CHAPTER TWENTY-FIVE

Radio Therapy

Radio-frequency energy can be applied to various parts of the human anatomy in order to produce a localized fever. The increase in temperature is effective for increasing circulation and for stimulating the action of the white corpuscles. The radio frequencies involved in radio therapy normally range from 6 to 16 meters in wavelength, although there has not yet been an accepted standard of frequencies for the treatment of any particular ailment.

The muscular cartilage, fatty and bone tissues all respond differently to applied radio waves. Some of these tissues are dielectrics while others are conductors, yet most of them have an intermediate characteristic, that of leaky dielectric shunted by a capacitance. The radio energy is dissipated in the form of a dielectric loss which increases the temperature of that portion of the body under treatment. This form of treatment is known as *radio therapy,* and the apparatus used for administering the radio-frequency current is called a *diathermy machine.*

A diathermy machine ordinarily consists of an oscillator with a maximum output of from 100 to 400 watts. The load impedance connected across the oscillator varies greatly; this requires special design of the oscillator circuit.

Treatment. The correct application of radio therapy depends upon the ailment and should, therefore, *be under the supervision of a skilled physician.* The diathermy machine usually has a means of controlling the power output. Often it has provision for frequency change in the form of plug-in coils. The radio energy is normally applied by means of a pair of rubber-covered metal electrodes which are placed on opposite sides of the portion of the body under treatment.

Radio therapy is used to kill certain bacteria in the body, much in the same manner as artificially-induced typhoid fever. Because careless use of radio therapy can and has caused extremely serious damage, self-treatment or the treatment of others by means of a home-built diathermy machine should *never* be attempted except under the supervision of a competent practitioner.

A circuit for an excellent portable diathermy machine is shown in figure 3. This circuit has certain features not found in most commercially-made portable machines. The oscillator circuit proper is a push-pull *Hartley* system in which the grid excitation is more constant than in most u.h.f.

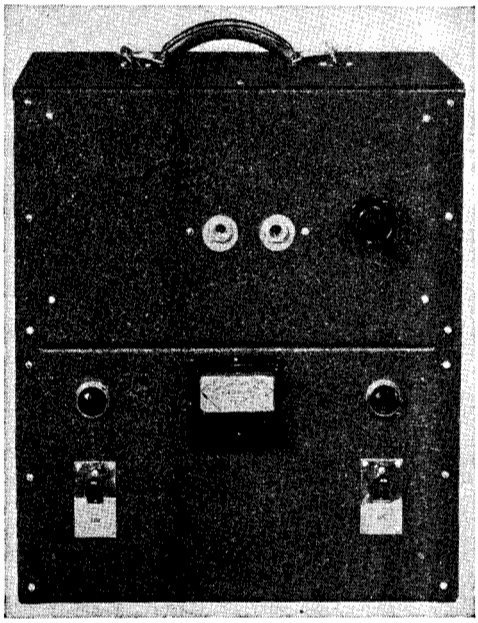

Figure 1.
FRONT VIEW OF 200-WATT PORTABLE DIATHERMY MACHINE.
This machine is of the type used for home treatment of diseases by radio therapy. It works on 15 meters, has sufficient output for most purposes, and produces a minimum of radio interference.

oscillator circuits for various load impedances.

This machine, illustrated in figures 1 and 2, is similar to the portable machines used by doctors for treating a patient in his own home. Such machines are ordinarily used only with standard type heating pads, no provision being made for electric cautery or "inductotherm" treatment. The latter calls for an insulated conductor to be coiled around the afflicted member or part of the body. The more common method of treatment with applicator pads is just as effective in most cases and usually is more convenient.

Construction. The oscillator and pad circuit are placed on the upper deck and the power supply on the lower deck of a two-deck metal chassis which is fitted with a ventilated cover having a handle. The latter item puts the machine in the category of "portable," as the machine is light enough to be carried by one person.

The oscillator is fixed-tuned to a wavelength of approximately 15 meters by the two plates which constitute C_1. The pads are resonated by the series condenser C_4, adjustment of this condenser providing a simple but entirely satisfactory method of regulating the output.

