United States Patent

Abe et al.

[15] **3,699,976**

[45] **Oct. 24, 1972**

[54] **METHOD FOR KILLING TOBACCO LEAF BUG INHABITANTS AND THEIR EGGS**

[72] Inventors: **Isao Abe**, Tokyo; **Tatsuo Hirose; Kotaro Ohshima**, both of Yokohama-shi, all of Japan

[73] Assignees: **The Japan Monopoly Corporation**, Tokyo; **Tokyo Shibaura Electric Co., Ltd.**, Kawasaki-shi, Japan

[22] Filed: **Jan. 27, 1970**

[21] Appl. No.: **6,144**

[30] **Foreign Application Priority Data**

Jan. 27, 1969 Japan 44/5430

[52] **U.S. Cl.** **131/121,** 21/54, 21/102, 99/221, 219/10.55

[51] **Int. Cl.** **H05b 9/06,** A24b 3/00, A24b 9/00

[58] **Field of Search**............219/10.47, 10.71, 10.55; 131/121, 140 P; 99/154, 217, 221; 21/54, 102

[56] **References Cited**

UNITED STATES PATENTS

3,614,365	10/1971	Lane	219/10.55
3,304,401	2/1967	Long	219/10.55
3,320,396	5/1967	Boehm	219/10.55
3,351,730	11/1967	Pahlman	219/10.55
3,365,562	1/1968	Jeppson	219/10.55
3,409,023	11/1968	Zygmunt da La Burde	131/121
3,478,900	11/1969	Jeppson	219/10.55
3,494,724	2/1970	Gray	219/10.55

Primary Examiner—J. V. Truhe
Assistant Examiner—Hugh D. Jaeger
Attorney—Kemon, Palmer and Estabrook

[57] **ABSTRACT**

Method and apparatus for upgrading by heat treatment vegetable matter such as the foliage of tobacco or tea, using high frequency electromagnetic waves of 900 MHz min. and additionally irradiating infrared rays during said heat treatment to elevate operating efficiency.

2 Claims, 9 Drawing Figures

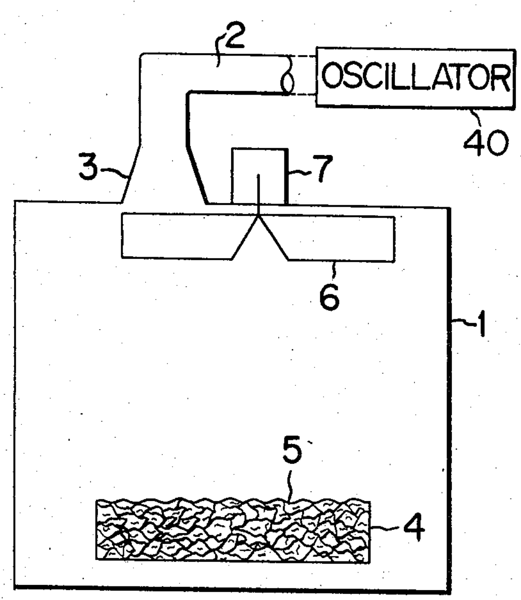


FIG. 1

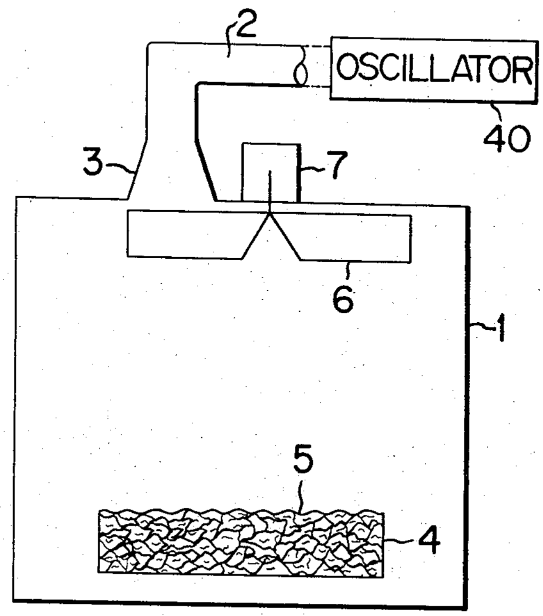
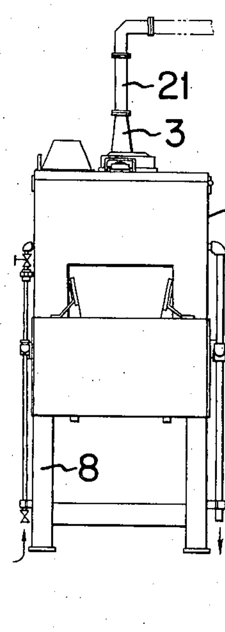


