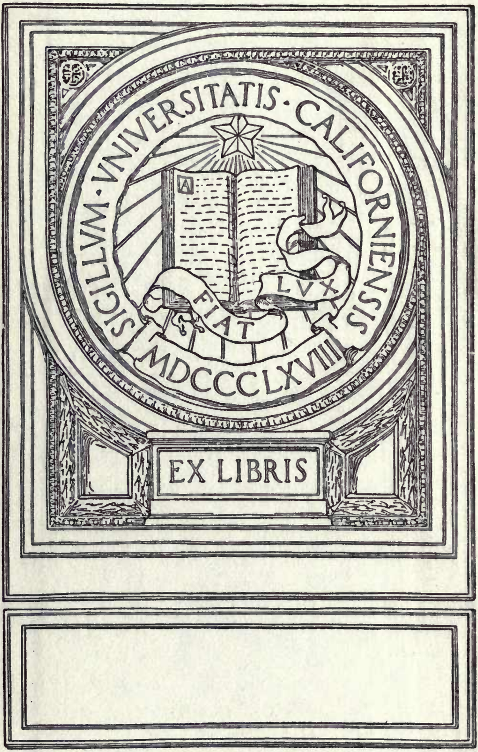
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STANDARD TABLES

FOR

ELECTRIC WIREMEN.

WITH

INSTRUCTIONS FOR WIREMEN AND LINE-
MEN, UNDERWRITERS' RULES,
AND USEFUL FORMULÆ
AND DATA.

BY

CHARLES M. DAVIS.

FOURTH EDITION,

THOROUGHLY REVISED AND EDITED BY
W. D. WEAVER.

NEW YORK:

THE W. J. JOHNSTON COMPANY, LTD.,
167-176 TIMES BUILDING.

PREFACE TO THIRD EDITION.

THE revision of this popular work had just been commenced, when it was sadly interrupted by the death of Mr. Davis, and has been completed by other hands.

Much that was alien to the purpose of the book has been discarded, and new material so extensively introduced as to render this a practically new work.

The wiring tables have all been recalculated on a uniform basis and arranged in a more convenient manner for practical use.

The object has been to produce a book for wiremen thoroughly reliable and practical in its data, and free from verbiage and padding.

PREFACE TO FOURTH EDITION.

THE new insurance rules of the Underwriters' International Electric Association, which have been generally adopted throughout the United States, and will, it is thought, finally supersede all others, have been substituted in the present edition.

An important section has been expressly prepared for this edition on the calculation of alternating current wiring, which, for the first time, brings this subject within the reach of practical men.

NOTE.—In order to still further improve future editions of this work, suggestions from those using it are cordially invited and will receive careful consideration.

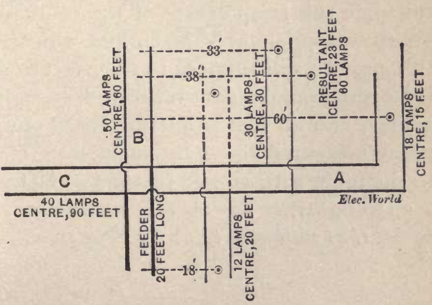
Address

Publishing Department.
THE W. J. JOHNSTON CO., Ld.,
Times Building, New York.

SIZES OF CONDUCTORS FOR INCANDESCENT CIRCUITS.

The most accurate method of determining the proper sizes of incandescent lamp conductors is to refer *all* measurements back to the dynamo, converter, or street tap.

To illustrate, suppose we have an installation of 150 lights, consisting of a feeder or dynamo main 20 feet long (to distributing point) and several mains A, B, and C, their lamps and lamp centres being respectively 60, 50, and 40 in number, and 38, 60, and 90 feet from the end of the feeder. Let us calculate the sizes of the feeder and one main, and of one branch having 12 lamps with centre 20 feet from the main, the branch starting 18 feet from the distributing point. (See cut.)



To find the size of the branch wire, refer to the appropriate table with 20 + 18 + 20 feet, or 58 feet for 12 lamps.

To find the size of the main, imagine the branches on one side to be revolved (or lay them out thus on a diagram) so that *all are on the same side of the main;* then estimate or calculate the lamp centre of the resultant group, which in this case we will suppose to be 23 feet from the main and 38 feet from the distributing point measured along the main, and refer to the table with 20 + 38 + 23 feet for 12 + 30 + 18 lamps, or 81 feet for 60 lamps.

To find the size of the feeder, suppose the mains to be revolved about the distributing point so that they all overlap, and with all the branches on one side of the overlapping mains; then estimate or calculate the lamp centre of the resultant group (comprising all the lamps), which in this case we will suppose to be 20 feet from the overlapping mains measured at right angles, and 48 feet from the distributing point measured along the main, and refer to the table with 20+48+20 feet or 88 feet for 150 lights, *or for the largest number of lights that will ever be used at one time.*

In simple cases the quantities may be estimated, either directly (especially for branches) or from rough diagrams, and for more complex cases or where a perfectly accurate result is desired, the following rules are given :—

For **BRANCHES**, follow the method given above.

For **MAINS**, multiply the number of lamps on each branch of a main by the distance of their lamp centre from the distributing point, *always measured along the lead of the main and branch;* add the products thus obtained for all the branches on the main and divide by the whole number of lamps on the branches. Add the length of feeder and refer to the table with the resultant distance and lamps.

EXAMPLE.—(See cut, main A.)

$$(18 + 20) \times 12 = 456$$
$$(33 + 30) \times 30 = 1890$$
$$(60 + 15) \times 18 = 1350$$

$\frac{456 + 1890 + 1350}{12 + 30 + 18} + 20 = 81$ feet for 60 lamps.

For **FEEDERS**, add the sum of the products obtained as above for all the mains, divide by the entire number of lamps on the feeder, add the length of the feeder, and refer to the table with this distance and all the lamps on the feeder, *or the largest number that will ever be used at one time.*

EXAMPLE.—(See cut.)

Main A. $456 + 1890 + 1350 = 3696$
Main B. $60 \times 50 = 3000$
Main C. $90 \times 40 = 3600$

$$\frac{3696 + 3000 + 3600}{150} + 20 = 88 \text{ feet for } 150$$

lamps.

Care must be taken not to confound a *lamp* centre (so called) with a *geometrical* centre. For example, suppose a series of branches of equal length radiating from the end of a main like the spokes of a wheel, and having lamps at equal intervals. Here the geometrical centre is the radiating point, while the lamp centre is on a circle passing through the centres of the various groups, or the length of the radius from the radiating point. In the case of the main A given above, the geometrical centre is 15 feet from the main, while the true lamp centre is 23 feet. It is to preclude the error of geometrical centres that the branches and mains are laid down, or imagined, revolved.

SUB-BRANCHES and **TAPS** may in general be considered as groups of lamps directly on the branch itself and thus included in the calculation for the branch.

The above method is applicable to all systems of wiring, and is particularly valuable and economical in securing proper distribution of light on low voltage circuits having a small percentage of loss. By stringing the branches first, when possible, this method may be easily followed without the aid of a diagram, even in complex cases. With the "closet" system of wiring, diagrams and calculations as a rule will not be required.

The "tree" system of wiring is to be avoided where possible, on account of the unequal distribution of light it entails. In many cases secondary centres of distribution may be substituted, and if carefully calculated the weight of wire in the latter case need not exceed that in the former.

The voltmeter should always be connected with the centre of distribution and not with the feeder near the dynamo, unless it is desirable to have a steady light in a particular locality, when it should be connected with the line there.

Owing to the exceedingly small current passing through a voltmeter, the resistance of even a very small wire in ordinary cases will not practically affect its readings. Where the line is very long, a No. 12 or 14 insulated iron wire may be used and the voltmeter at the dynamo set once for all by comparison with a standard voltmeter temporarily attached at the point which is to be maintained at a constant potential.

WIRING FORMULÆ AND TABLES.

Tables I–IV were calculated on the basis of 55 watt 16 candle-power lamps. While there are lamps taking somewhat less current than the above, it is advisable to allow some margin in wiring.

The formula deduced for calculating the tables is

$$A = \frac{2150 W}{aE^2} LN. \quad . \quad . \quad . \quad (1)$$

where A = section in circular mils.
W = watt rating of lamps.
E = voltage.
L = distance to centre of distribution, in feet.
N = number of lamps.
a = percentage of drop.

The **AMPERES** (C) being given, the size of wire in circular mils can be found from the following formula:

$$A = \frac{2150LC}{aE}. \quad . \quad . \quad . \quad (2)$$

EXAMPLE. Volts, 50; amperes, 100; feet to centre of distribution, 100; drop, 2%.

$$\frac{2150 \times 100 \times 100}{2 \times 50} = 215{,}000 \text{ circular mils.}$$

By referring to table IX, page 30, we find this to be about No. 0000 B. & S.

The **HORSE-POWER** (H. P.) and efficiency (*eff.*) of a motor being given, the size of the conducting wire in circular mils can be found from the following formula:

$$A = \frac{160{,}400{,}000 \times H.P. \times L}{aE^2 \times eff.} \qquad (3)$$

EXAMPLE. Horse-power, 10; volts, 500; drop, 3%; feet to distributing point, 600; efficiency of motor, 75%.

$$A = \frac{160{,}400{,}000 \times 10 \times 600}{3 \times 500 \times 500 \times 75} = 17{,}109.$$

Referring to table IX, page 30, we find this to be about No. 8 B. & S.

The gauge may be directly taken from the tables below 500 volts by means of the following formula of lamp equivalent, (Q):

$$Q = \frac{1360\ H.P.}{eff.} \qquad (4)$$

EXAMPLE. Horse-power, 5; volts, 110; drop, 3%; feet to distributing point, 200; efficiency of motor, 75%.

$$Q = \frac{1360 \times 5}{75} = \text{lamp equivalent} = 90.$$

Referring to table III, we find that No. 2 B. & S. wire corresponds to 90 lamps and 200 feet, the drop being 3%.

If the distance had been 400 feet, we could still have referred to the 200-feet column, but with 2 × 90 or 180 lamps.

Having the **HORSE-POWER**, and efficiency of a motor to go on a 500-volt circuit, to find the amperes with which to enter Table V, or to apply formula (2), we have the following:

$$C = \frac{149\, H.P.}{eff.} \quad (5)$$

EXAMPLE. Horse-power, $7\frac{1}{2}$; efficiency, 80%.

$$C = \frac{7\frac{1}{2} \times 149}{80} = 13.9 \text{ amperes.}$$

Table IV. is also a **220-VOLT** table, and can be used as such for motor wiring by means of formula (4).

Number of Lamps. Per cent of Loss.						16 C. P. Lamps.						
1%	2%	3%	4%	5%	10%	20′	25′	30′	35′	40′	45′	50′
½	1	1	2	2	5	16	16	16	16	16	16	16
1	2	3	4	5	10	16	16	16	16	16	16	16
1	3	4	6	7	15	16	16	16	16	15	15	14
2	4	6	8	10	20	16	16	15	15	14	14	13
2	5	7	10	12	25	16	15	14	14	13	13	12
3	6	9	12	15	30	15	14	14	13	12	12	11
3	7	10	14	17	35	14	14	13	12	12	11	11
4	8	12	16	20	40	14	13	12	12	11	11	10
4	9	13	18	22	45	13	12	12	11	11	10	10
5	10	15	20	25	50	12	12	11	11	10	10	9
6	12	18	24	30	60	12	11	11	10	9	9	9
7	14	21	28	35	70	11	11	10	9	9	8	8
8	16	24	32	40	80	11	10	9	9	8	8	7
9	18	27	36	45	90	10	10	9	8	8	7	7
10	20	30	40	50	100	10	9	8	8	7	7	6
12	25	37	50	62	125	9	8	8	7	6	6	5
15	30	45	60	75	150	8	8	7	6	5	5	4
17	35	52	70	87	175	8	7	6	5	5	4	4
20	40	60	80	100		7	6	6	5	4	4	3
22	45	67	90	112		7	6	5	4	4	3	3
25	50	75	100	125		6	5	5	4	3	3	2
27	55	82	110	137		6	5	4	3	3	2	2
30	60	90	120	150		5	5	4	3	2	2	1
32	65	97	130	162		5	4	3	3	2	2	1
35	70	105	140			5	4	3	2	2	1	1
40	80	120	160			4	3	3	2	1	1	0
45	90	135				3	3	2	1	1	0	0
50	100	150				3	2	2	1	0	0	00
55	110	165				3	2	1	0	0	00	00
60	120					2	2	1	0	00	00	000
65	130					2	1	0	0	00	00	000
70	140					2	1	0	00	00	000	000
75	150					1	0	0	00	00	000	0000

TABLE I.
VOLTS.

B. & S. Gauge.										Heating Limits.	
60′	70′	80′	90′	100′	120′	140′	160′	180′	200′	Gauge Wire	No. of Lamps
16	16	16	16	16	15	15	14	14	13	16	4
15	15	14	14	13	12	12	11	11	10	14	9
14	13	12	12	11	10	10	9	9	8	12	13
										10	18
12	12	11	11	10	9	9	8	8	7	8	22
11	11	10	10	9	9	8	7	7	6	7	27
11	10	9	9	8	8	7	6	6	5	6	31
										5	41
10	9	9	8	8	7	6	6	5	5	4	45
9	9	8	8	7	6	6	5	4	4	3	54
9	8	8	7	6	6	5	5	4	4	2	63
										1	86
9	8	7	7	6	5	5	4	4	3	0	90
8	7	6	6	5	5	4	3	3	2	00	109
7	6	6	5	5	4	3	3	2	2	000	132
										0000	160
6	6	5	5	4	3	3	2	2	1		
6	5	5	4	3	3	2	2	1	1		
5	5	4	4	3	2	2	1	1	0		
5	4	3	3	2	2	1	0	0	0		
4	3	3	2	1	1	0	0	00	00		
3	2	2	1	1	0	0	00	000	000		
2	2	1	1	0	0	00	000	000	0000		
2	1	1	0	0	00	000	000	0000	0000		
1	1	0	0	00	000	000	0000	0000			
1	0	0	00	00	000	0000	0000				
1	0	00	00	000	000	0000					
0	0	00	00	000	0000	0000					
0	00	00	000	000	0000						
0	00	000	000	0000	0000						
00	000	000	0000	0000							
00	000	0000	0000								
000	0000	0000									
000	0000										
0000	0000										
0000											
0000											

Number of Lamps. Per cent of Loss.						16 C. P. Lamps.						
1%	2%	3%	4%	5%	10%	20′	25′	30′	35′	40′	45′	50′
½	1	1	2	2	5	16	16	16	16	16	16	16
1	2	2	4	5	10	16	16	16	16	16	16	16
1	3	4	6	7	15	16	16	16	16	16	16	16
2	4	6	8	10	20	16	16	16	16	16	16	16
2	5	7	10	12	25	16	16	16	16	16	16	16
3	6	9	12	15	30	16	16	16	16	16	15	15
3	7	10	14	17	35	16	16	16	16	15	15	14
4	8	12	16	20	40	16	16	16	15	15	14	14
4	9	13	18	22	45	16	16	15	15	14	14	13
5	10	15	20	25	50	16	16	15	14	14	13	13
6	12	18	24	30	60	16	15	14	14	13	12	12
7	14	21	28	35	70	15	14	14	13	12	12	11
8	16	24	32	40	80	14	14	13	12	12	11	11
9	18	27	36	45	90	14	13	12	12	11	11	10
10	20	30	40	50	100	14	13	12	11	11	10	10
12	25	37	50	62	125	13	12	11	10	10	9	9
15	30	45	60	75	150	12	11	10	10	9	9	8
17	35	52	70	87	175	11	10	10	9	9	8	7
20	40	60	80	100	200	11	10	9	8	8	7	7
22	45	67	90	112	225	10	9	9	8	7	7	6
25	50	75	100	125	250	10	9	8	7	7	6	6
27	55	82	110	137		9	9	8	7	6	6	5
30	60	90	120	150		9	8	7	7	6	5	5
32	65	97	130	162		9	8	7	6	6	5	5
35	70	105	140	175		8	7	7	6	5	5	4
40	80	120	160	200		8	7	6	5	5	4	4
45	90	135	180	225		7	6	5	5	4	4	3
50	100	150	200	250		7	6	5	4	4	3	3
55	110	165	220			6	5	5	4	3	3	2
60	120	180	240			6	5	4	4	3	2	2
65	130	195				5	5	4	3	3	2	2
70	140	210				5	4	4	3	2	2	1
75	150	225				5	4	3	3	2	1	1

TABLE II.
VOLTS.

