NATIONAL BUREAU OF STANDARDS REPORT

4369

Cable Splices with Scotchcast Kit and AMP Wire Connectors.

by

R. W. Crouch

Report to

Airways Engineering Division
Office of Federal Airways
Civil Aeronautics Administration

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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R. W. Crouch
Photometry and Colorimetry Section
Optics and Metrology Division

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1. SCOPE

This report describes a series of laboratory tests to determine the merits of a type of wire connector and a type of splice covering applied with a "Scotchcast Splicing Kit". The tests were made with multipair low-voltage cables. They were designed to test the products from three aspects; the resistance of the spliced conductors, the time required for making the splice, and the watertightness of the completed splice covering.

2. DEVICES TESTED

The following material was provided by the Airways Engineering Division of the Office of Federal Airways, C.A.A., for carrying out these tests:

1 length, 26 pair, No. 19 gauge, communication cable with plastic insulation and cover.

1 length, 26 pair, No. 19 gauge, communication cable with paper insulation, lead cover, steel ribbon armor, and a coat of fibrous material saturated with a bituminous compound.

700 AMP Connectors, manufactured by the Aircraft-Marine Products, Inc., Harrisburg, Pa.

2 crimping tools of different sizes.

14 Scotchcast Splicing Kits, No. 89-A2, manufactured by the Minnesota Mining and Mfg. Co., St. Paul 6, Minn.

A manual of instructions for applying the kits.

The AMP connectors consist of copper tubes 0.6 inch long encased in insulating tubes which project about 0.2 inch beyond the copper at each end. The inside of the copper tube appears to have been coated with tin. The connectors are fastened to the wires by crimping with plier-type crimping tools.

The splicing kits consist of all the materials necessary for forming a hollow compartment designed to be water tight and provide both electric shielding and adequate insulation for the conductors. Each kit includes plastic sheet for wrapping the spliced conductors, a metal splice shield in two parts, a metal cover in two parts, a self curing plastic for filling the space between the shield and the cover, and supplementary materials. The design provides for a calking dike at each end of the splice compartment to prevent water which may have entered the cable from passing into the splice compartment and vice versa. The splice shield is held together by tape. The self curing compound is furnished as two components in separate compartments of a pouch. By a suitable manipulation of the pouch, the separating membrane is pierced and the two components become mixed.

3. TEST PROCEDURES

Fourteen splices were made. All were of the "in-line" type. They included the combinations of cable types, methods of joining wires, and, in two cases, use of desicant as indicated in table I. The splicing involves two stages: first, the preparation of the cables and the joining of the conductors; second, the building of the protecting enclosure. The instructions furnished with the kits relate mainly to the second stage but also specify the overall length of the splice which is determined in the preparation of the cable and the joining of the first pair of wires. The instructions were followed throughout the work. The splicing was done by two laboratory technicians who had not had previous experience in splicing communication cables.

Sections of uniform length were cut from the cables and the outer coverings removed from each end of these sections to expose the wires. Each cable contained one pair of wires having a different combination of colors from the others. These tracer wires were joined first to establish the length of the splice.

The wire connectors were fastened to the wires with the use of the crimping tools. Technician M.E.R. used the smaller of the two crimping tools which had been furnished with the cable in making the first splice. It required a great deal of pressure to close the crimping tool. On the second splice a crimping tool already available to this Bureau was tried and found to accomplish the crimping with much less effort. On the third splice the larger of the two crimping tools furnished with the cable was used. This tool also was satisfactory.

