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VOL. 1, NO. 4 • DEC. 1955 - JAN. 1956

RCA ENGINEER

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TECHNICAL JOURNAL PUBLISHED BY **RADIO CORPORATION OF AMERICA,** PRODUCT ENGINEERING, CAMDEN, N. J.

Send all inquiries to Bldg. 2-8, Camden, N. J.

OBJECTIVES

To disseminate to the RCA engineer technical information of professional value.

To publish in an appropriate manner the important technical developments at RCA, and the part played by contributing engineers.

To serve as a medium of interchange of technical information between various engineering groups.

To create a community of engineering interest within the company by stressing the interrelated nature of all technical contributions.

To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.

To provide a convenient means by which the RCA engineer may review his professional work before associates and engineering management.

To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.

OUR COVER

THE RCA BIZMAC System is the Subject of our cover this issue. R. E. Montijo, Design and Development Engineer (standing) and R. H. Strominger, BIZMAC Equipment Operator are shown inspecting a section of the BIZMAC Tapefile. Lower file drawer contains Tape Station, upper has electronic amplifying and control circuits. For a description of the BIZMAC System see articles in this issue by J. W. Leas and W. K. Halstead.

A COMMUNITY OF ENGINEERING INTEREST

It is no accident that a fraternal atmosphere pervades the many fields of engineering. The interrelated nature of all technical endeavor is a result of certain similarities that exist between all phases of engineering. For example, (1) The same basic scientific laws apply to all technical fields (2) all engineers have the same goal of achieving the optimum design and (3) a free exchange of knowledge is a necessary requirement in solving the complicated technical problems of today.

Development and design in electronics today require the coordinated effort of engineers from practically every field — electrical, mechanical, physical and chemical, optical — and many more to arrive at the best possible electronic product designs. Each engineer knows that he must rely on associates to assist and guide him in areas in which he does not specialize. Today, he expects and receives this assistance, and freely gives of his own store of knowledge. This is the true spirit of a community of engineering interest! RCA engineers, famous for their pioneering and quality engineering, continue to accomplish their goals by fostering this community spirit.

It is, therefore, appropriate that the RCA ENGINEER magazine includes the "creation of a community of engineering interest" among its objectives.

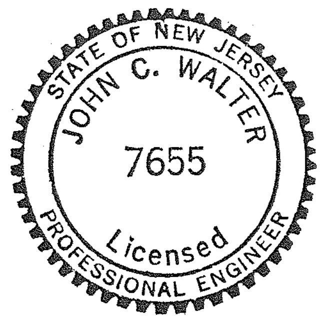
Vice President
Product Engineering
Radio Corporation of America

THE REGISTERED PROFESSIONAL ENGINEER

THE NATIONAL Society of Professional Engineers (NSPE) has expressed its belief in the precept that as engineering assumes a more important professional status, responsibility accrues to each individual to be representative of a learned profession. This fundamental belief is exemplified in the organization of NSPE and in its programs by their emphasis on the individual member and by the firm resolution that only as individuals are accorded professional status will the engineering profession assume the position to which it is entitled. Such professional status, however, is not bestowed upon individuals unless so merited.

INCREASED STATURE

The integration of the recent graduate into the engineering world is a most important matter, both for the young man himself and for the future of the profession. We must expect to give increasing attention to this question, to take every opportunity to inculcate the spirit of professionalism in our younger men, and to promote the ideal of attaining professional registration, as an important step toward increased stature.



by **J. C. WALTER, P.E.**
Chief Product Engineer
Communications Engineering
Engineering Products Division
Camden, N. J.

REGISTRATION LAWS

Several years ago the registration laws in the various States were anything but uniform. In recent years, however, a majority of the States have adopted more or less uniform registration requirements based upon recommendations of NSPE, the Engineers Joint Council (EJC) and other professional organizations.

New Jersey has an excellent registration law that is exemplary of the highest recommended standards. The State Board of Professional Engineers and Land Surveyors administers this law under the jurisdiction of the Department of Law and Public Safety, Division of Professional Boards.

HOW TO ATTAIN REGISTRATION

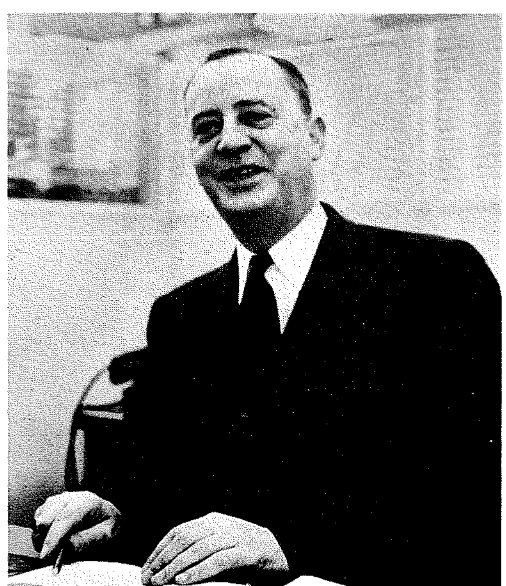
There are two ways to attain registration under the model law. The first method permits the recent graduate to sit for a written examination in Basic Engineering Sciences and upon successful completion thereof, to apply for registration as an Engineer-in-Training. After having acquired the requisite number of years of responsible engineering experience he becomes qualified for examination in the remaining two elements. These are: Part 2—Structural Design, and Part 3—Major Field of Engineering—(i.e., Civil, Mechanical, Electrical, Chemical or Mining Engineering).

The second method is the direct application by those engineers who have already acquired the necessary experience in engagements of increasing professional responsibility. Such qualified applicants may sit for all three phases of the examination.

J. C. WALTER, Chief Product Engineer of Communications Engineering, J. C. Walter was graduated from the University of Notre Dame, in 1924. Following three years of radio-telegraph work in Central America, he designed high-power carrier current systems.

Mr. Walter began his RCA career in 1936 by designing 50-500 kw. broadcast transmitters. During World War II, he served with the Navy's Bureau of Ships and in the Pacific. Back with RCA in 1946, Mr. Walter supervised design of equipments such as a 150 kw. international broadcast transmitter, a 1000 kw. Navy telegraph transmitter and a color TV transmitter incorporating the first UHF transmission at 1000 kw. ERP.

Mr. Walter is a Member of the AIEE, American Society of Naval Engineers, Franklin Institute, NSPE and a Senior Member of IRE. He holds posts on AIEE Committees on Electronic Power Converters and Hot Cathode Power Converters. Mr. Walter also is a Commander, USNR.



QUALIFICATIONS

In either method the final issuance of a Professional License by the State is contingent upon the recommendations of the Board after consideration of all qualifying factors of the applicant. These factors include moral and ethical characteristics as well as technical proficiency and evidence of professional development.

Most engineers who have attained sufficient experience to qualify for direct application are likely to be concerned about their ability to pass a rigorous examination in Basic Engineering Sciences—Part 1 of the

Editor's Note: Our thanks to H. Krieger, Mgr., EPD Personnel and to the author for furnishing us the information necessary to complete the list of Registered Professional engineers in EPD. All other Divisions are also invited to send us their rosters for publication in future issues of the **RCA ENGINEER!**

REGISTERED PROFESSIONAL ENGINEERS IN ENGINEERING PRODUCTS

Name	Section	State	Licensed as	License No.
E. Ackerlind	582	Calif.	Electrical Eng.	870
H. D. Albrecht	596	N.J.	Professional Eng.	6261
R. W. Allen	585	N.J.	Professional Eng.	7826
R. J. Ansell	595	Ohio	Electrical Eng.	12002
F. F. Appleton	596	Mo.	Mech. & Struct.	E 4023
J. J. Ayres	585	N.J.	Professional Eng.	7820
R. F. Bailey	591	Ill.	Professional Eng.	10521
R. H. Baker	577	Calif.	Mechanical Eng.	ME 9114
R. Beagles	582	Calif.	Electrical Eng.	780
H. J. Benzuly	587	N.J.	Professional Eng.	8645
F. C. Blancha	587	N.J.	Professional Eng.	6013
W. H. Brearley, Jr.	577	Del.	Professional Eng.	989
W. H. Brearley, Jr.		N.J.	Professional Eng.	7645
W. H. Brearley, Jr.		N.Y.	Professional Eng.	025173
W. H. Brearley, Jr.		Ohio	Professional Eng.	17250
W. H. Brearley, Jr.		Penna.	Professional Eng.	11357
R. Bricker	582	Calif.	Mechanical Eng.	9803
L. A. Brockwell	589	N.Y.	Professional Eng.	25174
P. Bronckhurst	582	Calif.	Mechanical Eng.	8197
I. Brown	593	Penna.	Electrical Eng.	1536-E
J. M. Brumbaugh	591	Penna.	Electrical Eng.	—
M. J. Campanella	596	N.J.	Professional Eng.	8858
J. B. Cecil	596	Neb.	Electrical Eng.	E 697
D. R. Crosby	584	N.J.	Professional Eng.	8401
W. C. Curtis	579	Ala.	Electrical Eng.	901
J. D. Duffin	596	N.J.	Professional Eng.	8653
R. P. Dunphy	572	Wash., D.C.	Professional Eng.	2283
H. R. Dyson	594	N.J.	Professional Eng.	5946
J. E. Eiselein	599	N.J.	Professional Eng.	PE 6215
C. Felheimer	595	Ala.	Professional Eng.	1617
F. H. Fowler, Jr.	598	N.Y.	Professional Eng.	20943 P-E
F. H. Fowler, Jr.	598	Wash., D.C.	Professional Eng.	3206
J. German	596	N.J.	Professional Eng.	8825
R. W. Greenwood	578	Penna.	Electrical Eng.	15496
J. I. Herzlinger	580	N.J.	Professional Eng.	6095
D. B. Holmes	596	N.J.	Electrical Eng.	7152
D. G. Hymas	584	Can.	Electrical Eng.	9830
A. F. Inglis	587	Wash., D.C.	Professional Eng.	168
S. L. Katten	596	Penna.	Mechanical Eng.	1740-E
B. P. Kerfoot	596	N.J.	Professional Eng.	8449
J. Kimmel	577	Penna.	Electrical Eng.	9271
G. W. K. King	593	Mich.	Professional Eng.	6590
G. W. K. King		Penna.	Professional Eng.	2233-E
L. J. Krawitz	581	N.J.	Eng.-in-Training	302
I. D. Kruger	596	N.J.	Professional Eng.	6262
G. H. Kunstadt	580	Mass.	Professional Eng.	6471
H. J. Laiming	585	N.J.	Professional Eng.	6245
K. S. Lewison	589	N.Y.	Professional Eng.	27728
R. J. Linhardt	580	N.Y.	Professional Eng.	28339 P-E
R. J. Linhardt		N.J.	Professional Eng.	8241
J. E. Love	596	N.J.	Professional Eng.	5758
H. S. Markstone	572	Penna.	Mechanical Eng.	10865
T. Mead	598	Calif.	Mechanical Eng.	6560
W. F. Meeker	593	N.Y.	Professional Eng.	23710 P-E
R. L. Meisenheimer	589	N.J.	Professional Eng.	8648
I. K. Munson	577	Wash., D.C.	Elec./Electronics	2321
H. H. Nishino	596	Calif.	Professional Eng.	—
G. V. Nolde	598	Calif.	Electrical Eng.	630
D. J. Oda	580	Ind.	Eng.-in-Training	2080
C. C. Osgood	591	Maine	Mechanical Eng.	651
J. F. Page	598	N.J.	Professional Eng.	8876
S. R. Parker	598	N.Y.	Professional Eng.	28390 P-E
S. R. Parker		N.J.	Professional Eng.	8091
E. M. Pritchard	594	Mass.	Professional Eng.	6607
R. S. Putnam	596	N.J.	Professional Eng.	8839
T. C. Reeves	577	Penna.	Mechanical Eng.	2332-E
C. M. Ryerson	599	Wash., D.C.	Professional Eng.	2105
V. A. Schlenker	593	N.Y.	Professional Eng.	10863 P-E
V. A. Schlenker		N.J.	Electrical Eng.	3111 EE
E. N. Scott	596	N.J.	Professional Eng.	8853
I. Scott	596	Penna.	Mechanical Eng.	14398
H. C. Shepard	587	N.J.	Professional Eng.	7322
H. J. Siegel	596	N.Y.	Professional Eng.	21548
H. J. Siegel	596	Fla.	Mechanical Eng.	3148
J. Smith	582	Calif.	Electrical Eng.	4155
E. Smuckler	582	Calif.	Electrical Eng.	4506
I. Sofen	582	Calif.	Electrical Eng.	4697
K. Solomon	585	Wash., D.C.	Eng.-in-Training	—
L. Swartz	580	Penna.	Mechanical Eng.	14343
F. H. Symes	598	Ind.	Civil Engineer	3127
A. Vose	582	Calif.	Electrical Eng.	4844
S. Wald	581	N.J.	Professional Eng.	PE 5611
J. C. Walter	584	N.J.	Professional Eng.	7655
H. Waters	582	Calif.	Mechanical Eng.	8154
H. R. Wege	596	N.J.	Professional Eng.	8159
B. F. Wheeler	584	N.J.	Professional Eng.	8083
F. W. Widmann	596	N.J.	Professional Eng.	8131
G. H. Williams	585	N.J.	Professional Eng.	7768
H. S. Wilson	584	Ont.	Professional Eng.	10302
E. Witkin	577	Penna.	Professional Eng.	2491-E

THE REGISTERED ENGINEER
continued

written examination. Similarly, Electrical Engineers who have specialized in Communications or Electronics—especially in product design—may feel a bit rusty in Part 2, Structural Design.

Review courses helpful in preparing for the State Board examinations are given locally on an annual schedule by Rutgers University and others. The Rutgers course for Part 3, Electrical Engineering is currently being given by D. R. Crosby, P.E., of our Communications Engineering Department.

APPLY TO STATE BOARD

Qualified engineers interested in registration should request information directly from the State Board. Upon request, the Board will forward appropriate application blanks and all necessary information concerning statutory requirements. Inquiries should be made to the appropriate State Board as listed below. Written examinations are presently held in May and November of each year by the N. J. Board.

A roster of Registered Professional Engineers employed by RCA in the Engineering Products Division appears elsewhere in this issue. Its publication is intended both as a token of recognition and as an incentive for other engineers to aim for acknowledged professional status.

WHERE TO GET INFORMATION ON PROFESSIONAL ENGINEERING REGISTRATION

If you live in . . .	Write to State Board of Engineering Examiners, care of . . .
Alabama	Clifton C. Cobb, executive secretary, 609 Monroe St., Montgomery
Alaska	Linn A. Forrest, secretary, Box 251, Juneau
Arizona	Mrs. Rayma Neeb, executive secretary, Room 319, Arizona Title Bldg., 128 N. 1st St., Phoenix
Arkansas	V. E. Scott, secretary, Box 175, Pulaski Hts. Station, Little Rock
California	William A. White, executive secretary, 529 Business & Professional Bldg., Sacramento
Colorado	M. E. Langsteiner, asst. secretary, 20 Capitol Bldg., Denver
Connecticut	William K. Simpson, secretary, 30 Oak St., Hartford 6
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Idaho	S. M. Barton, asst. secretary, 623½ Main St., Boise
Illinois	Fedric B. Selcke, supt. of registration, State House, Springfield
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Kentucky	C. S. Crouse, secretary, c/o Univ. of Kentucky, Lexington
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Minnesota	Helen D. Carlson, executive secretary, 316 New York Bldg., St. Paul 1
Mississippi	O. B. Curtis Sr., secretary, P.O. Box 3, Jackson
Missouri	Mrs. Clemie V. Wall, secretary, Box 184, Jefferson City
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Nebraska	Roy M. Green, secretary, 210 Ferguson Hall, Univ. of Nebraska, Lincoln 8
Nevada	Stanley G. Palmer, secretary, c/o College of Engineering, Univ. of Nevada, Reno
New Hampshire	Henry T. Spear, acting secretary, P.O. Box 235, Laconia
New Jersey	Thomas E. Heathcote, secretary-director, 921 Bergen Ave., Jersey City 6
New Mexico	John R. Erickson, secretary, P.O. Box 1079, Santa Fe
New York	Newell L. Freeman, secretary, 23 South Pearl St., Albany
North Carolina	Robert B. Rice, secretary, c/o Dept. of Diesel Engineering, N. C. State College, Raleigh
North Dakota	A. L. Bavone, secretary, P.O. Box 1265, Minot
Ohio	Robert N. Waid, secretary, 21 West Broad St., Columbus 15
Oklahoma	Gwynne B. Hill, secretary, 2901 Classen Blvd., Oklahoma City 6
Oregon	E. A. Buckhorn, secretary, 717 Board of Trade Bldg., Portland
Pennsylvania	Miss Rebecca J. Nickles, secretary, 324 Education Bldg., Harrisburg
Puerto Rico	Joaquin Mercado-Cruz, secretary-treasurer, P.O. Box 9156, Santurce
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Vermont	Walter D. Emerson, secretary, c/o Norwich Univ., Northfield
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West Virginia	Robert Williamson Jr., secretary, 301 Morrison Bldg., Charleston
Wisconsin	W. A. Piper, secretary, 1140 State Office Bldg., Madison 2
Wyoming	Mrs. Wilma H. Lang, asst. secretary, 201 State Capitol Bldg., Cheyenne

Chart by Courtesy of Machine Design (Oct. 1955)

CRYSTAL SELECTION IN STABILIZED FREQUENCY CONTROL

by **E. M. WASHBURN & R. R. BIGLER**
Frequency Control Engineering
Engineering Products Division
Camden, N. J.

FREQUENCY CONTROL is the key to any reliable radio communications system. For the most efficient utilization of our over-crowded frequency spectrum, precise, reliable and stable frequency control is imperative.

The initial source of frequency control is an oscillator, which may be any one of four types: LC, RC, magnetostrictive, or crystal.

BASIC OSCILLATOR TYPES

The LC Oscillator is most widely known and used, but this general type does not produce a very accurate or stable frequency. Some special designs are capable of ±.01% accuracy. A typical example is the HF oscillator used in general coverage superheterodyne receivers.

The RC Oscillators are used predominantly for audio and very low radio frequencies. They are very seldom used for direct-frequency control because of their rather poor stability. An example is the oscillator used in audio test equipment.

The Magnetostrictive Oscillator shows promise at low radio frequencies. While the principle of this type of oscillator has been known for many years, practical application has lagged until quite recently. They have a potential accuracy of ±.01%. One example is the beat frequency oscillator in the AN/ARC-21 Air Force equipment.

The Crystal Oscillator or Crystal Controlled Oscillator covers the widest frequency range of any of the common oscillators, yet achieves a high order of accuracy and stability. Oscillators controlled by quartz crystals are now available over the frequency range of 800 cycles to 150 megacycles. Crystal oscillators, while very stable and accurate when properly designed, still are limited to but one frequency per crystal unit.

FREQUENCY SYNTHESIS

Various schemes have been utilized to retain the accuracy and stability of crystal control and yet also obtain some of the flexibility of master oscillator operation. The term "frequency synthesis" is often used to describe these schemes.

Direct synthesis is the process whereby the desired output frequency is obtained by addition, subtraction, multiplication, or division of specific frequencies which may be generated from one base oscillator or from multiple oscillators. In general, direct synthesis presents rather severe problems in the relationship of unwanted frequencies to the desired frequency.

The second class of frequency synthesis is the comparison or monitor type. In this group a master oscillator operates at the output frequency and is monitored by a series of control circuits which compare the master oscillator to the base frequency in a ratio specified by the operator's setting of the controls. Servo-mechanisms then constantly correct any drift of the oscillator from the desired ratio. This system, in general, reduces the problems associated with spurious or unwanted radiations.

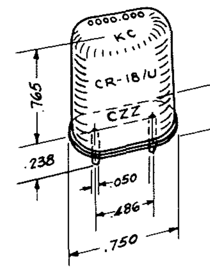


Fig. 1—CR-18/U

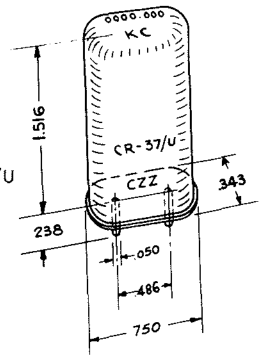


Fig. 2—CR-37/U

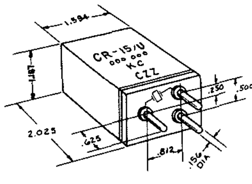


Fig. 3—CR-15/U

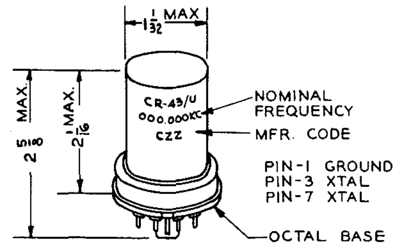


Fig. 4—CR-43/U

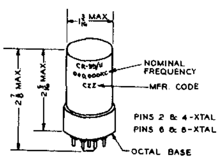


Fig. 5—CR-39/U

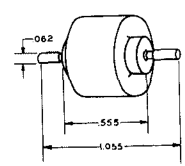
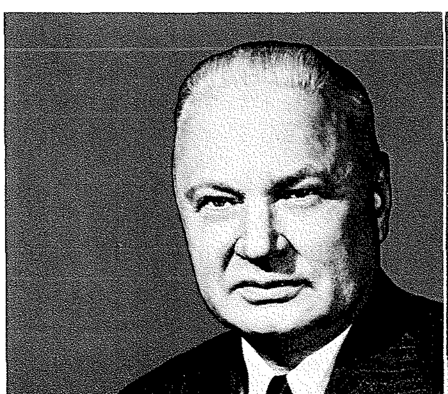


Fig. 6—CR-24/U

E. M. Washburn



R. R. Bigler

EDWARD M. WASHBURN received his B.S. degree in E.E. from the University of Vermont in 1916. He was employed by the Votey Organ Co. until the end of 1929, first as Chief Draftsman and later as Assistant Superintendant. He joined early in 1930, starting as draftsman and progressively working up to engineer on Broadcast and Police Transmitters. In 1941 he was appointed manager of the Frequency Control Engineering Section where he has served to date. Mr. Washburn is a Senior Member of the IRE and Secretary of the RETMA subcommittee SQ-1 on quartz crystals.

ROBERT R. BIGLER graduated from Ohio State University in 1941 with a degree of B.E.E., and joined Collins Radio, Cedar Rapids, Iowa.

In World War II he served in the Signal Corps, rising to rank of Captain. He returned to Collins Radio in 1946 specializing on quartz crystal utilization. He joined RCA in 1949 where he has served to date in the Frequency Control Engineering Section, specializing on circuitry. He has one patent and two patent disclosures to his credit.

TABLE I

QUARTZ CRYSTAL UNIT CHART
(FOR DETAILED SPECIFICATIONS REFER TO MIL-C-3098A)

CRYSTAL UNIT FREQUENCY	SERIES RESONANCE TYPE	PARALLEL RESONANCE		FREQUENCY TOLERANCE PERCENT	TEMP. RANGE °C	HOLDER TYPE	FIGURE NO.
		TYPE	LOAD CAP. MMFD				
16-100 KC	CR-50/U	CR-38/U	20	±.012	—40 +70	HC-13/U	2
75-100 KC		CR-43/U	45	±.01	—30 +75	HC-16/U	4
80-200 KC	CR-16/U	CR-15/U	32	±.01	—40 +70	HC-5/U	3
80-200 KC	CR-30/U	CR-29/U	32	±.002	75	HC-5/U	3
90-250 KC		CR-37/U	20	±.02	—40 +70	HC-13/U	2
90-250 KC		CR-42/U	32	±.003	75	HC-13/U	2
160-330 KC	CR-39/U			±.007	—55 +75	HC-15/U	5
160-330 KC	CR-40/U			±.003	70	HC-15/U	5
200-500 KC	CR-25/U	CR-46/U	20	±.01	—40 +70	HC-6/U	1
200-500 KC	CR-26/U	CR-47/U	20	±.002	75	HC-6/U	1
800-15000 KC	CR-19/U	CR-18/U	32	±.005	—55 +90	HC-6/U	1
800-15000 KC		CR-27/U	32	±.002	75	HC-6/U	1
800-20000 KC	CR-28/U			±.002	75	HC-6/U	1
800-20000 KC	CR-35/U			±.002	85	HC-6/U	1
800-15000 KC		CR-36/U	32	±.002	85	HC-6/U	1
800-3000 KC	CR-49/U	CR-48/U	32	±.0075	—55 +90	HC-6/U	1
10-25 MC		CR-33/U	32	±.005	—55 +90	HC-6/U	1
10-61 MC	CR-51/U	Unplated		±.005	—55 +90	HC-6/U	1
10-61 MC	CR-52/U			±.005	—55 +90	HC-6/U	1
10-75 MC	CR-23/U			±.005	—55 +90	HC-6/U	1
10-75 MC	CR-32/U			±.002	75	HC-6/U	1
15-20 MC	FUND.	CR-44/U	32	±.002	85	HC-6/U	1
15-50 MC	CR-24/U			±.005	—55 +90	HC-10/U	6
50-87 MC	CR-53/U	Unplated		±.005	—55 +90	HC-6/U	1
50-87 MC	CR-54/U			±.005	—55 +90	HC-6/U	1

BASIC FREQUENCY CONTROL

The basic method of frequency control presently available is the crystal controlled oscillator. Many misconceptions about crystal control have grown up over the years. A crystal unit when used properly can produce fantastic accuracies, and reliabilities approaching perfection. The identical crystal unit used incorrectly may result in extremely unreliable operation and astounding inaccuracies.

For successful frequency control the cardinal rule to follow must be, *The crystal oscillator is for stabilized frequency control only!* The day of the crystal controlled power oscillator is finished.

CRYSTAL STANDARDS

Through years of experience and the combined recommendations of many equipment and crystal manufacturers, certain standard conditions of crystal operation have evolved. The Military Services have specified standard crystal units for Service applications. All crystal suppliers know of these designations, and engineers who are familiar with Military Specifications MIL-C-3098A instinctively turn to that folder for guidance in choosing a suitable crystal unit for a specific application. Reference to those data sheets is highly advisable, whether the application be government or commercial. This paper is presented largely to encourage this practice and to provide information which describes briefly the basic properties of the most common crystal unit types. In addition to the performance data, reference is made in the included charts under each unit to an illustration which shows its dimensions, and also to one or more typical circuits in which the crystal unit should give satisfactory performance.

Table I shows 32 different "CR" type crystal units and their standardized frequency ranges, operating conditions and maximum permissible frequency deviations as functions of temperature change. Eighteen of these units are intended for use at series resonance and fourteen at anti-resonance into a load capacitance between 20 and 45 mmfds as shown. Ten units are for temperature controlled operation at 70°C, 75°C or 85°C, while the balance are intended to provide low frequency deviations when subjected to wide changes in temperature, such as ±.005% (50 cycles per megacycle) over the range of —55°C to +90°C.

For Government equipment a standard crystal unit should be selected from this chart, without any exceptions, and it should be noted that HC-

6/U type crystals with pig-tail leads are *not* standard. For commercial applications it is permissible to make minor exceptions, such as specifying a narrower temperature range or a wider frequency tolerance. The chart does not indicate limits of crystal unit activity or to use the more modern term, limits of maximum permissible effective resistance. The referenced specifications MIL-C-3098A do give that information which is appropriate for both Government and Commercial crystal units.

Crystals designed for use at a fixed elevated temperature may be employed in small commercial ovens available from several sources. Such ovens may be specified to operate from 6.3 volts, 12 volts or 24 volts and to hold the crystal unit at the specified temperature within about ±5°C. These are quite satisfactory in many types of equipment where space is at a premium and component costs are a major factor. For greater frequency stability and reliability, the TMV-129-N or TMV-129-Q4 RCA oven may be employed for any crystal which is mounted in an HC-6/U holder. The frequency stability realized by use of either of these RCA ovens is usually more than 10 to 1 better than by use of the smaller commercial ovens. Furthermore, the reliability of performance is greatly increased by selection of the TMV-129 type oven, largely due to the premium type thermostat employed. These RCA ovens have the further advantage of operating directly from 115 volt lines, without the use of any step-down transformer.

Table II lists eleven types of RCA temperature controlled ovens, using the same basic heater, thermostat, compensator, outer case and 6-prong base. These units primarily are for use in broadcast transmitters and other critical applications where maximum frequency precision and performance reliability are the paramount considerations. They require a special six-prong socket. An external 110 volt pilot lamp may be used to in-

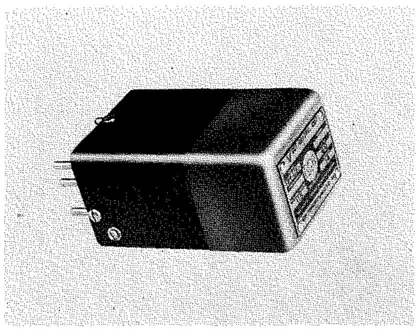


Fig. 7—TMV-129-G Crystal Oven

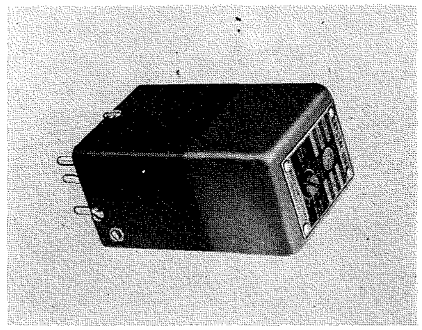


Fig. 8—TMV-129-F Crystal Oven

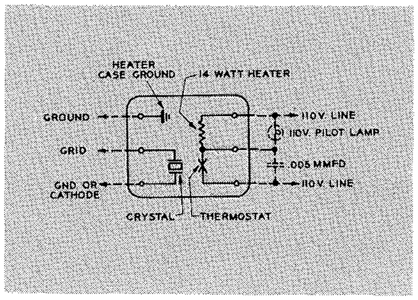


Fig. 9—Bottom view TMV-129 unit

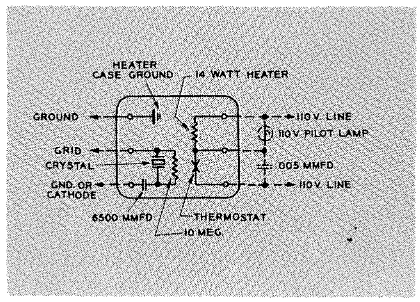


Fig. 10—Bottom View TMV-129-B Unit

TABLE II
RCA TEMPERATURE CONTROLLED CRYSTAL UNITS

CRYSTAL UNIT FREQUENCY	RCA TYPE	OPERATING TEMPERATURE °C	AMBIENT RANGE °C	TYPICAL USE	FIGURE NO.	SCHEMATIC NO.
70-350 KC	TMV-129-G	70	—15 +65	Low freq.	7	9
325-3000 KC	TMV-129-B	60	—25 +55	Broadcast	7	10
500 KC Up	TMV-129-N	70	—15 +65	HC-6/U units	7	9
1800-8500 KC	TMV-129-F	60	—25 +55	Var. Freq.	8	9
2000-7500 KC	TMV-129-C	60	—25 +55	Fundamental	7	9
2000-8000 KC	TMV-129-C1	60	—25 +55	VHF T.V.	7	9
2000-8000 KC	TMV-129-C2	60	—25 +55	VHF T.V.	7	9
2000-8000 KC	TMV-129-C3	60	—25 +55	VHF T.V.	7	9
9000-14000 KC	TMV-129-Q4	75	—10 +70	VHF T.V.	7	9
7.5-20 MC	TMV-129-C	60	—25 +55	Overtone	7	9
20-45 MC	TMV-129-P	75	—10 +70	UHF T.V.	7	9

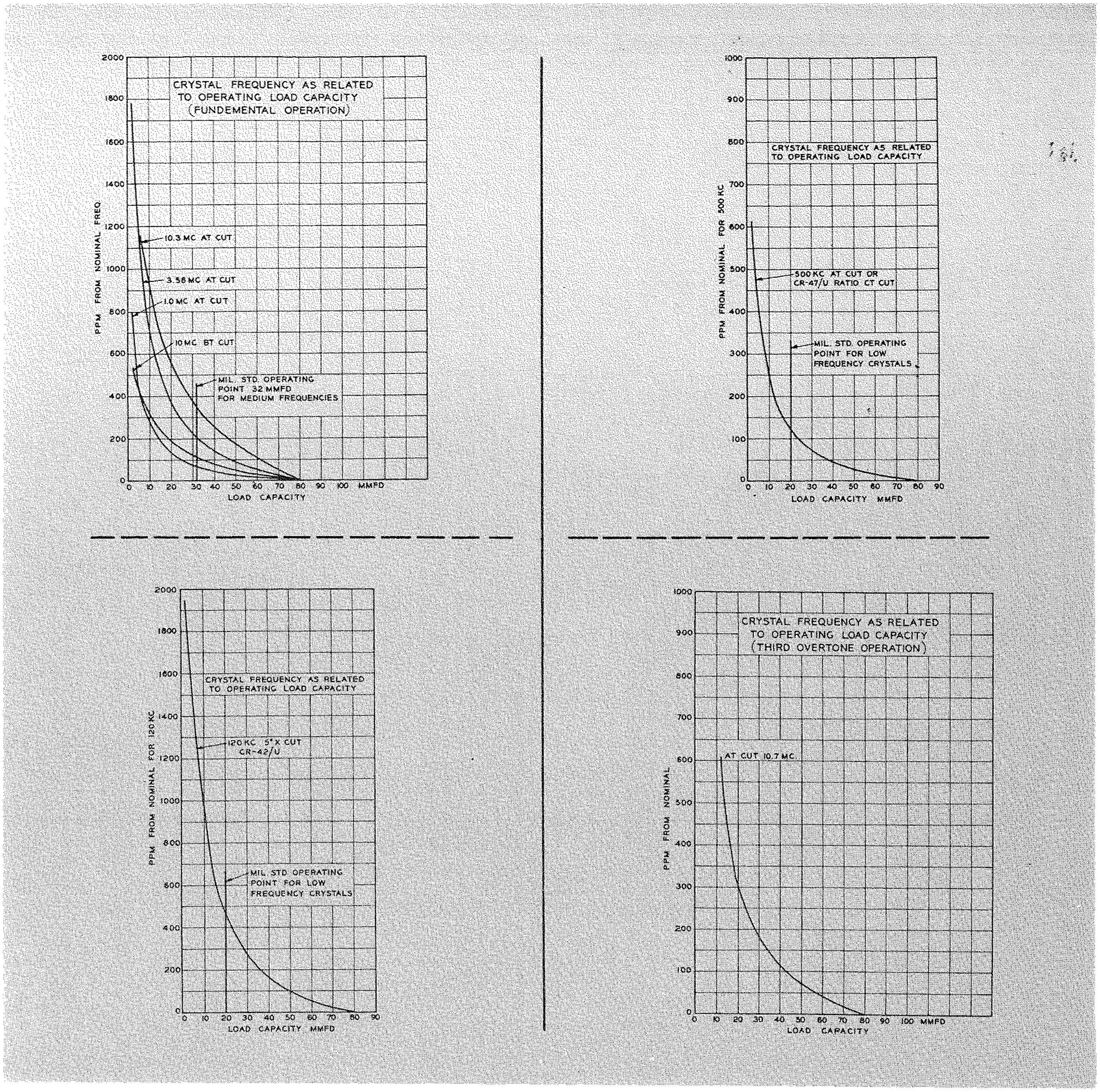


Fig. 11, 12, 13, 14—Relationship of frequency to load capacitance for several representative crystal units

dicate thermostat cycling and a .005 mfd capacitor should be connected across the thermostat terminals as shown in the illustrations Figs. 9 and 10.

CRYSTAL CIRCUITRY CONSIDERATIONS

The circuits in which these crystal units are employed must include some scheme of varying the crystal frequency for adjustment to zero beat and to compensate for minor aging effects as well as for differences in circuits and tubes. After this adjustment has been made, units of the TMV-129 series maintain exceptionally stable frequencies, in the order of plus or minus 1 or 2 cycles at the lower frequencies and less than $\pm .0001\%$ at higher frequencies.

Zero beat adjustment of a crystal oscillator usually is obtained by a small variable capacitor in the oscillator control-grid circuit. The relationship of frequency to load capacitance is shown in Figs. 11, 12, 13, and 14 for several representative crystal units. As will be recognized from the curves, convenient practical compromises exist between the desire for a "rubber" crystal oscillator and the desire for rigid stabilized control. These points are 20 mmfd and 32 mmfd for the operating load capacity. The slope of df/dC_L is observed to rise very steeply as the load capacity C_L becomes small. As a consequence, to expect an accuracy of $\pm .0012\%$ with a load capacity of 5 mmfd is unduly optimistic. The slightest change in effective load capacity caused by tube or component variation may cause the frequency to exceed the specified limits.

From an inspection of these curves the reader can readily see the disadvantage in operating at very low load capacities. For example: A "plus or minus 50 ppm" ($\pm .005\%$) oscillator is desired with no trimmer capacitor. At a 5 mmfd operating load capacity the slope of the frequency-load capacity curve is 125 ppm/mmfd. A deviation of 0.1 mmfd from one oscillator to another would cause a frequency shift of 12.5 ppm, one fourth of the permissible tolerance. At a load capacity of 32 mmfd the curve has a slope of 10 ppm/mmfd. Under these conditions a shift in operating capacity of 0.5 mmfd would cause a 5 ppm shift, one-tenth of the tolerance. The standard load capacity established by the Armed Services is 32 ($\pm$0.5) mmfd.

The exact frequency of a crystal oscillator is influenced by the drive level as well as by the load capacity. When an overall frequency tolerance is $\pm$0.1%, a shift in frequency due to drive level changes of $\pm$.005% is negligible, but for an overall tolerance of $\pm$.005% a shift due to drive level of $\pm$.001% becomes very serious. The old test of placing a 60 ma pilot light bulb in series with the crystal as an indicator of drive level is completely and unequivocally out of date. Modern crystals, with their potentially superior performance, are designed for maximum power dissipation levels of 0.1 to 20 milli-watts in the crystal unit itself, depending upon frequency.

The power output of crystal oscillators should be held to very low levels if the full potentialities of crystal frequency control are to be realized. A recent publication, National Bureau of Standards Report 3749, covers the design of a very precise frequency standard. The output of the two-stage oscillator is less than 0.5 milli-watt. For lower orders of stability higher outputs are permissible.

TYPICAL OSCILLATOR CIRCUITS

Some typical oscillator circuits are briefly outlined in the following paragraphs. The exact components of the oscillators and the selection of the type of oscillator is influenced by many factors such as frequency, accuracy and reliability, to name a few. The basic families of oscillators may be defined as fundamental oscillators, overtone oscillators, and special application oscillators, which may be some version of either of the first two.

The fundamental frequency oscillators would have basic circuits as shown in Figs. 15, 16, and 17. The electron coupled oscillator is very desirable because of the decoupling between the oscillator portion and the output circuit.

There are many kinds of overtone oscillator circuits. The basic characteristic of an overtone oscillator is that the lowest frequency appearing in the circuit will be very near but not exactly equal to an odd harmonic of the frequency which would be found if the same crystal were to be plugged into a fundamental oscillator. Oscillation will occur only at odd overtones of the fundamental frequency, i.e. 3-5-7-9, etc. Two types of overtone oscillators are shown in Figs. 18 and 19.

Certain applications, where the utmost in stability and accuracy are desired, call for special oscillator circuits to maintain a low drive level and minimize the effect of changes in components upon the frequency. The best known of these is the Meecham Bridge which is often used for frequency standards. A second type which is beginning to find acceptance uses a form of AGC. It is currently being used in the TS-710/TSM CI meter. These two circuits are diagrammed in Figs. 20 and 21.

It is hoped that this article will be found of assistance to many engineers, but it is recognized that each particular crystal oscillator design will raise questions not answered in this paper. The Frequency Control Engineering Section in Building 6-4, Camden, will be glad to give detailed consideration and offer recommendations for specific problems pertaining to stabilized frequency control.

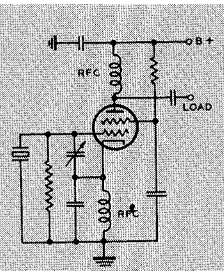


Fig. 15—Electron Coupled Colpitts Oscillator

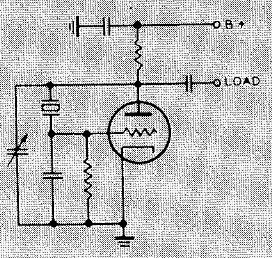


Fig. 16—Pierce Oscillator

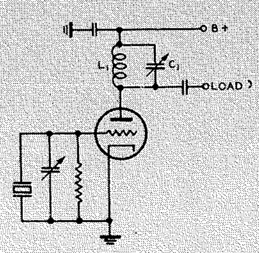


Fig. 17—Miller Oscillator

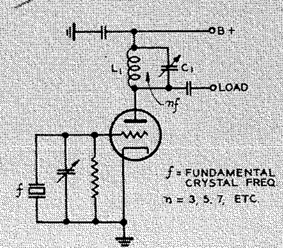


Fig. 18—Miller Overtone Oscillator (medium frequencies)

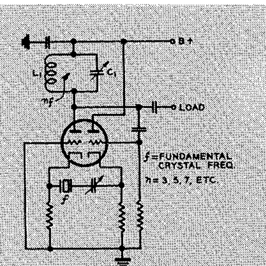


Fig. 19—Butler Overtone Oscillator for high frequencies (series resonance operation)

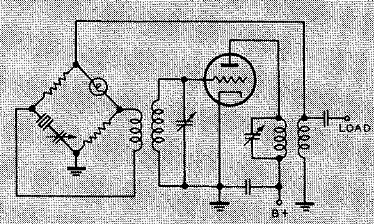


Fig. 20—Meecham Bridge Oscillator (series resonance operation)

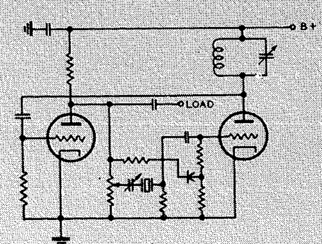


Fig. 21—Low Frequency Crystal Impedance Meter Oscillator (series resonance operation)

ENGINEERING THE RCA BIZMAC SYSTEM

by **J. WESLEY LEAS**
Chief Product Engineer, Computer Engineering
Engineering Products Division, Camden, N. J.

ENGINEERING effort on RCA business machines started in 1949. In the intervening years, RCA has designed a complete electronic data processing system, which is now being installed at the U. S. Army Ordnance Tank-Automotive Command in Detroit. It is the largest electronic data processing system ever built.

From the early conception to the present climax, the engineering program can be traced through a number of important stages:

The first inquiries by a task force of RCA system engineers, marketing personnel and consultants into the application problems;

The advanced development of computer circuits and associated mechanisms;

The "logic" design, programming, and construction of RCA's first large digital computer which was put into operation in 1953;

The very substantial equipment development and design effort which expanded the early concepts, brought in new techniques, reflected the increasing knowledge about the expected uses, and brought into being the complete system described on the succeeding pages.

