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AERONAUTICAL RECOMMENDED PRACTICE

ARP 461A

Issued 7-1-55
Revised 11-15-59

SYNCHROS

1. SCOPE:

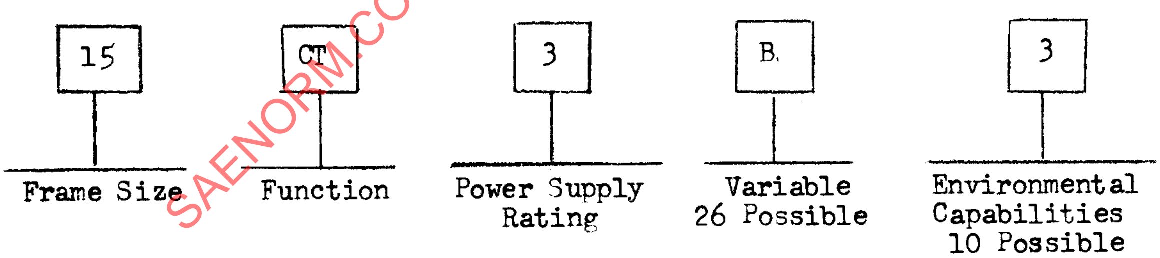
1.1 This document is limited to units meeting the definitions of para. 1.3 and covers the following general class of synchros:

26 volt, 400 cycle synchros
115 volt, 400 cycle synchros
115 volt, 60 cycle synchros

1.1.1 Under each of the above general classes of synchros the following specific type of synchro is covered by this document:

Synchro Transmitter - Torque
Synchro Transmitter - Control
Synchro Control Transformer
Synchro Differential Transmitter - Torque
Synchro Differential Transmitter - Control
Synchro Differential Receiver
Synchro Receiver
Synchro Resolver Transmitter
Synchro Resolver Control Transformer
Synchro Resolver Differential

1.2 Code for Type Designation of Synchros: Synchros are classified according to frame size, function, power supply rating, environmental capabilities and the type of shaft and method of electrical connection. This information is contained in the type designation which consists of five blocks of alternate numerals and letters as follows:



1.2.1 Frame Size: The first two numerals of the type designation number indicate the maximum diameter of the unit in tenths of an inch. If the diameter is not exactly a whole number of tenths, the next higher tenth is used.

Frame Size (2 Numerals)
Nominal Diameter

08	0.750 inch diameter
10	0.937 inch diameter
11	1.062 inch diameter
15	1.437 inch diameter
16	*1.537 inch diameter
18	1.750 inch diameter
19	**
23	2.250 inch diameter
31	3.100 inch diameter

* Size 15 characteristics with rotatable stator
** Size 18 characteristics with rotatable stator

1.2.2 Function: The second block of the type designation number consists of two letters which indicates the functional applications as follows:

Function (Two Letters)

TX	Transmitter - Torque
CX	Transmitter - Control
CT	Control Transformer
TD	Differential Transmitter - Torque
CD	Differential Transmitter - Control
DR	Differential Receiver
TR	Receiver
RX	Resolver - Transmitter
RC	Resolver - Control Transformer
RD	Resolver - Differential

1.2.3 Power Supply Rating: The third block of the type designation number consists of one numeral which indicates the nominal power supply system utilized as follows:

Power Supply Rating (1 Numeral)

	Nominal Voltage	System Frequency
1	115	60
2	115	400
3	26	400

1.2.4 Variable: The fourth block of the type designation number consists of a letter which indicates a variable applicable to the particular unit such as terminals, leads, shaft, etc., in accordance with the following table:

Variable (One Letter)

A	Terminal connection, smooth shaft
B	Flexible leads, smooth shaft
C	Terminal connection, splined shaft
D	Flexible leads, splined shaft
E	Rotatable - outline figure 3

1.2.5 Environmental Capabilities: The fifth block of the type designation number consists of one numeral to indicate the service conditions which the unit is designed to withstand according to the following table:

Environmental Capabilities
(1 Numeral)

1. Unexposed (-55°C to +71°C)	Units which are normally installed within protected areas that do not require more than a 24 hour humidity check, such as sealed instruments.
2. Exposed (-55°C to +71°C)	Units which are normally installed in unprotected areas that do require more than 24 hour humidity check, such as unprotected units in computer racks.
3. Hi-Temp. (-55°C to +150°C)	Units which are normally installed in areas subjected to ambients between 71°C and 150°C for periods of 24 hours.

1.2.6 Illustration: 15CT3B3 indicates a size 15 Synchro Control Transformer for use in a 26 volt, 400 cps system, has a smooth shaft and flexible leads, and was designed for operation in ambients over 71°C and under 150°C.

1.3 Definitions:

1.3.1 Synchro: A synchro is an electro-magnetic device which is primarily used for transmission, reception or conversion of angular data.

1.3.1.1 Synchro Transmitter: A unit wherein the rotor is mechanically positioned for transmitting electrical information corresponding to angular position of the rotor with respect to the stator.

(a) A torque transmitter is constructed primarily for operation with receivers, torque differential transmitters, and differential receivers.

(b) A control transmitter is constructed primarily for operation with control transformers or control differential transmitters.

1.3.1.2 Synchro Control Transformer: A unit wherein the stator is supplied with electrical angular information and the rotor output is a voltage proportional to the sine of the difference between the electrical input angle and the control transformer rotor angle. This unit is constructed primarily for operation with control transmitters and control differential transmitters.

1.3.1.3 Synchro Differential Transmitters: A unit wherein the rotor is mechanically positioned for modifying electrical angular information received by the stator from a transmitter and re-transmitting electrical information corresponding to the sum or difference of the electrical input angle and its rotor position angle depending on the system wiring.

(a) A torque differential transmitter is constructed primarily for operation with torque receivers.

(b) A control differential transmitter is constructed primarily for operation with control transformers.

1.3.1.4 Synchro Differential Receiver: A unit wherein the rotor is free to turn to assume a position with respect to the stator in accordance with the sum or difference of the electrical angular information received by the stator from one transmitter and by the rotor from a second transmitter. This unit is constructed primarily for operation with two synchro torque transmitters.

1.3.1.5 Synchro Receiver: A unit wherein the rotor is free to turn, to assume a position with respect to the stator in accordance with the electrical information received when the rotor is properly energized. This unit is primarily constructed for operation with torque transmitters and torque differential transmitters.

1.3.1.6 Resolver - Transmitter: A unit which has two perpendicular windings on the stator, that has its rotor mechanically positioned for transmitting electrical information corresponding to angular position of the rotor with respect to the stator. This unit is intended primarily for use with Resolver - Control Transformers and Resolver - Differentials.

1.3.1.7 Resolver - Control Transformer: A unit which has two perpendicular windings on the stator that transforms electrical angular information from the stator to a voltage proportional to the sine of the difference between the electrical input angle and the resolver control rotor angle. This unit is intended primarily for use with Resolver - Transmitters and Resolver - Differentials.

1.3.1.8 Resolver - Differential: A unit which has two perpendicular windings on both the rotor and stator that has its rotor mechanically positioned for modifying electrical angular information received from a transmitter and re-transmitting the electrical information corresponding to the sum or difference of the electrical input angle and its rotor position angle, depending on the system wiring. This unit is intended primarily for use with Resolver - Transmitters and Resolver - Control Transformers.

1.3.2 Definitions of Terms:

1.3.2.1 Direction of Rotation: Clockwise or counter-clockwise is determined when facing the shaft extension end of the synchro. When two shaft extensions exist, the one opposite the lead or terminal end shall be the one considered for this definition.

1.3.2.2 Rotor Angle: The rotor angle of the synchro is the angular displacement of its rotor from the synchro zero position (see 1.3.2.6) measured as an increasing positive angle in a counter-clockwise direction.

1.3.2.3 Primary and Secondary Windings: The primary winding is the one which receives energizing power from either the supply line (as in transmitters or receivers) or from another synchro (as in control transformers). In the case of differential transmitters and differential receivers, the primary winding is the outer winding.

1.3.2.4 Electrical Angle:

1.3.2.4.1 Transmitter and Receiver: The electrical angle is the angle "a" displaced in a positive direction from synchro zero which satisfies the relative magnitudes and polarities of the secondary voltages of a synchro transmitter or receiver in accordance with the following equations:

$$E\ (S_{13}) = n\ E\ (R_{21}) \sin a$$

$$E\ (S_{32}) = n\ E\ (R_{21}) \sin (a + 120^\circ)$$

$$E\ (S_{21}) = n\ E\ (R_{21}) \sin (a + 240^\circ)$$

Where: n is the ratio between the maximum rms voltage between any two secondary terminals, with the third terminal open, and the primary voltage:

$E\ (R_{21})$ is the voltage between terminals R_2 and R_1.

$E\ (S_{13})$ is the voltage between terminals S_1 and S_3.

Other voltages are similarly defined. These secondary voltages are in time phase with one another and usually displaced a nominal amount in time phase from the primary voltage.

1.3.2.4.2 Control Transformer: The electrical angle "a" is the angle displaced in a positive direction from synchro zero which satisfies the relative magnitude and polarities of the secondary voltage of a synchro control transformer in accordance with the following equations:

$$E\,(R_{12}) = n\,[E\,(S_{13})\sin\,(a + 120) - E\,(S_{32})\sin a]$$

$$E\,(S_{13}) + E\,(S_{32}) + E\,(S_{21}) = 0$$

Where: n is the ratio between the maximum rms voltage between the secondary terminals and the primary voltage which is applied between any one primary terminal and the other two primary terminals which are connected together.

$E\,(R_{12})$ is the voltage between terminals R_1 and R_2

$E\,(S_{13})$ is the voltage between terminals S_1 and S_3.

Other voltages are similarly defined.

1.3.2.4.3 Differential Transmitter and Receiver: The electrical angle "a" is the angle displaced in a positive direction from synchro zero which satisfies the relative magnitudes and polarities of the secondary voltages of a synchro differential transmitter or a differential receiver in accordance with the following equations:

$$E_{(R13)} = n\,[E\,(S_{13})\sin\,(a + 120) - E\,(S_{32})\sin a]$$

$$E_{(R32)} = n\,[E\,(S_{13})\sin a - E\,(S_{32})\sin\,(a + 240)]$$

$$E_{(R21)} = n\,[E\,(S_{13})\sin\,(a + 240) - E\,(S_{32})\sin\,(a + 120)]$$

$$E\,(S_{13}) + E\,(S_{32}) + E\,(S_{21}) = 0$$

Where: n is the ratio between the maximum rms voltage between any two secondary terminals, with the third terminal open, and the primary voltage which is applied between any one primary terminal and the other two primary terminals, which are connected together.

$E\,(R_{12})$ is the voltage between terminals R_1 and R_2

$E\,(S_{13})$ is the voltage between terminals S_1 and S_3

Other voltages are similarly defined.

1.3.2.4.4 Resolver Transmitter: The electrical angle "a" is the angle displaced in a positive direction from synchro zero which satisfies the relative magnitudes and polarities of the secondary voltages of a resolver transmitter in accordance with the following equations:

$$E\ (S_{13}) = n\ E\ (R_{13}) \cos a$$

$$E\ (S_{24}) = n\ E\ (R_{13}) \sin a$$

Where: n is the ratio between the maximum rms voltage between two secondary terminals (S1 and S3 or S2 and S4), with the other two terminals open, and the primary voltage:

$E\ (R_{13})$ is the voltage between terminals R_1 and R_3

$E\ (S_{13})$ is the voltage between terminals S_1 and S_3

Other voltages are similarly defined.

1.3.2.4.5 Resolver Control Transformer: The electrical angle "a" is the angle displaced in a positive direction from synchro zero which satisfies the relative magnitudes and polarities of the secondary voltage of a resolver control transformer in accordance with the following equation:

$$E\ (R_{24}) = n\ \left[E\ (S_{24}) \cos a - E\ (S_{13}) \sin a\right]$$

Where: n is the ratio between the maximum rms voltage between the secondary terminals and the primary voltage applied between two primary terminals (S1 and S3 or S2 and S4).

$E\ (R_{24})$ is the voltage between terminals R_2 and R_4

$E\ (S_{13})$ is the voltage between terminals S_1 and S_3

Other voltages are similarly defined.

1.3.2.4.6 Resolver Differential: The electrical angle "a" is the angle displaced in a positive direction from synchro zero which satisfies the relative magnitudes and polarities of the secondary voltages of a resolver differential in accordance with the following equations:

$$E\ (R_{13}) = n\ \left[E\ (S_{13}) \cos a + E\ (S_{24}) \sin a\right]$$

$$E\ (R_{24}) = n\ \left[E\ (S_{24}) \cos a - E\ (S_{13}) \sin a\right]$$

Where: n is the ratio between the maximum rms voltage between two secondary terminals (R1 and R3 or R2 and R4), with the other two terminals open, and the primary voltage which is applied between two primary terminals (S1 and S3 or S2 and S4).

$E\ (R_{13})$ is the voltage between terminals R_1 and R_3

$E\ (S_{13})$ is the voltage between terminals S_1 and S_3

Other voltages are similarly defined.

1.3.2.5 Time Phase: The time phase at a point in a synchro system is the phase of the voltage at that point with respect to the energizing voltage of the synchro system. The time phase is measured in degrees. Time phase as defined here shall not be confused with electrical angle which is also measured in degrees.

1.3.2.6 Synchro Zero:

1.3.2.6.1 Transmitters and Receiver: The synchro zero position of transmitters and receiver is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit S_1 - S_3 and at which the secondary voltages E (S_{12}) and E (S_{32}) are approximately in time phase with the primary voltage E (R_{21}). The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.6.2 Control Transformer: The synchro zero position of a control transformer is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit R_1 - R_2 when the unit is energized by applying 0.866 times the rated voltage between terminal S_2 and the terminal S_1 which is connected to S_3. It is so determined that for small deflections of the rotor counter-clockwise from synchro zero the induced voltage E (R_{12}) is approximately in time phase with the voltage E (S_{21}) or E (S_{23}). The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.6.3 Differential Transmitters and Differential Receiver: The synchro zero position of differential transmitters and differential receivers is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit R_1 - R_3 and at which the voltages E (R_{32}) and E (R_{12}) are approximately in time phase with the corresponding voltages E (S_{32}) and E (S_{12}) when the synchro is energized by applying 0.866 times the rated voltage between terminal S_2 and terminal S_1 which is connected to S_3. The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.6.4 Resolver Transmitter: The synchro zero position of a resolver transmitter is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit S_2 - S_4 when the unit is energized with rated voltage between terminals R_1 and R_3. It is so determined that for small deflections of the rotor counter-clockwise from synchro zero the induced voltage E (S_{24}) is approximately in time phase with E (R_{13}). The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.6.5 Resolver Control Transformer: The synchro zero position of a resolver control transformer is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit R_4 - R_2 when the unit is energized with rated voltage between terminals S_1 and S_3. It is so determined that for small deflections of the rotor counter-clockwise from synchro zero the induced voltage E (R_{42}) is approximately in time phase with E (S_{13}). The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.6.6 Resolver Differential: The synchro zero position of a resolver differential is that position of the rotor with respect to the stator at which minimum voltage is induced in the secondary circuit R_2 - R_4 and at which the voltage E (R_{13}) is approximately in time phase with the primary voltage E (S_{13}) when the synchro is energized by applying rated voltage between terminal S_1 and S_3. The minimum voltage position is defined as the point where the secondary voltage of fundamental frequency, that is in time phase with the secondary voltage at maximum coupling, is zero.

1.3.2.7 Transformation Ratio: The transformation ratio of a synchro is the ratio of the no-load maximum fundamental secondary voltage to the fundamental supply voltage applied to the primary.

1.3.2.8 Electrical Error: The error at a given rotor position is defined as the mechanical rotor position minus the electrical position.

1.3.2.9 Units: Unless otherwise specified the units for Angles are degrees, minutes, and seconds. Potential is volts rms. Impedance is ohms. Current is amperes rms.

2. SYNCHRO CHARACTERISTICS: Whenever the atmospheric and power conditions for a particular test are not definitely specified, it is understood that the test is to be made at the following standard conditions:

Temperature: 25°C ± 5°C
Pressure: 30" Hg ± 2" Hg
Humidity: 75% Max.
Source Voltage: Nominal ±2%
Source Frequency: Nominal ±2%
Source Waveform: Essentially sinusoidal

2.1 Physical:

2.1.1 Envelope Dimensions: Figures 1, 2, 3, and 4, together with their accompanying dimensional charts, gives the synchro envelope dimensions, shaft configurations, and electrical connections.

2.1.2 Lead Wire Identification: For units using lead wires instead of terminals, the following color designation is to be considered standard:

TRANSMITTERS, CONTROL TRANSFORMERS AND RECEIVERS

Rotor	Stator
R_1 - Red	S_1 - Blue
R_2 - Black	S_2 - Black
	S_3 - Yellow

DIFFERENTIAL - (TRANSMITTER, RECEIVER)

Rotor	Stator
R_1 - Yellow	S_1 - Blue
R_2 - Black	S_2 - Black
R_3 - Blue	S_3 - Yellow

RESOLVER - (TRANSMITTER, CONTROL TRANSFORMER AND DIFFERENTIAL)

Rotor	Stator
R_1 - Red	S_1 - Red
R_3 - Black	S_3 - Black
R_2 - Yellow	S_2 - Yellow
R_4 - Blue*	S_4 - Blue

*In the case of 3 wire rotors the color of R_3 and R_4 common will be black.

DIMENSIONAL CHART for FIGURE NO. 1

SYNCHRO SIZES

DIMENSIONS AND LIMITS	08	10	11	15
A ±1/32	7/16	3/8	5/16	1/2
B +.003 -.010	0.750	0.937	1.062	1.437
C +.0000 -.0005	-	0.8123	1.000	1.3120
D+.0000 -.0005	0.5000	0.5000	0.6250	0.5000
E +.0000 -.0005	0.1200	0.0900	0.1200	0.1200
F Max.	*1.658 **1.812	1.246 -	1.687 -	1.627 1.978
G ±.005	0.040	0.038	0.062	0.040
H ±.005	-	0.062	0.062	0.132
I ±.005	0.062	0.062	0.093	0.093
J ±.005	0.062	0.062	0.050	0.078
K ±.005	0.625	0.835	0.975	1.312
L	-	3-(2-64)	4-(4-40)	4-(4-40)
M ±.003	-	0.678	0.812	0.875
N	-	0.001	0.001	0.001
P	-	0.001	0.001	0.001

* For unit with flexible leads.

** For unit with terminals (exclusive of screws)

DIMENSIONAL CHART for FIGURES NOS. 2 and 3

SYNCHRO SIZES

DIMENSIONS & LIMITS	11	15	16(a)	18
A ±.010	0.555	0.540	0.540	0.540
B +.003 -.005	1.062	1.437	1.437	1.750
C +.000 -.0005	1.000	1.3120	1.3120	1.5620
D +.0000 -.0005	0.6250	0.8750	0.8750	0.9375
E +.000 -.002	0.185	0.185	0.185	0.185
F Max.	1.789	1.93	2.593	2.67
G ±.003	0.062	0.040	0.040	0.040
H ±.003	0.062	0.132	0.132	0.132
I ±.003	0.093	0.093	0.093	0.093
J ±.005	0.050	0.078	0.078	0.078
K ±.005	0.975	1.312	1.312	1.625
L	4-(4-40)	4-(4-40)	4-(4-40)	4-(4-40)
M ±.003	0.812	1.100	1.100	1.250
N	1.318	1.646	1.646	1.959
P	0.001	0.001	0.001	0.001
R	+0.0005 +0.0015 +.003 * +.005	0.0005 0.0015	0.0005 0.0015	0.0005 0.0015
S Max.	0.302	0.263	0.263	0.263
T Max.	0.365	0.200	0.200	0.200
U	21	21	21	21

*Receivers only

DIMENSIONAL CHART
for
FIGURES NOS. 2 and 3
(Con't)
SYNCHRO SIZES

DIMENSIONS & LIMITS	11	15	16(a)	18	19
V	120	120	120	120	120
W ±.005	0.175	0.175	0.1750	0.1750	0.1750
Y +.0000 -.0005	*0.1247 0.1872	0.1872	0.1872	0.1872	0.1872
Z Max.	0.155	0.155	0.155	0.155	0.155
AA	20°	20°	20°	20°	20°
AB	10-32NF-2 *5-40NF-2A	10-32NF-2	10-32NF-2	10-32NF-2	10-32NF-2
AC ±.003	0.125	0.125		0.125	
AD Ref.	0.062	0.062		0.062	
AE +.000 -.006	0.506	0.665		0.810	
AF ±5°	45°	45°		45°	
AG +.008 -.000	0.170	0.281		0.281	
AH Min.	0.125	0.100		0.100	
AJ			0.281		0.281
AK Max.			0.325		0.325
AL			0.565		0.565
AM +.000 -.002			1.451		1.825
AN			96		120
AP			72		72
AR +.0000 -.0005			1.3333		1.6666
AW +.0000 -.0002	*0.1247 0.1872				
AX Min.	0.146				

*Receiver only
(a) Dimensions for Control Transformers only.

