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# RADIO FREQUENCY CURRENT

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If the question, "What are the kinds of electrical current?" were put to the average layman slightly versed in electrical nomenclature, the answer would probably be, after some thought, alternating and direct current. Through scant knowledge other statements might be erroneously added. Seldom will radio frequency current be added as a distinct type. It would be futile to attempt to give a definition and the significance of radio frequency current in a single statement and expect the reader to grasp the meaning, unless he was well acquainted with the subject. The subject is too obscure to attempt this. Also, theories have not existed long enough to completely stand the tests of research.

The electrical engineer of a very few years past knew nothing of radio frequency current. The necessity for research on the subject was apparent when, in the design of insulation and equipment for radio use, radio engineers found a lack of ready information on the subject. Henceforth experiments were conducted, some of the results of which are to date puzzling and but partly explained. Radio development might be said to have passed through a "low loss" period. "Low loss" refers to low electrical losses through insulation of radio frequency circuits. Radio designers found that they could not utilize insulation that would pass criticism in the use of such currents as low potential alternating or direct current. The "low loss" period developed and brought into use such remarkable insulators as Pyrex, Insulantite, and Bakelite. During this and previous periods engineers were beginning to become interested in the prospects of such a field for research. Their investigations are just beginning to materialize. Investigators at first were hindered by the lack of instruments. Necessity brought forth many new and improved instruments such as vacuum tube voltmeters, thermalcouple meters, and methods for accurate resistance measurements.

### HOW RADIO FREQUENCY CURRENT IS GENERATED

The contents of this article would, perhaps, be clearer if, first, a brief description of the theory and manner in which radio frequency current is generated would be given. Let us first consider the heart of the circuit, the vacuum tube (prop-

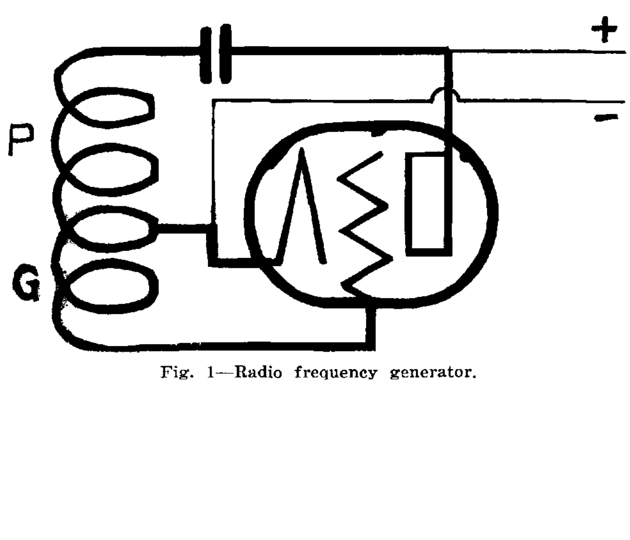


Fig. 1—Radio frequency generator.

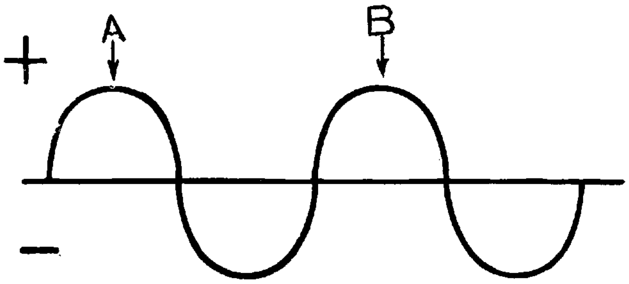


Fig. 2—Alternating current curve.

erly termed the triode tube). This tube, as implied in its name, triode, contains three elements. One element is maintained at a high temperature so as to emit electrons; another acts as a screen to control the electrons by its polarity charge; the third element, due to its positive charge, receives the negatively charged electrons. The first element is termed a filament, the second, a grid, and the third, a plate.

The circuit is shown in Fig. I. For purposes of illustration the circuit is eliminated of all the unimportant parts. Upon examination we find an inductance, a triode tube, a plate blocking condenser, and power supply leads. The inductance is tapped with a lead to the filament which divides the inductance into two parts P and G (signifying the plate and grid sections of the inductance). The filament supply and connections are eliminated, as they would add unnecessary confusion to the diagram. We will suppose that the filament is heated and is emitting electrons. Grid leak, grid condenser, and inductance tuning condenser were all omitted from the circuit diagram as they are unimportant in explaining the theory of operation. The circuit is technically known as the Hartley, but the theory of all radio frequency generators is the same. The heavy lines in the circuit diagram are used to denote the parts of the circuit in which radio frequency current is flowing.

Let us suppose that the circuit is adjusted to proper operating conditions. The electron emission from the filament completes the circuit through the portion of the inductance known as P. At the present state there is current flowing from the minus lead of the power supply through the tube elements, then out the plate element to the positive lead, and back to the power supply. At the same time a current flows through the inductance P and back to the plate through the plate-blocking condenser. This instantaneous current in coil P causes a current to flow in inductance G. The grid element of the tube becomes negatively charged. The grid gets the negative charge in a simple manner. The minus supply lead (that comprises one end of inductance G) causes the inductance end nearest it to be positive; therefore the other end must assume a negative charge. The negative end of the inductance is connected to the grid element and thus the grid gets the negative charge. Now let us

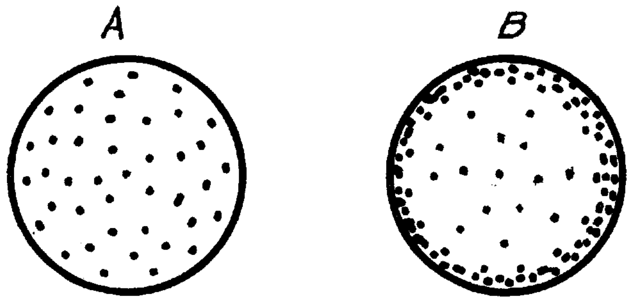


Fig. 3—Left: Cross-section of wire carrying direct current. Right: Cross-section of wire carrying radio frequency current.

