

- [54] METHOD FOR TREATING FIBERS BY
SUBJECTING THEM TO HIGH
FREQUENCY ELECTRIC FIELDS

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- [63] Continuation of Ser. No. 196,122, Nov. 5, 1971,
abandoned.

- [52] **U.S. Cl.**..... **132/33**, 219/10.77

- [51] **Int. Cl.**..... **A45d 7/00**

- [58] **Field of Search** 132/7, 9, 40, 33; 219/222, 219/224, 10.49, 10.77; 128/422; 331/183

- [56]

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- [57]

ABSTRACT

Method and apparatus for treating fibers by enclosing them within a resonant cavity to which high frequency current is supplied, the resonant frequency and impedance of said cavity being matched to that of its supply.

10 Claims, 11 Drawing Figures

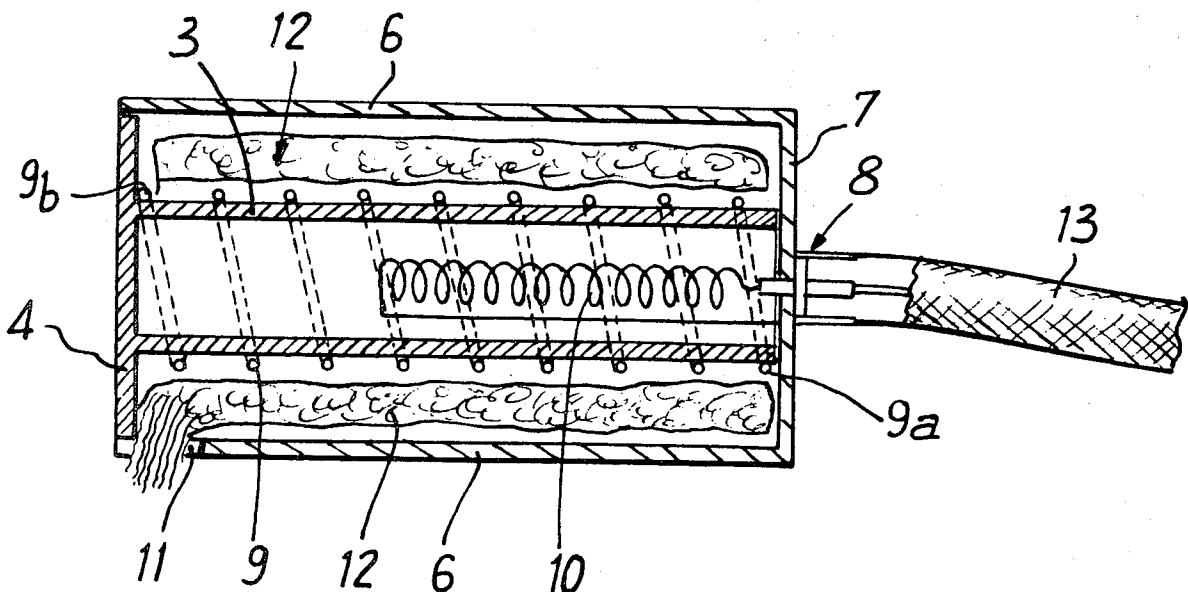


Fig. 1

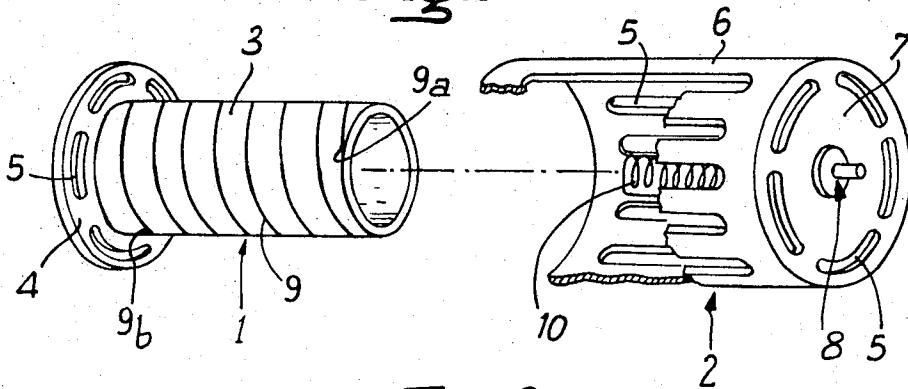


Fig. 2

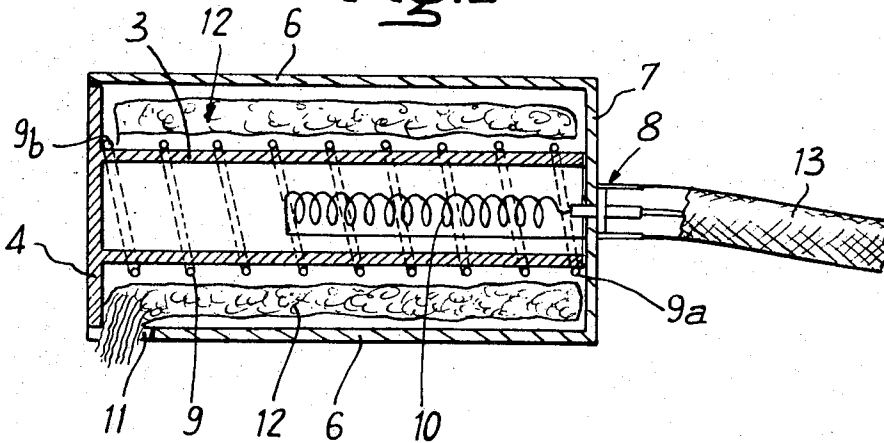
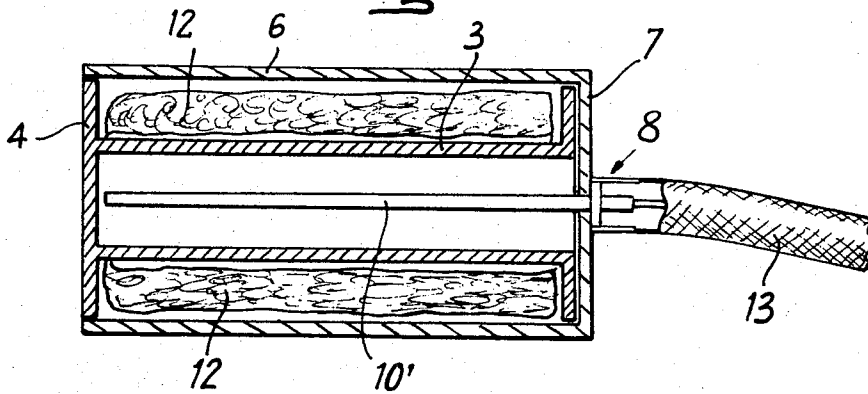


