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Transistor Measurements With The HF-VHF Bridge

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Figure 1. The author is shown measuring a transistor, using the RX Meter, a battery power supply, and a specially made transistor measuring jig.

Introduction

The very high-power efficiency at low-power levels together with the reliability and low-cost potentials of the transistor have led to increased usage of this device by circuit designers in both the commercial and military fields of electronics. Hearing aids, portable radios, phonographs, dictating machines, portable cameras, machine-tool controls, clocks, and watches are but a few examples of the commercial applications of transistors. Along with many other applications, the military have employed the transistor in the "Explorer" and "Vanguard" satellites now circling the earth.

As the usage of the transistor increases it is apparent that there is a need to develop new measuring techniques. The transistor circuit designer can no longer get by with specifications published by transistor manufacturers alone; (Normally, the manufacturers will specify transistor parameters for a given set of bias conditions and a single frequency only.) he is now often faced with the problem of determining parameters for a wide range of bias and frequency conditions. This article describes a transistor measuring technique, using the RX Meter and certain hybrid equations, which will yield information about the parameters of transistors over a wide range of bias and frequency conditions.

The RX Meter is well suited to transistor measurements because its bridge elements will pass, directly, a current of up to approximately 50 milliamperes, and its two-terminal measurements can furnish the parameters for radio-frequency transistor circuit design. Contributing to the ease with which transistor measurements can be made are the self-contained design of the instrument, with the signal generator, bridge, and detector in a single, compact package, and the fact that the "unknown" terminals are located on the flat, top surface of the instrument, where attachment of the measuring jig may be conveniently made.

The idea of using the RX Meter for transistor measurements is not a new one; a number of research, development, and production groups have been engaged in this type measurement for some time. For example, Messrs. Earhart and Brower of Texas Instruments recently used the RX Meter to measure a new VHF silicon transistor.[4] Because of the lack of published information on the theory and practice of transistor

Figure 2. Jig h_{11e}, shown, includes binding posts to which the 103-A series coil or other components may be connected for extending the RX Meter capacitance, inductance, or resistance range.

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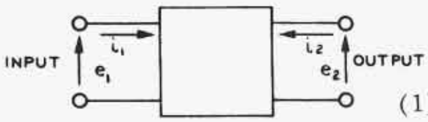
measurements with the RX Meter, however, it has been found that few of these groups are using the RX Meter to the limit of its capabilities. This article is intended to fill the gap in the literature, and at the same time, promote a more complete understanding of the use of the RX Meter for measuring transistors by persons currently using the instrument for this purpose, and by those persons unaware of its transistor-measuring application.

Transistor Parameters

Consider the following network equivalent of the transistor.



(1)

Linear equations can be written using a set of independent variables to relate e_1, e_2, i_1 and i_2; the independent variables being the input, output, and transfer characteristics of the transistor commonly known as the transistor parameters. These transistor parameters are constants for a given set of bias and frequency conditions. One of the most popular and most widely used sets of transistor parameters is the hybrid or h set of parameters. The linear equations for the transistor, represented by network (1), in terms of hybrid parameters are:

$$e_1 = h_{11}i_1 + h_{12}e_2$$
$$i_2 = h_{21}i_1 + h_{22}e_2$$

where the h parameters are h_{11}, h_{22}, h_{12}, and h_{21}. The choice of number subscripts here is based on personal preference. IRE Standards[3] suggest the use of either number or letter subscripts, as convenient. Table I is a cross-reference of number and letter subscripts assuming a common-base transistor configuration.

TABLE I

COMMON-BASE SUBSCRIPTS

Number	Letter
h_{11b}	h_{ib}
h_{12b}	h_{rb}
h_{21b}	h_{fb}
h_{22b}	h_{ob}

Determining the Hybrid (h) Parameters

The h parameters can be determined by solving the hybrid equations. By arbitrarily open- and short-circuiting pairs of terminals in (1), a current or a voltage can be made zero to aid in the solution. Parameters h_{11}, h_{22}, h_{21}, and h_{12}, are numerically evaluated with the help of RX Meter measurements. The method of evaluation is outlined in Table II below.

