# TRANSMISSION OF HEAT THROUGH COLD-STORAGE INSULATION

PAULDING

D. VAN NOSTRAND COMPANY


UNIVERSITY OF CALIFORNIA
ANDREW
SMITH
HALLIDIE:
REGENT
1868
1901

THE

# Transmission of Heat

THROUGH

# Cold-Storage Insulation

FORMULAS, PRINCIPLES, AND DATA RELATING TO INSULATION OF EVERY KIND

---

*A MANUAL FOR REFRIGERATING ENGINEERS*

---

BY

CHARLES P. PAULDING, M.E.

NEW YORK

D. VAN NOSTRAND COMPANY

23 MURRAY AND 27 WARREN STREETS

1905

ROBERT DRUMMOND, PRINTER, NEW YORK

# PREFACE.

The laws and experiments given by the French physicist, Péclet, in his famous "Traité de la Chaleur," have been the basis of all treatises on artificial heating that have since been written.

They are equally applicable to the art of refrigeration, and it is the purpose of this book to present them in convenient form with the additional data required for modern practice.

# THE TRANSMISSION OF HEAT THROUGH COLD-STORAGE INSULATION.

---

**1. General Principles.**—Let figure 1 represent a section of a wall of a refrigerated room, and let the wall be of the same material throughout its thickness. Let this room be maintained at a constant temperature, lower than that of the external air, by the withdrawal of heat from it by any of the usual methods. Assume the room to be filled, or partially filled, by articles in storage, and suppose that the temperature of the air in the room and that of the air on the outside have remained constant long enough for the flow of heat in through the wall to have become steady; in other words, that the wall has become as cold as under these conditions it ever will become.

Consider, first, the inner surface of the wall; on account of the difficulty which heat experiences in escaping from the surface of a body, this surface is appreciably warmer than the air within the room, and it gives out heat to the room in two ways, by *radiation* and by *air contact*.

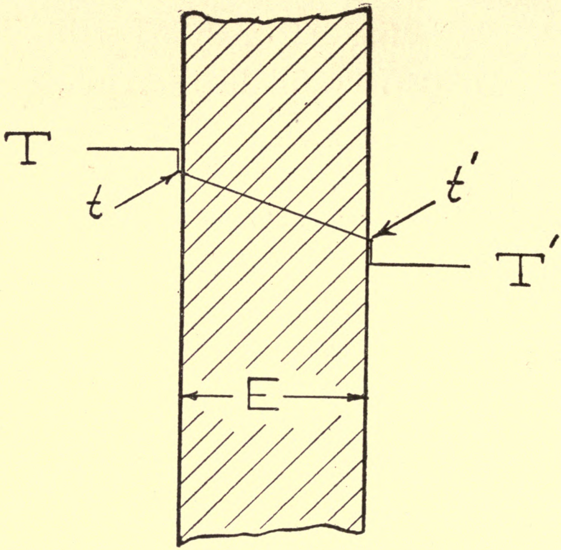


FIGURE 1.

The radiant heat travels in straight lines from the wall-surface to the objects in the room, passing through the air without much, if any, heating of it, but the heat thus imparted to the objects is given up by them to the air by air contact. The objects receiving the radiant heat will evidently be at a temperature slightly higher than the air; we may neglect this in all calculations, but in measuring the air temperature of a refrigerated room by a thermometer we should always take care to protect it from radiation from the walls, and we should also prevent it from radiating heat to any cooling-surfaces such as brine pipes and so forth.

The heat given out by air contact, or convection, as it is perhaps more usually called, is emitted by the wall-surface to the air actually in contact with that surface. As this air is heated it rises, forming an ascending current along the surface, and therefore the higher the wall the less energetic is this action, although the decrease with height is less than might be expected.

The heat thus given to the air and that absorbed by it by contact with the objects heated by radiation is, of course, carried by it to the cooling-pipes; it enters these and is carried away by the cooling-liquid or gas circulating through them.

Turning to the outer wall-surface we again find a sudden difference of temperature between the air and the surface, this difference being necessary to draw the heat in through the resistance of the surface. Part of the heat is radiated to the surface from the surrounding objects and the rest is brought to it by air contact; in this case the current of air along the surface is a descending one instead of an ascending one, as in the case of the inner wall-surface.

Once within the wall, the heat is drawn through the body of it by the difference of temperature between the inner and outer surface. In a homogeneous wall, such as we are considering, the temperature of the wall decreases regularly from the outer to the inner surface, forming a steady slope down which the heat flows by virtue of the conductivity of the insulation. The difference of temperatures governing this action is that of the surfaces, and must not be confused with that of the inner and outer air.

For a given area of wall, the quantities of heat absorbed by the outer surface, transmitted through the body of the wall and emitted by the inner surface, must evidently be equal during any given period of time and constant conditions of temperature.

Having outlined the general principles we now turn to the methods and data for numerical calculations.

**2. Radiation.**—"The quantity of heat emitted by radiation per square foot of surface per hour is independent of the form and size of the body, provided that its surface has no reëntrant portions; it depends solely on the nature of the surface, on the excess of its temperature over that of the objects to which radiation takes place, and on the absolute value of the temperature of these objects.*

It makes no difference whether the surface is radiating heat to other objects, as is the case for the inner surface of a wall of a refrigerated room, or is receiving heat by radiation from other objects, as is the case for the outer wall-surface, the amount of heat emitted or absorbed will be the same for otherwise identical circumstances.

For all practical purposes connected with insulation we may simply take the radiation to be proportional to the difference of temperature between the wall and the objects radiated to, although this is not precisely true, and we may entirely neglect the variation due to the particular temperature of the objects radiated to, but as there will always arise special cases in which these

---

* Péclet. Traité de la Chaleur.

variations might be important, and also in order that individual judgment may have free play, we will give the necessary tables for more exact calculations.

TABLE I.* VALUES OF $K$ FOR DIFFERENT SURFACES.

In B.T.U. radiated per hour, per square foot, per one degree difference of temperature between temperature of surface and temperature of objects radiated to.

| | | | |
|---|---|---|---|
| Polished silver | .027 | Zinc | .049 |
| Silvered paper | .085 | Polished tin | .044 |
| Polished brass | .053 | Tin plate | .086 |
| Gilded paper | .047 | Sheet iron—polished | .092 |
| Polished copper | .033 | Sheet iron—leaded | .133 |
| Cast iron—new | .649 | Sheet iron—ordinary | .567 |
| Cast iron—rusted | .688 | Sheet iron—rusted | .688 |
| Glass | .596 | Building-stone | .737 |
| Powdered chalk | .680 | Plaster and brick | .737 |
| Sawdust | .723 | Wood | .737 |
| Powdered charcoal | .700 | Woolen cloth | .753 |
| Fine sand | .741 | Calico or canvas | .747 |
| Oil paint | .759 | Silk | .759 |
| Paper | .772 | Water | 1.087 |
| Lampblack | .820 | Oil | 1.482 |

Thus in our calculations any painted wall which is three degrees cooler than the objects radiating heat to it would absorb $3 \times .759 = 2.28$ B.T.U. per hour per square foot. For more refined estimates we modify the figures of Table I by multiplying by a coefficient $c'$ depending on the difference of temperatures, and then by another coefficient $c''$ varying with the tempera-

* Péclet. Traité de la Chaleur.

ture of the objects to which radiation takes place. Then the number of B.T.U. radiated per hour per square foot is

$$K \times c' \times c'' \times \text{diff. of temp.} \quad . \quad . \quad (1)$$

The difference of temperature is, as before, that between the radiating surface and the objects radiated to.

TABLE II. VALUES OF $c'$.

| Difference of Temperature between Surface and Objects Radiated to | $c'$. |
|---|---|
| 5 | 1.11 |
| 10 | 1.12 |
| 20 | 1.14 |
| 40 | 1.18 |
| 80 | 1.28 |
| 160 | 1.54 |
| 320 | 2.30 |

TABLE III. VALUE OF $c''$.

| Temperature of Objects Radiated to | $c''$. |
|---|---|
| 0 | .80 |
| 20 | .86 |
| 40 | .93 |
| 60 | 1.01 |
| 80 | 1.10 |
| 100 | 1.19 |
| 150 | 1.47 |
| 200 | 1.82 |

Now return to the example given just after Table I, and assume that the painted wall is at a temperature of thirty-three degrees and the objects to which it radiates at a temperature of thirty degrees; then we have by formula (1)

$$\text{Heat radiated} = .759 \times 1.11 \times .90 \times 3 = 2.28.$$

This result is the same that we obtained before. Now it will be shown further on that it is necessary for simplification to use a value of $K$, the mean between that for the outer wall and that for the inner. An inner temperature of fifteen degrees and outer of forty-five degrees would give the conditions used in the above calculation. Take an inner temperature of forty degrees and an outer of eighty degrees, then the mean is sixty and we would have

$$\text{Heat radiated} = .759 \times 1.11 \times 1.01 \times 3 = 2.55.$$

These cases are toward the two extremes of practice, yet the difference is only about one ninth part of the smaller. If we had been using the two values of $K$, .759 and $.759 \times 1.11 \times 1.01 = .85$, in computing the loss of heat through a wall six inches thick of any ordinary insulating material the difference in the result would have been about one per cent, which is less than the probable error of any calculation of this kind.

**3. Air Contact.**—"The loss of heat arising from air contact is independent of the nature of the surface of the body, and of the absolute value of the temperature of the surrounding air; it depends solely on the excess of the temperature of the body over that of the surrounding air, and on the form and dimensions of the body."*

In all calculations in this book, unless specifically stated otherwise, we will assume the air-contact loss to vary directly as the difference of temperatures of the air and of the wall-surface and will take the loss for plane vertical walls directly from the following table.

Thus for a wall thirty-two feet high at a temperature of eighty degrees and exposed to air at a temperature of eighty-three degrees the heat absorbed per square foot per hour by air contact will be $= K' \times$ diff. of temp. $= .27 \times 3 = .81$.

TABLE IV. VALUES OF $K'$ FOR A PLANE VERTICAL WALL.

In B.T.U. per hour, per square foot, per one degree difference of temperature of wall-surface and surrounding air.

| Height of Wall in Feet. | Value of $K'$. |
|---|---|
| 1 | .40 |
| 2 | .35 |
| 4 | .32 |
| 8 | .30 |
| 16 | .28 |
| 32 | .27 |
| 64 | .26 |

* Péclet. Traité de la Chaleur.

As the air-contact loss, like the radiation loss, does not vary precisely as the difference of temperature, we will give the following formulas and tables for those who may wish to make more exact calculations.

The air-contact loss in B.T.U. per square foot per hour

$$=K' \times c \times \text{diff. of temp.}, \quad . \quad . \quad . \quad . \quad (2)$$

in which the difference of temperature is that between the surface and the surrounding air, $c$ a coefficient depending on this difference of temperature and to be taken from Table V, and $K'$ a number depending on the form and size of the object and given by the following formulas.

For vertical plane surfaces

$$K' = .361 + \frac{.233}{\sqrt{h}}, \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $h$ is the vertical height of the surface in feet.

For horizontal pipes of circular section

$$K' = .421 + \frac{.307}{r}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where $r$ equals the outside radius in inches.

For vertical pipes of circular section

$$K' = .204\left(.726 + \frac{.216}{\sqrt{r}}\right)\left(2.43 + \frac{1.584}{\sqrt{h}}\right), \quad . \quad (5)$$

where $r$ is the outside radius in inches and $h$ the height in feet.

TABLE V. VALUES OF $c$.

| Diff. of Temp. | $c$. |
|---|---|
| 2 | .57 |
| 4 | .67 |
| 6 | .73 |
| 8 | .78 |
| 10 | .82 |
| 20 | .97 |
| 40 | 1.13 |
| 60 | 1.24 |
| 80 | 1.33 |
| 100 | 1.40 |
| 150 | 1.55 |
| 200 | 1.64 |
| 300 | 1.82 |

It will be noticed that the values of Table IV do not agree with formula (3). This is because these values have already been multiplied by the coefficient $c$ taken from Table V for a difference of temperature of four degrees.

**4. Conduction.**—The quantity of heat transmitted through the insulation from outer surface to inner surface varies directly as the area of the wall, directly as the conductivity of the material, inversely as its thickness, and directly as the difference of temperature between the two surfaces.

The formula for an area of one square foot of a homogeneous wall with plane parallel surfaces is then

$$M = \frac{C(t-t')}{E}, \quad \ldots \ldots \quad (6)$$

in which $M$ = B.T.U. transmitted per hour per one square foot;
$C$ = the conductivity of the wall as given in the following tables;
$E$ = the thickness of the wall in inches;
$t$ = the temperature of the outer wall-surface;
$t'$ = the temperature of the inner wall-surface.

The conductivity, designated by $C$, is the quantity of heat that would traverse in one hour a plate of the given material one square foot in area, one inch thick, and with its surfaces maintained at temperatures differing by one degree.

In Table VI are given the values of *C* for a large number of materials as determined with great care and skill by Péclet.

TABLE VI. VALUES OF *C*.

In B T.U. transmitted per hour, per square foot, for one inch of thickness, for one degree difference of surface temperatures.

SOLID MATERIALS.

| | Density. | *C*. |
|---|---|---|
| Marble, gray, fine-grained | 2.68 | 28.1 |
| Marble, white, coarse-grained | 2.77 | 22.4 |
| Limestone, fine-grained | 2.34 | 16.8 |
| Limestone, " | 2.27 | 13.6 |
| Limestone, " | 2.17 | 13.7 |
| Limestone, coarse-grained | 2.24 | 10.6 |
| Limestone, " | 2.22 | 10.2 |
| Plaster, ordinary | 2.22 | 2.67 |
| Plaster, " , very fine | 1.25 | 4.20 |
| Brick | 1.98 | 5.56 |
| Brick | 1.85 | 4.11 |
| Fir (wood), perpendicular to fibres | .48 | .75 |
| Fir " parallel " " | .48 | 1.37 |
| Walnut, perpendicular " " | .48 | .86 |
| Walnut, parallel " " | | 1.40 |
| Oak, perpendicular " " | | 1.70 |
| Cork | .22 | 1.15 |
| India-rubber | .22 | 1.37 |
| Gutta-percha | .22 | 1.39 |
| Starch paste | 1.02 | 3.43 |
| Glass | 2.44 | 6.05 |
| Glass | 2.55 | 7.10 |

(*Continued on next page.*)

TABLE VI—*Continued.*

MATERIALS IN A STATE OF POWDER.

| | Density. | C. |
|---|---|---|
| Quartz sand | 1.47 | 2.18 |
| Brick-dust—large grains | 1.00 | 1.12 |
| Brick-dust—passed through a sieve of silk | 1.76 | 1.33 |
| Brick-dust—fine powder obtained by decantation | 1.55 | 1.13 |
| Chalk, in powder, slightly damp | .92 | .897 |
| Chalk, in powder, washed and dried | .85 | .694 |
| Chalk, in powder, washed, dried, and compressed | 1.02 | .855 |
| Wood-ashes | .45 | .484 |
| Mahogany sawdust | .31 | .524 |
| Charcoal, powdered | .49 | .637 |
| Charcoal, powdered and passed through silk | .41 | .653 |
| Coke, in powder | .77 | 1.290 |

TEXTILE MATERIALS.

| | Density. | C. |
|---|---|---|
| Canvas, of hemp, new | .54 | .420 |
| Canvas, " " old | .58 | .347 |
| White writing-paper | .85 | .347 |
| Gray blotting-paper | .48 | .274 |
| Calico, new, of any density | .... | .403 |
| Cotton wool, " " " | .... | .323 |
| Sheep's wool, " " " | .... | .323 |
| Eiderdown, " " " | .... | .315 |

Table VII was computed from tests of steam-pipe coverings. The figures given are averages of a large number of tests and are believed to be very reliable. *

* See Paulding, "Condensation of Steam in Covered and Bare Pipes." Van Nostrand, 1904.