B. & S. Gauge.										Heating Limits.	
60′	70′	80′	90′	100′	120′	140′	160′	180′	200′	Gauge Wire.	No. of Lamps.
16	16	16	16	16	16	16	16	16	16	16	6
16	16	16	16	16	16	15	15	14	14	14	13
16	16	16	15	15	14	14	13	12	12	12	20
										10	27
16	15	14	14	14	13	12	12	11	11	8	34
15	14	13	13	13	12	11	11	10	10	7	40
14	14	13	12	12	11	10	10	9	9	6	44
										5	61
14	13	12	12	11	10	10	9	9	8	4	68
13	12	12	11	11	10	9	9	8	8	3	81
13	12	11	11	10	9	9	8	8	7	2	95
										1	129
12	11	11	10	10	9	8	8	7	7	0	136
11	10	10	9	9	8	8	7	6	6	00	162
11	10	9	9	8	7	7	6	6	5	000	197
										0000	240
10	9	9	8	8	7	6	6	5	5		
9	9	8	8	7	7	6	5	4	4		
9	8	8	7	7	6	5	5	4	4		
8	7	7	6	6	5	5	4	3	3		
7	7	6	6	5	4	4	3	3	2		
7	6	5	5	4	4	3	2	2	1		
6	5	5	4	4	3	2	2	1	1		
5	5	4	4	3	2	2	1	1	0		
5	4	4	3	3	2	1	1	0	0		
5	4	3	3	2	2	1	0	0	00		
4	4	3	2	2	1	1	0	00	00		
4	3	3	2	2	1	0	0	00	00		
4	3	2	2	1	0	0	00	00	000		
3	2	2	1	1	0	00	00	000	000		
2	2	1	1	0	0	00	000	000	0000		
2	1	1	0	0	00	000	000	0000	0000		
2	1	0	0	00	00	000	0000	0000			
1	1	0	00	00	000	000	0000				
1	0	0	00	00	000	0000	0000				
1	0	00	00	000	000	0000					
0	0	00	000	000	0000	0000					

Number of Lamps. Per cent of Loss.						16 C. P. Lamps.						
1%	2%	3%	4%	5%	10%	20′	25′	30′	35′	40′	45′	50′
½	1	1	2	2	5	16	16	16	16	16	16	16
1	2	3	4	5	10	16	16	16	16	16	16	16
1	3	4	6	7	15	16	16	16	16	16	16	16
2	4	6	8	10	20	16	16	16	16	16	16	16
2	5	7	10	12	25	16	16	16	16	16	16	16
3	6	9	12	15	30	16	16	16	16	16	16	16
3	7	10	14	17	35	16	16	16	16	16	16	16
4	8	12	16	20	40	16	16	16	16	16	16	16
4	9	13	18	22	45	16	16	16	16	16	16	16
5	10	15	20	25	50	16	16	16	16	16	16	16
6	12	18	24	30	60	16	16	16	16	16	15	15
7	14	21	28	35	70	16	16	16	16	15	15	14
8	16	24	32	40	80	16	16	16	15	15	14	14
9	18	27	36	45	90	16	16	15	15	14	14	13
10	20	30	40	50	100	16	16	15	14	14	13	13
12	25	37	50	62	125	16	15	14	13	13	12	12
15	30	45	60	75	150	15	14	13	13	12	11	11
17	35	52	70	87	175	14	14	13	12	11	11	11
20	40	60	80	100	200	14	13	12	12	11	10	10
22	45	67	90	112	225	13	12	12	11	10	10	9
25	50	75	100	125	250	13	12	11	11	10	9	9
27	55	82	110	137	275	12	12	11	10	9	9	9
30	60	90	120	150	300	12	11	10	10	9	9	8
32	65	97	130	162	325	12	11	10	9	9	8	8
35	70	105	140	175	350	11	11	10	9	9	8	8
40	80	120	160	200		11	10	9	9	8	7	7
45	90	135	180	225		10	10	9	8	7	7	6
50	100	150	200	250		10	9	8	8	7	6	6
55	110	155	220	275		9	9	8	7	6	6	5
60	120	180	240	300		9	8	7	7	6	6	5
65	130	195	260	325		9	8	7	6	6	5	5
70	140	210	280	350		9	8	7	6	5	5	4
75	150	225	300			8	7	6	6	5	5	4

TABLE III.
VOLTS.

B. & S. Gauge.										Heating Limits.	
60′	70′	80′	90′	100′	120′	140′	160′	180′	200′	Gauge Wire.	No. of Lamps.
16	16	16	16	16	16	16	16	16	16	16	10
16	16	16	16	16	16	16	16	16	16	14	20
16	16	16	16	16	16	16	16	15	15	12	30
										10	40
16	16	16	16	16	16	15	15	14	14	8	50
16	16	16	16	16	15	14	14	13	13	7	60
16	16	16	15	15	14	14	13	12	12	6	70
										5	90
16	16	15	15	14	14	13	12	12	11	4	100
16	15	15	14	14	13	12	12	11	11	3	120
15	15	14	14	13	12	12	11	11	10	2	140
										1	190
15	14	14	13	13	12	11	11	10	10	0	200
14	14	13	12	12	11	11	10	9	9	00	240
14	13	12	12	11	11	10	9	9	9	000	290
										0000	350
13	12	12	11	11	10	9	9	8	8		
12	12	11	11	10	9	9	8	8	7		
12	11	11	10	10	9	9	8	7	7		
11	10	10	9	9	8	8	7	6	6		
10	10	9	9	8	7	7	6	6	5		
10	9	9	8	8	7	6	5	5	4		
9	9	8	7	7	6	5	5	4	4		
9	8	7	7	6	6	5	4	4	3		
8	8	7	6	6	5	4	4	3	3		
8	7	6	6	5	5	4	4	3	3		
7	7	6	6	5	4	4	3	3	2		
7	6	6	5	5	4	3	3	2	2		
7	6	5	5	4	4	3	2	2	1		
6	5	5	4	4	3	2	2	1	1		
6	5	4	4	3	3	2	1	1	0		
5	4	4	3	3	2	1	1	0	0		
5	4	3	3	2	2	1	0	0	00		
4	4	3	3	2	1	1	0	0	00		
4	3	3	2	2	1	0	0	00	00		
4	3	2	2	1	1	0	00	00	000		
3	3	2	1	1	0	0	00	00	000		

THREE-WIRE SYSTEM.

Number of Lamps. Per cent of Loss.					16 C. P. Lamps.						
1%	2%	3%	4%	5%	20′	25′	30′	35′	40′	45′	50′
2	5	7	10	12	16	16	16	16	16	16	16
5	10	15	20	25	16	16	16	16	16	16	16
7	15	22	30	37	16	16	16	16	16	16	16
10	20	30	40	50	16	16	16	16	16	16	16
12	25	37	50	62	16	16	16	16	16	16	16
15	30	45	60	75	16	16	16	16	16	16	16
17	35	52	70	87	16	16	16	16	16	16	16
20	40	60	80	100	16	16	16	16	16	16	16
22	45	67	90	112	16	16	16	16	16	16	15
25	50	75	100	125	16	16	16	16	16	15	15
27	55	82	110	137	16	16	16	16	16	15	15
30	60	90	120	150	16	16	16	16	15	15	14
32	65	97	130	162	16	16	16	15	15	15	14
35	70	105	140	175	16	16	16	15	15	14	14
40	80	120	160	200	16	16	15	14	14	13	13
45	90	135	180	225	16	16	15	14	14	13	13
50	100	150	200	250	16	15	14	13	13	12	12
55	110	165	220	275	15	15	14	13	13	12	12
60	120	180	240	300	15	14	13	13	12	11	11
65	130	195	260	325	15	14	13	13	12	11	11
70	140	210	280	350	14	14	13	12	11	11	11
80	160	240	320	400	14	13	12	12	11	10	10
90	180	270	360	450	13	12	12	11	10	10	9
100	200	300	400	500	13	12	11	11	10	9	9
112	225	337	450	562	13	12	11	10	10	9	9
125	250	375	500	625	12	11	11	10	9	9	8
137	275	412	550	687	12	11	10	10	9	9	8
150	300	450	600	750	11	10	9	9	9	8	8
175	350	525	700		11	10	9	9	8	7	7
200	400	600			10	9	8	8	7	6	6
225	450	675			10	9	8	7	7	6	6
250	500	750			9	8	7	7	6	6	5
300	600				8	7	6	6	5	5	4

TABLE IV.

LAMPS.

THREE-WIRE SYSTEM.

B. & S. Gauge.										Heating Limits.	
60′	70′	80′	90′	100′	120′	140′	160′	180′	200′	Gauge Wire.	No. of Lamps
16	16	16	16	16	16	16	16	16	16	16	20
16	16	16	16	16	16	16	16	16	15	14	40
16	16	16	16	16	16	15	15	15	14	12	60
										10	80
16	16	16	16	16	15	14	14	13	13	8	100
16	16	16	15	15	14	14	13	13	12	7	120
16	16	15	15	14	14	13	13	12	11	6	140
										5	180
16	15	15	14	14	13	13	12	12	11	4	200
15	14	14	13	13	12	11	11	10	10	3	240
15	14	14	13	13	12	12	11	11	10	2	280
										1	380
14	14	13	13	12	12	11	11	10	9	0	400
14	14	13	13	12	11	11	10	10	9	00	480
14	13	13	12	12	11	10	10	9	9	000	580
										0000	700
13	13	12	12	11	10	10	9	9	8		
13	13	12	11	11	10	10	9	9	8		
12	11	11	10	10	9	9	8	8	7		
12	11	11	10	10	9	9	8	8	7		
11	10	10	9	9	8	8	7	7	6		
11	11	10	9	9	8	8	7	7	6		
10	10	9	9	8	7	7	6	6	5		
10	10	9	9	8	7	7	6	6	5		
10	9	9	8	8	7	6	5	5	4		
9	9	8	7	7	6	5	5	4	4		
9	8	7	7	6	6	5	4	4	3		
8	8	7	6	6	5	4	4	3	3		
8	8	7	6	6	5	4	4	3	3		
8	7	6	6	5	5	4	3	3	2		
7	7	6	5	5	4	3	3	3	2		
7	6	6	5	5	4	3	2	2	1		
6	5	5	4	4	3	2	2	1	1		
5	4	4	3	3	2	1	1	0	00		
5	4	4	3	3	2	1	1	0	00		
4	4	3	2	2	1	1	0	0	000		
3	3	2	1	1	0	0	00	00	000		

B. & S. Gauge. Per cent Loss.			*Amperes at top of*					
2%	5%	10%	2	4	6	8	10	14
		0000	122500	61125	40750	30560	24450	17460
		000	97000	48500	32290	24250	19400	13835
		00	77000	38400	25660	19250	15400	11000
	0000	0	61110	30550	20375	15275	12220	8730
	000	1	48600	24300	16200	12150	9720	6945
	00	2	38600	19300	12875	9650	7720	5520
	0	3	30600	15300	10210	7650	6120	4375
0000	1	4	24250	12125	8075	6065	4850	3465
000	2	5	19250	9625	6410	4810	3850	2750
00	3	6	15200	7600	5080	3800	3040	2180
0	4	7	12100	6050	4040	3025	2420	1730
1	5	8	9610	4805	3200	2400	1920	1375
2	6	9	7600	3800	2535	1900	1520	1090
3	7	10	6050	3025	2015	1510	1210	865
4	8	11	4800	2400	1600	1200	960	685
5	9	12	3800	1900	1265	950	760	545
6	10	13	3010	1505	1000	750	600	430
7	11	14	2400	1200	800	600	480	340
8	12	15	1900	950	635	475	380	270
9	13	16	1510	760	500	375	300	215
10	14	.....	1200	600	400	300	240	170
11	15	.....	950	478	315	235	190	
12	16	.....	755	380	250	185		
13	....	.....	600	300	200			
14	.....	.....	475	240				
15	.....	.....	375	190				
16	.....	.....	300					

ABLE V.

OLTS.

olumns, Feet below.

20	30	40	50	75	100	150	200
2220	8150	6110	4890	3260	2445	1630	1222
9700	6455	4850	3875	2580	1940	1290	970
7700	5130	3850	3080	2050	1540	1025	770
6110	4075	3055	2445	1630	1220	815	610
4860	3240	2430	1945	1295	970	650	485
3860	2575	1930	1545	1030	770	515	385
3060	2040	1530	1225	815	610	410	305
2425	1615	1215	970	645	485	325	240
1935	1280	960	770	515	385	260	195
1520	1015	760	610	405	304	200	
1210	810	605	485	325	240		
960	640	480	385	255	190		
760	510	380	305	200			
605	400	300	240				
480	320	240	190				
380	250	190					
300	200						
240							
190							

Heating Limits for Interior Wiring.

Gauge	Amp.
16	5
14	10
12	15
10	20
8	25
6	35
5	45
4	50
3	60
2	70
1	95
0	100
00	120
000	145
0000	175

1000

B. & S. Gauge. Per cent of Loss.			Amperes at top of					
2%	5%	10%	2	4	6	8	10	12
		0000	489000	244500	163000	122250	97800	81500
		000	387500	194000	129150	97000	77500	64575
		00	308000	154000	102650	77000	61600	51325
	0000	0	244500	122200	81500	61100	48900	40750
	000	1	194500	97200	64800	48600	38900	32400
	00	2	154500	77200	51500	38600	30900	25750
	0	3	122500	61200	40820	30600	24500	20415
0000	1	4	97000	48500	32300	24250	19400	16150
000	2	5	77000	38500	25650	19250	15400	12825
00	3	6	61000	30400	20330	15200	12200	10165
0	4	7	48500	24200	16170	12100	9700	7085
1	5	8	38450	19220	12815	9610	7690	6410
2	6	9	30500	15200	10150	7600	6100	5075
3	7	10	24200	12100	8065	6050	4840	4030
4	8	11	19200	9600	6400	4800	3840	3200
5	9	12	15200	7600	5065	3800	3040	2530
6	10	13	12100	6020	4015	3010	2410	2010
7	11	14	9600	4800	3200	2400	1920	1600
8	12	15	7600	3800	2535	1900	1520	1270
9	13	16	6050	3025	2015	1510	1210	1010
10	14	.....	4800	2400	1600	1200	960	800
11	15	....	3800	1902	1270	950	760	635
12	16	.....	3020	1510	1005	755	605	500
13	.....	.....	2400	1200	800	600	480	400
14	.....	.....	1900	950	630	475	380	315
15	.....	.....	1510	755	500	375	300	250
16	.....	.....	1195	600	400	300	240	200

TABLE VI.

VOLTS.

Columns, Feet below.

10	20	25	30	40	50	75	100
61125	48900	39120	32600	24450	19560	13040	9780
48500	38750	31000	25830	19400	15500	10330	7750
38500	30800	24640	20530	15400	12320	8210	6160
30550	24450	19560	16300	12220	9780	6550	4890
24300	19450	15560	12960	9720	7780	5190	3890
19300	15450	12360	10300	7720	6180	4120	3090
15300	12250	9800	8165	6120	4900	3265	2450
12125	9700	7760	6460	4850	3880	2585	1940
9625	7700	6160	5130	3850	3080	2050	1540
7600	6100	4880	4065	3040	2440	1625	1220
6050	4850	3880	3230	2420	1940	1295	970
4805	3845	3076	2560	1920	1540	1025	770
3800	3050	2440	2030	1520	1220	815	610
3035	2420	1940	1610	1210	970	645	485
2400	1920	1540	1280	960	770	510	
1900	1520	1220	1010	760	610	405	
1505	1210	965	800	600	480		
1200	960	770	640	480	385		
950	760	610	505	380			
760	605	485	400	300			
600	480	385	320				
475	380	305	255				
380	302	240					
300	240	190					
240	190						
190	150						
150							

2000

B. & S. Gauge. Per cent of Loss.			Amperes at top of					
2%	5%	10%	1	2	3	4	6	8
		0000	1956000	978000	652000	489000	326000	244500
		000	1550000	775000	516660	387500	258300	194000
		00	1232000	616000	410660	308000	205300	154000
	0000	0	978000	489000	326000	244500	163000	122200
	000	1	778000	389000	259330	194500	129600	97200
	00	2	618000	309000	206000	154500	103000	77200
	0	3	490000	245000	163330	122500	81660	61200
0000	1	4	388000	194000	129330	97000	64600	48500
000	2	5	308000	154000	102660	77000	51300	38500
00	3	6	244000	122000	81330	61000	40660	30400
0	4	7	194000	97000	64660	48500	32300	24200
1	5	8	153800	76900	41260	38450	25630	19220
2	6	9	122000	61000	40660	30500	20300	15200
3	7	10	96800	48400	32260	24200	60130	12100
4	8	11	76800	38400	25600	19200	12800	9600
5	9	12	60800	30400	20260	15200	10130	7600
6	10	13	48200	24100	16060	12100	8030	6020
7	11	14	38400	19200	12800	9600	6400	4800
8	12	15	30400	15200	10130	7600	5070	3800
9	13	16	24200	12100	8060	6050	4030	3025
10	14	.. .	19200	9600	6400	4800	3200	2400
11	15	....	15220	7610	5070	3805	2540	1902
12	16	.....	12800	6040	4020	3020	2010	1510
13	....	... .	9600	4800	3200	2400	1600	1200
14	...	.....	7600	3800	2530	1900	1265	950
15	..	....	6040	3020	2010	1510	1005	755
16	...	..	4780	2390	1590	1195	795	600

TABLE VII.

