June 7, 1949. F. J. GROVEN 2,472,293

VENTILATED AND SHIELDED INFRARED OVEN

Filed Sept. 20, 1945 2 Sheets-Sheet 1

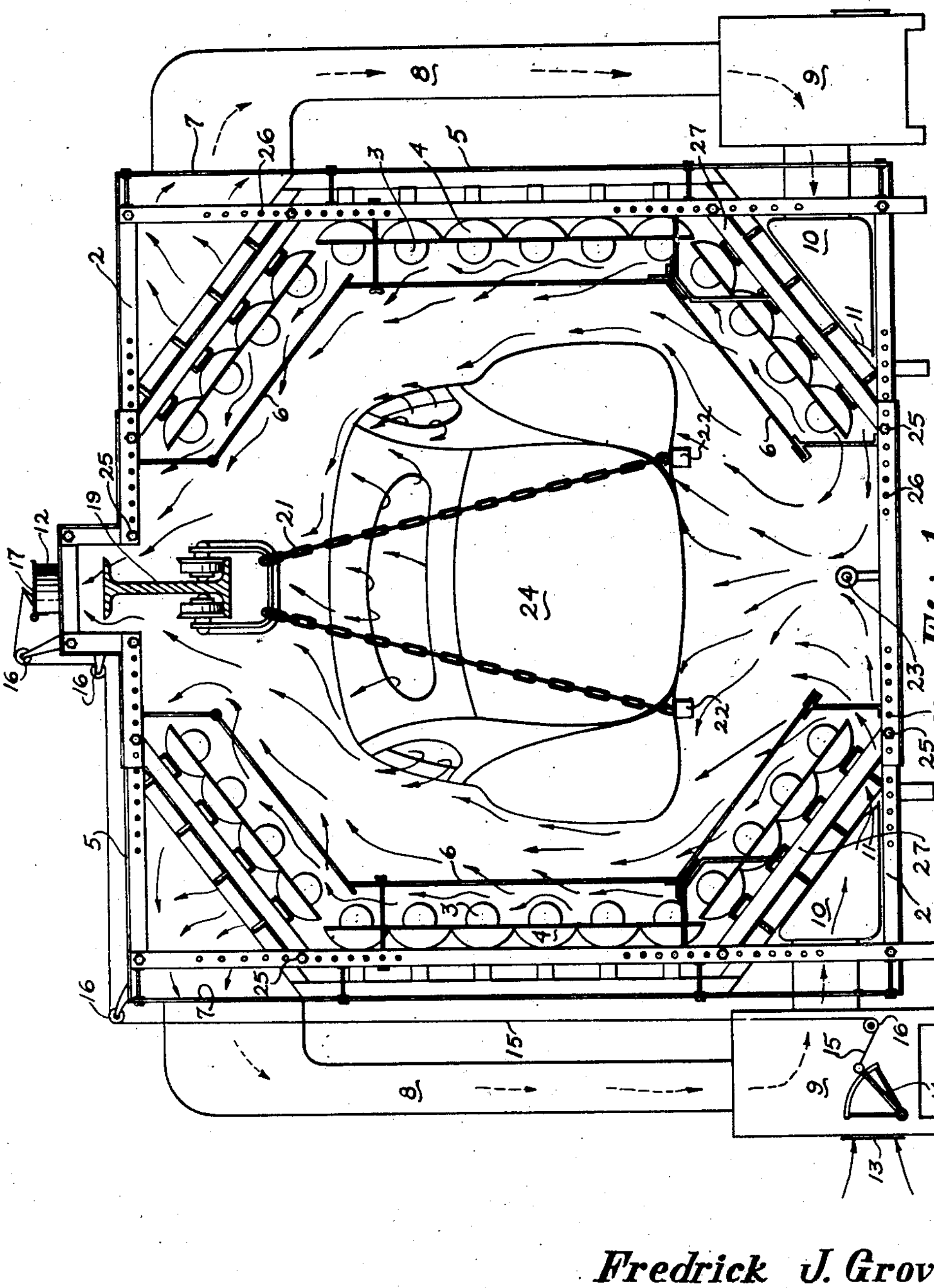

Fig. 1

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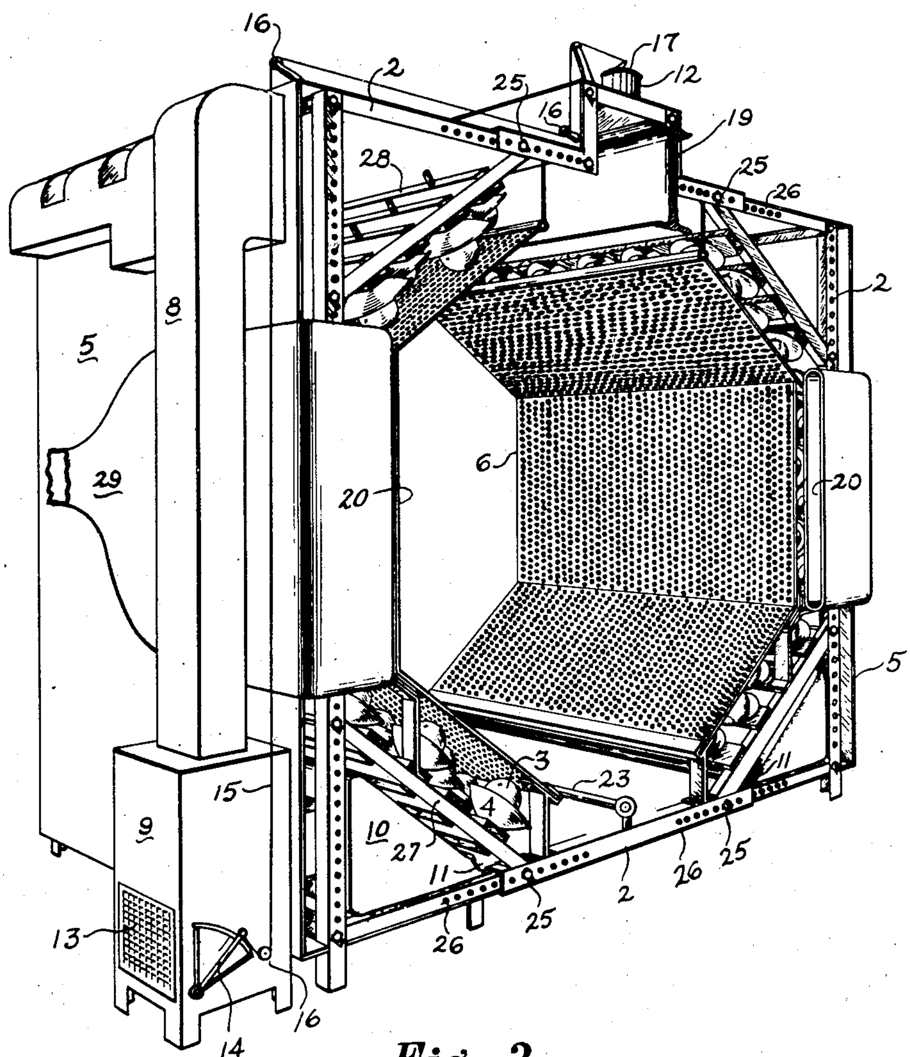

Fig. 2

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VENTILATED AND SHIELDED INFRARED OVEN

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4 Claims. (Cl. 34—60)

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This application concerns a paint-baking apparatus; and, more particularly, an improved infrared ray paint baking oven which, through a combination of radiant and convection heating, improves the present paint-drying processes and successfully cures all colors of paint without discoloration.

It is an object of this invention to provide an infrared ray oven which will properly dry and cure paint including white, black and colored synthetic enamel without discoloration.

A second object of this invention is to provide a paint-baking oven which utilizes infrared ray lamps as a heat source and one which will insure an evenly distributed heat which will dry and cure all surfaces of a painted object including surfaces not directly exposed to the infrared rays.

A third object of the invention is to provide a paint-baking oven which, through a combination of radiant and convection heat will successfully dry, bake and cure paints of high infrared reflectability as thoroughly as those of high infrared absorbability.

