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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter Circular
LC 224

(February 21, 1927)

FORMULAS AND TABLES FOR THE CALCULATION OF ANTENNA CAPACITY.*

Contents

1. Introduction

The capacities of the common forms of antennas used in radio transmission and reception may be calculated from the formulas herein. In addition to the formulas, tables (Nos. 2, 4 and 9) are given by which capacities may be obtained directly without calculation, for three kinds of antennas; these are the single-wire horizontal, single-wire vertical, and two-wire horizontal.

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These formulas were derived by two methods, one being Howe's method, the other being the reciprocal relation between capacity and inductance. Howe's method makes the calculations on the preliminary assumption of a uniform distribution of charge along the antenna, the potential being calculated on this basis at various points of the antenna and the average of these potentials being taken as the final equilibrium potential. The reciprocal relation method is the less general in its applicability, but in those cases where its use may be justified it agrees exactly with Howe's method. A scientific paper explaining the methods of calculation and giving a discussion of their justification is in preparation.

2. Formulas for Calculating Capacity of Various Forms of Antennas.

In the following formulas the capacity is in micromicrofarads (10^{-12} farads); logarithms are to the base 10. Ample accuracy in the values of the logarithms will be attained by the use of a four-place table, although, if a five-place table be employed, interpolations will be unnecessary. Linear dimensions are given both in centimeters and in feet. The use of subscripts, as explained below, will make clear which system is meant in all cases. However, where the ratio of two dimensions is used as a parameter, either system may be used, as long as both dimensions are expressed in the same system, and this fact will be indicated by the omission of subscripts.

The following nomenclature is common to practically all the formulas. Other symbols are explained where they occur.

d = diameter of wire

D = distance between centers of parallel wires

U = potential coefficient for unit charge density per unit length of the antenna

C = capacity, in micromicrofarads

ℓ_1 = length of a horizontal wire, in centimeters

m_1 = length of a vertical wire, in centimeters

ℓ_2 = length of a horizontal wire, in feet

m_2 = length of a vertical wire, in feet

h_1 = height of a horizontal wire above earth, in centimeters

h_2 = height of a horizontal wire above earth, in feet

h'_1 = height of lower end of a vertical wire above earth, in centimeters

h'_2 = height of lower end of a vertical wire above earth, in feet

n = number of wires joined in parallel

a. Single Horizontal Wire.

$$C = \frac{0.2416\,\ell_1}{\log \frac{4h}{d} - K} = \frac{7.36\,\ell_2}{\log \frac{4h}{d} - K} \qquad (13)$$

where[1] K is to be taken from Table 1 for either the ratio $\frac{2h}{\ell}$ or

1 The number (13) is given to the first formula because that is the number in the more complete paper, of which this Letter Circular is a portion.

$\frac{\ell}{2h}$, depending upon which is less than unity.

In Table 2 are given values of the capacity of single-wire horizontal antennas of various lengths and heights. This should be useful in certain practical cases.

Example 1.- For a single wire 100 feet long, stretched 50 feet above ground, and assuming the diameter of the wire to be 0.24 inch = 0.02 ft., we find $\frac{4h}{d} = \frac{200}{0.02} = 10.000$, and thus $\log \frac{4h}{d} = 4000$. The value of $\frac{2h}{\ell}$ is $\frac{100}{100} = 1$, and from Table 1, K = 0.336.

Thus

$$C = \frac{7.36\ (100)}{3.664} = 200.9\ \mu\mu f.$$

This value is in agreement with that calculated from Howe's tables.

b. Single Vertical Wire.[2]

The wire is supposed to have a length m and its lower end is at a height h' above the surface of the earth.

$$C = \frac{0.2416\ m_1}{\log \frac{2m}{d} - k} = \frac{7.36\ m_2}{\log \frac{2m}{d} - k} \qquad (14)$$

in which the constant k is to be obtained from Table 3 for the value of $\frac{h'}{m}$ or $\frac{m}{h'}$ depending upon which is less than unity.

2 Caution: The formula for the capacity does not apply for the limiting case where the distance between the lower end of the vertical wire and the earth is vanishingly small, but an error of not more than a few per cent results if this distance is as small as one foot.

Example 2.- Suppose a vertical wire 40 ft. long, with its lower end 10 ft. from the ground. The diameter of the wire will be taken as 0.24 inch as in the preceding example.

Thus in formula (14) we have $m = 40$, $h' = 10$, $\frac{2m}{d} = 4000$

$\log_{10} \frac{2m}{d} = 3.602$. From Table 3, with $\frac{h'}{m} = 0.25$, $k = 0.291$, and thus

$$C = \frac{7.36\ (40)}{3.602 - 0.291} = 88.9\ \mu\mu f$$

In Table 4 is given the capacity of vertical wires covering a considerable range of lengths, diameters, and heights above the ground.

c. Single Wire Inverted L Antenna [2]

Suppose the length of the horizontal portion is ℓ, that of the vertical portion m, the height of the vertical portion from the ground h', and thus the height of the horizontal portion is $h = h'+m$. Then the capacity is given by

$$C = \frac{0.2416\ (\ell_1 + m_1)}{U} = \frac{7.36\ (\ell_2 + m_2)}{U}$$

in which

$$U = \frac{\ell}{\ell + m}\left[\log \frac{4h}{d} - K\right] + \frac{m}{\ell + m}\left[\log \frac{2m}{d} - k\right] + X \qquad (15)$$

The term X takes into account the mutual effect of the two portions of the antenna. Its value is obtained from Table 5 for different values of the ratios $\frac{\ell}{m}$ $\frac{m}{\ell}$, and $\frac{h'}{m}$ or $\frac{m}{h'}$. The values of K and k are to be taken from Tables 1 and 3, respectively, as in the preceding examples.

As a first approximation the capacity of the inverted L may be calculated as the sum of the capacities of the component wires taken separately. This approximate method always gives a value larger than the true values.

Example 3.- Let us consider an inverted L antenna made up of the horizontal wire treated in example 1, and the vertical wire of example 2. Then $\ell = 100$, $m = 40$, $h'=10$, $d = 0.24$ inch,

$\frac{\ell}{\ell + m} = \frac{100}{140} = \frac{5}{7}$, $\frac{m}{\ell + m} = \frac{2}{7}$. With $\frac{m}{\ell} = 0.4$, $\frac{h'}{m} = 0.25$ in Table 5

we find $X = 0.194$. Thus $U = \frac{5}{7}(3.664) + \frac{2}{7}(3.311) + 0.194 = 3.757$

and
$$C = \frac{7.36\ (140)}{3.757} = 274.3\ \mu\mu f$$

The simple sum of the separate capacities of the horizontal and vertical portions is 289.8, which is more than five per cent. too large.

d. Single Wire T Antenna.

The antenna consists of a horizontal wire of length ℓ at a height h above the ground. To the center of this is attached a vertical wire of length m. The height of the lower end of this above ground is denoted by h'. The capacity is calculated from the formula

$$C = \frac{0.2416\ (\ell_1 + m_1)}{U'} = \frac{7.36\ (\ell_2 + m_2)}{U'} \tag{16}$$

in which

$$U' = \frac{\ell}{\ell + m}\left(\log\frac{4h}{d} - K\right) + \frac{m}{\ell + m}\left(\log\frac{2m}{d} - k\right) + \frac{\ell + 2m}{\ell + m} \cdot X_1$$

The constants K, k, and X_1 are to be taken from Tables 1, 3 and 5 respectively, the latter for the argument $\frac{m}{\ell}$ = ratio of m and $\frac{\ell}{2}$.

Example 4.- Consider a T antenna made up of the horizontal and vertical wires of examples 1 and 2. Then $\ell = 100$, $m=40$, $h'=10$, $d = 0.24$ in., $\frac{\ell}{\ell + m} = \frac{5}{7}$, $\frac{m}{\ell + m} = \frac{2}{7}$, $\frac{\ell + 2m}{\ell + m} = \frac{9}{7}$. From Table 5, with the argument $\frac{m}{\ell} = 0.8$, $\frac{h'}{m} = 0.25$, $X = 0.263$. Thus $U' = 3.901$, and therefore

$$C = \frac{7.36\ (140)}{3.901} = 264.2\ \mu\mu f$$

If the simple sum of the separate capacities of the component wires had been used the error would have been about ten per cent.

It is interesting to note that for the given horizontal wire joined to the given vertical wire the capacity is about 3.5 per cent smaller with the wires connected as a T antenna than as an inverted L, and for both these cases the capacity is less than the sum of the capacities of the wires taken separately. This follows from the fact that the potential of the charge of each wire is increased by the proximity of the charge on the other wire. On the average the two wires of the T antenna are closer together than the two parts of the inverted L, and the mutual effect of the two wires is therefore greater in the former case.

e. Parallel Horizontal Wires in the Same Horizontal Plane. (Flat-Top Antenna).

The wires are supposed to have a diameter d, and to be of equal length ℓ. They will be assumed to be n in number, arranged parallel to one another in a horizontal plane, at a height h above the surface of the earth. If the spacing is D, the width of the

antenna between the extreme wires is (n-1)D, and this dimension is supposed to be not greater than about one quarter of the length of the wires. The formula for the capacity is then

$$C = \frac{0.2416\, l_1}{F} = \frac{7.36\, l_2}{F}\ \mu\mu f \qquad (17)$$

in which

$$F = \frac{P + (n-1)Q}{n} - K_n$$

$$P = \log\frac{4h}{d} - K$$

$$Q = \log\frac{2h}{D} - K$$

The constant K_n, which depends only upon the number of the wires, may be obtained from Table 6; the constant K is to be taken from Table 1, as in preceding examples. The expression for F may also be written

$$F = \frac{\log\frac{4h}{d} + (n-1)\log\frac{2h}{D}}{n} - (K + K_n) \qquad (17a)$$

For the common case of a two-wire flat top antenna, K_n=0, and the general formula (17) becomes

$$C = \frac{14.73\, l_2}{\log\frac{4h}{d} + \log\frac{2h}{D} - 2K} \qquad (18)$$

In Table 9 will be found the values of the capacity of certain two-wire antennas. This should be useful where a moderate accuracy will suffice.

Example 5.- A flat-top antenna is composed of 6 wires spaced 2 feet apart, the length of the wires being 100 feet, their height 50 feet, and their diameter 0.24 inch as before. D = 2, $\frac{4h}{d}$ =10000,

$\frac{2h}{D} = 50$, $\frac{2h}{l} = 1$. From Table 1, K=0.336, and from Table 6, K_n=0.252.

Thus, using the last form (17a) for F, its value is obtained as follows:

$\log\frac{4h}{d} = 4.000$ $\qquad K + K_n = 0.588$

$5\log\frac{2h}{D} = 8.495$ $\qquad F = 1.494$

Sum ÷ 6 = 2.082

and the capacity is $C = \frac{7.36\,(100)}{1.494} = 492.6\ \mu\mu f$

Example 6.- Attention has been called to the small gain from the use of many wires in parallel. Thus Austin states that, for parallel wires of moderate dimensions, a spacing of one meter is sufficient to give 90% of the possible capacity. This assumes a certain width of antenna which is kept constant as more wires are added. As an illustration of this point, the capacity was calculated for different numbers of wires, each 100 feet long, 0.24 inch in diameter, placed 50 feet above the earth, the spacing being chosen in each case such that for n wires nD = 15 feet. The results are given in table 10.

Table 10.

n	C $\mu\mu f$	Per cent of maximum	n	C $\mu\mu f$	Per cent of maximum	n	C $\mu\mu f$	Per cent of maximum
2	330.5	51.0	9	565.7	87.2	17	609.8	94.0
3	408.7	62.9	10	577.2	89.0	18	611.8	94.4
4	460.6	70.9	11	582.7	89.8	19	613.8	94.7
5	495.7	76.3	12	588.8	90.6	20	615.9	94.9
			13	594.0	91.5	30	626.4	96.5
6	520.5	80.2	14	598.9	92.3	40	635.0	97.9
7	539.6	83.2	15	602.8	92.9	50	637.8	98.5
8	554.2	85.4	16	606.3	93.5	100	643.9	99.3

When these values of the capacity are plotted against the reciprocal of the number of the wires, a limiting capacity of about 650 $\mu\mu f$ is indicated. This value has been used in computing the values in the column headed "per cent of maximum". A spacing of one meter would be obtained with five or six wires, the capacity being some 80 per cent of the maximum. Even with so few as two wires, the capacity is about 50% of the maximum, and if the two wires were placed 15 feet apart, instead of only 7.5, as in the table the capacity would be 354.4, or 54 per cent of the maximum.

These conclusions were checked by deriving the formula for the capacity of a horizontal rectangular plate having a length ℓ, a width nD, and a thickness d, situated at a height h above the earth. The treatment of this case was based upon the integration of the Howe expression (3) for a filament of length ℓ over the width of the rectangle. The final formula, which is long and involved, will not be given here (see appendix 1). For the dimensions assumed in the previous example the limiting capacity should be 635 micro-microfarads. The difference of more than one per cent between this value and that given above, is probably to be explained by the fact that the ratio of width to length is rather large in this special case, and that the terms neglected in (17) are appreciable. For the more favorable case nD = 5, ℓ = 100, formula (17) gives for a 100 wire antenna C = 455.7 $\mu\mu f$, while the value for the solid rectangular plate is 454.7 $\mu\mu f$.

f. Antenna of Parallel Wires Equally Spaced in a Vertical Plane.

Adopting the same nomenclature as in the preceding case, we find, for an antenna where the extreme width is not greater than, say, one quarter of the length of the wires

$$C = \frac{0.2416 \ell_1}{V} = \frac{7.36 \ell_2}{V}$$

in which

$$V = \frac{1}{n} \log \frac{2m}{d} + \frac{n-1}{n} \log \frac{m}{D} - (k + K_n) \quad (19)$$

The quantities k and K_n are to be obtained from Tables 3 and 6, respectively.

Example 7.- For six vertical wires, each 40 ft. long, arranged with a spacing of 2 feet, and with the bottom ends of the wires 10 ft. above the ground, m = 40, D = 2, h'= 10. Assume d = 0.02 ft.

As in example 2, k=0.291, $K_n = 0.252$, $\frac{m}{D} = 20$, $\log \frac{m}{D} = 1.301$

$\log \frac{2m}{d} = 3.601$, so that

$$\frac{1}{n} \log \frac{2m}{d} = 0.600 \qquad k + K_n = 0.543$$

$$\frac{n-1}{n} \log \frac{m}{D} = 1.118 \qquad V = 1.175$$

$$C = \frac{7.36(140)}{1.175} = 250.6 \ \mu\mu f.$$

g. Parallel Wire Inverted L Antenna.

With the length of the horizontal portion equal ℓ, length of the vertical wires m, height of horizontal wires h, height of lower ends of the vertical wires h', spacing of wires D,

$$C = \frac{0.2416 (\ell_1+m_1)}{L} = \frac{7.36 (\ell_2+m_2)}{L}$$

in which

$$L = \frac{P' + (n-1) Q'}{n} - K_n + X \quad (20)$$

$$P' = \frac{\ell}{\ell+m} (\log \frac{4h}{d} - K) + \frac{m}{\ell+m} (\log \frac{2m}{d} - k)$$

$$Q' = \frac{\ell}{\ell+m} (\log \frac{2h}{D} - K) + \frac{m}{\ell+m} (\log \frac{m}{D} - k)$$

The constants K, k, X, and K_n are to be taken from Tables 1,3,5 and 6, respectively. This formula is less accurate, the wider the antenna in comparison with its length.

Example 8.- Suppose a parallel wire inverted L antenna composed of the wire systems of examples 5 and 7, joined to form one conducting system.