FIG. 2B

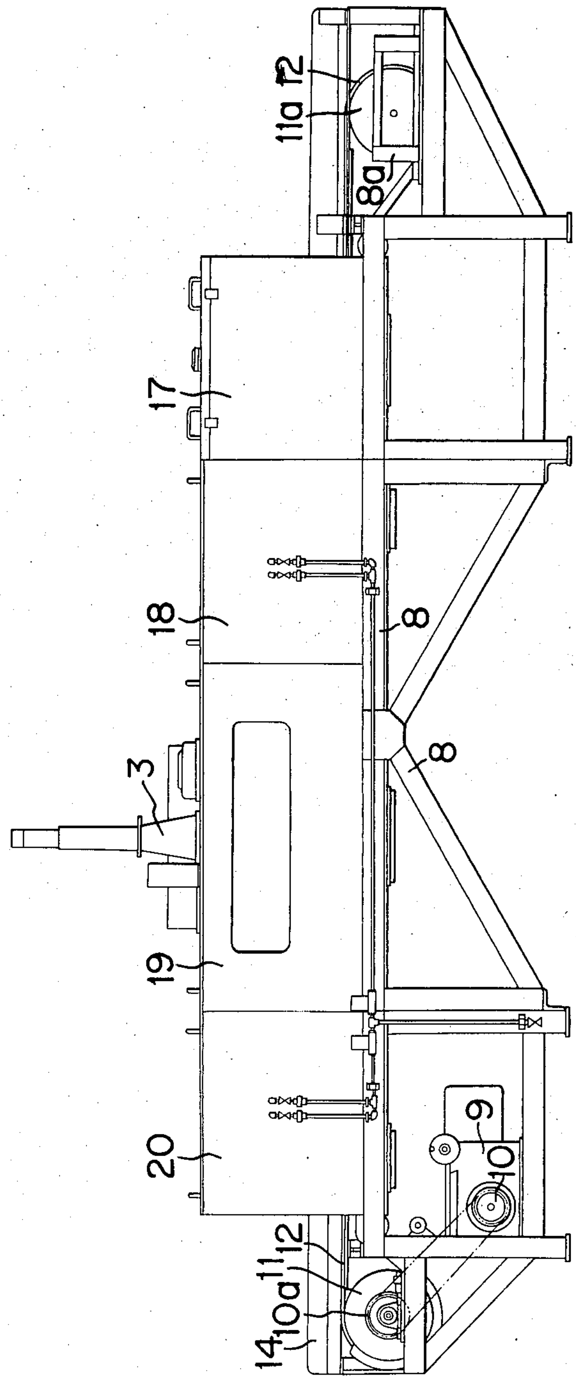


INVENTOR.

BY Isao Abe
Tatsuro Hirose
Kotaro Ohshima

Kenyon, Palmer & Estabrook

FIG. 2A



INVENTOR.

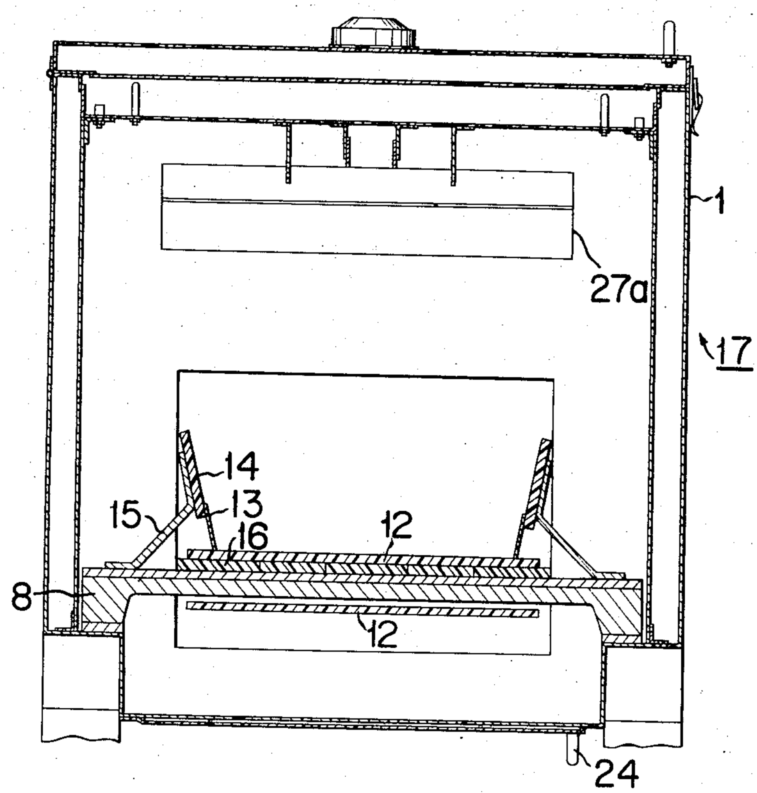
Isao Abe

BY Tatsuo Hirose

Kotaro Ohshima

Kernan, Palmer & Estabrook

FIG. 3

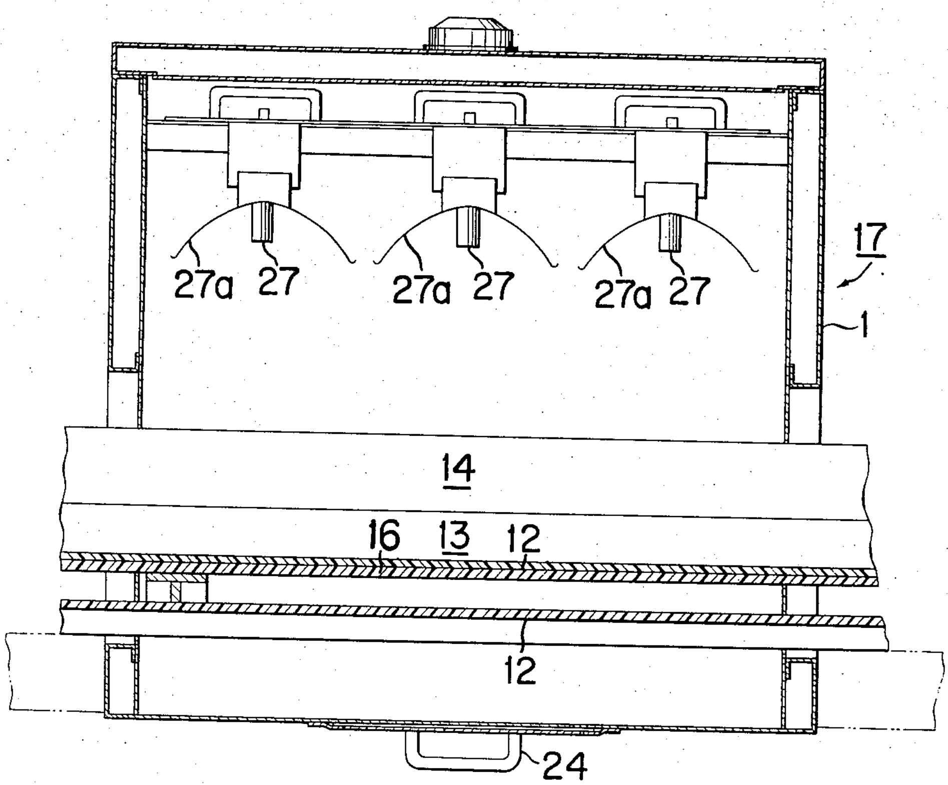


INVENTOR.