TABLE VII. VALUES OF *C*.

| | |
|---|---|
| Hair-felt | .32 |
| Remanit | .36 |
| Mineral wool (*a*) | .38 |
| " " (*b*) | .40 |
| " " (*c*) | .47 |
| Compressed sheet cork | .47 |
| Magnesia | .45 |
| Asbestos (*a*) | .57 |
| " (*b*) | .61 |
| " (*c*) | .67 |
| " (*d*) | .74 |

Mineral wools *a* and *b* contained eighteen per cent of magnesia, while *c* had only three per cent of that substance. Asbestos *a* and *d* are made by the same firm, but *a* is much the more expensive covering, probably of selected material. Asbestos *b* and *c* are formed of small air-cells.

Table VIII was computed from the results of experiments given by Mr. J. E. Starr in a paper read before the American Warehousemen's Convention in 1901.*

TABLE VIII. VALUES OF *C*.

| | |
|---|---|
| Lampblack | .91 |
| Pitch | .74 |
| " | .95 |
| American spruce | .93 |
| " " | .94 |
| Mineral wool | .69 |
| " " | .82 |
| Granulated cork | .48 |
| Calcined pumice | .61 |
| Mill-shavings | .65 |

* See "Ice and Refrigeration," Nov. 1901.

Table IX is from Jude and Gossin—"Physics," 1899.

TABLE IX. VALUES OF $C$.

| | |
|---|---|
| Silver | 4440 |
| Copper | 3192 |
| Gold | 2100 |
| Zinc | 888 |
| Tin | 572 |
| Iron | 476 |
| Lead | 334 |
| Ice | 17.42 |
| Snow | 2.03 |
| Water | 4.41 |
| Air | 0.16 |

Péclet states that dampness greatly increases the conductivity of insulating materials, a fact now well known to all refrigerating engineers. One of the most important problems in the construction of insulated walls is to prevent the entrance of moisture.

**5. Formula for a Homogeneous Wall.**—Let figure 1 represent, as before, a wall of the same material throughout its thickness. Let $T$ and $t$ be the temperatures of the outer air and the outer wall-surface respectively, and $T'$ and $t'$ the temperatures of the inner air and the inner wall-surface. Let $M$ be the B.T.U. transmitted through one square foot of the wall in one hour: this is, of course, the quantity we wish to determine. Then from paragraphs 2 and 3 we know that

$$M = (K + K')(T - t) = Q(T - t) \quad . \quad . \quad (7)$$

and $$M = (K + K')(t' - T') = Q(t' - T'), \quad . \quad (8)$$

and from paragraph 4 we have

$$M = \frac{C(t - t')}{E} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Now in practice we never know the temperatures $t$ and $t'$ of the wall-surfaces, but since the three equations above are all equal to one another (see paragraph 1) we can by combining them obtain the following formula in terms of the inner and outer air temperatures, which we may always easily measure.

$$M = \frac{CQ(T - T')}{2C + QE}, \quad . \quad . \quad . \quad . \quad . \quad (10)$$

in which $M$ = B.T.U. transmitted per hour per one square foot;
$C$ = the conductivity of the material (par. 4);
$Q = K + K'$ (pars. 2 and 3);
$E$ = the thickness of the wall in inches;
$T$ = the temperature of the outer air;
$T'$ = the temperature of the inner air.

For example take a wall of brick sixteen inches thick and thirty-two feet high. Let the temperature of the outer air be sixty degrees and that of the inner air forty degrees. From Table I, par. 2, we find that $K=.74$; from Table IV, par. 3, we find that $K'=.27$, then $Q=.74+.27=1.01$, and from Table VI, par. 4, we find the value of $C$ to be about 5. Then each square foot of this brick wall under the given temperature conditions will transmit

$$M=\frac{5\times 1.01(60-40)}{2\times 5+1.01\times 16}=3.87 \text{ B.T.U.}$$

per hour.

Returning now to formula (10) we must note that in order to have such a simple formula it has been necessary to make some assumptions which are not strictly true. Their effect on the results are however comparatively small. In equations 7 and 8 we have set the sums of $K+K'$ for both outer and inner wall-surfaces equal to $Q$, which is of course to assume them equal. In finding $Q$ it is perhaps best to take for $K$ and $K'$ averages of the values appropriate to the inner and outer walls, where, as generally happens, these values are different. In formula (7) we assume that the objects which radiate heat to the walls are at the same temperature as the outer air. This assumption is unavoidable and under practical conditions the error is probably more or less compensatory, the transmission being greater on a clear day and less on a clear night. In formula (8) we assume that the objects to which the inner wall-surfaces radiate are at the temperature of the inner air, and this is practically true except when the wall radiates directly to cold pipe surfaces, and this is negligible unless the proportion of surface thus exposed is unusually large. In such unusual cases an allowance may be made in the value of $Q$. In comparing the insulating values of different walls, one of the most important uses of these formulas, these errors either do not exist or else have so nearly the same value for all the cases as not to influence the comparative results.

It is evident from an inspection of the formula that the transmission of heat varies directly as the difference of the inner and outer air temperatures, but not quite inversely as the thickness of the wall. Thus if the wall had been eight inches thick the value of $M$ would have been 5.59, and not twice 3.87 or 7.74, as might have been thought.

**6. Formula for a Compound Wall.**—Take first a wall of two different materials as represented by figure 2. Let $C$ and $C'$ be the conductivities and $E$ and $E'$ the thicknesses of the two materials,

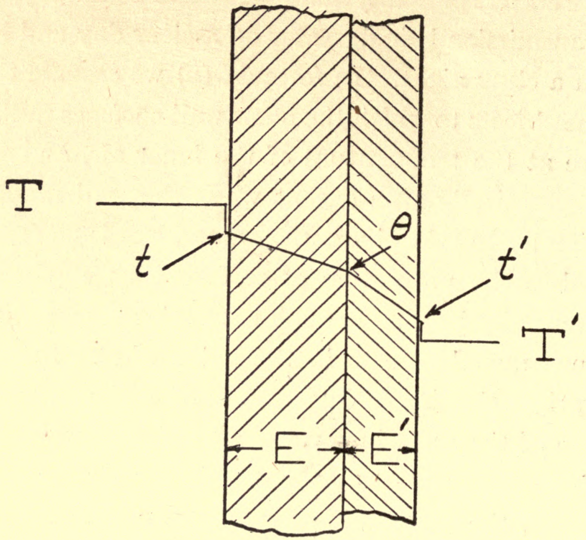


FIGURE 2.

and let $\theta$ represent the temperature at the junction of the materials. Then as in paragraph 5 we may write the following equations:

$$M = Q(T - t), \qquad M = Q(t' - T'),$$

$$M = \frac{C(t - \theta)}{E}, \qquad M = \frac{C'(\theta - t')}{E'}.$$

Combining these we have

$$M = \frac{Q(T - T')}{2 + Q\left(\frac{E}{C} + \frac{E'}{C'}\right)} \quad . \quad . \quad . \quad . \quad (11)$$

For a wall made up of any number of layers of different materials we would have

$$M = \frac{Q(T - T')}{2 + Q\left(\frac{E}{C} + \frac{E'}{C'} + \frac{E''}{C''} + \ldots\right)}, \quad . \quad (12)$$

in which $M$ = B.T.U. transmitted per hour per one square foot;

$C$, $C'$, $C''$ = the respective conductivities of the different layers (par. 4);

$Q = K + K'$ (pars. 2 and 3);

$E$, $E'$, $E''$ = the respective thicknesses in inches of the different layers;

$T$ = the temperature of the outer air;

$T'$ = the temperature of the inner air.

For an example take the wall shown in figure 3. This consists of an outer layer of seven-eighth-inch tongued and grooved spruce sheathing (conductivity from Table VIII equals .93), then a layer of water-proof paper about. 03 inch thick (conductivity by Table VI equals .27), then 1½ inches of hair-felt (conductivity by Table VII

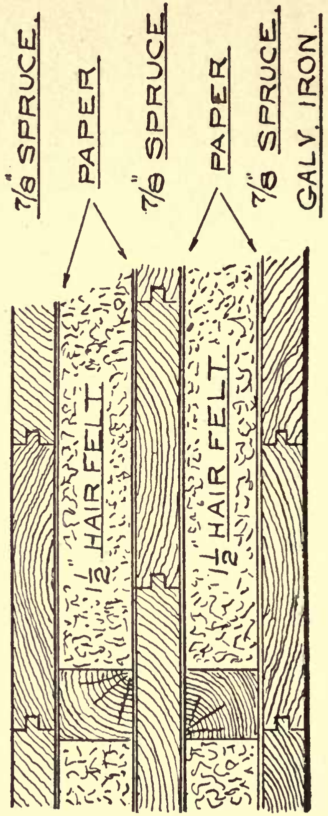


FIGURE 3.

equals .32), then paper, spruce, paper, hair-felt, paper, spruce, and galvanized iron.

On account of the ease with which it transmits heat, we may pay no attention to the galvanized iron except to choose a value of $K$ midway between that due to the iron (.57) and that due to the outer painted surface (.76).

Let us suppose the height of the wall to be 10 feet. Then $Q = .30 + \frac{1}{2}(.57 + .76) = .97$.

Let the temperature of the outer air be ninety degrees and that of the inner twenty degrees. Then by formula (12) we have

$$M = \frac{.97(90-20)}{2 + .97\left[3\left(\frac{.875}{.93}\right) + 4\left(\frac{.03}{.27}\right) + 2\left(\frac{1.5}{.32}\right)\right]} = 4.78.$$

**7. Formula for a Wall Containing an Air-space.**—Let figure 4 represent two walls built with an air-space, closed at top and bottom, between them. Let $x$ and $x'$ be the temperatures of the two sides of the air-space, then the heat will be carried across by radiation and by air contact, and we may say without much error that

$$M = (K + K')(x - x') = Q(x - x').$$

Now if the air-space were filled with insulating material of thickness $E$ and conductivity $C$, the transmission would be equal to $\frac{C}{E}(x - x')$. Then in the general formula we may substitute $\frac{1}{Q}$ for $\frac{E}{C}$ and we have, for one air-space,

$$M=\frac{Q(T-T')}{2+Q\left(\frac{E}{C}+\frac{1}{Q}+\frac{E'}{C'}\right)}, \quad . \quad . \quad . \quad (13)$$

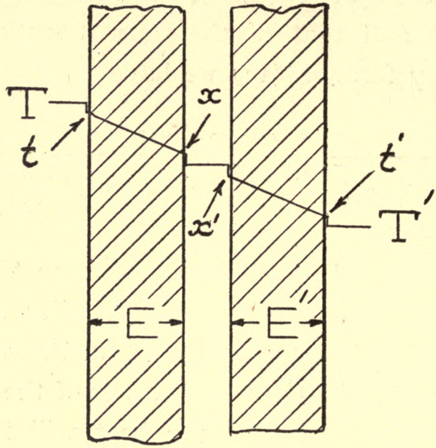


FIGURE 4.

and for any number of air-spaces

$$M=\frac{Q(T-T')}{2+Q\left(\frac{E}{C}+\frac{1}{Q}+\frac{E'}{C'}+\frac{1}{Q}+\frac{E''}{C''}+\ldots\right)}. \quad (14)$$

For the notation see equation (12) of the previous paragraph.

As a numerical example let figure 4 represent a double brick wall 32 feet high, with an air-space, and let each half of the wall be 8 inches thick. Let the temperature of the outer air be sixty degrees and that of the inner forty degrees. Then, referring to the numerical example given in paragraph 5, a solid brick wall 16 inches thick, we have $C=5$ and $Q=1.01$. Then, by formula (13),

$$M=\frac{1.01(60-40)}{2+1.01\left(\frac{8}{5}+\frac{1}{1.01}+\frac{8}{5}\right)}=3.24.$$

Now the 16-inch solid wall transmitted 3.87 B.T.U. per hour per square foot; we have then decreased the transmission about sixteen per cent by adding the air-space.

For a second example we may turn to figure 3 and suppose the hair-felt removed, leaving two air-spaces, but all other conditions of the example in paragraph 6 remaining unchanged. In the formula, then, we drop out the term representing the hair-felt and substitute the value of $\frac{1}{Q}$, which in this case would be $\frac{1}{.30+.76}=\frac{1}{1.06}$; we have then

$$M=\frac{.97(90-20)}{2+.97\left[3\left(\frac{.875}{.93}\right)+4\left(\frac{.03}{.27}\right)+2\left(\frac{1}{1.06}\right)\right]}=9.70.$$

We have, in this case, practically doubled the transmission by substituting air-spaces for hair-felt.

These two examples show how we may determine the value of an air-space in any given case, but a general view of the subject may be useful.

Returning to the formula, equation (13), or, better, to the reasoning preceding it, we see that the thickness of the air-space is of no effect. Experiments have repeatedly shown this to be true, or approximately so, for ordinary thicknesses. Taking one inch as a practical thickness for ordinary construction, and the value of $\frac{1}{Q}$, lying very near to unity, for a material to be of the same value as the air-space, $\frac{C}{E}$ must equal unity, and for the same thickness, namely one inch, $C$ must equal unity. This is about true for ordinary spruce; for almost any of the other materials used in insulation the air-space would be a disadvantage in a wall of fixed thickness. Of course an added air-space that does not displace any insulating material is always a help, but space is frequently too valuable for this construction to be used.

**8. Floors and Ceilings.**—The formulas of the preceding paragraph are in strictness only applicable to vertical walls; but they are equally applicable to floors and ceilings in every respect except the air-contact action, represented in the formulas by the coefficient $K'$, for the conductivity and the radiation are of course unaffected by the position of the wall. In practical cases, on account of the considerable thickness of the insulation we may use the same value of $K'$ as for the side walls without fear of much error, for, though the air-contact action will be low for the ceiling, it should be high for the floor, and the average cannot be far enough from the usual value of $K'$ to seriously affect the result.

**9. Experimental Proof of the Formulas.** — Reliable experiments on the transmission of heat through insulation, under conditions representing actual practice, are very rare, but the following tests, made some years ago by the Nonpareil Cork Manufacturing Co., are believed to be unusually good.

The apparatus consisted of an insulated box, $6' \times 3' \times 3'$ inside measurement, containing an electric heating-coil, the whole placed in a room $12' \times 10' \times 8'$ maintained at a constant temperature by air cooled by an ice-machine. One side of the insulated box was removable, and sides built up of any desired insulation could be substituted for it. The area exposed was taken as the mean of the exterior and interior surfaces. The figures hereinafter given for the transmission in each case are per degree difference of inner and outer air temperatures and are taken from blue-prints issued by the cork company about 1899. In another circular they state that the inner and outer temperatures were held at one hundred degrees and ten degrees respectively; this does not, however, enter into our calculations.

The insulations tested were all combinations of spruce sheathing and compressed sheet cork; they are shown in detail in the following figures. The value of the conductivity of spruce we take from Table VIII as .93; that of water-proof paper .27, as indicated by Table VI; and that of compressed sheet cork as .50, as indicated by the experiments themselves. The value of *K* we

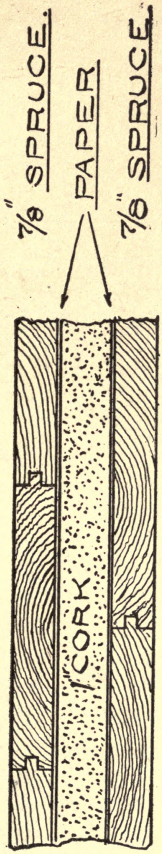


FIGURE 5.

find from Table I to be .74; and from Table IV *K′* is .33, and therefore *Q* equals 1.07.

## EXPERIMENT I.

### INSULATION AS SHOWN IN FIGURE 5.

Heat transmitted, in B.T.U. per hour, per square foot, per degree difference of temperature: by the experiment = .175.