VOLTS.

Columns, Feet below.

10	12	16	20	25	30	40	50
195600	163000	122250	97800	79240	65200	48900	39120
155000	129150	97000	77500	62000	51665	38750	31000
123200	102650	77000	61600	49380	41065	30800	24640
97800	81500	61000	48900	39120	32600	24450	19560
77800	64800	48600	38900	31120	25930	19450	15560
61800	51500	38600	30900	24720	20600	15450	12360
49000	40830	30600	24500	19600	16330	12250	9800
38800	32300	24250	19400	15520	12930	9700	7760
30800	26650	19250	15400	13320	10265	7700	6160
24440	20330	15200	12200	9760	8130	6100	4880
19400	16170	12100	9700	7760	6465	4850	3880
15380	12815	9610	7690	6150	5125	3845	3075
12200	10150	7600	6100	4880	4065	3050	2440
9680	8065	6050	4840	3870	3225	2420	1935
7680	6400	4800	3840	3070	2560	1920	1535
6080	5065	3800	3040	2430	2025	1520	1215
4820	4015	3010	2410	1930	1605	1210	965
3840	3200	2400	1920	1535	1280	960	770
3040	2535	1900	1520	1215	1010	760	610
2420	2015	1510	1210	970	805	605	
1920	1600	1200	960	770	640		
1520	1270	950	760	610			
1280	1005	755	605				
960	800	600	480				
760	630	475					
605	500	375					
480	400						

ODD VOLTAGES AND

	50 Volts.					55		
Per cent column.	1%	2%	3%	4%	5%	1%	2%	3%
50-volt table.....	1.0	2.0	3.0	4.0	5.0	.8	1.6	2.4
75 " "	2.2	4.5	6.7	9.0	12.2	1.8	3.7	5.6
110 " "	4.8	9.6	14.4	19.2	24.0	4.0	8.0	12.0

	70 Volts.					75		
Per cent column.	1%	2%	3%	4%	5%	1%	2%	3%
50-volt table.....	.5	1.0	1.5	2.0	2.5	.4	.9	1.3
75 " "	1.2	2.3	3.4	4.6	5.7	1.0	2.0	3.0
110 " "	2.5	5.0	7.5	10.0	12.5	2.1	4.2	6.3

	90 Volts.					95		
Per cent column.	1%	2%	3%	4%	5%	1%	2%	3%
50-volt table.....	.3	.6	.9	1.2	1.5	.3	.5	.8
75 " "	.7	1.4	2.1	2.8	3.5	.6	1.2	2.0
110 " "	1.5	3.0	4.5	6.0	7.5	1.3	2.7	4.0

	110 Volts.					115		
Per cent column.	1%	2%	3%	4%	5%	1%	2%	3%
50-volt table....	.2	.4	.6	.8	1.0	.2	.4	6
75 " "	.4	.9	1.4	1.8	2.3	.4	.8	1.3
110 " "	1.0	2.0	3.0	4.0	5.0	.9	1.8	2.7

By means of the above table, Tables I-III can be used for any voltage or percentage of loss with an accuracy within the limits of practice.

For example, suppose the wiring is to be for 90 volts with 2% per cent loss. Referring to the body of the 90-volt section, we find the nearest percentage of loss given is 2.1%; then

VIII.

PERCENTAGES.

Volts.		60 Volts.					65 Volts.				
4%	5%	1%	2%	3%	4%	5%	1%	2%	3%	4%	5%
3.3	4.1	.7	1.4	2.1	2.8	3.5	.6	1.2	1.8	2.4	3.0
7.4	9.3	1.5	3.1	4.7	6.2	7.8	1.3	2.6	3 9	5.2	6.5
16.0	20.0	3.4	6.7	10.0	13.4	16.8	2.8	4.7	8.6	11.5	13.3

Volts.		80 Volts.					85 Volts.				
4%	5%	1%	2%	3%	4%	5%	1%	2%	3%	4%	5%
1.8	2.2	.4	.8	1.2	1.6	2.0	.3	.7	1.0	1.4	1.7
4.0	5.0	.8	1.6	2.4	3.2	4.1	.8	1.6	2.3	3.1	4.0
8.4	10.5	1.9	3.8	5.7	7.6	9.5	1.7	3.4	5.1	6.8	8.5

Volts.		100 Volts.					105 Volts.				
4%	5%	1%	2%	3%	4%	5%	1%	2%	3%	4%	5%
1.0	1 3	.2	.5	.7	1.0	1.2	.2	.4	.7	.9	1.2
2.5	3.1	.5	1.1	1.7	2.2	2.8	.5	1.0	1.5	2.0	2.5
5.4	6.7	1.2	2.4	3.6	4.8	6.0	1.1	2.2	3.3	4.4	5.5

Volts.		120 Volts.					125 Volts.				
4%	5%	1%	2%	3%	4%	5%	1%	2%	3%	4%	5%
.8	1.0	.2	.3	.5	.7	.8	.2	.3	.5	.7	.8
1.7	2.1	.4	.8	1.2	1.6	2.0	.4	.7	1.0	1 4	1.8
3.6	4.5	.8	1.7	2.5	3.3	4.2	.8	1.5	2.2	3.0	3.8

following the horizontal and vertical columns in turn we find that this corresponds to the 75-volt table, using the 3% column of that table. That is, wiring for 75 volts with 3% loss is the same as wiring for 90 volts with 2% loss.

Similarly, we find that for a loss of .6% with 110 volts we may use the 3% column of the 50-volt table.

TABLE IX.

DIMENSIONS AND RESISTANCES OF COPPER WIRE.

No. in B. & S. Gauge.	Diam. in Inches.	Cir. Mils. d^2.	Sec. Area in Inches. $d^2 \times .7854$.	R. in Ohms, per 1,000 feet. 97 per cent. cond. 75° Fahr.	R. in Ohms, per Mile.	Diameter in Millimeters.	Sec. Area in Millimeters.
0000	.46000	211600	166190	.051288	.27080	11.68	107 219
000	.40964	167805	131790	.064672	.34147	10.405	85.028
00	.3648	133079	104520	.081549	.43058	6.266	67.431
0	.32495	105592	82932	.1027	.54223	8.254	53.504
1	.28930	83694	65733	.129668	.684627	7.348	42.409
2	.25763	66373	52130	.1635	.86328	6.544	33.632
3	.22942	52634	41339	.2062	1.08874	5.827	26.670
4	.20431	41742	32784	.2599	1.37237	5.189	21.151
5	.18194	33102	25998	.32785	1.731048	4.621	16.773
6	.16202	26250	20617	.41343	2.1829	4.115	13.301
7	.14428	20816	16349	.5213	2.7525	3.665	10.548
8	.12849	16509	12966	.65737	3.47091	3.264	8.366
9	.11443	13094	10284	.8288	4.37606	2.907	6.635
10	.10189	10381	8153	1.0454	5.51971	2.588	5.260
11	.09074	8234	6467	1.31801	6.9601	2.305	4.172
12	.08 81	6530	5129	1.6619	8.7748	2.053	3.309
13	.07196	5178	4067	2.09588	11.066	1.828	2.618
14	.06408	4107	3147	2.6424	13.87187	1.628	2.081
15	.05707	3257	2558	3.33205	17.5993	1.540	1.650
16	.05082	2583	2029	4.2007	22.17969	1.291	1.309
17	.04526	2048	1609	5.299078	27.9787	1.150	1.038
18	.04030	1624	1276	6.68258	35.2836	1.024	.823
19	.03539	1252	984	8.86814	45.7670	.899	.6346
20	.03196	1021	802	10.34128	54.6020	.812	.5176

TABLE X.

EDISON SYSTEM.

EDISON GAUGE.

E. S. G. Gauge No.	Diameter in mils.	Circular Mils. in Even Thous.	Maximum Amperes.	Ohms per Foot.	Pounds per Foot
3	55	3000.	12.5	.0034976	.00908372
5	71	5000.	18.3	.0020986	.01513924
8	90	8000.	26.0	.0013118	.02422034
12	110	12000.	35.2	.0008746	.03632824
15	123	15000.	41.6	.0006997	.04540984
20	142	20000.	51.6	.0005247	.06054840
25	158	25000.	61.0	.0004198	.07568210
30	173	30000.	70.0	.0003498	.09081666
35	187	35000.	78.6	.0002999	.10595483
40	200	40000.	86.8	.0002624	.12108200
45	222	45000.	94.9	.0002332	.13622748
50	224	50000.	102.7	.0002099	.15135683
55	235	55000.	110.3	.0001908	.16650083
60	245	60000.	117.7	.0001749	.18162452
65	255	65000.	125.0	.0001615	.19677218
70	265	70000.	132.1	.0001499	.21190130
75	274	75000.	139.1	.0001399	.22704321
80	283	80000.	146.0	.0001312	.24217648
85	292	85000.	152.8	.0001235	.25730349
90	300	90000.	159.5	.0001166	.27243450
95	308	95000.	166.1	.0001105	.28758723
100	316	100000.	172.6	.0001049	.30270928
110	332	110000.	185.4	.0000954	.33299060
120	346	120000.	198.0	.0000845	.36326663
130	361	130000.	210.2	.0000807	.39352714
140	374	140000.	222.2	.0000750	.42379665
150	387	150000.	234.0	.0000700	.45406140
160	400	160000.	245.6	.0000656	.48432800
170	412	170000.	257.0	.0000617	.51462206
180	424	180000.	268.3	.0000583	.54488423
190	436	190000.	279.4	.0000552	.57513978
200	447	200000.	290.4	.0000525	.60542734

TABLE XI.

DIFFERENT WIRE GAUGES IN USE IN THE UNITED STATES.

Dimensions of Sizes, in Decimal Parts of an Inch.

Number of Wire Gauge.	American, or Brown & Sharpe.	Birmingham, or Stubs'.	Washburn & Moen Mfg. Co. Worcest'r, Ms.	Trenton Iron Co. Trenton, N. J.	G. W. Prentiss, Holyoke, Mass.	Old English.	Number of Wire Gauge.
000000	......	....	.46	.....	.....	.....	000000
00000	......	....	.43	.45	.....	.....	00000
0000	.46	.454	.393	.4	.....	.....	0000
000	.40964	.425	.362	.36	.3586	.....	000
00	.3648	.38	.331	.33	.3282	.....	00
0	.32486	.34	.307	.305	.2994	.....	0
1	.2893	.3	.283	.285	.2777	.....	1
2	.25763	.284	.263	.265	.2591	.....	2
3	.22942	.259	.244	.245	.2401	.....	3
4	.20431	.238	.225	.225	.223	.....	4
5	.18194	.22	.207	.205	.2047	.....	5
6	.16202	.203	.192	.19	.1885	.....	6
7	.14428	.18	.177	.175	.1758	.....	7
8	.12849	.165	.162	.16	.1605	.....	8
9	.11443	.148	.148	.145	.1471	.....	9
10	.10189	.134	.135	.13	.1351	.....	10
11	.090742	.12	.12	.1175	.1205	.....	11
12	.080808	.109	.105	.105	.1065	.....	12
13	.071961	.095	.092	.0925	.0928	.....	13
14	.064084	.083	.08	.08	.0816	.083	14
15	.057068	.072	.072	.07	.0726	.072	15
16	.05082	.065	.063	.061	.0627	.065	16
17	.045257	.058	.054	.0525	.0546	.058	17
18	.040303	.049	.047	.045	.0478	.049	18
19	.03589	.042	.041	.04	.0411	.04	19
20	.031961	.035	.035	.035	.0351	.035	20
21	.028462	.032	.032	.031	.0321	.0315	21
22	.025347	.028	.028	.028	.029	.0295	22
23	.022571	.025	.025	.025	.0261	.027	23
24	.0201	.022	.23	.0225	.0231	.025	24
25	.0179	.02	.02	.02	.0212	.023	25
26	.01594	.018	.018	.018	.0194	.0205	26
27	.014195	.016	.017	.017	.0182	.01875	27
28	.012641	.014	.016	.016	.017	.0165	28
29	.011257	.013	.015	.015	.0163	.0155	29
30	.010025	.012	.014	.014	.0156	.01375	30
31	.008928	.01	.0135	.013	.0146	.01225	31
32	.00795	.009	.013	.012	.0136	.01125	32
33	.00708	.008	.011	.011	.013	.01025	33
34	.006304	.007	.01	.01	.0118	.0095	34
35	.005614	.005	.0095	.0095	.0109	.009	35
36	.005	.004	.009	.009	.01	.0075	36
37	.004453	....	.0085	.0085	.0095	.0065	37
38	.003965	....	.008	.008	.009	.00575	38
39	.003531	....	.0075	.0075	.0083	.005	39
40	.003144	....	.007	.007	.0078	.0045	40

TABLE XII.

BARE AND INSULATED WIRES.

No. in B. & S. Gauge.	Approximate No. of Feet per Pound.						
	Underwriters.	"Competition" N. Y. Ins. Wire Co.	Okonite, braided [medium thick].	Simplex T. Z. R. No. 1.	Roebling Weather-proof.	Ansonia Weather-proof.	Naked Wire.
0000	1.		1.		1.5		1.56
000	1.5		1.4		1.9		1.97
00	2.		1.7		2 34		2.49
0	2.75	2.5	2.1	2.5	2.9	2.7	3.13
1	3.20	3.25	2.73	3.	3.66	3.26	3.95
2	4.	4.25	3.37	4.5	4.54	4.27	4.99
3	5.	5.25	3.88	5.5	5.6	5.	6.29
4	6.25	6.25	4.68	6.75	7.1	5.9	7.93
5	8.	8.	5.64	8.33	8.7	7.4	10.
6	9.50	10.	6.67	10.	10.75	9.	12.61
7	12.5	12.25	8.73	12 5	13.	10.	15.9
8	14.5	14.	12.42	13.75	15.6	12.5	20.05
9	17.		16.3		18.	15.3	25.28
10	20.		17.9	19.75	22.7	18.	31.88
11	26.				27.		40.20
12	32.		27.21	25.	33.3	24.	50.69
13					38.5		63.91
14	45.		36.9	50.	49.		80.59
15					59.		101.63
16	70.		53.8		71.4		128.14
17					85.		161.59
18	90.		72.1		93.		203.76
19					111.		264.26
20	110.		82.5		133.		324.00

TABLE XIII.

LIMITING CURRENTS FOR INTERIOR WIRING.

(KENNELLY.)

Applies to insulated copper house-wires of 98 per cent conductivity, carrying steady currents, and encased in wooden moulding. The rule followed is that the temperature elevation of any wire shall not, with the proposed current, exceed 18° F. or 10° C.

Amperes.	Number in B. & S.	Diameter in inches.	Circular Mills.	Amperes.	Number in B. & S.	Diameter in inches.	Circular Mills.
1000		1.47	2160900	61	3	.2294	52634
900		1.37	1876900	52	4	.2043	41742
800		1.27	1612900	43	5	.1819	33102
700		1.16	1345600	36	6	.1620	26244
600		1.049	1100401	30	7	.1442	20822
550		.988	976144	25	8	.1284	16512
500		.928	861184	22	9	.1144	13110
475		.897	804609	18	10	.1019	10381
450		.865	748225	15	11	.0907	8226
425		.832	692224	12	12	.0808	6528
400		.800	640000	10.5	13	.0719	5184
375		.766	586756	9.0	14	.0641	4110
350		.732	535824	7.25	15	.0571	3260
325		.697	485809	6.00	16	.0508	2581
300		.660	435600	5.50	17	.0452	2044
275		.623	388129	4.00	18	.0403	1624
250		.585	342225	3.25	19	.0359	1253
225		.545	297025	2.75	20	.0319	1024
200		.504	254016	2.25	21	.0285	820
174	0000	.460	211600	2.00	22	.0253	626
147	000	.4096	167805	1.75	23	.0226	510
124	00	.3648	133079	1.50	24	.0201	404
103	0	.3249	105592	1.25	25	.0179	320
87	1	.2893	83694	1.00	26	.0159	254
73	2	.2576	66373				

TABLE XIV.