Isao Abe
BY Tatsuo Hirose
Kotaro Ohshima

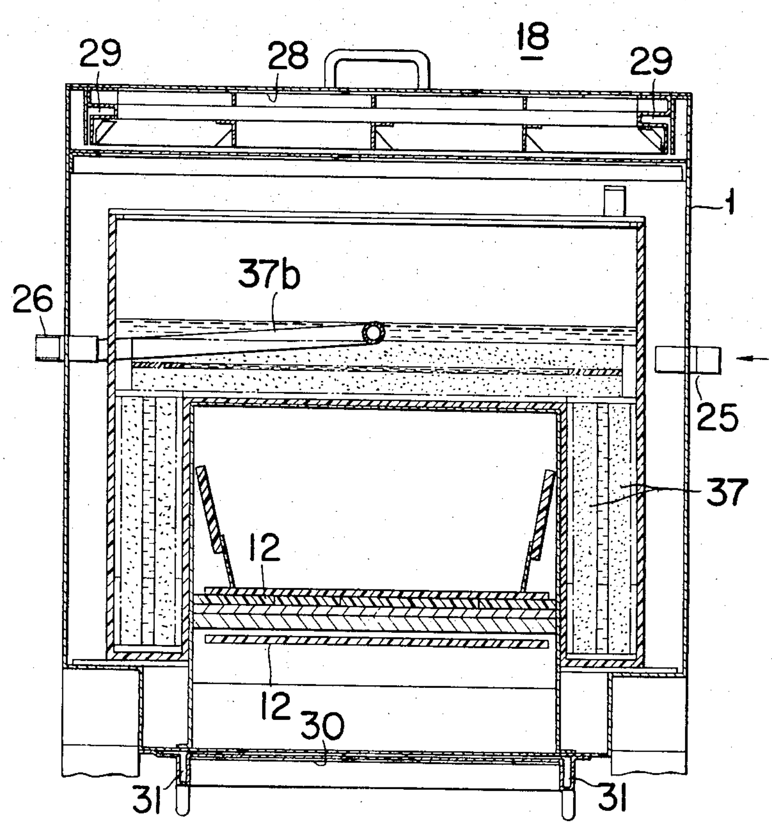
Kenyon, Palmer & Estabrook

FIG. 4



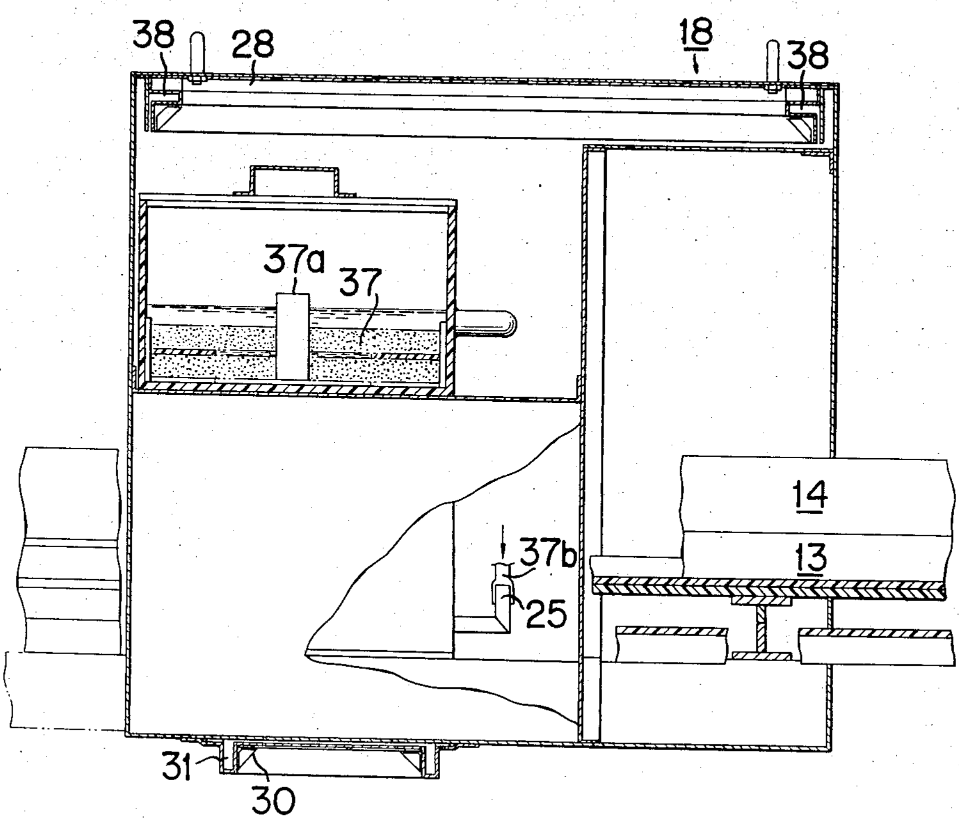
INVENTOR.
Isao Abe
BY Tatsuo Hirose
Kotaro Ohshima
Kemon, Palmer & Estabrook

