SPECIAL PRODUCTS DIVISION

Signalite

Has over 100 different types of microwave gas discharge

100

NOISE SOURCES AND MINIATURE NOISE GENERATORS

currently available for use in noise figure test equipment and for monitoring system receiver sensitivities.

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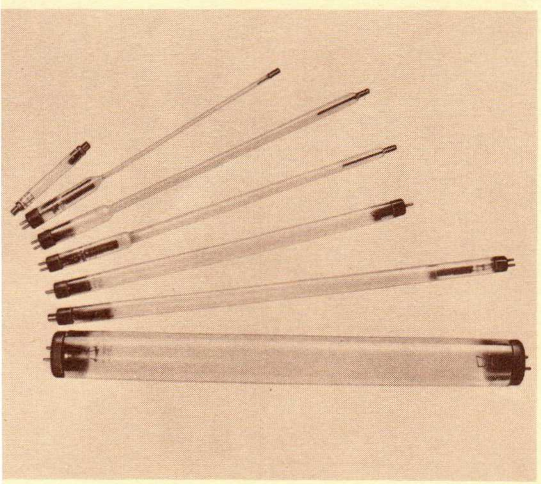
1.0 INTRODUCTION

This "100" brochure is a summary of the history, fundamentals, characteristics and application information on gas discharge noise sources generated over the past ten years by the engineering group which is presently at Signalite and which was formerly at Bendix Red Bank Division.

The Signalite gas discharge noise source is the element in a microwave or rf system which makes possible accurate measurements of the noise figure of the receiver or its components. The requirements of a device used for making such noise figure measurements include broad bandwidth inherent in the active element, stability, ease of operation and long life. When the gas discharge noise source is mounted and terminated normally it presents a "white signal" of constant intensity over a bandwidth limited only by the system or mount. In general, the range of usefulness of these noise sources permits measurements of noise figures from about 2 to 30 db. Existing mountings provide a useful frequency range of approximately 100 Mc to 100 Gc.

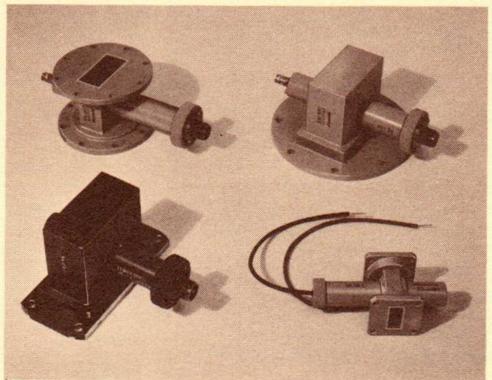


DEFINITIONS

NOISE SOURCE:

An electron tube filled with a rare gas, generally argon or neon, and normally operated in a positive column mode at currents from 50 to 250mA.

There are also noise sources which contain mixtures of argon and mercury.



NOISE GENERATOR:

A noise source mounted in an appropriate waveguide or coaxial mount.

The noise source and/or the noise generator should meet the following general requirements:

a) When not operating, it should present a low insertion loss and VSWR to the system.

b) When operating, it should provide an adequate signal level.

c) Its output should be frequency independent.

d) Its output should exhibit minimum spurious oscillations.

Lists of available noise sources and noise generators are given in Appendices I & II.

2.0 HISTORY

A brief history of noise source measurements is appropriate at this time.

From Mumford's original work in 1949[1] to about 1952[2]-[7] the predominant effort was on the understanding of the basic gas discharge phenomena and on some preliminary attempts to make absolute measurements based on the use of modified Dicke[8] radiometers. The accuracy of these measurements probably was of the order of .5 to 1 db. Since the agreement with existing theory [9, 10] appeared to be within the error of measurement, no significant attempt was made to improve the accuracy. From about 1953 to 1962, additional measurements [11]-[18] were made on various tubes at differing frequencies and at varied tube currents. When all of these measurements were reduced to a common set of conditions, the net result and the existing theory all agreed within a spread of ±.5 db for argon S-band tubes. An average value of 15.2 db was used until about 1959 for all argon tubes.

In 1959, values appropriate to the variety of diameters and pressures were published and included in our specifications. It was acknowledged that the absolute center value was still in doubt. However, the accuracy of comparison measurements was sufficient that industrial users and the government services accepted the values and tolerances quoted, since all tubes in the field were referenced back against the results, from 1955, on one S-band tube averaged over all absolute measurements available at the time.

The measurement setups presently at Signalite for making excess noise ratio, insertion loss and VSWR measurements were initiated in 1954. After approximately 5 years of constant revision and improvement the equipment was sufficiently refined so that noise measurements could be reproduced to ±.02 db over a short time. About 1959, the equipment was essentially resolved in its final, present, form and the new values of excess released.

In January of 1962 NBS Boulder[19] completed the first phase, X-band, of a program of making accurate radiometer hot body load noise measurements. This program had been started in late 1955 and is continuing.[20]-[22] An important feature of this program was that the excess noise ratio determined by NBS on a noise generator that we had first measured agreed within .03 db of the value of excess noise ratio which we had been using for the previous three years. That is, the numbers which had been used at X-band, based on historical measurements, were almost unchanged after the NBS measurements had been finalized. These NBS measurements were generally one order of magnitude better in tolerances than any previous absolute measurement. A Ku-band service is now available at NBS also.

3.0 BASIC DISCUSSION

A gas discharge noise source is basically a fundamental device which provides a stable source of purely random white noise covering the entire rf and microwave spectrum.

3.1 NOISE POWER:

The available noise power from a gas discharge noise source is essentially kT_eB power coupled to the guide from the positive column of the discharge. T_e is determined as follows: In the positive column of an argon gas discharge at appropriate operating currents and pressures ambipolar diffusion predominates. In the same current and pressure ranges, the ratio of electron mean free path to tube radius, λ_e/R, is such that the effective electron temperature, T_e, can be approximated by the method of von Engel and Steenbeck.[9,10] In microwave power measurements consideration is given to the noise temperature, T_n, which when multiplied by k gives the power per unit bandwidth of a noise generator. As derived by Parzen and Goldstein[2] and measured by Easley and Mumford[3] and Collings[16], T_n for a normal gas discharge noise source is nearly equal to T_e.

3.2 EXCESS NOISE RATIO:

The important characteristic in microwave measurements is the ratio of the difference between operating and non-operating temperatures to the non-operating temperature; namely the ratio : $\frac{T_e - 290}{290}$. When expressed in db, this number is called the Excess Noise Ratio:

$$(N_r - 1) = 10 \log \left(\frac{T_e}{290} - 1\right)$$

At the usual pressures and operating currents, $(N_r - 1)$ for argon is approximately 15.5 db and for neon is approximately 18.0 db. The exact value for any noise source is influenced by the tube radius and pressure, and to some degree by current.

4.0 DISCUSSION OF CALIBRATIONS

4.1 CALIBRATION SERVICES:

The NBS calibration service is set up to calibrate a complete noise generator; that is, they calibrate the tube rigidly held in its own properly terminated mount. Under these conditions and with the accuracy of their system, they presently report results of ±.1 db.

Signalite is providing calibrations of noise sources and noise generators with measurement tolerances of as close as ±.07 to .09 db, despite the doubt in the absolute center value of as much as ±.1 db. Obviously the absolute accuracy of such calibrations, with a tolerance better than that which NBS can supply, is unrealistic until specific note is taken of the fact that the absolute center value has a margin of error above the comparison tolerance stamped on the tube or generator. With this fact accepted, Signalite will continue to provide a calibration service with the measurement tolerances stamped on the tube or generator; however, on the certification sheet which accompanies each calibrated unit specific mention will be made of the tolerances reported by NBS on the absolute center value of our in-house units measured by them. A sample certification sheet is included as Appendix III.

4.2 TRANSITIONS AMONG BANDS:

The transition measurements from one band to another are based on the fact that the noise power per unit bandwidth coupled into waveguide from the positive column of the discharge is frequency independent. Then the actual transition from one band to another is made in the following manner: Tubes are constructed of a proper length and with appropriate connectors for the longer of the two mounts to be used and of a diameter appropriate for the smaller of the two mounts. The excess noise ratio is measured at the band in which we have known information, namely X-band or Ku-band, and the insertion loss of the operating tube in the mount also is measured in the known band. Using the insertion loss correction, $\frac{L}{L-1}$ [23], the excess noise ratio of the tube alone is computed.

The tube then is inserted in the mount appropriate for the band at which information is desired, the operating insertion loss is measured, and the excess noise ratio of tube-in-mount is computed. At this time, tubes of the length and diameter appropriate for the band in question are calibrated against the transition noise generator.

In all cases, it is established first that the cold and hot VSWR of tube-and-mount are less than 1.10 and generally less than 1.05 so that corrections for mismatch are negligible. Further, all tubes are grommeted in position in the various mounts to insure centering and correct positioning along the axis of the mount shaft.

Using the above procedure, and based on an S-band tube-in-mount at 250 mAdc with an excess noise ratio determined from the results compiled in 1955, we had established the value of a particular X-band noise generator at 200 mAdc as 15.64 db in 1962. The NBS report on an equivalent X-band noise generator with tube current at 200 mAdc was 15.61 ±.1 db.

