F-27-04

INCH-POUND

NOTICE OF VALIDATION

MIL-STD-220A
NOTICE 1
19 SEPTEMBER 1988

MILITARY STANDARD

METHOD OF INSERTION-LOSS MEASUREMENT

MIL-STD-220A dated 15 DECEMBER 1959 , has been reviewed and determined to be valid for use in acquisition.

Custodian:
Army - CR
Navy - EC
Air Force - 11

Preparing Activity
Army - CR

Review Activities:
Army - CR
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Air Force -
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User Activities:
Army -
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F-27-04

MIL-STD-220A
15 December 1959

SUPERSEDING
MIL-STD-220
25 June 1952

MILITARY STANDARD

METHOD OF INSERTION-LOSS MEASUREMENT.

THIS DOCUMENT CONTAINS 31 PAGES.

Information Handling Services, DODSTD Issue 93-05.

MIL-STD-220A
8 March 1978

DEPARTMENT OF DEFENSE
Washington, D. C. 20301

Method of Insertion-Loss Measurement

MIL-STD-220A

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Communications Research and Development Command, ATTN: DRDCO-CM, Fort Monmouth, New Jersey 07703, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Supersedes page ii of 15 December 1959.

Information Handling Services, DODSTD Issue 93-05.

FOREWORD

The test methods in this standard are intended to provide data for quality control during quantity production of power line filters. The test conditions specified with 50 ohm input and output terminations are satisfactory for this purpose, but do not represent conditions that exist in actual circuits or installations. In general, there is little correlation between MIL-STD-220A quality control tests and the performance of a filter in a particular application. This is because power line filters are normally used under conditions where the power source and load impedances are independent of each other and can vary widely as a function of frequency. In addition, the power source impedance varies from line to line in general practice.

☆U.S. GOVERNMENT PRINTING OFFICE: 1978—703-122/1791

Information Handling Services, DODSTD Issue 93-05.

MIL-STD-220A
NOTICE 1
8 March 1978

MILITARY STANDARD

METHOD OF INSERTION-LOSS MEASUREMENT

TO ALL HOLDERS OF MIL-STD-220A:

1. THE FOLLOWING PAGES OF MIL-STD-220A HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
ii	8 March 1978	ii	15 December 1959
iia	8 March 1978	New Page	8 March 1978
DD Form 1426	8 March 1978		

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-220A will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodians:
Army - EL
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Review activities:
Army - EA, MD, MI
Navy - YD
Air Force -

Preparing activity:
Army - EL

(Project EMCS-0015)

EMCS

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FIGURES

Figure

1. Basic test circuit.

2. Test circuit for rapid measurement.

3. Alternate test circuit for rapid measurement.

4. Basic test circuit for measurement with full load applied.

5. Test circuit for rapid measurement with full load applied.

6. Alternate test circuit for rapid measurement with full load applied.

7. RF–DC-insertion-loss-measuring-equipment assembly.

Information Handling Services, DODSTD Issue 93-05.

1. SCOPE

1.1 This standard covers a method of measuring, in a 50-ohm system, the insertion loss of feed-through suppression capacitors, and of single- and multiple-circuit, radio-frequency (RF) filters at frequencies up to 1,000 megacycles (mc).

2. REFERENCED DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this standard:

SPECIFICATIONS

FEDERAL

QQ-S-571	— Solder: Lead Alloy; Tin Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form.

MILITARY

MIL-C-17	— Cables, Radio Frequency; Coaxial, Dual Coaxial, Twin-Conductor, and Twin Lead.
MIL-C-71	— Connectors, "N", for Radio Frequency Cables.
MIL-I-631	— Insulation, Electrical, Synthetic - Resin Composition, Nonrigid.
MIL-C-11693	— Capacitors, Feed Through, Radio-Interference Reduction, Paper Dielectric, AC and DC (Hermetically Sealed in Metallic Cases).

STANDARDS

MILITARY

MS35140	— Strap, Retaining, Single Hole, Open End Type.
MS35229	— Screw, Machine, Pan Head, Slotted, Brass, Plain Finish, NC-2A and UNC-2A.
MS35271	— Screw, Machine, Drilled, Fillister-Head, Slotted, Brass, Plain Finish, NC-2A and UNC-2A.
MS35289	— Screw, Cap, Hexagon Head (Finished Hexagon Bolt), Low Carbon Steel, Plain Finish, UNC-2A.

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MS35333	— Washer, Lock, Flat, Internal Tooth.
MS35337	— Washer, Lock, Split, Helical, Light Series.
MS35446	— Terminal, Lug Solder Type, Copper Tubing, One Hole.

AIR FORCE-NAVY AERONAUTICAL

AN931	— Grommet—Elastic.
AN3102	— Connectors — Electrical, Receptacles, Box Mounting.
AN3106	— Connectors — Electrical, Plugs, Straight.

(Copies of specifications and standards required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

3. DEFINITIONS

3.1 Insertion loss. At a given frequency, the insertion loss of a feed-through suppression capacitor or a filter connected into a given transmission system is defined as the ratio of voltages appearing across the line immediately beyond the point of insertion, before and after insertion. As measured herein, insertion loss is represented as the ratio of input voltage required to obtain constant output voltage, with and without the component, in the specified 50-ohm system. This ratio is expressed in decibles (db) as follows:

$$\text{Insertion loss} = 20 \log \frac{E_1}{E_2}$$

Where:

E_1 = The output voltage of the signal generator with the component in the circuit.

E_2 = The output voltage of the signal generator with the component not in the circuit.

4. GENERAL REQUIREMENTS

4.1 Test setup. The test circuit shall be arranged as shown on figure 1, 2, 3, 4, 5, or 6. Using the RF-dc-insertion-loss-measuring-equipment assembly shown on figure 7, the test setup shall be capable of indicating a constant value of insertion loss within ±1.0 db over the required frequency range, when the standard attenuator (see 4.2.6) is measured by the method specified in 5.2.2. All test equipment shall be well shielded, and shall be filtered to the extent that leakage, either conducted or radiated, from the signal generator or any portion of the signal-source circuitry shall not affect the output of the receiver when the generator and receiver are operating at the output level and sensitivity, respectively, needed to make the required maximum insertion-loss measurement. The test setup shall be in accordance with 4.1.1 for each frequency at which an insertion-loss measurement is to be made.

Caution: The direct-current (dc) source used in making insertion-loss measurements with full load applied shall be a floating dc source and shall not be connected to ground.

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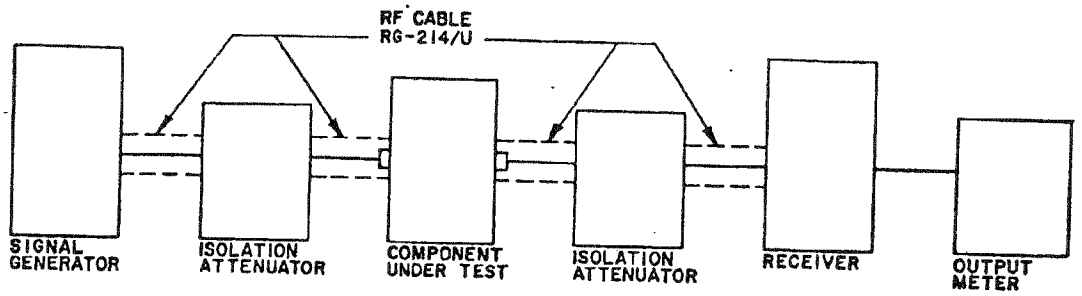

Figure 1. Basic test circuit.

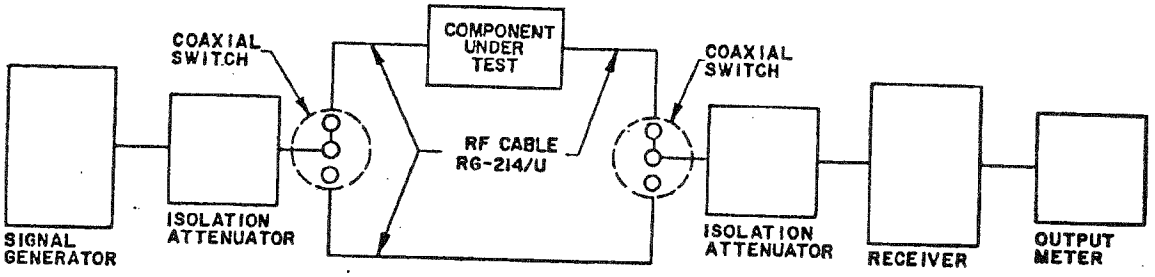

Figure 2. Test circuit for rapid measurement.

