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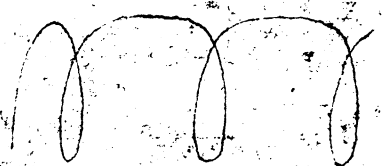
# Distributed Capacity and Dead End Effect.

If an inductance is inserted in an oscillating circuit a difference of potential will be found to exist across its terminals due to its impedence.

Also there will be a difference of potential betwuen turns and therefore electro-static lines of force will pass between turns. Electro-static energy is stored between a turn and the neighboring turns and since capacity is necessary to store electro-static energy



we have in effect a capacity scattered or distributed along the whole lenght of the coil.

This capacity has several effects, sometimes decireable and sometimes not and a coil therefore cannot be considered as a simple inductance but account must be taken of this distributed capacity which may be regarded or treated as as equivalent capacity shunted around the true inductance.

One effect is that if a coil having a marked distributed capacity is used in conjunction with a condenser forming perhaps the closed circuit of a receiving set which is to be used to tune to low wave lengths, it may be found that the distributed capacity interferes to some extent in this way. The wave length of the circuit would not be equal to

$$\lambda = 59.6\sqrt{L_{cms.}\,C_{mfds.}}$$

where L is the true inductance of the coil and C is the capacity of the condenser but would be equal to

$$\lambda = 59.6\sqrt{L_{cms}\,(C_{mfd} + C_{d\,mfd})}$$

where L and C are as before and $C_d$ is the distributed capacity. $C_d$ might easily be more than C when tuning to low wave lengths and the circuit would not develope the disired highest potential, say in connection with an audion detector.

Another effect is that if a coil having distributed capacity is excited, perhaps by an aperiodic buzzer circuit it will oscillate quite freely and powerfully at a period determined by the familiar equation

$$T = 2\pi\sqrt{L C_d}$$

L being its effective inductance and $C_d$ being the distributed capacity ~~both of course being in the same units.~~

Also it follows the wave length at which this coil will naturally oscillate will be given by

$$\lambda = 59.6\sqrt{L C_d}$$

L, its inductance in cms. and its capacity $C_d$ being in Mfds.

This leads the way to a more or less simple method of measuring the distributed capacity. The effective inductance may be measured by comparing it with a standard or calculated using the formulae furnished by the Bureau of Standards. Then the coil may be set oscillating, conveniently by a highly damped impulse from a buzzer and its wave length measured with the aid of a wave meter.

Now by transposing the terms of the equation already given, ~~$\lambda = 59.6\sqrt{LC_d}$~~ we get

$$C_d = \frac{\lambda^2}{59.6^2 L}$$

the capacity of the coil in microfarads.

Another method of measuring the distributed capacity of an inductance is due to Drude. The following formula, using the physical dimensions of the coil was taken from Prof. Goldsmith's Article in the Wireless Age.

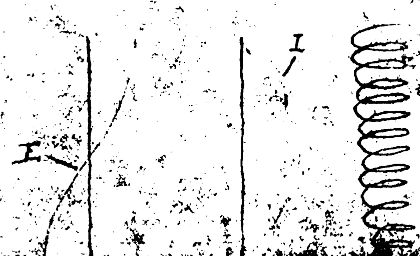
$$C_d = 2 k r \frac{2 + \frac{h^2}{r^2} + \frac{r^2}{h^2}}{10 + 4\frac{h^2}{r^2} + 3\frac{r^2}{h^2}} \text{ mmfd.}$$

where h equals the length of coil in cms., r equals radius coil in cms. and k is a constant due to the length of the coil divided by the diameter and ranges from .3 to 1.8 with an air core inductance.

| h / 2r | k | h / 2r | k |
|---|---|---|---|
| 6 | 1.81 | 0.8 | 1.10 |
| 5 | 1.64 | 0.6 | 1.07 |
| 4 | 1.47 | 0.4 | 0.94 |
| 3 | 1.37 | 0.2 | 0.69 |
| 2 | 1.25 | 0.1 | 0.49 |
| 1 | 1.12 | 0.05 | 0.28 |

There is still another simple method of measuring the distributed capacity, namely to shunt the coil with a calibrated variable condenser and then exciting the circuit with a wave meter and plotting the wave lengths squared against the capacities at the various frequencies. A straight line is obtained which instead of starting at zero capacity will intersect the base at a certain minus value which would be the distributed capacity (effective) of the inductance.

It is interesting to note that when we set a coil oscillating at its natural period it behaves exactly like an Hertz Oscillator or the aerial of a station with its image. While the current value in a closed circuit at a given instant is the same all around, the current distribution along the oscillating




coil L would be as shown, the greatest current value being at the center while the greatest potential would be present at the ends. That high potential at the end ought to look good to the users of the audion.

Now for the Dead End Effect.

If we had an aerial arrangement as in the figure, using part of a coil having distributed capacity in series with the antenna, we have actually, two closely coupled circuits. One the antenna, part of the coil and the ground; the other the entire coil shunted with its distributed capacity.

Really a system of two degrees of freedom. The coil with its distributed capacity may easily have a natural wave length of 600 meters the wave

tuned to. This coil or secondary circuit then seems to absorb quite nearly all of the energy and the detector gets none. I will have to ask you where the energy goes but it goes alright. $I^2R$ perhaps?