CURRENTS AND CORRESPONDING ELEVATIONS OF TEMPERATURE OF OPEN-AIR CONDUCTORS IN CALM WEATHER. (BLACK INSULATION.)

(Compiled from Kennelly's Experiments.)

Gauge B. & S.	9° F.	18° F.	36° F.	72° F.
0000	250	345	480	680
000	210	295	405	565
00	175	245	350	480
0	145	205	290	400
1	125	175	250	345
2	105	150	210	290
3	90	125	175	240
4	75	110	150	210
5	65	90	125	175
6	55	75	105	145
7	50	65	95	125
8	40	55	80	110
10	30	45	60	80
12	25	30	45	60
14	20	25	35	45
16	15	20	25	35

Rise in temperature at top of columns, amperes below.

TABLE XV.

EQUIVALENTS OF WIRES.

(Brown & Sharpe Gauge.)

0000	2 No. 0	4 No. 3	8 No. 6	16 No. 9	32 No. 12	64 No. 15
000	2 " 1	4 " 4	8 " 7	16 " 10	32 " 13	64 " 16
00	2 " 2	4 " 5	8 " 8	16 " 11	32 " 14	64 " 17
0	2 " 3	4 " 6	8 " 9	16 " 12	32 " 15	64 " 18
1	2 " 4	4 " 7	8 " 10	16 " 13	32 " 16	64 " 19
2	2 " 5	4 " 8	8 " 11	16 " 14	32 " 17	64 " 20
3	2 " 6	4 " 9	8 " 12	16 " 15	32 " 18	64 " 21
4	2 " 7	4 " 10	8 " 13	16 " 16	32 " 19	64 " 22
5	2 " 8	4 " 11	8 " 14	16 " 17	32 " 20	64 " 23
6	2 " 9	4 " 12	8 " 15	16 " 18	32 " 21	64 " 24
7	2 " 10	4 " 13	8 " 16	16 " 19	32 " 22	64 " 25
8	2 " 11	4 " 14	8 " 17	16 " 20	32 " 23	64 " 26
9	2 " 12	4 " 15	8 " 18	16 " 21	32 " 24	64 " 27
10	2 " 13	4 " 16	8 " 19	16 " 22	32 " 25	64 " 28
11	2 " 14	4 " 17	8 " 20	16 " 23	32 " 26	64 " 29

TABLE XV.—*Continued.*

12	2 No. 15	4 No. 18	8 No. 21	16 No. 24	32 No. 27	64 No. 30
13	2 " 16	4 " 19	8 " 22	16 " 25	32 " 28	
14	2 " 17	4 " 20	8 " 23	16 " 26	32 " 29	
15	2 " 18	4 " 21	8 " 24	16 " 27	32 " 30	
16	2 " 19	4 " 22	8 " 25	16 " 28		
17	2 " 20	4 " 23	8 " 26	16 " 29		
18	2 " 21	4 " 24	8 " 27	16 " 30		
19	2 " 22	4 " 25	8 " 28			
20	2 " 23	4 " 26	8 " 29			
21	2 " 24	4 " 27	8 " 30			

By means of the above table the gauges and corresponding number of wires can be selected that are equivalent to a given solid wire. For example, two No. 3 or sixteen No. 12 wires are equivalent to a No. 0.

TABLE XVI.

RESISTANCES.

Material.	Approximate Comparative Resistances.	Resistance of 100 Feet of No. 20 (B. & S.) Wire, in Ohms.
Copper..........	1	1.016
Aluminum.	1.8	1.82
Zinc.............	3.4	3.45
Platinum.	5.5	8.81
Iron.............	6	6.03
Nickel...........	7.6	7.68
Tin..............	8	8.12
Lead.	12	12.1
German-silver ...	13	13.6
Antimony........	21	......
Ferro-nickel	50	50.8
Mercury	58	... ..
Bismuth	80	......
Sulphuric acid...	2.6×10^6	......

GAUGES (B. & S.) OF DIFFERENT WIRES FUSED BY 100 AMPERES.

(PREECE.)

Copper, ...	No. 17
Aluminum, ...	" 15
Platinum, ...	" 13
German-silver, ...	" 13
Platinoid, ...	" 12
Iron, ...	" 10
Tin, ...	" 6
Lead, ...	" 6
Tin-lead alloy, ...	" 5

TABLE XVII.

WEIGHT AND RESISTANCE OF GALVANIZED IRON WIRE PER MILE.

(ROEBLING.)

Gauge. B. & S.	Weight per Mile.	Resistance. Ohms.	Gauge. B. & S.	Weight per Mile.	Resistance. Ohms.
6	550	10	11	216	20
7	470	12.1	12	170	32.7
8	385	14.1	14	100	52.8
9	330	16.4	16	62	91.6
10	268	20			

TABLE XVIII.

TABLE OF RESISTANCES OF 18 PER CENT GERMAN-SILVER WIRE.

(AMERICAN ELECTRICAL WORKS.)

B. & S. Gauge.	Ohms per 1000 ft.	Ohms per lb.	B. & S. Gauge.	Ohms per 1000 ft.	Ohms per lb.
No. 8	11.772	.23598	No. 25	606.312	626.31
9	11.832	.37494	26	764.586	995.958
10	18.72	.59652	27	964.134	1583.622
11	23.598	.94842	28	1215.756	2518.075
12	29.754	1.50786	29	1533.06	4004.082
13	37.512	2.39778	30	1933.038	6368.356
14	47.304	3.8124	31	2437.236	10119.978
15	59.652	6.0624	32	3073.77	16096.356
16	75.222	9.639	33	3875.616	25589.628
17	94.842	15.327	34	4888.494	40712.76
18	119.61	24.3702	35	6163.974	64729.87
19	155.106	40.9896	36	7770.816	102876.482
20	190.188	61.614	37	9797.166	163524.78
21	239.814	97.974	38	12357.198	257764.68
22	302.382	155.772	39	15570.828	409546.8
23	381.33	247.734	40	19653.57	652024.62
24	480.834	393.93			

WHITE CEDAR POLES.

(Electrical Supply Co.)

Size.	Average Weight, Pounds each.	Approximate No. of Poles to a Car.	Size.	Average Weight, Pounds each.	Approximate No. of Poles to a Car.
25′, top 4″	160	170	35′, top 7″	650	90
25′, " 5″	200	150	35′, " 8″	700	85
25′, " 6″	250	120	35′, " 9″	850	70
25′, " 7″	325	100	40′, " 6″	800	80
25′, " 8″	475	75	40′, " 7″	900	75
25′, " 9″	550	60	40′, " 8″	950	70
30′, " 5″	300	110	45′, " 6″	1000	65
30′, " 6″	350	90	45′, " 7″	1200	55
30′, " 7″	420	75	50′, " 6″	1400	52
30′, " 8″	600	55	50′, " 7″	1500	40
30′, " 9″	700	45	55′, " 7″	1600	37
35′, " 6″	550	100	60′, " 7″	1700	35

Green chestnut poles weigh about 50 per cent more than the above figures.
Poles 40 ft. long and over require two cars.

DIMENSIONS OF CROSS ARMS.

Regular size, 3¼ inches × 4½ inches, 1½-inch holes.

Special size, 4 inches × 5 inches, 1½-inch holes.

2-pin, 3 feet long; 4-pin, 4 or 5 feet long; 6-pin, 6 feet long.

CANDLE-POWER OF ARC LAMPS.

(ANTWERP ELECTRICAL EXPOSITION.)

Amperes.	Volts.	Maximum C. P.	Horizontal C. P.	Upper Hemisphere. Mean C. P.	Lower Hemisphere. Mean C. P.	Mean C. P.	Watts.
4	37.2	390	74	17	119	136	157
6	46.2	1090	168	63	298	361	259
6.8	46	1240	240	65	320	385	313
8	46	1550	334	70	385	454	350
10	45.5	2070	421	102	640	750	491

LIGHT CUT OFF BY GLOBES.

Clear glass..	10 per cent		
Light ground glass..........	30	"	"
Heavy ground glass.....	45 to 50	"	"
Strong opals............	50 to 60	"	"

An incandescent lamp gives off from $\frac{1}{5}$ to $\frac{1}{10}$ the heat of an equivalent gas-jet.

An arc lamp gives off from $\frac{1}{20}$ to $\frac{1}{40}$ as much heat as gas-jets producing an equal light.

A 5-foot (16 c. p.) gas-jet vitiates as much air as four men.

ELECTRICAL UNITS.

Unit.	Symbol.	Name of Unit.	Derivation.
Electro-motive force	E	Volt	Ampere × ohm
Resistance	R	Ohm	Volt ÷ ampere
"	$R \times 10^6$	Megohm	1 million ohms
"	$R \times 10^{-6}$	Microhm	1 millionth ohm
Current	C	Ampere	Volt ÷ ohm
"	$C \times 10^{-3}$	Milliampere	1 thousandth ampere
Quantity	Q	Coulomb	Ampere × second
Capacity	K	Farad	Coulomb ÷ volt
"	$K \times 10^{-6}$	Microfarad	1 millionth farad
Energy	W	Watt	Volt × ampere
"	....	Erg	Volt × ampere × 10^{-7}
Heat	W_j	Joule	Volt × colomb

ELECTRICAL UNITS.—*Continued.*

Unit.	Symbol.	Name of Unit.	Derivation.
Self-induction.	L	Henry	Second × ohm
Force	....	Dyne	Gravity ÷ 981

A **VOLT** is almost equal to the E. M. F. of a Daniell cell.

An **OHM** is the resistance of about 1000 feet of No. 10 (B. & S.) copper wire.

An **AMPERE** will deposit 62 grains of silver per hour.

A **MICROFARAD** is about equal to the capacity of $2\frac{1}{2}$ miles of Atlantic cable.

A **WATT** is $\frac{1}{746}$ of a horse-power.

A **HENRY** is about $\frac{1}{10}$ the inductance of a Morse receiver magnet.

TOOLS REQUIRED.

The following-named tools will probably be required in constructing a plant for city or commercial lighting :

(DAVIS.)

Article.	Size.	Cost about
Stubs' pliers, plain....	8 in.	$2.00
Climbers and straps	....	3.00
Pulley-block and ecc. clamp.... ...	To	8.00
Come-along and strap	No. 3	2.25
Splicing clamps........	B.&S.	2.50
Linemen's tool-bag and strap... ...	....	4.80
Soldering furnace...	....	6.00
Gasoline blow-pipes........	....	6.00
Soldering coppers...	2 lb.	.95
Pole-hole shovels	8 ft.	1.50
Pole-hole spoon, regular.........	7 ft.	1.25
Octagon digging-bars.....	8 ft.	3.50
Tamping-bars.......................	7 ft.	2.60
Crowbar.........	10 lb.	.90
Pick-axe....	....	.75
Carrying-hook, heavy................	....	6.00
Cant-hook............	4 ft.	2.00
Pike-poles..........................	16 ft.	2.40
Pole-supporter	6 ft.	12.00
Comb, pay-out reel and straps......	....	20.00
Nail-hammer.	1 lb.	1.00
Linemen's broad hatchets...........	6 in.	1.50
Drawing-knives.....................	12 in.	2.10
Hand-saw..	26 in.	1.50
Ratchet-brace, bits.................	10 in.	3.00
Screw-drivers.........	8 in.	.80
Wrench..........	12 in.	1.25
Bastard file.........................	12 in.	.30

APPROXIMATE LIST OF SUPPLIES

REQUIRED IN INSTALLING 15 CITY LAMPS AND 20 COMMERCIAL LAMPS ON A FIVE-MILE CIRCUIT, SETTING POLES 132 FEET APART.

(DAVIS.)

Articles.	Size or Diameter	Price about.	Quantity.
Electric-light poles......	30 ft., 6 in.	$2.40 each	180
Electric-light poles......	35 ft., 7 in.	4.15 "	
Electric-light poles......	40 ft., 7 in.	5.50 "	40
Cross arms, 4-pin........	4 ft.	.30 "	200
Painted oak pins	1½ in.	.02 "	800
Oak pins and bolts......	1½ in.	.07 "	24
Iron break-arms.........		.75 "	25
Lag-screws and washers.	½ × 7 in.	.04 "	400
Glass insulators, D. G....		.7½ "	850
Pole steps................	⅝ × 8 in.	.05 "	2500
Guy stranded cable......	⅝ in.	.07 lb.	500 lbs.
Cross-arm brace & bolts.		.20 each	40
Line wire................	6 BS	125.00 mi.	6 miles

MATERIAL REQUIRED FOR CONNECTING IN LAMPS.

(DAVIS.)

Sleet-proof pulleys......		$0.75 each	30
Street-lamp cleats, iron..		.25 "	15
Arc-lamp cordage.......	⅜ in.	1.25 hd ft	25
Suspension cable........	¼ in.	.02½ ft.	3000 ft.
Hard-rubber tube........	⅜ × ⅝ in.	1.50 lb.	5 lbs.
Soft-rubber tubing......	⅜ in.	.20 ft.	200 ft.
Arc cut-out......		3.50 each	20
Porcelain insulators and screws		2.40 hd.	400
Oak brackets and spikes.		2.50 "	150

Commercial horse power rating of simple high speed, single or double acting engines, based on 40 pounds mean indicated pressure with 80 pounds initial pressure.

D = diameter in inches;
S = stroke " "
N = number of revolutions per minute.

80 pounds boiler pressure,

$$\text{H. P.} = \frac{D^2SN}{6300}.$$

90 pounds boiler pressure,

$$\text{H. P.} = \frac{D^2SN}{5600}.$$

100 pounds boiler pressure,

$$\text{H. P.} = \frac{D^2SN}{5000}.$$

EXAMPLE. Diameter cylinder, 10 in.; stroke, 10 in.; revolutions per minute, 300.

$$\text{H. P.} = \frac{(10 \times 10) \times 10 \times 300}{6300} = 47.6$$

at 80 pounds pressure.

Similarly,

H. P. = 53.5 at 90 pounds pressure.
H. P. = 60 " 100 " "

HORSE POWER OF BOILERS.

The following commercial rating of boilers is based on heating surface, and on 80 pounds pressure and 40 pounds of water per indicated horse power.

D = diameter of boiler in inches;
d = " " tubes " "
L = length " " " feet;
l = " " " " inches,
n = number " "

HORIZONTAL TUBULAR BOILERS.

(To 200 H. P.)

CASE 1. $L(D + nd)$ is less than 50000.

$$\text{H. P.} = \frac{L(D + nd)}{62}.$$

CASE 2. $L(D + nd)$ is between 50000 and 70000.

$$\text{H. P.} = \frac{L(D + nd)}{55}.$$

CASE 3. $L(D + nd)$ is over 70000.

$$\text{H. P.} = \frac{L(D + nd)}{50}.$$

EXAMPLE. Diameter boiler, 48 in.; length tubes, 14 ft.; diameter tubes, 3 in.; number tubes, 52.

$$\text{H. P.} = \frac{14(48 + 52 \times 3)}{62} = 45.$$

UPRIGHT TUBULAR BOILERS—FULL LENGTH TUBES.

(To 60 H. P.)

$$\text{H. P.} = \frac{l(D + nd)}{620}.$$

EXAMPLE. Diameter, 36 in.; length tubes, 51 in.; diameter tubes, 2 in.; number tubes, 77.

$$\text{H. P.} = \frac{51(36 + 77 \times 2)}{620} = 15.$$

UPRIGHT TUBULAR BOILERS. — SUBMERGED TUBES.

(To 60 H. P.)

$$\text{H. P.} = \frac{l(D + nd)}{500}.$$

EXAMPLE. Diameter boiler, 24 in.; length tubes, 30 in.; diameter tubes, 2 in.; number tubes, 31.

$$\text{H. P.} = \frac{30(24 + 31 \times 2)}{500} = 5.$$

NOTE.—In the above formulæ for boilers, allowance has been made for the greater efficiency of heating surface exposed to direct radiation.

RULES FOR CALCULATING THE SPEED OF PULLEYS AND GEARS.

To find the **REVOLUTIONS** of a **DRIVEN** shaft, multiply the diameter of the *driving* pulley by its speed in revolutions and divide by the diameter of the *driven* pulley.