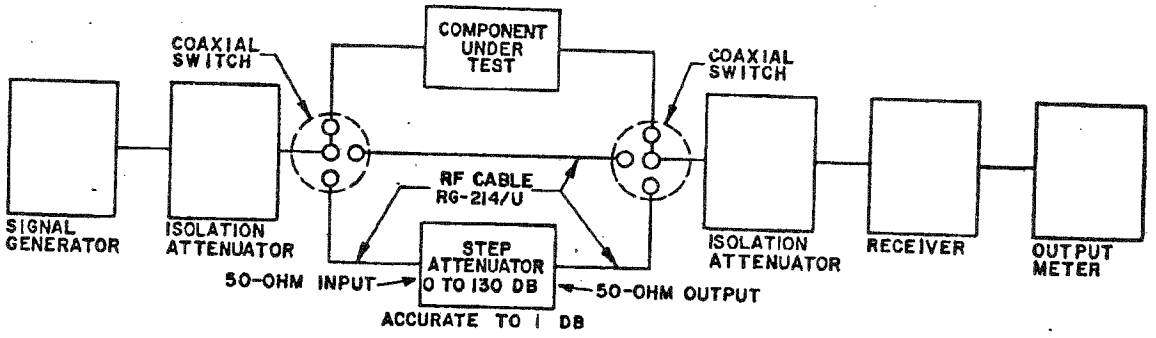

Figure 3. Alternate test circuit for rapid measurement.

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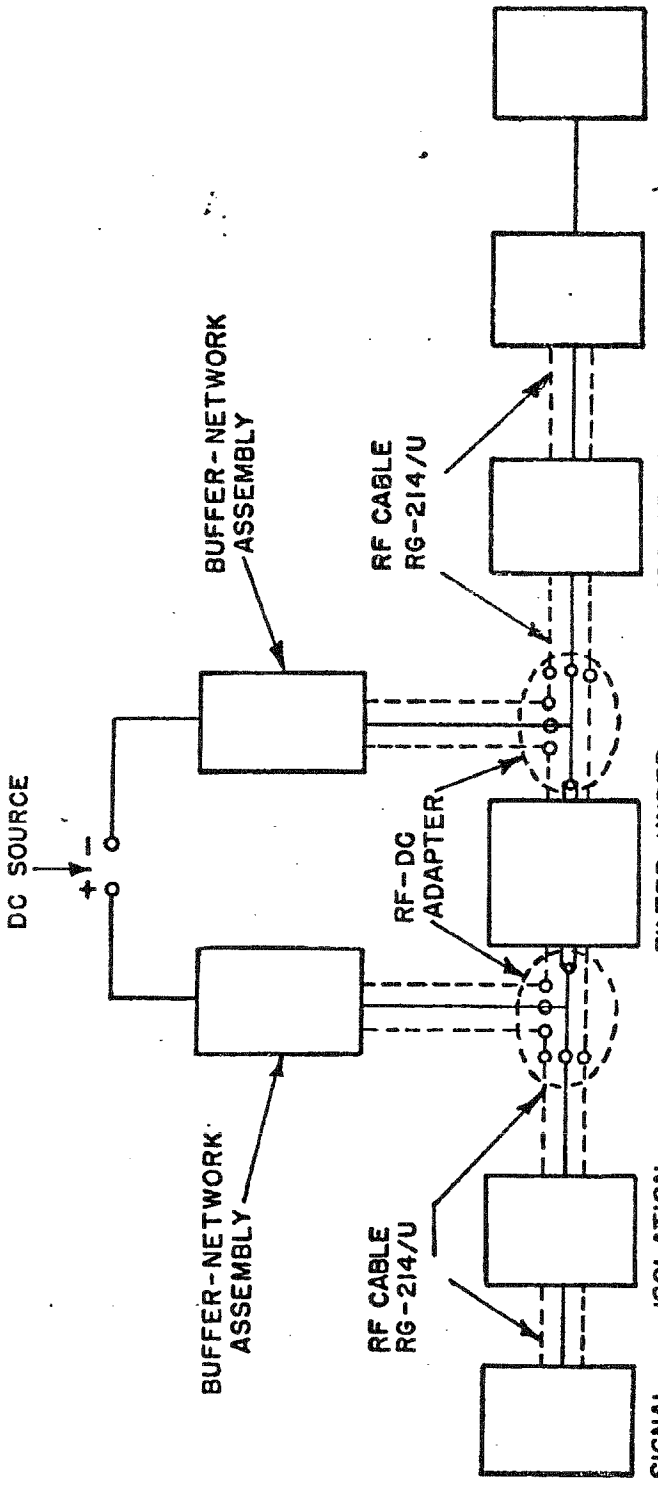

FIGURE 4. *Basic test circuit for measurement with full load applied.*

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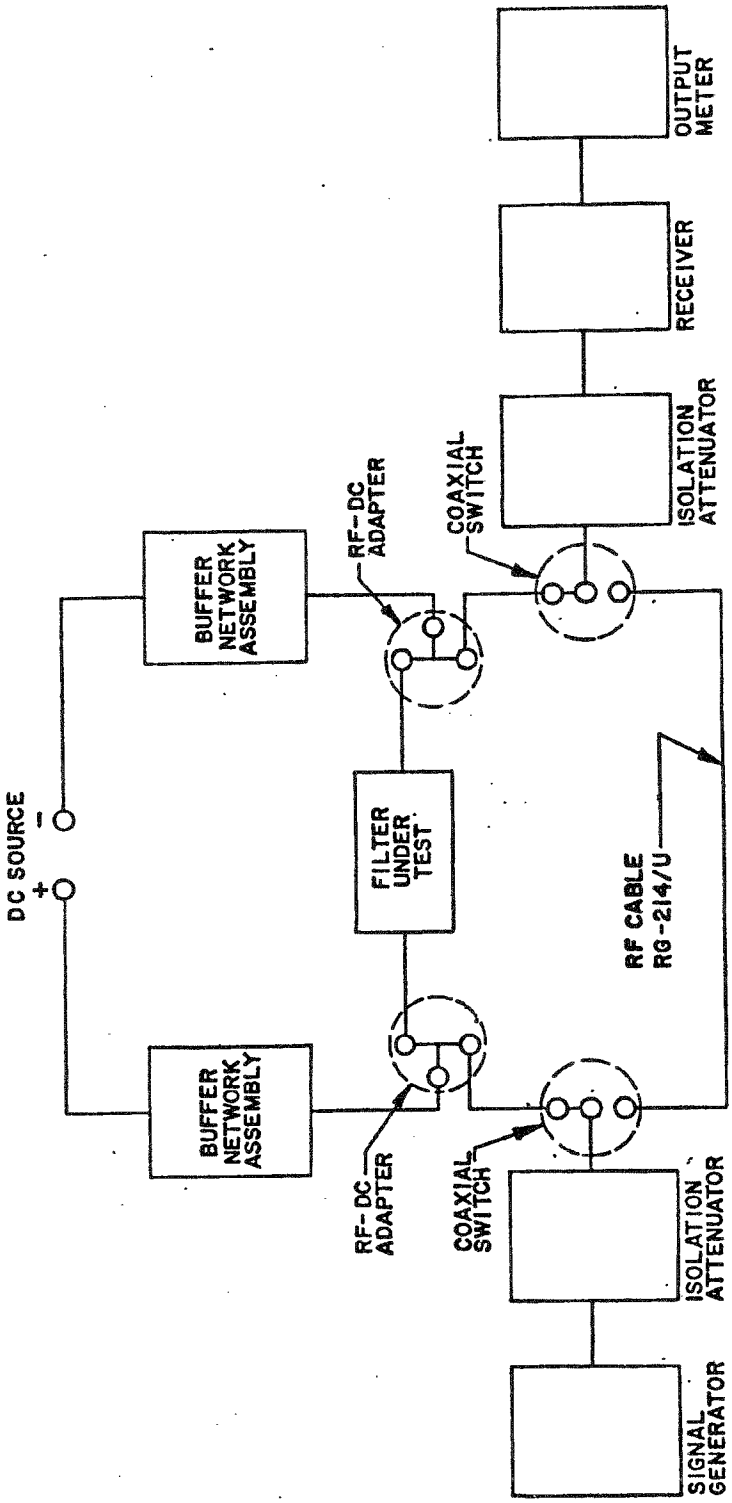