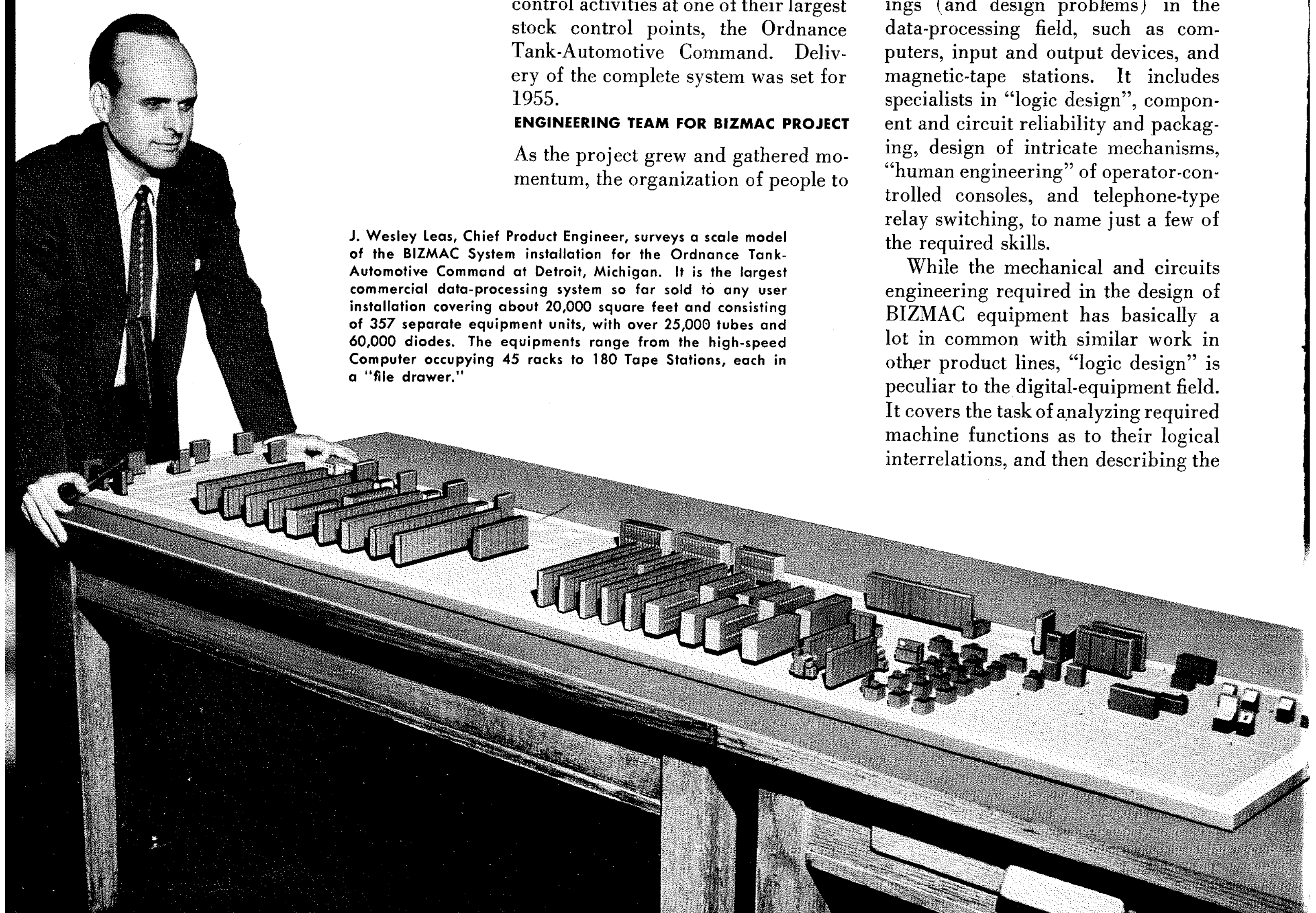
A contract was negotiated in 1951 with the Army Ordnance Corps for equipping one of their large supply depots (Letterkenny, Pa.) with the RCA BIZMAC electronic data processing system. In 1952, the Ordnance Corps requested enlargement of the contract to cover the inventory control activities at one of their largest stock control points, the Ordnance Tank-Automotive Command. Delivery of the complete system was set for 1955.

ENGINEERING TEAM FOR BIZMAC PROJECT

As the project grew and gathered momentum, the organization of people to handle it also expanded. The early work was undertaken by several teams of advanced development engineers, now in the General Engineering Development Section at Camden. At the beginning, this work was sparked by members of the RCA Laboratories Staff, who provided valuable system guidance and know-how in specialized techniques. The Computing Systems Engineering Section has the over-all engineering responsibility for the development and design of the BIZMAC System. To handle this task, two major engineering groups have been set up.

The Development and Design Group is concerned primarily with equipment engineering. It is organized to handle the major equipment groupings (and design problems) in the data-processing field, such as computers, input and output devices, and magnetic-tape stations. It includes specialists in "logic design", component and circuit reliability and packaging, design of intricate mechanisms, "human engineering" of operator-controlled consoles, and telephone-type relay switching, to name just a few of the required skills.

While the mechanical and circuits engineering required in the design of BIZMAC equipment has basically a lot in common with similar work in other product lines, "logic design" is peculiar to the digital-equipment field. It covers the task of analyzing required machine functions as to their logical interrelations, and then describing the



J. Wesley Leas, Chief Product Engineer, surveys a scale model of the BIZMAC System installation for the Ordnance Tank-Automotive Command at Detroit, Michigan. It is the largest commercial data-processing system so far sold to any user installation covering about 20,000 square feet and consisting of 357 separate equipment units, with over 25,000 tubes and 60,000 diodes. The equipments range from the high-speed Computer occupying 45 racks to 180 Tape Stations, each in a "file drawer."

whole machine in detail as a network which can be implemented with a given set of switching circuits such as gates, flip-flops, pulse amplifiers, etc.

The Systems and Advanced Product Development Group consists of three partially-related activities, two of which are quite peculiar to the digital computer field. One is concerned with the field of analysis and programming; that is to say, the analysis of work which is to be carried out by the BIZMAC system, and the development of techniques for creating the detailed operating instructions for the various machines in the system. In the data-processing field, the ability of equipment to carry out a specific job is very intimately related both to the details of the job and the detailed equipment characteristics. Tying the job and the equipment characteristics together is the joint task of the Analysts and Programmers, with representatives of BIZMAC Marketing. These units are staffed in part by mathematicians, and in part by professionals in the fields of economics, business administration and accounting.

Making the equipment function on a "day-in and day-out" basis is the task of the Operations Unit. These are people primarily concerned with getting equipment tested and working. They work closely with factory and model shop test personnel whom they are training in testing the BIZMAC equipment. They also have the job of analyzing the performance of equipment in the field, and providing support requested by the RCA Service Company, to make each installation a going concern.

There is an Advanced Development unit which is concerned with the development of new techniques and of selected new equipments. This group works in close collaboration with product design engineers, analysts and programmers, and also with the digital computer engineers of the General Engineering Development section and component development engineers of the Electronic Components Engineering, Tube Division, Camden, who are continuing to make valuable contributions.

To take advantage of digital engineering manpower at the West Coast, a Special Projects group was established early in 1955 at our West Los Angeles Plant.

RELATED RCA ACTIVITIES

There are related activities in RCA that must be mentioned to round out the picture of over-all teamwork that goes into this project. One such team member is the RCA Service Company which provides engineers specially trained to assure the proper operation and continued maintenance of BIZMAC equipment at customer installations.

Another is the product planning analysis staffs of the BIZMAC Marketing Department. Out of their work comes information regarding desirable changes in equipment performance, and for their work they get much information from the Engineering section, primarily through the analysis and programming work.

Several groups at the RCA Laboratories are continuing their work in fields which make contributions to the BIZMAC project. Dr. J. A. Rajchman's research work into magnetic core devices has provided a tremendous push forward in the art of designing reliable and fast digital computer equipment. Mr. C. J. Young's group, concerned with high-speed printing and character display techniques, has devised an image display tube capable of translating business machine code to visible characters at electronic speeds. The activity on the Electrofax process will provide a new technique of fast reproduction which, in conjunction with the display tube just mentioned, will lead to very high-speed electronic printing. Mr. R. Serrell's Computation Laboratory has also produced some important formal techniques for the logic design of digital equipment.

J. WESLEY LEAS, appointed head of Computer Engineering in 1952, received a BSEE degree from Ohio State University in 1938. Following three years of sales engineering work, Mr. Leas entered military service and went to England with the Electronics Training Group in 1942. He later joined the RAF Radar Laboratory. In the United States, he became Assistant Head for Engineering of the Combined Research Group at the Naval Research Laboratory. At war's end, Mr. Leas was appointed Airborne Radar Chief of the Airborne Instruments Laboratory. He afterward transferred to the Air Transport Association. In 1949, he joined the Air Navigation Development Board. He came to RCA in June 1951. A senior member of IRE, Mr. Leas also belongs to Eta Kappa Nu, the Association for Computing Machinery and the Armed Forces Communication Association.

DESIGN FOR RELIABILITY

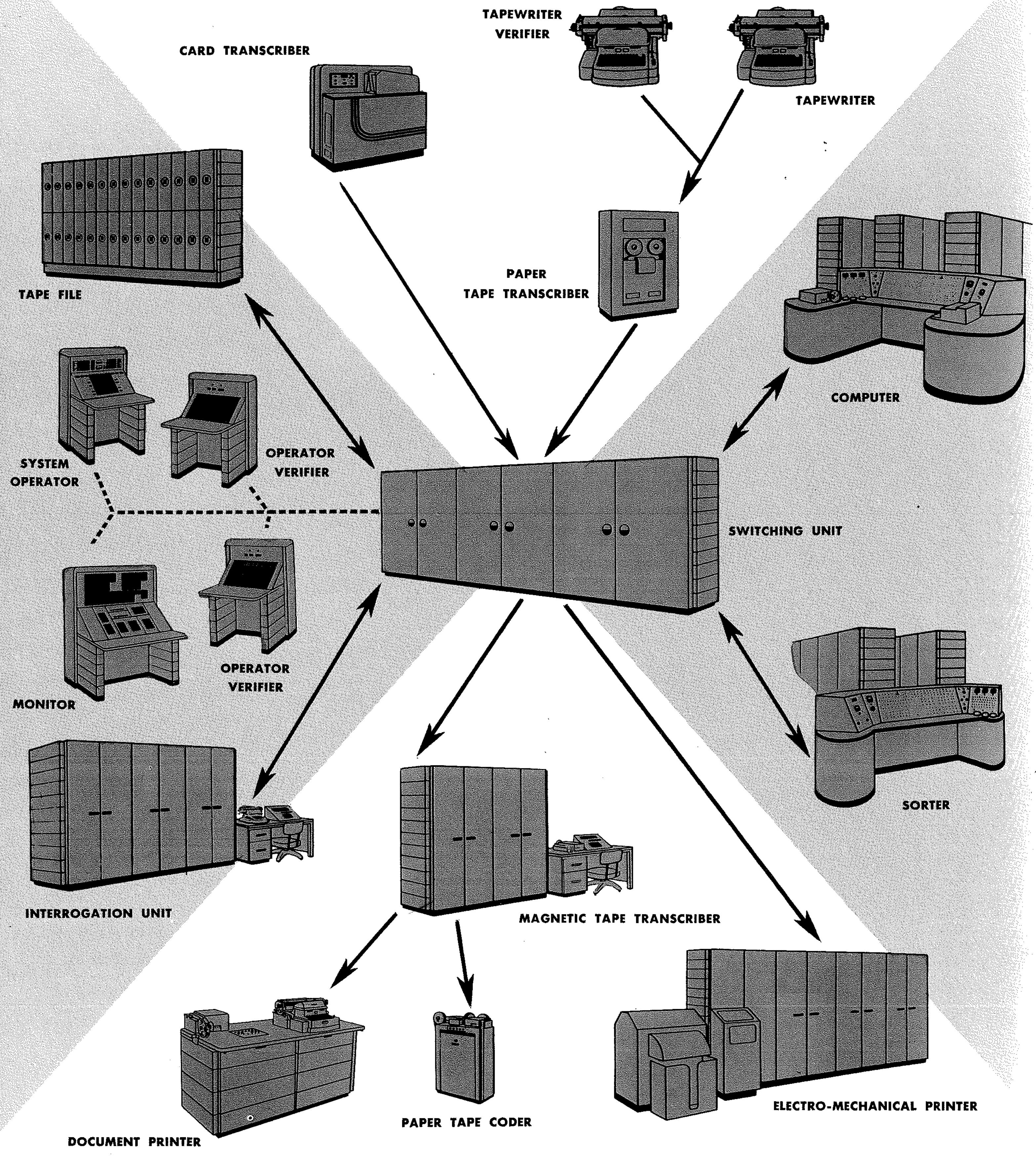
In the design of digital equipment, equipment reliability and data accuracy have a high-priority claim on the attention of the engineer.

Equipment reliability is expressed in sound and conservative designs of the many moving mechanisms, and in the deliberate de-rating of electronic components so that circuits will work over wide ranges of component characteristics, supply voltages, and signal amplitudes. All active circuits are assembled on "plug-in units" so that they may be quickly removed, and others of like design substituted without need for further trimming adjustments in the machines.

Control of data accuracy occurs in many ways in the BIZMAC System. Where there is a chance for human error, independent duplication or check-up is provided. BIZMAC machines have an abundance of built-in checking and warning devices which monitor the detailed functioning of the apparatus as well as the content and form of the data passing through. The BIZMAC character code itself is "redundant", i.e., it contains more elements than absolutely necessary to define each character, and the extra element in each character is used to guard against its accidental mutilation, wherever any such character is handled in the system. In the computer which is the machine with the most complex data-processing task of all, the instruction programs can be written to contain their own checks, both mathematical and procedural, and this method of programmed accuracy control can be carried just as far as the user may desire.

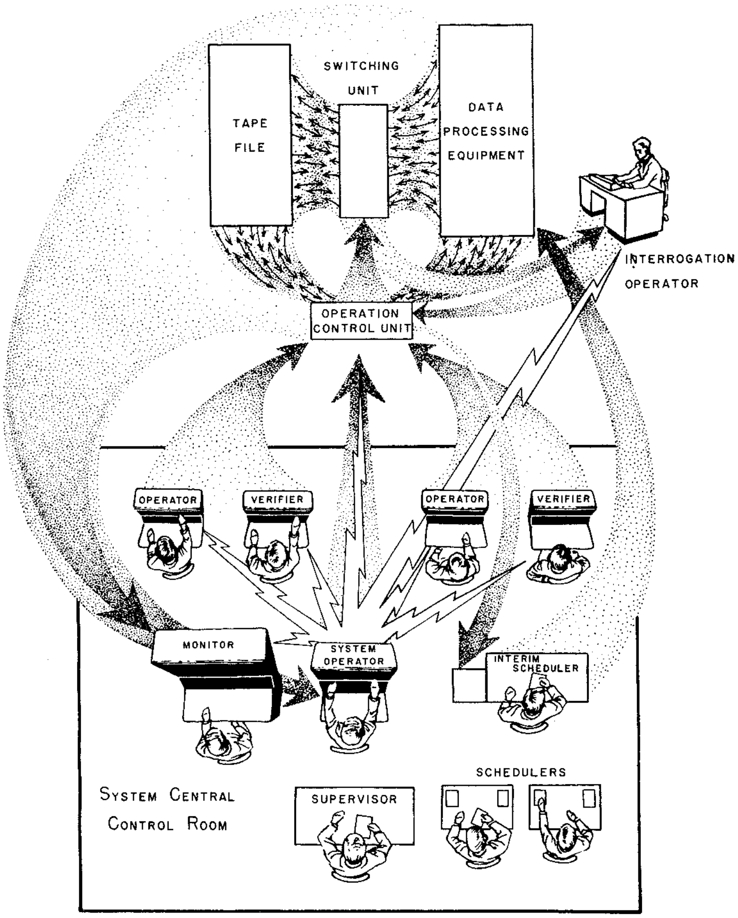
The story and pictures on the following pages will further describe the BIZMAC System, and should give the reader a feeling for the extent of the engineering effort that was necessary to bring it into being. It is barely possible to begin giving proper credit to all those who have participated in the work. The people shown in the pictures are representative of most of the groups that have made important contributions to the project.

THE RCA BIZMAC ELECTRONIC ACCOUNTING SYSTEM



by **W. K. HALSTEAD, Mgr.**
Systems and Advanced Product Development
Computer Engineering
Engineering Products Division
Camden, N. J.

THE RCA BIZMAC System is the most highly integrated business machine system announced so far. The preceding paper by Mr. Leas has given the reader some appreciation for the co-ordinated engineering effort which went into this project. It has resulted in a data processing system which is very flexible in its arrangement, and is capable of the greatest possible expansion under complete centralized control.

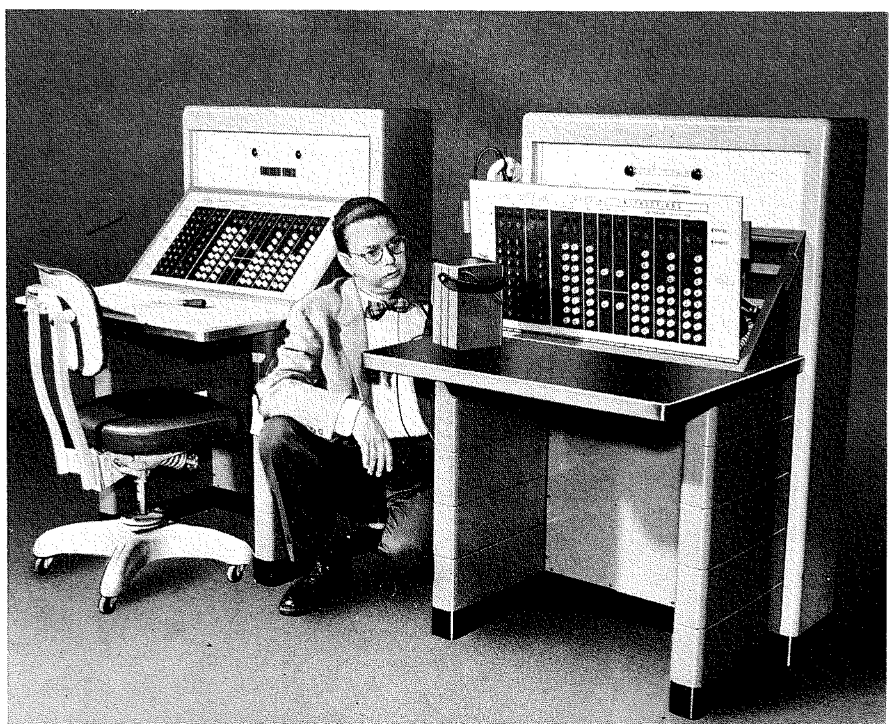


This diagram shows BIZMAC System operation under the control of System Central. The lightning strokes show the System Operator's control over both the operating team and the BIZMAC machines. The broad arrows show the flow of operating instructions from the operating team into the system and the feedback from the system to the operators. The schedulers are a part of the operation planning activity. They complete the preparation of operating instructions for the operators.

BUSINESS DATA HANDLING VS. SCIENTIFIC COMPUTING

Business problems have many characteristics which distinguish them from scientific problems. Scientific problems involve a relatively small amount of numerical input and rather large amounts of internal computation. The output in the case of scientific problems often exceeds input in quantity but is usually quite limited in scope.

Most business problems on the other hand involve a very large amount of input and output information, but relatively simple computations to be performed internally. Therefore, in electronic machines developed for business problems it is necessary to put emphasis on high speed input and output data handling devices. This required the development of completely new devices, such as fast magnetic tape handling mechanisms and high-speed printers. In addition there is considerable emphasis on sorting, arranging, and extracting of data with respect to the recorded files. This leads to the development of special purpose data processing machines.

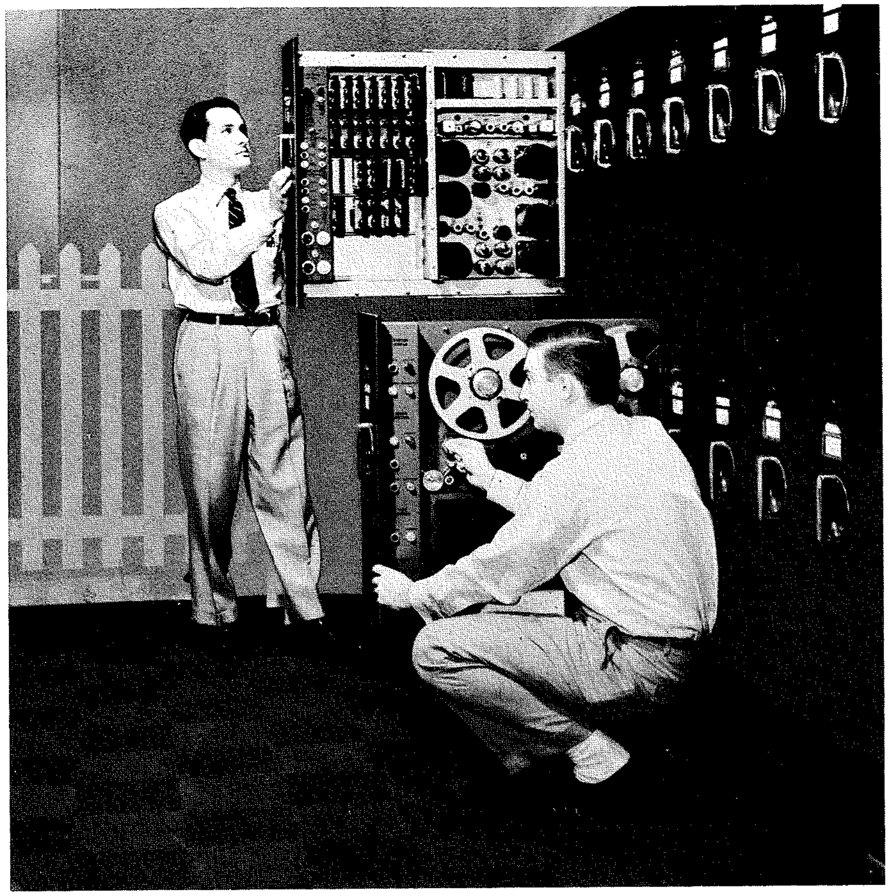


J. L. Owings, Leader, System Central Engineering, checks signals in a Verifier Console. The pair of consoles shown is used to establish detailed equipment connections. Independent duplication of "set-up" by two operators guards against human errors.

The handling of large amounts of business information necessitates the development of an integrated electronic system capable of accepting, re-arranging, and changing such information, and printing output documents, *all at very high speed.* A single piece of equipment may not be developed without reference to others no matter how satisfactory it might be in itself. The complete system must be integrated and balanced. The operating speed and capabilities of one machine should be in an approximate balance with those of the other machines in the system. There must be some machine capable of performing every necessary function. The RCA BIZMAC System is not merely a computer with adjuncts. It is a complete integrated *information processing system.*

EQUIPMENT FUNCTIONS

The System consists of a variable and flexibly-arranged collection of equipments performing the following functions: input devices which bring information into the system, with that information eventually being recorded on magnetic tape; storage devices which handle the magnetic tape and read and write the information on the tape; data-processing machines which handle the information at high speeds, re-arrange the sequence of messages, match and modify the contents, and generally perform the bulk of the data-processing job; output devices which transfer the processed information into other media where it can be used by people or further processed in other machines external to the BIZMAC System; and finally, the System Central equipment which serves to provide overall coordination of the use of the BIZMAC System in a large, complicated data-processing job.



R. E. Montijo, Design and Development Engineer, and R. H. Strominger, BIZMAC Equipment Operator, are inspecting a section of the BIZMAC Tapefile. Lower file drawer contains Tape Station, upper has electronic amplifying and control circuits. Drawers are stacked in groups, share common power supply.

TAPE FILE

The bulk of the business data handled by the BIZMAC System is recorded on magnetic tape. Each reel of tape is mounted in a Tape Station which, together with its associated Amplifier-Control Unit, forms a unit of the Tape File. The tape file is quite analogous to a conventional file and may be expanded or contracted according to need.

SPECIAL TAPE USED

The Tape itself is made of a Mylar base, with an iron oxide coating, and is ⅝″ wide. One 10½″ diameter reel will store 2,400 feet of it. It moves over the read-write heads in the Tape Station at a speed of 80″/second, and can be read going either forward or in reverse. The forward direction is used for reading or writing in normal data-processing work while certain checking operations take place when the tape is being rewound.

CHARACTER RECORDING

Data characters in the seven-bit BIZMAC code are recorded sequentially on the tape, at a packing density of 125 characters/inch. This, together with the tape speed of 80″/second, gives a reading or writing speed of 10,000 characters/second which is observed wherever tape is used in the BIZMAC System.

Actually, each character is recorded twice on the tape for safety. There are fourteen discrete parallel tracks on the tape, and the recording gaps of their heads are staggered in zig-zag fashion. Thus, it is possible to record corresponding bits for each character separated laterally by about ¼″ and lengthwise by ⅛″. This duplication and separation gives practically perfect protection against "drop-outs" due to pinholes or lumps in the tape, or due to grains of dust accidentally carried by the tape over the heads. The protection is achieved at substantially no cost in electronic equipment other than the provision for the extra tracks in the heads.

AMPLIFIER CONTROL UNITS

All the electronic equipment to go with a Tape Station is located in the Amplifier-Control Unit. This covers the read, write, and reel-servo amplifiers, and some "logic" circuits which receive and execute control signals from the System Central or the data-processing machine to whose trunk the Tape Station is connected.

For those Tape Stations which carry "reference file" data and which are normally used in an orderly, sequential fashion, it is not necessary to provide uniquely assigned Amplifier-Control Units. One such Unit can serve, in succession, a group of Tape Stations. About half the Tape Stations delivered to the Ordnance Corps are arranged this way, with five Stations to each Amplifier-Control Unit. The other Stations in the System have individual Units because they are to be used primarily to carry input or output data and intermediate records, and therefore must of necessity be available for work assignments on a flexible schedule.

INFORMATION ORGANIZATION

The information is organized for recording on magnetic tape in a new and more flexible way than in other electronic computing systems in current use. This flexible arrangement has led to substantial space savings on tape, and this in turn has made possible the storing of tape records in fixed stations in the Tape File, removing the need for much mounting and dismounting of tape reels.

A group of characters conveying one or several pieces of information is called an Item. Items may be of variable length and will occupy only the number of tape character spaces contained in the items, plus the Item Separator Symbol which precedes each item. This provides the optimum use of the tape and holds to negligible amounts the time required to process tape which does not carry information.

A serial group of related items is called a Message. Thus, all the information regarding one particular stock number in the inventory record is considered as a message. This is also the unit of data written on or read from tape at one time. The message is always begun with a Start Message Symbol and terminated with an End Message Symbol. Messages may also be of variable length in the following two ways. When data are not present in a particular item of a message, only the Item Separator need be shown to indicate the absence of normally present data. Also, when a consecutive string of missing items appears at the end of a message, they may be eliminated by placing the End Message code at the end of the last item containing significant data. This latter feature augments the tape savings realized through variable item length.

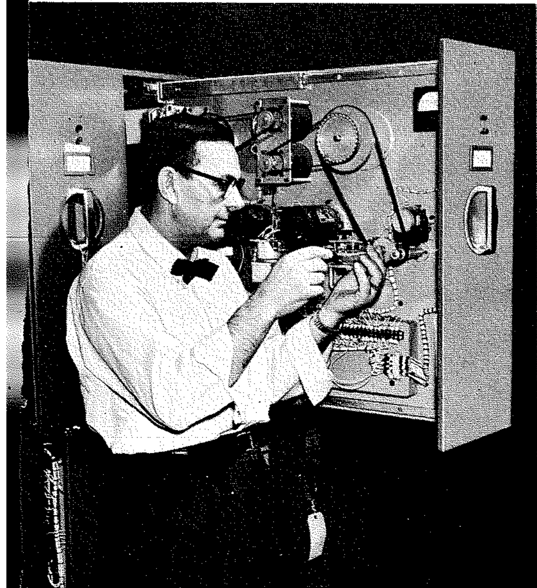
Messages of the same general character are combined into files. These may consist of part of one or several tapes. The end of significant data on a tape is indicated by an End of Data Symbol unless it is also the end of a file in which an End of File Symbol is used.

The various control symbols are recognized and interpreted for proper action by the data-processing machines.

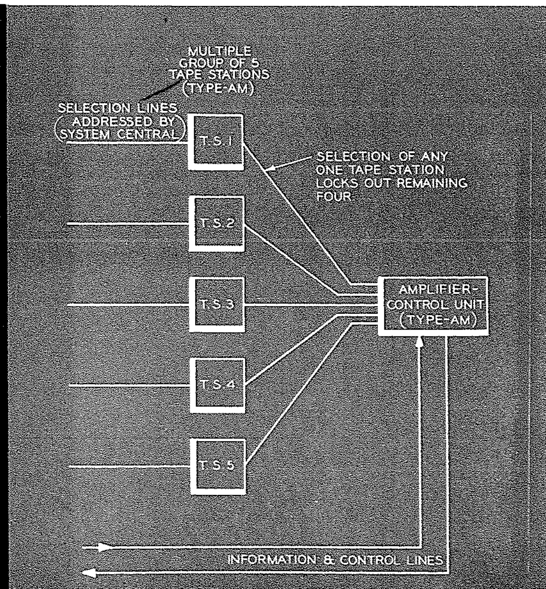
SYSTEM CENTRAL

One of the innovations in the RCA BIZMAC System is a scheme whereby magnetic tapes containing information may be left mounted indefinitely in their Tape Stations. Access to the information for a variety of data-processing steps is given through a flexible relay-switching equipment functioning much like a telephone exchange. Thus it makes no difference whether the data on a given tape are to be used for computing, sorting, printing or interrogation; the "System Central" connects that particular Tape Station to the desired processing machine. Similarly, stations containing blank tapes or tapes with obsolete data may be connected so that new data may be recorded.

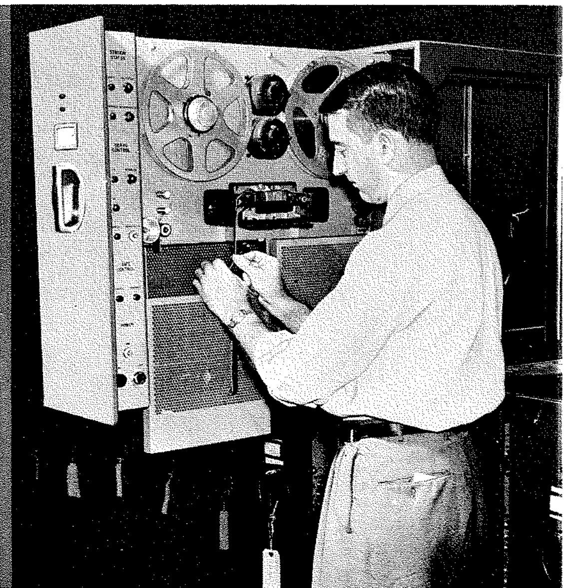
The analogy to the telephone exchange may be carried further. Just as telephone operators establish your long-distance connections with the aid of specially-designed switchboards, so in the BIZMAC System Central, operators use a group of consoles to establish the desired tape-to-machine connections and, in some cases, instruct the processing machine as to what kind of operation to perform. Once this is done, though, detailed control of the tape stations passes to the machine using them,



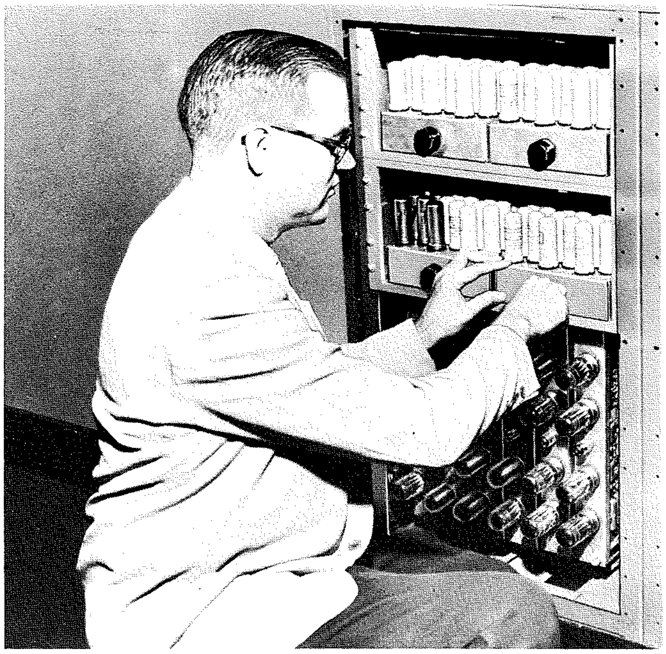
A. V. Stavrakis, Mechanical Engineer, checks performance of Tape Station. This is rear view of mechanism shown at right. Note separate servo motors (top) which drive tape reels and synchonous motors (centers) for capstans. Voice-coil mechanisms (below capstan motors) serve as fast-acting solenoids to drive start-stop actuators.



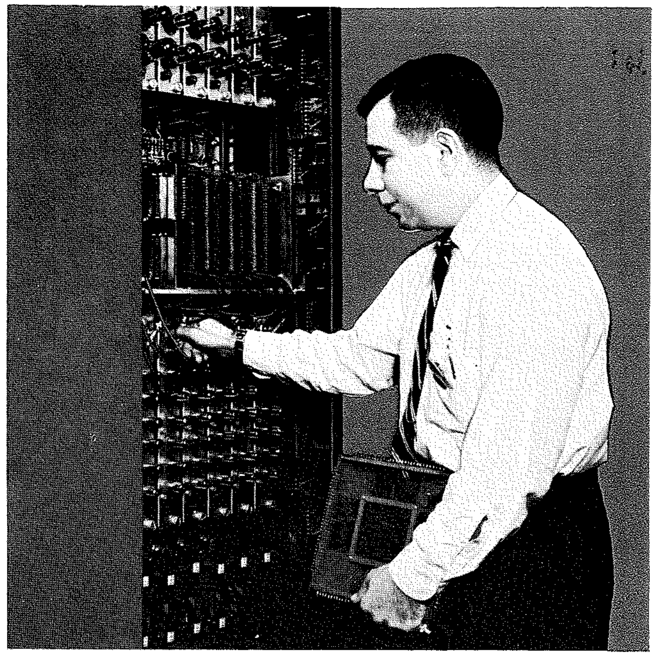
Several Tape Stations may time-share a single amplifier control unit where the content of the tapes is file reference material. In this case, access to a group of tapes is usually sequential, and only one of the group of stations needs to be connected to the BIZMAC System at any time.



Fresh tape is threaded into Tape Station by R. L. Wemple, Electrical Engineer on the Tapefile project. Drawer can be pulled out on tracks for easy servicing, remains operative through flexible cable at right. Tape Station contains tape reels and servo drive motor (top); head assembly (center) with start-stop mechanisms; and perforated-cover bins which act as "surge tanks."



W. Saeger, Electrical Engineer, is inserting a chassis with mercury relays used for connecting read and write amplifiers to various sections of the memory in the Computer. Throughout the computer and other BIZMAC equipment, RCA Computer-type tubes are used.



H. M. Elliott, Leader of High-Speed-Memory Engineering, is showing construction of a block of magnetic-core memory in the BIZMAC Computer. Memory block consists of seven planes like the one held by Mr. Elliott, each containing 1,024 small magnetic cores. Computer has four memory blocks—total high-speed memory capacity of 4,096 characters.

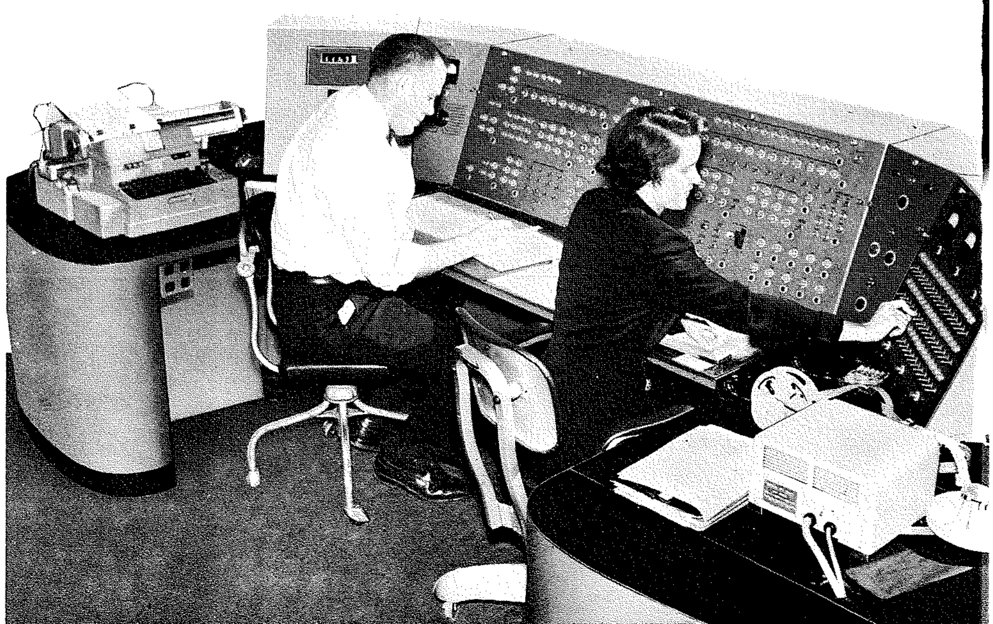
and the operators can forget about it until "the conversation is finished."

System Central consists of three major parts: the Switching Unit, which makes the actual relay connections between the Tape Stations and the machines using information on tape or writing on it; the Operation Control Unit, again a relay device, which actuates the switching unit in detail and which also transmits certain set-up instructions to the processing equipment; and the operator-attended consoles which are used in a team set-up to dispatch the work to the machines and to monitor overall system performance.

APPARATUS FOR SYSTEM MANAGEMENT

The design of the System Central was carried out by a team of RCA engineers with previous experience in the relay-switching field. Construction of the relay equipment is being handled by one of the leading manufacturers in the telephone equipment field. Planning and layout of the operator consoles was done with the assistance of a team of industrial psychologists, who are consultants in "human engineering." From the user's viewpoint, operation of a large data-processing system really poses a practical management problem. Techniques of effective management were employed in sorting out the functions of planning, decision, execution, and monitoring so that every operator in the

Computer is checked from its own console by Mrs. H. P. Dehm, Mathematician, and R. W. Rose, Leader in the Operations Unit. Lights on center panel display status of Computer at all times. Switches at right panel can be used for "marginal checking," i.e., preventive maintenance tests. Special instructions may be loaded into machine through paper tape reader at right. Electric typewriter will print out contents of a memory on demand, is used as a monitor. During routine operation, this console is unattended, and the Computer is operated from the System Central Consoles.



System Central team winds up with a task which is well within the scope of efficient performance by a single person, and the group as a whole operates with the greatest possible efficiency.

The diagram shows the operator complement in the System Central for the Ordnance Corps—a very large system by anybody's standards. A more recent design suitable for smaller systems with a much lower dispatching load recombines the various functions into two consoles and thus minimizes the operator manpower needed to run the system. In pilot installations it is also possible to omit System Central altogether and connect individual Tape Stations permanently to specific data-processing machines; this of course requires much more frequent manual interchange of tape reels, which may be tolerated on a pilot basis.

BIZMAC COMPUTER AND SORTER

COMPUTER

The Computer is the most versatile data-processing machine in the BIZMAC System. It can accept data from up to five "input" Tape Stations, at the rate of 10,000 characters per second, and store this information in its high-speed memory up to 4,000 characters worth of data at a time.

It can perform arithmetic operations at the rate of 50,000 decimal-digit additions per second.

It can record selected information from its high-speed memory in up to ten "output" Tape Stations.

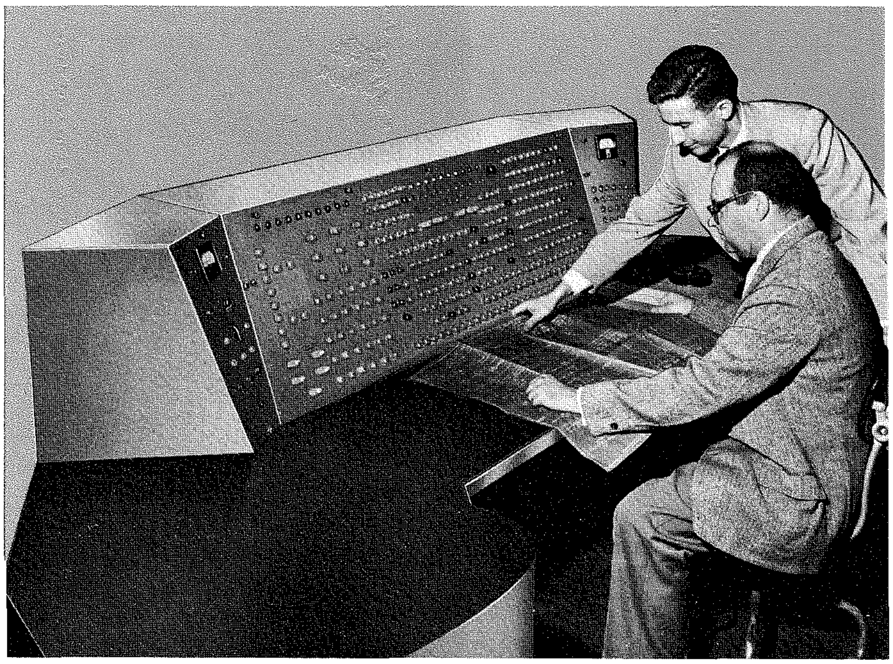
It can retain at any one time over 4,000 detailed and separate operating instructions.

It can interpret the data fed to it and from this it can select the proper sequence of operating instructions to be carried out.

Under proper control, it can even generate its own program of operating instructions for subsequent data-processing jobs.

SORTER

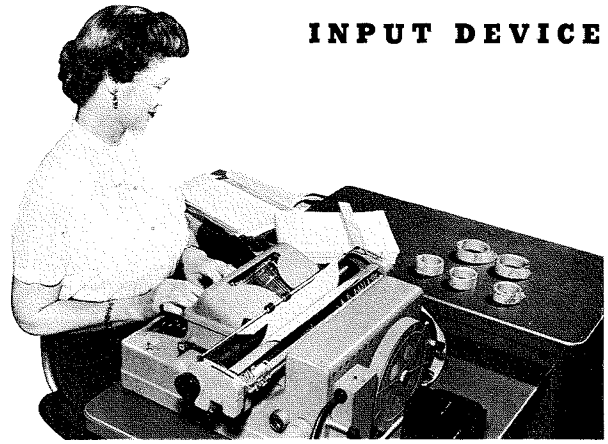
The BIZMAC Sorter was designed specifically to fit the needs of clerical data processing jobs. It is a special-purpose machine, with fixed, "wired-in" operating routines rather than the flexible instruction programs which permit the Computer to perform such a wide variety of different operations. Anything the Sorter is designed and built to do, the Computer can also be programmed to do, but the Sorter performs its particular jobs more efficiently and at less cost, and without the necessity of expensive programming. With business data—files, orders, receipts payments, bills, etc. —recorded on magnetic tape, the Sorter does the electronic equivalent of "paper shuffling." It does so at the rate of 10,000 characters per second, reading information selectively from



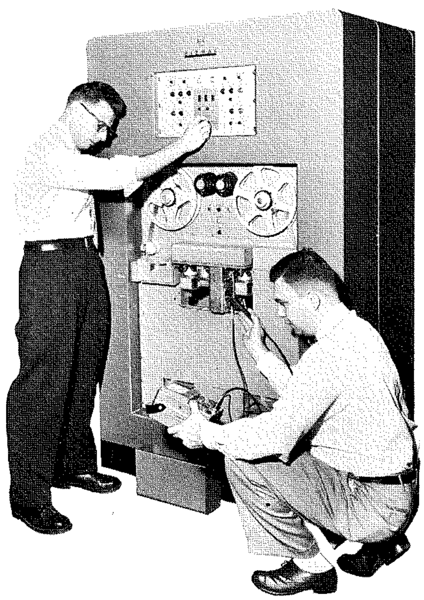
Test procedures for the BIZMAC Sorter are discussed by B. Adler, Leader, Sorter Engineering (right), and H. P. Guerber, Electrical Engineer. Sorter is capable of rearranging information contained on magnetic tape by selective re-recording, thus substantially relieves work load of the Computer. Three Sorters are included in Ordnance Corps System.