All presently quoted numbers are based on NBS reports at X-band or Ku-band with transitions to other bands accomplished as described in the previous paragraphs.

5.0 METHODS OF OPERATION

5.1 Exisiting noise sources generally fall in one of the three following classes of operation:

5.1.1 DC with filamentary cathode: The DC supply of Figure 1 is fed to the tube through an inductance, L_1, and current limiting resistances, R_1 and R_2. Upon closing the starting switch, SW_1, current flows through the inductance, resistance R_2 and the tube cathode all in series. When the switch is opened, the collapse of the magnetic field in L_1 provides a high voltage spike which ionizes the gas in the tube and establishes the discharge from anode to cathode. The current is then limited by R_1 to the rated value. SW_1 must be capable of fast break operation and of withstanding the high peak voltage developed.

5.1.2 Pulse operation wtih cathodes which exhibit long life under millions of starts: The circuit of Figure 2 provides an electronic method of providing the starting spike and is applicable where switch characteristics or switch life is a problem. The pentode or beam tube acts like the switch of Figure 1, interrupting the current flow in L_1 when the cut-off bias switch is closed. The resultant voltage spike developed is impressed across the noise source. The current is limited by R_3 to rated value. Capacitor C_1 flattens the pulse peak and assists in initiating the discharge. C_1 must not be large enough to lower the voltage spike below the firing voltage of the tube and must be of a high voltage rating. Current through the beam tube is adjusted by R_4 to provide rated choke current.

This circuit can also be modified to drive the grid of the switch tube with pulses, thus pulsing the noise output. For high repetition rates or for control of pulse shape, modifications to the circuit, such as shown in Figure 3, are necessary to insure extinguishing of the noise tube current.

5.1.3 AC with filamentary cathodes: When operation directly from an AC source is desired and AC modulation of the noise is not objectionable, the circuit of Figure 4 is suitable. Transformer T_1 must provide a voltage high enough to strike the discharge. L_1 may be included in the transformer as leakage reactance but should be of a size to limit the average tube current to the specified value. SW_1 can be eliminated if the secondary voltage of T_1 is made high enough to provide a cold start without filament preheat.

Operation of a single ended tube in this circuit will result in excessive anode heating with probable failure of the anode seal.

5.2 Characteristics of the above methods of operation are as follows:

5.2.1 Tubes utilizing DC power with filamentary cathodes generally require from 700 to 2500 V starting spikes, operate at currents from 100 to 250 mAdc and exhibit operating tube drops of the order of 40 to 150 Vdc. Their life under conditions of essentially continuous operation, with only occasional starts, is generally in excess of 10,000 hours and may be as high as 50,000 hours. Their life under pulse conditions, without careful circuit design to prevent large negative spikes following the starting spike, generally is short.

5.2.2 Tubes designed principally for pulse operation usually require starting spikes in the order of 700 to 3000 V, operate at peak currents from 75

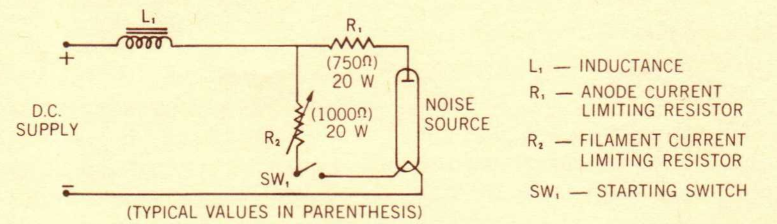


Figure 1 Typical starting circuit for DC-operated tubes

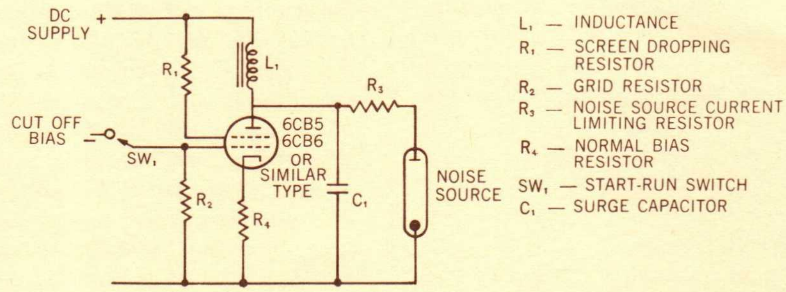


Figure 2 Alternate starting circuit capable of being pulsed

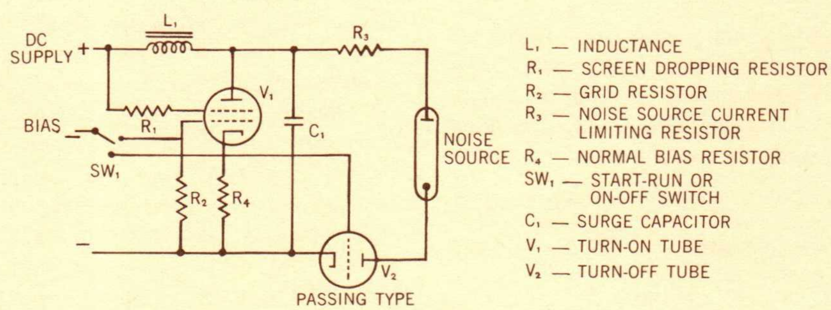


Figure 3 Typical driving circuit for pulse-operated tubes

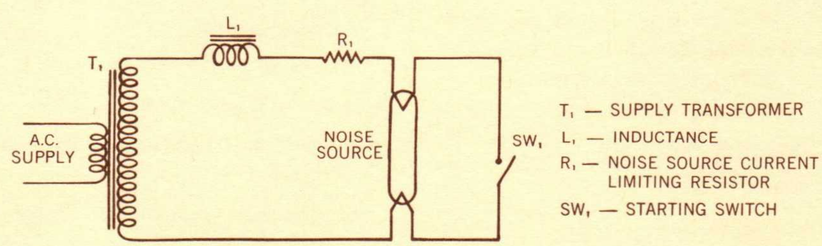


Figure 4 Typical AC-operation circuit

to 175 ma, and have tube drops from 100 to 250 V. Under pulse conditions with duty cycles up to 50%, their life is typically 2000-5000 hours.

In general, under intermittent DC conditions, they have adequate life of at least 1000 hours.

5.2.3 AC tubes operated under nominal 60 to 400 cps sine wave conditions generally require starting voltages of the order of 1000 to 2500 Vac, operate at currents from 100 to 250 mAac and exhibit tube drops of the order of 40 to 150 Vac. Typical life under 60 cps conditions is at least 1000 hours, again depending on circuit parameters.

5.3 IONIZATION TIME:

Because of the presence of the rare gas, there is a finite time required for the discharge to become stable in any gas discharge noise source. In argon filled tubes, the discharge will normally become stable in from 20 to 80 μs after the completion of the starting spike. These times may be modified drastically by the circuit however. If there is appreciable ringing in the circuit, or if the supply voltage is relatively close to the tube operating voltage at the rated current, the time for a tube to establish a stable discharge may be much longer. For neon these times are of the order of 40 to 150 μs, and for argon-mercury, about 70 to 300 μs. In general, by proper circuit design, these indicated times can be attained for any of the types of operation mentioned above.

5.4 DEIONIZATION TIME:

Again because of the presence of the rare gases, these tubes have finite deionization times. In argon at 200 mA plate current and at 20 mm pressure, the deionization times are of the order of 70 to 300 μs, depending on tube diameter. In neon at the same current and pressure, deionization times are normally from 150 to 500 μs, and in argon-mercury, from 300 to 800 μs. These deionization times can be improved by the application of a slight negative voltage when the tube is being turned off, in a pulse application for example. The deionization times generally increase with current.

6.0 MICROWAVE CHARACTERISTICS

6.1 GENERAL CONSIDERATIONS:

The level of the excess noise ratio which can be attained from any noise generator is determined by the coupling of the noise source in the mount and by the available excess noise ratio from the noise source itself. The available excess noise ratio from the noise source is determined principally by the type of gas and the pressure and, to some small extent, by the tube current. The coupling in the mount is determined mainly by the insertion angle of the tube-in-mount and by the type of gas fill. The coupling also is affected by the gas pressure and the tube current. The user has control in general only over the tube current. The mounting is so important that the success with which any combination of noise source, mount and termination meet the requirements at the end of Section 1.0 depends as much on the mounting method as on any other single feature.

6.2 MOUNTING METHODS:

The most common mounting methods and their relative advantages and disadvantages include:

a) 10° to 30° E-plane Insertion; Advantages: extremely broadband (within the tolerances of the excess noise ratio specified for tube-and-mount this style of mounting yields a frequency independent noise generator), very low VSWR, very low non-operating insertion loss, high operating insertion loss (therefore, very little reduction in the available excess noise ratio from the noise source itself); Disadvantages: relatively large size, high voltage starting spike, and relatively high tube drop.

b) 90° E-plane Insertion, Transmission Type; Advantages: fair VSWR, very small size, low voltage starting spike, low tube drop, and low nonoperating insertion loss; Disadvantages: low operating insertion loss (therefore, appreciable reduction in the available excess noise ratio), relatively narrow bandwidth (approximately 10 to 20%).

c) 90° E-plane Insertion, Shorted Type; Advantages: small size, low voltage starting spike, low tube drop and low non-operating insertion loss; Disadvantages: poor VSWR, very narrow bandwidth (the order of 5 to 10%).

d) 90° H-plane Insertion, Transmission Type; Advantages: low non-operating insertion loss, fairly small size, good non-operating VSWR, moderate voltage starting spike and tube drop; Disadvantages: poor operating VSWR, low operating insertion loss (with resultant reduction in available excess noise ratio), and very narrow bandwidth.

e) Coaxial, Helix Coupled; Advantages: permits use of the noise sources originally designed for waveguide bands down into the UHF region, relatively broadband, good operating insertion loss, relatively good operating VSWR, good non-operating insertion loss and VSWR in the prescribed bands; Disadvantages: relatively large, size, high voltage starting spike and relatively high tube drop.

