DETERMINATION OF PREFABRICATED LINE LENGTHS FOR CAA LOCALIZERS

By

S E Taggart and V E Willey
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DETERMINATION OF PREFABRICATED LINE LENGTHS FOR C. A A LOCALIZERS

SUMMARY

This Report covers a series of tests conducted at Reading, Pennsylvania, during the latter part of 1946 to determine proper lengths of R. F tie-lines and matching stubs for use with an eight-loop localizer antenna system. The loops used were type CA-1220 which feature a built-in quarter-wave matching transformer. The transmission line was Amphenol type RG-8/U using moulded Tee junctions. It was hoped that the moulded Tee junctions and transmission line would be sufficiently uniform to permit prefabricating the tie-lines, stub positioning length and matching stub, for any pair of loops, as one complete unit

As a result of the early part of these tests, it was decided to discontinue the use of moulded Tee junctions in favor of type UG-28/U metallic fittings. Tests conducted using type UG-28/U and type UG-21B/U fittings in conjunction with RG-8/U transmission line indicate that standing wave ratios can be of low value when tie-lines, stub positioning lengths and matching stubs all are pre-cut for any of the six localizer frequencies. It was found possible to use one compromise set of tie-lines for the entire range of 108 3 to 110 3 megacycles.

DISCUSSION

This project was more or less of a repetition of work performed by the writers at the southwest localizer at Indianapolis in the early part of 1946. There are, however, several important differences

1 The loops used were a new type manufactured by Air Associates of Los Angeles, California These newer loops were especially designed for the localizer band of frequencies, 108.3 to 110 3 megacycles, and included a quarter-wave transformer which matched the impedance of a loop to the impedance of the transmission line (See Fig 1)

2 Type RG-8/U instead of type RG-11/U transmission line was to be employed.

3 Moulded Tee junctions were to be used at the junction of the two tie-lines and at the junction of the matching stub, stub positioning length and feed line It was hoped that the moulded Tees and the type RG-8/U transmission line would be sufficiently uniform to permit prefabricating a given set of tie-lines, stub positioning length, and the matching stub as an integral unit

4. Type "N" fittings were to be substituted for the Amphenol "83" series which had been used on previous installations.

A. Tests of Loops

The eight loops to be used in the Reading installation were arbitrarily designated 3SL, 2SL, 1SL, CL, CR, 1SR, 2SR, and 3SR before any checks were made, either of individual patterns or of standing wave ratios (See Fig 2). In the final installation the loops were placed in the above order, loop 3SL being the left loop of the third sideband pair when the observer was facing the runway For checking field patterns, the on-course monitor of the installation was put in service A crystal detector was used instead of the diode detector of the monitor because of the more linear characteristics of the former. Calibration was accomplished by placing a "hang-on" meter on a loop, varying the transmitter power, and plotting monitor readings against corresponding antenna current readings. (See Fig. 3) To take a field pattern of a given loop, the loop was rotated in 15-degree steps and monitor readings and corresponding loop bearings were recorded. Maximum deviation from circularity was found to be less than 3 5 percent After the check of the field pattern of a loop was completed, the standing wave ratio in the transmission line feeding the loop was determined (See Table I)

B. Tests of Tie-Lines Using Moulded Tee Junctions

After all checks of individual loops were completed, the loops were mounted in their permanent locations and tests to determine proper tie-line lengths were started A length of RG-8/U cable approximately 22 feet long was connected to one of the third sideband loops while power was applied to the carrier loops.

A "hang-on" meter was used to measure currents on the four faces of the third sideband loop and short lengths were then cut from the open end of the line connected to this loop A curve was drawn plotting loop current against line length and the length of line producing the minimum amount of parasitic current was determined from the curve When the third sideband tie-line was made, each half was cut one quarter wave length longer than the length of the open line which gave minimum parasitic current in the third sideband loop A similar procedure was used to determine the lengths of the tie-lines for the other pairs of loops except that when the length of the carrier tie-line was determined, power was applied to the first sideband loops and parasitic currents were measured in the carrier loop being used in the test.

C. Tests for Electrical Equivalence of the Two Halves of a Given Tie-Line

Several methods of testing a tie-line for electrical equivalence of its two halves were tried and rejected in favor of the simple procedure of measuring the location of the on-course null of a given pair of excited loops Power was applied to the pair of loops under consideration, and the null determined with respect to the center-line of the runway. The tie-line was then reversed and the location of the null again determined If the locations of the nulls coincided, the two halves of a tie-line would be considered equivalent electrically If the locations of the nulls did not coincide, the electrically longer half of the tie-line being tested was shortened by small amounts until the proper condition was obtained. This procedure was applied to all three sideband loop tie-lines. With the field strength meter used for locating nulls, it was possible to make repeat readings which coincided within two inches at a point 500 feet from the antenna array.

Testing the carrier tie-line for electrical symmetry presented a slightly different problem because the field strength pattern of the carrier loops does not have a null, moreover, the carrier tie-line was too short to be used temporarily on the first sideband loops while power was applied to the carrier loops through another symmetrical tie-line The method finally used to test the carrier tie-line was to leave it connected in the normal manner to the carrier loops and to measure parasitic currents in the first sideband loops. The carrier tie-line was then reversed and parasitic currents in the first sideband loops were again measured. These data are shown in Table II It will be noted that with line C1 connected to loop CL, the parasitic current was approximately the same in each of the first sideband loops. The carrier tie-line was left with end C1 connected to loop CL and with end C2 connected to loop CR and readings made of parasitic currents in all sideband loops at the six localizer frequencies. These readings are shown in Table III

In connection with the tests for electrical equivalence of the two halves of a given tie-line, it was observed that the nulls did not remain fixed in location, but that they appeared to go through a definite cycle during a 24-hour period. It should be noted that the nulls of a given pair of loops did not shift materially with respect to each other, but that the shift was with respect to the center-line of the runway. It was observed that the nulls of the first sideband loops always shifted oppositely to those of the second and third sideband loops. Extensive tests indicated the probable cause of the shifting of the nulls of the loop pairs to be due to the effects of temperature variation.

After the tie-lines had been adjusted so that the two halves of each line were electrically equivalent, the physical lengths were checked In no case were the two halves of any tie-line equal and in the case of the first sideband tie-line, the difference in length of its two halves was nearly one inch, which approximates an electrical length of five degrees at 109 megacycles (See Table IV)

D. Test of Tie-Lines Using Metallic Tee Connectors

New sets of tie-lines were then made for the first and the second sideband loops, but this time type UG-28/U Tee connectors were used instead of the moulded Tee junctions The two halves of each tie-line were cut to exactly equal physical lengths and terminated in type UG-21B/U plugs Checks of the positions of the nulls of the driven loops agreed to within two inches at a distance of 500 feet when the tie-lines were reversed, so it could be assumed that the two halves of each tie-line were substantially equal electrically

Because of the discrepancy in physical lengths of the electrically equal halves of the various tie-lines made with moulded Tee junctions and, because of the close agreement in the electrical lengths of the physically equal halves of the first and second sideband loop tie-lines made with type UG-28/U Tee connectors and type UG-21B/U plugs, it was decided to fabricate new tie-lines using type UG-28/U Tee connectors, type UG-21B/U plugs, and type RG-8/U transmission line, and to make no further effort, at the time, to employ tie-lines using moulded Tee junctions.

