63-3-2

Bendix
Red Bank

THE Bendix CORPORATION

RED BANK DIVISION • EATONTOWN, NEW JERSEY

Best
Available
Copy

Red Bank Division
THE BENDIX CORPORATION
Eatontown, New Jersey

Qualified requesters may obtain copies of this report from ASTIA.

Report No. 345
3200 CPS Electrical Power
Distribution Characteristics

July 14, 1961

Prepared Under Navy Bureau of
Weapons Contract NOas 60-6121-C
Item 2

Approved by ______________
Chief Engineer, Bendix

____
Project Engineer, Bendix

Witnessed by ______________
AFQCR, Eatontown, N. J.

Certified by Charles S Voy
BuWeps Rep., Teterboro, N. J.

ABSTRACT

This report demonstrates the distribution characteristics associated with 3200 CPS Electrical Power. The specific characteristics of a variety of wiring techniques are analyzed and relative comparisons made.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Section I Contractual Requirements

In accordance with Item 1 of BuWeps Contract NOas 60-6121-C, Bendix Red Bank has conducted a study to determine the feasibility of generating, controlling, and distributing 3200 CPS AC electrical power on aircraft to support missiles. The final report on this study, Contract Item No. 2, was forwarded as Bendix Red Bank Report 337, dated April 27, 1961.

As stated in Section I of Report 337, the characteristics contained in that report were obtained analytically and additional laboratory testing would be conducted to provide actual characteristics. Therefore, since the major problem associated with 3200 CPS electrical power is in the area of distribution, Bendix Red Bank has conducted a series of tests designed specifically to demonstrate distribution characteristics. The results of these laboratory tests and conclusions are being forwarded in this report and are intended to supplement the information contained in Bendix Red Bank Report No. 337.

Section II General Information

The 3200 CPS distribution characteristics shown in this report are broken down into two basic catagories:

1) Impedance Characteristics and 2) Mutual Inductance Characteristics. The specific details of the test conducted, characteristics, and conclusions for each of these catagories is discussed in Sections III and IV respectively.

In order to provide as much information as possible on the results of this study, Appendix A and B have been included in this report. Appendix A is a copy of the detailed test procedure which was used to obtain the necessary laboratory data. This test procedure, Bendix Red Bank Report No. 331, Rev. B is entitled "3200 CPS Electrical Power Distribution Test Procedures". The actual test data obtained by laboratory testing has been included as Appendix B. The characteristics shown in this report are taken from this data.

It should be noted that throughout this report reference is made to test procedure numbers. These numbers reference the various tests as outlined by the procedures of Appendix A. The test data from each specific test contains reference to the same applicable test procedure number. The tables contained in the body of this report also include a reference to the test procedure number. This has been included as a cross reference and to facilitate further analysis of the test results.

The source of electrical power for these tests was a "breadboard" version of the 3200 CPS generating section being fabricated under Item No. 5 of this contract. This 3200 CPS generating section will be used as part of the dual frequency generating system being manufactured by Bendix Red Bank. This 3200 CPS, single phase generator is rated at 6 KVA, therefore the tests described herein are limited to these parameters.

The impedance characteristics demonstrated in Section II of this report were obtained by tests conducted within the Red Bank Laboratory. The actual test set up was isolated from all possible sources of induced potentials so as to minimize error. However, since the mutual induction tests outlined by Section IV were much more critical with respect to induced potential, the actual testing was conducted outside of the laboratory. Three photographs, Figures 1, 2 and 3 have been included to show the test set up.

From these pictures, it should be noted that extreme care was used in the spacing of all conductors. The conductors being tested were kept at uniform spacing by the use of wooden blocks. All other leads were placed either perpendicular to the test leads or at a minimum distance of 6 feet. The particular test area was chosen because it is completely isolated from any power lines, under ground pipes, or conduit.

Figure 1 shows the "breadboard" generator being driven by a portable drive. A forced blower is being used to insure adequate generator cooling. Figure 2 shows the test set up as viewed from the generating end. Figure 3 shows the test set up as viewed from the load end. Test Procedures 9 through 15 made use of this particular test set up.

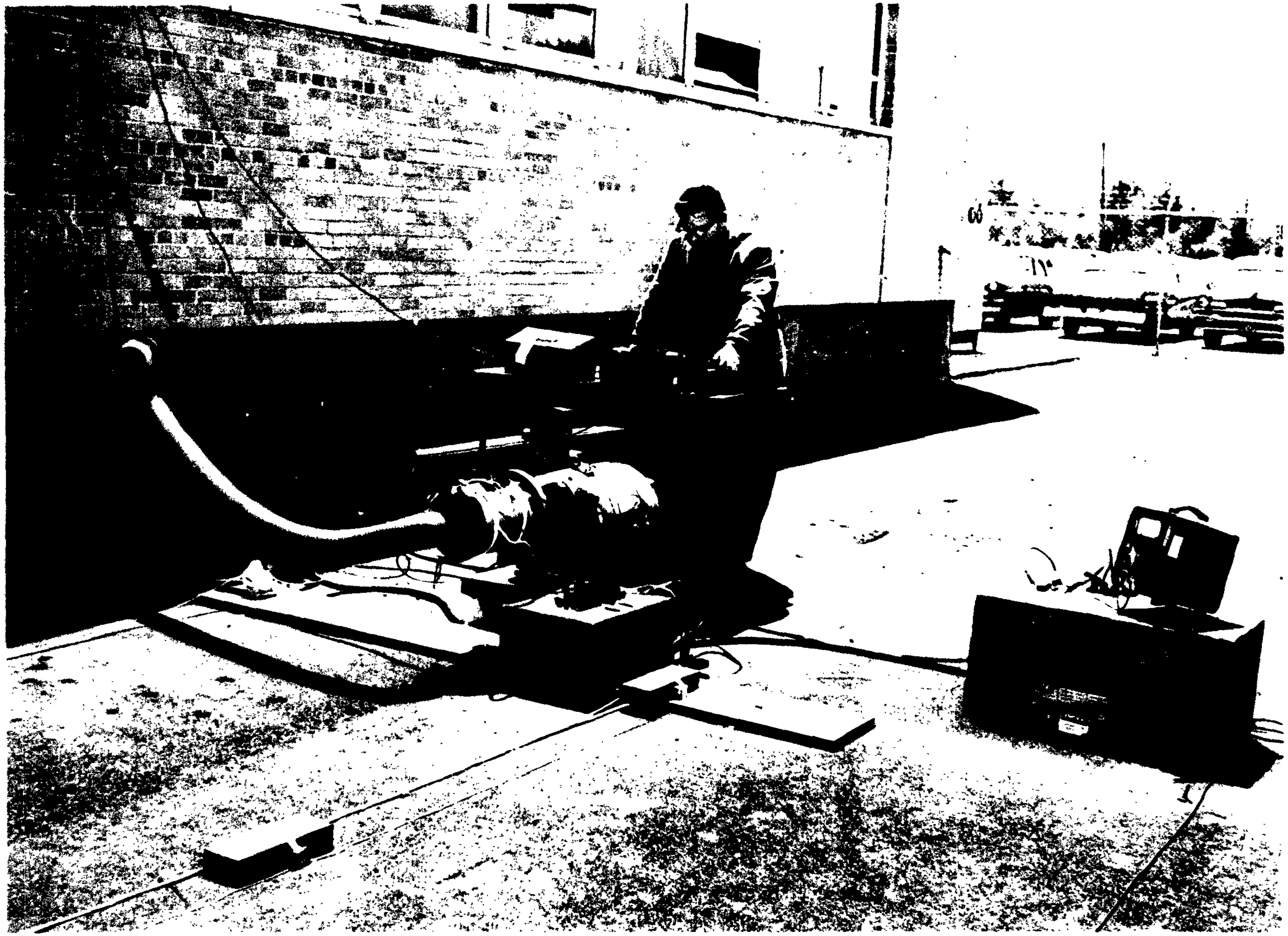


Figure 1 Laboratory Set Up for Mutual Induction Tests

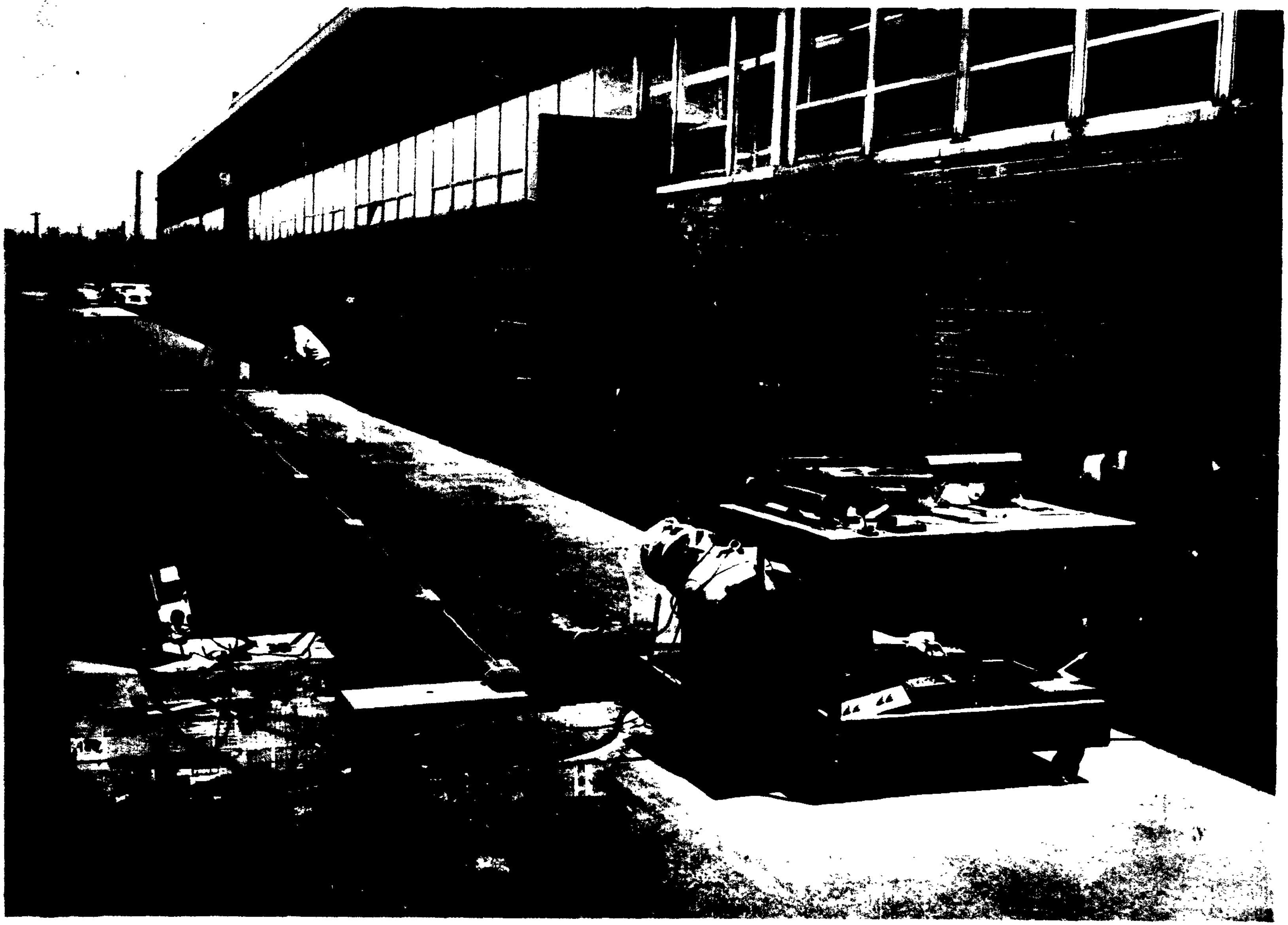


Figure 2 Laboratory Set Up for Mutual Inductance Tests

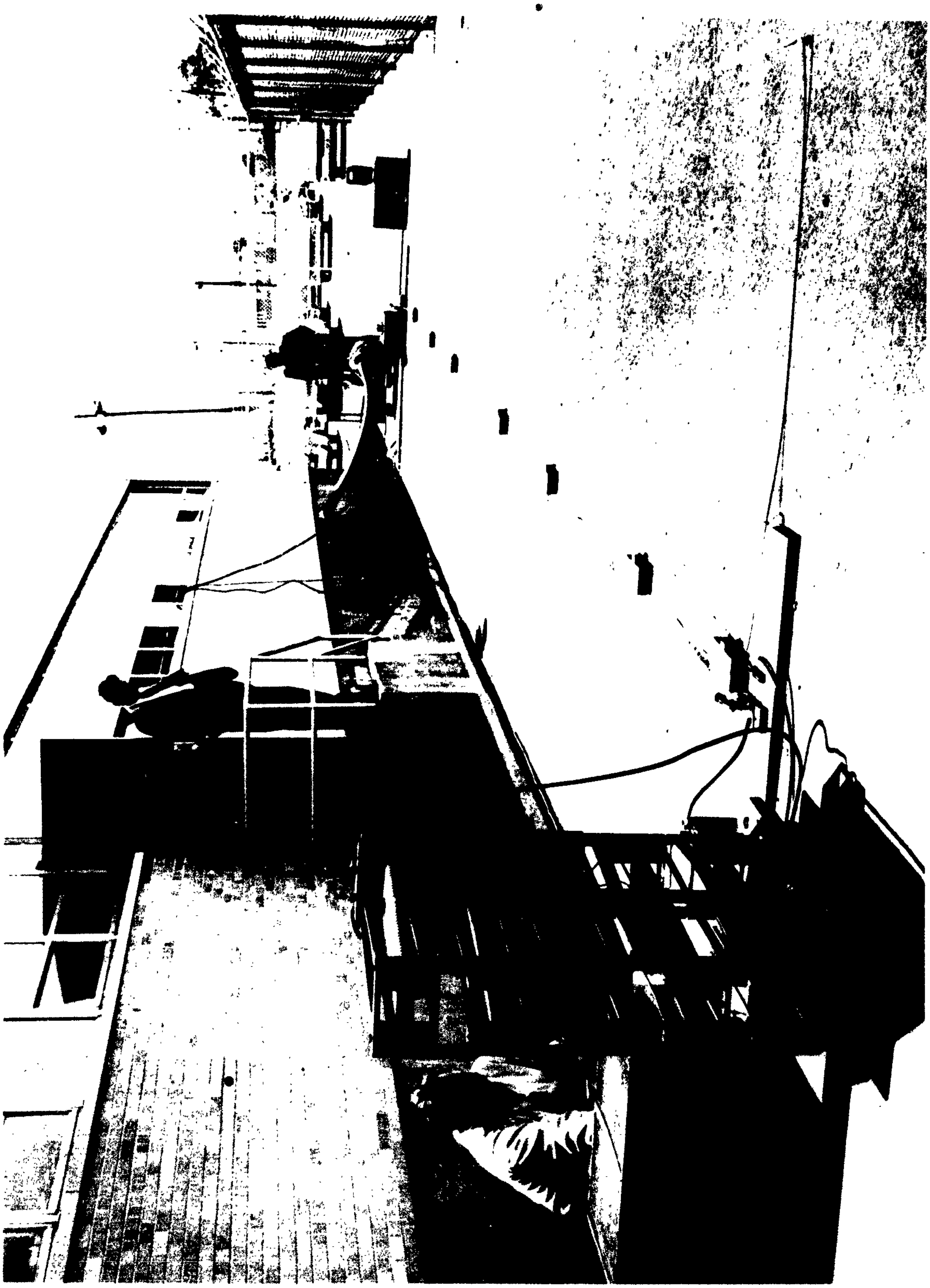


Figure 3 Laboratory Set Up for Mutual Induction Tests

Section III Impedance Characteristics

A. General

The object of this section is to demonstrate the impedance characteristics associated with the distribution of 3200 CPS electrical power. It should be pointed out that these characteristics are for stranded type wires and, for uniformity, operating at a temperature of 25°C. As indicated in the various tables of this section and in Appendix B, a great deal of data was taken at temperatures above this standard. Therefore, the values used for comparison purposes were adjusted to this predetermined temperature.

The various tables in this section of the report compare calculated values of resistance (R), Reactance (X), and Impedance (Z) with values obtained by laboratory testing. In some instances, these tables show a considerable difference between the two values. This difference can be attributed primarily to a variation of the reactance factor due to the effects of proximity. These effects are basically the interaction of magnetic fields on current distribution within a conductor and the resulting change in apparent reactance. It should be noted that only the impedance factors obtained by testing were used in demonstrating the characteristics shown in this report.

As stated above, the characteristics shown herein, are for stranded wire types. If Litz type wire were used, the impedance factors would have to be modified to indicate a reduced resistance (approximately the DC value) and a decreased reactance. Since the stranded wire characteristics are more severe, they were chosen for the purpose of this report.

It is realized that there are a variety of methods and test procedures which could be employed to determine the impedance factors of various wiring configurations. The one used in the preparation of this study was chosen because of the simplicity and low cost. The procurement of special test equipment as required by alternate test methods could not be justified under this phase of the basic contract.

B. Two Conductor System

A single phase, two conductor system is one in which a single conductor is used to transmit electrical power from a generating source to a load and a second conductor completes the return circuit to the generating source. Tables 1, 2, 3 and 4 have been included in the following pages to show the distribution impedance characteristics for various wiring configurations. The configurations analyzed are: two conductors side by side; two conductors side by side on an aluminum plate; two conductors spaces two inches apart; and two conductors cabled. Wires sizes #6, #10, #16, and #20 are analyzed.

Table 5 provides a comparison of the resistance and reactance components of various wire sizes for the referenced distribution configurations. The figures for the intermediate wire sizes were obtained by interpolating between the values shown on Tables 1 through 4. It should be noted that as the result of proximity, a very slight reduction in resistance is achieved by a spacing between conductors.