Design of BIZMAC plug-in units is discussed in office of J. A. Brustman, Manager of Product Development and Design (left). Other conferees are (left to right) P. T. O'Neil, Manager, Data-Handling Devices; R. N. Knox, Leader, Program Control Engineering; C. T. Cole, Jr., Manager, Input-Output Devices; and H. H. Asmussen, Mechanical Coordinator.

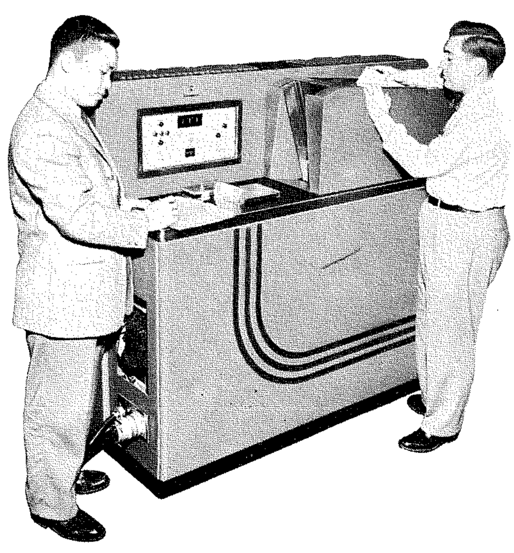
INPUT DEVICES



Mrs. M. L. Windish, BIZMAC Operator, is shown at Tapewriter, preparing punched paper tapes used in acceptance test of first BIZMAC System. This is first step in transferring written information to machine language. Manual input can be checked by independent duplication in Tapewriter-Verifier.



Paper Tape Transcriber transfers information from punched paper tape to magnetic tape. Holes in paper tape are read photoelectrically. Output of photocells is being checked here by J. B. Anderson, RCA Service Company engineer, while N. C. Florio, Laboratory Assistant, handles controls.



Dr. K. L. Chien, Project Engineer, is recording performance in log book of Card Transcriber. Every machine going through test has its own log which forms a complete record of tests made and maintenance performed. Punched cards are being removed from output hopper by Gerard Spector, electrical engineer. Cards travel through Transcriber at rate of 400 per minute, are "read" twice as an accuracy-control measure and recorded on magnetic tape in BIZMAC code.

up to three input tapes and recording it simultaneously on one or two output tapes. It can sort into proper order a number of related messages that originally appear on magnetic tape in random sequence.

It can do a complicated file maintenance job by extracting from a long, basic file of accounts (inventory records, stock usage) those that need processing during the current cycle, in accordance with a list of transaction messages (deliveries, stock orders), while at the same time merging back into the main file the updated file messages from the previous accounting cycle. In many large files, the active accounts in any one cycle number less than 10% of the total file. Thus, the use of the Sorter saves the Computer from having to "read" through a lot of inactive accounts. In the OTAC system which contains large basic files, this results in impressive operating savings.

ANALYSIS AND PROGRAMMING

In other fields of endeavor for which RCA makes electronic equipment, the exact use of the equipment is often of very little concern to the design engineer. In TV broadcasting, for instance, "programming" is a task for the network's or station's program director, and for producers, actors and announcers. The engineer cares little about this, except to be sure that the equipment provides the right frequency bands, picture clarity, etc. Similarly, in mobile communications, the engineer is concerned with transmitter power, receiver sensitivity and area coverage; he cares little whether the conversation pertains to a doctor's call, the dispatching of a taxi, or the scheduling of a long-distance truck.

In digital data-processing, on the other hand, the characteristics of the type of job to be performed have a very direct influence on the design of the equipment, and in turn, the performance details of existing equipment determine very largely the manner and efficiency with which a given data-processing task can be handled. Analysis and programming forms the bridge between equipment and application.

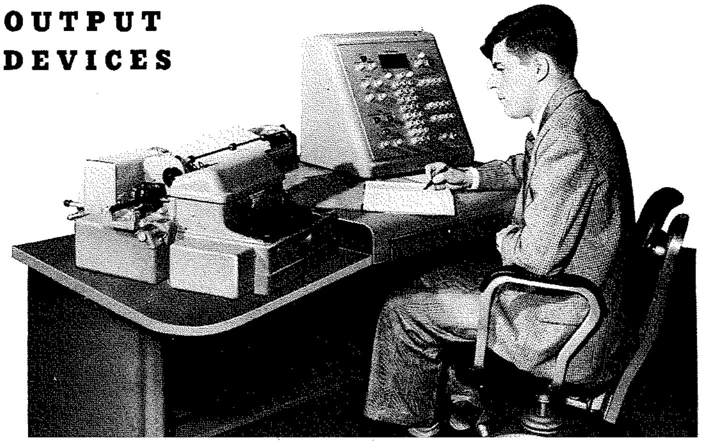
Fitting a data-processing task to the characteristics of the BIZMAC System starts with an *analysis* of the elements of that task—defining the volume and details of the information available at the start (input) and of the information needed at the end (output), as well as the logical processes to be performed in between. A "first round" of this analysis is best undertaken without too much consideration of equipment details so that the basic structure of the data process is clearly brought out. This often shows that parts of existing procedures have outgrown their usefulness, that like Spanish moss they have come to festoon and obscure the basic tree. Thus, a good analysis can do much toward streamlining the data process itself, and give the user more efficient performance all around. One substantial benefit comes from "integration," that is the consolidation of files and process parts previously handled separately because of the limitations imposed by earlier machines or by manual processes.

Once the task is defined basically it is then matched to system performance characteristics. In the study of a new application this leads to the *machine complement* required to carry out the task. For a given machine system, it leads to an *operating schedule.*

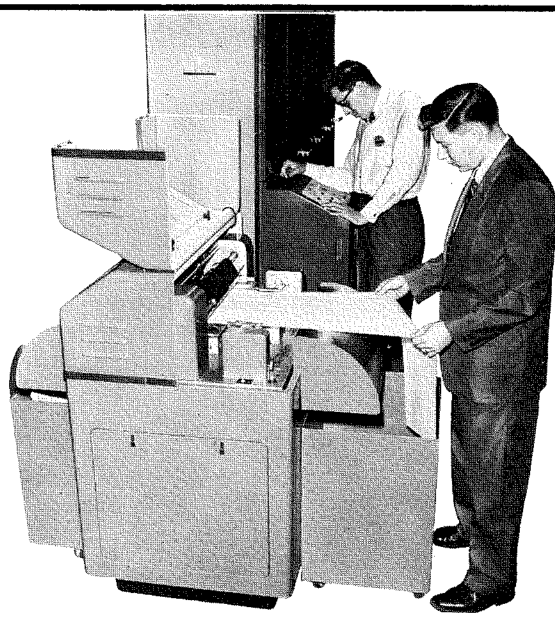
For all machines except the Computer the required equipment and the operating schedule are figured out fairly easily—the operating times are related rather simply to the volumes and details of the input or output data. For the Computer, however, that tells only part of the story —to get a really good figure of "usage" time the detailed processing steps for the Computer must be worked out. In any event, this must be done before the Computer can actually be put to work.

Programming, then, is the job of taking a clear, logical statement of the data process and reworking it into a form which the Computer can understand and carry out. This usually involves "flow-charting" to describe most clearly the sequential character of the process and the alternatives or "branches" existing within it, and "coding" which finally turns out the detailed operating in-

OUTPUT DEVICES

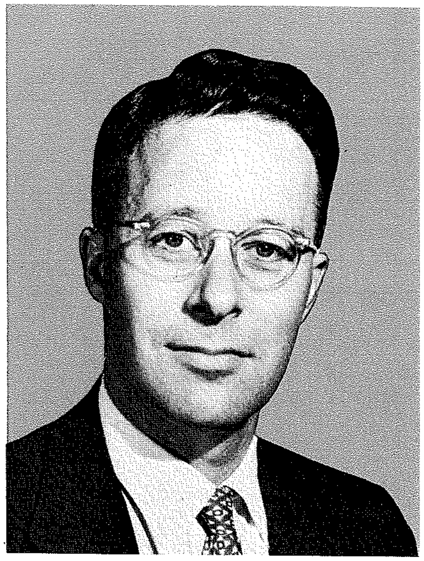


D. E. Beaulieu, Electrical Engineer, is making performance tests at console of Interrogation Unit. Control panel at right permits proper "set-up" of Interrogation Unit, including selection of Tape Stations to be interrogated. Serial number of desired account is typed in through keyboard at left. Then the wanted message is typed out automatically by the electric typewriter. Interrogation Unit is another special-purpose machine, unique to the RCA BIZMAC System, which takes burden off the Computer.



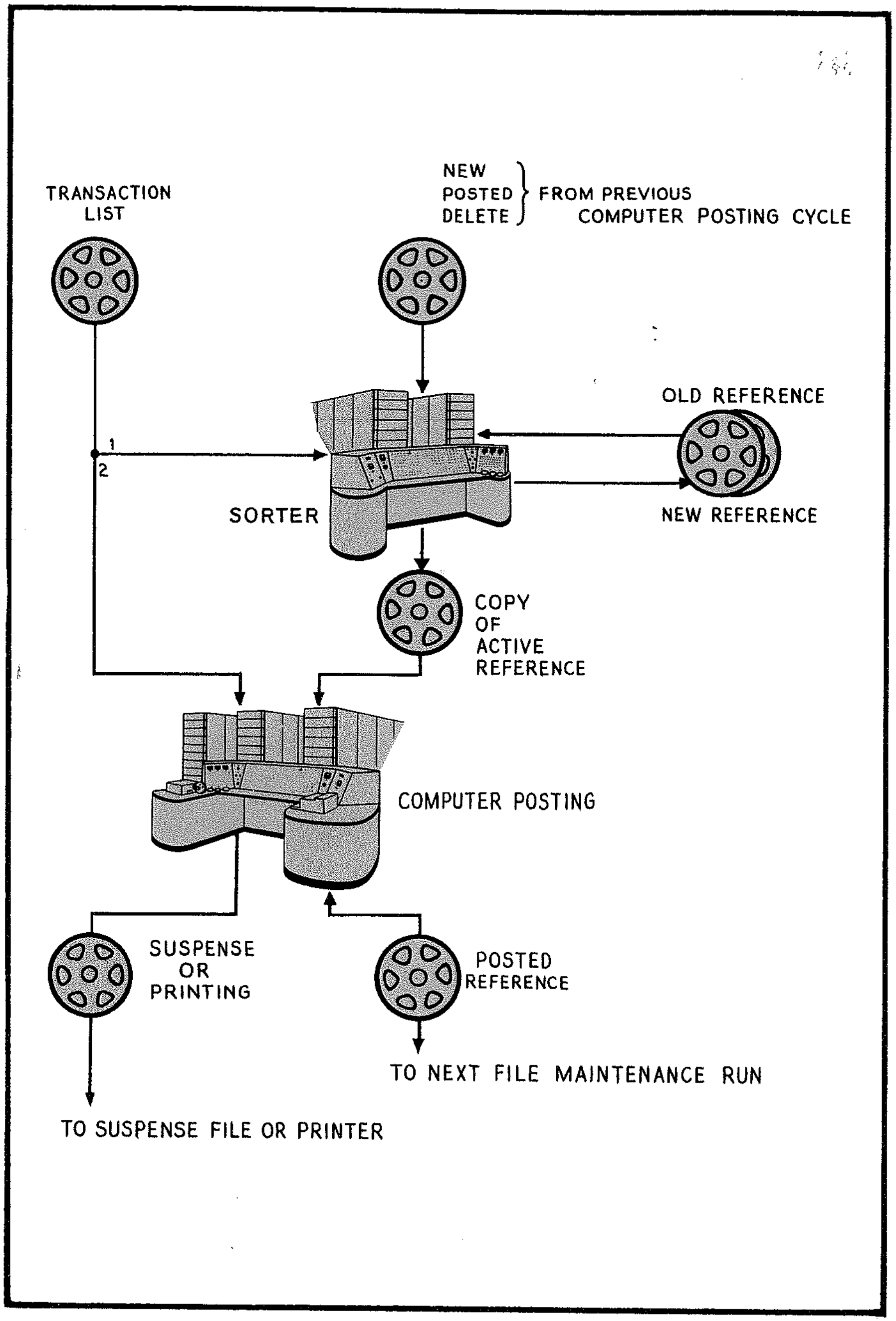
D. Flechtner, Leader of Output Devices Engineering, checks print quality of high-speed Electro-Mechanical Printer while C. C. Eckel, electrical engineer, handles controls. Printer is capable of printing ten lines per second, 120 characters per line, turns out paper at the rate of 500 linear feet per hour. Electronic equipment in racks at rear performs functions of storing information for one line of printing at a time (being read from magnetic tape), translating from BIZMAC character code to special printer code, applying proper tabular format control, and "firing" print hammer solenoids at the exact instant each character impression is desired.

Development of electric-charge image in Electrofax process is demonstrated by H. G. Reuter, Jr., Leader of Electrofax Printer Development. Process was invented by scientists at RCA Laboratories, Princeton, permits rapid making of photographic enlargements without expense of silver-halide light-sensitive coatings on paper.



W. K. HALSTEAD graduated from Massachusetts Institute of Technology with a BS in EE in 1939 and from Ohio State University with the MS degree in 1941. From 1939 to 1941 he taught as an assistant and instructor in the Electrical Engineering Department at Ohio State University, and from 1941 to 1944 in similar positions at MIT. From 1944 to 1947 he was employed by the Polaroid Corp., Cambridge, Mass., and from 1947 to 1950 as Chief Engineer of the W. S. MacDonald Co., Inc., Cambridge. In 1950 he joined RCA in the Advanced Development Section, and became associated with the BIZMAC project. He was Supervisor in charge of the development of the BIZMAC Laboratory System and in 1953 transferred to the Computing Systems Engineering Section where he is now Manager of Computer Systems and Advanced Product Development.

Mr. Halstead is a member of Tau Beta Pi, Eta Kappa Nu, an associate of Sigma Xi, Senior Member of IRE, a member of the Association for Computing Machinery and of the Society for Industrial and Applied Mathematics.

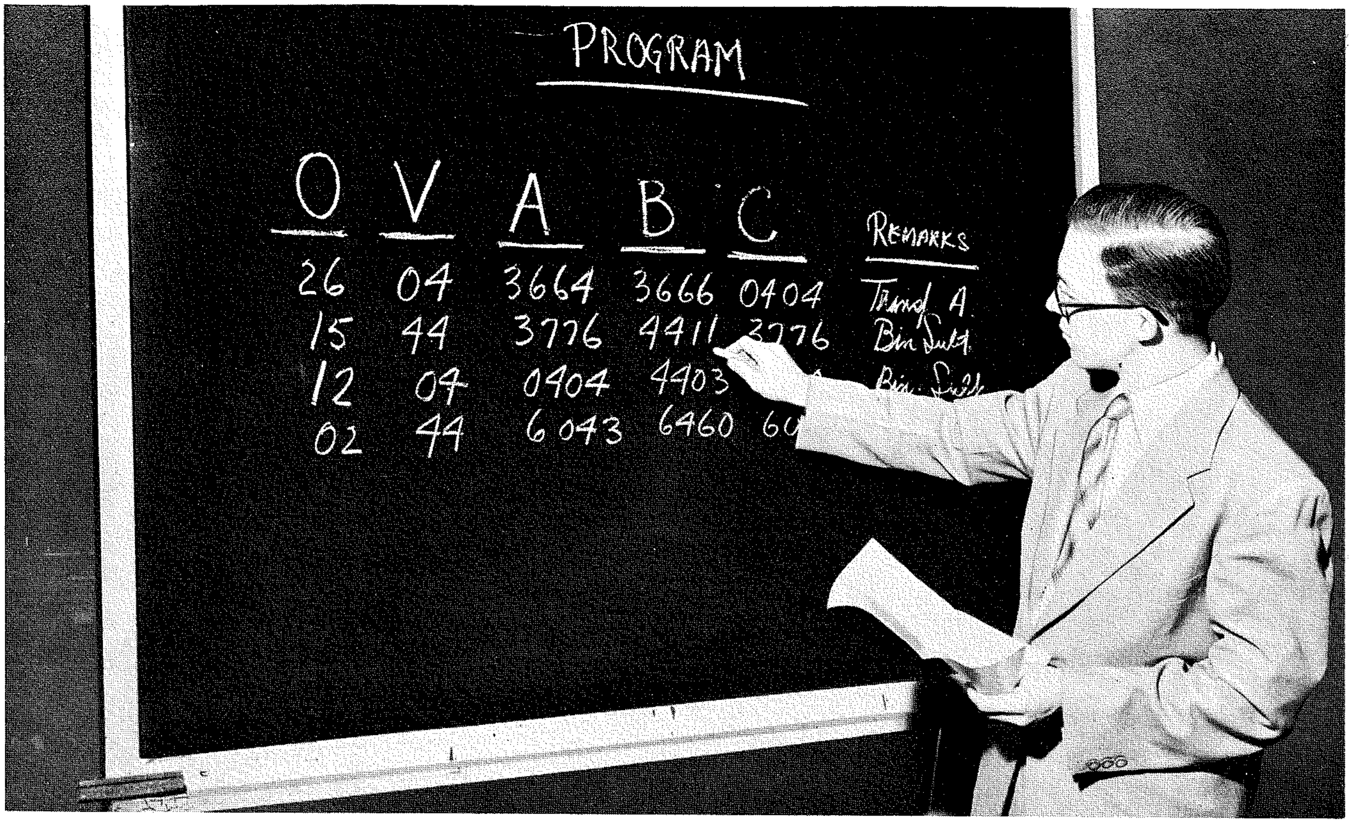


Simplified process diagram shows part of a file posting operation. First, incoming transactions on magnetic tape (top left) are matched in Sorter against main inventory file (right). Active file messages are extracted while at the same time updated inventory records from previous posting cycle are merged back into main file. Next, active inventory records are brought up to date in Computer.

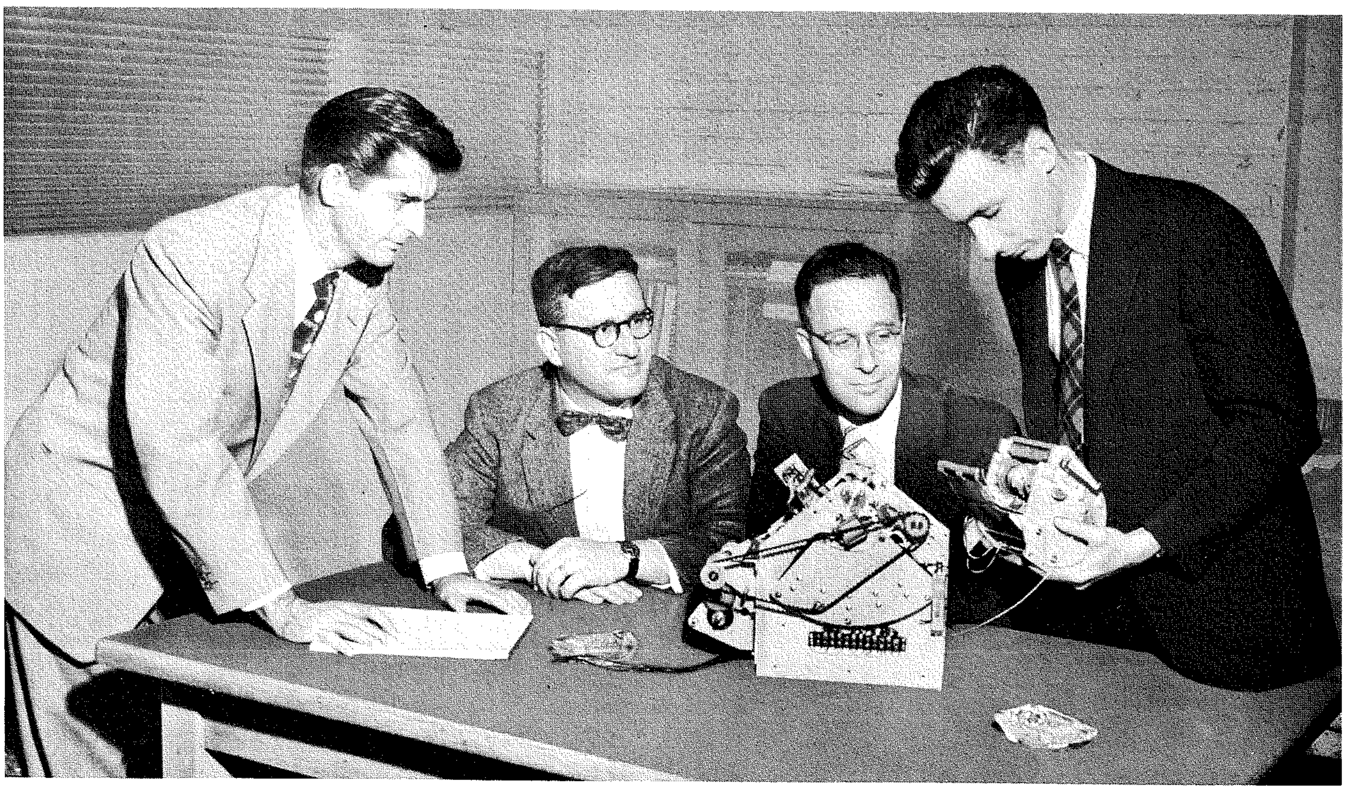
structions in computer language (see picture, page 21). The instructions are then keypunched to create the program tape, and loaded into the Computer for program testing with sample data to check on the correctness of the program as written. Then it can finally be turned over for use in regular production work on the Computer.

Of course, the break between analysis and programming in practice is not nearly as definite as indicated above. For best results, the analyst-programmer should be able to range over the entire task, should have a good knowledge both of the business in which the data-processing job occurs, and of the methods of using the data-processing equipment.

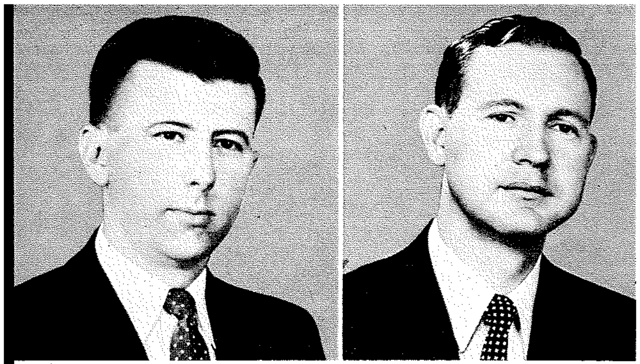
Fortunately, techniques are now being developed which take much of the drudgery out of the programming task, and promise to eliminate a threatening bottleneck in the widespread use of data-processing systems. *Automatic programming* uses the Computer to help with the strictly formal portions of the programming task, turns out computer programs which are known to be correct and self-consistent. The development of such techniques comes under the heading of programming research which is yet another facet of work peculiar to computer engineering.



R. A. C. Lane, Leader of Analysis and Programming, is shown lecturing on the details of a BIZMAC Computer program. Sample of program listed on blackboard contains four instruction steps, each consisting of an "operation" (O) code which tells the Computer what to do; a "variation" (V) code which defines how to do it; and three "addresses" (A, B, C) which designate locations in the High-Speed Memory where operands are to be found and where result of operation is to be stored.



Advanced development model of a special mechanism is demonstrated in the office of the author by J. S. Baer, Leader of Mechanism Development. Others are (left to right) C. E. Yearsley, Mechanical Draftsman Designer, A. M. Spielberg, Manager, Computer Advanced Development, and W. K. Halstead.



TRANSISTORIZED OUTPUT METER

by

J. J. LAWLER AND J. D. HODGE

Technical Products Service Department

RCA Service Company

Cherry Hill, N. J.

J. J. LAWLER, received the BS in EE degree from the University of Massachusetts in 1950 at which time he joined the RCA Service Company as a Field Engineer. He was engaged in part time graduate work at Syracuse University in 1952, and returned to the University of Massachusetts in 1953 receiving the MS in EE in 1954. He then returned to the RCA Service Company where he is now engaged as an Engineer in the Computing Systems Service Section of the Technical Products Division, RCA Service Company.

J. D. HODGE, received the BS degree in Mathematics from Limestone College in 1950. Shortly after graduation entered army and served with signal corps in Korea. In 1951 he entered the RCA Institute to study Radio and Television broadcasting. He graduated from the RCA Institute in August of 1954 at which time he joined RCA Service Company, Technical Products Division.

WITH the recent advent of stereophonic sound in the motion picture industry, the need arose for a sensitive portable output meter, capable of measuring sound levels in preamplifier and intermediate amplifier circuits of sound systems.

Since the RCA Service Company Technical Products Department Field Engineers were already equipped with Weston Model 695 type 11 output meters, an effort was made to increase the sensitivity of this meter rather than add another piece of test equipment to the field engineer's already burdensome load.

TRANSISTORS SOLVE A PROBLEM

A suggestion was made by Edward Stanko, Manager of the Engineering Section, Technical Products Department, that transistors be investigated for this application, and if possible, sufficient sensitivity be added to the output meter so that measurements in the order of —30 db could be made.

Transistors were chosen for the modification so that an external power supply would not be required, thereby allowing the instrument to remain light and portable. The transistors are rugged and require very little power, and are therefore ideal for this application. As can be seen in Fig. 1, extremely small components had to be used to maintain the overall compactness of the instrument.

RCA-2N79 TRANSISTORS SELECTED

The Weston model 695 type 11 output meter consists of a sensitive meter movement and rectifier preceded by a "T" pad attenuator network which is divided into attenuation steps of 4 db. The meter switch positions range from —4 db to +36 db. The decibel scale on the meter is calibrated for a reference level of 6 milliwatts with a 500 ohm load. The input resistance to the meter is constant at 20,000 ohms.

Since a change of 8 db corresponds to a voltage ratio of 2.5 and a 12 db change corresponds to a voltage ratio of 4, multiple voltage ranges with decibel ratios of these values are combined in the meter. A series blocking capacitor is also provided for measurements where d-c voltage is present.

Since the output of the "T" pad attenuator network was approximately 10,000 ohms (impedance of rectifier & meter movement), the transistor amplifier input and output impedances should approximate this value.

Several test amplifiers were constructed using various junction type transistors. It was found that better than 35 db gain could be obtained with the proper terminal impedances using a two stage amplifier. RCA 2N79 (junction p-n-p) transistors were finally selected because of their high quality, uniformity and hermetic seal.

TWO-STAGE AMPLIFIER REQUIRED

In order to obtain the proper termination impedances a two-stage amplifier was necessary. The first stage shown in Fig. 2, is a grounded collector circuit which is somewhat anal-

Fig. 1—Weston model 695 output meter showing modification

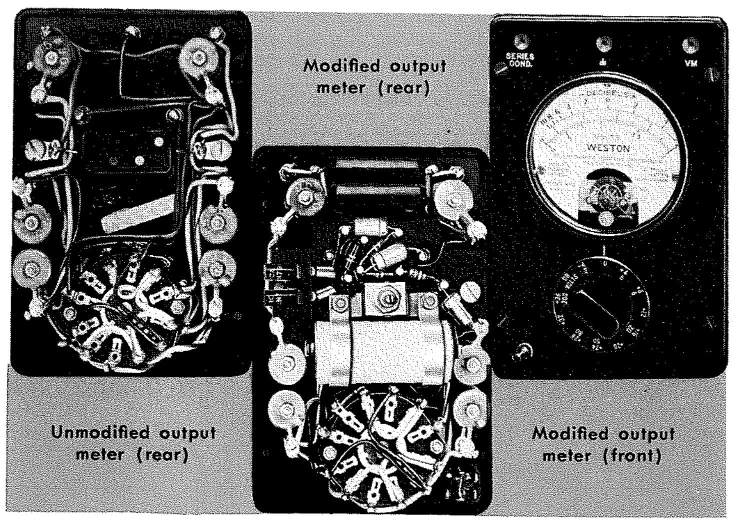
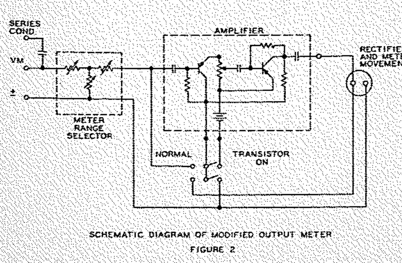


Fig. 2—Schematic diagram of modified output meter



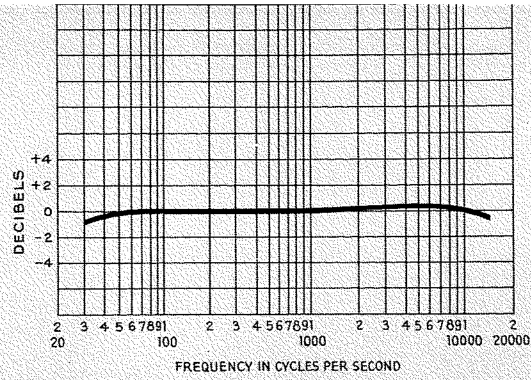
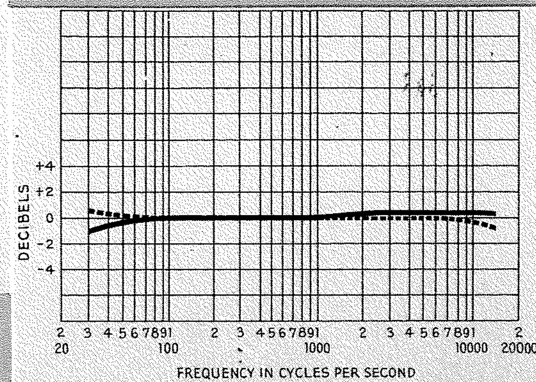


Fig. 3—Frequency responses of the amplifier and meter

Fig. 4—Frequency correction curve for modified output meter



ogous to a conventional cathode follower. This stage has a high input and low output impedance. The second stage, a grounded emitter circuit which is somewhat analogous to a grounded-cathode vacuum tube stage has a low input and high output impedance. The phase of the signal is not reversed in the first stage, but is reversed 180° in the second stage, thus the input and output of the amplifier are 180° out of phase, and the possibility of regeneration is reduced. Phase reversal eliminated the need for shielded wires and critical lead dress. It also simplified the switching problem since practically any small switch could be used to switch the amplifier into the circuit without capacity problems.

CONVENIENT SWITCHING PROVIDED

As shown in Fig. 2, a switching arrangement involving a standard miniature double-pole, double-throw toggle switch which could accomplish all the necessary switching was devised. In the normal position the attenuator output is directly across the meter terminals and both the input and the output of the amplifier are shorted. The battery is also disconnected from the circuit. When the switch is in the transistor position the attenuator output goes directly to the amplifier input and the amplifier output is connected to the meter terminals. The battery is also connected in this position, providing power for the amplifier. In either position the test probes remain in the same jacks.

LONG-LIFE BATTERY

An RCA transistor battery, type VS088 was selected and pruned to 12.6 volts. This battery was designed for applications utilizing current drains up to 10 milliamps. Since the total current drain for the amplifier shown was .6 milliampere the consumed power was less than 8 milliwatts. Long battery life was thus assured.

Miniature tantalum capacitors were used as coupling capacitors since they provided large values of capacity in small physical sizes.

RESPONSE MEASUREMENTS

One of the major uses for a power level meter of this type is for frequency response measurement of audio amplifying systems. It was essential, therefore, that the response of the amplifier be as good as that of the original meter. Fig. 3 shows the relative response of (A) the amplifier alone, and (B) the meter alone. Fig. 4 shows the response of the combination. Although at extreme low frequencies the amplifier response falls off, the combination curve Fig. 4 may be used to correct any measurements made by the instrument.

CALIBRATION METHOD

A method of calibration of the amplifier was considered necessary since some gain would be lost as the battery aged. A gain control was inserted between the two amplifier stages. This control was a miniature potentiometer with a slotted shaft assembled such that it could be adjusted through a hole in the back of the meter case. In making frequency response measurements audio signal sources are usually available, and can be used to provide a calibration voltage. The modified output meter may be calibrated in the following manner:

With the toggle switch in the normal position and the attenuator switch on the —4db, (0-2 volt range), an input signal of 1 volt at 1000 cycles per second is applied to the input jacks causing an indication of 1 volt on the 0-2 volt scale. The attenuator switch is then set to the plus 36 db position and the toggle switch thrown to the transistor position. The gain control is now adjusted for a meter deflection of 1 volt on the 0-2 volt scale. The transistor amplifier is now calibrated and the instrument is ready for use. With the attenuator switch on the 0-2 volt range, the meter now reads 0-20 millivolts. The existing voltage ranges indicated on the attenuator switch may therefore be used by applying a multiplication factor of .01.

When the attenuator switch is now set to the 0 db position a, zero indication of the db scale will correspond to —40 db. The algebraic sum of the db scale reading, the attenuator switch factor, and a factor of —40 will give the actual power level in decibels across a 500 ohm load.

USES FOR THE METER

A modified output meter of this type has been successfully used for frequency response measurements in theater and TV film projector sound systems.

It has also been useful in the exploration of stray 60 cycle fields in connection with various types of apparatus maintained by the RCA Service Company. This type of measurement is accomplished by attaching a small probe coil to the input terminals of the meter. Fields inducing voltages in the order of a few millivolts can be easily detected.

Although the modification described was designed primarily for the Weston output meter it would also be useful for extending the range of any portable a-c instrument of this nature.

APPLICATION OF FERRITES TO DEFLECTION COMPONENTS*

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FOR THE past several years, ferrite cores have been an important part of every commercial television receiver. Their specific properties are used to greater advantage in deflection components than in any other portion of the receiver. Ferrite core manufacturers, however, have frequently found it difficult to determine the optimum properties for deflection applications. This paper discusses the effects upon performance of variations in core parameters such as losses, permeability, and mechanical fit. Specific measurements necessary to define the merit of the core are described, and precautions necessary in the evaluation of core material are enumerated. Suggestions are given for improvements in properties which can make ferrite cores more ideal for application to deflection components.

DEFLECTING YOKES

Ferrite cores used in deflecting yokes serve as a partial return path for the flux which traverses the neck of the kinescope to provide deflection of the electron beam. Fig. 1 shows some of the numerous core shapes and sizes used for black-and-white and color television deflecting yokes. Although the shape of the core is usually cylindrical, it is advantageous to increase the diameter of the portion of the core which encompasses the forward part of the kinescope, as shown for the center core in Fig. 1.

* Presented at the Metal Powder Association's 11th Annual Meeting in Philadelphia, Pa.; May 12, 1955.

CORE DIMENSIONS

The important dimensions of a four-piece (a) and a two-piece (b) cylindrical core are shown in Fig. 2. The two-piece structure has the advantage of reduced variation in performance characteristics and shorter assembly time. However, the difficulty of maintaining mechanical dimensions of this structure has resulted in the use of the four-piece core.

The diameter of the cores (shown in Fig. 2) is a function of the kinescope-neck diameter and the clearance required for insertion of the deflecting coil between the kinescope neck and the core. The length is a function of the particular yoke design and the deflection angle of the kinescope. The thickness is a function of either core saturation or manufacturability. In most cases, the limit of the dimen-

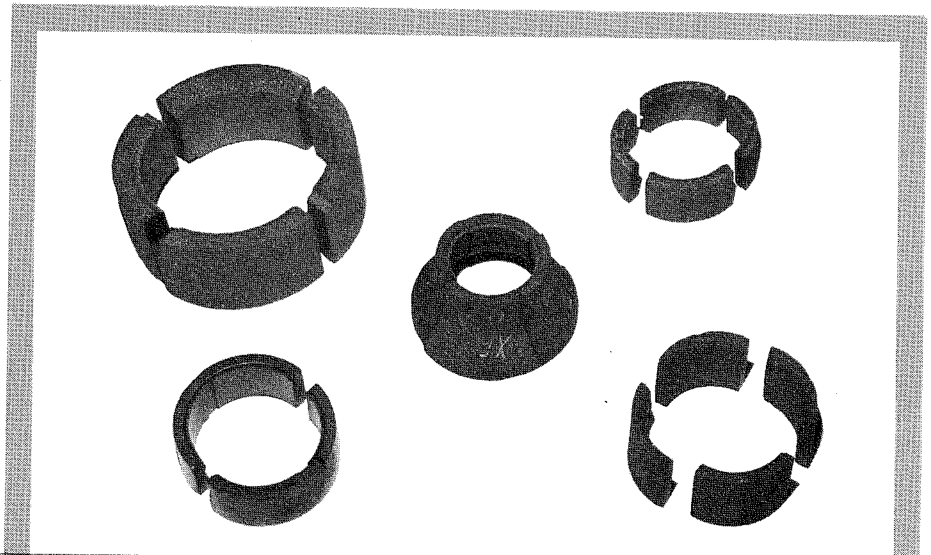
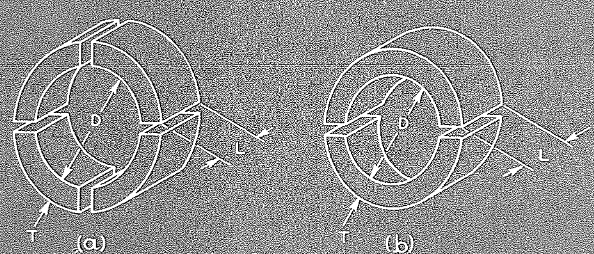


Fig. 1—Typical ferrite cores used in deflection yokes for black-and-white and color television receivers.

Fig. 2—Diagram of four-piece (a) and two-piece (b) cylindrical cores for deflecting yokes, showing important dimensions.



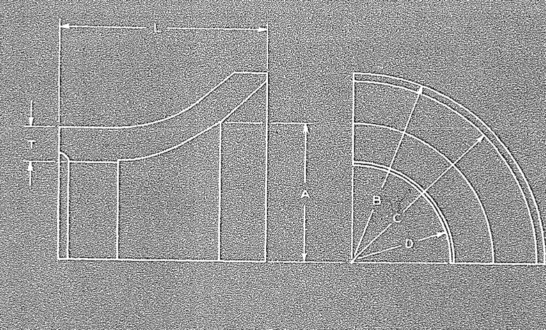


Fig. 3—Diagram of deflecting-yoke core which provides improved deflection sensitivity.

sion is determined by warpage of the core during "firing" or heat treatment. The importance of the T dimension with respect to performance considerations will be discussed later.

In some applications, dimension T is made very large to permit the use of a larger diameter, D, on the portion of the core which is near the forward portion of kinescope. A larger diameter in this area permits design of both the kinescope and the deflecting coil to follow the path of the electron beam. The deflection yoke thus has a larger effective length, and improved deflection sensitivity is obtained at the expense of added core material. The same advantages can be obtained with less core material by the use of a core such as that shown in the center of Fig. 1 and in Fig. 3. The core thickness of this design is determined by manufacturing feasibility, but the diameter is varied to provide a contour which permits the length of the deflection coil to be increased to any desired size. The degree to which this design is employed depends on the facility of core manufacture, the cost of the deflecting coils, and the advantages obtained. This type of design also provides additional improvements besides improved deflection sensitivity, but discussion of these other advantages is beyond the scope of this paper. It should be noted that the variation in the diameter "D" has slight discontinuities to facilitate molding of the core.

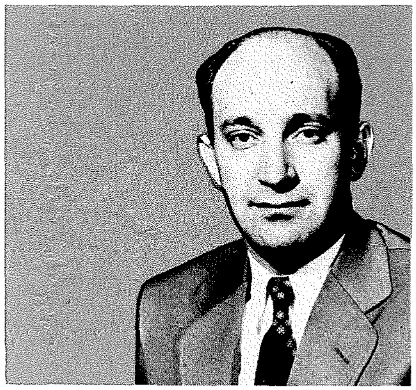
ELECTRICAL PROPERTIES

An accurate gauge for the definition of electrical and mechanical specifications for cores used with deflecting yokes may be obtained by the use of actual performance data.

Theoretical relationships governing the loss of horizontal and vertical sensitivity as a function of core permeability are shown in Fig. 4. Actual measured values agree rather closely with theoretical results when core materials having permeabilities of 100 or greater are employed. Because the core helps to guide the flux to the region where it is effective, as well as to increase the magnetic flux, values differ more widely from theoretical results when extremely low-permeability cores are used or when the core is completely removed. Correlation at the horizontal scanning rate is also influenced by core losses because increased losses reduce the amount of stored energy that can be recovered from the system, resulting in reduced B++ (boost) voltage and less scan. At the vertical scanning rate, core losses are negligible and correlation should be excellent.

Some small improvements can be effected in yoke performance by the substitution of ferrite for powdered iron, as shown in Fig. 5. This change, however, was produced by a drastic change in permeability and losses. The ratio of the permeability of ferrite to that of powdered iron at the operating flux density was 12 to 1; the ratio of losses was 9 to 1. The merit of the core material is judged on the basis of the input power required, the horizontal and vertical scan provided, and the ultor voltage developed. The data given in Fig. 5 show a smaller increase in power input, more loss in horizontal scan, and less loss in ultor voltage than data usually given for these two materials. In most methods of measurement, the core material is evaluated by the substitution of a new yoke core with no accompanying change in the deflection transformer. Such tests, therefore, determine the ability of the transformer to withstand a change in yoke inductance rather than the true merit of the core material in the yoke.