Then
$$P' = 2.617 + 0.946 = 3.563$$
$$Q' = 0.974 + 0.289 = 1.263$$
$$K_n = 0.252 \qquad X = 0.194$$

Therefore
$$L = 1.588, \text{ and } C = \frac{7.36\ (140)}{1.588} = 648.9\ \mu\mu f$$

The sum of the separate capacities of the horizontal and vertical portions is 743.2, which is more than 14 per cent too large.

h. Parallel Wire T Antenna.

The antenna is supposed to be composed of n similar T's joined in parallel. Thus the horizontal wires have the same spacing as the vertical. The total length of the horizontal portion is taken as ℓ , the meaning of the other symbols is the same as in the preceding cases.

$$C = \frac{0.2416\ (\ell_1+m_1)}{T} = \frac{7.36\ (\ell_2+m_2)}{T}$$

$$T = \frac{P' + (n-1)Q'}{n} - K_n + \frac{\ell + 2m}{\ell + m} \cdot X \qquad (21)$$

$$P' = \frac{\ell}{\ell + m} \left(\log \frac{4h}{d} - K\right) + \frac{m}{\ell + m} \left(\log \frac{2m}{d} - k\right)$$

$$Q' = \frac{\ell}{\ell + m} \left(\log \frac{2h}{D} - K\right) + \frac{m}{\ell + m} \left(\log \frac{m}{D} - k\right)$$

The constants K, k, X, and K_n are to be obtained from Tables 1,3,5, and 6, respectively, using for X the ratio of $\frac{\ell}{2}$ to m for $\frac{\ell}{m}$ in Table 5.

Example 9.- A T antenna is made by joining the vertical wires of example 7 to the middle points of the horizontal wires of example 5. The constants are the same as in the preceding example, except that X = 0.263. The value of T comes out 1.732, so that

$$C = \frac{7.36\ (140)}{1.732} = 594.9$$

which is more than 8 per cent less than the value for the inverted L. The following summary presents concisely the results of the

examples.

Horizontal Parallel Portion Alone	492.6 μμf
Vertical " " "	250.6 "
	743.2
Same Wires Connected as Inverted L Antenna	648.9
Same Wires Connected as a T Antenna	594.9

i. Horizontal "Cage" Antenna.

The following formula supposes that the distance between the n wires is small compared with their average distance from the ground. The axis of the cage is at a height h above ground.

$$C = \frac{0.2416 \ell_1 n}{U_c} = \frac{7.36 \ell_2 n}{U_c} \tag{22}$$

in which

$$U_c = \log \frac{4h}{d} + \sum_{r=1}^{r=n-1} \left(\log \frac{2h}{D_r} + 0.434 \frac{D_r}{\ell}\right) - nK$$

and D_r is the distance between any given wire and another wire.

If δ = the diameter of the circle on whose circumference the wires are arranged, then

$$D_r = \delta \sin r \frac{\pi}{n}$$

The quantity K is obtained from Table 1 for the given value of $\frac{\ell}{2h}$ or $\frac{2h}{\ell}$.

Example 10.- Six wires, each 100 feet long and 0.02 foot in diameter are arranged as elements of a cylinder 5 feet in diameter. The axis of the cylinder lies horizontally 50 feet above the surface of the earth.

Here $n = 6$, $\delta = 5$, $h = 50$, $\frac{2\ell}{d} = 10000$. The distances between the wires are then $D_1 = D_5 = 2.5$, $D_2 = D_4 = \frac{5}{2}\sqrt{3}$, $D_3 = 5$.

From Table 1 for $\frac{2h}{\ell} = 1$, $nK = 2.016$

$$\log \frac{4h}{d} = 4.000 \qquad 0.434 \frac{D_1}{\ell} = 0.011$$

$$\log \frac{2h}{D_1} = 1.602 \qquad 0.434 \frac{D_2}{\ell} = 0.018$$

$\log \frac{2h}{D_2} = 1.364$ $0.434 \frac{D_3}{\ell} = 0.022$

$\log \frac{2h}{D_3} = 1.301$ $\therefore U_c = 9.297$

$$C = \frac{7.36 \ (100) \ 6}{9.297} = 475.0 \ \mu\mu f$$

If the same wires had been spaced at the same distance apart in the horizontal plane as the length of the chord of the circle the capacity by formula (17) would have been 520.5 $\mu\mu$f. Thus the arrangement in a cage results here in a loss of capacity of about eight per cent. This is due to the decrease in the average distance between wires brought about by the arrangement in the cage. The advantage of this form of antenna lies of course in the saving of space.

Formula (22) was derived on the assumption that the effect of the earth can be evaluated with sufficient accuracy by assuming the charges on the image wires and the charges on the wires of the cage to be situated along the axis of the image and the cage of the axis. To determine the order of the error committed, an accurate evaluation was made of the effect of the image wires, using the antenna of the preceding example. It was found that, although the potentials, contributed by the image wires together, differed by as much as 5 per cent for the different wires of the cage, the total effect did not differ as much as one part in ten thousand from that calculated by the simplifying assumption used in deriving formula (22).

j. Vertical "Cage" Antenna.

The n wires of diameter d and length m are arranged as elements of a cylinder of diameter δ, whose axis is vertical, and whose lower end is at a height h' above the ground.

$$C = \frac{0.2416 \ n \ m_1}{U'_c} = \frac{7.36 \ n \ m_2}{U'_c} \qquad (23)$$

and

$$U'_c = \log \frac{2m}{d} + \sum_{r=1}^{r=n-1} \left(\log \frac{m}{D_r} + 0.434 \frac{D_r}{m}\right) - nk$$

The value of k is obtained from Table 3, and the distance D_r between any two wires is given by

$$D_r = \delta \sin r \frac{\pi}{n}$$

Example 11.- Six vertical wires, each 100 feet long, and 0.02 feet in diameter are arranged as elements of a cylinder, four feet in diameter, with their lower ends 25 feet from the ground. Thus $m=100$, $h'=25$, $\delta=4$, $d=0.02$, and $\frac{2m}{d} = 10000$, $\frac{h'}{m} = \frac{1}{4}$.

From Table 3, k = 0.291.

Accordingly $D_1 = D_5 = 2$, $D_2 = D_4 = 2\sqrt{3}$, $D_3 = 4$.

$$\log \frac{2m}{d} - nk = 4.000 - 1.748 = 2.252$$

$$\sum \log \frac{m}{D_r} = 2\ (1.699 \div 1.460) + 1.398 = 7.716$$

$$0.434 \sum \frac{D_r}{m} = 0.065$$

$$\therefore U'_c = 10.033$$

and $$C = \frac{7.36\ (600)}{10.033} = 440.2\ \mu\mu f.$$

k. Single V Antenna.

The antenna is supposed to consist of two wires in a horizontal plane meeting at an angle θ. The lengths of the wires are ℓ and m, their diameters d and d' and their common height above ground h.

Then
$$C = \frac{0.2416\ (\ell_1+m_1)}{U_v} = \frac{7.36\ (\ell_2+m_2)}{U_v} \qquad (24)$$

where $$U_v = \frac{\ell}{\ell + m}\left(\log \frac{4h}{d} - K\right) + \frac{m}{\ell + m}\left(\log \frac{4h}{d'} - K'\right) + Y$$

The quantities K and K' are to be obtained from Table 1 for the values of $\frac{2h}{\ell}$ and $\frac{2h}{m}$ respectively, (or their reciprocals if the latter are less than unity).

The quantity Y is the difference of two terms Y_1 and Y_2, the first being a function of the angle θ and the ratio $\frac{m}{\ell}$ (supposed to be less than unity), while Y_2 which refers to the effect of the earth is a function of θ, $\frac{m}{\ell}$ and $\frac{2h}{\ell}$. Values of Y_1 and Y_2 are given in Tables 7 and 8.

If both wires have the same diameter of cross section, then

$$U_v = \log \frac{4h}{d} - \frac{\ell}{\ell+m} K - \frac{m}{\ell+m} K' + Y \qquad (25)$$

and if, further, $m = \ell$, (an important case)

$$U_v = \log \frac{4h}{d} - K + Y \qquad (26)$$

Since in the case of existing antennas, the distance between the free ends of the V will be readily measured, rather than the angle, the distance s, thus measured may be used in the formula

$$\cos \theta = \frac{\ell^2 + m^2 - S^2}{2\ell m}$$

to determine the angle θ.

Example 12.- If we suppose the case ℓ =100, m=50, h=50, $\theta = 45°$, and $\frac{4h}{d} = 10000$, then $\frac{2h}{\ell} = 1$, $\frac{m}{2h} = \frac{1}{2}$, and from Table 1 $K = 0.336$, $K' = 0.541$. From Table 7, for $\theta = 45°$, and $\frac{m}{\ell} = \frac{1}{2}$ $Y_1 = 0.497$, and from Table 8 for $\theta = 45°$, $\frac{m}{\ell} = \frac{1}{2}$, and $\frac{2h}{\ell} = 1$, $Y_2 = 0.131$. Thus $Y = 0.366$. By formula (25)

$$U_v = 4.000 + 0.366 - \frac{2}{3}(0.336) - \frac{1}{3}(0.341) = 3.962.$$

$$C = \frac{7.36\ (150)}{3.962} = 278.6\ \mu\mu f.$$

The sum of the capacities of the two wires taken singly is (see example 1) 200.9 + 106.4 = 307.3 μμf. Thus the mutual effect of the two wires is to reduce the capacity of the combination in a V by about 9.3 per cent.

1. Two Horizontal Wires Inclined to One Another, but Not Intersecting.

The wires are supposed to have lengths ℓ and m, diameters d and d', and their distances from their point of intersection, if supposed to be produced, ℓ' and m', (see Fig.2).

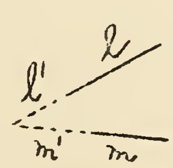

Fig. 2.

For this case the same formula is used as in the preceding case, except that the value for Y is different. This is obtained as before as the difference of two terms, one applying to the top and the other to the image wires. Tables 7 and 8 are used, but instead of a single entry in the table for each of the two terms Y_1 and Y_2, several have to be made for each.

$$Y = \frac{\ell + \ell' + m + m'}{\ell + m} \cdot Y_{\ell+\ell', m+m'} - \frac{(\ell + \ell' + m')}{\ell + m} \cdot Y_{\ell+\ell', m'}$$

$$- \frac{(\ell' + m + m')}{\ell + m} Y_{\ell', m+m'} + \frac{\ell' + m'}{\ell + m} Y_{\ell', m'} \qquad (27)$$

In this the following abbreviated nomenclature is used:- $Y_{\ell+\ell', m+m'}$ is used for the difference between the value of Y_1 for the wires $(\ell + \ell')$ and $(m + m')$ and the quantity Y_2 for the same wires, etc. For $\ell' = m' = n$,

$$Y = \frac{\ell + m + 2n}{\ell + m} Y_{\ell+n, m+n} - \frac{(\ell + 2n)}{\ell + m} Y_{\ell+n, n} - \frac{(m + 2n)}{\ell + m} Y_{n, m+n}$$

$$+ \frac{2n}{\ell + m} Y_{n,n} \qquad (28)$$

and for the specially important case that $\ell' = m' = n$, and $\ell = m$,

$$Y = \frac{\ell + 2n}{\ell} (Y_{n,n} - Y_{\ell+n,n}) \qquad (29)$$

Example 13.- Two wires of equal length 100 feet make an angle of 30°, and if prolonged until they intersect, the point of intersection is 100 feet from the nearer end of each. The wires have each a diameter of cross section of 0.02 foot, and they lie in a horizontal plane 50 feet above the ground.

Here $\ell = m = 100$, $h = 50$, $d = 0.02$, $\ell' = m' = n = 100$, $\theta = 30°$. Then for $Y_{n,n}$ we have the argument (1, 30°) in Table 7, and 1, 30°, and $\frac{2h}{\ell} = 1$ in Table 8. Thus $Y_{n,n} = 0.687 - 0.197 = 0.490$. For $Y_{\ell+n,n}$ the argument in Table 7 is $(\frac{1}{2}, 30°)$, and in Table 8 $(\frac{1}{2}, 30, \frac{1}{2})$, so that $Y_{\ell+n,n} = 0.601 - 0.187 = 0.414$. Thus

$$Y = \frac{\ell+2n}{\ell}(Y_{n,n} - Y_{\ell+n,n}) = 3(0.490-0.414) = 0.228$$

and

$$U_v = \log\frac{4h}{d} - K + Y = 4.000 - 0.336 + 0.228 = 3.892$$

and

$$C = \frac{7.36\ (200)}{3.892} = 378.2\ \mu\mu f.$$

Each of the wires alone has a capacity of 200.9 $\mu\mu$f, (see example 1), so that the sum of their individual capacities is 401.8 $\mu\mu$f. Thus the mutual effect of the wires is to reduce the capacity by about six per cent.

If the same wires were so placed as to have their ends in contact, still keeping the angle between them equal to 30°, then $Y = 0.687 - 0.197 = 0.490$, $U_v = 4.154$, and $C = 354.4\ \mu\mu f$. The mutual effect here is nearly twelve per cent, or nearly twice as great as in the previous case.

m. <u>Single Wire Inclined to the Earth's Surface</u>.

The wire is assumed to have a length ℓ, a diameter of cross section d, and to make an angle θ with the earth's surface. Let the height of the lower end be h' above the ground. Then the capacity is given by

$$C = \frac{0.2416\,\ell_1}{U_s} = \frac{736\,\ell_2}{U_s} \qquad (30)$$

and

$$U_s = \left(\log\frac{2\ell}{d} - 0.133\right) - \frac{\ell+2n}{\ell}(Y'_{n,n} - Y'_{\ell+n,n})$$

The quantities Y'_{nn} and $Y'_{\ell+n,n}$ are to be taken from Table 7 using the angle 2θ and $n = \frac{h'}{\sin\theta}$. (It is to be noted that the constants here require no entries in Table 8 as in the preceding example.)

When θ = 90°, this case goes over into that of a single vertical wire. The angle in Table 7 is 180°, n = h', and it can be shown that the above formula checks with that given for the single vertical wire.

<u>Example 14.</u>- Suppose a wire 50 feet long, making an angle of 45° with the earth's surface, the distance of the lower end from the ground being $25\,\frac{\sqrt{2}}{2} = 17.68$ feet. Then n = 25. Let the diameter of cross section be taken such that $\frac{2\ell}{d} = 5000$. Then the first term of U_s is (3.699 - 0.133) = 3.566. For Y'_{nn} the argument

in Table 7 is (1, 90°) so that $Y'_{nn} = 0.383$. For $Y'_{\ell+n,n}$, the argument is $(\frac{1}{3}, 90°)$, and the same table gives $Y'_{\ell+n,n} = 0.304$. Thus the second term in U_s is $2(0.383 - 0.304) = 2(0.079) = 0.158$. Therefore, $U_s = 3.408$ and $C = 108.0$ μμf.

If the same wire were swung about its lower end as center until it reached the vertical position, then we would have to use $\frac{h'}{\ell} = \frac{25}{50}\frac{\sqrt{2}}{2} = \frac{1}{4}\sqrt{2} = 0.354$, and for this Table 3 gives k = 0.269. The capacity comes out 107.3 μμf.

If the same wire were swung about the lower end into a horizontal position, $h = \frac{25\sqrt{2}}{2}$, $\frac{2h}{\ell} = \frac{\sqrt{2}}{2}$, and from Table 1, K = 0.256, the resulting capacity being 111.8 μμf. Thus the capacity of the inclined wire lies between the values corresponding to the vertical and horizontal positions, as would be expected.

n. Parallel Wire V Antenna.

The antenna is supposed to consist of n' wires of equal length ℓ' and diameter d', joined to another set of n" wires of equal length ℓ'' and diameter d". Each of these sets of wires is supposed to lie in a horizontal plane at a height h above the ground and the axes of the two sets meet at an angle θ, at a point situated at distances ℓ'_o and ℓ''_o, respectively, from the nearer ends of the sets of wires. Let the spacing of the wires in the two sets be D' and D".