After new tie-lines, using type UG-28/U Tee connectors and type UG-21B/U plugs, had been made for the third sideband loops and the carrier loops, a complete set of parasitic current readings was taken These data are shown in Table V

The tie-line lengths were then adjusted in small amounts until parasitic currents were approximately the same at both ends of the band Final values are shown in Tables VI and VII The high frequency end of the band was favored slightly because experience has shown that there is a slight tendency toward aging. Whether aging is due to changes in the loops or changes in the tie-lines was not definitely determined, although there is some evidence to show that the change is not in the tie-lines

E. Matching Tie-Lines to Feed Lines

After the lengths of the tie-lines had been determined, matching of the feed lines between the Tee connector and the transmitter was done After matching, the maximum observed standing wave ratio was 1 03 During the matching process, all unused loops and tie-lines were in place. Unused loops were not shorted out because it was believed desirable to flatten the tie-lines under the conditions in which they would be used. Data pertaining to this operation are found in Table VIII Matching was done at an average temperature of approximately 20 degrees F Physical lengths were checked at approximately 75 degrees F

Two new sets of tie-lines were then cut, using the data appearing in Table VI The values of parasitic current measured with these tie-lines substituted for the original tie-lines is given in Tables IX, X, XI, and XII

Using the data appearing in Table VIII, matching stubs and stub positioning lengths were fabricated for 109 5 megacycles and 110 3 megacycles When these were used in conjunction with the new sets of tie-lines referred to above, the maximum standing wave ratio measured was 1 07 while the average was approximately 1 05 A check of the positions of the nulls of the three sideband loop pairs showed a separation of about six inches at a distance of 500 feet Such a small difference in the position of the nulls can be tolerated easily, it can also be used to advantage to place the null on, or nearer to, the center-line of the runway in case the center-line of the antenna array is not quite normal to the center-line of the runway.

F Fabrication of Tie-Lines

Experience has demonstrated that accurate measurements are required if duplication of lines is to be accomplished

Holding the cable straight while measurements are made removes the greatest source of error This is done by placing the cable in a grooved "two-by-four" a little longer than the longest section of transmission line to be made When the cable used is Amphenol type RG-8/U, the groove is made 7/16 inch wide and 1/4 inch deep

The end of the cable should have a clean, square cut which does not disturb the symmetry of the dielectric and leaves the inner conductor free of burrs This is best accomplished by using a knife to cut the transmission lines

Errors can be further reduced by fitting a plug on one end of the cable before cutting it to exact length Assuming that a plug has already been fitted on one end of the cable, the cable is then cut 1/2 inch shorter than the required overall length of the finished transmission line A type UG-21B/U plug adds 1/2 inch to the length of the unfinished transmission line

The procedure used by the writers in preparing the cable end and assembling the plug is as follows

(1) The jam nut, the friction ring, and the gasket are placed on the transmission line in the order named

(2) The vinyl jacket is removed for a distance of 1/2 inch from the end of the transmission line. Care is exercised to obtain a true, smooth cut without damage to the braided copper shielding

(3) The collar is then placed over the braided copper shielding using care to have every strand of the braid through the collar. The braided shielding is then folded back over the collar and trimmed as shown in Fig. 4.

(4) Three-sixteenths of an inch of the polyethylene dielectric is removed from the end of the transmission line This is done carefully so as not to damage the inner conductor

(5) The exposed end of the inner conductor is then tinned Speed is essential in order to avoid overheating of the polyethylene dielectric.

(6) A small amount of solder is flowed into the needle The tinned end of the inner conductor of the transmission line is then pushed into the needle as far as it will go while the needle is kept hot. The needle is heated no longer than necessary, so that excessive softening of the polyethylene dielectric is avoided.

(7) As soon as the polyethylene dielectric has hardened, the remaining flux and the pinpoint of solder are removed from the needle. Usually the needle has been pushed into the polyethylene a slight amount. The dielectric is trimmed flush with the end of the needle so as to give a clean, square shoulder The prepared end of the cable is then pushed into the shell portion of the plug until the dielectric of the cable contacts the dielectric in the shell.

(8) The gasket and the friction ring are pushed into the shell by means of a blunt tool (See Figs 5 and 6) The jam nut is screwed into the shell snugly but not so tightly as to distort the transmission line or to ruin the gasket. At this point, the overall length is checked and the finished line is inspected for proper assembly

If the point of the needle protrudes too far beyond the guide portion of the plug, the fitting with which it is used may be irreparably damaged. If the point of the needle does not extend nearly to the end of the guide portion of the plug, no contact, or intermittent contact, may result when the plug is used with its companion fitting.

Occasionally, a small metallic thread is found inside the guide portion of the plug These threads are formed during the manufacture of the plug When the line is checked with a megger, their presence is easily detected

CONCLUSION

The results obtained at Reading, Pennsylvania, using prefabricated lines of the lengths listed in Table VIII show considerable promise. Standing wave ratios as measured on the feed lines were found to be approximately 1 07 and no attempt was made to improve them Parasitic current ratios in the various loops are high at the center of the localizer band of frequencies, and reasonably high at the two ends of the localizer band Some improvement in the parasitic current ratios at the ends of the localizer band of frequencies could be obtained through the use of two sets of tie-lines, one peaking at approximately 108 7 megacycles, the other at approximately 109 9 megacycles Although this would result in doubling the parasitic current ratios at the ends of the band, the present values appear to be acceptable

TABLE I

TESTS OF INDIVIDUAL LOOPS - READING LOCALIZER

Loop	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
Standing Wave Ratio								
108.3 mc.	-	-	-	-	-	1.87	-	2.0
109.5 "	-	-	-	-	-	1.065	-	-
110.3 "	1.56	1.56	1.59	1.45	1.53	1.81	1.49	1.69
Circularity of Pattern								
108.3 mc.								
Maximum	-	-	-	-	-	450	-	430
Average	-	-	-	-	-	435	-	420
Minimum	-	-	-	-	-	427	-	412
109.5 mc.								
Maximum	-	-	-	-	-	440	-	-
Average	-	-	-	-	-	427	-	-
Minimum	-	-	-	-	-	420	-	-
110.3 mc.								
Maximum	473	464	450	467	452	450	434	432
Average	462	453	440	457	440	439	425	426
Minimum	455	446	434	451	435	430	420	420

CURRENTS IN LOOP FACES AS INDICATED BY "HANG-ON" METER

	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108.3 mc.								
Face 1	-	-	-	-	-	110	-	110
2	-	-	-	-	-	106	-	111
3	-	-	-	-	-	109	-	108
4	-	-	-	-	-	111	-	109
109.5 mc								
Face 1	-	-	-	-	-	110	-	-
2	-	-	-	-	-	111	-	-
3	-	-	-	-	-	107	-	-
4	-	-	-	-	-	111	-	-
110.3 mc.								
Face 1	110	110	110	110	110	110	110	
2	113	112	110	106	108	110	110	
3	111	110	108	108	109	109	109	108
4	111	111	111	107	107	111	109	110

All of the above values are comparative only.