FIG. 5A



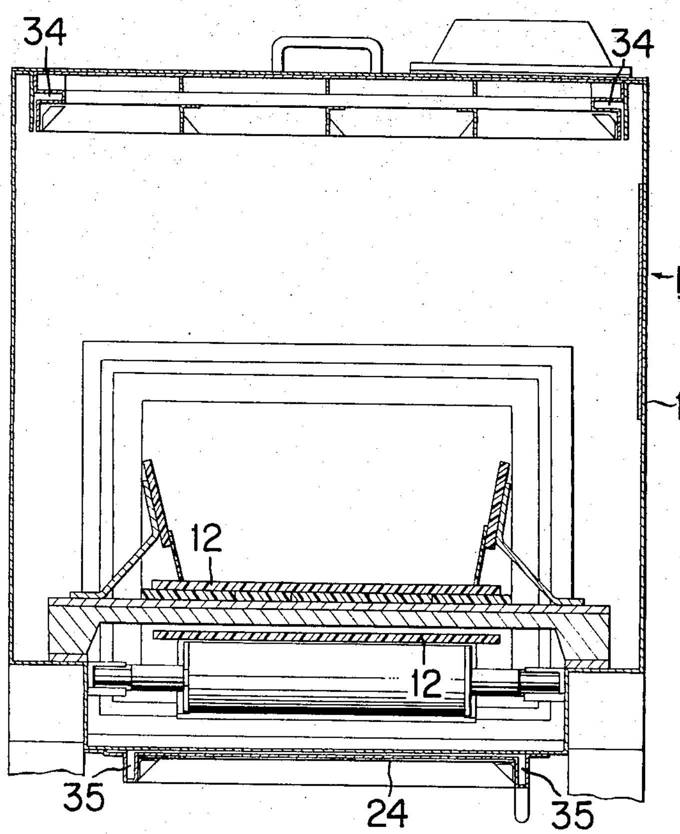
INVENTOR.
Isao Abe
BY Tatsuo Hirose
Kotaro Ohshima
Kemon, Palmer & Estabrook

FIG. 5B



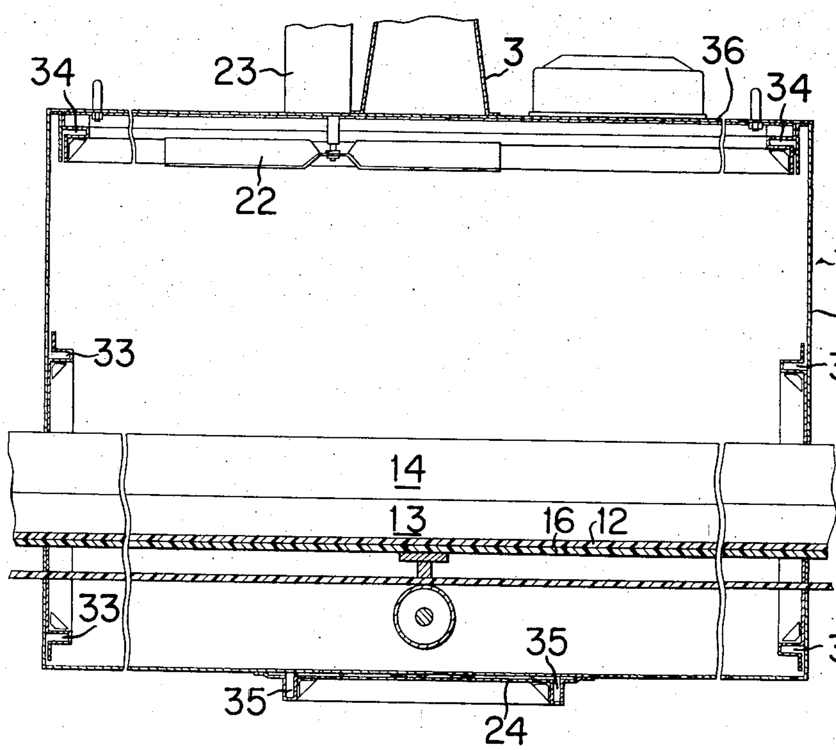
INVENTOR.
Isao Abe
BY Tatsuro Hirose
Kotaro Ohshima
Kenyon, Palmer & Estabrook

FIG. 6A



INVENTOR.
Isao Abe
BY Tatsuo Hirose
Kotaro Ohshima
Kenyon, Palmer & Estabrook

FIG. 6B



INVENTOR.
Isao Abe
BY Tatsuo Hirose
Kotaro Ohshima
Kenyon, Palmer + Estabrook

METHOD FOR KILLING TOBACCO LEAF BUG INHABITANTS AND THEIR EGGS

This invention relates to a method and apparatus for heat treating vegetable matter such as tobacco to kill bugs inhabiting said matter, for example, moths and beetles, and to upgrade its quality.

In general, dried rush is inhabited by harmful bugs, for example, mite, including the larvae and eggs, and tobacco leaves by tobacco moths or cigarette beetles, thus exerting various undesirable effects on such products when they are manufactured or stored. In the case of the dried rush, such effects even extend to men using it. Referring to tobacco leaves, there is the possibility that the eggs of the aforesaid bugs present in the tobacco leaves will grow into larvae or imagoes after the leaves are made into product to eat the circumjacent zone of the preservation and deteriorate the quality of the product due to the resultant exhaustion of raw material.

Tests were conducted in applying high frequency electromagnetic waves to exterminate bugs inhabiting the leaves of tobacco (the term "bugs" is construed hereinafter to include their pupae, larvae and eggs).

Past experiments involving application of high frequency electromagnetic waves sometimes failed to kill the aforesaid bugs while degrading the quality of the vegetable matter. The particular problem is that there appear small electrical discharges on the surface of vegetable matter when high frequency electromagnetic waves are applied thereon, decomposing or oxidizing the vegetable matter with the resultant deterioration of its quality. Accordingly, dried rush is partly carbonized by such discharges and reduced in physical strength. The same phenomenon is also observed in tobacco, namely, tobacco leaf is partly carbonized with the tobacco sauce or flavor impregnated therein, making its quality quite useless. Sometimes, the aforesaid discharge scorches or even burns the tobacco, preventing the treating apparatus from being used continuously and making its operation unstable.

Further, bugs exhibit different degrees of heat resistance according to the species and metamorphic stages. Table 1 below is an illustration of this fact.

