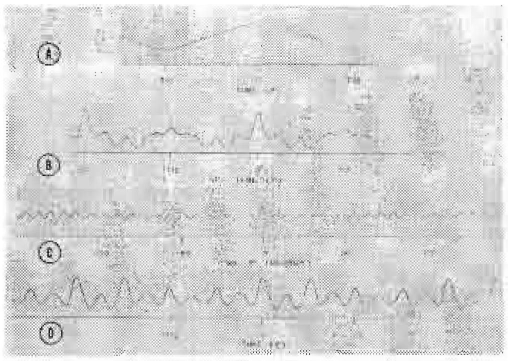

Fig. 5: Autocorrelation function of random time function taken on sample from Fig. 4

correlation functions, cross-correlation functions usually do not have a maximum at $\tau = 0$ and are not symmetrical around $\tau = 0$. The latter is observable in Fig. 5d.

Simcor, the simple analog device described in this article, has been found useful in automatically evaluating and plotting the correlation functions of time functions. Its principal virtue is its simplicity combined with sufficient accuracy for application in many practical correlation analyses.

Grateful acknowledgment is given to Messrs. James Titus and Daniel Monacelli who designed and assembled the gearing contained in the box shown in Fig. 2, and to Messrs. James Burke and Joseph Reynolds who built the film cutter for making time function tapes from magnetic recordings and reduced the automatic recording feature of Simcor to practice.

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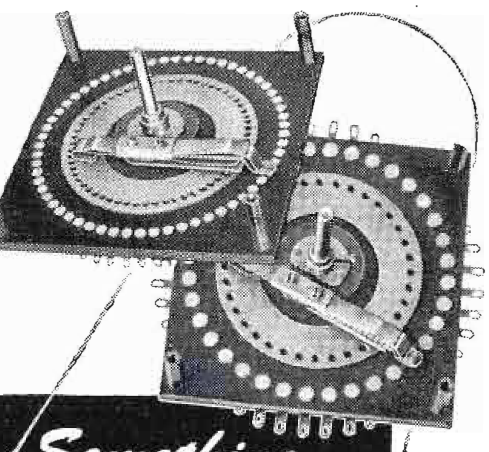

Dummy Loads

(*Continued from page* 94)

be performing any real cooling effect. It is, therefore, necessary to reduce the attenuation constant still further in the entrance section of the load and this can be done by several methods. One method would be to grade the mix used in the dissipative wall section so that the first sections have lower attenuation constants.

A second more satisfactory method from a mechanical point of view (excessive graphite being structurally weak) for dstributing the power is to use walls which are partially dissipative and partially conducting, since this has several inherent advantages. Mechanically, it provides for a homogenous mixing material which can be controlled more easily in filling the dummy load section. From a production point of view, this is much simpler to control and use. By providing metallic wedges in the broad faces of the dummy load, a smooth metal wall can be achieved at the point of the highest electrical field intensity and for high powered considerations, is a very pronounced advantage over a graded type dummy load for many waveguide sizes. Since, with any dissipative wall material the surface roughness will be far greater than that produced in rigid rectangular waveguide; 125 micro-inches surface roughness being typical for dissipative wall materials and by the inherent fact that discrete particles are used in general for the dissipative material, there will always be electric field stress concentrations around these rough dissipative sections which will, in general, result in corona, ionization and/or early breakdown for uniform dissipative wall dummy loads. By inserting a metallic wedge in the broad face of the dummy load and allowing the narrow walls to be dissipative, the attenuation at this point can be controlled to provide the necessary uniform power dissipation over the finned area.

Wedge Section Design

The design of these wedged sections can be performed by approximate methods, knowing the attenuation constant of the material over the frequency range for which it is to be used, and knowing the incremental power dissipation per length that is desired for the finned area.

The thermal considerations in the design of the finned sections are

(*Continued on page* 161)

straightforward, based on conventional applications of the design of thermal devices and the design of the first sections are such so as to provide maximum cooling without the use of forced air circulation and to reduce hot spot temperatures with restricted cooling. Typical test results for a 350 watt X_L dummy load are shown in Fig. 4. This shows the variation of temperature along the load compared with the temperature rise of conventional dummy loads. Fig. 5 shows the actual load under test and the test equipment used to make these tests. A CW magnetron operated at 2000 watts average power was used to operate the dummy load and a bi-directional coupler was used to measure the VSWR and power level during these tests. The stability of VSWR with power as a function of time and hot point temperature is shown in Table III, for a 3 x 1½ ("S" Band) dummy load.