TABLE II

SOLUTION OF THE HYBRID EQUATION

(Assuming Common-base Configuration)

Parameter	Circuit Condition	Description
$h_{11b} = \frac{e_1}{i_1}$	$e_2 = 0$	Input impedance with output short-circuited.
$h_{12b} = \frac{e_1}{e_2}$	$i_1 = 0$	Reverse voltage transfer ratio with input open-circuited.
$h_{21b} = \frac{i_2}{i_1} = -\alpha$	$e_2 = 0$	Forward short-circuit current transfer ratio with output short-circuited.
$h_{22b} = \frac{i_2}{e_2}$	$i_1 = 0$	Output admittance with input open-circuited.

The various circuit conditions for each h parameter refer to the ac circuit only. DC bias voltages are not disturbed when the ac circuit conditions are changed. From Table II it should be obvious that an input measurement on the RX Meter provides h_{11b} directly. By converting an output RX Meter measurement to an admittance, h_{22b} is also obtained directly.

Parameters h_{21b} and h_{12b} relate voltages and currents on both input and output sides of the network providing the network transfer characteristics. The h_{21b} parameter is found numerically from the ratio of two input impedance measurements. Parameter h_{12b} is found from the product of the difference of two output admittances and the ratio of h_{11b} over $-h_{21b}$. The derivation of h_{21b} and h_{12b} is given in the appendix. In summary, the method of obtaining the common-base h parameters from RX Meter measurements is simply and conveniently shown in Table III.

To obtain common-emitter or common-collector h parameters a set of simple conversion formulas can be used. As an example, we can convert h_{22b} to h_{22e} with the formula

$$h_{22e} = \frac{h_{22b}}{(1 + h_{21b})}.$$

The above formula and other conversion formulas are given by Scher[6]. These formulas yield approximate values.

RX Meter Jigs

The RX Meter measurements indicated in configurations A through D in Table III require the use of four jigs which attach the transistor to the RX Meter and supply proper dc bias. These jigs can all be operated from a common power supply. A schematic diagram of the jigs with a transistor in the socket is shown in Figure 3. Each diagram represents one of the configurations correspondingly marked A through D in Table III.

The specific jigs described in this article were designed for a Raytheon Type 2N417 PNP transistor for measurements in the 20-mc range. The 0.01 μf ceramic by-pass capacitors, power supply, and jig socket selections all reflect the transistor to be measured and the approximate frequency range. The by-pass capacitors have good by-passing action in the 20-mc range and the jigs perform well in this range. For frequencies appreciably different from 20-mc, different capacitors may have to be selected. At frequencies approaching 250-mc the jig series inductance may require evaluation. However, no serious problems are anticipated in using similar jigs over the entire 500-kc to 250-mc range of the RX Meter.

Since the power supply (Figure 4) has high resistance in the emitter bias

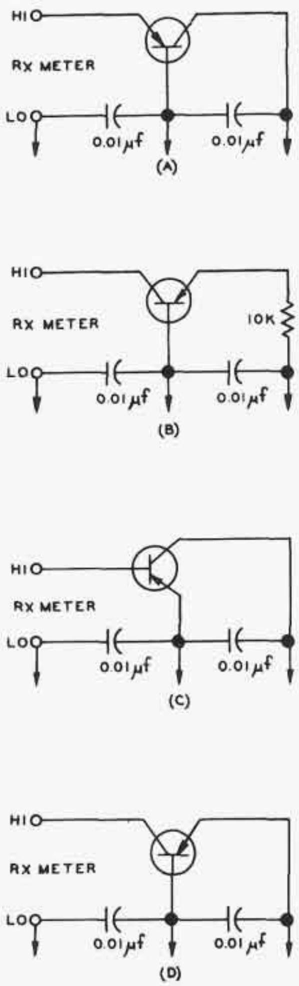


Figure 3. Jig Schematics

Typical Measurements and Calculations

To illustrate transistor measurements the common-base h parameters of a Raytheon Type 2N417 transistor have been determined for the following conditions using the RX Meter and the jigs.

$$V_{CB} = -6 \text{ volts}$$
$$i_e = 5 \text{ ma.}$$
$$f = 20 \text{ mc}$$

The four necessary RX Meter measurements (one measurement in each of the four jigs) and necessary conversions to rectangular and polar impedance and admittance coordinates are shown in Table IV.