By formula (12),

$$M=\frac{1.07\times 1}{2+1.07\left(2\times\frac{.875}{.93}+2\times\frac{.03}{.27}+\frac{1}{.50}\right)}=.168$$

## EXPERIMENT II.

Insulation as in Exp. I., except two inches of cork instead of one inch.

Heat transmitted: by experiment = .135.

By formula (12),

$$M=\frac{1.07\times 1}{2+1.07(4.10+2)}=.126$$

## EXPERIMENT III.

Insulation as in Exp. II. except three inches of cork instead of two.

Heat transmitted: by experiment = .094.

By formula (12),

$$M=\frac{1.07\times 1}{2+1.07(6.10+2)}=.100$$

## EXPERIMENT IV.

INSULATION AS SHOWN IN FIGURE 6.

Heat transmitted: by experiment =.125.

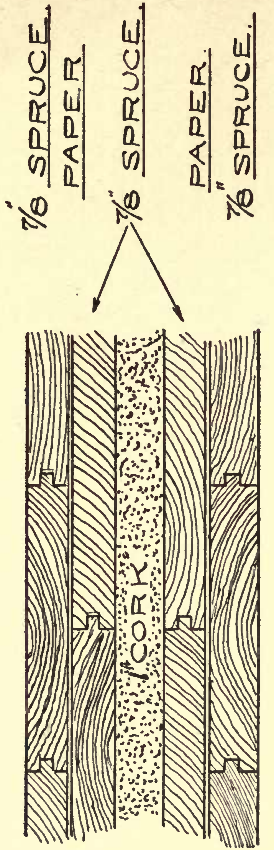


FIGURE 6.

By formula (12),

$$M = \frac{1.07 \times 1}{2 + 1.07(4 \times .94 + 2 \times .11 + 2)} = .128$$

## EXPERIMENT V.

INSULATION AS SHOWN IN FIGURE 7.

For the air-space, $\frac{1}{Q} = .93$.

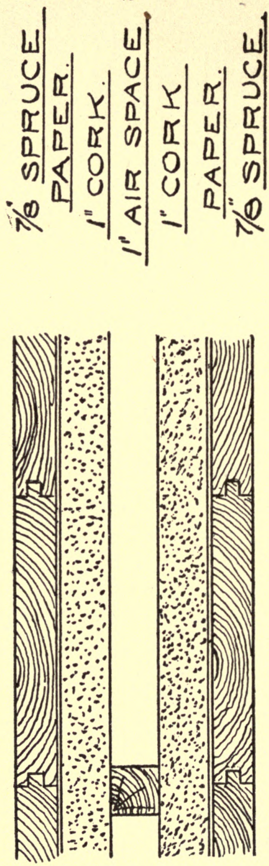


FIGURE 7.

Heat transmitted: by experiment = .117

By formula (13),

$$M = \frac{1.07 \times 1}{2 + 1.07(2 \times .94 + 2 \times .11 + 2 \times 2 + .93)} = .112$$

### Experiment VI.

Insulation as in figure 7, except that a layer of one-inch cork is replaced by one of seven-eighths spruce sheathing.

Heat transmitted: by experiment = .146

By formula (13),

$$M = \frac{1 \times 1.07}{2 + 1.07(3 \times .94 + 2 \times .11 + 2 + .93)} = .128$$

To those who are familiar with the difficulties of tests of this kind the agreement between theory and tests will probably be not unsatisfactory, except in the case of the last experiment. It will be noticed that the insulation in this experiment is the same as in the previous one except that a layer of spruce sheathing has been substituted for a layer of cork. To get the result given in the test we should have to assume the spruce to be of no value whatever, which is obviously absurd.

Some steam-pipe coverings of compressed cork were included in some very extensive tests made a few years ago by Mr. Geo. H. Barrus, and I have computed the value of the conductivity in that case to have been .47. This agrees fairly with the value .50 found to suit best the tests just described.

**10. Insulation of Brine-pipes.**— In the case of a covered pipe conveying cold brine or ammonia-gas, there are four stages in the process of the absorption of heat:

1st. The passage of the heat from the air into the surface of the covering, by radiation from the surrounding objects and the air-contact action of the surrounding air.

2d. The conduction of the heat through the covering from its outer to its inner surface.

3d. The conduction of the heat through the metal of the pipe

4th. The escape of the heat from the inner surface of the pipe to the liquid or gas traversing the pipe.

On account of the high conductivity of the metal of the pipe, the ease with which heat escapes from a surface to a *rapidly moving* liquid, or even gas, bathing that surface, and the small quantity of heat permitted to pass by the insulating covering, we may entirely neglect the third and fourth stages of the process. This is equivalent to saying that the temperature of the inner surface of the covering is the same as that of the brine or gas circulating through the pipe.

The first and second stages depend on exactly the same principles as in the case of the walls of a refrigerated room, and from these laws we get the following formula:

$$U = \frac{2\pi R'Q(T-t')}{1 + \frac{12NR'Q}{C}}, \quad . \quad . \quad . \quad (15)*$$

---

* If we consider an infinitely thin annular element of the covering, one foot long, at radius $r$, its thickness is $dr$, its area $2\pi r$, its conductivity per one foot thickness is $C'$, equal to $\frac{C}{12}$, and the difference between the temperature of its inner and outer surfaces is $dt$. Then, treating it as a flat plate, we have by paragraph 4

$$U = \frac{2\pi r C' dt}{dr}, \quad \text{or} \quad C' \int_{t'}^{t} dt = \frac{U}{2\pi} \int_{R}^{R'} \frac{dr}{r},$$

where $t$ = temperature of the outer surface of the covering. Integrating, and changing from hyperbolic to common logarithms, we get

$$U = \frac{2\pi C'(t-t')}{2.3(\log R' - \log R)} = \frac{2\pi C'(t-t')}{N}.$$

We know from the principles of paragraphs 2 and 3 that

$$U = 2\pi R'Q(T-t).$$

By combining these last two equations and writing $\frac{C}{12}$ for $C'$ we get

$$U = \frac{2\pi R'Q(T-t')}{1 + \frac{12NR'Q}{C}}. \quad . \quad . \quad . \quad . \quad . \quad (15)$$

in which $U$ = the B.T.U. per hour *per foot run* absorbed through the covering;

$\pi = 3.1416$;

$R'$ = radius in feet of the outer surface of the covering (see Table X);

$N$ = 2.3 (logarithm of $R'$ − logarithm of $R$) where $R$ is the radius in feet of the outer surface of the pipe (see Table X);

$Q = K + K'$, in which $K$ is the radiation coefficient appropriate to the material forming the surface of the covering, and is to be taken from Table I; while $K'$ is the air-contact coefficient to be taken from Table X or from formula 4 or 5 of paragraph 3;

$C$ = the conductivity of the material of the covering taken from the tables of paragraph 4;

$T$ = the temperature of the air surrounding the covered pipe;

$t'$ = the temperature of the brine or gas circulating through the pipe.

TABLE X.—FOR USE WITH FORMULA (15).

| Nominal Pipe Size. | Thickness of Covering in Inches. | Radius in Feet. $R'$. | Square Feet per Foot Run. $2\pi R'$. | $12R'N$. | For Horizontal Pipe. $K'$. |
|---|---|---|---|---|---|
| 1″ | 0 | .055 | .356 | ..... | .89 |
| | ½ | .097 | .609 | .660 | .68 |
| | 1 | .138 | .870 | 1.530 | .61 |
| | 1½ | .180 | 1.130 | 2.560 | .56 |
| | 2 | .221 | 1.389 | 3.688 | .54 |
| | 2½ | .263 | 1.652 | 4.928 | .52 |
| | 3 | .305 | 1.915 | 6.260 | .50 |
| 1½″ | 0 | .078 | .491 | ..... | .75 |
| | ½ | .121 | .759 | .639 | .63 |
| | 1 | .163 | 1.022 | 1.425 | .58 |
| | 1½ | .204 | 1.283 | 2.350 | .55 |
| | 2 | .246 | 1.546 | 3.390 | .52 |
| | 2½ | .288 | 1.810 | 4.505 | .51 |
| | 3 | .329 | 2.069 | 5.665 | .50 |
| 2″ | 0 | .099 | .62 | ..... | .68 |
| | ½ | .141 | .89 | .593 | .60 |
| | 1 | .183 | 1.15 | 1.335 | .56 |
| | 1½ | .224 | 1.41 | 2.190 | .54 |
| | 2 | .266 | 1.67 | 3.145 | .52 |
| | 2½ | .308 | 1.94 | 4.192 | .50 |
| | 3 | .349 | 2.19 | 5.273 | .49 |
| 2½″ | 0 | .120 | .75 | ..... | .63 |
| | ½ | .162 | 1.02 | .579 | .58 |
| | 1 | .204 | 1.28 | 1.290 | .55 |
| | 1½ | .245 | 1.54 | 2.093 | .52 |
| | 2 | .287 | 1.80 | 2.997 | .51 |
| | 2½ | .328 | 2.06 | 3.952 | .50 |
| | 3 | .370 | 2.32 | 4.999 | .49 |
| 3″ | 0 | .146 | .92 | ..... | .60 |
| | ½ | .188 | 1.18 | .565 | .56 |
| | 1 | .229 | 1.44 | 1.240 | .53 |
| | 1½ | .271 | 1.70 | 2.010 | .51 |
| | 2 | .313 | 1.96 | 2.857 | .50 |
| | 2½ | .354 | 2.22 | 3.754 | .49 |
| | 3 | .396 | 2.49 | 4.730 | .49 |

TABLE X—*Continued.*

| Nominal Pipe Size. | Thickness of Covering in Inches. | Radius in Feet. $R'$. | Square Feet per Foot Run. $2\pi R'$. | 12 $R'N$. | For Horizontal Pipe. $K'$. |
|---|---|---|---|---|---|
| 4″ | 0 | .188 | 1.18 | ..... | .56 |
| | ½ | .229 | 1.44 | .553 | .53 |
| | 1 | .271 | 1.70 | 1.196 | .51 |
| | 1½ | .313 | 1.96 | 1.915 | .50 |
| | 2 | .354 | 2.22 | 2.682 | .49 |
| | 2½ | .396 | 2.49 | 3.533 | .49 |
| | 3 | .438 | 2.75 | 4.434 | .48 |
| 5″ | 0 | .232 | 1.46 | ..... | .53 |
| | ½ | .273 | 1.72 | .541 | .51 |
| | 1 | .315 | 1.98 | 1.160 | .50 |
| | 1½ | .357 | 2.24 | 1.847 | .49 |
| | 2 | .398 | 2.50 | 2.574 | .49 |
| | 2½ | .440 | 2.77 | 3.371 | .48 |
| | 3 | .482 | 3.03 | 4.220 | .48 |
| 6″ | 0 | .276 | 1.73 | ..... | .51 |
| | ½ | .318 | 2.00 | .534 | .50 |
| | 1 | .359 | 2.26 | 1.133 | .49 |
| | 1½ | .401 | 2.52 | 1.795 | .49 |
| | 2 | .443 | 2.78 | 2.512 | .48 |
| | 2½ | .484 | 3.04 | 3.259 | .48 |
| | 3 | .526 | 3.30 | 4.063 | .47 |
| 8″ | 0 | .359 | 2.26 | ..... | .49 |
| | ½ | .401 | 2.52 | .529 | .49 |
| | 1 | .443 | 2.78 | 1.110 | .48 |
| | 1½ | .484 | 3.04 | 1.738 | .48 |
| | 2 | .526 | 3.30 | 2.410 | .47 |
| | 2½ | .568 | 3.57 | 3.120 | .47 |
| | 3 | .609 | 3.83 | 3.859 | .46 |

For a numerical example we will take a 1½-inch standard pipe, running horizontally, covered with an insulation two inches thick and of conductivity .64. Let the temperature of the surrounding air be eighty degrees and the brine within the pipe be at a temperature of twenty degrees. What will be the absorption of heat per hour per foot run in B.T.U.?

In this example we may take the quantities $2\pi R'$, $12NR'$, and $K'$ directly from Table X; their values are 1.55, 3.39, and .52 respectively. If we suppose the outer surface of the covering coated with paint we may take $K=.76$, then $Q=.52+.76=1.28$ and our formula becomes

$$U=\frac{1.55\times 1.28(80-20)}{1+\frac{3.39\times 1.28}{.64}}=15.30.$$

If the brine in this pipe were to travel at a speed of 150 feet per minute, there would pass in one hour 8940 pounds of a specific gravity of 1.12 and a specific heat of .86. To raise the temperature of this one degree would require $8940\times .86=7688$ B.T.U. If we divide this figure by 15.30 we get the length of pipe through which the brine may be carried before its temperature rises one degree. This works out at about 500 feet.

Returning to formula (15) we see at once that the amount of heat absorbed varies directly as the difference of temperatures of the surrounding air and the brine. In regard to the variation due to the conductivity, $C$, of the covering, we see from the formula that although the absorption does not vary directly with this, still the departure from this law is not great. Thus in our numerical example, if we had employed hair-felt with a conductivity of .32 instead of the material with $C$ equal to .64 we should have found $U$ to equal 8.17, which is not so far from half of 15.30. But in regard to the variation of the absorption as the thickness of the covering is changed the law is complicated. If we consider a covering composed of two cylindrical layers of equal thickness, it is evident that while the resistance due to thickness will be the same in both, the outer layer will present a greater area for the passage of the incoming heat and therefore will be less effective than the inner layer. Moreover, the addition of the outer layer has increased the superficial area per foot run, thus giving a greater opportunity for air contact and radiation. The greater the diameter of the pipe the nearer does each layer come to being equally effective. Returning to our numerical example the variation of absorption with thickness would be as follows:

| $1\frac{1}{4}$-inch Pipe, Horizontal. Thickness of Covering. ($C$=.64) | Brine, 20°; Air, 80°. B.T.U. per Hour per Foot Run. (Diff. of Temp.=60°) |
|---|---|
| $\frac{1}{2}''$ | 26.55 |
| 1 " | 20.58 |
| $1\frac{1}{2}''$ | 17.35 |
| 2 " | 15.30 |

By the principles laid down in paragraphs 2 and 3 the absorption of heat by a bare pipe under the conditions of our numerical example can be readily obtained.

The formula is:

$$U = 2\pi R'Q(T - t'), \quad . \quad . \quad . \quad (16)$$

and from Table X, $2\pi R'$ is .491, while $K'$ is .75. From Table I, $K$ is about .57, therefore $Q = .75 + .57 = 1.32$ and $U = .491 \times 1.32 \times 60 = 38.89$.

This figure shows that the two-inch covering has reduced the loss to $15.30 \div 38.89 = 39.4$ per cent of that which occurs with a bare pipe. If the covering had been of hair-felt, which represents about the highest commercially obtainable efficiency, the loss would be only $8.17 \div 38.89 = 21$ per cent. Of course a bare pipe would soon coat itself with snow and thus decrease the absorption, but for purposes of comparison we cannot consider this.