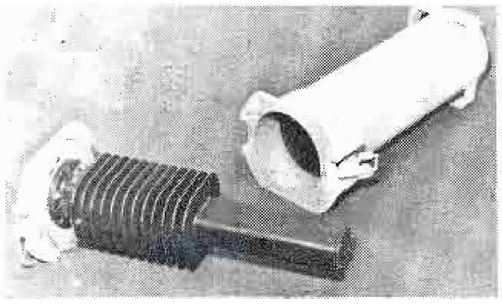

Fig. 8: Military style dummy load for 1½ x ¾ waveguide size complete with transit case designed for field service

Another very serious problem in dummy loads designed for field service, is the problem of moisture absorption. In most dissipative wall devices, the wall material has some inherent porosity and, as a result of this, there will be some tendency for moisture absorption with repeated humidity cycling or extremes of heat and cold under high humidity conditions. This water condensation even though very slight, will result in problems if connected to normal waveguide structures. Since the dummy load will be the hottest point in the system, exclusive, in general, of the magnetron, any water which is occluded in the dummy load will be vaporized and, since these things are connected directly to the waveguide transmission line run without any impediment, the moisture laden air will carry back into the waveguide to a point where the conditions are just right for re-condensing this water vapor. This will generally occur along a single line in the waveguide system so that all of the water so vaporized will condense in one spot and generally in the

(Continued on page 163)

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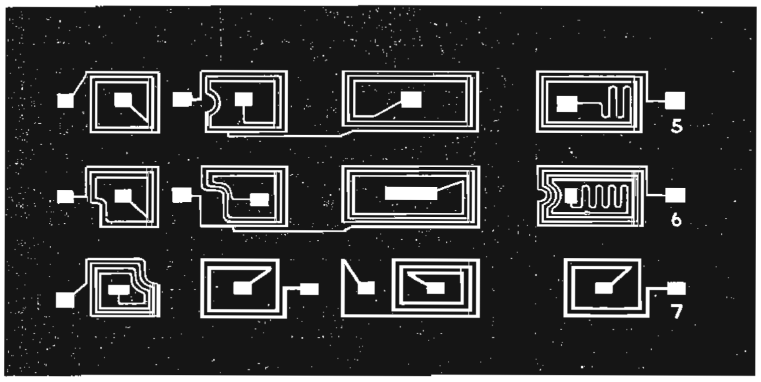

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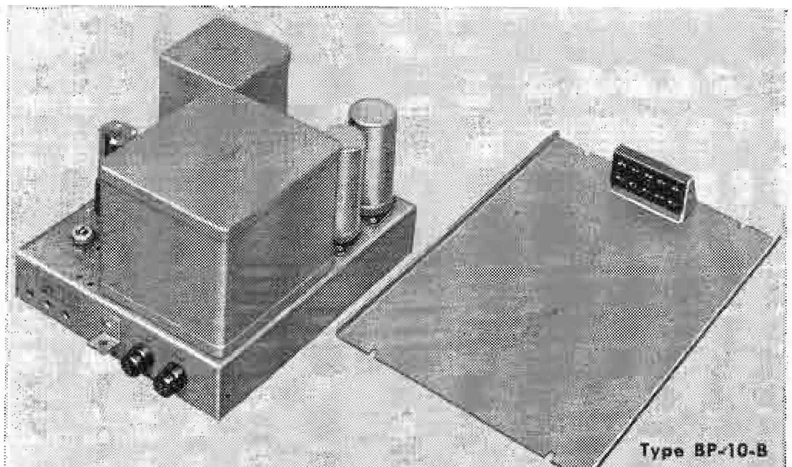

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middle of the broad fact at the point of highest electric field intensity so that the possibility of getting breakdown in high peak power systems and resultant damage to transmitting equipment, magnetron, etc., is something that should be avoided at all costs.

It has been shown that moisture absorption of less than 0.5% is required to provide a satisfactory moisture free dummy load under field service conditions. This is practically impossible in the dissipative mix material which will allow for

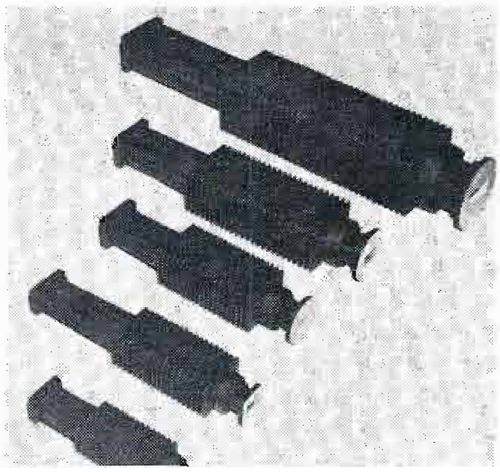

Fig. 9: Series of extremely high power waveguide dummy loads for 3 x 1½ to 1 x ½ waveguide systems covering the frequency range from 2600 to 12,400 megacycles with a peak power rating equal to rigid guide

ready fabrication and be economical to produce. A solution to this problem is the use of a mica window directly across the opening to the waveguide dissipative mix so as to provide an essentially sealed dummy load dissipative structure which would not allow the free interchange of moisture ladened air. The use of a mica window placed across this section introduces some problems of matching, typical of any waveguide window design. By keeping the waveguide window thin, the VSWR contribution for mica window can be safely neglected and satisfactory electrical operation can be easily achieved.