RX Meter readings are the parallel R_p and C_p equivalent of the unknown and can be readily converted to rectangular and polar impedance forms. Readings are converted to rectangular admittance by taking the reciprocal of the RX Meter parallel equivalents expressed in ohms. The reciprocal of R_p is the conductance G and the reciprocal of XC_p in ohms is the susceptance B, where G and B are in ohms.

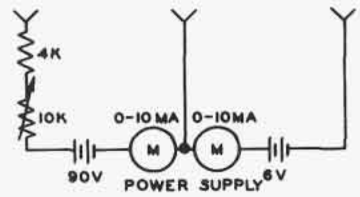


Figure 4. Power Supply Schematic

When converting from the parallel equivalents to the rectangular form of impedance, a series-parallel conversion chart such as is found in the RX Meter Instruction Manual is of help. In working with the data in Table IV, it was convenient to divide the parallel equivalents by 20 to enter them into the chart and to multiply the series equivalent answers by 20 after removing the values from the chart. To use the chart properly, a given combination of R_p and C_p must both be divided by and the answers multiplied by the same number. An ordinary reactance chart was used in converting C_p readings to reactance.

Using jig B of Figure 3 to make the RX Meter measurement necessary to obtain h_{22b}, the input circuit of the transistor is effectively open-circuited circuit, the power supply resistance determines the emitter bias current and bias will be a constant as different transistors are plugged into the jigs. Use of the 90-volt bias battery permits sufficient bias to be developed even with the h_{22b} jig which has a fixed 10k resistor in the emitter circuit.

The socket used in our jigs accommodates the transistor type with four pins mounted on a 0.200-inch diameter circle. However, the jigs can be modified slightly to accommodate sockets for different type transistors, including the new universal transistors sockets.

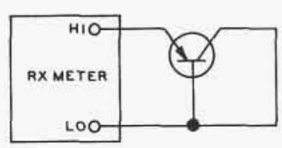
As a special feature, the h_{11e} and h_{11b} jigs utilize Q Meter binding posts in parallel with the RX Meter terminals for use in extending the RX Meter ranges.

A drawing showing construction details of the jigs is being prepared. Interested persons may obtain a copy by calling or writing Boonton Radio Corporation, or one of our representatives.

TABLE III

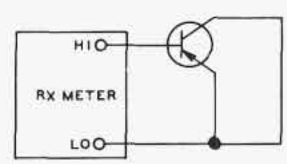
METHOD FOR OBTAINING, COMMON-BASE h PARAMETERS FROM RX METER MEASUREMENTS

Parameter	Formula	Units	Required RX Meter Measurements
h_{11b}	$\frac{(Rp)(XCp)}{Rp + XCp}$	Ohms	Configuration A below
h_{22b}	$\frac{1}{Rp} + \frac{1}{XCp}$	Ohms	Configuration B below
$h_{21b} = -\alpha$	$-\frac{h_{11b}}{h_{11e}} + 1$	Magnitude and phase angle	Configuration A & C below
h_{12b}	$(y_{22b} - h_{22b})\frac{h_{11b}}{-h_{21b}}$	Magnitude and phase angle	Configurations A, B, C, & D below



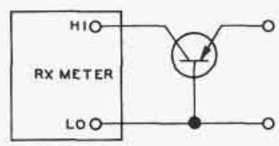
Yields h_{11b} (See formula above)

(A)



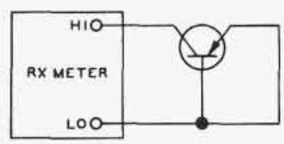
Yields h_{11e} $h_{11e} = \frac{(Rp)(XCp)}{Rp + XCp}$

(C)



Yields h_{22b} (See formula above)

(B)



Yields $y^{22}{}_b$ $y_{22b} = \frac{1}{Rp} + \frac{1}{XCp}$

(D)

with a 10k resistor. To test the effectiveness of this open circuit, 7.5k and 4.7k resistors were substituted for the 10k resistor, while constant emitter bias was maintained, without materially changing the RX Meter's indication of output admittance.