In order to provide a better indication of trends and to ease making comparisons, the details contained in Tables 1 through 5 have been plotted to provide Figures 4 through 7.

Figure 4 shows the 3200 CPS resistance for various wire sizes. Included in this figure are the characteristics for a two-conductor system and a single-conductor system which uses an aluminum plate as the ground return. Since the effective resistance of a large aluminum plate is negligable, the curves show the resistance of two conductors as compared to that of of one. Cabling (twisting conductors around each other - as per MIL-C-7078A) of the two conductors would tend to increase the resistance per foot of distribution length above that indicated for a two-wire system primarily because more wire per foot would be used.

Figure 5 shows the effect of the various wiring configurations on conductor reactance for wires between sizes #6 through #22. By comparing Curves 1 and 2, it is apparent that a reduction in reactance can be achieved for smaller wire sizes by placing them on an aluminum plate (simulates an airframe). This reduction can be attributed to an increased capacitive reactance between the conductors and the plate.

As Curve 3 indicates, increasing the space between two conductors will tend to increase the apparent reactance. By spacing conductors, the capacitance between conductors is reduced thereby resulting in a higher net inductive reactance.

Curve 4 shows that for small wire sizes a decreased reactance can be obtained by cabling. This difference in reactance is compounded by the fact that more turns per foot can be used with smaller wire sizes.

Figure 6 shows the total 3200 CPS impedance per foot of distribution length for various wire sizes. Each of the four wiring configurations are considered. It should be noted that for larger wire sizes the major portion of the impedance is made up of inductive reactance. Therefore, in this area the curves approximate the impedance of the inductive reactance (see Figure 5). As wire size decreases, the resistive component of impedance becomes more predominant. For wire sizes #20 and #22, the total im pedance approaches that of the resistive component as shown in Figure 4.

The ratio of resistive to reactive components also affects the power factor of the wiring configurations. The power factor variation with wire size is shown in Figure 7. Each of the four wiring techniques are presented. In all cases, the large wire sizes reflect a smaller power factor due to the magnitude of the reactive factor as compared to the resistive impedance factor. The predominance of the resistance factor for smaller wire sizes results in an increasing power factor. The reduction in reactance obtained by placing two conductors on an aluminum plate can be seen by comparing Curves 1 and 2. This technique, however, is only beneficial for larger wire sizes.

The effects of cabling, as indicated by Curve 4, provides a definite power factor advantage for smaller wire sizes. Of course, with the smaller wire size, a greater number of turns per foot can be realized.

Curve 3 indicates that spacing wires will result in reducing the power factor of the distribution system.

Distribution Impedance Characteristics

Comparison of calculated impedance with impedances obtained by laboratory testing. Impedance is for a two conductor system with conductors side by side. ("O"spacing.)See Procedure I in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance R	Impedance X	Impedance Z	Average Test Impedance @25°C R	Average Test Impedance @25°C X	Average Test Impedance @25°C Z	pf
#6	Calc		.000923	.00398	.00408				
	Test	34	.000923	.00404	.00413				
	Calc		.000925	.00398	.00409				
	Test	35	.000925		.00503*				
	Calc		.000890	.00398	.00407				
	Test	26.5	.000890	.00412	.00422	.000890	.00408	.00418	.213
#10	Calc		.002135	.00410	.00461				
	Test	44	.002125	.00383	.00438				
	Calc		.002085	.00410	.00460				
	Test	39	.002085	.00381	.00435				
	Calc		.002040	.00410	.00460				
	Test	32	.002040	.00381	.00431	.002032	.00382	.00432	.469
#16	Calc		.00874	.00493	.01010				
	Test	64	.00874	.00792	.01180				
	Calc		.00850	.00493	.00982				
	Test	55	.00850	.00725	.01118				
	Calc		.00799	.00493	.00940				
	Test	37	.00799	.00668	.01042	.00792	.00728	.01075	.736
#20	Calc		.02300	.00535	.02360				
	Test	76	.02300	.01480	.02915				
	Calc		.02120	.00535	.02200				
	Test	51	.02120	.01855	.02820				
	Calc		.02025	.00535	.02090				
	Test	38	.02025	.01878	.02765	.02015	.01738	.02651	.759

* Not Used

Table 1

Impedance In Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance is for a two conductor system with conductors side by side on an aluminum plate. See Procedure 2 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance R	Impedance X	Impedance Z	Average Test Impedance @25°C R	Average Test Impedance @25°C X	Average Test Impedance @25°C Z	Average Test Impedance @25°C pf
#6	Calc		.000925	.003175	.00330				
	Test	38	.000925	.00298	.00328				
	Calc		.000924	.003175	.00329				
	Test	36	.000924	.00326	.00338				
	Calc		.000895	.003175	.00330				
	Test	29	.000895	.003215	.00334	.000890	.003152	.00327	.272
#10	Calc		.002125	.00410	.00461				
	Test	44	.002125	.00358	.00416				
	Calc		.002080	.00410	.00460				
	Test	35	.002080	.00356	.00411				
	Calc		.002040	.00410	.00459				
	Test	32	.002040	.00358	.00411	.002032	.00382	.00432	.470
#16	Calc		.00840	.00493	.00975				
	Test	53	.00840	.00726	.01110				
	Calc		.00817	.00493	.00955				
	Test	44	00817	00717	.01088				
	Calc		.00786	.00493	.00930				
	Test	33	.00786	.00787	.01205	.00792	.00728	.01076	.736
#20	Calc		.02295	.00535	.02355				
	Test	74	.02295	.01850	.02945				
	Calc		.02120	.00535	.02185				
	Test	50	02120	.01185	.02440				
	Calc		.02025	.00535	.02095				
	Test	38	.02025	.01120	.02315	.02015	.01738	.02660	.756

Table 2

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance is for a two conductor system with conductors two inches apart. See Procedure 3 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance R	Impedance X	Impedance Z	Average Test Impedance @25°C R	X	Z	pf
#6	Calc		.000927	.00606	.00615				
	Test	40	.000927	.00815	.00820				
	Calc		.000921	.00606	.00615				
	Test	33	.000921	.00822	.00825				
	Calc		.000892	.00606	.00615				
	Test	27	.000892	.00824	.00828	.000892	.00820	.00823	.108
#10	Calc		.002122	.00695	.00727				
	Test	42	.002122	.00940	.00963				
	Calc		.002075	.00695	.00726				
	Test	33	.002075	.00937	.00960				
	Calc		.002035	.00695	.00725				
	Test	30	.002035	.00949	.00970	.002025	.00942	.00964	.210
#16	Calc		.00840	.00830	.01180				
	Test	53	.00840	.01260	.01512				
	Calc		.00817	.00830	.01165				
	Test	43.5	.00817	.01240	.01487				
	Calc		.00788	.00830	.01147				
	Test	34.5	.00788	.01253	.01480	.00785	.01251	.01476	.531
#20	Calc		.02295	.00908	.02460				
	Test	74	.02295	.01740	.02880				
	Calc		.02120	.00908	.02310				
	Test	50	.02120	.01702	.02720				
	Calc		.02025	.00908	.02220				
	Test	38	.02025	.01598	.02575	.02010	.01682	.0262	.766

Table 3

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance is for a two conductor system with conductors cabled. See Procedure 4 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance R	Impedance X	Impedance Z	Average Test Impedance @ 25°C R	X	Z	pf
#6	Calc		.000946	.00264	.00281				
	Test	40	.000946	.00356	.00368				
	Calc		.000940	.00264	.00280				
	Test	33	.000940	.00360	.00372				
	Calc		.000913	.00264	.00280				
	Test	29	.000913	.00364	.00374	.000913	.00360	.00372	.245
#10	Calc		.002140	.00341	.00402				
	Test	31	.002140	.00378	.00434				
	Calc		.001995	.00341	.00395				
	Test	56	.001995	.00451	.00495				
	Calc		.002050	.00341	.00398				
	Test	44	.002050	.00438	.00485	.002135	.00426	.00477	.447
#16	Calc		.00895	.00411	.00985				
	Test	57	.00895	.00682	.01125				
	Calc		.00870	.00411	.00936				
	Test	50	.00870	.00820	.01192				
	Calc		.00839	.00411	.00906				
	Test	35	.00839	.00606	.01025	.00832	.00703	.01090	.764
#20	Calc		.02475	.00446	.02515				
	Test	65	.02475	.01295	.02785				
	Calc		.02285	.00446	.02330				
	Test	51	.02285	.01295	.02620				
	Calc		.02185	.00446	.02230				
	Test	37	.02185	.00692	.02285	.02175	.01295	.02532	.858

Table 4

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Two Conductors in Various Configurations
(Summary)

3200 CPS @ 25°C Temp.

Stranded Wire

R - Resistance
X - Reactance

Impedance in Ohms Per Foot of Distribution Length

Spacing / Wire Size	0"		0" (On Alum. Plate)		2"		Cabled		DC Ohms/Ft (2 conductor)
	R	X	R	X	R	X	R	X	
#6	.000890	.00408	.000890	.003152	.000892	.00820	.000913	.00360	.000790
#8	.00132	.00370	.00132	.00325	.00131	.00860	.001290**	.00385	.001256
#10	.002032	.00382	.002032	.00357	.002025	.00942	.002135	.00426	.001998
#12	.00345	.00402	.00345	.00425*	.00342	.00995	.00365	.00500	.003176
#14	.00505	.00485	.00505	.00555*	.00503	.01090	.00575	.00600	.005050
#16	.00792	.00728	.00792	.00743*	.00785	.01251	.00832	.00703	.008032
#18	.01275	.01160	.01275	.01045	.01273	.01445	.0134	.00950	.012704
#20	.02015	.01738	.02015	.01385	.02010	.01682	.02175	.01295	.02020
#22	.0310	.02505	.0310	.02255	.03095	.02070	.03310	.01740	.032128

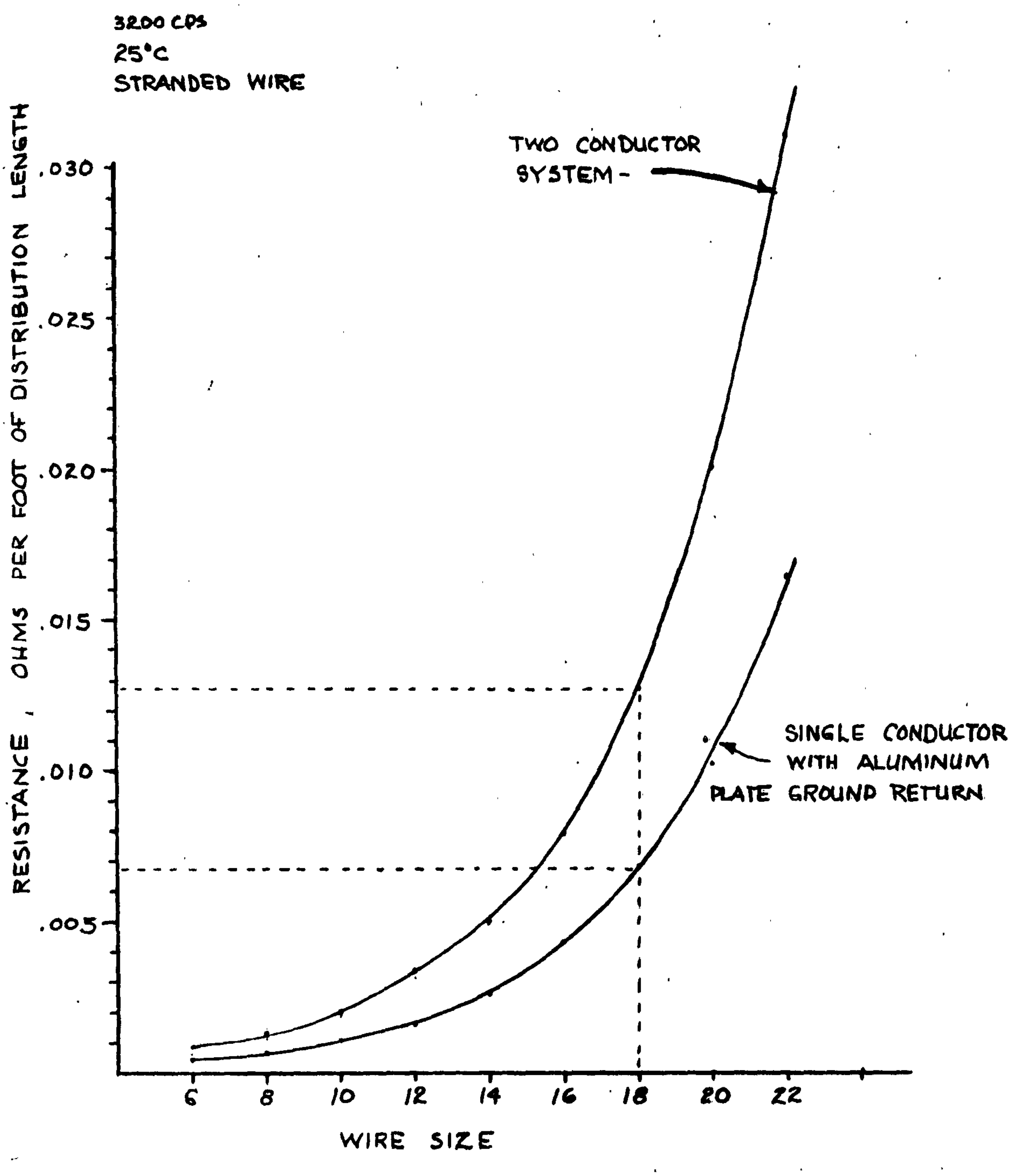
*Variation in reactance trend due to ratio of proximity effect and insulation thickness.