EXAMPLE. Engine pulley, 42 in.; engine revolutions, 240; dynamo pulley, 8 in.

$$\text{Dynamo rev.} = \frac{42 \times 240}{8} = 1260.$$

To find the **DIAMETER** of a **DRIVEN** pulley, multiply the diameter of the *driving* pulley by its speed in revolutions and divide by the required speed of the *driven* shaft.

EXAMPLE. Engine pulley, 66 in.; engine revolutions, 303; dynamo speed, 2000 rev.

$$\text{Diam. dynamo pulley} = \frac{66 \times 303}{2000} = 10 \text{ in.}$$

To find the **DIAMETER** of a **DRIVING** pulley, multiply the diameter of the *driven* pulley by its revolutions and divide by the revolutions of the *driving* shaft.

EXAMPLE. Dynamo revolutions, 1500; dynamo pulley, 10 in.; counter speed, 600 rev.

$$\text{Diam. counter-driver} = \frac{10 \times 1500}{600} = 25 \text{ in.}$$

Where a **COUNTER** is to be used, the problem is in two parts, the countershaft being first considered the *driven* and next the *driver*, or *vice versa*. The above rules can similarly be extended to any number of intermediate shafts or counters.

EXAMPLE. Shafting pulley, 48 in.; shafting revolutions, 120; counter *driven* pulley, 12 in.; dynamo pulley, 8 in.; dynamo revolutions, 1500. Required counter *driving* pulley.

$$\text{Counter rev.} = \frac{48 \times 120}{12} = 480.$$

$$\text{Diam. counter driver} = \frac{8 \times 1500}{480} = 25 \text{ in.}$$

For **GEARS**, substitute the number of *teeth* in the above rules for the *diameter* in inches.

INSTRUCTIONS FOR WIREMEN AND LINEMEN.

(JAS. I. AYER.)

When cutting wire, grip the line with the cutting jaws of pliers and move up and down at right angles with the wire two or three times, so that you cut the insulation part of the way round on both sides ; then hold your pliers firmly bend the wire once or twice up and down with your left hand, and the wire will break. Never try to break the wire by twisting your pliers, unless you first move the line out of the cutting jaws. There is no excuse for nicks in the cutting jaws of Stubs' pliers, and careful linemen rarely have it happen.

In stripping the ends of wire to make a connection, always cut along the wire towards the end, in much the same manner as if whittling a stick. Never cut round the wire with the edge of the knife or pliers, excepting when cutting the wire.

In making joints, be careful never to let the cutting jaws or edge of your tools "score" the wire. If you do, don't cover it up, but make a new joint.

After a joint is made with not less than four turns each side of the connectors, dip or moisten with acid. If you are on the ground, dip the joint in melted solder and hold it there a few seconds, to thoroughly heat the joint, then take it out. If well "tinned," dip it in water to remove any acid which may be on the ends of the wire near the insulation.

If where you cannot dip the joint, but have to use the ladle, pour the solder frequently over the joint until it leaves a thin smooth coating on the wire. It is not properly done if the solder is in lumps or in a thick layer.

If you are obliged to use a "blow-pot," hold the joint in the flame until the solder will easily melt when held against the wire after the flame is removed. When this is accomplished, apply the solder with the flame and *not before*.

Solder is put on the joint to keep it from corroding, thereby insuring good contact where the two wires come together, and is of no use if not well applied.

After the joint is well cleaned of acid after being soldered, paint it thoroughly with insulating compound, then cover with a layer of tape, which you will start on one side of the joint against the insulation of the wire but not over it. Have the first layer cover the joint and bare wire only. When this is done paint it; then start back over the joint and tape until you have run over the line insulation about two inches, then wrap two layers, painting each when done.

In wrapping tape, cover what you have laid half, or lap one half. After four layers are on paint the whole thoroughly.

Whenever you find a break in the insulation on the line anywhere, paint it first, then tape and paint it. Don't forget this.

No joints should be permitted to be made and left without being soldered.

Never fail to put in "drip-loops" in line where entering building.

In all electrical work, remember where insulation is desired it can never be *too good*, or when contact is desired you can never make it *too good or strong*. *Always avoid temporary work.*

In making house connections, where wires enter building, have not less than six inches clearance from cornices of walls. All wiring running over cornices or other building projections should be protected with rubber tubing thoroughly taped and painted at the ends. Never let a wire, however well protected, come in contact with the outside portion of the building.

In placing tubing on wire, carefully paint and tape at the upper end, leaving the *lower end open*, so that moisture can escape if it should get in.

In placing converters and making connections to same, you should always leave the line connection where you branch to be made after all other work is completed. The primary fuses at the converter must be left out until the final line connections are completed.

In making connections to constant potential (alternating or 500-volt) circuits, always finish one connection before breaking the insulation on the other line. Remember this: that you must have but one wire or joint bare at a time when working on the lines.

After completing a converter connection and before closing line connections, carefully paint the entire outfit (except glass insulators) with insulating paint.

See that all wires leading out of converters and out of fuse-boxes are well taped and painted where they leave the converter; and all converters must be placed as far from doors, balconies, windows, and other openings, as possible, and sufficiently high above ground or roof, to prevent accidental contact; in other words, out of reach.

All secondary wires from the converter to house should be as well insulated and protected from grounds as if carrying high-pressure currents.

In plugging brick or stone buildings, paint the plugs with insulating compound before driving them.

All supports for converters and fuse-boxes placed on buildings must be well painted with insulating paint.

In renewing fuses of secondary wires, be sure that the binding-post screws which hold the line wires are firmly set. Fuses are frequently blown by loose line conductors.

When primary fuses are blown, examine converter for short circuit or leakage before replacing them.

When main-line secondary fuses are blown, test with the current on both legs for ground, if circuit is being used. If not, you may test with magneto bells, first removing both fuses on main block and testing wires to lamps only.

In placing fuses in secondary circuits, always open the switch on the branch before fused, or turn the lamps "off" at sockets before replacing fuse.

When replacing fuses, always test for

grounds or short circuits on lines where fuses are blown.

Use your fuse test wire for all tests on secondaries, if testing with current. Where grounds are found, unless cleared by you, the branch grounded must be left cut out.

When placing guard wires on street crossings, always use iron pins and glass insulators to attach both ends of guard wires to. Never tie on cross arm or pole, as in stormy weather, when they should be of use, they will thus become dangerous.

In working on lines all circuits must at all times be regarded as *alive and grounded.* With many wires, some of which may be carrying heavy currents, some using ground returns, the line you are on may "come alive" any time. Be careful.

See that all tools are securely fastened in your belt when working on pole or ladder, and in handling lines and wires on poles have a proper regard for the safety of those passing beneath.

When working on poles always use your safety belt, as well as other desirable safety devices. It takes but little time to make yourself safe, and many weeks to mend a broken bone.

Never lay tools down when above the ground.

In putting in jumpers, be careful that the loop of jumper does not lie on wires below and thus make a cross possible if the insulation does not hold.

Always run wires in straight parallel lines, and make square turns where possible. Twelve inches between wires is the proper space for arc-lighting circuits, where practicable.

Never fasten a cut-out box against the wall. Always place glass or porcelain knobs between the box and wall.

In tying in, never draw the tie wire so as to bend a kink in the line or cut through the insulation with the tie. A tie will properly hold the wire in place without drawing it so tight as to do either.

In using pulley-blocks on the line, avoid the use of "come-alongs" when possible, by taking a series of half hitches, or making a "noose wrap" with a small line on the wire to hook the block to. If you do use "come-alongs," see that you do not score, cut, or kink the wire, and always paint and tape broken insulation.

Groundmen are especially cautioned to watch the line in "paying out" and prevent "kinking." Should a short "kink" get pulled into the line, cut it out rather than take the risk of breaking.

Never use porcelain knobs where they will be exposed to moisture or the weather, and never use them anywhere else if glass can possibly be substituted.

Porcelain knob circuit breakers may be used where necessary, provided not more than two lamps are on the loop. In making them, paint and insulate with tape the joints in connecting wire or loop.

In removing lamps ordered out, always close the loop at the line where it was originally cut in and remove all dead wire. Never leave dead or unnecessary wire in circuit.

Always use iron pins on arms where wires turn a corner or leave the line.

Never screw an insulator on an iron pin or bracket very tightly, nor without first putting inside the glass a strip of paper folded twice or three times. This will prevent the glass being broken, as iron expands with heat nearly twice as rapidly as glass, and unless there is room enough the difference in temperature between winter and summer will burst insulators in summer that were placed in winter.

RULES AND REQUIREMENTS

FOR THE INSTALLATION OF

ELECTRIC LIGHT AND POWER,

AS

REVISED AND CODIFIED

BY THE

UNDERWRITERS' INTERNATIONAL ELECTRIC ASSOCIATION.*

CLASS A.

CENTRAL STATIONS.

FOR LIGHT OR POWER.

These Rules also apply to Dynamo Rooms in Isolated Plants, connected with or detached from buildings used for other purposes; also to all varieties of apparatus therein of both high and low potential.

1. **GENERATORS—**

a. Must be located in a dry place.

b. Must be insulated on floors or base frames, which must be kept filled to prevent absorption of moisture, and also kept clean and dry.

* See Appendix for definitions of the word APPROVED and rules for the introduction of Automatic Fire Alarm Systems.

c. Must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings or combustible material.

d. Must each be provided with a waterproof covering.

2. **CARE AND ATTENDANCE.**—A competent man must be kept on duty in the room where generators are operating.

Oily waste must be kept in *approved* metal cans and removed daily.

3. **CONDUCTORS**— from generators, switchboards, rheostats or other instruments, and thence to outside lines—

a. Must be in plain sight, and readily accessible.

b. Must be wholly on non-combustible insulators, such as glass or porcelain.

c. Must be separated from contact with floors, partitions, or walls through which they may pass by non-combustible insulating tubes, such as glass or porcelain.

d. Must be kept rigidly so far apart that they cannot come in contact.

e. Must be covered with non-inflammable insulating material sufficient to prevent accidental contact, except that "bus bars" may be made of bare metal.

f. Must have ample carrying capacity, to prevent heating. (See Capacity of Wires Table.)

4. **SWITCHBOARDS—**

a. Must be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

b. Must be accessible from all sides when the connections are on the back; or may be placed against a brick or stone wall when the wiring is entirely on the face.

c. Must be kept free from moisture.

d. Must be made of non-combustible material, or of hard wood in skeleton form, filled to prevent absorption of moisture.

e. Bus bars must be equipped in accordance with Rule 3 for placing conductors.

5. **RESISTANCE BOXES AND EQUALIZERS—**

a. Must be equipped with metal or other non-combustible frames.

b. Must be placed on the switchboard, or, if not thereon, at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive, insulating material.

6. **LIGHTNING ARRESTERS—**

a. Must be attached to each side of

every overhead circuit connected with the station.

b. Must be mounted on non-combustible bases in plain sight on the switchboard, or in an equally accessible place, away from combustible material.

c. Must be connected with at least two "earths" by separate wires, not smaller than No. 6 B. & S., which must not be connected to any pipe within the building.

d. Must be so constructed as not to maintain an arc after the discharge has passed.

7. **TESTING.**

a. All series and alternating circuits must be tested every two hours while in operation to discover any leakage to earth, abnormal in view of the potential and method of operation.

b. All multiple-arc low-potential systems (300 volts or less) must be provided with an indicating or detective device, readily attachable, to afford easy means of testing where the station operates continuously.

c. Data obtained from all tests must be preserved for examination by insurance inspectors.

These rules on testing to be applied at such places as may be designated by the association having jurisdiction.

8. **MOTORS**—

a. Must be wired under the same precautions as with a current of the same volume and potential for lighting. The motor and resistance box must be protected by a double-pole cut-out and controlled by a double-pole switch.

b. Must be thoroughly insulated, mounted on filled dry wood, be raised at least eight inches above the surrounding floor, be provided with pans to prevent oil from soaking into the floor, and must be kept clean.

c. Must be covered with a waterproof cover when not in use, and, if deemed necessary by the Inspector, be enclosed in an *approved* case.

9. **RESISTANCE BOXES**—

a. Must be equipped with metal or other non-combustible frames.

b. Must be placed on the switchboard or at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive, insulating material.

CLASS B.

Arc (Series) Systems.

OVER 300 VOLTS.

10. **OUTSIDE CONDUCTORS.**—All outside overhead conductors (including services)—

a. Must be covered with some *approved* insulating material, not easily abraded, firmly secured to properly insulated and substantially built supports, all tie wires having an insulation equal to that of the conductors they confine.

b. Must be so placed that moisture cannot form a cross-connection between them, not less than a foot apart, and not in contact with any substance other than their insulating supports.

c. Must be at least seven feet above the highest point of flat roofs and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached.

d. Must be protected by *dead insulated guard irons* or *wires* from possibility of contact with other conducting wires or substances to which current may leak.

Special precautions of this kind must be taken where sharp angles occur or where any wires might possibly come in contact with electric light or power wires.

e. Must be provided with petticoat insulators of glass or porcelain. Porcelain knobs or cleats and rubber hooks will not be approved.

f. Must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered to insure preservation, and covered with an insulation equal to that on the conductors.

11. **SERVICE BLOCKS—**

a. Must be covered over their entire surface with at least two coats of waterproof paint.

b. Telegraph, telephone, and similar wires must not be placed on the same cross-arm with electric light or power wires.

12. **ALL INTERIOR CONDUCTORS—**

a. Must be covered where they enter buildings from outside terminal insulators to and through the walls with extra waterproof insulation, and must have drip loops outside. The hole through which the conductor passes must be bushed with waterproof and non-combustible insulating tube or hard rubber tube, slanting upward toward the inside. The tube must be sealed with tape, thoroughly painted, and securing the tube to the wire.

b. Must be arranged to enter and leave the building through a double contact service switch, which will effectually close the main circuit and disconnect the interior wires when it is turned "off." The switch must be so constructed that it shall be automatic in its action, not stopping between points when started, and prevent an arc between the points under all circumstances; it must indicate on inspection whether the current be "on" or "off," and be mounted in a non-combustible case, and kept free from moisture and easy of access to police or firemen.

c. Must be always in plain sight, and never encased, except when *required* by the Inspector.

d. Must be covered in all cases with an *approved* non-combustible material that will adhere to the wire, not fray by friction, and bear a temperature of 150° F. without softening.

e. Must be supported on glass or porcelain insulators, and kept rigidly at least eight inches from each other, except within the structure of lamps or on hanger boards, cut-out boxes, or the like, where less distance is necessary.

f. Must be separated from contact with walls, floors, timbers, or partitions through which they may pass by non-combustible insulating tube or hard-rubber tube.

g. Must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered to insure preservation, and covered with an insulation equal to that on the conductors.

13. **ARC LAMPS**—in every case—

a. Must be carefully isolated from inflammable material.

b. Must be provided at all times with a glass globe surrounding the arc, securely fastened upon a closed base. No broken or cracked globes to be used.

c. Must be provided with an *approved* hand switch, also an automatic switch, that will shunt the current around the carbons should they fail to feed properly.

d. Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.

e. Must be carefully insulated from the circuit in all their exposed parts.

f. Must be provided with a wire netting around the globe and an *approved* spark arrester above to prevent escape of sparks, melted copper or carbon, where readily inflammable material is in the vicinity of the lamps. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

g. Hanger-boards must be so constructed that all wires and current-carrying devices thereon shall be exposed to view, and thoroughly insulated by being mounted on a water-proof, non-combustible substance. All switches attached to the same must be so constructed that they shall be automatic in their action, not stopping between points when started, and preventing an arc between points under all circumstances.

14. **INCANDESCENT LAMPS IN SERIES CIRCUITS HAVING A MAXIMUM POTENTIAL OF 300 VOLTS OR OVER—**

a. Must be governed by the same rules as for arc lights, and each series lamp provided with an approved hand-spring switch and automatic cut-out.

b. Must have each lamp suspended from a hanger-board by means of a rigid tube.

c. No electro-magnetic device for switches and no system of multiple-series or series-multiple lighting will be approved.

d. Under no circumstances can series lamps be attached to gas fixtures.

CLASS C.

INCANDESCENT (LOW-PRESSURE) SYSTEMS.

300 VOLTS OR LESS.

15. **OUTSIDE OVERHEAD CONDUCTORS**—

a. Must be erected in accordance with the rules for arc (series) circuit conductors.

b. Must be separated not less than 12 inches, and be provided with an *approved* fusible cut-out that will cut off the entire current as near as possible to the entrance to the building and inside the walls.