The target of this example is the four common-base h parameters. From Table IV h_{11b} and h_{22b} are directly available in rectangular impedance form.

$$h_{11b} = 65 - j66 \text{ ohms}$$

$$h_{22b} = (0.505 + j1.80) \times 10^{-3} \text{ mhos}$$

From Table III:

$$h_{21b} = -\alpha = -\left(\frac{h_{11b}}{h_{11e}} + 1\right)$$

$$= (1.105 - j.49)\,(10^{-3})\,(1 \angle -8^\circ)$$

$$= (1.21 \times 10^{-3} \angle -24^\circ)\,(1 \angle -8^\circ)$$

$$h_{12b} = 1.21 \times 10^{-3} \angle -32^\circ$$

A summary of the h parameters measured and calculated for the 2N417 transistor are given in Table V.

RX Meter Operating Techniques

In preparation for a measurement, the RX Meter is balanced as usual with a jig attached to the terminals but without a transistor in the socket. The use of the jigs does not in any way interfere with normal operation of the RX Meter.

With normal bridge operating conditions, the voltage appearing at the RX Meter terminals may be 100 to 500 millivolts or more. This is sufficient, in many cases, to drive a transistor beyond its linear range of operation. The terminal voltage, however, may be reduced to 20 millivolts or, in some cases less than 20 millivolts, by reducing the level of the oscillator output with a series resistor in the oscillator+B lead. (See page 16 of the Instruction Manual and Notebook #6[2].) During the measurements to obtain the data presented in Table V, good operation of the RX Meter was obtained at actual measured terminal voltages of 5 to 25 millivolts. The RX Meter measurements did not vary over this voltage range, indicating linear operation of the transistor for this range of signal level.

The Q Meter binding posts on the h_{11e} and h_{11b} jigs provide for easy connection of Type 103-A Inductors and good commercially available capacitors and resistors to extend the RX Meter capacitance, inductance, and resistance ranges. RX Meter range extension is explained in detail in the Instruction Manual and in a previous Notebook article[2].

Application of the *h* Parameters

The maximum power gain for the 2N417 in the common-base configuration can be readily calculated assuming conjugate input and output impedance matching and lossless neutralization[7].

$$\text{P. G.} = \frac{(h_{21b})^2}{4h_{11br}\, h_{22br} - 2\,\text{Re}\,(h_{12b}\, h_{21b})}$$

In this equation, h_{11br} and h_{22br} are real parts of h_{11b} and h_{22b} and Re $(h_{12b}h_{21b})$ is the real part of the product of h_{21b} and h_{21b}. The values from Table V are substituted in the formula for power gain and the necessary calculations are performed.

TABLE IV

CONVERSION OF RX METER MEASUREMENTS TO RECTANGULAR AND POLAR IMPEDANCE AND ADMITTANCE COORDINATES

Jig	RX Meter Readings		Parallel Equivalent		Rectangular Z	Rectangular Y	Polar Z
	Rp (ohms)	Cp ($\mu\mu$f)	Rp (ohms)	Cp (ohms)	ohms	ohms	ohms
C (h_{11e})	168	+ 17.5	168	+ j 454	— 144 — j 52		153 $\angle$ + 200°
A (h_{11b})	130	— 60.7	130	— j 131	65 — j 66		93 $\angle$ —45°
D (y_{22b})	620	+ 9.0	620	+ j 885		1.61 + j 1.13	
B (h_{22b})	1980	+ 14.3	1980	+ j 556		0.505 + j 1.80	

Values of polar coordinates from Table IV are substituted in this equation and the following calculations are performed.

$$-\alpha = -\left(\frac{93 \angle -45^\circ}{153 \angle 200^\circ} + 1\right)$$

$$= -(.61 \angle -245^\circ + 1)$$

$$= -(-.26 - j.56 + 1)$$

$$= -(+.74 - j.56)$$

$$= -(0.93 \angle -37^\circ)$$

$$h_{12b} = -\alpha = 0.93 \angle 143^\circ$$

Again from Table III:

$$h_{12b} = (y_{22b} - h_{22b})\,\frac{h_{11b}}{-h_{21b}}.$$

Inserting values from Table IV, the following calculations are performed.

$$h_{12b} = \Big[(1.61 + j\,1.31) - (.505 + j\,1.80)\Big]\,(10^{-3})\,\frac{93 \angle -45^\circ}{93 \angle -37^\circ}$$