** Should be slightly greater to follow resistance trend. Variation due to meter readings or calculations.

Table 5

Red Bank Division
THE BENDIX CORP.
G. T. H. 6/8/61

DISTRIBUTION CHARACTERISTICS
CONDUCTOR RESISTANCE VS WIRE SIZE FOR
ONE AND TWO CONDUCTOR SYSTEMS



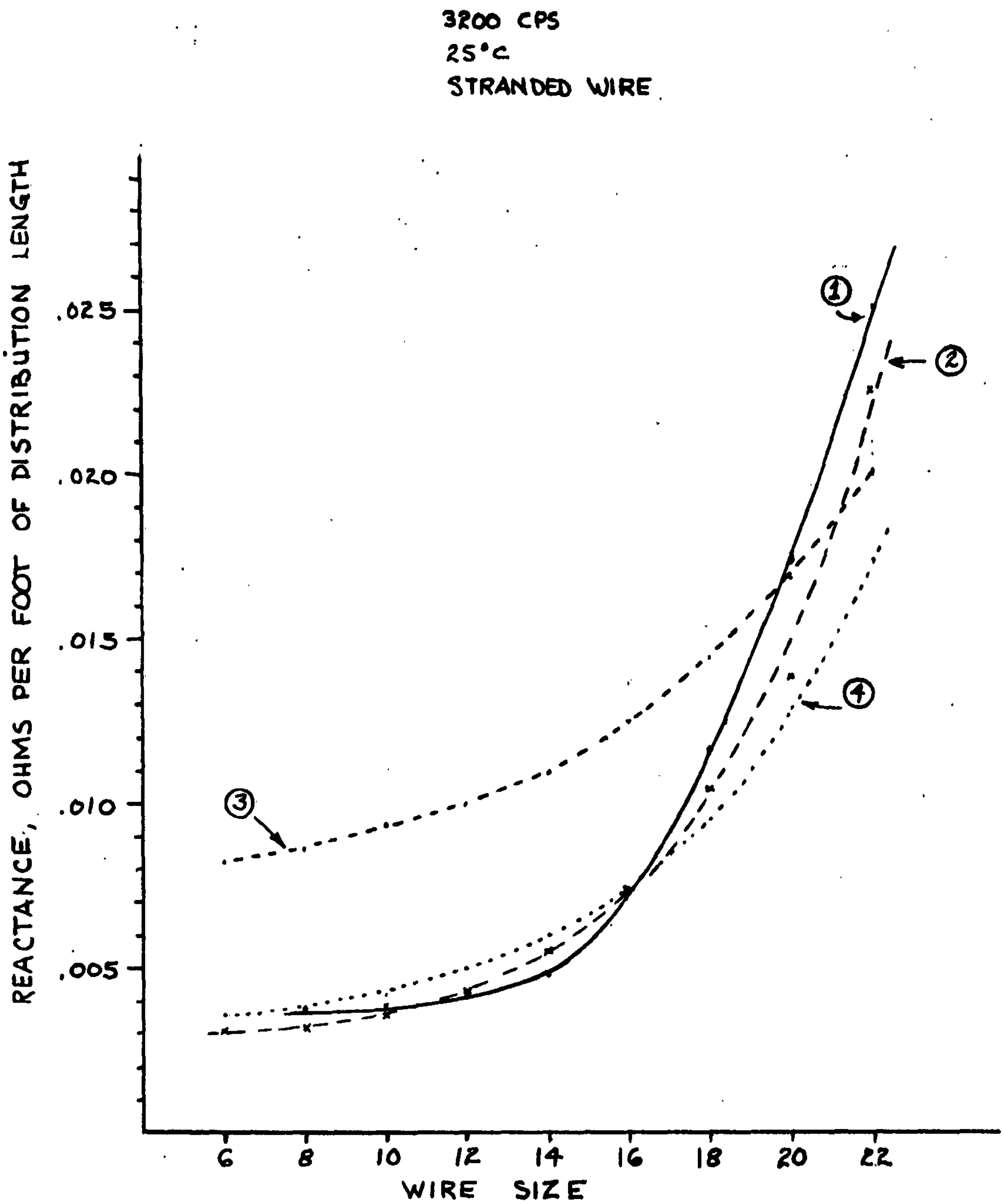
RED BANK DIVISION
THE BENDIX CORP

FIGURE 4

GTH 6/8/61

DISTRIBUTION CHARACTERISTICS
TWO CONDUCTORS IN VARIOUS CONFIGURATIONS

REACTANCE VS WIRE SIZE



① CONDUCTORS SIDE BY SIDE
② CONDUCTORS SIDE BY SIDE ON ALUM. GND.
③ 2" SPACING BETWEEN CONDUCTORS
④ CONDUCTORS CABLED

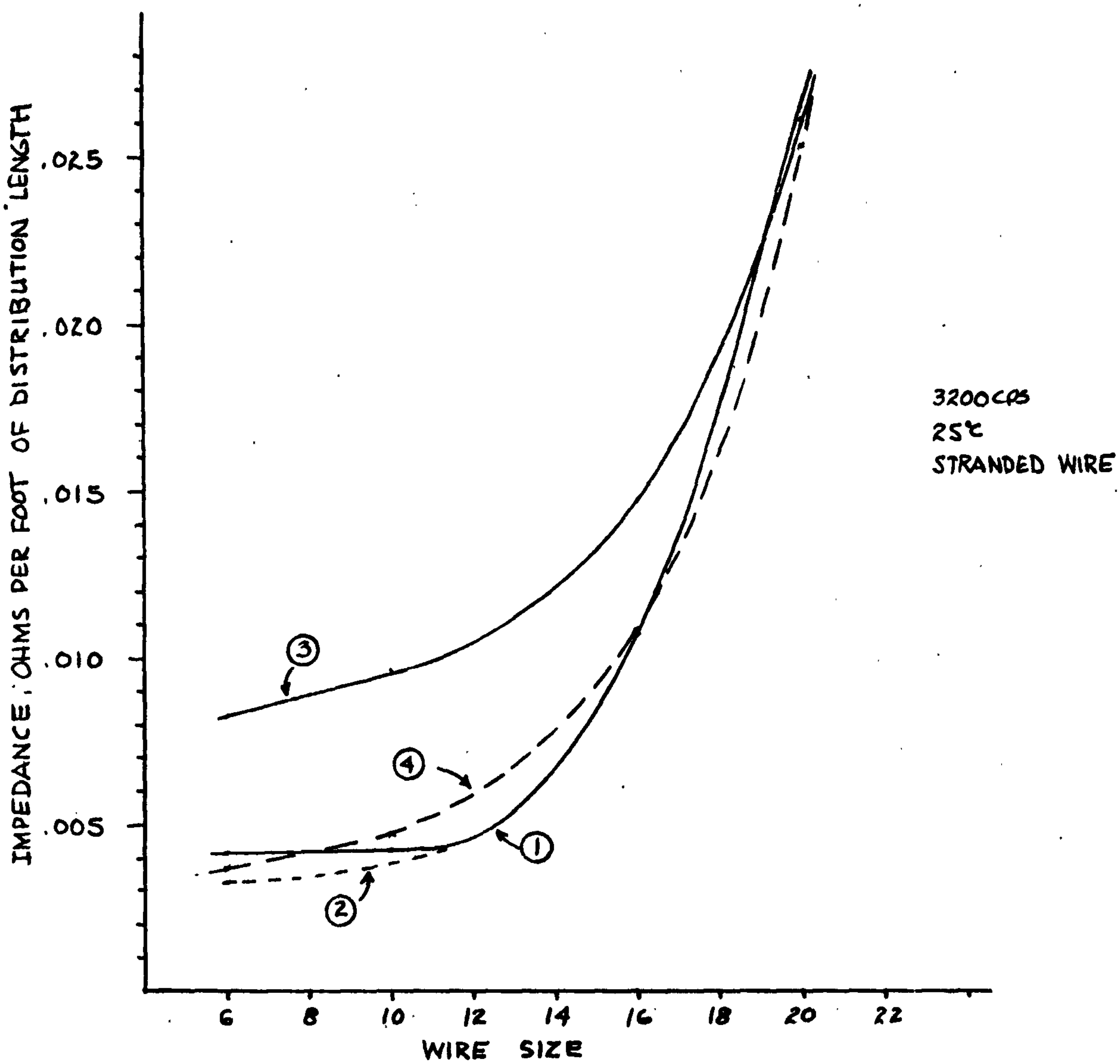
RED BANK DIVISION
THE BENDIX CORP

FIGURE 5

G.T.H 6/9/61

DISTRIBUTION CHARACTERISTICS
TWO CONDUCTORS IN VARIOUS CONFIGURATIONS

IMPEDANCE VS WIRE SIZE



1. SIDE BY SIDE
2. SIDE BY SIDE ON ALUM GND
3. 2 INCH SPACING
4. CABLED

RED BANK DIVISION
THE BENDIX CORP

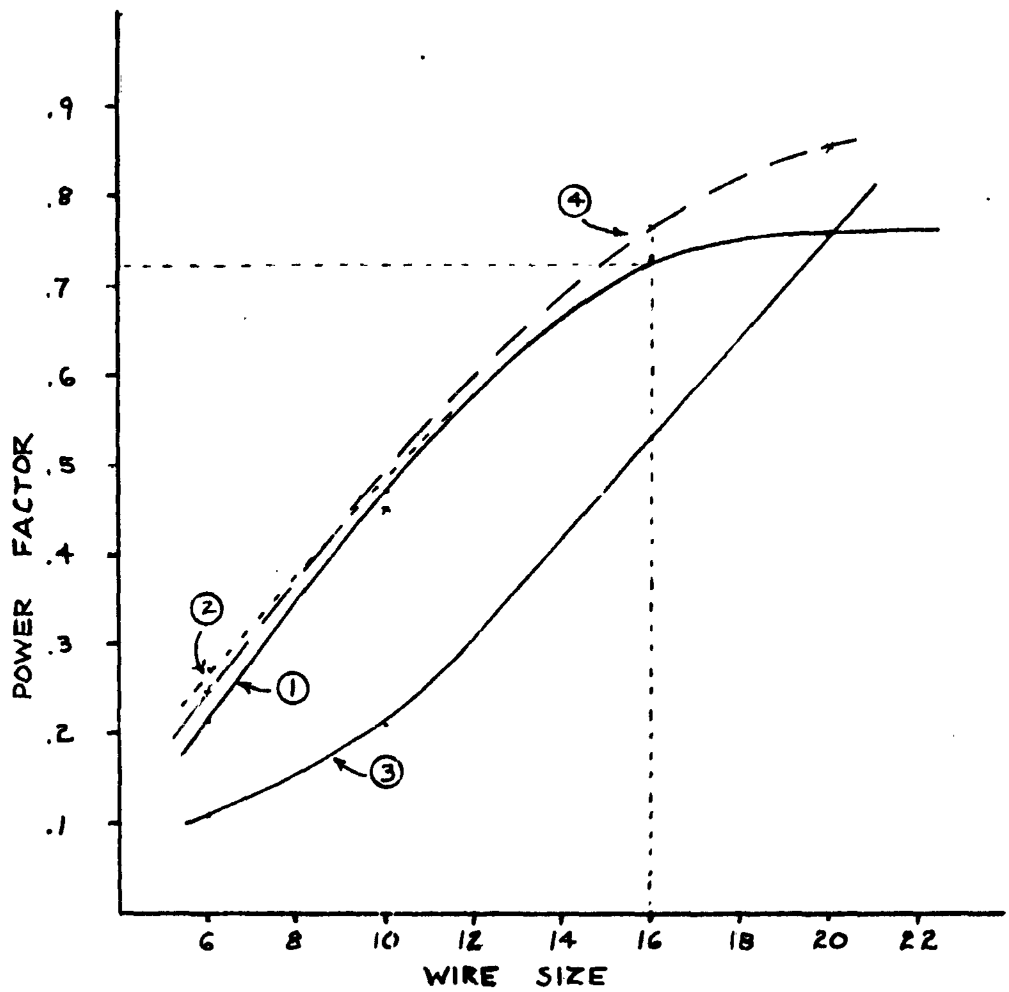
FIGURE 6

GTH 6/12/61

DISTRIBUTION CHARACTERISTICS
TWO CONDUCTORS IN VARIOUS CONFIGURATIONS

POWER FACTOR VS WIRE SIZE

3200 CPS
25°C
STRANDED WIRE



(1) SIDE BY SIDE
(2) SIDE BY SIDE ON ALUM GND
(3) 2 INCH SPACING
(4) CABLED

RED BANK DIVISION
THE BENDIX CORP.

FIGURE 7

GTH 6/12/61

C. Single Conductor Systems

The single conductor systems referred to in the following paragraphs are distribution systems in which electrical power is transmitted from the generating source to a load by means of a single wire. The circuit is completed by a return through an aluminum plate. This aluminum plate is treated as a ground and is intended to simulate the frame of an airborne vehicle. Since the impedance of a large aluminum plate is very small as compared to that of a single conductor of the size being tested, it will be considered as negligible throughout this report.

The main variable to be analyzed in a single conductor system is the distance between the conductor and the aluminum plate ground return. This distance is referred to as spacing. The spacing variations analyzed in this report are zero inches (conductor lying on a plate), one inch, three inches, and five inches. The effect of these spacings on system impedance is demonstrated in Tables 6, 7, 8 and 9 respectively. These tables were originated from laboratory test data and are limited to Wire Sizes # 6, #10, #16 and #20. For a comparison of the impedance factors of these wire sizes and the intermediate sizes, refer to Table 10. The intermediate values shown here were obtained by interpolation. A slight reduction in resistance is noted with metered spacing. This reduction is attributed to the proximity effects.

Figure 4, in the previous pages of this report, shows the variation of 3200 CPS conductor resistance with wire size for a single conductor system. The variation of the reactance factor with wire size and spacing is shown in Figure 8. As shown by these curves, any spacing will result in a considerable increase in reactive impedance.

The impedance per foot of distribution length for various wire sizes and with the referenced spacings is shown in Figure 9. The predominant reactive factor for larger wire sizes results in the curves resembling the curves of Figure 8 (Reactance vs. Wire Size).

However, as the wire size decreases the resistive factor becomes more predominant and the resulting curves approach the characteristic shown in Figure 4 (Resistance vs. Wire Size).

The effect of wire size and spacing on power factor is shown in Figure 10. The increasing relative magnitude of the resistance factor with decreasing wire sizes is indicated by an increasing power factor. Under all conditions, however, the maximum power factor can be obtained by minimizing the space between the conductor and aluminum plate.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance is for a single conductor system using an aluminum plate as ground return (conductor lying on plate - no spacing) See Procedure 5 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance R	Impedance X	Impedance Z	Average Test Impedance @ 25°C R	Average Test Impedance @ 25°C X	Average Test Impedance @ 25°C Z	Average Test Impedance @ 25°C pf
#6	Calc		.000445	.00125	.001328				
	Test	26	.000445	.00209	.00212				
	Calc		.000445	.00125	.001328				
	Test	26	.000445	.00219	.002230	.000445	.00214	.002183	.204
#10	Calc		.00108	.00157	.001865				
	Test	28	.00108	.00217	.002435				
	Calc		.00100	.00157	.001865				
	Test	26	.00100	.00290	.003070	.00108	.00254	.002725	.396
#16	Calc		.00450	.00216	.00498				
	Test	48	.00450	.00426	.00616				
	Calc		.00435	.00216	.00486				
	Test	33	.00435	.00392	.00586	.00435	.00409	.00597	.728
#20	Calc		.01025	.00262	.01115				
	Test	40	.01025	.00905	.01370				
	Calc		.01020	.00262	.01105				
	Test	31	.01020	.00732	.01253	.01020	.00819	.01308	.780

Table 6

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance for a single conductor system using an aluminum plate as ground return (conductor located 1 inch from plate) See Procedure 6 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance			Average Test Impedance @25°C			
			R	X	Z	R	X	Z	pf
#6	Calc		.000445	.00346	.00340				
	Test	27	.000445	.00436	.00439				
	Calc		.000445	.00346	.00340				
	Test	25	.000445	.00437	.00440	.000445	.004365	.00437	.102
#10	Calc		.00106	.00406	.00409				
	Test	34	.00106	.00503	.00514				
	Calc		.00101	.00406	.00408				
	Test	25	.00101	.00504	.00515	.00106	.005035	.00513	.206
#16	Calc		.00450	.00488	.00666				
	Test	51	.00450	.00645	.00785				
	Calc		.00445	.00488	.00665				
	Test	47	.00445	.00668	.00803	.00430	.00657	.00778	.553
#20	Calc		.01025	.00544	.01162				
	Test	43	.01025	.00985	.01472				
	Calc		.01020	.00544	.01153				
	Test	31	.01020	.00927	.01380	.01020	.00956	.01410	.723

Table 7

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance for a single conductor system using an aluminum plate as ground return (conductor located 3 inches from plate). See Procedure 7 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance			Average Test Impedance @ 25°C			
			R	X	Z	R	X	Z	pf
#6	Calc		.000443	.00483	.00487				
	Test	26	.000443	.00582	.00585				
	Calc		.000443	.00483	.00487				
	Test	26	.000443	.00589	.00592	.000443	.00586	.00589	.133
#10	Calc		.00098	.00539	.00554				
	Test	27	.00098	.00650	.00655				
	Calc		.001005	.00539	.00555				
	Test	33	.001005	.00600	.00608	.00098	.00625	.006325	.155
#16	Calc		.00434	.00612	.00803				
	Test	55	.00434	.00820	.00925				
	Calc		.00397	.00612	.00800				
	Test	36	.00397	.00823	.00915	.00425	.008215	.00925	.460
#20	Calc		.01060	.00680	.01488				
	Test	47	.01060	.61185	.01522				
	Calc		.00996	.00680	.01485				
	Test	34	.00996	.01058	.01459	.01122	.01005	.01501	.747

Table 8

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Comparison of calculated impedances with impedances obtained by laboratory testing. Impedance for a single conductor system using an aluminum plate as ground return (conductor located 5 inches from plate). See Procedure 8 in Appendix A and B for test procedure and laboratory data.

Wire Size	Method	Temp °C	Impedance			Average Test Impedance @25°C			
			R	X	Z	R	X	Z	pf
#6	Calc		.000430	.00547	.00551				
	Test	26	.000430	.00685	.00686				
	Calc		.000428	.00547	.00551				
	Test	25	.000428	.00685	.00685	.000430	.00685	.00686	.0625
#10	Calc		.00099	.00600	.00615				
	Test	32	.00099	.00745	.00750				
	Calc		.00098	.00600	.00615				
	Test	28	.00098	.00738	.00745	.00097	.00742	.00748	.130
#16	Calc		.00426	.00683	.00858				
	Test	51	.00426	.00916	.01010				
	Calc		.00389	.00683	.00855				
	Test	32	.00389	.00919	.00997	.00420	.00918	.01042	.402
#20	Calc		.01062	.00745	.01522				
	Test	47	.01062	.01243	.01639				
	Calc		.00994	.00745	.01520				
	Test	33	.00994	.01179	.01542	.01005	.01211	.01570	.636

Table 9

Impedance in Ohms Per Foot of Distribution Length
°C indicates average measured conductor temperature.