16. **UNDERGROUND CONDUCTORS**—

a. Must be protected against moisture and mechanical injury, and be removed at least two feet from combustible material when brought into a building but not connected with the interior conductors.

b. Must have a switch and a cut-out for each wire between the underground conductors and the interior wiring when the two parts of the wiring are connected.

These switches and fuses must be placed as near as possible to the end of the underground conduit and connected therewith by specially insulated conductors, kept apart not less than two and a half inches.

c. Must not be so arranged as to shunt the current through a building aiound any catch-box.

17. At the entrance of every building there shall be an *approved* switch placed in the service conductors by which the current may be entirely cut off.

18. **CONDUCTORS**—

a. Must have an *approved* insulating covering, and must not be of sizes smaller than No. 14 B. & S., No. 16 B. W. G., or No. 4 E. S. G., except that, in conduit installed under Rule 22, No. 16 B. & S., No. 18 B. W. G., or No. 4 E. S. G. may be used.

b. Must be protected when passing through FLOORS, or through walls, partitions, timbers, etc., in places liable to be exposed to dampness by waterproof, non-combustible, insulating tubes, such as glass or porcelain.

Must be protected when passing through walls, partitions, timbers, etc., in places not liable to be exposed to dampness by *approved* insulating bushings specially made for the purpose.

c. Must be kept free from contact with gas, water, or other metallic piping, or any other conductors or conducting material which they may cross (except high potential conductors) by some continuous and firmly fixed non-conductor creating a separation of at least one inch. Deviations from this rule may sometimes be allowed by special permission.

d. Must be so placed in crossing high potential conductors that there shall be a space of at least one foot at all points between the high and low tension conductors.

e. Must be so placed in wet places that an air-space will be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run *over* all pipes upon which condensed moisture is likely to gather, or which by leaking might cause trouble on a circuit.

INSIDE WIRING—SPECIAL RULES.

19. **WIRING NOT ENCASED IN MOULDING OR APPROVED CONDUIT—**

a. Must be supported wholly on non-combustible insulators, constructed so as to prevent the insulating coverings of the wire from coming in contact with other substances than the insulating supports.

b. Must be so arranged that wires of opposite polarity, with a difference of potential of 150 volts or less, will be kept apart at least two and one half inches.

c. Must have the above distance increased proportionately where a higher voltage is used unless they are encased in moulding or approved conduit.

d. Must not be laid in plaster, cement, or similar finish.

e. Must never be fastened with staples.

IN UNFINISHED LOFTS, BETWEEN FLOOR AND CEILINGS, IN PARTITIONS AND OTHER CONCEALED PLACES—

f. Must have at least one inch clear air-space surrounding them.

g. Must be at least ten inches apart when possible, and should be run singly on separate timbers or studding.

h. Wires run as above immediately under roofs, in proximity to water tanks or pipes, will be considered as exposed to moisture.

i. Wires must not be fished for any great distance, and only in places where the Inspector can satisfy himself that the above rules have been complied with.

j. Twin wires must never be employed in this class of concealed work.

20. **MOULDINGS—**

a. Must never be used in concealed work or in damp places.

b. Must have at least two coats of waterproof paint or be impregnated with a moisture repellant.

c. Must be made of two pieces, a backing and capping, so constructed as to thoroughly encase the wire, and maintain a distance of one half-inch between conductors of opposite polarity, and afford suitable protection from abrasion.

21. **SPECIAL WIRING,**

In breweries, packing-houses, stables, dye-houses, paper and pulp mills, or other buildings specially liable to moisture or acid, or other fumes liable to injure the wires or insulation, except where used for pendants, conductors—

a. Must be separated at least six inches.

b. Must be provided with an approved waterproof covering.

c. Must be carefully put up.

d. Must be supported by glass or porcelain insulators. No switches or fusible cut-outs will be allowed where exposed to inflammable gases or dust, or to flyings of combustible material.

e. Must be protected when passing through floors, walls, partitions, timbers, etc., by waterproof, non-combustible, insulating tubes, such as glass or porcelain.

22. **INTERIOR CONDUITS** *—

a. Must be continuous from one junc-

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* The object of a tube or conduit is to facilitate the insertion or extraction of the conductors, to protect them from mechanical injury, and, as far as possible,

tion box to another, or to fixtures, and must be of material that will resist the fusion of the wire or wires they contain, without igniting the conduit.

b. Must not be of such material or construction that the insulation of the conductor will ultimately be injured or destroyed by the elements of the composition.

c. Must be first installed as a complete conduit system, without conductors, strings, or anything for the purpose of drawing in the conductors, and the conductors then to be pushed or fished in. The conductors must not be placed in position until all mechanical work on the building has been, as far as possible, completed.

d. Must not be so placed as to be subject to mechanical injury by saws, chisels, or nails.

e. Must not be supplied with a twin conductor, or two separate conductors, in a single tube.

f. Must have all ends closed with good adhesive material, either at junction boxes or elsewhere, whether such ends are con-

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from moisture. Tubes or conduits are to be considered merely as raceways, and are not to be relied on for insulation between wire and wire or between the wire and the ground.

cealed or exposed. Joints must be made air-tight and moisture-proof.

g. Conduits must extend at least one inch beyond the finished surface of walls or ceilings until the mortar or other similar material be entirely dry, when the projection may be reduced to half an inch.

23. **DOUBLE-POLE SAFETY CUT-OUTS—**

a. Must be in plain sight or enclosed in an approved box, readily accessible.

b. Must be placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller).

c. Must be supported on bases of non-combustible, insulating, moisture-proof material.

d. Must be supplied with a plug (or other device for enclosing the fusible strip or wire) made of incombustible and moisture-proof material, and so constructed that an arc cannot be maintained across its terminals by the fusing of the metal.

e. Must be so placed that on any combination fixture no group of lamps requiring a current of six amperes or more shall be ultimately dependent upon one cut-out. Special permission may be given *in writing* by the Inspector for departure from this rule in case of large chandeliers.

f. All cut-out blocks must be stamped

with their *maximum* safe carrying capacity in amperes, and *when installed* must be marked with the current they are intended to carry.

24. **SAFETY FUSES**—

a. Must all be stamped or otherwise marked with the number of amperes they will carry indefinitely without melting.

b. Must have fusible wires or strips (where the plug or equivalent device is not used), with contact surfaces or tips of harder metal, soldered or otherwise, having perfect electrical connection with the fusible part of the strip.

c. Must all be so proportioned to the conductors they are intended to protect that they will melt before the maximum safe carrying capacity of the wire is exceeded.

25. **TABLE OF CAPACITY OF WIRES**—

It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects, and not upon the amount of current to be used on the circuit. Below is a table showing the safe carrying capacity of conductors of different sizes in Birmingham, Brown & Sharpe, and Edison gauges, which must be followed in the placing of interior conductors:

Brown & Sharpe. Gauge No.	Amperes.	Birmingham. Gauge No.	Amperes.	Edison Standard. Gauge No.	Amp's.
0000	175	0000	175	200	175
000	145	000	150	180	160
00	120	00	130	140	135
0	100	0	110	110	110
1	95	1	95	90	95
2	70	2	85	80	85
3	60	3	75	65	75
4	50	4	65	55	65
5	45	5	60	50	60
6	35	6	50	40	50
7	30	7	45	30	40
8	25	8	35	25	35
10	20	10	30	20	30
12	15	12	20	12	20
14	10	14	15	8	15
16	5	16	10	5	10
18	3	18	5	3	5
		20	3	2	3

26. **SWITCHES—**

a. Must be mounted on moisture-proof and non-combustible bases, such as slate or porcelain.

b. Must be double-pole when the circuits which they control supply more than six 16 candle-power lamps, or their equivalent.

c. Must have a firm and secure contact, must make and break readily, and not stop when motion has once been imparted by the handle.

d. Must have carrying capacity sufficient to prevent heating.

e. Must be placed in dry, accessible places, and be grouped as far as possible, being mounted—when practicable—upon slate or equally non-combustible back-boards. Jack-knife switches, whether provided with friction or swing stops, must be so placed that gravity will tend to open rather than close the switch.

27. **FIXTURE WORK.**

a. In all cases where conductors are concealed within or attached to gas fixtures, the latter must be insulated from the gas-pipe system of the building by means of approved joints. The insulating material used in such joints must be of a substance not affected by gas, and that will not shrink or crack by variation in temperature. Insulating joints with soft rubber in their construction will not be approved.

b. Supply conductors, and especially the splices to fixture wires, must be kept clear of the grounded part of gas-pipes, and where shells are used the latter must be constructed in a manner affording sufficient area to allow this requirement.

c. When fixtures are wired outside, the conductors must be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture.

d. All conductors for fixture work must have a waterproof insulation that is durable and not easily abraded, and must not in any case be smaller than No. 18 B. & S., No. 20 B. W. G., or No. 2 E. S. G.

e. All burrs or fins must be removed before the conductors are drawn into a fixture.

f. The tendency to condensation within the pipes should be guarded against by sealing the upper end of the fixture.

g. No combination fixture in which the conductors are concealed in a space less than one-fourth inch between the inside pipe and the outside casing will be approved.

h. Each fixture must be tested for "contacts" between conductors and fixtures, for "short circuits," and for ground connections before the fixture is connected to its supply conductors.

i. Ceiling blocks of fixtures should be made of insulating material; if not, the wires in passing through the plate must be surrounded with hard-rubber tubing.

28. **ARC LIGHTS ON LOW-POTENTIAL CIRCUITS—**

a. Must be supplied by branch conductors not smaller than No. 12 B. & S. gauge.

b. Must be connected with main conductors only through double-pole cut-outs.

c. Must only be furnished with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as stoves.

Incandescent lamps must not be used for resistance devices.

d. Must be supplied with globes and protected as in the case of arc lights on high-potential circuits.

29. ELECTRIC GAS LIGHTING.

Where electric gas-lighting is to be used on the same fixture with the electric light—

a. No part of the gas-piping or fixture shall be in electrical connection with the gas-lighting circuit.

b. The wires used with the fixtures must have a non-inflammable insulation, or, where concealed between the pipe and shell of the fixture, the insulation must be such as required for fixture wiring for the electric light.

c. The whole installation must test free from "grounds."

d. The two installations must test perfectly free from connection with each other.

30. **SOCKETS—**

a. No portion of the lamp socket exposed to contact with outside objects must be allowed to come into electrical contact with either of the conductors.

b. In rooms where inflammable gases may exist, or where the atmosphere is damp, the incandescent lamp and socket should be enclosed in a vapor-tight globe.

31. **FLEXIBLE CORD—**

a. Must be made of conductors, each surrounded with a moisture-proof and non-inflammable layer, and further insulated from each other by a mechanical separator of carbonizable material. Each of these conductors must be composed of several strands.

b. Must not sustain more than one light not exceeding 50 candle-power.

c. Must not be used, except for pendants, wiring of fixtures, and portable lamps or motors.

d. Must not be used in show-windows.

e. Must be protected by insulating bushings where the cord enters the socket. The ends of the cord must be taped to prevent fraying of the covering.

f. Must be so suspended that the entire weight of the socket and lamp will be borne by knots under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws.

g. Must be equipped with keyless sockets as far as practicable, and be controlled by wall switches.

CLASS D.

ALTERNATING SYSTEMS. — CONVERTERS OR TRANSFORMERS.

32. **CONVERTERS**—

a. Must not be placed inside of any building, except the Central Station, unless by special permission of the Underwriters having jurisdiction.

b. Must not be placed in any but metallic or other non-combustible cases.

c. Must not be attached to the outside walls of buildings, unless separated therefrom by substantial insulating supports.

IN THOSE CASES WHERE IT MAY NOT BE POSSIBLE TO EXCLUDE THE CONVERTERS AND PRIMARY WIRES ENTIRELY FROM THE BUILDING, THE FOLLOWING PRECAUTIONS MUST BE STRICTLY OBSERVED—

33. Converters must be located at a point as near as possible to that at which the primary wires enter the building, and must be placed in a room or vault constructed of, or lined with, fire-resisting material, and used only for the purpose. They must be effectually insulated from

the ground, and the room in which they are placed be practically air-tight, except that it shall be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue.

34. **PRIMARY CONDUCTORS—**

a. Must each be heavily insulated with a coating of moisture-proof material from the point of entrance to the transformer, and, in addition, must be so covered and protected that mechanical injury to them or contact with them shall be practically impossible.

b. Must each be furnished, if within a building, with a switch and a fusible cut-out where the wires enter the building, or where they leave the main line, on the pole or in the conduit. These switches should be enclosed in secure and fireproof boxes preferably outside the building.

c. Must be kept apart at least ten inches, and at the same distance from all other conducting bodies when inside a building.

35. **SECONDARY CONDUCTORS—**

a. Must be installed according to the rules for "Low-Potential Systems."

CLASS E.

ELECTRIC RAILWAYS.

36. **All rules** pertaining to arc-light wires and stations shall apply (so far as possible) to street-railway power stations and their conductors in connection with them.

37. **POWER STATIONS**—

a. Must be equipped in each circuit as it leaves the station with an approved automatic "breaker" or other device that will immediately cut off the current in case the trolley wires become grounded. This device must be mounted on a fire-proof base and in full view and reach of the attendant.

38. **TROLLEY WIRES**—

a. Must be no smaller than No. 0 B. & S. copper or No. 4 B. & S. silicon bronze, and must readily stand the strain put upon them when in use.

b. Must be well insulated from their supports, and, in case of the side or double-pole construction, the supports shall also be insulated from the poles immediately outside of the trolley wire.

c. Must be capable of being disconnected at the power-house, or of being divided into sections, so that, in case of fire on the railway route, the current may be shut off from the particular section and not interfere with the work of the firemen. This rule also applies to *feeders*.

d. Must be safely protected against contact with all other conductors.

39. **CAR WIRING—**

a. Must be always run out of reach of the passengers, and must be insulated with a waterproof insulation.

40. **LIGHTING AND POWER FROM RAILWAY WIRES—**

a. Must not be permitted under any pretence in the same circuit with trolley wires with a ground return, nor shall the same dynamo be used for both purposes, except in street railway cars, electric car houses, and their power stations.

41. **CAR HOUSES—**

Must have special cut-outs located at a proper distance outside so that all circuits within any car house can be cut out at one point.

42. **GROUND RETURN WIRES.**

Where ground return is used it must be so arranged that no difference of potential will exist greater than five volts to 50 feet, or 50 volts to the mile, between any two points in the earth or pipes therein.

CLASS F.

43. **STORAGE OR PRIMARY BATTERIES.**

a. When current for light and power is taken from primary or secondary batteries the same general regulations must be observed as apply to similar apparatus fed from dynamo generators developing the same difference of potential.

b. All secondary batteries must be mounted on *approved* insulators.

c. Special attention is directed to the rules (page 73) for rooms where acid fumes exist.

d. The use of any metal liable to corrosion must be avoided in connections of secondary batteries.

44. **MISCELLANEOUS.**

a. The wiring in any building must test free from grounds, *i. e.*, each main supply line and every branch circuit shall have an insulation resistance of at least 25,000 ohms, and should have an insulation resistance between conductors and between all conductors and the ground (not including attachments, sockets, etc.) of not less than the following:

Up to	10 amperes	....	4,000,000
"	25 "	....	1,600,000
"	50 "	....	800,000
"	100 "	....	300,000
"	200 "	. .. .	160,000
"	400 "	....	80,000
"	800 "	....	22,000
"	1,600 "	....	11,000

All cut-outs and safety devices in place in the above.

Where lamp sockets, receptacles and electroliers, etc , are connected, one half of the above will be required.

b. Ground wires for lightning arresters of all classes and ground detectors must not be attached to gas-pipes within the building.

c. Where telephone, telegraph, or other wires connected with outside circuits are bunched together within any building, or where inside wires are laid in conduit or duct with electric light or power wires, the covering of such wires must be fire-resisting, or else the wires must be enclosed in an air-tight tube or duct.

d. All conductors connecting with telephone, district-messenger, burglar-alarm, watch-clock, electric-time, and other similar instruments, must be provided near the point of entrance to the building with some protective device which will operate to shunt the instruments in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor, through which it may become charged with a relatively high pressure.

e. The following formula for soldering fluid is suggested:

Saturated solution of zinc........	5 parts.
Alcohol..............................	4 parts.
Glycerine..........	1 part.

APPENDIX.

Definitions recommended by the Electrical Committee for the word APPROVED as used in the Rules of Electric Wiring recommended by the Underwriters' International Electric Association.