TABLE V

MEASURED AND CALCULATED h PARAMETERS

Parameter	Numerical Value
h_{11b}	65 — j 66 ohms
h_{22b}	(0.505 × j 1.80) + 10^{-3} mhos
h_{21b}	0.93 $\angle$ 143°
h_{12b}	1.21 × 10^{-3} $\angle$ —32°

$$\text{P. G.} = \frac{(.93 \angle 143^\circ)^2}{4 \times 65 \times .505 \times 10^{-3} - 2\,\text{Re}\,(1.21 \times 10^{-3} \angle -31^\circ \times .93 \angle 143^\circ)}$$

$$= \frac{.864 \angle 286^\circ}{131 \times 10^{-3} - 2\,(.403 \times 10^{-3})}$$

$$= \frac{.864 \angle 286^\circ}{131 \times 10^{-3} - .806 \times 10^{-3}}$$

$$= \frac{.864 \angle 286^\circ}{130.194 \times 10^{-3}}$$

$$\text{Power Gain} = 6.62 \angle 286^\circ = 6.62$$

The author wishes to express his appreciation to Mr. D. E. Thomas of the Bell Telephone Laboratories for his valuable assistance in connection with this work.

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THE AUTHOR

George P. McCasland joined the BRC staff as Sales Engineer in January, 1958. From 1954 to 1957 he was associated with the Esso Standard Oil Co., holding posts with Electrical Engineering and Budget Groups of that company's Baton Rouge Refinery.

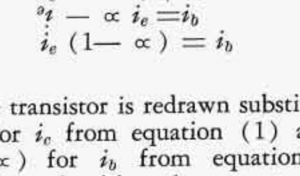
Mr. McCasland received a BEE degree with a Communications Option from the University of Virginia in 1952 and a masters degree in Industrial Management from M.I.T. in 1954.

APPENDIX

Derivation of h_{21} and h_{12} Formulas

h_{21b}

The elementary current relationships of the junction transistor are shown in the following schematic diagram:



where: $i_e = i_c + i_b$ by Kirchhoff's law (1)

$i_c = \propto i_e$ by definition. (2)

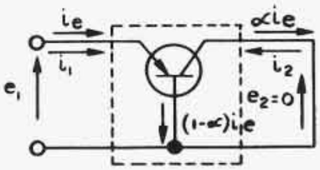
Substituting (2) in (1):

$$i_e = \propto i_e + i_b$$

$$i_e - \propto i_e = i_b$$

$$i_e\,(1 - \propto) = i_b \qquad (3)$$

The transistor is redrawn substituting $\propto i_e$ for i_c from equation (1) and $i_e\,(1 - \propto)$ for i_b from equation (3) and short-circuiting the output circuit in (4). The dotted box symbolizes the network for which network current $i_1 = i_e$ and $i_2 = -\propto i_e$.



(4)

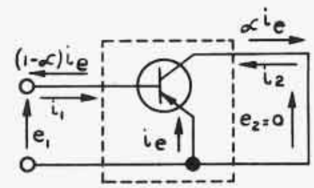
$$h_{11b} = \frac{e_1}{i_1}, \qquad (5)$$

when $e_2 = 0$ by definition.

Substituting i_e for i_1 in (5), since $i_1 = i_e$ from (4)

$$h_{11b} = \frac{e_1}{i_e} \qquad (6)$$

The transistor is now redrawn schematically in the common-emitter configuration.



(7)

where: $i_1 = -i_b = -(1 - \propto)\, i_e$.

Now, by definition, $h_{11e} = \frac{e_1}{i_1}$. when $e_2 = 0$. (8)

Substituting the equality $i_1 = -(1 - \propto)\, i_e$ shown in (7);

$$h_{11e} = \frac{e_1}{-(1 - \propto)\, i_e} \qquad (9)$$

$$h_{11b} = \frac{e_1}{i_e}, \text{ repeating } (6)$$

By examination of (6) and (9), we see that if h_{11e} of (9) is multiplied by $-(1 - \propto)$, the product will be equal to h_{11b} of (6) as expressed in (10) below.

$$h_{11e}\left[-(1 - \propto)\right] = h_{11b} \qquad (10)$$

$$\text{then: } -(1 - \propto) = \frac{h_{11b}}{h_{11e}}$$

$$\propto = \frac{h_{11b}}{h_{11e}} + 1$$

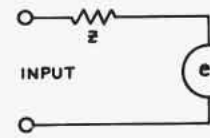
$$h_{21b} = -\propto = -\left(\frac{h_{11b}}{h_{11e}} + 1\right) \qquad (11)$$

h_{12b}

For the transistor network shown below, representing a transistor in the common-base configuration, the reverse voltage transfer ratio by definition is:

$$h_{12b} = \frac{e_1}{e_2}, \text{ when } i_1 = 0. \qquad (12)$$

By Thevenin's Theorem, the input to the network can be represented as shown below.



