HIGH FREQUENCY CURRENTS

by

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Chapter I

Introduction:

This Thesis deals with the discussion of high frequency currents. The trend of modern electrical work is toward higher potentials; 220,000 volt lines have been put into successful operation, and even higher transmission voltages are being contemplated. On these high voltage lines, the high frequency phenomenon introduced by surges, lightning and other transients become very important. High frequency currents which are of an osciallatory nature have real practical application in the field of research, as it is quite common in practice to use high frequency currents in the commercial tests on insulators. High frequency currents are also used in X-Ray, Violet Ray machines and certain types of inductive furnaces.

Chapter II

General Survey - History.

Ever since the earliest time, man has looked with awe upon nature's marvelous electrical demonstrations in the form of lightning. It remained for Benjamin Franklin to be the first to attempt to learn something of the science connected with this remarkable manifestation of electrical energy. His well known experiment with a kite in the eighteenth century marked the beginning of high voltage, and high frequency experimentation. Since then there has been great development in electrical science. Such men as Tesla and Steinmetz have given much valuable information regarding high frequency currents.

Chapter III

Purpose of this Study:

This thesis has a two-fold purpose; it not only affords the opportunity to study the highly interesting high frequency currents, and their application, but to construct a more efficient exhibit for the annual Engineers Day. The high frequency experiments have always been the most spectacular, and has received the most favorable comment from spectators of all of the exhibits. It is a fitting advertisement for the School of Engineering. The photograph (Fig 1) shows the apparatus at the University of Tennessee.

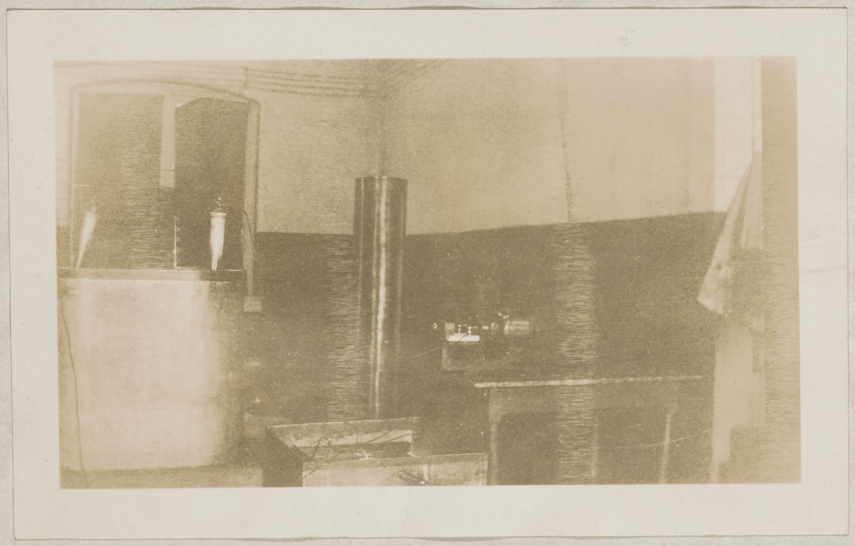


Fig 1

Chapter IV

General Theory:

In order to obtain high frequency currents by means of an oscillatory circuit it is necessary to supply power to a circuit containing suitable inductance and capacity. The circuit will contain some resistance, but this will not effect the valve of the frequency, which is determined by the following equation:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Where l = Inductance of circuit in henries.

c = Capacity of circuit in farods.

f = Frequency of oscillation per second.

The resistance which will allow a current to oscillate is called the critical resistance which is expressed as

$$R = 2\sqrt{\frac{L}{C}}$$

Therefore in order to produce oscillation the value of R must be made low so that R is less than . This is easily accomplished by using conductors of low resistance in oscillatory circuit.