6.3 COMPARATIVE NOISE MEASUREMENTS:

Comparative measurements are made in systems such as that in Figure 5. Since they depend only on the stability of the gain set, and this stability can be checked by visual observation of the output meter over a period of time long compared with the measurement time, the tolerances to which Signalite excess noise ratio specifications are written are at least ten times wider than the system accuracy.

6.4 VARIATIONS WITH TUBE CURRENT:

As has been mentioned earlier, the existing theory does not show any current dependence of excess noise ratio. Since a change in current causes a slight change in tube drop, and thereby a slight change in the field in the positive column, there is a small correction to the excess noise ratio of a tube as a result of actual change in effective electron temperature. Further, there is an additional small change to the available excess noise ratio from tube-in-mount as a result of a changing insertion loss caused by the change in current. Finally the hot insertion loss varies significantly with current.

6.4.1 NOISE VS. CURRENT:

In the past the general statement had been an approximate change in (Nr-1) of –.003 to –.005 db/mA. To provide the user with more accurate information, the curves of Figures 6 to 10 present actual data of the change in excess noise ratio as a function of tube current for representative types, both argon and neon. The data are presented for current values both higher and lower than the respective rated tube currents for the purpose of showing the user the detailed variation around the rated currents. The presentation of the data at higher than rated currents does not imply recommended operation at these currents. Since these noise sources are extremely reproducible[17] the user may consider these curves as true indications of the performance of any particular tube.

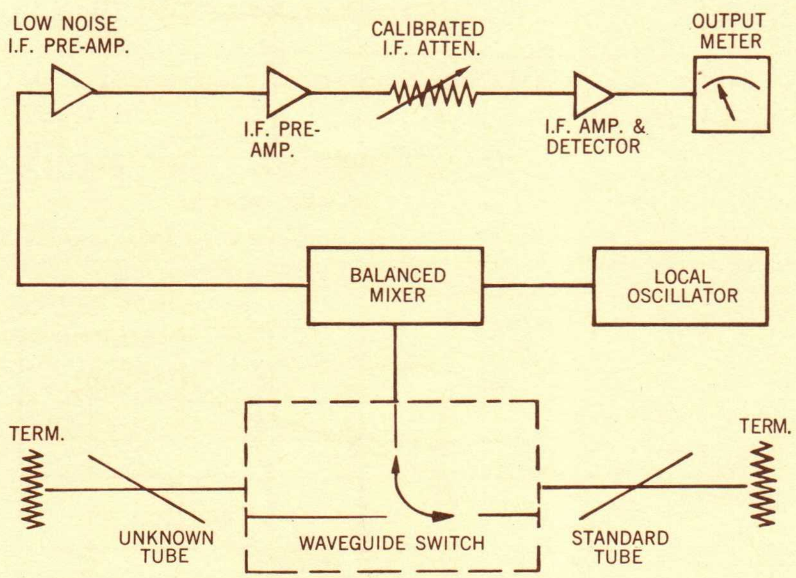


Figure 5 **Schematic diagram of set-up for measuring noise ratio.**

6.4.2 TUBE DROP VS. CURRENT:

The variation in tube drop with current for representative types is provided in Figures 11 to 15.

6.4.3 INSERTION LOSS VS. CURRENT:

Nominal values of operating and non-operating insertion loss for argon noise sources in specific waveguides are given in Table I below. The tube to tube variation for hot loss values less than 20 db is ±.2 –.5 db, for hot loss values from 20-30 db is ±.4 –1.0 db, and for hot loss values greater than 30 db is ±1 -3 db.

TABLE I: COLD AND HOT INSERTION LOSS FOR ARGON NOISE SOURCES

Band	Type	Mount and Meas't. Freq. (Gc)	Typical Insertion Loss (db)						
			Ib = 0	125	150	175	200	250	300mAdc
S	TD-12 -38	WR-284, 10°E; 3.3	.12	13.0	13.5	14.2	15.4	16.0	17.1
C	TD-10 -39	WR-187, 10°E; 5.5	.11		16.0		18.0	19.5	
J	TD-10 -39	WR-137, 10°E; 7.0	.16		19.0		23.0	25.5	
X	TD-40	WR-90, 10°E; 9.0	.18		20.8	22.8	24.4		
X	TD-11 -72	WR-90, 10°E; 9.0	.06	23.5	25.5	27.6	29.7	34	
Ku	TD-18 -41	WR-62, 10°E; 16.0	.07	26.5	31	35	40	51	
K	TD-13 -42	WR-42, 10°E; 24.0	.10	26.0	32	37	44	57	

