CABLE TESTING
POLING FOR SIDE-SIDE CROSSTALK REDUCTION
3-POINT POLING

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1. GENERAL

1.01   This section describes a method of poling K carrier facilities at three splicing points per repeater section. The specifications for each specific job will indicate whether this method or some other method of poling is to be employed.

1.02   In this method, one pair of each quad is spliced "straight" at each poling point and a choice of poling is made in splicing the other pair of each quad at each poling point, these choices at the three poling points being coordinated simultaneously to give the best over-all side-to-side poling for the repeater section within each quad.

1.03   At each poling point, as well as at the other splicing points, the quads that are to be spliced together are selected on a "planned" basis as covered in the specifications for each project. If facilities are being unloaded for Type K service, the poling is done after the loading is removed. It is always done after the splices have been made at all points except the poling points.

1.04   Poling may be done independently on each group or complement of quads as it is being prepared for carrier service.

1.05   For poling, side-to-side measurements are made on each carrier quad, one pair being energized at either end of the repeater section regardless of the direction of Type K transmission, and the measuring equipment being applied at the other end. The measurements are essentially side-to-side far-end crosstalk measurements, but they are made with a capacity unbalance set and conductance unbalance attachment. Eight measurements are made on each quad, one for each of the combinations of wire connections that are possible with "straight" or "reversed" connections at each of the three poling points. These combinations are called poling patterns. From these measurements it is determined which poling pattern is most likely to result in the least far-end crosstalk coupling upon completion of all crosstalk balancing work. The quad is spliced according to this poling pattern.

2. CABLE ARRANGEMENTS FOR 3-POINT POLING

2.01   For the purpose of poling, each carrier repeater-section is divided into four approximately equal lengths in order to obtain three poling points. On cables in which the carrier quads have been spliced in accordance with capacitance unbalance measurements in each loading section, those voice-frequency loading points which are nearest the repeater-section quarter-points are used as the poling points. On cables in which the carrier quads have been spliced without capacitance unbalance measurements, those splices, whether loading splices or otherwise, which are nearest the quarter-points of the repeater-sections are used as the poling points.

2.02   The selection of quads to be spliced together at the poling points is made in accordance with the splicing plan for the particular cable involved. The purpose of poling is to determine the poling pattern that should be followed for each quad as it is spliced. One pair of the quad is spliced wire-to-wire and mate-to-mate while the other pair is spliced wire-to-wire and mate-to-mate or wire-to-mate and mate-to-wire, in accordance with the poling pattern selected for use.

2.03   The poling measurements are made between **the output sealed test terminal** at one end of the repeater section and **the cable terminal on the line side of the balancing coils** at the other end, **with the balancing panels disconnected.** The splice between the main or the lateral cable and the stub cable of the output sealed test terminal should be made on a temporary basis before the poling is started. After poling, this splice should be rearranged to bring the pair count and the tip and ring of each pair at the two ends of the repeater section into agreement. (The splice between the stubs of the input sealed test terminal and the cable terminal on the office side of the bal-

ancing coils is made on a planned basis, as covered in another section of practices.)

2.04   In order to make the crosstalk poling measurements, both pairs of each quad must be identified and tagged at each poling point. The cable pair numbers for the repeater section involved, as determined by the count at the cable terminal immediately adjacent to the section, should be used for this purpose. The pairs at the output sealed test terminal at the other end of the section should be temporarily designated with these same numbers.

2.05   In new cables all of the quads should be spliced temporarily at the poling points in accordance with the quad splicing plan before the poling measurements are started.

2.06   Wire and mate of Side 2 of each quad should be identified by cutting "long" and "short" wires at the poling points.

3. APPARATUS REQUIRED

3.01   Fig. 1 indicates schematically the apparatus required for poling and the method of connecting the various apparatus units. Poling is done at a frequency of 850 ± 50 cycles in order that existing voice-frequency apparatus units may be used. This particular testing frequency and a D-156721 filter are used in order that a satisfactory signal-to-noise ratio will be obtained with respect to certain sources of noise, such as 1000-cycle ringers and voice-frequency telegraph systems.

3.02   The apparatus units required at the sending and measuring ends and at the poling points are as follows:

Sending End

8A, 13A, 17B*, 51A** or similar type variable frequency oscillator.

D-99461 terminating network.

Telephone set.