Fig. 3



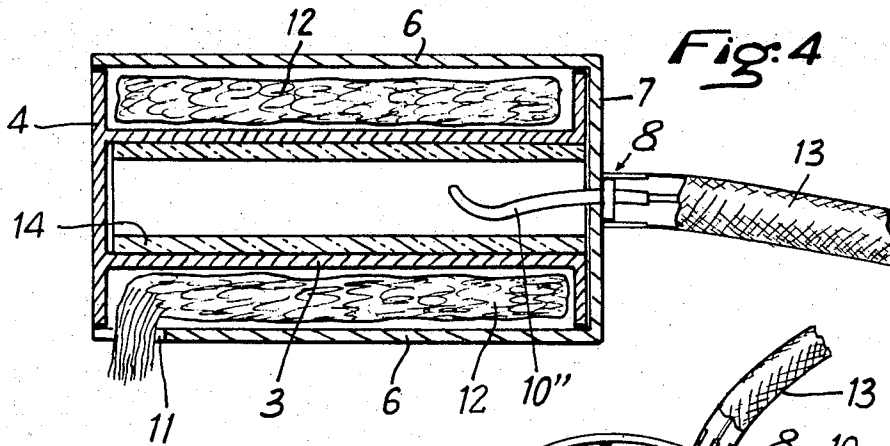


Fig. 5

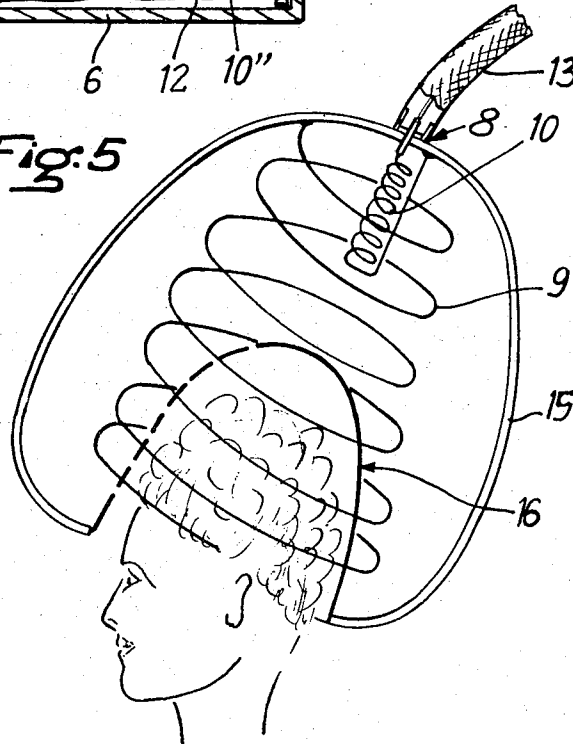
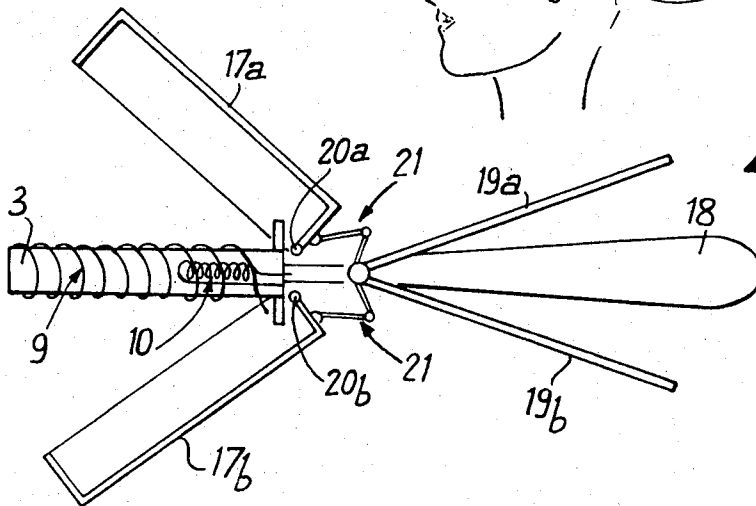
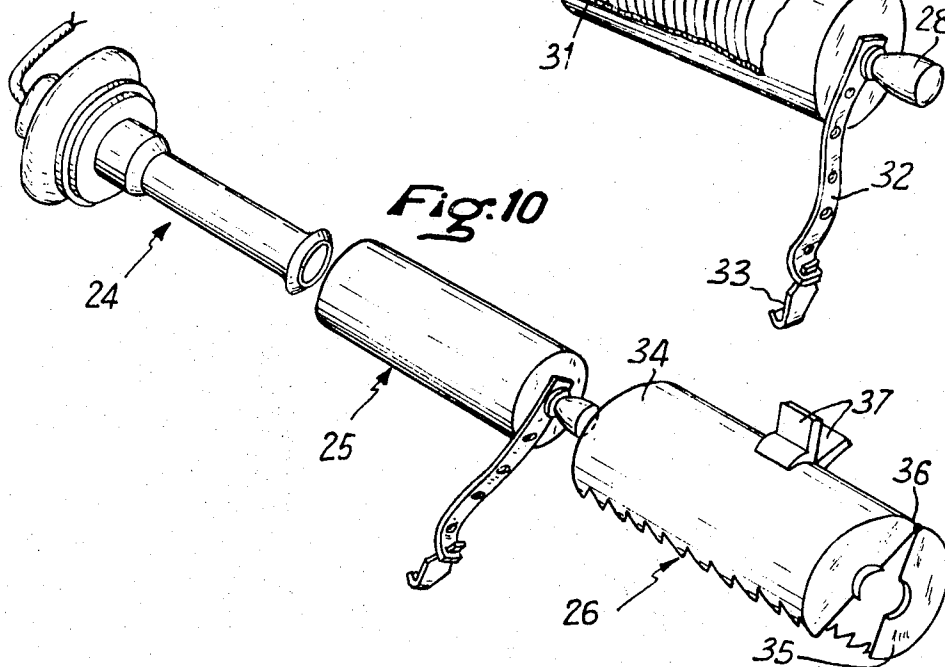
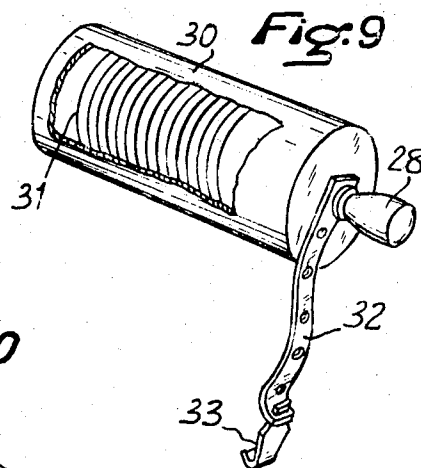
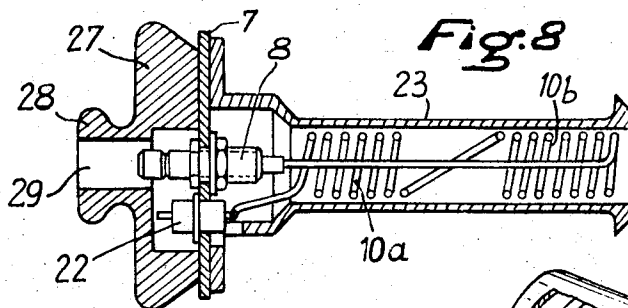
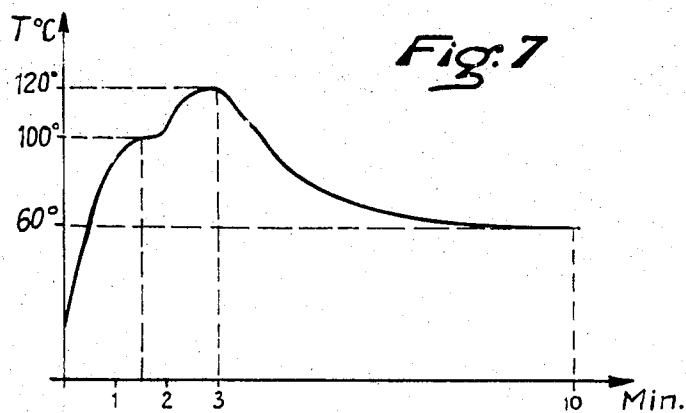