# IMPORTANT BOOKS.

—ON—

# Refrigeration and Ice-Making.

**Dixon, A. J.**—Manual of Ice-Making and Refrigerating Machines. A Treatise on the Theory and Practice of Cold-Production by Mechanical Means. 16mo, cloth. St. Louis, 1894.................................... $1.00

**Hausbrand, E.**—Evaporating, Condensing and Cooling Apparatus; Explanations, Formulæ, and Tables for Use in Practice. Translated from the Second Revised German Edition by A. C. Wright, M.A. With numerous figures, tables and Diagrams. 8vo., Cloth. Illustrated. 400 pp. London, 1902............net 5.00

**Leask, A. Ritchie.**—Refrigerating Machinery. Its Principles and Management. With numerous illustrations. *Second Edition, Revised.* 8vo., Cloth. 296 pp. London, 1901....................... .......... 2.00

**Ledoux, M.**—Ice-Making Machines: The Theory of the action of the various forms of cold-producing, or so-called Ice Machines. Translated, revised and transformed into English units by J. E. Denton, D. S. Jacobus and A. Reisenberger. With tables, figures and diagrams. **Fifth Edition, Revised.** 16mo, Cloth. Illustrated. 190 pp. New York, 1902...... .50

**Levy, J.**—Refrigerating Memoranda; a collection of useful information relating to Ice-Making and Refrigerating, gathered from engine-room practice. With tables and diagrams. 32mo, limp leather, illustrated. 76 pp. Chicago, 1902.............................. .75

**Lorez, H. (Prof.)**—Modern Refrigerating Machinery; Its Construction, Methods of Working and Industrial Applications. A guide for Engineers and Owners of Refrigerating Plants. Authorized Translation from the Third German Edition by Thos. H. Pope, B.Sc., with chapters on American Practice in Refrigeration, Insulation, Auditorium, and Other Cooling, by H. M. Haven, S.B., and F. W. Dean, S.B. 8vo., Cloth, Illustrated, 396 pp. New York, 1905...........net 4.00

**Paulding, C. P.**—Practical Laws and Data on the Condensation of Steam in Covered and Bare Pipes; to which is added a translation of Peclet's "Theory and Experiments on the Transmission of Heat through Insulating Materials." With tables, figures and diagrams. 8vo., Cloth, illustrated. 102 pp. New York, 1904.......................... ................net 2.00

———Transmission of Heat through Cold-Storage Insulation: Formulas, Principles and Data relating to insulation of every kind. A manual for refrigerating engineers. 12mo, cloth. 41 pages, Illustrated. New York, 1905........... ...... ..........net 1.00

**Redwood, I. I.**—Theoretical and Practical Ammonia Refrigeration. A practical handbook for the use of those in charge of refrigerating plants. Illustrated, with numerous Tables. **Third edition, revised and corrected.** 12mo, cloth. New York, 1898.... 1.00

**Schmidt, L. M.,** Ph.B.—Principles and Practice of Artificial Ice-Making and Refrigerating. Comprising principles and general consideration—practice as shown by particular systems and apparatus—insulation of cold-storage and ice-houses, refrigerators, etc. Useful information and tables. Illustrated with numerous folding plates and diagrams. **Second edition, Revised and enlarged.** 8vo., cloth, illustrated. 291 pp. Philadelphia, 1904.................. 2.50

**Selfe, N.**—Machinery for Refrigeration: being sundry observations with regard to the principal appliances employed in ice-making and refrigeration, and upon the laws relating to the expansion and compression of gases, principally from an Australian standpoint. Containing many tables, diagrams and half-tone cuts. 8vo, Cloth, illustrated. Chicago, 1904.... ....... 3.50

**Siebel, J. E.**—Compend of Mechanical Refrigeration. A comprehensive digest of Applied Energetics and Thermodynamics for the Practical Use of Ice-Manufacturers, Cold-Storage Men, Contractors, Engineers, Brewers, Packers and others interested in the Application of Refrigeration. With numerous tables. **Sixth Edition.** 8vo., cloth. 389 pp. Chicago, 1904 ...... ...............................net 3.00

**Stephanshy, P. C. O.**—The practical running of an Ice and Refrigerating Plant. Illustrated. Boston, 1897 2.00

**Vincent, C.**—Ammonia and its Compounds: their manufacture and uses. Translated from the French by M. J. Salter. 113 pp. illustrated. 8vo., cloth. 1901. net 2.00

## *Catalogue of Scientific Publications*

*and Importations of the D. Van Nostrand Company, 23 Murray Street and 27 Warren Street, New York.*

---

**A B C CODE. (See Clausen-Thue.)**

**ABBOT, H. L., Gen'l. The Defence of the Seacoast of** the United States. Lectures delivered before the U. S. Naval War College. 8vo, red cloth. . . . . . . . . . . . . . . . . . . . . . . $2.00

**ABBOTT, A. V. The Electrical Transmission of Energy.** A Manual for the Design of Electrical Circuits. *New edition, revised, and entirely rewritten.* Fully illustrated. 8vo, cloth. $4.50

**ADAM, P. Practical Bookbinding. With illustrations** and figures. Translated from the German by Thomas E. Maw. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net,* $2.50

**ADAMS, J. W. Sewers and Drains for Populous Dis-**tricts. Embracing Rules and Formulas for the dimensions and construction of works of Sanitary Engineers. 8vo, cloth. . . . $2.50

**ADDYMAN, F. T. Practical X-Ray Work. Part I,** Historical. Part II, Apparatus and its Management. Part III, Practical X-Ray Work. Illustrated with twelve plates from photographs. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . *net,* $4.00

**A 1 CODE. (See Clausen-Thue.)**

**AIKMAN, C. M., Prof. Manures and the Principles of** Manuring. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.50

**ALEXANDER, J. H. Universal Dictionary of Weights** and Measures, Ancient and Modern, reduced to the Standards of the United States of America. *New Edition, enlarged.* 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $3.50

**ALEXANDER, S. A. Broke Down: What Should I Do?** A Ready Reference and Key to Locomotive Engineers and Firemen, Round-house Machinists, Conductors, Train Hands and Inspectors. With 5 folding plates. 12mo, cloth. . . . . . . . $1.50

**ANDERSON, G. L., A.M. (Captain of U. S. Artillery).** Handbook for the use of Electricians in the operation and care of Electrical Machinery and Apparatus of the United States Seacoast Defenses. Prepared under the direction of the Lieutenant-General Commanding the Army. With tables, diagrams and illustrations. 8vo, cloth, illustrated.................... $3.00

**ANDERSON, J. W. Prospector's Handbook. A Guide** for the Prospector and Traveller in search of Metal-bearing or other Valuable Minerals. *Eighth Edition, revised.* 8vo, cloth....$1.50

**ANDERSON, W. On the Conversion of Heat into Work.** A Practical Handbook on Heat-engines. *Third Edition.* Illustrated. 12mo, cloth.............................. $2.25

**ANDÉS, L. Vegetable Fats and Oils: Their Practical** Preparation, Purification and Employment for Various Purposes. Their Properties, Adulteration and Examination. A Handbook for Oil Manufacturers and Refiners, Candle, Soap and Lubricating-oil Manufacturers, and the Oil and Fat Industry in general. Translated from the German. With 94 illus. 8vo, cloth....*net,* $4.00

**—— Animal Fats and Oils. Their Practical Produc**tion, Purification and Uses for a great variety of purposes; their Properties, Falsification and Examination. A Handbook for Manufacturers of Oil and Fat Products, Soap and Candle Makers, Agriculturists, Tanners, etc. Translated by Charles Salter. With 62 illustrations. 8vo, cloth.................... *net,* $4.00

**—— Drying Oils, Boiled Oil, and Solid and Liquid Driers.** A practical work for manufacturers of Oils, Varnishes, Printing Inks, Oilcloth and Linoleum, Oil-cakes, Paints, etc. 8vo, cloth, illustrated.......................................... *net,* $5.00

**—— Iron Corrosion, Anti-fouling and Anti-corrosive** Paints. Translated from the German by Charles Salter. Illustrated with engravings and half-tone cuts. 8vo, cloth..*net,* $4.00

**—— Oil Colors, and Printers' Ink. A Practical Hand** book treating of Linseed-oil, Boiled Oil, Paints, Artists' Colors, Lampblack, and Printers' Inks (black and colored). Translated from the German by Arthur Morris and Herbert Robson. With 56 figures and diagrams. 8vo, cloth, 212 pages........*net,* $2.50

**ARNOLD, E. Armature Windings of Direct-Current** Dynamos. Extension and Application of a General Winding Rule. Translated from the original German by Francis B. DeGress, M.E. With numerous illustrations. 8vo, cloth... $2.00

**ARNOLD, R., Dr. Ammonia and Ammonium Compounds.** A Practical Manual for Manufacturers, Chemists, Gas Engineers and Drysalters. *Second Edition.* 12mo, cloth.... $2.00

**Art of Dyeing Wool, Silk and Cotton. Translated from** the French of M. Hellott, M. Macquer and M. Le Pileur D'Apligny. First published in English in 1789. 8vo, cloth, illustrated, *net,* $2.00

**ASHE, S. W., and KEILEY, J. D. Electric Railways,** Theoretically and Practically Treated. With 200 diagrams and engravings. Ready Sept., 1904.

**ATKINSON, A. A., Prof. (Ohio University). Electrical** and Magnetic Calculations, for the use of Electrical Engineers and Artisans, Teachers, Students and all others interested in the Theory and Application of Electricity and Magnetism. *Second Edition, revised.* 8vo, cloth, illustrated. .............. *net,* $1.50

**ATKINSON, P. The Elements of Electric Lighting.** including Electric Generation, Measurement, Storage and Dis tribution. *Tenth Edition, fully revised and new matter added-* Illustrated. 12mo, cloth.............................. $1.50

**—— The Elements of Dynamic Electricity and Magnetism.** *Fourth Edition.* 120 illustrations. 12mo, cloth. . $2.00

**—— Power Transmitted by Electricity and its Application** by the Electric Motor, including Electric Railway Construction. *Fourth Edition, fully revised, new matter added.* 12mo, cloth, illustrated................................ $2.00

**AUCHINCLOSS, W. S. Link and Valve Motions Simplified.** Illustrated with 29 woodcuts and 20 lithographic plates, together with a Travel Scale, and numerous useful tables. *Fourteenth Edition, revised.* 8vo, cloth. ....................... $2.00

**AXON, W. E. A. The Mechanic's Friend. A Collection** of Receipts and Practical Suggestions relating to Aquaria, Bronzing, Cements, Drawing, Dyes, Electricity, Gilding, Glass-working, Glues, Horology, Lacquers, Locomotives, Magnetism, Metal-working, Modelling, Photography, Pyrotechny, Railways, Solders, Steam-engine, Telegraphy, Taxidermy, Varnishes, Waterproofing, and Miscellaneous Tools, Instruments, Machines and Processes connected with the Chemical and Mechanic Arts. With numerous diagrams and woodcuts. 12mo, cloth, illustrated......... $1.50

**AYRTON, H. The Electrical Arc. With numerous figures,** diagrams and plates. 8vo, cloth, illustrated. ........ $5.00

**AYRTON, W. E., M.I.C.E. Practical Electricity. A Laboratory** and Lecture Course for the first-year students of Electrical Engineering, based on the International Definitions of the Electrical Units. Vol. I, Current, Pressure, Resistance, Energy, Power, and Cells. Completely rewritten and containing many figures and diagrams. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.00

**BACON, F. W. A Treatise on the Richards Steam-engine** Indicator, with directions for its use. By Charles T. Porter. Revised, with notes and large additions as developed by American practice; with an appendix containing useful formulæ and rules for engineers. Illustrated. *Fourth Edition.* 12mo, cloth. . $1.00

**BADT, F. B. New Dynamo Tender's Handbook. With** 140 illustrations. 16mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . $1.0C

**——— Bell-hangers' Handbook. With 97 illustrations.** *Second Edition.* 16mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . $1.00

**——— Incandescent Wiring Handbook. With 35 illustra-**tions and 5 tables. *Fifth Edition.* 16mo, cloth. . . . . . . . . . . $1.00

**——— Electric Transmission Handbook. With 22 illus-**trations and 27 tables. 16mo, cloth. . . . . . . . . . . . . . . . . . . . . $1.00

**BAKER, Arthur L., Prof. (Univ. of Rochester). Quater-**nions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *In Press.*

**BAKER, M. N. Potable Water and Methods of Detect-**ing Impurities. 16mo, cloth. (*Van Nostrand's Science Series*) .50

**BALCH, G. T., Col. Methods of Teaching Patriotism** in the Public Schools. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . $1.00

**BALE, M. P. Pumps and Pumping. A Handbook for** Pump Users. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.50

**BARBA, J. The Use of Steel for Constructive Purposes.** Method of Working, Applying and Testing Plates and Bars. With a Preface by A. L. Holley, C.E. 12mo, cloth. . . . . . $1.50

**BARKER, A. H. Graphic Methods of Engine Design.** Including a Graphical Treatment of the Balancing of Engines. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.50

**BARNARD, F. A. P. Report on Machinery and Pro-**cesses of the Industrial Arts and Apparatus of the Exact Sciences at the Paris Universal Exposition, 1867. 152 illustrations and 8 folding plates. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . $5.00

**BARNARD, J. H. The Naval Militiaman's Guide.** Full leather, pocket size .................................... $1.25

**BARRUS, G. H. Boiler Tests: Embracing the Results** of one hundred and thirty-seven evaporative tests, made on seventy-one boilers, conducted by the author. 8vo, cloth. $3.00

**——Engine Tests: Embracing the Results of over one** hundred feed-water tests and other investigations of various kinds of steam-engines, conducted by the author. With numerous figures, tables, and diagrams. 8vo, cloth, illustrated.. $4.00
**The two books sent prepaid for** ........................ $6.00

**BARWISE, S., M.D. (London). The Purification of** Sewage. Being a brief account of the Scientific Principles of Sewage Purification and their Practical Application. 12mo, cloth, illustrated.......................................... $2.00

**—— The Bacterial Purification of Sewage. Being a** Practical Account of the Various Modern Biological Methods of Purifying Sewage. With plates and diagrams. 8vo, cloth, illustrated.......................................... *net*, $2.50

**BAUER'S Marine Engines and Boilers.** .........*In Press.*

**BAUMEISTER, R. The Cleaning and Sewerage of Cities.** Adapted from the German with permission of the author. By J. M. Goodell, C.E. *Second Edition, revised and corrected, together with an additional appendix.* 8vo, cloth, illustrated. $2.00

**BEAUMONT, R. Color in Woven Design. With 32** colored plates and numerous original illustrations. Large, 12mo.......................................... $7.50

**BEECH, F. Dyeing of Cotton Fabrics. A Practical** Handbook for the Dyer and Student. Containing numerous recipes for the production of Cotton Fabrics of all kinds, of a great range of colors, thus making it of great service in the dye-house, while to the student it is of value in that the scientific principles which underlie the operations of dyeing are clearly laid down. With 44 illustrations of Bleaching and Dyeing Machinery. 8vo, cloth, illustrated.......................................... *net*, $3.00

**—— Dyeing of Woolen Fabrics. With diagrams and** figures. 8vo, cloth, illustrated.......................... *net*, $3.50

**BECKWITH, A. Pottery. Observations on the Materials** and Manufacture of Terra-cotta, Stoneware, Firebrick, Porcelain, Earthenware, Brick, Majolica, and Encaustic Tiles. *Second Edition.* 8vo, paper.......................................... .60

**BEGTRUP, J., M.E. The Slide Valve and its Functions.** With Special Reference to Modern Practice in the United States. With numerous diagrams and figures. 8vo, cloth........$2.00

**BERNTHSEN, A. A Text-book of Organic Chemistry.** Translated by George M'Gowan, Ph.D. *Fourth English Edition,* revised and extended by author and translator. Illustrated. 12mo, cloth.......................................... $2.50

**BERSCH, J., Dr. Manufacture of Mineral and Lake** Pigments. Containing directions for the manufacture of all artificial artists' and painters' colors, enamel colors, soot and metallic pigments. A text-book for Manufacturers, Merchants, Artists and Painters. *Translated from the second revised edition* by Arthur C. Wright, M.A. 8vo, cloth, illustrated..... *net,* $5.00

**BERTIN, L. E. Marine Boilers: Their Construction and** Working, dealing more especially with Tubulous Boilers. Translated by Leslie S. Robertson, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.N.A., containing upward of 250 illustrations. Preface by Sir William White, K.C.B., F.R.S., Director of Naval Construction to the Admiralty, and Assistant Controller of the Navy. *New and Revised Edition.* 8vo, cloth, illustrated........ $7.50