The capacity is given by

$$C = \frac{0.2416\,(n'\ell_1' + n''\ell_1'')}{U'_v} = \frac{7.36\,(n'\ell_2' + n''\ell_2'')}{U'_v} \qquad (31)$$

in which

$$U'_v = \frac{n'\ell'}{n'\ell' + n''\ell''}\,u' + \frac{n''\ell''}{n'\ell' + n''\ell''}\,u'' + \frac{n'\,n''\,(\ell'\,\ell'')}{n'\ell' + n''\ell''}\cdot Y$$

$$u' = \log\frac{4h}{d'} + (n'-1)\log\frac{2h}{D'} - n'\,(K' + K'_n)$$

$$u'' = \log\frac{4h}{d''} + (n''-1)\log\frac{2h}{D''} - n''\,(K'' + K''_n)$$

The constants K' and K" are to be obtained from Table 1 for the arguments $\frac{2h}{\ell'}$ and $\frac{2h}{\ell''}$, respectively, and the constants K'_n and K''_n

from Table 6 for the values of n' and n". The last term in U'_V takes account of the mutual effect between one set of wires and the other set and its image. This is obtained on the assumption that the effect is sensibly the same as though the two sets of wires were replaced by wires along the axes of the parallel sets and carrying the same total charges as the parallel wire sets. The error due to this simplifying assumption will not amount to as much as one per cent in most practical cases.

To calculate Y we have the equation

$$Y = \frac{\ell'+\ell_0'+\ell''+\ell_0''}{\ell'+\ell''} Y(\ell'+\ell_0', \ell''+\ell_0'') - \frac{(\ell'+\ell_0'+\ell_0'')}{\ell'+\ell''} Y(\ell'+\ell_0', \ell_0'')$$
$$- \frac{(\ell_0'+\ell''+\ell_0'')}{\ell'+\ell''} Y(\ell_0', \ell''+\ell_0'') + \frac{\ell_0'+\ell_0''}{\ell'+\ell''} Y(\ell_0', \ell_0'') \quad (31a)$$

each of the terms being the difference of two quantities Y_1 and Y_2 taken from Tables 7 and 8, respectively, for the arguments θ, and the ratio of the lengths which appear in the parentheses which follow the symbol Y in the formula, and for the value of 2h divided by the greater of the two lengths in each case.

In most practical cases, however, there will be simplifying conditions. The following are the most important of these special cases.

When the wires have all the same diameter, the same spacing, and the number in each leg of the V is the same, then d' = d" = d, D' = D" = D, n' = n" = n. The capacity is now

$$C = \frac{0.2416\,(\ell_1'+\ell_1'')}{U'} = \frac{7.36\,(\ell_2'+\ell_2'')}{U'} \quad (32)$$

with

$$U' = \frac{\log\frac{4h}{d} + (n-1)\log\frac{2h}{D}}{n} - \frac{\ell'}{\ell'+\ell''}K_1 - \frac{\ell''}{\ell'+\ell''}K_2 - K_n + Y$$

As the simplest cases of all, we may assume, in addition, that the wires of the two legs of the V have the same length ℓ, and that their ends have the same distance from the intersection of their axes, that is, $\ell' = \ell'' = \ell$, $\ell_0' = \ell_0'' = \ell_0$. Then in formula (32)

$$U' = \frac{\log\frac{4h}{d} + (n-1)\log\frac{2h}{D}}{n} - (K + K_n) + Y \quad (33)$$

and

$$Y = \frac{\ell+2\ell_0}{\ell}\left[Y(\ell_0, \ell_0) - Y(\ell+\ell_0, \ell_0)\right]$$

Example 15.- As an illustration of the preceding formulas we may take the case of a parallel wire V antenna, each leg consisting of six wires of diameter 0.02 ft., spaced 2 feet apart; the whole antenna is supposed to be in a plane 50 ft. above the ground. Suppose further, that the length of the wires in one set is 100 ft. and those of the other set 50 ft., and that the point of the intersection of the axes of the two sets is respectively 50 and 25 feet from the nearer ends of the two legs, their angle being 45°.

Then $\ell' = 100$, $\ell_o' = 50$, $\ell'' = 50$, $\ell_o'' = 25$, $D = 2$, $n = 6$, $d = 0.02$, $\Theta = 45°$.

From Table 1, for $\frac{2h}{\ell'} = 1$, $K' = 0.336$, and for $\frac{2h}{\ell} = \frac{1}{2}$, $K''=0.541$,

so that

$$U' = \frac{4.000 + 5(1.699)}{6} - \frac{2}{3}(0.336) - \frac{1}{3}(0.541) - 0.252 + Y$$

To calculate Y we have

$$\frac{\ell''+\ell_o''}{\ell'+\ell_o'} = \frac{75}{150} = \frac{1}{2} \qquad \frac{\ell_o''}{\ell'+\ell_o'} = \frac{25}{150} = \frac{1}{6} \qquad \frac{\ell_o'}{\ell''+\ell_o''} = \frac{50}{75} = \frac{2}{3} \qquad \frac{\ell_o''}{\ell_o'} = \frac{25}{50} = \frac{1}{2}$$

$$\frac{2h}{\ell'+\ell_o'} = \frac{100}{150} = \frac{2}{3} \qquad \frac{2}{3} \qquad \frac{2h}{\ell''+\ell_o''} = \frac{100}{75} = \frac{4}{3} \qquad \frac{2h}{\ell_o'} = \frac{100}{50}$$

Y_1 =	0.497	0.286	0.535	0.497
Y_2 =	0.150	0.050	0.117	0.070
Diff.=	0.347	0.236	0.418	0.427

$$\frac{\ell'+\ell_o'+\ell''+\ell_o''}{\ell'+\ell''} = \frac{225}{150} = \frac{3}{2} \qquad \frac{\ell'+\ell_o'+\ell_o''}{\ell'+\ell''} = \frac{175}{150} = \frac{7}{6} \qquad \frac{\ell_o'+\ell''+\ell_o''}{\ell'+\ell''} = \frac{125}{150} = \frac{5}{6} \qquad \frac{\ell_o'+\ell_o''}{\ell'+\ell''} = \frac{75}{150} = \frac{1}{2}$$

$$Y = \frac{3}{2}(0.347) - \frac{7}{6}(0.275) - (0.418)\frac{5}{6} + \frac{1}{2}(0.427) = 0.112$$

and finally $U' = 1.538$ $\qquad C = \frac{7.36\ (150)}{1.538} = 717.3\ \mu\mu f.$

The capacity calculated by simply adding the capacities of the legs taken separately is 778.1 $\mu\mu f$, so that the mutual effect of the two legs is to reduce the capacity by about 8 per cent. If the ends of the two legs came together, so that $\ell_o' = \ell_o'' = 0$, and we would find from Tables 7 and 8 that $Y_1 = 0.497$, $Y_2 = 0.131$, so that $Y = 0.366$, and the capacity comes out 616.1 $\mu\mu f$.

o. Antenna of Parallel Wires in a Plane Inclined to Ground.

The antenna is supposed to consist of n wires spaced a distance D apart, the whole set being situated in a plane making an angle Θ with the surface of the earth. The wires have each a diameter d and are of equal length ℓ, while the lower ends of the wires are

at a height h' above the ground.

The capacity is calculated by the formula

$$C = \frac{0.2416\ell_1}{U_i} = \frac{7.36\ell_2}{U_i} \tag{34}$$

in which

$$U_i = \frac{\log \frac{2\ell}{d} + (n-1)\log \frac{\ell}{D}}{n} - (0.133 + K_n) - Y'$$

The term Y', which takes into account the effect of the charges upon the earth, is calculated on the assumption that its value is closely given by supposing the wire charges and image charges to be concentrated along the axes of the set of wires and the images, respectively. Its value is obtained by formula (29), using Table 7.

Example 16.- Suppose 6 wires spaced 2 feet apart, in a plane inclined 45° to the ground. The wires are of diameter 0.02 ft., and 50 ft. long, and their lower ends are 50 ft. above the ground. Then $\frac{2\ell}{d} = 5000$, $\frac{\ell}{D} = 25$, $K_n = 0.252$. To calculate Y' we use formula (29), The distance $\ell' = 50\sqrt{2}$, $\frac{\ell'}{\ell+\ell'} = 0.586$. Then from Table 7 for the argument (1, 90°) we find $Y(\ell', \ell') = 0.383$, and for the argument (0.586, 90°) we find $Y(\ell_0', \ell+\ell') = 0.361$, so that $Y' = \frac{(50 + 100\sqrt{2})}{50}(0.022) = 0.084$.

Then

$$U_i = \frac{3.699 + 5(1.398)}{6} - (0.133 + 0.252) - 0.084 = 1.313$$

and the capacity is

$$C = \frac{7.36\ (50)}{1.313} = 280.3\ \mu\mu f.$$

If the same wires were placed in a horizontal plane 50 ft. above the ground, the capacity would be 285.5 μμf, and if they were placed vertical with their lower ends 50 ft. above the ground, the capacity would be 278.2 μμf.

p. Conical Antenna.

Let the conical antenna consist of n wires of length ℓ, and of diameter of cross section d, spaced at equal angles as elements of a cone whose half angle is φ, and whose point is a distance of h' from the ground, the axis of the cone extending vertically above the apex, see Fig. 3.

Fig. 3.

The capacity is found by the formula

$$C = \frac{0.2416 \ell_1 n}{U_k} = \frac{7.36 \ell_2 n}{U_k} \qquad (35)$$

Here

$$U_k = \log \frac{2\ell}{d} - 0.133 + \sum Y' - \frac{n}{\cos\varphi}(k - 0.133) \qquad (35a)$$

the constant k being obtained from Table 3 for the argument $\frac{h}{\ell \cos\varphi}$

The term $\sum Y'$ is the sum of the Y_1 terms for any wire and the remaining wires, the values being taken from Table 7 for arguments θ given by the angles between the wires. The lengths of the wires being the same, the length ratio in Table 7 is unity in each case.

The last term in U_k takes into account the effect of the earth. The expression for this is not exact, but the error in practical cases will be only a few per cent in the value of this term which is not more than about one tenth of the whole quantity U_k. To calculate exactly the effect of the earth necessitates in this case the use of complicated formulas. The approximation here employed in obtaining formula (35a) is to replace the antenna and image wires each by a single wire along the axis of the cone the distance between the nearer ends of these two vertical wires being 2h, their lengths each being $\ell \cos\varphi$, and the linear charge density on each being taken as $\frac{q}{\cos\varphi}$, where q is the actual linear density originally assumed upon each wire in obtaining the capacity formula.

Example 17.- Suppose the wires composing a conical antenna are six in number, spaced at equal intervals upon a cone of half angle 30°, with its apex 50 ft. above the ground. Each wire has a length of 100 feet, and a diameter of 0.02 foot. Then $\frac{2\ell}{d} = 10000$, $\varphi = 30°$, h = 50, $\ell \cos\varphi = 86.6$, and thus in Table 3 we have to take the value of k corresponding to the argument $\frac{50}{86.6} = 0.583$, that is, k = 0.238. To obtain the second term in U_k we find that the angles between the wires are as follows:

Wires 1 and 2, and 1 and 6,	28°.96	$Y' = 0.705$
" 1 " 3, " 1 " 5,	51°.3	$Y' = 0.520$
" 1 " 4,	60°	$Y' = 0.477$

Thus $\Sigma Y' = 2(0.705 + 0.520) + 0.477 = 2.927$, and for U_k we have $4.000 - 0.133 + 2.927 - 0.727 = 6.066$. The capacity is therefore

$$C = \frac{7.36\ (600)}{6.066} = 728.0\ \mu\mu f.$$

With such an antenna it should be pointed out that the gain from increasing the number of wires is largely offset by the reduction in capacity resulting from the mutual effects of the wires. Compared with a vertical cage antenna, the capacity is greater with the conical antenna, but the gain is not in proportion to the amount of space occupied.

q. Umbrella Antenna.

The same formula for the capacity is to be employed as for the conical antenna. The approximation made in taking into account the effect of the earth in the conical case is not so accurate for the umbrella type. However, the error in practical cases will not exceed one per cent in the value of the capacity.

r. Fan or Harp Antenna.

This is made up of n wires joined together at their lower ends. From this junction the wires are carried upward and are attached at equal intervals along a horizontal guy rope, (see Fig.4).

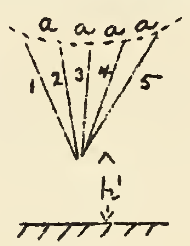

Fig. 4.

The dimensions required are the lengths of the different wires ℓ_s the distances between their points of attachment on the guy rope a and the distance of the point of junction from the ground h'. Then the angles between the various wires are to be calculated. Thus for any two consecutive wires of lengths ℓ_r and ℓ_s, whose points of attachment are separated by a distance a, the angle θ is found from the relation $\cos\theta = \dfrac{\ell_r^2 + \ell_s^2 - a^2}{2\ell_r\ell_s}$

The potential of any one of the wires is, then, that due to its own charge, plus that due to the charges on each of the other wires of the fan, minus that due to the image charges. The effects of the other wires are evaluated by the constants given in Table 7 which hold for wires intersecting at an angle θ. The effect of the image may be accurately enough taken into account by supposing both antenna top and images to be replaced by vertical wires having a length equal to the average vertical component of the lengths of

the wires, the charge upon these equivalent wires being taken to have a density equal to the sum of the densities on the individual wires. The equivalent wires are supposed to lie in the same straight line with their nearer ends separated by twice the height of the lowest point of the fan from the ground.

Carrying through these operations we find for the capacity formula

$$C = \frac{0.2416 \sum l_1}{U_f} = \frac{7.36 \sum l_2}{U_f} \tag{36}$$

in which the quantity U_f is given by

$$U_f = \frac{1}{\sum l}\left[\sum_s l_s \log \frac{l_s}{d} + \sum_{r,s} \frac{(l_r + l_s)}{2} Y'_{rs}\right] - 0.133 - \frac{\sum l_s}{\lambda}(K - 0.133) \tag{36a}$$

The constants Y'_{rs} are to be taken from Table 7 for the angle between the pairs of wires r and s, and for the ratio of the smaller length to the greater. The constant λ is the average of the vertical components of the lengths of the wires of the fan, and k is to be taken from Table 3 for the argument $\frac{h}{\lambda}$. An example will make clear the use of the formula.

Example 18.- Suppose in Figure 4 that there are five wires meeting at a point 50 ft. above the ground, and that the wires are fastened to a horizontal wire at points 10 ft. apart. The middle wire is vertical and has a length of 100 ft. and the diameter of the wires is 0.02 ft.

The lengths of the wires are then found to be $l_1 = l_5 = 102.5$, $l_2 = l_4 = 100.5$, and $l_3 = 100$, so that $\sum l = 505$. The mean value of $\log_{10} \frac{l_s}{d}$, weighted according to the lengths of the wires, is 4.004. The angles between the wires work out as follows:

1 and 2 = 4 and 5,	5°.60	
2 and 3 = 3 and 4,	5°.71	
1 and 3 = 3 and 5,	11°.31	2 and 4, 11°.42
1 and 4 = 2 and 5,	17°.02	
1 and 5	22°.62	

By rather rough interpolation from Table 7 the constants, corresponding to these angles and the ratios of the lengths of the wires of the pairs, were found to be

Pair	Y'	Pair	Y'	Pair	Y'
1,2 or 4,5	1.323	2,5 or 1,4	0.882	2,3 or 3,4	1.314
3,5 or 1,3	1.034	1,5	0.785	2,4	1.043

Thus the terms $\sum_{r,s} \frac{l_r + l_s}{2} Y'_{rs}$ give a final result of 4.372. The average vertical component of the lengths of the wires is $\lambda = 100$,

and from Table 3 for $\frac{h}{l} = \frac{50}{100} = 0.5$, $k = 0.247$, so that the image term is $\frac{505}{100} \cdot 0.114 = 0.576$, and the capacity is $C = \frac{7.36(505)}{7.667}$ $= 484.6$ μμf.