Fig. 6





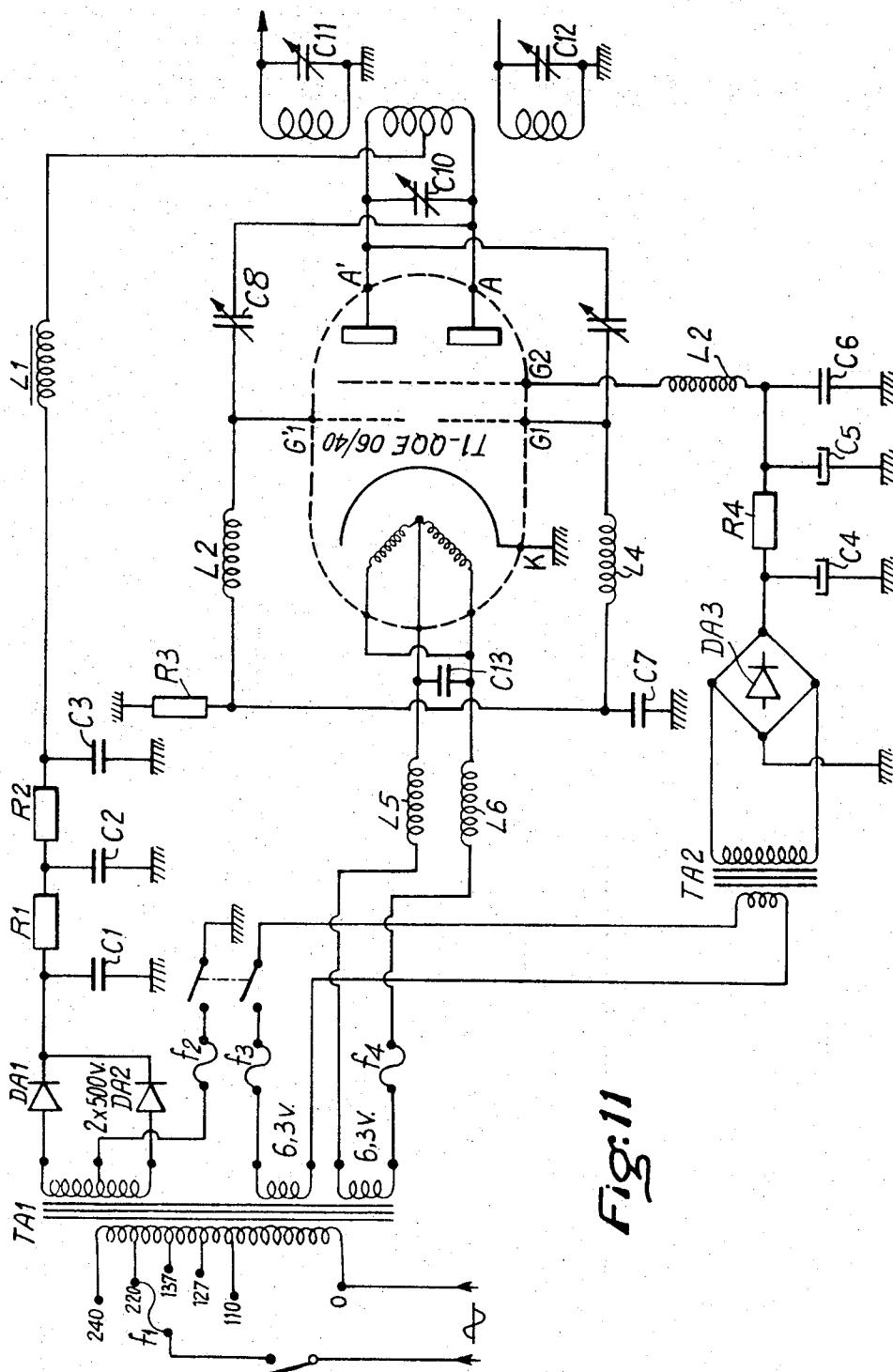


Fig. 11

METHOD FOR TREATING FIBERS BY SUBJECTING THEM TO HIGH FREQUENCY ELECTRIC FIELDS

This application is a continuation of Ser. No. 196,122
filed Nov. 5, 1971 now abandoned.

SUMMARY OF THE INVENTION

This invention relates to a new method of treating hair utilizing the heating effect resulting from dielectric losses, and to devices for carrying out this method. There are a number of known processes for treating hair which utilize chemical means. In particular, there are permanent waving methods which utilize, during a first step, a reducing composition which opens the SS bonds of the keratin and then, after the hair has been shaped, reconstitute these SS bonds by means of an oxidizing agent or bond-forming agent.

There are also known processes for bleaching or lightening the shade of hair which utilize oxidizing agents. Similarly there are known processes for imparting a different color to the hair by utilizing direct dyes or oxidation dyes. There are also known processes in which the hair is heated by heating devices, which usually comprise hoods which supply hot air, or electrical resistances which may be incorporated in or attached to hair rollers. This heating of the hair may also accompany the aforesaid chemical treatments.

In like manner, it has also been proposed that the hair be subjected to high frequency electromagnetic fields in order to create dielectric losses which increase its temperature. In particular, it has been suggested that the hair be placed between two members analogous to the plates of a condenser to which the high frequency current is applied.

The processes of this type which have been heretofore suggested have not given satisfactory results because the assembly comprising the hair and the devices for applying electromagnetic energy thereto is incapable of absorbing a substantial portion of the applied energy, with the result that this energy is returned to the supply line, giving rise to standing waves which are capable of producing high voltages and substantial leakages, and which give rise to a substantial reactive force.

Another disadvantage of these known processes resides in the fact that the external plates are themselves substantially heated, which is in practice unacceptable.

The present invention relates to a new process based on the utilization of high frequency electromagnetic fields which does not have the aforesaid disadvantages and makes it possible to increase the temperature of the mass of hair itself. This has the effect of accelerating any chemical reactions which may take place, producing a particularly intense and deep drying of the hair, and even of plastifying the keratinic fiber by a simple increase in its temperature.

It is the object of the present invention to provide a new process for treating hair by subjecting it to a high frequency electromagnetic field characterized by the fact the hair to be treated is placed in a resonator matched to the generator and to the transmission line through which the high frequency current is received.

The resonators are conventional components of electrical circuits, which have not heretofore been used for the purpose of treating hair with a high frequency electromagnetic field.

Suitable resonators according to the invention should have the following properties:

A. A closed outer jacket (in the electromagnetic sense of the term) which is preferably grounded. By a closed outer jacket is meant a jacket which is electrically conductive and comprises a closed or substantially closed surface, any openings in which have dimensions such that they will not pass a substantial quantity of the electromagnetic energy present inside the jacket.

B. A coupling member which is mounted at or terminates at the end of the line through which the high frequency energy is received.

In accordance with the invention, the resonant frequency of the resonator must be so selected as to be equal to the frequency of the generator. The frequencies which may be used in accordance with the invention may vary within broad limits. They may, for example, range from several megacycles to several hundreds of thousands of megacycles.

The frequency of the resonator used in accordance with the invention depends on the form and dimensions of the closed jacket, the components or elements which it contains, and, to a slight extent, on the shape and dimensions of the coupling which is placed inside the jacket. However, the coupling has the essential purpose of matching the generator and the high frequency input line to the resonator and not to modify the frequency of the resonator itself.

In other words, the coupling member is a device which is adapted to permit the introduction of high frequency current supplied by the generator into the closed jacket of the resonator under good conditions.

The coupling member may consist, for example, of a coil, one end of which is connected to the central conductor of the coaxial cable which constitutes the input line, and the other end of which is connected to the sheath of the coaxial cable, or by like means to an antenna comprising a conductor of any suitable shape which serves to extend the central conductor of the coaxial cable into the resonator. In these two cases the jacket is connected to the sheath of the coaxial cable. It is obvious that any modification of this coupling member in order to improve the coupling has an influence on the resonant frequency of the resonator itself, but this influence is slight as compared with the other factors which determine the frequency of the resonator.

In accordance with the invention it is, in a certain number of cases, necessary to mount inside the resonator a supplemental device which has the purpose of modifying, and in general, reducing the frequency of the resonator so as to make this frequency correspond to the frequency of the generator which is to be used.

These frequency modifying devices may be of various types. In particular, in order to obtain a resonant frequency which is of the order of 10 to 2,000 megacycles this device may be constituted by a coil positioned inside the closed jacket. Such a coil may be electrically connected to the jacket of the resonator at one end whereas its other end is free. It may also be free at both ends while not connected to the envelope of the resonator or connected thereto at one or more points.

In order to obtain a resonant frequency for the resonator lying somewhere between about 1,000 and about 4,000 megacycles it is possible to utilize a coaxial resonator which comprises a linear conductor positioned

along the axis of a closed cylindrical jacket, with one end of said conductor either connected or not connected to the jacket.