**BIGGS, C. H. W. First Principles of Electricity and** Magnetism. A book for beginners in practical work, containing a good deal of useful information not usually to be found in similar books. With numerous tables and 343 diagrams and figures. 12mo, cloth, illustrated.......................... $2.00

**BINNS, C. F. Ceramic Technology. Being Some Aspects** of Technical Science as applied to Pottery Manufacture. 8vo, cloth.......................................... *net,* $5.00

**—— Manual of Practical Potting. Compiled by Experts.** *Third Edition, revised and enlarged.* 8vo, cloth ....... *net,* $7.50

**BIRCHMORE, W. H., Dr. How to Use a Gas Analysis.** 12mo, cloth, illustrated..............................*In Press.*

**BLAKE, W. P. Report upon the Precious Metals. Being** Statistical Notices of the Principal Gold and Silver producing regions of the world, represented at the Paris Universal Exposition. 8vo, cloth.................................... $2.00

**BLAKESLEY, T. H. Alternating Currents of Electricity.** For the use of Students and Engineers. *Third Edition, enlarged.* 12mo, cloth.......................................... $1.50

**BLYTH, A. W., M.R.C.S., F.C.S. Foods: Their Composition and Analysis.** A Manual for the use of Analytical Chemists, with an Introductory Essay on the History of Adulterations. With numerous tables and illustrations. *Fifth Edition, thoroughly revised, enlarged and rewritten.* 8vo, cloth..... $7.50

**—— Poisons: Their Effects and Detection. A Manual** for the use of Analytical Chemists and Experts, with an Introductory Essay on the Growth of Modern Toxicology. *Third Edition, revised and enlarged.* 8vo, cloth................ $7.50

**BODMER, G. R. Hydraulic Motors and Turbines. For** the use of Engineers, Manufacturers and Students. *Third Edition, revised and enlarged.* With 192 illustrations. 12mo, cloth.................................................. $5.00

**BOILEAU, J. T. A New and Complete Set of Traverse** Tables, showing the Difference of Latitude and Departure of every minute of the Quadrant and to five places of decimals. 8vo, cloth.............................................. $5.00

**BONNEY, G. E. The Electro-platers' Handbook. A** Manual for Amateurs and Young Students of Electro-metallurgy. 60 illustrations. 12mo, cloth......................... $1.20

**BOTTONE, S. R. Electrical Instrument Making for** Amateurs. A Practical Handbook. With 48 Illustrations. *Fifth Edition, revised.* 12mo, cloth........................ .50

**—— Electric Bells, and All About Them. A Practical** Book for Practical Men. With more than 100 Illustrations. *Fourth Edition, revised and enlarged.* 12mo, cloth......... .50

**—— Electro-motors: How Made and How Used. A** Handbook for Amateurs and Practical Men. *Second Edition.* 12mo, cloth.............................................. .75

**BOURRY, E. Treatise on Ceramic Industries. A Complete** Manual for Pottery, Tile and Brick Works. Translated from the French by Wilton P. Rix. With 323 figures and illustrations. 8vo, cloth, illustrated.............................. *net,* $8.50

**BOW, R. H. A Treatise on Bracing. With its applica**tion to Bridges and other Structures of Wood or Iron. 156 illustrations. 8vo, cloth.................................. $1.50

**BOWIE, AUG. J., Jr., M.E. A Practical Treatise on** Hydraulic Mining in California. With Description of the Use and Construction of Ditches, Flumes, Wrought-iron Pipes and Dams; Flow of Water on Heavy Grades, and its Applicability, under High Pressure, to Mining. *Ninth Edition.* Small quarto, cloth. Illustrated .................................... $5.00

**BOWKER, Wm. R. Dynamo, Motor and Switchboard** Circuits. For Electrical Engineers. A practical book, dealing with the subject of Direct, Alternating, and Polyphase Currents. With over 100 diagrams and engravings. 8vo, cloth. . *net*, $2.25

**BOWSER, E. A., Prof. An Elementary Treatise on** Analytic Geometry. Embracing Plane Geometry, and an Introduction to Geometry of three Dimensions. *Twenty-first Edition.* 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.75

**—— An Elementary Treatise on the Differential and** Integral Calculus. With numerous examples. *Twentieth Edition.* 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.25

**—— An Elementary Treatise on Analytic Mechanics. With** numerous examples. *Sixteenth Edition.* 12mo, cloth. . . . . . $3.00

**—— An Elementary Treatise on Hydro-mechanics. With** numerous examples. *Fifth Edition.* 12mo, cloth. . . . . . . . . $2.50

**—— A Treatise on Roofs and Bridges. With Numerous** Exercises, especially adapted for school use. 12mo, cloth. Illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $2.25

**BRASSEY'S Naval Annual for 1904. Edited by T. A.** Brassey. With numerous full-page diagrams, half-tone illustrations and tables. Eighteenth year of publication. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $6.00

**BRAUN, E. The Baker's Book: A Practical Handbook** of the Baking Industry in all Countries. Profusely illustrated with diagrams, engravings, and full-page colored plates. Translated into English and edited by Emil Braun. Vol. I., 8vo, cloth, illustrated, 308 pages. . . . . . . . . . . . . . . . . . . . . . . . . . . $2.50
Vol. II. 363 pages, illustrated. . . . . . . . . . . . . . . . . . . . . . . . $2.50

**British Standard Sections. Issued by the Engineering** Standards Committee, Supported by The Institution of Civil Engineers, The Institution of Mechanical Engineers, The Institution of Naval Architects, The Iron and Steel Institute, and The Institution of Electrical Engineers. Comprising 9 plates of diagrams, with letter-press and tables. Oblong pamphlet, $8\frac{3}{4} \times 15$. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.00

**BROWN, WM. N. The Art of Enamelling on Metal. With** figures and illustrations. 12mo, cloth, illustrated. . . . . *net*, $1.00

**—— Handbook on Japanning and Enamelling, for Cycles,** Bedsteads, Tinware, etc. 12mo, cloth, illustrated. . . . . *net*, $1.50

**BROWN, WM. N.** House Decorating and Painting. With Numerous illustrations. 12mo, cloth. . . . . . . . . . . . . . . . . *net*, $1.50

—— History of Decorative Art. With Designs and Illustrations. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $1.25

—— Principle and Practice of Dipping, Burnishing, Lacquering and Bronzing Brass Ware. 12mo, cloth. . . . . . . . . *net*, $1.00

—— Workshop Wrinkles for Decorators, Painters, Paper-Hangers and Others. 8vo, cloth . . . . . . . . . . . . . . . . . . . . . *net*, $1.00

**BUCHANAN, E. E.** Tables of Squares. Containing the square of every foot, inch, and sixteenth of an inch, between one sixteenth of an inch and fifty feet. For Engineers and Calculators. 16mo, oblong, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.00

**BURGH, N. P.** Modern Marine Engineering, Applied to Paddle and Screw Propulsion. Consisting of 36 colored plates, 259 practical woodcut illustrations and 403 pages of descriptive matter. The whole being an exposition of the present practice of James Watt & Co., J. & G. Rennie, R. Napier & Sons, and other celebrated firms. Thick quarto, half morocco. . . . . . . $10.00

**BURT, W. A.** Key to the Solar Compass, and Surveyor's Companion. Comprising all the rules necessary for use in the field; also description of the Linear Surveys and Public Land System of the United States, Notes on the Barometer, Suggestions for an Outfit for a Survey of Four Months, etc. *Seventh Edition.* Pocket size, full leather. . . . . . . . . . . . . . . . . . . . . . $2.50

**CAMPIN, F.** On the Construction of Iron Roofs. A Theoretical and Practical Treatise, with woodcuts and plates of roofs recently executed. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . $2.00

**CARTER, E. T.** Motive Power and Gearing for Electrical Machinery. A treatise on the Theory and Practice of the Mechanical Equipment of Power Stations for Electrical Supply and for Electric Traction. 8vo, cloth, illustrated. . . . . . . . . . $5.00

**CATHCART, WM. L., Prof.** Machine Design. Part I. Fastenings. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . *net*, $3.00

—— **and CHAFFEE, J. I.** Course of Graphic Statics Applied to Mechanical Engineering. . . . . . . . . . . . . . . . . . . . . . . *In Press.*

**CHAMBER'S MATHEMATICAL TABLES**, consisting of Logarithms of Numbers 1 to 108,000, Trigonometrical, Nautical and other Tables. *New Edition.* 8vo, cloth. . . . . . . . . . . . . $1.75

**CHARPENTIER, P. Timber. A Comprehensive Study** of Wood in all its Aspects, Commercial and Botanical. Showing the Different Applications and Uses of Timber in Various Trades, etc. Translated into English. 8vo, cloth, illus... *net*, $6.00

**CHAUVENET, W., Prof. New Method of Correcting** Lunar Distances, and Improved Method of Finding the Error and Rate of a Chronometer, by Equal Altitudes. 8vo, cloth. $2.00

**CHILD, C. T. The How and Why of Electricity. A** Book of Information for non-technical readers, treating of the Properties of Electricity, and how it is generated, handled, controlled, measured and set to work. Also explaining the operation of Electrical Apparatus. 8vo, cloth, illustrated....... $1.00

**CHRISTIE, W. W. Chimney Design and Theory. A** Book for Engineers and Architects, with numerous half-tone illustrations and plates of famous chimneys. *Second Edition, revised.* 8vo, cloth.................................. $3.00

**—— Furnace Draft: its Production by Mechanical Methods.** A Handy Reference Book, with figures and tables. 16mo, limp cloth, illustrated ........................................ .50

**—— Boiler-waters, Scale, Corrosion, Foaming.**....*In Press.*

**CLAPPERTON, G. Practical Paper-making. A Manual** for Paper-makers and Owners and Managers of Paper Mills, to which is appended useful tables, calculations, data, etc., with illustrations reproduced from micro-photographs. 12mo, cloth, illustrated.......................................... $2.50

**CLARK, D. K., C.E. A Manual of Rules, Tables and** Data for Mechanical Engineers. Based on the most recent investigations. Illustrated with numerous diagrams. 1012 pages. 8vo, cloth. *Sixth Edition*.................................. $5.00
Half morocco.......................................... $7.50

**—— Fuel: its Combustion and Economy; consisting of** abridgments of Treatise on the Combustion of Coal. By C. W. Williams, and the Economy of Fuel, by T. S. Prideaux. With extensive additions in recent practice in the Combustion and Economy of Fuel, Coal, Coke, Wood, Peat, Petroleum, etc. *Fourth Edition.* 12mo, cloth.......................... $1.50

**—— The Mechanical Engineer's Pocket-book of Tables,** Formulæ, Rules and Data. A Handy Book of Reference for Daily Use in Engineering Practice. 16mo, morocco. *Fifth Edition, carefully revised throughout*.................. $3.00

**CLARK, D. K., C.E. Tramways: Their Construction and** Working. Embracing a comprehensive history of the system, with accounts of the various modes of traction, a description of the varieties of rolling stock, and ample details of Cost and Working Expenses. *Second Edition, rewritten and greatly enlarged, with upwards of* 400 *illustrations.* Thick 8vo, cloth. . . . . . . . . . . . $9.00

**CLARK, J. M. New System of Laying Out Railway Turn-**outs instantly, by inspection from tables. 12mo, cloth. . . $1.00

**CLAUSEN-THUE, W. The A B C Universal Commercial** Electric Telegraphic Code; specially adapted for the use of Financiers, Merchants, Ship-owners, Brokers, Agents, etc. *Fourth Edition.* 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $5.00
*Fifth Edition of same.* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $7.00

**—— The A 1 Universal Commercial Electric Telegraphic** Code. Over 1240 pages and nearly 90,000 variations. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $7.50

**CLEEMANN, T. M. The Railroad Engineer's Practice.** Being a Short but Complete Description of the Duties of the Young Engineer in Preliminary and Location Surveys and in Construction. *Fourth Edition, revised and enlarged.* Illustrated. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.50

**CLEVENGER, S. R. A Treatise on the Method of Gov-**ernment Surveying as prescribed by the U. S. Congress and Commissioner of the General Land Office, with complete Mathematical, Astronomical, and Practical Instructions for the use of the United States Surveyors in the field. 16mo, morocco. . . . . . $2.50

**CLOUTH, F. Rubber, Gutta-Percha, and Balata. First** English Translation with Additions and Emendations by the Author. With numerous figures, tables, diagrams, and folding plates. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . *net,* $5.00

**COFFIN, J. H. C., Prof. Navigation and Nautical Astron-**omy. Prepared for the use of the U. S. Naval Academy. *New Edition.* Revised by Commander Charles Belknap. 52 woodcut illustrations. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . *net,* $3.50

**COLE, R. S., M.A. A Treatise on Photographic Optics.** Being an account of the Principles of Optics, so far as they apply to photography. 12mo, cloth, 103 illus. and folding plates. . $2.50

**COLLINS, J. E. The Private Book of Useful Alloys and** Memoranda for Goldsmiths, Jewelers, etc. 18mo, cloth. . . . . . .50

**COREY. Water-supply Engineering. Fully illustrated.** 8vo, cloth . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *In Press*,

**COOPER, W. R., M.A. Primary Batteries: Their Construction and Use.** With numerous figures and diagrams. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $4.00

**CORNWALL, H. B., Prof. Manual of Blow-pipe Analysis,** Qualitative and Quantitative. With a Complete System of Determinative Mineralogy. 8vo, cloth, with many illustrations. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.50

**COWELL, W. B. Pure Air, Ozone and Water. A Practical** Treatise of their Utilization and Value in Oil, Grease, Soap. Paint, Glue and other Industries. With tables and figures. 12mo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $2.00

**CRAIG, B. F. Weights and Measures. An Account of** the Decimal System, with Tables of Conversion for Commercial and Scientific Uses. Square 32mo, limp cloth. . . . . . . . . . . . . . . .50

**CROCKER, F. B., Prof. Electric Lighting. A Practical** Exposition of the Art. For use of Engineers, Students, and others interested in the Installation or Operation of Electrical Plants. Vol. I. The Generating Plant. *New Edition, thoroughly revised and rewritten.* 8vo, cloth, illustrated . . . . . . . . . *In Press.*
Vol. II. Distributing Systems and Lamps. *Second Edition.* 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $3.00

**—— and WHEELER, S. S. The Practical Management** of Dynamos and Motors. *Fifth Edition (Sixteenth Thousand), revised and enlarged.* With a special chapter by H. A. Foster. 12mo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.00

**CROSSKEY, L. R. Elementary Perspective: Arranged to** meet the requirements of Architects and Draughtsmen, and of Art Students preparing for the elementary examination of the Science and Art Department, South Kensington. With numerous full-page plates and diagrams. 8vo, cloth, illustrated . . $1.00

**—— and THAW, J. Advanced Perspective, involving the** Drawing of Objects when placed in Oblique Positions, Shadows and Reflections. Arranged to meet the requirements of Architects, Draughtsmen, and Students preparing for the Perspective Examination of the Education Department. With numerous full-page plates and diagrams. 8vo. cloth, illustrated. . . . . . . . . . $1.50

**DAVIES, E. H. Machinery for Metalliferous Mines.** A Practical Treatise for Mining Engineers, Metallurgists and Managers of Mines. With upwards of 400 illustrations. *Second Edition, rewritten and enlarged.* 8vo, cloth . . . . . . . . . . . . *net*, $8.00

**DAVIES, D. C. A Treatise on Metalliferous Minerals and** Mining. *Sixth Edition, thoroughly revised and much enlarged* by his son. 8vo, cloth........................................ *net,* $5.00