As is set forth in United States Patent Nos. 1,998,615, 2,057,776 and 2,186,067, all of which have been issued to the applicant, the process of drying and baking paints by infrared rays generally consists of subjecting the painted surface to direct infrared radiation generated by a battery of carbon filament lamps equipped with gold reflectors. The infrared rays emanating from these lamps penetrate and are absorbed by the paint, whereupon the rays are transformed into heat energy which drives off the volatile matter in the paint and dries and cures the residue and pigment. It is well-known that this method of drying is faster and more efficient than any other and that the former drying time of several hours in many instances has been reduced to as many minutes by the infrared process.

It is an accepted fact that the absorption by the painted surface of the infrared rays and the action of these absorbed rays on the painted surface raises the temperature of the paint layer uniformly throughout the interior of the layer rather than from the surface inwardly, as in the case of a purely convection heating system. It has been found, too, that the speed with which a paint layer reaches the drying and curing temperature depends not only upon the quantity of infrared absorbed, but also the intensity of those rays. Further, experimentation has revealed that the quantity, rate and uniformity of absorption depends to a certain degree upon the color of the paint being treated. It has been shown that a

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black paint absorbs infrared rays to a greater extent than does a white paint and that generally the rate of absorption increases as the hue of the paint darkens. In general, it may be said that the heat build-up in a particular paint or enamel is dependent upon the amount of infrared rays which are absorbed, transmitted through, or reflected by that paint or enamel.