When higher resonant frequencies are desired, for example from 3,000 to 30,000 megacycles, it suffices to insert one or more dielectric materials inside the jacket.

For example, it is possible to position a tube of dielectric material inside a cylindrical jacket.

It is obvious that the different means which have been indicated to regulate the resonant frequency of the resonator have been given purely by way of example and that, in accordance with the invention, it is simply necessary to have a resonator the resonant frequency of which is equal or substantially equal to the frequency of the generator, which resonator is impedance matched to the generator and the supply line.

The hair which is to be treated is inserted inside the jacket of the resonator.

In accordance with the invention it is necessary to match the resonator to the assembly comprising the generator and the high frequency transmission line.

This may be simply accomplished by placing the hair in the state in which it is to be treated inside the resonator and modifying the shape and/or nature of the coupling member so as to reduce to a minimum the magnitude of the standing waves which form in the high frequency supply line.

The coupling may, for example, be adjusted by changing the number of coils in the coupling member if this consists of a helical coil. The coupling may also be adjusted by regulating the length of the antenna, if the coupling element is of this type, or by changing the relative position of the coupling element and the jacket.

Of course, the adaptation of the resonator depends on all the characteristics of the system and especially on the characteristics of the current generator and all the components which constitute or contain the resonator proper.

The coupling is especially dependent on the state and quantity of hair which is introduced into the resonator, as well as on the position of the hair inside the resonator. For this reason it is necessary to adjust the resonator with the hair in the condition in which the apparatus is to be used.

In particular, if, at the beginning of treatment, the hair is wet, the adjustment must be made with the hair wet.

In accordance with an improvement of the aforesaid invention, an element made of a material the dielectric constant of which and the dielectric loss factor of which increase with temperature is positioned inside the resonator. Consequently, the resonator automatically adjusts itself as the hair dries.

In effect, the resonator having been first adapted for moist hair at ambient temperature, to the extent of the drying, the electrical energy which dissipates in the hair progressively diminishes while bringing about a progressive deterioration of the adjustment of the resonator.

However, when a material is used in which the dielectric loss factor increases with temperature, the energy which dissipates in dielectric losses inside this material increases with the increase in heat and assures a substantially constant adjustment of the resonator.

In a general way, when, in discussing the present invention, reference is made to the adjustment of the resonator, this term is not used in a rigorously defined sense, but refers to a state approximating that for which the standing waves formed in the input line remain at an acceptable value.

In other words, it is considered that there is adequate adjustment in the sense of the present invention when a substantial proportion of the energy of the generator is dissipated in the resonator, for example more than 70 percent, and it is considered that satisfactory adjustment has been obtained even if some standing waves are produced in the input line, provided that these standing waves do not seriously interfere with the operation of the process.

In a first method of carrying out the invention the hair is treated by the dielectric loss method after having been impregnated with a composition having a chemical effect on the hair, the different constituents of which must react with each other after the composition has been applied to the hair: The dielectric treatment according to the invention then has the effect of increasing the rapidity and efficacy of the chemical treatment. In this case the treatment according to the invention is generally carried out on moist hair which has been impregnated with the compositions having a chemical effect. In this first embodiment, the treatment need not necessarily be continued until the hair has been completely dried. The hair may, however, also be dried in a single step, as, for example, when the hair is being set by means of compounds having a chemical effect on the hair, as for example, in the case of permanent waving.

In a second method of carrying out the invention, the hair is dielectrically treated beginning at the stage at which the hair is moistened so as to bring it into a state in which it is dried.

In this case the hair may be, for example, simply wet with water, and then wound on rollers which will be hereinafter described, with the process according to the invention making it possible to set the hair in a relatively short time with a certain number of advantages. In this method of carrying out the invention it is also possible to impregnate the hair with a solution of compounds which do not have any direct effect on the hair but which have the advantage of facilitating the setting. This is the case, for example, with setting solutions of known types comprising as a principal constituent a resin which, during setting, holds the hair in place.

In a third method of carrying out the process according to the invention the hair is dielectrically treated while initially in the dry state, and the increase in temperature which results is then used to shape the hair by plastic deformation.

In this case the resonator must of course be adjusted while the hair is dry.

This third method of carrying out the invention may be combined with the second method, beginning when the hair is damp. In a first stage the hair is dried by the process according to the invention and then in a second stage it is heated to a temperature sufficient to result in permanent deformation.

The methods of carrying out the invention which have been described above have been given purely by way of example and do not exclude the application of dielectric treatment to the hair while carrying out other methods.

The process of treating the hair according to the invention is based on the known phenomenon of heating by dielectric loss. It is known, in effect, that when a dielectric material is subjected to an alternating electromagnetic field having a sufficient frequency and intensity a dissipation of energy inside the material is produced which results in heating of the material.

This heating has the peculiarity of occurring inside the material itself and being a function of the dielectric coefficient of the material under consideration and of the nature of the alternating electric field which is applied thereto.

Since, according to the invention, the hair is subjected to a high frequency electromagnetic field while positioned inside the jacket of a resonator, it absorbs the major part of the high frequency which is produced by the generator.

Moreover, this energy is confined inside the resonator, the jacket of which is grounded, so that the person treated and the person carrying out the treatment are, to a large extent, eliminated from exposure to the high frequency electromagnetic field.

In addition, the process according to the invention has the following advantages:

In the first place, the heat is directly engendered inside the hair so as to permit this to be heated to a much higher temperature than is possible utilizing the traditional heating methods under conventional conditions.

In effect, in the case of heating by dielectric loss, the heat is engendered directly inside the hair which makes it possible to avoid exposing the scalp to the heating action.

On the contrary, in conventional methods of heating the hair, the heat is furnished by means, generally a fluid, at a higher temperature than the one which is to be imparted to the hair, and it is difficult to avoid heating the scalp by this means.

This is even more true as the temperature of the hair is increased, since it is necessary that the temperature of the means which supplies the heat be substantially greater than the temperature of the hair.

Moreover, with conventional means of heating the hair the heating is doubly irregular.

In the first place, when the hair is wound on rollers those parts of the locks of hair which find themselves inside the coil are subjected to much more rapid and much more intense heat than those portions which are outside the coil and thus further removed from the device which brings in the heat.

Moreover, when the hair is dried by conventional means, an important inequality of drying within the section of the fiber itself results, since the periphery of the fiber is subjected to much more intense drying than the central portion. In effect, to obtain complete drying of the fiber, it is necessary to establish, by diffusion to the center of the hair, an equilibrium in the relative humidity of the hair at its different points.

It has also been established that when moist hair is treated according to the invention there is a spontaneous regulation of the temperature of the hair resulting from the fact that at the beginning of the process the hair which has been moistened has a high coefficient of dielectric loss which decreases progressively to the extent that it is dried.

The process of dielectrically heating the hair also has the advantage that it may be applied to hair in a sufficiently localized manner to obtain drying of the hair in

a much shorter time than is generally required with conventional apparatus. It is thus true that, as a consequence of the process according to the invention, it is possible to completely dry a head of hair in less than 10 minutes.

Finally, the process of treating the hair according to the invention has a very favorable influence on the reactions which takes place inside the hair, whether these reactions take place between the constituents of the hair and the composition which is applied thereto, between the different constituents of the composition, or between the internal chemical groups in the hair, as is particularly the case in setting treatments or in permanent waving treatments in which the hair is plastified by an increase in temperature.

The present invention also has as an object the provision of a new article of manufacture, namely a device characterized by the fact that it comprises at least one coupling connecting a high frequency transmission line to a conductive jacket forming an electromagnetically closed resonator and preferably grounded, said jacket containing means for receiving or supporting the hair, and said coupling being such that it adjusts the resonant cavity constituted by the jacket and the hair to the generator and the high frequency transmission line.