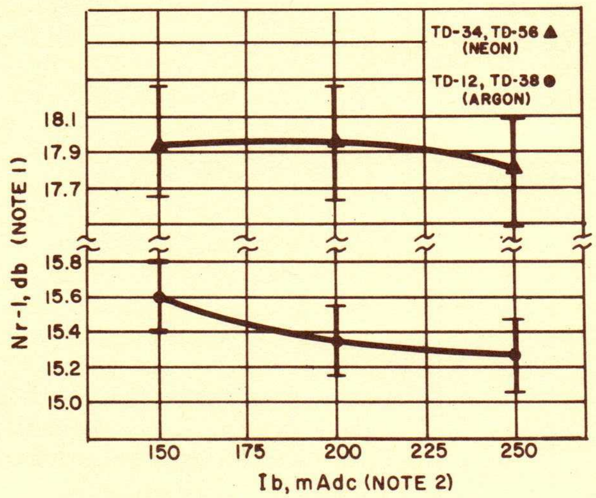


Figure 6 Noise vs. tube current for S-band noise sources

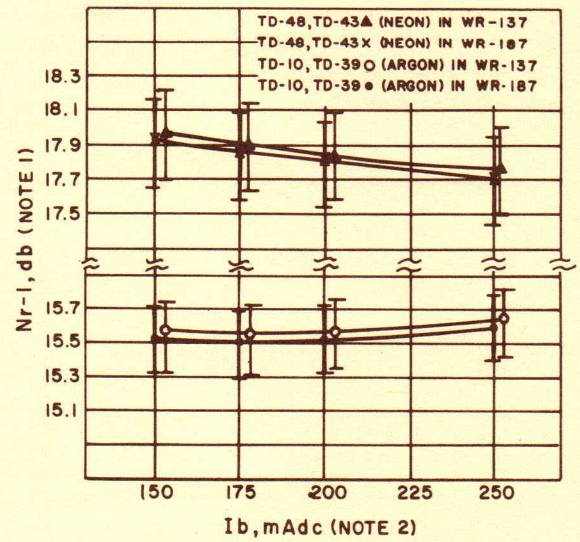


Figure 7 Noise vs. tube current for C- and J-band noise sources

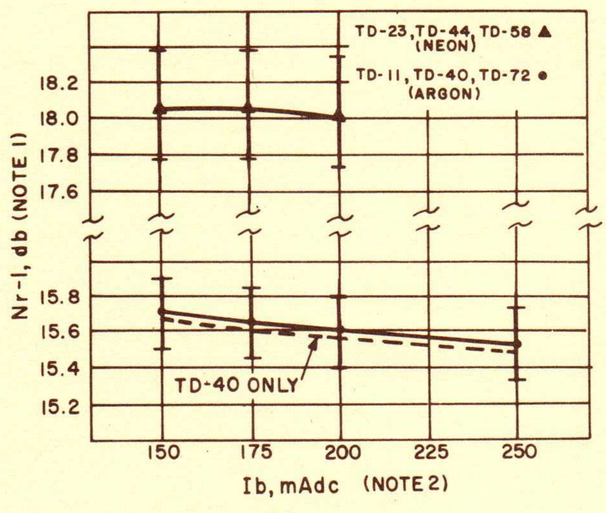


Figure 8 Noise vs. tube current for X-band noise sources

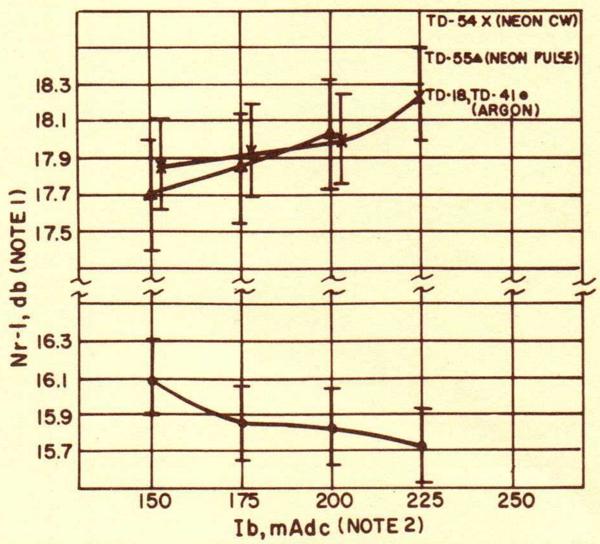


Figure 9 Noise vs. tube current for Ku-band noise sources

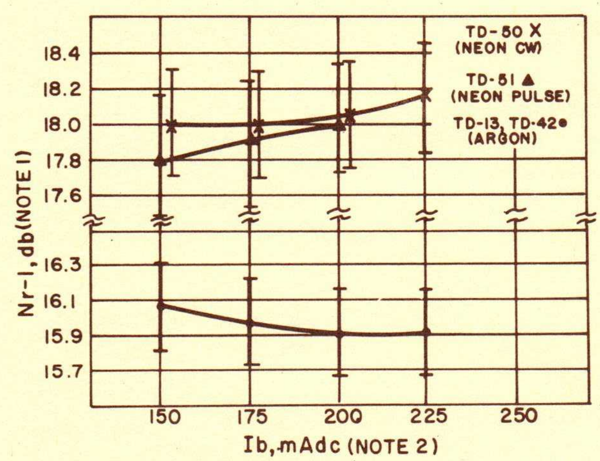


Figure 10 Noise vs. tube current for K-band noise sources

NOTES:

1. Center values are appropriate for both the CW and pulse types. Tolerances are shown for CW types only. For tolerances on pulse types, see individual tube data sheets.

2. Presentation of data at currents higher than the rated currents does not imply recommended use at these currents but is provided only for customer information.

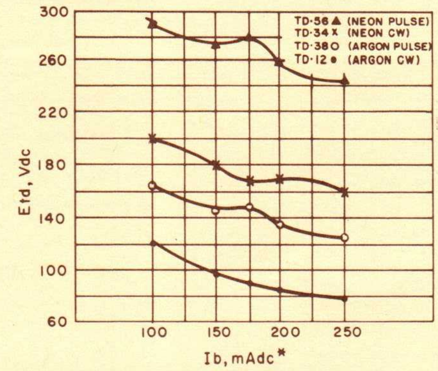


Figure 11 Tube drop vs. tube current for S-band noise sources

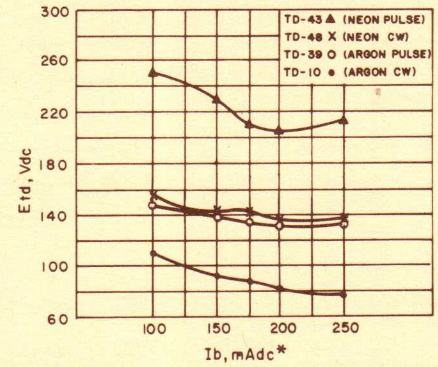


Figure 12 Tube drop vs. tube current for C- and J-band noise sources

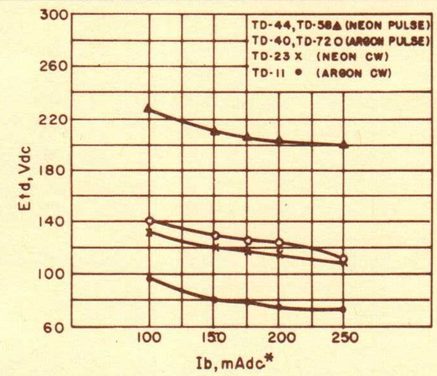


Figure 13 Tube drop vs. tube current for X-band noise sources

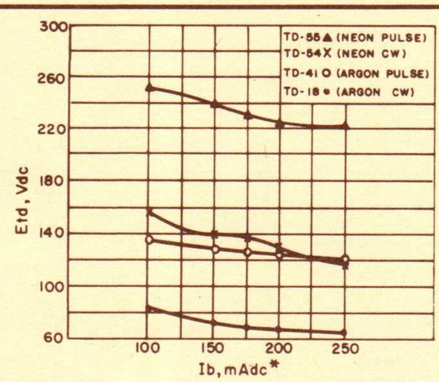


Figure 14 Tube drop vs. tube current for Ku-band noise sources

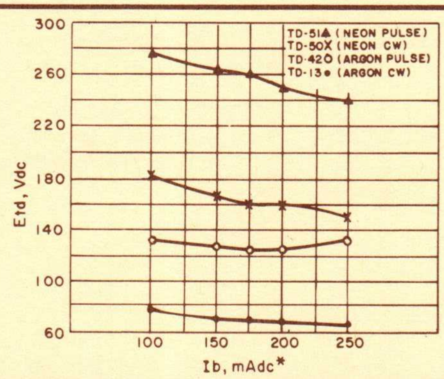


Figure 15 Tube drop vs. tube current for K-band noise sources

* Presentation of data at currents higher than the rated currents does not imply recommended use at these currents but is provided only for customer information.

7.0 GENERAL OPERATING NOTES

7.1 Since all noise sources are polarized devices, except those specifically designated for ac operation, they should never be operated in reverse. Under conditions of reverse operation the life will be extremely short with failure due to anode seal breakage as the result of excess heating.

7.2 All rare gas filled noise sources can be operated over a temperature range of $-55°$ to $+125°C$. Some noise generators cannot be operated over this range because built-in shorting plates or terminations may present temperature dependent characteristics.

There is a definite temperature correction necessary for fluorescent tubes which contain mercury; this correction is on the average $-.055$ db/°C.[24] Because of this last mentioned variation with tempertaure, because of the comparative wide spread of excess noise ratio within a group[3],[5],[24] and because of the relative instability with time[1],[3],[5] Signalite manufacturers no mercury noise sources. By contrast the argon noise sources are temperature independent, extremely reproducible[17], and time independent.

7.3 In general noise sources are satisfactory under vibration and shock, with the smaller tubes being the best. Since there exists such a large variety of sizes and shapes, the user should determine the vibration and shock ratings of the individual unit he is planning to use.

8.0 LIST OF APPENDICES

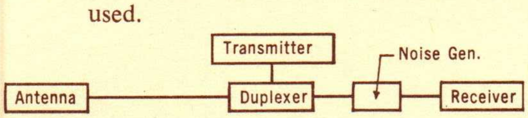
9.0 APPLICATIONS

9.1 The basic use of noise sources is the DETERMINATION OF THE NOISE FIGURE of a component or system. This determination stems from the relation: (F) = (Nr − 1) − (Y − 1)(23) Where (F) is the system noise figure, (Nr− 1) is the excess noise ratio of the noise generator, (Y) is the output meter reading, $Y = \text{antilog}\,\frac{(Y)}{10}$, and the parenthical terms in the relation are in db.

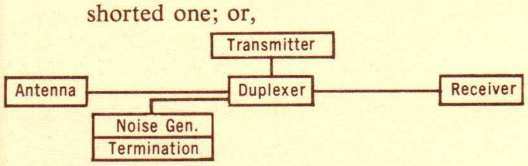
9.2 Noise sources are the basic component of NOISE FIGURE TEST SETS. Commercial models exist which are complete with the noise source and mount, the driver supply (either modulated or DC), IF, video and output, so that all this is necessary to obtain noise figure is to connect the device in question to the test set and read the answer.

9.3 Noise generators frequently are used as BUILT-IN RECEIVER MONITORS directly in a radar system.

9.3.1 Directly in the RECEIVER ARM between the receiver and duplexer in which case a transmission mount is used.



9.3.2 The generator can be mounted in the ANTENNA ARM via a switch or directional component, in which case the generator is a terminated or shorted one; or,



9.3.3 In general, because the discharge can be initiated by sufficiently high levels of RF power, the method of 9.3.1 is used for high power systems, and the method of 9.3.2. is used for low or medium power systems.

