breast-feed her child. Where this is impossible then a tubercle-free milk—certified or pasteurized—should be used, and if this is not obtainable, boiled milk, which, I am assured by experienced paediatricians, is very suitable for the infant.

In populous centres tubercle-free milk is available and even insisted upon by legislative procedure. On the other hand, the higher incidence of bovine infection in rural districts shown by the present figures and those of others^{46 47} suggests a greater contamination with live tubercle bacilli in country than in town milk. Efficient pasteurization of milk is a cheap and effective method of dealing with tuberculous and other infections—for example, typhoid, dysentery, diphtheria, and scarlet fever, etc. Price⁴⁸ in Toronto has shown the practical disappearance of bovine infections following pasteurization of the city's milk supply.

It has been suggested that the consumption of milk infected with bovine bacilli may immunize against later infection with the human type. This view has been chiefly based on the alleged lower virulence for the human subject of the bovine bacillus. It is true that relatively fewer deaths are due to bovine than to human infections. Further, healed lesions in mesenteric glands—nearly always the result of bovine infection—are common findings in adult necropsies. As I have already pointed out,¹ however, the fact that generalization is infrequent in such cases probably depends on the efferents from these glands not draining directly into the blood stream as in the glands associated with the lungs. From the clinical point of view Cumming *et al.*⁴⁹ and Munro and Walker⁵⁰ have found that phthisis due to bovine infection frequently runs a very acute course. Moreover, as Griffin and myself⁵¹ have shown 22 per cent. of cerebral tuberculosis in children is due to the bovine bacillus. In addition to the mortality from bovine infection, it is the cause of much suffering in early life, 53.8 per cent. of surgical tuberculosis in my 1932 series being due to this type. Accordingly, one wonders if the price which we pay for this doubtful immunity is not too high. It has also been suggested that in eliminating bovine infection the incidence of tuberculosis due to the human type may rise, but in Toronto, where bovine infection has been completely eradicated, no increased incidence of disease due to the human type of bacillus has yet been observed.

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ULTRA-HIGH FREQUENCY*

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Short-wave therapy aims at making selected tissues of the body the seat of electrical oscillations of very high frequency. In order to attain this objective the tissues are included in an oscillating circuit in which, subsequently, conditions required to bring about resonance with a high-frequency generator are satisfied. From a practical point of view the administration consists in adjusting the resonating circuit to the exigencies created by the complex load. As only the resonating circuit of a short-wave apparatus primarily concerns the operator, these remarks will be limited to this system, the component parts of which will be dealt with one by one, mentioning their function in relation to the main issue—the treatment of the patient.

The resonating circuit of a short-wave machine can be divided into four parts:

- (a) The resonating circuit proper.
- (b) The leads.
- (c) The measuring instruments.
- (d) The load.

The resonating circuit proper, like all circuits capable of oscillating, incorporates inductance and capacity; the former is usually in the shape of a coil and the latter in the shape of a condenser. This condenser is most often of the variable type, to enable one to satisfy conditions required for the transference of oscillating electrical energy from the generator proper to the resonating circuit. In order to ensure a balanced output at the electrodes it is essential that the resonating circuit be symmetrical, such a condition being easily obtained by careful design.

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Simple Resonating Circuit

In its simplest form the resonating circuit of an ultra-high-frequency generator consists of a coil L (see Fig. 1)

FIG. 1.

FIG. 2.

with its axis parallel with the axis of the oscillator coil. The ends of this coil are bridged by a variable condenser, C . During operation, when resonance exists—that is, when the product of the capacity by the inductance in the resonator circuit equals that in the oscillator—a high-frequency electromotive force is developed across O and P .

It is possible to subject tissues to high-frequency oscillation by inserting them between the plates of the condenser and tuning in by means of a variable inductance; indeed this method is adopted in certain machines, but disadvantages inherent in variable inductances are likely to appear (see Fig. 2). A more generally employed scheme makes use of two transmission lines attached to points O and P . Such a circuit, with its two leads (see Fig. 3),

FIG. 3.

is of some importance from the point of view of therapeutic application, as the efficiency of such a system is greater under certain circumstances than others.