In a variation of this embodiment, the resonator jacket also contains a device adapted to modify the resonant frequency of the resonator to make it equal to that of the generator. Said device may consist of a coil, a coaxial wire, or a mass of dielectric material.

A first embodiment of the invention comprises a roller for the hair made in two parts which interfit. The first part comprises a support for the hair to be treated, and possibly a device for modifying the resonant frequency of the resonator, while the other part comprises the jacket of the resonator and a coupling member connected to the generator, for example, by a coaxial cable.

In a second embodiment of the invention the device according to the invention comprises a heating hood, the jacket of which has an opening sufficiently large to permit the introduction of a person's head into the resonator.

In a third embodiment of the invention, the device according to the invention is in the form of a curling iron, with the jacket made in two parts which may be closed over hair which is wound on a support such as a roller.

In accordance with the invention, it is advantageous in certain cases to provide one or more trimmer condensers which are mounted on the coupling so as to facilitate the adjustment of the resonator by modifying the capacity of these condensers.

The current may have a frequency lying between several megacycles and several hundred gigacycles. The power supplied for a single roller is on the order of 10 to 30 watts. This power depends in part on the temperature at which it is desired to treat the hair and in part on the frequency of the current used, with high frequencies requiring less power. In accordance with the invention, a high frequency generator of a conventional type may be used which supplies the different rollers necessary to treat a head of hair through a power divider.

The present invention may also be used to treat synthetic or artificial fibers, and in particular fibers in-

tended to be used in the manufacture of wigs or artificial furs.

The treatment according to the invention may be carried out on moistened fibers by using a process analogous to a setting process. It may also be carried out on dry fibers, so as to cause waving of the fibers by increasing their temperature to a point which approaches their softening point.

By way of example, the artificial or synthetic fibers which may be treated in accordance with the invention include vinylchloride/acrylonitrile copolymers treated with cellulose acetate and, in particular the fibers sold under the trademark KANEKALON which is sold by the KANEGAFUSHI CHEMICAL INDUSTRY CO.

A process for preparing fibers of this type is described in French Pat. No. 1,489,902.

One may also use vinylchloride/acrylonitrile copolymer fibers which are made less brilliant by the addition of titanium oxide or a deposit of colloidal silicon. It is also possible to use polyvinylchloride fibers such as those sold under the trademarks VENICELON and TEVILON, vinylchloride/vinylalcohol copolymers, such as those sold under the trademarks CORDELA, AIRFULL, and SEFLORE, or even polyamide fibers such as those sold under the CELTA.

The synthetic or artificial fibers of this type which are generally used for making wigs have an average denier between 45 and 55. When such fibers are to be used in making imitation fur the sizes of fibers must clearly be quite different and the fibers may have a denier of from 2 to 500.

In carrying out the process according to the invention the fibers are permanently deformed by heating them to a temperature which is dependent upon their composition.

For example, polyamide fibers have a waving temperature which is of the order of 140°C, polyvinylchloride/polyacrylonitrile fibers have a waving temperature of about 90°C, and polyvinyl-chloride fibers have a waving temperature slightly less than 80°C.

Moreover, and in particular in the case of vinylchloride/acrylonitrile copolymers, it is desirable to use a waving temperature which is lower for lightly dyed fibers than for deeply dyed fibers. Thus the dry waving temperatures for the KANEKALON fibers which have been lightly dyed is about 90°C whereas for the same fibers deeply dyed the temperature for waving is 95°C.

The lower temperature for the lighter shades is intended to avoid yellowing of the fiber due to heating.

When moistened fibers are treated the waving temperature may be increased to 100°C which corresponds to that at which water evaporates.

In order that the invention may be better understood, several embodiments thereof will be now described, purely by way of illustration and example, with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view showing a device for carrying out the invention with part of the jacket broken away;

FIG. 2 shows the device illustrated in FIG. 1 in axial section while being used to treat a lock of hair;

FIGS. 3 and 4 show variations of the device illustrated in FIGS. 1 and 2;

FIG. 5 shows another device for carrying out the process according to the invention, in the form of a hairdrying hood;

FIG. 6 shows yet another device for carrying out the invention in the form of a curling iron;

FIG. 7 is a curve showing the change in temperature during the process according to the invention as a function of time;

FIG. 8 is an axial sectional view of the central part of another embodiment of the device for carrying out the invention;

FIG. 9 is a perspective view of the part which encircles the roller of FIG. 8, with its jacket partially broken away to show the roller on which the hair is wound;

FIG. 10 is a perspective view showing the three parts of the device comprising the parts shown in both FIGS. 8 and 9; and

FIG. 11 is a circuit diagram of a high frequency generator adapted for use in carrying out the invention.

Referring now to FIG. 1, this is a perspective view showing a hair roller for use in carrying out the invention with its cover partly broken away. In this particular embodiment the roller comprises the principal parts 1 and 2. Part 1 comprises a cylinder 3 made of a material which is not a conductor of electricity and is attached at one end to a base 4 made of a material which does conduct electricity and which is provided with slots 5. Part 2 consists of a cylinder 6 having a larger diameter than the cylinder 3 and which is made of a material which is a conductor of electricity and connected at one end to the base 7, which is also made of a conductive material. Like the base 4, the cylinder 6 and the base 7 are provided with openings 5, the object of which is to permit the dissipation of the water vapor which forms during the treatment of the hair in accordance with the invention.

The dimensions of the two parts 1 and 2 correspond to the extent that the cylinder 3 may be introduced inside the cylinder 6, while the periphery of the base 4 is positioned at the open end of the cylinder 6. It will be appreciated that, in this position, the assembly comprising the components 4, 6 and 7 forms a substantially closed jacket in the electromagnetic sense of the term.

It is this closed jacket which constitutes the resonating chamber inside which the hair is treated in accordance with the invention. A terminal 8 for a coaxial cable is schematically shown at the end 7, and the high frequency electromagnetic power is brought in through this terminal.

An adapter or coupling 10 which may take the form of a helical coil is connected to the central conductor and to the sheath of the coaxial terminal 8 and mounted axially of the part 2. The adapter 10 is positioned in the center of the cylinder 3 during the mounting of the part 1.

The cylinder 3 supports a device for reducing the resonant frequency of the jacket comprising components 4, 6 and 7, and consists of a helical coil 9 the end 9a of which is electrically free whereas its other end 9b is electrically connected to the base 4. The cylindrical part 6 comprises a slot 11 in one end, shown in FIG. 2, which contacts the base 4 to define a passage for the lock of hair which is to be treated in accordance with the invention, and which is wound around the cylinder 3 for this purpose.

In a variation of the device shown on FIG. 1 it is possible to position at the end of the cylinder 3 remote from the base 4 a flange analogous to the base 4 but made of a nonconductive material adapted to limit the location of the hair which is wound on the cylinder 3.

To use the hair roller which has just been described, the parts 1 and 2 are separated and the lock of hair 12 is wound on the cylinder 3. The part 1 is then inserted into the part 2 while taking care to place the base of the lock 12 in the slot 11 in the cylinder part 6 of the jacket. The coaxial cable 13 shown on FIG. 2 is then connected to a generator of high frequency current. A practical example of the use of the device which has just been described with reference to FIGS. 1 and 2 will now be given. This device may be used with a high frequency generator having a frequency of 10 to 2,000 megacycles. The resonant frequency of the resonator may be modified by varying the number of turns on the coil 9 and possibly by modifying the electrical connections of this coil.

For example, it is possible to use a coil 9 which is not electrically connected to the jacket or even a coil 9 electrically connected to the jacket at a point or several points not positioned at either end of the coil.

The matching of the generator and the line to the resonator which has just been described may take place by modifying the number of turns of the coupling 10 or even by modifying the shape or position of this coupling with respect to the jacket of the resonator.

FIG. 3 shows a device for treating hair in accordance with the invention utilizing a higher frequency, for example 1,000 to 4,000 megacycles.

For this purpose a resonator of the coaxial type is used in which the coupling 10' consists of a simple straight conductor positioned along the axis of the cylinder 6 and connected to the central conductor of the coaxial cable whereas the end of the jacket of the resonator is connected to the sheath of the coaxial cable 13.