10.0 REFERENCES:

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APPENDIX I
SIGNALITE-GAS NOISE SOURCE TUBES

Freq. Range, Gc	Band	Wave-guide	Signalite/ EIA Type Numbers	Outline (Note 1)	Mount Type	Recm'd. Mode of Operation (Note 2)	Maximum Starting Voltage Spike, KV	Anode Current, mAdc (Note 3)	Tube Drop, Vdc (Note 3)	Tube-in-Mount Excess Noise Ratio, db (Note 3, 4)
1.12 to 1.70	L	WR-650	TD-21/6881	1	90°H	D.C.	4.0	250	65	15.2**
			TD-62/7992	1	90°H	D.C.	4.5	250	(145)	18.0**
			TD-33/7147	1a	90°H	A.C., D.C.	4.0	250	75	15.2**
			TD-29/7101	1a	90°H	A.C., D.C.	4.5	250	130	18.0**
			TD-49	1	90°H	PULSE*	4.0	200	125	15.2**
			TD-75	1	90°H	PULSE*	4.5	200	235	18.0**
			TD-91	S	10°E	D.C.	7.0	250	230	15.2**
2.60 to 3.95	S	WR-284	TD-12/6358	2	10°E	D.C.	2.7	250	80	15.30
			TD-34/7148	2	10°E	D.C.	2.7	250	165	17.80
			TD-31	2a	10°E	A.C., D.C.	2.7	250	85	15.30
			TD-32	2a	10°E	A.C., D.C.	2.7	250	170	17.80
			TD-22/6782	S	90°H	A.C., D.C.	2.5	250	45	8.85
			TD-38/8151	2	10°E	PULSE*	3.3	200	145	15.35
			TD-56/8286	2	10°E	PULSE*	3.5	200	265	17.90
			TD-82	S	90°E	D.C.	0.9	75	55	18.50
3.30 to 4.90	S	WR-229	TD-24	S	10°E	A.C., D.C.	2.5	250	65	15.30
			TD-30	S	10°E	A.C., D.C.	2.5	250	110	17.80
3.95 to 5.85	C(G)	WR-187	TD-10/6356	3	10°E	D.C.	3.1	250	75	15.60
			TD-48/7989	3	10°E	D.C.	2.7	250	135	17.70
			TD-39/7999	3	10°E	PULSE*	3.5	175	140	15.50
			TD-43/8287	3	10°E	PULSE*	3.5	175	210	17.85
			TD-83	S	90°E	D.C.	0.9	100	55	18.90
5.85 to 8.20	X(J)	WR-137	TD-10/6356	3	10°E	D.C.	3.1	250	75	15.65
			TD-48/7989	3	10°E	D.C.	3.5	250	135	17.75
			TD-39/7999	3	10°E	PULSE*	3.5	175	140	15.55
			TD-43/8287	3	10°E	PULSE*	3.5	175	210	17.90
			TD-67/8288	3	15°E	PULSE*	3.5	150	225	18.00
8.20 to 12.40	X	WR-90	TD-11/6357	4	10°E	D.C.	2.7	200	75	15.60
			TD-23/6882	4	10°E	D.C.	2.7	200	115	18.00
			TD-40/8152	4	10°E	PULSE*	3.3	175	125	15.60
			TD-72/8059	4	10°E	PULSE*	3.3	175	128	15.65
			TD-44/7988	4	10°E	PULSE*	3.5	175	205	17.90
			TD-58/8293	4	10°E	PULSE*	3.5	175	208	18.00
			TD-73	S	90°E	D.C.	0.9	100	54	14.50
			TD-66/8289	S	15°E	PULSE*	3.0	150	185	17.60
			TD-53	S	20°E	PULSE*	(3.0)	175	(164)	(15.5)
12.40 to 18.00	KU	WR-62	TD-18/6684	5	10°E	D.C.	2.7	200	67	15.80
			TD-54/7991	5	10°E	D.C.	2.7	200	130	18.00
			TD-46	S	20°E	A.C., D.C.	(1.2)	100	35	15.2**
			TD-41/8030	5	10°E	PULSE*	3.3	175	125	15.85
			TD-55/8290	5	10°E	PULSE*	3.5	175	230	17.85
			TD-92	5	10°E	PULSE*	3.3	175	125	15.75
18.00 to 26.50	K	WR-42	TD-13/6359	6	10°E	D.C.	2.7	200	68	15.90
			TD-50/7990	6	10°E	D.C.	2.7	200	157	18.05
			TD-42/8031	6	10°E	PULSE*	3.3	175	125	16.00
			TD-51/8291	6	10°E	PULSE*	3.5	175	260	17.90
			TD-81	S	10°E	PULSE*	3.3	150	130	16.15
26.50 to 40.00	KA	WR-28	TD-76/7993	7	10°E	D.C.	2.7	125	130	(16.0)
			TD-77/8292	7a	10°E	PULSE*	3.0	100	175	(16.0)
33.00 to 50.00	Q	WR-22	XD-972	8	10°E	D.C.	3.0	(30)	(200)	(16.0)
50.00 to 75.00	V	WR-15	XD-972	8	10°E	D.C.	3.0	(30)	(200)	(16.0)
60.00 to 90.00	E	WR-12	XD-972	8	10°E	D.C.	3.0	(30)	(200)	(16.0)

Note 1: Outlines are shown on pp. 12 and 13. "S" means special; these types are shown individually. "a" and "b" indicate variations.

Note 2: D.C. operation — Cathode at one end only.
A.C. and D.C. operation — Cathodes at both ends
Pulse operation — Cathode at one end specially designed for pulse operation.

Note 3: Anode current and tube drop are D.C. values. Values in parenthesis are tentative.

Note 4: The Excess Noise Ratio in db is $10 \log\left(\frac{T_e}{290} - 1\right)$. For tolerances, see individual type specifications.

*If the anode current during the "on time" of a square pulse (of greater than 100 microsec. duration) is nominally the same as the rated D.C. anode current, the tube drop during this period will be approximately the same as the rated D.C. tube drop.

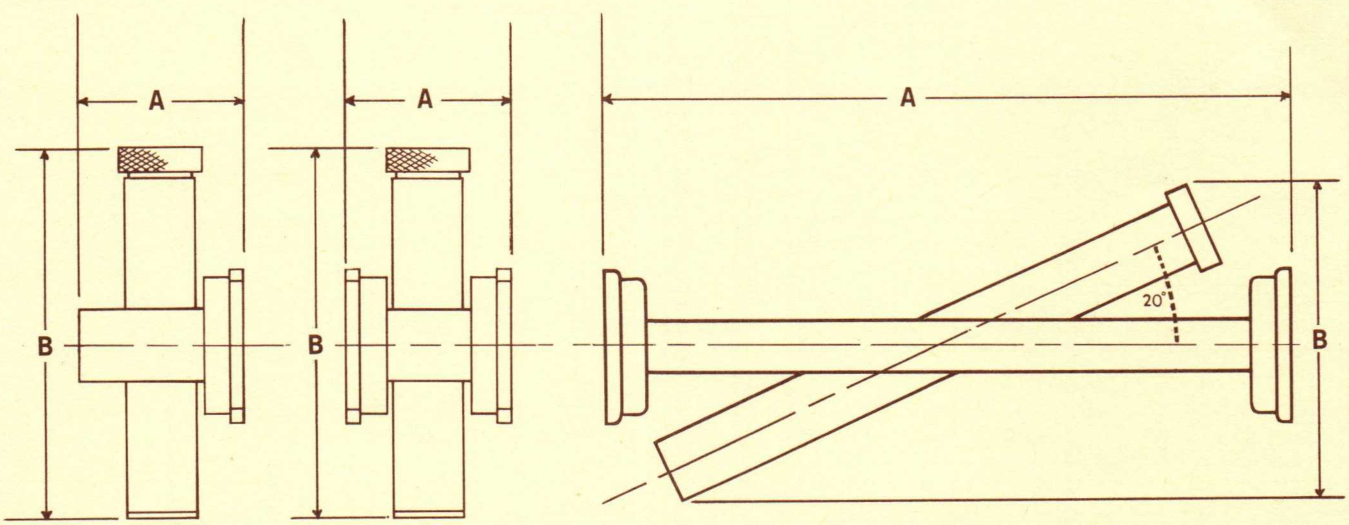
**Excess noise ratio of tube only.

APPENDIX II
MINIATURE NOISE GENERATORS

Signalite Type No.	Frequency, Gc	Waveguide	Mount	Outline No.	Dimensions, In. A	Dimensions, In. B	Weight Oz.	Starting Volts	Tube Operating Current, mA (Note 1)	Tube Drop Volts (Note 1)	Excess Noise Ratio, db (Notes 1, 2)	Replacement Tube Type Number
TN-3	2.7 - 2.9	WR-284/Alum.	90°E Shorted	1	3.5	5.5	10	900	75	53	18.5 ±0.3	TD-82
XN-727	2.6 - 3.95	WR-284/Brass	20°E Trans.	3	19.5	6.0	32	900	(100)	(53)	(14.5)	XD-730
XN-725	3.95- 5.85	WR-187/Brass	20°E Trans.	3	15.0	3.0	28	900	(100)	(53)	(14.5)	XD-728
TN-17	4.6 - 5.4	WR-187/Alum.	90°E Trans.	1	2.5	6.5	12	900	125	55	(18.5)	XD-853
TN-10	5.0 - 5.85	WR-187/Alum.	90°E Shorted	1	2.5	6.5	12	900	100	55	18.5 ±0.3	TD-83
XN-895	5.1 - 5.8	WR-187/Alum.	90°E Shorted	2	2.5	7.0	12	900	150	70	14.3 ±.5	XD-896
XN-726	5.85- 8.2	WR-137/Brass	20°E Trans.	3	10.0	3.0	25	900	(100)	(55)	(14.5)	XD-729
TN-13	7.05-10.0	WR-112/Brass	20°E Trans.	3	10.0	3.0	20	900	(100)	(55)	(14.5)	XD-655
TN-1	8.5 - 9.6	WR-90/Alum.	90°E Trans.	2	2.0	4.5	4½	900	(100)	54	14.5 ±0.5	TD-73
TN-2	8.5 - 9.6	WR-90/Alum.	90°E Shorted	1	2.0	4.5	12	900	100	54	(14.5)	XD-820
XN-867	8.5 - 9.6	WR-90/Alum.	90°E Term.	1	2.0	4.5	12	900	100	54	(18.5)	XD-879
TN-6	8.2 -12.4	WR-90/Brass	20°E Trans.	3	7.5	3.0	16	1500	(100)	(55)	(15)	XD-655
TN-7	12.4-18.0	WR-62/Brass	20°E Trans.	3	6.5	3.0	15	1500	(100)	(55)	(15)	XD-656
TN-8	18.0-26.5	WR-42/Brass	20°E Trans.	3	5.5	2.5	13	2000	(100)	(55)	(15)	XD-657

Note 1. Operating current and tube drop are D.C. values. Values in parenthesis are tentative.

