as E is the same in equation (1) as in (2) then

$$(X+G+B)\,k\,d_2 = \left(R+\frac{G\,S}{G+S}+B\right)k\,d_1\,\frac{S}{G+S}$$

omitting B which is very small and cancelling k

$$(X+G)\,d_2 = \left(R+\frac{G\,S}{G+S}\right)d_1\,\frac{G+S}{S}$$

$$\therefore X = \frac{\left\{\left(R+\frac{G\,S}{G+S}\right)d_1\,\frac{G+S}{S}\right\}}{d_2} - G$$

and substituting the values as given above we get

X = 20,007,920 ohms or 20 megs. fully.

4. The electro-chemical equivalent of zinc is .00034. What do you understand by this? What would be the deposit in an Edison chemical meter, the German silver shunt having a resistance of .01 ohms, and the resistance of the voltameter and the coil in series with it being 48.96 ohms, when a current of 100 amperes has been passing for 4 hours. Make a diagram showing the arrangement.

ANSWER.—One coulomb deposits .00034 grams. electro chemical equivalent.

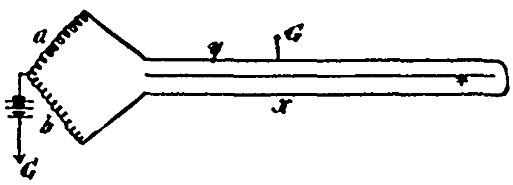
∴ Amount of current × electro chem. equivalent × time in seconds = deposit.

In the question the resistances are as .01 : 48.96

∴ 1/4897 of 400 × .00034 × 3600 = 100 milligrams will be the deposit.

5. In an Edison underground 3-wire system, the distance from power-house to feeder junction box is 6,000 feet. The copper resistance is .017 ohms per 1,000 feet. The two outside wires are looped together at one end (the junction box), and at the other the ends of the loop are attached to the terminals of the galvanometer. A 150-ohm resistance coil of 200 turns is also connected to the terminals of the galvanometer, and at a distance of 20 turns from one end one pole of a 4-cell battery is attached, the other pole being attached to ground. In this position there is no deflection of the needle. Find the location of the fault and give distance in feet from the power house.

ANSWER.—



a = 15 ohms.
b = 135 ohms.
l = total length x + y = .2040 ohms.
x = l-y.
a x = b y.
a (l-y) = b y.
a l = y (a + b).

$y = \frac{a\,l}{a+b} = .0204$ ohms or 1200 feet.

6. What is the size of the conductor in the above question?

ANSWER.—Knowing that the resistance of one mil foot is 10.4 ohms we can easily find the diameter in mils.

or $d = \sqrt{611{,}750} = 782$ mils or .782" diameter.

7. What data would you require to determine the permeability of an electro-magnet core which lifts a weight P pounds? Investigate a formula. What do you understand by permeability?

ANSWER.—The lifting power of a magnet in dynes is $\frac{B^2 A}{8\pi}$ where B = induction per square centimeter and A = area in square centimeters, from which we can easily get

$$B'' = \sqrt{\frac{\text{pull in lbs.}}{\text{area in square inches}}} \times 8494 \qquad (1)$$

when B" is = lines of force per square inch.

The law of the magnetic circuit being

$$\text{magnetic flux } N = \frac{\text{Magneto motive force}}{\text{Reluctance}} = \frac{\frac{4\pi\ \text{Amp. turns}}{10}}{\frac{l}{A\,u}}$$

$$= \frac{4\pi\,\text{Amp. turns} \times A\,u}{10\,l} \text{ for centimeter measurement,}$$

from which we get

$$N = \frac{3.2\ \text{amp. turns} \times A\ u}{l''} \text{ for inch measurement}$$

when A" = area in square inches.
l" = length in inches.
u = permeability.