Distribution Impedance Characteristics

Single Conductor with Aluminum Ground Return

3200 CPS @ 25°C Temperature
(Test Results)

R - Resistive
X - Reactive

Stranded Wire

Impedance in Ohms Per Foot

Spacing / Wire Size	0"		1"		3"		5"		DC Ohms/Ft
	R	X	R	X	R	X	R	X	
#6	.000445	.00214	.000445	.004365	.000443	.00586	.000430	.00685	.000395
#8	.000722	.00235	.000722	.00458	.000720	.00602	.00715	.00703	.000628
#10	.00108	.00254	.00106	.005035	.00098	.00625	.00097	.00742	.000999
#12	.00165	.00295	.00162	.00545	.00161	.00658	.00159	.00780	.001588
#14	.00265	.00345	.00261	.00595	.00260	.00723	.00258	.00842	.002525
#16	.00435	.00409	.00430	.00657	.00425	.008215	.00420	.00918	.004016
#18	.00685	.00565	.00682	.00765	.00681	.00956	.00679	.01025	.006352
#20	.01020	.00819	.01020	.00956	.01010	.01122	.01005	.01211	.01010
#22	.01650	.01115	.01645	.01280	.01640	.01375	.01635	.01495	.016064

Spacing Indicates Distance Between Conductor and Aluminum Ground

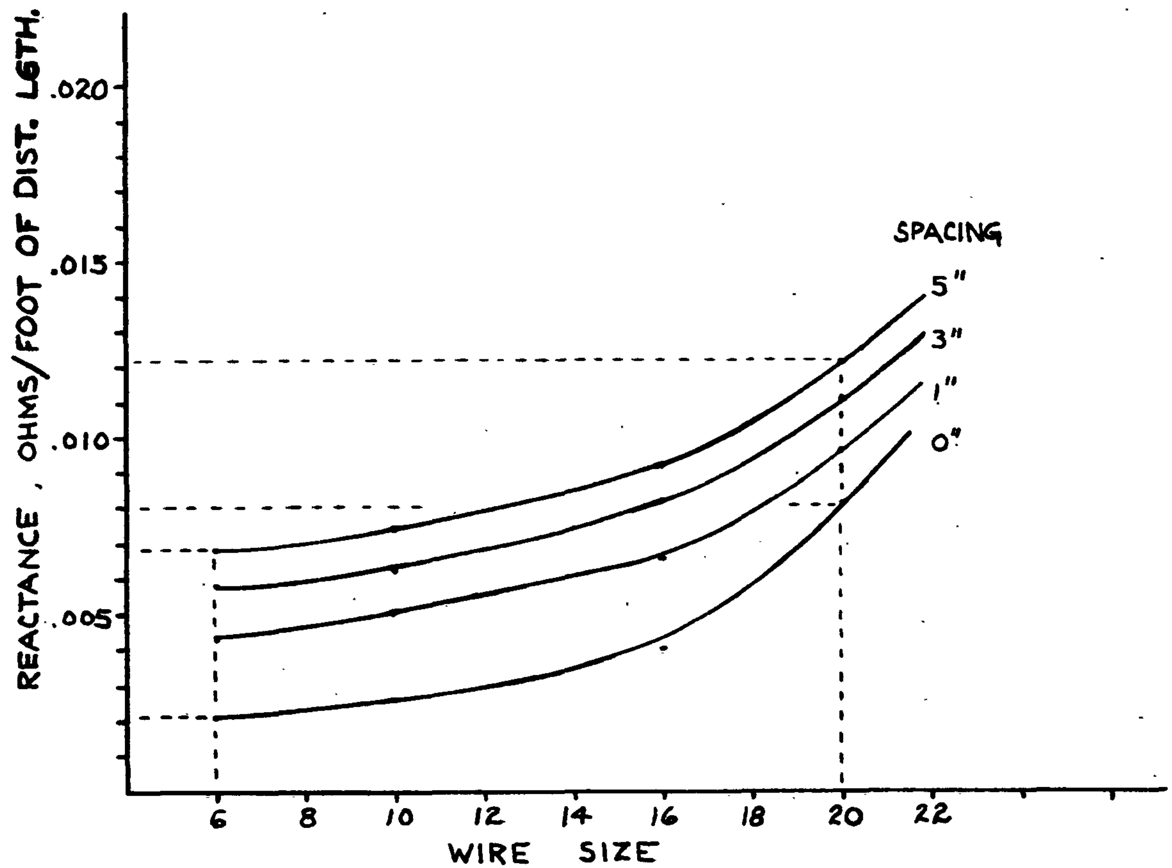
Table 10

Red Bank Division
THE BENDIX CORP.
G. T. H. 6/8/61

DISTRIBUTION CHARACTERISTICS
SINGLE CONDUCTOR WITH ALUM. PLATE RETURN

REACTANCE VS WIRE SIZE AND SPACING

3200 CPS
25°C
STRANDED WIRE



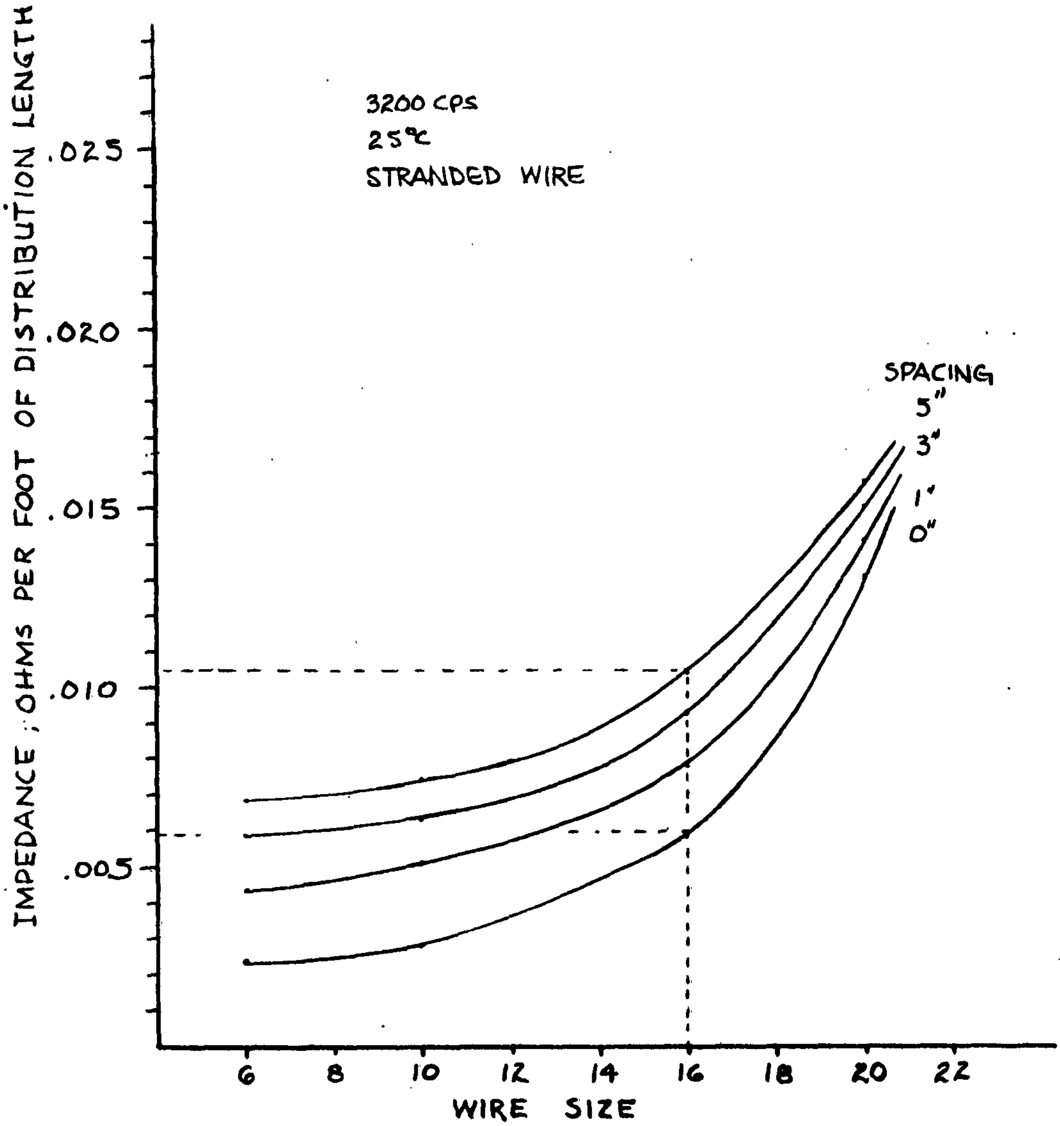
RED BANK DIVISION
THE BENDIX CORP.

FIGURE 8

GTH 6/8/61

DISTRIBUTION CHARACTERISTICS
SINGLE CONDUCTOR WITH ALUM. PLATE RETURN

IMPEDANCE VS WIRE SIZE AND SPACING



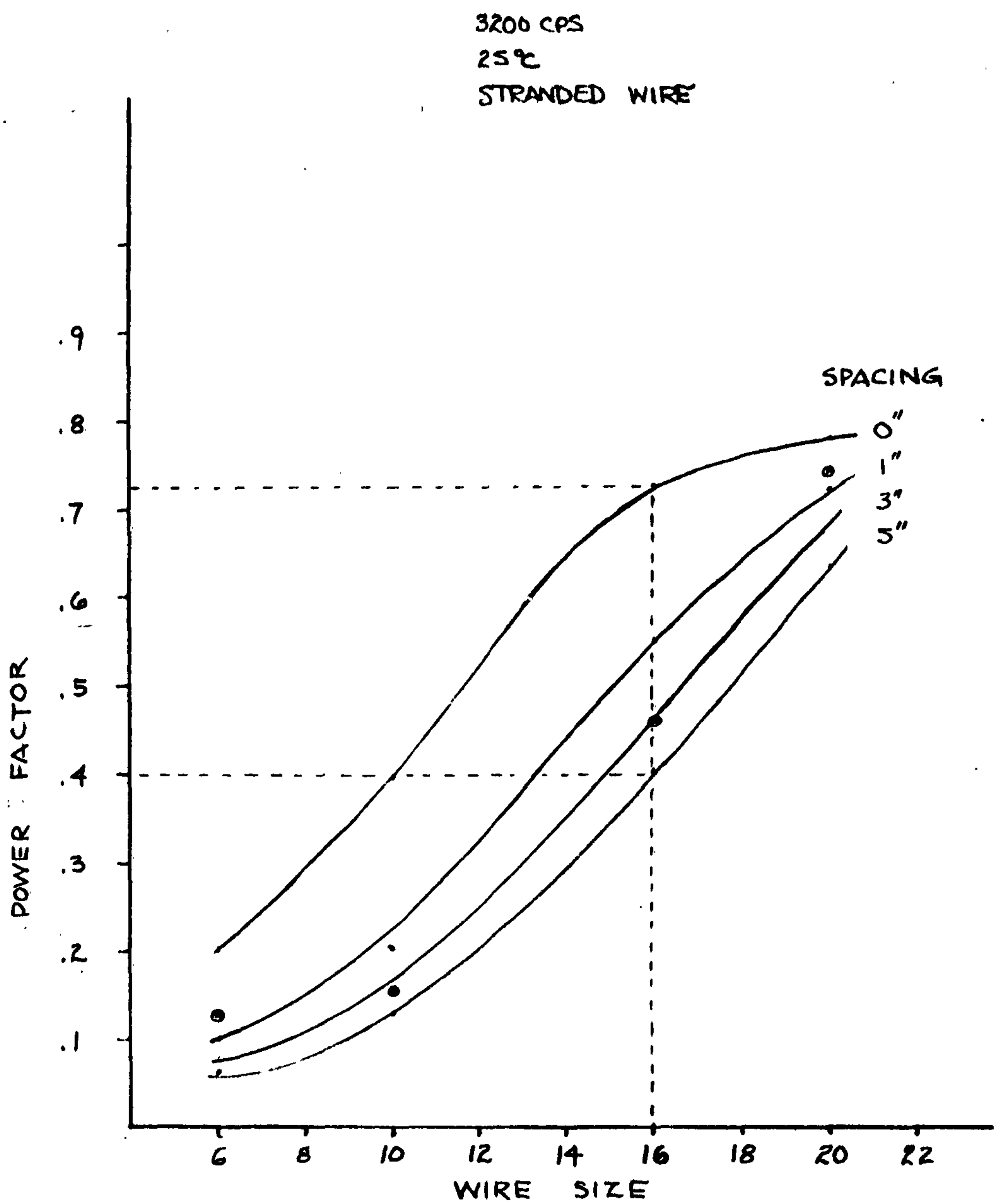
RED BANK DIVISION
THE BENDIX CORP

FIGURE 9

GTH 6/13/61

DISTRIBUTION CHARACTERISTICS
SINGLE CONDUCTOR WITH ALUM. PLATE RETURN

POWER FACTOR VS WIRE SIZE AND SPACING



RED BANK DIVISION
THE BENDIX CORP.

FIGURE 10

GTH 6/13/61

Section IV **Mutual Inductance Characteristics**

A. General

The term "mutual inductance", as used in this report, refers to the induction of a potential into a conductor which is in the local vicinity of another conductor which is carrying a 3200 CPS AC current. This potential is referred to as induced voltage. The conductor transmitting the 3200 CPS current will be called the primary. The conductor being affected by the induced potential is referred to as the secondary.

For the conditions described in this section, all test conductors are parallel. Conductors not directly involved with the test condition are perpendicular to the test plane or are at a distance sufficient to prevent their magnetic fields from influencing the given test condition. Test Procedures 9 through 18 in Appendix A and B provide details of the test set up and corresponding laboratory data.

Since the curves and pictures referenced in this section were extracted directly from the data of Appendix B, detailed tables have not been used to outline characteristics.

B. Induced Voltage

The basic effect of placing a 3200 CPS current carrying conductor in the local vicinity of a second conductor is shown in Figure 11. These curves show the induced voltage impressed by a 3200CPS primary current for various distances from a secondary conductor. It is noted, that as the distance between conductors (spacing) increases, the induced voltage decreases.

Also shown in this figure are the characteristics of a 400 CPS distribution system operating under the same conditions. As anticipated, the potential induced by a 3200 CPS line is approximately 8 times that of an equivalent 400 CPS line. This characteristic can cause a considerable problem area in high frequency power systems.

Since induced potential is dependent upon primary current and exposure length, values of Ampere Feet have been included in Figure 11. These values were obtained by multiplying the test current by the exposure length (50 feet). These ampere feet characteristics can be utilized in analyzing other 3200 CPS distribution configurations. The induced voltage of a 30 amp 50 foot system will be equivalent to that of a 50 amp 30 foot system for a standard set of conditions.

In order to determine the effect shielding would have on mutual induction, Test Procedure 11 was included. The initial test with the secondary shielded by aluminum thin wall tubing showed no effect on induced voltages. The shielding was then placed on the primary conductor (see page 12 of Appendix B) and only a minor reduction was noted. A comparison of test data from the two identical conditions, one with primary shielded and one without, will indicate only a few tenths of a volt difference. Since the difference is so slight, only the 5 inch spacing test was conducted.

The fact that only a very small reduction was noted on the secondary induced voltage can be attributed to the eddy currents which were generated in the shielding. These currents, in turn, induced a potential into the secondary conductor. Proof as to the presence of eddy currents was noted when the aluminum tubing became extremely hot.

Test Procedure 10 was designed to determine the amount of potential which would be induced into a secondary winding if the primary was energized but not carrying current. This induced potential can be attributed to capacitive coupling between the two conductors. The data from this test is included with that of Procedure 9. The readings are shown as O current or "C Open". From the data it can be seen that the effect of capacitive coupling is in the order of millivolts.

Figure 12 shows a general comparison of the effect of primary current, spacing, and wiring configuration on induced voltages. Also included are several 400 CPS characteristics which are intended to be used for comparison purposes. These curves are based on an exposure length of 50 feet. Similar curves for other lengths can be originated by assuming this to be a per unit basis and increasing the induced voltage by the ratio of exposure length.

Curve 1 shows the induced voltage characteristics of the primary and secondary conductors are side by side. The induced voltage of a comparable 400 CPS system is indicated by Curve 4.

If a two conductor primary is used (assuming the second wire to be the return), and the conductors are cabled, the induced voltage into a secondary winding will be reduced considerably. Curve 3 shows the condition with the single secondary wire at zero spacing with the primary conductors cabled. Cabling appears to reduce the induced voltage by approximately a five to one ratio.

If the primary is a single conductor, and the secondary a two conductor system, cabling the secondary will result in reducing the induced voltage to the limit shown by Curve 2. It should be noted that a slight advantage can be obtained by cabling primary conductors rather than secondary conductors of approximately the same size. This advantage, however, can be offset if the primary conductors are very large as compared to the secondary.

The relative effects of cabling the primary conductors of a 3200 CPS system and 400 CPS system can be seen by comparing Curves 2 and 5. As anticipated, the voltage induced by a 3200 CPS system is several times greater than that of an equivalent 400 CPS system.

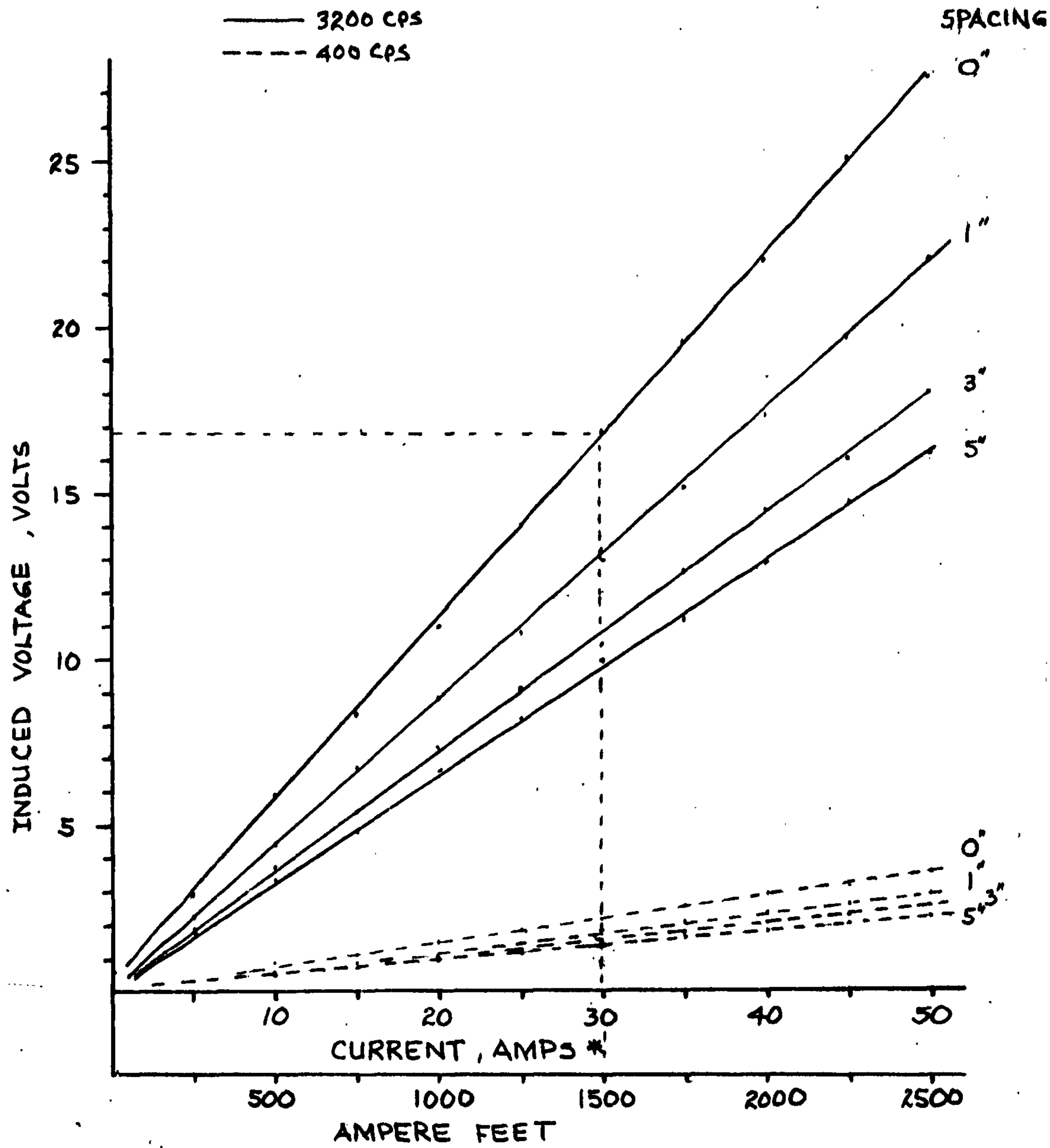
DISTRIBUTION CHARACTERISTICS

MUTUAL INDUCTANCE IN PARALLEL CIRCUITS

AMPERE FEET VS INDUCED VOLTAGE AND SPACING

3200 CPS VS 400 CPS

TEST PROCEDURES # 9 & # 12



1φ SYSTEMS

RED BANK DIVISION
THE BENDIX CORP.