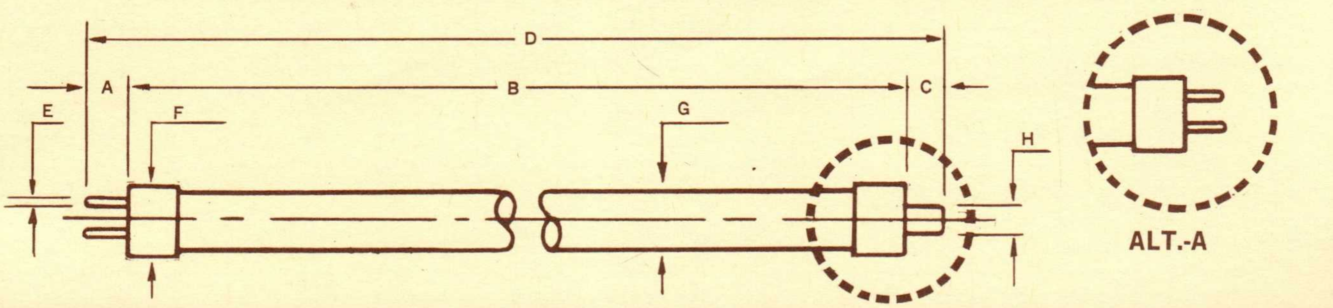
Note 2. The Excess Noise Ratio in db is $10 \log \left(\frac{Te}{290} - 1\right)$.



Outline 1   Outline 2   Outline 3

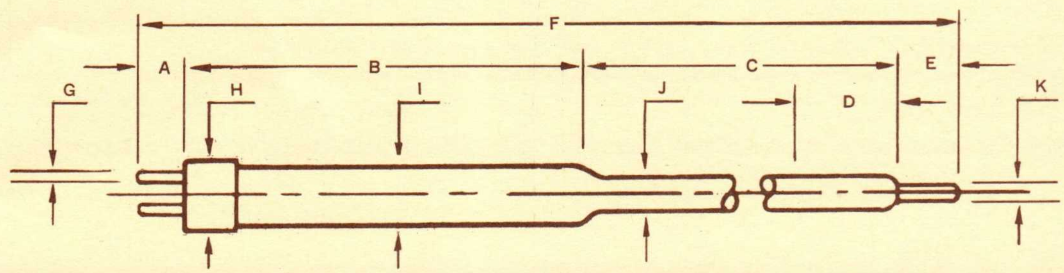
Drawings not to scale.

OUTLINE DRAWINGS



Outline Number:	1		2		3	
Frequency (Gc):	1.12 — 1.70		2.60 — 3.95		3.95 — 5.85 5.85 — 8.20	
Dimensions	Min.	Max.	Min.	Max.	Min.	Max.
A	.260	.325	.260	.325	.260	.325
B	—	—	16.937	17.437	13.875	14.375
C	—	½	.310	.360	.270	.320
D	14⅝	15	17.625	18.000	14.375	15.000

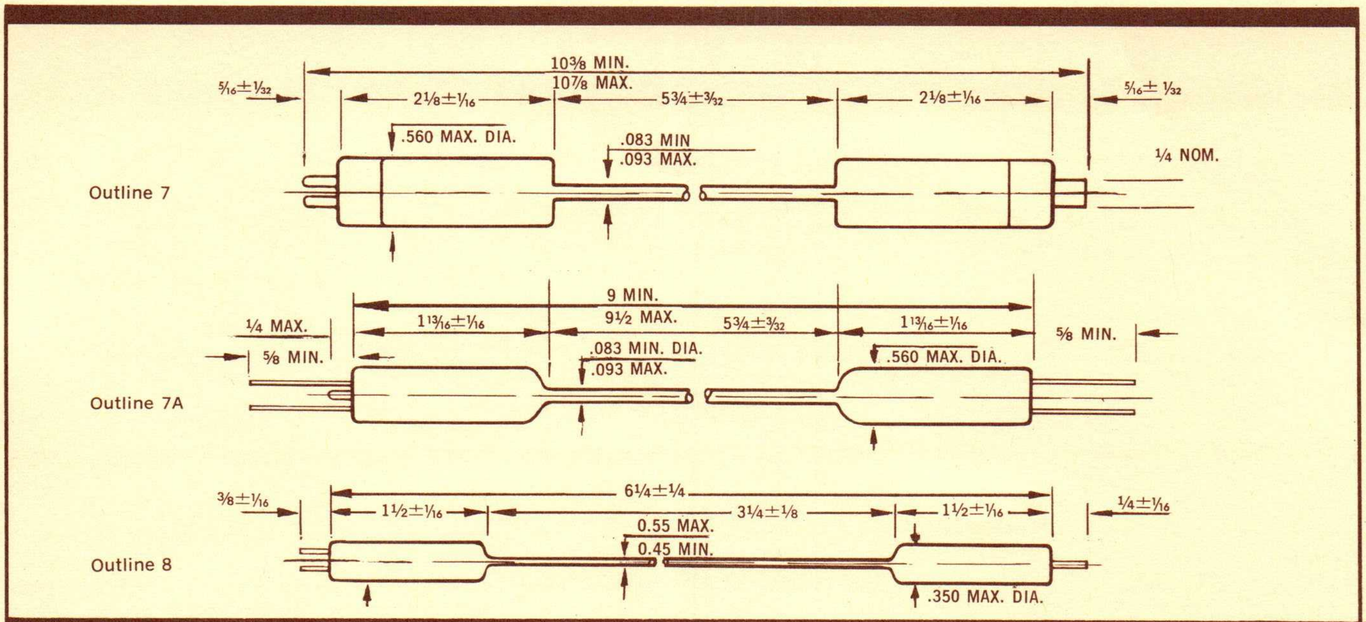
Outline Number:	1		2		3	
Frequency (Gc):	1.12 — 1.70		2.60 — 3.95		3.95 — 5.85 5.85 — 8.20	
Dimensions	Min.	Max.	Min.	Max.	Min.	Max.
E	.090	.105	.090	.105	.090	.105
F	1.350	1.435	—	.990	—	.555
G	1.475	1.550	.975	1.050	.547	.579
H	—	3/16	.305	.325	.245	.265