As in the previous case, the cylinder 3 is not electrically conductive and its essential purpose is to support the lock of hair wound on it. In this embodiment, the end of the cylinder 3 which is remote from the base 4 is provided with a flange which makes it possible to hold the lock of hair in place better.

The embodiment of FIG. 4 shows a device similar to the devices illustrated in FIGS. 2 and 3. In the case of FIG. 4 the coupling 10'' consists of a conductor in the form of an antenna which is directly connected to the central wire of the coaxial cable. The embodiment of FIG. 4 shows the various components of the devices of FIGS. 2 and 3 identified by the same reference numerals. In the embodiment of FIG. 4 there is a cylinder 14 inside the cylinder 3 which is made of a material having a dielectric constant and dielectric loss factor which increases with the temperature.

In this manner it is possible to provide a certain automatic adaptation of the coupling during the drying of the lock 12 as has already been explained.

FIG. 5 schematically shows an embodiment of the device according to the invention in the form of a drying hood for treating a hair-do when the hair does not have to be wound up on a roller.

In this embodiment the jacket consists of an electrically conductive wall 15 which is connected to the sheath of the coaxial cable 13. This jacket 15 is provided with orifices which permit the escape of the water vapor which is liberated during the treatment of the hair according to the invention.

At its lower end the jacket 15 has an opening the dimensions of which are sufficient to admit the upper part of the hair of the person whose hair-do is being treated. The position of the hair inside the jacket 15 is

determined by a wall 16 made of a non-conductive material which is also provided with orifices sufficient to permit the escape of water vapor.

As in the embodiment of FIGS. 1 and 2, an adapter or coupling 10 is connected to the end of the coaxial cable, as well as a coil 9 which serves to match the resonant frequency of the resonator to the frequency of the line.

In this embodiment of the invention the relative position of the coil 9 and the wall 16 is such that the electromagnetic radiation penetrates only slightly inside the space defined by the wall 16 so that the hair may be treated without the electromagnetic radiation having an effect on the scalp.

Similarly, the opening which is provided in the jacket 15 to admit the head is not large enough to prevent the jacket 15 from being considered substantially closed with respect to electromagnetic radiation.

Fig. 6 shows an embodiment of the invention in the form of a curling iron.

This embodiment also has a cylinder 3 made of a material which is not a conductor of electricity which carries a coil 9 and inside of which is the adapter 10, connected to the coaxial cable, not shown in FIG. 3.

The jacket comprises two perforated halves made of an electrically conductive material 17a and 17b which may be either located in an open position as shown in FIG. 6 or closed over the cylindrical member 3 by actuating, through levers 21, the levers 19a and 19b which control the movement of the parts 17a and 17b which are articulated at 20a and 20b.

In order to use the device which has just been described a lock of hair is wound on the cylinder 3 while the different parts of the apparatus are located in the position shown in FIG. 3, and levers 19a and 19b are pressed to close the jacket consisting of the two halves 17a and 17b, thus placing the hair in a position in which it may be treated by high frequency electromagnetic energy supplied by a generator, not illustrated.

The conditions under which it is possible to use a setting roller of the type shown in FIGS. 1 and 2 will now be described. In the embodiment of the invention under consideration the cylinder 6, the base 4, and the end 7 are made of aluminum provided with orifices having dimensions of several millimeters. The inner diameter of the cylinder 6 is 34 millimeters and its length is 65 millimeters. The cylinder 3 is made of a super polyamide such as the one sold under the trademark NYLON ZYTEL 101 or ZYTEL 42 by the Dupont DeNemours Co., or the polytetrafluoroethylene sold by the same firm under the trademark TEFLON.

The cylinder 3 has an external diameter of 19 millimeters.

The coil 9 is made with a copper wire 0.5 millimeters in diameter and comprises 30 turns wound at a pitch of 1.2 millimeters. One end of the coil is connected to the base 4 whereas its other end is electrically free.

The coupling member 10 consists of a coil of insulated copper wire 1 millimeter in diameter, with the coil comprising 19 contiguous turns wound on a diameter of 7 millimeters.

The coil is connected to ground, that is to say, to the jacket and to the sheath of the coaxial cable through a condenser of 220 pF. The characteristics of the coupler which have been set forth above result in a minimum of standing waves in the coaxial conductor when a lock of moist hair weighing 2 grams is wound around the cyl-

inder 3 as shown at 12 in FIG. 2. For example, such a lock comprises 1.25 grams of dry hair and 0.75 grams of water.

FIG. 7 shows the change in temperature as a function of time when an initial electromagnetic power of 30 watts is applied under the foregoing conditions. The temperature shown on the curve is the temperature measured on the internal wall of the cylinder 3. This temperature is less than the actual temperature inside the lock of hair. This measurement of the temperature has been selected because it is the easiest to obtain and reproduce.

It will be seen from FIG. 3 that the temperature reaches 100°C after about 1½ minutes and that it increases to 120°C in 3 minutes, after leveling out for about 1 minute at the temperature of 100°C because of the evaporation of the water contained in the lock of hair.

At the end of 10 minutes the temperature falls to 60°C. When the lock of hair is removed from the apparatus it will be found that the hair is perfectly dry and presents a wavy appearance corresponding to a set of good quality.

FIGS. 8, 9, and 10 show another embodiment of the roller used for treating hair according to the invention. FIG. 10 is a perspective view of the three components of this device. This figure shows the part 24 which comprises the coupling, the part 25 on which the hair is rolled up, and which may comprise means for modifying the resonant frequency of the resonator, and the part 26 which constitutes the outer jacket of the resonant cavity.

FIG. 8 shows in greater detail the part 24 which is illustrated in section on a larger scale. FIG. 8 shows the coupler or adapting member which in the present case comprises two coils 10a and 10b connected between the central conductor 8 of the coaxial cable and ground 7. This latter connection is made through a bypass condenser.

The coils 10a and 10b are protected by a cover 23 made of an inert material, for example polytetrafluoroethylene.

The end member 27 comprises a knob 28 for use in gripping this part of the device. The opening 29 permits the introduction of the coaxial cable and its connection to the terminal 8.

In this embodiment the adapter is, as seen, made from two coils 10a and 10b which are separated by a certain distance even though electrically connected.

This arrangement facilitates the search for and completion of the coupling between the line and the resonant cavity, in particular by modifying the distance between the two coils 10a and 10b.

In the embodiment described, the coils 10a and 10b have a diameter of 10 millimeters, are made of enameled wire having a diameter of 0.6 millimeters, and these coils are spaced about 13 millimeters apart. The

comprise 6 and 7 turns respectively without counting the turn which connects them. The condenser 22 has a value of 2,200 pF.

FIG. 9 shows a cylinder 30 on which the hair to be treated in accordance with the invention is wound. FIG. 9 shows this cylinder partly broken away. This cylinder carries a knob 28 adapted to facilitate its manipulation.

The cylinder 30 also contains a device for modifying the frequency consisting of a coil 31 which may be positioned inside the cylinder 30 or inside its walls. For example, the coil 31 may be mounted between two cylinders which are made of an inert material, such as polytetrafluoroethylene, with the inner cylinder serving as the support and the outer cylinder, which is as thin as possible, protecting the winding 31. The part 25 also comprises an elastic member 32, the end of which is provided with a hook 33. This elastic member is adapted to hold the lock of hair wound on the cylinder 30 by being passed over the lock, with the hook 33 then engaging the opposite edge of the cylinder 30.

The respective dimensions of the members 24 and 25 are such that the member 25 (or at least the part of this member which carries the coils 10a and 10b) may fit inside the cylinder 3.

In the embodiment shown, the coil 31 has 40 turns of enameled wire having a diameter of 0.6 millimeters with the coil having a diameter of 20 millimeters.