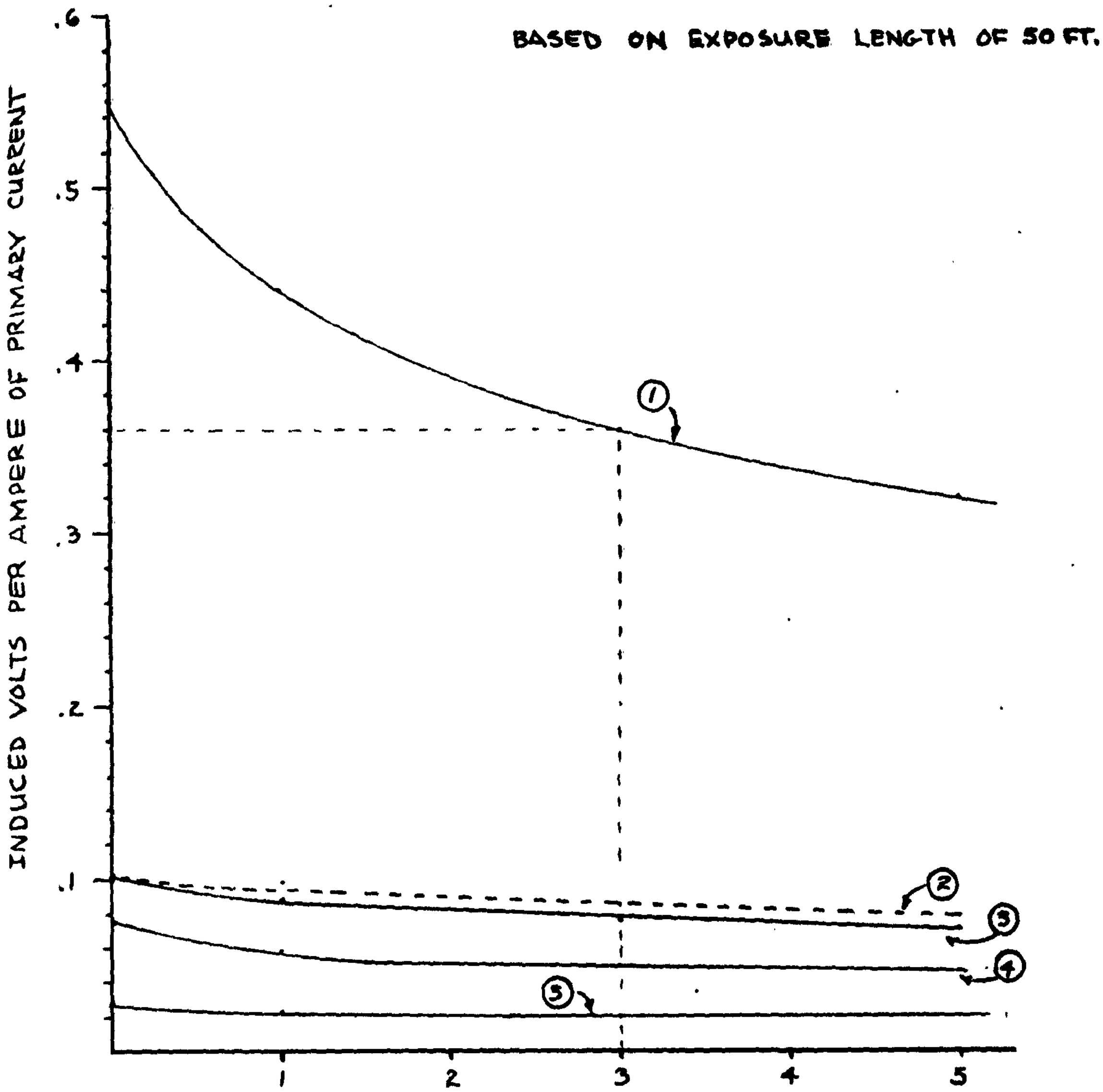
*EXPOSURE LENGTH 50 FT

FIGURE 11

GTH 6/13/61

DISTRIBUTION CHARACTERISTICS
MUTUAL INDUCTANCE IN PARALLEL CIRCUITS

EFFECT OF PRIMARY CURRENT, SPACING, AND WIRING CONFIGURATION ON INDUCED VOLTAGE



(1) 3200~ PRIMARY CONDUCTOR WITH SINGLE SECONDARY CONDUCTOR (PROC. # 9)
(2) 3200~ PRIMARY CONDUCTOR WITH CABLED SECONDARY CONDUCTORS (PROC # 14)
(3) 3200~ PRIMARY CONDUCTORS CABLED WITH SINGLE SECONDARY CONDUCTOR (PROC # 13)
(4) 400~ PRIMARY CONDUCTOR WITH SINGLE SECONDARY CONDUCTOR (PROC # 12)
(5) 400~ PRIMARY CONDUCTORS CABLED WITH SINGLE SECONDARY CONDUCTOR (PROC # 15)

RED BANK DIV.
THE BENDIX CORP.

FIGURE 12

GTH 6/13/61

C. Effect on Wave Shapes

It is interesting to note the effect a 3200 CPS current carrying conductor will have on another conductor carrying a different type of electrical power. For this reason, test procedure numbers 16, 17 and 18 were originated.

From the test data on Pages 21, 24 and 25 of Appendix B, the effects of 3200 CPS power on DC power can be seen. With a 10 amp DC load the maximum ripple measured was .83 volts. With a 50 amp 3200 CPS conductor along side for an exposure length of 50 feet, the ripple was increased to 16.5 volts.

If a two wire 3200 CPS system were used, and conductors cabled, the ripple was reduced to 3.2 volts. This approximate 5 to 1 reduction in ripple is comparable to the induced voltage characteristics previously discussed.

The actual change in wave shape can be seen by referring to Photograph 1, 2, 3, and 4 on Pages 24 and 25 of Appendix B.

The effects of 3200 CPS power on 400 CPS power is also interesting to note. Page 22 of Appendix B denotes the change in harmonic content of a 400 CPS potential before and after a 3200 CPS current carrying conductor is placed in close proximity.

The eighth harmonic, as would be expected, is increased considerably--from 1.2 to 5%. The actual change in wave shape can be seen in photographs 5 and 6 on Page 26 of Appendix B.

It should be noted that if the 3200 CPS system employed cabled leads the 400 CPS harmonic content would be expected to approach the initial readings.

Section V Conclusions

The detailed information contained in this report is intended to show the basic characteristics associated with the distribution of 3200 CPS electrical power. There is no intent to analyze a specific application but to provide general information which can be utilized at some future time to assist with system design by suggesting methods of circumventing possible problem areas.

The distribution characteristics of 3200 CPS electrical power are quite different in many respects than those associated with power of a lower frequency level. In most cases these characteristics can be considered as limitations to using a high frequency electrical power. By the same token, however, higher frequency power does provide many advantages in other areas of system operation and performance. Therefore, by necessity, each application must be analyzed independently and completely. From this analysis the choice can be made as to which type of electrical power is most advantageous.

APPENDIX "A"

April 17, 1961
Revision B

Bendix Red Bank
Report No. 331

3200 CPS Electrical Power Distribution Test Procedures

Object

Observe and record the distribution characteristics of single phase 3200 cps electrical power.

Equipment

6 KVA, single phase breadboard generator (rheostat controlled with a 17.5 mfd series compensating capacitor.)
Variable resistance load bank capable of providing a maximum load of 50 amps.
Various lengths of stranded wire, sizes 6, 8, 10, 12, 16 and 20.
Standard laboratory meters and measuring devices.
10 AMP DC supply.
400 cps supply.
1/4" x 6" aluminum plate of various lengths.

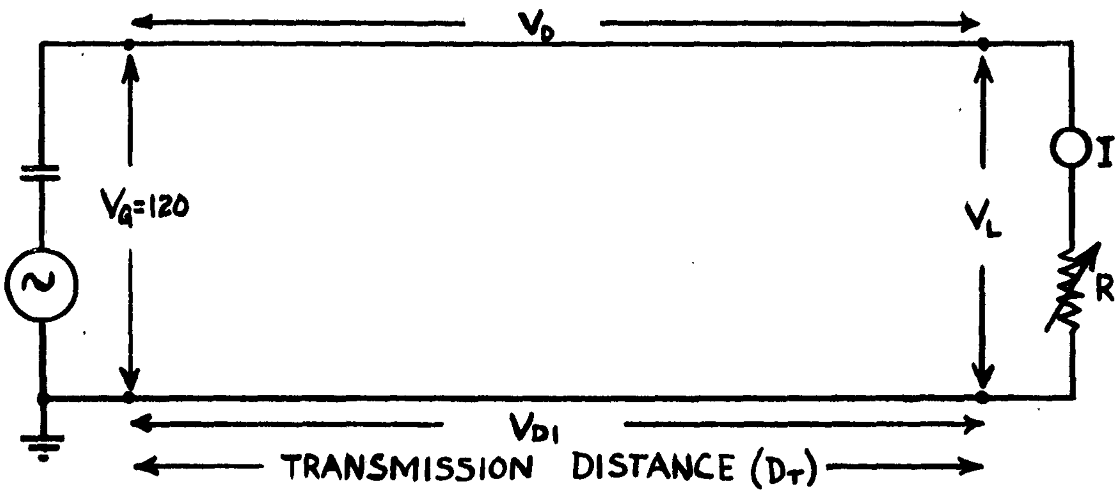
Test Conditions

All tests to be conducted under room ambient conditions.
All sensing and instrument leads must be kept perpendicular to primary power leads for a minimum distance of 6 feet.
Uniform wire spacing from aluminum plate may be accomplished using low density wood strips or blocks.
Where cabling is required, the lay of cable shall be from 8 to 14 times the diameter of the cable (two times the diameter of an individual wire). Value shall be recorded.
All tests shall be conducted in an area relatively free from other possible sources of induced signals or power.
Where thermo couples are required, they shall be placed at the beginning, and at five foot intervals to the end of the indicated transmission distance. The installation shall be made on the wire to insure a true indication of conductor temperature and to minimize the effect of ambient conditions. Thermo couple locations and readings shall be indicated on data sheets.

APPENDIX A

<u>Test Procedure</u> <u>Line Impedance</u>

1. Determine line impedances in ohms/ft. for the following dual conductor distribution conditions. The test circuit shall be connected as follows with the conductors placed side by side (no spacing). Thermo couples shall be used to sense conductor temperature over the indicated transmission distance.



APPENDIX A

Record all parameters and conductor temperature.

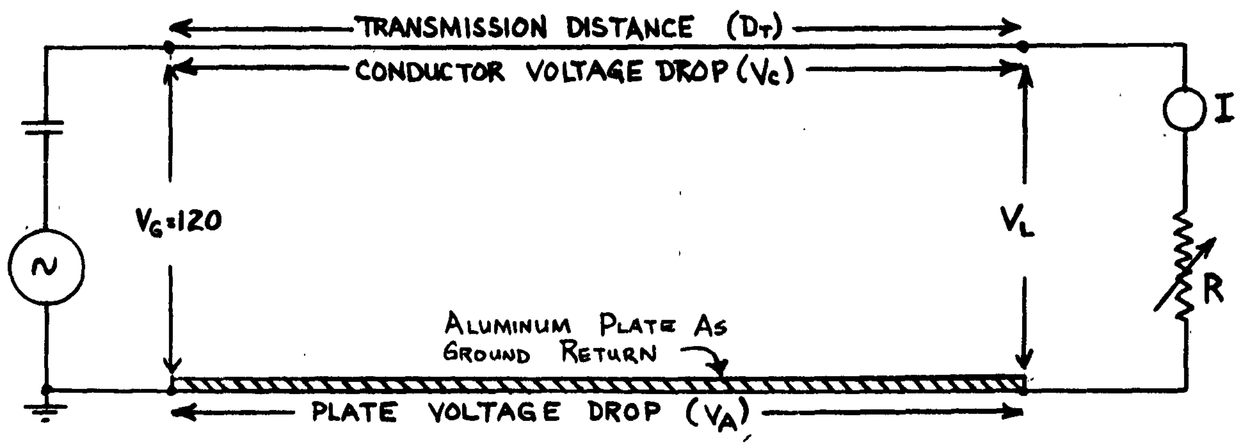
Wire Size	D_T (ft)	I (amp)	V_D (volts)	V_{D1} (volts)	V_G (volts)	$Z = \frac{V_D+V_{D1}}{I}$ (Ohms)	$Z/2D_T$ ohm/ft.	Conductor Temp. °C	V_L (volts)
6	30	50							
		40							
		30							
10	30	40							
		30							
		25							
16	20	25							
		22							
		15							
20	20	15							
		11							
		8							

2. Repeat No. 1 with conductors laying on an aluminum plate which has been grounded to earth (to simulate aircraft ground).

3. Repeat No.1 using a 2-inch spacing between center lines of conductors.

4. Repeat No. 1 with cabled conductors. Record valve of turns per foot.

5. Determine single conductor impedance characteristics using the setup shown below. The impedance (ohms/ft.) shall be determined for the following conditions with the insulated conductor adjacent to the aluminum plate (zero spacing) throughout the entire transmission distance D_T.



APPENDIX A

Record all parameters and conductor temperature

Wire Size	D_T (ft)	I (amps)	V_C (volts)	V_A (volts)	V_G (volts)	V_L (volts)	$Z_C = \frac{V_C}{I}$ (Ohms)	$Z_A = \frac{V_A}{I}$ (Ohms)	Z_C / D_T	Z_C / D_T	Temp Conductor °C
6	30	50									
	30	40									
10	30	40									
	30	30									
16	20	25									
	20	15									
20	20	15									
	20	10									

6. Repeat No. 5 with conductor 1 inch from aluminum plate.

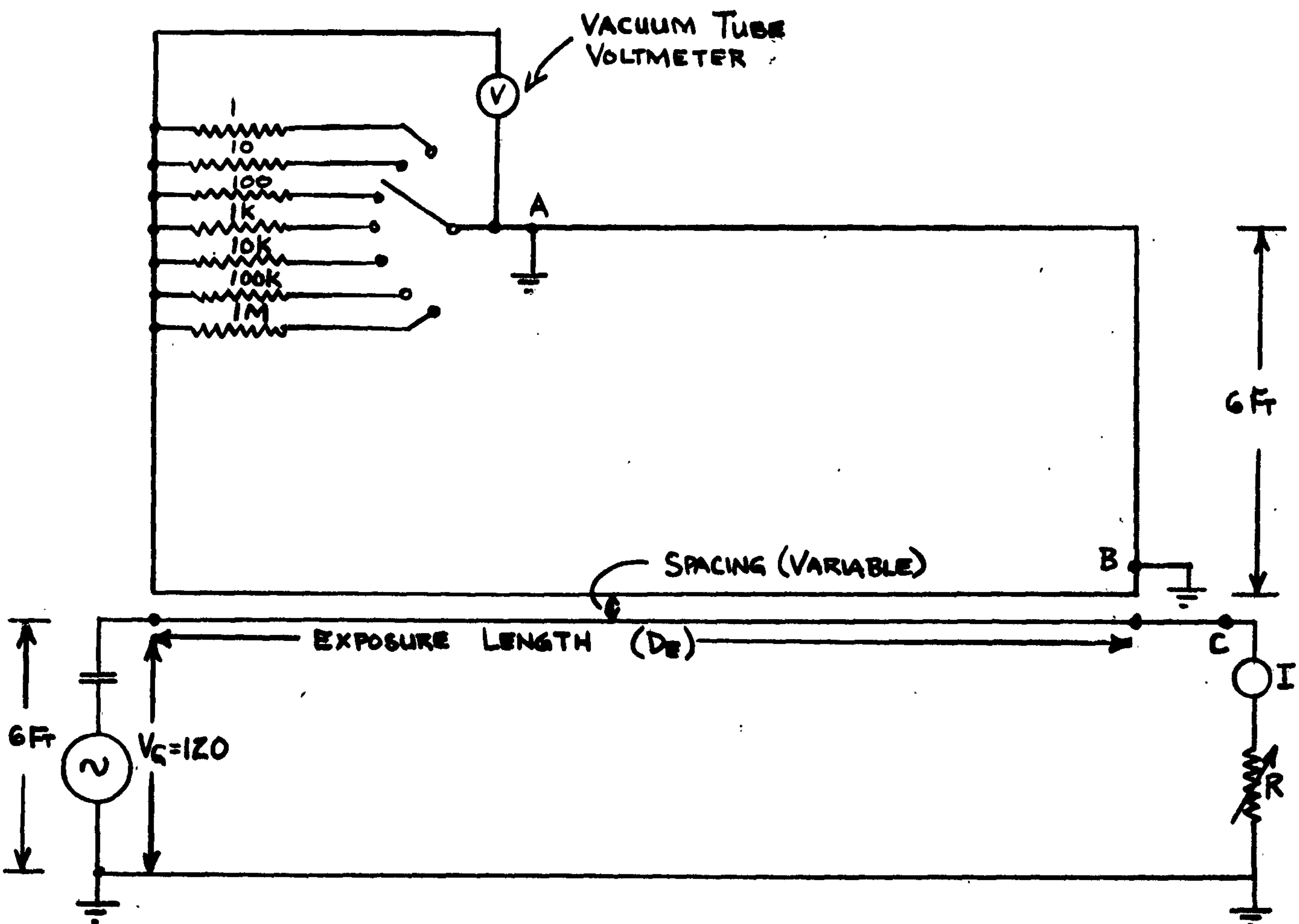
7. Repeat No. 5 with conductor 3 inches from aluminum plate.