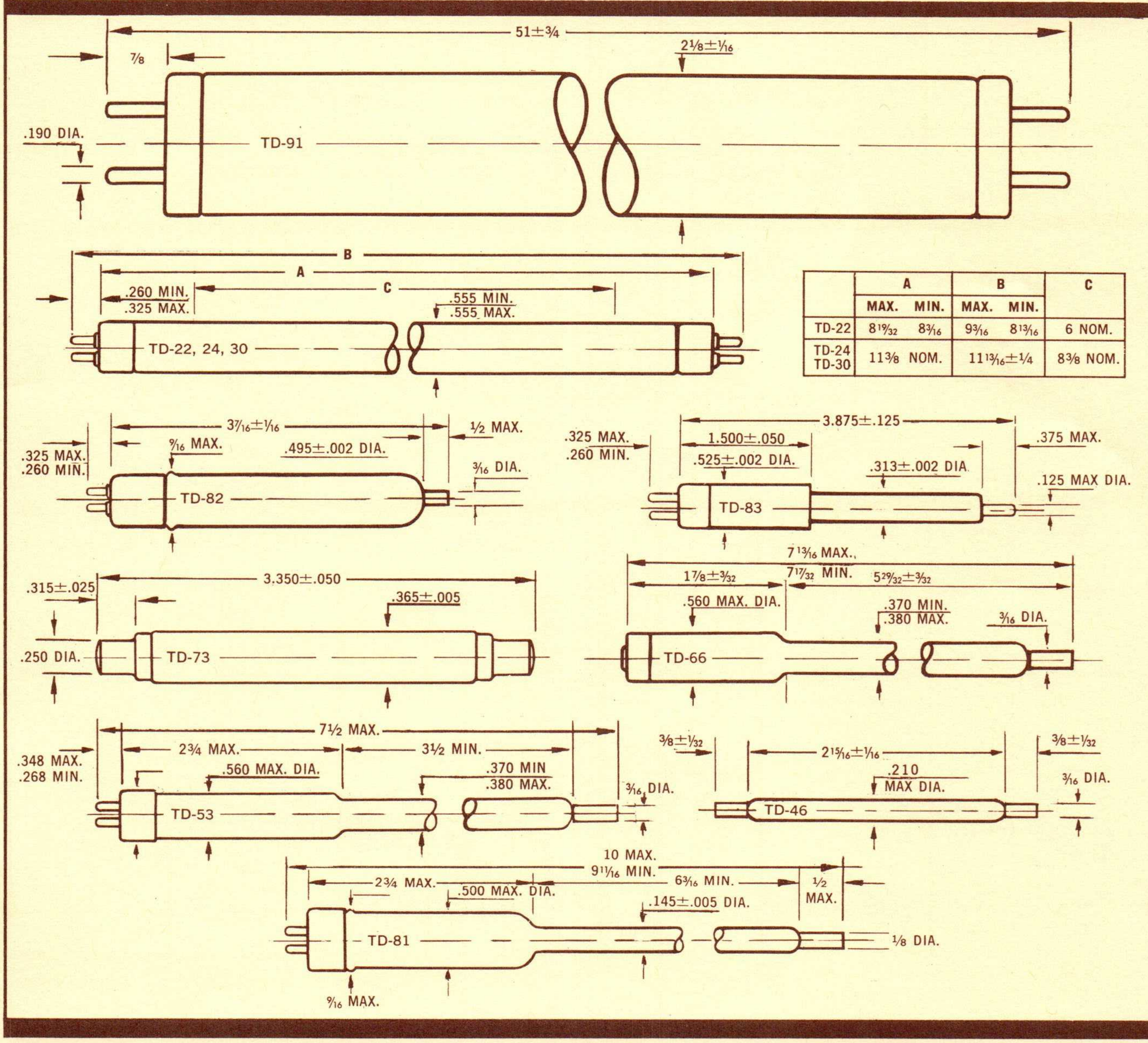


Outline Number:	4		5		6	
Frequency (Gc):	8.2 — 12.4		12.4 — 18.0		18.0 — 26.5	
Dimensions	Min.	Max.	Min.	Max.	Min.	Max.
A	.260	.325	.260	.325	.260	.325
B	—	2.750	—	2.750	—	2.750
C	8.625	—	7.375	—	6.187	—
D	—	1.500*	—	1.25**	—	1.25***
E	—	.500	—	.500	—	.500
F	11.937	12.250	10.875	11.250	9.687	10.000

Outline Number:	4		5		6	
Frequency (Gc):	8.2 — 12.4		12.4 — 18.0		18.0 — 26.5	
Dimensions	Min.	Max.	Min.	Max.	Min.	Max.
G	.090	.105	.090	.105	.090	.105
H	—	.555	—	.555	—	.555
I	—	.550	—	.500	—	.500
J	.370	.380	.235	.265	.160	.194
K	—	.187	—	.187	—	.187

* = .380 max., no min., dimensions on diameter for this length of tube
** = .265 max., no min., dimensions on diameter for this length of tube.
*** = .194 max., no min., dimensions on diameter for this length of tube.

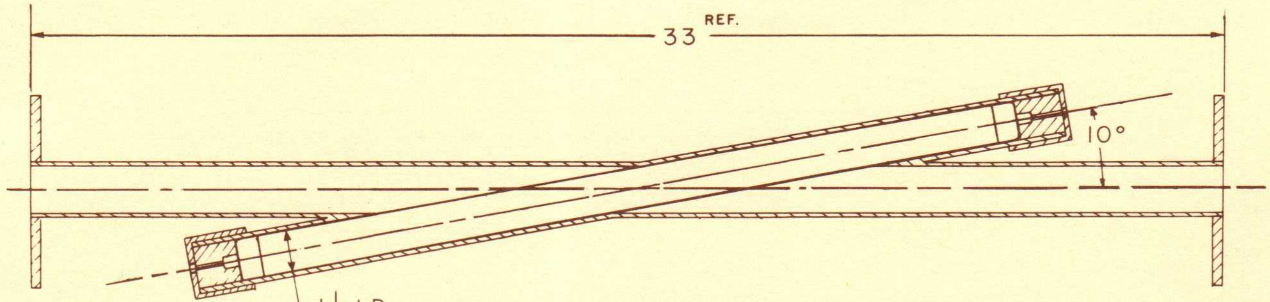




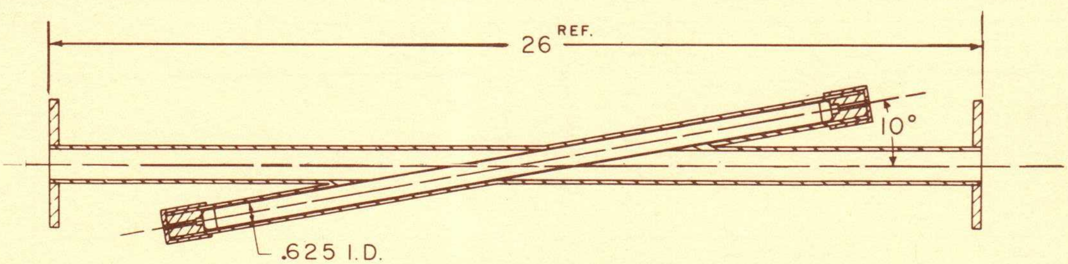
	A		B		C
	MAX.	MIN.	MAX.	MIN.	
TD-22	8 19/32	8 3/16	9 3/16	8 13/16	6 NOM.
TD-24 TD-30	11 3/8 NOM.		11 13/16 ± 1/4		8 3/8 NOM.

SPECIALS

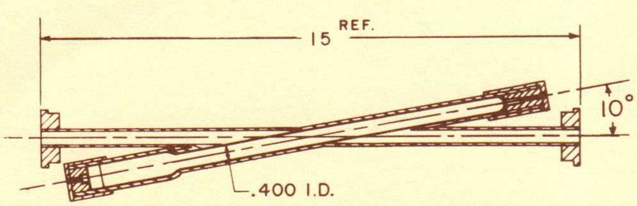
MOUNT DRAWINGS



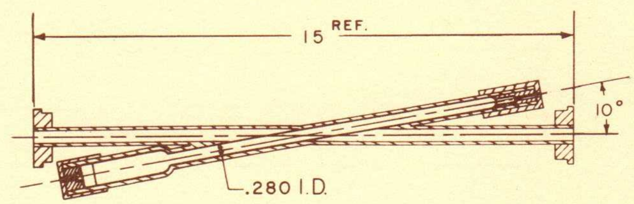
WAVE GUIDE MOUNT ASSEMBLY WR-284



WAVE GUIDE MOUNT ASSEMBLY WR-187 or WR-137



WAVE GUIDE MOUNT ASSEMBLY WR-90



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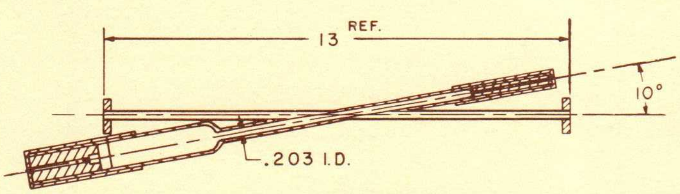

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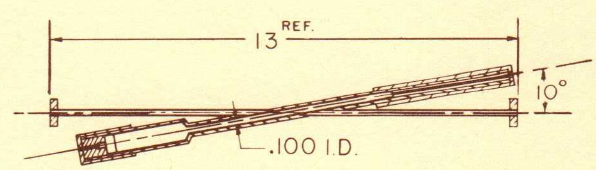
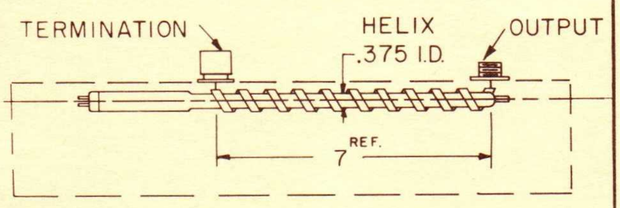
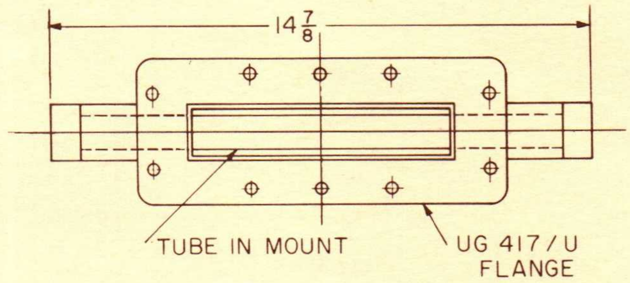


WAVE GUIDE MOUNT ASSEMBLY WR-28



TYPICAL COAX NOISE GENERATOR



WAVE GUIDE MOUNT ASSEMBLY WR-650 (90° H-PLANE)

APPENDIX III

-FACSIMILE-

Signalite INCORPORATED

NEPTUNE, N.J.

CERTIFICATE OF CALIBRATION

Test Date *________________

Noise Source Type________________ Serial No.________________

Waveguide Band________________ Calibration No.________________

Calibration Data (Note 1)

f_c	I_b	Nr-1 (Tube-in-mount)	L	$\frac{L}{L-1}$	Nr-1 (Note 2) (Tube only)
GHz	mAdc	db	db	db	db

Tested By:________________ Certified By:________________

The Calibration Standards are traceable to the National Bureau of Standards.

Note 1: For explanation of symbols and insertion loss correction, see p. 2.

Note 2: In addition to the calibration measurement tolerances indicated, the absolute center values of Nr-1 of the standards are reported by NBS to ±.1 db. This uncertainty in absolute value is not included in the measurement tolerance on Nr-1 given above.

*This certificate is valid for one (1) year from test date.