*If the 17B oscillator is employed, use 600-ohm output.

**It is practicable to use the 51A oscillator only where there is no existing service in the cable. When this oscillator is used, adjust its frequency to the lowest value obtainable (1100 to 1200 cycles) and omit the D-156721 filter; connect the capacitance unbalance set directly to the 107A or 4B amplifier.

Measuring End

4A or 3A capacity unbalance set.
D-99462 conductance unbalance attachment.
D-156721 filter.
107A or 4B amplifier.
528 or similar type telephone receiver.
Telephone set.

Poling Points

DPDT knife switch.
Telephone set.

3.03   For convenience the knife switches should be mounted
on boards of suitable size and the switch terminals wired
to Fahnestock clips, as indicated schematically in Fig. 1. The
switch should be wired and the clips designated W and M in
such fashion that W_A will be connected to W_B and M_A to M_B
when a switch is closed in the position designated "S." Simi-
larly, the switch should be wired so that W_A will be connected
to M_B and M_A to W_B when the switch is closed in the "X"
position.

4. GENERAL POLING PROCEDURE

4.01   A tester will be required at each repeater station and
a splicer at each poling point. It will be necessary to
establish a talking circuit from one repeater station to the other
which will be used by the tester at the measuring end in com-
municating with the tester at the sending end and with the
splicers at each poling point.

Arrangement of Measuring Apparatus

4.02   For measuring the capacitance and conductance unbal-
ance in the section from repeater station A to repeater
station B connect the apparatus as shown on Fig. 1. Keep all

SENDING END
REPEATER STATION
A

LINE

MEASURING END-REPEATER STATION B

Poling Pt. No. 1   No. 2   No. 3

Note: All leads should be twisted pair, as short
as practicable and separated from other
pairs as much as practicable. Patch cord
may be used for oscillator, if convenient.

Side
2

Side
1

Quad

Fig. 1

Receiver

{ Sealed test term. at one end }
{ Sealed cable term. at other end }

WIRING OF POLING SWITCH

D-99461
Termi-
nating
Network

Output
8A, 13A
17B or
51A Osc.

D-99462
Conduct-
ance
Unbalance
Attach-
ment

White
Mate
Gnd
Black
Mate

W
M
G
B
M

3A or 4A
Capac-
itance
Unbalance
Set

C.U.Set Amp.

D-156721
Filter

4B
or
107A
Ampli-
fier

W_A W_B
S

X

M_A M_B

Fahnestock
Clips
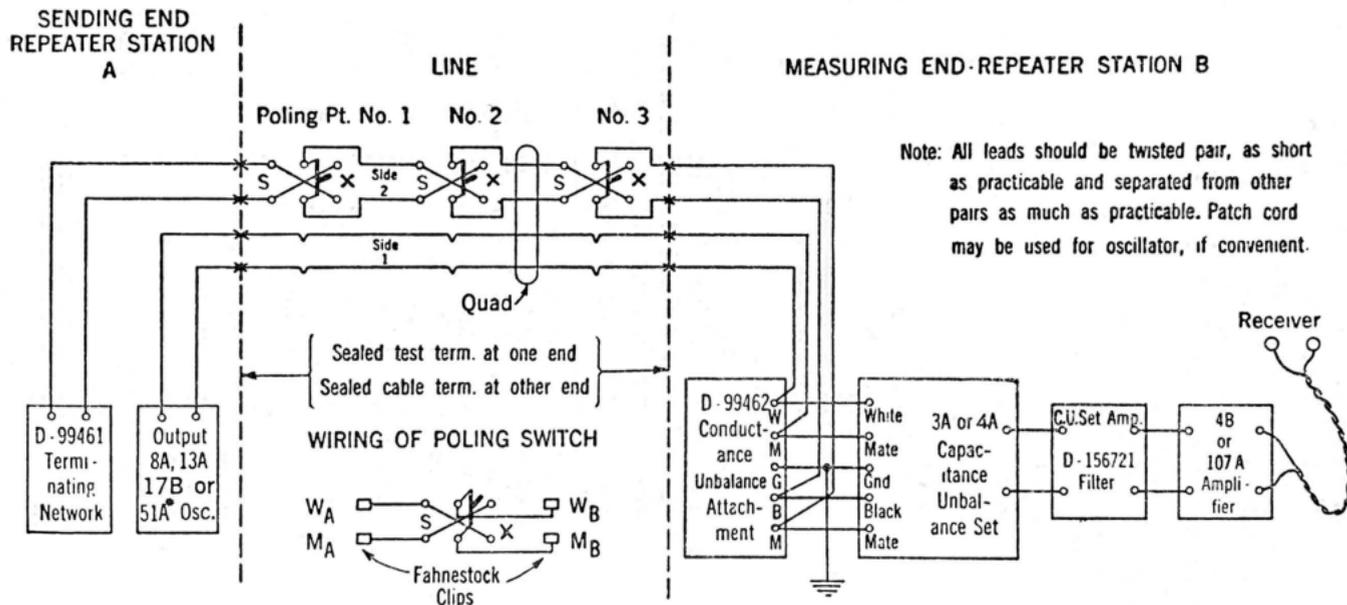
* If 51A oscillator is used, omit D-156721 filter and connect Capacitance Unbalance Set
directly to the 107A or 4B Amplifier