TABLE II

Parasitic Currents Measured in the First Sideband Loops With the Carrier Loops Energized Tie-Lines Using Moulded Tee Junctions Reading, Pennsylvania, Localizer

Line C1 to Loop CL			Line C1 to Loop CR		
Face	Loop 1 SL	Loop 1SR	Face	Loop 1SL	Loop 1SR
1	96	95	1	95	109
2	118	116	2	104	120
3	112	108	3	104	112
4	109	117	4	106	120
Totals	435	436	Totals	409	461

TABLE III

Parasitic Currents in Sideband Loops of Reading Localizer Using Tie-Lines With Moulded Tee Junctions Lines Trimmed to Give Electrical Equality of Halves

Freq	Face	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108 3	1	50	30	162	1500	1640	166	30	38
"	2	40	40	168	1640	1560	182	30	48
"	3	40	35	178	1640	1600	176	40	42
"	4	48	40	180	1480	1640	168	30	38
		178	145	688	6260	6440	692	130	166
108.7	1	43	22	124	1640	1800	130	20	35
"	2	35	30	150	1840	1760	142	22	44
"	3	38	30	142	1800	1720	138	32	38
"	4	44	35	136	1680	1820	144	20	35
		160	117	552	6960	7100	554	94	152
109 1	1	38	20	112	1720	1880	120	10	25
"	2	30	10	125	1960	1840	128	25	38
"	3	30	10	125	1900	1800	124	38	30
"	4	38	30	125	1800	1960	124	10	22
		136	70	487	7380	7480	496	83	115
109 5	1	30	40	98	1780	1920	96	30	15
"	2	18	20	120	2000	1880	115	40	30
"	3	20	20	115	1920	1880	108	50	25
"	4	25	50	112	1840	2020	115	30	20
		93	130	445	7540	7700	434	150	90
109 9	1	20	67	80	1680	1840	68	50	0
"	2	0	45	95	1840	1760	102	70	22
"	3	0	46	91	1880	1780	95	74	20
"	4	20	72	95	1680	1860	90	55	0
		40	230	361	7080	7240	355	249	42
110 3	1	28	100	70	1720	1900	30	87	20
"	2	20	78	72	1880	1800	92	105	36
"	3	20	80	60	1890	1800	88	108	38
"	4	36	105	76	1720	1900	50	86	20
		104	363	278	7210	7400	260	386	114

Parasitic Current Ratios
Total Current in Carrier Loops to Currents in Sideband Loops

Freq.	First Sideband Loops			Second Sideband Loops			Third Sideband Loops		
	1SL	1SR	1SL + 1SR	2SL	2SR	2SL + 2SR	3SL	3SR	3SL + 3SR
108.3	18 5	18 4	9.2	87 6	97.9	46.2	71.3	76 5	37 0
108 7	25 5	25 4	12 7	120.2	149.6	66 6	87 9	92 5	45 1
109 1	30 5	30 0	15.1	212 3	179 0	97.1	109.3	129 2	59.4
109 5	34 3	35.1	17 3	117 3	101.6	54 4	163 9	169 3	83 3
109 9	39 7	40 3	20 0	62.3	57.6	30 0	358 0	340.9	174.6
110.3	52 6	56.2	27.2	40.2	37.8	19.5	140 5	128 1	67.0

TABLE IV

Lengths of Tie-Lines, Using Moulded Tee Junctions Each Half of a Given Tie-Line Trimmed to be Electrically Equivalent to the Other. Reading, Pennsylvania, Localizer.

Line	Length (inches)
3S1	266-1/16
3S2	265-11/16
2S1	195-5/8
2S2	195
1S1	87-19/32
1S2	86-21/32
C1	52-5/16
C2	52-3/16

TABLE V

Parasitic Currents in Sideband Loops of Reading Localizer Using RG-8/U Tie-Lines, UG-28/U Connectors and UG-21B/U Plugs Initial Overall Lengths, Halves of Each Line Approximately Equal Physically

Freq	Face	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108 3	1	48	55	52	1380	1440	48	86	52
"	2	44	66	58	1480	1360	82	84	57
"	3	44	60	52	1520	1400	76	88	52
"	4	46	62	50	1380	1440	48	78	48
		182	243	212	5760	5640	254	336	209
108.7	1	46	42	64	1530	1580	38	74	45
"	2	40	50	50	1640	1520	78	70	50
"	3	40	45	40	1700	1520	68	76	42
"	4	42	50	56	1500	1600	30	64	42
		168	187	210	6370	6220	214	284	179
109 1	1	40	30	86	1575	1640	38	52	30
"	2	30	35	57	1720	1560	68	50	30
"	3	30	25	42	1720	1580	60	50	25
"	4	40	40	70	1560	1640	30	45	25
		140	130	255	6575	6420	196	197	110
109.5	1	30	30	111	1540	1640	66	30	20
"	2	20	20	70	1680	1520	73	30	20
"	3	20	10	86	1680	1560	68	40	10
"	4	30	38	98	1520	1640	50	25	15
		100	98	365	6420	6360	257	125	65
109 9	1	25	45	140	1480	1560	110	20	5
"	2	5	20	94	1600	1480	114	25	25
"	3	5	22	104	1640	1500	116	30	25
"	4	25	50	130	1480	1580	90	20	5
		60	137	468	6200	6120	430	95	60
110.3	1	25	56	240	1480	1560	224	30	20
"	2	10	40	180	1600	1480	240	45	30
"	3	10	40	200	1640	1490	240	46	35
"	4	30	60	220	1480	1600	196	40	20
		75	196	840	6200	6130	900	161	105

Parasitic Current Ratios
Total Current in Carrier Loops to Currents in Sideband Loops

Freq.	First Sideband Loops			Second Sideband Loops			Third Sideband Loops		
	1SL	1SR	1SL + 1SR	2SL	2SR	2SL + 2SR	3SL	3SR	3SL + 3SR
108.3	53.7	44 9	24 5	47 0	34.0	19 7	62 7	54 6	29 2
108.7	60 0	58 7	29.7	67 3	44.3	26 8	75.0	70.3	36 3
109 1	51 0	66.4	28 9	100 0	65 9	39 9	92 8	118 0	52 0
109.5	35 0	49 7	20.5	130 0	102.0	57 3	128.0	197.0	77 4
109 9	26.4	28 7	13.8	90.0	130.0	53 2	205.0	205 0	103 0
110 3	14 7	13 7	7 1	63 0	76 6	34 6	164 0	117 4	68 5

Tie-Line Lengths

Line	C1	C2	1S1	1S2	2S1	2S2	3S1	3S2
Length (inches)	86-9/16	86-17/32	88-9/32	88-11/32	194-5/32	194-3/16	265-1/4	265-1/4

TABLE VI

Parasitic Currents in Sideband Loops of Reading Localizer Using RG-8/U Tie-Lines, UG-28/U Connectors and UG-21B/U Plugs Lines Cut to Final Overall Lengths, Halves of Each Line Approximately Equal Physically.

Freq	Face	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108 3	1	40	50	86	1360	1490	78	60	40
"	2	36	56	95	1500	1410	100	60	46
"	3	38	54	91	1540	1410	90	62	40
"	4	38	54	93	1380	1500	75	58	40
"		152	214	365	5780	5810	343	240	166
108 7	1	38	48	93	1720	1820	72	55	38
"	2	38	54	93	1900	1740	100	55	44
"	3	38	48	88	1920	1740	83	58	35
"	4	40	50	100	1700	1820	60	52	38
"		154	200	374	7240	7120	315	220	155
109 1	1	25	30	69	1520	1640	38	40	20
"	2	22	30	55	1700	1580	76	40	25
"	3	22	24	50	1680	1580	62	42	22
"	4	25	35	77	1580	1660	32	39	22
"		94	119	251	6480	6460	208	161	89
109 5	1	20	20	55	1720	1840	30	20	15
"	2	5	15	25	1920	1800	45	22	20
"	3	5	10	22	1940	1760	48	35	20
"	4	10	36	58	1740	1900	42	20	10
"		40	81	160	7320	7300	165	97	65
109 9	1	30	46	78	1600	1740	45	20	20
"	2	15	22	22	1800	1640	70	38	25
"	3	18	30	20	1820	1660	70	46	35
"	4	30	56	84	1620	1760	60	22	18
"		93	154	204	6840	6800	245	126	98
110 3	1	54	76	111	1600	1680	94	56	42
"	2	40	56	50	1720	1610	118	67	46
"	3	42	60	50	1730	1600	121	70	57
"	4	55	84	114	1620	1720	93	57	38
"		191	276	325	6670	6610	426	250	183

Parasitic Current Ratios
Total Current in Carrier Loops to Currents in Sideband Loops

