ELECTRONICS IN MEDICINE

Courtesy Terma Electric Co., Inc.
Terma Commander generates diathermy waves.

Part VI—Use of Shortwave Diathermy

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THE remarkable curative powers of heat have been known for centuries. Diathermy is an electronic technique for applying heat to the deeper body tissues. Because of its penetrating action it is considerably superior to older, more superficial, treatment methods. Its value is also enhanced by the other therapeutic procedures which can be performed with the same apparatus (electrosurgery and hyperthermy).

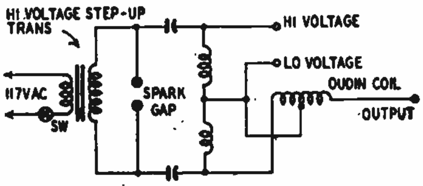


Fig. 1—Simple spark-gap diathermy generator.

It was once customary to distinguish between longwave and shortwave diathermy. However, longwave equipment, which operated at a frequency of about 1 mc, is no longer manufactured because of difficulty in controlling spurious radiation.

All present-day diathermy equipment operates under the regulations of the Federal Communications Commission which has allocated three frequencies for this equipment. These frequencies, together with the frequency tolerance and band width, are:

Frequency (mc)	Tolerance (%)	Band Width (kc)
13.66	±.05	15
27.32	±.05	270
40.98	±.05	40

The radiation must not exceed 15 microvolts per meter at a distance of 1,000 feet.

Diathermy currents heat tissues because they are of high frequency and voltage. The high frequency sets into motion any electrons in its field; the rapid motion generates heat.

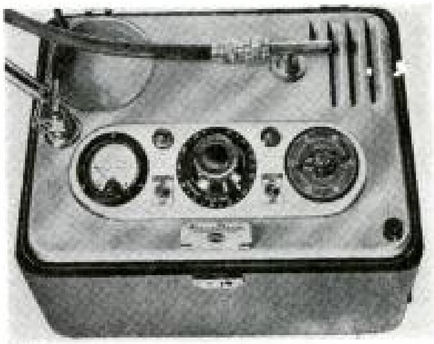
There are two major ways to generate such currents—with spark-gap apparatus and with vacuum tubes. Representative circuits for both methods are shown in Figs. 1 and 2. Each consists essentially of a voltage step-up circuit (which increases the voltage from 117 to 2,000 or more) and an oscillator circuit. In the spark-gap equipment, the oscillator circuit consists of an inductor, two capacitors, and a spark gap. Its output is a train of damped high-frequency waves.

Although spark-gap apparatus can be designed to operate in the shortwave diathermy range, the cost is so great that vacuum-tube equipment is employed almost exclusively in the United States. However, spark-gap instruments are widely used for electrosurgery.

Both grid and tank circuits of vacuum-tube oscillators are usually factory adjusted at a fixed frequency.

Most instruments, such as that in Fig. 2, employ full-wave rectification and filtering to eliminate hum and line disturbances and to prevent the frequency instability which would result if a.c. were applied to the plates of the oscillator tubes. Spurious radiations are suppressed by shielding the oscillator circuit from the line and output sides of the apparatus by means of an r.f. filtering network.

The current is applied to the patient by special electrodes, one type of which is shown in the photograph of the instrument diagrammed in Fig. 2. In shortwave diathermy it is not usually necessary to place these in contact with the body. The electrodes, their distance from the body, and the thickness and



Courtesy Raytheon Mfg. Co.
The Microtherm is u.h.f. diathermy generator.

dielectric constants of the portion of the body placed between them determine the capacitive load on the output circuit. This "patient's circuit" must be tuned with capacitors C so that it is in resonance with the tank circuit to secure the maximum transfer of energy.