DIMENSIONAL CHART for FIGURES NOS. 2 and 3 (Con't)

SYNCHRO SIZES

DIMENSIONS & LIMITS	11	15	16(a)	18	19
AS +.0000 -.0005			1.3611		
AT MAX.			1.2959		
AU			20		
AV ±.005			1.537		
AY +.000 -.010	1.062				

DIMENSIONAL CHART FOR FIGURE NO. 4 SYNCHRO SIZES

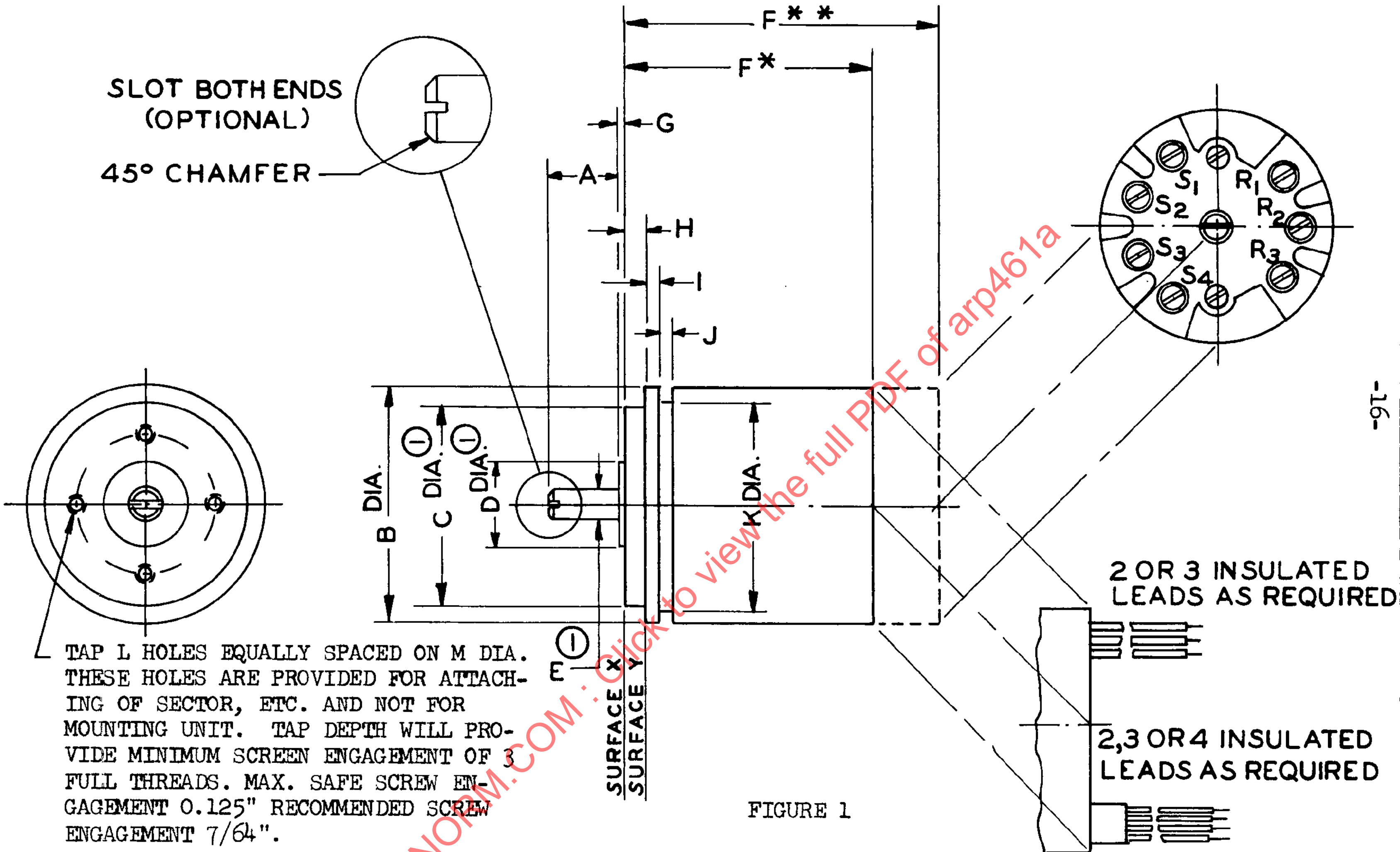
DIMENSION	23	31
A	0.719 +.000 -.026	0.676 +.000 -.015
B	1.990 +.000 -.005	2.700 Max.
C	2.250 +.000 -.001	3.100 +.000 -.002
D	1.9995 +.0000 -.0005	2.750 ±.001
E	1.990 +.000 -.005	2.700 Max.
F	0.2405 +.000 -.001	0.2405 +.000 -.001
G	3.580 *3.830 Ref.	4.524 Ref.
H	0.422 +.000 -.012	0.990 +.001 -.006

*Differential

(a) Dimensions for Control Transformer Only.

DIMENSIONAL CHART FOR FIGURE NO. 4
SYNCHRO SIZES

DIMENSION	23	31
I	0.420 +.000 -.005	0.625 +.000 -.003
J	0.250 +.000 -.002	0.250 ±.001
K	0.203 ±.005	0.250 ±.005
L	1.9995 +.0000 -.0010	2.750 ±.001
M	0.005	0.002
N	0.003	0.002
P	0.001	0.001
R	0.001	0.001
S	0.267 +.015 -.000	0.267 ±.015
T	0.387 +.005 -.000	0.468 Max.
U	22	22
V	96	96
W	0.2291 +.0000 -.0020	0.2291 +.0000 -.0020
AA	0.2405 +.0000 -.0002	0.2405 +.0000 -.0002
AB	0.205 Max.	0.205 Max.
AC	20°	20°
AD	1/4-28UNF-2A	1/4-28UNF-2A
AE	0.125 ±.001	-
AF	0.062 ±.003	-
AG	0.064 +.010 -.000	-
AH	45 ±1°	-

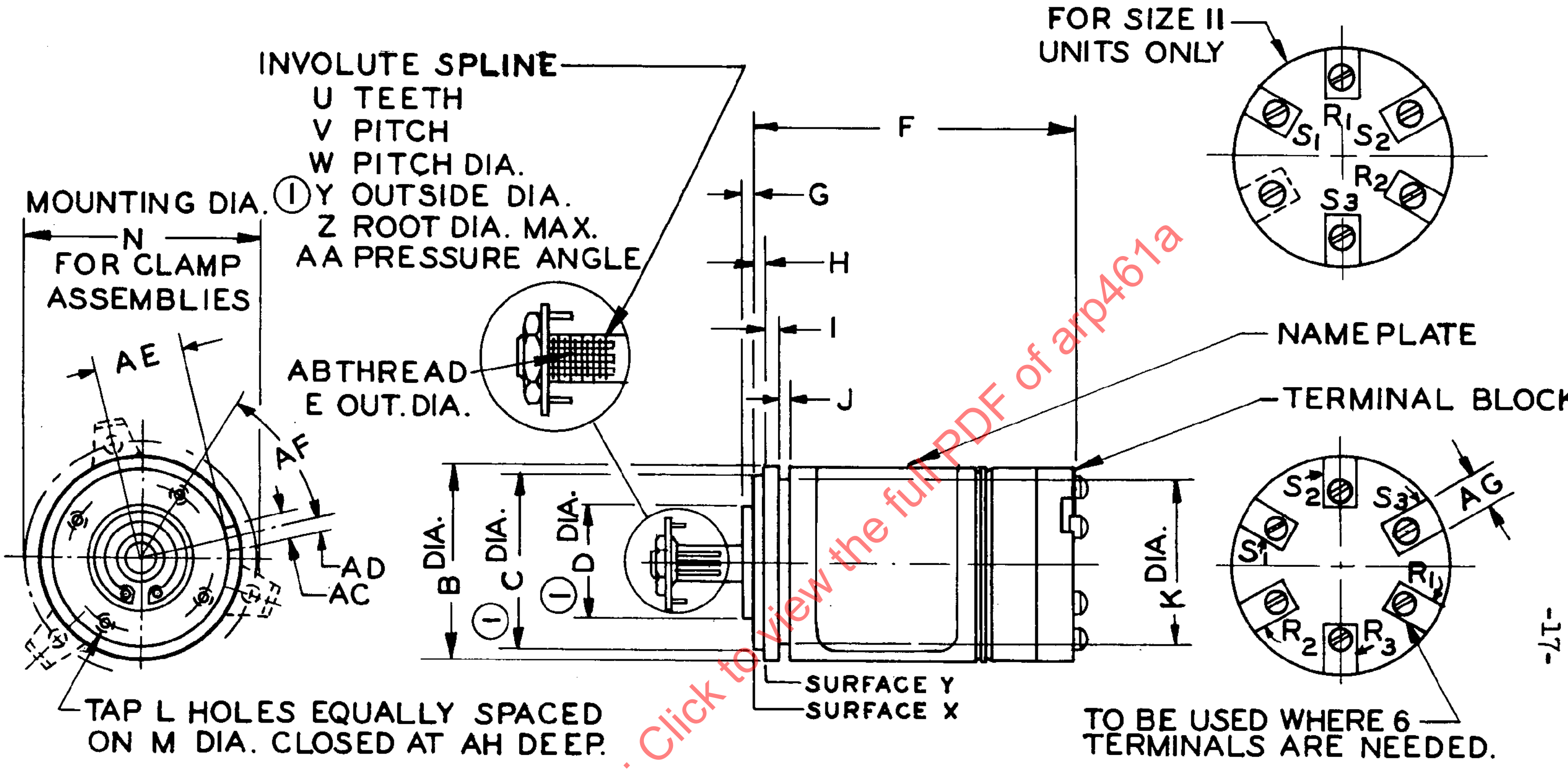


TAP L HOLES EQUALLY SPACED ON M DIA. THESE HOLES ARE PROVIDED FOR ATTACHING OF SECTOR, ETC. AND NOT FOR MOUNTING UNIT. TAP DEPTH WILL PROVIDE MINIMUM SCREEN ENGAGEMENT OF 3 FULL THREADS. MAX. SAFE SCREW ENGAGEMENT 0.125" RECOMMENDED SCREW ENGAGEMENT 7/64".

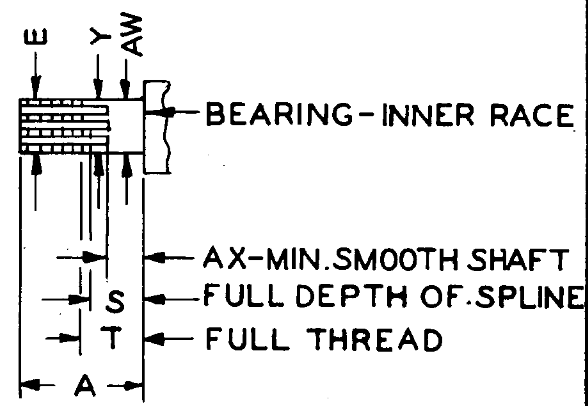
FIGURE 1

UNIT TYPE	END PLAY		RADIAL PLAY	
	Amount	Gage Load	Amount	Gage Load
Receiver	.001 Min .005 Max.	4 oz.	.001 Max	4 oz.
All Others	.0002 Min .0015 Max	4 oz.	.001 Max.	4 oz.

1. DIAMETERS MARKED ① ARE CONCENTRIC WITHIN N FULL INDICATOR READING.
2. RUNOUT AT END OF SHAFT WILL NOT EXCEED P FULL INDICATOR READING.
3. DIAMETER MARKED B IS EXCLUSIVE OF NAMEPLATE WHICH SHALL NOT EXCEED .010 THICKNESS.
4. SURFACES X AND Y PERPENDICULAR TO CENTER OF ROTATION OF SHAFT WITH .001"/INCH OF DIA. WITHIN 1/16" OF OUTSIDE EDGE OF SURFACE.
5. SURFACES X AND Y FLAT TO .001"/INCH.
6. SURFACE Y IS RECOMMENDED MTG. SURFACE.
7. RADIAL PLAY OF SHAFT MEASURED 1/8" FROM FRONT OF HOUSING.

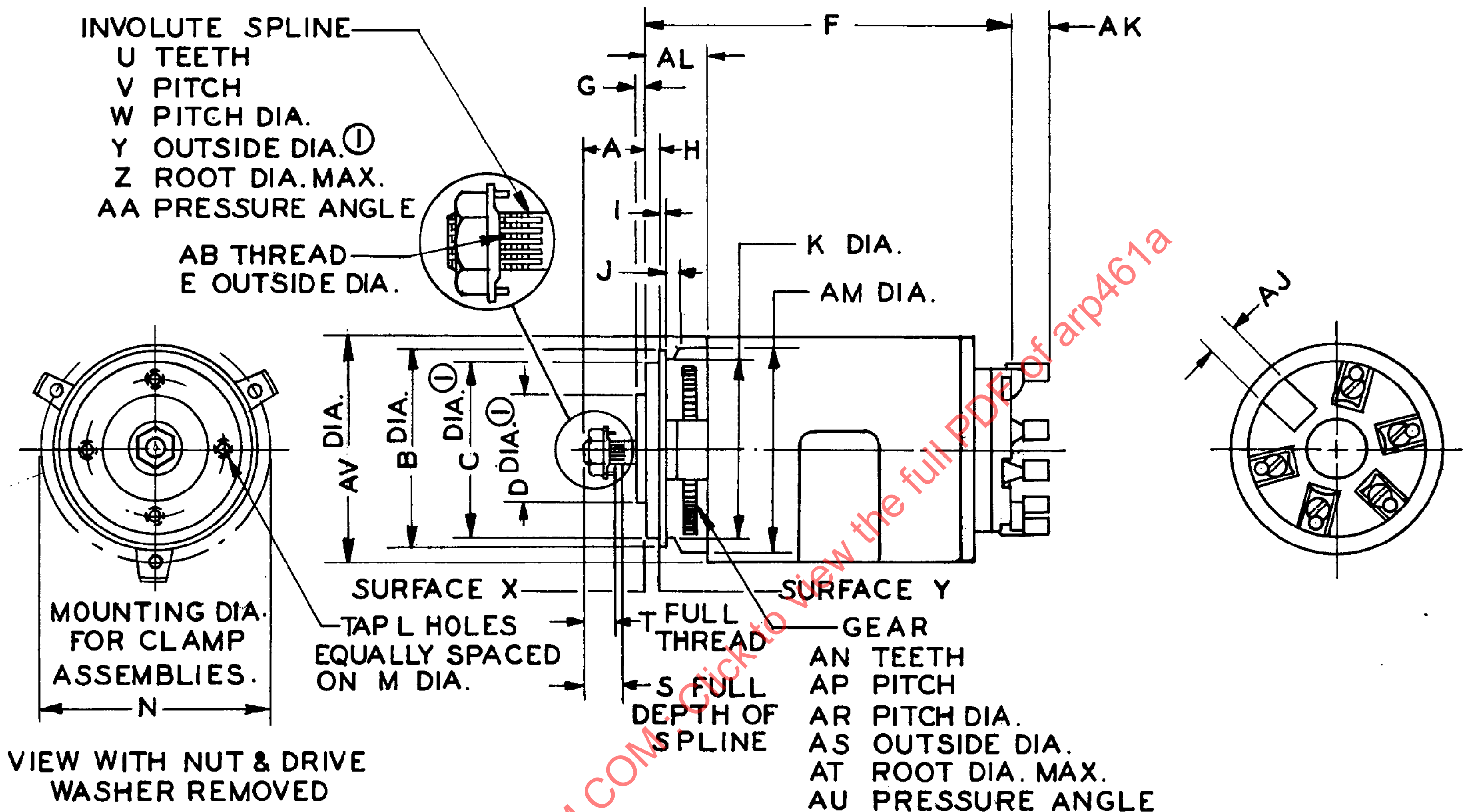


VIEW WITH NUT AND DRIVE WASHER REMOVED



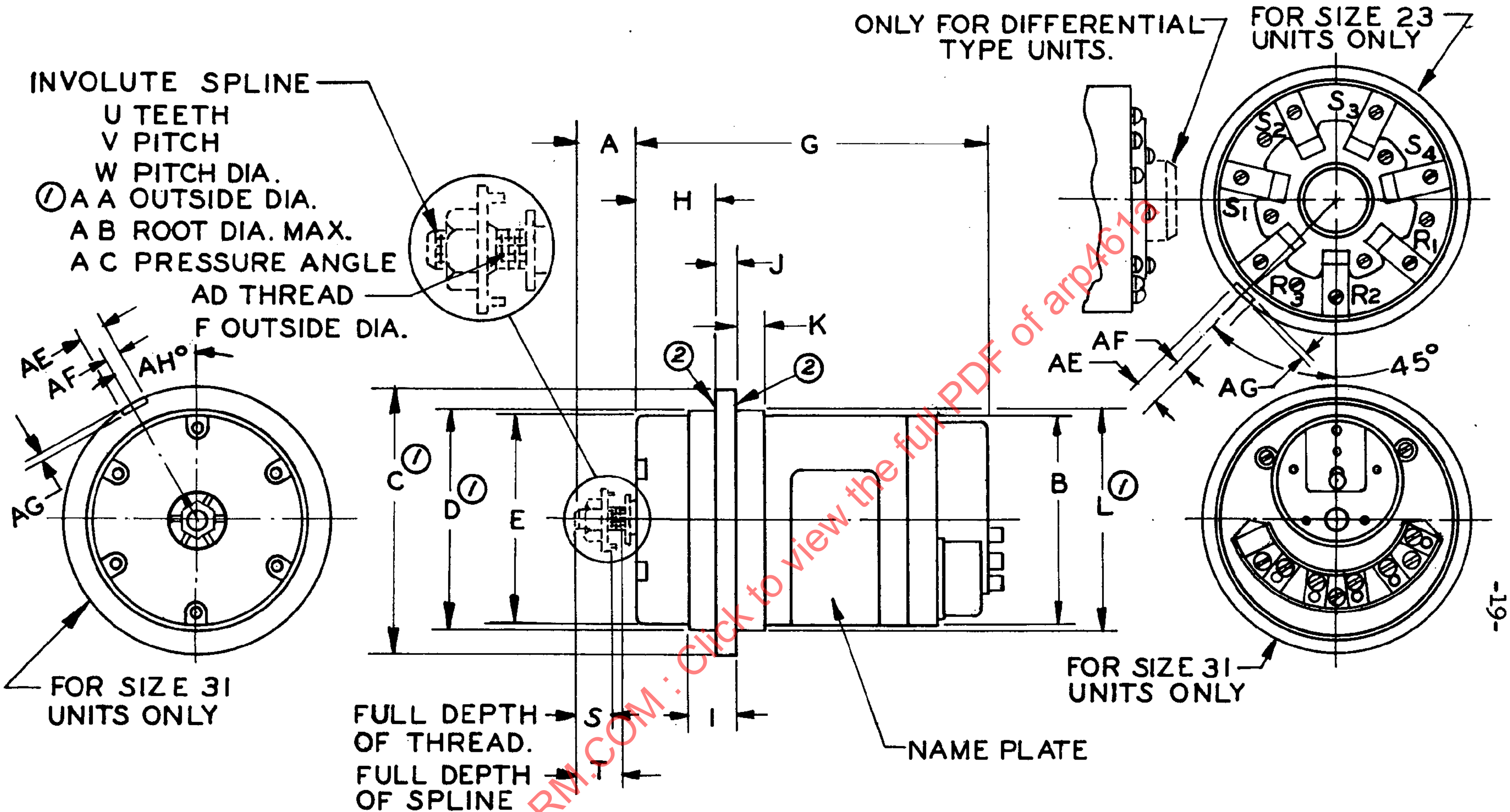
1. DIA. MARKED B IS EXCLUSIVE OF NAMEPLATE WHICH SHALL NOT EXCEED .010 THICKNESS.
2. END PLAY OF SHAFT MUST BE R MAX. & MUST BE MEASURED WITH THE SHAFT AT REST IN ONE POSITION UNDER ONE POUND FORCE TO THE AT REST POSITION UNDER A ONE POUND FORCE IN THE OPPOSITE DIRECTION.
3. DIAMETERS MARKED (I) ARE CONCENTRIC WITHIN P FULL INDICATOR READING.
4. WHEN MARK ON SHAFT END IS IN LINE WITH ARROW ON FRONT OF HOUSING, THE UNIT IS SET ON ELECTRICAL ZERO.
5. HOUSING FINISH: NATURAL ANODIZE.
6. SEE NOTES 4, 5, & 6, FIG. 1.
7. RADIAL PLAY OF SHAFT MEASURED 1/8" FROM BRG WITH 8 OZ. REVERSED GAGE LOAD SHALL BE .0008" MAX. FOR RECEIVERS AND .0004" MAX. FOR ALL OTHER TYPES.

FIGURE 2



1. DIMENSION V IS FULL DEPTH OF THREAD.
2. DIMENSION U IS FULL DEPTH OF SPLINE.
3. DIAMETERS MARKED 1 ARE CONCENTRIC WITHIN R FULL INDICATOR READING.
4. SHAFT EXTENSION SHALL RUN TRUE IN SHAFT BEARINGS WITHIN P FULL INDICATOR READING.
5. DIAMETER MARKED AV IS EXCLUSIVE OF NAME-PLATE WHICH SHALL NOT EXCEED .010 THICKNESS.
6. TO SET SYNCHRO AT APPROX. ELECT. ZERO, LOCK INNER AND OUTER HOUSING WITH A .060 PIN. WHEN ARROW AND SHAFT MARK ARE IN LINE SYNCHRO IS AT APPROX. ELECT. ZERO.
7. NOTE 4 FIG. 1.
8. NOTE 5 FIG. 1.
9. NOTE 6 FIG. 1.
10. RADIAL PLAY OF SHAFT MEASURED 1/8" FROM BEARING WITH 8 OZ. REVERSED GAGE LOAD SHALL BE .004" MAX.