leads as short as possible. At repeater station A, connect the oscillator to Side 1 of a quad and the terminating network to Side 2 of the quad. At repeater station B, connect Side 1 of the quad to "white" and "mate" and Side 2 to "black" and "mate" of the capacity unbalance set and strap corresponding terminals of the conductance unbalance attachment to the capacity unbalance set. As shown in Fig. 1 this will necessitate placing the conductance unbalance set so that its terminals are on the side adjacent to the capacity unbalance set. **It is important that the sending pair, Pair 1, be connected to the "white" and "mate" terminals of the conductance attachment since these have the necessary terminating network connected internally.** Connect the amplifier, filter and receivers as indicated.

4.03   Operate the capacity unbalance set keys to "S-S" and "white."

4.04   At each of the poling points Side 1 of the quad should be spliced wire-to-wire and mate-to-mate. Side 2 of the quad should be connected to the DPDT switch at each poling splice by the splicers, "wires" to W_A and W_B, and "mates" to M_A and M_B.

Preliminary Adjustments

4.05   Request each of the splicers to close his switch in the position marked "S." Request the tester at repeater station A to set the oscillator output control for considerable output, that is, approaching "maximum" output for long sections. Adjust the dials of the capacity unbalance and conductance sets to approximately "maximum" position. Hold the telephone receiver which has been connected to the 107A amplifier in front of the transmitter of the telephone set connected to the talking circuit. Request the station A tester to slowly vary the frequency of the oscillator over the range from 800 to 900 cycles and to listen to the volume of tone in the receiver of his telephone set. Advise the station A tester to adjust the oscillator to the frequency which results in the greatest volume of tone in his receiver. This adjustment is made to obtain the best transmission through the D-156721 filter, and hence the greatest signal-to-noise ratio. This adjustment having been made, the power output of the oscillator may be reduced to as low a value as compatible with accuracy in the measurements, in order to minimize the possibility that the tone will affect working quads.

4.06   Make readings of capacitance and conductance unbalance by adjusting the dials of the capacity unbalance and conductance unbalance sets until the testing tone is no longer heard. Determine over what portion of both dials the testing tone is inaudible, that is, the "spread." If this spread is undesirably wide because of cable noise, etc., there may be con-

siderable difficulty in obtaining accurate unbalance measurements. In this case, a recheck per 4.05 should be made to determine whether a change in the adjustment and output of the oscillator will result in minimizing the spread. This recheck is made with the unbalance sets off balance.

4.07   After the proper oscillator frequency and output have been determined, measure the unbalances for Quad 1. Request station A tester to reverse the connection of the leads from the oscillator at the sealed terminal and note the effect on the readings of the unbalance sets. Request tester at station A to restore the oscillator leads to the original connection and to reverse the leads from the D-99461 terminating network at the sealed terminal. Note the effect on the readings of the unbalance sets for both of these reversals. If satisfactory reversal is not obtained, that is, if the unbalance set readings are not the same for the three conditions, the trouble can be isolated as between apparatus or leads by making the reversal tests in succession at the sealed terminal and at the apparatus at station A. If reversal of the apparatus alone is satisfactory and reversal of the leads is not, trouble is in the leads. In any event, such troubles should be cleared before proceeding. This may involve the use of new leads, greater separation between leads or apparatus units, clearing of apparatus trouble, etc.