8. Repeat No. 5 with conductor 5 inches from aluminum plate.

APPENDIX A

Mutual Inductance

9. Determine induced voltage in resistive loads due to inductive coupling. The test set up shown below shall be used. Primary power leads shall be size #8, secondary leads shall be size #20. Record the voltage induced in each resistive lead for the following conditions. The following load currents shall be used for each test condition: 50, 45, 40, 35, 30, 25, 20, 15, 10, 5, and 1 amp.



APPENDIX A

Spacing	Exposure Length (ft) D_E	Current I (amps)	Induced Voltage						
			R 1	R 10	R 100	R_{1K}	R_{10K}	R_{100K}	R_{1M}
*Together	50	50 ↓ 1							
* 1"(C/L)	50	50 ↓ 1							
* 3"(C/L)	50	50 ↓ 1							
* 5"(C/L)	50	50 ↓ 1							

10. Repeat No. 9 test conditions with primary 3200 CPS power energized but with the circuit open at point C (I=0).

11. Repeat No. 9 with the secondary circuit conductor shielded between points A and B. Record length of cable shielded.

12. Repeat No. 9 test conditions shown by asterisk (*) with 400 CPS power in lieu of 3200 CPS power.

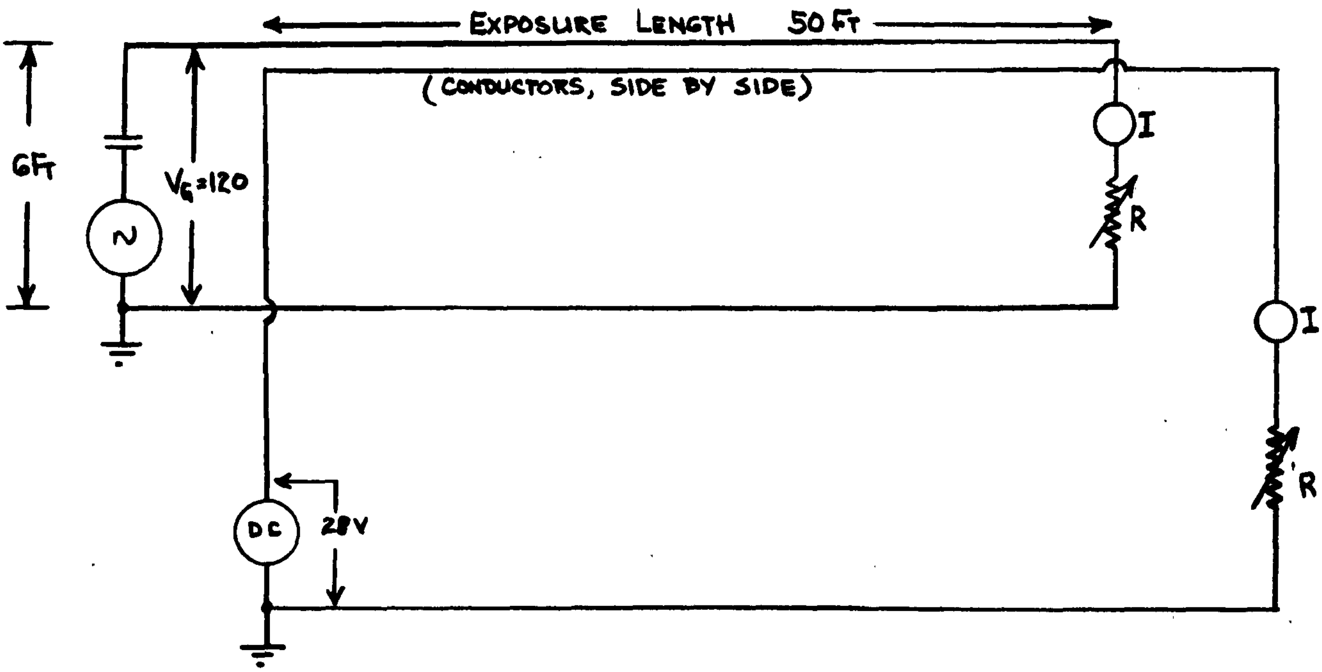
APPENDIX A

13. Repeat No. 9 with primary power leads cabled instead of using 6-foot spacing. Secondary leads should be spaced.

14. Repeat No. 9 with secondary power leads cabled instead of using 6-foot spacing. Primary leads should be spaced.

15. Repeat No. 13 test conditions shown by asterisk (*) using 400 CPS power in lieu of 3200 CPS power.

16. Determine induced voltage affect on DC power line. The test setup should be as shown below. Primary power leads to be size #8, secondary (DC) leads to be size #12.



With a 10 amp DC load and no 3200 CPS load, measure DC ripple and take photo of wave shape. Energize AC load to provide 6 KVA, 3200 CPS output. Record DC ripple and take comparison photo of wave shape.

APPENDIX A

[redacted]

17. Repeat No. 16 with 3200 CPS power leads cabled in lieu of using 6-foot spacing.

18. Repeat No. 16 using a 10 amp 400 CPS supply in lieu of the 10 amp DC supply. Measure harmonic content prior to and during the 3200 CPS loading. Take corresponding photos.

Revision A - Changed reference test numbers to be compatible with desired results
4/3/61 GTH

Revision B - Changed in accordance with Douglas - Bendix TelCon on 4/14/61
4/17/61 GTH

GTH/is

APPENDIX A

APPENDIX "B"

FORM 270A REV 12 59

G. HEINZMAN	[illegible]
H. DOUGHTIE	[illegible]
P. HARTLEY	[illegible]
ENG. FILE	[illegible]

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1069-1
Date of Test 5-4-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

OBJECT: OBSERVE AND RECORD THE DISTRIBUTION CHARACTERISTICS OF SINGLE PHASE 3200 C.P.S. ELECTRICAL POWER.

PROCEDURE: DISTRIBUTION TESTS WERE CONDUCTED AS PER BENDIX, RED BANK REPORT NO. 231 ENTITLED 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TEST. PROCEDURES 1 THRU 18 WERE RECORDED AS FOLLOWS.

(NOTE)

PROCEDURE #9 CHANGE IN WIRING LAYOUT

NOTE: #12 WIRE REPLACING #20 WIRE

NOTE: CONNECT A, B, C, D POINTS TO ALUMINUM PLATE

SEE PAGE: 23

NOTE: INDUCED VOLTAGE READING COULD NOT BE TAKEN FOR SEVERAL CONDITIONS REQUIRING THE SMALLER TEST RESISTANCE. EXCESSIVE INDUCED CURRENTS RESULTED IN BURNING-UP THE RESISTORS

Pages

ENGINEERING COPY

Page

Book R-370 Page 1 1 OF 26

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-4-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

3200 CPS GENERATOR SER # 1117218
Procedure # 1

	1-121 G-48	METER R-60	METER R-60	METER E-65	METER E-66			METER L-110	METER J-62	TEMP. IN °C							
DT	IL	V D	V DI	V GEN	V LOAD	Z D-DI	Z Ω/FT	If	Ef	Amb	1	2	3	4	5	6	7
						#6 WIRE											
30'	50	3.0	3.2	120	117.1	.124	.0020	2.05	18.7	19	35	38	31	32	35	30	30
30'	40	2.45	3.6	120	117.4	.101	.0017	1.91	16.8	19	31	34	29	30	32	28	28
30'	30	1.87	1.94	120	118.1	.0762	.0013	1.79	15.7	20	22.5	28	24	25	27	23	25
						#10 WIRE											
30'	40	2.66	2.60	120	116.1	.131	.00218	1.92	17.4	26	35	42	45	44	51	36	41
30'	30	1.97	1.95	120	117.2	.130	.00216	1.81	16.2	26	32	34	36	36	40	33	36
30'	25	1.63	1.61	120	117.9	.130	.00216	1.75	15.5	26	29	31	32	32	35	29	32
						#16 WIRE											
20'	25	2.80	3.10	120	114.5	.236	.0059	1.74	15.2	22	50	79	76	74	42		
20'	22	2.42	2.50	120	115.0	.2236	.00558	1.73	15.1	22	44	66	64	63	40		
20'	15	1.55	1.58	120	116.8	.2087	.00523	1.66	14.6	22	34	42	41	40	30		
						#20 WIRE											
20'	15	4.55	4.20	120	111.0	.5833	.01455	1.68	14.7	24	46	105	94	84	50		
20'	11	3.0	3.2	120	114.0	.5636	.01405	1.64	14.2	24	38	64	60	54	38		
20'	8	2.22	2.20	120	116.0	.5525	.0138	1.63	14.2	24	30	44	44	42	30		

THERMO COUPLE LOCATIONS:
FIVE FEET APART FROM GENERATOR TO LOAD BANK
THERMO COUPLE #1 AT THE BEGINNING OF
TRANSMISSION DISTANCE, #7 AT END.

Pages
Page

ENGINEERING COPY

Book R-370 Page 2 2 OF 26

APPENDIX B

[redacted]

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

ENG. FILE

Test Report No. ES0 1069-1
Date of Test 5-5-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure # 2

DT	IL	V D	V D1	V GEN	V LOAD	Z D+D1	Z Ω/FT	IF	EF	Amb	1	2	3	4	5	6	7
										TEMP IN °C							
# 6 WIRE																	
30'	50	2.38	2.53	120	112.2	.0982	.00164	2.06	18.1	23	43	36	35	34	40	35	34
30'	40	1.98	2.07	120	117.3	.1012	.00168	1.90	16.8	24	38	32	31	32	36	32	32
30'	30	1.47	1.53	120	118.2	.100	.00167	1.82	16.0	24	32	28	28	28	30	28	30
#10 WIRE																	
30'																	
30'	40	2.55	2.45	120	111.3	.125	.00208	1.93	17.4	25	34	42	47	46	52	37	40
30'	30	1.90	1.80	120	112.4	.1233	.00206	1.8	15.9	24	29	34	34	36	40	31	34
30'	25	1.58	1.50	120	117.9	.1232	.00208	1.75	15.5	24	29	31	33	32	36	30	32
#16 WIRE																	
20'	25	2.8	2.78	120	114.5	.2232	.00558	1.75	15.5	24	43	62	64	52	44		
20'	22	2.4	2.38	120	115.2	.2345	.00588	1.75	15.0	24	36	50.5	53	42	38		
20'	15	1.82	1.80	120	16.9	.2413	.00604	1.67	14.6	24	28.5	36	32.5	31	30.5		
#20 WIRE																	
20'	15	4.45	4.4	120	111.1	.590	.01470	1.63	14.6	24	44	100	95	83	50		
20'	11	2.70	2.68	120	114.0	.489	.00122	1.62	14.3	24	36	61	65	57	40		
20'	8	1.90	1.81	120	116.0	.4637	.001155	1.61	14.2	24	30	45	40	43	31		

Pages
Page*

ENGINEERING COPY

Book R-320

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-5-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure # 3

Dr	I_L	V_D	V_{D1}	V_{GEN}	V_{LOAD}	Z_{D+D1}	Z Ω/FT	I_F	E_F	TEMP IN °C Amb	1	2	3	4	5	6	7
						# 6 WIRE											
30'	50	6.0	6.3	120	115.9	.2463	.00412	2.03	18.4	22	41	42	36	36	38	36	36
30'	40	4.9	5.0	120	116.6	.2471	.00413	1.90	17.1	22	34	36	31	31	33	37	31
30'	30	3.7	3.75	120	118.1	.2482	.00414	1.69	15.6	21	28	29	26	26	28	27	27
						# 10 WIRE											
30'	40	5.87	5.70	120	115.2	.289	.00481	1.90	16.9	26	35	42	43	42	46	35	42
30'	30	4.40	4.25	120	117.0	.281	.00468	1.80	15.9	24	28	32	34	34	36	29	34
30'	25	3.67	3.60	120	117.5	.2905	.00492	1.75	15.4	23	27	29	30	30	32	26	32
						# 16 WIRE											
20'	25	3.79	3.77	120	114.2	.3024	.00756	1.74	15.5	24	43	62	64	52	44		
20'	22	3.25	3.30	120	115.0	.2977	.00743	1.73	15.4	24	36	50.5	53	42	36		
20'	15	2.21	2.24	120	116.9	.2966	.00742	1.66	14.6	24	28.5	36	37.5	31	30.5		
						# 20 WIRE											
20'	15	4.30	4.35	120	111.7	.5766	.01442	1.63	14.9	24	44	100	95	83	50		
20'	11	2.99	3.00	120	114.1	.5445	.01331	1.63	14.3	24	36	61	55	57	40		
20'	8	2.05	2.07	120	116.1	.5150	.01288	1.62	14.4	24	30	45	40	43	31		

Pages ____
Page* ____

ENGINEERING COPY

Book R-370 Page 4

APPENDIX B

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

ENG. FILE

Test Report No. ESO 1068-1
Date of Test 5-8-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #4

Dr	I_L	V_D	V_{D1}	V_{GEN}	V_{LOAD}	Z_{D+D1}	Z Ω/FT	I_F	E_F	Amb	1	2	3	4	5	6	7
							#6 WIRE		(1 TURNS IN 8")								
30'	50	2.71	2.8	120	117.1	.110	.001832	2.08	19.5	22	40	43	38	39	37	37	35
30'	40	2.20	2.28	120	118.0	.112	.001866	1.96	18.9	22	34	38	34	35	33	33	31
30'	30	1.67	1.70	120	118.2	.1123	.001872	1.80	15.9	22	30	31	28	29	29	28	28
							#10 WIRE		(3 TURNS/FT)								
30'	40	2.71	2.50	120	116.5	.130	.002132	1.93	17.3	23	26	31	31	31	36	28	29
30'	30	2.30	2.16	120	117.3	.1487	.002478	1.81	16.0	23	28	36	36	36	42	31	32
30'	25	2.07	1.57	120	117.8	.1456	.002429	1.75	15.3	23	32	46	46	46	54	38	38
							#16 WIRE		(4 TURNS/FT)								
20'	25	2.82	2.81	120	114.4	.225	.00563	1.75	15.4	26	38	78	63	59	46		
20'	22	2.61	2.69	120	115.1	.241	.00602	1.73	15.2	25	35	67	54	51	42		
20'	15	1.55	1.52	120	117.0	.205	.00512	1.66	14.5	26	30	40	38	36	32		
							#20 WIRE		(12 TURNS/FT)								
20'	15	4.18	4.18	120	111.1	.557	.01422	1.66	14.6	25	41	75	67	79	51		
20'	11	2.85	2.92	120	114.1	.525	.01311	1.63	14.4	25	35	50	51	67	40		
20'	8	1.84	1.83	120	115.9	.455	.01139	1.61	14.4	25	32	41	36	4	34		

ENGINEERING COPY

Book R-370 Page 5 5 of 26

Pages ____
Page* ____

APPENDIX B

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

ENG. FILE

Test Report No. ESO 1068-1
Date of Test 5-9-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure # 5

													TEMP IN °C						
DT	IL	V Conductor	V Alum.	V Gen	V Load	Z Conductor	Z Alum	ZC Ω/FT	ZA Ω/FT	If	Ef	Amb	1	2	3	4	5	6	7
						#20 WIRE													
20'	15	4.05	.068	120	115.6	.270	.00675	.0135	.003375	1.67	14.5	24	38	40	42	58	44		
20'	10	2.46	.048	120	117.3	.246	.00614	.0123	.003058	1.64	14.4	23	30	30	31	40	32		
						#16 WIRE													
20'	25	3.00	.09	120	116.8	.120	.0030	.006	.000150	1.75	15.5	24	48	50	40	71	46		
20'	15	1.72	.042	120	118.0	.114	.00285	.0057	.000143	1.66	14.8	24	34	35	31	40	33		
						#10 WIRE													
30'	40	2.71	.21	120	117.6	.0677	.001128	.00226	.000577	1.95	18.1	20	27	31	34	36	40	35	30
30'	30	2.63	.14	120	118.2	.0877	.001461	.00292	.000487	1.80	15.6	21	26	27	29	30	32	31	27
						#6 WIRE													
30'	50	3.00	.19	120	117.9	.060	.0010	.002	.000333	2.12	19.2	22	27	28	26	29	33	32	29
30'	40	2.53	.16	120	118.1	.0642	.00106	.00214	.000357	1.44	17.3	22	27	27	26	27	30	30	28

Pages
Page

ENGINEERING COPY

Book R-370 Page 6 6 of 26

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-11-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #6

DT	IL	Volts Conductor	Volts AL	Volts GEN	Volts Load	Z Conductor	Z AL	Z C Ω/FT	Z AL Ω/FT	If	Ef	Amb	TEMP IN °C 1	2	3	4	5	6	7
						#20 WIRE													
20'	15	4.20	.23	120	115.5	.280	.0155	.014	.00078	1.67	14.6	24	38	46	47	58	44		
20	10	2.60	.16	120	117.0	.260	.0160	.013	.0008	1.63	140	23	28	33	32	38	32		
						#16 WIRE													
20'	25	3.70	.23	120	116.9	.148	.0092	.0074	.00046	1.75	15.5	23	47	62	61	73	60		
20'	15	2.20	.21	120	118.0	.146	.014	.0073	.0007	1.66	14.6	23	33	37	32	41	33		
						#10 WIRE													
30'	40	6.53	.66	120	117.1	.1382	.0162	.00461	.00054	1.93	17.1	22	47	33	32	38	38	40	30
30'	30	4.10	.52	120	118.2	.136	.0172	.00454	.000574	1.80	15.8	21	24	26	26	30	30	32	26
						#6 WIRE													
30'	50	5.78	.81	120	117.7	.1156	.0162	.00385	.00054	2.1	19.0	22	26	29	27	30	31	32	28
30'	40	4.63	.65	120	118.0	.1157	.0162	.00386	.0004	1.93	17.1	22	24	27	25	28	28	28	27