FIGURE 3



1. MARK ARROW AS SHOWN TO INDICATE ELECTRICAL ZERO WITH REFERENCE TO MARK ON SHAFT.
2. END PLAY SHALL NOT EXCEED M WITH 1 LB. REVERSED GAGE LOAD.
3. DIAMETERS MARKED ① TO BE CONCENTRIC TO ROTOR SHAFT WITHIN N FULL INDICATOR READING - INDICATOR MOUNTED ON SHAFT.
4. SURFACES MARKED ② TO BE PERPENDICULAR TO C_L WITHIN P FULL INDICATOR READING.
5. SHAFT EXTENTION SHALL RUN TRUE IN SHAFT BEARING WITHIN R FULL INDICATOR READING.
6. DIAMETER MARKED B IS EXCLUSIVE OF NAMEPLATE WHICH SHALL NOT EXCEED .004 THICKNESS.
7. RADIAL PLAY MEASURED 1/8" FROM BEARING SHALL NOT EXCEED .001" WITH 1 LB. REVERSED GAGE LOAD.

Figure 4

2.1.3 Coarse Synchro Zero Marking: When required by the detail specification, synchro zero shall be approximately located to within 10° by providing an arrow stamped on the frame and an index mark on the shaft extension.

2.2 Electrical:

2.2.1 High Potential Tests: The synchro should withstand satisfactorily a specified sinusoidal potential at a frequency of 60 cycles per second applied for 15 seconds between windings and case and between windings insulated from each other, but on the same iron structure. The applied potential should be raised from zero to the specified value in not less than 5 seconds and reduced to zero at the same rate. Windings having nominal ratings of 115, 90 and 57.5 volts should be tested at 900 volts R.M.S. and those rated at 26 and 11.8 volts should be tested at 500 volts R.M.S. The High Potential test should be performed only once on the completed synchro. Repeated High Potential tests, made by any agency after shipment from point of manufacture, are to be made at values not to exceed 80% of those specified for the completed unit.

2.2.2 Insulation Resistance: The insulation resistance of the synchro should be measured after the high potential test. With 500 volts d-c applied between the windings and the frame for a duration of one minute, the insulation resistance should not be less than 50 megohms.

2.2.3 Open Circuit Current and Power: The input current should be measured with the synchro energized as described under paragraph 2.2.8 and with the secondary leads open. The measurements should be made with the synchro at normal operating temperature. The open circuit current and power should not vary by more than 2 percent as the rotor is turned through a complete revolution.

2.2.3.1 Accuracy of Measurement: In order to assure correlation of measurement with the manufacturer, meters having the following accuracy are recommended:

Current: Dynamometer type milliammeter with an accuracy of .25%

Power: Low power factor wattmeter with an accuracy of .50%.

2.2.4 Synchro Zero: Measurements of all angular displacements of the rotors of synchros shall be referred to a standard position which will be designated as "Synchro Zero", as defined in paragraph 1.3.2.6. Caution should be taken in testing units without dampers to prevent their spinning. External friction may be applied or the voltage made very low at first and then increased to normal after the rotor has come to rest. The values of applied voltages for types are tabulated below:

Nominal System Volts	Applied Volts					
	Figures					
	5-6	7-8	9-10	11-12	13-14	15-16
115	115	78	78	115	90	90
26	26	10.2	10.2	26	11.8	11.8

2.2.4.1 Synchro Zero of Transmitters and Receiver: The synchro zero position of a transmitter or receiver shall be determined by connecting the primary and secondary as shown in figure 5.

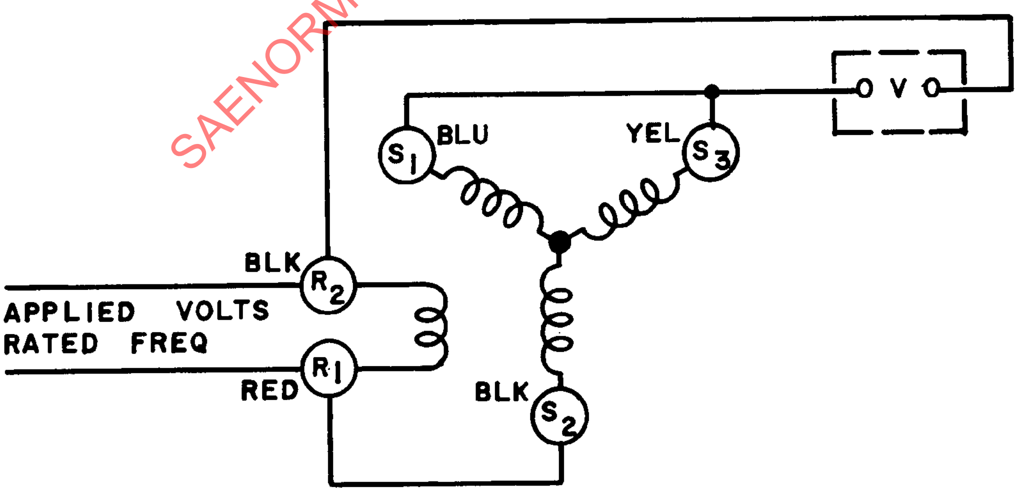


Figure 5

The synchro shaft will rotate to either of two positions which are 180° apart. The correct approximate position is that one which produces the smaller voltage reading in V. The synchro zero position should be accurately determined as follows: Without rotating the synchro shaft, reconnect synchro as shown in figure 6.

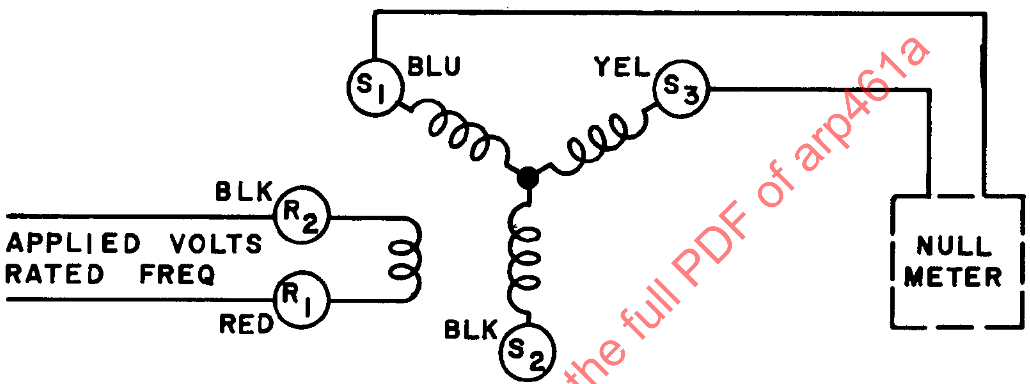


Figure 6

Rotate the synchro shaft through the smaller angle that will produce a minimum reading on the null meter. That position is the synchro zero position.

2.2.4.2 Synchro Zero of Control Transformers: The synchro zero position of a control transformer shall be determined by connecting the synchro as shown in figure 7.

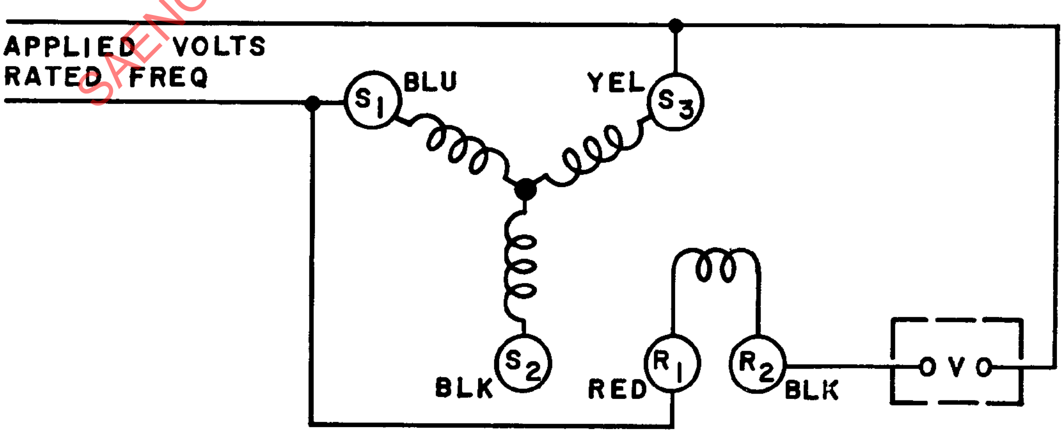


Figure 7

The synchro zero position is approximately at the minimum voltage position. This position should be accurately located by connecting the synchro as shown in figure 8, without rotating the synchro shaft.

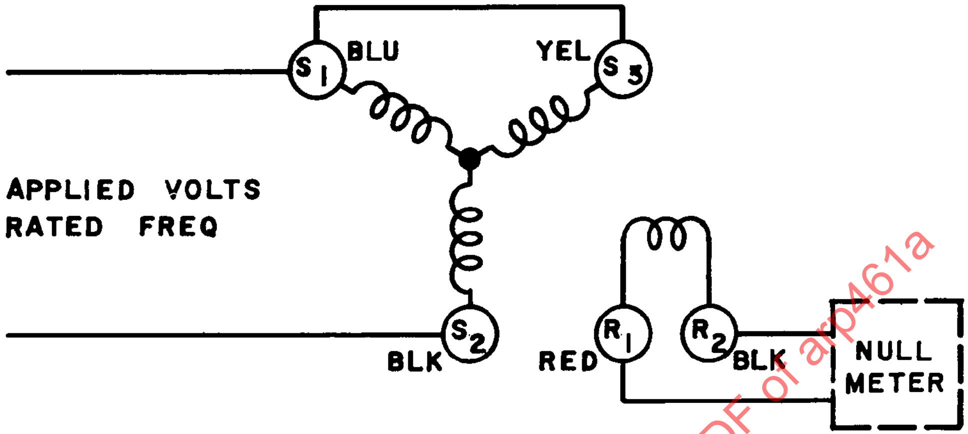


Figure 8

Rotate the synchro shaft through the smallest angle that will produce a minimum reading on the null meter. That position is the synchro zero position.

2.2.4.3 Synchro Zero of Differential Transmitters and Differential Receiver: The synchro zero position of a differential transmitter or receiver shall be determined by connecting the synchro as shown in figure 9.

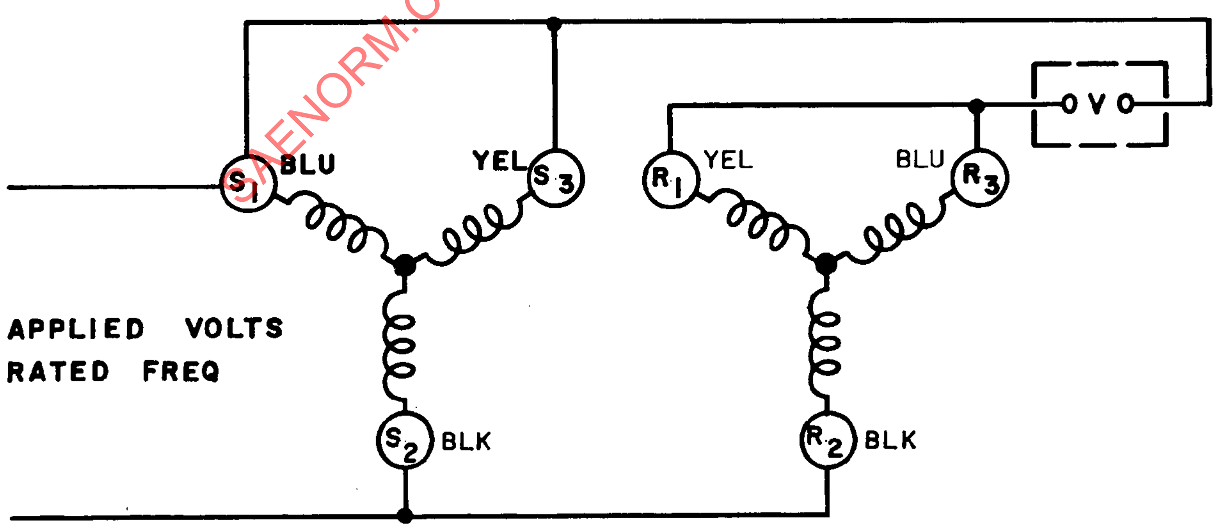


Figure 9

The synchro shaft will rotate to either of two positions which are 180° apart. The correct approximate position is the one which produces the small voltage reading in V. The synchro zero position should then be accurately determined as follows: Without rotating the shaft, reconnect the synchro as shown in figure 10.

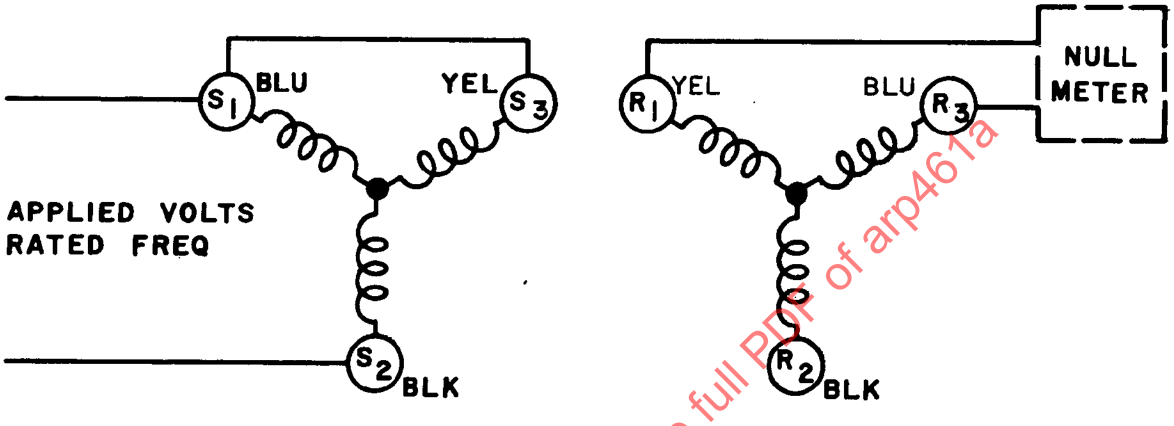


Figure 10

Rotate the synchro shaft through the smallest angle that will produce a minimum reading of the null meter. That position is the synchro zero position.

2.2.4.4 Synchro Zero of Resolver Transmitter: The synchro zero of a resolver transmitter shall be determined by connecting the primary and secondary as shown in figure 11.

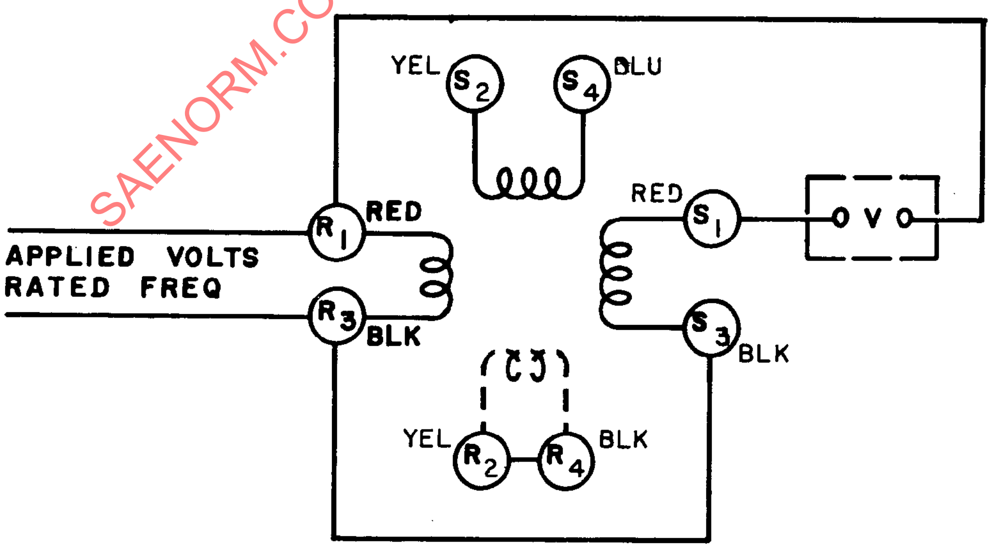


Figure 11

The resolver shaft shall be rotated to the position that produces the smallest reading in V. The synchro zero position should then be accurately determined as follows: Without rotating the resolver shaft, reconnect the resolver as shown in figure 12.

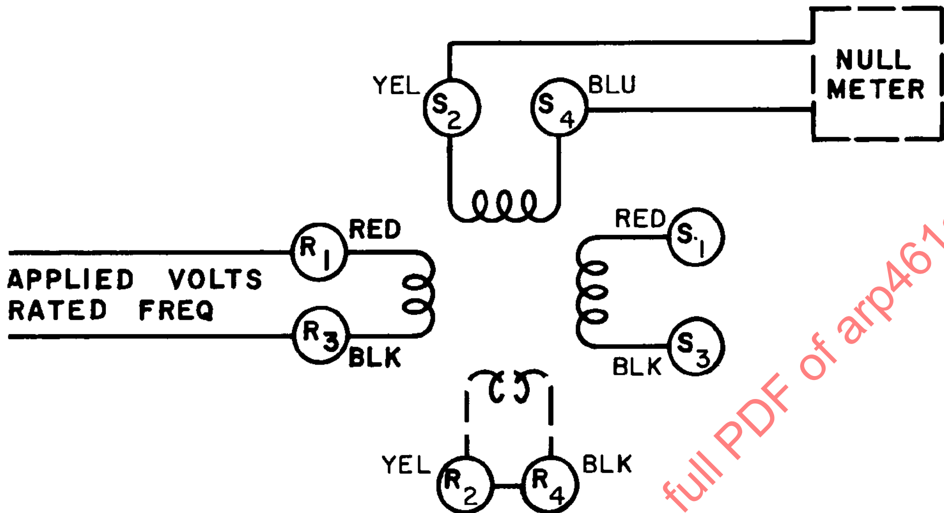


Figure 12

Rotate the resolver shaft through the smaller angle that will provide a minimum reading on the null meter. That position is the synchro zero position.

2.2.4.5 Synchro Zero of Resolver Control Transformer: The synchro zero of a resolver control transformer shall be determined by connecting the primary and secondary as shown in figure 13.

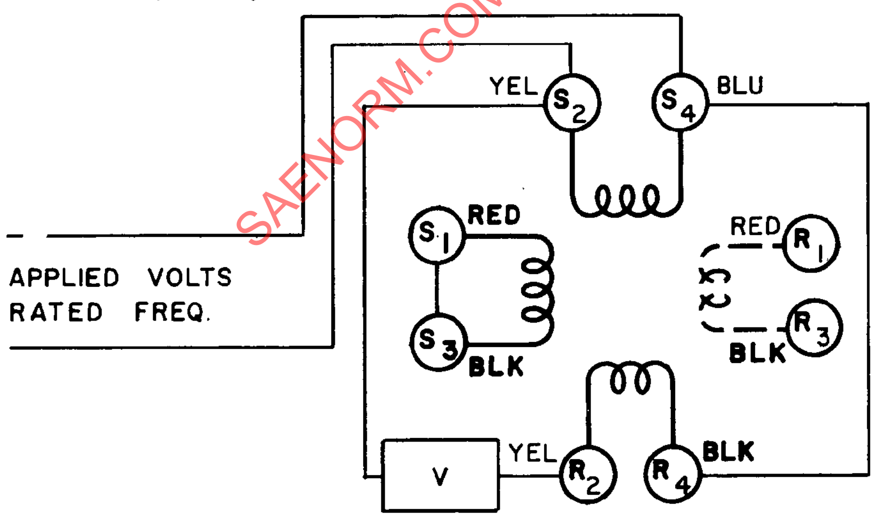


Figure 13

The resolver shaft shall be rotated to the smaller peak voltage position as read in V. The synchro zero position should then be accurately determined as follows: Without rotating the resolver shaft, reconnect the resolver as shown in figure 14.