**—— Mining Machinery**.............................*In Press.*

**DAVISON, G. C., Lieut. Water-tube Boilers.** ....*In Press.*

**DAY, C. The Indicator and its Diagrams. With Chap-** ters on Engine and Boiler Testing; including a Table of Piston Constants compiled by W. H. Fowler. 12mo, cloth. 125 illustrations........................................ $2.00

**DE LA COUX, H. The Industrial Uses of Water. With** numerous tables, figures, and diagrams. Translated from the French and revised by Arthur Morris. 8vo, cloth.......*net,* $4.50

**DENNY, G. A. Deep-level Mines of the Rand, and their** future development, considered from the commercial point of view. With folding plates, diagrams, and tables. 4to, cloth, illustrated........................................ *net,* $10.00

**DERR, W. L. Block Signal Operation. A Practical** Manual. Pocket Size. Oblong, cloth. *Second Edition*....$1.50

**DIBDIN, W. J. Public Lighting by Gas and Electricity.** With tables, diagrams, engravings and full-page plates. 8vo, cloth, illustrated........................................ *net,* $8.00

**—— Purification of Sewage and Water. With tables,** engravings, and folding plates *Third Edition, revised and enlarged.* 8vo, cloth, illus. and numerous folding plates.... $6.50

**DIETERICH, K. Analysis of Resins, Balsams, and Gum** Resins: their Chemistry and Pharmacognosis. For the use of the Scientific and Technical Research Chemist. With a Bibliography. Translated from the German, by Chas. Salter. 8vo. cloth........................................ *net,* $3.00

**DIXON, D. B. The Machinist's and Steam Engineer's** Practical Calculator. A Compilation of Useful Rules and Problems arithmetically solved, together with General Information applicable to Shop-tools, Mill-gearing, Pulleys and Shafts, Steam-boilers and Engines. Embracing valuable Tables and Instruction in Screw-cutting, Valve and Link Motion, etc. *Third Edition.* 16mo, full morocco, pocket form........................ $1.25

**DOBLE, W. A. Power Plant Construction on the Pacific** Coast........................................ *In Press.*

**DODD, GEO. Dictionary of Manufactures, Mining, Machinery, and the Industrial Arts.** 12mo, cloth. . . . . . . . . . . . $1.50

**DORR, B. F. The Surveyor's Guide and Pocket Table-book.** *Fifth Edition, thoroughly revised and greatly extended.* With a second appendix up to date. 16mo, morocco flaps. . $2.00

**DRAPER, C. H. An Elementary Text-book of Light,** Heat and Sound, with Numerous Examples. *Fourth Edition.* 12mo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $1.00

**—— Heat and the Principles of Thermo-dynamics. With** many illustrations and numerical examples. 12mo, cloth. . . $1.50

**DYSON, S. S. Practical Testing of Raw Materials. A** Concise Handbook for Manufacturers, Merchants, and Users of Chemicals, Oils, Fuels, Gas Residuals and By-products, and Paper-making Materials, with Chapters on Water Analysis and the Testing of Trade Effluents. 8vo, cloth, illustrations, 177 pages. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net,* $5.00

**EDDY, H. T., Prof. Researches in Graphical Statics.** Embracing New Constructions in Graphical Statics, a New General Method in Graphical Statics, and the Theory of Internal Stress in Graphical Statics. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . $1.50

**—— Maximum Stresses under Concentrated Loads.** Treated graphically. Illustrated 8vo, cloth. . . . . . . . . . . . $1.50

**EISSLER, M. The Metallurgy of Gold. A Practical Treatise** on the Metallurgical Treatment of Gold-bearing Ores, including the Processes of Concentration and Chlorination, and the Assaying, Melting and Refining of Gold. *Fifth Edition, revised and greatly enlarged.* Over 300 illustrations and numerous folding plates. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $7.50

**—— The Hydro-Metallurgy of Copper. Being an Account** of processes adopted in the Hydro-metallurgical Treatment of Cupriferous Ores, including the Manufacture of Copper Vitriol. With chapters on the sources of supply of Copper and the Roasting of Copper Ores. With numerous diagrams and figures. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net,* $4.50

**—— The Metallurgy of Silver. A Practical Treatise on the** Amalgamation, Roasting and Lixiviation of Silver Ores, including the Assaying, Melting and Refining of Silver Bullion. 124 illustrations. *Second Edition, enlarged.* 8vo, cloth. . . . . $4.00

**EISSLER, M. The Metallurgy of Argentiferous Lead. A** Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on Various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. With 183 illustrations. 8vo. cloth.................................................. $5.00

**—— Cyanide Process for the Extraction of Gold and its** Practical Application on the Witwatersrand Gold Fields in South Africa. *Third Edition, revised and enlarged.* Illustrations and folding plates. 8vo, cloth................................ $3.00

**—— A Handbook on Modern Explosives. Being a Prac-**tical Treatise on the Manufacture and Use of Dynamite, Guncotton, Nitroglycerine, and other Explosive Compounds, including the manufacture of Collodion-cotton, with chapters on Explosives in Practical Application. *Second Edition, enlarged with* 150 *illustrations.* 12mo, cloth.......................... $5.00

**ELIOT, C. W., and STORER, F. H. A Compendious** Manual of Qualitative Chemical Analysis. Revised with the cooperation of the authors, by Prof. William R. Nichols. Illustrated. *Twentieth Edition, newly revised by Prof. W. B. Lindsay.* 12mo, cloth.......................................... *net,* $1.25

**ELLIOT, G. H., Maj. European Light-house Systems.** Being a Report of a Tour of Inspection made in 1873. 51 engravings and 21 woodcuts. 8vo, cloth.................... $5.00

**ERFURT, J. Dyeing of Paper Pulp. A Practical Treatise** for the use of paper-makers, paper-stainers, students and others, With illustrations and 157 patterns of paper dyed in the pulp, with formulas for each. Translated into English and edited, with additions, by Julius Hübner, F.C.S. 8vo, cloth, illustrated............................................ *net,* $7.50

**EVERETT, J. D. Elementary Text-book of Physics.** Illustrated. *Seventh Edition.* 12mo, cloth.............. $1.50

**EWING, A. J., Prof. The Magnetic Induction in Iron** and other metals. *Third Edition, revised.* 159 illustrations. 8vo, cloth................................................ $4.00

**FAIRIE, J., F.G.S. Notes on Lead Ores: Their Distribu-**tion and Properties. 12mo, cloth...................... $1.00

**—— Notes on Pottery Clays: The Distribution, Properties,** Uses and Analysis of Ball Clays, China Clays and China Stone. With tables and formulæ. 12mo, cloth.................. $1.50

**FANNING, J. T. A Practical Treatise on Hydraulic and** Water-supply Engineering. Relating to the Hydrology, Hydrodynamics and Practical Construction of Water-works in North America. 180 illus. 8vo, cloth. *Fifteenth Edition, revised, enlarged,* and *new tables and illustrations added.* 650 pp......$5.00

**FAY, I. W. The Coal-tar Colors: Their Origin and Chem-**istry. 8vo, cloth, illustrated. ........................*In Press.*

**FISH, J. C. L. Lettering of Working Drawings. Thir-**teen plates, with descriptive text. Oblong, 9×12½, boards. $1.00

**FISHER, H. K. C., and DARBY, W. C. Students' Guide** to Submarine Cable Testing. *Third (new and enlarged) Edition.* 8vo, cloth, illustrated.......................... $3.50

**FISHER, W. C. The Potentiometer and its Adjuncts.** 8vo, cloth........................................ $2.25

**FISKE, B. A., Lieut., U.S.N. Electricity in Theory and** Practice; or, The Elements of Electrical Engineering. *Eighth Edition.* 8vo, cloth.................................. $2.50

**FLEISCHMANN, W. The Book of the Dairy. A Manual** of the Science and Practice of Dairy Work. Translated from the German, by C. M. Aikman and R. Patrick Wright. 8vo, cloth........................................ $4.00

**FLEMING, J. A., Prof. The Alternate-current Trans-**former in Theory and Practice. Vol. I., The Induction of Electric Currents; 611 pages. *New Edition,* illustrated. 8vo, cloth, $5.00
Vol. II., The Utilization of Induced Currents. Illustrated. 8vo, cloth........................................ $5.00

**—— Centenary of the Electrical Current, 1799–1899.** 8vo, paper, illustrated.................................. .50

**—— Electric Lamps and Electric Lighting. Being a** course of four lectures delivered at the Royal Institution, April–May, 1894. 8vo, cloth, fully illustrated.................. $3.00

**—— Electrical Laboratory Notes and Forms, Elementary** and Advanced. 4to, cloth, illustrated...................... $5.00

**—— A Handbook for the Electrical Laboratory and Test-**ing Room. 2 volumes. 8vo, cloth.................each $5.00

**FLEURY, H. The Calculus Without Limits or Infinitesi-**mals. Translated by C. O. Mailloux.................*In Press.*

**FOLEY, N., and PRAY, THOS., Jr. The Mechanical** Engineers' Reference Book for Machine and Boiler Construction, in two parts. Part 1—General Engineering Data. Part 2—Boiler Construction. With 51 plates and numerous illustrations, specially drawn for this work. Folio, half morocco..... $25.00

**FORNEY, M. N. Catechism of the Locomotive. Second** *Edition, revised and enlarged.* 46th thousand. 8vo, cloth..$3.50

**FOSTER, J. G., Gen., U.S.A. Submarine Blasting in** Boston Harbor, Massachusetts. Removal of Tower and Corwin Rocks. Illustrated with 7 plates. 4to, cloth............ $3.50

**FOSTER, H. A. Electrical Engineers' Pocket-book. With** the Collaboration of Eminent Specialists. A handbook of useful data for Electricians and Electrical Engineers. With innumerable tables, diagrams, and figures. *Third Edition, revised* Pocket size, full leather, 1000 pp...................... $5.00

**FOSTER, J. Treatise on the Evaporation of Saccharine,** Chemical and other Liquids by the Multiple System in Vacuum and Open Air. *Third Edition.* Diagrams and large plates. 8vo, cloth.......................................... $7.50

**FOX, WM., and THOMAS, C. W., M.E. A Practical** Course in Mechanical Drawing. *Second Edition, revised.* 12mo, cloth, with plates.................................. $1.25

**FRANCIS, J. B., C.E. Lowell Hydraulic Experiments.** Being a selection from experiments on Hydraulic Motors on the Flow of Water over Weirs, in Open Canals of uniform rectangular section, and through submerged Orifices and diverging Tubes. Made at Lowell, Mass. *Fourth Edition, revised and enlarged,* with many new experiments, and illustrated with 23 copper-plate engravings. 4to, cloth.................. $15.00

**FULLER, G. W. Report on the Investigations into the** Purification of the Ohio River Water at Louisville, Kentucky, made to the President and Directors of the Louisville Water Company. Published under agreement with the Directors. 3 full-page plates. 4to, cloth...................... *net,* $10.00

**FURNELL, J. Students' Manual of Paints, Colors, Oils** and Varnishes. 8vo, cloth, illustrated.............. *net,* $1.00

**GARCKE, E., and FELLS, J. M. Factory Accounts:** their principles and practice. A handbook for accountants and manufacturers, with appendices on the nomenclature of machine details, the rating of factories, fire and boiler insurance, the factory and workshop acts, etc., including also a large number of specimen rulings. *Fifth Edition, revised and extended.* 8vo, cloth, illustrated........................................ $3.00

**GEIPEL, WM., and KILGOUR, M. H. A Pocket-book** of Electrical Engineering Formulæ. Illus. 18mo., mor. . .$3.00

**GERBER, N. Chemical and Physical Analysis of Milk,** Condensed Milk, and Infants' Milk-food. 8vo, cloth...... $1.25

**GERHARD, WM. P. Sanitary Engineering. 12mo,** cloth. .......... $1.25

**GESCHWIND, L. Manufacture of Alum and Sulphates,** and other Salts of Alumina and Iron; their uses and applications as mordants in dyeing and calico printing, and their other applications in the Arts, Manufactures, Sanitary Engineering, Agriculture and Horticulture. Translated from the French by Charles Salter. With tables, figures and diagrams. 8vo, cloth, illustrated. .......... *net*, $5.00

**GIBBS, W. E. Lighting by Acetylene, Generators, Burners** and Electric Furnaces. With 66 illustrations. *Second Edition, revised.* 12mo, cloth.......... $1.50

**GILLMORE, Q. A., Gen. Treatise on Limes, Hydraulic** Cements and Mortars. Papers on Practical Engineering, United States Engineer Department, No. 9, containing Reports of numerous Experiments conducted in New York City during the years 1858 to 1861, inclusive. With numerous illustrations. 8vo, cloth. .......... $4.00

**—— Practical Treatise on the Construction of Roads,** Streets and Pavements. *Tenth Edition.* With 70 illustrations 12mo, cloth. .......... $2.00

**—— Report on Strength of the Building Stones in the** United States, etc. 8vo, illustrated, cloth.......... $1.00

**GOLDING, H. A. The Theta-Phi Diagram. Practically** Applied to Steam, Gas, Oil and Air Engines. 12mo, cloth, illustrated. .......... *net*, $1.25

**GOODEVE, T. M. A Text-book on the Steam-engine.** With a Supplement on Gas-engines. *Twelfth Edition, enlarged.* 143 illustrations. 12mo, cloth. .......... $2.00

**GORE, G., F.R.S. The Art of Electrolytic Separation of** Metals, etc. (Theoretical and Practical.) Illustrated. 8vo, cloth. .......... $3.50

**GOULD, E. S. The Arithmetic of the Steam-engine.** 8vo, cloth. .......... $1.00

**GOULD, E. S. Practical Hydrostatics and Hydrostatic Formulas.** With numerous figures and diagrams (*Van Nostrand's Science Series, No.* 117.) 16mo, cloth, illustrated, 114 pp... .50

**GRAY, J., B.Sc. Electrical Influen e Machines: Their** Historical Development, and Modern Forms, with instructions for making them. With numerous figures and diagrams. *Second Edition, revised and enlarged.* 12mo, cloth, illus., 296 pp....$2.00

**GRIFFITHS, A. B., Ph.D. A Treati e on Manures, or** the Philosophy of Manuring. A Practical Handbook for the Agriculturist, Manufacturer, and Student. 12mo, cloth... $3.00

**—— Dental Metallurgy. A Manual for Students and** Dentists. 8vo, cloth, illustrated, 208 pp. . ............*net*, $3.50

**GROSS, E. Hops, in their Botanical, Agricultural and** Technical Aspect, and as an article of Commerce. Translated from the German by Charles Salter. With tables, diagrams, and illustrations. 8vo, cloth, illustrated............ *net*, $4.50

**GROVER, F. Practical Treatise on Modern Gas and** Oil Engines. 8vo, cloth, illustrated....................... $2.00

**GRUNER, A. Power-loom Weaving and Yarn Numbering,** according to various systems, with conversion tables. An auxiliary and text-book for pupils of weaving schools, as well as for self-instruction, and for general use by those engaged in the weaving industry. Illustrated with colored diagrams. 8vo, cloth.............................................. *net*, $3.00

**GURDEN, R. L. Traverse Tables: Computed to Four-**place Decimals for every single minute of angle up to 100 of Distance. For the use of Surveyors and Engineers. *New Edition.* Folio, half morocco................................. $7.50

**GUY, A. E. Experiments on the Flexure of Beams,** resulting in the Discovery of New Laws of Failure by Buckling. Reprinted from the "American Machinist." With diagrams and folding plates. 8vo, cloth, illustrated, 122 pages..... *net*, $1.25

**GUY, A. F. Electric Light and Power: Giving the Result** of Practical Experience in Central-station Work. 8vo, cloth, illustrated.............................................. $2.50

**HAEDER, H., C.E. A Handbook on the Steam-engine.** With especial reference to small and medium-sized engines. For the use of Engine-makers, Mechanical Draughtsmen, Engineering Students and Users of Steam Power. Translated from the German, with considerable additions and alterations, by H. H. P. Powles. *Third English Edition, revised.* 8vo, cloth, illustrated, 458 pages.................................. $3.00