Pages ____
Page* ____

ENGINEERING COPY

Book R-370 Page 7 7 OF 26

APPENDIX B

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-11-61.
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #7

DT	IL	Volts Conductor	Volts AL	Volts Gen	Volts Load	Z Conductor	Z AL	Z C R/FT	Z AL R/FT	IR	ER	Amb	TEMP. IN °C 1, 2	3, 4	5, 6	7
						#20 WIRE										
20'	15	4.22	.36	120	116.3	.281	.024	.0141	.0012	1.67	14.6	23	39, 46	48, 59	47	
20'	10	2.66	.26	120	117.1	.266	.026	.0133	.0013	1.63	14.4	23	30, 34	33, 38	34	
						#16 WIRE										
20'	26	4.00	.68	120	116.8	.160	.0252	.008	.00126	1.75	15.1	22	42, 63	52, 70	60	
20'	15	2.36	.38	120	118.0	.157	.0253	.00785	.001265	1.67	14.6	23	32, 39	34, 40	34	
						#10 WIRE										
30'	40	6.67	1.30	120	116.7	.1692	.0325	.0058	.00108	1.92	16.9	21	26, 33	32, 38	36, 39	30
30'	30	4.47	1.0	120	118.0	.149	.033	.00496	.0011	1.81	15.7	21	24, 27	25, 30	29, 31	26
						#6 WIRE										
30'	80	7.16	1.63	120	117.1	.143	.0326	.0048	.00108	2.08	18.8	22	25, 29	26, 30	29, 30	28
30	40	5.80	1.31	120	117.9	.145	.0327	.00483	.00109	1.94	17.2	22	24, 27	24, 28	27, 28	26

Pages
Page*

ENGINEERING COPY

APPENDIX B

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-12-61
By C.SWIGON R.WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure # B

													TEMP IN °C			
DT	I L	Volts Conductor	Volts AL	Volts Gen	Volts Load	Z Conductor	Z AL	Z C Ω/FT	Z AL Ω/FT	I f	E f	Amb	1 / 2	3 / 4	5 / 6	7
					# 20 WIRE											
20'	15	4.40	.51	12.0	115.3	.293	.034	.0146	.0017	1.67	14.7	23	36 / 45	50 / 56	47	
20'	10	2.74	.35	120	117.2	.274	.035	.0137	.00175	1.64	14.4	23	29 / 33	34 / 37	32	
					# 16 WIRE											
20'	25	4.20	.82	120	117.0	.168	.0328	.0084	.00164	1.75	15.4	23	42 / 56	45 / 66	44	
20'	15	2.51	.48	120	117.9	.1678	.0321	.00839	.0016	1.66	14.4	23	28 / 33	31 / 38	30	
					# 10 WIRE											
30'	40	7.20	1.80	120	111.0	.180	.045	.006	.00150	1.93	16.7	21	21 / 32	30 / 35	36 / 37	28
30'	30	5.40	1.30	120	117.8	.180	.0433	.006	.00144	1.81	15.7	22	25 / 28	26 / 30	30 / 32	26
					# 6 WIRE											
30'	50	7.90	2.40	120	112.0	.158	.048	.0527	.00160	2.1	19.9	22	25 / 28	26 / 30	30 / 32	28
30'	40	6.40	1.83	120	117.4	.160	.0457	.0534	.00152	1.92	16.9	22	24 / 26	24 / 26	36 / 28	26

ENGINEERING COPY

APPENDIX B

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO-1068-1
Date of Test 4-17-61
By C. SWIGAN R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

PROCEDURE #9 Primary + Secondary wires together

INDUCED VOLTAGE

I Load	$R_{1\Omega}$	$R_{10\Omega}$	$R_{100\Omega}$	$R_{1K\Omega}$	$R_{10K\Omega}$	$R_{100K\Omega}$	$R_{1M\Omega}$	C only
50				27.5	27.5	27.5	27.5	[illegible]
45				25.0	25.0	25.0	25.0	
40				22.2	22.2	22.2	22.0	
35				19.5	19.5	19.5	19.5	
30				16.8	16.8	16.8	16.8	
25				14.0	14.0	14.0	14.0	
20				11.0	11.0	11.0	11.0	
15				8.3	8.3	8.3	8.3	
10	3.0	5.12	5.8	5.9	5.9	5.9	5.9	
6	1.5	2.72	2.93	2.93	2.93	2.93	2.93	
1	.30	.56	.65	.65	.65	.65	.65	
C open 0	.0007	.0016	.0034	.006	.009	.009	.009	

Procedure #9 WIRES 1 INCH APART

I Load	$R_{1\Omega}$	$R_{10\Omega}$	$R_{100\Omega}$	$R_{1K\Omega}$	$R_{10K\Omega}$	$R_{100K\Omega}$	$R_{1M\Omega}$
50			21.8	22.0	22.0	22.0	22.0
45		18.0	19.4	19.7	19.7	19.7	19.7
40		16.0	17.2	17.3	17.3	17.3	17.3
35		14.0	15.1	15.2	15.2	15.2	15.2
30	7.0	12.0	12.9	13.0	13.0	13.0	13.0
25	5.8	10.0	10.7	10.8	10.8	10.8	10.8
20	4.6	8.2	8.75	8.8	8.8	8.8	8.8
15	3.4	6.2	6.6	6.7	6.7	6.7	6.7
10	2.2	4.05	4.39	4.4	4.4	4.4	4.4
5	1.15	2.1	2.22	2.26	2.26	2.26	2.26
1	.22	.44	.465	.47	.47	.47	.47
C. open 0	.0008	.0013	.0023	.0062	.0088	.0095	.009

ENGINEERING COPY

Pages
Page*

APPENDIX B

FORM 2... 1230

ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1061-1
Date of Test 5-1-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #9 WIRES 3" APART

INDUCED VOLTAGE

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50			17.8	18.0	18.0	180	18.0
45		14.9	15.8	16.0	16.0	16.0	16.0
40		13.2	14.3	14.5	14.5	14.5	14.5
35	6.8	11.8	12.5	12.7	12.7	12.7	12.7
30	5.8	9.8	10.2	10.4	10.4	10.4	10.4
25	4.9	8.6	9.05	9.1	9.1	9.1	9.1
20	3.85	6.8	7.3	7.4	7.4	7.4	7.4
15	2.8	5.0	5.35	5.4	5.4	5.4	5.4
10	2.0	3.5	3.7	3.75	3.75	3.75	3.75
5	1.0	1.81	1.92	1.93	1.93	1.93	1.93
1	.202	.375	.39	.40	.40	.40	.40
C-OPEN 0	.00074	.0013	0023	.0065	.0098	0098	.0098

Procedure #9 WIRES 5" APART

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50			16.0	16.2	16.2	16.2	16.2
45		13.7	14.5	14.7	14.7	14.7	14.7
40	6.7	11.8	12.5	12.8	12.8	12.8	12.8
35	5.9	10.4	11.0	11.2	11.2	11.2	11.2
30	5.4	9.4	9.9	10.0	10.0	10.0	10.0
25	4.35	7.75	8.2	8.25	8.25	8.25	8.25
20	3.5	6.25	6.65	6.7	6.7	6.7	6.7
15	2.5	4.5	4.75	4.8	4.8	4.8	4.8
10	1.83	3.2	3.35	3.4	3.4	3.4	3.4
5	.95	1.68	1.79	1.81	1.81	1.81	1.81
1	.19	.33	.358	.36	.36	.36	.36
C-OPEN 0	.0008	.0012	.0023	.0077	.011	.011	.011

ENGINEERING COPY

Pages ____
Page* ____

APPENDIX B

ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-4-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #11 (Primary wire shielded) 5" APART

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50			15.8	16.0	16.0	16.0	16.0
45		12.5	13.8	14.0	14.0	14.0	16.0
40	5.2	11.6	12.6	12.8	12.8	12.8	12.8
35	4.8	10.0	11.0	11.2	11.2	11.2	11.2
30	4.1	8.8	9.6	9.7	9.7	9.7	9.7
25	3.39	7.25	7.9	8.0	8.0	8.0	8.0
20	2.75	5.9	6.4	6.5	6.5	6.5	6.5
15	1.9	4.2	4.6	4.62	4.62	4.62	4.62
10	1.42	2.95	3.25	3.3	3.3	3.3	3.3
5	.73	1.65	1.70	1.72	1.72	1.72	1.72
1	.15	.32	.33	.35	.35	.35	.35

Procedure #13 5" APART (4 TURNS PER FT.)

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50	2.05	3.3	3.5	3.55	3.55	3.55	3.55
45	1.70	3.0	3.19	3.21	3.21	3.21	3.21
40	1.60	2.75	2.83	2.90	2.90	2.90	2.90
35	1.42	2.46	2.61	2.62	2.62	2.62	2.62
30	1.21	2.07	2.19	2.19	2.19	2.19	2.19
25	1.0	1.75	1.85	1.86	1.86	1.86	1.86
20	.8	1.41	1.49	1.5	1.5	1.5	1.5
15	.61	1.01	1.09	1.1	1.1	1.1	1.1
10	.38	.725	.77	.78	.78	.78	.78
5	.22	.375	.4	.4	.4	.4	.4
1	.044	.074	.08	.08	.08	.08	.08

ENGINEERING COPY

Pages
Page*

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 8-5-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE POWER DISTRIBUTION TESTS

Procedure #13 3" APART

INDUCED VOLTAGE

I LOAD		R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50		2.0	3.30	3.55	3.59	3.59	3.59	3.59
45		1.80	3.01	3.21	3.25	3.25	3.25	3.25
40		1.58	2.79	2.96	2.98	2.98	2.98	2.98
35		1.41	2.40	2.54	2.57	2.57	2.57	2.57
30		1.22	2.11	2.50	2.26	2.26	2.26	2.26
25		1.0	1.77	1.88	1.90	1.90	1.90	1.90
20		.84	1.40	1.49	1.50	1.50	1.50	1.50
15		.65	1.08	1.15	1.17	1.17	1.17	1.17
10		.42	.74	.79	.795	.795	.795	.795
5		.220	.385	.410	.415	.415	.415	.415
1		.046	.080	.085	.086	.086	.086	.086

Procedure #13 1" APART

I LOAD		R 1Ω	R 10Ω	R 100Ω	R 1K	R 10K	R 100K	R 1M
50		2.19	3.95	4.19	4.20	4.20	4.20	4.20
45		2.12	3.45	3.70	3.75	3.75	3.75	3.75
40		1.96	3.21	3.45	3.50	3.50	3.50	3.50
35		1.68	2.80	2.90	3.00	3.00	3.00	3.00
30		1.40	2.41	2.56	2.58	2.58	2.58	2.58
25		1.19	2.01	2.13	2.16	2.16	2.16	2.16
20		.97	1.60	1.71	1.73	1.73	1.73	1.73
15		.76	1.25	1.32	1.35	1.35	1.35	1.35
10		.505	.87	.93	.94	.94	.94	.94
5		.275	.460	.490	.495	.495	.495	.496
1		.0545	.092	.098	.0995	.0995	.0995	.0995

Pages ____

ENGINEERING COPY

Page* ____

Book R-370 Page 13 13 of 26

APPENDIX B

ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-5-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #13 Together

INDUCED VOLTAGE

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50	3.05	5.0	5.25	5.4	5.4	5.4	5.4
45	2.65	4.45	4.75	4.8	4.8	4.8	4.8
40	2.22	3.90	4.20	4.25	4.25	4.25	4.25
35	2.10	3.40	3.61	3.68	3.68	3.68	3.68
30	1.80	2.95	3.10	3.15	3.15	3.15	3.15
25	1.54	2.60	2.75	2.79	2.79	2.79	2.79
20	1.25	2.10	2.22	2.25	2.25	2.25	2.25
15	.99	1.61	1.71	1.72	1.72	1.72	1.72
10	.66	1.02	1.13	1.15	1.15	1.15	1.15
5	.35	.57	.62	.63	.63	.63	.63
1	.075	.115	.124	.126	.126	.126	.126

Procedure #14 (toguther) 6 TURNS/FT

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50	3.20	5.35	5.79	5.8	5.8	5.8	5.8
45	2.70	4.70	5.12	5.2	5.2	6.2	5.2
40	2.50	4.35	4.65	4.7	4.7	4.7	4.7
35	2.10	3.70	4.0	4.02	4.02	4.02	4.02
30	1.90	3.19	3.41	3.45	3.45	3.45	3.45
25	1.58	2.72	2.94	2.98	2.98	2.98	2.98
20	1.28	2.20	2.36	2.40	2.40	2.40	2.40
15	.94	1.56	1.67	1.69	1.69	1.69	1.69
10	.60	1.0	1.04	1.05	1.05	1.05	1.05
5	.34	.58	.635	.64	.64	.64	.64
1	.073	.110	.124	.126	.126	.126	.126

Pages
Page*

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-23-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

PROCEDURE # 14 1" APART

I LOAD	I	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50		2.60	4.50	4.85	4.90	4.90	4.90	4.90
45		2.40	4.0	4.30	4.35	4.35	4.35	4.35
40		2.05	3.55	3.80	3.82	3.82	3.82	3.82
35		1.80	3.15	3.35	3.39	3.39	3.39	3.39
30		1.55	2.76	2.96	2.98	2.98	2.98	2.98
25		1.26	2.20	2.37	2.39	2.39	2.39	2.39
20		1.09	1.82	1.97	1.98	1.98	1.98	1.98
15		.83	1.36	1.45	1.47	1.47	1.47	1.47
10		.54	.92	.98	.995	.995	.995	.995
5		.28	.50	.54	.545	.545	.545	.545
1		.058	.099	.105	.106	.106	.106	.106

PROCEDURE # 14 3" APART

I LOAD	I	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50		2.25	3.75	4.10	4.15	4.15	4.15	4.15
45		2.0	3.36	3.70	3.75	3.75	3.75	3.75
40		1.85	3.0	3.25	3.30	3.30	3.30	3.30
35		1.60	2.75	2.93	2.96	2.96	2.96	2.96
30		1.41	2.30	2.49	2.50	2.50	2.50	2.50
25		1.12	1.92	2.09	2.11	2.11	2.11	2.11
20		.94	1.59	1.65	1.67	1.67	1.67	1.67
15		.715	1.12	1.21	1.23	1.23	1.23	1.23
10		.480	.820	.865	.88	.88	.88	.88
5		.220	.379	.410	.415	.415	.415	.415
1		.045	.082	.088	.089	.089	.089	.089

ENGINEERING COPY

Pages

Page

Book R-370 Page 15 15 OF 26

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-24-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #14 5" APART

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	1MΩ
50	2.11	3.45	3.82	3.85	3.85	3.85	3.85
45	1.99	3.30	3.50	3.55	3.55	3.55	3.55
40	1.72	2.90	3.01	3.05	3.05	3.05	3.05
35	1.52	2.55	2.71	2.73	2.73	2.73	2.73
30	1.24	2.18	2.35	2.38	2.38	2.38	2.38
25	1.02	1.84	1.96	1.99	1.99	1.99	1.99
20	.86	1.41	1.53	1.56	1.56	1.56	1.56
15	.650	1.07	1.13	1.16	1.16	1.16	1.16
10	.370	.690	.799	.815	.815	.815	.815
5	.240	.355	.382	.385	.385	.385	.385
1	.042	.076	.083	.084	.084	.084	.084

Procedure #15 Together

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	1MΩ
50	.835	1.33	1.42	1.43	1.43	1.43	1.43
45	.76	1.21	1.30	1.31	1.31	1.31	1.31
40	.685	1.09	1.15	1.17	1.17	1.17	1.17
35	.60	.960	.990	1.0	1.0	1.0	1.0
30	.50	.805	.879	.881	.881	.881	.881
25	.40	.680	.730	.735	.735	.735	.735
20	.310	.530	.590	.595	.595	.595	.595
15	.220	.40	.420	.425	.425	.425	.425
10	.159	.275	.292	.298	.298	.298	.298
5	.078	.128	.144	.145	.145	.145	.145
1	.0160	.0260	.028	.0315	.0315	.0315	.0315

ENGINEERING COPY

APPENDIX B

ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-24-61
By C.SWIGON R.WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #15 1" APART

INDUCED VOLTAGE

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50	.72	[illegible]	1.20	1.22	1.22	1.22	1.22
45	.665	1.03	1.10	1.12	1.12	1.12	1.12
40	.58	.94	.99	1.0	1.0	1.0	1.0
35	.495	.810	.880	.885	.885	.885	.885
30	.425	.710	.762	.770	.770	.770	.770
25	.360	.585	.625	.630	.630	.630	.630
20	.285	.465	.50	.505	.505	.505	.505
15	.20	.304	.362	.365	.365	.365	.365
10	.120	.232	.252	.255	.255	.255	.255
5	.068	.115	.122	.124	.124	.124	.124
1	.0130	.0235	.0252	.026	.026	.026	.026