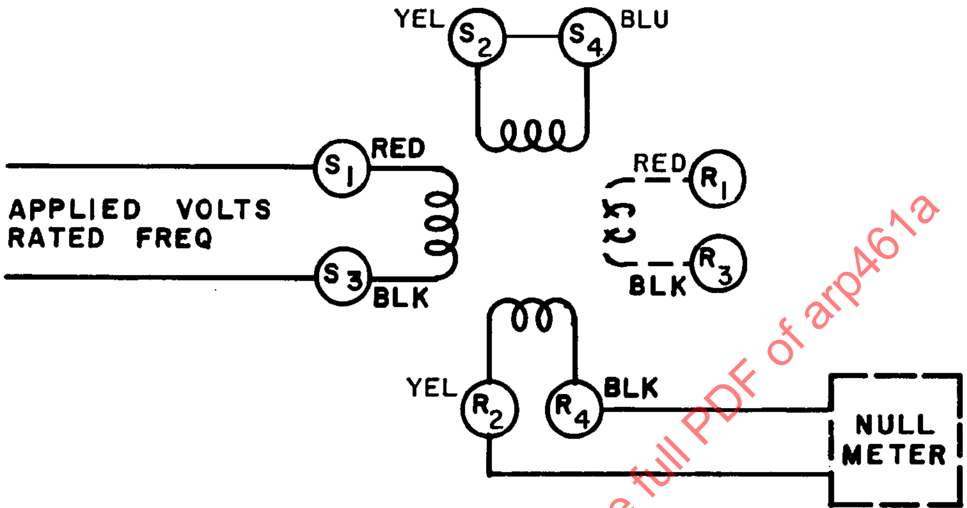


Figure 14

Rotate the resolver shaft through the smaller angle that will provide a minimum reading on the null meter. That position is the synchro zero position.

2.2.4.6 Synchro Zero of Resolver Differential: The synchro zero of a resolver differential shall be determined by connecting the primary and secondary as shown in figure 15.

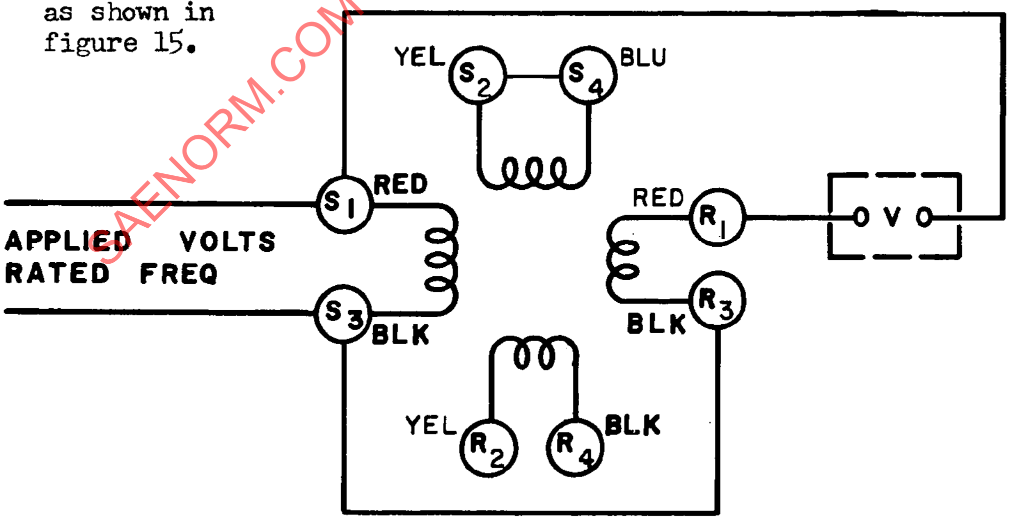


Figure 15

The resolver shaft shall be rotated to the position that produces the smallest reading in V. The synchro zero position shall then be accurately determined as follows:

Without rotating the resolver shaft, reconnect the resolver as shown in figure 16.

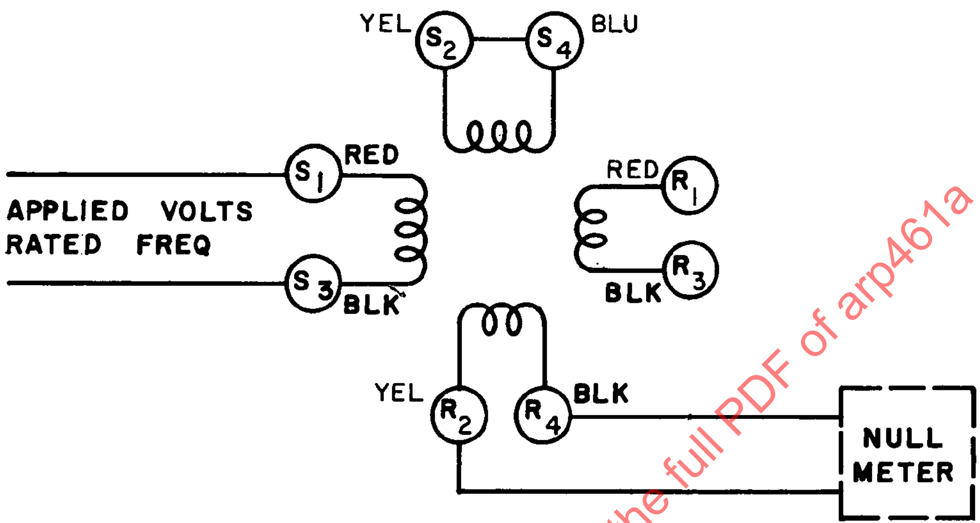


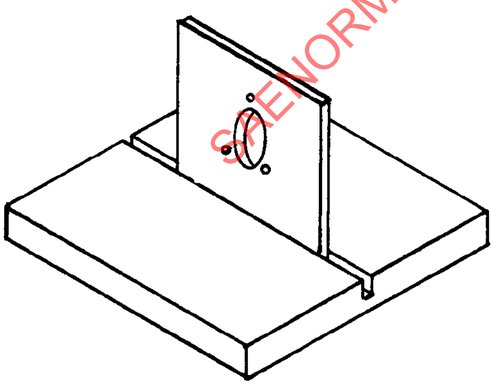
Figure 16

Rotate the resolver shaft through the smaller angle that will provide a minimum reading on the null meter. That position is the synchro zero position.

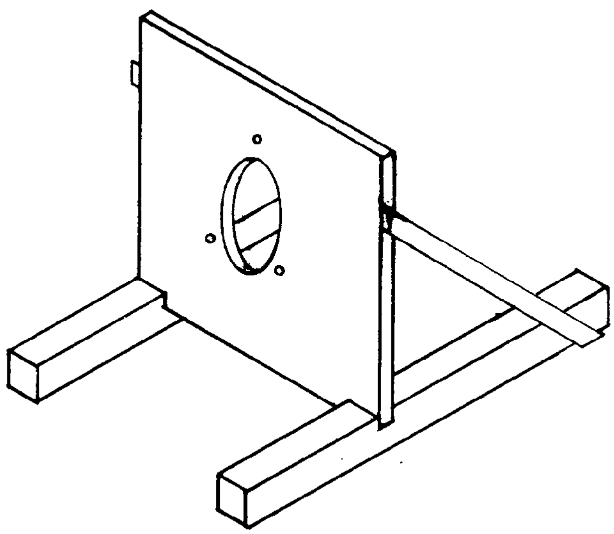
2.2.5 Impedance: In order to assure correlation in impedance measurement the following procedures are specified. Specific impedance values are not part of this recommended practice and should be negotiated with the synchro manufacturer.

2.2.5.1 General: The synchro should be mounted in a fixture as shown in Figure No. 17 during impedance measurement. The synchro should be held in place by standard mounting clamps. The mounting plate should be finished with black anodize. The mounting plate should be supported by a base made of any suitable heat insulating material. The base should allow approximately 1/4" clearance between the mounting plate and any other surface. The synchro and its mounting should be located to assure minimum effect from air currents and ambient temperature rise, and should be maintained in an atmosphere of 22°C. ± 3°C until the synchro reaches a state of equilibrium.

2.2.5.1.1 Mounting-Fixture: The details of the mounting fixtures pictured in Figure No. 17 are shown in Figure No. 18 and 19.



FOR SIZE 19 AND SMALLER
(REFERENCE FIG. 18)

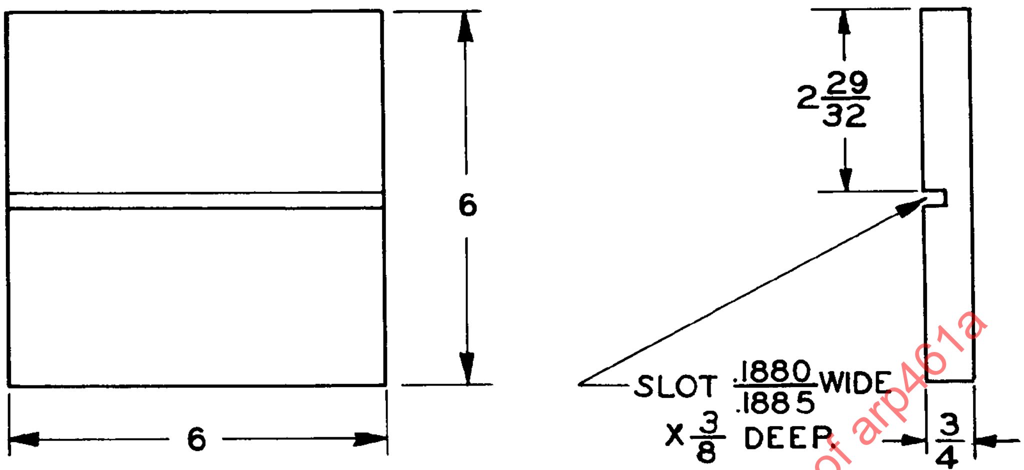


FOR SIZE 23 AND LARGER
(REFERENCE FIG. 19)

SYNCHRO MOUNTING FIXTURES

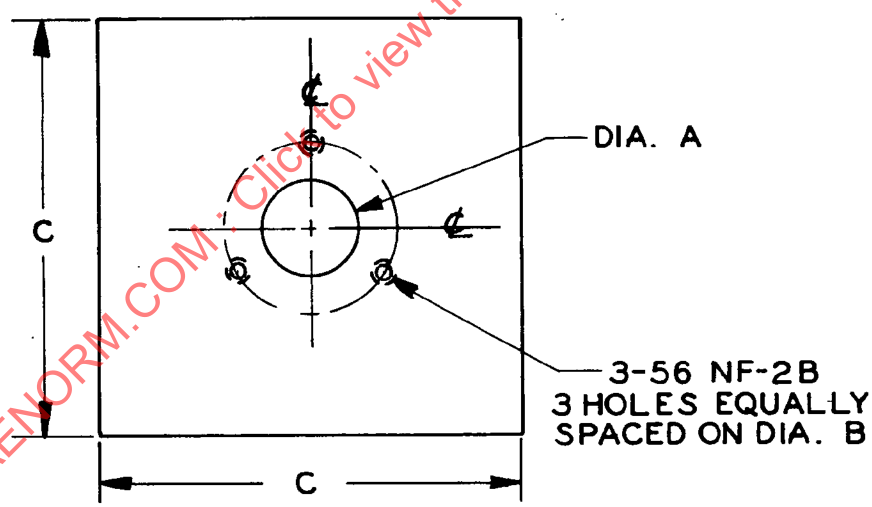
FIGURE NO. 17

BASE



Material: Linen Laminated Bakelite or other suitable Insulating Material.

MOUNTING PLATE



Frame Size	Dimensions - Inches DIA. A +.001 -.000	DIA. B ±.002	C
8	0.501	1.000	2 1/4
10	0.812	1.187	2 13/16
11	1.001	1.312	3 13/64
15	1.313	1.687	4 5/16
18	1.563	1.956	5 1/4

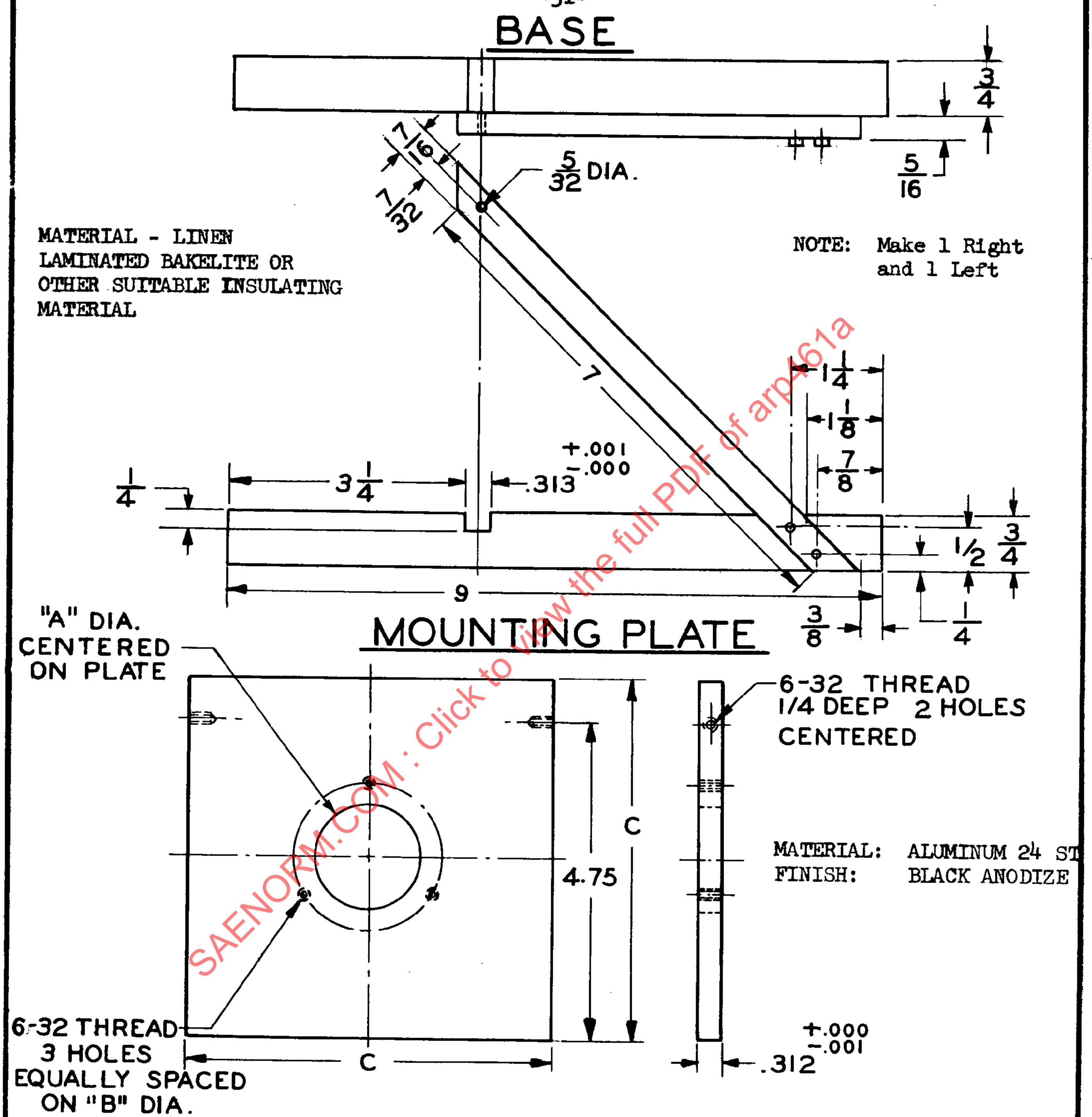
Material: Aluminum 24 ST .187 max. Thick

Finish: Black Anodize

NOTE 1: Unless specified, tolerance on decimals ±.005, fractions ±1/64

SYNCHRO MOUNTING FIXTURE, FOR SIZE 19 AND SMALLER

FIGURE 18



Frame Size	Dia. A +.001 -.000	Dia. B ±.002	C
23	2.001	3.00	6 3/4
31	2.751	3.50	9 5/16

Dimensions - Inches

NOTE 1: Unless otherwise specified tolerance on decimals ±.005, fractions ± 1/64

SYNCHRO MOUNTING FIXTURE
FOR SIZE 23 AND LARGER
FIGURE 19

2.2.5.1.2 **Circuit:** Impedance readings should be taken after the synchro has been excited for one hour or has reached a stable temperature condition. The unit should be set at synchro zero except where otherwise noted. The power source should be sinusoidal with a harmonic content not to exceed 2%. Both voltage and frequency regulation should be better than 1% at the points of measurement.

The impedance values in ohms should be determined with a series resonance bridge as shown in Figure 20. The elements of this bridge must have an accuracy of at least 0.1%. The null detector should be of the oscilloscope type, if possible. If vacuum tube voltmeters are used, they should have an accuracy of at least 1%.

2.2.5.1.3 **Procedure:**

1. Adjust excitation voltage until the voltage at the VTVM is at specified voltage.
2. Energize synchro for 1 hour or until thermally stabilized while mounted in recommended test fixture.
3. Adjust C and R for null reading. $R_A = R_B \approx R$
4. $Z = R + j\frac{1}{2\pi fC}$

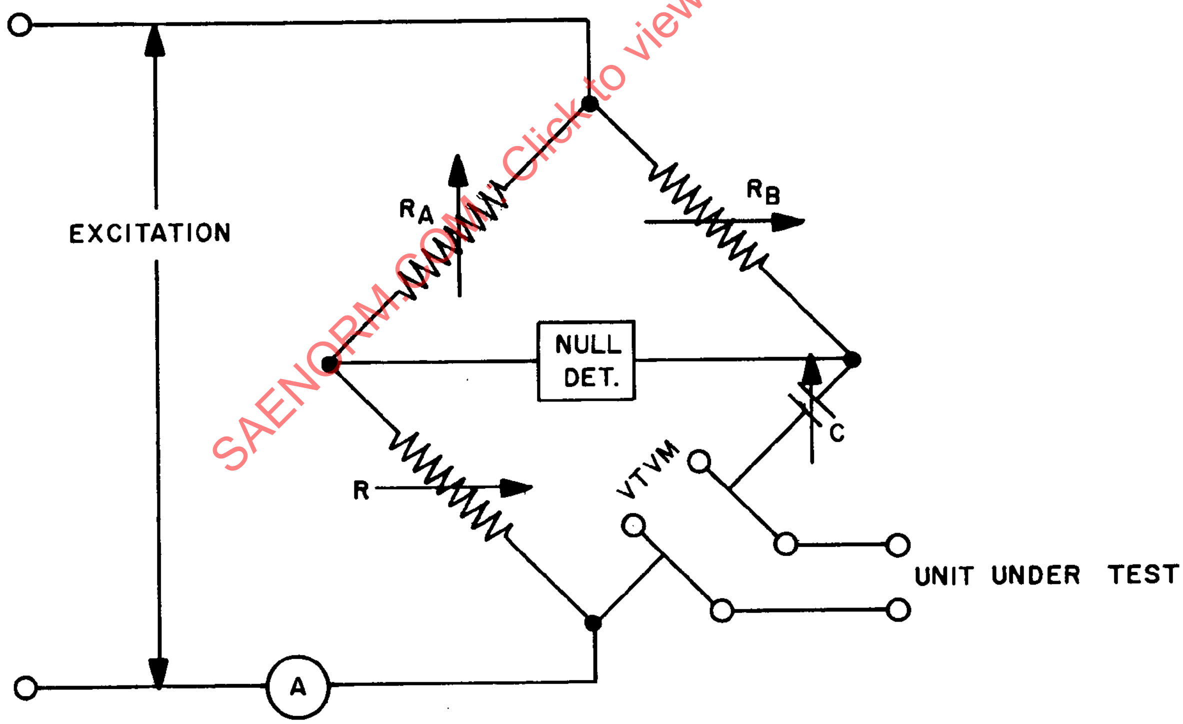


FIGURE 20

2.2.5.2 Measurements:

2.2.5.2.1 Transmitters, Control Transformers, Receiver: Impedance measurements shall be made at synchro zero except as noted below. The readings shall be recorded after the synchro has been excited for one hour or has reached a stable temperature condition.

The following impedance measurements are to be made:

(a) Impedance Z_{RO}

Excite rotor at nominal rated excitation, see Section 2.2.8, with stator open circuited.

(b) Impedance Z_{SO}

Excite stator single phase at nominal rated excitation, see Section 2.2.8, with the rotor open circuited. For this test, connect terminals S_1 and S_3 together and apply excitation between the strapped $S_1 - S_3$ terminals and S_2.

(c) Impedance Z_{RS}

Excite the rotor, with the stator short circuited, at the current value obtained in measurement Z_{RO}.

(d) Impedance Z_{SO} - 90 (For Salient Pole Synchros)

Apply nominal rated excitation, see Section 2.2.8, to terminal S_2 and S_1. Connect S_3 to S_1. Rotor terminals shall be open circuited. Rotor to be positioned 90° from synchro zero.

2.2.5.2.2 Differentials - Transmitters, and Receiver: Impedance measurements shall be made at synchro zero except as noted below. The readings shall be recorded after the synchro has been excited for one hour or has reached a stable temperature condition.

The following impedance measurements are to be made:

(a) Impedance Z_{RO}

Apply nominal rated excitation, see Section 2.2.8, to terminals R_2 and R_1. Connect R_3 to R_1. Stator terminals to be open circuited.

(b) Impedance Z_{SO}

Excite the stator single phase at nominal rated excitation, see section 2.2.8, with the rotor open circuited. For this test, connect terminals S_1 and S_3 together and apply excitation between the strapped S_1 - S_3 terminals and S_2.

(c) Impedance Z_{RS}

Connect R_3 to R_1 and excite the rotor terminals R_1 and R_2, with the stator short circuited, at the current value obtained in measurement Z_{RO}.