The layout of the power supply components is not critical; they may be arranged in any way which will permit inclusion of all of them on the lower deck. The r.f. components should be laid out approximately as illustrated in figure 2. Both the oscillator coil and the two plates constituting the tank condenser C_1 are supported on two ceramic pillars spaced 4½ inches. These plates, measuring 4¼ by 3½ inches high, overlap approximately 3¾ inches of their length, and are separated by approximately 3/16 inch, the exact spacing being finally adjusted until the wavelength of the machine is approximately 15 meters. In no case, however, should the plates be spaced closer than ⅛ inch; otherwise arcing may occur between them when there is no load on the machine.

The pads are coupled by means of a 3 or 4 turn coil which can be "folded" into the center of the oscillator coil, the latter being wound in two sections separated sufficiently to make room for the coupling coil. The coupling coil is covered with "spaghetti" to prevent shorted turns and prevent high voltage being impressed upon the coupling coil by contact with the oscillator coil.

The oscillator coil consists of 8 turns, with a gap of approximately 1 inch in the center and the whole coil spaced to approximately 3¼ inches. Both the oscillator coil and coupling coil are 2½ inches in diameter and wound with no. 10 or no. 8 enamelled wire. The coupling coil is supported from two ceramic pillars, the position of the coil with respect to the oscillator coil being adjusted by bending the wire until the desired degree of loading is obtained. The coupling is increased until the plate current to the oscillator measures approximately 350 ma. when the pads are applied to the body and C_4 is tuned to exact resonance. The coupling need not be touched after this adjustment is once made, all further adjustment of the output being made by means of C_4.

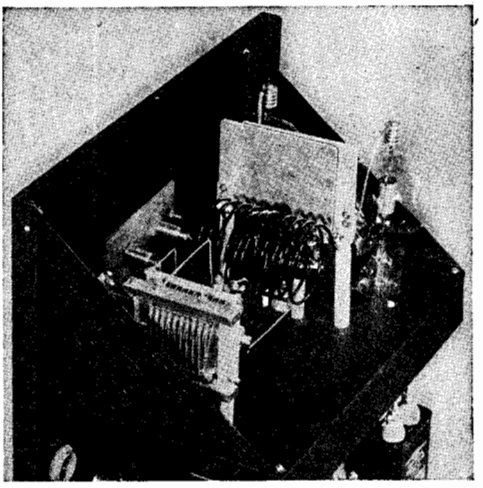

Figure 2.
BACK VIEW OF 200-WATT DIATHERMY WITH COVER REMOVED.
All power supply components including overload relay are mounted on the lower deck. All r.f. components are mounted on the upper deck.

The condenser C_3 is merely a blocking condenser and has no effect upon the circuit except to protect the patient in the event of structural failure of the pillars supporting the coils or a flash-over between coils. As direct current cannot pass through either C_4 or C_5, the patient is thus protected from the high voltage plate supply under all contingencies, the rubber insulation on the pads affording further protection.

The grid taps on each tank coil are made exactly the same distance from each side of center. If one tube heats more than the other, the taps have not been made symmetrically. To adjust the taps to their proper position, disconnect the pads from