In order to obtain the maximum discharge from the secondary of the coil, the primary and secondary should be turned to the same frequency. Since the inductance

and distributed capacitance of the secondary are practically fixed valves, the inductance of the primary must be varied by varying the number of primary turns, and the capacity must be charged by varying the number of condensers in parallel until the point of maximum secondary discharge is reached. At this point the following relationship will be true:

$$L_p C_p = L_s C_s$$

P = Primary
S = Secondary

Hence the natural frequency of the primary circuit will be equal to that of the secondary circuit since Lp and Ls represent the inductances of the primary and secondary respectively and Cp and Cs represent the capacities of the primary and secondary.

The circuit is almost identical to that of a radio transmitter. Practically all radio sets which send out damped waves generate the high frequency currents required by charging up a condenser from a suitable source of power, then letting this condenser discharge through on an inductance in series with a spark gap. In general the oscillatory power so generated is transferred by coupling of some kind to another circuit from which it is radiated. In Fig II is shown the circuit; the condenser C charged to voltage F is to be connected to the circuit consistency of L and R in series when switch is closed.

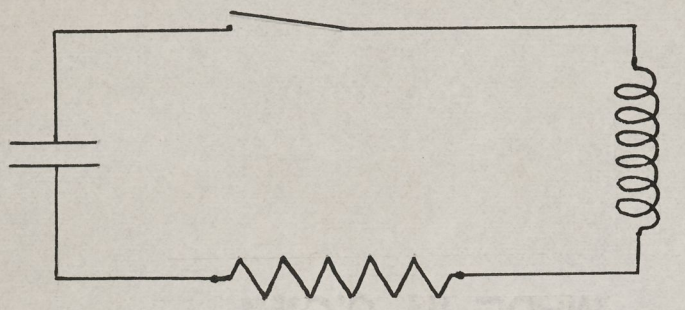
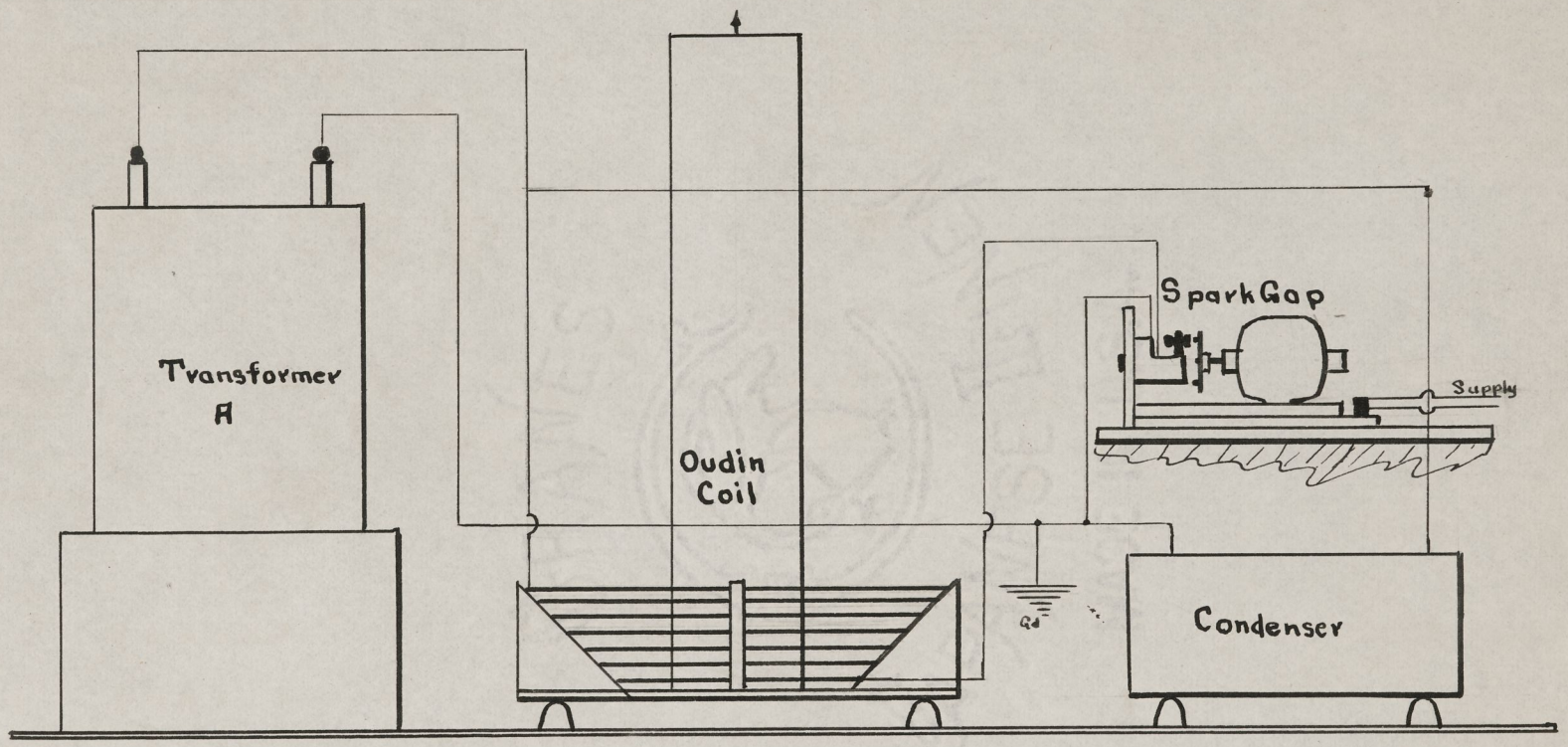