**HALL, W. S., Prof. Elements of the Differential and** Integral Calculus. *Fourth Edition, revised.* 8vo, cloth, illustrated. . . . . . . . . . *net,* $2.25

**—— Descriptive Geometry, with Numerous Problems and** Practical Applications. Comprising an 8vo volume of 76 pages of text and a 4to atlas of 31 plates. 2 vols., cloth. . . . *net,* $3.50
Postage, 0.32

**HALSEY, F. A. Slide-valve Gears. An Explanation of** the Action and Construction of Plain and Cut-off Slide Valves. Illustrated. *Seventh Edition.* 12mo, cloth . . . . . . . . . . $1.50

**—— The Use of the Slide Rule. With illustrations and** folding plates. *Second Edition.* 16mo, boards. (*Van Nostrand's Science Series,* No. 114.). . . . . . . . . . .50

**—— The Locomotive Link Motion, with Diagrams and** Tables. 8vo, cloth, illustrated. . . . . . . . . . $1.00

**—— Worm and Spiral Gearing. Revised and Enlarged** *Edition.* 16mo, cloth (*Van Nostrand's Science Series,* No. 116.) Illustrated. . . . . . . . . . .50

**—— The Metric Fallacy, and "The Metric Failure in** the Textile Industry," by Samuel S. Dale. 8vo, cloth, illustrated. . . . . . . . . . $1.00

**HAMILTON, W. G. Useful Information for Railway** Men. *Tenth Edition, revised and enlarged.* 562 pages, pocket form. Morocco, gilt. . . . . . . . . . $2.00

**HAMMER, W. J. Radium, and Other Radio-active Sub-**stances; Polonium, Actinium and Thorium. With a consideration of Phosphorescent and Fluorescent Substances, the Properties and Applications of Selenium, and the treatment of disease by the Ultra-Violet Light. *Second Edition.* With diagrams, engravings and photographic plates. 8vo, cloth, illustrated, 72 p.,
$1.00

**HANCOCK, H. Text-book of Mechanics and Hydro-**statics, with over 500 diagrams. 8vo, cloth. . . . . . . . . . $1.75

**HARRISON, W. B. The Mechanics' Tool-book. With** Practical Rules and Suggestions for use of Machinists, Ironworkers and others. With 44 engravings. 12mo, cloth. . . . $1.50

**HART, J. W. External Plumbing Work. A Treatise on** Lead Work for Roofs. With numerous figures and diagrams. 8vo cloth, illustrated. . . . . . . . . . *net,* $3.00

**HART, J. W. Hints to Plumbers on Joint Wiping, Pipe** Bending, and Lead Burning. Containing 184 figures and diagrams. 8vo, cloth, illustrated........................ *net,* $3.00

—— **Principles of Hot-water Supply. With numerous** illustrations. 8vo, cloth.............................. *net,* $3.00

—— **Sanitary Plumbing and Drainage. With numerous** diagrams and figures. 8vo, cloth, illustrated ......... *net,* $3.00

**HASKINS, C. H. The Galvanometer and its Uses. A** Manual for Electricians and Students. *Fourth Edition.* 12mo, cloth.............................................. $1.50

**HAUFF, W. A. American Multiplier: Multiplications and** Divisions of the largest numbers rapidly performed. With index giving the results instantly of all numbers to $1000 \times 1000 = 1.000,000$; also tables of circumferences and areas of circles. Cloth, $6\frac{1}{2} \times 15\frac{1}{2}$.............................................. $5.00

**HAUSBRAND, E. Drying by Means of Air and Steam.** With explanations, formulas, and tables, for use in practice. Translated from the German by A. C. Wright, M.A. 12mo, cloth, illustrated.......................................... $2.00

—— **Evaporating, Condensing and Cooling Apparatus:** Explanations, Formulæ, and Tables for Use in Practice. Translated from the Second Revised German Edition by A. C. Wright, M.A. With numerous figures, tables and diagrams. 8vo, cloth, illustrated, 400 pages............................. *net,* $5.00

**HAUSNER, A. Manufacture of Preserved Foods and** Sweetmeats. A Handbook of all the Processes for the Preservation of Flesh, Fruit, and Vegetables, and for the Preparation of Dried Fruit, Dried Vegetables, Marmalades, Fruit-syrups, and Fermented Beverages, and of all kinds of Candies, Candied Fruit, Sweetmeats, Rocks, Drops, Dragees, Pralines, etc. Translated from the Third Enlarged German Edition, by Arthur Morris and Herbert Robson, B.Sc. 8vo, cloth, illustrated........*net,* $3.00

**HAWKE, W. H. The Premier Cipher Telegraphic Code,** containing 100,000 Words and Phrases. The most complete and most useful general code yet published. 4to, cloth....... $5.00

—— **100,000 Words Supplement to the Premier Code.** All the words are selected from the official vocabulary. Oblong quarto, cloth.......................................... $5.00

**HAWKINS, C. C., and WALLIS, F. The Dynamo: its** Theory, Design, and Manufacture. 190 illustrations. 12mo, cloth.............................................. $3.00

**HAY, A.** Principles of Alternate-current Working. 12mo, cloth, illustrated.................................. $2.00

**HEAP, D. P., Major, U.S.A.** Electric l Appliances of the Present Day. Report of the Paris Electrical Exposition of 1881. 250 illustrations. 8vo, cloth..................... $2.00

**HEAVISIDE, O.** Electromagnetic Theory. 8vo, cloth, two volumes......................................each, $5.00

**HECK, R. C. H., Prof. (Lehigh University).** The Steam-Engine. A text-book for Engineering Colleges.........*In Press.*

**HEERMANN, P.** Dyers' Materials. An Introduction to the Examination, Valuation, and Application of the most important substances used in Dyeing, Printing, Bleaching and Finishing. Translated by Arthur C. Wright, M.A. 12mo, cloth, illustrated.............................................*net*, $2.50

**HENRICI, O.** Skeleton Structures, Applied to the Building of Steel and Iron Bridges. 8vo, cloth, illustrated....... $1.50

**HERMANN, F.** Painting on Glass and Porcelain and Enamel Painting. On the basis of Personal Practical Experience of the Condition of the Art up to date. Translated by Charles Salter. *Second greatly enlarged edition.* 8vo, cloth, illustrated, *net*, $3.50

**HERRMANN, G.** The Graphical Statics of Mechanism. A Guide for the Use of Machinists, Architects and Engineers; and also a Text-book for Technical Schools. Translated and annotated by A. P. Smith, M.E. *Fourth Edition.* 12mo, cloth, 7 folding plates ................................ $2.00

**HERZFELD, J., Dr.** The Technical Testing of Yarns and Textile Fabrics, with reference to official specifications. Translated by Chas. Salter. With 69 illustrations. 8vo, cloth *net*, $3.50

**HEWSON, W.** Principles and Practice of Embanking Lands from River Floods, as applied to the Levees of the Mississippi. 8vo, cloth...................................... $2.00

**HILL, J. W.** The Purification of Public Water Supplies. Illustrated with valuable tables, diagrams, and cuts. 8vo, cloth, 304 pages...................................... $3.00

—— Interpretation of Water Analysis. 12mo, cloth. *In Press.*

**HOBBS, W. R. P.** The Arithmetic of Electrical Measurements, with numerous examples, fully worked. Revised by Richard Wormell, M.A. *Ninth Edition.* 12mo, cloth........ .50

**HOFF, WM. B., Com., U.S.N.** The Avoidance of Collisions at Sea. 18mo, morocco.................................... .75

**HOLLEY, A. L.** Railway Practice. American and European Railway Practice in the Economical Generation of Steam, including the Materials and Construction of Coal-burning Boilers, Combustion, the Variable Blast, Vaporization, Circulation, Superheating, Supplying and Heating Feed Water, etc., and the Adaptation of Wood and Coke-burning Engines to Coal-burning; and in Permanent Way, including Road-bed, Sleepers, Rails, Joint Fastenings, Street Railways, etc. With 77 lithographed plates. Folio, cloth.............................. $12.00

**HOLMES, A. B.** The Electric Light Popularly Explained. *Fifth Edition.* Illustrated. 12mo, paper.................. .40

**HOPKINS, N. M.** Model Engines and Small Boats. New Methods of Engine and Boiler Making, with a chapter on Elementary Ship Design and Construction. 12mo, cloth...... $1.25

**HOUSTON, E. J., and KENNELLY, A. E.** Algebra Made Easy. Being a clear explanation of the Mathematical Formulæ found in Prof. Thompson's "Dynamo-electric Machinery and Polyphase Electric Currents." With figures and examples. 8vo, cloth, illustrated.................................. .75

—— The Interpretation of Mathematical Formulæ. With figures and examples. 8vo, cloth, illustrated............. $1.25

**HOWARD, C. R.** Earthwork Mensuration on the Basis of the Prismoidal Formulæ. Containing Simple and Labor-saving Methods of obtaining Prismoidal Contents directly from End Areas. Illustrated by Examples and accompanied by Plain Rules for Practical Use. Illustrated. 8vo, cloth......... $1.50

**HOWORTH, J.** Art of Repairing and Riveting Glass, China and Earthenware. *Second Edition.* 8vo, pamphlet, illustrated.................................... *net,* $0.50

**HUBBARD, E.** The Utilization of Wood-waste. A Complete Account of the Most Advantageous Methods of Working Up Wood Refuse, especially Sawdust, Exhausted Dye Woods and Tan as Fuel, as a Source of Chemical Products for Artificial Wood Compositions, Explosives, Manures, and many other Technical Purposes. Translated from the German of the *second revised and enlarged edition.* 8vo, cloth, illustrated, 192 pages.. *net,* $2.50

**HUMBER, W., C.E. A Handy Book for the Calculation** of Strains in Girders, and Similar Structures, and their Strength; consisting of Formulæ and Corresponding Diagrams, with numerous details for practical application, etc. *Fourth Edition.* 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.50

**HURST, G. H., F.C.S. Color. A Handbook of the Theory** of Color. A practical work for the Artist, Art Student, Painter, Dyer and Calico Printer, and Others. Illustrated with 10 colored plates and 72 illustrations. 8vo, cloth. . . . . . . . . . . . . . . . *net*, $2.50

**—— Dictionary of Chemicals and Raw Products Used** in the Manufacture of Paints, Colors, Varnishes and Allied Preparations. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $3.00

**—— Lubricating Oils, Fats and Greases: Their Origin,** Preparation, Properties, Uses and Analysis. 313 pages, with 65 illustrations. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . *net*, $3.00

**—— Soaps. A Practical Manual of the Manufacture of** Domestic, Toilet and other Soaps. Illustrated with 66 engravings. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $5.00

**—— Textile Soaps and Oils: A Handbook on the Preparation**, Properties, and Analysis of the Soaps and Oils Used in Textile Manufacturing, Dyeing and Printing. With tables and illustrations. 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net*, $2.50

**HUTCHINSON, W. B. Patents and How to Make Money** out of Them. 12mo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . $1.25

**HUTTON, W. S. Steam-boiler Construction. A Practical** Handbook for Engineers, Boiler-makers and Steam-users. Containing a large collection of rules and data relating to recent practice in the design, construction and working of all kinds of stationary, locomotive and marine steam-boilers. With upwards of 540 illustrations. *Fourth Edition, carefully revised and much enlarged.* 8vo, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . $6.00

**—— Practical Engineer's Handbook, comprising a Treatise** on Modern Engines and Boilers, Marine, Locomotive and Stationary. *Fourth Edition, carefully revised, with additions.* With upwards of 570 illustrations. 8vo, cloth. . . . . . . . . . . . . . . . . $7.00

**—— The Works' Manager's Han book of Modern Rules,** Tables and Data for Civil and Mechanical Engineers, Millwrights and Boiler-makers, etc., etc. With upwards of 150 illustrations. *Fifth Edition, carefully revised, with additions.* 8vo, cloth. . . $6.00

**INGLE, H. Manual of Agricultural Chemistry. 8vo,** cloth, illustrated, 388 pages. . . . . . . . . . . . . . . . . . . . . . . . *net*, $3.00

**INNES, C. H.** **Problems in Machine Design. For the** use of Students, Draughtsmen and others. *Second Edition*, 12mo, cloth. . . . . . . . . . *net*, $2.00

—— **Centrifugal Pumps, Turbines and Water Motors.** Including the Theory and Practice of Hydraulics. *Third and enlarged edition.* 12mo, cloth . . . . . . . . . . *net*, $2.00

**ISHERWOOD, B. F.** **Engineering Precedents for Steam** Machinery. Arranged in the most practical and useful manner for Engineers. With illustrations. Two volumes in one. 8vo, cloth. . . . . . . . . . $2.50

**JAMIESON, A., C.E.** **A Text-book on Steam and Steam-**engines Specially arranged for the use of Science and Art, City and Guilds of London Institute, and other Engineering Students. *Thirteenth Edition.* Illustrated. 12mo, cloth. . . . . . . . . . $3.00

—— **Elementary Manual on Steam and the Steam-engine.** Specially arranged for the use of First-year Science and Art, City and Guilds of London Institute, and other Elementary Engineering Students. *Third Edition.* 12mo, cloth. . . . . . . . . . $1.50

**JANNETTAZ, E.** **A Guide to the Determination of Rocks:** being an Introduction to Lithology. Translated from the French by G. W. Plympton, Professor of Physical Science at Brooklyn Polytechnic Institute. 12mo, cloth. . . . . . . . . . $1.50

**JEHL, F., Mem. A.I.E.E.** **The Manufacture of Carbons** for Electric Lighting and Other Purposes. A Practical Handbook, giving a complete description of the art of making carbons, electros, etc. The various gas generators and furnaces used in carbonizing, with a plan for a model factory. Illustrated with numerous diagrams, tables and folding plates. 8vo, cloth, illustrated. . . . $4.00

**JENNISON, F. H.** **The Manufacture of Lake Pigments** from Artificial Colors. A useful handbook for color manufacturers, dyers, color chemists, paint manufacturers, drysalters, wallpaper-makers, enamel and surface-paper makers. With 15 plates illustrating the various methods and errors that arise in the different processes of production. 8vo, cloth. . . . . *net*, $3.00

**JOHNSON, W. McA.** **"The Metallurgy of Nickel."** *In Press.*

**JOHNSTON, J. F. W., Prof., and CAMERON, Sir Chas.** Elements of Agricultural Chemistry and Geology. *Seventeenth Edition.* 12mo, cloth. . . . . . . . . . $2.60

**JONES, H. C.** **Outlines of Electrochemistry. With** tables and diagrams. 4to, cloth, illustrated. . . . . . . . . . $1.50

**JONES, M. W.** The Testing and Valuation of Raw Materials used in Paint and Color Manufacture. 12mo, cloth, . *net,* $2.00

**JOYNSON, F. H.** The Metals Used in Construction. Iron, Steel, Bessemer Metal, etc. Illustrated. 12mo, cloth... .75

—— Designing and Construction of Machine Gearing. Illustrated. 8vo, cloth.................................. $2.00

**JÜPTNER, H. F. V.** Siderology: The Science of Iron. (The Constitution of Iron Alloys and Iron.) Translated from the German. 8vo, cloth, 345 pages, illustrated......... *net,* $5.00

**KANSAS CITY BRIDGE, THE.** With an Account of the Regimen of the Missouri River and a Description of the Methods used for Founding in that River, by O. Chanute, Chief Engineer, and George Morison, Assistant Engineer. Illustrated with 5 lithographic views and 12 plates of plans. 4to, cloth. $6.00

**KAPP, G., C.E.** Electric Transmission of Energy and its Transformation, Subdivision and Distribution. A practical handbook. *Fourth Edition, revised.* 12mo, cloth........ $3.50

—— Dynamos, Motors, Alternators and Rotary Converters. Translated from the *third German edition,* by Harold H. Simmons, A.M.I.E.E. With numerous diagrams and figures. 8vo, cloth, 507 pages.................................. $4.00

**KEIM, A. W.** Prevention of Dampness in Buildings. With Remarks on the Causes, Nature and Effects of Saline Efflorescences and Dry Rot. For Architects, Builders, Overseers, Plasterers, Painters and House Owners. Translated from the *second revised, German edition.* With colored plates and diagrams. 8vo, cloth, illustrated, 115 pages............... *net,* $2.00

**KELSEY, W. R.** Continuous-current Dynamos and Motors, and their Control: being a series of articles reprinted from *The Practical Engineer,* and completed by W. R. Kelsey. With many figures and diagrams. 8vo, cloth, illustrated. . $2.50

**KEMP, J. F., A.B., E.M.** A Handbook of Rocks. For Use without the microscope. With a glossary of the names of rocks and of other lithological terms. 8vo, cloth, illustrated..... $1.50
*Third Edition, revised.*

**KEMPE, H. R.** The Electrical Engineer's Pocket-book of Modern Rules, Formulæ, Tables and Data. Illustrated. 32mo, morocco, gilt.................................. $1.75

**KENNEDY, R. Modern Engines and Power Generators.** Vol. I. A Practical Work on Prime Movers and the Transmission of Power: Steam, Electric, Water, and Hot-air. With tables, figures, and full-page engravings. 4to, cloth, illustrated.. $3.50

**KENNEDY, R. Electrical Installations of Electric Light,** Power, Traction, and Industrial Electrical Machinery. With numerous diagrams and engravings.