If the oscillating circuit CL is tuned to be in resonance with a generator it can be demonstrated by means of a neon indicator that nodes of high voltage exist along the lines OQ and PR , and, furthermore, that the distances between those points bear a direct relation to the wave-length. To take a concrete example: if the apparatus is a six-metre machine the distance between the nodes will be equal to half the wave-length—that is, three metres. Moreover, the highest potential differences will occur at points Q and R when the leads OQ and PR are each equal to one-quarter of the wave-length, or one and a half metres in our particular instance. As it is essential to apply the highest possible electromotive force to the patient, particularly when making use of small electrodes, the optimum length of the leads is a quarter of the wave-length.

Experimental Verification

In order to bear out this contention the following experiment was carried out:

Two bare cables were stretched so as to be parallel to one another and a small condenser field was arranged with a patient so as to allow observations to be made at various distances from the machine (Fig. 4). It was found that where nodes of high tension existed, at one-quarter and three-quarter wave-lengths away, heat was developed in the patient, whereas none could be detected with the condenser in antinode positions at a half and a full wave-length away. Briefly, the positions one-quarter and three-quarters of a wave-length away from the condenser C terminals may be considered as nodes of maximum electromotive force and minimum current, while the positions one-half and one wave-length away from the condenser correspond to antinodes of minimum electromotive force and maximum current in the leads.

It is interesting to note here that in a circuit like the one just described the electromotive force measured across the plates of the variable condenser C is directly proportional to the current developed in the patient's con-

FIG. 4.

denser when the latter is across high-tension nodes. This phenomenon has been exploited with advantage in an ultra-high-frequency generator constructed in this country.

Measuring Current

Referring to Fig. 5, which represents the resonating circuit of the apparatus in question, we see that the tuning condenser C is shunted by two small condensers

FIG. 5.

connected in series by means of a resistance which acts as the heating element of the thermo-couple, which is connected to a moving-coil instrument. Theoretically, this meter measures the current produced in the meter circuit by the heating of the bi-metal junction. The heating is a function of the electromotive force developed across the condenser C , which, as mentioned before, is proportional to the current in the condenser field provided the leads are one-quarter of the wave-length. This proportionality makes it possible to calibrate the meter in amperes, and thus estimate by direct reading the current in the condenser field. With this method of measuring the current it is important that the patient's leads be exactly a quarter wave-length long, as otherwise readings of the meter are not related to the current between the electrodes.

The Condenser Field

Of all the components constituting the resonating circuit of an ultra-high-frequency generator in operation, the most important and most perplexing is the condenser field when it incorporates a load in the shape of living tissue. Thanks to their complex structure and their heterogeneous composition, tissues when included in an oscillating field bring about alterations which may be summarized as follows:

- (a) Distortion of the field.
- (b) Alteration of capacity.
- (c) Change of power factor.
- (d) Damping.

The high dielectric constant value of the tissue fluids bestows on them the property of increasing the capacity of the field into which they are introduced, and at the same time they cause distortion.

The density of the field between the plates of an air condenser in an oscillating circuit is, except near the edges, sensibly the same throughout. If, however, a body of higher dielectric constant be introduced into this field, concentration of the field will take place in this body as if its permeability to this force were greater than that of air. Tissues have a very high dielectric constant, and on this account distortion occurs to a marked degree in treatment with ultra-high-frequency, particularly when the space between electrodes and tissues is small. By means of test tubes held in a rack so as to assume various shapes it is possible to determine where concentration of a field takes place under different conditions.

DETERMINING FIELD CONCENTRATION

A rack holding a large number of closely packed test tubes filled with saline was introduced in a six-metre field. Precautions were taken to screen the outer tubes from draughts to avoid uneven cooling. After some time the temperature of the fluids in each tube was measured by means of a thermo-couple instrument and recorded. This experiment was performed with a square rack holding thirty-six tubes with electrodes of different sizes and with various degrees of spacing. It was then repeated with a circular rack holding thirty-seven tubes. Variations of this method of assessing the field strength were adopted.

Besides distorting the field, the introduction of tissue into a condenser field alters the capacity of the condenser as a whole. With this high capacity or power for storing electricity there are associated effects of which the full significance can only be grasped when tissues are regarded as histological structures of great complexity. That is, not as homogeneous masses with a uniform dielectric constant throughout, but as a complicated heterogeneous structure composed of materials of widely varying dielectric constants.