Procedure #15 3" APART

I LOAD	R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50	.625	1.0	1.06	1.08	1.08	1.08	1.08
45	.595	.945	.990	1.0	1.0	1.0	1.0
40	.460	.835	.905	.910	.910	.910	.910
35	.395	.725	.780	.790	.790	.790	.790
30	.350	.620	.670	.680	.680	.680	.680
25	.30	.515	.550	.555	.555	.555	.555
20	.221	.405	.437	.440	.440	.440	.440
15	.180	.30	.322	.325	.325	.325	.325
10	.119	.210	.231	.234	.234	.234	.234
5	.053	.099	.107	.109	.109	.109	.109
1	.0118	.020	.022	.023	.023	.023	.023

ENGINEERING COPY

Pages ______
Page* ______

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. E30 1068-1
Date of Test 5-25-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #15 5" APART

% LOAD		R 1Ω	R 10Ω	R 100Ω	R 1KΩ	R 10KΩ	R 100KΩ	R 1MΩ
50		.580	.980	.990	1.0	1.0	1.0	1.0
45		.550	.880	.940	.945	.945	.945	.945
40		.475	.785	.840	.845	.845	.845	.845
35		.415	.680	.736	.740	.740	.740	.740
30		.360	.585	.610	.625	.625	.625	.625
25		.298	.480	.515	.520	.520	.520	.520
20		.230	.380	.405	.410	.410	.410	.410
15		.183	.290	.306	.310	.310	.310	.310
10		.120	.198	.210	.211	.211	.211	.211
5		.056	.097	.099	.10	.10	.10	.10
1		.0122	.021	.023	.024	.024	.024	.024

ENGINEERING COPY

Book R-370 Page 18 18 OF 26

Pages
Page*

APPENDIX B

ENG. FILE	

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-25-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #12 5" APART

INDUCED VOLTAGE

I LOAD		1Ω	10Ω	100Ω	1KΩ	10KΩ	100KΩ	1MΩ
50		1.32	2.01	2.28	2.34	2.34	2.34	2.34
45		1.10	1.93	2.07	2.09	2.09	2.09	2.09
40		.995	1.62	1.84	1.87	1.87	1.87	1.87
35		.875	1.59	1.60	1.61	1.61	1.61	1.61
30		.80	1.30	1.37	1.39	1.39	1.39	1.39
25		.67	1.02	1.13	1.15	1.15	1.15	1.15
20		.50	.879	.938	.940	.940	.940	.940
15		.370	.660	.70	.705	.705	.705	.705
10		.240	.435	.461	.470	.470	.470	.470
5		.126	.221	.238	.240	.240	.240	.240
1		.024	.042	.045	.047	.047	.047	.047

Procedure #12 3" APART

I LOAD		1Ω	10Ω	100Ω	1KΩ	10KΩ	100KΩ	1MΩ
50		1.38	2.32	2.49	2.51	2.51	2.51	2.51
45		1.29	2.11	2.25	2.27	2.27	2.27	2.27
40		1.09	1.88	2.01	2.03	2.03	2.03	2.03
35		1.0	1.63	1.75	1.77	1.77	1.77	1.77
30		.860	1.37	1.49	1.50	1.50	1.50	1.50
25		.750	1.17	1.23	1.25	1.25	1.25	1.25
20		.580	.900	.980	1.0	1.0	1.0	1.0
15		.395	.682	.758	.770	.770	.770	.770
10		.220	.430	.479	.480	.480	.480	.480
6		.144	.240	.255	.258	.258	.258	.258
1		.019	.043	.049	.051	.051	.051	.051

Pages
Page*

ENGINEERING COPY

Book R-370 Page 19 19 of 26

APPENDIX B

FORM 270A REV 12-55

ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-25-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

Procedure #12 — 1" APART

INDUCED VOLTAGE

I LOAD	1Ω	10Ω	100Ω	1KΩ	10KΩ	100KΩ	1MΩ
50	1.67	2.68	2.91	2.93	2.93	2.93	2.93
45	1.46	2.45	2.63	2.65	2.65	2.65	2.65
40	1.38	2.40	2.35	2.38	2.38	2.38	2.38
35	1.16	1.90	2.04	2.06	2.05	2.05	2.05
30	1.02	1.65	1.76	1.78	1.78	1.78	1.78
25	.850	1.34	1.43	1.45	1.45	1.45	1.45
20	.695	1.09	1.16	1.18	1.18	1.18	1.18
15	.500	.815	.865	.875	.875	.875	.875
10	.345	.565	.595	.600	.600	.600	.600
5	.129	.265	.295	.298	.298	.298	.298
1	.033	.055	.0585	.061	.061	.661	.061

Procedure #12 — TOGETHER

I LOAD	1Ω	10Ω	100Ω	1KΩ	10KΩ	100KΩ	1MΩ
50	2.05	3.35	3.55	3.60	3.60	3.60	3.60
45	1.80	3.0	3.18	3.20	3.20	3.20	3.20
40	1.70	2.73	2.92	2.95	2.95	2.95	2.95
35	1.51	2.38	2.59	2.60	2.60	2.60	2.60
30	1.20	2.00	2.20	2.21	2.21	2.21	2.21
25	1.00	1.65	1.82	1.85	1.85	1.85	1.85
20	.820	1.35	1.46	1.48	1.48	1.48	1.48
15	.610	.980	1.06	1.08	1.08	1.08	1.08
10	.440	.690	.775	.779	.779	.779	.779
5	.196	.320	.360	.365	.365	.365	.365
1	.042	.073	.080	.083	.083	.083	.083

ENGINEERING COPY

APPENDIX B

G. HEINZMAN			
P. HARTLEY			
ENG. FILE			

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-29-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

PROCEDURE #16

INDUCED VOLTAGE ON DC POWER LINE

10 AMP DC LOAD NO 3200 CPS

RIPPLE
.80 +-
.83 -+

SEE PHOTO OF WAVE SHAPE PAGE 24

10 AMP DC LOAD WITH 3200 CPS

RIPPLE
VOLTS 16.4 +-
VOLTS 16.5 -+

PROCEDURE #17

INDUCED VOLTAGE ON DC POWER LINE

POWER LEADS CABLED

10 AMP DC LOAD NO 3200 CPS

RIPPLE
VOLTS 1.1 +1
VOLTS 1.15 -+

SEE PHOTO OF WAVE SHAPE PAGE 25

10 AMP DC LOAD WITH 3200 CPS

RIPPLE
VOLTS 3.1 +-
VOLTS 3.2 -+

METER NOS
E-65
L-56
K-116

Pages
ENGINEERING COPY
Page*
Book R-370 Page 21 21 & 26

APPENDIX B

FORM 270A REV 12 55

G. HEINZMAN
P. HARTLEY
ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-31-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

PROCEDURE # 18 METER NOS V-89 AMP- L-75

HARMONIC CONTENT (28E10 GENERATOR)

WITH 10 AMP LOAD 400 CYCLES

HARMONIC NO.	100 %	T1-N	120 VOLTS			
3	.73 %		19	.032 %	35	0
5	2.0 %		21	0 %	53	.18
7	1.3 %		23	0 %	65	.12
8	1.2 %		25	.052 %		
11	.18 %		27	0 %		
13	.2 %		29	0 %		
15	.04 %		31	0 %		
17	.07 %		33	0 %		

SEE WAVE SHAPE PHOTOS PAGE 26

PROCEDURE # 18

HARMONIC CONTENT 3200 CPS LOAD

HARMONIC NO. 1	100 %	6 KVA	120 VOLTS	
3	.75 %		19	.08 %
5	2.0 %		20	0 %
7	1.6 %		21	0 %
8	5.0 %		22	0 %
9	.15 %		23	0 %
10	.13 %		24	.5 %
11	.2 %		25	.1 %
12	.05 %		26	0 %
13	.25 %		32	.1 %
14	0 %		40	.15 %
15	.04 %		53	.2 %
16	.35 %		55	.1 %
17	0 %			
18	0 %			

ENGINEERING COPY

Pages
Page*

APPENDIX B

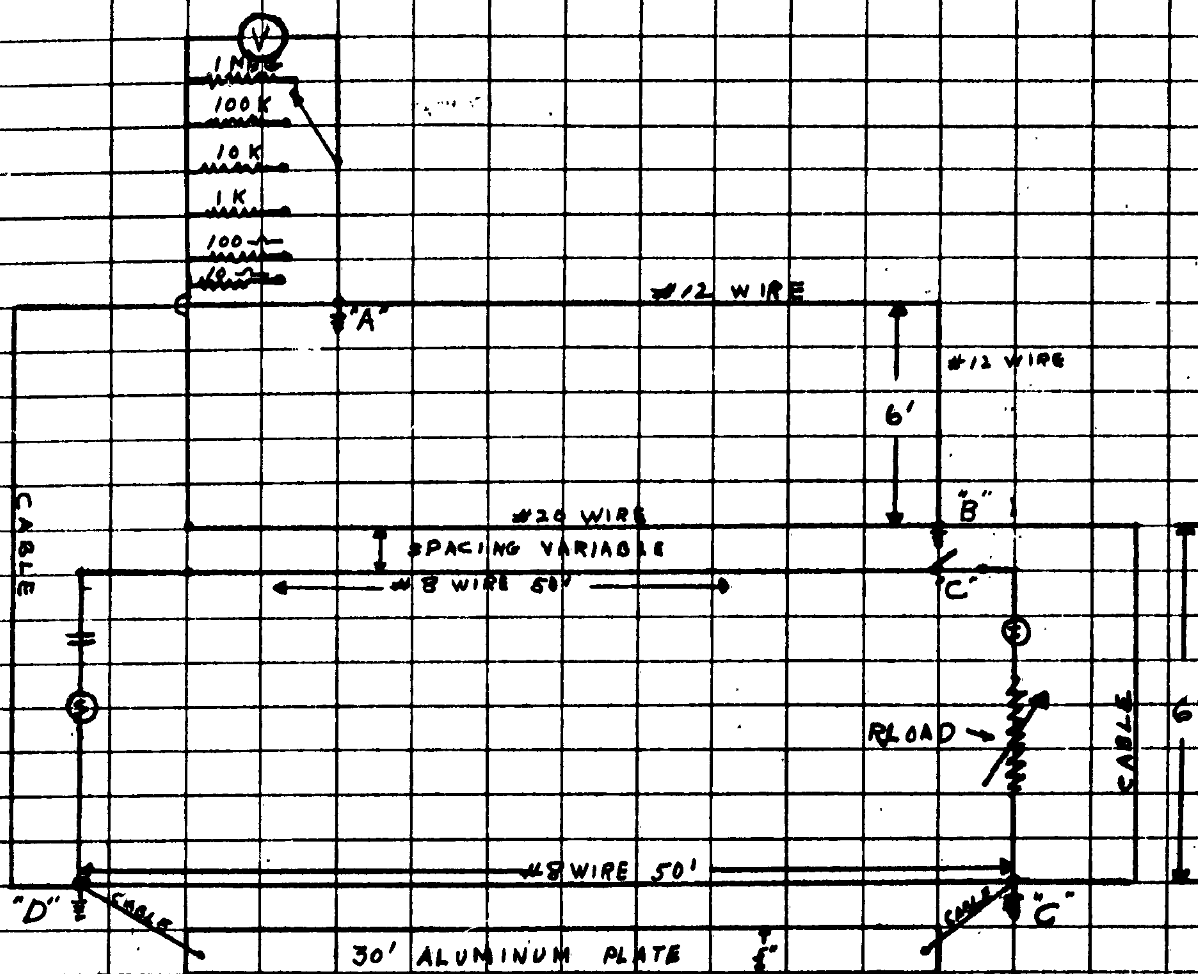
ENG. FILE

THE BENDIX CORPORATION
RED BANK DIVISION
EATONTOWN, N. J.

Test Report No. ESO 1068-1
Date of Test 5-25-61
By C. SWIGON R. WILLIAMSON

Title 3200 CYCLE ELECTRICAL POWER DISTRIBUTION TESTS

PROCEDURE # 9



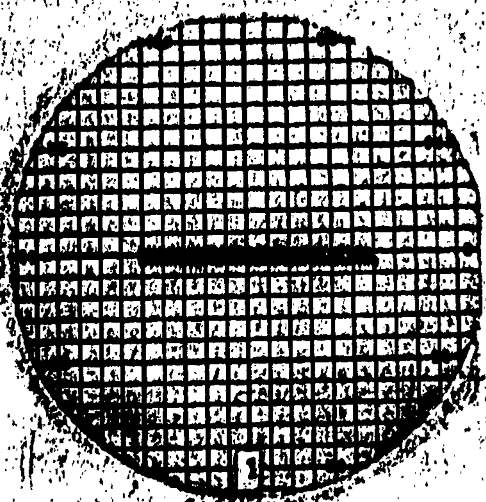
ENGINEERING COPY

Pages
Page

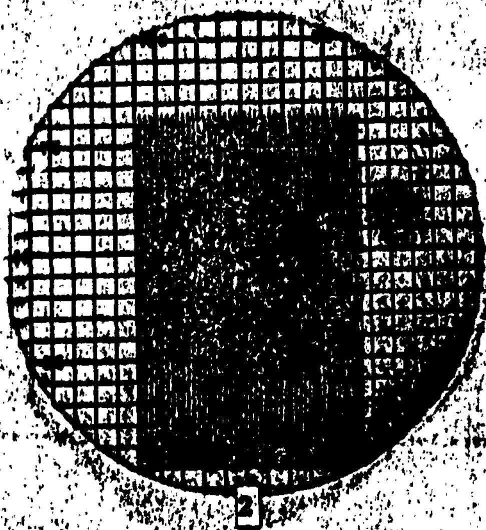
Book R-370 Page 23 28 & 26

APPENDIX B

Induced voltage affect on DC power line DC ripple with a 10 Amp DC load with no 3200 CPS and with AC load to provide 6 KVA, 3200 CPS output.

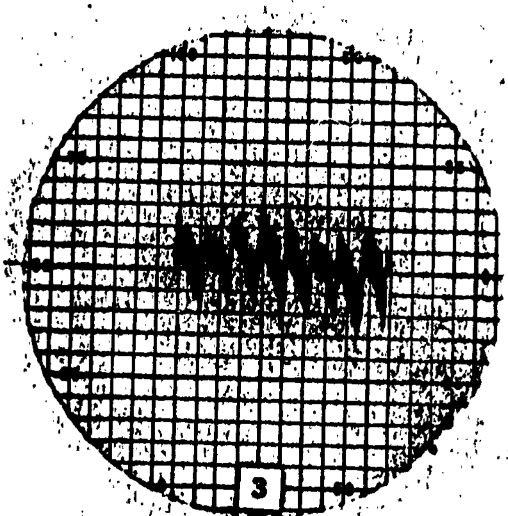


No 3200 CPS Load
2 Divisions = 1 Volt

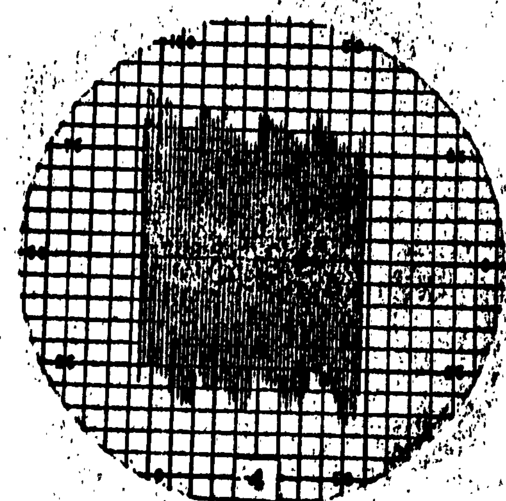


With 3200 CPS 6 KVA Load
120 Volts . 2 Divisions = 1 Volt

Induced voltage affect on DC power line with power leads cabled. DC ripple with a 10 amp DC load without 3200 CPS, and with 3200 CPS 6 KVA 120 volt load.

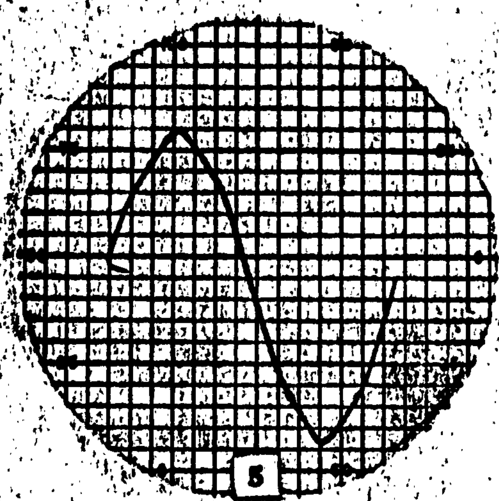


No 3200 CPS Load
4 Divisions = 1 Volt

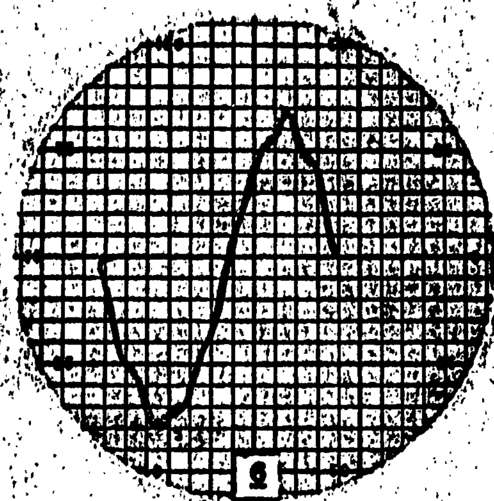


With 3200 CPS 6 KVA Load
120 Volts 4 Divisions = 1 Volt

Harmonic content using a 10 Amp 400 CPS 120 Volt load. Without 3200 CPS 6 KVA 120 Volt load, and with a 3200 CPS 6 KVA 120 Volt load.



No 3200 CPS Load
4 Divisions = 1 Volt



With 3200 CPS 6 KVA Load
120 Volts 4 Divisions = 1 Volt