3. Use of Tables for Three Common Forms of Antennas.

The capacities of certain common forms of antennas may be obtained without calculation from Tables 2, 4 and 9. These tables are respectively, for single-wire horizontal, single-wire vertical, and two-wire horizontal antennas. The length of each horizontal wire is denoted by l and of the vertical wire by m.

In each case there is given the capacity (c) in micromicrofarads, and the capacity per unit length in micromicrofarads per foot. It will be noted that the capacity per unit length varies but slowly with the length and the height above the ground. Thus accurate interpolation of the capacity per unit length may be made for antennas not included in the tables, and so by multiplication by the length, the capacity of the antenna.

In addition to the capacity and linear capacity the tables include the potential coefficient of the antenna for unit charge density per unit length of the antenna. This quantity U is useful in calculating the capacity of combinations of horizontal and vertical wires, such as for example the calculation of the effect of lead-in wires. This point will be illustrated in the succeeding section.

Four different sizes of wires (0.005, 0.01, 0.015, and 0.02 feet in diameter) are included in each table. These sizes, it is believed, cover the majority of antennas met in practice. Interpolation in the tables may be made for sizes lying between these values. The table for two-wire horizontal antennas covers three spacings of the wires, viz., one foot, two feet and three feet. It is hoped that the range here covered will suffice for the large majority of practical cases.

Example 19.- Suppose the capacity of a two-wire antenna of 0.0125 ft. wires, 125 ft. long, spaced 2 ft. apart, at a distance of 75 ft. from the ground is to be found from the Table 9.

The following values of the linear capacity were interpolated from the table using second differences, for the required length of 125 feet.

h	d = 0.01	0.015	0.02
60	2.675	2.764	2.831
80	2.629	2.714	2.778
100	2.601	2.684	2.746

Interpolating from these for the length 75 ft. the resulting values are

d = 0.01	0.015	0.02
2.638	2.724	2.788

and interpolating, finally, for the given diameter of wire we find for the capacity per foot, 2.684, so that the capacity of the antenna is 335 $\mu\mu$f. The case just considered is purposely taken complicated to illustrate what is possible with the table. In general it will be well to use the formula (18) directly, when more than two interpolations have to be made in the table. For this case the formula gives 334.9 $\mu\mu$f.

4. Calculation of Capacity of Lead-in Wires.

A problem frequently met is the calculation of the capacity of the combination of two sets of wires joined together, each of the elements being readily calculable singly by methods and formulas already given. A first approximation is to add the capacities of the elements, but this takes no account of the mutual effect of the elements upon one another, and gives a value which is too high.

In general the simplest method for obtaining the accurate value of the capacity of the combination is to obtain the unit potential coefficients of the separate elements either from tables 2, 4, or 9. Likewise the mutual unit potential coefficients are to be obtained. With these values the linear charge density ratios for the elements are to be so determined as to make the potentials equal for all the elements. The process is illustrated in the next example, which has been so chosen as to employ the tabulated values of unit potential coefficients in Tables 2, 4, 9.

Example 20.- A two-wire horizontal antenna, 200 ft. long, and 20 ft. above the earth, has joined to one of its ends as a lead-in a single vertical wire 60 ft. long. The diameter of all the wires will be assumed as 0.02 ft., and the spacing of the wires of the horizontal portion as 2 ft.

From Table 9 the linear potential coefficient of the horizontal portion is found to be 2.771, and from Table 4, with m = 60 and h'=20, we find U_{22}=3.505. The mutual potential coefficient will be obtained with sufficient accuracy if we assume that the charge upon the horizontal portion is concentrated upon a single wire half way between the actual wires. Then from Table 5, for the argument

$\frac{m}{\ell} = \frac{60}{200} = 0.3$, and for $\frac{h'}{m} = \frac{1}{3}$, there is found X = 0.168. To obtain the linear mutual potential coefficients from the constant X which is useful in calculations with wires at right angles, we note that we may write $X = \frac{x}{2.303\,(\ell+m)}$, $U_{12} = \frac{x}{4.605\ell}$,

$U_{21} = \frac{x}{4.605m}$ so that $U_{12} = \frac{\ell+m}{2\ell} \cdot X$, $U_{21} = \frac{\ell+m}{2m} \cdot X$ are the general relations connecting these linear potential coefficients and the tabulated quantity. Thus for the present case $U_{12} = 0.109$, $U_{21} = 0.364$.

If we assume the linear charge densities upon the horizontal and vertical portions as q_1 and q_2, respectively, then we may write for the potentials of the two portions

$$v_1 = q_1 U_{11} + q_2 U_{12}$$

$$v_2 = q_1 U_{21} + q_2 U_{22}$$

and the condition that these may be equal is $\frac{q_2}{q_1} = \frac{U_{11}-U_{21}}{U_{22}-U_{12}} = \frac{2.407}{3.396}$ $= 0.709$.

Thus the common potential is $v = q_1\left[2.771 + 0.709\ (0.109)\right]$ $= 2.848\ q_1$, the total charge $Q = q_1\left[200 + 60(0.709)\right] = 242.5\ q_1$, and the capacity $C = \frac{7.36\ (242.5)}{2.848} = 625.2\ \mu\mu f$. The sum of the capacities of the separate portions is from Tables 4 and 9, $531.1 + 126.0 = 657.1\ \mu\mu f$ which is thus seen to be about five per cent too large.

It is evident that this method is applicable in the general case of the calculation of the capacity of lead-in wires. To go into all the types of lead-in wires which occur in practice would take us too far afield. It is clear, however, that the formulas already given should cover usual arrangements insofar as the capacity of the lead-in wires in themselves are concerned. To take into account their effect upon the other parts of the antenna system it will usually suffice to make some simplifying assumption as was done in the preceding example, since this mutual effect is a relatively small part of the whole capacity.

5. Tables for Antenna Capacity Calculation.

Three of the following tables give directly the capacities of three simple forms of antennas; they are tables 2, 4, and 9. The other tables are auxiliary to certain of the formulas.

Table 1.

Values of the Constant K for Use in Formula (13) and for Horizontal Wires in General.

(The argument to be used is either $\frac{2h}{\ell}$ or $\frac{\ell}{2h}$, according to which is less than unity)

$\frac{2h}{\ell}$	K	$\frac{\ell}{2h}$	K	$\frac{\ell}{2h}$	K
0	0	1.00	0.336	0.50	0.541
0.1	0.042	0.95	0.350	0.45	0.576
.2	.082	.90	.364	.40	.617
.3	.121	.85	.379	.35	.664
.4	.157	.80	.396	.30	.721
0.5	0.191	0.75	0.414	0.25	0.790
.6	.223	.70	.435	.20	.874
.7	.254	.65	.457	.15	.990
.8	.283	.60	.482	.10	1.155
0.9	.310	.55	.510	.05	1.445
1.0	0.336	0.50	0.541		

Further values may be calculated from the formulas

$$K = \frac{\frac{2h}{\ell} - \left(\sqrt{1+\left(\frac{2h}{\ell}\right)^2} - 1\right)}{2.303} + \log_{10} \frac{1 + \sqrt{1 + \left(\frac{2h}{\ell}\right)^2}}{2}$$

$$\text{for } \frac{2h}{\ell} \leqq 1$$

and

$$K = \frac{0.3069 - \frac{2h}{\ell}\left(\sqrt{1+\left(\frac{\ell}{2h}\right)^2} - 1\right)}{2.303} + \log_{10} \frac{\frac{\ell}{2h} + \sqrt{1 + \left(\frac{\ell}{2h}\right)^2}}{\frac{\ell}{2h}}$$

$$\text{for } \frac{\ell}{2h} \leqq 1$$

Table 2.

Constants for Single-Wire Horizontal Antennas.
(Symbols used above columns, etc., are defined on p.2).

Diameter of wire = 0.06 inch = 0.005 ft.

	h = 10			h = 15			h = 20		
ℓ	U	C	C/ℓ	U	C	C/ℓ	U	C	C/ℓ
10	3.362	21.89	2.189	3.397	21.67	2.167	3.414	22.57	2.257
20	3.567	41.27	2.064	3.629	40.56	2.028	3.663	40.18	2.009
30	3.660	60.30	2.011	3.743	58.99	1.966	3.790	58.26	1.942
40	3.712	79.31	1.983	3.810	77.27	1.932	3.868	76.11	1.903
50	3.746	98.24	1.965	3.856	95.44	1.909	3.921	93.85	1.877
60	3.770	117.1	1.952	3.888	113.6	1.893	3.961	111.5	1.858
80	3.801	154.9	1.936	3.931	149.8	1.872	4.013	146.7	1.834
100	3.821	192.6	1.926	3.958	186.0	1.860	4.047	181.9	1.819
150	3.848	286.9	1.913	3.997	276.2	1.841	4.096	269.5	1.797
200	3.861	381.3	1.906	4.017	366.4	1.832	4.122	357.1	1.786

ℓ	h = 25			h = 30			h = 40		
10	3.427	21.48	2.148	3.434	21.30	2.130	3.442	21.38	2.138
20	3.684	39.96	1.998	3.698	39.81	1.990	3.715	39.64	1.982
30	3.819	57.82	1.927	3.839	57.57	1.919	3.862	57.17	1.906
40	3.905	75.39	1.885	3.930	74.91	1.873	3.964	74.27	1.856
50	3.965	92.88	1.858	3.995	92.1	1.842	4.036	91.2	1.824
60	4.009	110.2	1.836	4.044	109.2	1.820	4.091	107.9	1.799
80	4.070	144.7	1.809	4.111	143.2	1.790	4.169	141.2	1.765
100	4.110	179.1	1.791	4.157	177.0	1.770	4.222	174.3	1.743
150	4.168	264.9	1.766	4.223	261.4	1.743	4.303	256.6	1.711
200	4.199	350.6	1.753	4.259	345.6	1.728	4.348	338.5	1.692

	h = 50			h = 60			h = 80		
10	3.447	21.35	2.135	3.451	21.3	2.135	3.455	21.3	2.130
20	3.728	39.5	1.974	3.735	39.4	1.970	3.743	39.3	1.966
30	3.881	56.9	1.896	3.891	56.75	1.892	3.905	56.5	1.885
40	3.985	73.9	1.847	3.999	73.6	1.840	4.016	73.3	1.833
50	4.061	90.6	1.812	4.078	90.2	1.805	4.100	89.8	1.795
60	4.120	107.2	1.787	4.140	106.7	1.778	4.167	106.0	1.767
80	4.206	140.0	1.750	4.232	139.1	1.739	4.265	138.0	1.726
100	4.266	172.5	1.725	4.296	171.3	1.713	4.337	169.7	1.697
150	4.358	253.3	1.687	4.398	251.0	1.673	4.453	247.9	1.653
200	4.411	333.7	1.668	4.458	330.2	1.651	4.523	325.4	1.627

	h = 100		
10	3.458	21.3	2.128
20	3.748	39.3	1.964
30	3.913	56.4	1.881
40	4.029	73.1	1.827
50	4.113	89.5	1.789
60	4.182	105.6	1.760
80	4.286	137.4	1.718
100	4.362	168.7	1.687
150	4.489	245.9	1.639
200	4.567	322.3	1.612

Table 2 (continued)

Diameter of wire = 0.12 inch = 0.01 ft.

	h = 10 ft.			h = 15			h = 20		
l ft.	U	C	C/l	U	C	C/l	U	C	C/l
10	3.061	24.0	2.404	3.096	23.8	2.377	3.113	23.6	2.364
20	3.256	45.1	2.254	3.328	44.2	2.212	3.362	43.8	2.189
30	3.359	65.7	2.191	3.442	64.2	2.138	3.489	63.3	2.109
40	3.411	86.3	2.158	3.509	83.9	2.098	3.567	82.5	2.064
50	3.445	106.8	2.136	3.555	103.5	2.070	3.620	101.6	2.033
60	3.469	127.3	2.122	3.587	123.1	2.052	3.660	120.7	2.012
80	3.500	168.2	2.102	3.630	162.2	2.028	3.712	158.6	1.982
100	3.520	209.1	2.091	3.657	201.3	2.013	3.754	196.1	1.961
150	3.547	311.2	2.075	3.659	298.7	1.991	3.795	290.9	1.939
200	3.560	413.5	2.068	3.716	396.1	1.980	3.821	385.3	1.926
	h = 25			h = 30			h = 40		
10	3.126	23.5	2.354	3.133	23.5	2.349	3.141	23.4	2.343
20	3.383	43.5	2.176	3.397	43.3	2.166	3.414	43.1	2.156
30	3.518	62.8	2.091	3.536	62.4	2.080	3.561	62.0	2.067
40	3.604	81.7	2.042	3.629	81.1	2.028	3.663	80.4	2.009
50	3.684	100.4	2.008	3.694	99.6	1.992	3.735	98.5	1.971
60	3.708	119.1	1.985	3.743	118.0	1.967	3.790	116.5	1.942
80	3.769	156.2	1.952	3.810	154.5	1.931	3.868	152.2	1.902
100	3.809	193.2	1.932	3.856	190.9	1.909	3.921	187.7	1.877
150	3.867	285.5	1.903	3.922	281.5	1.877	4.002	275.9	1.839
200	3.898	377.6	1.888	3.958	371.9	1.860	4.047	363.7	1.818
	h = 50			h = 60			h = 80		
10	3.146	23.4	2.339	3.150	23.4	2.336	3.154	23.3	2.334
20	3.427	43.0	2.148	3.434	42.9	2.144	3.442	42.8	2.138
30	3.580	61.8	2.059	3.590	61.5	2.050	3.604	61.3	2.042
40	3.684	79.9	1.998	3.698	79.6	1.990	3.715	79.2	1.981
50	3.760	97.8	1.957	3.777	97.4	1.949	3.801	96.8	1.936
60	3.819	115.6	1.927	3.839	115.0	1.917	3.866	114.2	1.903
80	3.905	150.8	1.885	3.931	149.8	1.872	3.964	148.5	1.856
100	3.965	185.6	1.856	3.995	184.2	1.842	4.036	182.4	1.824
150	4.057	272.1	1.814	4.097	269.5	1.797	4.152	265.9	1.773
200	4.110	358.2	1.791	4.157	354.1	1.770	4.220	348.6	1.743
	h = 100								
10	3.157	23.3	2.330						
20	3.447	42.7	2.135						
30	3.612	61.1	2.038						
40	3.728	79.0	1.974						
50	3.812	96.5	1.931						
60	3.881	113.8	1.897						
80	3.985	147.8	1.847						
100	4.061	181.2	1.812						
150	4.188	263.6	1.757						
200	4.266	345.1	1.726						

Table 2 (continued)

Diameter of wire = 0.18 inch = 0.015 ft.