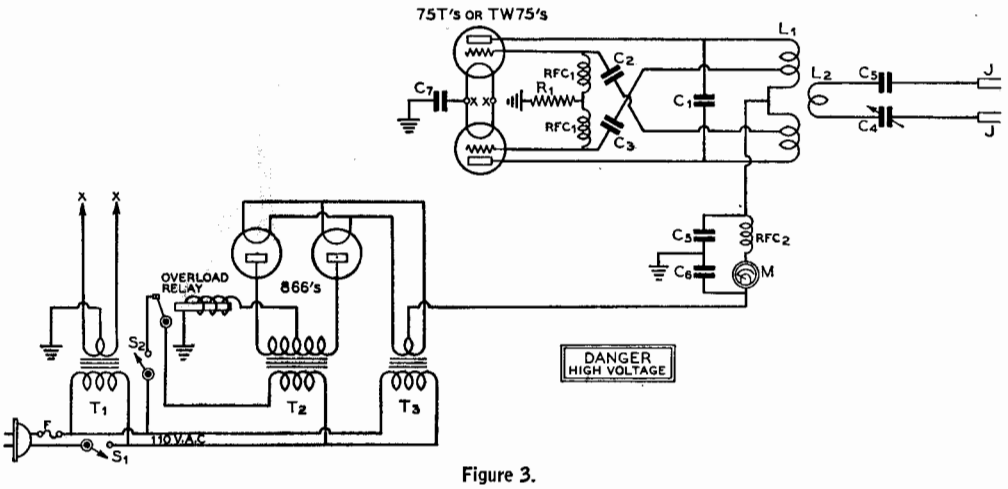

Figure 3.

WIRING DIAGRAM OF THE 200-WATT PORTABLE DIATHERMY.

C_1—Two aluminum plates mounted on ceramic pillars (see text)
C_2, C_3—.005-μfd. 5000 v. mica
C_4—100 $\mu\mu$fd., 3000 v. spacing
C_5—.001 μfd. 2500 v. mica
C_6—0.5 μfd. 2000 v. oil condenser
C_7—.001 μfd. 1000 v. mica
R_1—7500 ohms, 50 watts for 75-T's; 2500 ohms, 50 watts for TW-75's
RFC_1—High frequency r.f. chokes (see text)
RFC_2—1 or 2.5 mh. 500 ma. r.f. choke
T_1—5¼ v., 13 amp.
T_2—1200 v. each side c.t., 350 ma.
T_3—2½ v. 10 amp., 7500 v. insulation
M—0-500 ma. d.c.
Overload Relay—Adjustable 300-500 ma. type
L_1—8 turns no. 8 or no. 10 enameled 2½" dia., wound with 2 halves spaced 1" and coil spaced to 3¼"
L_2—3 or 4 turns same wire same dia. inserted between 2 halves of L_1. Slip "spaghetti" over wire for insulation

their circuit, place a 0-150 ma. milliammeter in series with the grounded end of the grid leak R_1, and move the taps out towards the ends of the coil in one inch steps until the grid current reads approximately 65 ma. for 75-T's or 125 ma. for TW-75's. This should be done with the pads removed from the machine (entirely disconnected) and the overload relay shorted out. The correct points will be approximately ⅛ to ½ the distance from the center to the ends of the coil. The taps may first be placed approximately ¼ the distance from the center to the ends and then moved outwardly from there until the specified grid current is obtained.

When the pads are connected and applied to a patient, the grid current will fall off considerably; hence it is necessary to adjust the excitation taps (with the tubes unloaded) for as much grid current as the tubes will stand safely.

A grid meter can be permanently incorporated in this diathermy machine, if desired. It is absolutely necessary, however, only for the initial adjustment.

The grid condensers C_2 and C_3 should be spaced at least one inch from the chassis and each other. The bakelite in which these condensers are encased is not an especially good dielectric at 15 meters, and the condensers will overheat if they have appreciable capacity to each other or to ground.

The high r.f. voltage at these points also necessitates extra good r.f. chokes for RFC_1. The usual 2½-mh. 125-ma. chokes ordinarily used for grid chokes are not particularly effective, and will usually burn up after a short time. Most any "all-band" choke is none too effective at 15 meters when high r.f. voltages are involved. Hence it is desirable to use at RFC_1 chokes which are especially designed for work at frequencies of this order. Either National R-154-U chokes or Ohmite Z-2 chokes will prove satisfactory, most other chokes having a tendency to burn out the "pie" at the hot end of the choke. The latter effect can be avoided to an extent by using "tapered pie" chokes, with the smaller pies connected to the grids. Use of the grid chokes specified, however, will eliminate all possibility of trouble from burned chokes. Very little r.f. voltage is impressed upon the plate choke RFC_2; hence any type choke will be satisfactory here.