Freq.	First Sideband Loops			Second Sideband Loops			Third Sideband Loops		
	1SL	1SR	1SL + 1SR	2SL	2SR	2SL + 2SR	3SL	3SR	3SL + 3SR
108.3	31 8	33.8	16.4	54.2	48 3	25.6	76 3	70 0	36 5
108 7	38 4	45 6	20.9	71.8	65 3	34 2	93.2	92 6	46 4
109 1	51.6	62 3	28 2	108 7	80.4	46 2	137 8	145 6	70 8
109 5	91 5	88 7	45.1	181 0	151.0	82 3	366.0	225 0	139 4
109 9	66.9	55 8	30 4	88 5	108 2	48.7	147 0	139.3	71 4
110.3	40.8	31.2	17 7	48 1	53.2	25.2	69 4	72 5	35.5

Tie-Line Lengths

Line	C1	C2	1S1	1S2	2S1	2S2	3S1	3S2
Length (inches)	51-9/16	51-5/8	87-1/2	87-1/2	194	194	264-31/32	265

TABLE VII

Parasitic Currents in Carrier Loops of Reading Localizer Using RG-8/U Tie-Lines, UG-28/U Connectors and UG-21B/U Plugs. Lines Cut to Final Overall Lengths, Halves of Each Line Equal Physically

Freq.	Face	1SL	CL	CR	1SR
108.3	1	1140	42	95	1200
"	2	1200	106	58	1210
"	3	1180	98	60	1220
"	4	1160	42	94	1200
"		4680	288	307	4830
108 7	1	1220	37	90	1260
"	2	1240	110	58	1260
"	3	1260	98	57	1280
"	4	1240	38	91	1240
"		4960	283	296	5040
109 1	1	1280	22	85	1320
"	2	1320	115	60	1360
"	3	1300	95	58	1360
"	4	1300	34	93	1340
"		5200	266	296	5380
109.5	1	1860	15	30	1860
"	2	1860	48	30	1900
"	3	1820	35	22	1880
"	4	1840	20	30	1860
"		7380	118	112	7500
109.9	1	1760	48	30	1800
"	2	1780	100	80	1840
"	3	1800	72	65	1860
"	4	1800	64	50	1800
"		7140	284	225	7300
110.3	1	1840	82	20	1880
"	2	1880	80	110	1960
"	3	1840	52	84	1980
"	4	1880	88	40	1960
"		7440	302	254	7780

Parasitic Current Ratios - Total Current in First Sideband Loops to Currents in Carrier Loops

Freq.	Carrier Loops		
	CL	CR	CL - CR
108.3	33.1	31.0	16 0
108 7	35.3	33.8	17 3
109.1	39.7	35.7	18.8
109.5	126.0	133.0	64 8
109.9	50.8	64.2	28.4
110 3	50.4	60.0	27.4

	Tie-Line Lengths			
Line	C1	C2	1S1	1S2
Lengths (inches)	51-9/16	51-5/8	87-1/2	87-1/2

TABLE VIII

Tie-Lines, Stub Positioning Lengths and Matching Stubs, Reading Localizer

Carrier Loops	108.3	108 7	109 1	109.5	109.9	110.3
Standing Wave Ratios						
Unmatched	6.0	4.5	3 75	3 1	2.84	2.68
Matched	1.02	1.03	1 02	1 02	1 02	1.02
Lengths (in inches)						
Tie-Line (A)	51-5/8	51-5/8	51-5/8	51-5/8	51-5/8	51-5/8
Stub Position (B)	37-5/16	37-7/16	37-7/8	38-5/16	39-1/4	39-11/16
Matching Stub (C)	11-11/16	10-15/16	10-1/16	9-1/16	8-5/16	8-1/16
First Sideband Loops						
Standing Wave Ratios						
Unmatched	3 75	2 92	2 21	1.88	2.0	2.4
Matched	1 02	1 02	1 02	1 005	1 02	1 03
Lengths (in inches)						
Tie-Line (A)	87-1/2	87-1/2	87-1/2	87-1/2	87-1/2	87-1/2
Stub Position (B)	37-3/16	37-11/16	38-3/4	40-1/2	42-3/4	43
Matching Stub (C)	10-3/16	8-1/4	6-3/4	5	5-7/16	7-1/16
Second Sideband Loops						
Standing Wave Ratios						
Unmatched	3.35	2 55	2 3	2 31	2 62	3 28
Matched	1 01	1 02	1.02	1.02	1.02	1.03
Lengths (in inches)						
Tie-Line (A)	194	194	194	194	194	194
Stub Position (B)	38-3/4	39-1/4	40-3/4	41/3/16	41-5/8	41-1/8
Matching Stub (C)	9-1/4	7-13/16	6-15/16	6-7/8	7-13/16	8-13/16
Third Sideband Loops						
Standing Wave Ratios						
Unmatched	3 35	2.5	2.13	2.18	2 83	2.52
Matched	1 03	1 02	1 03	1.02	1.02	1 02
Lengths (in inches)						
Tie-Line (A)	265	265	265	265	265	265
Stub Position (B)	38-7/8	39-3/16	40-3/4	41-11/16	41-7/8	41-1/4
Matching Stub (C)	9-3/8	7-5/8	6-1/2	6-9/16	7-5/8	8-7/8

TABLE IX

Parasitic Currents in Sideband Loops of Reading Localizer Using Tie-Lines Intended for Installation at Tulsa Lengths of New Lines Determined from Previous Data (Table VI)

Freq	Face	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108 3	1	44	56	85	1240	1360	82	70	44
"	2	39	64	108	1360	1260	110	70	50
"	3	39	59	98	1360	1260	105	75	44
"	4	40	60	100	1260	1360	75	65	44
"		162	239	391	5220	5240	372	280	182
108.7	1	42	48	78	1460	1600	60	60	39
"	2	40	58	98	1640	1500	100	58	44
"	3	40	50	93	1680	1500	90	64	39
"	4	40	52	98	1470	1580	50	52	39
"		162	208	367	6250	6180	300	234	161
109 1	1	30	25	58	1480	1560	30	40	20
"	2	20	37	64	1600	1520	80	44	30
"	3	20	24	64	1600	1500	74	58	25
"	4	22	37	61	1500	1600	23	38	22
"		92	123	247	6180	6180	207	180	97
109.5	1	20	22	48	1490	1600	20	20	10
"	2	10	18	40	1640	1520	75	30	20
"	3	10	15	30	1610	1520	66	40	20
"	4	15	30	52	1520	1620	22	18	5
"		55	85	170	6260	6260	183	108	55
109 9	1	22	38	64	1520	1620	48	20	20
"	2	15	20	40	1640	1560	90	38	25
"	3	15	23	28	1640	1560	82	44	35
"	4	23	48	61	1540	1650	44	20	20
"		75	129	193	6340	6390	264	122	100
110 3	1	44	65	100	1380	1500	70	45	39
"	2	38	45	60	1520	1440	116	60	44
"	3	38	52	50	1500	1420	117	63	50
"	4	44	71	92	1400	1520	68	48	38
"		164	233	302	5800	5880	371	216	171

Parasitic Current Ratios
Total Current in Carrier Loops to Currents in Sideband Loops

Freq	First Sideband Loops			Second Sideband Loops			Third Sideband Loops		
	1SL	1SR	1SL + 1SR	2SL	2SR	2SL + 2SR	3SL	3SR	3SL + 3SR
108.3	26 8	28 1	13.7	43.8	37 4	20.2	64.5	57 5	30.4
108 7	34 0	41 5	18 7	59.8	53 2	28.2	76 8	77 3	38.5
109.1	50 1	59 8	27 2	100 5	68.7	40.8	134 5	127 7	65 4
109 5	73 8	68 5	35.5	147 6	106.2	64 9	228 0	228 0	114 0
109.9	66 0	48 3	27 9	98 8	104 3	50.8	170.0	127 3	72.8
110 3	38.6	31 5	17.4	50.1	54 0	26 0	71 2	68.2	34.8