TABLE 1

Heat treating temperature (°C)	Heat treating period 5 min (%)	10 min (%)	15 min (%)	20 min (%)
40	0	0	10	10
50	0	0	20	30
60	100	100	100	100
70	100	100	100	100

The above Table 1 shows the death rate of the larvae of cigarette beetles by heat treatment under dry condition. As apparent from Table 1, full extermination of bugs requires heat treatment for about 5 min at a temperature of 60°C. However, such heating method involves problems in that it is practically difficult to fully treat large amounts of raw material under the aforesaid conditions during the making of cigarettes. Also the elevation of heating temperature to as high a level as 60°C adversely affects the smoking taste of cigarettes.

Accordingly, said heating method has heretofore been barred from use.

Further, the fact that there has been available substantially no effective means for increasing the filling capacity of tobacco leaves has often obstructed quality control.

An object of the present invention is to provide a method for improving the quality of vegetable matter by applying electromagnetic waves to said vegetable matter with the least possible deterioration of quality.

Another object of the present invention is to provide an apparatus for continuously killing said bugs to attain the above-mentioned object. The apparatus of the present invention basically consists of a means for irradiating high frequency electromagnetic waves of 900 MHz min. on vegetable matter and additionally of an infrared ray oven means and high frequency electromagnetic wave absorption means.

This invention can be more fully understood from the following detailed description reference to the accompanying drawings, in which:

FIG. **1** is a principle sectional view of the main section of an apparatus for heat treating vegetable matter according to the present invention;

FIGS. **2A** and **2B** jointly illustrate said apparatus according to an embodiment of the invention; FIG. **2A** is a front view of said apparatus and FIG. **2B** is a side view of said microwave oven means;

FIG. **3** is a cross sectional view of an infrared ray oven means involved in the apparatus of FIG. 2;

FIG. **4** is a front sectional view of said infrared ray oven means involved in the apparatus of FIG. 2,

FIGS. **5A** and **5B** are respectively a cross sectional view and front view partly in section of a microwave absorption means according to an embodiment of the invention; and

FIGS. **6A** and **6B** are respectively a cross sectional view and sectional front view of a microwave oven means involved in the apparatus of FIG. 2.

There will now be described an embodiment of the present invention by reference to the appended drawings. The present invention involves a considerably high frequency. The reason is that an electromagnetic field of high frequency has a relatively low intensity as compared with the magnitude of power applied thereto and is free from local discharges which might result when the field strength is increased. Accordingly, the present invention enables vegetable matter requiring an insecticidal treatment to be subjected to a sufficient amount of high frequency power to display an insecticidal effect without causing the quality of said matter to be deteriorated by the aforementioned local discharges. Such a relatively high frequency for industrial application is generally of the order of 900 MHz min.

Referring to FIG. **1**, there is disposed a waveguide **2** on a box member **1** constructed of a material capable of reflecting electromagnetic waves, for example, a metal by the aid of a slightly flared connection member **3** fitted with said guide **2**. At the end of said waveguide **2** is provided an oscillator **40** of high frequency electromagnetic waves such as a magnetron, which applies pulsed or continuous waves into the box. Said box member **1** contains a tray **4** for receiving vegetable matter. Said tray is desired to be made of such material as will cause little loss of high frequency current, that is, tanδ has a small value even when the temperature within said box member 1 slightly rises, for example, to about 100°C, will allow the tray to preserve a constant shape, will not to evolve noxious substances changing or deteriorating the quality of vegetable matter placed in said tray or will not react with said vegetable matter. While the size of said box member 1 varies with the frequency of electromagnetic waves used, it is only required to be larger than is demanded by the wavelength thereof.

Further to apply high frequency waves all over vegetable matter, there is fitted to the underside of the top wall of said box member 1 a stirrer 6 with its operating plane turned downward. Said stirrer 6 is actuated by a motor 7 at a suitable rotating speed. High frequency wave from the oscillator is conducted into the box member 1 through the waveguide 2 and connection member 3. The vegetable matter 5 is heated by allowing said power to be applied to the whole of it through operation of the stirrer 6.

Experiments showed that where a heap of tobacco shreds about 15 cm in apparent thickness placed about 2 to 3 cm above the floor of said box member 1 about 50 cm high, about 63 cm wide and about 190 cm deep was subjected to about 4 KW of high frequency waves of 2,450 MHz, then the eggs larvae and imagoes of bugs present in said tobacco leaves were all exterminated in the lengths of time listed in Table 2 given later. Throughout said experiments, the vegetable matter presented no degradation of quality. High frequency heating may generally be expressed by the following equation:

$$W = kE^2\epsilon f\tan\delta \qquad (1)$$

where:

W = heating power
E = field strength of high frequency waves
k = constant
ϵ = dielectric constant of heated matter
f = frequency used
$\tan\epsilon$ = loss tangent at frequency f in heated part

As seen from the Equation (1) above, the heating power will increase in proportion to f in the case of the same field strength. Since the dielectric constant ϵ and δ rise generally with f, they will assist in elevating a heating effect. It is also found that to kill the aforesaid bugs, it is sufficient to heat them to about 50°C, together with the vegetable matter inhabited therein, application of such temperature will not harmfully affect the vegetable matter at all and that where power requirement for said temperature is calculated, with a high frequency field strength E (which may be deemed as the intensity of an electric field) set at such a level as will not cause local discharges (or 300 V/cm max. as a field intensity), then a frequency f of 900×10^6 Hz min. will be sufficient.