ℓ ft.	h = 10 ft. U	C	C/ℓ	h = 15 U	C	C/ℓ	h = 20 U	C	C/ℓ
10	2.885	25.5	2.549	2.920	25.2	2.521	2.937	25.1	2.506
20	3.090	47.6	2.382	3.152	46.7	2.335	3.186	46.2	2.310
30	3.183	69.4	2.312	3.266	67.6	2.253	3.313	66.6	2.222
40	3.235	91.0	2.277	3.333	88.3	2.208	3.391	86.8	2.170
50	3.269	112.6	2.252	3.379	108.9	2.178	3.444	106.8	2.137
60	3.293	134.1	2.235	3.411	129.5	2.158	3.484	126.8	2.112
80	3.324	177.1	2.214	3.451	201.4	2.131	3.536	166.5	2.081
100	3.344	220.1	2.201	3.481	211.4	2.114	3.570	206.2	2.062
150	3.369	327.7	2.185	3.520	313.6	2.091	3.619	305.1	2.034
200	3.384	435.0	2.175	3.540	415.0	2.075	3.645	403.8	2.019

ℓ ft.	h = 25 U	C	C/ℓ	h = 30 U	C	C/ℓ	h = 40 U	C	C/ℓ
10	2.950	24.9	2.495	2.957	24.9	2.489	2.965	24.8	2.482
20	3.207	45.9	2.295	3.221	45.7	2.285	3.238	45.5	2.273
30	3.342	66.1	2.203	3.362	65.7	2.189	3.385	65.2	2.174
40	3.428	85.9	2.147	3.453	85.3	2.132	3.437	84.4	2.111
50	3.488	105.5	2.110	3.518	104.6	2.092	3.559	103.4	2.068
60	3.532	125.0	2.083	3.567	123.8	2.063	3.614	122.2	2.037
80	3.592	163.9	2.049	3.634	162.0	2.025	3.688	159.7	1.996
100	3.633	202.6	2.026	3.680	200.0	2.000	3.745	196.5	1.965
150	3.691	299.1	1.994	3.746	294.7	1.965	3.826	288.6	1.924
200	3.722	395.5	1.978	3.782	389.2	1.946	3.871	380.3	1.902

ℓ ft.	h = 50 U	C	C/ℓ	h = 60 U	C	C/ℓ	h = 80 U	C	C/ℓ
10	2.970	24.8	2.476	2.974	24.8	2.475	2.978	24.7	2.472
20	3.251	45.3	2.264	3.256	45.2	2.259	3.266	45.1	2.254
30	3.404	64.9	2.162	3.414	64.7	2.150	3.428	64.4	2.147
40	3.512	83.8	2.096	3.522	83.6	2.090	3.559	82.7	2.068
50	3.584	102.7	2.054	3.601	102.2	2.044	3.623	101.6	2.032
60	3.643	121.2	2.002	3.663	120.6	2.010	3.690	119.7	1.995
80	3.729	157.9	1.974	3.755	156.8	1.960	3.788	155.4	1.942
100	3.789	194.2	1.942	3.819	192.7	1.927	3.860	190.7	1.907
150	3.881	284.5	1.897	3.921	281.6	1.877	3.976	277.7	1.851
200	3.934	374.2	1.871	3.981	369.8	1.849	4.046	363.8	1.819

ℓ ft.	h = 100 U	C	C/ℓ
10	2.981	24.7	2.469
20	3.271	45.0	2.250
30	3.436	64.3	2.142
40	3.552	82.9	2.072
50	3.636	101.2	2.024
60	3.705	119.2	1.987
80	3.811	154.5	1.932
100	3.885	189.4	1.894
150	4.012	275.2	1.835
200	4.110	358.2	1.791

Table 2 (concluded).

Diameter of wire = 0.24 inch = 0.02 foot.

ℓ ft.	U	C	C/ℓ	U	C	C/ℓ	U	C	C/ℓ
	h = 10 ft.			h = 15			h = 20		
10	2.760	26.7	2.667	2.795	26.3	2.634	2.812	26.2	2.617
20	2.965	49.6	2.482	3.027	48.6	2.432	3.061	48.1	2.404
30	3.058	72.2	2.407	3.141	70.3	2.343	3.188	69.3	2.309
40	3.110	94.7	2.366	3.208	91.8	2.294	3.266	90.1	2.254
50	3.144	117.0	2.341	3.254	113.1	2.262	3.319	111.2	2.224
60	3.168	139.4	2.323	3.286	134.4	2.240	3.359	131.5	2.192
80	3.199	184.1	2.301	3.329	176.9	2.212	3.411	172.6	2.158
100	3.219	228.6	2.286	3.356	219.3	2.193	3.445	213.6	2.136
150	3.246	340.1	2.274	3.395	325.2	2.168	3.494	316.0	2.107
200	3.259	451.7	2.258	3.415	431.0	2.155	3.520	418.2	2.091
	h = 25			h = 30			h = 40		
10	2.825	26.0	2.605	2.832	26.0	2.599	2.840	25.9	2.592
20	3.082	47.8	2.388	3.096	47.6	2.378	3.113	47.3	2.364
30	3.217	68.6	2.288	3.237	68.2	2.274	3.260	67.7	2.258
40	3.303	89.1	2.228	3.328	88.5	2.212	3.362	87.6	2.189
50	3.363	109.4	2.188	3.393	108.5	2.170	3.434	107.2	2.144
60	3.407	129.6	2.160	3.442	128.3	2.138	3.489	126.6	2.110
80	3.468	169.8	2.122	3.509	167.8	2.098	3.567	165.1	2.064
100	3.508	209.8	2.098	3.555	207.0	2.070	3.620	203.3	2.033
150	3.566	309.6	2.064	3.621	304.9	2.033	3.701	298.3	1.989
200	3.597	409.2	2.046	3.657	402.5	2.012	3.746	393.0	1.965
	h = 50			h = 60			h = 80		
10	2.845	25.9	2.587	2.849	25.8	2.583	2.853	25.8	2.580
20	3.126	47.1	2.354	3.133	47.0	2.349	3.141	45.9	2.343
30	3.279	67.3	2.245	3.289	67.1	2.238	3.303	66.8	2.228
40	3.383	87.1	2.177	3.397	86.7	2.166	3.414	86.2	2.156
50	3.459	106.4	2.128	3.476	105.9	2.118	3.502	105.1	2.102
60	3.518	125.5	2.092	3.538	124.8	2.080	3.565	123.9	2.065
80	3.604	163.4	2.042	3.630	162.2	2.028	3.663	160.7	2.009
100	3.664	200.9	2.009	3.694	199.2	1.992	3.735	197.1	1.971
150	3.756	293.9	1.959	3.796	290.8	1.939	3.851	286.7	1.911
200	3.809	386.5	1.932	3.856	381.7	1.908	3.921	375.4	1.877
	h = 100								
10	25.8	2.577	2.856						
20	46.8	2.340	3.146						
30	66.7	2.223	3.311						
40	85.9	2.148	3.427						
50	104.8	2.096	3.511						
60	123.4	2.056	3.580						
80	159.8	1.998	3.684						
100	195.7	1.957	3.760						
150	284.0	1.893	3.887						
200	371.3	1.856	3.965						

Table 3.

Values of the Constant k used in Formula (14) and for Vertical Wires in General.

(The argument is $\frac{h'}{m}$ or $\frac{m}{h'}$ according to which is less than unity)

$\frac{h'}{m}$	k	$\frac{h'}{m}$	k	$\frac{m}{h'}$	k
		0.3	0.280	1.0	0.207
0.02	0.403	.4	.261	0.9	.202
.04	.384	.5	.247	.8	.196
.06	.369	.6	.236	.7	.190
.08	.356	.7	.227	.6	.184
0.10	0.345	0.8	0.219	0.5	0.177
.15	.323	0.9	.2125	.4	.170
.20	.305	1.0	0.207	.3	.162
.25	.291			.2	.153
0.30	0.280			0.1	.144
				0	0.133

Further values may be calculated from the formula

$$k = 0.4343 + \frac{h'}{m} \log_{10} \frac{4h'}{m} + \left(1 + \frac{h'}{m}\right) \log_{10} \left(1 + \frac{h'}{m}\right) - \left(1 + \frac{2h'}{m}\right) \log_{10} \left(1 + \frac{2h'}{m}\right)$$

$$\text{for } \frac{h'}{m} \leqq 1$$

and

$$k = 0.1333 + \frac{h'}{m} \left(1 + \frac{m}{h'}\right) \log_{10}\left(1 + \frac{m}{h'}\right) - \frac{2h'}{m}\left(1 + \frac{m}{2h'}\right) \log \left(1 + \frac{m}{2h'}\right)$$

$$\text{for } \frac{m}{h'} \leqq 1$$

Table 4.

Constants for Single-Wire Vertical Antennas.

(Symbols used above columns, etc., are defined on p.2.)

Diameter of wire = 0.06 inch = 0.005 foot.

	h' = 5 ft.			h' = 10		
m ft.	U	C	C/m	U	C	C/m
10	3.355	21.9	2.194	3.395	21.7	2.168
20	3.612	40.8	2.038	3.656	40.3	2.013
30	3.762	58.7	1.956	3.806	58.0	1.934
40	3.872	76.0	1.901	3.913	75.2	1.881
50	3.956	93.0	1.860	3.996	92.1	1.842
60	4.025	109.7	1.828	4.063	108.7	1.812
80	4.138	142.3	1.779	4.173	141.1	1.764
100	4.224	174.2	1.742	4.257	172.9	1.729
	h' = 20			h' = 50		
10	3.425	21.5	2.149	3.449	21.3	2.134
20	3.696	39.8	1.992	3.733	39.4	1.972
30	3.850	57.4	1.912	3.895	56.7	1.890
40	3.957	74.4	1.860	4.008	73.4	1.836
50	4.040	91.1	1.822	4.094	89.9	1.798
60	4.107	107.5	1.792	4.163	106.1	1.768
80	4.214	139.7	1.746	4.272	137.8	1.722
100	4.297	171.3	1.713	4.355	169.0	1.690

Diameter of wire = 0.12 inch = 0.01 foot.

				h' = 5 ft.			h' = 10		
m ft.	U	C	C/m	U	C	C/m	U	C	C/m
10	2.867	25.7	2.567	3.054	24.1	2.410	3.094	23.8	2.379
20	3.168	46.5	2.323	3.311	44.5	2.223	3.355	43.9	2.194
30	3.344	66.0	2.201	3.461	63.8	2.127	3.505	63.0	2.100
40	3.469	84.9	2.122	3.571	82.4	2.061	3.612	81.5	2.038
50	3.566	103.2	2.064	3.665	100.7	2.014	3.695	99.6	1.992
60	3.645	121.2	2.020	3.724	118.6	1.977	3.762	117.4	1.957
80	3.770	156.2	1.952	3.837	153.5	1.919	3.872	152.1	1.901
100	3.867	190.3	1.903	3.923	187.6	1.876	3.956	186.0	1.860
	h' = 20			h' = 50					
10	3.124	23.6	2.356	3.148	23.4	2.338			
20	3.395	43.4	2.168	3.432	42.9	2.144			
30	3.549	62.2	2.074	3.594	61.4	2.048			
40	3.656	80.5	2.013	3.707	79.4	1.983			
50	3.739	98.4	1.968	3.793	97.0	1.940			
60	3.806	116.0	1.933	3.862	114.3	1.905			
80	3.913	150.5	1.881	3.970	148.3	1.854			
100	3.996	184.2	1.842	4.054	181.6	1.816			

Table 4 (continued)

Diameter of wire = 0.18 inch = 0.015 foot.

	h' = 5 ft.			h' = 10		
m ft.	U	C	C/m	U	C	C/m
10	2.878	25.6	2.557	2.918	25.2	2.522
20	3.135	46.9	2.348	3.179	46.3	2.315
30	3.285	67.2	2.240	3.329	66.3	2.211
40	3.395	86.7	2.168	3.436	85.7	2.142
50	3.479	105.8	2.116	3.519	104.6	2.092
60	3.548	124.5	2.075	3.586	123.2	2.052
80	3.661	160.8	2.010	3.696	159.3	1.981
100	3.747	196.4	1.964	3.780	194.7	1.947

	h' = 20			h' = 50		
10	2.948	25.0	2.497	2.972	24.8	2.476
20	3.219	45.7	2.286	3.256	45.2	2.260
30	3.373	65.5	2.182	3.418	64.6	2.153
40	3.480	84.6	2.115	3.531	83.4	2.084
50	3.563	103.3	2.066	3.617	101.7	2.034
60	3.630	121.7	2.028	3.686	119.8	1.997
80	3.737	157.6	1.970	3.794	155.2	1.940
100	3.820	192.7	1.927	3.878	189.8	1.898

Diameter of wire = 0.24 inch = 0.02 foot.

	h' = 5 ft.			h' = 10		
m ft.	U	C	C/m	U	C	C/m
10	2.753	26.7	2.673	2.793	26.4	2.635
20	3.010	48.9	2.445	3.054	48.2	2.410
30	3.160	69.8	2.329	3.204	68.9	2.297
40	3.270	90.0	2.251	3.311	88.9	2.223
50	3.354	109.7	2.194	3.394	108.4	2.168
60	3.423	129.0	2.150	3.461	127.6	2.127
80	3.536	166.5	2.081	3.571	164.9	2.061
100	3.622	203.2	2.032	3.655	201.4	2.014

	h' = 20			h' = 50		
10	2.823	26.1	2.607	2.847	25.8	2.585
20	3.094	47.6	2.379	3.131	47.0	2.350
30	3.248	68.0	2.266	3.293	67.0	2.235
40	3.355	87.8	2.194	3.406	86.4	2.161
50	3.438	107.0	2.141	3.492	105.4	2.108
60	3.505	126.0	2.100	3.561	124.0	2.067
80	3.612	163.0	2.038	3.670	160.4	2.005
100	3.695	199.2	1.992	3.753	196.1	1.961

Table 5.

Values of the Constant X for Wires at Right Angles - Formula (15).

	h'/m						m/h'				
m/ℓ	0	0.2	0.4	0.6	0.8	1.0	0.8	0.6	0.4	0.2	0
0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.055	0.064	0.072	0.078	0.083	0.088	0.093	0.097	0.106	0.125	0.158
0.2	.099	.116	.129	.137	.146	.155	.165	.174	.187	.207	.239
0.3	.135	.157	.173	.184	.195	.206	.214	.226	.241	.262	.291
0.4	.164	.189	.207	.222	.233	.243	.252	.263	.276	.296	.325
0.5	.186	.214	.233	.248	.260	.269	.278	.290	.305	.323	.343
0.6	0.204	0.233	0.253	0.267	0.278	0.286	0.297	0.309	0.323	0.340	0.363
0.7	.218	.247	.267	.282	.293	.302	.311	.322	.335	.352	.373
0.8	.229	.258	.278	.292	.302	.311	.320	.330	.342	.358	.379
0.9	.237	.265	.285	.298	.308	.317	.326	.336	.347	.362	.382
1.0	0.243	0.271	0.290	0.303	0.313	0.321	0.329	0.338	0.350	0.365	0.383

	h'/m						m/h'				
ℓ/m	0	0.2	0.4	0.6	0.8	1.0	0.8	0.6	0.4	0.2	0
0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.130	0.137	0.141	0.144	0.146	0.147	0.147	0.150	0.153	0.155	0.159
0.2	.189	.200	.207	.213	.216	.218	.221	.224	.228	.232	.239
0.3	.222	.237	.247	.254	.260	.265	.269	.272	.275	.282	.291
0.4	.241	.259	.271	.279	.285	.290	.295	.300	.306	.314	.325
0.5	.250	.271	.285	.295	.302	.307	.312	.318	.325	.335	.348
0.6	0.254	0.277	0.292	0.303	0.310	0.317	0.323	0.330	0.338	0.349	0.363
0.7	.254	.279	.295	.306	.314	.322	.329	.336	.346	.357	.373
0.8	.252	.278	.295	.307	.316	.324	.331	.340	.350	.362	.379
0.9	.248	.275	.293	.306	.315	.323	.330	.339	.350	.364	.382
1.0	0.243	0.271	0.290	0.303	0.313	0.321	0.329	0.338	0.350	0.365	0.383

Table 6.

Values of the Constant K_n for Use in Formula (17)
and Other Parallel Wire Antenna Formulas.

n	K	n	K	n	K
2	0	11	0.460	30	0.847
3	0.067	12	.492	40	0.970
4	.135	13	.522	50	1.063
5	.197	14	.550	100	1.357
6	.252	15	.576		
7	.302	16	.601		
8	.347	17	.625		
9	.388	18	.647		
10	0.425	19	.668		
		20	0.688		

The general formula for K_n is

$$4.605\, K_n = \frac{4}{n^2}\left[\log_n (n-1) + 2 \log_n (n-2) + 3 \log_n (n-3) + \ldots + (n-2) \log_n 2 \right]$$

or

$$K_n = \frac{2}{n^2}\left[\log_{10} (n-1) + 2 \log_{10} (n-2) + 3 \log_{10} (n-3) + \ldots + (n-2) \log_{10} 2 \right]$$

Table 7.