Tie-Line Lengths

Line	C1	C2	1S1	1S2	2S1	2S2	3S1	3S2
Length (inches)	51-5/8	51-5/8	87-1/2	87-1/2	194	194	265	265

TABLE X

Parasitic Currents in Carrier Loops of Reading Localizer Using Tie-Lines Intended for Installation at Tulsa Lengths of New Lines Determined from Previous Data. (Table VII)

Freq.	Face	1SL	CL	CR	1SR
108.3	1	1120	50	90	1160
"	2	1160	123	60	1200
"	3	1160	111	62	1200
"	4	1160	48	100	1160
"		4600	332	312	4720
108 7	1	1240	35	78	1280
"	2	1280	118	55	1280
"	3	1280	110	50	1290
"	4	1280	35	85	1260
"		5080	298	268	5110
109 1	1	1400	38	72	1440
"	2	1440	123	50	1440
"	3	1440	106	50	1460
"	4	1420	35	82	1440
"		5700	302	254	5780
109.5	1	1640	38	54	1660
"	2	1680	114	65	1680
"	3	1640	94	50	1680
"	4	1660	39	64	1660
"		6620	285	233	6680
109 9	1	1840	55	30	1880
"	2	1880	105	80	1900
"	3	1900	76	65	1900
"	4	1900	58	39	1880
"		7520	294	214	7560
110 3	1	1600	60	40	1600
"	2	1600	60	88	1640
"	3	1620	50	75	1640
"	4	1600	68	40	1600
"		6420	238	243	6480

Parasitic Current Ratios
Total Current in First Sideband Loops to Currents in Carrier Loops

Freq.	Carrier Loops		
	CL	CR	CL + CR
108 3	28 0	29.8	14.5
108.7	34 2	38.0	18.0
109 1	38 0	45 2	20 7
109 5	46 7	57.2	25 7
109 9	51 3	70 4	29.7
110.3	54 3	53 1	26 8

Tie-Line Lengths

Line	C1	C2	1S1	1S2
Length (inches)	51-5/8	51-5/8	87-1/2	87-1/2

TABLE XI

Parasitic Currents in Sideband Loops of Reading Localizer
Using Tie-Lines Fabricated for Final Installation at Reading.
Lengths of New Lines Determined from Previous Data (Table VI).

Freq.	Face	3SL	2SL	1SL	CL	CR	1SR	2SR	3SR
108 3	1	48	60	96	1240	1320	91	72	42
"	2	42	67	106	1380	1280	109	68	48
"	3	42	62	106	1360	1260	105	74	44
"	4	45	64	108	1260	1340	84	65	42
"		177	253	416	5240	5200	389	279	176
108 7	1	40	45	100	1420	1540	75	55	30
"	2	39	52	98	1560	1480	95	54	40
"	3	38	45	90	1560	1480	92	58	35
"	4	40	52	105	1400	1520	70	50	36
"		157	194	393	5940	6020	332	217	141
109 1	1	35	30	73	1460	1560	45	39	20
"	2	28	39	60	1600	1500	70	40	30
"	3	25	30	61	1600	1480	60	45	22
"	4	30	40	79	1500	1600	39	35	22
"		118	139	273	6160	6140	214	159	94
109.5	1	22	22	64	1480	1580	35	20	15
"	2	10	20	30	1640	1520	52	25	20
"	3	10	15	25	1620	1520	44	38	20
"	4	20	30	63	1520	1620	25	20	10
"		62	87	182	6260	6240	156	103	65
109 9	1	20	35	65	1500	1600	50	20	20
"	2	10	15	20	1640	1520	72	38	22
"	3	5	20	15	1620	1520	68	44	30
"	4	20	44	65	1520	1640	44	22	15
"		55	114	165	6280	6280	234	124	87
110 3	1	40	65	93	1520	1640	80	44	42
"	2	32	44	38	1680	1560	110	60	42
"	3	30	50	30	1720	1560	110	64	50
"	4	42	70	88	1520	1660	75	50	35
"		144	229	249	6440	6420	375	218	169

Parasitic Current Ratios
Total Current in Carrier Loops to Currents in Sidebands Loops

Freq.	First Sideband Loops			Second Sideband Loops			Third Sideband Loops		
	1SL	1SR	1SL + 1SR	2SL	2SR	2SL + 2SR	3SL	3SR	3SL + 3SR
108 3	25 2	26.9	13 0	41 3	37 4	19.6	59 0	59 3	29.6
108.7	30 4	36.0	16 5	61 7	55 2	29 1	76 2	84.9	40.2
109 1	45 1	57 5	25 3	88.5	77 4	41.3	104 2	131 0	58 0
109 5	68 7	80.2	37.0	143 8	121.5	65.9	202.0	193.0	98 4
109 9	76 1	53 6	31 5	110 0	101 1	52.8	228 0	144 2	88 4
110 3	51 7	34.3	20.6	56 2	58 9	28 8	89.2	76 0	41 1

Tie-Line Lengths

Line	C1	C2	1S1	1S2	2S1	2S2	3S1	3S2
Length	51-5/8	51-5/8	87-1/2	87-1/2	194	194	265	265

TABLE XII

Parasitic Currents in Carrier Loops of Reading Localizer
Using Tie-Lines Fabricated for Final Installation at Reading.
Lengths of New Lines Determined from Previous Data. (Table VII).

Freq.	Face	1SL	CL	CR	1SR
108.3	1	1120	42	79	1180
"	2	1180	118	50	1200
"	3	1160	101	50	1200
"	4	1160	40	88	1160
"		4620	301	267	4740
108.7	1	1240	35	64	1280
"	2	1280	102	45	1280
"	3	1280	88	40	1300
"	4	1280	30	72	1280
"		5080	255	221	5140
109 1	1	1400	33	58	1440
"	2	1440	118	55	1480
"	3	1440	93	48	1480
"	4	1440	33	70	1440
"		5720	277	231	5840
109 5	1	1640	45	44	1680
"	2	1680	112	74	1720
"	3	1680	78	60	1720
"	4	1680	50	55	1680
"		6680	285	233	6800
109.9	1	1840	78	45	1860
"	2	1860	85	102	1880
"	3	1880	60	90	1880
"	4	1880	80	48	1860
"		7460	303	285	7480
110.3	1	1600	88	45	1600
"	2	1600	55	100	1640
"	3	1600	42	85	1640
"	4	1620	90	52	1600
"		6420	275	282	6480

Parasitic Current Ratios
Total Current in First Sideband Loops to Currents in Carrier Loops

Freq.	Carrier Loops			
	CL	CR	CL + CR	
108 3	31 1	35 1	16 5	
108 7	40 2	46 3	21 5	
109.1	41.8	50.1	22 8	
109 5	47 3	57 8	26 0	
109 9	49 4	52.5	25.5	
110 3	47 0	45 7	23 2	