For continuation of the aforementioned operation, the present invention provides an apparatus jointly illustrated by FIGS. 2A and 2B. Infrared rays oven means 17, microwave absorption means 18, microwave oven means 19 and microwave absorption means 20 are all supported on a frame 8. To the output side of said frame 8 is fitted a motor 9 equipped with a reduction gear. Outputs from said motor 9 are transmitted through a pulley 10 to a pulley 10a fitted to a drum 11 by means of a belt to rotate said drum 11. On the inlet side of the frame 8 for vegetable matter there is fixed to a frame 8a another drum 11a paired with the aforementioned drum 11, and across these drums 11 and 11a is stretched a conveyor belt 12. The material of said conveyor belt 12 is required to have the same electrical, thermal and chemical properties as those demanded of the material of the saucer shown in FIG. 1 and additionally some degree of flexibility. Since the selection of the material of said conveyor belt requires care, there is adapted for the apparatus of the present invention a type consisting of glass wool fabric impregnated with fluorine resin. This belt has been found satisfactory. In each of said infrared ray oven means 17, microwave absorption means 18, microwave oven means 19 and microwave absorption means 20 is provided a support plate 16 shown in FIG. 3 for supporting said conveyor belt 12 from below so as to prevent it from sagging while it travels through these means. Said support plate 16 should have substantially the same electrical and thermal properties as said conveyor belt 12 and additionally a considerable mechanical strength. For this reason, said plate preferably consists of, for example, polypropylene resin. Where said plate is used for vegetable matter such as tobacco shreds, there is disposed a flexible insulation member 13 (preferably made of fluorine resin) in a manner to abut against both sides of said conveyor belt 12 to prevent tobacco shreds from falling off said belt 12. Said insulation member 13 is further fixed to another insulation member 14 for guiding tobacco shreds carried by said conveyor belt 12 (a plate about 10 mm thick preferably made of polypropylene). Said second insulation member 14 is fitted to the frame 8 by a metal support 15 (FIG. 3).

Vegetable matter is put on said conveyor belt 12 at the right end of the apparatus as shown in FIG. 2A. The vegetable matter is initially carried into the infrared rays oven means 17 to prevent the temperature of its surface from falling (due to evaporation of water or the like from said surface). Said infrared rays oven means 17 has infrared rays lamps 27 and reflection shades 27a positioned on the underside of its top wall so as to supply the surface of said vegetable matter with infrared rays heat. While the number of said infrared rays lamps 27 and power consumption naturally vary with the speed at which said conveyor belt 12 travels, use of three such lamps with 1KW attains the object of preheating in this case. Of course, the greater the speed of said conveyor belt 12, the more infrared rays lamps will be required. Part of the bottom cover plate of said infrared rays oven means 17 is made detachable and is provided with a handle for its removal. The vegetable matter which has been treated to prevent its surface temperature from falling is conducted to a high frequency electromagnetic field section (hereinafter referred to as the "microwave oven means 19"). If, in this case, said microwave oven means 19 is positioned adjacent to said infrared rays oven means 17, then there would occur undesirable effects, for example, that the infrared rays lamps 27 would be unnecessarily heated by the high frequency field of said microwave oven means 19 to reduce their life or the vegetable matter would be unduly heated. If, to prevent these drawbacks, there is placed a wire net below said infrared rays lamps, it will undesirably absorb infrared rays. Further, part of the high frequency waves used in said microwave oven means **19** will escape outside with the resultant occurrence of various difficulties.

To avoid the aforementioned troubles associated with high frequency waves, the apparatus of the present invention has a microwave absorption means **18** interposed between the outlet of said infrared rays oven means **17** and the inlet of said microwave oven means **19** and another microwave absorption means **20** positioned adjacent to the outlet of said microwave oven means **19**. As shown in FIGS. **5A** and **5B**, each of said microwave absorption means **18** and **20** has a microwave absorption member **37** provided on both sides of that part thereof through which said conveyor belt **12** passes. Said microwave absorption member **37** is cooled with water running therethrough from its inlet **25** to its outlet **26**. On the top of said microwave absorption means **18** and **20** is formed a detachable cover plate **28** so as to afford convenience in the maintenance of and access to the devices included therein. If, as described later, said cover plate **28** does not tightly contact the box member **1**, there will sometimes occur sparks in the interstice therebetween due to migration of microwaves thereto and their leakage from said interstice. To prevent the latter event, there is formed at the end of said cover plate **28** a microwave choke **29** which is assembled from the mutually contacting end portions of the adjacent walls of the box member **1** and between box members. The bottom of the box member **1** is located slightly apart from said conveyor belt **12** to allow for the possible heating of the vegetable matter even in said microwave absorption means **18** and **20** by microwaves escaping from said microwave oven means **19**. The distance between said bottom of the box member **1** and conveyor belt is preferably more than about one-fourth of the length of microwaves. At the bottom of said box member **1** is disposed a detachable cover plate **30** to take out the vegetable matter falling off said conveyor belt **12**. Also at the end of said detachable cover plate **30** is formed a microwave choke **31**. **37*a*** is a water level gauge and **37*b*** is a soft polyvinyl chloride tube.

The vegetable matter carried through said microwave absorption means **18** by the conveyor belt is brought to said microwave oven means **19**. At the inlet and outlet of said microwave oven means there are defined as shown in FIGS. **6A** and **6B** microwave chokes **32** and **33** respectively by the walls of said oven means **19** with those of said microwave absorption means **18** and **20** adjacent thereto, thereby preventing the occurrence of difficulties due to sparks generated between said oven means **19** and both absorption means **18** and **20**. The conveyor belt **12** is set appreciably apart from the bottom of the box member **1** constituting said microwave oven means **19**. The interval between said conveyor belt **12** and the bottom of said box member **1** is preferably about one-fourth of the length of microwaves as described above. Microwaves for heating are generated by, for example, a magnetron and introduced into said microwave oven means **19** through the waveguide **21** and the slightly flared connection member **3**(FIG. **2B**). In the microwave oven means **19** is provided a stirrer **22** (FIG. **6B**) for scattering microwaves to obtain uniform microwave energies at various parts of said oven means **19**, said stirrer **22** being rotated by a motor **23** at a proper speed. The upper cover plate **36** (including part of said waveguide **21** and scattering means **22**) is detachably fitted for the maintenance of and access to the devices contained in said box member **1**. At both ends of said upper cover plate **36** are formed microwave chokes **34** to prevent the leakage of microwaves to the outside and occurrence of sparks due to poor contact between said box member **1** and upper cover plate **36**. To the underside of the bottom of said box member **1** is also detachably fitted a cover plate **24** (FIG. **6A**) for the same reason as given above. At both ends of said bottom cover plate **24** are provided microwave chokes **35**. The vegetable matter fully subjected to an insecticidal treatment in said microwave oven means **19** again passes through said second microwave absorption means **20** to the outside.