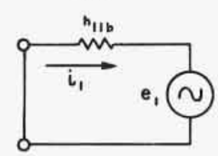
(13)

The open circuit input voltage, e_1, can be assumed to be caused by a voltage generated within the network, which in this case is a voltage transferred back from the output circuit. Z is the short-circuit input impedance, a part of Thevenin's concept. Since h_{11b} is the short-circuit input impedance of (13), it can be substituted for Z. The input can then be short-circuited and the result shown in (15), where:

$$e_1 = h_{11b} i_1$$

and

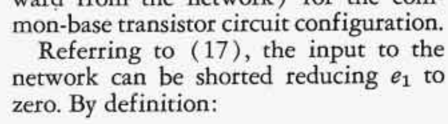
$$\frac{e_1}{h_{11b}} = i_1. \qquad (14)$$



(15)

Now the transistor is drawn as a network, (17), and by definition:

$$h_{22b} = -\frac{i_2}{e_2}, \text{ where } i_1 = 0 \qquad (16)$$



(17)

The negative sign in (16) stems from network convention, where i_2 is shown flowing toward the network but actually flows in the opposite direction (outward from the network) for the common-base transistor circuit configuration.

Referring to (17), the input to the network can be shorted reducing e_1 to zero. By definition:

$$y_{22b} = -\frac{i_2}{e_2}, \text{ when } e_1 = 0. \qquad (18)$$

In equation (18), y_{22b} is one of the admittance family of parameters. If the open-circuited output admittance, h_{22b}, is subtracted from the short-circuited output admittance y_{22b}, the resultant output circuit admittance is that due to the current flowing in the short-circuited input circuit, or in other words, to the short-circuit input admittance. This relationship is shown in (19), where:

$$y_{22b} - h_{22b} = -\frac{i_2}{e_2} =$$

short-circuited input admittance appearing in the output (19)

$$\text{Now: } h_{21b} = -\alpha = \frac{i_2}{i_1}$$

and

$$h_{21b}\, i_1 = i_2. \qquad (20)$$

Substituting (20) in (19):

$$y_{22b} - h_{22b} = \frac{-h_{21b} i_1}{e_2} \qquad (21)$$

$$i_1 = \frac{e_1}{h_{11b}} \text{ as shown in} \qquad (15)$$

Substituting (15) in (21):

$$y_{22b} - h_{22b} = -\frac{h_{21b} e_1}{h_{11b} e_2} \qquad (22)$$

and

$$(y_{22b} - h_{22b}) = \frac{h_{11b}}{-h_{21b}} = \frac{e_1}{e_2} \qquad (23)$$

Equation (23) is true for the case when i_1 flows and e_1 is the generated feedback voltage which does not appear at the input terminals for the short-circuited case.

In measuring h parameters it is assumed that all measurements are performed at signal levels for which the transistor is a linear network.

If the short-circuit of (14) is removed, e_1 will appear across the input terminals and at the same time i_1 will go to zero. Therefore, equation (23) holds when i_1 is zero as well as when i_1 is flowing.

$$(y_{22b} - h_{22b}) \frac{h_{11b}}{-h_{21b}} = \frac{e_1}{e_2} = h_{12b},$$

when i_1 is zero.

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HARRY J. LANG, ***Sales Manager***

Founded by Earl Lipscomb in 1947, Earl Lipscomb Associates of Dallas, Texas, is the only engineering sales representative organization in the Southwest specializing exclusively in the field of electrical and electronic instrumentation. The company maintains offices in Dallas, Houston, and El Paso, and offers complete technical service to customers in Texas, Oklahoma, Arkansas, Louisiana, and Mississippi.