The jacks on the front panel (for the pad cords) should have at least a half inch clearance, and be mounted on Victron, hard rubber, Mycalex, or Lucite. Ordinary bakelite will break down, as it has a poor power factor at this frequency.

A red ink "warning" marker should be drawn on the scale of the plate meter at the point of 300 ma., to make certain that this value of plate current will not be exceeded. The plate meter is the only essential meter in the machine, although some physicians insist upon an r.f. meter in the pad circuit. Neither plate current nor r.f. output is more than an approximate index of the degree of heating; they are not relied upon except as a relative check when the pads are in any *given position* on a *certain patient*. The actual temperature of that portion of the patient's body under treatment is the only safe barometer of the amount of heating effect being supplied.

The small filter condenser (0.5 μfd.) provides sufficient filtration to prevent the oscillator tubes from going out of oscillation instantaneously 120 times per second. "Hash" on the lower frequencies including the broadcast band will result from such momentary cessation of oscillation. The ripple voltage will still be quite high, with the small filter, but interference on frequencies other than the operating frequency will be eliminated.

It is not advisable to use higher capacity; otherwise the plate voltage will rise to excessive values when the pads are not loaded and the plate current is relatively low. This, in turn, results in excessive grid current. The grid current normally tends to rise anyway when an oscillator is not loaded.

Overload Relay. The overload relay is of the type that can be adjusted to trip anywhere from 300 to 500 ma. After the excitation taps are fixed and the position of the coupling coil is tentatively adjusted, the overload relay can then be set to trip at 325 ma. This will protect the tubes from excessive plate current, and from severe damage that would otherwise result should the tubes go out of oscillation.

If during treatment the relay is continually "kicking out" when adjusted to trip at 325 ma., it indicates that the loading is too heavy, and that the coupling should be backed off a bit.

High-Frequency Interference. If this diathermy machine causes interference to nearby amateurs on the 5-, 10- and 20-meter bands, the cure lies in the installation of a heavy duty *choke-input filter,* consisting of a 30-henry 350-ma. swinging choke and a 4-μfd. 2000-volt condenser. This permits a high degree of filtering without sacrificing voltage regulation. The interference will then be confined to a very narrow range of frequencies. If a choke input filter is used, a higher voltage plate transformer will be required (1500 v.).

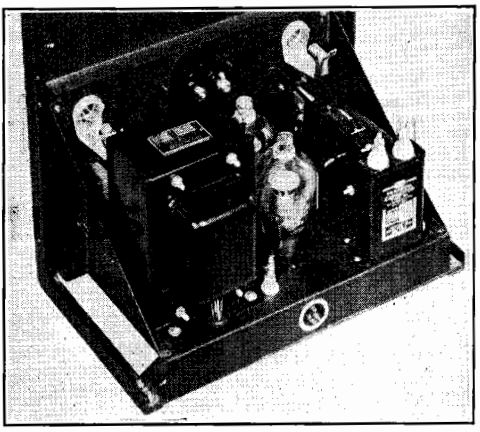

Figure 4.
ILLUSTRATIVE ARRANGEMENTS OF POWER SUPPLY COMPONENTS.
All power supply components are mounted on the lower deck. In this view, the top deck has been removed in order to show the power supply components.

Rectifier Time Delay. In order to prolong the life of rectifier and oscillator tubes, it is important that they be permitted to warm up for a period of 20 or 30 seconds before plate voltage is applied. Switch SW_2 should never be thrown *on* until switch SW_1 has first been turned on.

If desired, a time delay relay may be used to automatically protect the rectifiers.

Heating Pads. The applicator pads are a standard item, available from most medical supply houses and some electrical and radio supply houses. In ordering pads it is necessary to specify the approximate frequency on which the machine is to operate; otherwise the length of the cords may be too short to permit resonance even with the series condenser entirely meshed. If the cord pads are too *long* they can be cut off 6 inches at a time until they resonate satisfactorily; but if they are too short nothing can be done about it.

Information as to the availability of the heating pads may be obtained by writing the publishers and enclosing a stamped, self-addressed envelope.