Where an apparatus of the aforementioned arrangement is manufactured, it may be possible to integrally assemble it, but the integral fabrication of a plurality of box members in which there prevail different modes presents not only difficulties in manufacture but also inconvenience in the maintenance of and inspection to the devices contained therein. Further, where vegetable matter is desired to be treated in increasing amounts the correspondence of the capacity of treating equipment to such demand is considerably restricted. Namely, it is necessary to adjust the travelling speed of the conveyor belt and the input of high frequency power accordingly. However, a microwave oscillator, for example, a magnetron does not admit of such a free correspondence of output. It will be rather simple to additionally prepare a separate oscillator or oven of similar type but of different capacity and connect it in series to the original one. It will therefore be advisable to separately fabricate an infrared rays oven means, microwave absorption means and microwave oven means and assemble them in proper combinations. It is also possible to use a suitable combination of microwave oven means generating different frequencies so as to control the treating effect on vegetable matter. In the case of the aforesaid arrangement, there should be avoided the leakage of microwaves from the interstice between said oven means and absorption means or the occurrence of sparks resulting from the different potentials prevailing in both types of means (namely, due to poor contact therebetween), with the resultant necessity of using a large number of the aforementioned microwave chokes. However, utilization of such chokes makes possible the attainment of the above-described object. If they have a frequency of 900 MHz min. (a wavelength of about 33 cm) as described above, electromagnetic waves used in this insecticidal method will display good results. The higher the frequency, the more compact and effective the entire apparatus (as apparent from the Equation (1) above). However, electromagnetic waves of high frequency generally present difficulties in generating great power.

The foregoing description relates to the case where there are employed continuous microwaves. However, it is not indispensable to apply such continuous microwaves. Use of high frequency pulsed electromagnetic waves, for example, will bring about a good effect. In this case, it is possible to use prominently high peak power as compared with the average power applied, thereby realizing a considerably stronger insecticidal effect than is possible with said average power. The pulsation of microwaves thus used had a width of 2 micro-seconds and a number of 300 per second and produced a peak power of 5 MW, obtaining the same effect as in the case where there was conducted an insecticidal treatment with an average output of 5 KW using continuous microwaves. If they are made to pulsate, electromagnetic waves can be used in very high frequency, thus allowing the entire apparatus to be compact.

As mentioned above, the present invention utilizing microwave dielectric heating upgrades the quality of tobacco in an extremely short period of time by allowing it to pass through a high frequency electromagnetic field. Unlike external heating, dielectric heating realizes sharp temperature rise, thereby exterminating bugs by thermal shocks leading to their environmental ineptitude. Various forms of tobacco (leaf tobacco, shredded tobacco, cigarettes and packaged cigarettes) to such microwave dielectric heating. The death rate of said bugs was solely affected by temperature rise due to said dielectric heating and substantially not by the variety and form of tobacco tested.

Referring to the sensitivity of various kinds of bugs to said dielectric microwave heating, cigarette beetles presented a somewhat stronger resistance than tobacco moths. With respect to the metamorphic stages of bugs, larvae and pupae tended to withstand said heating more than eggs and imagoes.

Tests were made to determine the conditions for effecting a 100 percent death rate with due consideration to the aforementioned experimental results, the data obtained being presented in Table 2 below.

TABLE 2

T_1 (°C)	ΔT (°C)	T_2(°C)	*t* (sec)
20	31	51	40 to 80
30	23	53	20 to 45
40	16	56	10 to 20
50	7	57	5 to 16

As apparent from the above table, the death rate of bugs inhabiting tobacco is affected by the temperature to which the tobacco is heated. The higher the temperature T_1 initially applied to the tobacco, the less required the subsequent temperature rise ΔI. However, the maximum temperature reached during insecticidal treatment should be set in advance at a slightly higher level than specified. While treating time t is desired to be as short as possible from the standpoint of quickly finishing the operation, the lengths of time listed in Table 2 above were found adequate in the sense that bugs could be fully killed and the partial damage of tobacco by heating due to application of excess power would be avoided.

The data given above show that the prominently high frequency allowed by microwaves enables insecticidal treatment to be carried out in a short time and at a stable condition of the apparatus, without giving rise to dangers, for example, the occurrence of sparks, even where tobacco has a high impedance or where it assumes such irregular shapes as presented by shreds thereof.

Referring to the incidental effect of the present invention of improving the aroma and taste of tobacco and tea, the dielectric microwave heating employed by the invention easily attains said object. When there are irradiated microwaves on tobaccoes or tea, they themselves constitute a heat element, allowing vapor to be vigorously evolved from the tissue of shreds or leaves. The temperature gradient therein falls from the central part to the peripheral part and the vapor pressure is generated in the same direction in a manner to diffuse the interior moisture to escape outside. Accordingly, the offensive and irritative ingredients contained in tobacco or tea are dispersed, permitting said vegetable products to have a mild taste an aroma, as proved by the examinations conducted by test smoking or drinking specialists. The lower the class of tobacco or tea, the more prominent said effect.

Three brands of Japanese cigarettes, i.e. Peace, Hi-Lite and Shinsei were particularly conditioned by heating them from normal temperature to 60°C by irradiation of microwaves and thereafter conditioning under a temperature of 20°C and a relative humidity of 60 percent. These cigarettes were examined by specialists for their smoking taste.

The specified testing panel consisted of seven specialists. They comparatively tested the aforementioned three brands of cigarettes by a profile method for their odor (aroma), taste, mildness and general feeling with untreated cigarettes used as control by allotting seven marks (−3 to +3) to each of these cigarettes. The numerals in Table 3 below are totals for each category given by said seven specialists in comparison with the control. The pulse mark denotes the improved quality of the tested cigarettes over the control.