Because the tertiary winding of the transformer is tuned to a specific frequency and phase relative to the fundamental retrace time of the horizontal deflection system, it is important that the retrace period be maintained constant to minimize changes in the mode of operation of the deflection transformer. The change in core material from ferrite to powdered iron decreased the inductance of the vertical winding by 7.8% and the horizontal winding by 7%. The transformer must provide a tap which will maintain an inductance match to the driver tube and constant retrace time. Good correlation exists between theoretical and measured results for vertical deflection. Horizon-



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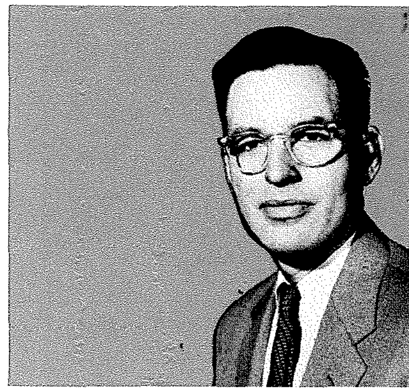
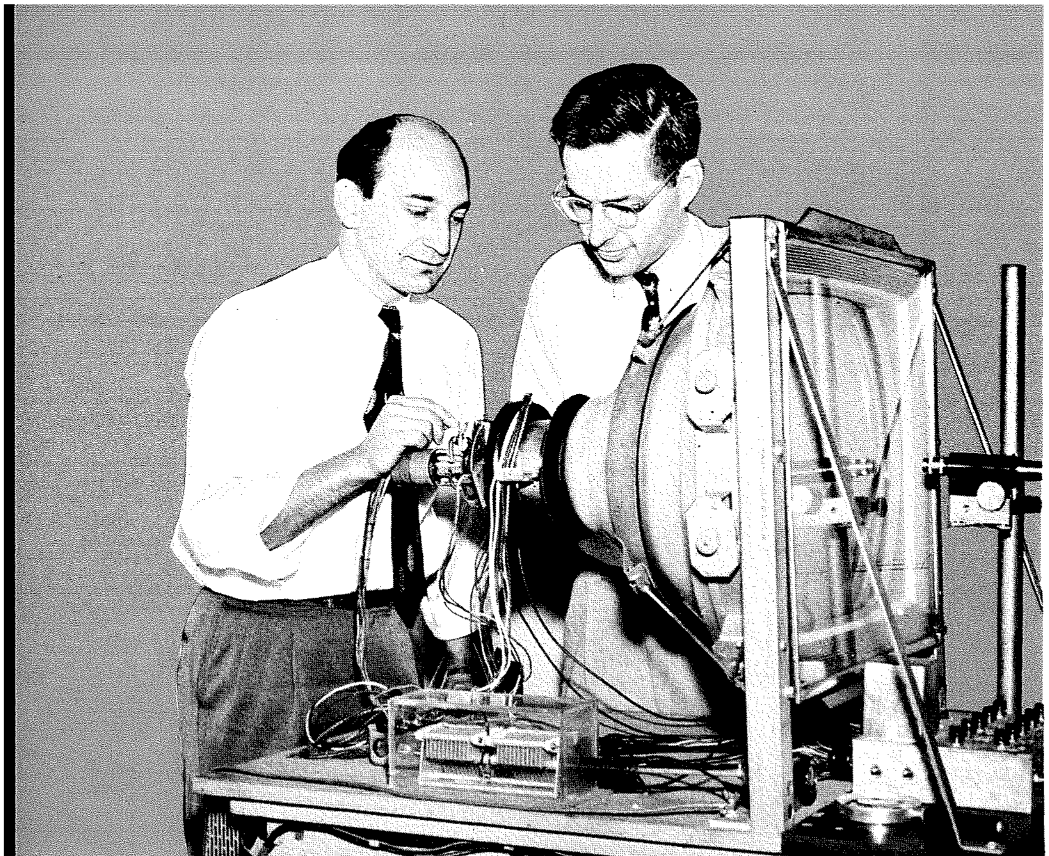


WILLIAM H. BARKOW—Mr. Barkow received the B.S. degree in Electrical Engineering from the University of Oklahoma in 1943 and is currently working toward an M.S. degree at the University of Pennsylvania. He joined RCA in Camden as a Quality Control Engineer and continued with this work until 1950. At that time he transferred to deflecting yoke development in the Transformer Development Activity in Electronic Components Engineering. He is an Associate Member of the Institute of Electrical Engineers and a member of Eta Kappa Nu.



The authors examine some of the components required for successful operation of the RCA color kinescope, 21AXP22. Ferrite is an essential part of these components.

tal deflection decreased by more than the theoretical 2.7% because of the increased core losses in the powdered-iron core, as compared to those of ferrite. The results show that the core material may vary rather widely without excessive degradation in the performance of the deflecting yoke.

A further study of the role of the core in a deflecting yoke may be made by consideration of the performance attainable when the core is completely removed. The inductance decreases by approximately 33%, the ultor voltage developed and the input power are unchanged, the horizontal deflection decreases by 29% and vertical deflection decreases by 53%.

1. $H = \frac{0.4\pi NI}{L} = K_1 NI$. K Defined by Yoke Geometry

2. $\mu_e = \frac{L_{IRON}}{L_{AIR}} = \frac{L_I}{L_A}$

3. $D = \text{Deflection} = K_2\phi = K_3\mu_e H = K_4 \frac{L_I}{L_A}(K_1 NI) = K \frac{L_I}{L_A} NI$

   $D = K_V L_I \qquad K_V = \frac{KNI}{L_A}$ All parameters unaffected by change in core material (Vertical Deflection)

   For Horizontal Deflection $\quad I = \left(\frac{I}{\sqrt{L}}\right)$

4. $D = K \frac{L_I N}{L_A \sqrt{L_I}} = K_H \sqrt{L_I}$

Fig. 4—Theoretical relationships governing the loss in horizontal and vertical deflection sensitivity as a function of core permeability.

These results are obtained when properly matched operation compensates for inductance change, and are a function of the particular deflecting yoke used. The results represent a yoke for which the removal of the core has the most profound effect, i.e., one in which the core is in intimate contact with the deflecting coils. Results may differ from the theoretical value for reasons discussed above.

The effects of ferrite-core thickness on performance were determined for a yoke in which the core operates at a flux density representative of a typical 90° yoke. A decrease of 40% in the thickness resulted in a one-per-cent loss in anode voltage, a 2.4% decrease in horizontal deflection, a 3.1% decrease in vertical deflection, and a 3.2% decrease in vertical and horizontal inductance. The increased core losses caused approximately a one-per-cent loss in horizontal deflection.

MECHANICAL CONSIDERATIONS

Poor performance of ferrite cores may also be caused by improper physical dimensions. For black-and-white television applications, variations in deflection sensitivity may result from improperly fitting cores or from variations in inductance which impair over-all efficiency of the deflection system. Fig. 6 shows the variation in performance which results when the spacing between core and coil is increased by .0375 inches. The vertical sensitivity is decreased by 7.5% which is the same as the percentage reduction of vertical inductance. The horizontal inductance changes by 5.3% and the resultant theoretical decrease in horizontal deflection for properly matched conditions is 2.3% The loss of horizontal scan was actually 4.5% as a result of the shortened retrace time when the core was moved away from the coils. Addition of external loading capacitance to equalize retrace time reduced the scan deviation to the expected lower value.

Decrease in deflection may also be caused by air gaps between the mating portions of the quarter segments of the core. Such gaps result from either improper radius of the core segment or warpage occurring during "firing."

In color television applications, additional ill effects may be observed. Tests have revealed that gaps of 0.005 inch between mating sections of quarter sections can cause convergence changes of as much as 0.060 inch, the total variation normally permissible for a completed yoke assembly. Variations in core diameter, i.e., differences in spacing between yoke coil and core, may cause serious convergence errors as may large permeability variations between core pieces.

DEFLECTION AND HIGH VOLTAGE TRANSFORMERS

Ferrite cores used in deflection transformers have been made in various shapes and sizes, many apparently derived without recourse to logical design considerations. Recently, however, most of the cores have been made in the "C" or "U" shape. Fig. 7 shows several cores currently used for black-and-white and color television applications. It is interesting to note that the ratio of volume between the largest and smallest of these cores is 5.5 to 1. The smaller core finds frequent application in 70° black-and-white systems while the largest core is used in color systems.

Some of the more important dimensions of a C-type core are shown in Fig. 8. Dimension A, which determines the cross-sectional area of the core, is a function of many parameters, including; electrical properties of the core material, reactive energy which the transformer must handle, ultor voltage required, type of winding (flat or universal) to be employed, and the combination of core and coil in consideration of these parameters which yields the most economical system. The value of A, therefore, is a result of many compromises which can yield several divergent answers. The degree of this divergence was illustrated in design of deflection transformers for 70° black-and-white deflection systems. Although the cross-sectional area of cores varied by a ratio of nearly 2.5 to 1, all systems yielded essentially the same performance.

The dimensions B and C of the core are more clearly defined, as shown in Fig. 9. The C dimension is determined by the spacing required at C to prevent voltage breakdown between the edge of the high voltage winding and the core and by the space required by the deflection winding. Dimension E is made as small as permissible consistent with good insulation practice. The B dimension is a function of the length required for dimension D to prevent excessive voltage gradient along the high-voltage winding; sufficient clearance must be provided at B to prevent voltage breakdown.

ELECTRICAL REQUIREMENTS

The development of an ideal ferrite core for deflection transformers requires consideration of the following requirements:

1. Losses. Losses should be kept to a minimum at scanning and retrace frequencies at the operating induction levels. The maximum operating flux density for most deflection transformers is between 600 and 1500 gausses. The relative importance of the losses at the two frequencies is shown in Fig. 10. If eddy-current losses can be neglected at the retrace frequency, P_T reduces to P_S. It is important that the core losses do not increase excessively at operating temperatures up to 100° C.
2. Normal Permeability. High values of permeability are most useful if the core characteristics permit operation at high flux densities. Stability of permeability as a function of temperature at high flux densities is a very important consideration.
3. DC Magnetization and Incremental Permeability. Normal operation of deflection transformers imposes a moderate amount of polarizing current in a portion of the transformer winding. However, efforts to reduce acoustic radiation from ferrites usually require the use of an air gap between the mating portions of the C-shaped cores. In addition, because normal permeability of cores of the same grade may vary as much as 50 to 75%, a large

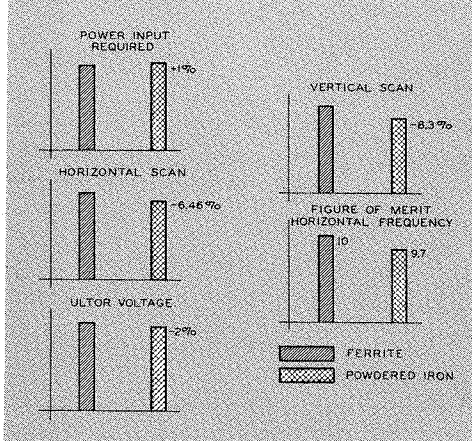


Fig. 5—Relative performance data for deflecting yokes using ferrite and powdered-iron cores.

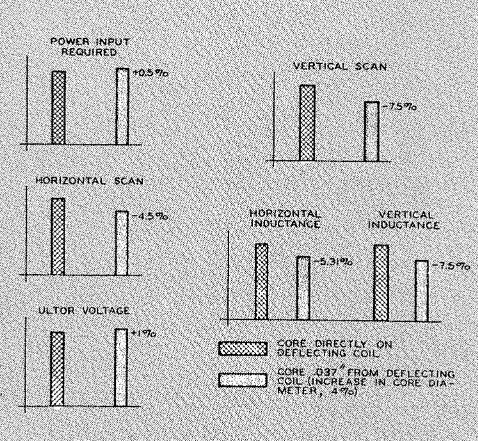


Fig. 6—Relative performance data for deflecting yokes having different spacings between core and coil.

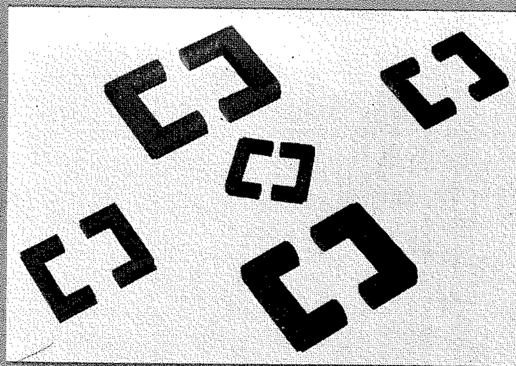


Fig. 7—Typical cores used in deflection transformers for black-and-white and color television receivers.

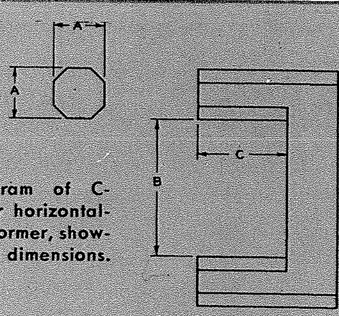


Fig. 8 — Diagram of C-shaped core for horizontal-deflection transformer, showing important dimensions.

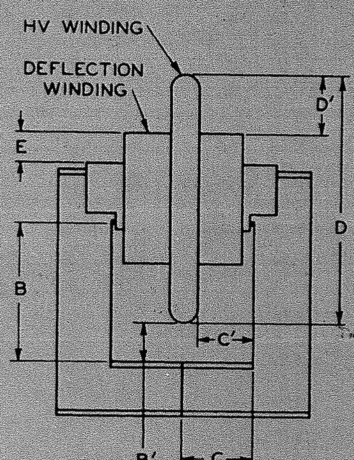


Fig. 9—Diagram of C-shaped core showing determining factors for dimensions B and C.

gap must be used to minimize performance variations of the completed product. In most instances, therefore, a sufficient gap is provided to minimize the problem of d-c magnetization. Special circuit arrangements at some added costs can also be used to circumvent this problem. If the normal permeability of the core is high enough, sufficient gap can be added to eliminate this problem with no deterioration in performance. This method will be illustrated later.

EFFECT OF CORE MATERIAL

The contribution of the core material to the performance of a deflection system may be evaluated by means of a comparison between a ferrite core and a core of inferior quality, such as powdered iron. The results of such a comparison are shown in Fig. 11. The ratio of core losses of the materials at the operating flux density, and the frequencies discussed previously were in the ratio of 9 to 1; losses for the ferrite were 3.9 watts per pound. The ratio of permeabilities for the two cores was approximately 15 to 1, however, the ratio of the effective permeabilities in the assembled transformers was reduced to 5 to 1 as a result of the optimized 10-mil gap used with the ferrite core to minimize saturation. No gap was used with the powdered-iron core. The relative merit of the core may be judged by the input power, the horizontal scan, and the ultor voltage. A further disadvantage of the powdered-iron core is the excessive temperature rise resulting from high losses.

The performance data shown in Fig. 11 are based on equal volumes of core material and equal weights of copper. An evaluation of this type must be undertaken with some care so that the contribution of the core to the system performance will not be confused with other changes in operation. These changes will be explained and demonstrated later. The reduced core losses and increased permeability characteristic of ferrites offer distinct advantages in deflection transformer design.

SIMPLE QUALITY CHECK

As mentioned earlier, loss and permeability measurements at proper frequencies and correct induction levels over the normal operating temperatures define the suitability of a core for application in deflection transformers. Because these measurements are somewhat difficult to make, however, some simplified testing methods are desirable for control purposes. For example, it is desirable to test the cores at a frequency of 1000 cps because several available bridges designed for operation at this frequency provide simultaneous measurements of inductance and quality factor, or "Q." A typical set-up of the equipment necessary to complete these measurements is shown in Fig. 12. For an assigned low-loss standard test coil, the merit of the core for application in horizontal deflection transformers is indicated by values of "L" and "Q" measured at 1 kc at the correct flux density.

Some discretion must be exercised in the use of a control test of this type. Because the normal permeability of ferrites is essentially unchanged within the frequency range encountered in horizontal-deflection circuits, the value of "L" at 1000 cps is an accurate indication of its value at sweep and retrace frequencies. "LQ" is a relative measure of the losses of the core, provided the test coil contributes negligible loss and the core losses are directly proportional to frequency. At flux densities normally encountered in deflection transformers, hysteresis losses are considerably larger than eddy-current and residual losses even at the retrace frequency. Consequently, the product of "L" and "Q" measured at 1000 cps is a *relative* indication of the losses exhibited by the core material under actual operating conditions. A minimum inductance specification at the highest operating temperature at the maximum flux density to be encountered in operation completes the necessary control measurements.

The use of these control measurements for evaluation of the relative merit of a core may be demonstrated by comparison of performance and "L" and "Q" parameters for ferrites representing wide variations in permeability and losses. Apparent discrepancies may often be obtained unless proper care is taken. In most deflection systems, the core loss represents less than 10% of the power dissipated in the complete system. If, therefore, the loss is decreased by a factor of 2 to 1, the actual change of power loss in the system is less than 5%. If this change in core loss is simultaneously accompanied by a large change in permeability of the core material, as is usually the case, the retrace frequency is changed. The transformer operation is frequently adversely affected by such a change because of the careful tuning of the high voltage winding with respect to the fundamental retrace time of the system. Fig. 13 shows the relative scan as a

$$P_T = \frac{P_S}{2} + \frac{T_R}{T_S}\,(P_R)$$

WHERE:

P_S = Losses at Horizontal Scanning Frequency (15.75 kc)

P_R = Losses at Retrace Frequency (50–62.5 kc)

T_R = Retrace Time (8–10 μsec)

T_S = 1 Horizontal Line (63.4 μsec)

Fig. 10—Equation showing relative importance of losses at scanning and retrace frequencies.

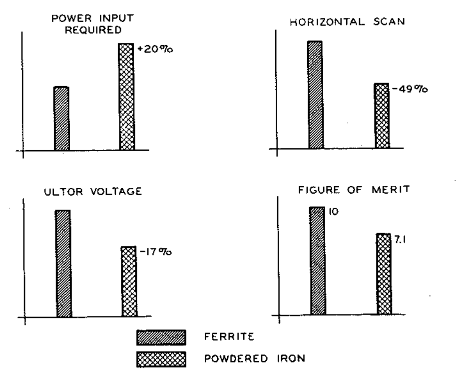


Fig. 11—Relative performance data for deflection transformers using ferrite and powdered-iron cores

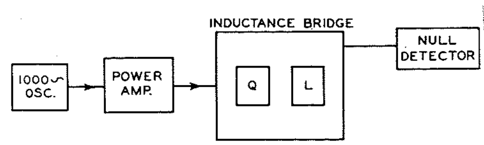


Fig. 12—Test setup for simple quality check of cores for deflection transformers.

function of the ratio between the transformer inductance, L_T and the yoke inductance L_Y. L_T refers to the open circuit inductance of the portion of the transformer connected to the deflecting yoke. The ordinate scale in Fig. 13 could also be accurately labeled $\frac{1}{f_o^2}$ where f_o is the retrace frequency of the system. Changes in retrace frequency of 2 to 3% may influence the operation of the deflection system as much as a change of 5% in the power loss of the system.

Fig. 14 shows the variation which occurred in ultor voltage when cores having different permeability values were substituted in the same deflection transformer. The magnetic circuit was diluted by means of a gap which reduced the total effective variation in inductance of the assembled transformer. Cores having increased permeability and decreased core losses actually showed a decrease in ultor voltage. It is apparent, therefore, that if a group of cores having different characteristics are to be evaluated for relative merit, the test transformer must be judiciously chosen.

In subsequent tests, a transformer coil designed to take partial advantage of cores having higher permeability and decreased losses was used. The transformer coil was optimized for operation with a core having a permeability which represented the approximate average of all cores to be tested. The "LQ" value was measured at a frequency of 1000 cps. Results of these tests are shown in Fig. 15. The amount of increase in ultor voltage as the "LQ" of the core is increased depends on the rate of deviation of the retrace time from the optimum value as the permeability of the core is increased compared to the rate of decrease in core losses. Test results for a coil optimized for operation with the best core of the group are shown in Fig. 16.

Another method of core evaluation maintains a fixed retrace time by adjustment of the air gap in the magnetic circuit to compensate for changes in core permeability. This method provides an accurate indication of the effect of core losses, but

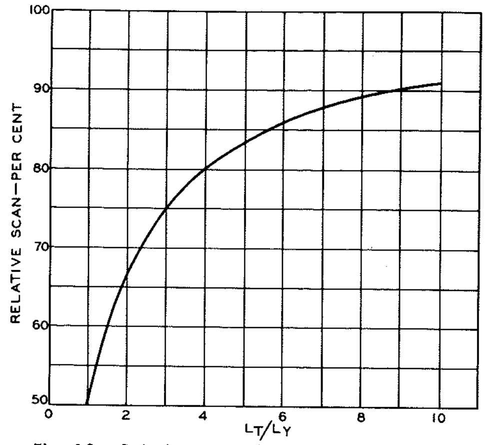


Fig. 13—Relative scan of deflection system as a function of the ratio between transformer inductance, L_T, and yoke inductance, L_Y.

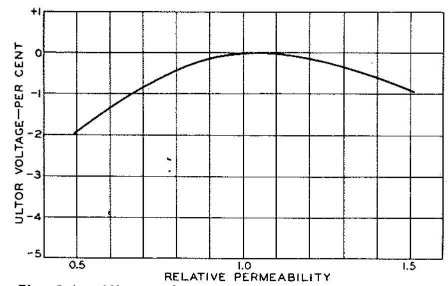


Fig. 14—Ultor voltage as a function of relative permeability for different cores in same deflection transformer.

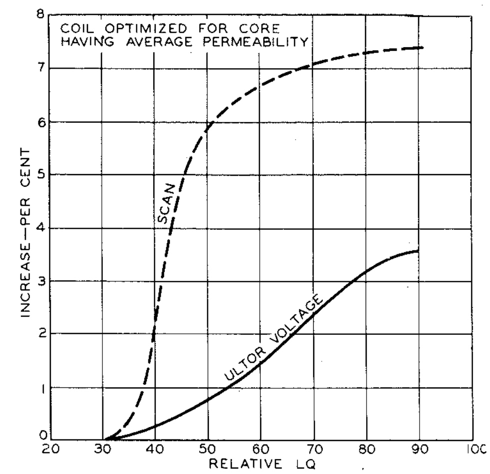


Fig. 15—Relative performance of cores as a function of "LQ" values at 1000 cycles per second when test coil was optimized for operation with a core having permeability which represented the average of all cores to be tested.

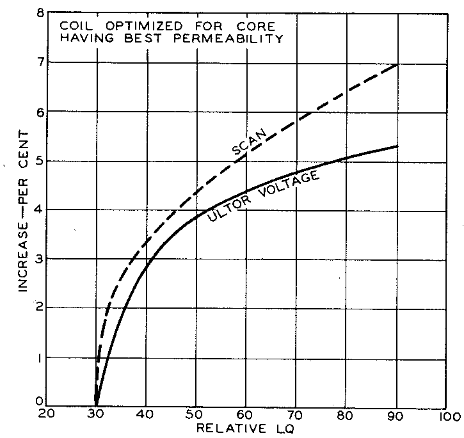


Fig. 16—Relative performance of cores as a function of "LQ" values when test coil was optimized for operation with best core.

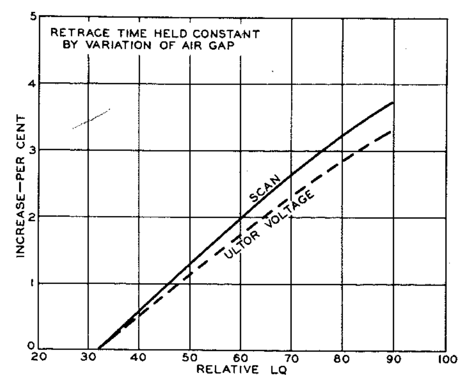


Fig. 17—Relative performance of cores as a function of "LQ" values when air gap in magnetic circuit was adjusted to maintain a fixed retrace time.

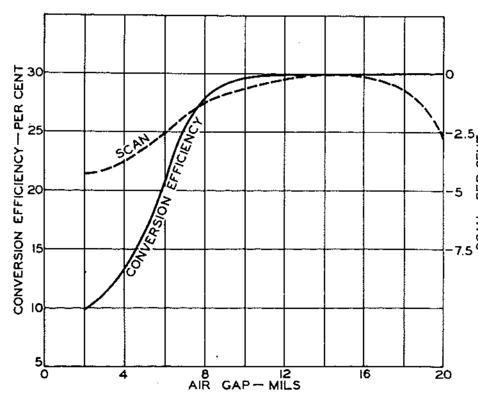


Fig. 18—Relative performance as a function of an air gap in magnetic circuit for a deflection transformer using improved ferrite core.

penalizes the core having high permeability because of excessive air-gap dilution. The results of these measurements are shown in Fig. 17.

Although good correlation exists between actual performance and "L" and "Q" measurements at 1000 cps, these measurements provide only a relative indication of merit. They are presented because of their simplicity as compared to the more accurate and absolute loss and permeability measurements at proper frequencies.

USE OF IMPROVED FERRITES

The results obtained when ferrites of improved grades were substituted in the same deflection transformer indicate that some other methods are desirable to realize the full capabilities of the improved material. A rather substantial improvement in performance or a reduction in over-all cost should be possible through the use of proper application methods. Two special transformers were prepared using cores which had approximately a 2.5 to 1 ratio for permeability and losses. The improved core permits operation at higher flux density provided core saturation is not a limiting factor. The transformers were designed for a deflection system used in a color receiver, and performance was judged on the basis that the operation of the tubes associated with the deflection circuit, the ultor power and scan provided, and the stability as a function of operating time would remain the same.

The volume of the improved core used was approximately 55% of the volume of the poorer core used, and the operating flux density of the better core was increased by 45%. A reduction of approximately 20% in copper was effected with the improved core. All performance data were basically the same, except that retrace time was increased 5%, or 0.5 μsec for the smaller core. Because the smaller unit was designed to operate at a rather high flux density, certain precautions were necessary to provide performance stability. It is interesting to note the effects of d-c magnetization in this core caused by the rather high polarized current passing through a portion of the winding.

The performance of this transformer as a function of air gap in the magnetic circuit is shown in Fig. 18. The transformer must provide an output of 25 kv at 20 watts for ultor power to the color kinescope. Conversion efficiency is defined as the ratio between this power output and the power input to the system, exclusive of power input to the screen grid of the driver tube. A gap of 10 to 18 mils provides optimum operation from the standpoint of conversion efficiency and scan. It is very important, however, that the ouput be unchanged as a function of operating time. Fig. 19 shows the "slump," which is defined as the ratio between the ultor power output of a "cold" transformer and that of one which has reached its final operating temperature. The plate-current increase as a function of gap is also shown for the "cold" transformer. In the region where slump is pronounced plate current increased with temperature. The optimum gap appears to be between 16 and 18 mils.

As shown in Figs. 18 and 19 excessive "slump" and poor conversion efficiency existed when a 6-mil gap was used. A modified circuit arrangement which cancelled the effect of d-c magnetization provided essentially the same performance as that obtained with the increased gap. The deviation depends on the influence of transformer inductance upon retrace time as previously explained.

Fig. 20 shows the reason for degradation in performance of a transformer having low gap values. The curves of Fig. 20 represent a core having a 6-mil air gap, as shown in Figs. 18 and 19. The d-c magnetizing force for the curve labeled 2.8 oersteds is the same as that which exists under actual operating conditions. The value of "H" shown on the curve is the total magnetizing force and neglects the decrease due to the air gap. The actual d-c magnetizing force in the core for the curve labeled 1.4 oersteds is approximately 0.3 oersted. Similarly, the curve labeled 2.8 oersteds is also reduced from the labeled value. The actual d-c magnetizing force in the core under the optimized condition is approximately 0.25 oersted. This value, in conjunction with the large gap, provides a relatively small change of inductance as a function of temperature.

IMPROVEMENT OF CORES

The trend to wider deflection angles in monochrome receivers and the desire for improved efficiency with reduced size in color deflection systems dictate the use of ferrite cores which permit operation at increasingly higher flux densities. As a result, higher permeability is required to permit reduction of copper requirements.

Examination of the geometry of the large C-shaped cores used for color transformers shows that the leg lengths are determined by the space required for copper rather than by insulation requirements. For example, if the permissible operating flux density of the smaller color transformer discussed earlier were doubled, the dimension C on the leg length could be reduced by 42% with no increased insulating difficulties. This change would improve the molding geometry and would permit the design of cores having decreased weight, size and cost.

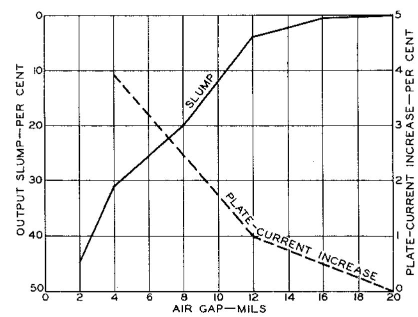


Fig. 19—Output "slump" and plate-current increase as functions of air gap for improved ferrite core.

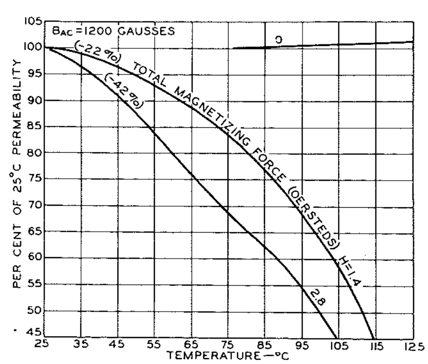


Fig. 20—Variation in permeability as a function of ambient temperature for two values of magnetizing force.

INTRODUCING

EDITORIAL REPRESENTATIVES AT CHERRY HILL, NEW YORK CITY, PRINCETON AND INDIANAPOLIS

The Cherry Hill Editorial Board was formed early in March 1955—shortly after the basic plans for the RCA ENGINEER were discussed with the Chief Engineers of the Television Division and the Radio and "Victrola" Division. It consists of a chairman and seven editorial representatives—an engineer from each of the four Sections comprising the Television Division Engineering Department, one from Radio and "Victrola" Engineering, plus two representatives covering Resident Engineering at Indianapolis and Bloomington. In addition, the RCA Service Company editorial representatives have been invited to attend the Cherry Hill Editorial Board meetings.

Monthly meetings are held to schedule new papers and discuss the status of papers in preparation. A four-step approval procedure has been established by the Editorial Board which insures the approvals of the author's [illegible]d the Chief Engi[illegible]r can be submitted to the RCA ENGINEER for final approvals and publication. Once a paper has been scheduled, it is the responsibility of the Editorial Representative to work with the author in the preparation of the paper, secure the necessary approvals, and facilitate the release of the paper to the RCA ENGINEER. To date the results have been excellent and enough papers have been scheduled to insure Cherry Hill representation in the RCA ENGINEER for many future issues.

In addition to the Cherry Hill Editorial Board, and those groups described in earlier issues—the Radiomarine Corporation, RCA Victor Record Division, and the RCA Laboratories each has appointed one engineering editorial representative. Although these three engineers do not operate as members of an editorial board, they do assume similar editorial responsibilities at their particular locations.

W. H. BOHLKE
Editorial Representative
Consumer Products Service Dept.
RCA Service Company
Cherry Hill, N. J.

Mr. Bohlke graduated from Rutgers University in 1927 with a B. S. in E.E. degree, and was employed by Westinghouse as student engineer from 1927-1928. He joined RCA as a field engineer in 1928, handling all field phases of application, installation and service. He supervised centralized radio installations until 1934 and in 1935 managed the Service Publications and Lecture Group. After working on the first all-electronic television field tests in 1936 he returned to Camden in 1938 to prepare television service publications. From 1939 through 1941, as Director of Test Equipment Merchandising, he introduced the RCA Dynamic Demonstrator and the RCA Voltohmyst, Jr. in service lectures throughout USA. He was assigned to "Block" engineering section after Pearl Harbor on accessory designs, writing and editing instruction books. In 1944 Mr. Bohlke was made Staff Assistant to the Chief Engineer. From 1944 to 1947 he managed the Specialties Group of Electronic Apparatus Section. In 1948 he did administrative work with the RCA Service Company handling post war Antenaplex, etc., being made Merchandising Coordinator in 1950. In 1951 he was appointed Manager, "Custom Service Operations." In early 1953 he was made Assistant to Vice President—Consumer Products Division, RCA Service Company. Since 1953 Mr. Bohlke has been assigned to special administrative projects in the Consumer Products Division. Mr. Bohlke is a past associate member of AIEE and IRE.

E. T. DICKEY
Editorial Representative
Research
RCA Laboratories
Princeton, N. J.

Mr. Dickey received his B. S. degree from the College of the City of New York in 1918. After graduation he joined the Research Department of the Marconi Wireless Telegraph Company of America. Upon the formation of RCA in 1919, he transferred to that organization working in the Research Department. In 1929, he was in charge of competitive receiver testing and technical publications in the RCA Victor Division at Camden. In 1941, he transferred to RCA Laboratories, where he is now Coordinator, Technical Publications.

Mr. Dickey, active in the field of radio standardization, has been a member of the following committees of IRE: Standardization, Sub-Committee on Radio Receivers, Symbols, Meetings and Papers, Papers Procurement (of which he was Vice-Chairman), Membership, and Admissions. He was also a member of the following committees of RETMA: Committee on Broadcast Receivers and Power Supply (Chairman for several years), Safety Section, and American Research Committee on Grounding. He was also a member of the Joint IRE, RETMA, and NEMA Coordination Committee on Interference, the Standardization Committee of the ASTM, and the IRE representative on the ASA Sectional Committee on the NE Safety Code. He is a Senior Member of the IRE, a Fellow of the Radio Club of America, and a member of the Society of Sigma Xi.

R. D. FLOOD, *Editorial Representative*
Color TV Engineering
RCA Victor Television Division
Cherry Hill, N. J.

Mr. Flood, an activity coordinator in Color Television Engineering, graduated from the University of Oklahoma in 1948 with a B.S. degree in E.E. He joined RCA in June, 1948 and after completing the Company's Specialized Training Program, was assigned to the Advanced Development Department in Home Instruments. He worked on the original "P" Converters for UHF ex-

ENGINEERING REPRESENTATIVES
(continued)

perimentation at Bridgeport. Since 1950 he has specialized in Color Television Receiver Design. His activity is responsible for the accumulation and integration of design information into a final instrument for production. Mr. Flood is a member of Kiwanis International.

J. F. HOLLABAUGH
Editorial Representative
Government Service Department
RCA Service Company
Cherry Hill, N. J.

Mr. Hollabaugh attended Arkansas State College from 1932-35 and majored in Engineering. From 1938-39 he attended Arkansas Polytechnic College, same curriculum. He entered the U. S. Navy in 1942 and held the rank of Assistant Electronics Officer. From 1948-50 he attended Tulane University. In 1950 he joined the RCA Service Company as a technical writer and later transferred to Field Support Engineering. Mr. Hollabaugh has also worked on the engineering of Battle Announce systems for Government Application. His present position is Manager, Field Support Engineering, Government Service Department.

F. T. KSIAZEK
Editorial Representative
Black and White TV Engineering
RCA Victor Television Division
Cherry Hill, N. J.

Mr. Ksiazek attended the Case School of Applied Science in Cleveland and graduated from the Illinois Institute of Technology in Chicago with a degree of B.S. in E.E. He also attended the Wharton Evening School, University of Pennsylvania. Mr. Ksiazek was first employed at RCA in 1948 as a Specialized Trainee. He later joined Product Design Engineering on Black and White Television Receivers. His work has included the design of I-F Amplifier Systems and Intercarrier Sound Systems. He has also designed and developed printed circuits for Picture I-F Amplifiers, currently in production. He is a member of Eta Kappa Nu, Rho Epsilon and IRE.

J. OSMAN
Editorial Representative
Resident Engineering
RCA Victor Television Division
Indianapolis, Ind.

J. Osman, an electrical engineer of the Indianapolis Plant, received the B.S. degree in E.E. from Rose Polytechnic Institute in 1942. Following graduation he joined the Studio Broadcast Equipment Group at RCA, Indianapolis, as a Design Engineer. From 1943 to 1950 he served as liaison engineer and coordinator on various projects, including the M-7 mechanism, RC-199 Signal Corps project and on two guided missile projects. In 1950 Mr. Osman transferred to the Resident Engineering Department of Home Instruments at Indianapolis, where he is at present Electrical Group Leader, RCA Victor Television Division.

S. D. RANSBURG
Editorial Representative
Record Engineering
RCA Victor Record Division
Indianapolis, Ind.

Mr. Ransburg graduated from Tri-State College, Angola, Indiana in 1943 with a Ch.E. degree. His first employment was with the Cooper-Bessemer Corporation, Mt. Vernon, Ohio, where he was a Sand Technologist and later Asst. Metallurgist. In 1943, Mr. Ransburg joined RCA at the Indianapolis Record Engineering Development Laboratory where he worked as development engineer on record formulations and molding problems. In 1944 he entered USNR and completed courses in Pre-Radio, E.E. and R.M. and Advanced Radio training. Mr. Ransburg rejoined RCA in 1946 as a Development Engineer on phonograph records. He helped pioneer 45 rpm records in both molding and formulation procedures and did development work on molding techniques of Gruv-Gard records. Mr. Ransburg is presently engaged in development work on fully automatic molding of 45 rpm records. He is a Charter Member of the Central Indiana Chapter of The Society of Plastics Engineers.

E. T. DICKEY
RCA Laboratories
Princeton, N. J.

W. H. BOHLKE
RCA Service Company
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W. S. SKIDMORE
RCA Victor Radio & "Victrola" Div. Cherry Hill, N. J.

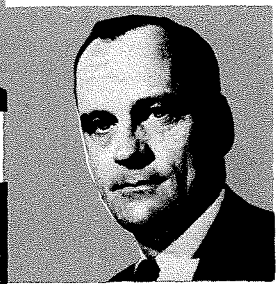
C. M. SINNETT
RCA Victor Television Division
Cherry Hill, N. J.

E. STANKO
RCA Service Company
Cherry Hill, N. J.

M. SCHOENFELD
Editorial Representative
New Products Engineering
Radiomarine Corporation of America
New York City

Mr. Schoenfeld joined the Consumer Custom Products Division of RCA in 1948. When this group was terminated, he was assigned to the Radio and Phonograph Engineering Department at Camden, where he served as a Product Designer. In 1951, he transferred to the Radiomarine Corporation as their New Products Engineer and has been active in the development of several product lines for the marine field. He attended Rutgers University and Polytechnic Institute in Brooklyn, majoring in Mechanical Engineering. Prior to his employment at RCA, he

R. D. FLOOD
RCA Victor Television Division
Cherry Hill, N. J.



J. F. HOLLABAUGH
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W. A. SONNTAG
RCA Victor Television Division
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K. G. WEABER
RCA Victor Television Division
Cherry Hill, N. J.

was associated with the Engineering Departments at the Lewyt and Noma Electric Corporation.

C. M. SINNETT
Chairman, Editorial Board
RCA Victor Television Division
Cherry Hill, N. J.

Mr. Sinnett received his B.S. in E.E. from the University of Maine in 1924 and joined the Engineering Department of the Westinghouse Electric and Manufacturing Company in July of that year. In November, 1929 he was transferred to Camden, N. J. as Manager of the Phonograph Development and Design Section of the RCA Manufacturing Company and later became Manager of the Loudspeaker and Phonograph Section. In 1945 Mr. Sinnett was appointed Manager of the Home Instrument Advanced Development Section, which position he still holds in the RCA Victor Television Division. He was Chairman of the Philadelphia Section of the IRE in 1952 and was elected IRE fellow in 1955. He is a member of Tau Beta Pi and has 30 patents to his credit in the fields of audio and acoustics.

W. S. SKIDMORE
Editorial Representative
Radio & "Victrola" Engineering
RCA Victor Radio & "Victrola" Div.
Cherry Hill, N. J.

Mr. Skidmore received his B.S. in E.E. degree at West Virginia University and is a native of that state. He joined RCA as a Specialized Trainee in September, 1951. Upon completion of the Training Program he was assigned to the Advanced Development Section of the Home Instrument Department. At present he is with the Radio & "Victrola" Division where he is working on Radio Receiver Printed Wiring Design and Development.

R. W. SONNENFELDT
Editorial Representative
Advanced Development Engineering
RCA Victor Television Division
Cherry Hill, N. J.

Mr. Sonnenfeldt received a B.S. degree from Johns Hopkins University in 1949. He was engaged in industrial electronic design work from 1941-1943 and 1946-1949 for the Charles Transformer Company of Baltimore, Md. He joined RCA in 1949 as a Specialized Trainee and is now a Development Engineer with the TV Circuits Group of Television Division Advanced Development Section. Mr. Sonnenfeldt is a Senior Member of the IRE, a member of Tau Beta Pi, and Omicron Delta Kappa.

W. A. SONNTAG
Editorial Representative
Resident Engineering
RCA Victor Television Division
Bloomington, Ind.

Mr. Sonntag, of Resident Engineering at the Bloomington Plant, received the B.S. degree in E.E. from Purdue University in February, 1948. He has been employed by RCA since that date. Mr. Sonntag started with RCA as a Test Design Engineer, and transferred to the Resident Engineering Section in March, 1951. He is a member of the IRE.

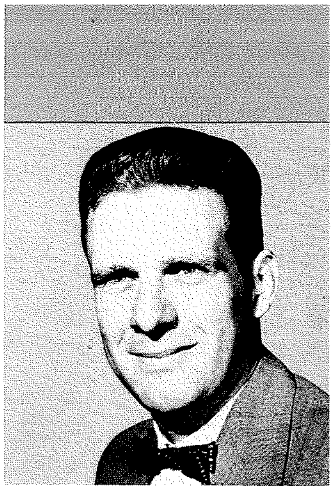
E. STANKO
Editorial Representative
Technical Products Service Dept.
RCA Service Company
Cherry Hill, N. J.

Edward Stanko attended National Radio Institute, Lincoln College Preparatory School, Standard Institute of Therapeutics, Lafayette Institute, University of Buffalo and College of South Jersey. Mr. Stanko, who started as a ship's radio operator in 1920, has held various positions in Radio Broadcast Engineering and Operation. In 1929 he joined Electrical Research Products in Sound Engineering. In 1937 he joined RCA as a Sound Engineer and later worked as senior engineer on specialized products for government applications. Mr. Stanko holds three electronics patents which are assigned to RCA. In 1943 he was appointed Manager of RCA's Technical Products and District Operations Groups and in 1952 promoted to his present position, Manager of Engineering, Technical Products Division, which includes the specialized training of field personnel, preparation of technical information, and development of new and improved methods for installation and servicing of RCA technical products.

Mr. Stanko is a Senior Member of IRE, Charter Member of the Niagara-Buffalo Section and Member of the SMPTE.

K. G. WEABER
Editorial Representative
Engineering Services
RCA Victor Television Division
Cherry Hill, N. J.

Mr. Weaber graduated from Phillips University in 1939 and received his M.S. in Physics from the University of Oklahoma. He joined RCA as a specialized trainee in manufacturing in 1941. Since then he has worked successively as a factory engineer where he approved substitute materials, as an optics engineer in the Plastics Department where he developed glass grinding and vacuum coating equipment, and as an optics engineer in the Advanced Development Section. He joined the Engineering Services Section in 1952 and since then has done liaison work with Purchasing and outside suppliers. His work results in Engineering approval of components for Television Production.



MARSHALL C. KIDD received the B.Ch.E. degree from Ohio State University in 1944. From 1944 to 1945 he was associated with Bakelite Corporation in Bound Brook, New Jersey. In 1945 he joined the Allen B. DuMont Laboratories in Passaic, N. J., where he worked with cathode-ray tubes. In 1946 he returned to Ohio State University and received the B.E.E. degree in 1948. He joined the Advanced Development Section of the RCA Victor Television Division, where he worked on loud speakers and television. His present work is with transistor circuits. Mr. Kidd is a Senior Member of the I.R.E.

TRANSISTOR VIDEO AMPLIFIERS

by **M. C. KIDD**

Advanced Development Engineering
RCA Victor Television Division
Cherry Hill, N. J.

TRANSISTOR VIDEO amplifiers are receiving increased attention in the laboratories today. Since the first transistor was made seven years ago, steady progress has been made in improving the high-frequency characteristics and the reliability of the semiconductor amplifier. Transistor video amplifiers are now being used in special applications where size and weight are at a premium and cost is a secondary consideration.

This paper discusses the performance of transistor video amplifiers at the present state of the art. Undoubtedly better transistors will be developed which will greatly reduce the design problems and increase the utility of transistor amplifiers.