Tie-Line Lengths

Line	C1	C2	1S1	1S2
Length (inches)	51-5/8	51-5/8	87-1/2	87-1/2

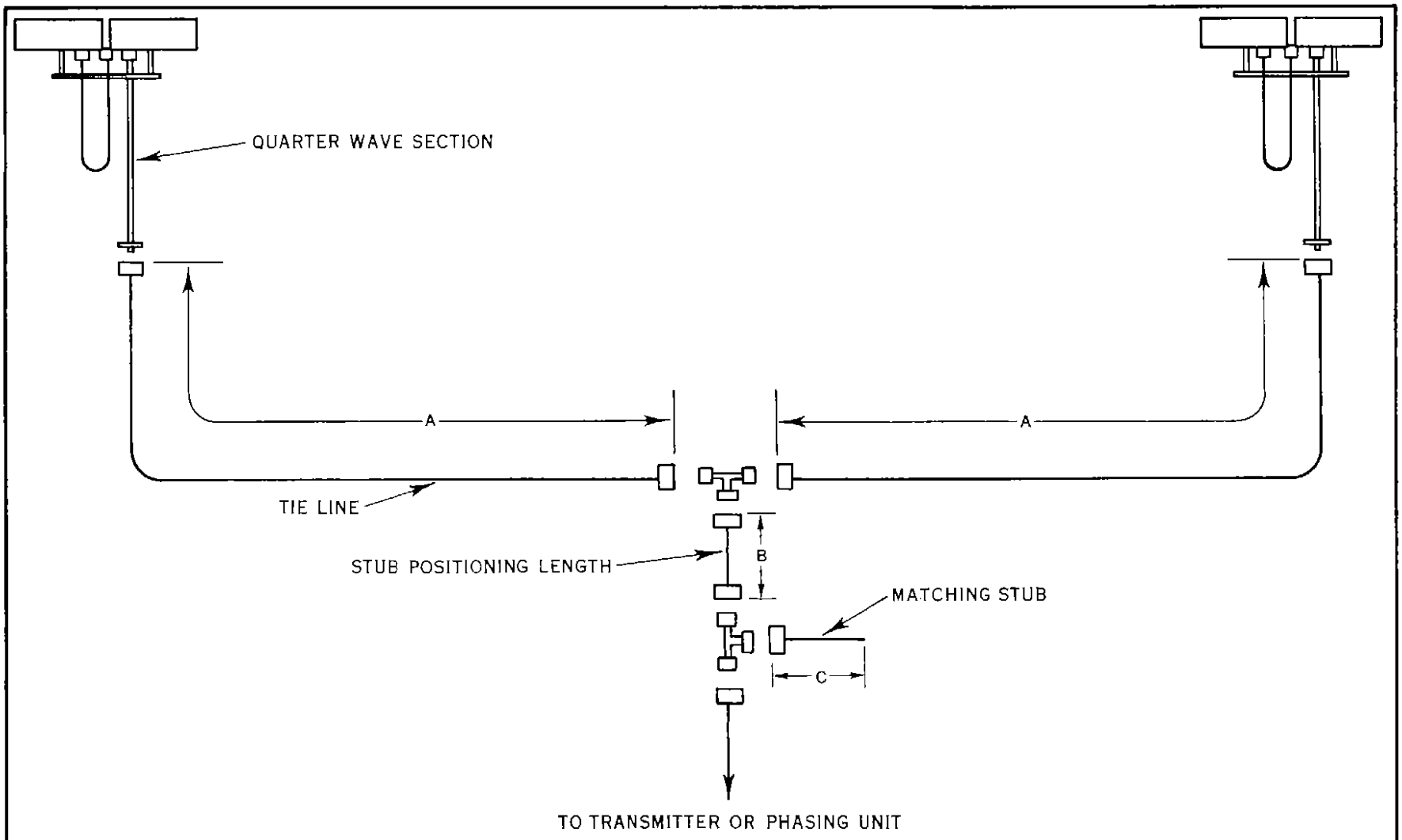

Figure 1. Details of Loops and Lines.