Values of the Constant Y_1 for Wires Intersecting at an Angle -- Formulas (24) ff.

θ	$\frac{m}{\ell}$=1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
180°	0.3010	0.3004	0.2983	0.2942	0.2873	0.2764	0.2598	0.2346	0.1957	0.1323
165	.3029	.3023	.3002	.2960	.2891	.2781	.2613	.2359	.1967	.1329
150	.3086	.3080	.3056	.3016	.2944	.2832	.2660	.2400	.1999	.1348
135	.3185	.3179	.3156	.3112	.3037	.2920	.2741	.2469	.2053	.1380
120	.3334	.3326	.3303	.3255	.3176	.3051	.2860	.2573	.2134	.1427
105	.3542	.3534	.3508	.3457	.3370	.3234	.3028	.2714	.2244	.1492
90	0.3828	0.3820	0.3790	0.3732	0.3635	0.3433	0.3254	0.2911	0.2393	0.1578
85	.3945	.3936	.3905	.3844	.3743	.3584	.3346	.2989	.2453	.1612
80	.4075	.4065	.4033	.3970	.3863	.3697	.3448	.3076	.2518	.1650
75	.4220	.4211	.4176	.4109	.3997	.3833	.3560	.3172	.2591	.1691
70	0.4383	0.4372	0.4336	0.4265	0.4146	0.3962	0.3686	0.3277	0.2670	0.1736
65	.4565	.4554	.4515	.4440	.4313	.4118	.3825	.3395	.2759	.1786
60	.4771	.4759	.4718	.4636	.4501	.4292	.3981	.3526	.2857	.1842
55	.5004	.4992	.4946	.4859	.4713	.4489	.4156	.3678	.2966	.1903
50	0.5271	0.5257	0.5208	0.5112	0.4954	0.4712	0.4354	0.3838	0.3089	0.1971
45	.5579	.5563	.5509	.5404	.5230	.4966	.4580	.4025	.3227	.2048
40	.5937	.5920	.5859	.5742	.5550	.5260	.4839	.4239	.3354	.2136
35	.6360	.6340	.6272	.6140	.5925	.5603	.5139	.4486	.3566	.2236
30	0.6870	0.6846	0.6767	0.6616	0.6371	0.6009	0.5494	0.4778	0.3780	0.2354
25	.7498	.7470	.7376	.7198	.6915	.6502	.5923	.5128	.4035	.2494
20	.8299	.8264	.8148	.7933	.7598	.7118	.6457	.5563	.4351	.2668
15	0.9376	0.9330	0.9180	0.8909	0.8499	0.7926	0.7155	0.6129	0.4762	0.2892
10	1.0960	1.0892	1.0681	1.0318	0.9793	0.9082	.8149	.6934	.5345	.3210
5	1.3789	1.3663	1.3314	1.2771	1.2034	1.1079	0.9863	0.8320	0.6346	0.3757

Table 8.

Values of the Constant Y_2 for Wires in Parallel Planes and Inclined at an Angle with One Another -- Formulas (24) ff.

$$\frac{m}{\ell} = 1$$

θ	$\frac{2h}{\ell} = 0$	0.2	0.5	1.0	0.5	$0.2 = \frac{\ell}{2h}$
0°	∞	0.648	0.359	0.203	0.106	0.043
15	0.938	0.584	0.349	0.202	0.106	0.043
30	.687	.497	.328	.197	.106	.043
45	.558	.432	.304	.191	.1045	.043
60	.477	.384	.282	.185	.103	.043
75	.422	.348	.264	.178	.102	.043
90	.383	.321	.249	.172	.101	.043
105°	0.354	0.300	0.237	0.167	0.099	0.043
120	.333	.285	.228	.163	.098	.0425
135	.319	.274	.221	.160	.097	.0425
150	.309	.267	.216	.158	.097	.0425
165	0.303	0.262	.213	.156	.096	.0425
180°	0.301	0.261	0.212	0.156	0.096	0.0425

$$\frac{m}{\ell} = 0.75$$

θ	$\frac{2h}{\ell} = 0$	0.2	0.5	1.0	0.5	$0.2 = \frac{\ell}{2h}$
0°	∞	0.571	0.312	0.175	0.091	0.037
15	0.905	.528	.306	.174	.091	.037
30	.670	.461	.292	.171	.091	.037
45	.546	.406	.274	.167	.091	.037
60	.468	.364	.257	.163	.090	.037
75	.414	.331	.242	.158	.089	.037
90°	0.377	0.307	0.230	0.154	0.088	0.037
105	.348	.288	.220	.150	.087	.037
120	.328	.274	.212	.147	.086	.037
135	.314	.264	.206	.144	.086	.037
150	.304	.257	.202	.142	.085	.037
165	.298	.253	.199	.141	.085	.037
180°	0.297	0.251	0.198	0.141	0.085	0.037

Table 8 (continued)

$\frac{m}{\ell} = 0.5$

0°	∞	0.432	0.239	0.135	0.071	0.029
15	0.798	0.414	0.236	0.135	0.071	0.029
30	.601	.379	.229	.133	.071	.029
45	.496	.343	.221	.131	.0705	.029
60	.429	.313	.210	.129	.070	.029
75	.382	.289	.200	.126	.0695	.029
90°	0.348	0.270	0.192	0.124	0.069	0.029
105	.323	.255	.186	.121	.069	.029
120	.305	.244	.180	.1195	.068	.029
135	.292	.235	.175	.118	.068	.0285
150	.283	.230	.172	.117	.0675	.0285
165	.278	.225	.171	.116	.067	.0285
180°	0.276	0.223	0.170	0.116	0.067	0.0285

$\frac{m}{\ell} = 0.25$

0°	∞	0.238	0.136	0.079	0.042	0.017
15	0.550	.235	.136	.079	.042	.017
30	.432	.226	.134	.079	.042	.017
45	.366	.215	.131	.078	.042	.017
60	.322	.204	.128	.0775	.042	.017
75	.291	.194	.125	.077	.042	.017
90°	0.270	0.185	0.122	0.076	0.042	0.017
105	.251	.178	.120	.075	.042	.017
120	.238	.172	.117	.074	.041	.017
135	.228	.167	.116	.074	.041	.017
150	.222	.164	.114	.073	.041	.017
165	.162	.162	.113	.073	.041	.017
180°	0.217	0.161	0.113	0.073	0.041	0.017

$\frac{m}{\ell} = 0.1$

0°	∞	0.099	0.059	0.035	0.019	0.008
15	0.289	.099	.059	.035	.019	.008
30	.235	.097	.059	.035	.019	.008
45	.205	.096	.058	.035	.019	.008
60	.184	.092	.058	.035	.019	.008
75	.169	.092	.057	.035	.019	.008
90°	0.158	0.090	0.057	0.035	0.019	0.008
105	.149	.088	.056	.035	.019	.008
120	.143	.086	.056	.034	.019	.008
135	.138	.085	.055	.034	.019	.008
150	.135	.084	.055	.034	.019	.008
165	.133	.084	.055	.034	.019	.008
180°	0.132	0.0835	0.055	0.034	0.019	0.008

Table 9.

Constants for Two-Wire Horizontal Antennas.
(Symbols used above columns, etc., are defined on p.2)

Diameter of wire = 0.06 inch = 0.005 foot.

l	U			Capacity			Capacity per ft.		
ft.	D = 1	2	3	D=1	2	3	D=1	2	3
				Height = 10 ft.					
10	2.082	1.932	1.844	35.3	38.1	39.9	3.534	3.810	3.991
20	2.277	2.126	2.038	64.6	69.2	72.2	3.232	3.460	3.610
30	2.366	2.216	2.128	93.3	99.7	103.8	3.111	3.322	3.460
40	2.416	2.266	2.178	121.9	129.9	135.2	3.048	3.248	3.380
50	2.450	2.299	2.211	150.2	160.1	166.4	3.004	3.202	3.328
60	2.472	2.322	2.234	178.6	190.2	197.7	2.977	3.170	3.295
80	2.502	2.352	2.264	235.3	250.3	260.1	2.941	3.129	3.251
100	2.522	2.372	2.284	291.8	310.4	322.3	2.918	3.104	3.223
150	2.548	2.398	2.310	433.2	460.4	477.9	2.888	3.069	3.186
200	2.561	2.410	2.322	574.8	610.7	633.8	2.874	3.054	3.169
				Height = 15 ft.					
10	2.118	1.967	1.879	34.8	37.4	39.1	3.476	3.742	3.914
20	2.339	2.188	2.100	62.9	67.3	70.1	3.146	3.363	3.504
30	2.449	2.298	2.210	90.2	96.1	99.9	3.005	3.202	3.330
40	2.514	2.364	2.276	117.2	124.5	129.4	2.928	3.112	3.235
50	2.560	2.409	2.321	143.8	152.8	158.6	2.876	3.056	3.172
60	2.590	2.440	2.352	170.5	181.0	187.8	2.842	3.017	3.130
80	2.632	2.482	2.394	223.7	237.2	246.0	2.796	2.965	3.074
100	2.659	2.508	2.420	276.8	293.4	304.1	2.768	2.934	3.041
150	2.698	2.547	2.459	409.3	433.4	449.0	2.729	2.889	2.993
200	2.717	2.566	2.478	541.8	573.6	593.9	2.709	2.868	2.970
				Height = 20 ft.					
10	2.134	1.984	1.895	34.5	37.1	38.8	3.448	3.710	3.884
20	2.373	2.222	2.134	62.0	66.2	69.0	3.102	3.312	3.448
30	2.496	2.346	2.258	88.5	94.1	97.8	2.949	3.138	3.260
40	2.572	2.422	2.334	114.4	121.6	126.1	2.860	3.039	3.152
50	2.624	2.474	2.386	140.2	148.8	154.2	2.804	2.975	3.084
60	2.664	2.513	2.425	165.8	175.7	182.1	2.763	2.928	3.035
80	2.714	2.564	2.476	216.9	229.6	237.8	2.712	2.870	2.972
100	2.748	2.598	2.510	267.8	283.3	293.3	2.678	2.833	2.933
150	2.796	2.646	2.558	394.8	417.2	431.6	2.632	2.781	2.877
200	2.822	2.672	2.584	521.6	551.0	569.8	2.608	2.755	2.849
				Height = 25 ft.					
10	2.148	1.996	1.909	34.3	36.9	38.6	3.427	3.686	3.855
20	2.394	2.243	2.156	61.5	65.6	68.3	3.074	3.282	3.414
30	2.525	2.374	2.286	87.4	92.0	96.6	2.915	3.100	3.219
40	2.610	2.458	2.371	112.8	119.8	124.2	2.820	2.994	3.105
50	2.668	2.518	2.430	137.9	146.2	151.4	2.758	2.924	3.028
60	2.712	2.560	2.473	162.9	172.5	178.6	2.715	2.875	2.977
80	2.772	2.620	2.534	212.4	224.7	232.4	2.656	2.809	2.905
100	2.811	2.660	2.572	261.8	276.7	286.1	2.618	2.767	2.861
150	2.868	2.718	2.630	384.9	406.3	419.8	2.566	2.709	2.799
200	2.899	2.748	2.660	507.8	535.7	553.3	2.539	2.678	2.766

Table 9 (continued)

Diameter of wire = 0.06 inch = 0.005 foot.

l	U			Capacity			Capacity per foot		
ft.	D=1	2	3	D=1	2	3	D=1	2	3
				Height = 30 ft.					
10	2.154	2.004	1.916	34.2	36.7	38.4	3.416	3.673	3.841
20	2.408	2.258	2.170	61.1	65.2	67.8	3.056	3.260	3.392
30	2.545	2.394	2.306	86.8	92.2	95.7	2.898	3.074	3.191
40	2.634	2.484	2.396	111.8	118.5	122.9	2.794	2.962	3.072
50	2.698	2.548	2.460	136.4	144.4	149.6	2.728	2.888	2.992
60	2.746	2.596	2.508	160.8	170.1	176.1	2.680	2.835	2.935
80	2.812	2.662	2.574	209.4	221.2	228.8	2.617	2.765	2.859
100	2.858	2.708	2.620	257.5	271.8	281.0	2.575	2.718	2.810
150	2.924	2.773	2.685	377.6	398.1	411.2	2.517	2.654	2.741
200	2.960	2.809	2.721	497.4	524.0	541.0	2.487	2.620	2.705
				Height = 40 ft.					
10	2.162	2.012	1.924	34.0	36.6	38.2	3.403	3.658	3.825
20	2.425	2.274	2.186	60.3	64.7	67.3	3.014	3.236	3.366
30	2.568	2.418	2.330	86.0	91.3	94.8	2.866	3.043	3.159
40	2.668	2.518	2.430	110.3	116.9	121.2	2.758	2.922	3.029
50	2.740	2.589	2.501	134.3	142.1	147.1	2.686	2.842	2.942
60	2.794	2.643	2.555	158.1	167.1	172.8	2.635	2.785	2.880
80	2.870	2.720	2.632	205.1	216.5	223.7	2.564	2.706	2.795
100	2.923	2.772	2.684	251.8	265.5	274.2	2.518	2.655	2.742
150	3.004	2.853	2.765	367.6	387.0	399.3	2.451	2.580	2.662
200	3.049	2.898	2.810	482.8	508.0	523.8	2.414	2.540	2.619
				Height = 50 ft.					
10	2.168	2.017	1.929	34.0	36.5	38.2	3.396	3.649	3.818
20	2.438	2.288	2.200	60.4	64.4	66.9	3.019	3.218	3.346
30	2.587	2.438	2.348	85.4	90.6	94.0	2.845	3.021	3.134
40	2.690	2.539	2.451	109.5	116.0	120.1	2.738	2.900	3.002
50	2.764	2.614	2.526	133.1	140.8	145.7	2.662	2.816	2.914
60	2.822	2.672	2.584	156.5	165.3	170.9	2.610	2.755	2.848
80	2.908	2.757	2.669	202.5	213.6	220.6	2.531	2.670	2.758
100	2.967	2.816	2.728	248.1	261.3	269.8	2.481	2.613	2.698
150	3.058	2.908	2.820	361.0	379.6	391.5	2.407	2.531	2.610
200	3.112	2.960	2.872	473.1	497.2	512.4	2.366	2.486	2.562

Table 9 (continued)

Diameter of wire = 0.06 inch = 0.005 ft.