TYPICAL HIGH FREQUENCY TRANSITORS

Frequency and dissipation characteristics of some transistors that might be considered in a video amplifier are tabulated in Fig. 1. The manufacturers' data for $f_{\alpha o}$ or f_{max}, collector voltage and collector dissipation are also given for comparison of the units. The alpha cutoff, $f_{\alpha o}$ is the frequency at which the emitter to collector current gain is reduced to 70% of its low frequency value, and f_{max} is the maximum frequency of oscillation or the frequency for unity power gain. Either $f_{\alpha o}$ or f_{max} may be given to specify high-frequency response. There is no simple relationship for these two frequencies for all types of transistors but for alloy junctions f_{max} may be three or four times the $f_{\alpha o}$ frequency, while surface barrier transistors may have $f_{\alpha o}$ about the same as f_{max}. All of the values of $f_{\alpha o}$ and f_{max} in Fig. 1 are above 4 mc, indicating that the transistors will have some gain in the normal video range. Both V_c max, the maximum allowable collector voltage, and the maximum collector dissipation, are far below the usual 100 volts at 0.5 watt that is used to drive a kinescope. There are two possible solutions to this limitation problem. First, transistors with higher ratings will probably be developed; second, kinescope drive requirements might be reduced. However, such reduction will currently sacrifice other desirable characteristics. Present transistors are suitable for low-level amplifiers such as used in cameras.

TRANSISTOR TYPE	$f_{\alpha o}$	f MAX.	Vc MAX	COLLECTOR DISSIPATION
ALLOY JUNCTION PNP TYPE A	7 MC		20 VOLTS	75-100 MW
ALLOY JUNCTION PNP TYPE B	4	12 MC	16	35
ALLOY JUNCTION PNP TYPE C	20		12	50
ALLOY JUNCTION PNP TYPE D	20		6	50
ALLOY JUNCTION NPN	6		20	30
GROWN JUNCTION NPN		80	30	50
GROWN JUNCTION SILICON	8		30	150
SURFACE BARRIER		30-65	4.5-10	10-30

Fig. 1—Comparative data of some high-frequehcy transistors

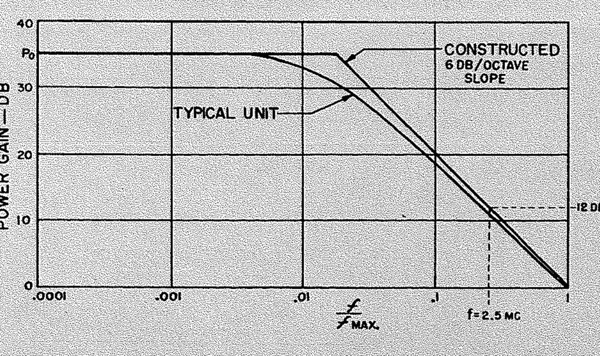


Fig. 2—Transistor power gain vs. frequency

POWER GAIN

While we normally consider tube video amplifiers as voltage amplifiers, with transistors it is often preferable to work with power gain since the input power is not negligible. It has been observed that most transistors have a power gain versus frequency curve that falls off at a rate approaching 6 db per octave above a given low-frequency value. If the low-frequency power gain P_o and the maximum frequency of oscillation are known for a particular unit, an approximate power gain versus frequency curve can be constructed as in Fig. 2. This curve can be used then to estimate the maximum power gain for a given video amplifier bandwidth. For example, if the maximum frequency of oscillation is 10 mc, the maximum power gain for 2.5 mc bandwidth would be 12 db (Fig. 2). The actual gain would be somewhat lower than this since matched conditions would be only approximated in a practical amplifier.

EQUIVALENT CIRCUIT

From the standpoint of circuit design, it is desirable to have an equivalent circuit to work with. Many circuits have been proposed but to date no one circuit has been found to describe accurately all types of transistors over the video frequency region. The Johnson-Giacoletto hybrid-pi circuit is useful in understanding and predicting the operation of alloy-junction transistors for small signal operation. The circuit is shown in Fig. 3 for the common emitter connection with values for developmental transistor designed for 455 kc i-f operation.

This circuit has the advantage of having frequency-independent elements that are related to the geometry of the device. In simplified form, it consists of two resistors, two capacitors and a current generator. Also, at low frequencies the output current generator actuated by $V_{b'e}$ is much like the equivalent circuit of the pentode vacuum tube. $R_{bb'}$, the base lead resistance to the internal base, causes a drop in the input voltage so that the signal applied to the active transistor is $V_{b'e}$. $R_{b'e}$ and g_m are directly related to the forward biased base-emitter junction, while $C_{b'e}$ is the capacitance associated with the diffusion of the minority carriers through the base. The feedback capacitance $C_{b'e}$ across the base collector junction acts very much like the plate to grid capacitance in a triode that requires neutralization in high-frequency amplifiers. The equivalent circuit of the transistor is a combination of a pentode type current generator with triode high frequency characteristics and a low-impedance, frequency-limiting input circuit.

While the elements of the equivalent circuit can be measured with suitable bridges, it is useful to know the relationships with the more commonly measured parameters such as β and $f_{\beta o}$. These are given in the following approximate equations.

$$\beta = \alpha_{cb} \approx \frac{qI_E}{kT} r_{b'e} = \frac{I_E}{26} r_{b'e} \quad (1)$$

$$f_{\beta o} \approx \frac{1}{2\pi\, r_{b'e}\, C_{b'e}} \quad (2)$$

$$f_{\alpha o} \approx \beta f_{\beta o} = \frac{I_E}{163\, C_{b'e}} \quad (3)$$

$$f_{max} \approx \frac{1}{4\pi} \sqrt{\frac{g_m}{r_{bb'}\, C_{b'e}\, C_{b'c}}} \quad (4)$$

Where

- β is the common emitter current gain
- q the charge on the electron
- k Boltzman's constant
- T Degrees Kelvin
- I_E Emitter current
- $f_{\beta o}$ the frequency at which β is 70% of its low-frequency value
- $f_{\alpha o}$ the frequency at which α is 70% of its low-frequency value
- f_{max} the frequency of maximum oscillation or unity power gain

From the above relations it can be seen that the hybrid-pi equivalent circuit may be used to determine other useful parameters of the transistor.

DESIGN CONSIDERATIONS

A transistor may be operated common-base connection, common-emitter connection, or common-collector connection. This means that any of three terminals may be connected to the common return for the input and the output circuits. In video amplifier circuits the common-emitter connection is the most practical. This connection has the advantage of having both current and voltage gain and at low and medium frequencies always has more power gain than the other two connections. Fig. 4 shows the relative input impedance of the three connections for a typical transistor that might be used in a video amplifier. For maximum power gain the input and output impedances should, of course, be equal but with most transistors this is not possible for multiple-stage amplifiers. The common-emitter connector comes closest to meeting this condition.

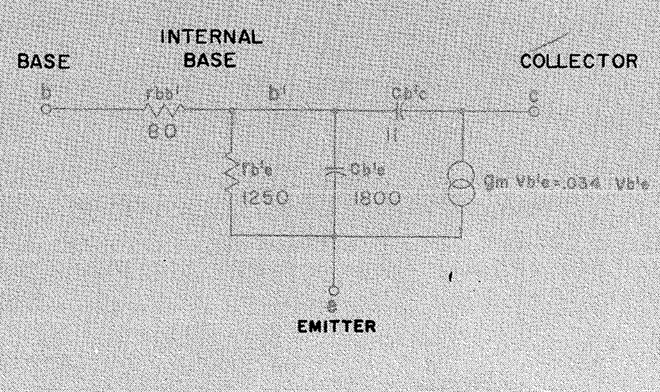


Fig. 3—Hybrid pi equivalent circuit

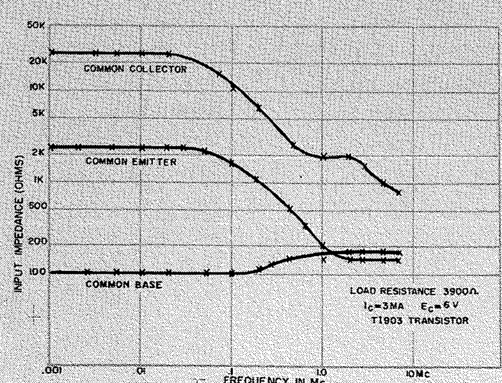


Fig. 4—Amplifier input impedance

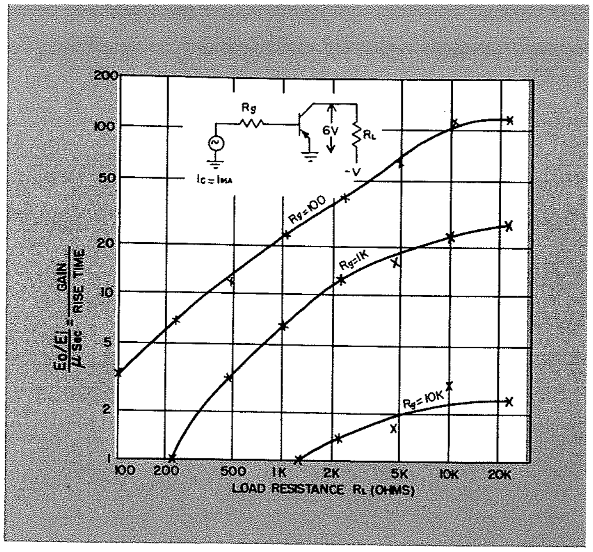


Fig. 5—Gain/rise-time characteristics

It can be shown for the common-emitter connection, with load and input impedances equal, the voltage gain-bandwidth product is equal to $f_{\alpha o}$, or in terms of the equivalent circuit,

$$G_o\,BW = f_{\alpha o} = \frac{g_m}{2\pi\, C_{b'e}}$$

This means that only unity voltage gain can be achieved at the alpha cut-off frequency. The above equation is similar to a pentode amplifier figure of merit where $C_{b'e}$ is replaced with the effective output capacitance.

The gain rise-time quotient is also used as a figure of merit in video amplifiers. For transistors this number is not constant, however, and some curves are given in Fig. 5 showing its variations with generator and load resistance. The gain increases with the load resistance, but the rise time does not increase at as fast a rate, giving an improved quotient. The optimum performance (maximum gain/rise time) will be obtained with small generator and large load resistances. This approaches the matched input and output condition but can only be met when driving a high-impedance load such as a grid of a kinescope. Feedback can be used to exchange gain for rise time in the practical amplifier.

	EFFECT OF INCREASING COLLECTOR CURRENT	EFFECT OF INCREASING COLLECTOR VOLTAGE
$r_{bb'}$	SMALL (DECREASES)	SMALL (INCREASES)
$r_{b'e}$	INVERSELY PROPORTIONAL	INCREASES (NON-LINEAR)
$c_{b'e}$	DIRECTLY PROPORTIONAL	DECREASES (NON-LINEAR)
g_m	DIRECTLY PROPORTIONAL	SMALL
$c_{b'c}$	INCREASES	DECREASES
α	SMALL DECREASES	INCREASES SOMETIMES > 1
$\beta = \alpha_{CB}$	DECREASES	INCREASES SOMETIMES TO ∞
Power Gain	SMALL (DECREASES)	INCREASES
$f_{\alpha o}$	SMALL	INCREASES
Z_{IN}	DECREASES	DEPENDS ON CONFIGURATION
Z_{OUT}	DECREASES	

Fig. 6—Effect of current and voltage on transistor characteristics

CURRENT AND VOLTAGE EFFECTS

Before going into the actual circuitry used for video amplifiers some of the current and voltage relationships that effect the transistor will be considered. Fig. 6 lists the effects of increasing current and voltage on the operation of transistors.

As the current is increased, $r_{b'e}$ decreases, and $C_{b'e}$ increases proportionally, maintaining a fairly constant product so the frequency response is only affected slightly by moderate current variations. This decrease in input impedance is associated with an equal increase in g_m so that the gain also does not change appreciably with current. In contrast to the effects of current, when the voltage is increased the effective base width decreases and the space charge layer widens, increasing the high frequency response, the power gain and reducing $C_{b'e}$. Thus, the collector voltage should be as high as possible for maximum high-frequency performance. This limit is set by operating life and stability limitations. The maximum collector dissipation limits the current that can be used with a given collector voltage.

LOW LEVEL AMPLIFIER

A transistor low level video amplifier capable of giving several volts output is shown in Fig. 7. The input and output impedances are 1000 ohms so that pairs of these amplifiers can be connected. The overall gain for 0.08 μsec rise time is 40 db using transistors with f_{max} values of 40-50 mc. The circuit uses local negative feedback combined with selective high-frequency positive feedback between the emitter circuits. The positive feedback com-

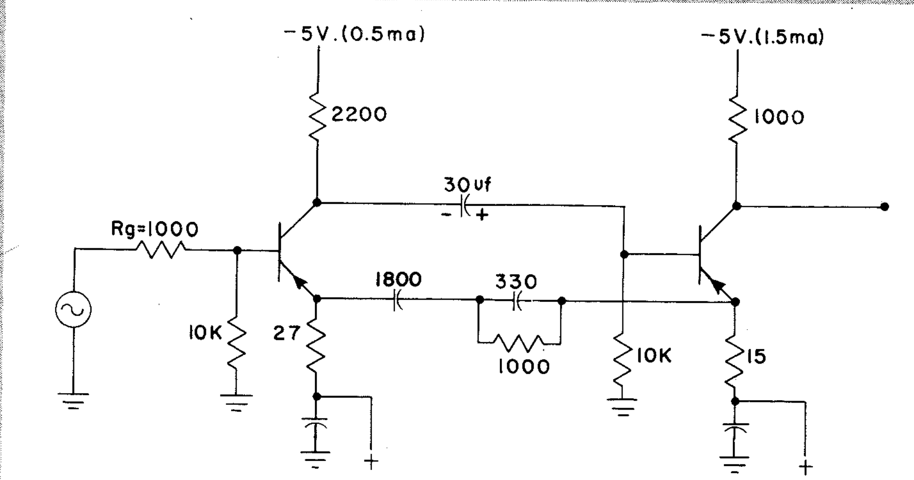


Fig. 7—Low-level video amplifier

pensates for the internal negative feedback due to $C_{b'c}$ and could be considered as neutralization. Other techniques not involving positive feedback such as series and shunt peaking can be used but give somewhat less gain. Many other combinations of local and overall feedback can be used to increase the bandwidth.

HIGH LEVEL AMPLIFIER

Referring to Fig. 1 again, the maximum collector voltage and dissipation become important when considering the suitability of transistors as high level amplifiers of the type used to drive a kinescope. Also, linearity and symmetry of the transient response are necessary for good picture quality.

With the exception of the tetrode, the transistors having *high* collector voltage ratings usually have *poorer* high-frequency response characteristics and vice versa since voltage ratings are largely proportional and frequency response inversely proportional to base thickness. The tetrode is not a true tetrode since it has only three elements. It obtains its increased high-frequency response at a sacrifice in emitter efficiency. It appears to be inherently a small-signal device when operated as a linear amplifier. Transistors such as the silicon-grown junction types have good frequency characteristics but poor transient characteristics with the turn-off time longer than the turn-on time for large-signal operation. The large-signal transient response is more symmetrical with alloy junction transistors than grown-junction types, though there seems to be considerable variation among the units measured. In the selection of the high-level output transistor, the importance of these various factors must be weighed and a transistor selected that best meets all the requirements.

A circuit giving 30 volts output is shown in Fig. 8. The amplifier uses two common emitter stages with emitter peaking on both transistors. This combination was found superior to the common-collector-to-common-emitter combination since the gain rise-time quotient is higher for the common emitter connection. Series peaking is used in the input of both transistors and also in the output. The output transistor was selected for the best compromise between maximum output signal, frequency response and transient response.

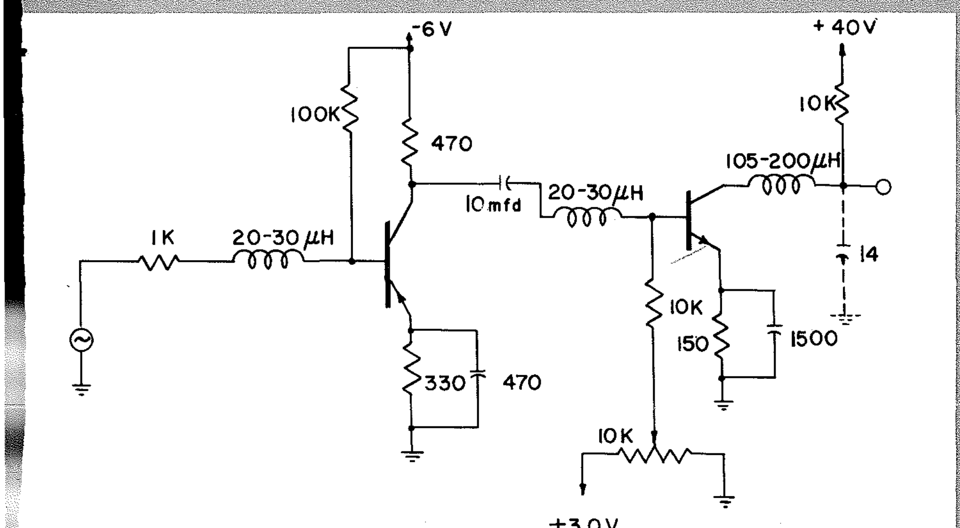


Fig. 8—High-level video amplifier

Using a 1000-ohm source impedance and 10-k load for a 4 mc bandwidth a turn-on time of 0.1 µsec was observed with an overall voltage gain of 50. The turn-off time is a function of level, however, and for maximum output, it may approach 0.4 µsec. This large signal transient dissymmetry is one of the limitations of high-level transistor operation.

There have been a number of other methods used to obtain large signals for driving a kinescope such as operation of two units in series where the output voltage can be almost double the voltage allowed on each transistor. Push-pull operation can be used to drive the kinescope grid and cathode out of phase. These methods are not ideal because they use two transistors for a job that no single presently available transistor can do. The new transistors such as the drift, p-n-i-p or diffusion types should overcome the collector voltage, power and frequency response limitations.

CONCLUSIONS

Transistor video amplifiers can be built using commercially available units. For low-level applications transistor video amplifiers show marked superiority over tube circuits in size, weight, and efficiency. Design of transistor video amplifiers includes consideration of the lower input impedance, the variation of characteristics over the video band, the lower power output, and the smaller gain-bandwidth product. Transistors suitable for higher voltage and higher power operation will further increase the usefulness of transistor video amplifiers.

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NOMOGRAPHS FOR DETERMINING SIGNIFICANT DIFFERENCES*

by

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THE NOMOGRAPHS presented here make it possible to determine quickly the significance of attributive test results on two samples of equal size. These nomographs are particularly valuable to both research and production engineers, as well as plant managers, purchasing agents and quality control workers. Real differences in test results are easily separated from chance occurrences, thus avoiding the possibility of costly indecision or adoption of false conclusions. When a test has shown qualitatively that one process, product, or material is better than another in a certain respect, the use of the nomographs makes it possible to determine quantitatively how reliable the test results are. With this information, it is possible to make systematic comparisons of the two processes, products or materials, weighing together such other factors as economic considerations, engineering difficulties, and the like.

USE OF NOMOGRAPHS

The four nomographs shown cover a range of sample sizes from 8 to 100,000. As mentioned above, these nomographs can be used only when the samples to be compared are of equal or very nearly equal size. In such cases, the procedure is as follows:

1. Find the difference between the number of defectives ($D = d_2 - d_1$).
2. Draw a straight line on the appropriate nomograph connecting the sample size ($n_1 = n_2$) on the n-scale to the point representing the difference between the numbers of defectives ($D = d_2 - d_1$) on the D-scale.
3. Find the sum of the numbers of defectives ($S = d_2 + d_1$).
4. Connect the four points $S = d_2 + d_1$ on the four S-scales with a straight line.
5. Find the point of intersection of the lines mentioned in items 2 and 4 above. The region in which this point lies defines the region of significance sought.

The terms "probably significant," "significant," "very significant," and "very, very significant" are used to designate differences between test results for which the probabilities of occurrence due to chance alone are less than one in ten, twenty, one hundred, or one thousand respectively.[1,2] Conclusions obtained from the use of the nomographs, therefore, would be wrong less than one time in ten, twenty, one hundred, or one thousand cases, respectively.

Because "acceptable" and "defective" are attributes, they may be interchanged in using the nomographs and will yield the same probability statement. This change is desirable when $S > n_1 = n_2$ because the left portions of the S-scales are more accurate than the right portions. The use of the nomographs is best illustrated by examples.

Example A:

Situation — The Tube Division has been purchasing nickel alloys for use in electron-tube cathodes from Vendor X exclusively. Vendor Y claims that his nickel alloys, although slightly more expensive than those of Vendor X, are much better in performance. Test results show that of 30 sample cathodes made from alloys supplied by Vendor X, 6 (or 20 per cent) are defective; of 30 sample cathodes made from alloys supplied by Vendor Y, 1 (or 3.3 per cent) does not meet the specification.

Question—Does the difference between the numbers of defectives in the two samples constitute sufficient evidence to warrant the purchase of the nickel alloys from Vendor Y at slightly higher cost?

Method of Analysis—The numbers of defectives being 6 for sample X and 1 for sample Y, their difference and sum are 5 and 7 respectively. A line is drawn on nomograph No. 1, there-

*The construction of these nomographs is described in articles entitled "A Nomograph for Evaluating the Significance of Some Test Results" by C. H. Li, published in ASTM BULLETIN No. 194, December 1953, and "Additional Nomographs for Significance Tests" by C. H. Li, published in ASTM BULLETIN No. 205, April 1955. This paper, with minor modifications, is also scheduled for publication in METAL PROGRESS.

[1] R. A. Fisher, "Statistical Methods for Research Workers," Oliver & Boyd, Ltd., London (1950)

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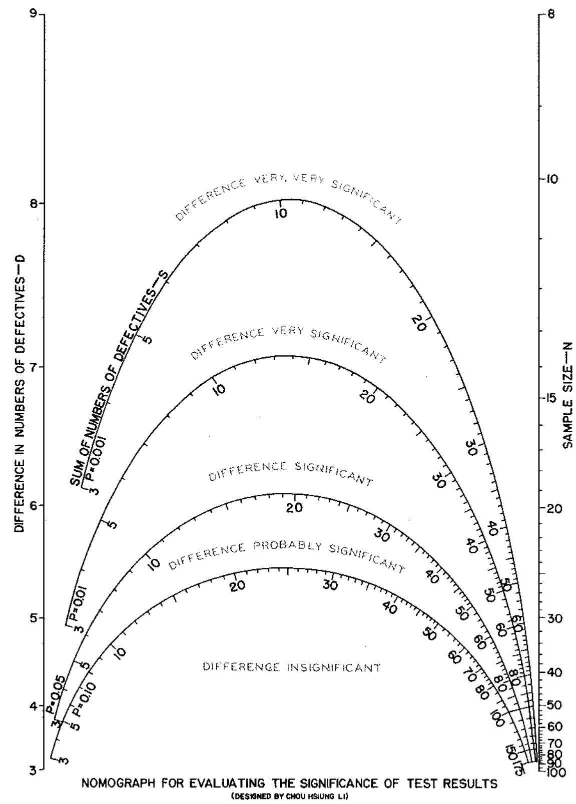


Fig. 1—For sample size from 8 to 100

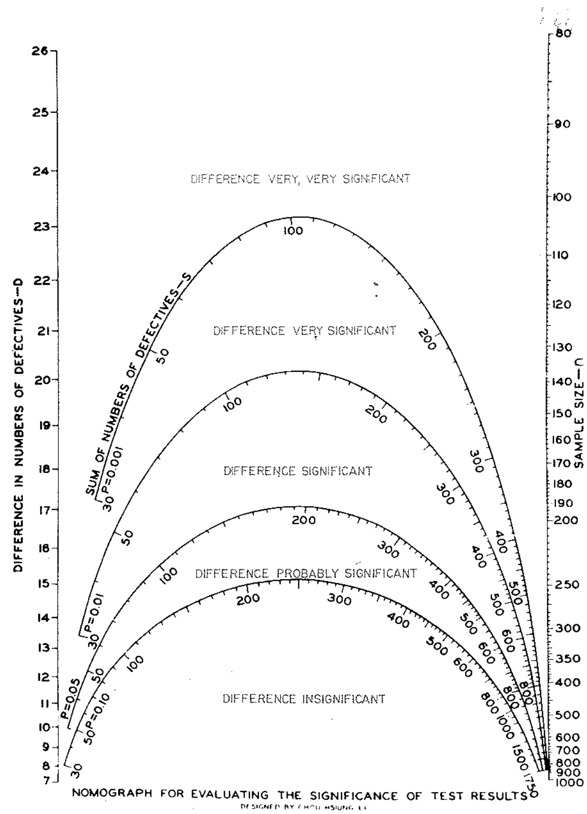


Fig. 2—For sample size from 80 to 1000

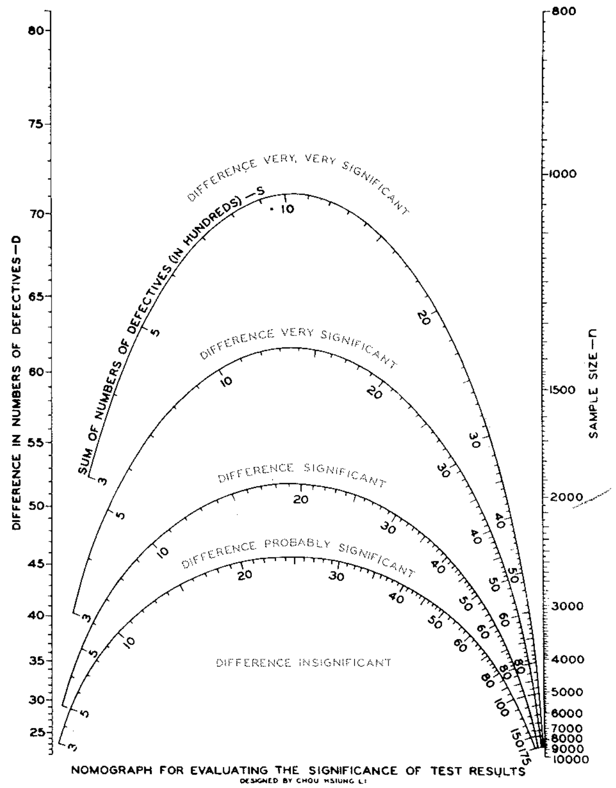


Fig. 3—For sample size from 800 to 10,000

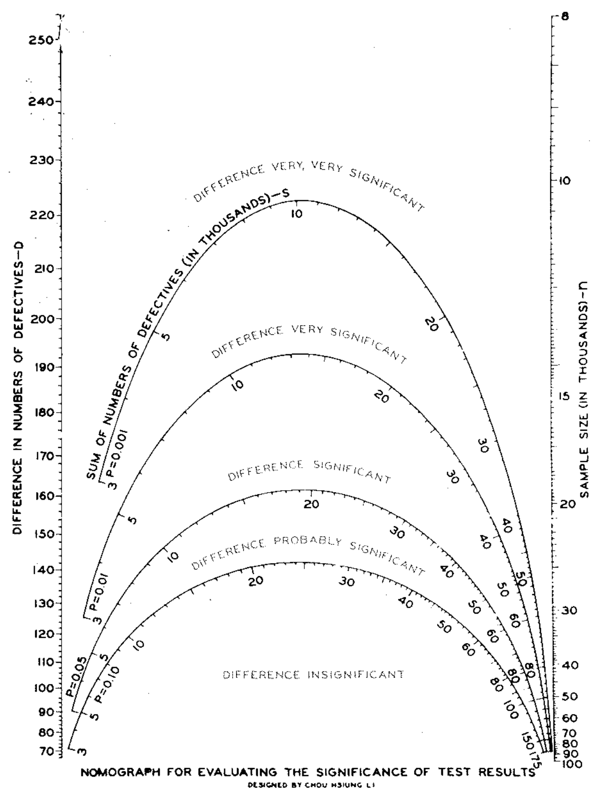


Fig. 4—For sample size from 8000 to 100,000

fore, connecting the point 30 on the n-scale with the point 5 on the D-scale. Another line connecting the 7's on the four S-scale intersects this line in the area marked "difference probably significant." Hence, the difference is significant at a level between 0.10 and 0.05 or the probability of such a difference occurring due to chance alone is less than one time in ten but greater than one time in twenty.

Conclusion—The observed difference between the numbers of defectives in the two samples could happen occasionally due to chance alone. If the nickel alloys from Vendor Y are better than those from Vendor X, therefore, more evidence will be needed for proof. However, it is quite probable that examination of a larger sample from each of the two Vendors will show the alloys of Vendor Y to be distinctly better than those of Vendor X. On the basis of the above test results, it is inadvisable to change suppliers of the nickel alloys.

Example B:

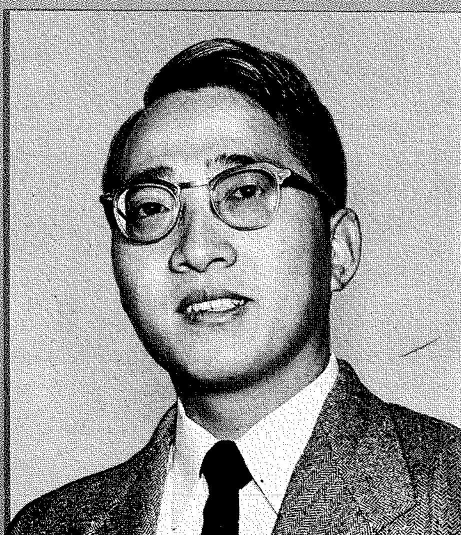
Situation—A grid inspector finds that of 1500 grid assemblies manufactured in period Y, 265 (or 17.7 per cent) are defective. From a more recent lot of 1500 grids manufactured in period X, 330 (or 22 per cent) are defective.

Question—Could the sudden increase in number of defectives in the manufactured grids be due solely to chance variation?

Method of Analysis — A straight line is drawn on nomograph No. 3 connecting 65 on the D-scale with 1500 on the n-scale. Another line joining the points representing 595 (the sum of the numbers of defectives) on the S-scale intersects this line in the region of very significant difference. Hence, the difference is significant at a level between 0.01 and 0.001, or the conclusion reached on the basis of the results would be correct 99.0 to 99.9 per cent of the time.

Conclusion — The very significant difference between the numbers of defectives in the two manufacturing periods X and Y shows that the manufacturing process was out of control in period X as compared to period Y. It is necessary, therefore, to seek assignable causes for the lack of control and to adopt corrective measures quickly.

In the examples given above, the difference between the percentage of defectives in the samples X and Y was much greater in example A than in Example B. Because of the varying sample sizes, however, the difference between the samples was probably significant in example A, but very significant in Example B. These examples illustrate how easily erroneous conclusions may be reached if the use of statistical techniques is neglected. It can also be seen that comparative test results expressed in terms of per cent defective may be very misleading if the actual sample size is not given.



C. H. LI was born in China in 1923. After receiving the B.S. degree in mining and metallurgical engineering from Chiao Tung University in 1944, he worked on developmental aspects of ferrous and non-ferrous melting and foundry in an arsenal and later worked in a steel plant in Shanghai. He came to the United States in 1948, and received the M.S. and Ph.D. degrees in metallurgy from Purdue University in 1949 and 1951, respectively. He joined the Tube Division of the Radio Corporation of America at Marion, Indiana in January, 1951. He is now located at the Harrison, N. J. plant, where his work includes research, development, and controlled experimentation. Dr. Li is an associate member of Sigma Xi.

PROGRESS IN HIGH-FREQUENCY TRANSISTORS

by **HARWICK JOHNSON**
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THE ACCEPTANCE of transistors in low-power audio circuits is an accomplished fact with a substantial number of transistor types available commercially. These transistors have demonstrated their reliability and, in addition, possess inherent advantages of small size and low power consumption. For somewhat higher frequencies, such as are encountered in radio broadcast receivers, commercial transistors are also becoming generally available. Transistors for still higher frequencies are, by and large, in the experimental stage in the laboratory. This paper will review some of the devices being developed in various laboratories to extend the frequency range of transistors and will indicate, in so far as information is available, the results which have thus far been obtained.

In the advance toward higher frequencies, the point contact transistor was the first to attain operation in the ultra-high-frequency region. An oscillation limit of about 400 megacycles per second was reported[1] for a close-spaced point-contact unit using p-type germanium. Little or no work appears to have been done in this direction recently with point-contact types and no further discussion of this type will be given here. However, the effort to extend junction transistor operation to higher frequencies has been extensive and a recent report[2,13] indicates that an oscillation frequency of approximately 1200 megacycles per second has been attained. Germanium remains the favorite material over silicon for high-frequency transistor construction. This is partly due to the more advanced techniques available for handling germanium but, more fundamentally, because of the greater speed with which charge carriers in germanium move through the crystal.

In a fundamental sense, the high-frequency behavior of any electron device depends on the time required for the charge carriers to traverse the various regions of the device. This transit time depends on the extent of the regions and hence high-frequency devices are generally small structures. This is somewhat alleviated in those cases where transit time is essential to the mode of operation, as in traveling wave tubes. However, it remains true, even in those devices, that the elementary interaction regions must be appropriately small. The transit time also depends on the speed with which the charge carriers move in the medium of the device. Thus, in vacuum devices electrons move through the vacuum without hindrance and high speeds may be readily obtained. In gaseous or solid-state electron devices the same freedom of motion does not exist. In these devices, the charge carriers suffer many collisions with the gas atmosphere or with the crystal lattice. In these instances, the ease with which the carriers can move through the medium under the influence of a field is measured in terms of a mobility, μ. The mobility is the average speed of carriers moving under the influence of a unit electric field. Carrier motion under the influence of a field is referred to as a "drift" flow.

In addition to carrier flow under the influence of a drift field, there is another type of carrier flow which is of importance in transistor devices but which has not been of major importance in vacuum devices. This is diffusion flow or the tendency of a concentration of charge to disperse due to its own "pressure," moving to regions of lower concentration under the influence of thermal agitation. This is analogous to the way in which a tiny stream of colored dye dropped into a beaker of water will diffuse outward into all regions of the beaker. The transit time with diffusion flow also depends on the mobility, even when no drift field is present.

The flow of charge in solid-state devices is hindered by the crystal lattice, a handicap in comparison to vacuum devices. For operation at the same limiting frequency, spacings in solid-state devices, as we know them today, must be smaller than those in vacuum devices. However, this is counterbalanced by the fact that vacuum devices are made as an assemblage of individual parts which must be carefully fitted together while the solid-state device is an integral structure. With improved techniques in handling solids, spacings in solid-state devices are already smaller than those developed in the relatively long history of the tube art. Further,

GLOSSARY OF TERMS

Intrinsic semiconductor—a pure semiconductor. For semiconductors of interest in transistors, the conductivity of the pure semiconductor is small at room temperature.

Forbidden energy gap—the energy barrier which must be overcome to make electron-hole pairs available for conduction in intrinsic material.

Impurity semiconductor—a semiconductor containing impurity atoms which are normally ionized at room temperature to make electrons or holes (electron vacancies) available for conduction.

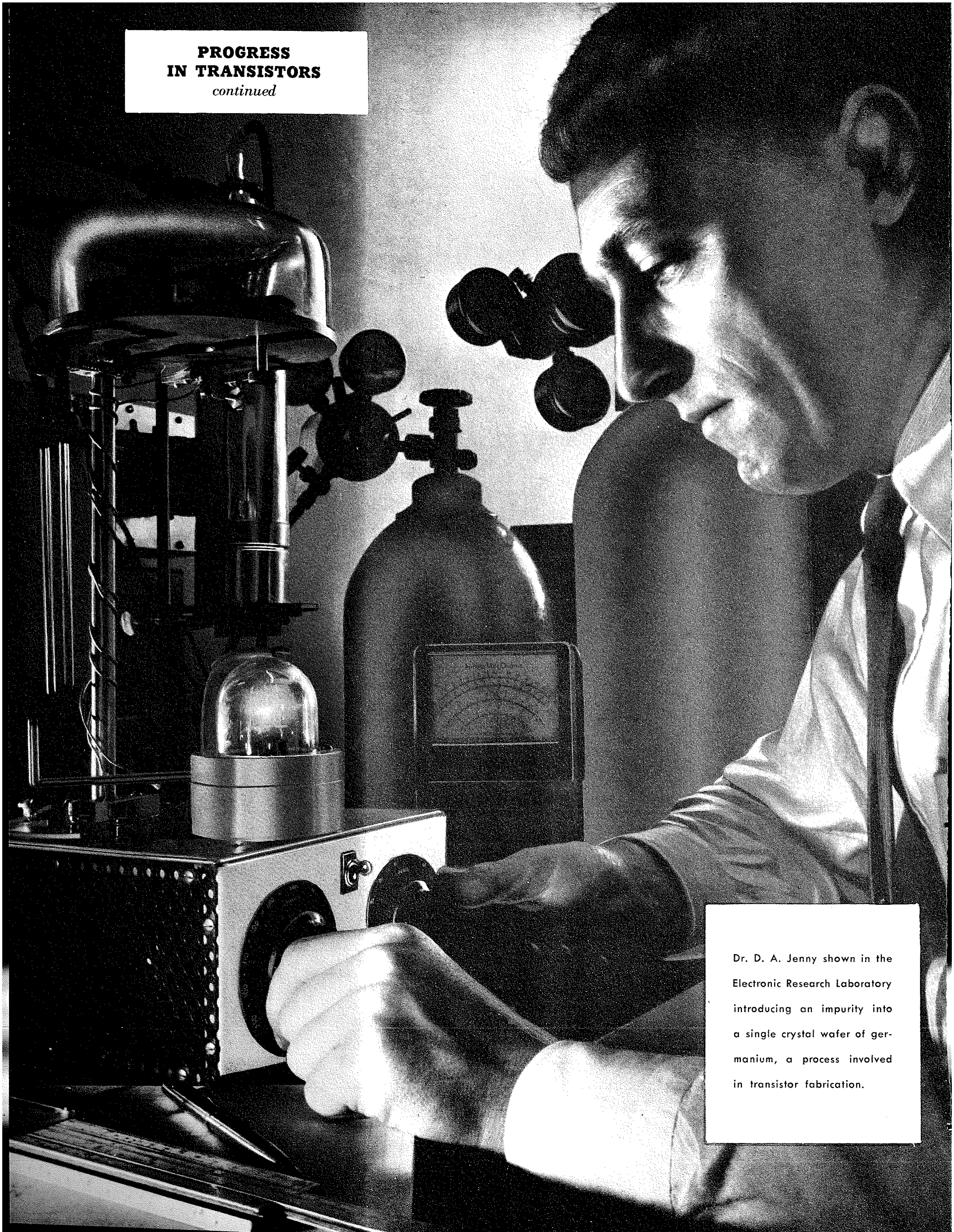
n-type semiconductor—an impurity semiconductor in which current conduction is due principally to electrons (negatively charged carriers).

p-type semiconductors—an impurity semiconductor in which current conduction is due principally to holes (positively charged carriers).

Minority carrier—electrons in p-type material or holes in n-type material.

Bipolar transistor—a transistor in which both electrons and holes play essential roles in its operation.

Depletion or space charge layer—a region at the junction between p-type and n-type material which is devoid of mobile electrons and holes leaving an uncompensated charge of the ionized impurity atoms.



Dr. D. A. Jenny shown in the Electronic Research Laboratory introducing an impurity into a single crystal wafer of germanium, a process involved in transistor fabrication.

effort in the transistor field has largely been confined to one type of device—the bipolar transistor, which uses both holes and electrons in its operation. It is not improbable that solids may be used in other ways to develop devices which may be superior in high-frequency performance.

FREQUENCY RESPONSE OF JUNCTION TRANSISTORS

At high frequencies, e.g., frequencies near the oscillation limit, the equivalent circuit[3] of a junction transistor reduces to that illustrated in Fig. 1. Here the conductive elements normally shown in parallel with the susceptive elements have been omitted. While the circuit shown in Fig. 1 describes the high-frequency behavior of the alloyed junction transistor with good accuracy, a somewhat more complex arrangement[4] would be necessary to deal in detail with some of the other transistor constructions. However, for the purposes of the present discussion, the general considerations deduced from Fig. 1 will apply in a qualitative manner to other bipolar transistor constructions.

A figure of merit for the high-frequency performance of a transistor may be taken as proportional to the high-frequency power gain in the region where the circuit shown in Fig. 1 applies. Thus, it can be shown to a good approximation, that

$$F \propto \frac{1}{r_{bb'} C_c \tau}, \qquad (1)$$

where $r_{bb'}$ is the base-lead resistance, C_c is the collector capacitance and τ is the transit time of the injected minority carriers through the base region. The transconductance, because it enters both into the shunt capacitance and the output generator, cancels out in this approximate treatment. The transit time, τ, is inversely proportional to the *minority* carrier mobility (for example, holes in a p-n-p transistor). $r_{bb'}$ is inversely proportional to the speed at which *majority* carriers move through the base material, i.e., is inversely proportional to the *majority* carrier mobility (for example, electrons in a p-n-p transistor). C_c depends basically on the impurity density and so does not directly involve the mobilities. Such approximate reasoning indicates that the product of the minority and majority carrier mobilities is implicit in the figure of merit. Thus, one expects that the figure of merit is about the same for n-p-n and p-n-p structures having similar geometry and equal C_c's. This figure of merit has also been applied to the evaluation of different semiconductor materials for high-frequency transistors.[5]

To appreciate the motivation behind the various high-frequency transistor structures described below it will be worthwhile to discuss briefly the physical significance of the factors appearing in the figure of merit.

To illustrate the base-lead resistance, consider the construction of the simple alloy transistor shown in section (see Fig. 2). The current flowing through the base contact must flow through the resistance of the germanium wafer into the very narrow region between the emitter and collector electrodes. This gives rise to the base-lead resistance of a transistor through which signal currents must flow. At high frequencies where capacitive effects, e.g. C_c, become important the charging currents flow through this resistance to limit the frequency response. In some types of transistor construction, notably the grown junction types, the base-lead resistance is of a more complex nature than the simple ohmic resistance depicted above. While a discussion of these details is beyond the scope of this paper, the significant points for our purpose are that the base-lead resistance will depend upon the transistor geometry and the resistivity of the base material.

The collector capacitance of an ordinary junction transistor is principally the barrier layer capacitance of the collector p-n junction. When a voltage is applied to a p-n junction in the reverse direction, mobile charge carriers are depleted in the vicinity of the junction leaving a thin non-conducting layer of germanium which may be thought of as the dielectric in a parallel plane condenser. If there is a low density of mobile charges to remove (i.e., relatively high-resistivity regions), the thickness of this layer will be increased and the capacitance decreased. As explained subsequently, this principle can be employed to reduce collector capacitance in high-frequency transistor constructions, without necessarily raising the base resistance.

The third factor in the figure of merit is the transit time of the minority carriers injected into the base region by the emitter. In the conventional transistor these injected carriers flow to the collector by a process of diffusion. This is illustrated symbolically in Fig. 3 sketch where injected carriers suffer many

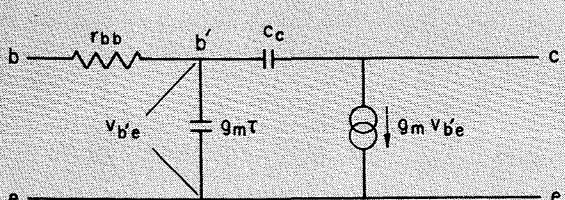


Fig. 1—Equivalent circuit of a junction transistor at high frequencies.