Page 1 of 2

I SYMBOLS:

1. f_c: calibration frequency
2. I_b: tube current
3. Nr-1: excess noise ratio, defined as $10 \log(\frac{Te}{290} - 1)$, where Te is the effective electron temperature of the discharge.
4. L: insertion loss of the operating tube-in-mount. (Note 3)
5. $\frac{L}{L-1}$*: the correction to be added to the excess noise ratio obtained from tube-in-mount to obtain the excess noise ratio of the tube only.

II INSERTION LOSS CORRECTION:*

The noise stamped on the calibrated tube is the excess noise ratio of the unmounted tube at its rated current. To calculate the noise-in-mount, it is necessary to make an insertion loss correction. This correction should be subtracted from the noise stamped on the tube.

Loss Correction: Determine the hot insertion loss in db of the tube-in-mount at the rated tube current. This number, L db, is used as follows:

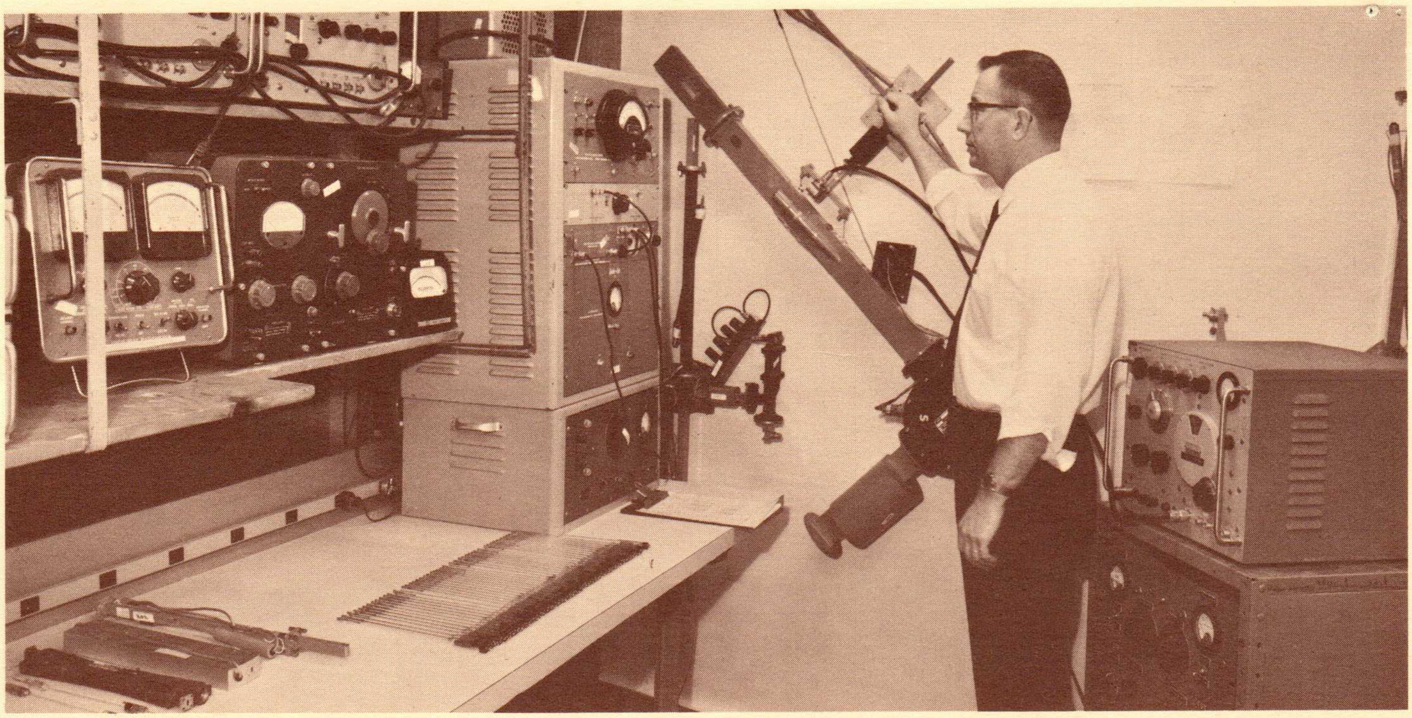
Let L db = 10 log L', where L' is the actual power ratio represented by L db. The value of the correction, Δ, is $\frac{L}{(L-1)}$, expressed in db or may be calculated from L db - (L-1) db = Δ db.

Note 3: To insure accuracy in making loss measurements, and in using the tube-in-mount for noise measurements, a tube-in-mount should be operated for at least 10 minutes prior to use so the mount can reach a stable temperature.

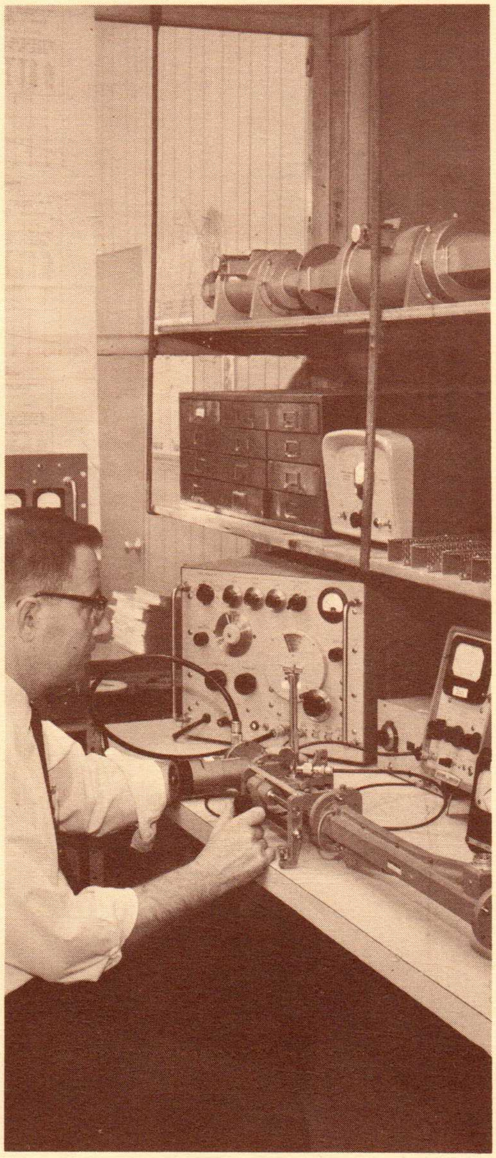
*If a waveguide mount has lossy material added inside the waveguide-beyond-cutoff region of the tube holder, or in series with the tube, in the case of a coaxial mount, this correction procedure is not appropriate.

Also if the cold insertion loss in db of the tube-in-mount is greater than 1% of the hot insertion loss in db, the above correction procedure becomes inaccurate.

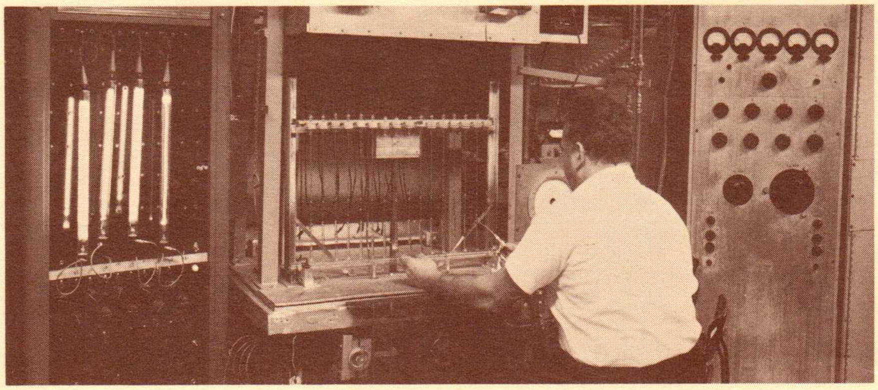
Page 2 of 2



Excess Noise Ratio Calibration Equipment



VSWR Testing



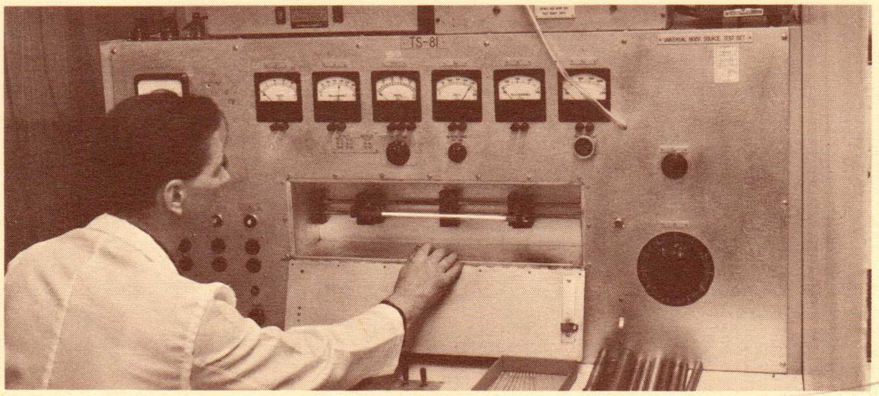
Exhaust and Run-In

SPECIAL PRODUCTS DIVISION

Signalite

INCORPORATED

Neptune, New Jersey
Area Code 201-775-2490
TWX 201-775-2255



Electrical Testing