Height = 60 ft.

l	U			Capacity			Capacity per ft.		
ft.	D=1	2	3	D=1	2	3	D=1	2	3
10	2.172	2.021	1.933	33.9	36.4	38.1	3.389	3.642	3.808
20	2.445	2.295	2.206	60.2	64.1	66.7	3.010	3.207	3.336
30	2.597	2.446	2.358	85.0	90.2	93.6	2.834	3.008	3.120
40	2.704	2.553	2.465	108.9	115.3	119.4	2.722	2.882	2.985
50	2.782	2.631	2.543	132.3	139.9	144.7	2.646	2.798	2.894
60	2.842	2.692	2.604	155.4	164.0	169.6	2.590	2.733	2.827
80	2.934	2.783	2.695	200.7	211.6	218.5	2.509	2.645	2.731
100	2.997	2.846	2.758	245.6	258.6	266.8	2.456	2.586	2.668
150	3.098	2.948	2.860	356.3	374.5	386.0	2.375	2.497	2.573
200	3.158	3.008	2.920	466.1	489.4	504.2	2.330	2.447	2.521
				Height = 80 ft.					
10	2.176	2.025	1.937	33.8	36.4	38.0	3.383	3.635	3.800
20	2.453	2.302	2.214	60.0	63.9	66.5	3.000	3.196	3.324
30	2.611	2.458	2.372	84.6	89.8	93.1	2.829	2.994	3.102
40	2.720	2.570	2.482	108.2	114.6	118.6	2.705	2.865	2.965
50	2.804	2.653	2.565	131.3	138.7	143.5	2.626	2.774	2.870
60	2.870	2.720	2.631	153.9	162.4	167.8	2.565	2.706	2.797
80	2.966	2.816	2.728	198.5	209.1	215.8	2.481	2.614	2.698
100	3.038	2.888	2.800	242.3	254.9	262.9	2.423	2.549	2.629
150	3.154	3.003	2.915	350.1	367.6	378.7	2.334	2.451	2.525
200	3.223	3.072	2.984	456.7	479.1	493.2	2.284	2.396	2.466
				Height = 100 ft.					
10	2.178	2.028	1.939	33.8	36.3	38.0	3.378	3.629	3.796
20	2.458	2.308	2.220	59.9	63.8	66.3	2.994	3.180	3.316
30	2.619	2.468	2.380	84.3	89.4	92.8	2.810	2.982	3.092
40	2.734	2.583	2.495	107.7	114.0	118.0	2.692	2.850	2.950
50	2.816	2.666	2.578	130.7	138.0	142.8	2.614	2.760	2.855
60	2.884	2.734	2.640	153.1	161.5	166.8	2.552	2.692	2.780
80	2.988	2.837	2.749	197.1	207.5	214.2	2.464	2.594	2.678
100	3.063	2.912	2.824	240.3	252.7	260.1	2.403	2.527	2.601
150	3.190	3.039	2.951	346.1	363.3	374.1	2.307	2.420	2.490
200	3.267	3.116	3.028	450.6	472.3	486.1	2.253	2.362	2.430

Table 9 (continued)

Diameter of wire = 0.12 inch = 0.01 foot.

Height = 10 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.932	1.782	1.694	38.1	41.3	43.5	3.810	4.131	4.346
20	2.126	1.976	1.888	69.2	74.5	78.0	3.461	3.724	3.898
30	2.216	2.065	1.977	99.7	106.9	111.7	3.322	3.563	3.723
40	2.266	2.116	2.028	129.9	139.2	145.2	3.248	3.480	3.630
50	2.300	2.148	2.060	160.0	171.3	178.6	3.200	3.426	3.572
60	2.322	2.172	2.084	190.2	203.4	212.0	3.170	3.390	3.532
80	2.352	2.202	2.114	250.3	267.5	278.6	3.129	3.344	3.482
100	2.372	2.221	2.133	310.4	331.4	345.1	3.104	3.314	3.451
150	2.398	2.248	2.160	460.4	491.2	511.2	3.069	3.275	[illegible]
200	2.410	2.260	2.172	610.7	651.3	677.7	3.054	3.256	3.388

Height = 15 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.967	1.816	1.728	37.4	40.5	42.6	3.742	4.052	4.258
20	2.188	2.038	1.950	67.3	72.2	75.5	3.363	3.612	3.774
30	2.298	2.148	2.060	96.1	102.8	107.2	3.202	3.427	3.573
40	2.364	2.214	2.126	124.5	133.0	138.5	3.112	3.325	3.462
50	2.409	2.258	2.170	152.8	162.9	169.5	3.056	3.258	3.390
60	2.440	2.290	2.202	181.0	192.9	200.6	3.017	3.215	3.343
80	2.482	2.331	2.244	237.2	252.5	262.4	2.965	3.156	3.281
100	2.508	2.358	2.270	294.0	312.1	324.2	2.940	3.121	3.242
150	2.547	2.396	2.308	433.4	460.7	478.2	2.890	3.071	3.188
200	2.566	2.416	2.328	573.6	609.3	632.3	2.868	3.046	3.162

Height = 20 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.984	1.834	1.746	37.1	40.1	42.1	3.709	4.013	4.212
20	2.222	2.072	1.984	66.2	71.0	74.2	3.312	3.552	3.710
30	2.346	2.195	2.107	94.1	100.6	104.8	3.138	3.353	3.493
40	2.422	2.272	2.184	121.6	129.6	134.8	3.040	3.240	3.370
50	2.474	2.324	2.236	148.8	158.4	164.6	2.975	3.168	3.292
60	2.513	2.362	2.274	175.7	186.9	194.2	2.928	3.115	3.236
80	2.564	2.414	2.326	229.6	244.0	253.2	2.870	3.050	3.165
100	2.602	2.451	2.363	282.9	300.3	311.5	2.829	3.003	3.115
150	2.646	2.496	2.408	417.2	442.4	458.6	2.781	2.969	3.057
200	2.672	2.521	2.433	550.7	583.9	605.0	2.754	2.920	3.025

Height = 25 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.997	1.846	1.758	36.9	39.9	41.8	3.686	3.987	4.185
20	2.244	2.092	2.005	65.6	70.4	73.4	3.280	3.518	3.671
30	2.374	2.224	2.136	93.0	99.3	103.4	3.100	3.310	3.447
40	2.459	2.308	2.220	119.7	127.6	132.6	2.992	3.190	3.315
50	2.518	2.367	2.280	146.2	155.5	161.4	2.923	3.110	3.228
60	2.561	2.410	2.322	172.4	183.2	190.1	2.873	3.053	3.166
80	2.621	2.470	2.383	224.6	238.4	247.1	2.808	2.980	3.089
100	2.660	2.510	2.422	276.6	293.3	303.9	2.766	2.933	3.039
150	2.718	2.567	2.480	406.2	430.1	445.3	2.708	2.867	2.969
200	2.748	2.598	2.510	535.6	566.7	586.5	2.678	2.834	2.932

Table 9 (continued)

Diameter of wire = 0.12 inch = 0.01 foot.

Height = 30 ft.

ℓ	U			Capacity			Capacity per ft.		
ft.	D=1	2	3	D=1	2	3	D=1	2	3
10	2.004	1.854	1.766	36.7	39.7	41.7	3.673	3.971	4.169
20	2.258	2.107	2.019	65.2	69.9	72.9	3.260	3.493	3.646
30	2.394	2.244	2.156	92.2	98.4	102.4	3.074	3.280	3.413
40	2.484	2.334	2.246	118.5	126.2	131.1	2.962	3.155	3.278
50	2.548	2.398	2.310	144.4	153.5	159.3	2.888	3.070	3.186
60	2.596	2.446	2.358	170.1	180.6	187.3	2.835	3.010	3.132
80	2.662	2.512	2.424	221.2	234.4	242.9	2.765	2.930	3.036
100	2.708	2.557	2.469	271.8	287.8	298.1	2.718	2.878	2.981
150	2.773	2.622	2.534	398.1	421.0	435.6	2.654	2.807	2.904
200	2.808	2.658	2.570	524.1	553.8	572.8	2.620	2.769	2.864

Height = 40 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	2.012	1.862	1.774	36.6	39.5	41.5	3.658	3.954	4.150
20	2.274	2.124	2.036	64.7	69.3	72.3	3.236	3.465	3.610
30	2.418	2.267	2.179	91.3	97.4	101.3	3.044	3.247	3.377
40	2.518	2.368	2.280	116.9	124.4	129.2	2.922	3.109	3.229
50	2.589	2.438	2.350	142.1	150.9	156.6	2.842	3.018	3.132
60	2.643	2.492	2.404	167.1	177.2	183.7	2.785	2.953	3.062
80	2.720	2.570	2.482	216.5	229.2	237.3	2.706	2.864	2.966
100	2.772	2.622	2.534	265.5	280.7	290.4	2.655	2.807	2.904
150	2.853	2.702	2.614	387.0	408.5	422.3	2.580	2.723	2.815
200	2.898	2.747	2.660	507.9	535.9	553.4	2.540	2.680	2.767

Height = 50 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	2.017	1.866	1.778	36.5	39.5	41.4	3.649	3.954	4.138
20	2.288	2.137	2.049	64.4	68.9	71.8	3.218	3.444	3.592
30	2.436	2.286	2.198	90.6	96.6	100.4	3.021	3.220	3.345
40	2.539	2.388	2.300	116.0	123.3	128.0	2.900	3.082	3.200
50	2.614	2.464	2.376	140.8	149.4	154.9	2.816	2.988	3.098
60	2.672	2.522	2.434	165.3	175.1	181.5	2.755	2.918	3.025
80	2.757	2.606	2.518	213.6	225.9	233.8	2.670	2.824	2.922
100	2.816	2.666	2.576	261.3	276.1	286.5	2.613	2.761	2.855
150	2.908	2.758	2.670	379.6	400.4	413.6	2.531	2.669	2.757
200	2.960	2.810	2.722	497.2	523.8	540.8	2.486	2.619	2.704

Table 9 (continued)

Diameter of wire = 0.12 inch = 0.01 foot.

Height = 60 ft.

l	U			Capacity			Capacity per ft.		
ft.	D=1	2	3	D=1	2	3	D=1	2	3
10	2.021	1.870	1.782	36.4	39.4	41.3	3.642	3.935	4.129
20	2.294	2.144	2.056	64.2	68.7	71.6	3.208	3.433	3.580
30	2.446	2.296	2.208	90.2	96.2	100.0	3.008	3.206	3.333
40	2.553	2.402	2.314	115.3	122.5	127.3	2.882	3.062	3.182
50	2.631	2.480	2.392	139.9	148.8	153.8	2.798	2.968	3.078
60	2.692	2.542	2.454	164.0	173.8	180.0	2.733	2.897	3.000
80	2.783	2.632	2.544	211.6	223.7	231.4	2.645	2.796	2.892
100	2.846	2.696	2.608	258.6	273.0	282.2	2.586	2.730	2.822
150	2.948	2.798	2.710	374.5	394.6	407.5	2.497	2.631	2.717
200	3.008	2.857	2.769	489.4	515.2	531.6	2.447	2.578	2.658

Height = 80 ft.

l	D=1	2	3	D=1	2	3	D=1	2	3
10	2.025	1.874	1.786	36.3	39.3	41.2	3.635	3.926	4.120
20	2.302	2.152	2.064	63.9	68.4	71.3	3.196	3.420	3.566
30	2.460	2.308	2.222	89.7	95.7	99.4	2.991	3.189	3.312
40	2.570	2.420	2.332	114.6	121.7	126.3	2.865	3.042	3.158
50	2.654	2.504	2.416	138.7	147.0	152.4	2.774	2.940	3.047
60	2.719	2.568	2.480	162.4	171.9	178.0	2.707	2.865	2.967
80	2.816	2.666	2.578	209.1	220.9	228.4	2.614	2.761	2.855
100	2.888	2.737	2.649	254.9	268.9	277.6	2.549	2.689	2.776
150	3.003	2.852	2.764	367.6	387.0	399.3	2.451	2.580	2.662
200	3.072	2.922	2.834	479.1	503.8	519.4	2.396	2.519	2.597

Height = 100 ft.

l	D=1	2	3	D=1	2	3	D=1	2	3
10	2.028	1.878	1.790	36.3	39.2	41.1	3.629	3.920	4.113
20	2.308	2.157	2.069	63.8	68.2	71.2	3.190	3.412	3.558
30	2.468	2.318	2.231	89.4	95.3	99.0	2.982	3.175	3.299
40	2.583	2.432	2.344	114.0	121.0	125.6	2.850	3.025	3.140
50	2.666	2.516	2.428	138.0	146.3	151.6	2.760	2.926	3.032
60	2.734	2.384	2.496	161.5	170.9	177.0	2.692	2.848	2.950
80	2.837	2.686	2.598	207.5	219.2	226.6	2.594	2.740	2.832
100	2.912	2.762	2.674	252.7	266.5	275.2	2.527	2.665	2.752
150	3.039	2.388	2.800	363.3	382.2	394.2	2.422	2.548	2.628
200	3.116	2.966	2.878	472.2	496.3	511.5	2.362	2.432	2.558

Table 9 (continued)

Diameter of wire = 0.18 inch = 0.015 foot.

Height = 10 ft.

ℓ	U			Capacity			Capacity per ft.		
ft.	D=1	2	3	D=1	2	3	D=1	2	3
10	1.844	1.694	1.606	39.9	43.5	45.8	3.991	4.346	4.584
20	2.038	1.888	1.800	72.2	78.0	81.8	3.611	3.898	4.089
30	2.128	1.977	1.889	103.8	111.7	116.9	3.460	3.723	3.897
40	2.178	2.028	1.940	135.2	145.2	151.8	3.380	3.630	3.795
50	2.211	2.060	1.972	166.4	178.6	186.6	3.328	3.572	3.732
60	2.234	2.084	1.996	197.7	212.0	221.3	3.295	3.533	3.688
80	2.264	2.114	2.206	260.1	278.5	290.7	3.251	3.481	3.634
00	2.284	2.133	2.045	322.3	345.1	259.9	3.223	3.451	3.599
50	2.309	2.158	2.070	478.1	511.5	533.2	3.187	3.410	3.555
00	2.322	2.172	2.084	633.8	677.7	706.3	3.169	3.388	3.532

Height = 15 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.879	1.728	1.640	39.2	42.6	44.9	3.918	4.258	4.486
20	2.100	1.950	1.862	70.1	75.5	79.0	3.505	3.744	3.952
30	2.210	2.060	1.972	99.9	107.2	112.0	3.330	3.573	3.733
40	2.276	2.126	2.038	129.4	138.5	144.5	3.234	3.462	3.612
50	2.321	2.170	2.082	158.6	169.6	176.7	3.171	3.391	3.534
60	2.352	2.202	2.114	187.8	200.6	208.9	3.130	3.343	3.482
80	2.394	2.244	2.156	246.0	262.4	273.1	3.074	3.282	3.414
00	2.420	2.270	2.182	304.1	324.2	337.3	3.041	3.241	3.373
50	2.459	2.308	2.220	449.0	478.2	497.2	2.993	3.188	3.315
00	2.478	2.328	2.240	593.9	632.3	657.1	2.970	3.162	3.286

Height = 20 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.896	1.746	1.658	38.8	42.2	44.4	3.882	4.217	4.440
20	2.184	1.984	1.896	69.0	74.2	77.6	3.448	3.710	3.882
30	2.258	2.107	2.019	97.8	104.8	109.4	3.260	3.493	3.647
40	2.334	2.184	2.096	126.1	134.8	140.5	3.152	3.370	3.512
50	2.386	2.236	2.148	154.2	164.6	171.4	3.084	3.292	3.428
60	2.425	2.274	2.186	182.1	194.1	202.0	3.035	3.235	3.367
80	2.476	2.326	2.238	237.8	253.2	263.2	2.972	3.165	3.290
00	2.510	2.359	2.271	293.3	312.0	324.0	2.933	3.120	3.240
50	2.559	2.408	2.320	431.4	458.6	476.0	2.876	3.057	3.173
00	2.584	2.433	2.345	569.8	605.0	627.7	2.849	3.025	3.138

Height = 25 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.909	1.758	1.670	38.6	41.9	44.1	3.855	4.187	4.406
20	2.157	2.006	1.918	68.2	73.4	76.7	3.412	3.669	3.836
30	2.286	2.136	2.048	96.6	103.4	107.8	3.219	3.447	3.593
40	2.371	2.220	2.132	124.2	132.6	138.1	3.105	3.315	3.452
50	2.430	2.279	2.192	151.4	161.5	167.9	3.028	3.230	3.358
60	2.473	2.322	2.234	178.6	190.2	197.6	2.977	3.170	3.293
80	2.533	2.382	2.295	232.4	247.2	256.6	2.906	3.090	3.208
00	2.572	2.422	2.334	286.1	304.0	315.3	2.861	3.040	3.153
50	2.630	2.479	2.392	419.8	445.3	461.6	2.799	2.969	3.077
00	2.660	2.510	2.422	553.3	586.6	607.8	2.766	2.933	3.039

Table 9 (continued)

Diameter of wire = 0.18 inch = 0.015 foot.