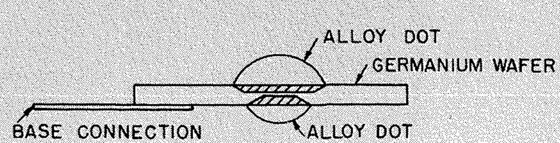


Fig. 2—Section of alloyed junction transistor to illustrate resistance of germanium between base lead and transistor junctions.

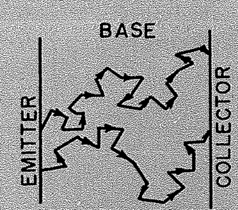


Fig. 3—Diffusion flow of carriers shown across the base region of conventional transistor.

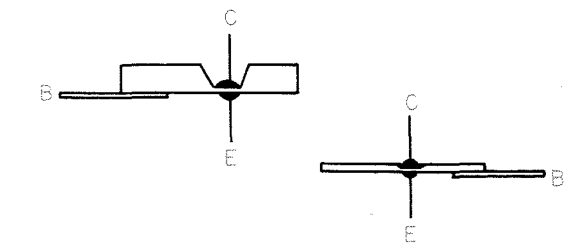


Fig. 4—Structure of h-f alloyed junction transistor (left) and surface barrier transistor (right).

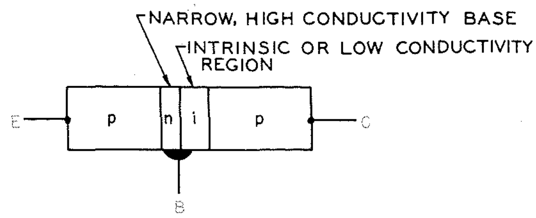


Fig. 5—Schematic structure for a p-n-i-p transistor.

collisions with the germanium crystal and changes of direction in their transit between the emitter and collector. As a consequence a sharp pulse injected at the emitter, by the time it reaches the collector, is quite spread out and loses high-frequency components. Although this is a diffusion phenomenon, there is a general relationship between diffusion and drift phenomena which will enable us to write down the results in terms of an "equivalent electrical drift field." We choose to do so to facilitate a subsequent comparison to a new type of transistor employing a drift field. In these terms the average velocity of the carriers may be written as

$$v = \xi\mu = \frac{2kT/q}{W}\mu \qquad (2)$$

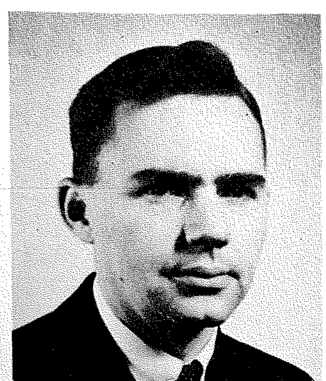
where ξ is the "equivalent drift field" and corresponds to a voltage of twice thermal energy, $(\frac{kT}{q})$, or about 0.05 volts (at room temperature) applied across the base width, W.

EXPERIMENTAL HIGH-FREQUENCY TRANSISTORS

From the above consideration of the important factors in the high-frequency figure of merit, the straightforward methods of improving the frequency performance of the ordinary p-n-p or n-p-n transistor are evident. To reduce the base lead resistance, the base region is made of high-conductivity material and the geometry chosen to minimize the resistance to the base contact. To decrease the collector capacitance the collector area is reduced and to reduce the transit time, the spacing, W, is reduced. These are not independent adjustments, however, for a higher base conductivity increases the collector capacitance and may otherwise injure transistor performance through decreased emitter injection efficiency. Examples of this approach are the high-frequency alloyed-junction transistor[6] and the surface barrier[7] transistor. These constructions are shown (see Fig. 4). In the alloy-junction transistor construction, the germanium wafer tapers into a thick section to retain a low base resistance. The spacing, W, and electrode areas are modest in relation to those reported below for other constructions. In the surface barrier transistor the electrodes are plated rather than being recrystallized germanium.

This straight-forward approach to a high-frequency construction involves compromises between the base-material conductivity, the collector capacitance and breakdown voltage. This compromise is avoided in the p-n-i-p[8] construction shown in Fig. 5 where a region of high resistivity (intrinsic) material is sandwiched between the n-type base region and the p-type collector region. The intrinsic region is a region of relatively few mobile charges. The depletion region of the collector junction (upon application of the collector voltage) readily extends through this region giving a much thicker depletion region and hence a lower collector capacitance than that of the ordinary transistor. The n-type base region can therefore be of greater conductivity than in the ordinary construction without increasing the collector capacitance. Since the collector voltage is distributed over a greater distance, the collector breakdown voltage is high and also is not diminished by the high conductivity of the n-type base region. Transit time considerations through the n-type base region remain the same as discussed earlier. The additional time required for transit through the intrinsic layer is small because of the high electric field in this layer due to the collector voltage.

In the above constructions decreases in transit time have been accomplished by reduction in the spacing, W. To further reduce the transit time for a given spacing one must, in terms of (2) above, increase the "equivalent drift field" above its diffusion value of 0.05/W volts/cm. One method[9] of accomplishing this is to vary the conductivity of the base region so that the conductivity is high near the emitter and low (near intrinsic) at the collector. Such a variation in conductivity is obtained by grading the distribution of impurity atoms in the base with the highest of concentration near the emitter. See Fig. 6. This graded distribution may be produced by solid state diffusion of the impurity atoms. In such a non-uniform conductivity distribution, the electron density (in n-type base material, for example) is greatest in the high-conductivity region. These electrons tend to diffuse out of the region of high concentration but in doing so set up a restraining electric field due to the now uncompensated positive charge on the atom from which the electron originated. Thus a drift field is set up in such a direction as to keep the remaining electrons near the emitter side of



HARWICK JOHNSON received his B.S. degree in electrical engineering from the Michigan College of Mining and Technology and his M.S. and Ph.D. degrees from the University of Wisconsin. From 1938 to 1942 he was a research fellow and teaching assistant in the Department of Electrical Engineering at the University of Wisconsin. Since 1942 he has been associated with RCA Laboratories Division at Princeton, N. J., where he has been associated with work on f-m radar, receiving tubes, noise phenomena, and transistors. Dr. Johnson is a member of the Institute of Radio Engineers, American Physical Society, and Sigma Xi.

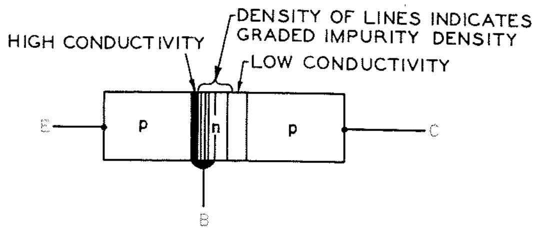


Fig. 6 — Schematic structure for a p-n-p graded impurity drift transistor.

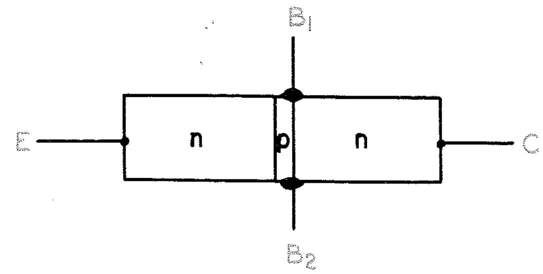


Fig. 7—n-p-n grown junction tetrode transistor structure.

the base. However, holes injected by the emitter are accelerated by the drift field towards the collector because of their opposite electrical charge.

There are limitations to the drift voltage (integral of the drift field) that can be built into the base region. Too great a conductivity under the emitter lowers the injection efficiency of the emitter and may increase the emitter transition capacitance to where it becomes an important factor in limiting the frequency response. It turns out that the "equivalent drift voltage" must be limited to less than one-half the forbidden energy gap of the semiconductor. For germanium, an equivalent drift voltage of 0.20 volts appears feasible. This is four times the "equivalent drift voltage" given earlier for the ordinary transistor. Thus, according to (2) the transit time in a drift transistor may be but one fourth of that in an ordinary transistor of the same base width, W. In addition, the high conductivity of the emitter side of the base region satisfies the requirement of a low base-lead resistance while the near intrinsic conductivity on the collector side satisfies the requirements of a low collector capacitance and high breakdown voltage. Thus, the overall frequency limit of the drift transistor may be an order of magnitude greater than that of the p-n-p transistor.

The transistor structure for which the highest oscillation frequency has been reported to date is the tetrode structure (see Fig. 7). This is a very small grown-junction arrangement which may be made by doping while growing. Two base connections are made on opposite sides of the base layer. By placing a bias between these base connections most of the emitter is biased off and transistor operation occurs only in a very small area near one of the leads. Thus, by electrical means, a very small area is attained in contrast to other structures in which the area is that of the physical geometry. By this means the base-lead resistance and capacitances are very effectively reduced so that operation at high frequencies is attained.

With the very small spacings employed and the high temperature processing involved in fabrication, the classification of transistor types in practice is less clear than the logical distinctions made above. Thus, a particular tetrode or p-n-i-p, for example, may also have a built in drift field. To obtain an appreciation of the very small spacings involved a comparison may be made to the thickness of the paper on which this is printed. The thickness of this paper is 0.004 inch or 130 times greater than the spacing reported for the surface barrier transistor and 40 times that reported for other high-frequency types.

SUMMARY OF REPORTED PERFORMANCE

The reported performance of experimental high-frequency transistors embodying the principles discussed above is summarized in Table I. The data for the h-f alloy and point-contact transistors are from early investigations into high-frequency devices. In neither case are data available for spacings comparable to those listed for the other types. The closest spacing is achieved in the surface barrier transistor. The surface barrier constructions, thus far reported, have been what we have earlier termed a straight forward extension to higher frequencies. Consequently a closer spacing is required to achieve a performance comparable to those constructions employing the refinements discussed above. As in earlier reported data the tetrode construction continues to give the highest oscillation frequency which is about twice that of triodes of similar spacing.

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12. R. Williams, "High Frequency Surface Barrier Transistors," Paper presented at Semiconductor Research Conference, Philadelphia, Pa., June, 1955
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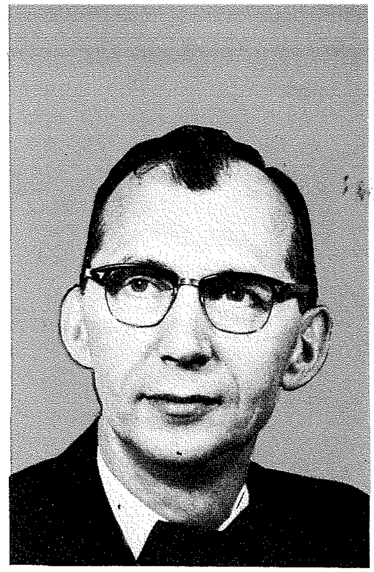
TABLE I
Performance of Experimental High-Frequency Transistors

Transistor	Spacing (inches)	Current Gain Factor	Power Gain at 10 mc/s (decibels)	Highest Reported Oscillation Freq. (mc/s)
HF Alloyed Jnct[6]	0.0005	40	14	75
Point Contact[1]	0.0005	—1.5	—	420
Surface Barrier[12]	0.00003	—	20	500
p-n-i-p[8, 10]	0.0003	25	20	440
p-n-p Drift[11]	0.0001	20	30	400-500
Tetrode[2, 13]	0.0001	150	20	1200

PAUL P. MELROY graduated from Penn State in 1925, with B.S. in E.E., and immediately began work with General Electric Company as a testman. This led to Contract Service in the Radio Engineering Department. He transferred to RCA in 1928 and continued his field engineering activity in Europe and America, covering most every product of RCA. In 1940, his assignment as first RCA field engineer to the U.S. Navy was the start of RCA's 15 years of continuous service to National Defense, which now has achieved world-wide recognition as the Government Service Department of the RCA Service Company, Inc.



THE RCA FIELD ENGINEER IN NATIONAL DEFENSE

By **P. P. MELROY**
Government Service Department
RCA Service Company, Inc.
Cherry Hill, N. J.

THE INCREASING scope of RCA activities in national defense is attested by the volume of RCA products and services used by the Government. The thousands of RCA family members who are contributing include skilled engineers of research, design, development, sales, production and field service. RCA's role in national defense is continuous "from drawing board to line of defense."

IMPORTANCE OF FIELD SUPPORT

To reach the line of defense, the path of the product from the shipping doors is extremely rugged. The field support required to attain prompt and effective utilization of the system still has to be performed. This is the job of the last man on the defense team—the Government Service field engineer.

Fortunately, both RCA and the Department of Defense fully recognize the important aspects of the after-production period when a new defense product first goes into operation. Most equipment buyers of the Government now include field support as a necessary line item in the contract. The value of any system is enhanced by the inclusion of a comprehensive field program including environmental test, specialized training of military personnel, installation supervision, on-the-job training, maintenance, and contractor depot maintenance facilities. All of this is interlocked with prompt availability of instruction books, maintenance parts, special test equipment, and bench mock-ups. The mutual advantages of a good field support program include two-way flow of technical information between field and factory for close check on product performance, field failure reports for reliability and quality control, and prompt modification of design when epidemic failures or design deficiencies are detected. Any oversight or delay in advance programming of field services can result later in considerable confusion for both the military and the contractor, necessitating emergency corrective measures.

FIELD ENGINEERING HAS A WIDE SCOPE

The maintenance of an adequate field support organization requires cooperative action, particularly within the defense product team, among sales, engineering, production and service. Proper scheduling and timely assignment of field engineers hinges on early contractual coverage in the product contract. Specialized training of field engineers hinges on the availability of an early product unit and any required special test equipment for installation in established training quarters—also for later use in training military personnel. Engineering assistance is needed in the preparation of instruction books and parts identification catalogs. Accessibility to assembly and final production test centers is essential to the education of technical instructors and field service supervisors.

With an appreciation of the job that has to be done in the field support of modern military weapons systems take a look at the magnitude of Government owned resources devoted to maintenance of all types of military equipment, based on a recent estimate made by the Director of Maintenance, Department of Defense. These figures do not reflect the large numbers of contractor personnel and facilities employed in the maintenance of defense materiel.

1. Over 800,000 people (military and civil service) are required.
2. Maintenance costs average 8 billion dollars per year.
3. The covered floor space (Government buildings) devoted to maintenance amounts to 6,000 acres.
4. About 21,000 buildings around the world are devoted to maintenance of materiel.

In the face of these requirements, considerable progress has been made by RCA in field support activities for general electronics services to the Government as well as for specific RCA defense products. A brief description of the RCA Service Company field support organization and what it does should prove interesting and informative.

GOVERNMENT SERVICE DEPARTMENT ORGANIZATION

Today, the Government Service Department of the RCA Service Company, Inc., has attained a recognized national leadership in the electronics industry, earned by the performance of a quality service for all branches of the Government, covering defense products of RCA and other manufacturers. During the fifteen consecutive years of its service and assistance to the military, its growth has been most phenomenal since its organization as a Department in 1950.

Its organization has only four staff managers — Administration, Operations, RCA Defense Products, and Missile Test Project. Administration brings in the new field requirements, prepares proposals, negotiates and administers the contract. Operations recruits and trains technical personnel, implements the contract with men and material, supervises the performance of services, and finally renders invoices to the Government. Defense Products Service plans, develops, implements, and executes field service programs involving all RCA defense products. Missile Test Project covers the management and operation of the Air Force Missile Test Center at Patrick Air Force Base, Florida, with responsibilities including planning, systems engineering, installation, operation and maintenance of instrumentation for data acquisition, and data reduction, incidental to Air Force guided missile test programs.

The Home Office is at the RCA Cherry Hill headquarters, with Field Offices located at Washington, Dayton, San Francisco, Tucson, Japan and Germany.

THE FIELD ENGINEER AND HIS ASSIGNMENTS

A typical field engineer of the Government Service Department has two or more years of active military service and four and one-half years of industrial or private enterprise in electronics as a livelihood. Forty-three percent have been graduated at accredited colleges in scientific study, another twenty-two percent have completed specialized training at trade or other technical schools. Each has a clearance of national security as required by the defense job. Deviating from the average background, within

Fig. 1.—Marvin Bryson, RCA Field Engineer instructs Air Force personnel on test equipment at Kelly AFB, Texas.

Fig. 2.—Typical of the problems encountered by communications men in Korea is this job of rehabilitating phone lines.

this Department, are former Admirals, Colonels, Captains, and others retired from the Services, Doctor and master-degree men, and quite a few Company pioneers with over a quarter century service with RCA. This is the backbone of the organization of RCA Field Engineers who serve most every branch of national defense.

In the selection of personnel for this Department, the factors of job location and working associates receive greater than normal consideration. The field engineer may work at isolated points anywhere in the world—continental or overseas—where and when the military may request. Today, Government Service field engineers are located in more than twenty-eight countries as well as at most installation centers within continental U.S.A. His associates may be any nationality, color, or creed, with a wide intellectual level. Initiative and self-starting ability are important personal requisites due to the absence of any constant direct supervision for he is often thousands of miles away from the Home Office. He must know how to get along and work with other people regardless of their military or civilian status.

Field Engineering offers a multitude of opportunities to the man entering this field of electronics. An overseas assignment can be an education in itself by presenting problems that would never be encountered in this country. Not only does an overseas assignment present additional technical problems, but the Field Engineer must also be a diplomat in many locations. Several assignments near the "iron curtain" are currently manned by RCA Field Engineers in such places as Yugoslavia and Turkey.

During the Korean conflict RCA Field Engineers were working hand-in-hand with military personnel at front line and rear area repair depots. Many official letters of commendation have been received by these men for their devotion to duty and versatility. Overseas assignments may range from Thule, Greenland with 60 and 70 degree below zero temperatures to Bermuda, Paris or Hawaii.

One of the most interesting and responsible positions open to engineers in the Government Service Department is in connection with the Military Defense Assistance Program (MDAP). RCA was the first and is the largest, supplier of aid to the Armed Forces in this program. Field Engineers attached to this program are instructing military personnel of Korea, Thailand, Iran, Turkey, Norway, Japan and other free countries in the basic principles and maintenance of electronic equipment supplied under the various foreign aid programs.

Fig. 3.—RCA Field Engineer Al Pontus listens while control tower operator checks installation of communication console equipment.

FIELD ENGINEERING IN MANY PRODUCT AREAS

The broad scope of electronics in military applications has made it necessary to establish groups of engineers, each with specialized experience and skills including communications, radar, fire control, guided missile, photography, and optics—which, again, are separated into ground, airborne, and shipborne systems. Further breakdown of techniques in communications alone requires specialization in LF, VHF, UHF, microwave, single sideband, television, scatter propagation, teletype, facsimile, etc. In general, the day is past when any one field engineer is a "Jack of all trades."

There is a significant and increasing trend in government procurement of field services toward package projects, having objectives which differ considerably from the conventional man-months type of service. Under this new concept of technical assistance, the end responsibility may involve the completion of a turn-key installation, the preparation of a survey or logistic support report or hundreds of installation planning drawings, the establishment and maintenance of a depot level maintenance facility, or the complete operation of a test site. In addition to the management and administrative direction, these technical operations involve the assignment of engineers seasoned in electronics, communications, optics, photography, aerodynamics, meteorology, and physics. Fully aware of these demands, the Government Service Department has expanded its organization to contribute effectively in areas of these demands. A few of the most interesting projects completed or currently in process, include:

Scatter Propagation, Fort Monroe/Woodbridge Project for DEP/Army, with planning, instrumentation, installation, operation, training, and performance reports, under turn-key responsibility.

Atomic Tests at Frenchman's Flat, Survival Town, U.S.A., covering planning, installation, survey and final report.

Battle Surveillance Project for Army Signal Corps at Fort Huachuca, covering a new look at techniques required in modern warfare central control relative to the integration of communication, radar, optics, photography, infra-red, and allied sciences.

CAA Communications System and net-work, including civil and communications engineering talent for planning and installation.

Navy Target Designation System, with assistance to DEP in shipborne installation planning, performance evaluation, and operational training in monochrome and color.

Air Force Missile Test Center, Patrick AFB, including responsibilities for all the electronics and communications phases of the Base and Range operations—from initial planning to the final data acquisition and reduction on all types of long range missiles in development.

In addition to these and other projects of package and system nature under Government contracts, there are services procured by and rendered for many Departments of the Corporation, some of which prevent diversion of the efforts of high-level strictly engineering talent. Among the tasks currently being done by the Government Service Department for Defense Electronic Products, David Sarnoff Research Center, and RCA International Division, are::

Customer warranty service—Environmental and performance test — Drafting — Installation and Maintenance — Formal and on-the-job training—Preparation of instruction books and parts lists — Reliability, data acquisition, reduction and analysis — Customer liaison — Installation and layout planning—Design of systems cabling and interconnections.

CONCLUSION

In summary, the RCA Field Engineer in Government Service is an important member of the RCA defense products team, performing an essential service in the program for national defense. In the increasing demands of the Government for field support assistance with every major weapon system of the future, the RCA Field Engineer will accept added responsibilities, relying on the cooperative effort of his team mates to provide advance scheduling of his field services with the Military and the early availability of new products for his specialized training. His feed-back information on product performance, failures, and changing requirements are invaluable to the research, design, and production engineers; his experience and wealth of information on field conditions and product utilization contribute to better defense products from RCA.

Fig. 4.— Overseeing the installation of communication equipment in these NATO tanks in Belgium is RCA Field Engineer W. J. LaPerch.

Fig. 5.— W. Schieferstein, RCA Field Engineer instructs Belgian paratrooper in the use of portable transmitter-receiver.

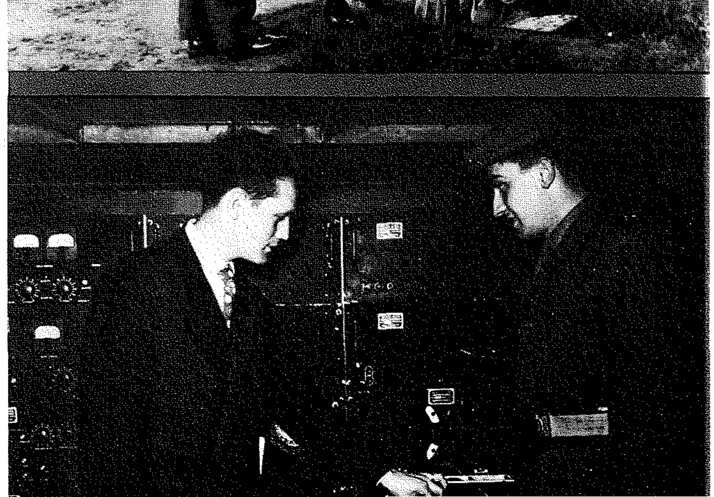


Fig. 6.—Operation of search radar equipment is explained by RCA Field Engineer R. A. Huggard to Belgian NCO.

NYLON FOR TEST-SOCKET COVERS INCREASES PRODUCTION EFFICIENCY

(Big Savings on Small Item)

by

IRVING WEISS

Tube Division, Harrison, N. J.

IRVING WEISS received his B.S. degree in Electrical Engineering from the University of Houston in Texas in February, 1951. After working for the Western Electric Company as a Central Office Equipment Engineer, he joined the Equipment Design electrical activity of the RCA Tube Division in Harrison, N. J. in June 1953.

Mr. Weiss is a member of the honorary scholastic society Phi Theta Kappa.

A PROGRAM for the substitution of long-wearing nylon test-socket covers for phenolic covers in the receiving-tube factories is the result of a recent decision by the Electrical Maintenance Cost Reduction Committee of Equipment Development at the Harrison Tube plant. This changeover is expected to result in increased efficiency of the factory tube-testing operation, together with a cost savings of about $20,000.00 a year. The Committee consists of eight members selected from the Electric Development and Technical Services Activities of Equipment Development, from the Electric Service Shop of Plant Engineering, and from the Manufacturing Activity. This Committee, on the basis of its broad knowledge of plant operations, assigns investigators to specific maintenance problems to determine the areas in which equipment redesign may contribute most to improved tube quality and economical production. An investigation into the costly maintenance problem of socket replacement was suggested to the Committee by Ralph Fichtl, General Foreman, Factory 4, and the author was assigned to the project.

FAILURES OF PHENOLIC COVERS INVESTIGATED

The center portion of a conventional phenolic test-socket cover for seven-pin miniature tubes is shown in Fig. 1. The primary cause of failure in this cover is wear-out and eventual break-through of the material between pin holes. Abrasion, caused by continual insertion and withdrawal of tubes, enlarges the pin holes until they become greatly elongated and the separating sections are finally worn away. Fig. 2 is an enlarged photograph of the center portion of a phenolic cover after approximately 30,000 tube insertions.

The first step in this investigation was the selection of a material which would have greater resistance to abrasion. Materials investigated included a glass polyester, a laminated plastic with a nylon cloth filler, and a nylon compound, (Zytel* 101). Sample covers made of these materials were installed on high-production test sets in two receiving-tube factories (1 and 4) so that an accurate indication of their relative merit could be obtained in the shortest possible time.

NYLON PRODUCES BEST RESULTS

Of all the samples tested, the nylon covers produced the best results. The center portion of a seven-pin miniature nylon cover is shown in Fig. 3. The pin holes on these covers remained concentric and true to size for a much longer period of time than those on other covers. Moreover, less scratch and surface wear was evident. The natural lubricating quality of nylon permitted very smooth insertion and extraction of the tube pins. Sample covers made of other materials under investigation failed due to excessive wear after about 15,000 insertions. At the same point in the test, the nylon covers looked like new.

On the basis of these early results, additional sample covers made of nylon were distributed to the factories for comparative tests with phenolic-compound covers. Results of these tests were most encouraging. The life of a phenolic cover was from 20 to 30 thousand tube insertions, the life of a nylon cover from 300 to 500 thousand. One nylon cover, shown in Fig. 4, remained in service for 558,900 insertions. Even at the end of this time, the material between the pin holes had not broken through.

SOCKET CLIPS LAST LONGER

The test run of nylon covers disclosed an extra advantage associated with

* Trade Mark of E. I. DuPont de Nemours Co., Inc..

their use—longer wearing time of socket clips. Because the pin holes of phenolic covers become eccentric as they wear out, undue wear occurs on the sides of the socket clips as the tube pins strike them. As a result, socket clip are usually changed as often as socket covers. When nylon covers were used, however, the longer-lasting concentricity of the pin holes reduced the wear of the socket clips. It was found that clips had to be changed only three or four times during the much longer life of the nylon cover, and maintenance due to clip failure was greatly reduced.

LOW-LOSS CHARACTERISTICS

Although the electrical properties of the covers are not critical at the test frequency of 60 cycles per second, it is of interest to note that the nylon covers also showed great superiority in this respect. The loss factor (a combination of power factor and dielectric constant) of the phenolic compound (wood-flour filler) at a frequency of 60 cycles per second, room temperature, and zero water absorption ranges from 0.25 to 2.7 Under the same conditions, the nylon compound has a loss factor of 0.08, or from 3 to 32 times better than that of the phenolic.

BIG SAVINGS EFFECTED

The basic cost of nylon powder is about $2.10 per pound as compared to a cost of about 30 cents per pound for phenolic resin. However, because production costs are much lower for nylon covers, which are injection-molded, than for phenolic covers, which must be compression-molded, the cost of both types of covers is about the same. The cost of new molds for the manufacture of nylon covers to accommodate the various types of tube bases can be off-set within six months by the savings (up to $20,000 a year) effected by the longer-wearing capabilities of these covers.

On the basis of the results of this investigation, the Electrical Maintenance Cost Reduction Committee approved a change to nylon test-socket covers, and arrangements were made for the purchase of the required new molds. It is estimated that nylon covers for seven-pin miniature, nine-pin miniature, and octal tubes for all factory test sets will be available at an early date.

The Electrical Maintenance Cost Reduction Committee of Equipment Development at the Harrison Tube Plant was inaugurated in September, 1954 to review types of equipment having excess maintenance and, when possible, to reduce maintenance costs and increase equipment efficiency. The permanent membership of the Committee is assisted by special members assigned on a temporary basis when detailed knowledge of particular jobs is required. The photograph was taken at a recent meeting of this group; seated clockwise around the desk are P. Farina (Chairman, at desk), R. Fichtel, I. Weiss, A. Gorman, F. Yannotti, F. Barkalow, J. Watts, and E. Soucy (Secretary).

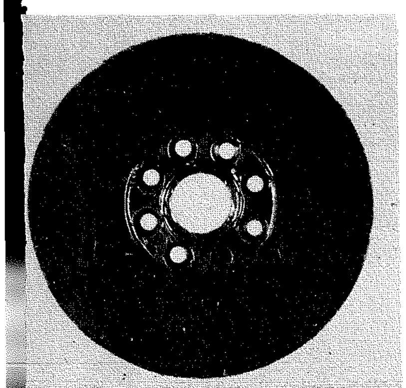


Fig. 1—Center portion of unused phenolic test-socket cover for seven-pin miniature tubes showing unmarked surface and small, sharp pin holes.

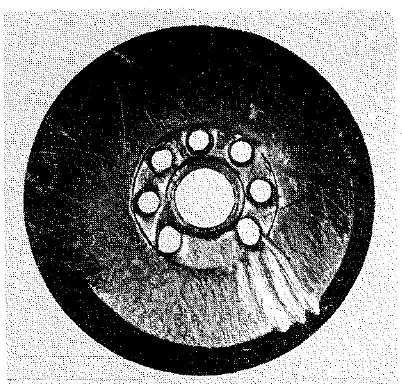


Fig. 2—Center portion of phenolic cover after 30,000 tube insertions. Note enlarged pin holes and grooved surface.

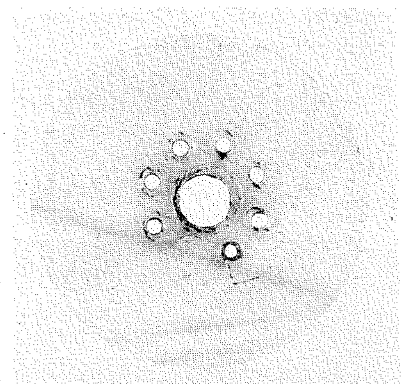


Fig. 3—Center portion of unused nylon test-socket cover for seven-pin miniature tubes.

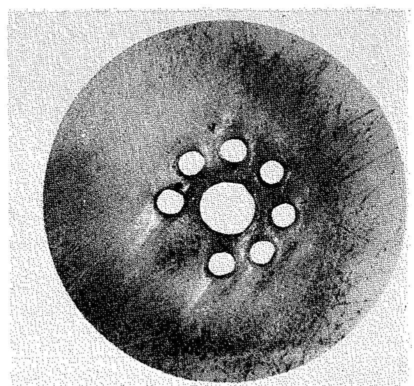
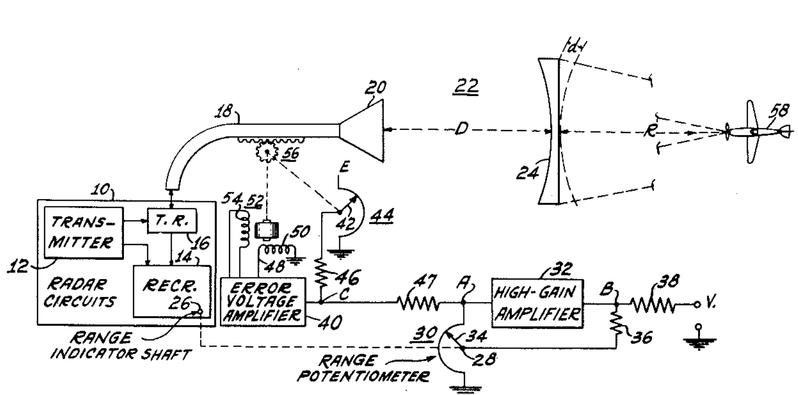


Fig. 4—Center portion of nylon cover after 558,900 tube insertions. Although pin holes are enlarged and surface is scratched, cover is still in usable condition.

Patents Granted

TO RCA ENGINEERS

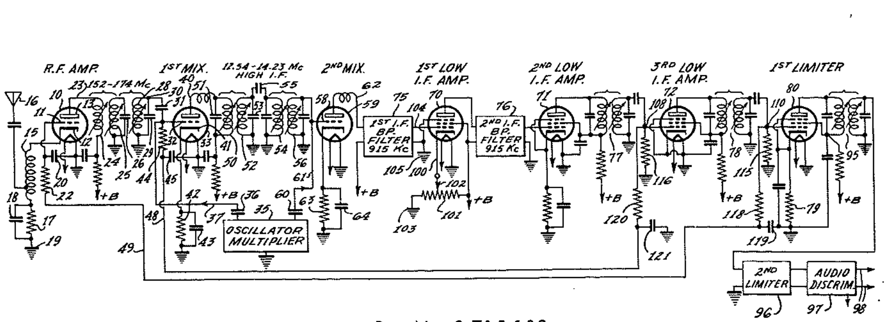
BASED ON SUMMARIES RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS



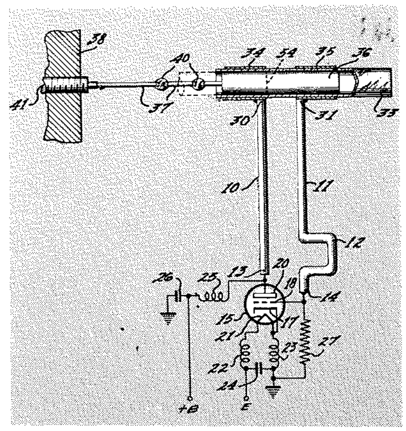
Pat. No. 2,716,746

FOCUSING OF RADAR BEAMS FOR A TRACKING RADAR (Patent No. 2,716,746)—granted August 30, 1955 to R. W. HOWERY, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. This applies to a radar system where the radio beam is focused so that the point of focus is at a finite distance from the antenna. Thus, in ground control approach as now used, the radio beam from the antenna may be focused at the desired touchdown point of the glide path. This invention resides in maintaining the radio beam automatically focused on the reflecting object; specifically, when the range changes, a lens and horn combination are moved relative to each other to change the focus.

NARROW-BAND COMMUNICATION RECEIVERS AND THE LIKE (Patent No. 2,715,180)—granted August 9, 1955 to R. A. BEERS, JR., ENGINEERING PRODUCTS DIVISION, Camden, N. J. The high-frequency receiver system includes an r-f amplifier followed by a mixer and further receiver stages. AGC voltages are applied to the r-f and Mixer stages in sequence by deriving a first AGC voltage at some later stage in the receiver responsive to a low signal level to apply to the r-f amplifier, and by deriving a second AGC voltage at an earlier stage than the first AGC responsive to a high signal level to apply to the mixer stage.

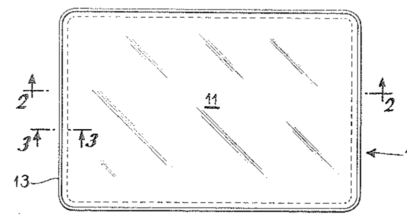


Pat. No. 2,715,180



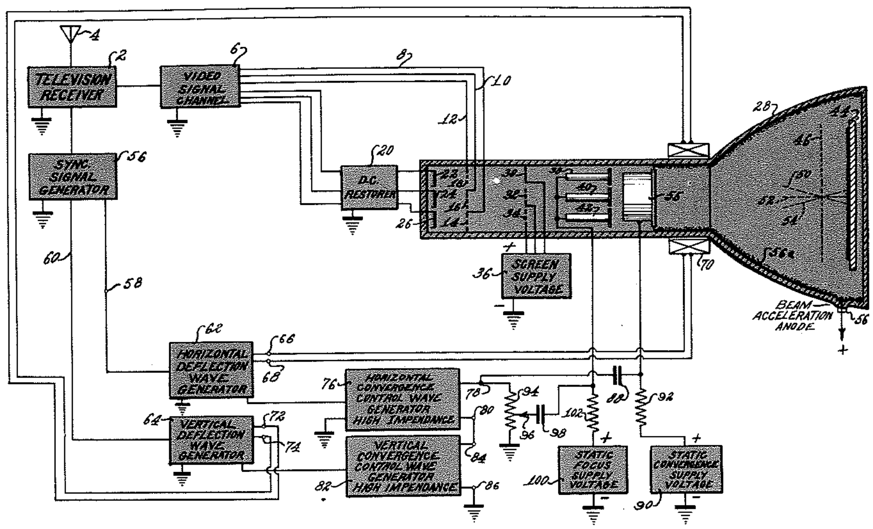
Pat. No. 2,717,313

TUNABLE CIRCUIT STRUCTURE (Patent No. 2,717,313)—granted September 6, 1955 to W. Y. PAN, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The resonant line comprises a pair of parallel conductors terminated by a variable capacitor. The capacitor plates comprise a pair of cylindrical members, one fastened to the end of each line, and an axially-movable core which is insulated from the cylindrical members. When the core is out, that is minimum capacity across the end of the line, the line operates as a half-wave line, the frequency being determined by the physical length thereof. When the core is inserted into the cylindrical members the line operates in the quarter wave mode, the length being extended by the inductance of the core between the cylindrical member. A loop is provided in one of the parallel line conductors to compensate for the "out" position of the core.

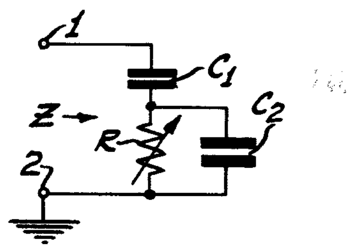


Pat. No. 2,708,774

MULTIPLE GLAZED UNIT (Patent No. 2,708,774)—granted May 24, 1955 to H. R. SEELEN, TUBE DIVISION, Lancaster, Pa. Insulating windows comprising two spaced sheets of glass with a vacuum or dead air space therebetween have been variously constructed. According to this invention a plurality of glass sheets each having a pair of parallel surfaces joined by a peripheral surface are held in vacuum tight spaced relation by an endless metallic frame member having web portions intermediate the glass sheets, land portions integral with the ends of said web portions sealed by a non-metallic, glass-to-metal seal to opposing surfaces of said glass sheets, and wing portions integral with the ends of said land portions sealed by a non-metallic, glass-to-metal seal along said peripheral surfaces of said glass sheets. According to an embodiment of the invention the metallic frame maintains the glass sheets in compression over a wide range of temperature.



Pat. No. 2,716,718

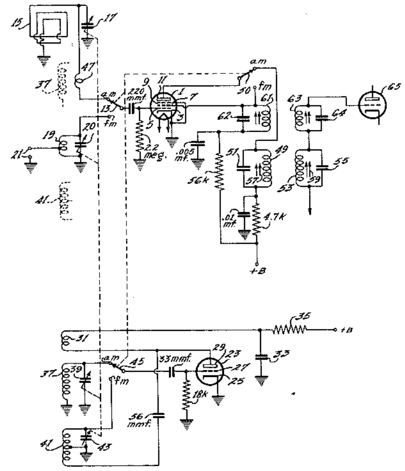


Pat. No. 2,708,739

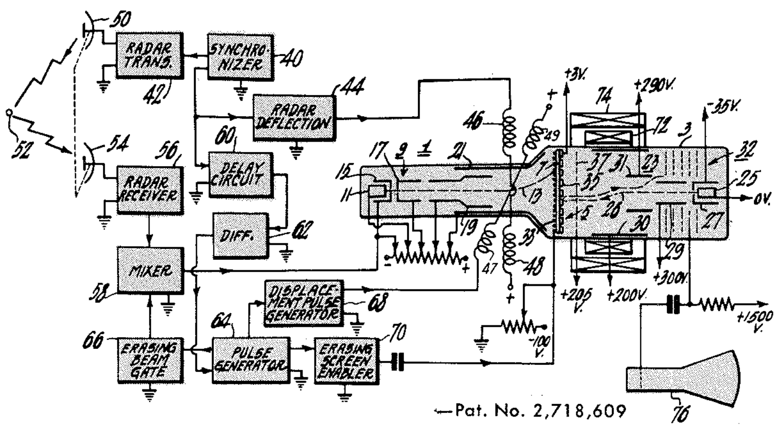
OSCILLATOR FREQUENCY CONTROL (Patent No. 2,708,739)—granted May 17, 1955 to T. T. N. Bucher, Engineering Products Division, Camden, N. J. Pair of non-linear resistances (e.g. diodes) are connected across tank circuit of oscillator, through fixed reactance (condenser). By varying control current flowing in series through diodes, their resistances are varied, thus varying susceptance across tank circuit and the oscillator frequency.

DYNAMIC ELECTRON BEAM CONTROL SYSTEMS (Patent No. 2,716,718)—granted August 30, 1955 to R. W. Sonnenfeldt, RCA Victor Television Division, Cherry Hill, N. J. Dynamic beam convergence and beam focus in a multigun color kinescope can be improved by adding a properly phased sinusoid control waveform to the convergence and focus electrodes thereof. Present invention provides simple means for developing the required sinusoidal high voltage. An L-C circuit resonant at line rate is connected in cathode circuit of horizontal output tube. The L comprises primary winding of high turns ratio transformer to produce required sinusoidal across its secondary winding.

SUPERHETERODYNE MIXER CIRCUIT (Patent No. 2,715,179)—granted August 9, 1955 to E. Cornet, RCA Victor Radio & "Victrola" Division, Cherry Hill, N. J. A pentode mixer tube has two output circuits, one for AM, the other for FM. The second output circuit is connected permanently to the screen grid and switch means are provided to selectively connect the anode of the tube to the first circuit for pentode operation or to the screen grid for triode operation with the second circuit.



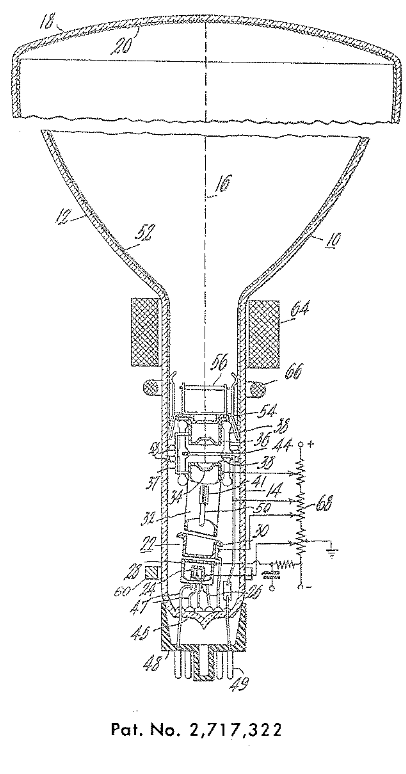
Pat. No. 2,715,179



—Pat. No. 2,718,609

SCAN CONVERSION SYSTEM WITH PROGRESSIVE CYCLICAL ERASURE (Patent No. 2,718,609)—granted September 20, 1955 to F. D. Covely, 3rd, Engineering Products Division, Camden, N. J. In the Metrechon type storage tube, the reading process does not erase the stored data. Erasure is achieved, according to the invention, by displacing the tube writing beam a predetermined number of lines (including one) in the direction of writing in the intervals between successive writing operations. The displaced writing beam is utilized to erase data stored on the target portion scanned by the displaced beam. The tube reading beam is employed to scan the target during the intervals of both writing and erasing.