After the conductors were all joined, the joined wires were wrapped with a plastic sheet which was held in place with three bands of plastic tape. Rings were then constructed at proper distances at either side of the spliced bundle using a plastic putty furnished in the kit for this purpose. The metal shield rests on these rings at each end and is held together by a strip of plastic tape over each of the joints. The outside metal casing rests directly against the sheathing of the cable at each end and the two halves were fastened together by bending over clips provided for this purpose. The forming of the metal cover provides for two open slits on one side. These are used for introducing the plastic compound. During this operation the cases were placed with one end slightly higher than the other and the ingredients for the plastic part of the covering were mixed and poured through the lower of the two slits. This was done immediately after mixing the ingredients because considerable heat is liberated when the two compounds come together and the pouring must be completed before the compound becomes too hot to handle. The compound soon cools, however, and becomes hard immediately upon reaching room temperature.

On the inner side of each half of the metal shield there is a wire which projects beyond the shield and is arranged to protrude through the completed splice at both ends. The wires, called rip wires in the manual, are designed for opening the splice compartments in case it should prove necessary to repair the splice.

Each wire in the thirteen splices was tested for continuity, resistance, and insulation. The instrument used for the insulation test provides a potential difference of 10,000 volts dc, but the current is limited to 100 microamperes which is considered nondestructive of insulation.

After the completion of the electrical tests the splices were placed for a period of 24 hours in salt water which was approximately a 2% solution. The splices were at a depth of 10 feet at which depth the pressure is approximately 5 pounds per square inch. When the splices were removed from the water, attempts were made to open the splice compartments by means of the rip wires. It very soon became apparent that the splice compartments could not be opened by this method. It was attempted on six splices and in every case the rip wire broke before more than a few inches of the compartment wall had been torn open. Four of the compartments were then opened by sawing crosswise through them and the remainder were tested for leakage by drilling 1/4" holes through the wall of the splice compartment.

Most of the splices contained salt water. Those which did not show leakage and two which did were tested with air. The 1/4" hole was tapped and fitted with a tube to which an air pressure of 7 pounds per square inch was applied. With the pressure still applied the splice was then submerged in water to observe the presence of air leakage.

In order to determine if the variations in resistance have any significance, the values given in tables II and III have been analyzed in accordance with the following procedure. A series of resistance intervals from 0 to a value greater than the largest resistance measured was computed so that the ratio of each interval to the next larger interval was the cube root of 10. To each of the values so determined 45 milliohms were added to allow for the resistance of the wire itself. The number of resistances found to lie within each of these intervals has been tabulated in table IV. The results do not seem to be indicative of any systematic differences between the different cables. The total number of resistances in each interval for all 13 cables is shown in the last line of this table. From these values the percentage values plotted in figure 1 were computed. This curve gives the best indication which can be deduced from the measurements of the probability that an individual conductor will have a splice resistance less than a selected value. The last column of table IV gives the average resistance of all of the connections, exclusive of wire resistance, for each of the splices.

4. RESULTS

The type of cables, kind of splice, splicing time, and results of the continuity check are shown in table I. The splicing time is the time for joining wires and building the splice compartment. The last column of this table gives the initials of the technician who made the splice in each case. Except for the splices made with plastic cable to plastic cable with the AMP connectors, there are too few cases of any one type to warrant applying analytical methods for the interpretation of the results.

The resistance of each individual wire in all 13 splices is shown in tables II and III. An inspection of these tables shows a wide variation in the resistances. To determine how much of the measured resistance was that of the wire itself, the resistance of each wire in a 24-foot length of the same cable was measured and the resistance was calculated for a section of the length used in the splices. This calculation showed that the resistance of the wire is approximately 47 milliohms. Some of the measured values, including the resistance of a splice, were less than this value. These lower values are believed due in part to variations in the resistance of the wires and, in part, to the accidental errors of measurement.

The insulation tests showed no breakdown when 10,000 volts was applied between the group of red wires and the group of white wires, or when it was applied between the wires and the outside metal case. The current leakage between the two groups of wires and between the wires and the case indicated a resistance of 10,000 megohms for the splices in which both cables had plastic insulation, but these resistances fell to 20 to 30 megohms for the splices in which one of the cables was of the lead covered type. Since the lead covered cables had paper insulation this lower resistance may well be due to the paper insulation having absorbed some moisture from the atmosphere between the time when the cable was cut into sections and the time when the leakage measurements were made. In any case a resistance of 20 to 30 megohms is presumably adequate if the cables are to be used for low voltage control circuits only.