$$\frac{N}{A''} = B'' = \frac{3.2\ \text{amp. turns} \times u}{l''}$$

But in (1) $B = \sqrt{\frac{\text{lbs.}}{\text{area}}} \times 8494$

$$\therefore \frac{3.2\ \text{amp turns} \times u}{l''} = \sqrt{\frac{\text{lbs.}}{\text{area}}} \times 8494$$

from which we get

$$u = \sqrt{\frac{\text{lbs.}}{\text{area}}} \times \frac{l''}{\text{amp. turns}} \times 2660$$

From this equation we see that the data necessary for determining the permeability, u, the specific conductivity for magnetic lines or multiplying power of the material which lifts a weight of P lbs. will be the following: The area in square inches of the magnet, the length of the core in inches and the number of ampere turns.

8. A current of 20 amperes, flowing through a resistance of 10 ohms, heats 20 lbs. of water from 60° to 70° Fah. How long was current flowing, supposing there was no loss by radiation?

ANSWER.— Let J = Joules mechanical equivalent.
H = No. of heat units.
1 lb. deg. Fah. = 1047.3 watts.
J H = Work done = C^2 R t
where t = time in seconds

$$\therefore t = \frac{J\,H}{C^2\,R} = \frac{1047.3 \times 20\,(70-60)}{20 \times 20 \times 10}$$

= 52.4 seconds nearly.

9. What is the efficiency of an electric motor when running up to its maximum? Prove it.

ANSWER.—*When motor is standing still the current that will flow through the winding will be* $\frac{E}{R}$ where E = E M F of supply and when running

$$C = \frac{E - \text{counter E M F}}{R}$$

Useful work = C × *counter E M F* = *counter E M F* $\left(\frac{E - C.\ E\ M\ F}{R}\right)$

Work spent in heating the conductors = C^2 R

Total watts = E C = C^2 R + C × counter E M F

$$= C^2 R + \text{counter E M F}\left(\frac{E - C.\ E\ M\ F}{R}\right)$$

but C^2 R = C × counter E M F

∴ E.C = 2 C^2 R

E = C 2 R

$$C = \frac{E}{2\,R}$$

which shows that one-half the total power supplied is spent in heating the wires, and that the mechanical work given out by the motor is a maximum when the current is reduced to one-half the strength it would be if the motor was standing, and its efficiency is therefore ½ or 50%.

10. Describe the Aron or Thomson wattmeter.

ANSWER.—The Thomson wattmeter is sufficiently well known that no description here is necessary. The following may prove interesting to some regarding the Aron meter.

Let E = E M F at service
C = current
T = term of one oscillation of correct clock
T_1 = " " " " retarded "
g = gravity
C. E H = magnetic force
l = length of pendulum

$$T = \pi\sqrt{\frac{l}{g}} \qquad T_1 = \pi\sqrt{\frac{l}{g - \text{C. E. H}}}$$

$$\frac{T}{T_1} = \frac{\pi\sqrt{\frac{l}{g}}}{\pi\sqrt{\frac{l}{g - \text{C E. H.}}}} = \frac{\sqrt{\frac{l}{g}}}{\sqrt{\frac{l}{g - \text{C. E. H.}}}}$$

$$\left(\frac{T}{T_1}\right)^2 = \frac{\frac{l}{g}}{\frac{l}{g - \text{C. E. H.}}} = \frac{l\,(g - \text{C. E. H.})}{l\,g}$$

$$\left(\frac{T}{T_1}\right)^2 = 1 - \frac{\text{C. E. H.}}{g} \text{ or } \frac{T}{T_1} = \sqrt{1 - \frac{\text{C. E. H.}}{g}}$$

So that this meter will record accurately the magnetic force, which should be very small compared with gravity, therefore $\frac{\text{C. E. H.}}{g}$ must also be very small compared with unity.

$$\therefore \left(1 - \frac{\text{C. E. H.}}{g}\right)^{\frac{1}{2}} = \left(1 - \frac{\text{C. E. H.}}{2\,g}\right) \text{very nearly}$$