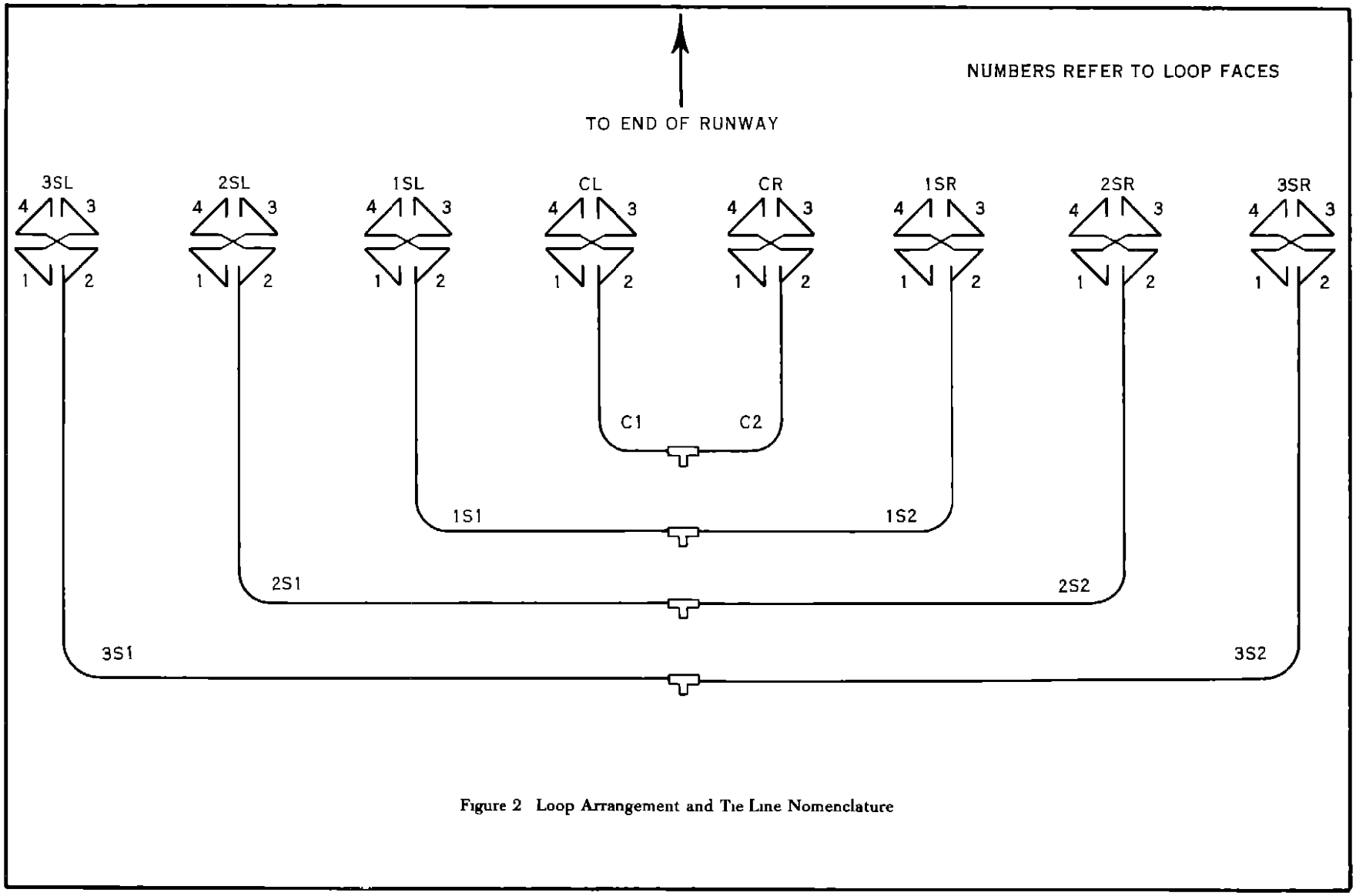

Figure 2 Loop Arrangement and Tie Line Nomenclature

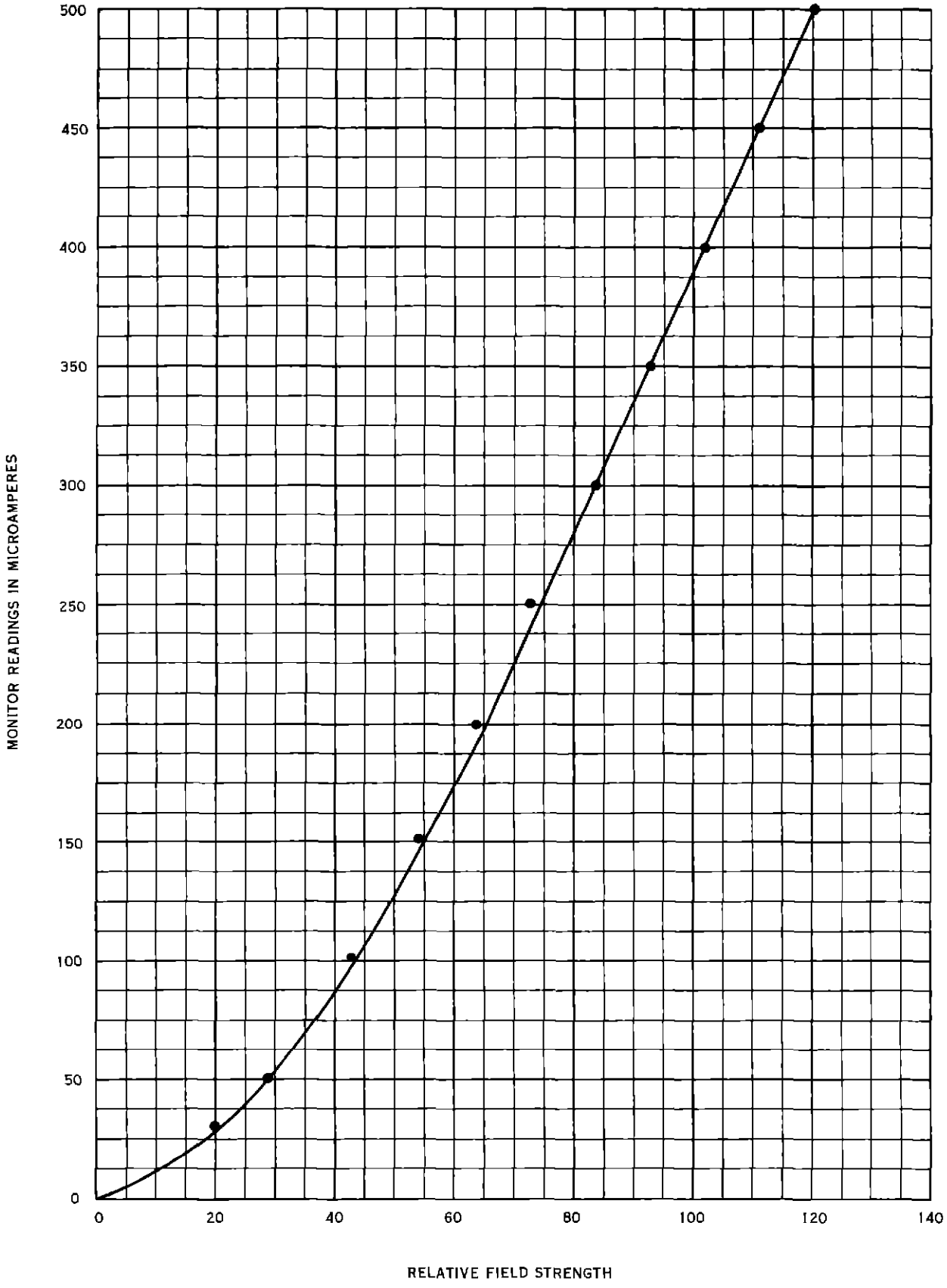

Figure 3 Calibration of Monitor – Reading Localizer

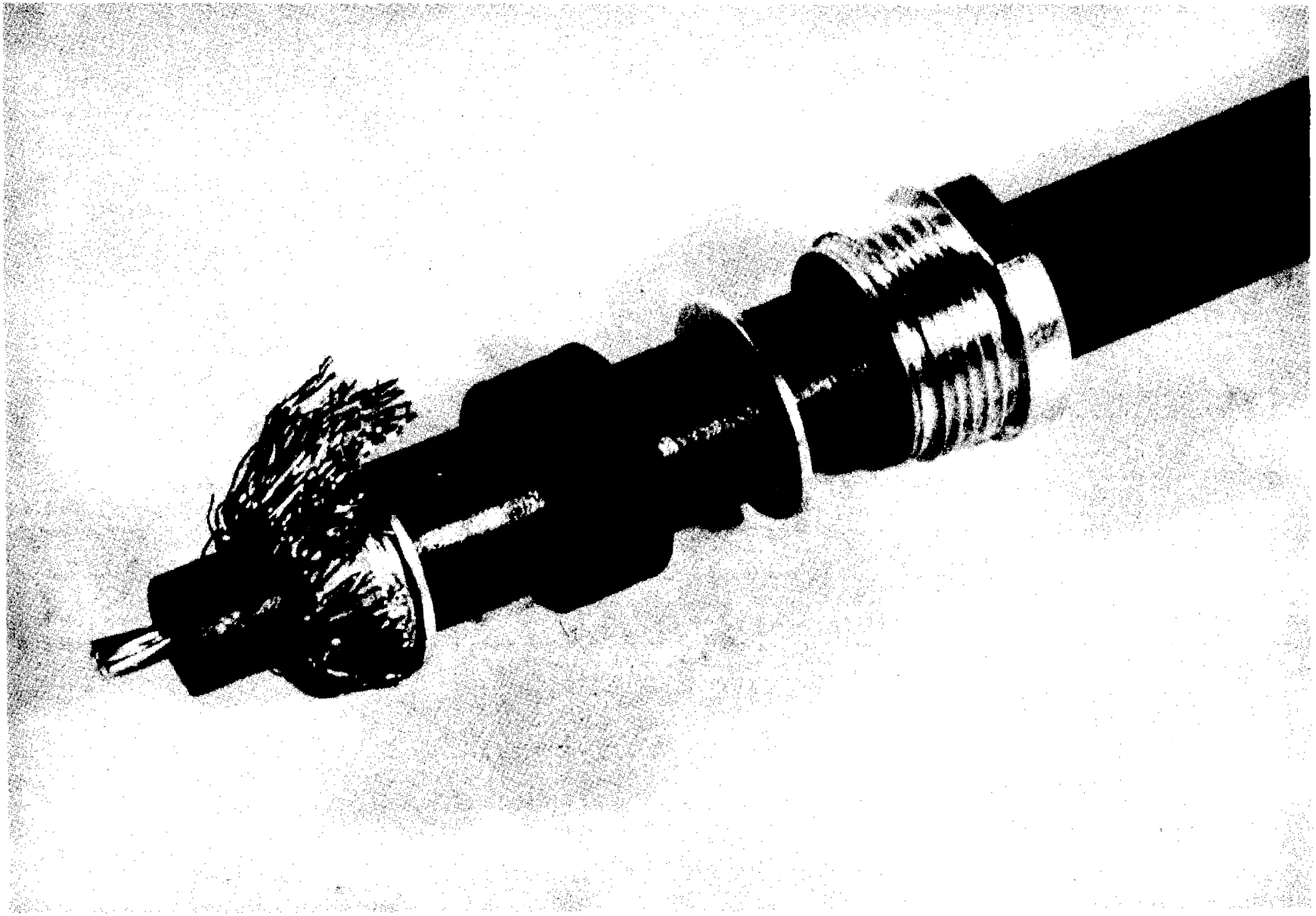

Figure 4. Unfinished Cable End Partially Trimmed.