FIGURE 5. *Test circuit for rapid measurement with full load applied.*

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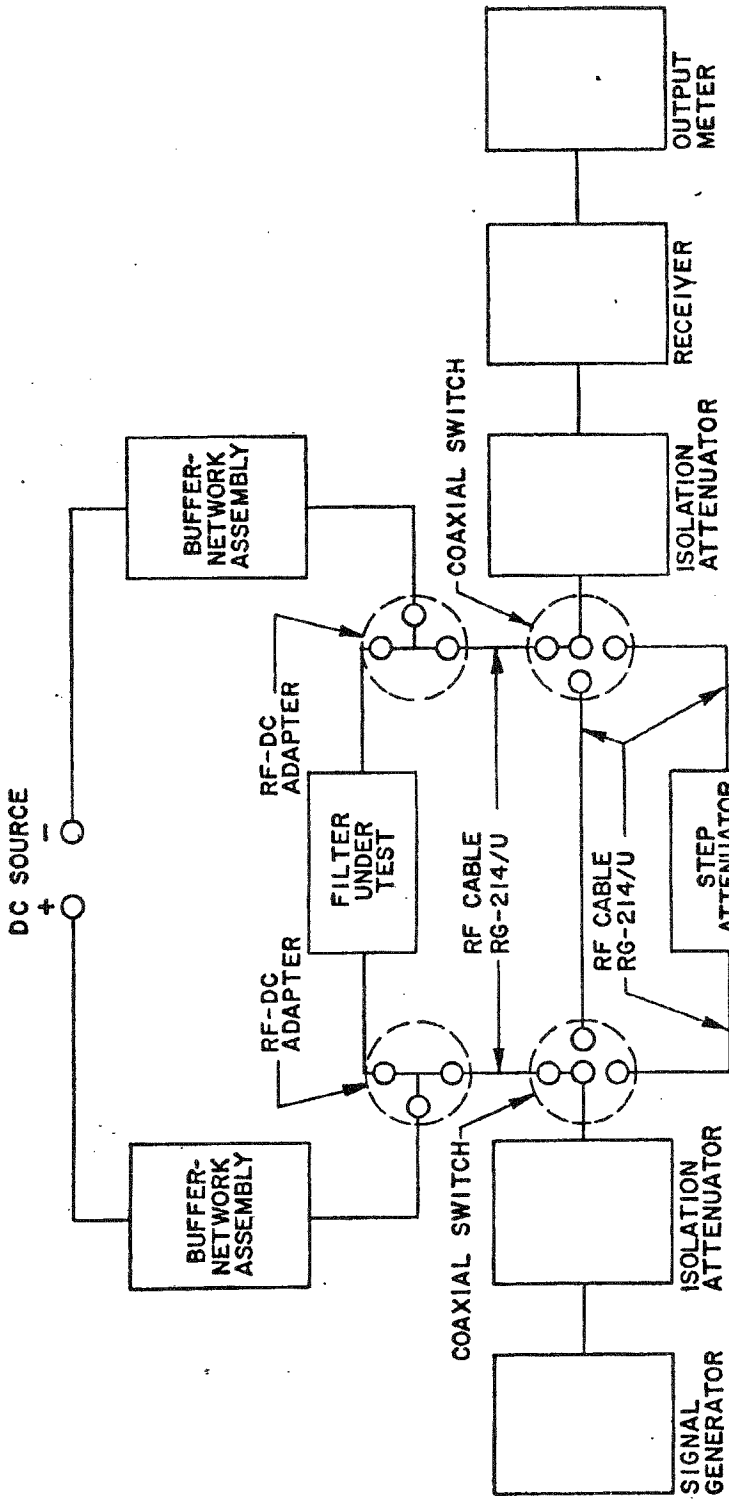

FIGURE 6. *Alternate test circuit for rapid measurement with full load applied.*

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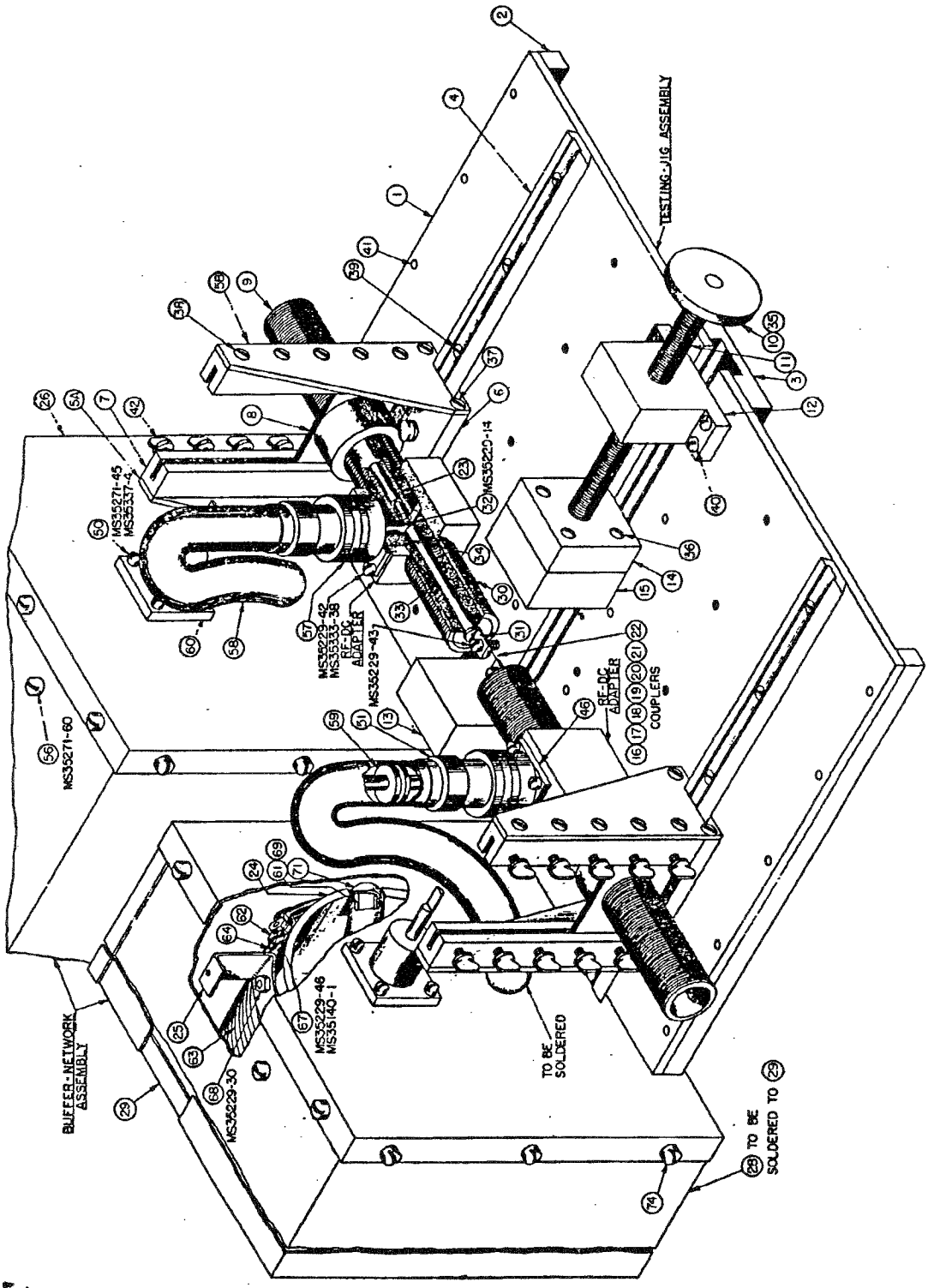