Fig II

The question is often asked, "Why are high frequency currents harmless to the human body?" With frequencies of this high value, the reversals of the current are so rapid that the current does not have time to penetrate into the tissues of the body. Hence the major portion of the current passes over the surface of the body and little; if any, inconvenience is experienced. The frequency obtained from different coils varies over quite a range, depending on the inductance and capacity of the coils; the variation being from about 120,000 cycles for the largest coil to as high as a million cycles for the small coils.



HIGH FREQUENCY APPARATUS

Fig III

Chapter V

Description:

The Oudin Coil differs from Tesla coils in that one end of secondary is connected to primary and the discharge takes place from the free end of the secondary, while in a Tesla coil the charge takes place between the two secondary terminals neither of which are connected to the primary. The Tesla coil is nothing more than an air core transformer; plenty of insulation being provided between primary and secondary.

Fig. III shows the diagramatic hook up of apparatus used. The power supplied to transformer (A) was varied by use of resistance in series with the primary. The transformer consists of four coils as shown in Fig IV. as the secondary and the primary.

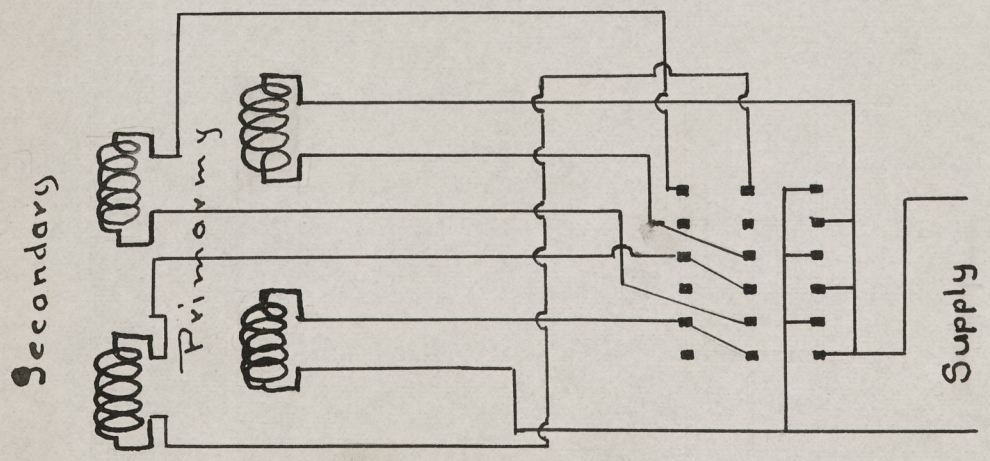


Fig IV

The condenser consisted of a steel tank 30" x 30" x 13", filled part full with oil in which alternate layers of 1 1/4" glass as a dielectric and tinfoil were placed. Much trouble was experienced in building a condenser to stand up under the heavy voltage. A spark gap was placed across the condenser to act as a safe guard against puncturing the dielectric with the heavy current. The oil has an added advantage over a solid dielectric, in that a disruptive breakdown does not spoil the condenser, the oil repairing itself with no dileterious effects unless sufficient arcing occurs in the oil to produce considerable carbonization. Castor oil has been found to be excellent for this use, but the condenser in the University laboratory contained transformer oil.