CATHODE RAY TUBE GUNS (Patent No. 2,717,322)—granted September 6, 1955 to D. C. Ballard, Tube Division, Lancaster, Pa. In electrostatic focus cathode ray tubes, loss of focus control has been noticed and attributed to deposits of metal 58 on tube neck 14. These deposits become charged and distort the focusing field between electrodes 33, 44, and 36. Deposits 58 come from metal evaporated from disc 33 due to electron heat of electron bombardment and to prevent this the surfaces of the disc 33 are roughened and/or blackened to improve heat dissipating capabilities so that disc 33 will not be heated enough for metal to evaporate from said disc.



Pat. No. 2,717,322

PATENTS GRANTED

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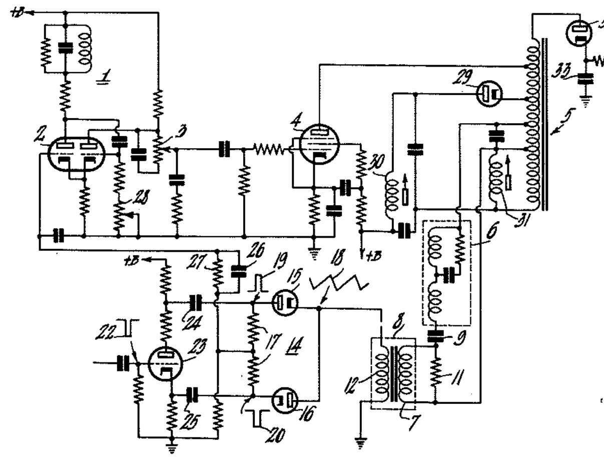
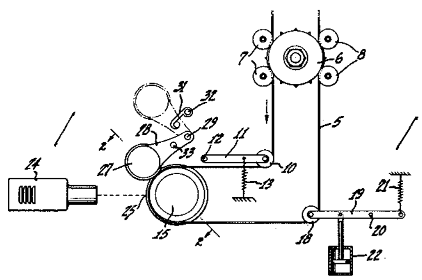


Pat. No. 2,708,689

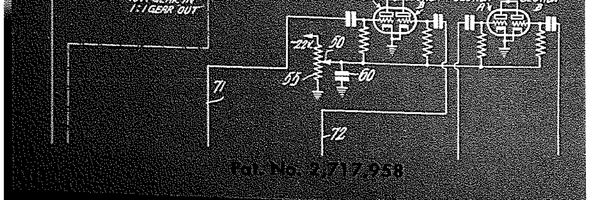
AUTOMATIC FREQUENCY CONTROL OF TELEVISION DEFLECTION APPARATUS (Patent No. 2,708,689)—granted May 17, 1955 to B. Vonderschmitt, Tube Division, Camden, N. J. Horizontal deflection AFC system uses a small transformer with primary in series with yoke to develop sawtooth reference wave for phase comparison by phase detector with sync signals for producing frequency control voltage for deflection wave oscillator.



Pat. No. 2,709,596

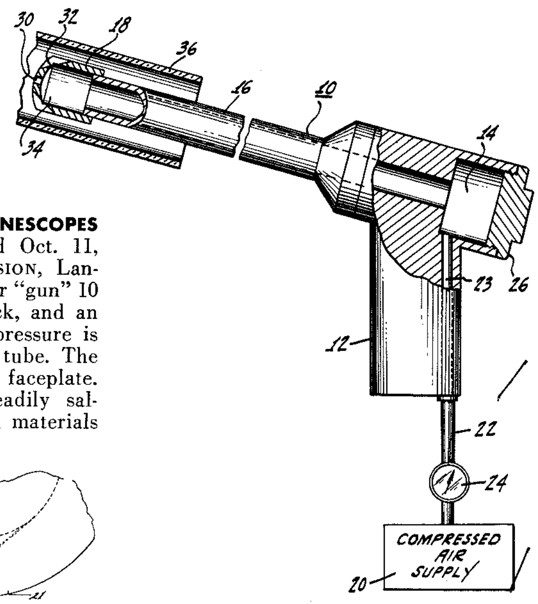
COMBINATION PHOTOGRAPHIC AND MAGNETIC SOUND MECHANISM (Patent No. 2,709,596)—granted May 31, 1955 to J. L. Pettus, Engineering Products Division, Hollywood, Calif. Early combination magnetic and optical sound recorders and reproducers were patterned after optical standard units. This invention uses a magnetic head in contact with the magnetic film while the film is on the drum. The head thus serves as a pressure shoe to aid the mechanical filter of the film transport system.

ELECTRICAL PULSE TIMING OR DELAY CIRCUIT (Patent No. 2,717,958)—granted September 13, 1955 to D. J. Oda, Engineering Products Division, Camden, N. J. An improvement over the Woodward type loran receiver in which counter circuits are used to produce sweep triggering pulses of the desired delay. Improvement resides in so switching and combining pulses (taken off the counter circuits) that there is momentary absence of a pulse as one pulse is dropped and another one picked up during switching. Both pulses are present in phase 2; then the first pulse is dropped in phase 3.

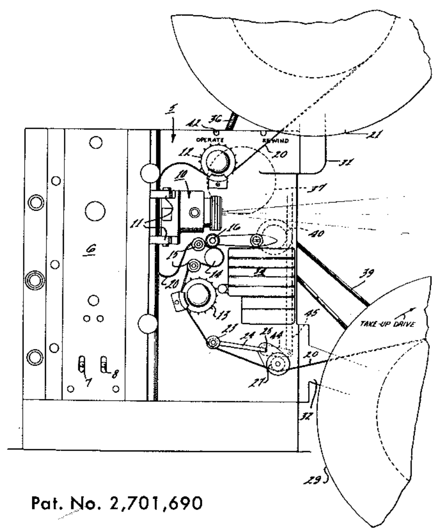


Pat. No. 2,717,958

REMOVAL OF SCREENS FROM KINESCOPES (Patent No. 2,720,493)—granted Oct. 11, 1955 to L. P. Fox, Tube Division, Lancaster, Pa. The nozzle 18 of the air "gun" 10 is inserted through the tube neck, and an air jet at 80 to 100 lbs. gauge pressure is directed onto the screen of the tube. The blast blows the screen off the faceplate. Removed phosphors may be readily salvaged by subjecting the removed materials to a water bath.



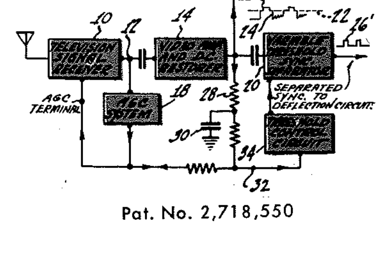
Pat. No. 2,720,493



Pat. No. 2,701,690

FILM REEL DRIVE MECHANISM (Patent No. 2,701,690)—granted February 8, 1955 to W. R. Isom, Engineering Products Division, Camden, N. J. A sound film projector, particularly a 16 millimeter projector, is provided with a sensing roller 23 for varying the position of an idler roller 48 to vary the tension in belt 67 driving takeup reel 29. An arcuate lever 41 has warning thereon when in rewind position, lever 41 shifting gear carrying lever 50 to mesh gear 52 with a drive gear 64 when in rewind position. Crank arms 72 and 46 control tension in spring 76, which controls position of roller 48 and tension in belt 67.

COMBINED DIRECT CURRENT REINSERTER AND VARIABLE THRESHOLD SYNCHRONIZING SIGNAL SEPARATOR (Patent No. 2,718,550)—granted September 20, 1955 to C. W. Hoyt and L. P. Thomas, RCA Victor Television Division, Cherry Hill, N. J. Prior art television receivers generally employ an AGC system developing an AGC bias representing only the amplitude of received sync signals. Also sync separation is made a function of this AGC bias. Present invention additionally develops a voltage solely representative of picture brightness. This picture brightness voltage is then mixed with either or both potentials used for AGC bias control and sync separation.



Pat. No. 2,718,550

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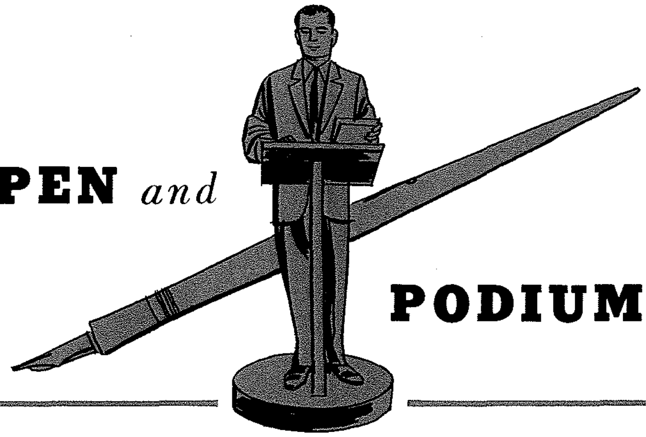


Based On Reports Received Over a Period of About Two Months

THE PRACTICE OF ENGINEERING . . . By J. T. Cimorelli, Administrative Engineer, Product Engineering, Camden, N. J. Presented at the Annual Freshman Orientation Session (The Green Engineering Camp), The Cooper Union, N. J., September 14, 1955. The transition from academic life to the practice of engineering is difficult without appreciation of some fundamental differences. These include the change from individual to cooperative effort, the need for compromise to best meet design objectives, and the importance of communications. They require understanding of organization, responsibilities, and the profit motive. Continued progress requires the reading of pertinent technical papers and planned study programs. In the practice of engineering there are rewards of status, accomplishment, and economic security and accompanying obligations to support technical societies, to publish technical work, to develop professional attitudes, and to give the employer the fullest measure of performance.

RCA PREMIUM TUBES . . . By H. E. Stumman, Tube Division, Harrison, N. J. Presented at Federal Telephone and Radio, Clifton, N. J., September 13, 1955. The paper reviews briefly the development of premium tubes for industrial and military applications requiring higher reliability than that of tubes designed primarily for the entertainment field. "Special Red" tubes are discussed for applications requiring 10,000-hour life, rigid construction, uniformity, and stability. Premium miniature types developed for the aircraft industry and for the Armed Services are also described. Various factors which contribute to increased reliability in these premium tubes are discussed, including tube design features, materials, quality-control procedures, and testing specifications. Current development for new premium tubes is evaluated.

THE USE OF CONCENTRIC-LINE TRANSFORMERS IN UHF MEASUREMENTS . . . By W. A. Harris and J. J. Thompson, Tube Division, Harrison, N. J. Published in TRANSACTIONS OF IRE Professional Group on Instrumentation, October, 1955. Concentric lines fitted with movable, adjustable stubs have been designed for use in measurements within the frequency range from 500 to 1000 megacycles per second. The lines are used as calibrated transformers connected to the input and output terminals of a tube. The design and calibration of the lines are discussed, and the results of measurements on several tube types are presented. The data obtained with calibrated lines and associated equipment are used to determine input, output, forward, and feedback admittances, and for the analysis of triode noise. (Previously presented at IRE/AIEE Conference on High-Frequency Measurements, Washington, D. C., January 1955.)

FREQUENCY CHARACTERISTICS OF LOCAL OSCILLATORS . . . By W. Y. Pan, RCA Victor Television Division, Camden, N. J. Published in the September issue of RCA REVIEW. The frequency characteristics of local oscillators under conditions of heat flow inside and outside the oscillator tubes can be expressed approximately in simple mathematical formulas. With the aid of such an analytical treatment, the various factors affecting the instantaneous oscillator frequency may be evaluated. This investigation discloses the possibility of more accurate compensations for oscillator frequency deviations, particularly during the warm-up period, by logical approaches, thus eliminating trial-and-error processes.

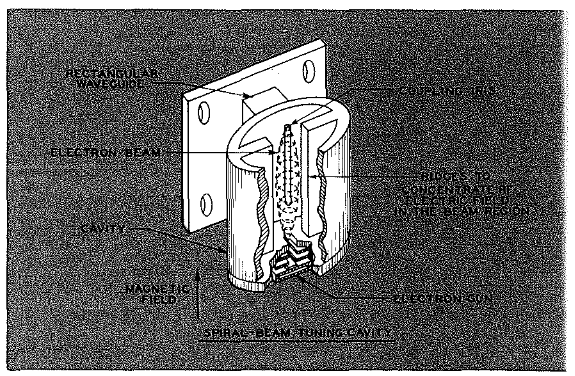
AUTOMATION RE-EXAMINED . . . By J. J. Graham, Mgr. Manufacturing Engineering Administration, Camden, N. J. (now studying under the Advanced Mgm't Program). Presented by Lewis Iby, Engineering Products Division, Camden, N. J. at the Industrial Electronics Conference, Detroit, Mich., September 29, 1955. Now that the initial furore about automation has subsided the author re-examines the subject to reorient thinking along constructive lines which will utilize the concept as are other valuable tools in our industrial storeroom. Many phases of the trend from manual to mechanized production are discussed; including standardization and the effects of custom versus high quantity production. The mechanization involved in the production of printed boards are described. The requirements for numbers and training of people are increased by the whole mechanization program—rather than decreased.

HYBRID RADIO . . . By K. E. Loofbourrow, Tube Division, Harrison, N. J. Published in ELECTRONIC DESIGN, October 1955. This paper describes the use of junction transistors in class B in hybrid receivers in place of a power-output tube. The use of transistors effects an increase in available power output and a substantial reduction in required battery power. A circuit diagram of a part-tube, part-transistor battery-operated portable radio receiver is illustrated, and battery-power requirements are compared with those for an all-tube receiver. Performance is also compared.

STABILIZATION OF PULSE DURATION IN MONOSTABLE MULTIVIBRATORS . . . By Arch C. Luther, Jr., Engineering Products Division, Camden, N. J. Published in September issue of RCA REVIEW. The elementary principles of multivibrator operation are reviewed to develop the circuit properties which affect the duration of the timing interval. Stabilization of the duration by means of a particular circuit containing d-c feedback is described. Theory for this circuit is developed to the extent that the effects of tolerances are explained. Further improvement is demonstrated for constant-frequency applications by the insertion of average operating point feedback. Practical circuits are described for frequency division and pulse generation in broadcast television equipment.

NAVY INTERIOR COMMUNICATIONS . . . By M. E. Hawley, Engineering Products Division, Camden, N. J. Presented to the Research Section of U. S. Navy Reserve at Franklin Institute, Philadelphia, September 22, 1955. There was described an operational analysis of the interior communication system on submarines which in approach is applicable to other vessels and other communication problems. Also described were the equipments and techniques used for speech communication when acoustic noise is a serious problem.

WIDE-RANGE ELECTRONIC TUNING OF MICROWAVE CAVITIES . . . By F. R. Arams and H. K. Jenny, Tube Division, Harrison, N. J. Published in PROCEEDINGS OF THE I.R.E., September 1955. This paper discusses some novel methods for tuning resonant circuits by means of low-pressure gas discharges and compares them to corresponding methods operating in vacuum. The use of gas atmospheres permits tuning over frequency ranges in the microwave region which are several times larger than those obtainable with corresponding tuning methods in vacuum.



X-BAND Cavity Using Spiral-Beam Tuning

A FUNCTIONAL APPROACH TO AUTOMATIC SYSTEMS AND STANDARDIZATION . . . By F. C. Collings and K. Hesdoerffer, Engineering Products Division, Camden, N. J. Presented at the Automation Symposium of RETMA, University of Pennsylvania, Sept. 27, 1955. The paper describes a functional approach to automatic manufacturing systems which is derived to seek requirements of machines and controls in terms of the function to be performed rather than in terms of given end products. Automatic factory concepts for job-shop type production are described to differ from conven-

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continued

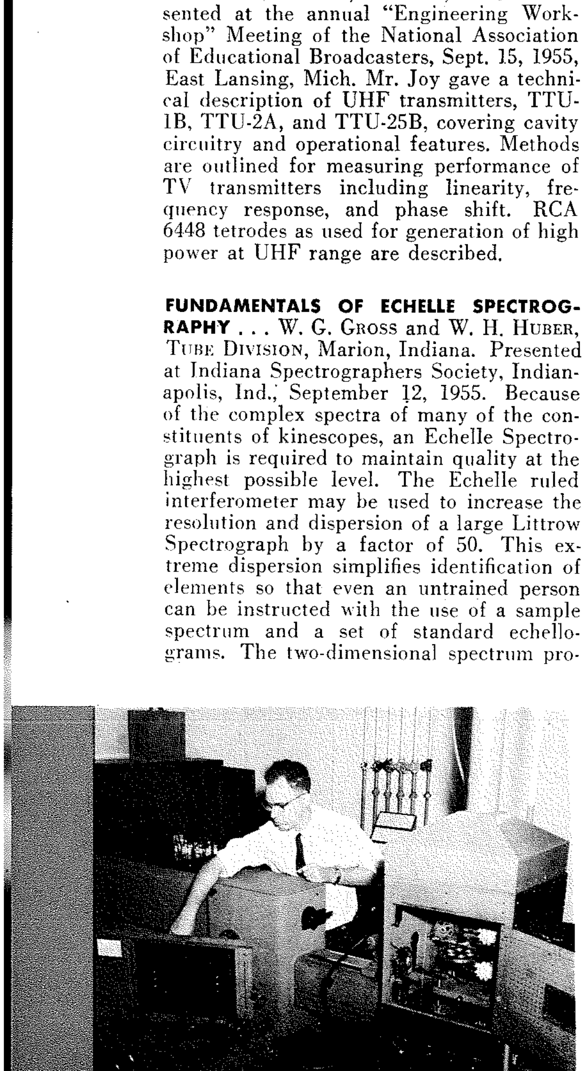
tional man production concepts in the degree of automaticity and the scope of planning required. An outline of objectives is related to functional machine requirements.

AUTOMATION IN THE ELECTRONICS INDUSTRY . . . By L. F. Jones, Engineering Products Division, Camden, N. J. Presented at the Electronics and Automatic Production Symposium sponsored by the Stanford Research Inst. and Nat. Industrial Conference Board, Aug. 22-23, San Francisco, Calif. The paper points out that there is no one concept of automation in the electronics industry. Automation is viewed and used differently by the broadcaster, the tube manufacturer, the record manufacturer, the components manufacturer, the end product assembler. An example is given of how the automatic assembly of electronic products can be planned systems-wise, yet be installed piece-meal over a period of years. As part of the systems planning, engineering standards must be established and thorough studies of basic circuit functions must be conducted so as to select those functions, sub-modules and sub-assemblies appropriate for high mechanization.

UHF TELEVISION TRANSMITTER AND MEASUREMENTS . . . By J. E. Joy, Engineering Products Division, Camden, N. J. Presented at the annual "Engineering Workshop" Meeting of the National Association of Educational Broadcasters, Sept. 15, 1955, East Lansing, Mich. Mr. Joy gave a technical description of UHF transmitters, TTU-1B, TTU-2A, and TTU-25B, covering cavity circuitry and operational features. Methods are outlined for measuring performance of TV transmitters including linearity, frequency response, and phase shift. RCA 6448 tetrodes as used for generation of high power at UHF range are described.

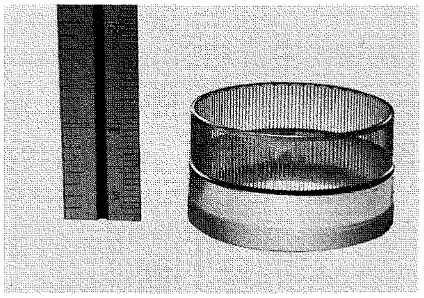
FUNDAMENTALS OF ECHELLE SPECTROGRAPHY . . . W. G. Gross and W. H. Huber, Tube Division, Marion, Indiana. Presented at Indiana Spectrographers Society, Indianapolis, Ind., September 12, 1955. Because of the complex spectra of many of the constituents of kinescopes, an Echelle Spectrograph is required to maintain quality at the highest possible level. The Echelle ruled interferometer may be used to increase the resolution and dispersion of a large Littrow Spectrograph by a factor of 50. This extreme dispersion simplifies identification of elements so that even an untrained person can be instructed with the use of a sample spectrum and a set of standard echellograms. The two-dimensional spectrum produced upon three 10-inch plates covers the spectral range from 2150 to 8000 Angstroms.

Quantitative spectrography is very similar to more conventional spectroscopy, except that the slit images are turned 90° because of the two-dimensional sawtooth pattern produced by the echelle. Only two extra accessories are required, an optical bench for a rotating logarithmic sector to calibrate plates for transmission-intensity measurements, and a low-power magnifier for comparison of echellograms.



W. G. Gross, Spectrographer in Chemical and Physical Laboratory at Marion Plant, is shown changing slit width in Littrow Spectrograph preparatory to cutting in Echelle attachment for analysis of a tungsten-molybdenum alloy.

UNISKAN EXTRUSION . . . By W. N. Parker, Tube Division, Lancaster, Pa. Presented at the Lancaster Chapter of the American Society of Tool Engineers, Lancaster, Pa., September 13, 1955. This paper describes a metal-working process known as Uniskan extrusion which greatly simplifies the production of fragile, cylindrical parts having wall thicknesses of 0.001 inch or less. The easily executed procedure involves simple tools mounted in a drill press. In some cases, the extrusion operation is followed by a chemical etching process. Typical Uniskan extrusion tools are illustrated.



Production of Cylindrical Parts with Wall Thickness of 0.001 inch is Simplified

DESIGN OF TRANSISTORIZED VIDEO AMPLIFIERS . . . By M. C. Kidd, RCA Victor Television Division, Cherry Hill, N. J. Presented before the RETMA-IRE Fall Meeting at Syracuse, N. Y., Oct. 18, 1955. Mr. Kidd presented a practical description of transistor video amplifiers, including power gain, equivalent circuit, design considerations and current and voltage effects. It is concluded that transistor video amplifiers can be built using commercially available units with certain design limitations.

SINGLE-ENDED CLASS-C AMPLIFIER DESIGN . . . By C. A. West, Tube Division, Harrison, N. J. Published in HAM TIPS, October 1955. This paper describes simplified design procedures for single-ended Class-C amplifiers using balanced plate-tank circuits. A "rule-of-thumb" approach is given for the selection of components for use in basic coupling circuits. This approach eliminates the use of formulas and equations, and provides workable circuits having adequate efficiency for most "ham" uses. A nomograph and a series of charts and curves enable the designer to determine quickly the value and rating of all circuit components.

NEW TV STUDIO EQUIPMENT . . . By W. L. Lyndon, Engineering Products Division, Camden, N. J. Presented at a meeting of the National Association of Educational Broadcasters held at Michigan State College, East Lansing, Mich., Sept. 12-16, 1955. Mr. Lyndon discussed basic principles and application of the following phases of television operation (1) program switching including a description of the TS-11 Switcher (2) program distribution for classroom service including the TM-41A Monitran and the TM-3A Utility Monitor (3) Transmission of TV program material by means of microwave, using our new TMV-1A Microwave Equipment (4) Reproduction of motion picture films and slides, with the TP6 Film Projector, TT3A Slide Projector and the TP-15 Multiplexer (5) a brief résumé was given of the closed circuit color demonstration put on by RCA and the Veterans' Administration Hospital in Philadelphia for the Annual Convention of the International College of Surgeons.

ACOUSTIC INTERFERENCE FOR NOISE CONTROL . . . By M. E. Hawley, Engineering Products Division, Camden, N. J. Presented at the National Noise Abatement Symposium, Chicago, Ill., October 21, 1955. Mr. Hawley pointed out that fundamental experiments were conducted by Olson & May and Simshauser and Hawley. Each approach was different. Recently, the Active Ear Defender and the Electronic Noise Reducer have received attention. The principal problems are: (1) The obtainment of significant noise reductions over a worthwhile area, (2) the construction of small inexpensive transducers with specified phase and amplitude response, (3) the generation of noise fields intense enough to interfere with very loud noise.

SMALL-SIGNAL OR LINEAR AMPLIFIERS (TRANSISTORS) . . . By R. M. Cohen, Tube Division, Harrison, N. J. Presented at National Security Agency, Washington, D. C., October 11, 1955. This paper compares the relative advantages and disadvantages of the common-base, common-emitter, and common-collector circuit configurations for transistors. Variations of transistor characteristics with temperature and their effect on circuit performance are also discussed. Some information on complementary-symmetry amplifiers is given.

FANTASIA TO FANTASIA . . . By O. B. Gunby, Engineering Products Division, Hollywood, California. Published in ENGINEERS DIGEST, Sept.-Oct. 1955. This paper traces the fifteen years of progress in the simplification and design of Theatre-Type Stereophonic Reproducing Equipment, dating from the first public showing of Fantasia. Methods employed, equipment used and system are compared to today's modern technical facilities.

HYBRID PI PARAMETER VARIATION WITH TEMPERATURE . . . By K. E. Palm, Engineering Products Division, Camden, N. J. Presented at the IRE Technical Discussion Meeting held at the University of Connecticut, Oct. 20-21, 1955. The paper shows how power gain of transistor amplifier varies with temperature, and compares this variation with those of the basic transistor parameters. Elements of the hybrid pi equivalent circuit were measured as a function of temperature. Power gain calculated from these data agrees with measured power gain over a wide temperature range. This provides the assurance that these data are realistic and can be used in the development and design of wide temperature range transistor circuits.

SOME FACTORS TO BE CONSIDERED IN THE APPLICATION OF ELECTRON TUBES . . . By D. P. HEACOCK, TUBE DIVISION, Harrison, N. J. Presented at IRE Long Island Section Meeting, Garden City, L. I., N. Y., Sept. 13, 1955 and at Air Force Reserves Meeting, Newark, N. J., September 27, 1955 and IRE Section Meeting, Grand Rapids, Iowa, October 19, 1955 by R. N. Peterson (Tube Division, Harrison, N. J.). This paper discusses some aspects of tube usage which are not discussed in published data and which are frequently ignored or misunderstood. The factors considered are generally detrimental to circuit performance and reliability unless considered in the early stages of circuit design. Included are the cause, effect, and cure (where possible) of such phenomena as grid current due to leakage, emission, gas, and contact potential; hum, microphonics, cathode interface, and Whippany effect.

AUTOMATION—A GENERAL VIEW AND A SPECIFIC STUDY . . . By K. HESDOERFFER, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in ENGINEERS DIGEST, Sept.-Oct. 1955. This paper describes the trend of industry toward automatic production. RCA has launched an automation program which will have far reaching effects not only on production, but also on product design. In this article, the author discusses the philosophy of automation and Engineering Products' approach to its problem.

MULTIPLE ANTENNA SYSTEM WITH ANTENNAS OF EQUAL HEIGHT . . . By L. J. WOLF, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at the Professional Group on Broadcast Transmission Systems —IRE, Washington, D. C. This paper discusses the target specification set-up by the consultants for stations WFAA (Channel 8) and KRLD (Channel 4) which required measurements to prove that the horizontal pattern, the cross-coupling and the input impedance of each antenna would not be degraded by the presence of the other antenna. Accurate scale models of the antenna and tower top were constructed and tested to provide data assuring that these target specifications would be met. The two stations have a combined antenna system to meet their requirements at a cost considerably less than two separate radiating systems. (Also see RCA ENGINEER Vol. 1, No. 2, "The Hill-Tower Antenna System" by R. H. Wright and J. V. Hyde)

RECENT IMPROVEMENTS IN THE 21AXP22 COLOR KINESCOPE . . . By R. B. JANES, L. B. HEADRICK, and J. EVANS, TUBE DIVISION, Lancaster, Pa. Presented by R. B. Janes at the IRE/RETMA Radio Fall Meeting, Syracuse, N. Y., October 19, 1955. The 21AXP22 has proven to be a high-quality color kinescope which is readily adaptable to quantity production. As a result of manufacturing experience in the making of thousands of tubes and changes made in the construction and processing, nearly perfect color purity and white uniformity have been achieved. A good deal of the processing improvements are due to changes made in the "lighthouse" on which the phosphor screens are exposed. After a brief review of the principles of the tube and data on its operation, both the tube and lighthouse changes are explained. Equipment used to obtain the data is also described.

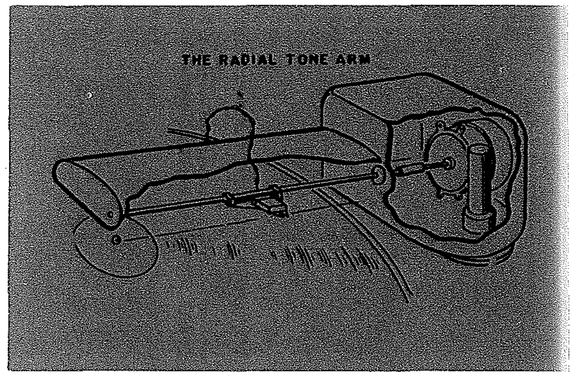
A PROGRAMMED MACHINE FOR AUTOMATION . . . By L. D. McMULKIN and G. H. WILLIAMS, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in ENGINEERS DIGEST, Sept.-Oct. 1955. The authors describe the automatic positioning system employed in RCA's printed circuit board assembly which results in great simplification. The system is applied to the control of a drill in the experimental model, but the usefulness of the positioning device is not limited to drilling.

PERFORMANCE CHARACTERISTICS OF RCA DIRECT VIEW STORAGE TUBE. By C. E. REEDER, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Presented before the IRE Professional Group on Electron Devices at the First Annual Technical Meeting, Oct. 24, 1955, Washington, D. C. The RCA Direct View Storage Kinescope is a cathode ray tube capable of providing a visual display of radar information at brightness levels that permit viewing under high ambient light conditions such as occur in aircraft cockpits. In addition to the feature of high brightness, the tube has unusually long storage, high writing speed, good half-tone rendition, controllable storage time, 450 line resolution and requires relatively low operating voltages. The author discusses the basic principles of operation of this tube and its characteristics as they apply to the tube's performance in an airborne radar indicator.

A DELUXE AMATEUR-BAND RECEIVER . . . By R. C. DENNISON, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in October 1955 issue of QST Magazine. The paper describes a receiver which features double conversion, switchable mechanical filters, band-switching, flywheel tuning, noise limiter, delayed AVC and an S-meter. Coverage includes the 80, 40, 20, 15, 11, and 10 meter ham bands. Nine tubes are employed in the receiver chassis and three more in the power unit which includes the audio output stage. The receiver is housed in a standard 8x16x8 inch metal cabinet. A large illuminated home made dial provides direct reading calibration for each band. Constructional details are given for the dial, flywheel, RF section and coils, and the alignment procedure. Three photographs and two schematics are included.

COLOR TELEVISION . . . By C. P. SMITH, TUBE DIVISION, Lancaster, Pa. Presented at Landisville Lions Club, Landisville, Pa., September 19, 1955. (Previously presented at Garden Spot Williamson Club, Lancaster, Pa., May 20, 1955.) This paper describes briefly the physical layout and facilities of the RCA Tube Division plant at Lancaster, Pa. where color kinescopes are manufactured. The operation of the color kinescope is described, and construction details of the tube are reviewed. Various components used with the kinescopes are discussed, including convergence and focusing devices. The theory of the RCA Compatible system of color television is reviewed and the decoding principle employed in the color receiver is explained.

THE RADIAL TONE ARM—A NEW PHONOGRAPH PICKUP SUSPENSION . . . By H. E. ROYS, ENGINEERING PRODUCTS DIVISION, Camden, N. J. and E. E. MASTERSON, ECKERT-MAUCHLY DIVISION, Remington Rand, Inc. (formerly with RCA). Presented at the Audio Engineering Society Convention, New York City, October 15, 1955. A new method of supporting a pickup while reproducing a phonograph record is described. The arrangement permits the pickup to follow along a radial line, thus eliminating tracking error. Static friction is greatly reduced so that the force required to pull the pickup across the record is small.



Sketch illustrating Radial Tone Arm

In addition, the arrangement provides mechanical resistance that is effective in a lateral direction and hence effective in damping tone arm resonance. The damping is ineffective in a vertical direction, so that the pickup readily follows warped records.

NEW CRITERIA FOR MICROWAVE COMPONENT SURFACES . . . By R. D. LENDING, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at the National Electronics Conference October 4, 1955, Chicago, Ill. Specification of surfaces for microwave components has frequently been vague and the use of such qualitative terms as "smooth" or "mirror smooth" is quite common. On the basis of experimental data which correlates fairly closely to theory, quantitative specifications for microwave surface finishes are given. The requirements for long waveguide runs and components requiring high Q's are differentiated from components comprising only a small fraction of the overall transmission line length. Experimental data on silver plated surface is given and from this data the effects of silver plating is dubious. Particularly in the millimeter region plating may actually cause a deterioration in the microwave surface conductivity. The effects of porosity, roughness and corrosion are evaluated.

WIDE-RANGE CAVITY TUNING FOR HIGH-POWER X-BAND MAGNETRONS . . . By F. E. VACCARO, TUBE DIVISION, Harrison, N. J. Presented at IRE Professional Group on Electron Devices, Washington, D. C., October 24. Use of a single external cavity to tune a magnetron over wide frequency ranges (10 per cent or greater) imposes performance limitations with respect to electronic efficiency, moding, cathode-temperature variation, and coupling change. This paper discusses the use of more than one external tuning cavity to improve magnetron performance. A demountable laboratory design which tunes over a range of 17 per cent is described, as well as a sealed-off tube having constant electronic efficiency, cathode temperature, and power output over a tuning range of 10 per cent. The multiple-cavity method permits the use of much higher-frequency ranges and output powers.

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continued

RCA AND UNIVERSITY OF DELAWARE CONDUCT SPEECH INTELLIGIBILITY STUDY . . . By M. E. HAWLEY, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in ENGINEERS DIGEST, Sept.-Oct. 1955. The author describes a laboratory built by RCA and located at the University of Delaware. It is intended for evaluating the intelligibility of speech communication equipment. Very loud noises can be generated without disturbing people outside the room. The lab has value for both acoustical and audio communications research in conjunction with systems for submarines, tanks, airplanes, helicopters and self-propelled guns.

APPLICATION OF RCA TRANSISTORS TO BATTERY-POWERED PORTABLE RECEIVERS . . . By JOHN W. ENGLUND, TUBE DIVISION, Harrison, N. J. Presented at IRE/RETMA Radio Fall Meeting, Syracuse, N. Y., October 18, 1955. This paper presents design considerations for the application of alloy-junction p-n-p transistors to broadcast portable receivers. Optimum operating conditions are given for both mixer-oscillator and converter input stages as regards signal-to-noise ratio and conversion transconductance.

Various intermediate-frequency amplifier circuits are discussed, including (a) base input, common emitter, (b) unilateralized, (c) emitter input, common base, and (d) split input. Considerations for design of networks for unilateralization at the optimum operating point are given. Problems involved in the application of automatic gain control to the i-f amplifiers are also discussed. The various i-f-amplifier circuits are evaluated for changes in input and output impedance, unilateralization, gain, and selectivity with operating point and with temperature. The relative merits of transistors and diodes in a second detector circuit are evaluated. An audio system using a typical driver and class B push-pull arrangement is briefly described. The overall performance of a receiver using p-n-p alloy-junction transistors is evaluated as to sensitivity, selectivity, and stability with temperature.

EPD PRIMARY FREQUENCY STANDARDS . . . By J. H. OLLIS, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in ENGINEERS DIGEST, Sept.-Oct., 1955. The author describes the facilities of the Measurement Engineering Laboratory which includes two GR Type 1100-AP Primary Frequency Standards. Each primary frequency standard consists of a high-precision piezo-electric oscillator, a 1000 cycle synchronous clock driven by this oscillator, a bank of multivibrators and a power supply. A radio receiver is used to monitor WWV Bureau of Standards radio time signals.

OPTIMUM TRANSIENT RESPONSE IN FIXED BANDWITH SYSTEMS . . . By T. MURAKAMI, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. Presented at the Philadelphia Section of IRE Professional Group on Circuit Theory. This paper shows that worthwhile compromises can be made between good high-frequency response and a good transient waveform. A comparison is made between the transient response of a minimum-phase low-pass filter and the corresponding linear-phase filter having the same amplitude characteristic. The unit-step responses of various low-pass filters with constant time delay are examined to determine a low-pass amplitude characteristic which gives the optimum transient response. It is shown that if the high-frequency response is modified, the transient response can be improved significantly.

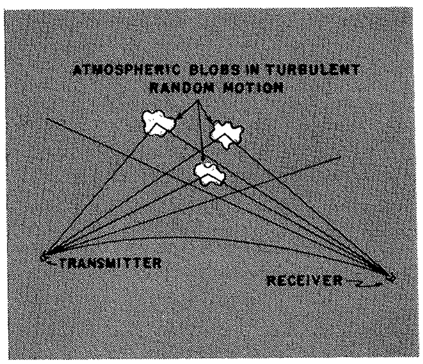
A LONG-LIFE C-BAND MAGNETRON FOR WEATHER RADAR APPLICATIONS . . . By W. F. BELTZ & R. W. KISSINGER, TUBE DIVISION, Harrison, N. J. Presented at the National Electronics Conference, Chicago, Ill., October 4, 1955. This paper describes a developmental C-band, medium-power, pulse magnetron designed especially for use in weather radar equipment. This tube, which operates at a peak anode voltage of 15 kilovolts and a peak anode current of 13.5 amperes, has a rated minimum power output of 75 kilowatts at an operating frequency of 5400 megacycles per second. Unlike most magnetrons used in military equipment, which are designed for operation near their maximum ratings to conserve weight and space, this tube is designed for operation at more conservative ratings to provide long life and high reliability in commercial airborne equipment. This output is designed for operation at altitudes up to 16,000 feet without pressurization. In preliminary life tests, the first tube of this design operated satisfactorily for 3400 hours under severe cycling conditions before failure was due to an open heater. This figure compares with lives of 250 to 500 hours for tubes of comparable ratings designed for military equipment.

ON THE PROBLEM OF OPTIMUM DETECTION OF PULSED SIGNALS IN NOISE . . . By A. H. BENNER and R. F. DRENICK, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in the Sept. issue of RCA REVIEW. A detection philosophy is introduced which distinguishes only the presence or absence of a pulsed signal, avoiding the designation of signal location. This so-called interval detector is formulated statistically as a composite hypothesis problem and solved by decision function theory. The optimum decision rule is derived, its superiority in principle to others is proven, and an illustrative mechanization is described. The explicit evaluation of this optimum relative to other detection procedures has been achieved only in special border cases, one of which is included as an example.

COLORIMETRIC PROBLEMS IN THE USE OF FILM FOR COLOR TELEVISION . . . By H. N. KOZANOWSKI and S. L. BENDELL, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at the 78th SMPTE Convention held October 6, 1955, Lake Placid, N. Y. Increasing use of film programming for color telecasting has emphasized the need for a more critical view of the capabilities of both the film and the television system for a greater understanding of the colorimetric behavior of the combination. A discussion of the main problems is presented, in which operational requirements of present-day broadcasting are considered. Various attempts at the solution of these problems are examined and recommendations are suggested for further improvement in the art.

A METHOD OF MEASURING THE OPTICAL SINE-WAVE SPECTRUM AND EFFECTIVE BANDWIDTH OF TV IMAGE DISPLAY DEVICES . . . By O. H. SCHADE, SR., TUBE DIVISION, Harrison, N. J. Presented at IRE/RETMA Radio Fall Meeting, Syracuse, N. Y., October 18, 1955. The capability of television-image display devices for reproducing fine detail is determined by the diameter and intensity cross section of electron beams, and a number of optical effects occurring in the translation of current densities into light intensities on a viewing screen. The paper describes a method and instrumentation for measuring the sine-wave spectrum of the optical "impulse" or point-image on the screen. Spectrum measurements can be made at any beam current or light level, at any point on the screen, and in any direction (horizontal or vertical). Not limited by phosphor decay, the method is useful in the analysis and specification of performance of color kinescopes and projectors.

FORWARD SCATTERING OF RADIO WAVES BY ANISOTROPIC TURBULENCE . . . By H. STARAS, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in the October 1955 issue of PROCEEDINGS OF IRE. In this paper, formulas are derived for the important radio system parameters under the assumption that the turbulence is anisotropic. The radio systems parameters evaluated include the frequency and distance dependence of the scattered radiation, the space correlation functions, the height-gain function and the bandwidth of the medium. A comparison is made between the theory developed here and some recent data from the National Bureau of Standards. This comparison indicates that the theory is rather close to average scatter conditions and, in particular, indicates that anisotropy in the turbulence does exist.



Sketch showing how signal at receiver located well beyond horizon of transmitter is result of "Scattering" by turbulence.

NOMOGRAPHS FOR MODIFICATION OF ELECTRON-TUBE PARAMETERS . . . By R. D. REICHERT, TUBE DIVISION, Harrison, N. J. Presented at IRE Professional Group on Electron Devices, Washington, D. C., October 25, 1955. This paper discusses the theory and use of three tube-design nomographs which make it possible to determine quickly the required modifications of physical parameters which will provide desired alterations in tube characteristics. A brief description is given of the electron-tube theory upon which the nomograph design is based. The use of the nomographs is explained by means of the solution of typical design problems. The nomographs, which are applicable to many diode, triode, and pentode problems, include parameters such as interelectrode spacings, wire sizes and grid TPI's, together with tube characteristics.

In the use of the nomographs, the parameters and characteristics of an existing tube type are the basis for the determination of the parameters required for a desired complement of characteristics. These nomographs are useful in both the development of new tube types and the modification of existing types to maintain "bogie" characteristics in factory production.

LINEARITY CONSIDERATIONS IN FEEDBACK PAIR AMPLIFIERS . . . By W. L. HURFORD, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at the National Electronics Conference, Chicago, Ill., October 3, 1955. The paper discusses feedback pair amplifiers which are coming into rather common use for a wide variety of critical applications in video amplifier design. This paper is concerned with optimizing the design for these applications with particular attention to the problems of linearity and pulse response. It is shown that the transfer characteristic may be linearized by proper choice of grid base and grain distribution between the stages of the mu circuit. It is also shown that this choice leads to the proper configuration for avoiding overload under pulse conditions. Phase variations arising from two principal sources in the feedback pair are described as are methods of reducing the magnitudes of these variations and of balancing one against another.

ON ELECTRICAL LOADING OF MICROPHONES . . . By R. E. WERNER, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented before the Audio Engineering Society Convention, New York City, Oct. 12, 1955. Current applications of transistors to microphone preamplifiers require consideration of the effects of resistive loads upon microphone response frequency characteristics. A study of the Thevenin equivalent circuits of certain types of broadcast microphones discloses that the input impedance of a general microphone preamplifier must be a minimum of 5 times the nominal impedance of the microphones with which it may be used in order to avoid undesirable alteration of the microphones' response-frequency characteristics. A preamplifier designed for use with a particular ribbon microphone may be equalized for loading effects as an alternative for a high input impedance, but this equalization will be suitable only for a particular microphone.

OPTICAL MULTIPLEXING IN TV FILM EQUIPMENT . . . By A. H. LIND and B. F. MELCHIONNI, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented by Mr. Lind at the 78th SMPTE Convention, October 7, 1955, Lake Placid, N. Y. The primary reason for multiplexing TV film cameras and TV film projectors is economy of equipment and/or space. A further reason can be the insurance of standby protection, at a nominal cost, when continuity of programming assumes a high order of importance. The optical multiplexer described in this paper can readily satisfy both requirements when integrated into a TV film pick-up system. Technical details of the design parameters and operating characteristics are discussed.