4.08   Check the zero adjustments of the unbalance sets by making capacitance and conductance unbalance readings with the normal connection of the testing set leads to the cable at the measuring end and with the leads to Side 1 or to Side 2 reversed at the cable. If these two sets of readings are not the same in magnitude and reversed in sign, adjust the zero indexes on both sets until both the capacitance and conductance readings will reverse.

Unbalance Measurements

4.09   After the zero adjustments have been made, measure the side-to-side unbalances, both capacitance, C, and conductance, G, for Quad 1 sending at repeater station A and receiving at repeater station B with the poling switches at the three points in the "S," or "straight," position. The small divisions on the scale of the conductance unbalance attachment are equivalent to two units. If possible, readings should be made to the nearest unit. Record the data as regards both sign and magnitude for this quad opposite the "SSS" poling pattern on a data sheet similar to that of Fig. 2 (discussed in Part 5) entering the conductance unbalance measurements under G and capacitance unbalance measurements under C.

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4.10 Advise the splicer at poling point No. 3, that is, the poling point nearest the measuring station, to throw his poling switch to the "X," or "reverse" position. Measure and record the unbalance for this poling pattern in a manner similar to Paragraph 4.09.

4.11 In succession, measure and record the unbalances for the other six possible poling patterns of Quad 1 by having the splicers at poling points No. 1, 2 and 3 operate their switches as follows:

Meas. Per	Poling Pattern No.	Poling Points		
		No. 1	No. 2	No. 3
Par. 4.09	1	S	S	S
Par. 4.10	2	S	S	X
Par. 4.11	3	S	X	X
"	4	S	X	S
"	5	X	X	S
"	6	X	X	X
"	7	X	S	X
"	8	X	S	S

Selection of Poling Pattern

4.12 Compute the quantity $25G + C$ for each pattern. That pattern should be selected for which the computed $25G + C$ has the smallest numerical value. The quantity $25G + C$ is the algebraic sum, that is, the signs of the G and C readings must be taken into account in the computation, but it is only the numerical value of the sum that determines the poling pattern to be used, not its sign. Examples of this method of selection are shown on the sample data sheet.

4.13 Advise splicers to remove poling switches from this pair and to splice the pair in accordance with the selected pattern. After the splicers have completed the splicing, make check unbalance measurements on Quad 1 to determine that no errors in splicing have been made. With correct splicing the check measurements should be in close agreement with the readings made for the chosen poling pattern while the switches were in the circuit.

4.14 Repeat the procedure outlined in Paragraphs 4.09 through 4.13 for the remaining quads to be poled.

Sectionalizing Computations

4.15 If the magnitudes of the unbalance readings for the best poling pattern for a particular quad are considerably greater than obtained on the other quads it is possible that the quad may be in trouble, for example, it may be split.

It is possible that even with the best poling pattern the magnitudes of the unbalances for particular quads which have no physical troubles, may be in excess of the unbalances that can later be neutralized by adjusting the balancing coils and condensers in the K stations. This could occur if the unbalances in one quarter-section were unusually high while the unbalances in each of the other quarter-sections were very low. The maximum G unbalance that one balancing coil can neutralize is about 15 to 18, as read on the conductance unbalance attachment. Likewise, the maximum C unbalance that can be neutralized conveniently by balancing condensers when a single coil is available for mounting the condensers is 200 mmf.

4.16   If crosstalk balancing is to be done on each repeater section, two balancing coils will be available for each side-to-side combination so that maxima of about twice the values given above, that is, G unbalances of 30 to 37 and C unbalances of 400 mmf, can be neutralized in side-to-side combinations. If balancing is to be done over 2 or 3 repeater sections as a unit, however, there will be two coils available for only the side-to-side combinations that are in the repeater section in which the balancing panel is located. The side-to-side combinations that exist in the other repeater section or sections will not appear as side-to-side combinations in the section containing the balancing coils, due to the planned frogging arrangements at repeater points. The maxima given above for a single coil apply, therefore, to the side-to-side combinations that are in sections other than the balancing section.