The results of the examination for water leakage which was made after submerging the splices in salt water are presented in Table V. It is to be noted that in only four cases was the splice compartment found free from water, and one of these four showed some leakage of air at one end under air pressure at 7 pounds per square inch. In view of these results the moisture proofing provided by the splice kits cannot be considered adequate.

The failure of the rip wires to assure access to the splice compartment in case of need has already been noted. In view of the very considerable difficulty experienced in opening these splice compartments with the aid of a hammer, pliers, and screwdriver, this aspect of the design appears to require careful consideration.

Table I

Splicing Record

Splice No.	Type of Cables Kind of Splice	Splicing Time Hr.	Min.	Continuity Check	Splice Made By
1	Plastic to Plastic AMP Connector	3	0	52 wires correct	M.E.R.
2	"	2	50	52 wires correct	M.E.R.
3	"	2	30	50 wires correct 2 red to white	M.E.R.
4	"	2	0	52 wires correct	R.W.C.
5	"	1	40	52 wires correct	R.W.C.
6	"	1	35	52 wires correct	R.W.C.
7	"	1	30	52 wires correct	R.W.C.
8	"	1	40	48 wires correct 4 wires red to white	R.W.C.
9	"	1	35	52 wires correct	R.W.C.
10	Plastic to Lead AMP Connector	2	30	50 wires correct 2 wires open	R.W.C.
11	Plastic to Lead Twisted and Taped Connections	2	40	52 wires correct	R.W.C.
12	Plastic to Lead Twisted and Taped With Desiccant	2	45	51 wires correct 1 wire open	R.W.C.
13	Plastic to Lead AMP Connectors With Desiccant	2	20	52 wires correct	R.W.C.

Table II

RESISTANCES OF INLINE CABLE SPLICES
Plastic to Plastic Cables

Splice No.

Resistances in Milliohms

1	2	3	4	5	6	7	8	9
48	56	112	660	51	101	53	50	79
61	48	652	220	50	100	62	65	267
49	49	49	360	50	115	65	95	53
51	71	45	660	54	61	83	61	62
64	47	74	59	51	83	110	85	61
66	44	73	1189	46	48	880	80	57
48	45	572	991	97	57	80	215	55
59	46	323	50	48	52	49	68	46
75	51	58	54	96	150	77	53	53
59	46	203	861	97	99	135	59	61
49	103	633	60	49	49	80	81	49
45	55	161	47	141	331	628	110	55
69	47	49	48	787	64	120	88	48
52	53	49	59	58	251	58	63	51
330	48	100	60	788	376	323	51	47
900	115	59	760	329	299	140	88	48
950	52	269	1140	63	49	133	69	140
1300	48	80	945	46	69	66	54	50
73	45	51	910	49	63	119	794	51
456	48	136	339	74	96	339	53	53
99	47	95	163	60	57	78	51	63
156	61	58	1753	58	92	68	216	52
1090	47	235	59	48	68	489	54	57
173	48	192	607	136	49	54	56	48
572	48	245	55	45	50	79	80	55
1100	48	76	601	49	52	60	75	60
48	49	66	51	77	1082	268	66	55
49	48	996	231	127	54	72	60	121
79	99	81	510	54	52	102	95	76
189	48	94	51	76	134	119	50	175
959	47	500	67	114	51	83	60	596
49	50	259	102	84	50	130	58	48
176	53	61	59	1334	61	72	83	109
49	48	51	1900	49	54	51	583	59
74	50	56	76	49	68	50	56	51
50	48	50	776	164	49	61	46	48
59	49	710	802	53	47	104	82	54
50	46	225	74	50	58	91	57	50
51	47	89	68	51	48	56	61	74