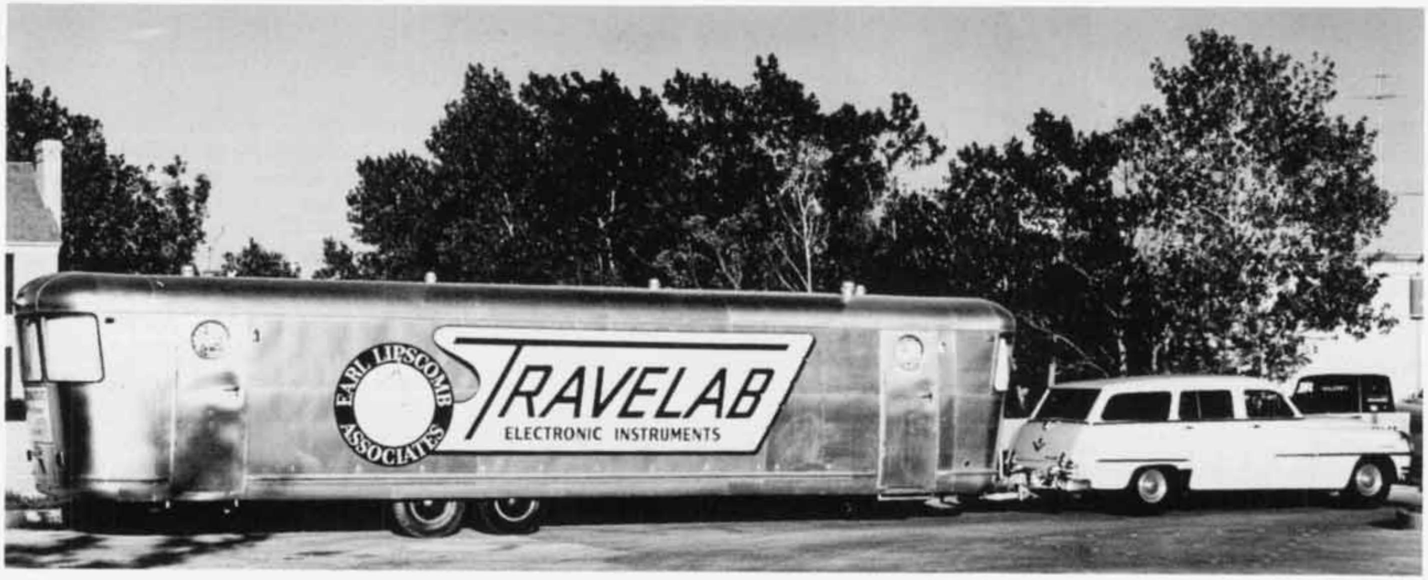
Radio and electronics are not new to Earl Lipscomb, the company's President; he has been active in the field since 1937 when he began as a consulting engineer. During World War II, he served in the training, production, and procurement phases of the Navy's electronic program. His five-year tour of duty included training at the Navy Radar School at M.I.T., and service with Navy Bureau of Personnel and the Navy Materiel Division. Upon completion of Navy service in 1947, he founded Earl Lipscomb Associates. In May of that year, Boonton Radio Corporation, recognizing the growing need for electronic instrumentation by customers throughout the Southwest, was one of the first companies to engage the services of the newly formed organization.

Earl Lipscomb

As the needs of the electronics industry expanded, so did the facilities and services of Earl Lipscomb Associates. The modern building, which houses the Dallas headquarters, comprises over 10,000 square feet of office and shop space and includes a complete clerical staff engaged in the distribution of technical information and processing of customer orders. Modern, well-equipped service laboratories at the Dallas and Houston locations provide calibration and repair service for all of the products manufactured by thirteen leading producers of precision electronic equipment. These facilities are staffed by six factory-trained service engineers.

A special group of five sales engineers, with specialized training in electronic measuring techniques, and two engineering trainees devote their entire effort to the solution of customer problems. This group is equipped to provide demonstrations of all equipment in the customer's laboratory; having at its disposal a unique "laboratory on wheels" known as the "Travelab". This mobile laboratory, which travels regularly throughout the Southwest, is completely equipped to provide operating demonstrations and serves to keep the customers abreast of the latest in instrument design and application.