4.17   If unbalance magnitudes exceeding those values given in 4.15 and 4.16 which are appropriate for the type of balancing contemplated are obtained with the best poling pattern or if the unbalances, either G or C, for particular quads are as much as five times the average unbalances, the computations outlined in 4.19 should be made. From these computations it will be possible to determine which of the quarter-sections is responsible for the high unbalances. Such unbalances may be inherent in the cable section or they may be due to a trouble condition such as an "open," "cross," "ground," "split quad," etc., or the presence of a loading unit that should have been installed on some other quad or that should have been removed from the quad in question. With the exception of the last item, the trouble conditions may be detected and located by methods covered in other sections of practices. A good method of detecting the presence of a loading coil on an otherwise non-loaded pair is to measure the transmission loss at some frequency in the K carrier range, say 28 kc. A loading coil would cause the measured loss to be considerably greater than that of non-loaded pairs of the same gauge.

4.18   If any trouble is detected, it should, of course, be cleared before the poling is completed on the quad that is in trouble. If no trouble is detected, it may be assumed that inherently high unbalances are present in the cable section, and Side 2 of the quad should be turned over at the mid-point of the high quarter-section in an effort to obtain better over-all results. After this turnover has been made, all eight poling patterns should be measured again. If a turnover at the mid-point of the quarter-section is not sufficiently effective, Side 2 should be poled at the 1/4 and 3/4 points of the quarter-section as well. Before this is done, the switches should be removed from the normal poling points of the repeater section, and the quad should be permanently spliced in the pattern that gave the lowest "25G + C." The switches should then be transferred to the quarter-points of the quarter-section that has the high unbalances, and measurements should be made from repeater station to repeater station on the eight possible poling patterns within the quarter-section. The quarter-section should then be spliced in the pattern that gave the smallest "25G + C."

4.19   The unbalance for each of the four quarter-sections may be computed by means of the following formulas:

$$A = 1/2 \ (SSS - XSS)$$
$$B = 1/2 \ (SSS - XXS)$$
$$C = 1/2 \ (SSS - SXX)$$
$$D = 1/2 \ (SSS + SSX)$$

where A, B, C, D respectively denote the unbalances in the first, second, third and fourth quarters of the repeater section, starting at the sending end. In these formulas the quantities in parenthesis represent the measurements for the poling patterns indicated. The G and C components for each section are computed separately.

4.20   To illustrate the computations assume that the unbalances as measured on a quad for the various poling patterns are as follows:

Poling Pattern	Unbalances	
	G	C
SSS	−90	−135
SSX	−51	+ 12
SXX	−90	−306
SXS	−51	+180
XXS	−87	+180
XXX	− 54	−315
XSX	−90	+ 21
XSS	−54	−150

By computation (Par. 4.12) it is found that the best poling pattern for this quad is SXS. With this pattern, however, the G unbalance is in excess of the maximum value given in 4.16. The sectionalizing computations are, therefore, carried out as follows:

			G	C
$A = \dfrac{SSS - XSS}{2}$		SSS	− 90	−135
		XSS	− 54	−150
		SSS − XSS	− 36	+ 15
		$\dfrac{SSS - XSS}{2}$	− 18	+ 7.5
$B = \dfrac{SSS - XXS}{2}$		SSS	− 90	−135
		XXS	− 87	+180
		SSS − XXS	− 3	−315
		$\dfrac{SSS - XXS}{2}$	− 1.5	−157.5
$C = \dfrac{SSS - SXX}{2}$		SSS	− 90	−135
		SXX	− 90	−306
		SSS − SXX	0	+171
		$\dfrac{SSS - SXX}{2}$	0	+ 85.5
$D = \dfrac{SSS + SSX}{2}$		SSS	− 90	−135
		SSX	− 51	+ 12
		SSS + SSX	−141	−123
		$\dfrac{SSS + SSX}{2}$	− 70.5	− 61.5

From these computations it is seen that the high G unbalance is due to quarter-section D. Having determined that length D is responsible, d-c tests should be made to determine whether the quad is in trouble in length D. If no trouble is found, additional turnovers within length D per 4.18 should be made.

5. CROSSTALK POLING DATA SHEET

5.01   Reference has been made to a data sheet for recording the crosstalk poling measurements and a copy of a suggested data sheet is given on Fig. 2. Data to illustrate the methods of selecting poling patterns have been recorded on this data sheet.

5.02   At the top left of the data sheet are spaces for recording the particular cable, repeater section, K pair numbers and measuring station.

5.03   In the middle, at the top, are spaces for indicating the locations of the poling points.

5.04   At the top right are spaces for indicating the data sheet numbers, date of test, length of cable, temperature and Estimate number.