Finally, FIG. 10 shows a particular embodiment of the jacket 26 which comprises two halves 34 and 35 which are pivotally connected along a common generatrix 36, and which have a tendency to close against each other in response to the bias of a spring not shown. The generatrix of the two halves opposite the generatrix 36 carries teeth which interengage to insure the electrical closing of the resonating cavity.

Two handles 37 attached to each of these halves 34 and 35 make it possible to bring them together or separate them and to close them over the hair wound on the cylinder 30, where they are held by the elastic member 32, as has been described. The device which has just been described is particularly convenient to use. It suffices, in effect, to wind the hair on the part 25 and hold the lock in place by means of the elastic member 32. Then the part 24 is introduced into the part 25 and the part 26 placed over both of them by moving apart the two halves. As will be hereinafter explained it is desirable, when this device is used, to have several parts 25. One may then roll the locks on the parts 25 in advance and treat them successively by introducing each of the several parts 25 successively into the part 24 and covering it with the part 26.

FIG. 11 is a circuit diagram showing the electronic circuit of a high frequency generator according to the invention. The electrical values of the different components of this circuit are summarized in the following Table 1.

HIGH FREQUENCY GENERATOR

Code	Components	Values
R 1	Coiled resistance 5%	47Ω, 10 W
R 2	do.	47Ω, 10 W
R 3	do.	10 KΩ, 10 W
R 4	do.	15Ω, 10 W
C 1	Scaled paper condenser 1000 V	1 μf, 10%
C 2	do.	1 μf, 10%
C 3	do.	1 μf, 10%

—Continued—
HIGH FREQUENCY GENERATOR

Code	Components	Values
C 4	Electrochemical condenser	50 μ f, 500 v
C 5	do.	50 μ f, 500 v
C 6	Paper condenser	0.22 μ f, 3000 v
C 7	do.	0.1 μ f, 3000 v
C 8	Variable ceramic condenser	0-10 pf 1500 v
C 9	do.	0-10 pf 1500 v
C 10	Adjustable condenser on steatite	2x20 pf 300 v
C 11	do.	250 pf 300 v
C 12	do.	250 pf 300 v
C 13	Mica condenser	220 pf 300 v
T 1	Double tetrode	QQ E 06/40 (Philips)
L 2-L 6	Induction coil made of enamelled wire	Each induction coil L 1 - L 6 comprises 45 contiguous turns having a diameter of 11 mm made of copper wire 1.5 mm in diameter
L 1	Induction coil with ferrite core	
TA 1	Supply transformer	Prim.: 0 - 240 V Second. 2x500 V; 200 mA 6.3 V, 6 A 6.3 V, 8 A
TA 2	Supply transformer	Prim. 0 - 220 V Second. 6.3 V; 6 W
DA 1	High voltage rectifier diode	IN 2901
DA 2	do.	do.
DA 3	Rectifier bridge 300V; 100 mh	
f 1	Fuse 5 x 20	1 A
f 2	do.	0.4 A
f 3	do.	1.4 A
f 4	do.	2.5 A

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Such a generator makes it possible to produce a power of 60 watts at a frequency of 40 megacycles. The output power is divided into two 30 watt outputs as shown at the right of the circuit diagram.

A number of examples of how to carry out the process according to the invention when treating hair or other fibers will now be given.

EXAMPLES OF METHODS OF UTILIZING THE PROCESS ACCORDING TO THE INVENTION

Example 1

In order to set a head of feminine hair utilizing the process according to the invention the procedure is as follows:

First, the hair is shampooed and rinsed. A first lock of moist hair is selected and wound up on the central cylinder 3 of a roller according to the invention as illustrated in FIGS. 1 and 2. When the hair has thus been wound up, the outer cylinder 6 is positioned over the lock so as to produce the arrangement shown in section in FIG. 2, in which the lock of hair is indicated by reference numeral 12.

Using a coaxial conductor 13, the roller is connected to the high frequency power source. In a particular application the power supply to the roller is about 30 watts at a frequency of 40 megacycles. A lock having a weight of one gram is thus dried in about 3 minutes.

In a variation, the power is supplied at a frequency of 435 megacycles and the drying time for a one-gram lock is reduced to about 2 minutes.

Using a higher power, for example 40 to 50 watts, makes it possible to further reduce the drying time.

During the drying of the first lock of hair a second one is selected and wound up on a second cylinder 3. When the first lock has been dried the outer part 2 is

removed and placed on the hair which has just been wound on the second cylinder 3. While the second lock is being subjected to the process according to the invention by being dried, the first cylinder 3 is recovered and another moist lock of hair may be wound upon it. It will be seen that by proceeding in this manner using two central parts 1 for rolling the lock of hair, and a single external part 2, it is possible to set a complete head of hair.

The time required to carry out this setting runs from about 15 to 20 minutes depending upon the size of the coiffure.

It will be remembered that, in accordance with the traditional procedure of setting by using hot air, for example, with a hood, it requires from 15 to 20 minutes to coil the locks of hair on the setting rollers. Then the drying proper takes another 30 to 45 minutes. It will thus be seen that, by utilizing the invention, the drying time is saved, since in accordance with the invention the complete time required for setting the hair corresponds to the time for rolling it in a conventional process. Moreover the comfort is much greater for the person whose hair is being set because his scalp is not subjected to any high temperature. Finally, the waves obtained in accordance with the process which has just been described hold better than conventional waves. This improved holding power takes the form of waves which last longer and resist humidity better.

Example 2

A head of hair is set in accordance with the process according to the invention by proceeding as indicated in Example 1 except that, instead of winding up on the setting roller hair which has simply been moistened, the hair is first impregnated with one of three setting lotions, the compositions of which are given below:

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a.	Copolymer comprising 80% vinyl acetate, 10% crotonic acid and 10% vinyl stearate	1	g
	Triisopropanolamine	0.175	g
	Ethanol	65	g
	Water q.s.	100	g
b.	Polyvinylpyrrolidone K 30 (molecular weight = 40,000)	3	g
	Ethanol	40	g
	Water q.s.	100	cc
c.	Copolymer comprising 75% N-vinylpyrrolidone, 15% vinyl stearate and 10% allyloxyacetic acid - (Viscosity = 2.0 centipoises for a solution containing 5% of the copolymer in dimethyl formamide at 35°C)	3	g
	2-amino-2-methyl-1,3-propanediol q.s.p. for neutralization at 100%		
	Ethanol	50	g
	Water q.s.	100	g

When the hair is then dried as indicated in Example 1, excellent results are obtained, with the set having a holding power superior to those obtained with the same composition, utilizing a conventional drying process.

Example 3

A head of hair is set by using the following process:

The head of hair was first bleached and the set was treated to restore its brilliance, flexibility and strength to the hair.

After having shampooed the hair and then rinsed it, 0.36 grams of a powdered mixture consisting of:

Monomethylol dicyan diamide	34.8	g
Methoxymethyl dicyan diamide	64.4	g
Sodium Metabisulfite	0.8	g

was introduced into 17 cc of a solution having the following composition:

PVP/VA Copolymer sold by General ANILINE under the tradename E735	2.6	g
Formic acid q.s. pH 3	2.6	g
Water q.s.	100	g

The mixture is made up in the ratio of 0.36 g of powdered mixture per 75 cm³ of solution. The hair is immediately impregnated with the liquid composition thus obtained, and set as described in Example 1. Independently of the qualities appropriate to a very good set, the hair had an improved brilliance and flexibility as well as improved mechanical properties after treatment, and in particular greater resistance to brushing and combing.

The results obtained according to the invention are superior to those obtained when conventional drying methods are used, such as a hot air hood, when the treating compositions are the same in the two cases.

Example 4

The process according to the invention makes it possible to set parts of the coiffure when it is desired to impart a wave only to one portion of the head of hair, for example several particular locks of hair.

This process may, for example, be used when the hair has been set some time ago and the effects are beginning to wear off and it is desired to impart a more characteristic wave to several locks of hair.