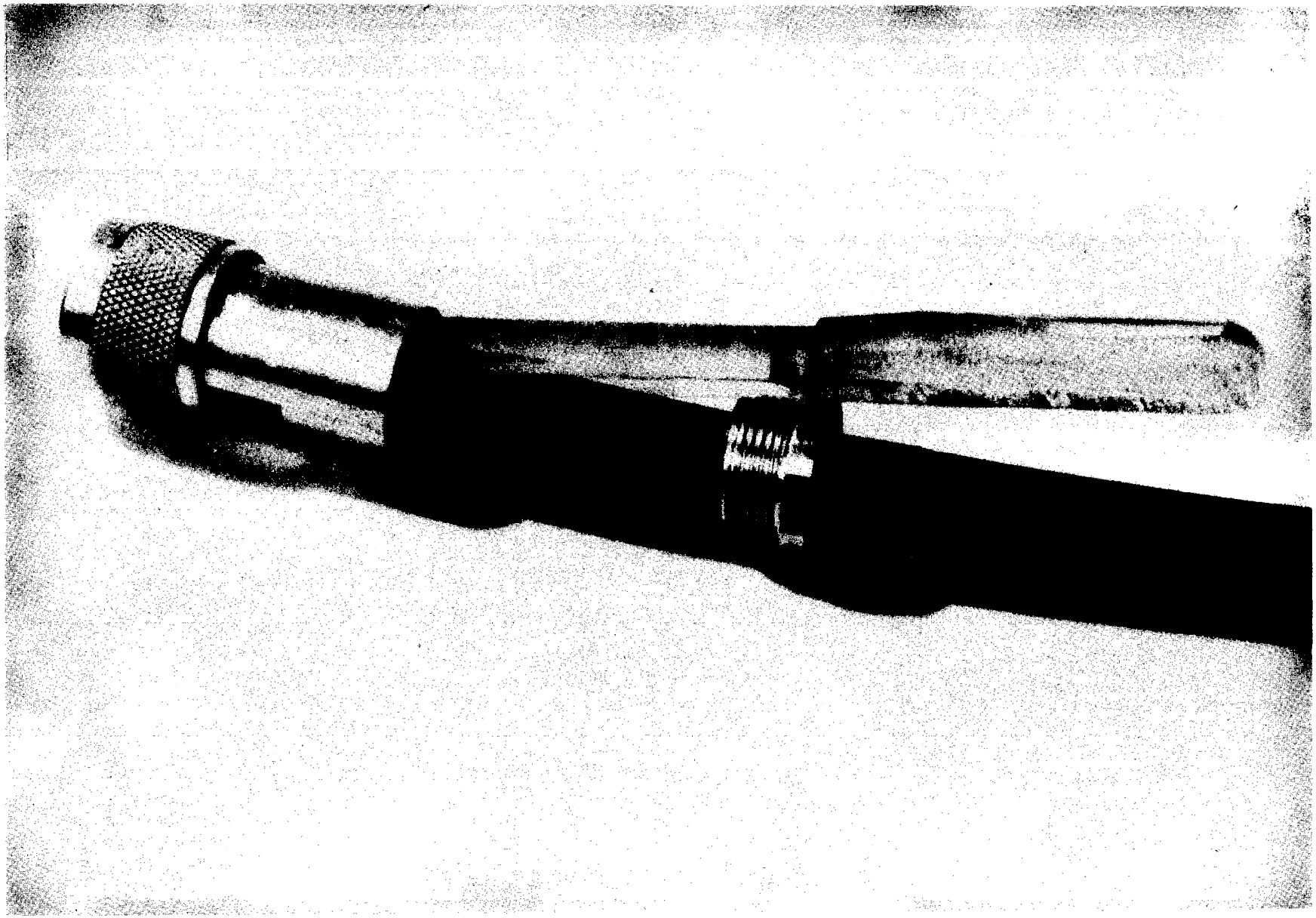

Figure 5. Seating Gasket and Friction Ring.

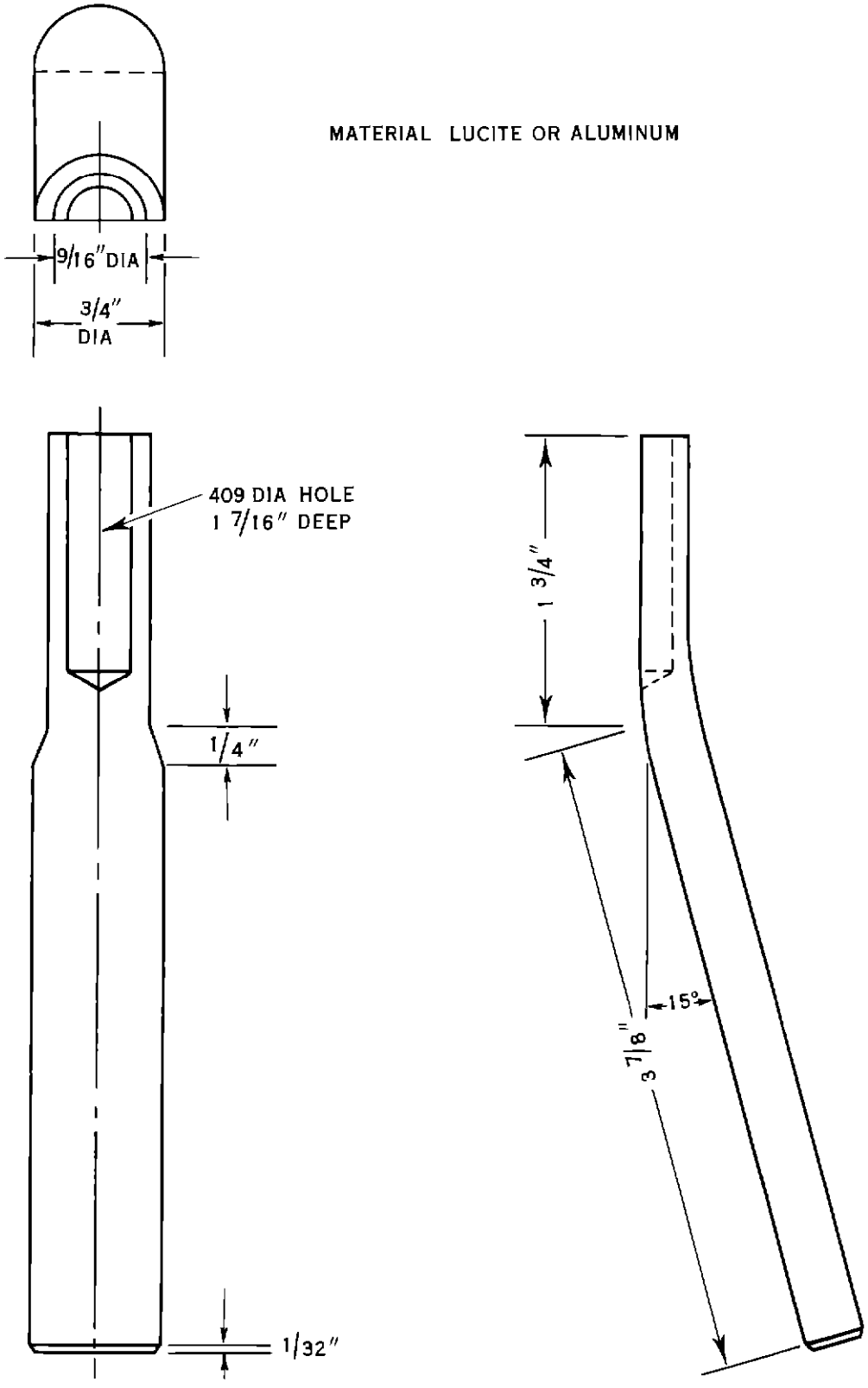

Figure 6 Gasket Placement Tool