Height = 30 ft.

l ft.	U D=1	2	3	Capacity D=1	2	3	Capacity per ft. D=1	2	3
10	1.916	1.766	1.678	38.4	41.7	43.9	3.840	4.169	4.388
20	2.170	2.019	1.931	67.8	72.9	76.2	3.392	3.646	3.812
30	2.306	2.156	2.068	95.7	102.4	105.8	3.191	3.413	3.560
40	2.396	2.246	2.158	122.9	131.1	136.5	3.072	3.278	3.412
50	2.460	2.310	2.222	149.6	159.3	165.6	2.992	3.186	3.312
60	2.508	2.358	2.270	176.1	187.3	194.6	2.935	3.122	3.243
80	2.574	2.424	2.336	228.8	243.0	252.1	2.859	3.038	3.151
100	2.620	2.460	2.381	280.8	298.1	309.1	2.808	2.981	3.091
150	2.685	2.534	2.446	411.2	435.6	451.2	2.741	2.904	3.008
200	2.720	2.570	2.482	541.1	572.8	593.1	2.706	2.864	2.966

Height = 40 ft.

l ft.	U D=1	2	3	Capacity D=1	2	3	Capacity per ft. D=1	2	3
10	1.924	1.774	1.686	38.2	41.5	43.7	3.825	4.150	4.367
20	2.186	2.036	1.948	67.3	72.3	75.6	3.366	3.615	3.778
30	2.330	2.179	2.091	94.8	101.3	105.6	3.159	3.377	3.520
40	2.430	2.280	2.192	121.2	129.2	134.3	3.030	3.229	3.358
50	2.501	2.350	2.262	147.1	156.6	163.6	2.942	3.132	3.253
60	2.555	2.404	2.316	172.8	183.7	190.6	2.880	3.062	3.177
80	2.630	2.480	2.392	223.9	237.5	246.2	2.799	2.969	3.078
100	2.684	2.534	2.446	274.2	290.4	307.8	2.742	2.904	3.008
150	2.765	2.614	2.526	399.3	422.3	437.0	2.662	2.815	2.913
200	2.810	2.659	2.572	523.8	553.6	572.3	2.619	2.768	2.862

Height = 50 ft.

l ft.	U D=1	2	3	Capacity D=1	2	3	Capacity per ft. D=1	2	3
10	1.929	1.778	1.690	38.2	41.4	43.5	3.816	4.138	4.354
20	2.200	2.040	1.961	66.9	71.8	75.1	3.346	3.592	3.753
30	2.348	2.198	2.110	94.2	100.4	104.6	3.134	3.348	3.488
40	2.452	2.302	2.214	120.1	127.9	132.9	3.002	3.198	3.322
50	2.526	2.376	2.288	145.7	154.9	160.9	2.914	3.098	3.218
60	2.584	2.434	2.346	170.9	181.4	188.3	2.848	3.023	3.138
80	2.669	2.518	2.430	220.6	233.8	242.3	2.758	2.923	3.029
100	2.728	2.580	2.494	269.8	285.3	295.1	2.698	2.853	3.951
150	2.820	2.670	2.582	391.5	413.6	427.7	2.610	2.755	2.851
200	2.872	2.722	2.634	512.4	540.8	558.8	2.562	2.704	2.794

Table 9 (continued)

Diameter of wire = 0.18 inch = 0.015 foot.

Height = 60 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.933	1.782	1.694	38.1	41.3	43.4	3.808	4.129	4.343
20	2.206	2.056	1.968	65.7	71.6	74.8	3.336	3.580	3.740
30	2.358	2.208	2.120	93.6	100.0	104.2	3.121	3.333	3.472
40	2.465	2.314	2.226	119.4	127.2	132.2	2.985	3.180	3.305
50	2.543	2.392	2.304	144.7	153.8	159.7	2.894	3.076	3.194
60	2.604	2.454	2.366	169.6	180.0	186.7	2.827	3.000	3.112
80	2.705	2.554	2.466	217.7	230.5	238.7	2.721	2.881	2.984
100	2.758	2.608	2.520	266.8	282.2	292.1	2.668	2.822	2.921
150	2.860	2.710	2.622	386.0	407.5	421.1	2.573	2.717	2.807
200	2.920	2.769	2.681	504.2	531.6	549.0	2.521	2.658	2.745

Height = 80 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.937	1.786	1.698	38.0	41.2	43.3	3.800	4.120	4.333
20	2.214	2.064	1.976	66.5	71.3	74.5	3.324	3.566	3.724
30	2.370	2.220	2.132	93.2	99.5	103.6	3.105	3.315	3.453
40	2.492	2.342	2.254	118.9	126.6	131.6	2.972	3.165	3.290
50	2.565	2.414	2.326	143.5	152.4	158.2	2.870	3.048	3.164
60	2.631	2.480	2.392	167.8	178.1	184.6	2.797	2.968	3.077
80	2.728	2.578	2.490	215.8	228.4	236.5	2.698	2.855	2.956
100	2.800	2.649	2.561	262.9	277.8	287.4	2.629	2.778	2.874
150	2.915	2.764	2.676	378.7	399.3	412.5	2.525	2.662	2.750
200	2.984	2.834	2.746	493.2	519.4	536.1	2.466	2.597	2.680

Height = 100 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.940	1.790	1.702	37.9	41.1	43.3	3.794	4.113	4.326
20	2.220	2.069	1.981	66.3	71.2	74.3	3.316	3.558	3.716
30	2.380	2.230	2.142	92.8	99.1	103.1	3.092	3.301	3.437
40	2.495	2.344	2.256	118.0	125.6	130.5	2.950	3.140	3.262
50	2.578	2.428	2.340	142.7	151.6	157.3	2.855	3.032	3.146
60	2.646	2.496	2.408	166.9	177.0	183.4	2.782	2.950	3.057
80	2.750	2.600	2.512	214.1	226.5	234.4	2.676	2.831	2.930
100	2.824	2.674	2.586	261.6	275.2	284.6	2.616	2.752	2.846
150	2.951	2.800	2.713	374.1	394.2	407.0	2.497	2.628	2.713
200	3.038	2.888	2.802	484.5	509.7	525.3	2.422	2.548	2.626

Table 9 (continued)
Diameter of wire = 0.24 inch = 0.02 foot.

Height = 10 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.782	1.631	1.543	41.3	45.1	47.7	4.131	4.513	4.770
20	1.976	1.826	1.738	74.5	80.6	84.7	3.724	4.032	4.236
30	2.065	1.914	1.827	106.9	115.3	120.9	3.563	3.843	4.030
40	2.116	1.965	1.877	139.2	149.8	156.8	3.480	3.745	3.921
50	2.148	1.998	1.910	171.3	184.2	192.7	3.426	3.684	3.854
60	2.172	2.021	1.933	203.4	218.5	228.4	3.390	3.642	3.807
80	2.202	2.051	1.963	267.6	287.1	300.0	3.345	3.589	3.749
100	2.221	2.070	1.982	331.4	355.5	371.3	3.314	3.555	3.713
150	2.248	2.097	2.009	491.2	526.5	549.5	3.275	3.510	3.663
300	2.260	2.110	2.022	651.3	697.8	728.2	3.256	3.489	3.641

Height = 15 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.816	1.666	1.578	40.5	44.2	46.6	4.052	4.418	4.664
20	2.038	1.888	1.800	72.2	78.0	81.8	3.612	3.900	4.090
30	2.148	1.998	1.910	102.8	110.5	115.6	3.427	3.683	3.853
40	2.214	2.063	1.975	133.0	142.7	149.1	3.325	3.568	3.728
50	2.258	2.108	2.020	163.0	174.6	182.2	3.260	3.492	3.644
60	2.290	2.139	2.051	192.9	206.4	215.3	3.215	3.441	3.588
80	2.332	2.181	2.093	252.5	270.0	281.3	3.156	3.375	3.516
100	2.358	2.208	2.120	312.1	333.4	347.3	3.121	3.334	3.473
150	2.396	2.246	2.158	460.7	491.5	511.6	3.071	3.277	3.411
300	2.416	2.266	2.178	609.3	649.8	676.0	3.046	3.249	3.380

Height = 20 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.834	1.683	1.595	40.1	43.7	46.1	4.014	4.373	4.614
20	2.073	1.922	1.834	71.0	76.6	80.3	3.552	3.830	4.014
30	2.195	2.044	1.956	100.6	108.0	112.8	3.353	3.600	3.762
40	2.272	2.121	2.033	129.6	138.8	144.8	3.240	3.470	3.620
50	2.324	2.173	2.085	158.4	169.4	176.5	3.168	3.387	3.530
60	2.362	2.212	2.124	186.9	199.6	207.6	3.115	3.327	3.460
80	2.414	2.263	2.175	244.0	260.2	270.7	3.050	3.252	3.384
100	2.447	2.296	2.208	300.8	320.5	333.3	3.008	3.205	3.333
150	2.496	2.345	2.257	442.4	470.8	489.1	2.949	3.139	3.261
300	2.521	2.370	2.282	583.9	621.0	644.9	2.920	3.105	3.224

Height = 25 ft.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.846	1.696	1.608	39.9	43.4	45.8	3.986	4.341	4.577
20	2.093	1.942	1.854	70.3	75.8	79.4	3.516	3.790	3.968
30	2.224	2.073	1.986	99.3	106.5	111.2	3.309	3.550	3.707
40	2.308	2.158	2.070	127.5	136.5	142.2	3.188	3.412	3.550
50	2.368	2.217	2.129	155.4	166.0	172.8	3.108	3.320	3.456
60	2.410	2.260	2.172	183.2	195.4	203.3	3.053	3.257	3.388
80	2.470	2.320	2.232	238.3	253.8	263.8	2.979	3.173	3.297
100	2.510	2.359	2.272	293.2	312.0	324.0	2.932	3.120	3.240
150	2.568	2.416	2.329	430.0	456.9	474.0	2.867	3.046	3.160
300	2.598	2.447	2.360	566.0	601.6	623.9	2.833	3.008	3.120

Table 9 (continued).

Diameter of wire = 0.24 inch = 0.02 foot.

Height = 30 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.854	1.703	1.615	39.7	43.2	45.6	3.971	4.322	4.557
20	2.107	1.958	1.868	69.9	75.2	78.8	3.493	3.758	3.939
30	2.244	2.094	2.006	98.4	105.5	110.1	3.280	3.517	3.670
40	2.334	2.183	2.095	126.2	134.9	140.5	3.155	3.372	3.512
50	2.398	2.247	2.159	153.5	163.8	170.4	3.070	3.276	3.409
60	2.466	2.295	2.207	180.6	192.4	200.1	3.010	3.207	3.335
80	2.511	2.361	2.273	234.4	249.4	259.0	2.930	3.118	3.238
100	2.557	2.406	2.318	287.8	305.8	317.4	2.878	3.058	3.174
150	2.622	2.472	2.384	421.0	446.6	463.1	2.807	2.977	3.087
200	2.658	2.506	2.420	553.8	587.4	608.4	2.769	2.937	3.042

Height =40 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.862	1.711	1.623	39.5	43.0	45.4	3.954	4.302	4.535
20	2.124	1.974	1.886	69.3	74.6	78.1	3.465	3.730	4.032
30	2.267	2.116	2.028	99.7	104.3	108.8	3.324	3.477	3.628
40	2.368	2.217	2.129	124.4	132.8	138.3	3.109	3.320	3.458
50	2.438	2.289	2.200	150.9	160.7	167.3	3.018	3.214	3.346
60	2.492	2.342	2.254	177.2	188.6	195.9	2.953	3.143	3.265
80	2.570	2.419	2.331	229.2	243.4	252.6	2.864	3.042	3.158
100	2.622	2.472	2.384	280.7	297.8	308.8	2.807	2.978	3.088
150	2.702	2.552	2.464	408.6	432.6	448.1	2.724	2.884	2.987
200	2.748	2.596	2.510	535.7	566.9	586.6	2.678	2.834	2.933

Height = 50 ft.

ℓ ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
10	1.866	1.716	1.628	39.4	42.9	45.2	3.943	4.289	4.521
20	2.137	1.986	1.898	68.9	74.1	77.5	3.443	3.705	3.877
30	2.286	2.136	2.048	96.6	103.4	107.8	3.220	3.447	3.593
40	2.388	2.238	2.150	123.3	131.6	136.9	3.082	3.289	3.422
50	2.464	2.313	2.225	149.4	159.1	165.4	2.988	3.182	3.308
60	2.522	2.371	2.283	175.2	186.3	193.4	2.920	3.105	3.223
80	2.606	2.456	2.368	225.9	239.7	248.6	2.824	2.996	3.108
100	2.666	2.515	2.428	276.1	292.6	303.2	2.761	2.926	3.032
150	2.758	2.607	2.519	400.4	423.5	438.2	2.669	2.827	2.901
200	2.810	2.658	2.572	523.8	553.8	572.4	2.619	2.769	2.862

Table 9 (continued).

Diameter of wire = 0.24 inch = 0.02 foot.

l ft.	U D=1	U 2	U 3	Capacity D=1	Capacity 2	Capacity 3	Capacity per ft. D=1	Capacity per ft. 2	Capacity per ft. 3
Height = 60 ft.									
10	1.870	1.720	1.632	39.3	42.8	45.1	3.932	4.279	4.510
20	2.144	1.994	1.906	68.7	53.8	77.2	3.433	3.692	3.862
30	2.296	2.146	2.058	96.2	102.9	107.3	3.206	3.430	3.577
40	2.402	2.252	2.164	122.5	130.8	136.0	3.062	3.270	3.400
50	2.480	2.330	2.242	148.4	157.9	164.1	2.968	3.158	3.282
60	2.542	2.391	2.303	173.8	184.7	191.8	2.897	3.078	3.197
80	2.632	2.482	2.394	223.7	237.2	246.0	2.796	2.965	3.074
100	2.697	2.546	2.458	272.9	289.0	299.4	2.729	2.890	2.994
150	2.798	2.607	2.559	394.6	417.1	431.4	2.631	2.781	2.876
200	2.854	2.702	2.618	515.8	544.9	562.2	2.579	2.724	2.811
Height = 80 ft.									
10	1.874	1.724	1.636	39.3	42.7	45.0	3.927	4.269	4.499
20	2.152	2.002	1.914	68.4	73.5	76.9	3.420	3.677	3.846
30	2.310	2.158	2.072	95.6	102.3	106.6	3.186	3.410	3.553
40	2.420	2.269	2.181	121.7	129.8	135.0	3.042	3.244	3.375
50	2.504	2.354	2.266	146.9	156.3	162.7	2.938	3.126	3.254
60	2.568	2.418	2.330	171.9	182.6	189.5	2.865	3.043	3.158
80	2.666	2.515	2.427	220.9	234.1	242.6	2.761	2.926	3.032
100	2.736	2.586	2.498	269.0	296.6	293.6	2.660	2.844	2.946
150	2.852	2.702	2.614	387.0	408.6	422.3	2.580	2.724	2.815
200	2.922	2.771	2.684	503.8	531.1	548.5	2.519	2.656	2.742
Height = 100 ft.									
10	1.878	1.727	1.639	39.2	42.6	44.9	3.920	4.262	4.491
20	2.156	2.006	1.918	68.3	73.4	76.7	3.414	3.668	3.836
30	2.318	2.168	2.080	95.3	101.9	106.2	3.175	3.397	3.540
40	2.432	2.282	2.194	121.0	129.0	134.2	3.025	3.222	3.355
50	2.516	2.365	2.277	146.3	155.6	161.6	2.926	3.112	3.232
60	2.584	2.433	2.345	170.9	181.5	188.3	2.848	3.025	3.138
80	2.686	2.536	2.448	219.2	232.2	240.5	2.740	2.902	3.006
100	2.762	2.612	2.524	266.5	281.8	291.7	2.665	2.818	2.917
150	2.888	2.738	2.650	382.2	403.2	416.6	2.548	2.688	2.777
200	2.966	2.816	2.730	496.3	522.8	539.3	2.492	2.614	2.696