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*

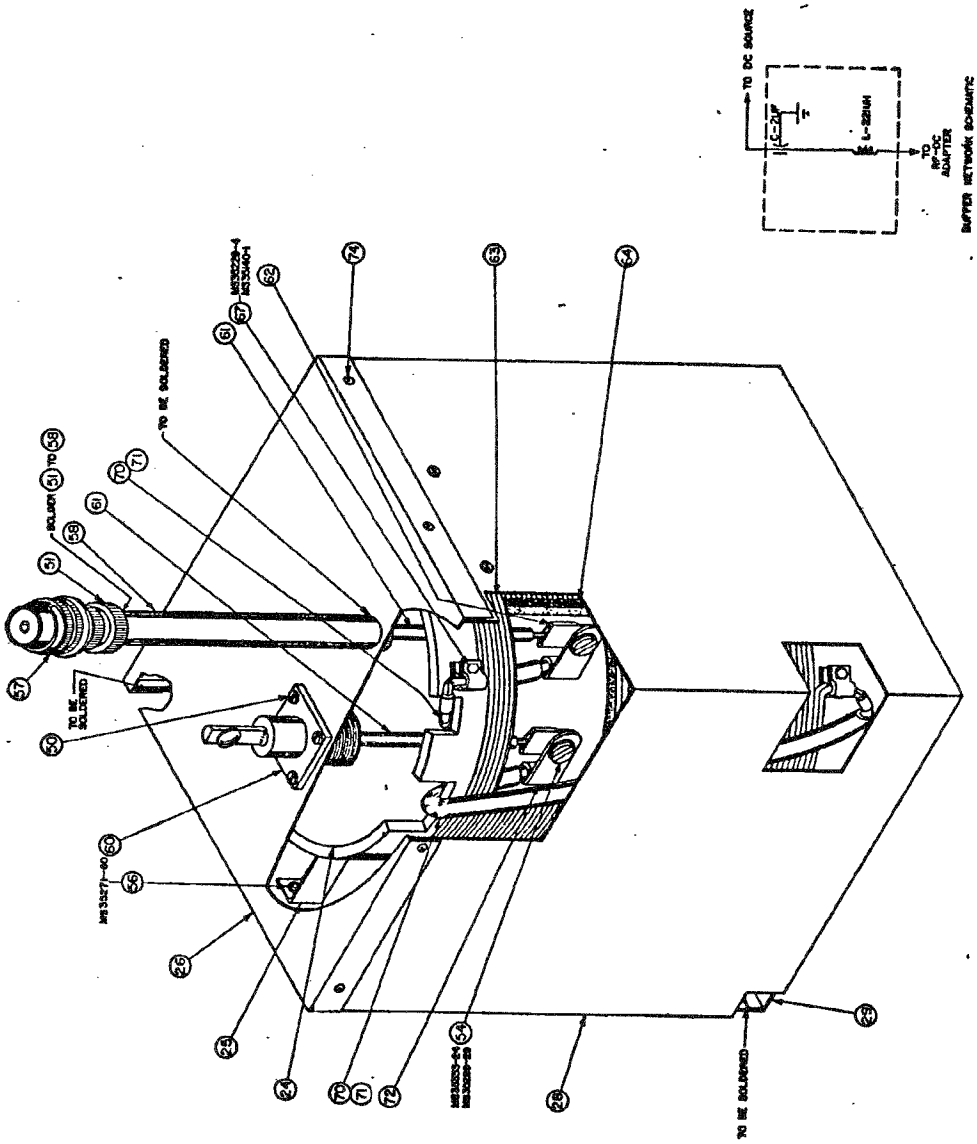

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.

Item No. or MS part No.	Description	Material	Quantity
1	Plate	Brass (chrome plated)	2
2	Bar		2
3	Channel		1
4	Track		2
5A	Right plate		2
5B	Left plate		2
6	Runner		2
7	Bar		4
8	Eye		2
9	Tube		2
10	Knob		1
11	Shaft	Steel (chrome plated)	1
12	Front block	Brass (chrome plated)	1
13	Rear block		1
14	Block		1
15	Block		1
16	Coupler		2
17	Coupler		2
18	Coupler		2
19	Coupler		2
20	Coupler		2
21	Coupler		2
22	Coupler		2
23	Connector		2
24	Coil form	Plastic	2
25	Bracket	Brass	8
26	Cover	Copper (1 side tinned)	2
28	Case		2
29	Bottom panel		2
30	Adapter body	Brass (chrome plated)	2

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.

Item No. or MS part No.	Description	Material	Quantity
31	Conductor	Copper (silver plated)	2
32	Conductor		2
33	Insulator	Acrylic plastic	2
34	Insulator		2
35	Set screw, cup point No. 8–32 NC–2A, ⅜ lg.	Steel	1
36	Screw, RHMS, No. 10–32 NF–2A, 1¼ lg.	Brass (zinc or cadmium plated)	4
37	Screw, FHMS, No. 8–32 NC–2A, ½ lg.	Brass (zinc or cadmium plated)	8
38	Screw, FHMS, No. 10–32 NF–2A, 5/16 lg.		20
39	Screw, FHMS, No. 10–32 NF–2A, ⅜ lg.		10
40	Screw, FIL H MS, No. 10–32 NF–2A, ⅝ lg.		6
41	Screw, FHMS, No. 10–32 NF–2A, ¾ lg.		20
42	Screw, thumb shoulder, No. 10–24 NC–2A, ½ lg.		24
46	Receptacle, per AN3102A–18–5S.	... ...	2
50	Hex nut, No. 8–32 NC–2B		8
51	Nut, per U–4864–3B Titeflex Metal Hose Co., or equiv.		2
54	Hex nut, No. 18 UNC–2B	Steel	4
56	Hex nut, No. 10–24 NC–2B	Brass	16
57	Connector, per AN3106A–18–6S.	... ...	2
58	Conduit shielding, per No. 152–48 Titeflex Metal Hose Co., or equiv. 8⅝ lg.		2

FIGURE 7. *RF-Dc-insertion — loss-measuring-equipment assembly.*—Continued.

Information Handling Services, DODSTD Issue 93-05.

Item No. or MS part No.	Description	Material	Quantity
59	Grommet, per AN931B5-9		8
60	Capacitor, feed through, CZ 34 per Spec. MIL-C-11693.		2
61	Cable, 6 tw, 600 volt		As reqd
62	Terminal, per MS35446-5		4
63	Coil, No. 6 rectangular form-ex wire(wound 2 layers for total of 48 turns.	... ...	As reqd
64	Kraft paper		As reqd (use optional)
67	Hex nut, No. 8-32 NC-2B	Brass	8
68	Hex nut, No. 6-32 NC-2B		16
69	Terminal, per No. 5040 Patton-MacGuyer Co., or equiv.	Copper (hot-tin dipped)	2
70	Cable, ¾ braided, 2 pc 5½ lg, 2 pc 16½ lg.	Copper	
71	Insulation, per Spec. MIL-I-631, 2 pc 5⅛ lg, 2 pc 16⅛ lg.	Vinyl	
72	Terminal, per No. 3007 Patton-MacGuyer Co., or equiv.	Copper	4
74	Screw, self tapping, FIL H, No. 6 type B, ⅜ lg.	Steel	24
MS35140-1	Strap, retaining		8
MS35229-14	Screw	Brass	1
MS35229-30	Screw		16
MS35229-42	Screw		8
MS35229-43	Screw		2
MS35229-46	Screw		4
MS35271-45	Screw		8
MS35271-60	Screw		16
MS36289-29	Screw		4
MS35333-24	Lockwasher	Steel	4
MS35333-38	Lockwasher		8
MS35337-4	Lockwasher		8

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.