2.2.5.2.3 Resolvers - Transmitter, Control Transformer and Differential: Impedance measurements shall be made at synchro zero except as noted below. The readings shall be recorded after the synchro has been excited for one hour or has reached a stable temperature condition.

The following impedance measurements are to be made:

(a) Impedance Z_{RO}

Excite rotor terminals R_1 and R_3 at nominal excitation, see Section 2.2.8, with the stator open circuited. For this test connect rotor terminals R_2 to R_4.

(b) Impedance Z_{SO}

Excite stator terminal S_1 - S_3 at nominal rated excitation, see Section 2.2.8, with the rotor open circuited. Stator terminals S_2 - S_4 should be shorted together.

(c) Impedance Z_{RS}

Excite the rotor terminals R_1 and R_3, with the stator short circuited, at the current value obtained in measurement Z_{RO}. For this test connect rotor terminals R_2 to R_4.

(d) Repeat steps (a), (b), and (c), but exciting the other phase windings R_2 - R_4 (etc.).

2.2.6 Accuracy:

2.2.6.1 Electrical Error - Proportional Voltage Method: Before testing the synchro for electrical error by the proportional voltage method, the synchro zero position of the synchro under test should be accurately determined as described in 1.3.2.6 as applicable. The synchro zero should be determined under open circuit conditions and shall not be adjusted before performing electrical error test.

2.2.6.1.1 This method consists in comparing the rotor angle of the synchro with the electrical angle. The electrical angle, a, of the synchro is related to the equivalent position ϕ, by the following expression:

$$a = \text{Electrical angle} = \phi + (N + 3M)\,60^\circ$$
$$R = 1/2 - 1/2\sqrt{3}\,\cot(\phi + 60^\circ)$$

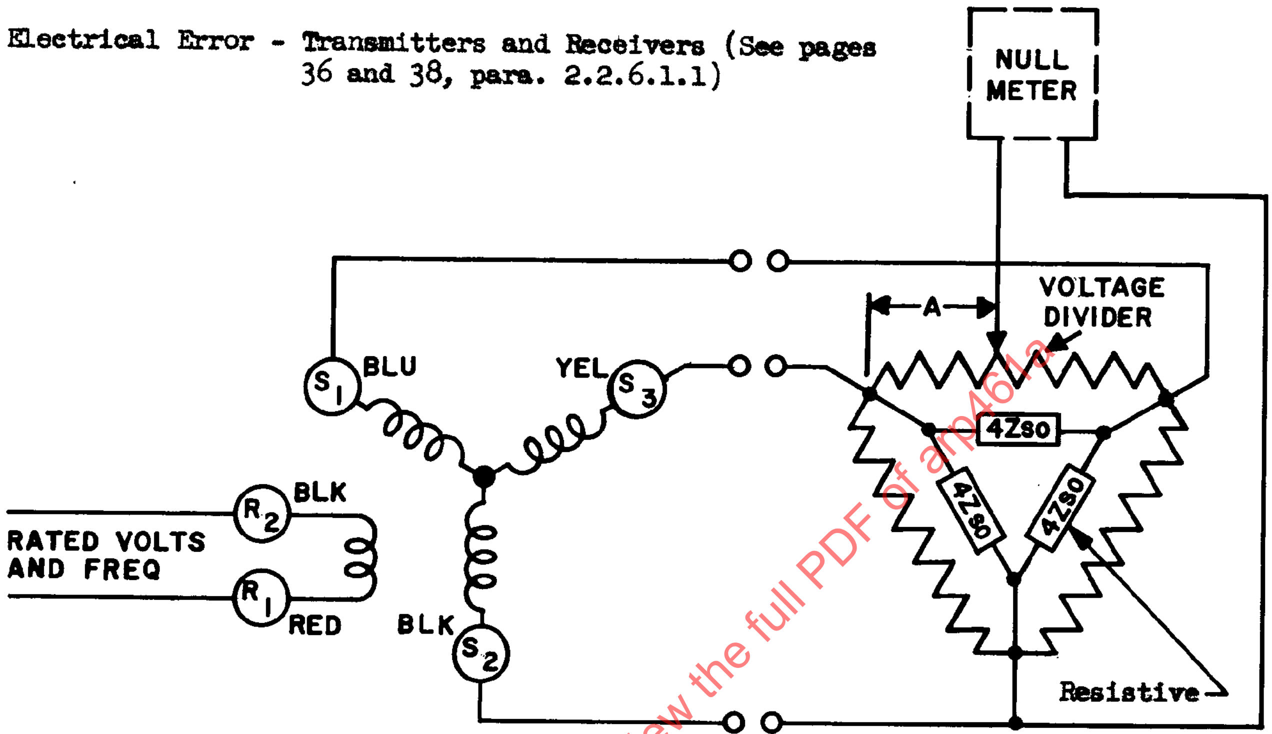
$$R = \frac{\text{one of the smaller secondary voltages}}{\text{largest secondary voltage}} = \frac{A}{10000}\ \text{ohms}$$

M = 0 when Voltage E (S_{13}) is in time phase with voltage E (R_{21}).
M = 1 when Voltage E (S_{13}) is 180° out of time phase with voltage E (R_{21}).
and N is determined from the following tables:

Terminals Giving Largest Secondary Voltage	Terminals Giving Smallest Secondary Voltage	Value of N
$S_2 - S_1$	$S_1 - S_3$	0
$S_1 - S_3$	$S_3 - S_2$	1
$S_3 - S_2$	$S_2 - S_1$	2

The basic circuit employed for electrical error testing of synchro transmitters is shown in figure 21. The unit should be energized with rated voltage and frequency across $R_1 - R_2$.

Electrical Error - Transmitters and Receivers (See pages 36 and 38, para. 2.2.6.1.1)



NOTE: The $4Z_{so}$ delta connected loads may be replaced by an equivalent wye connected load.

Figure 21

Basic Circuit Employed for Electrical Error Test of Synchro Transmitters and Receivers

Three 10,000 ohm resistors should be connected in delta across the output circuits S_1, S_2 and S_3. At least one of these resistors should be capable of being tapped. The three resistors should be equal to within 0.01%. The voltage divider should not produce a phase shift of more than 10 minutes. Taps should be such that the ratio R should be accurate to .01% at any point. Impedances shown as 4 Z_{so} should be four times the value of Z_{so} ± 15% of the type of unit under test (ref. paragraph 2.2.5.2). This load shall be resistive. This load should be such that when three error curves are made, each at one of the three possible connections of the load, the maximum difference in the error curves should not exceed 10% of the allowable transmitter error. With maximum output voltage of unit under test applied across one of the impedances, the maximum pickup across either of the other 2 impedances should not exceed 0.005% of the applied voltage. The voltage divider should be connected across the secondary terminals giving the largest voltage, and the resistors should be connected across the terminals giving the smaller voltage. The variable tap on the divider should be connected to the common terminal of the two fixed resistors through a phase sensitive electronic voltmeter having an impedance not less than that of a 500,000 ohm resistance shunted by a capacity of 30 mmfd, and should be capable of indicating 0.2 minute displacement of the unit under test from a null position. The reference phase of this voltmeter should be adjustable to coincide with the output voltage of the synchro under test. It should also be able to discriminate against a value of quadrature of 1% of maximum output voltage of the unit under test so as to produce a meter reading less than that produced by a 0.2 minute displacement from the null position of the unit under test. The voltage divider should be set at the proper ratio (R in the formula) for the desired electrical position and the synchro shaft should be turned until a zero reading of the null meter is obtained. The position of the rotor is then recorded. The error at a given rotor position is defined as the mechanical rotor position minus the electrical position. To facilitate the settings of the voltage divider, a table of values of R corresponding to various value of ϕ is given in the following table:

Values of R for Various Values of Angle ϕ

ϕ	R
0	.00000
5	.09617
10	.18479
15	.26795
20	.34730
25	.42423
30	.50000
35	.57577
40	.65270
45	.73205
50	.81521
55	.90383
60	1.00000

The maximum error, in absolute value, of transmitters should not exceed those given for its classification in tabulation under section 2.2.6.5.

2.2.6.1.2 Control Transformers: The basic circuit for electrical error testing of control transformers is shown in Figure 22. The stator terminals of the control transformer should be connected to the corresponding stator terminals of a matching control transmitter operated at rated voltage and frequency. The output terminals $R_1 - R_2$ of the control transformer should be connected to the null meter. The energizing transmitter should be turned until its electrical position, measured as described in 2.2.6.1.1, is at the desired value. The mechanical rotor position of the unit under test that produces a zero reading of the null meter should be determined. The error at a given rotor position is the mechanical rotor position minus the electrical position. The maximum errors, in absolute value, of control transformers should not exceed the limits given in 2.2.6.5. (When required, coding may be added to define the angular position of the second harmonic error).

2.2.6.1.3 Differential Transmitters:

2.2.6.1.3.1 Differential Transmitter Rotors: The basic circuit for electrical error testing of the rotor windings of differential synchros is shown in Figure 23. The unit should be energized at rated frequency with 0.866 times the rated voltage across terminal S_2 and terminal S_1 which is connected to S_3. The electrical position of the rotor is obtained from the following equation:

Electrical position = $\emptyset + (N + 3M)\ 60^\circ$
where $\emptyset$ is determined as described in Section 2.2.6.1.1.

M = 0 when voltage $E\ (R_{13})$ is in time phase with voltage $E\ (S_{23})$.
M = 1 when voltage $E\ (R_{13})$ is 180° out of time phase with voltage $E\ (S_{23})$ and N is obtained from the following table:

Terminals Giving Largest Secondary Voltage	Terminals Giving Smallest Secondary Voltage	Value of N
$R_3 - R_2$	$R_1 - R_3$	0
$R_1 - R_3$	$R_2 - R_1$	1
$R_2 - R_1$	$R_3 - R_2$	2

The error at a given rotor position is equal to the mechanical position of the rotor minus the electrical position. The maximum errors, in absolute value, of differential transmitters should not exceed the limits given in section 2.2.6.5.

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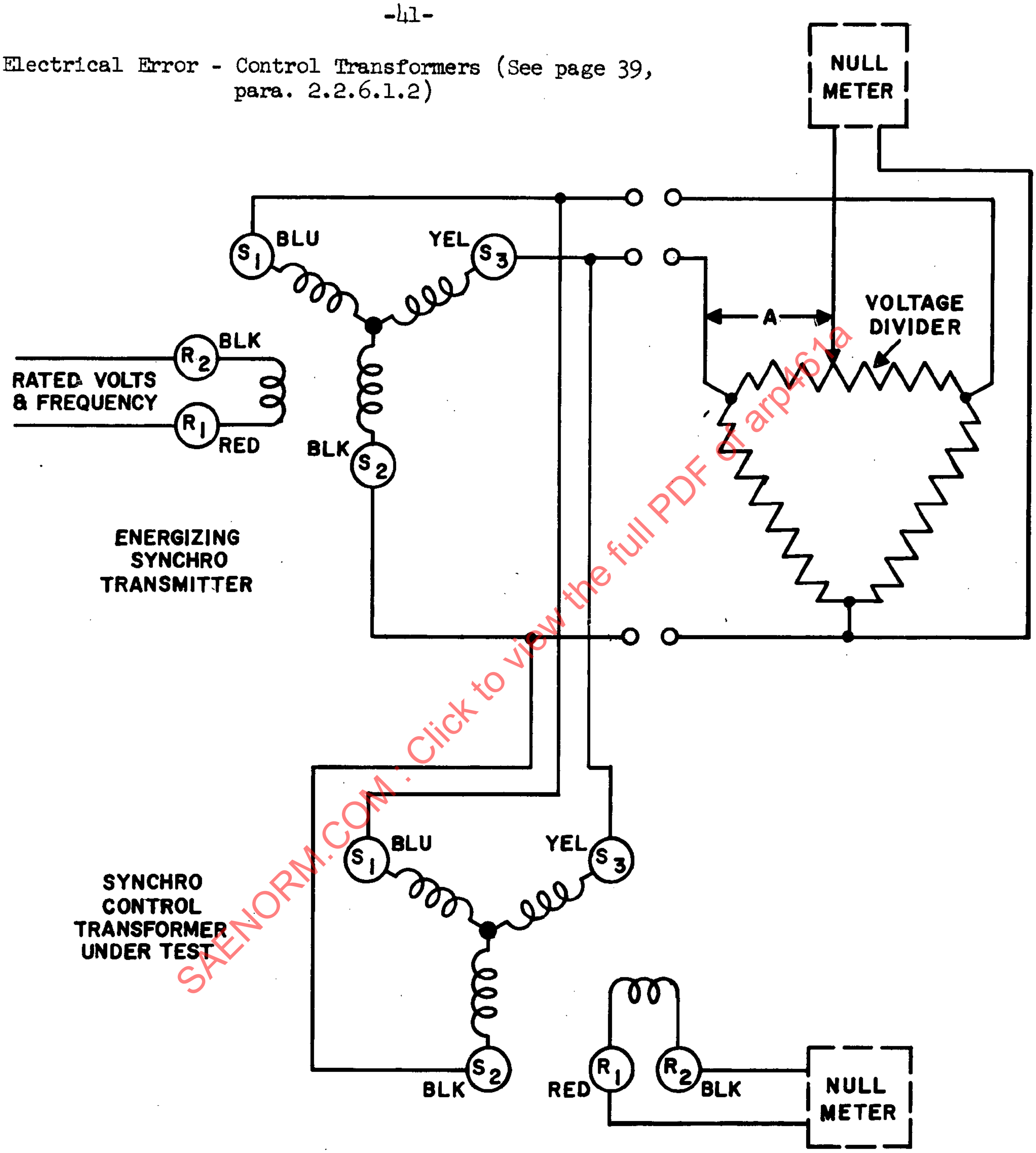
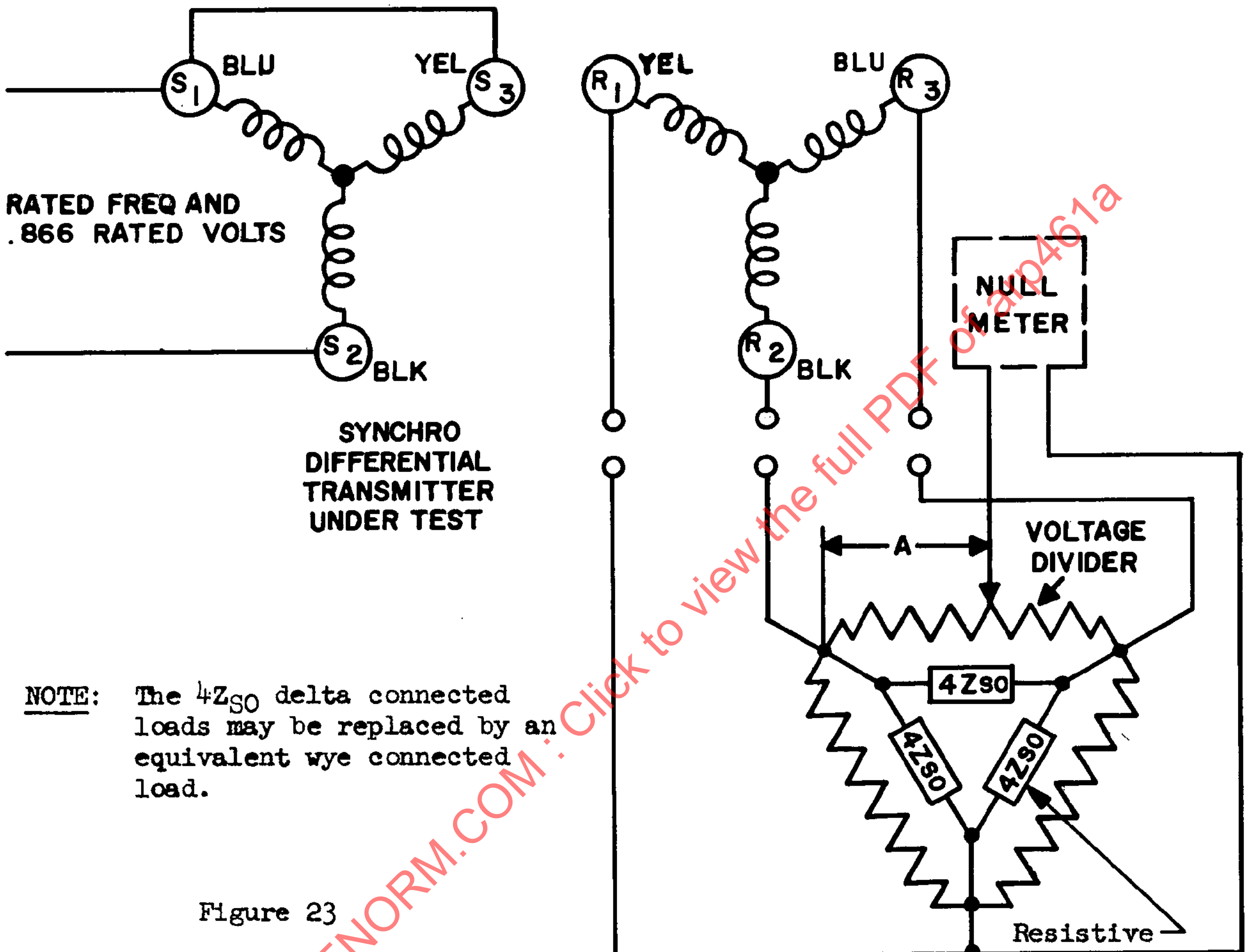
Electrical Error - Control Transformers (See page 39, para. 2.2.6.1.2)



BASIC CIRCUIT EMPLOYED FOR ELECTRICAL ERROR TEST OF CONTROL TRANSFORMERS

Figure 22

Electrical Error - Differential Transmitter Rotors (See page 39, para. 2.2.6.1.3.1)



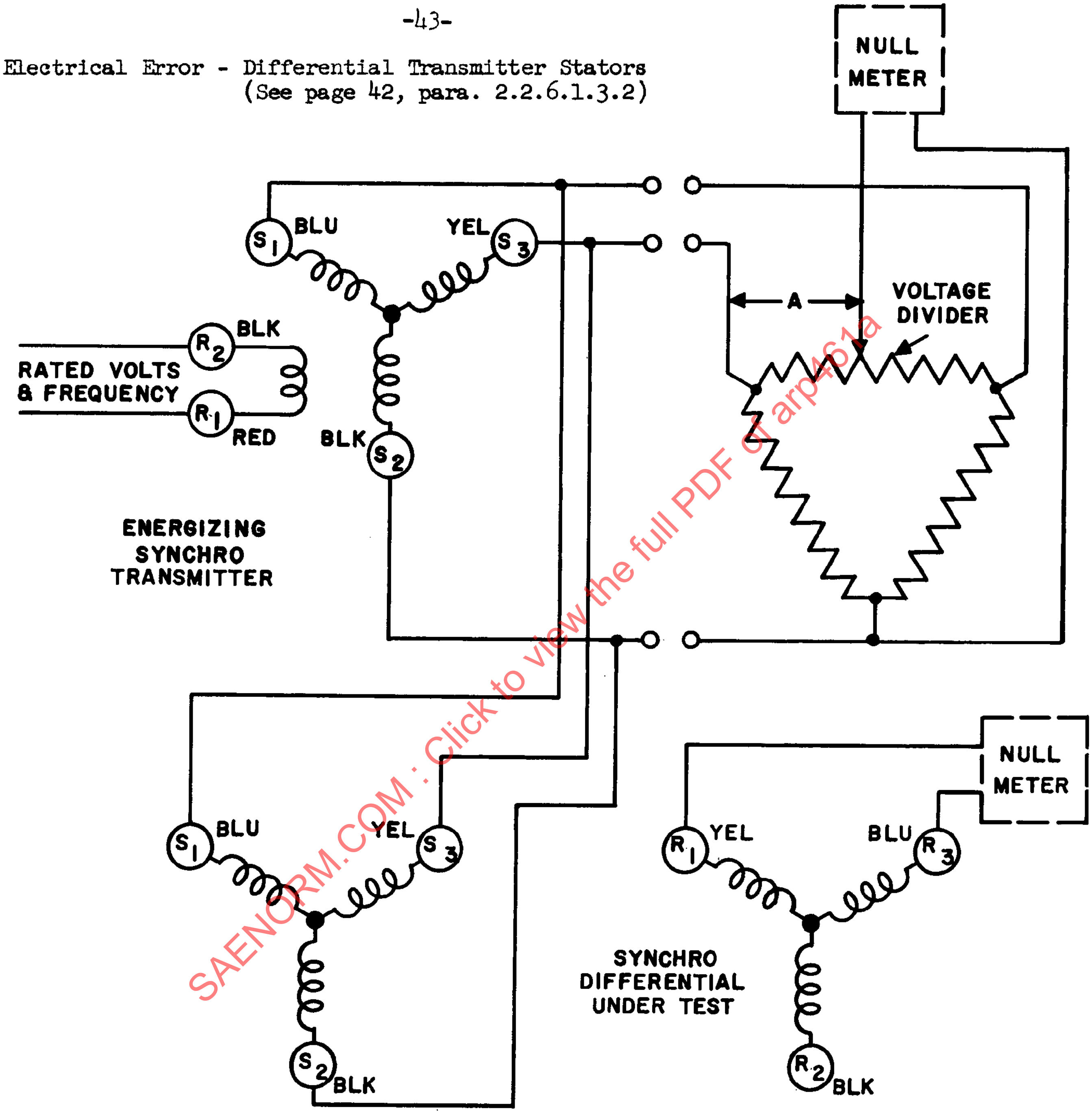
NOTE: The $4Z_{SO}$ delta connected loads may be replaced by an equivalent wye connected load.