Table II (Continued)

Splice No. 1	2	3	4	5	6	7	8	9
Resistances in Milliohms								
50	48	53	491	48	848	143	660	49
204	48	61	601	51	944	109	52	59
185	267	96	143	47	55	98	151	50
546	47	326	823	727	81	388	53	55
67	47	140	723	47	501	254	82	49
119	49	271	693	48	66	54	61	51
58	47	221	930	78	54	160	49	53
49	47	66	65	348	77	139	60	52
265	47	258	257	48	707	63	460	56
50	50	50	549	129	190	143	50	49
52	49	51	48	45	51	89	51	47
48	46	69	83	46	73	62	87	272
68	47	519	65	45	303	400	59	49

Table III

RESISTANCES OF INLINE CABLE SPLICES
Plastic to Lead Cables

Splice No. 10	11	12	13	Splice No. 10	11	12	13
Resistances in Milliohms							
49	46	51	47	49	49	56	55
393	49	48	45	49	50	75	48
48	49	55	45	50	53	128	53
97	613	47	47	50	48	144	61
47	46	238	60	50	48	73	50
47	176	81	45	59	139	49	46
49	416	690	45	54	49	50	48
50	49	640	45	51	46	50	51
65	47	48	47	48	49	53	47
49	52	49	70	54	48	50	48
48	49	52	45	51	72	48	413
52	52	59	47	49	50	54	52
48	49	62	47	89	46	439	46
48	49	255	547	50	49	49	50
49	71	82	557	54	48	52	53
49	58	54	47	50	47	55	55
50	46	81	47	47	47	95	47
49	75	49	185	51	516	57	47
51	55	51	47	48	170	189	84
50	514	67	47	49	540	50	550
56	90	46	47	50	640	83	48
50	480	48	47	48	830	368	47
50	430	49	47	49	105	54	48
open	510	205	47	132	695	open	49
open	468	48	47	48	48	51	124
53	48	68	53	49	378	55	47

Table IV

Distribution of Splice Resistances

Number in Each Interval Between Resistances Indicated

ohms

Splice No.	.000	.001	.002	.005	.010	.022	.047	.100	.215	.465	1.000	2.150	Means ohms
1	1	0	10	8	7	7	2	6	3	5	3		.179
2	3	16	18	7	3	1	3	0	1	0	0		.011
3	1	0	3	6	8	7	7	9	5	6	0		.149
4	0	1	2	4	9	5	2	4	3	18	4		.396
5	3	5	10	10	4	5	8	1	2	3	1		.097
6	0	1	6	10	9	7	7	3	5	3	1		.121
7	0	0	1	5	9	12	15	2	6	2	0		.105
8	0	1	1	12	15	13	3	3	1	3	0		.071
9	0	3	10	14	15	3	3	1	2	1	0		.029
10	0	3	20	20	3	1	2	0	1	0	0	2	.015
11	0	8	16	5	2	4	2	2	5	8	0	0	.136
12	0	2	10	13	7	8	3	4	2	2	0	1	.066
13	6	21	6	7	4	2	1	1	1	3	0	0	.045
Total	14	61	113	121	95	75	58	36	37	54	9	3	676

Table V

Splice No.	Method of Opening	Water in Splice Compartment	Leakage 7 PSI Air Pressure
1	Drilled	Present	--
2	Sawed	Present	--
3	Drilled	Present	--
4	Sawed	Present	--
5	Drilled	None	Leak at one end
6	Drilled	None	None
7	Drilled	None	None
8	Drilled	Present	--
9	Drilled	None	None
10	Sawed	Present	--
11	Drilled	Present	At end of lead cable
12	Sawed	Present	--
13	Drilled	Present	At end of lead cable