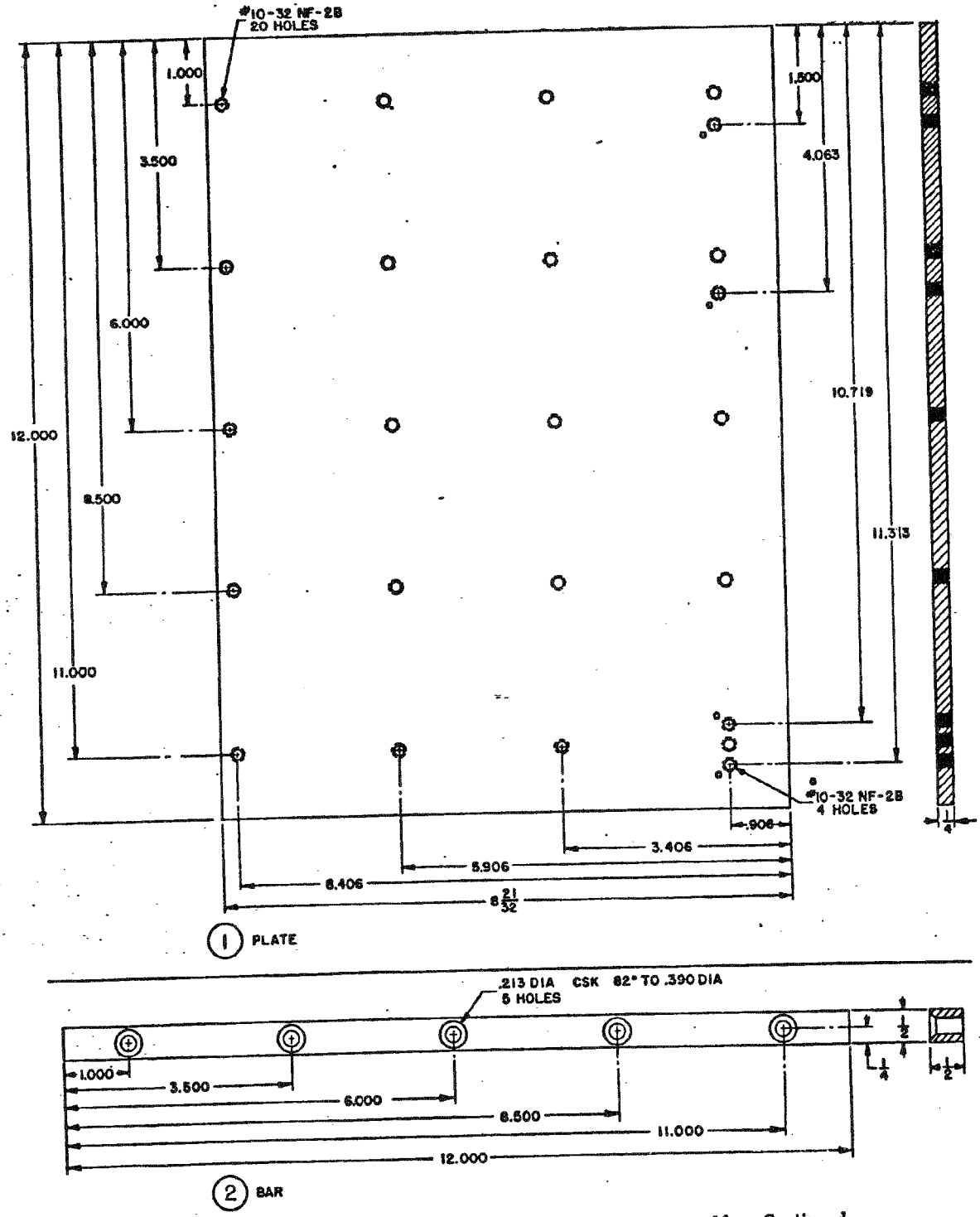

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

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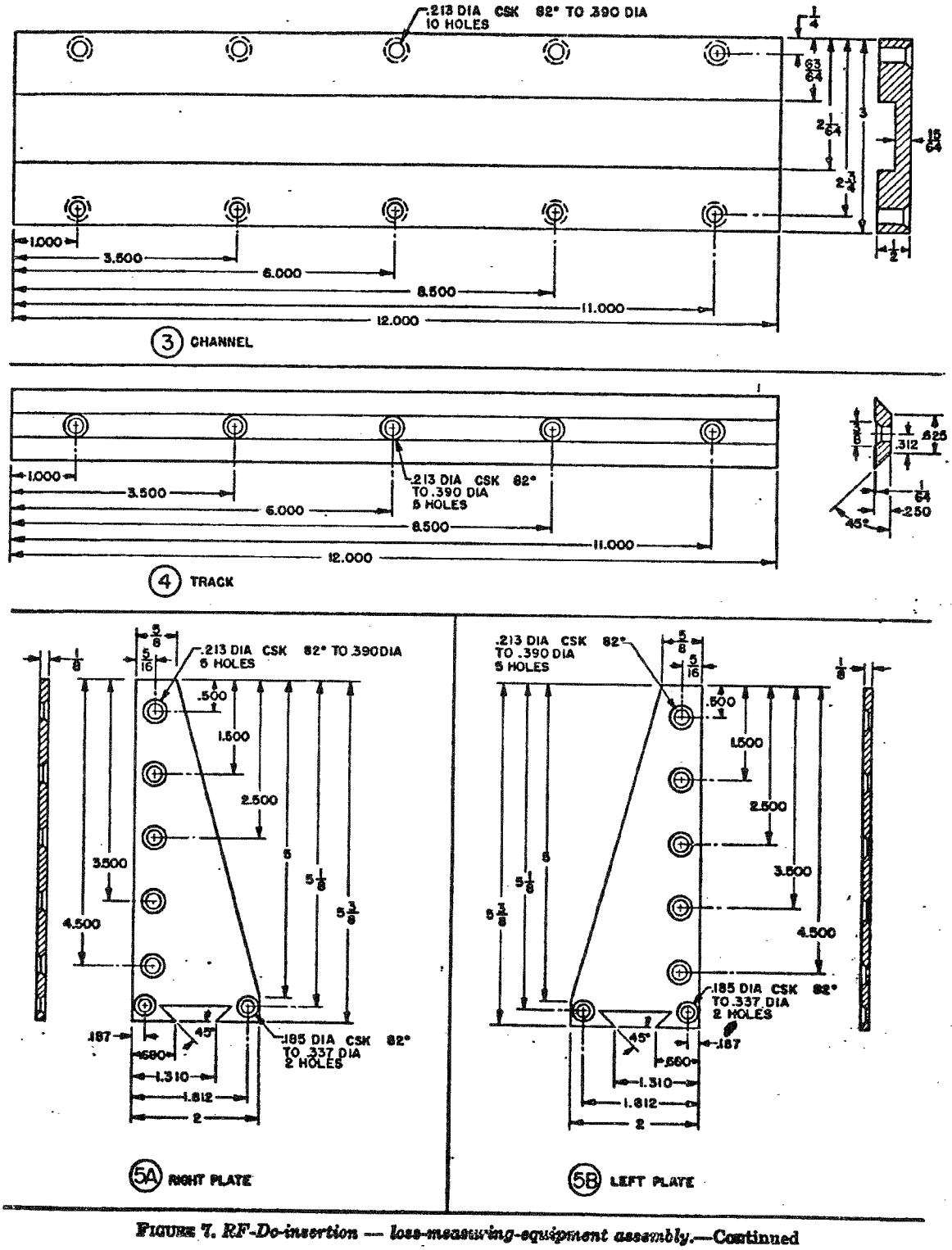


FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.

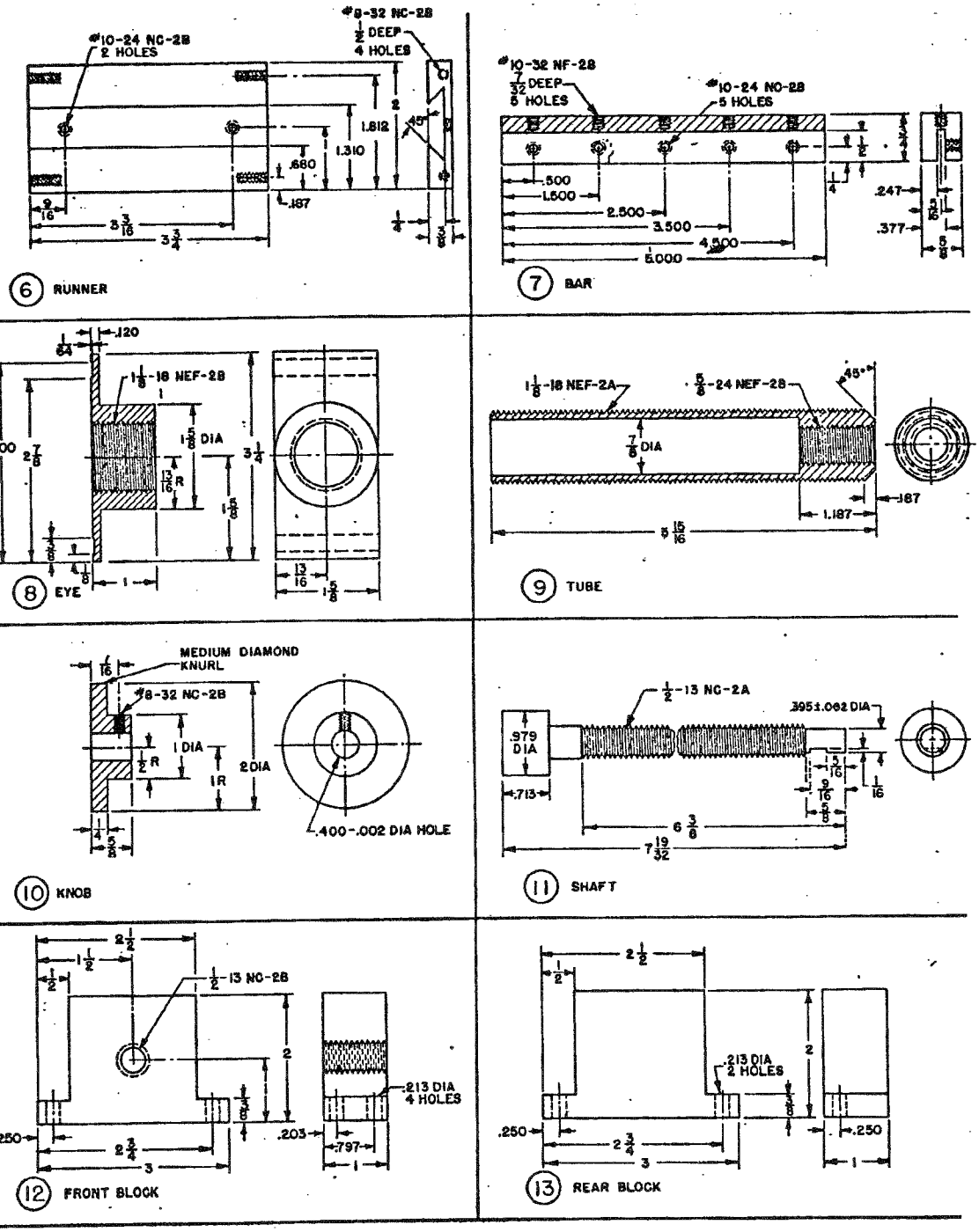
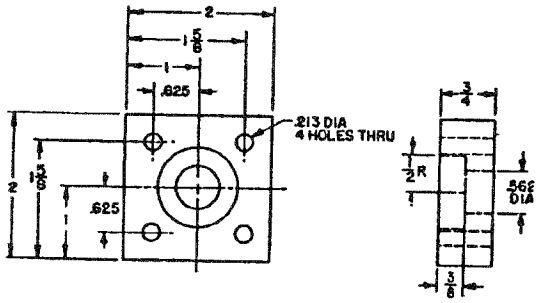


FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.