Shortwave diathermy equipment can also be used for a technique known as

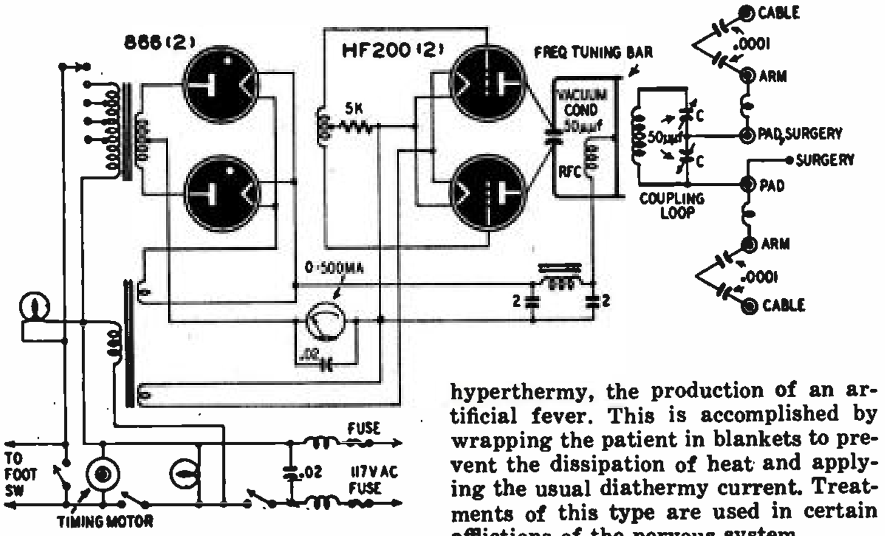
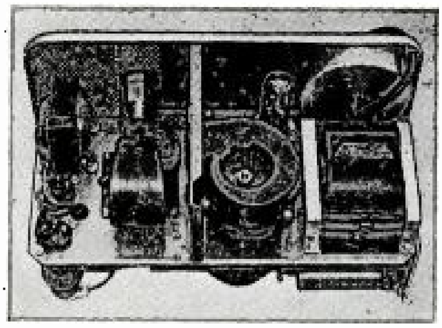
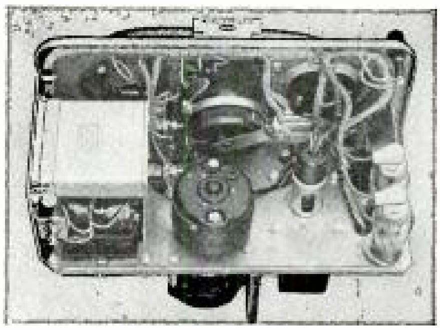


Fig. 2—This is the schematic diagram of Terma Commander, suitable also for surgery.

hyperthermy, the production of an artificial fever. This is accomplished by wrapping the patient in blankets to prevent the dissipation of heat and applying the usual diathermy current. Treatments of this type are used in certain afflictions of the nervous system.

Some of the greatest advances in surgery within the past decade have been

Blower and RK-5609 are on upper section of Raytheon Microtherm, left. Lower section at right.

made possible by the electrosurgical applications of shortwave diathermy equipment. The entire field of bloodless surgery owes its existence to diathermy.

There are three principal electrosurgical techniques: *electrodesiccation*, *electrocoagulation*, and *electrosection*. Electrodesiccation dries and shrinks the tissues. It is a so-called monoterminal technique, that is, only one electrode is employed. The modality used is a high-voltage, low-amperage current. It can be obtained from the spark-gap instrument in Fig. 1 through the Oudin-coil attachment. It can also be obtained from the SURGERY output terminals of the vacuum-tube instrument in Fig. 2.

Electrocoagulation and electrosection are both biterminal procedures, that is, two electrodes are necessary. Electrocoagulation currents are high-amperage modalities produced by both the spark-gap and vacuum-tube instruments. They seal cut blood vessels.

Electrosection or surgical cutting is a strictly shortwave procedure. It cannot be obtained with the spark-gap equipment of Fig. 1. The operating scalpel is connected to one output terminal of the apparatus and a large dispersing electrode is connected to the other terminal. A large amount of heat is concentrated on a very small area of the body by the sharp edge of the scalpel. The heat is not present in the scalpel but is generated in the tissues in the immediate vicinity of the scalpel. The knife glides through tissues with great ease, and the heat cauterizes as the knife cuts. The advantage of electrosection is the cleanness of the surgery possible.