Figure 23

BASIC CIRCUIT EMPLOYED FOR ELECTRICAL ERROR TEST OF THE ROTOR WINDINGS OF THE DIFFERENTIAL TRANSMITTERS

2.2.6.1.3.2 <u>Differential Transmitter Stators</u>: The basic circuit for electrical error testing of the stator windings of differential synchros is shown in Figure 24. The stator terminals of the synchro under test shall be connected to the corresponding stator terminals of a synchro transmitter of equal or larger size, operated at rated voltage and frequency. Rotor terminals R_1 - R_3 of the differential transmitter shall be connected to a null meter. The energizing transmitter shall be turned until its electrical position, measured as described in 2.2.6.1.1, is at the desired value. The angular position of the unit under test that produces a zero reading of the null meter shall be determined. The error at a given rotor position is defined as the mechanical rotor position minus the electrical position. The maximum errors, in absolute value, of differential transmitters shall not exceed the limits given in section 2.2.6.5.

Electrical Error - Differential Transmitter Stators
(See page 42, para. 2.2.6.1.3.2)



BASIC CIRCUIT EMPLOYED FOR ELECTRICAL ERROR TEST OF THE STATOR WINDINGS OF THE DIFFERENTIAL TRANSMITTERS

Figure 24

2.2.6.1.4 Electrical Error - Resolver Transmitter: This method consists of comparing the actual position of the synchro rotor with the electrical position of the synchro. The electrical position of the synchro is obtained from the following equation:

Electrical Position = $P\,\phi + (N + 1/2 - P/2 + 4M)\,45^\circ$

$\phi = \tan^{-1} R$

R = smaller secondary voltage/larger secondary voltage = $\frac{A_1}{A_2}$

$A_1 + A_2 = 10{,}000$ ohms

M = 0 when E (S_{13}) is in time phase with voltage E (R_{13})

M = 1 when E (S_{13}) is 180° out of time phase with voltage E (R_{13})

N is determined as follows:

N = 3 when V_3 is larger or equal to V_2 and V_1 is larger or equal to V_3.

N = 2 when V_2 is larger or equal to V_3 and V_1 is larger or equal to V_2.

N = 1 when V_2 is larger or equal to V_3 and V_1 is smaller or equal to V_2.

N = 0 when V_3 is larger or equal to V_2 and V_1 is smaller or equal to V_3.

P = + 1 when R increases with increasing positive angle.

P = - 1 when R decreases with increasing positive angle.

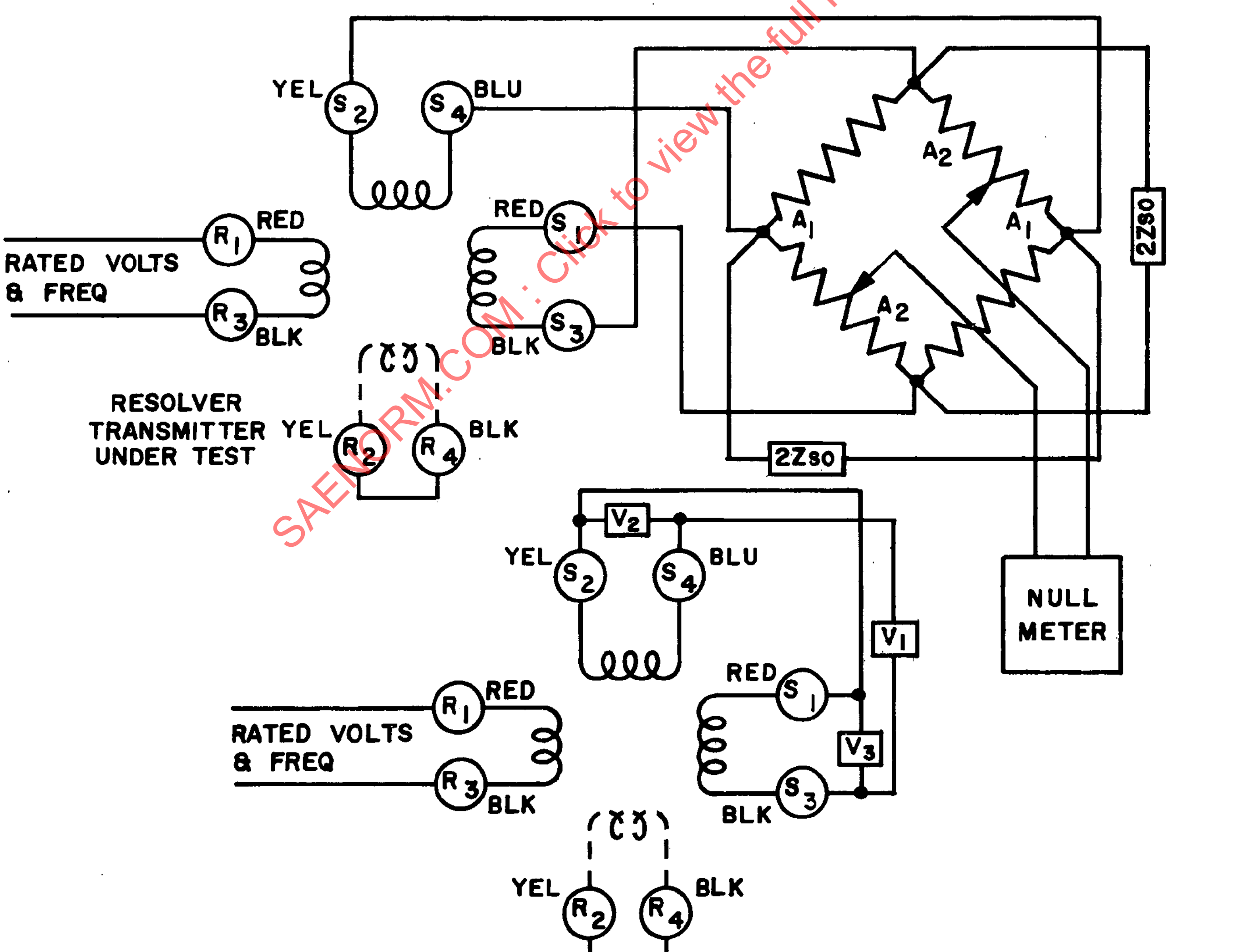


Figure 25

Electrical Error - Resolver Transmitter - (Cont. from pg. 44, para. 2.2.6.1.4)

Four non-inductive voltage dividers of 10,000 ohms each should be connected across the output circuits S_1-S_4, S_2-S_4 as shown in Figure 25. Impedances shown as $2Z_{so}$ should be two times the value of Z_{so} ± 15% of the type of unit under test (ref. paragraph 2.2.5). This load shall be resistive. This load should be such that four error curves are made, each at one of the four possible connections of the load, the maximum difference in the error curves shall not exceed 10% of the allowable transmitter error. With maximum output voltage of unit under test applied across one of the impedances the maximum pickup across the other impedance should not exceed 0.005% of the applied voltage. The voltage dividers should be equal to within 0.01% and produce a phase shift of no more than 10 minutes. The variable tap shall be connected to a null meter having an impedance not less than that of 500,000 ohm resistor shunted by a 30 mmf capacitance and should be capable of indicating 0.2 minutes displacement of the unit under test from a null position. It should also be able to discriminate against a value of quadrature of 1% of maximum output voltage of the unit under test so as to produce a meter reading less than that produced by a 0.2 minute displacement from the null position of the unit under test. The voltage divider should be set at the proper ratio (R in the formula) for the desired electrical position and the synchro shaft should be turned until a zero reading of the null meter is obtained. The position of the rotor is then recorded. The error at a given rotor position is defined as the mechanical rotor position minus the electrical position.

Values of R for Various Values of Angle Ø

Ø	R
0	.00000
5	.08749
10	.17633
15	.26795
20	.36397
25	.46631
30	.57735
40	.83910
45	1.00000

The maximum errors, in absolute value, of resolver transmitter should not exceed those given in section 2.2.6.5.

2.2.6.1.5 Resolver Control Transformers: The basic circuit for electrical error testing of resolver control transformers is shown in Figure 26.

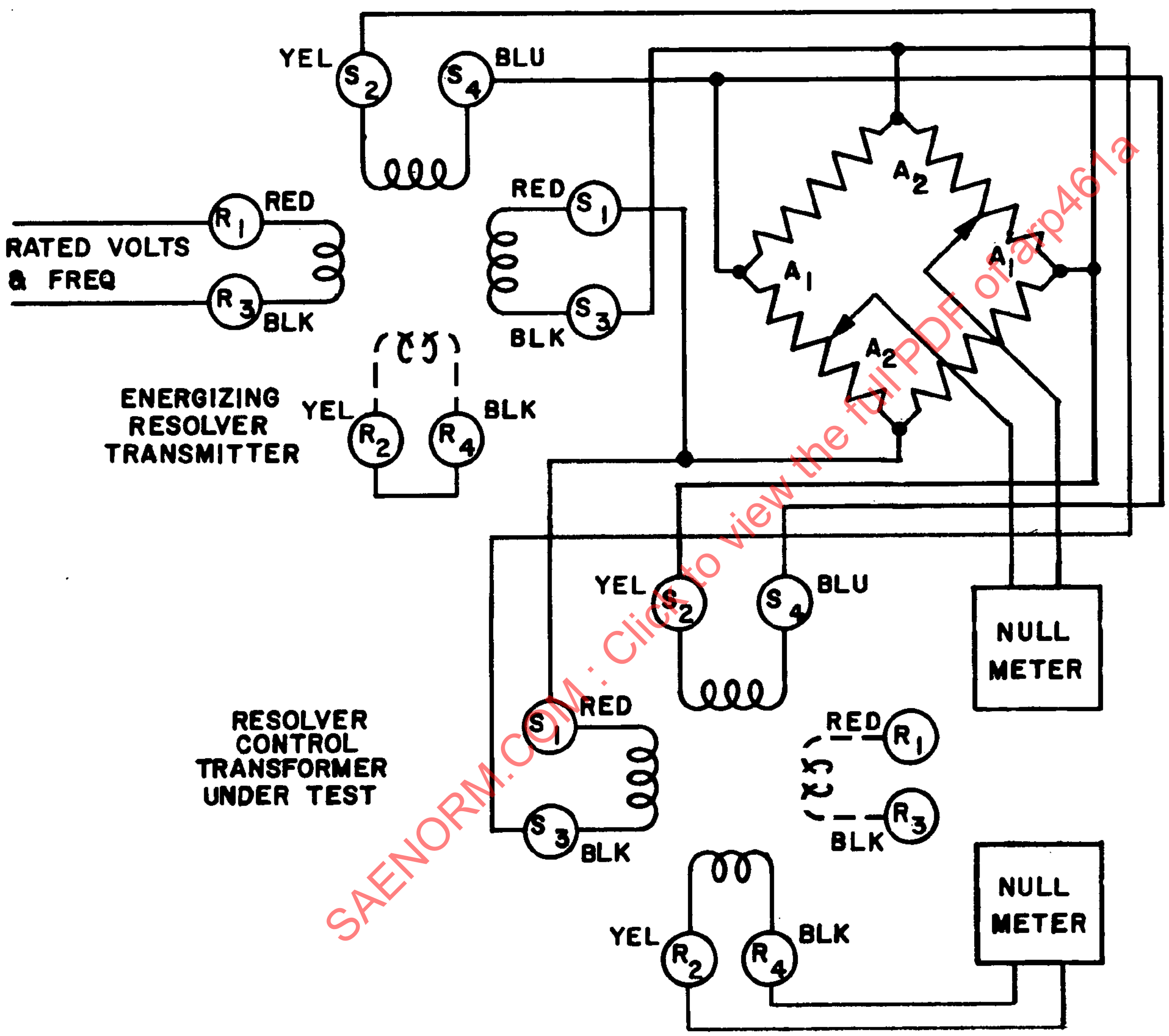


Figure 26

The stator terminals of the resolver transformer shall be connected to corresponding stator terminals of a resolver transmitter operated at rated voltage and frequency. The output terminals R_2 R_4 of the resolver control transformer shall be connected to the null meter. The energizing transmitter shall be turned until its electrical position, measured as described in 2.2.6.1.4, is at the desired value. The angular position of the unit under test that produces a zero reading of the null meter shall be determined. The error at a given rotor position is the mechanical rotor position minus the electrical position. The maximum errors, in absolute value, of resolver control transformers shall not exceed the limits given in section 2.2.6.5.

2.2.6.1.6 Resolver Differential:

2.2.6.1.6.1 Resolver Differential-Rotor: The basic circuit for electrical error testing of the rotor windings of resolver differentials is shown in Figure 27. Rated voltage and frequency should be applied to terminals S_1-S_3. The error at a given rotor position is the mechanical rotor position minus the electrical position. The maximum errors, in absolute value, of a resolver differential rotor should not exceed the limits given in section 2.2.6.5.

2.2.6.1.6.2 Resolver Differential-Stator: The basic circuit for electrical error testing of the stator windings of resolver differentials is shown in Figure 28. The stator terminals of the resolver differential should be connected to the stator terminals of a resolver transmitter of equal magnetic, electrical, and mechanical size. Rated voltage and frequency should be applied to the resolver transmitter. The output terminals R_2R_4 of the resolver differential should be connected to the null meter. The energizing transmitter should be turned until its electrical position, measured as described in 2.2.6.1.4 is at the desired value. The angular position of the unit under test that produces a zero reading of the null meter should be determined. The error at a given rotor position is the mechanical rotor position minus the electrical position. The maximum errors, in absolute values, of a resolver differential stator should not exceed the limits given in section 2.2.6.5.

2.2.6.2 Electrical Error - Alternate Methods: Production testing may be accomplished by comparison methods providing that the error curve so obtained will not vary more than 2 minutes from the error curve obtained by the proportional voltage method.

Electrical Error - Resolver Differential - Rotor (See page 47, para. 2.2.6.1.6.1)

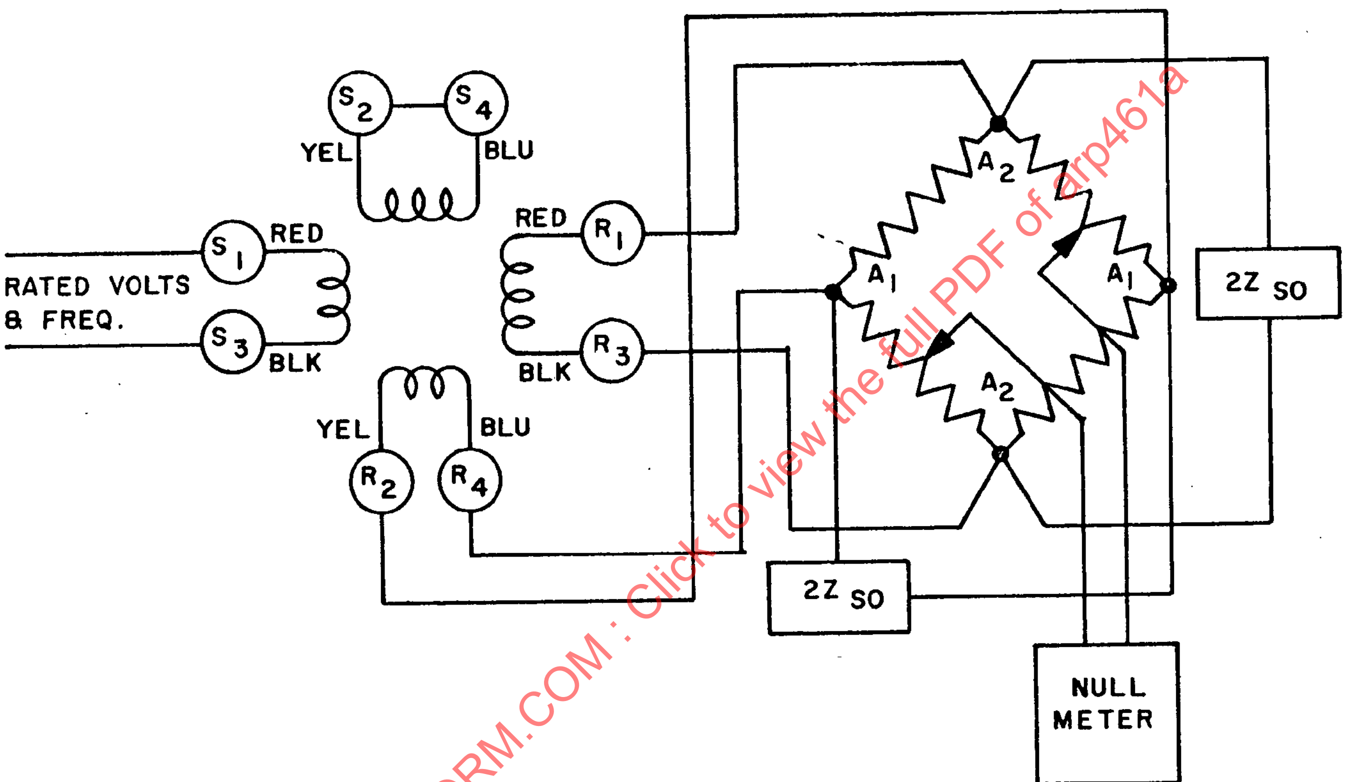


Figure 27

BASIC CIRCUIT FOR ELECTRICAL ERROR TESTING OF

RESOLVER DIFFERENTIAL ROTOR WINDINGS

Electrical Error - Resolver Differential - Stator (See page 47, para. 2.2.6.1.6.2)

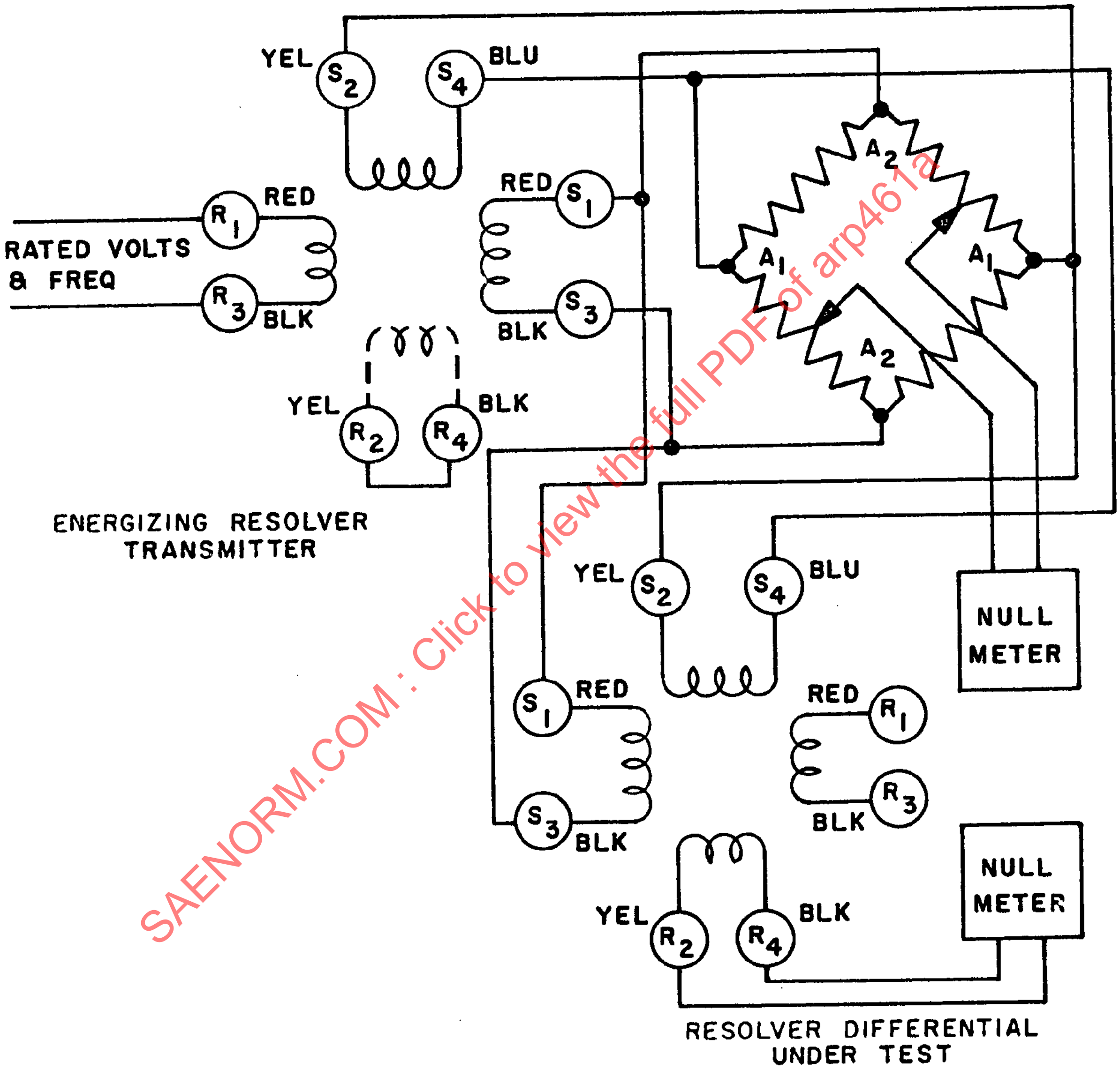


Figure 28

BASIC CIRCUIT FOR ELECTRICAL ERROR TESTING OF

RESOLVER DIFFERENTIAL STATOR WINDINGS

2.2.6.3 Receiver Error: Tests should be conducted under standard ambient conditions. The synchros should be excited at rated voltage and frequency and allowed to reach thermal equilibrium.