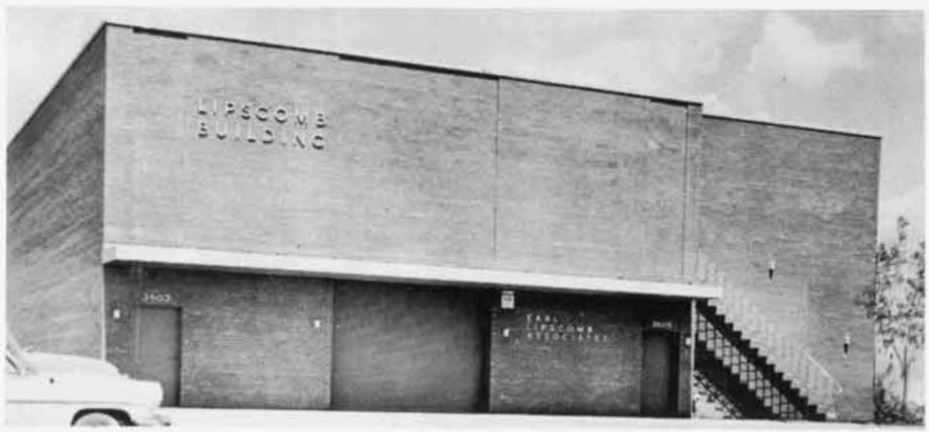
It is the objective of Earl Lipscomb Associates to not only provide the customer with the proper instrumentation for his specific needs, but also to insure that these products continue to provide reliable service. For their constant effort toward this end, and for their record of efficient and faithful service to our customers, BRC extends a vote of thanks to Earl Lipscomb Associates.



The "Travelab", carries a full line of instruments to the customers' laboratory or plant.

MODIFICATION OF TYPE 202-F SIGNAL GENERATOR

In order to provide equipment which is compatible with the recent extension of the telemetering band to 260 megacycles, BRC announces the availability of a modified version of the 202-F Signal Generator, on special order, with an overall frequency coverage of 195 to 270 megacycles. BRC will also modify existing 202-F Signal Generators currently in the field. Please call or write your sales representative or Boonton Radio for full particulars.



Dallas headquarters of Earl Lipscomb Associates

GENE FRENCH COMPANY

APPOINTED SALES REPRESENTATIVE

We are pleased to announce that, effective July 1, the Gene French Company has been appointed BRC sales representative in the New Mexico, Utah, and Colorado area. The company maintains offices in Albuquerque and Denver and is fully equipped to handle sales, application engineering, and service for all BRC products.

"Gene", who has previously handled BRC instruments in New Mexico, is handling that area. "Hugh" Hilleary is heading the new Denver office. Please do not hesitate to call upon them for information or demonstrations.

Gene French

Hugh Hilleary

EDITOR'S NOTE

Amateur radio has given thrills and pleasures to countless thousands of persons the world over. Few people realize, however, that this favorite pastime is almost as old as the art itself. There were radio amateurs before the beginning of the present century; not too long, in fact, after Marconi astounded the world with his invention of wireless telegraphy. But amateur radio came into its own when private citizens discovered this means of personal communication with others and set about learning enough about "wireless" to build homemade stations. Its progress since those early days has been remarkable. In the first years, amateurs were stuck with 200 meters and could barely get out of their backyards. Today, with years of experimentation under the amateur belt, international DX is a reality and QSOs with countries all over the world are commonplace.

Personal communications between HAMS is only part of the amateur radio story. These "home stations" have posted a brilliant record of public service. Amateur cooperation has played an important part in the success of many an expedition and, in many cases, has been the only means of outside communication during several hundred storm, flood, and earthquake emergencies in this country. These public service endeavors were so successful in fact, that in 1938 the American Radio Relay League (ARRL) inaugurated a new emergency-preparedness program, registering personnel and equipment in its Emergency Corps and putting into effect a comprehensive program of cooperation with the Red Cross.

The HAM and amateur radio is constantly in the forefront of technical progress too. Amateur radio developments have come to represent valuable contributions to the art. During World War II, thousands of skilled amateurs helped to develop secret radio equipment for both Government and private laboratories. In the prewar years, technical progress by amateurs provided the keystone for the development of modern military communications equipment.

Modern radio owes a lot to these indefatigable amateurs for their contributions to the art. We are proud to number among their lot eight of BRC's employees.

L. O. Cook	ex - 8BRU
V. E. Hopler	K2LTH
G. A. Sanford	K2ARW
N. L. Riemenschneider	W2LKO
G. P. McCasland	K2RLK
N. L. Greendyk	ex - W2KSR
D. M. Terp	KN2JTN
J. P. Van Duyne	W2MLX

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