TRANSISTORS . . . By C. F. WHEATLEY and A. PELDUNAS, TUBE DIVISION, Harrison, N. J. Presented at AIEE Student Branch Meeting, Newark College of Engineering, N. J., September 28, 1955. This talk describes the basic design principles of a junction transistor, and tells what it is, what it does, how it is made, and how it works. Equivalent circuits for junction transistors are discussed briefly, and typical static characteristics are given. A discussion is included of important extrinsic parameters associated with transistor operation.

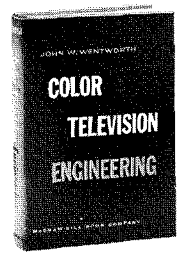
RCA PENCIL TUBES . . . By C. M. MORRIS, TUBE DIVISION, Harrison, N. J. Presented at Federal Telephone and Radio, Clifton, N. J., September 13, 1955. This talk gives some general facts about the development of pencil tubes, their construction, and the purposes for which they are intended. Reference is made to previous publications which describe the basic design principles of the pencil tube, and various improvements introduced in pencil-tube structure since the first tubes were announced. A brief evaluation is also given of pencil tubes currently in development.

TRACKING AND GUIDANCE ANTENNA PEDESTAL FOR BUMBLE BEE . . . By I. D. KRUGER, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Published in the September 1955 issue of the APPLIED PHYSICS LAB REVIEW of Johns Hopkins University. This article describes a unit designed and developed for the Applied Physics Lab of JHU to provide an advanced precision device for Missile Tracking and Guidance purposes. Design background related to the field in general is reviewed, and a design approach given. A number of photographs are included. Information as to success of unit in meeting required goals and a comment on diversified use of the pedestal are included.

UNUSUAL ELECTRON-TUBE EFFECTS OF CONCERN TO CIRCUIT DESIGNERS . . . By W. E. BABCOCK, TUBE DIVISION, Harrison, N. J. Presented at Northern New Jersey IRE Section Meeting, Nutley, N. J., October 12, 1955. In many applications the circuit designer may be completely unaware of the existence of certain electron tube phenomena and thus be at a loss to explain the peculiar effects noted with certain circuits or with certain tubes. The phenomena of cathode interface, Whippany effect, and d-c shift in electron tubes and their effect on circuit performance are discussed. Other electron tube phenomena, such as stray emissions, leakages, snivets and Miller effect are covered. Various methods of minimizing difficulties arising from these effects are pointed out.

RCA PREMIUM SUBMINIATURE TUBES . . . By R. E. BROOKS, TUBE DIVISION, Harrison, N. J. Presented at Federal Telephone and Radio, Clifton, N. J., September 13, 1955. This paper describes the development of reliable subminiature tubes for use in miniaturized communication equipment and in guided missiles. Reliability is defined as the effectiveness of a tube to operate satisfactorily in a particular piece of equipment for a specified period of time. Manufacturing techniques and quality-control procedures used to assure the quality of the tubes are discussed. Special problems inherent in the smaller-size tubes are also evaluated. Premium subminiature tubes presently in the RCA line are described, and plans for future work in this field are discussed briefly.

COLOR TELEVISION ENGINEERING . . . By JOHN W. WENTWORTH, ENGINEERING PRODUCTS DIVISION, Camden, N. J. 450 pages. 296 illustrations. McGraw-Hill. $8.00. This book gives a technical explanation of color television for engineers and technicians who are already familiar with basic principles of monochrome television. It covers physical and psychological aspects of color, colorimetric techniques used in television, underlying electronic principles of color television, and studio equipment, transmitters, test equipment, and receivers. The basic theory of color is reviewed, and the problems involved in transforming color images into electrical signals, then back again into color images. Various electronic techniques used for processing, multiplexing, and transmitting color television signals, by means now accepted or showing promise of future development and importance, also are discussed.



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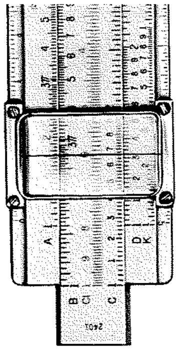
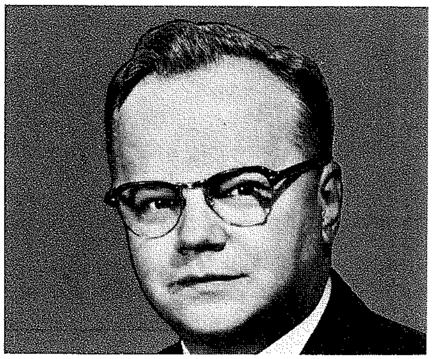
SIMPLIFIED DESIGN PROCEDURES FOR TUNED TRANSISTOR AMPLIFIERS . . . By C. C. CHENG, TUBE DIVISION, Harrison, N. J. Published in RCA REVIEW, September 1955. This paper describes a systematic and simplified method for the design of tuned amplifier systems using transistors. The method consists of three steps: (1) determination of the requirements of the amplifier system, (2) selection of transistor amplifiers, and (3) selection of coupling networks. Design procedures for various types of coupling networks are presented.

A BEAM POWER TUBE FOR ULTRA-HIGH-FREQUENCY SERVICE . . . By W. P. BENNETT, TUBE DIVISION, Lancaster, Pa. Published in RCA REVIEW, September 1955. This paper describes a new beam power tetrode, the RCA-6448, designed specifically for operation as a grid-driven (grounded-cathode) amplifier at frequencies up to 1000 megacycles. This tube has a cylindrically symmetrical electrode structure in which a centrally located plate is surrounded by an array of unit tetrode electron-optical systems. The geometry of each tetrode unit is similar to that used in conventional beam power tubes. Tube design features which virtually eliminate feedback effects are discussed. Other noteworthy features such as the thoriated-tungsten filaments and the ceramic insulators are also described. Characteristics of the tube are presented, together with data showing performance in television and continuous-wave service. Circuits for use at 900 megacycles are described, and suitability of the tube for the transmission of color-television signals is evaluated. Also see paper by Mr. Bennett in RCA ENGINEER, Vol. I, No. 1, June-July, 1955.

Engineering  NEWS *and* HIGHLIGHTS

DR. E. W. ENGSTROM NAMED SENIOR EXECUTIVE VICE PRESIDENT IN RECENT ANNOUNCEMENT

New executive assignments on the staff of the Chairman of the Board and the President of RCA were recently announced. Relating to Corporation activities on a wide scale, the new appointments involve both staff and engineering activities. In addition to the new appointments, three Vice Presidents were elected and the realignment of two divisions (EPD and TUBES) announced.



Dr. E. W. Engstrom

Dr. Elmer W. Engstrom was appointed Senior Executive Vice President. In this capacity, Dr. Engstrom is responsible for the RCA Laboratories, Defense Electronic Products, and the Commerical Electronic Products; he also is responsible for the Engineering Services, Manufacturing Services, and Product Planning staff activities. Reporting to Dr. Engstrom are Dr. D. H. Ewing, Vice President, RCA Laboratories; O. B. Hanson, Vice President, Engineering Services; B. Kreuzer, Director, Product Planning; F. Sleeter, Vice President, Manufacturing Services; T. A. Smith, Vice President and General Manager, Defense Electronic Products; and A. L. Malcarney, General Manager, Commercial Electronic Products. See *RCA ENGINEER*, Vol. I, No. 1 for biographies of *Dr. Engstrom* and *O. B. Hanson*.

Ewen C. Anderson, as Executive Vice President, Public Relations, is responsible for the Commercial Department, Press Relations and Institutional Advertising, Washington Office, and Community Relations.

Charles M. Odorizzi, as Executive Vice President, Sales and Services, is responsible for the RCA International Division, RCA Communications, Inc., RCA Service Company, Inc., RCA Victor Distributing Corp., and RCA Institutes, Inc.

Robert A. Seidel continues as Executive Vice President, Consumer Products, and is responsible for the RCA Victor Television Division, RCA Victor Radio and "Victrola" Division, and RCA Victor Record Division.

W. Walter Watts, Executive Vice President, Electronic Components, is responsible for the Radiomarine Corporation of America and the Tube Division.

STAFF POSITIONS

Ernest B. Gorin, Vice President and Treasurer, Edward M. Tuft, Vice President, Personnel, and Robert L. Werner, Vice President and General Attorney, who will continue in their present assignments, have been added to the Staff of the Chairman of the Board and the President.

THREE VICE PRESIDENTS ELECTED

Election of Dr. Douglas H. Ewing as Vice President, RCA Laboratories, Princeton, N. J., Charles P. Baxter as Vice President and General Manager, RCA Victor Television Division, and James M. Toney as Vice President and General Manager, RCA Victor Radio and "Victrola" Division, was announced by Brig. General David Sarnoff, Chairman of the Board, RCA.

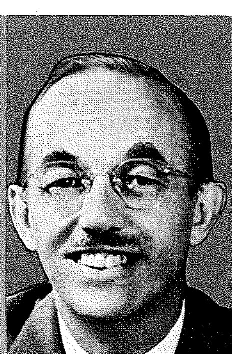
DR. DOUGLAS H. EWING joined RCA in 1945, after serving for two years on the faculty of Smith College in the Department of Physics and during World War II as a member of the technical staff of the Radiation Laboratory, M.I.T. He was assigned to the former RCA Victor Division as Manager of the Teleran Section and, subsequently, as Manager of Advanced Development. In 1949, he took leave of absence to become Director of Development of the Air Navigation Development Board in Washington.

Rejoining RCA in 1951, Dr. Ewing was appointed Director of Research Services of the RCA Laboratories. In 1953, he became Director of the Physical and Chemical Research Laboratory. He was named Administrative Director, RCA Laboratories, in 1954.

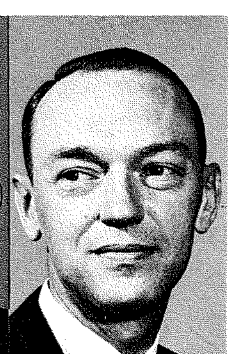
FOUR RCA ENGINEERS ASSUME NEW DUTIES

Dr. D. H. Ewing

Dr. A. M. Glover



O. B. Hanson



T. A. Smith

SMITH, MALCARNEY, GLOVER NAMED IN NEW POSTS

EPD . . . The activities of the Engineering Products Division have been realigned into Defense Electronic Products, of which Theodore A. Smith is Vice President and General Manager, and Commercial Electronic Products, of which A. L. Malcarney is General Manager. Both Mr. Smith and Mr. Malcarney will report to Dr. Engstrom, Senior Executive Vice President.

TUBES . . . Present announced plans contemplate expansion of the Tube Division into three operating divisions, Tubes, Semiconductors, and Component Parts. Appointment of Dr. Alan M. Glover as General Manager of the newly created RCA Semiconductor Division was announced Dec. 5th by W. Walter Watts, Executive Vice President, Electronic Components. Dr. Glover's appointment emphasizes the increasing importance of RCA's activities in the field of solid-state devices including transistors and rectifiers.

DR. ALAN M. GLOVER joined RCA in 1936 as an engineer on the development of phototubes at Harrison. From 1941 to 1950 he acted as manager of gas tube and tube engineering, first at Harrison and later at Lancaster, Pa. In 1950 he was made manager, power tubes, product administration, and in 1953 he became manager, controls and standards, in the power tube and cathode ray tube operations department. A year later he returned to Harrison as manager, semiconductor operations department.

He was graduated from the University of Rochester in 1930 with the degree of A.B., and continued his studies to obtain the graduate degrees of M.A., and Ph.D. in Physics. For many years, Dr. Glover has been active in the RETMA. He is a member of the American Physical Society, and a Fellow of the IRE.

THEODORE A. SMITH—After receiving his ME degree from Stevens Institute of Technology in 1925, he joined RCA's laboratories in New York City. Three years later, Mr. Smith took charge of television development. Mr. Smith entered commercial engineering in 1930 as district sales manager for RCA broadcast equipment. In 1938 he transferred to Camden where he held sales and engineering positions in the broadcast, scientific instruments and communications equipment activities. Mr. Smith later became general sales manager of EPD.

In 1951 Mr. Smith became assistant manager of Engineering Products and was elected Vice President and General Manager of Engineering Products in 1953.

Mr. Smith is a member of the IRE, the American Society of Naval Engineers and the Armed Forces Communications Association. He is Chairman of the Military Products Division of the RETMA and has been active in committee work of the National Security Industrial Association.

RCA ANNOUNCES ADDITION TO PLANT AT CAMBRIDGE . . . A $2,700,000 addition to RCA's plant at Cambridge, Ohio, will be constructed to meet demands for increased production of tape recorders and high fidelity instruments, according to a recent announcement by James M. Toney, Vice Pres. and General Manager, RCA Victor Radio and "Victrola" Division. The addition will add more than 210,000 square feet of floor space to the present 135,000 square feet at the Cambridge plant—now used for the manufacture of fabricated parts for record players, radios and television receivers as well as the assembly of record changers and "Victrola" phonographs. Work on the new addition is expected to be completed in 1956.

DR. E. W. ENGSTROM AWARDED PROGRESS MEDAL BY SMPTE . . . Dr. Engstrom spoke at the 78th semi-annual convention of the Society of Motion Picture and Television Engineers, following a ceremony in which he received the SMPTE Progress Medal Award "for his outstanding leadership and vision in sound motion picture and television development." Dr. Engstrom's talk dealt with the expansion and magnitude of scientific research efforts in this country and abroad.

JOHN P. TERRELL FETED AT RETIREMENT DINNER . . . John P. Terrell, third from the right (below) who retired in August, was recently feted at a dinner by former co-workers. At the dinner, Mr. Terrell, and his wife Elizabeth, received many gifts. In the picture with the former manager on Mechanical Coordination and Drafting, Computer Engineering, Engineering Products Division, are: far left, H. Kenny, Manager of Drafting, Computer Engineering; J. B. Coleman, Assistant to D. F. Schmit, Vice President, Product Engineering; J. W. Leas, Chief Product Engineer, Computer Engineering; M. C. Batsel, Chief Engineer, EPD; Mrs. Terrell, Mr. Terrell; H. J. Schrader, Manager, Technical Administration, and M. S. Gokhale, Division Standards.

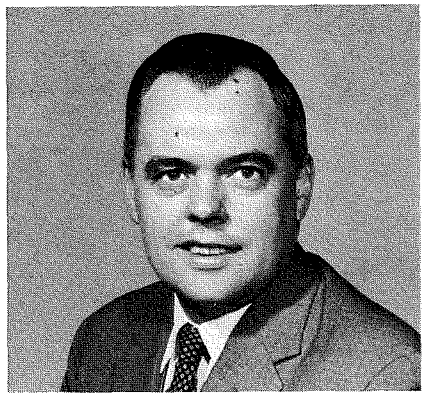
Mr. Terrell has been engaged by the Standards Engineering and Component Design Activity of EPD Engineering, effective November 16, 1955, as a consultant in mechanical engineering. Specifically, he will have the responsibility of planning, organizing and administering training courses for Mechanical Engineers and Designers. It is anticipated that this program will fill an important need in EPD and that through the rich experience of Mr. Terrell, young mechanical engineers and designers may rapidly adapt themselves to the electronics industry.

DR. HILLIER NAMED AS NEW CHIEF ENGINEER

Effective November 1, 1955, Dr. James Hillier, formerly of the RCA Laboratories and RCA Research and Engineering staff, was appointed Chief Engineer, Engineering Department, Commercial Electronic Products by A. L. Malcarney, General Manager of Commercial Electronic Products, located at Camden, N. J. In this capacity, Dr. Hillier is responsible for new product planning and development, engineering staff services, and functional guidance of all Commercial Electronic Products engineering activities.

DR. JAMES HILLIER attended the University of Toronto, Canada, where he received the degree of BA in Mathematics and Physics in 1937, the MA in Physics in 1938, and the PhD in Physics in 1941. From 1939 to 1940 Dr. Hillier was a research assistant and demonstrator at the Banting Institute of the University of Toronto Medical School. From 1940 to 1953 he was a research physicist at the RCA Laboratories in Camden and (since 1942) in Princeton, N. J. From 1953 to 1954 he was Director of Research Department, Melpar, Inc. From 1954 to 1955 Dr. Hillier was Administrative Engineer, Research and Engineering, RCA, before his appointment as Chief Engineer, Commercial Electronic Products Division.

Dr. Hillier is a Fellow of the American Physical Society, and the A.A.A.S., Senior Member of the IRE, a past president of the Electron Microscope Society of America, and a member of A.M.A. and Sigma Xi.



Dr. James Hillier

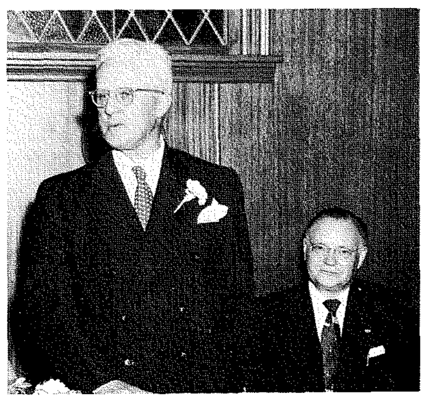
EPD ENGINEERS ASSIST IN LONDON WITH TV EQUIPMENT . . . J. H. Roe and L. E. Anderson of TV Broadcast Equipment Engineering, Engineering Products Division, Camden, were in London, England, for about three weeks beginning September 15 to assist in installation of RCA TV studio and film equipment purchased by Associated Rediffusion, Ltd., one of the newly created organizations for production of TV programs under commercial sponsorship. The equipment included three TK31A field camera chains housed in a mobile unit, two TK21A vidicon film chains, two TP16 film projectors, two TP35 film projectors, two TVM1A microwave relay systems, and some special effects equipment.

J. S. MARTIN and **P. D. STRUBHAR,** of the Lancaster Chemical and Physical Laboratory, participated in a TV program on WGAL-TV in Lancaster on Nov. 27, 1955. The program was entitled "Chemistry in Metallurgy" and was presented for the American Chemical Society. Mr. Strubhar, a metallurgist, graduated from Lehigh University in 1934, and has been with the Company since 1951. Mr. Martin who holds the degree of BS in Chemistry from Franklin and Marshall College (1943), joined RCA in April, 1955.

RETIREMENT DINNER FOR C. Y. KEEN, SERVICE COMPANY ENGINEER . . . A retirement dinner for C. Y. Keen was given on September 29, 1955, at the Black Horse Farms, Mt. Ephraim, N. J. Mr. Keen has been with RCA for 26 years and is retiring at the age of 65.

Mr. Keen began his career as a chemical engineer after graduation from the University of Washington. His pastime of radio and sound eventually proved more attractive, and he joined RCA Photophone in New York. From 1929 to 1937 Mr. Keen traveled the north-west of the country for Photophone, and became district service manager in Cincinnati in 1938. Just before World War II he joined engineering at the Indianapolis Plant, and later the RCA Service Company where he became a specialist in Theater TV operations.

SHORAN AND SPECIALTIES ENGINEERING OPERATE FLIGHT LAB . . . RCA has developed a Shoran bombing system as a logical outgrowth of the Shoran Navigation system. The devlopment and Field Evaluation program is under the direction of A. D. Zappacosta, Manager of Shoran Product Development. A fully equipped plane, C-47, operated from the RCA Flight Test Laboratory, New Castle County Airport in Delaware, enables field engineering tests under actual flight conditions. The plane is piloted by R. H. Mushlit, Chief Pilot, and R. J. White, Pilot, of the RCA Flight Laboratory. The flight crew who have laid the ground work and installed the equipment are A. Davies, L. DiPaolo, R. Lapidos, D. Lobel and V. Poehls. David Boom, Herbert Blount, L. Smith and W. Ursney of the RCA Service Company, under the supervision of A. J. Skavicus, Products Development Manager are also actively engaged in the flight test program. The ground stations necessary to test the equipment are located in Lancaster, Pa., and Clark, N. J. The Lancaster installation is operated by F. Long and W. Porter and the Clark installation is operated by N. MacInnes and E. Wojciechowski.



C. Y. Keen at retirement dinner. Seated is E. Stanko, Mgr. Engineering, Technical Products Service Department.

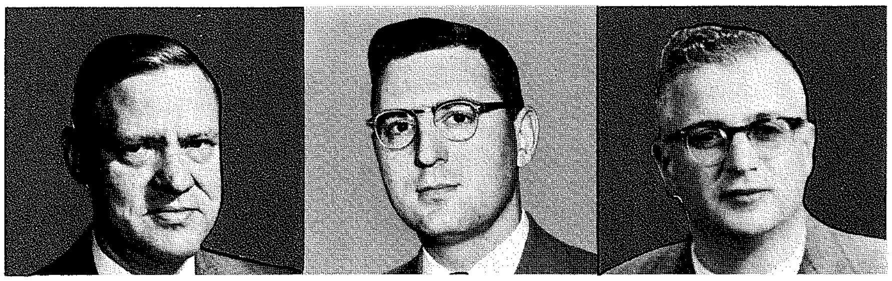
NEW EDITORIAL REPRESENTATIVES APPOINTED

JOHN E. VOLKMANN is the new RCA ENGINEER representative recently appointed to the EPD Editorial Board, covering activities in Theater and Industrial Engineering at Camden, N. J. Mr. Volkmann replaces J. A. Bauer, who has transferred to Moorestown, Missile and Radar Engineering. At Moorestown, Mr. Bauer will assume the editorial duties of T. G. Greene, assigned to a full-time major engineering project.

REINHARD E. RIST is the newly appointed Editorial Representative for the RCA ENGINEER covering the Semiconductor and Microwave Tube activities at Building 55, Tube Division, Harrison. Mr. Rist replaces James W. Ritcey, who is assuming new responsibilities in Semiconductor Engineering at Harrison.

HANNS J. WETZSTEIN is the RCA ENGINEER Editorial Representative appointed to cover the engineering activities at the new Waltham (Mass.) Aviation System Laboratory of the Engineering Products Division (See *Engineering News and Highlights*, RCA ENGINEER, Vol. I, No. 1).

The Editors of the RCA ENGINEER would like to welcome the new representatives and extend their appreciation and thanks to Messrs. Greene and Ritcey for the cooperation and assistance during the early formative stages of the RCA ENGINEER. Among the contents of the first three issues of the RCA ENGINEER which were published during their tenure was Mr. Greene's article (co-authored by P. C. Harrison) "The Role of the Mechanical Engineer in Electronic Equipment Design" (see RCA ENGINEER Vol. I, No. 2). This paper was instrumental in initiating a series of articles on the role of the mechanical engineer at RCA. Mr. Ritcey's work in the original magazine planning, and in suggesting and following through on the article, "Low-Noise Traveling Wave Tubes" RCA ENGINEER, Vol. I, No. 3 and others to appear in subsequent issues was invaluable.



J. E. Volkman — R. E. Rist — H. J. Wetzstein

JOHN E. VOLKMANN attended the University of Illinois, where he received his BS in Engineering Physics in 1927, his MS in Engineering Physics in 1928, and Professional Degree as Engineer-Physicist in 1940. Mr. Volkmann has 27 years' experience with RCA, starting with RCA Research in New York in 1928 as Assistant Physicist in Acoustic Research. In the interim to the present he has worked as an engineer, supervisor, or manager in Acoustic Development for RCA Photophone (New York), RCA Victor Co. (Camden), RCA Manufacturing Co. (Camden), RCA Victor Division (Indianapolis), RCA Victor Division (Camden), and Engineering Products Division. Mr. Volkmann is at present in Theater and Industrial Equipment Engineering as Staff Engineer. He is a Fellow of the Acoustical Society of America, a Fellow of the SMPTE, a Member of the Sigma Tau and an Associate Member of the Sigma Xi.

REINHARD E. RIST was graduated from Rutgers University in 1950 with a BS in Physics, and received his MS degree from Stevens Institute of Technology in 1954. From 1950-1952 he was employed by the Research Division of the National Union Radio Corp. where he was engaged in the development of multi-gun cathode ray and special purpose switching tubes. Mr. Rist joined RCA in September of 1952 as a Design and Development Engineer in the Semiconductor Development Shop where he worked on junction transistors and point contact diodes and transistors. He is presently in charge of the Semiconductor Methods and Process Laboratory Engineering group.

Dr. HANNS J. WETZSTEIN received his BS in EE from the University of Capetown, S. A. in 1947, his MS in EE from Harvard in 1948 and SD from Harvard in 1952. For six years he was Chief Designer with Phillips Denbigh in Communication Equipment and Components, and Industrial Electronics. Dr. Wetzstein was two years with Scientific Specialties Corporation as Project Engineer and Director of Research in Transistor Measurements and Data Handling. During this time he worked part-time at Harvard on cyclotron ion sources. At present, Dr. Wetzstein is with the Aviation System Laboratory at Waltham, in Airborne Fire Control Instrumentation.

ENGINEERING DATA AND CATALOGUES

REVISED EDITION OF THE RC-17 TUBE MANUAL NOW AVAILABLE . . . A revised and enlarged edition of the RCA Receiving Tube Manual RC-17 is now available from the Tube Division. One of the features is a 26-page supplement covering 51 newly added tube types including types developed especially for use in TV receiver circuits. Among the charts is one listing the operating characteristics of 64 RCA types of TV picture tubes including color tube types.

RCA SERVICE COMPANY ANNOUNCES NEW MANUAL FOR HOME COLOR TV SETS . . . Publication of a 36-page manual designed to aid television service dealers and technicians in installation and maintenance of color TV receivers has been announced by RCA Service Company. The supplement carries schematic diagrams and other data on RCA Victor's two new 21-inch color receivers.

NEW PRODUCT INSTALLATIONS

UNIVERSITY OF TEXAS HOSPITAL TO USE RCA ELECTRON MICROSCOPE IN CANCER RESEARCH . . . An RCA EMU-3 electron microscope—the most powerful type in the world—has been purchased for use in cancer research by The University of Texas M.D. Anderson Hospital and Tumor Institute, Texas Medical Center, Houston. The electron microscope enlarges specimens more than 300,000 times and permits studies of particles smaller than one 10-millionth of of an inch. The addition of the RCA electron microscope to the hospital's research institute was made possible through the gift of a Texas philanthropist.

TWO ELECTRON MICROSCOPES INSTALLED IN VENEZUELA . . . E. L. Saunders, RCA Service Company Electron Microscope Specialist is installing two Electron Microscopes for Dr. Fernandez-Moran, Director of Neurological Institute, Caracas, Venezuela.

UHF MOBILE SYSTEM DESIGN COMPLETED FOR CUBA . . . The Mobile Communications Engineering Design group of EPD Communications Engineering has completed the design of a UHF wide-band system (designated MM-2A) that will provide a multi-channel communications system for Cuba. This system features low cost, highly reliable equipment built in the mobile communications production factory. It consists of a receiver, power supply and transmitter that are capable of continuous-duty operation, and provides four voice channels, one voice service channel, and nine telegraph channels.

MOBILE COMMUNICATIONS SYSTEM ACCEPTED BY OHIO TURNPIKE COMMISSION . . . The Ohio Turnpike Microwave and Land-Mobile Communications System has been accepted by the Turnpike Commission and is in full operation from Pennsylvania to Indiana. All vehicles (patrol, maintenance, administration, and service) are able to establish immediate contact with each other, and with the Administrative Headquarters, toll interchanges and maintenance and service centers. Teletype circuits are available between district police headquarters. All stations (both VHF and microwave) are equipped with standby equipment and automatic supervision in order to provide service reliability in excess of 99.9%.

50-KW VHF TRANSMITTER DELIVERED TO WFAA IN DALLAS . . . The delivery of an RCA 50-kilowatt transmitter (TT50-AH) to Station WFAA in Dallas is virtually the final link in the over-all installation which features the RCA "candelabra" transmitting antenna (see "Hill-Tower Multiple Antenna System," by R. H. Wright and J. V. Hyde, RCA ENGINEER Vol. I, No. 2).

BREWERS INSTALL RCA BEER INSPECTION MACHINES . . . The Sicks' Company, of Seattle, Wash., which brews Rainier beer, has installed three RCA electronic inspection machines to provide continuous electronic-eye inspection of beverages at the rate of 450 bottles a minute. Each RCA-developed "inspector" scans bottles at the rate of 150 per minute and instantly and automatically detects and rejects those containing foreign particles. Two more major Breweries, the Gunther Brewing Company of Baltimore, Md., and Standard Brewing of Rochester, N. Y., are also slated for early delivery of inspection equipment.

COMMITTEE APPOINTMENTS

ENGINEERING PRODUCTS DIVISION . . . J. L. KRAGER, JR., Manager of Engineering Standards Packing Design, was appointed Chairman of the Judging Staff for the 10th National Packaging Competition.

J. L. PETTUS, Film Recording Engineering, Los Angeles, has been appointed to the Public Address and Recording Committee of the SMPTE.

L. E. THOMPSON, Communications Engineering, is appointed member of Papers Study and Procurement of the IRE Professional Group on Communications.

W. H. BREARLEY, JR., Mgr., Standards Engineering, has been appointed a member of the IRE National Committee on Industrial Electronics of which J. E. Eiselein is Chairman.

J. R. NEUBAUER has been appointed Chairman of the IRE National Convention Symposium Committee for Vehicular Communication. This appointment also makes Mr. Neubauer a member of the National Convention Technical Program Committee.

B. F. WHEELER has been appointed as the RCA engineering representative on the RETMA Microwave Section AdHoc Committee on Microwave Rules.

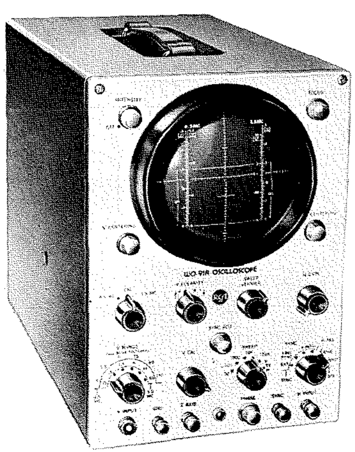
S. A. CALDWELL, Manager of the Sound and Visual group of the Theater and Industrial Equipment Engineering Section, has been appointed to the SMPTE Sub-committee on Magnetic Sound Standards.

N. E. EDWARDS, Communications Engineering, has been appointed to the RETMA Subcommittee TR 14.2.1 Multiplex Terminations.

TUBE DIVISION . . . FRANK R. ARAMS has recently been elected chairman of the New York Chapter of the IRE Professional Group on Engineering Management for the 1955-56 season. Mr. Arams, who has been with RCA since June, 1948, is presently responsible for Microwave Tube Application Engineering at Harrison.

NEW PRODUCTS

RCA WO-91A 5-INCH OSCILLOSCOPE . . . The WO-91A is a new low-cost 5-inch oscilloscope designed for use in production and servicing of both black-and-white and color TV receivers. It includes a multi-scale graph screen, scaled directly in volts, and a 2-position switch in the vertical amplifier which gives a choice of wide-band or narrow-band (high sensitivity) operation. Frequency response: Wide-band position, within ±1 db from 10 cps to 4.5 mc; narrow-band position, within —1 db from 10 cps to 0.5 mc; within —6 db at 1.5 mc. Sensitivity: 0.05 volt peak-to-peak per inch (0.018 volt rms) in narrow-band position: 0.15 volt peak-to-peak per inch (0.053 volt rms in wide-band position).



NEW ECONOMY-PRICED PRINTED-CIRCUIT TABLE MODEL RADIO ANNOUNCED . . . A new economy-priced table model radio, available in a choice of three colors has been announced by the RCA Victor Radio and "Victrola" Division.

The instrument—The Kerry (model 6X5) —will replace an existing model in RCA Victor's line, and features an improved type of printed-circuit chassis.

NEW RCA TUBE TYPES

RCA-6806 is a new super-power tube designed for operation as a grid-driven power amplifier at frequencies up to 1000 mc. It has a maximum plate-dissipation rating of 35 kilowatts. In color or black-and-white television service, the 6808 is capable of delivering a synchronizing-level power output of 30 kilowatts at 550 mc or 25 kilowatts at 750 mc. As a c-w amplifier in class C telegraphy service, the 6806 is capable of giving a useful power output of 25 kilowatts at 400 mc.

RCA-6810 is a head-on type of multplier phototube intended for use in scintillation counters and in other applications involving low-level, large-area light sources. Featuring fast response, high current gain, relative freedom from after-pulses, and small spread in electron-transit time, the 6810 is particularly useful for fast coincidence scintillation counting. The spectral response of the 6810 covers the range from about 3000 to 6500 angstroms. Maximum response occurs at approximately 4400 angstroms.

RCA-6AU8 and **RCA-6BH8** are medium-mu triode—sharp-cutoff pentodes suitable for TV applications. Featuring high transconductance (7000 microhms) the pentode units of these tubes are intended for use as video amplifier tubes. They may also be used as video i-f amplifier tubes, as sound i-f tubes, or as agc amplifier tubes.

The triode unit of the 6AU8 has an amplification factor of 40 and is intended for use in sync circuits. The triode unit of the 6BH8 has an amplication factor of 17 and is especially useful in low-frequency oscillator circuits.

RCA-3DT6 and **RCA 6DT6** are sharp-cutoff pentodes of the 7-pin miniature type intended particularly for use as FM detectors in television receivers. The design of these tubes includes separate base-pin terminals for grids No. 1 and No. 3. Each of these grids has a sharp-cutoff characteristic and can be used independently as a control electrode.

Because of the sharp-cutoff characteristic of grid No. 3, the 3DT6 and 6DT6 are especially suitable for use in locked-oscillator, quadrature grid FM detector circuits.

The 3DT6 is like the 6DT6 except that it has a 3.15-volt/0.6-ampere heater for use in TV receivers employing series-heater string arrangement.

RCA-3CS6 and **RCA-6CS6** are pentagrid amplifiers of the 7-pin miniature type intended especially for service as gated amplifiers in television receivers. In such service, each type can perform the dual functions of sync separator and sync clipper. Design includes separate base-pin terminals for grids No. 1 and No. 3. Each of these grids has a sharp-cutoff characteristic and can be used independently as a control electrode.

The 3CS6 is like the 6CS6 except that it has a 3.15-volt/0.6-ampere heater suitable for use in TV receivers employing a series-heater string arrangement.

RCA-4BC8 and **RCA 6BC8** are medium-mu twin triodes of the 9-pin miniature type having a semiremote-cutoff characteristic The 4BC8 is like the 6BC8 except that it has a 4.2-volt/0.6-ampere heater for use in TV receivers employing a series-heater string arrangement. The semiremote cutoff of these tubes reduces cross-modulation effects in the receiver. In addition, the high transconductance (6200 microhms) permits high gain with corresponding reduction in noise.

RCA-6562 is a fixed tuned uhf oscillator triode having a pencil type construction and intended for transmitting service in the radiosonde applications. Design of the tube incorporates two integral resonators of the cavity type. One of the resonators is fixed-tuned and connected between grid and cathode. The second resonator is connected between grid and plate, and is tunable over a narrow range centering at 1680 megacycles.

RADIOMARINE NEWS

Radiomarine Corporation of America will introduce a new addition to their "Golden Series" at the National Motor Boat Show at the Kingsbridge Armory, New York City, N. Y., on January 13, 1956. The newest equipment in this series is the "Golden Sentry" Model ET-8059, Radiotelephone—a low-priced unit rated at 20 watts and designed to comply with present and pending F.C.C. regulations. Five (5) crystal-controlled transmitting and receiving channels in the marine band are included plus a standard broadcast band receiver.

A "press-to-talk" microphone permits one-hand operation and an oval loud speaker is provided. Other features of the Golden Sentry include improved selectivity, a printed-wiring receiver circuit, output booster control and indicator for maximum antenna power, and Transmitter On-Off-Switch for minimum battery drain. The ET-8059 operates from a 6 or 12 V DC supply.

M. C. MYERS, Radiomarine, was a member of the Reliability in Equipment Systems and Communications Panel at the 1955 Fall Assembly Meeting of the Radio Technical Commission of Marine Services, which was recently held in New Orleans, La. Mr. Myers spoke to the Assembly on the reliability design considerations in compulsory equipment.

Also attending the RTCM from Radiomarine were, Captain George F. Sheckten and Mr. Arthur J. Costigan.

SEMINARS CONDUCTED FOR FIELD ENGINEERS ON COMMERCIAL ELECTRONIC PRODUCTS . . . J. D. Hodge, Beverage Inspection Specialist for the RCA Service Co., has been conducting seminars and training field engineers in the San Francisco, Hollywood, and Kansas City Districts. J. H. Greene, P. V. Smith, and Harry Taylor have been conducting similar seminars for "ITV," Metal Detectors, and Electronic Weighing Devices in the San Francisco, Hollywood, Dallas and Kansas City Districts.

IRE SYMPOSIUM ON MICROWAVE THEORY AND TECHNIQUES PLANNED . . . RCA Engineers participating in planning the program for the Symposium to be held by the IRE Professional Group on Microwave Theory and Techniques to be held in Philadelphia February 2nd and 3rd, 1956 include: N. C. Colby, D. R. Crosby, R. Klopfenstein, H. R. Mathwich and B. F. Wheeler, of EPD Engineering, Camden.

TV ENGINEERING COURSES OFFERED . . . Broadcast Studio Engineering of EPD in Camden is sponsoring two television courses in the Camden plant after-hours training program. The first of these is a 60-hour course in Elementary Television Engineering, with the instructorship shared by Robert G. Thomas and Robert N. Hurst. The second course is an Advanced TV Seminar, which has been organized by C. R. Monro, and is presented on Wednesday evenings, covering a period of 16 weeks. It consists of a series of sessions on specialized topics. This year's overall program includes "Transient Response in Video Circuits," "Circuit Stabilization Techniques," and "Video Test Techniques." Guest lecturers, in addition to Mr. Monro, include W. L. Hurford, A. C. Luther, and S. L. Bendell from Broadcast Studio Engineering and B. Rosen and H. Wuerffel from Standards Engineering.

SEMINARS GIVEN AT WALTHAM PLANT . . . A series of seminars were given at the Waltham Aviation Systems Laboratory from July to September, 1955, by Professor S. Lees and Professor E. E. Larrabee of Massachusetts Institute of Technology on "Instrument Engineering Including Servo-mechanisms and Flight Data Analysis."

TELEVISION MEETINGS COMPLETED FOR MILITARY . . . A series of meetings, titled, "Television for Military Applications" was recently concluded by RCA. Mr. A. C. Stocker, General Engineering Development, EPD, conducted the sessions in accordance with the schedule below. Audiences at the meetings were organized units of the Naval Research Reserve, a reserve activity under the Office of Naval Research. Officers attending encompassed a wide variety of fields, including Mathematics, Psychology, and Electronics.

Date 1955	*Place*	*Attendance (approx.)*
Feb. 17	New York City	50
Oct. 19	Princeton	40
Oct. 20	Philadelphia	30
Nov. 21	Wilmington	40
Dec. 1	Baltimore	40
Dec. 15	Washington	150*

*Joint meeting of four units in Washington area.

OPERATIONS RESEARCH SYMPOSIUM CONDUCTED AT U. OF PENN. . . . An Operations Research Symposium, sponsored jointly by the Phila. Section of the IRE, the Delaware Valley Section of the Society for Industrial and Applied Mathematics, and the Professional Group on Engineering Management, IRE, was conducted December 14, 1955, at the University of Pennsylvania, Philadelphia. The session was opened by a welcome by Symposium Committee Chairman J. Wesley Leas, Chief Project Engineer.

The objective of the symposium was to acquaint participants with the field and scope of Operations Research. Some of the techniques utilized in Operations Research and several case histories illustrating typical applications of these techniques were presented by the speakers.

RCA members of the Symposium Committee were J. Wesley Leas and Irving Cohen.

TALK GIVEN AT IRE SECTION MEETING BY W. E. BABCOCK . . . W. E. Babcock, Manager of the Applications Engineering Laboratory for the Entertainment Receiving Tube Engineering activity at Harrison gave a talk entitled, "Unusual Electron Tube Effects of Concern to Circuit Designers" at the October meeting of the Northern New Jersey Section of the IRE. The talk discussed the existence of certain electron tube phenomena that a circuit designer may be completely unaware of in many applications. Phenomena such as stray emissions, leakages, snivets, cathode interface, and others were described together with various methods employed to minimize difficulties arising from such effects.

TUBE DIVISION ENGINEERS DELIVER PAPERS AT JOINT MEETING OF I.R.E. AND RETMA . . . Improvements in the manufacturing processes of color TV picture tubes, the application of transistors to battery portable receivers, methods for the testing of horizontal deflection tubes, and a method for measuring the optical sine-wave spectrum of TV image display devices were outlined by RCA Tube Division engineers during the joint meeting of the I.R.E. and RETMA at the Hotel Syracuse, Syracuse, N. Y., October 18, 1955.

The papers given by RCA engineers are as follows:

"*Simple Production Methods for the Dynamic Testing of Horizontal Deflection Tubes*" by M. B. Knight.

"*Application of RCA Transistors to Battery Portable Receivers*" by J. W. Englund.

"*A Method of Measuring the Optical Sine-Wave Spectrum and Effective Bandwidth of TV Image Display Devices*" by O. H. Schade, Sr.

"*Recent Improvements in the 21AXP22 Color Kinescope*" by R. B. Janes and L. B. Headrick.

(See *PEN AND PODIUM*, this issue)

ENGINEERING MEETINGS AND CONVENTIONS

December, 1955 — February, 1956

DECEMBER 10-16
International Atomic Exposition
Cleveland Public Auditorium
Cleveland, Ohio

DECEMBER 29-30
Annual Christmas Symposium of the Division of Industrial and Engineering Chemistry of the American Chemical Society
Princeton University
Princeton, N. J.

JANUARY 9-10
Second National Symposium on Reliability and Quality Control in Electronics
Hotel Statler, Washington, D. C.
(Sponsored by IRE Professional Group on Reliability and Quality Control, and American Society for Quality Control, and RETMA)

JANUARY 24-28
1956 Southwestern Electronic Conference
Galvez Hotel, Galveston, Texas

JANUARY 30-FEBRUARY 2
Seventh Annual Instrumentation Symposium
University of Florida
Gainsville, Fla.

JANUARY 30-FEBRUARY 3
Winter General Meeting
American Institute of Electrical Engineers
New York City, N. Y.

FEBRUARY 2-3
IRE National Symposium on Microwave Techniques
University of Pennsylvania
Philadelphia, Pa.

FEBRUARY 8-11
Los Angeles High Fidelity Music Show
Alexandria Hotel
Los Angeles, Cal.
(Sponsored by West Coast Electronic Manufacturers' Association and Institute of High Fidelity Manufacturers)

FEBRUARY 8-10
AIEE-IRE-ACM Western Computer Conference
Fairmount Hotel, San Francisco, Cal.

FEBRUARY 9-10
Society of American Military Engineers Annual Technical Meeting
Palmer House, Chicago, Ill.

FEBRUARY 16-17
AIEE-IRE-Univ. of Pennsylvania Transistor Circuit Conference
University of Pennsylvania
Philadelphia, Pa.

FEBRUARY 24-25
Ninth Annual Meeting
Western Radio and Television Conference
San Francisco, Cal.

FEBRUARY 26-29
American Institute of Chemical Engineers
Statler Hotel, Los Angeles, Cal.

FEBRUARY 28-29
Scintillation Counter Conference
Shoreham Hotel
Washington, D. C.

RCA ENGINEER EDITORIAL REPRESENTATIVES

EDITOR'S NOTE: In order to avoid delay in the publication of Issue #4, the RCA ENGINEER staff has not attempted to correct Divisional names and titles to agree with recent organizational changes. Future issues of the RCA ENGINEER will carry this information as soon as it is released by Divisions affected.

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