2.2.6.3.1 Dynamic: Receivers should be tested against torque transmitters of equal magnetic and electrical characteristics. During this test the receiver should be mounted with the shaft horizontal. The receiver error should be determined for 1 complete revolution of the transmitter at 1 RPM in both the clockwise and counter-clockwise directions. The receiver errors, corrected for the calibration errors of the transmitter, should not exceed the values given in section 2.2.6.5.

2.2.6.4 Differential Receiver Error: Tests should be conducted under standard ambient conditions. The synchros should be excited at rated voltage and frequency and allowed to reach thermal equilibrium.

2.2.6.4.1 Dynamic: Differential receivers should be tested against two torque transmitters having magnetic and electrical characteristics equal to the differential receivers under test. One torque transmitter excites the stator and the other the rotor of the differential receiver under test. The differential receiver should be mounted with the shaft horizontal during this test. The differential receiver error should be determined for 1 complete revolution of each transmitter at 1 RPM in both the clockwise and counter-clockwise directions. The differential receiver errors, corrected for the calibration errors of the transmitters, should not exceed the values given in section 2.2.6.5.

2.2.6.4.1.2 Procedure: Energize both transmitters. One transmitter is electrically connected to the differential receiver stator, the other to the rotor. Lock one transmitter on synchro zero and vary the setting of the other transmitter continuously as described above.

Repeat the above test, but with the other transmitter clamped on synchro zero and vary the setting of the transmitter continuously as before.

2.2.6.5 Tabulation of Allowable Error:

2.2.6.5.1 115 Volt, 60 CPS Synchros:

Maximum in Minutes

Electrical Error

Type	Unit Size 18	19	23	31
Transmitter - Torque	10	10	8	8
Transmitter - Control	8		8	
Control Transformer	8	8	6	
Diff. Trans. - Torque - Stator			8	8
Diff. Trans. - Torque - Rotor			8	8
Diff. Trans. - Control - Stator			8	
Diff. Trans. - Control - Rotor			8	

Receiver Error

Type	Unit Size 18	19	23	31
Receiver	60	60	60	48
Differential Receiver - Stator			60	
Differential Receiver - Rotor			60	

2.2.6.5.2 115 Volt, 400 CPS Synchros:

Maximum in Minutes

Electrical Error

Unit Size

Type	8	10	11	15	16	18	19	23	31
Transmitter - Torque	10	10	10	12	12	8	8	8	8
Transmitter - Control	10	10	10	12	12	8	8	8	
Control Transformer	10	10	10	10	10	8	8	6	
Diff. Trans. - Torque - Stator				10	10	10	10	8	8
Diff. Trans. - Torque - Rotor				10	10	10	10	8	8
Diff. Trans. - Control - Stator			10	10	10	8	8	8	
Diff. Trans. - Control - Rotor			10	10	10	8	8	8	
Resolver - Transmitter									
Resolver - Cont. Transformer									
Resolver - Differential - Rotor									
Resolver - Differential - Stator									

Receiver Error

Unit Size

Type	8	10	11	15	16	18	19	23	31
Receiver	150	150	120	120	120	60	60	60	48
Differential Receiver - Stator								60	48
Differential Receiver - Rotor								60	48

2.2.6.5.3 26 Volt, 400 CPS Synchros:

Maximum in Minutes

Electrical Error

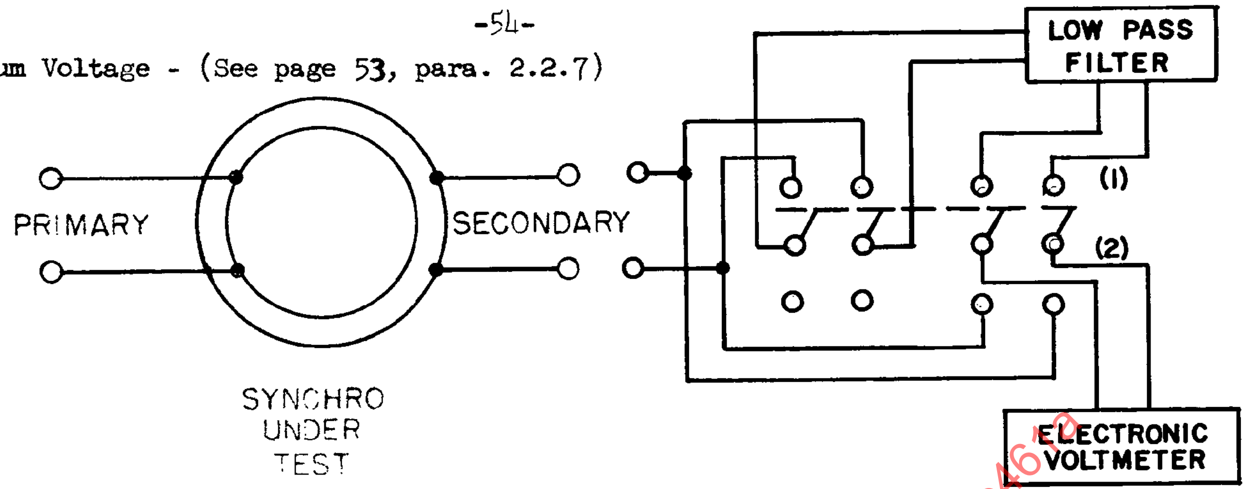
Type	Unit Size 8	10	11	15
Transmitter - Torque	10	10	10	15
Transmitter - Control	10	10	10	15
Control Transformer	10	10	10	15
Diff. Trans. - Torque - Stator				
Diff. Trans. - Torque - Rotor				
Diff. Trans. - Control - Stator		18	10	20
Diff. Trans. - Control - Rotor		18	10	20
Resolver - Transmitter		18		20
Resolver - Cont. Transformer		18		20
Resolver - Differential - Rotor				
Resolver - Differential - Stator				

Receiver Error

Type	Unit Size 8	10	11	15
Receiver	150	150	120	120
Differential Receiver - Stator				
Differential Receiver - Rotor				

2.2.7 Minimum Voltage: The minimum voltage and the fundamental component of the minimum voltage shall be determined by employing the circuit of Figure 29. These voltages shall be read on a vacuum tube voltmeter indicating the average value of the voltage wave in terms of the rms value of an equivalent sine wave. The synchro shall be connected as indicated in the table of Figure 29. The minimum voltage readings shall be made with the synchro approximately at the electrical angles shown in the table. With the switch in position (1) the rotor shall be turned to determine the minimum value of the fundamental voltage. Without further turning of the rotor, the switch shall be changed to position (2) and the total minimum voltage shall be read. The maximum values of the minimum voltage and of the fundamental component of the minimum shall not exceed the values specified in 2.2.7.1. The value of the fundamental voltage shall have been corrected for the attenuation of the filter used. The filter shall have a minimum input impedance of 10 times the maximum open circuit impedance of the secondary of the unit under test.

Minimum Voltage - (See page 53, para. 2.2.7)



Circuit for Determining Minimum Voltage

Figure 29

Table of Connections for Minimum Voltage Test

Test Unit	Primary Supply Across	Primary Supply Volts	Required Null Voltage Across Terminals	Required Null Voltage At Electrical Angles
CX	R_1 - R_2	115.0** (26)*	S_1 S_3 S_3 S_2 S_2 S_1	0° - 180° 60° - 240° 120° - 300°
CD	S_2-(S_1S_3)	78.0** (10.2)*	R_1 R_3 R_2 R_1 R_3 R_2	0° - 180° 60° - 240° 120° - 300°
CD	S_3-(S_1S_2	78.0** (10.2)*	R_2 R_1 R_3 R_2 R_1 R_3	0° - 180° 60° - 240° 120° - 300°
CD	S_1-(S_2S_3)	78.0** (10.2)*	R_3 R_2 R_1 R_3 R_2 R_1	0° - 180° 60° - 240° 120° - 300°
CT	S_2-(S_1S_3) S_1-(S_2S_3) S_3-(S_1S_2)	78.0** (10.2)* 78.0** (10.2)* 78.0** (10.2)*	R_1 R_2 R_1 R_2 R_1 R_2	0° - 180° 60° - 240° 120° - 300°

* Use these values for "26 Volt Units".
** Use these values for "115 Volt Units".

Table of Connections for Minimum Voltage Test (Cont'd)

Test Unit	Primary Supply: Across	Primary Supply: Volts	Required Null Voltage: Across Terminals	Required Null Voltage: At Electrical Angles
RX	$R_1 - R_3$	E	S_2 S_4 S_1 S_3	$0^\circ - 180^\circ$ $90^\circ - 270^\circ$
RC	$S_1 - S_3$	E	R_2 R_4	$0^\circ - 180^\circ$
	$S_2 - S_4$	E	R_2 R_4	$90^\circ - 270^\circ$
	$(S_1S_2)-(S_3S_4)$	.707E	R_2 R_4	$45^\circ - 225^\circ$
	$(S_1S_4)-(S_3S_2)$	.707E	R_2 R_4	$135^\circ - 315^\circ$
RD	$S_1 - S_3$	E	R_2 R_4 R_1 R_3	$0^\circ - 180^\circ$ $90^\circ - 270^\circ$
	$S_2 - S_4$	E	R_2 R_4 R_1 R_3	$90^\circ - 270^\circ$ $0^\circ - 180^\circ$
	$(S_1S_2)-(S_3S_4)$	.707E	R_2 R_4 R_1 R_3	$45^\circ - 225^\circ$ $135^\circ - 315^\circ$
	$(S_1S_4)-(S_3S_2)$	.707E	R_2 R_4 R_1 R_3	$135^\circ - 315^\circ$ $45^\circ - 225^\circ$

Where: E is the nominal (rated) rms primary voltage.

2.2.7.1 Tabulation of Allowable Minimum Voltages:

2.2.7.1.1 115 Volts, 60 CPS Synchros:

Type		Minimum Voltage (Millivolts - Max.) Unit Size 18	19	23	31
Transmitter - Control	TSV	125	125	100	100
	FSV	75	75	75	75
Control Transformer	TSV	90	90	75	60
	FSV	60	60	60	40
Differential Trans. - Control	TSV	125	125	100	100
	FSV	75	75	75	75

2.2.7.1.2 115 Volt, 400 CPS Synchros:

Type		Minimum Voltage (Millivolts - Max.) Unit Size 8	10	11	15	16	18	19	23	31
Transmitter - Control	TSV	125	125	125	125	125	115	115	100	100
	FSV	75	75	75	75	75	65	65	75	60
Control Transformer	TSV	90	90	90	80	80	75	75	75	65
	FSV	60	60	60	50	50	45	45	60	40
Diff. Trans. - Control	TSV	125	125	125	125	125	115	115	100	100
	FSV	75	75	75	75	75	65	65	75	60
Resolver - Transmitter	TSV	--	--	125	125	125	115	115	100	100
	FSV			75	75	75	65	65	60	60
Res. - Cont. Transformer	TSV	--	--	90	80	80	75	75	65	65
	FSV			60	50	50	45	45	40	40
Resolver - Differential	TSV	--	--	125	125	125	115	115	100	100
	FSV			75	75	75	65	65	60	60

Where: "TSV" indicates total signal volts
"FSV" indicates fundamental signal volts

2.2.7.1.3 26 Volt, 400 CPS Synchros: (Allowable minimum voltages)

Type		Minimum Voltage (Millivolts - Max.) Unit Size 8	10	11	15
Transmitter - Control	TSV	30	30	25	25
	FSV	20	20	15	15
Control Transformer	TSV	60	60	50	50
	FSV	40	40	30	30
Differencial Trans. - Control	TSV	30	30	25	25
	FSV	20	20	15	15
Resolver - Transmitter	TSV	30	30	25	25
	FSV	20	20	15	15
Resolver - Control Transformer	TSV	60	60	50	50
	FSV	40	40	30	30
Resolver - Differential	TSV	30	30	25	25
	FSV	20	20	15	15

Where: "TSV" indicates total signal volts
"FSV" indicates fundamental signal volts

2.2.8 Transformation Ratio: The ratio measuring device shall not alter the open circuit secondary voltage by more than .1%, and shall have an inherent accuracy of .2%. The frequency of the supply voltage shall be within 1% of the rated frequency of the synchro. The transformation ratio shall be within 2% for 115 volt synchros, or 4% for 26 volt synchros, of the value given in section 2.2.8.7.

SUGGESTED TEST CIRCUIT

A for transformation ratios greater than one (1).

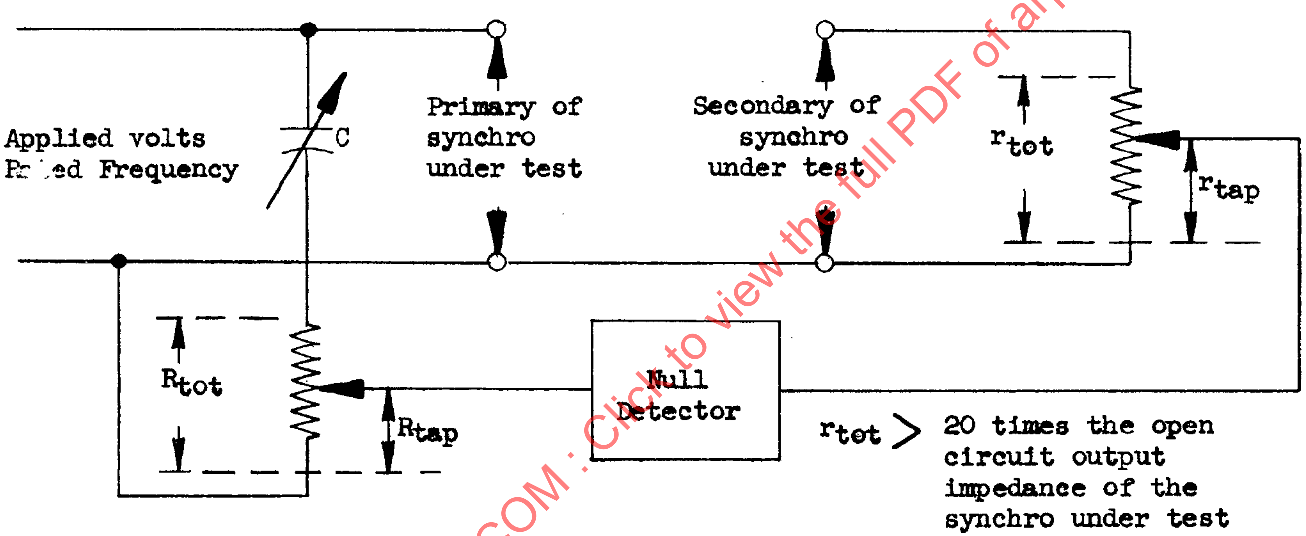


Figure 30

Connect the synchro as shown in the preceding diagram and position its rotor at the maximum output voltage position. Set r_{tap} at any arbitrary position, provided however that the ratio $\frac{r_{tot}}{r_{tap}}$ shall be greater than the transformation ratio of the unit under test. Vary R_{tap} and C for a minimum null meter reading. The transformation ratio of the unit under test is determined from the following equation:

Transformation Ratio - (Con't. from page 58, para. 2.2.8)

$$T.R. = \left(\frac{r_{tot}}{r_{tap}}\right)\left(\frac{R_{tap}}{R_{tot}}\right)\cos\theta$$

Where: $\theta = \tan^{-1}\frac{X_c}{R_{tot}}$

$$X_c = \frac{1}{2\pi fc}$$

B for transformation ratios less than one (1).

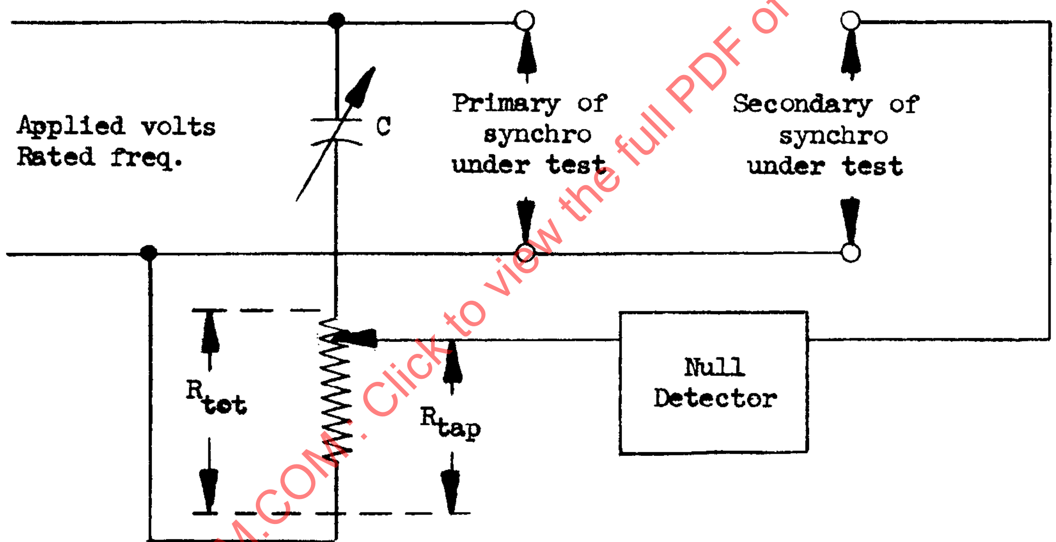


Figure 31

Connect the synchro as shown in the preceding diagram and position its rotor at the maximum output voltage position. Vary R_{tap} and C for a minimum null meter reading. The transformation ratio of the unit under test is determined from the following equation.

$$T.R. = \frac{R_{tap}}{R_{tot}}\cos\theta$$

Where: $\theta = \tan^{-1}\frac{X_c}{R_{tot}}$ $\quad X_c = \frac{1}{2\pi fc}$

NOTE: 1. In both A and B above, the phase shift of the unit under test is equal to the angle θ.

2. The preceding circuits will not function if the time phase of the output voltage of the unit under test lags the applied voltage.

2.2.8.1 Transmitters and Receiver: (Transformation ratio)

115 Volt Synchros: The transformation ratio of 115 volt transmitters and receivers shall be obtained by applying 115 volts ±1 percent across synchro terminals R_1-R_2 and turning the rotor until voltage $E(S_{13})$ is a maximum.

26 Volt Synchros: The transformation ratio of 26 volt transmitters and receivers shall be obtained by applying 26 volts ±1 percent across terminals R_1-R_2 and turning the rotor until voltage $E(S_{13})$ is a maximum.

2.2.8.2 Control Transformer:

115 Volt Synchros: The transformation ratio of 115 volt control transformer shall be obtained by applying 78 volts ±1 percent across terminal S_2 and terminal S_1 which is connected to S_3. The rotor shall be turned until voltage $E(R_{12})$ is a maximum.

26 Volt Synchros: The transformation ratio of 26 volt control transformer shall be obtained by applying 10.2 volts ±1 percent across terminal S_2 and terminal S_1 which is connected to S_3. The rotor shall be turned until voltage $E(R_{12})$ is a maximum.

2.2.8.3 <u>Differential Transmitters and Differential Receiver</u>: (Transformation ratio)

<u>115 Volt Synchros</u>: The transformation ratio of 115 volt differential transmitters and differential receivers shall be obtained by applying 78 volts ±1 percent across terminal S_2 and terminal S_1 which is connected to S_3. The rotor shall be turned until voltage $E(R_{13})$ is a maximum.

<u>26 Volt Synchros</u>: The transformation ratio of 26 volt differential transmitters and differential receivers shall be obtained by applying 10.2 volts ±1 percent across terminal S_2 and terminal S_1 which is connected to S_3. The rotor shall be turned until voltage $E(R_{13})$ is a maximum.

2.2.8.4 <u>Resolver-Transmitter</u>:

<u>115 Volt Resolvers</u>: The transformation ratio of 115 volt resolver transmitters shall be obtained by applying 115 volts ±1 percent between terminals R_1 and R_3 and turning the rotor until $E(S_{13})$ is a maximum.

<u>26 Volt Resolvers</u>: The transformation ratio of 26 volt resolver transmitters shall be obtained by applying 26 volts ±1 percent between terminals R_1 and R_3 and turning the rotor until $E(S_{13})$ is a maximum.

2.2.8.5 <u>Resolver-Control Transformer</u>:

<u>115 Volt Resolvers</u>: The transformation ratio of 115 volt resolver-control transformers shall be obtained by applying 90 volts ±1 percent between terminals S_1 and S_3 and turning the rotor until $E(R_{24})$ is a maximum.

<u>26 Volt Resolvers</u>: The transformation ratio of 26 volt resolver-control transformers shall be obtained by applying 11.8 volts ±1 percent between terminals S_1 and S_3 and turning the rotor until $E(R_{24})$ is a maximum.