5.05   At the bottom of the form are spaces for identifying the splicers, testers, and specific items of testing apparatus.

5.06   The sample data sheet contains spaces for recording a complete set of unbalance measurements for 5 quads. Spaces are provided also for results of any d-c measurements made in connection with the poling tests. When the group of quads being poled contains more than 5 quads, more than one data sheet will be required. The use of a separate sheet is recommended for poling tests within a quarter-section also.

5.07   Under the heading "PRELIM. MEAS." and opposite the proper "POLING PATT." are recorded the G and C readings in sign and magnitude as made in accordance with Paragraphs 4.09 to 4.11.

5.08   Under the heading "25G" is entered the quantity 25 times the G "PRELIM. MEAS."

5.09   Under the heading "25G + C" is entered the algebraic sum of 25G and C where this sum is determined as in Paragraph 4.12.

5.10   Under the heading "PATT. USED" a check mark is placed opposite that "POLING PATT." which has been chosen as the proper pattern to be used in splicing the quad.

TYPE K CARRIER SYSTEMS
SIDE–SIDE CROSSTALK POLING
3-POINT POLING

CABLE _Alpha · Omega_
SECTION _Gamma K1S- K2S_
MEAS. END _Gamma K2S_
K PAIRS _1-20_

POLING POINTS
1 MH 306
2 MH 340
3 MH 375

K Pr. Nos.	Poling Pattern	Prelim. Meas. G	Prelim. Meas. C	25G	25G + C	Patt. Used	Check Meas. G	Check Meas. C	Insulation Res. Megohm Miles			Wire Res. Ohms		Remarks
									Pr.	T	R	T	R	
1 2	SSS	−6	−29	−150	−179				Pr.	T	R	T	R	
	SSX	−10	−88	−250	−338									
	SXX	−5	−20	−125	−140									
	SXS	−10	−79	−250	−329									
	XXS	+8	+79	+200	+279									
	XXX	+3	+13	+75	+88	✓	+3	+12						
	XSX	+8	+80	+200	+280									
	XSS	+4	+22	+100	+122									
3 4	SSS	+3	−26	+75	+49				Pr.	T	R	T	R	
	SSX	−13	−130	−325	−455									
	SXX	−5	−60	−125	−185									
	SXS	−20	−166	−500	−666									
	XXS	+16	+108	+400	+508									
	XXX	0	+3	0	+3	✓	0	+5						
	XSX	+8	+72	+200	+272									
	XSS	−7	−33	−175	−208									
5 6	SSS	−22	−55	−550	−605				Pr.	T	R	T	R	
	SSX	+9	+16	+225	+241									
	SXX	−34	−52	−850	−902									
	SXS	+22	+15	+550	+565									
	XXS	−17	−80	−425	−505									
	XXX	+5	+40	+125	+165	✓	+5	+40						
	XSX	−30	−78	−750	−828									
	XSS	+18	+38	+450	+488									
7 8	SSS	−11	+50	−275	−225				Pr.	T	R	T	R	
	SSX	−12	+14	−300	−286									
	SXX	−8	+50	−200	−150									
	SXS	−14	+11	−350	−339									
	XXS	−20	+48	−500	−452									
	XXX	−1	+10	−25	−15	✓	−1	+10						
	XSX	−19	+56	−475	−419									
	XSS	−5	+5	−125	−120									
9 10	SSS	+10	+57	+250	+307				Pr.	T	R	T	R	
	SSX	+1	−11	+25	+14	✓	+1	−10						
	SXX	+8	+42	+200	+242									
	SXS	−1	−26	−25	−51									
	XXS	−2	+3	−50	−47									
	XXX	−11	−66	−275	−341									
	XSX	−4	−13	−100	−113									
	XSS	−13	−81	−325	−406									

SER. NO. CAP. UNB. SET _32413_
SER. NO. COND. UNB. SET _382_
SER. NO. & TYPE OF OSC. _14835-17B_

SPLICERS _A.B. Jones_
C.D. Smith
E.F. Brown

TESTERS _G.H. Green_
J.K. White

Fig. 2

5.11 Under the heading "CHECK MEAS." and opposite the check mark are entered the G and C readings which are made after the splicing of the quad has been completed per Paragraph 4.13.

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