—— **Vol. I. The Electrical Circuit, Measurement, Elements** of Motors, Dynamos, Electrolysis. 8vo, cloth, illus.. $3.50

—— **Vol. II. Instruments, Transformers, Installation Wiring,** Switches and Switchboards. 8vo, cloth, illustrated.... $3.50

—— **Vol. III. Production of Electrical Energy, Prime** Movers, Generators and Motors. 8vo, cloth, illustrated... $3.50

—— **Vol. IV. Mechanical Gearing; Complete Electric Installations;** Electrolytic, Mining and Heating Apparatus; Electric Traction; Special Applications of Electric Motors. 8vo, cloth, illustrated.......................................... $3.50

—— **Vol. V. Apparatus and Machinery used in Telegraphs,** Telephones, Signals, Wireless Telegraph, X-Rays, and Medical Science. 8vo, cloth, illustrated.......................... $3.50

**KENNELLY, A. E. Theoretical Elements of Electrodynamic** Machinery. 8vo, cloth.......................... $1.50

**KILGOUR, M. H., SWAN, H., and BIGGS, C. H. W. Electrical** Distribution: its Theory and Practice. 174 illustrations. 12mo, cloth.......................................... $4.00

**KING, W. H. Lessons and Practical Notes on Steam,** the Steam-engine, Propellers, etc., for Young Marine Engineers, Students and others. Revised by Chief Engineer J. W. King, United States Navy. 19*th Edition, enlarged.* 8vo, cloth....$2.00

**KINGDON, J. A. Applied Magnetism. An Introduction** to the Design of Electromagnetic Apparatus. 8vo, cloth.. $3.00

**KIRKALDY, W. G. Illustrations of David Kirkaldy's** System of Mechanical Testing, as Originated and Carried on by him during a Quarter of a Century. Comprising a Large Selection of Tabulated Results, showing the Strength and other Properties of Materials used in Construction, with Explanatory Text and Historical Sketch. Numerous engravings and 25 lithographed plates. 4to, cloth.......................................... $20.00

**KIRKBRIDE, J.** Engraving for Illustration: Historical and Practical Notes, with illustrations and 2 plates by ink photo process. 8vo, cloth, illustrated, 72 pages...... *net,* $1.50

**KIRKWOOD, J. P.** Report on the Filtration of River Waters for the Supply of Cities, as practised in Europe, made to the Board of Water Commissioners of the City of St. Louis. Illustrated by 30 double-page engravings. 4to, cloth .... $7.50

**KLEIN, J. F.** Design of a High-speed Steam-engine. With notes, diagrams, formulas and tables. *Second Edition, revised and enlarged.* 8vo, cloth, illustrated, 257 pages. .*net,* $5.00

**KNIGHT, A. M., Lieut.-Com. U.S.N.** Modern Seamanship. Illustrated with 136 full-page plates and diagrams. 8vo, cloth, illustrated. *Second Edition, revised*............. *net,* $6.00
Half morocco........................................ $7.50

**KNOTT, C. G., and MACKAY, J. S.** Practical Mathematics. With numerous examples, figures and diagrams. *New Edition.* 8vo, cloth, illustrated.................................. $2.00

**KOLLER, T.** The Utilization of Waste Products. A Treatise on the Rational Utilization, Recovery and Treatment of Waste Products of all kinds. Translated from the German *second revised edition.* With numerous diagrams. 8vo, cloth, illustrated, 280 pages.............................. *net,* $3.50

—— Cosmetics. A Handbook of the Manufacture, Employment and Testing of all Cosmetic Materials and Cosmetic Specialties. Translated from the German by Chas. Salter. 8vo, cloth....................................... *net,* $2.50

**KRAUCH, C., Dr.** Testing of Chemical Reagents for Purity. Authorized translation of the *Third Edition,* by J. A. Williamson and L. W. Dupre. With additions and emendations by the author. 8vo, cloth........................... *net,* $4.50

**LAMBERT, T.** Lead, and its Compounds, With tables, diagrams and folding plates. 8vo, cloth, 223 pages....*net,* $3.50

—— Bone Products and Manures. An Account of the most recent improvements in the manufacture of Fat, Glue, Animal Charcoal, Size, Gelatine and Manures. With plans and diagrams. 8vo, cloth, illustrated.................... *net,* $3.00

**LAMBORN, L. L.** Cotton-seed Products. With numerous diagrams and engravings............................. *In Press.*

**LAMPRECHT, R. Recovery Work after Pit Fires.** A description of the principal methods pursued, especially in fiery mines, and of the various appliances employed, such as respiratory and rescue apparatus, dams, etc. With folding plates and diagrams. Translated from the German by Charles Salter. 8vo, cloth, illustrated................................ *net*, $4.00

**LARRABEE, C. S. Cipher and Secret Letter and Telegraphic Code,** with Hog's Improvements. The most perfect Secret Code ever invented or discovered. Impossible to read without the key. 18mo, cloth......................... .60

**LASSAR-COHN, Dr. An Introduction to Modern Scientific Chemistry,** in the form of popular lectures suited to University Extension Students and general readers. Translated from the author's corrected proofs for the *second German edition*, by M. M. Pattison Muir, M.A. 12mo, cloth, illustrated....... $2.00

**LEASK, A. R. Breakdowns at Sea and How to Repair Them.** With 89 illustrations. *Second Edition.* 8vo, cloth. $2.00

**—— Triple and Quadruple Expansion Engines and Boilers** and their Management. With 59 illustrations. *Third Edition, revised.* 12mo, cloth.................................. $2.00

**—— Refrigerating Machinery: Its Principles and Management.** With 64 illustrations. 12mo, cloth........... $2.00

**LECKY, S. T. S. "Wrinkles" in Practical Navigation.** With 130 illustrations. 8vo, cloth. *Fourteenth Edition, revised and enlarged*........................................ $9.00

**LEFÊVRE, L. Architectural Pottery: Bricks, Tiles, Pipes,** Enameled Terra-Cottas, Ordinary and Incrusted Quarries, Stoneware Mosaics, Faiences and Architectural Stoneware. With tables, plates and 950 cuts and illustrations. With a preface by M. J.-C. Formigé. Translated from the French, by K. H. Bird, M.A., and W. Moore Binns. 4to, cloth, illustrated...... *net*, $7.50

**LEHNER, S. Ink Manufacture: including Writing, Copying,** Lithographic, Marking, Stamping and Laundry Inks. Translated from the *fifth German edition*, by Arthur Morris and Herbert Robson, B.Sc. 8vo, cloth, illustrated.......*net*, $2.50

**LEMSTROM, Dr. Electricity in Horticulture.** Illustrated.............................................*In Press.*

**LEVY, C. L. Electric-light Primer.** A simple and comprehensive digest of all the most important facts connected with the running of the dynamo, and electric lights, with precautions for safety. For the use of persons whose duty it is to look after the plant. 8vo, paper.............................. .50

**LIVACHE, ACH.** (Ingenieur Civil des Mines). **The Manufacture of Varnishes, Oil Crushing, Refining and Boiling, and Kindred Industries.** Describing the Manufacture and Chemical and Physical Properties of Spirit Varnishes and Oil Varnishes; Raw Materials; Resins; Solvents and Coloring Principles; Drying Oils, their Extraction, Properties and Applications; Oil Refining and Boiling; The Manufacture, Employment and Testing of Various Varnishes. Translated from the French, by John Geddes McIntosh. Greatly extended and adapted to English practice. With numerous original recipes by the translator. Illustrated with cuts and diagrams. 8vo, cloth ........ *net*, $5.00

**LIVERMORE, V. P., and WILLIAMS, J. How to Become** a Competent Motorman. Being a Practical Treatise on the Proper Method of Operating a Street Railway Motor Car; also giving details how to overcome certain defects. 16mo, cloth, illustrated, 132 pages.............................. $1.00

**LOBBEN, P., M.E. Machinists' and Draftsmen's Hand**book, containing Tables, Rules, and Formulas, with numerous examples, explaining the principles of mathematics and mechanics, as applied to the mechanical trades. Intended as a reference book for all interested in Mechanical work. Illustrated with many cuts and diagrams. 8vo, cloth......................... $2.50

**LOCKE, A. G. and C. G. A Practical Treatise on the** Manufacture of Sulphuric Acid. With 77 constructive plates, drawn to scale measurements, and other illustrations. Royal 8vo, cloth.......................................... $10.00

**LOCKERT, L. Petroleum Motor-cars. 12mo, cloth, $1.50**

**LOCKWOOD, T. D. Electricity, Magnetism, and Electro**telegraphy. A Practical Guide for Students, Operators, and Inspectors. 8vo, cloth. *Third Edition*................. $2.50

—— **Electrical Measurement and the Galvanometer: its** Construction and Uses. *Second Edition.* 32 illustrations. 12mo, cloth................................................ $1.50

**LODGE, O. J. Elementary Mechanics, including Hydro**statics and Pneumatics. *Revised Edition.* 12mo, cloth ... $1.50

—— **Signalling Across Space, Without Wires: being a** description of the work of Hertz and his successors. With numerous diagrams and half-tone cuts, and additional remarks concerning the application to Telegraphy and later developments. *Third Edition.* 8vo, cloth, illustrated................ *net*, $2.00

**LORD, R. T. Decorative and Fancy Fabrics. A Valuable** Book with designs and illustrations for manufacturers and designers of Carpets, Damask, Dress and all Textile Fabrics. 8vo, cloth, illustrated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *net,* $3.50

**LORING, A. E. A Handbook of the Electro-magnetic** Telegraph. 16mo, cloth, boards. *New and enlarged edition.* . .50

**LUCE, S. B., Com. Text-book of Seamanship. The** Equipping and Handling of Vessels under Sail or Steam. For the use of the U. S. Naval Academy. *Revised and enlarged edition,* by Lieut. Wm. S. Benson. 8vo, cloth, illustrated. . $10.00

**LUCKE, C. E., Prof. Columbia Univ. Gas Engine Design.**

**LUNGE, G., Ph.D. Coal-tar and Ammonia: being the** third and enlarged edition of "A Treatise on the Distillation of Coal-tar and Ammoniacal Liquor," with numerous tables, figures and diagrams. Thick 8vo, cloth, illustrated. . . . . . . . . *net,* $15.00

**—— A Theoretical and Practical Treatise on the Man**ufacture of Sulphuric Acid and Alkali with the Collateral Branches.

**—— Vol. I. Sulphuric Acid. In two parts, not sold separately.** *Second Edition, revised and enlarged.* 342 illus. 8vo, cloth. . $15.00

**—— Vol. II. Salt Cake, Hydrochloric Acid and Leblanc** Soda. *Second Edition, revised and enlarged.* 8vo, cloth . . . $15.00

**—— Vol. III. Ammonia Soda, and various other processes** of Alkali-making, and the preparation of Alkalis, Chlorine and Chlorates, by Electrolysis. 8vo, cloth. *New Edition,* 1896. . $15.00

**—— and HURTER, F. The Alkali Maker's Handbook.** Tables and Analytical Methods for Manufacturers of Sulphuric Acid, Nitric Acid, Soda, Potash and Ammonia. *Second Edition.* 12mo, cloth . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $3.00

**LUPTON, A., PARR, G. D. A., and PERKIN, H. Elec**tricity as Applied to Mining. With tables, diagrams and folding plates. 8vo, cloth, illustrated, 280 pages. . . . . . . . . . . . . . *net,* $3.50

**LUQUER, L. M., Ph.D. Minerals in Rock Sections.** The Practical Method of Identifying Minerals in Rock Sections with the Microscope. Especially arranged for Students in Technical and Scientific Schools. 8vo, cloth, illustrated. . . . . . . *net,* $1.50

**MACCORD, C. W., Prof. A Practical Treatise on the** Slide-valve by Eccentrics, examining by methods the action of the Eccentric upon the Slide-valve, and explaining the practical processes of laying out the movements, adapting the Valve for its various duties in the Steam-engine. *Second Edition.* Illustrated. 4to, cloth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $2.50

**MACKIE, JOHN. How to Make a Woolen Mill Pay.** 8vo, cloth........................................ *net*, $2.00

**MACKROW, C. The Naval Architect's and Ship-builder's** Pocket-book of Formulæ, Rules, and Tables; and Engineers' and Surveyors' Handy Book of Reference. *Eighth Edition, revised and enlarged.* 16mo, limp leather, illustrated............ $5.00

**MAGUIRE, E., Capt., U.S.A. The Attack and Defence** of Coast Fortifications. With maps and numerous illustrations, 8vo, cloth........................................ $2.50

**MAGUIRE, WM. R. Domestic Sanitary Drainage and** Plumbing Lectures on Practical Sanitation. 332 illustrations. 8vo........................................ $4.00

**MAILLOUX, C. O. Electro-traction Machinery. 8vo,** cloth, illustrated........................................ *In Press.*

**MARKS, E. C. R. Mechanical Engineering Materials:** Their Properties and Treatment in Construction. 12mo, cloth, illustrated........................................ .60.

**—— Notes on the Construction of Cranes and Lifting** Machinery. With numerous diagrams and figures. *New and enlarged edition.* 12mo, cloth........................ *net*, $1.50

**—— Notes on the Construction and Working of Pumps.** With figures, diagrams and engravings. 12mo, cloth, illustrated........................................ *net*, $1.50

**MARKS, G. C. Hydraulic Power Engineering. A Prac-**tical Manual on the Concentration and Transmission of Power by Hydraulic Machinery. With over 200 diagrams and tables 8vo, cloth, illustrated........................................ $3.50

**MAVER, W. American Telegraphy: Systems, Apparatus,** Operation. 450 illustrations. 8vo, cloth................ $5.00

**MAYER, A. M., Prof. Lecture Notes on Physics. 8vo,** cloth........................................ $2.00

**McCULLOCH, R. S., Prof. Elementary Treatise on the** Mechanical Theory of Heat, and its application to Air and Steam-engines. 8vo, cloth........................................ $3.50

**McINTOSH, J. G. Technology of Sugar. A Practical Treatise** on the Manufacture of Sugar from the Sugar-cane and Sugar-beet. With diagrams and tables. 8vo, cloth, illustrated. *net*, $4.50