In the secondary circuit the same thing happens. For example take the secondary of the United Wireless Type E Receiver. The coil is tapped off into ten sections and to tune to 300 hundred meters one section is used with a small variable condenser across it. The whole coil itself oscillates at a wave length of 275 meters. You can easily imagine the beautiful distance work you will be able to do with this coil absorbing most of the energy.

Just in this respect I think the amateur would find greatest interest in the dead end effect. The ordinary practice is to but a coupler that will tune from below 200 meters up to and sometimes over 2000 thousand meters. To get the longer wave length it is necessary to have a pretty good sized secondary coil and on measuring a few I found that the fundamental wave length of most of them varied from 200 to 300 meters just the waves the amateur uses. Therefore here is one of the reasons why you get no distance work on two hundred meters. When you go up to 500 meters why the coil is not in tune with the received signals and absorbs much less energy.

To give an example or two we have a secondary at East Side which has 7.25 inches of winding 3.5 inches in diameter wound with #28 S.S.C. Its natural wavelength is 290 meters. Much hope to tune to a 300 meter wave.

The secondary of the Type E Tuner oscillates unloaded at 275 meters having 3.5 inches of #28 S.S.C. winding 3.25 inches in diameter.

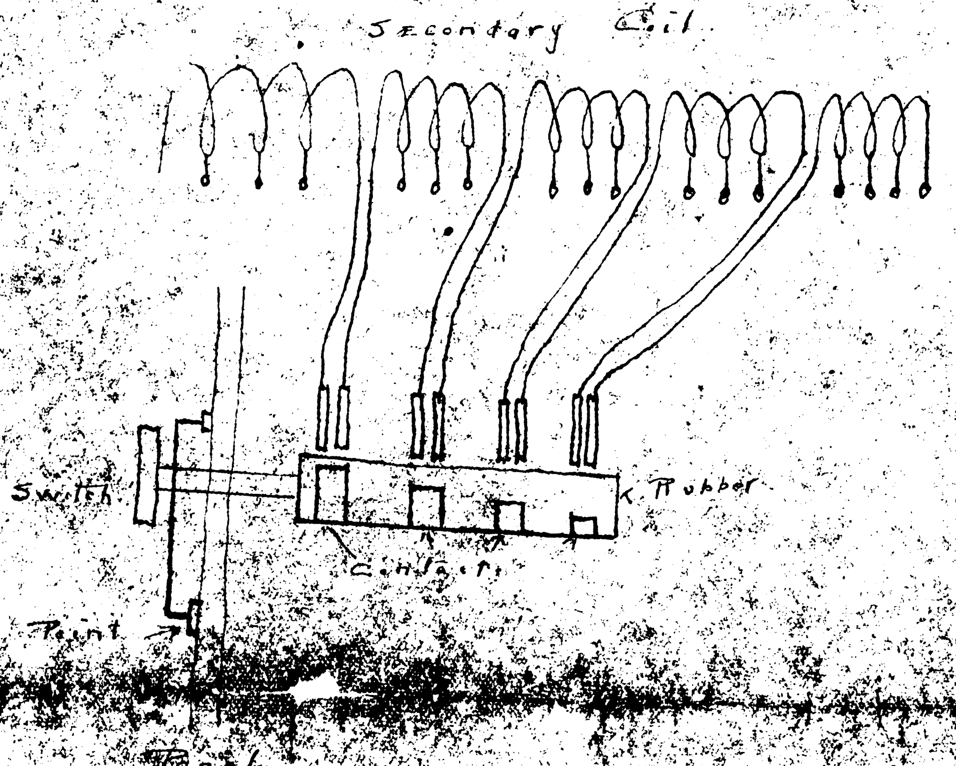
A loading coil used for long waves has 25 inches of winding of #20 S.S.C. 5.6 inches in diameter. Its natural wavelength is 570 meters. Soem larger coils or rather inductances also are 25 inches long and 5.6 inches in diameter but are wound with #28 S.S.C. wire, have something like 1750 turns and a natural wave length of 1600 meters.

Some people think it well, in order to eliminate this dead end [illegible] effect, to short circuit the unused part of the inductance. Under certain conditions this is alright. Other times it is all wrong. L. Cohen, in the Electrician, January 23, 1914 discussed this point and showed that if an inductance coil of a hundred turns had ten of its turns form part of an oscillatory circuit and the remaining ninety turns when shorted, there would be practically no loss, the current in the closed circuit being the same as if the ninety turns were not there.

But if seventy of the hundred turns were in the closed circuit and the remaining thirty turns were shorted, only 34 per cent of the current in the closed circuit without the shorted dead end would be available.

In the [illegible] using ninetynine and shorting one turn about a third of the primary energy is available. Though not in place I cannot help but point out again that this is where the great disadvantage of the slider contact of tuners comes in. Most sliders on the small wire inductances of tuners touch two turns at the same time, the case in mind. Try this out for yourself. Tune in any station, Cape Cod perhaps, so as to get good loud signals, then wind a single turn of bellwire around the primary. Generally you will find that no amount of tuning will bring in his signals readable.

If different inducat ctances cannot be used for different ranges of wave lengths, it is probably best to open the unused coil circuit several times, so as not to have sufficient inductance in any of the sections to tune naturally to any of the wave lengths received. This is what is done in the new Marconi Type 101 tuner, that can be tuned to all waves from 100 to 4000 meters. The switch arrangement is as shown.

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