The construction of the several commercial types of spark gaps in use at the present time may be conveniently subdivided into the following classes:

(a) Open gaps

(b) Rotating gap { Synchronous / Non-Synchronous

(c) Quenched gaps { Self cooled / Fan cooled.

The gap must possess high dielectric strength or resistance to puncture, previous to breakdown so that the condenser may be charged to a very high potential difference and after the gap has broken down it must have a

very low resistance, otherwise the damping of the oscillations will be excessive, and the apparatus inefficient, as most of energy being dissipated as I^2R loss is the gap. The rotary gap was used and it prevents the formation of a power arc after the condenser voltage had jumped the spark gap of the rotor. A stationary gap, unless of the quenched type would not be satisfactory. The apparatus used consists of a synchronous motor which revolves a dielective disk mounted with four electrodes connected to a copper band. The fixed electrodes are mounted on a platform which revolves about the shaft of motor. This will allow the electrodes to be opposite when the condenser is changed to its highest potential.

The primary coil consist of six turns of copper ribbon mounted on a circular step effect wooden frame. It has a mean radius of approximately 22". A clip was used for one connection in order that it could be turned to desired frequency.

The secondary consists of approximately five hundred and fifty turns of about number 20 D.S.C. wire mounted on a cardboard cylinder braced with wood. It is five feet and one foot in diameter. The free end is connected to a wire which has a sharpened end to obtain a better discharge.

Condensers were placed in parallel in the supply to prevent trouble in the lighting current.

Trouble was often experienced in insulating the circuit against short circuits when a discharge to side of the condenser tank, or to the floor from the coil. Placing the coils on insulators, and allowing ample room in the condensers was found to eliminate this to a great extent.

In determining the wave length of the primary and secondary coils much difficulty was experienced. The wave meter with head set was used in conjunction with a small buzzer equipped with dry batteries. As this method would not give results, a spark coil equipped with storage battery was connected as shown in Fig V.

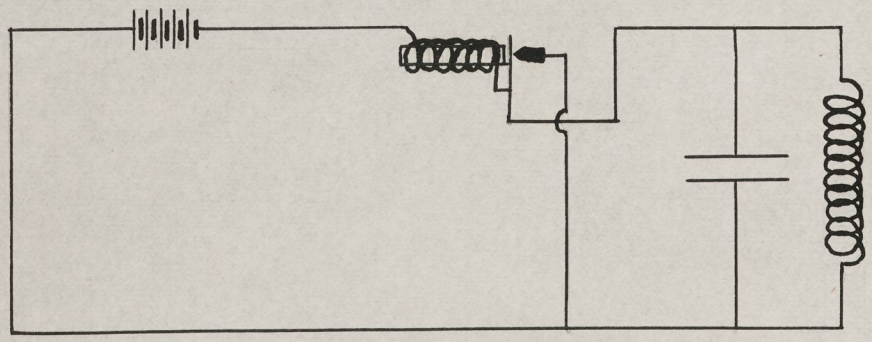


Fig V.

and a Leeds Northrop portable galvarometer was substituted for the head set as difficulty was experienced in hearing due to the loud noise of the spark gap. This worked very well and the wave length of the primary was found to be 1390. The secondary was also tested, and it was found to be approximately the same as the primary as we had adjusted it for maximum spark .

Chapter VII

Principals of Radio Communications by J.H. Morecroft was used in this work, and it contains large tables of data pertaining to radio transmission.

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it was submitted.

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