2.2.8.6 <u>Resolver-Differential</u>:

<u>115 Volt Resolvers</u>: The transformation ratio of 115 volt resolver-differentials shall be obtained by applying 90 volts ±1 percent between terminals S_1 and S_3 and turning the rotor until $E(R_{13})$ is a maximum.

<u>26 Volt Resolvers</u>: The transformation ratio of 26 volt resolver-differentials shall be obtained by applying 11.8 volts ±1 percent between terminals S_1 and S_3 and turning the rotor until $E(R_{13})$ is a maximum.

2.2.8.7 <u>Tabulation of Allowable Values</u>:

Nominal Voltage	System Frequency	Ratio of Transformation									
		TX	CX	CT	TD	CD	DR	TR	RX	RC	RD
115	60	.783	.783	.735	1.154	1.154	1.154	.783	--	--	--
115	400	.783	.783	.735	1.154	1.154	1.154	.783	.783	.639	1.000
26	400	.454	.454	2.203	1.154	1.154	1.154	.454	.454	1.906	1.000

2.2.9 Receiver Spin and Synchronizing Time: The purpose of this test is to determine whether the rotor of a receiver or differential receiver will come to rest at the position of synchronism from any initial angular position without spinning. The receiver shall be connected to a torque transmitter which is locked in the synchro zero position.

2.2.9.2 Receiver: The receiver under test shall be connected to the corresponding terminals of a torque transmitter of the same size. A test dial as shown in Figure 40 shall be mounted on the rotor of the unit.

The rotor of the receiver shall be displaced 178° $\pm 2°$ from synchro zero and the units energized with 110% nominal volts of rated frequency. This procedure shall be performed 3 times for a clockwise displacement and 3 times for a counter-clockwise displacement. The synchro shall be considered to have failed the spinning test if it fails to synchronize in any of the trials.

The synchronizing time is the length of time required for the receiver rotor to synchronize and remain in synchronism within 0.1° after energizing the system at the rated voltage and frequency. The synchronizing time shall be measured for initial displacements of 30° and 178° $\pm 2°$ by means of an oscillograph.

2.2.9.2 Differential Receiver: The differential receiver under test shall be connected to the corresponding terminals of a torque transmitter of the same size. A test dial as shown in Figure 40 shall be mounted on the rotor of the unit.

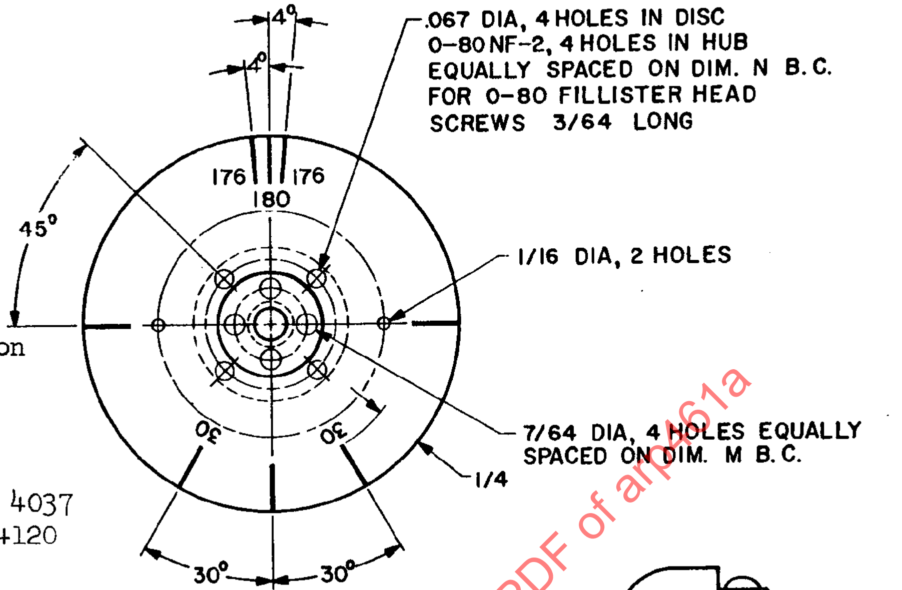
The differential receiver shall be energized by applying the voltage for the particular type as tabulated under section 2.2.4, between terminals S_2 and S_1 which is connected to S_3.

The torque transmitter shall be locked in its synchro zero position. The rotor of the differential receiver shall be displaced 178° $\pm 2°$ from its synchro zero position. This procedure shall be performed 3 times for a clockwise displacement and 3 times for a counter-clockwise displacement. The synchro shall be considered to have failed the spinning test if it fails to synchronize in any of the trails.

The synchronizing time shall be measured for initial displacements of 30° and 178° $\pm 2°$ by means of an oscillograph.

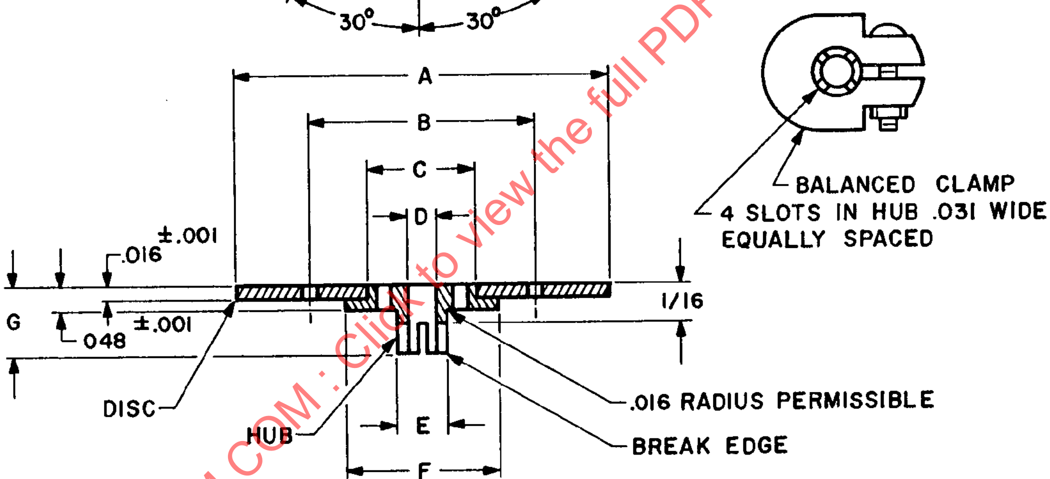
2.2.9.3 Tabulation of Allowable Synchronizing Time Limits:

Size	Unit	Maximum Synchronizing Time - Seconds					
		30° Displacement			179° Displacement		
		115V 60c	115V 400c	26V 400c	115V 60c	115V 400c	26V 400c
8	TR			2.0			4.0
	DR			2.0			4.0
10	TR			2.0			4.0
	DR			2.0			4.0
11	TR		2.0	2.0		4.0	4.0
	DR		2.0	2.0		4.0	4.0
15	TR		2.0	2.0		4.0	4.0
	DR		2.0	2.0		4.0	4.0
16	TR		2.0			4.0	
	DR		2.0			4.0	
18	TR	1.0	1.0		2.0	2.0	
	DR	1.0	1.0		2.0	2.0	
19	TR	-	-		-	-	
	DR	-	-		-	-	
23	TR	1.0	1.0		2.0	2.0	
	DR	1.0	1.0		2.0	2.0	
31	TR	1.0	1.0		2.0	2.0	
	DR	1.0	1.0		2.0	2.0	



NOTES:

1. Unless otherwise specified tolerances on fractions ±1/64 decimals ±.005 angles ±1°
2. Material:
   Disc-Aluminum per AMS 4037
   Hub-Aluminum per AMS 4120



SIZE OF SYNCHRO	DIMENSIONS AND TOLERANCES									
	A	B	C		D	E	F	G	M	N
			Disc	Hub						
	----	±.002	+.0004 -.0000	+.0000 -.0004	-------	±.001	-----	+.005 -.000	-----	-----
8					To fit Synchro Shaft .0001 to .0004 Free					
10										
11-15-16	1.500	1.200	.5625	.5625		.245	.812	.300	.375	.687
18-19	2.000	1.200	.5625	.5625		.245	.812	.300	.375	.687
23	2.671	2.000	.6250	.6250		.307	.875	.350	.437	.750
31	3.500	2.000	.6250	.6250		.307	.875	.350	.437	.750

Figure 32

SYNCHRO DIAL FOR SYNCHRONIZING & SPINNING TESTS

2.2.10 Temperature Rise:

2.2.10.1 General: The synchro should be mounted centrally in a square aluminum plate, as shown in Figure No. 17. The synchro shall be held in place by recommended mounting clamps. All surfaces of the plate shall be finished with black anodize. The plate shall be mounted on supports which allow approx. 1/4" clearance from other surfaces at the base and held in an upright position by 2 supporting arms. The base and upright supports are to be made of any suitable heat insulating material. The unit shall be maintained at 22°C ±3°C. until unit reaches a state of equilibrium. The unit and its mounting shall be located to assure minimum effect from air currents and ambient temperature rise.

2.2.10.2 Mounting Plates: The mounting plates, bases and supports are shown in Figures 17, 18 and 19.

2.2.10.3 Circuit: The temperature rise of both rotor and the stator of the unit shall be measured by the resistance change method. Measurements should be recorded until equilibrium, (1 degree rise in 30 minutes), is attained. The following formula should be used for calculating the temperature:

$$\text{Temperature Rise } ^\circ\text{C.} = \frac{R_H - R_C}{R_C}(234.5 + T_C)$$

R_H = resistance of winding at the final equilibrium temperature

R_C = resistance of winding at the starting temperature T

T_C = ambient temperature °C. at start of test

A schematic diagram of the circuit to be used for each type of synchro is shown in Figures 33 thru 38. Switch SW_1 connects the bridge to the rotor or stator as desired. Switch SW_2 connects the synchro to its excitation in the bridge circuit. It is imperative that there be no significant cooling of the synchro while the measurements are being made.

Temperature Rise - Transmitters and Receivers. (See page 55, para. 2.2.10.3)

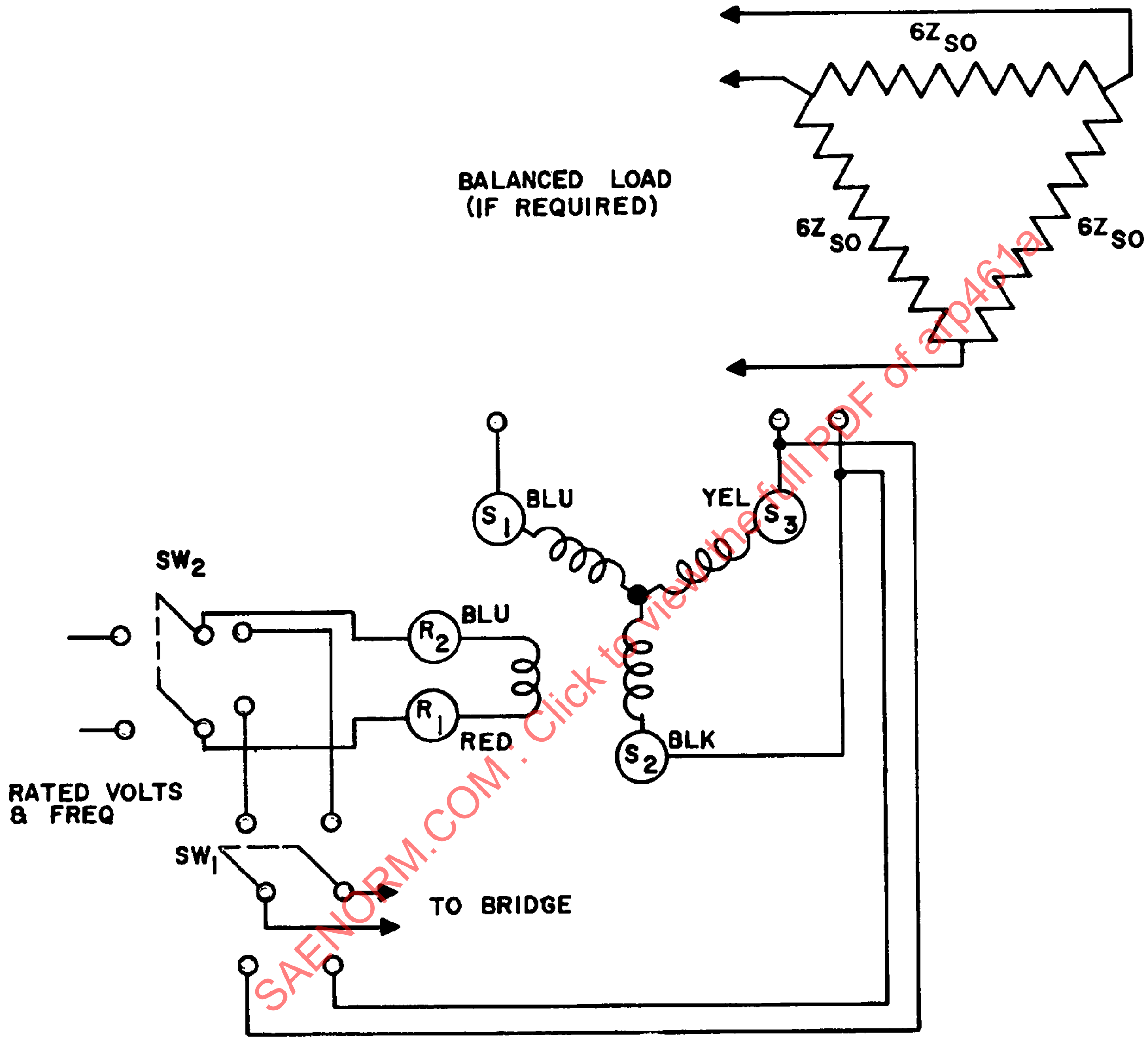


Figure 33

Circuit for Temperature Rise Test for Torque Transmitters, Control Transmitters and Receivers

Temperature Rise - Control Transformer (See page 65, para. 2.2.10.3)

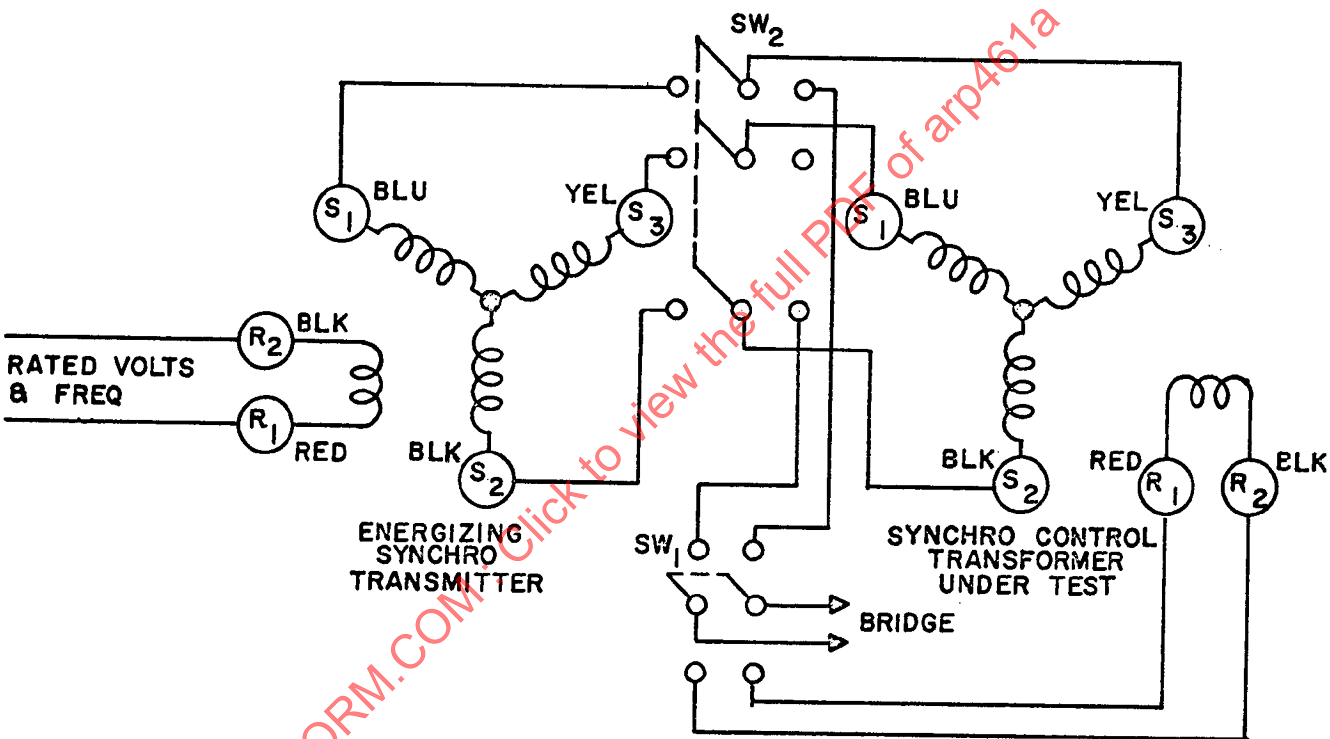
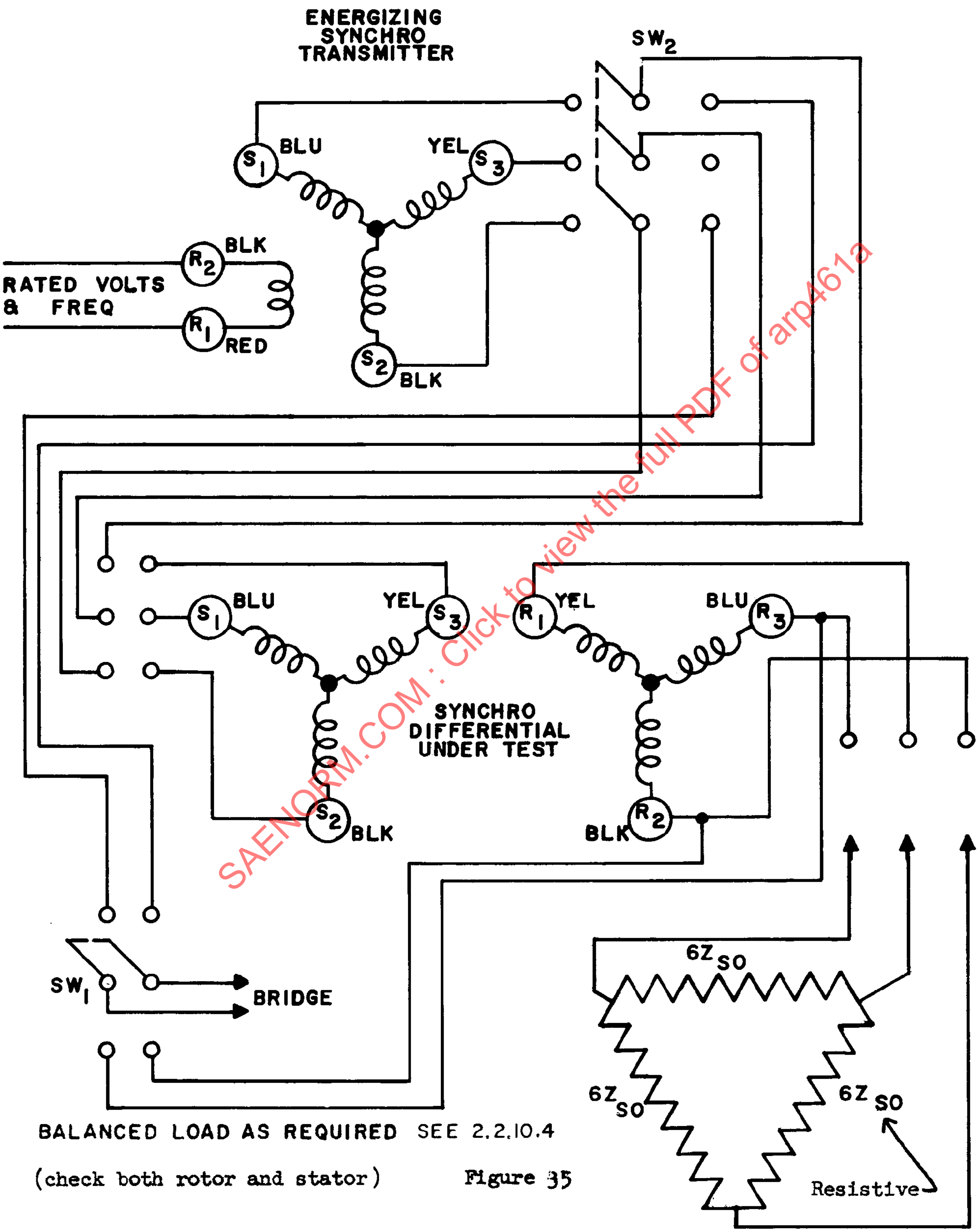


Figure 34

Circuit for Temperature Rise Test for Control Transformers

Temperature Rise - Differentials (See page 65, para. 2.2.10.3)



BALANCED LOAD AS REQUIRED SEE 2.2.10.4

(check both rotor and stator) Figure 35

Temperature Rise Test for Differential Transmitters and Differential Receivers