In this case it suffices to locally moisten the lock of hair which is to be waved and to place it on a setting roller to dry it as been described in connection with Ex-

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ample 1. In this way a partial set may be completed in a few minutes.

Partial wetting of the hair may be easily accomplished with an aerosol device containing the setting lotion, or even simply with pure water, which makes it possible to moisten the hair and then dry it in order to change the shape of the hair.

Example 5

The process described in Example 1 is used to set the hair of a wig made of artificial fibers.

The conditions of operation, drying time, and results are analogous to those described in Example 1. For example, a wig may be set which is made of artificial fiber consisting of a copolymer of vinylchloride and acrylonitrile, such as sold under the trademark KANEKALON, said fibers having a denier of 50 and being obtained according to French Pat. No. 1,489,902 of the KANEGAFUSHI COMPANY.

Analogous results may be obtained using wigs made of other artificial fibers or of natural hair.

Example 6

The process according to the invention may be used to wave a wig made from artificial fibers, for example, the KANEKALON fibers envisaged in Example 5. In this case the hair is rolled in the dry state on rollers according to the present invention. To produce a wave of a curly type the fibers are heated while wound up to a temperature of about 90°C.

This temperature is obtained by supplying electric power of about 30 watts at a frequency of 40 megacycles for about a minute and a half. In this manner a stable wave is produced in the artificial fiber of the wig by a treatment thereof in the dry state.

Example 7

Hair is dyed in the process according to the invention by operating as follows:

A dyeing solution having the following composition is prepared:

2,5 diamino toluene	6.1	g
2,4 diamino anisol sulfate	11.8	g
Sulfonates of fatty C ₁₂ -C ₁₄ alcohols oxyethylenated with 1.6 moles of ethylene oxide	200	g
Ammonia solution (d=0.9)	100	g
Sodium bisulfite solution (d=1.33)	10	g
E D T A	2	g
Water q.s.	1000	g

as well as a 6% solution of hydrogen peroxide.

50 cc of this solution is mixed with 50 cc of 6% hydrogen peroxide. The mixture thus obtained is applied to naturally grey hair. It is left in contact with the head of hair for 20 to 30 minutes at the ambient temperature. The hair is then rinsed with warm water, shampooed and again rinsed. The hair has acquired a medium blue color. It is then set as in Example 1. For purposes of comparison, the same treatment is used on the hair except that it is dried in a hood as is conventional when hair is being set.

(For a better comparison of the results, half of the head may be treated in accordance with the invention and the other half in accordance with a conventional setting technique.) It is found that the resistance to light of the color obtained is not as good when the conventional setting technique is used as when the technique according to the invention is used.

Example 8

The procedure is the same as in Example 7, except for the use of the following dyeing composition:

4-amino phenol	5.5	g
2,4 diamino anisol sulfate	11.8	g
Sulfonates of fatty C ₁₂ -C ₁₄ alcohols oxyethylenated with 1.6 moles of ethylene oxide	200	g
Ammonia solution (d=0.9)	100	g
Sodium bisulfite solution (d=1.33)	10	g
E D T A	2	g
Water q.s.	1000	g

A reddish tint is obtained. It is noted that the resistance of the resulting color to atmospheric factors is better in the case according to the invention than when the process is terminated by a conventional setting step.

Example 9

The process according to the invention is applied to the permanent waving of natural hair in the following manner:

After shampooing and rinsing the hair, the locks are impregnated and rolled simultaneously on setting rollers according to the invention.

The hair is impregnated with one of the reducing compositions having the following composition:

a.	Thioglycolic acid	7	g
	Ammonium bicarbonate	11.25	g
	Water q.s.	100	g
b.	Thioglycolic acid	3	g
	Ammonium bicarbonate	4.25	g
	Water q.s.	100	g
c.	Thioglycolic acid	3	g
	Ammonium bicarbonate	8	g
	Water q.s.	100	g

Electrical energy is applied at a frequency of 40 megacycles for about 4 minutes, with a power of about 20 watts per roller. At the end of this treatment, the locks are rinsed while rolled on the rollers, and then impregnated with an oxidizing composition consisting of 2.7% of pure hydrogen peroxide dissolved in water, the pH of which has been brought to 2 by adding orthophosphoric acid. This oxidizing solution is left to act 10 minutes. The hair is then unwound and rinsed in running water. It is then wound up again on the rollers and set as in Example 1. A permanent wave having excellent holding properties is obtained in this manner.

It will of course be appreciated that the embodiments which have been described have been given purely by way of example, and may be modified as to detail without thereby departing from the basic principles of the invention. In particular, it is clear that the hair may be treated with a resonator of a different type from those which have been specifically described, the essential condition being that the resonator holding the hair in the state in which it is found at the beginning of the treatment be coupled to the line and the generator furnishing the electrical power at high frequency.

Moreover, it follows that invention is not limited to the treatment of hair and in particular to living hair. The process according to the invention may also be used for treating other keratinic fibers, such as wool, or

even other natural artificial or synthetic materials.

What is claimed is:

1. Process of treating fibers which comprises the step of subjecting them to the action of a high frequency electromagnetic field characterized by the fact that the fibers to be treated are placed in a resonator connected through a transmission line to a high frequency generator which generates electrical power at a frequency substantially equal to the resonant frequency of said resonator.

2. Process as claimed in claim 1 in which said resonator comprises a coupling for matching its impedance to that of the generator and the transmission line.

3. Process of subjecting fibers to a high frequency electromagnetic field, which process comprises the steps of:

locating said fibers within the radially outer portion of an elongated cavity resonator,

supplying high frequency electrical current from a generator to said resonator through a flexible coaxial transmission line and through coupling means which matches the impedance of said resonator to that of said generator and transmission line,

the frequency of said current being less than the natural resonant frequency of a cavity having the volume of the cavity in said resonator,

causing said energy to create an electrical field within said resonator which is concentrated in said radially outer portion thereof, and

utilizing inductance means within said resonator to reduce its actual resonant frequency to that of the current supplied by said generator.

4. Process as claimed in claim 3 in which said frequency lies between 10 and 2,000 megacycles.

5. Process as claimed in claim 3 which comprises the step of rolling up said fibers on a cylinder to be positioned inside the resonator.

6. Process as claimed in claim 3 according to which a material having a dielectric constant and a dielectric loss factor which increase with temperature is placed inside the resonator to insure automatic adaptation of the resonant frequency of the resonator as the fiber dries.

7. Process as claimed in claim 3 in which said fibers are hair and are impregnated with a composition having a chemical effect thereon before being subjected to said field.

8. Process as claimed in claim 3 in which said fibers are hair and are impregnated with a composition containing constituents which react with each other before being subjected to said field.

9. Process as claimed in claim 3 in which said fibers are hair and are moistened with water at the beginning of the treatment and said treatment is continued until the hair is dry.

10. Process as claimed in claim 3 in which said fibers are hair and are impregnated with a setting lotion, and said treatment is continued until the hair is dry.

* * * * *

Disclaimer

3,863,653.—*Georges Boudouris*, Grenoble, and *Gregoire Kalopissis*, *Jean-Luc Levesque*, and *Paul Roussopoulos*, Paris, France. METHOD FOR TREATING FIBERS BY SUBJECTING THEM TO HIGH FREQUENCY ELECTRIC FIELDS. Patent dated Feb. 4, 1975. Disclaimer filed Apr. 15, 1975, by the assignee, *Societe Anonyme dite: L'Oreal*.

Hereby enters this disclaimer to claims 1 and 2 of said patent.
[*Official Gazette June 24, 1975.*]

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,863,653 Dated February 4, 1975

Inventor(s) GEORGES BOUDOURIS; GREGOIRE KALOPISSIS; JEAN-LUC LEVESQUE and PAUL ROUSSOPOULOS

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The third inventors name should read:

Jean-Luc Levesque

[30] Foreign Application Priority Data

Nov. 12, 1970 Luxembourg . . . 62.048

Signed and sealed this 1st day of April 1975.

(SEAL)

Attest:

RUTH C. MASON
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