RULE 2. **CARE AND ATTENDANCE.**

Approved waste cans shall be made of metal, with legs raising can three inches from the floor, and with self-closing covers.

RULE 8. **MOTORS.**

Section *c.* From the nature of the question, the decision as to what is an *approved* case must be left to the Inspector to determine in each instance.

RULE 10. **OUTSIDE CONDUCTORS.**

Section *a.* Insulation that will be *approved* for service wires must be solid, at least $\frac{3}{64}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime water, with a current of 550 volts and after three minutes, electrification.

RULE 12. **INTERIOR CONDUCTORS.**

Section *d.* Insulation that will be *approved* for interior conductors must be solid, at least $\frac{3}{64}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime-water, with a current of 550 volts and after three minutes' electrification.

RULE 13. **ARC LAMPS.**

Section *c.* The hand switch to be *approved*, if placed anywhere except on the lamp itself, must comply with requirements for switches on hanger-boards as laid down in new Section (*g*) of Rule 13.

RULE 13. **ARC LAMPS.**

Section *f.* An *approved* spark arrester is one which will so close the upper orifice of the globe that it will be impossible for any sparks thrown off by the carbons to escape.

RULE 15. **OUTSIDE OVERHEAD CONDUCTORS.**

Section *b.* An *approved* fusible cut-out must comply with the sections of Rules 23 and 24 describing fuses and cut-outs.

RULE 17.

The switch required by this rule to be *approved* must be double pole, must plainly indicate whether the current is "on" or "off," and must comply with Sections *a*, *c*, *d*, and *e* of Rule 26 relating to switches.

RULE 18. **CONDUCTORS.**

Section *a*. In so-called "concealed" wiring, moulding, and conduit work, *and* in places liable to be exposed to dampness, the insulating covering of the wire, to be *approved*, must be solid, at least $\frac{3}{64}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime-water, with a current of 550 volts and after three minutes' electrification.

For work which is *entirely* exposed to view throughout the whole interior circuits, and not liable to be exposed to dampness, a wire with an insulating covering that will not support combustion, will resist abrasion, is at least $\frac{1}{16}$ of an inch in thickness, and thoroughly impregnated with a moisture repellent, will be *approved*.

RULE 18. **CONDUCTORS.**

Section *b*. Second paragraph. Except for FLOORS, *and* for places liable to be exposed to dampness, Glass, Porcelain, *metal-sheathed* Interior Conduit, and Vulca Tube, when made especially for bushings, will be approved.

The two last named will not be approved if cut from the usual lengths of tube made for conduit work, nor when made without a head or flange on one end.

RULE 21. **SPECIAL WIRING.**

Section *b*. The insulating covering of the wire to be *approved* under this section must be solid, at least $\frac{3}{64}$ of an inch in thickness, and covered with a substantial braid. It must not readily carry fire, must show an insulating resistance of one megohm per mile after two weeks' submersion in water at 70 degrees Fahrenheit, and three days' submersion in lime-water with a current of 550 volts after three minutes' electrification, and must *also* withstand a satisfactory test against such chemical compounds or mixtures as it will be liable to be subjected to in the risk under consideration.

RULE 23. **DOUBLE POLE SAFETY CUT-OUTS.**

Section *a*. To be *approved*, boxes must be constructed, and cut-outs arranged, whether in a box or not, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

RULE 27. **FIXTURE WORK.**

Section *a*. Insulating joints to be *approved* must be entirely made of material that will resist the action of illuminating gases, and will not give way or soften under the heat of an ordinary gas flame. They shall be so arranged that a deposit of moisture will not destroy the insulating effect, and shall have an insulating resistance of 250,000 ohms between the gas-pipe attachments, and be sufficiently strong to resist the strain they will be liable to in attachment.

RULE 37. **POWER STATIONS.**

Section *a*. Automatic circuit-breakers should be submitted to the Committee for *approval* before being used.

RULE 43. **STORAGE OR PRIMARY BATTERIES.**

Section *b*. Insulators for mounting secondary batteries to be *approved* must be non-combustible, such as glass, or thoroughly vitrified and glazed porcelain.

Recommendations of the Electrical Committee as to approval of certain wires and materials, and the interpretation of certain rules.

RULE 4. **SWITCH-BOARDS.**

Section *a*. Special attention is called to the fact that switch-boards should not be built down to the floor, nor up to the ceiling, but a space of at least eighteen inches, or two feet, should be left between the floor and the board, and between the ceiling and the board, in order to prevent fire from communicating from the switch-board to the floor or ceiling, and also to prevent the forming of a partially concealed space very liable to be used for storage of rubbish and oily waste.

RULE 5. **RESISTANCE BOXES.**

Section *a*. The word "frame" in this section relates to the entire case and surrounding of the rheostat, and not alone to the upholding supports.

RULE 9. **RESISTANCE BOXES.**

Section *a*. The word "frame" in this section relates to the entire case and surrounding of the rheostat, and not alone to the upholding supports.

CLASS B.

It is the sense of the Electrical Committee that any circuit attached to any machine or combination of machines, which develop over 300 volts difference of potential between any two wires, shall be considered as a high potential circuit and coming under that class, unless an *approved* transforming device is used, which cuts the difference of potential down to less than 300 volts.

RULE 10. **OUTSIDE CONDUCTORS.**

Section *f.* It is the sense of the Electrical Committee that all joints must be soldered, even if made with the McIntyre or any other patent splicing device. This ruling applies to joints and splices in all classes of wiring covered by these Rules.

RULE 15. **OUTSIDE OVERHEAD CONDUCTORS.**

Section *b.* The cut-out required by this section must be placed so as to protect the switch required by Rule 17.

RULE 16. **UNDERGROUND CONDUCTORS.**

Section *b.* The cut-out required by this section must be placed so as to protect the switch.

RULE 22. **INTERIOR CONDUITS.**

It is recommended that the American Circular Loom Co. Tube, the *metal-sheathed* Interior Conduit Tube, and the Vulca Tube be approved for the class of work called for in this rule.

MATERIALS.

The following are given as a list of non-combustible, non-absorptive, insulating materials, and are listed here for the benefit of those who might consider hard rubber, fiber, wood, and the like, as fulfilling the above requirements. Any other substance which it is claimed should be accepted, must be forwarded for testing before being put on the market.

1. Thoroughly vitrified and glazed Porcelain.
2. Glass.
3. Slate without metal veins.
4. Pure Sheet Mica.
5. Marble (filled).
6. Lava (certain kinds of).

WIRES.

The following is a list of wires which have been tested by the Committee and found to comply with the requirements for an approved insulation under Rule 10 (*a*), Rule 12 (*d*), and Rule 18 (*a*).

Americanite.
Bishop.
Canvasite.
Clark.
Edison Machine.
Grimshaw (white core).
Habirshaw (red core).

Kerite.

National India Rubber Co. (N. I. R.).

Okonite.

Paranite.

Raven Core.

Safety Insulated { Requa white core. / Safety black core. }

Salamander (rubber covered).

Simplex (caoutchouc).

None of the above wires to be used unless protected with a substantial *braided* outer covering.

Rules Recommended by the Electrical Committee for the Introduction of Automatic Fire-alarm Systems.

THERMOSTATS must be placed—

1. Not more than 15 feet apart.

2. Not more than 10 feet from any side of any room.

3. Not more than 5 feet from any side of any room having windows or similar openings.

4. In every room in the building which is separated by partitions running from the floor to the ceiling.

5. At the top of each elevator well and hoistway in the building.

6. In any particular places required by the Inspector of the Association.

7. In buildings of so-called bay construction, so that there shall be a line in each bay, unless the thermostats are placed on a level with the lower side of the timbers forming the bays.

WIRES INSIDE BUILDINGS—

1. Must be equivalent in conductivity and tensile strength to No. 18 B. & S. copper wire,

2. Must have an approved insulating covering.

3. Unless encased in metal pipes, ap-

proved tubing, or thoroughly filled moulding, must be run in plain sight and supported entirely on non-combustible insulators.

4. Must be protected from abrasion and from accidental contact with other conductors.

WIRES OUTSIDE BUILDINGS—

1. Must be equivalent in conductivity and tensile strength to No. 12 galvanized iron wire.

2. Must have an approved insulating covering.

3. Must have their routes recorded by plans filed at the Central station of the alarm company operating them.

4. Must be provided near the point of entrance to the building with some protective device, which will operate to shunt the inside wires and apparatus in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow.

MANUAL ALARMS—

Must be located near all main and floor exits.

ALARM GONGS—

Must be installed in all buildings having a watchman.

IN SYSTEMS OPERATING WITHOUT A CENTRAL STATION there shall be—

1. An annuuciator on the outside of each risk.

2. A gong not less than seven inches in diameter on the outside of each risk.

3. Some means by which the entire system can be tested daily, and also some method by which any trouble which may arise will be located by this test.

4. At least two outside connections, besides the gong on the outside of the building itself. As a general rule these should be selected from the following list, taking the first two that are possible in any particular risk:

   (*a*) The nearest fire department house where there are permanent men stationed.

   (*b*) The house of the owner, or some responsible employee of the risk equipped, which must be within reasonable distance of the risk.

   (*c*) The house of some other party as described in Section (*b*).

   (*d*) In some of the larger cities with paid city fire-departments the first connection alone may be accepted.

5. A metallic circuit for the whole system.

NOTE.—It will be seen that the above rules do not in any way relate to what systems shall be approved. The Committee have not yet found it possible to enter into this subject, or to formulate detailed rules as to what a system shall accomplish or how it shall do it, or what the construction of the thermostats and other apparatus should be.

These rules simply relate to how a system which *has been approved* by any Board or Association should be installed so as to secure the best and most permanent efficiency from such system, regardless of the merits or demerits of the system itself.

THE following tables, calculated from Kennelly's formula, give the increase of drop due to impedance in circuits carrying alternating currents.

Each table is for a different frequency, as given: the first vertical column of a table gives the gauge of wire, the horizontal column at the top the distance apart of the two wires of a circuit, and the other columns the coefficients by which the drop due to a continuous current should be multiplied to find the true drop if an alternating current is used.

To lower the drop due to impedance it will be seen that large wires should be avoided. In inside work, particularly, a considerable saving of copper may often be made by dividing the feeders or mains into several circuits.

The following method will enable the tables to be applied with an approximation sufficiently close for practical purposes:

1° By means of one of the formulas on pages 11, 12, and 13 calculate, for the given lamps, amperes, or horse-power, the size of the wire (in circular mils) as if a continuous current were to be used, and from Table IX. find the nearest corresponding B. & S. gauge number.

2° Enter with the gauge thus found that one of the following tables which corresponds with the periodicity used and take out the corresponding coefficient.

3° Multiply the original circular mils by this coefficient and find the corresponding gauge again from Table IX.

4° Repeat the operation of 2°.

5° Multiply the original circular mils by this second coefficient and proceed otherwise as in 3°.

EXAMPLE. Amperes, 20; volts, 1000; drop, 5 per cent; distance, 4000 feet; periodicity, 130; distance of wires apart, 18 inches.

1° From formula (2), page 11,

$$A = \frac{2150LC}{aE} = \frac{2150 \times 4000 \times 20}{5 \times 1000} = 34400$$

or about No. 5 B. & S. gauge.

2° Referring to Table XXIII., we get the coefficient 1.38.

3° $34400 \times 1.38 = 47472$ cir. mils, or between gauges 3 and 4.

4° Referring to Table XXIII., we find the corresponding coefficient to be about 1.44.

5° $34400 \times 1.44 = 49536$, or about gauge No. 3.

If thought necessary a third or fourth approximation may be made by repeating the operations indicated in 4° and 5°.

The above rules and the tables apply to alternating currents that can be represented by simple sine waves (sinusoids). If the current waves are of more complex type, the drop due to impedance will be increased. The above values are therefore minimum values.

The tables are based on the assumption that the current density in a conductor remains uniform. With the frequencies used the error thus introduced is entirely negligible as relates to the calculation of impedances, as well as to the increase of drop due to the unequal distribution of current in a conductor.

TABLE XIX.
40 PERIODS PER SECOND.

Gauge B. & S.	Distance between Wires.											
	3″	6″	9″	12″	18″	24″	36″	48″	60″	100′	500′	1000′
0000	1.38	1.55	1.65	1.73	1.85	1.93	2.05	2.13	2.21	3.13	3.64	3.87
000	1.27	1.39	1.47	1.53	1.61	1.68	1.76	1.82	1.90	2.59	2.99	3.10
00	1.17	1.25	1.30	1.34	1.39	1.44	1.50	1.54	1.58	2.13	2.39	2.50
0	1.12	1.19	1.23	1.25	1.30	1.33	1.38	1.41	1.44	1.83	2.06	2.17
1	1.09	1.13	1.15	1.18	1.20	1.23	1.26	1.28	1.30	1.58	1.75	1.83
2	......	1.09	1.11	1.12	1.14	1.16	1.18	1.20	1.21	1.41	1.53	1.59
3	......	......	......	......	1.09	1.10	1.12	1.13	1.14	1.28	1.37	1.41
4	......	......	......	......	......	......	......	......	1.09	1.19	1.25	1.26
5	......	......	......	......	......	......	......	......	......	1.12	1.17	1.19
6	......	......	......	......	......	......	......	......	......	......	1.11	1.12
8	......	......	......	......	......	......	......	......	......	......	......	......

TABLE XX.
60 PERIODS PER SECOND.

Gauge B. & S.	Distance between Wires.											
	3″	6″	9″	12″	18″	24″	36″	48″	60″	100′	500′	1000′
0000	1.74	2.03	2.21	2.35	2.53	2.67	2.86	3.00	3.09	4.55	5.35	5.70
000	1.54	1.76	1.90	2.00	2.14	2.25	2.39	2.49	2.57	3.71	4.34	4.58
00	1.36	1.51	1.61	1.67	1.77	1.84	1.95	2.03	2.08	3.00	3.37	3.42
0	1.27	1.37	1.46	1.52	1.60	1.66	1.74	1.80	1.85	2.51	2.89	3.05
1	1.19	1.27	1.33	1.36	1.42	1.46	1.53	1.57	1.60	2.10	2.38	2.52
2	1.14	1.19	1.23	1.26	1.29	1.32	1.36	1.40	1.42	1.79	2.01	2.10
3	1.09	1.13	1.15	1.18	1.20	1.22	1.25	1.27	1.29	1.56	1.72	1.79
4	......	1.09	1.10	1.12	1.14	1.15	1.17	1.19	1.20	1.38	1.50	1.53
5	......	......	......	......	1.09	1.10	1.11	1.12	1.13	1.27	1.34	1.38
6	......	......	......	......	......	......	......	......	1.09	1.18	1.23	1.61
8	......	......	......	......	......	......	......	......	......	......	1.10	1.12

TABLE XXI.

80 PERIODS PER SECOND.

Gauge B. & S.	Distance between Wires.											
	3″	6″	9″	12″	18″	24″	36″	48″	60″	100′	500′	1000′
0000	2.10	2.56	2.82	3.00	3.26	3.40	3.71	3.90	4.06	6.01	7.08	7.54
000	1.86	2.18	2.38	2.51	2.72	2.87	3.06	3.19	3.31	4.87	5.71	6.04
00	1.61	1.81	1.95	2.05	2.20	2.30	2.45	2.56	2.63	3.91	4.42	4.69
0	1.46	1.64	1.75	1.83	1.94	2.03	2.14	2.23	2.30	3.31	3.86	4.46
1	1.32	1.45	1.53	1.59	1.67	1.74	1.84	1.89	1.93	2.66	3.05	3.23
2	1.23	1.32	1.38	1.42	1.48	1.53	1.59	1.65	1.68	2.22	2.53	2.66
3	1.16	1.23	1.26	1.29	1.34	1.37	1.42	1.45	1.48	1.88	2.11	2.43
4	1.11	1.15	1.18	1.20	1.23	1.25	1.29	1.31	1.33	1.62	1.79	1.84
5	......	1.11	1.12	1.14	1.16	1.17	1.19	1.21	1.23	1.43	1.56	1.62
6	......	......	......	1.09	1.11	1.12	1.13	1.14	1.15	1.30	1.38	1.42
8	......	......	......	......	......	......	......	......	......	1.13	1.17	1.19

TABLE XXII.