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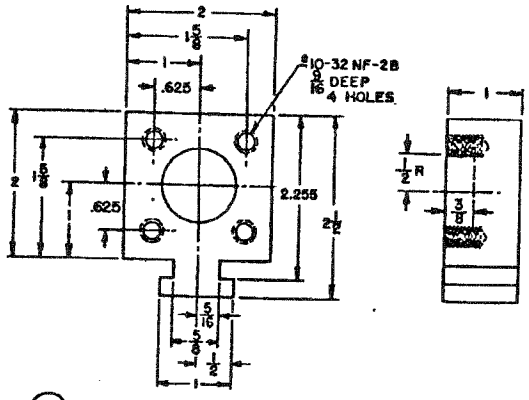

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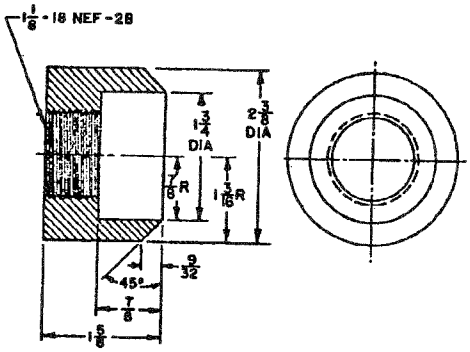

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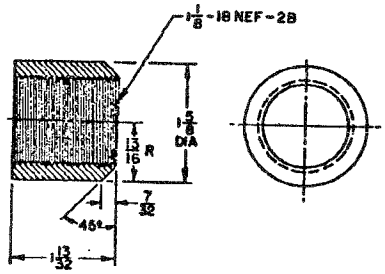

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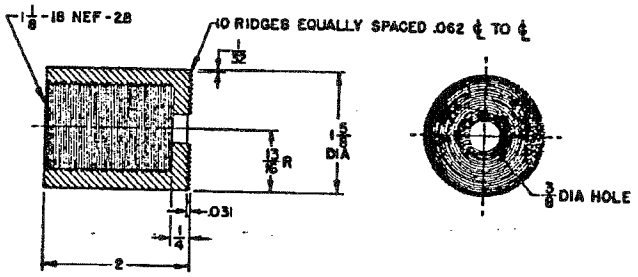

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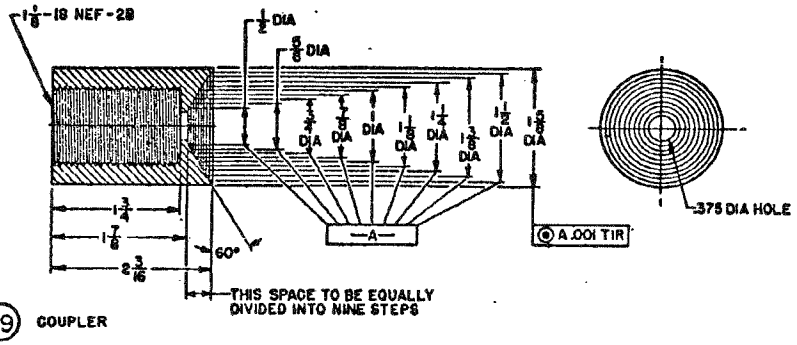
FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

Information Handling Services, DODSTD Issue 93-05.



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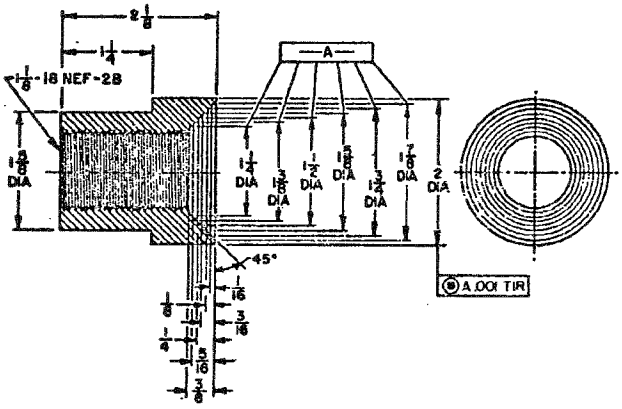

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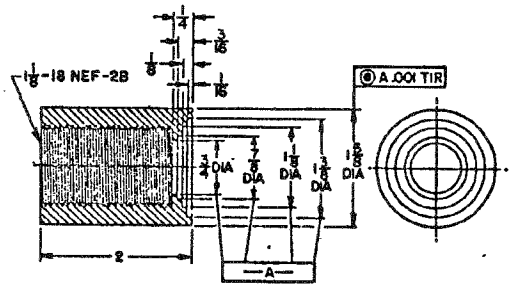

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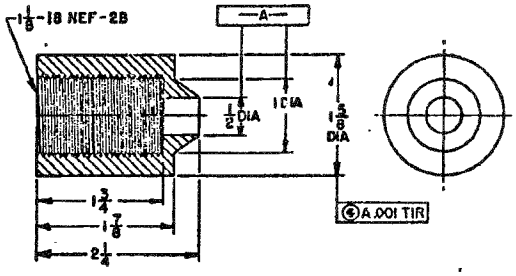

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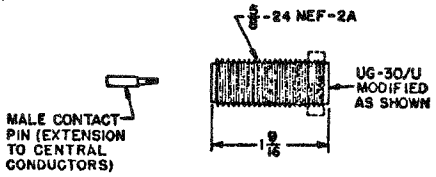

(23) CONNECTOR

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

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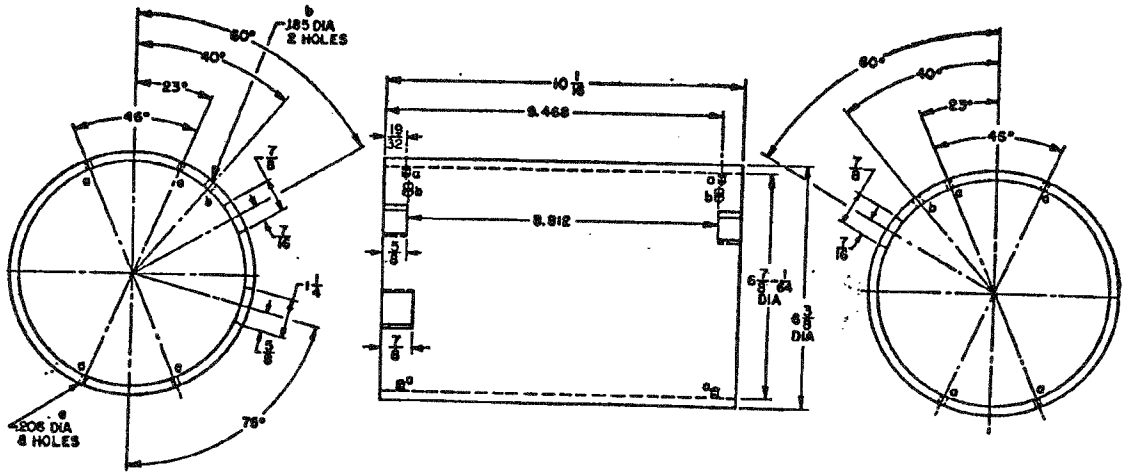

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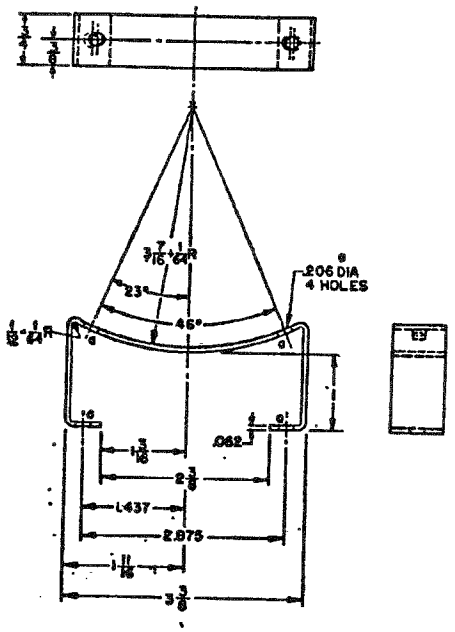