One of the most interesting aspects of electronics is that a single basic principle can have many very different applications. At first glance there would seem to be little connection between wartime radar and the treatment of disease. As a matter of fact, the very latest diathermy technique is a direct outgrowth of microwave research. The instrument, known as the Microtherm, is illustrated by the photograph and the schematic diagram of Fig. 3.

It operates in the 2,400-2,500-mc band approved for medical use by the FCC. The maximum power output is 125 watts, and the r.f. energy is applied to the patient through a director. The microwaves are generated in a continuous-wave magnetron oscillator which, except for the director and connecting cable, constitutes the entire r.f. circuit.

The apparatus employs filtered full-wave rectification, and uses separate plate and filament transformers. The input to the high-voltage transformer is controlled by a 3-minute, thermally actuated time-delay relay, an interval timer, and a variable autotransformer. The latter permits adjustment to various line voltages and controls the power output of the RK-5609 magnetron. The power level is indicated on a milliammeter which is calibrated in percentage of maximum power output. A motor-driven blower supplies cooling air.

The output of the magnetron is applied to the patient through a co-axial cable and director.

The RK-5609 requires a high initial plate voltage before plate current flows, and a very small change in voltage thereafter produces the maximum desired increase in plate current. For this reason an autotransformer and a variac are used. The transformer has both 117- and 180-volt primary taps. By placing the variac across these taps it is possible to vary the plate voltage from approximately 1,100 (with the line at 126 volts) to approximately 1,500 (with line at 105 volts). Anode current varies from zero at minimum setting to approximately 200 ma at maximum setting with a 126-volt line.

The magnetron operates as a diode with the anode at ground potential (note that B-plus is grounded) and oscillates at a frequency of 2,450 mc. The frequency is determined by the cavity construction of the tube, but in operation may shift ±20 mc. A series of cavities containing the necessary inductance and capacitance are tied together; the energy generated is picked up by a small coupling loop. The field of the magnet causes the electrons leaving the centrally located cathode to describe a circular path. When sufficient electron velocity is reached, the cavities begin to resonate. Anode current begins to flow at an anode potential of approximately 1,000-1,100 volts.

Energy picked up by the coupling loop is carried out through a glass seal on the center conductor of the co-axial output connection. To get this energy through the panel and to make a connection to the flexible co-axial cable, a transition unit is used, in effect, a co-axial tube with the center conductor supported at a quarter-wave point.

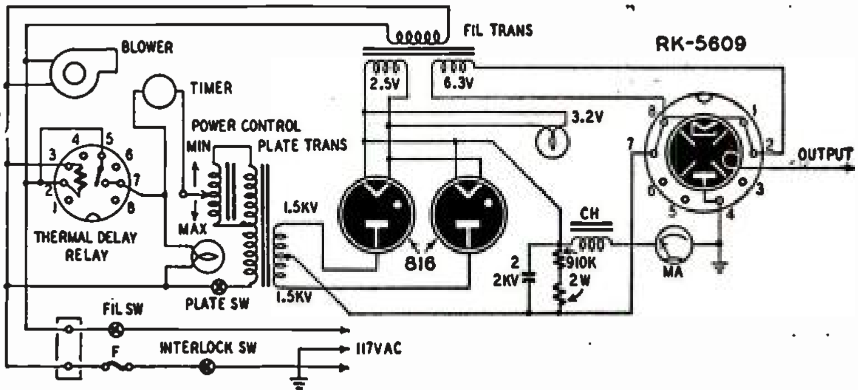


Fig. 3—Microtherm uses a magnetron to generate diathermy waves. Frequency is 2400-2500 mc.

The directors are connected to the transition unit through a co-axial cable. The various directors consist of a radiating element and a reflector which direct the energy in the required pattern, depending on the type of treatment. The radiator is always connected to the center conductor and the reflector to the shield.

Among the advantages claimed for microwave energy are that it provides great absorption, deep penetrating heat, precisely controlled application for both large and small areas, and does not require electrode pads.



These u.h.f. energy directors are used with the Microtherm for various methods of therapy.