Between the plates of a condenser such a heterogeneous dielectric produces an uneven field distribution of great complexity, and when we stop to consider how mechanical stresses in dielectrics vary with field density and other factors inherent in the nature of the dielectric, then we begin to realize what mechanical strains must occur at high frequency when tissues are submitted to short-wave therapy.

I postulated previously that this irritative process of strains produced at high frequency was responsible for the lowering of the threshold at which defensive tissue reactions take place. In other words, there occurs in deep tissues an effect similar to that termed "esophylaxis," which results from the "insulting" effects of ultra-violet irradiation on the skin. For very good and obvious reasons these reactions cannot be demonstrated by experiments on dead tissues or *in vitro*.

Tissues as a Load

Although, on account of their high dielectric constant, the tissues bestow an increased capacity on the field into which they are introduced, it must be remembered that they also act as conductors to the currents induced in them, and this phenomenon brings into existence two other effects. The most important is the alteration in the power factor. Briefly, when the load in an oscillating circuit is entirely capacitative the power factor is zero and no heat is produced, according to Joules's law, since in such a circuit the current is 90 degrees out of phase with the electromotive force. If, however, a resistive

component is included, the power factor tends towards unity and becomes one when the load is solely resistive—that is, when the current and the electromotive force are in step. In a mixed load like animal tissue heat is produced, with a consequent rise in temperature.

The second effect is not of great importance from a therapeutic point of view. It is the damping effect, and occurs in all resonating circuits when the capacity is shunted by resistance. In practice, whereas sharp tuning is obtained with pure capacity, flat tuning results from the introduction of a leaky dielectric. Some authorities reject the suggestion that ultra-high-frequency fields have any action other than the production of a rise in temperature in the tissues, but to this one may object that since tissues act as a capacity—that is to say, since they possess the property of storing electrical energy as a charge—they must become stressed when submitted to electromotive forces in an alternating electric field. Furthermore, actual strains must result from sheer irregularity in the stresses due to the lack of uniformity of field density. These uneven stresses, with consequent straining at high frequency, should not be visualized as causing coarse cellular movement, but rather as producing fine vibrations of smaller particles in various histological structures, calling forth a non-specific defensive reaction.

Although this effect is probably the one which invests ultra-short-wave therapy with its advantage over diathermy, the thermal component of the treatment should not be overlooked. Since a rise in temperature will cause an acceleration of pathological processes as well as of defensive processes, in a large number of conditions it will be found that better results are obtained in fields capable of producing but minimal rises or no rise at all in the temperature.

To summarize, it might be said that in short-wave therapy we have acquired a therapeutic agent capable primarily of making tissues react against antigens and secondarily of causing local pyrexia, thus accelerating biochemical activity.

According to the annual report the Rockefeller Foundation expended 12,725,439 dollars in 1935. It continued its efforts in public health through the International Health Division and supplemented Government agencies in the training of public health personnel and in the control of disease. Problems of individual behaviour and race development were attacked through the programmes of the medical sciences and the natural sciences. Work in mental health was furthered, particularly by aid to the teaching of psychiatry and to the study of the complex phenomena of mental disease and maladjustment. Grants were made for yellow fever studies in Brazil; for research on yellow fever, malaria, and other diseases at the Rockefeller Institute; for field research on malaria in various countries; and for laboratory studies of this disease at the University of Chicago; for investigation and control of hookworm disease in Egypt and in North Carolina; for studies of tuberculosis at Cornell University and in Alabama, Austria, Jamaica, and Tennessee; for the study of yaws in Jamaica and of undulant fever in France; for research at Columbia University on the common cold; for diphtheria investigations in Austria and Peiping; and for studies on influenza, typhoid fever, and small-pox vaccine. In addition, local and central Government health services were aided in many States and countries; and public health education was furthered by grants to institutions. In 1935 the Rockefeller Foundation appropriated 2,733,050 dollars for work in the field of medical science. Of this sum 1,459,450 dollars were contributed to projects for the advancement of psychiatry, and the National Hospital, Queen Square, London, received a grant towards a laboratory building. During the year the Foundation administered seventy-two fellowships in the medical sciences.