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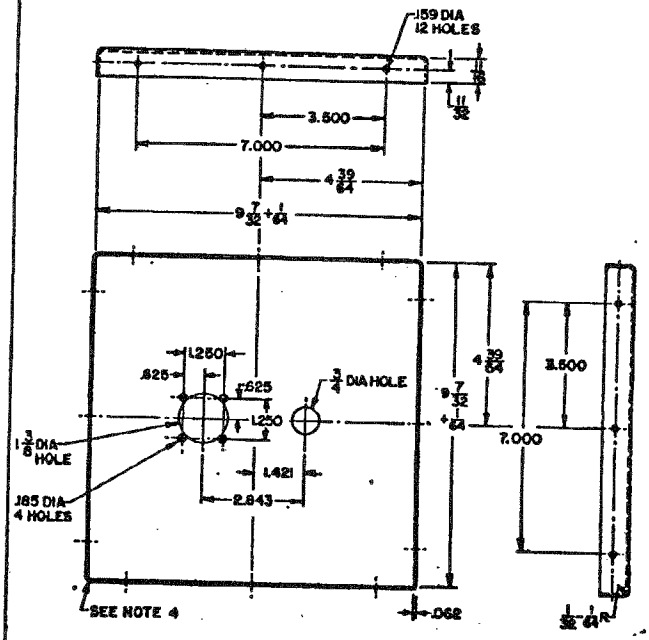

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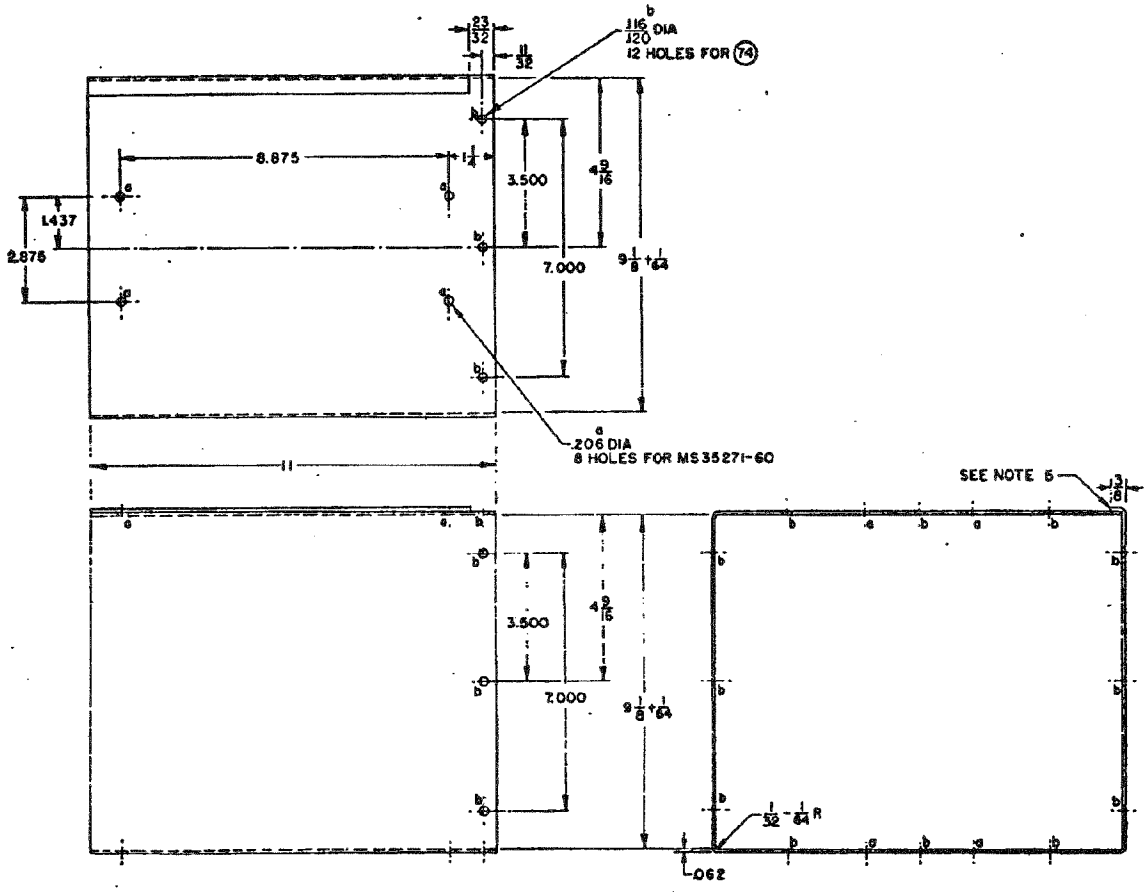
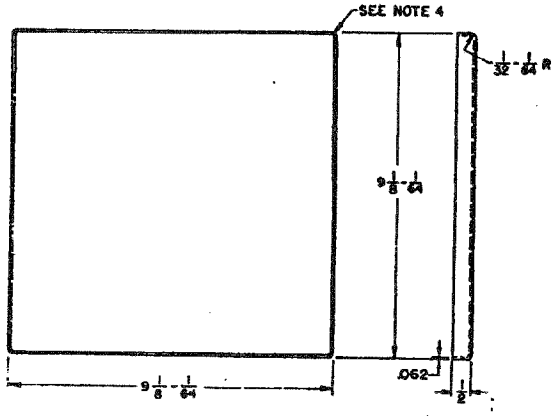
FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued



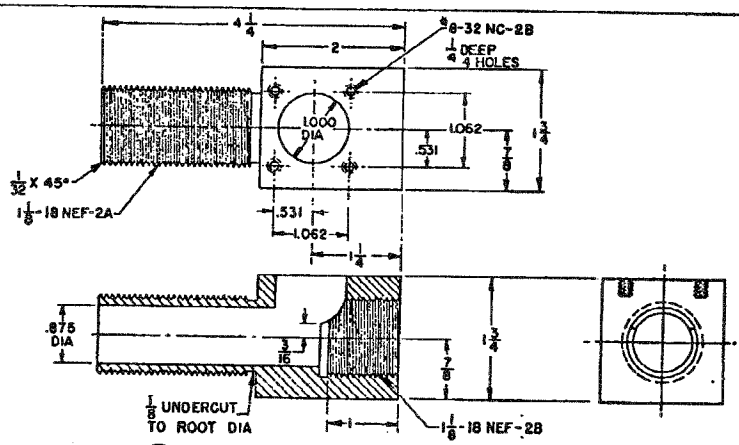
(28) CASE

FIGURE 7. *RF-Dc-insertion — loss-measuring-equipment assembly.*—Continued

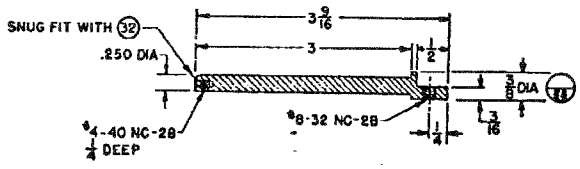
Information Handling Services, DODSTD Issue 93-05.



(29) BOTTOM PANEL



(30) ADAPTER BODY



(31) CONDUCTOR

FIGURE 7. *RF-De-insertion — loss-measuring-equipment assembly.*—Continued

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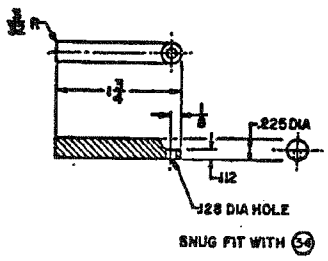
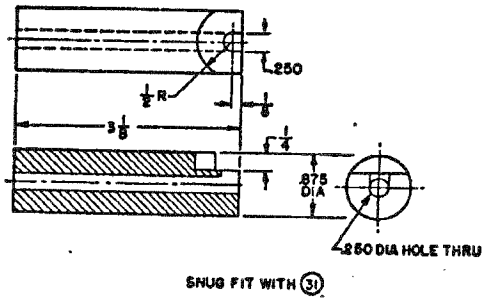
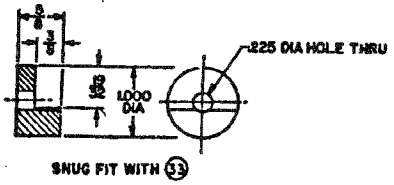


(32) CONDUCTOR



(33) INSULATOR



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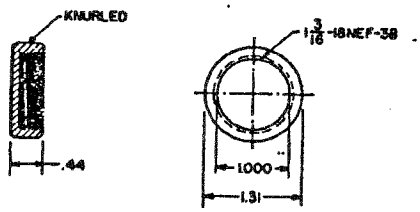

(51) NUT

NOTES:
1. ALL DIMENSIONS IN INCHES.
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ± 1/64 ON FRACTIONS, ±.005 ON DECIMALS, AND ±1° ON ANGLES.
3. SOLDER USED SHALL BE COMPOSITION Sn40 PER SPECIFICATION QQ-S-571.
4. CORNERS SHALL BE SOLDERED AND THEN ROUNDED OFF.
5. THE EDGE SHALL BE SECURELY SOLDERED.