The peak power performance of the various dummy load designs developed within 1 x ½ and 1¼ x ⅝ waveguide sizes. A schematic of this test set up is shown in Fig. 6. A 4J50 magnetron operated at 2½ μsec pulse width was used to feed into an evacuated section. The evacuated section was reduced in pressure until breakdown occurred and the equivalent peak breakdown for atmospheric pressure was determined from this measurement. In the computation of peak power, certain assumptions are made which are not completely valid. One such

(*Continued on page* 164)

assumption is that the peak power varies as the square of the absolute pressure. Although there may be theoretical error due to this assumption, the error will be constant and the relative magnitude of the results compared to breakdown are carefully made, sections of rigid waveguide will serve as accurate indications. This has been shown to be reasonably accurate by tests made in conjunction with Wheeler Laboratories using their spark gap breakdown equipment. The breakdown test data for a typical 1 x ½ dummy load with and without the mica window is shown in Table IV.

The minimum breakdown level obtained for this dummy load was 1.05 megawatts which is very closely the same as that obtained for rigid waveguide components on previous tests. A complete series of waveguide dummy loads has been designed using these basic principles and the test characteristics of these dummy loads and their approximate dimensions are shown in Fig. 7.

Fig. 8 shows a military style dummy load for 1½ x ¾ waveguide, complete with transit case designed for field service.

Fig. 9 shows a series of extremely high power waveguide dummy loads for 3 x 1½ to 1 x ½ waveguide systems covering the frequency range from 2600 to 12400 MC with a peak power rating equal to that of rigid waveguide.

The series of loads which have been described, have been evaluated for the average powers shown, and show a very conservative design factor insofar as the high temperature properties of the dissipative mix are concerned. The peak power rating for the 1 x ½ waveguide size indicate that they are equivalent to rigid waveguide in their peak power rating and since the same design parameters are used in the larger loads, it is felt that the same high peak power performance can be expected from the loads in the larger waveguide sizes.

TABLE IV

HIGH POWER BREAKDOWN TEST OF 44240 DUMMY LOAD 1 x ½

Condition of Sample	Breakdown Level (Megawatts)
Small Hole (Dummy Load	1.25
Punched in Interior	1.11
Mica Window Evacuated)	1.11
	1.11
	1.05
	1.20
	1.04
Mica Window (Shows window	1.32
Removed has no effect)	1.12
	1.13
	1.06

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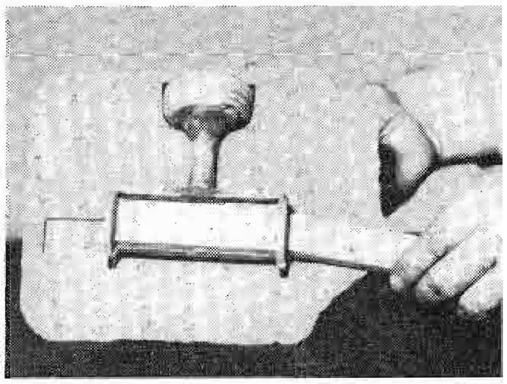

Waveguide as it appears during new molding process

California, affiliate of Sightmaster Corp. of New Rochelle, N. Y. Under this new development, metal casting molds are made from a master waveguide or microwave component out of sand and plastic resins. The resulting metal castings are reported to be extremely accurate dimensionally.

Use of casting molds for microwave waveguides and components offers many advantages when considered against precision machining and tooling techniques employed hitherto. Almost immediate duplication of any desired quantity of microwave components is possible. Also firms desiring to cast with special metal mixes of their own choosing need only to purchase the mold forms for the components desired. Where flanges or other discontinuities are involved, direct casting of same minimizes any possible mismatches. The development culminates five years of effort by Samuel Freedman, general manager of Sightmaster of California to resolve and perfect the problem of cheaply and more expeditiously producing microwave components where sizes and shapes are many, while quantity of individual items are few. Microwave components built under this new process will be ready for marketing within 60 days.

New Video Recorder

A new video recorder has been introduced by Allen B. Du Mont Labs., Inc. It employes a 7-in. special high voltage, high definition blue phosphor tube, the Type K1080-P11. The electromagnetically focused tube is aluminized to give double the normal light output, improve overall tonal gradation in dark areas and eliminate the need for an ion trap.

To maintain highlight definition, beam current is kept at a minimum but the accelerating voltage is raised to 30.

Video amplifiers used in the unit are flat to 10 MC. In addition, the Du Mont video recorder is equipped with a gamma correction section in the video amplifier to compensate for the compression of the shadow tones due to the inherent characteristics of recording cathode-ray tubes.