TABLE 3

	Aroma	Taste	Mildness	General feeling
Peace	−2	−4	−3	−3
Hi-Lite	+1	0	+2	+1
Shinsei	+5	+3	+7	+5

As apparent from the above table 3, the high class brand Peace presented slightly minus or negative values due to the aforementioned treatment, and the intermediate class brand Hi-Lite showed no prominent change in quality, where the low class brand Shinsei was favorably relieved of a irritable taste and displayed a mild, sweet flavor and aroma. If the above-mentioned treatment is applied to raw tobacco, it will be more effective.

From the standpoint of preserving the aroma and taste of tobacco, the temperature at which it is treated is generally desired to be 60°C max. The prior art failed to kill bugs inhabiting tobacco at such temperature. However, the aforesaid method of the present invention can display an insecticidal effect even at a temperature of less than 60°C without deteriorating the aroma and taste of tobacco.

The bulkiness of tobacco is one of the most important factors utilized in the tobacco industry. This property is used as the base on which the filling capacity of tobacco shreds is determined. Said filling capacity is expressed by the quantity of cigarettes manufactured from a given amount of shreds. The larger the quantity of cigarettes, the higher the effect of filling capacity of shreds contained therein. The hardness of tobacco shreds used in cigarettes or their rheological property is an important factor in evaluating the quality of cigarettes from the standpoint of controlling the manufacturing process, elevating commercial value and positively appealing to the mentality of smokers. Accordingly, where cigarettes are made from shreds having a low bulkiness, the amount of the shreds filled in a cigarette capacity, is inevitably increased and in consequence the effect of filling capacity is small.

Another effect realized by applying microwaves to leaf tobacco, shredded tobacco and cigarettes is that thermosetting resinous components contained in the cell membrane of the tissue of tobacco or membrous substances thereof are irreversibly hardened due to their own rapid heat buildup to increase in mechanical strength, thereby resulting in the larger bulkiness and apparent volume. Accordingly, application of microwaves according to the present invention permits cigarettes to be prepared with sufficient hardness with smaller amounts of raw tobacco than required in the past, contributing to its saving.

There will now be described the experiments where there were irradiated microwaves on cigarettes after their making with the resultant increased hardness thereof.

The cigarettes Peace and Shinsei were conditioned at a temperature of 20°C and relative humidity of 60 percent in a conditioning chamber. Those of the cigarettes which varied 10 mg in weight were selected and heated with the amount of microwave power and maximum treating temperature attained. After being again conditioned at the aforementioned temperature and humidity, said cigarettes were tested for hardness.

Determination of hardness was conducted by subjecting the cigarettes to a fixed strain in the diametrical direction, continuously recording the intensity of repulsive stress indicated by said cigarettes and calculating an average repulsive stress by integrating meter. As a result it was found as shown in Table 4 below that the treated cigarettes displayed increased hardness over the control, regardless of the brand and that the greater the scale of treatment the more prominently increased the hardness.

The method of the present invention provides a hard, well-shaped cigarettes of great commercial value and eliminates the unneccessary consumption of raw material.

TABLE 4

Brand	condition of cigarettes	Treating conditions: temp. Max attained (°C)	Treating conditions: period of irradiation (sec)	UHF power (KW/Kg)	hardness (g)	Equilibrium moisture content (% W.B.)	Weight per cigarette (mg/piece)
Peace	untreated (control)	—	—	—	49.5	13.3	1040
	treated	40	25	2	56.5	12.8	1040
	treated	40	14	4	52.0	13.1	1040
	treated	60	50	2	64.5	12.6	1040
	treated	60	27	4	57.5	12.7	1040
Shinsei	untreated (control)	—	—	—	78.5	12.2	1000
	treated	40	26	2	93.0	11.9	1000
	treated	40	15	4	83.0	12.0	1000
	treated	60	49	2	110.5	11.6	1000
	treated	60	26	4	102.5	11.8	1000

As mentioned above, the present invention uses high frequency waves of 900 MHz min. in killing bugs inhabiting vegetable matter, thereby displaying a full insecticidal effect and improving the quality of tobacco or tea without causing local discharges and changing their colors resulting from the increased field intensity or spoiling the quality of said vegetable matter, for example, its aroma and taste. Further, application of heat on the surface of said vegetable matter with infrared rays prevents its temperature from decreasing due to evaporation of, for example, moisture from said surface, allowing the insecticidal treatment by high frequency heating to be reliably conducted in a short period of time. Further, provision of a high frequency wave absorption means on both sides of said high frequency wave oven means prevents the infrared rays lamps involved in said infrared ray oven means from being unnecessarily heated by the high frequency field prevailing in said oven means and in consequence the life of said lamps from being unduly shortened, and also saves the vegetable matter from harmful effects, for example, of excessively heating it. In addition, formation of microwave chokes at the connection and contact of said high frequency wave oven means and high frequency wave absorption means prevents the occurrence of the leakage of microwaves or sparks. And in the case of one box member in which there are provided with the high frequency wave absorption means and infrared ray oven means, the apparatus may be done without microwave choke. But said infrared ray oven means, high frequency wave absorption means and high frequency wave oven means are separately fabricated and thereafter assembled as an insecticidal apparatus for vegetable matter, thus offering the advantage of simplifying the manufacturing process, facilitating maintenance and inspection of equipment and allowing said equipment to have a substantially full correspondence to the amount of vegetable matter to be treated. And various processes for treating vegetable matter, i.e. the treatment of infrared rays may be accomplished for afterheating.

What is claimed is:

1. A method of insecticidally treating tobacco leaf bug inhabitants and their eggs which comprises in combination first irradiating tobacco leaf with infrared rays to preheat the leaf at a first station, passing the preheated tobacco leaf through a microwave absorption device into a microwave oven, heating the tobacco leaf to a temperature of about 60°C. in the microwave oven by irradiating it with electromagnetic waves of at least 900 Mhz, passing the tobacco leaf out of said microwave oven through a second microwave absorption device and recovering treated tobacco leaf in which any bugs inhabiting the leaf or their eggs have been killed.

2. The method of claim 1 wherein said electromagnetic waves are in the form of high frequency pulsed waves.

* * * * *