see what happens inside the tube. The negative end of the inductance is connected to the grid element and thus the grid gets the negative charge. Now let us see what happens inside the tube. The negative electrons carrying current to the plate are repelled by the negatively charged grid. This stops the current from reaching the plate and breaks the circuit. There is now no current flowing in the circuit, and the motion of the electricity comes to a rest. The grid now assumes a neutral charge as there is no current flowing in the inductance to give the grid a negative charge. The above described action repeats itself. There has been described but one cycle of operation; actually the oscillations are very high (in the neighborhood of many thousands per second, depending on the characteristics of the circuit).

When this article speaks of radio frequency current it considers only those produced by undamped oscillations, as those explained above. This article will now attempt to characterize and compare radio frequency current with alternating or direct currents.

## CHARACTERIZATION OF RADIO FREQUENCY CURRENT

We must first summarize alternating current so as to have a basis for showing the characteristics of radio frequency current. It is believed that when a comparison of radio frequency current is made to alternating current none will have to be made to direct current as the difference is too apparent to warrant discussion. Radio frequency current is generally classified as alternating current, since the currents have a great deal in common.

Briefly, alternating current is an electrical current whose current flow alternates so many times per second giving it a definite frequency. So when we say a 60-cycle current, we mean that the current undergoes 60 alternations per second. On consulting Fig. 2, we find the current flow plotted against time. The current flow is reversed every time it crosses the neutral line marked O. The frequency would be the number of wave crests passing a fixed point such as A per second. Common industrial frequencies are 25 and 60 cycles. Special alternators have been built having frequencies of one hundred thousand cycles per minute. Direct current undergoes no oscillations as does alternating current. The current flow of direct current is continuous in one direction. Thus no curves are possible for direct current (a diagram would be a straight line). Direct current may be generated by chemical reaction as obtained from batteries that generate their current by different rates of decomposition of their elements. It may also be obtained from a mechanical source such as a generator.

It is a well-known fact that conductors carrying direct or alternating current utilize the entire mass of the conductor. Tests show that radio frequency current utilizes only part of the conductor, that nearest the surface. On referring to A in Fig. 3 we find a cross section of a conductor through which alternating or direct current is passing. The dots on the cross section represent the current distribution. It is easily seen that the current (shown by dots) is evenly distributed through the conductor. Diagram B in Fig. 3 represents a similar conductor cross-section through which is passing radio frequency current. The dots show that nearly all of the current flows along the surface of the conductor. From the above it may be deducted that a hollow conductor will pass nearly as much current as a solid one. It will be also easily seen that a hollow conductor will pass much more current, provided the mass of the solid conductor is equal to the mass of the hollow conductor. No law is feasible for the above because some of the radio frequency current passes through the center of the conductor. Also the larger the hollow conductor becomes the higher the capacity of the inductance becomes and capacity cuts down the radio frequency current.

The above fact brings up a most perplexing question. "If the radio frequency current travels along the surface of a conductor, then will a conductor whose surface is oxidized pass less radio frequency current than a conductor whose surface is a conductor such as silver?" Numerous tests and theories have been presented, the results of which are conflicting. If an oxidized surface does not hinder the passage of radio frequency current, then will this disprove the theory that radio frequency current does not pass through the center of a conductor? Should the above be so, where does the radio frequency current flow? One new theory has been advanced—that the current does not pass through the conductor, but through the ether just outside the conductor! This question is still open for the research engineer.

Now let us consider what happens in an inductance through which radio frequency current is passing. In Fig. 4 there is represented an inductance with the radio frequency flow represented by dots. Examination shows that the radio frequency seems to flow where the capacity of the circuit is greatest.

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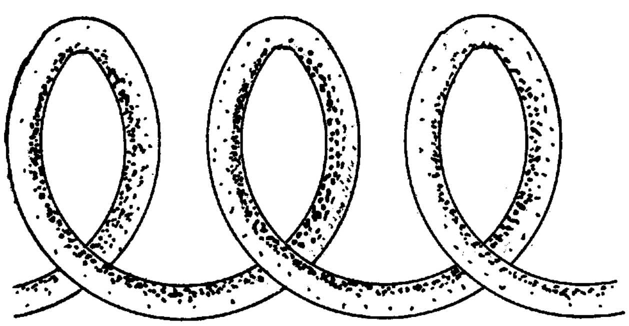

Fig. 4—Inductance Showing Radio Frequency Flow

## RADIO FREQUENCY CURRENT

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Alternating current can easily be transformed to any desired intensity or potential if the core and primary winding are designed to work with the potential and frequency of the current. Radio frequency may be transformed by means of resonated circuits. These are circuits that are both tuned to the same frequency. No core is needed as in the case of alternating current.

Another interesting phenomenon is the fact that when a metallic circuit is brought in the field of two radio frequency circuits in resonance, a current is generated in the metallic circuit although it may not be tuned to the resonant frequency.

It is a common thing to have radio frequency currents generated in powers up to 50 KW. With the use of properly designed equipment it is possible to generate radio frequency current with a power loss of only 25 per cent. The total loss is due to heating losses in the tube and resistance of the circuit. Present circuits will not give a better energy transfer.

This article has attempted by a few illustrations to show that a large and interesting field in radio frequency research is open to the investigator and engineer. The radio field is rapidly growing to be one of our great commercial enterprises and there is certainly a most interesting future awaiting anyone who is interested in its development and gifted with an analytical mind.