FIGURE 7. *RF-Dc-insertion — loss-measuring-equipment assembly.*—Continued

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4.1.1 *Shielding test.* With the equipment completely set up for the filter-out condition of insertion-loss measurement (see 5.2.2), the signal generator shall be disconnected from the powerline, and the receiver gain shall be adjusted to provide a convenient output indication of receiver fluctuation noise. The generator shall then be connected to the powerline, and its output voltage (E_2) shall be adjusted to provide a receiver output indication of 1.0 db above that obtained for receiver fluctuation noise. The receiver output indication shall be capable of being adjusted completely down to fluctuation noise by means of the generator output control, that is, in decreasing the generator output, a point shall not be reached at which lowering the output has no further effect on receiver indication while the receiver indication is perceptibly above fluctuation noise. Using the RF-dc-insertion-loss-measuring-equipment assembly specified in 4.2.5 with the coupler as shown on figure 7 (see detail drawings 16 to 22, inclusive), the test setup shall then be connected for the filter-in condition by substituting for the component a solid brass or copper plate at least ¼ inch thick with plane faces at least 2⅜ inches wide in all directions. This plate shall be placed across the coupler and center conductor of the RF-dc-insertion-loss-measuring-equipment assembly so that the signal source and load are completely short circuited by the faces of the plate. The output of the generator shall then be raised to the voltage (E_1) which causes a receiver-output indication of 1 db above receiver fluctuation noise. The insertion loss then obtained from the formula "Insertion loss = $20 \log \frac{E_1}{E_2}$" shall be at least 10 db greater than the insertion loss to be measured.

4.2 Test equipment.

4.2.1 *Signal generator.* After a 30-minute warmup period, the signal generator shall be capable of maintaining, within ±1.0 percent, any frequency to which it may be set, and the output voltage of the generator shall remain constant over any 2-minute test period within ±1.0 percent of any value to which it may be set. The generator shall be equipped, either internaly or externally, with an attenuator calibrated in terms of output-voltage increments and continuously variable from minimum to maximum; calibration shall be accurate within ± 5.0 percent in db when the geneartor is terminated with an impedance of 50 ohms. The output of the generator shall be fitted with or adapted to a coaxial connector in accordance with 4.2.3. When two or more generators are required to cover the specified frequency range, a coaxial switch in accordance with 4.2.3 may be used on the generator side of the isolation attenuator to facilitate changing of generators.

4.2.2 *Receiver.* After a 30-minute warmup period, the receiver shall be capable of maintaining, within ±1.0 percent, any frequency to which it may be tuned, and the overall gain of the receiver shall remain constant over any 2-minute test perior, maintaining an output voltage within ±1.0 percent of any value to which it may be set. The sensitivity shall be great enough and the level of circuit noise low enough to allow clear reception of the signal required for the measurement. The receiver automatic gain-control circuit shall be disabled during measurements, and an output meter shall be used to indicate relative voltage. The input to the receiver shall be fitted with or adapted to a coaxial connector in accordance with 4.2.3. When two or more receivers are required to cover the specified frequency range, a coaxial switch in accordance with 4.2.3 may be used on the receiver side of the isolation attenuator to facilitate changing of receivers.

4.2.3 *Coaxial lines, connectors, and switches.* All coaxial lines shall be Radio Frequency Cable RG-214/U, or equal, and shall con-

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form to Specification MIL-C-17. It is essential that cable with the characteristic impedance of type RG-214/U be used to connect the isolation attenuators together for the filter-out condition and to connect the component to the isolation attenuators for the filter-in condition. The length of cable connecting the isolation attenuators for the filter-out condition shall be within ±6 inches of the combined length of the two cables connecting the component to the isolation attenuators for the filter-in condition. Type N 50-ohm coaxial connectors conforming to Specification MIL-C-71 shall be used where applicable. When coaxial switches are used, they shall have a 50-ohm characteristic impedance, and a maximum voltage standing wave ratio (VSWR) of 1.1 to 1 at the frequency of measurement.

4.2.4 *Isolation attenuators.* The isolation attenuators shall be appropriate resistive networks having 50-ohm-input and 50-ohm-output impedances. The attenuators shall have a minimum insertion loss of 10 db measured in a 50-ohm system. Looking into either end of each attenuator with the other end terminated in 50 ohms, the VSWR shall be a maximum of 1.1 to 1 up to 400 mc, and a maximum of 1.2 to 1 from 400 to 1,000 mc, inclusive. The characteristics of the attenuators shall show no significant change when the system is subjected to the maximum signal-generator power required for measurement. The input and output of each attenuator shall be fitted with coaxial connectors in accordance with 4.2.3. These attenuators are for the purpose of obtaining a standard 50-ohm termination for all attenuation measurements.

4.2.5 *RF – Dc-insertion-loss-measuring-equipment assembly.* When the component under test has no provision for coaxial connections, the RF-dc-insertion-loss-measuring-equipment assembly shown on figure 7 shall be used to insert the component into the line, unless otherwise specified in the individual component specification. When a component has such a shape that it cannot be satisfactorily clamped in this assembly, other adequate clamping means shall be used.

4.2.5.1 *Buffer-network assembly and RF-dc adapter.*

4.2.5.1.1 *Full-load insertion-loss measurements.* The buffer-network assembly and RF-dc adapter shown on figure 7 shall be used for providing coaxial connections when performing insertion-loss measurements with rated current (dc ratings or equivalent) applied. The complete RF-dc-insertion-loss-measuring-equipment assembly shall be used for test measurements over the frequency range of 100 kilocycles (kc) to 20 mc, inclusive. The buffer network shown on figure 7 is suitable for continuous use with currents up to 100 amperes.

4.2.5.1.2 *No-load insertion-loss measurements.* The buffer-network assembly shown on figure 7 shall not be used when performing no-load insertion-loss measurements. The RF-dc adapter shown on figure 7 may be used at all frequencies for providing coaxial connections during no-load insertion-loss measurements.

4.2.6 *Standard attenuator.* A standard attenuator shall be provided with the following characteristics:

(a) Attenuation of 50 ± 0.5 db over the frequency range of 150 kc to 1,000 mc, inclusive.

(b) Maximum VSWR of 1.2 to 1 over the frequency range of 150 kc to 1,000 mc, inclusive.

(c) Input and output impedance of 50 ohms.

The standard attenuator shall be inserted into the system in place of a component, to test for proper operation as specified in 4.1.

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4.2.7 Output meter. An output meter, or similar indicating device, which will provide a readable indication of the magnitude of signal shall be used. The indicating device may be a part of the receiver or may be a separate instrument connected to the receiver.

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5. METHOD OF TEST

5.1 Test conditions. Unless otherwise specified in the individual component specification, all measurements shall be made at room ambient temperature, atmospheric pressure, and relative humidity.

5.2 Test procedure.

5.2.1 *Preliminary operation.* To insure stability, each signal generator and receiver shall be operated for a period of at least 30 minutes immediately before measurement.

5.2.2 *Method of measurement.* The test equipment shall be set up as shown on figure 1, 2, 3, 4, 5, or 6, except that a cable of the type and length specified in 4.2.3 for the filter-out condition shall be inserted between the attenuators to replace the component and its connecting cables. The signal generator shall be adjusted to the desired frequency, with the attenuator set for the lowest convenient value of output voltage. The receiver shall be tuned to resonance at the frequency of the generator, and the gain controls shall be set so that the sensitivity will be great enough and the level of circuit noise low enough to allow clear reception of the signal required for the measurements. The output of the generator (E_2) shall be adjusted to give the lowest possible stable and readable indication on the output meter, care being taken not to saturate or overload the receiver. The cable used for the filter-out condition shall then be removed, and the component and its connecting cables shall be inserted between the isolation attenuators, with the component connected to the cables as specified in 4.2.5. The receiver shall be returned to resonance, and the output of the generator (E_1) adjusted until the output meter gives the same indication as that obtained for the filter-out condition. The insertion loss of the component under the specified conditions and at the frequency of measurement may then be expressed in db as $20 \log \frac{E_1}{E_2}$ (see 3.1).

5.2.2.1 *Multiple-circuit components.* The insertion loss of each circuit of a multiple-circuit component shall be measured with each of the other circuits open and also with each of the other circuits short circuited; the short-circuit connections shall be as short and direct as possible. The insertion loss of the circuit at the frequency of the test shall be considered to be equal to the lesser of the two measurements.

5.2.2.2 *Test circuit for rapid measurement.* The test circuit for rapid measurement as shown on figure 2, 3, 5, or 6 may be used to facilitate the change from the filter-out condition to the filter-in condition. The coaxial switches shall be in accordance with 4.2.3.

5.2.2.3 *Full-load insertion-loss measurements.* Full-load insertion-loss measurements shall be performed as shown on figure 4. 5, or 6 over the frequency range of 100 kc to 20 mc, inclusive. The equipment specified in 4.2.5.1.1 shall be used for coaxial connections. The nominal dc rated current of dc components, or the dc equivalent of the peak alternating-current (ac) rated current of ac components shall be applied during these tests.

5.2.2.4 *No-load insertion-loss measurements.* No-load insertion-loss measurements shall be performed as shown on figure 1, 2, or 3. The equipment specified in 4.2.5.1.2 shall be used for coaxial connections.

Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be ob-

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