100 PERIODS PER SECOND.

Gauge B. & S.	Distance between Wires.											
	3″	6″	9″	12″	18″	24″	36″	48″	60″	100′	500′	1000′
0000	2.58	3.12	3.44	3.67	4.00	4.24	4.57	4.81	5.02	7.48	8.82	9.40
000	2.20	2.61	2.88	3.05	3.32	3.52	3.75	3.94	4.07	6.04	7.10	7.51
00	1.84	2.13	2.32	2.45	2.64	2.77	2.97	3.11	3.21	4.88	5.47	5.81
0	1.66	1.90	2.05	2.16	2.31	2.43	2.58	2.69	2.78	3.98	4.63	4.91
1	1.48	1.65	1.75	1.84	1.95	2.07	2.18	2.24	2.32	3.23	3.74	3.98
2	1.34	1.47	1.55	1.61	1.70	1.76	1.85	1.92	1.96	2.67	3.07	3.24
3	1.24	1.34	1.39	1.43	1.50	1.54	1.60	1.65	1.69	2.23	2.53	2.67
4	1.17	1.23	1.27	1.30	1.35	1.38	1.42	1.46	1.49	1.88	2.11	2.17
5	1.11	1.17	1.19	1.21	1.24	1.26	1.29	1.32	1.34	1.62	1.80	1.87
6	1.09	1.11	1.13	1.14	1.16	1.18	1.20	1.21	1.23	1.43	1.56	1.62
8	.....	......	......	......	......	......	......	1.09	1.10	1.20	1.26	1.29

TABLE XXIII.

130 PERIODS PER SECOND.

Gauge B. & S.	Distance between Wires.											
	3″	6″	9″	12″	18″	24″	36″	48″	60″	100′	500′	1000′
0000	3.25	3.97	4.40	4.70	5.14	5.45	5.89	6.20	6.48	9.68	11.4	12.2
000	2.73	3.29	3.65	3.88	4.23	4.49	4.80	5.05	5.23	7.81	9.19	9.72
00	2.23	2.65	2.90	3.08	3.35	3.51	3.77	3.95	4.09	6.22	7.06	7.51
0	2.00	2.34	2.53	2.68	2.88	3.04	3.24	3.39	3.51	5.10	5.96	6.33
1	1.73	1.98	2.13	2.24	2.43	2.53	2.71	2.79	2.89	4.13	4.79	5.10
2	1.54	1.72	1.84	1.93	2.04	2.13	2.25	2.36	2.41	3.37	3.91	4.14
3	1.38	1.53	1.60	1.67	1.76	1.82	1.92	1.98	2.04	2.77	3.19	3.37
4	1.27	1.37	1.43	1.47	1.54	1.59	1.65	1.70	1.74	2.30	2.62	2.71
5	1.19	1.26	1.30	1.33	1.38	1.41	1.46	1.50	1.53	1.94	2.19	2.29
6	1.14	1.17	1.20	1.23	1.26	1.29	1.32	1.34	1.37	1.67	1.85	1.93
8	......	......	......	......	1.09	1.13	1.15	1.16	1.17	1.32	1.41	1.45

DIAGRAMS.

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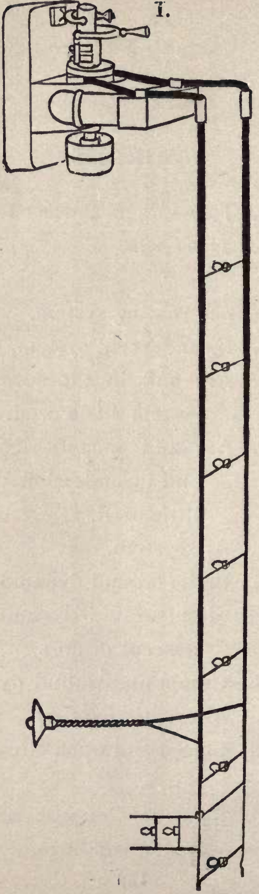

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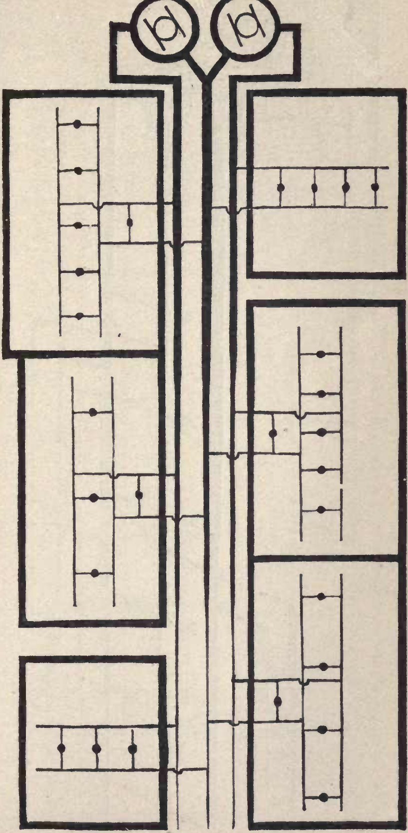

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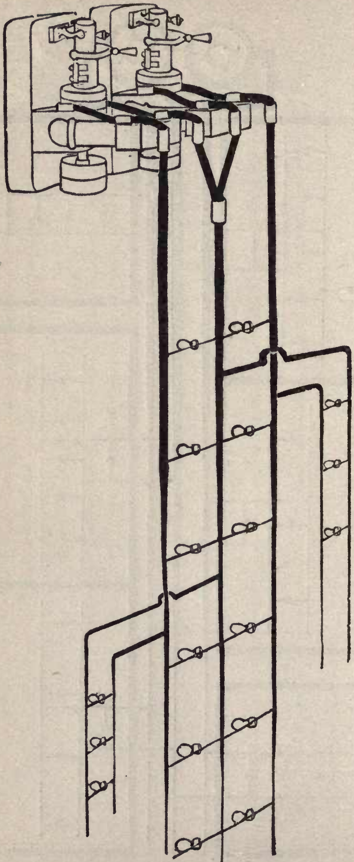

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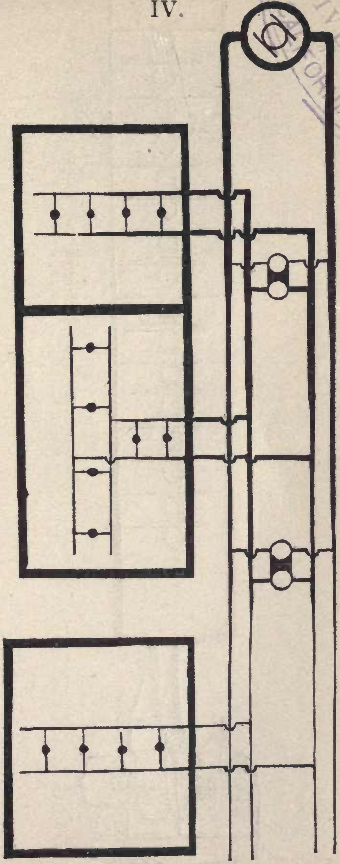

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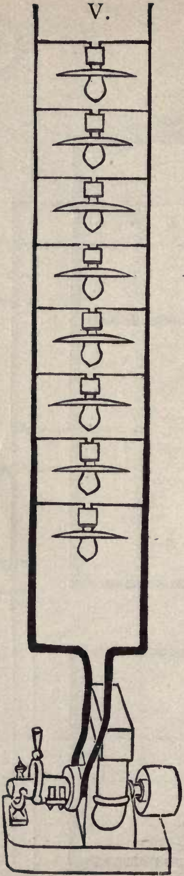

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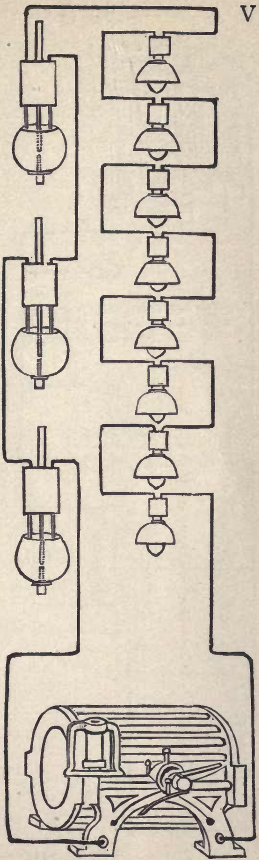

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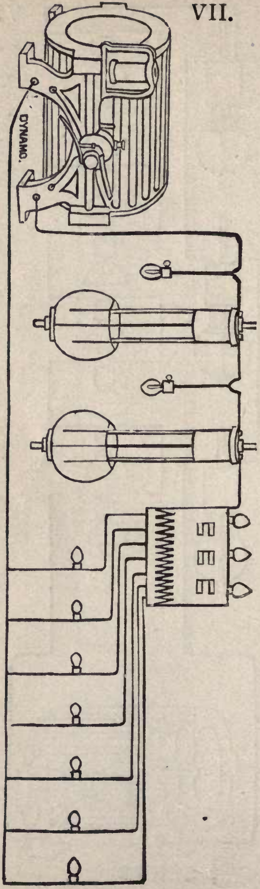

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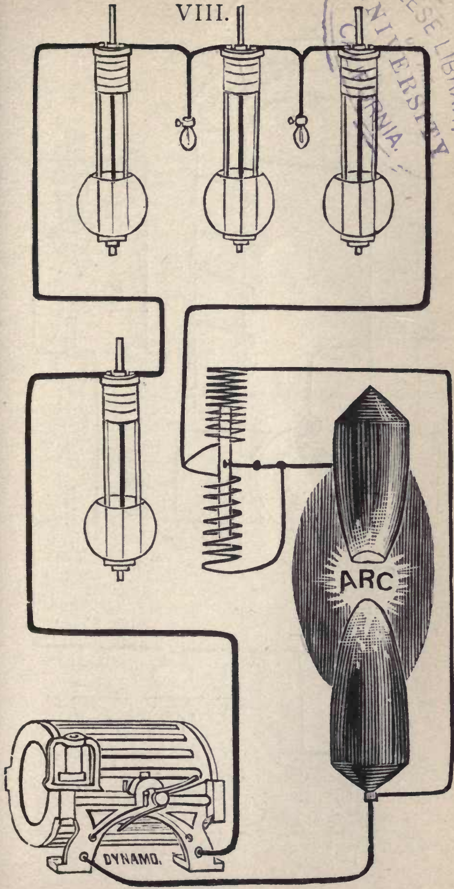

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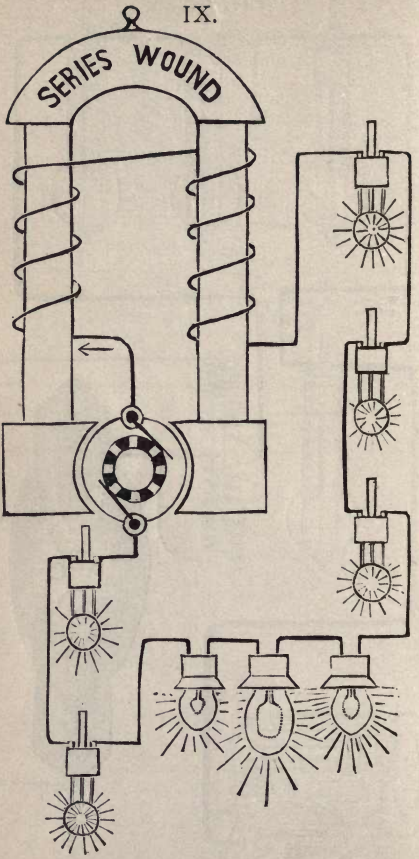

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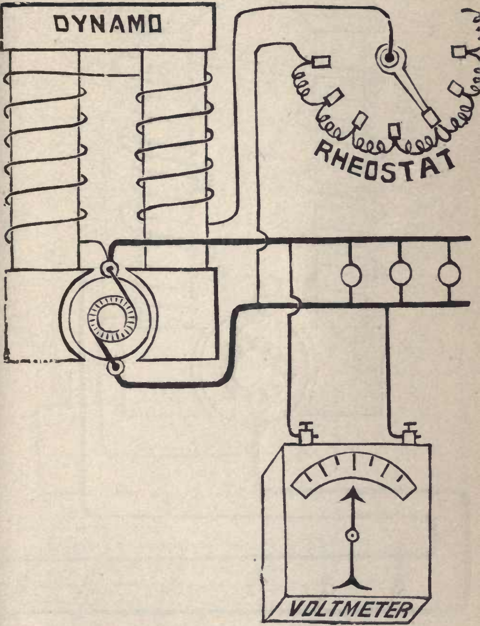

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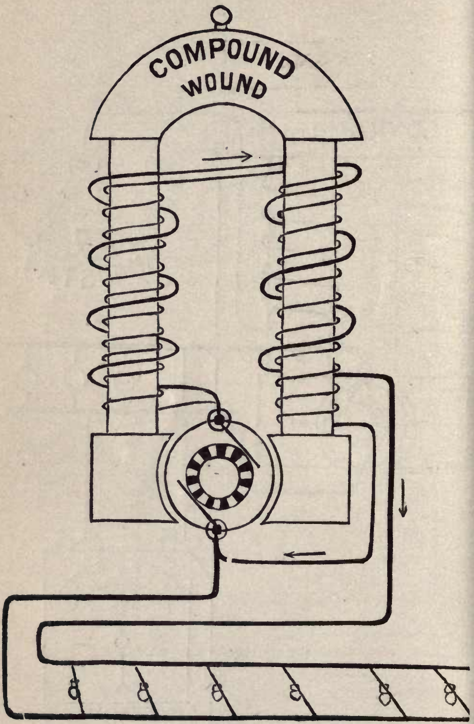

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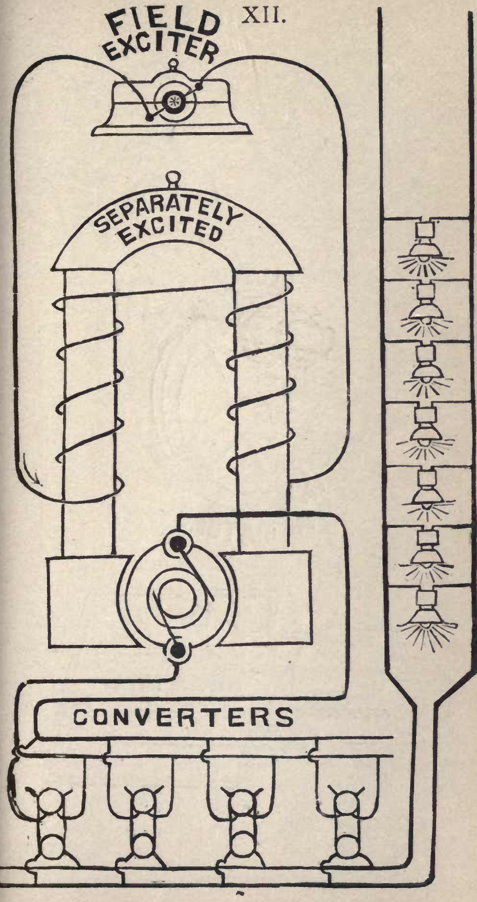

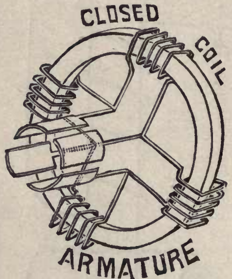
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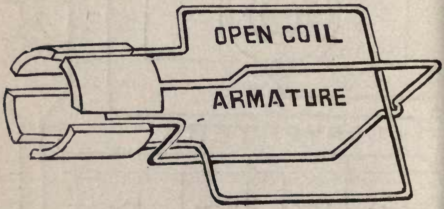
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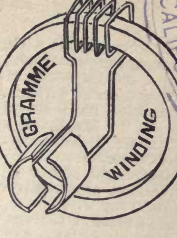

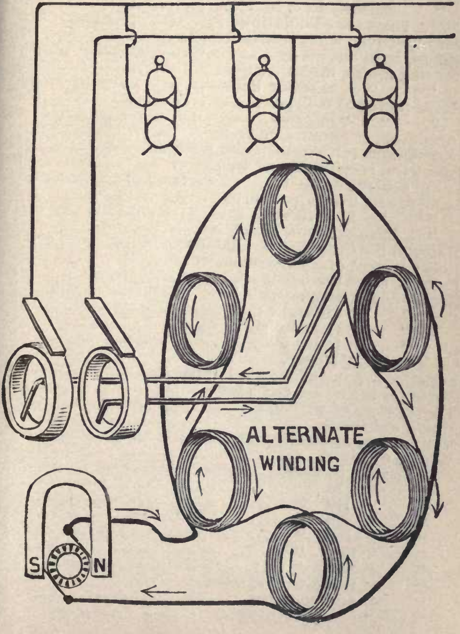

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