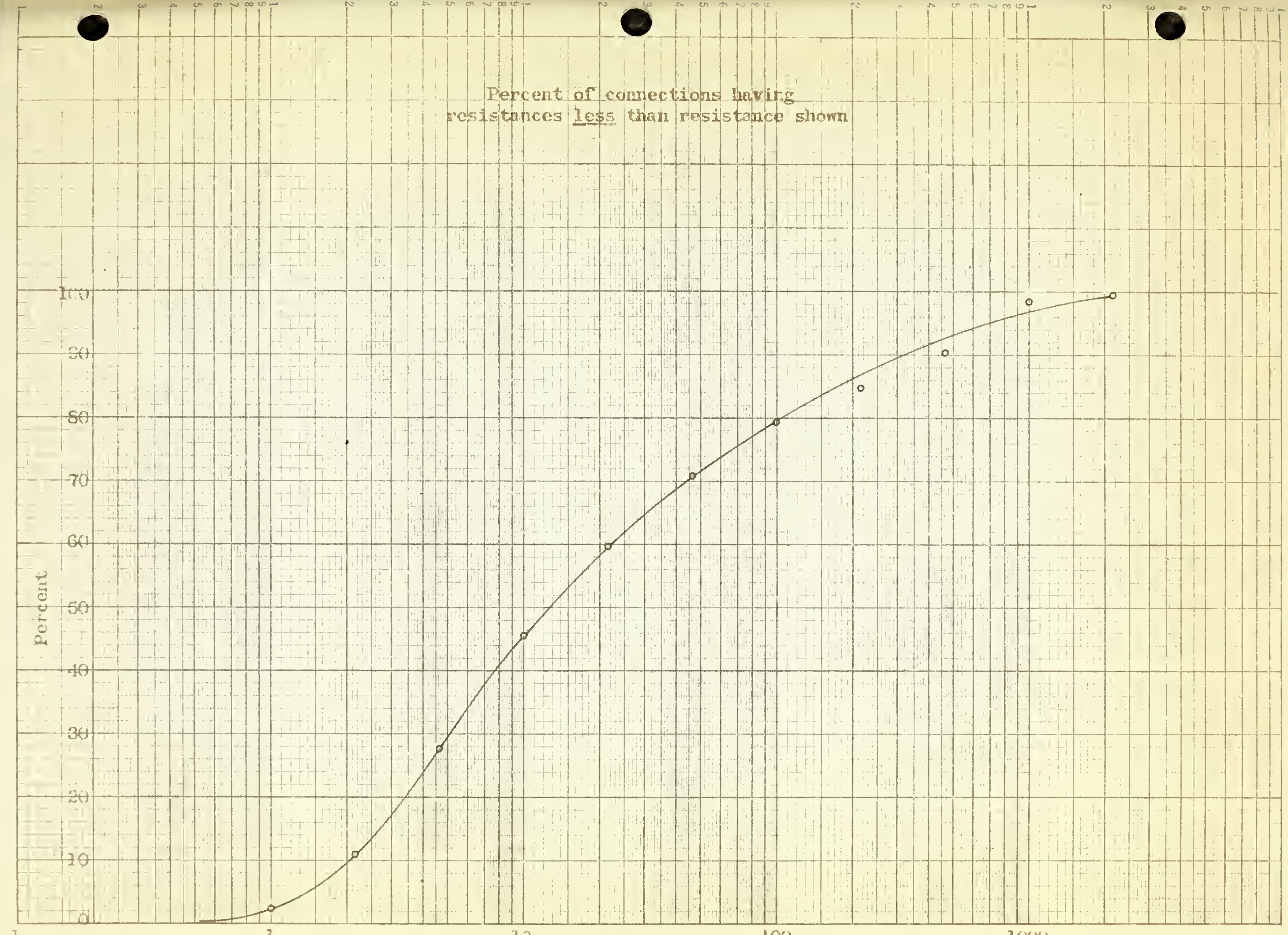

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Figure 1

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

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