In the drying and curing of synthetic enamel using infrared rays for the heat source, extreme difficulty has been experienced in the baking of automobile bodies coated with light colored finishes. Acute discoloration and streaking of such light finishes has presented a definite problem, and in many instances the use of infrared rays has been abandoned because no solution for the problem was known. This abandonment has necessitated the return to slower and bulkier types of drying equipment with an accompanying increase in production problems and costs.

It is obvious that the exclusive use of infrared paint-drying equipment for all types and colors of paint would be of great benefit inasmuch as such equipment is easily constructed, is economical to operate and service, and further, is less bulky and much safer than other types of paint-baking machinery.

The improved oven concerned here has been found to surmount the difficulties previously described. As outlined heretofore, it is indicated that the darker hued enamels absorb a greater quantity of the infrared rays and that the heating of such enamels is rapid and uniform throughout. The white and light colored enamels, however, being of high infrared reflectability, apparently are not capable of a rapid, voluminous and uniform absorption of the rays and it is practically impossible with the infrared equipment currently used in the art to avoid objectional discoloration and/or streaking.

As was indicated in the applicant's United States Patent No. 2,057,776, not all of the infrared rays directed at any painted surface reach or fully penetrate that surface, nor is such penetration uniform; that is, the number of rays which penetrate to the bottom of the given layer of paint is but a fraction of the total rays aimed at the surface of that layer, and the number of rays which do so penetrate beyond the paint surface is appreciably less in the case of colors having a high infrared reflectability.

Finding that to subject a highly reflective, light hued enamel to an intense barrage of infrared rays results in a discolored surface, it was first believed that a mere reduction of the operating voltage of the infrared ray lamps would reduce the number of rays and prevent discoloration. It was found, however, that the reduction of the voltage lowered the efficiency of the lamp and adversely affected the effectiveness of the rays to the extent that the paint was improperly cured. Attempts were made to correct the condition by reducing the number of lamps used but this, it was found, resulted in an uneven distribution of rays and in an unevenly dried surface. Lamps of a lower wattage were employed, but this plan was discarded when it was found that the output of infrared rays was then insufficient and that sufficient uniform heat was lacking in the oven.

The instant arrangement has been proven to bring about highly satisfactory results and, although all of the reasons for the success achieved are not ascertainable at this time, it has been found that the instant-improved oven arrangement apparently modifies the infrared ray barrage upon the enamel surface to the extent that uneven drying is prevented. High and uniform oven temperatures are maintained, and finishes are produced which are properly dried and cured, and in the case of light-hued finishes particularly, are free from discoloration or streaking. Results were also obtained indicating that the instant invention further reduces the total drying time of synthetic enamels; the drying time of the primer or undercoat on an automobile body being reduced from a total of 12.6 minutes to 5 minutes.

It should be noted also that in the infrared oven drying of enamel finishes—on automobile bodies particularly—much difficulty has been experienced in properly and rapidly drying areas not in the direct path of the infrared rays. This was particularly true around window or door frames and on floor panels. Similar difficulty was experienced in the drying of the undersides of fenders and the like. The maintenance of a higher and more uniform over-all temperature, however, as is possible in my improved oven, plus a more complete utilization of all infrared rays produced in the oven, results in complete drying and proper curing of all portions of the painted surface.

A further problem in infrared ray oven drying of automobile bodies results from the nonsymmetrical nature of the bodies. Although improvements have been made in the arrangement of the infrared ray lamps in the ovens, it has not been possible thus far to produce a lamp arrangement in a conveyor type tunnel oven wherein every portion of the body will be at the same distance from the heat source. It is recognized that the method of applying heat to an object by radiation is the most efficient, provided the path that the radiant energy has to travel is not to long. Therefore, in the efficient handling of nonsymmetrical bodies in an infrared oven, extreme care must be taken in the placement of the lamps and in the control of the intensity of the radiations to produce even drying. Intensifying the radiations to achieve maximum drying efficiency of those portions of the body farthest from the lamps, results in damage to those portions closest to the lamps. Therefore, it has heretofore been necessary to operate the lamps to bring about proper drying on the near portions at the expense of the far portions.

With these and other objects in view, the invention consists of the arrangement, construction, and combination of the various parts of my improved device, as described in the specification, claimed in the claims, and illustrated in the accompanying drawings, in which:

Figure 1 is an elevation of my improved infrared ray oven showing a typical method of suspending an automobile body therein.

Figure 2 is a perspective view of the improved oven, showing the interior detail and the use of an air curtain across the open ends of the oven.

As shown in Figure 1, the improved oven comprises an adjustable boxlike framework **2**, to which are affixed banks of infrared lamps **3** in reflectors **4**. The lamps used are of the conventional type having carbon filaments and are placed in gold-plate reflectors. The lamps and reflectors are mounted in horizontal strips to gain a uniform coverage of the infrared rays, each lamp being capable of being focused in its own reflector, thereby permitting the further control of the spread of the infrared rays assuring full and adequate coverage and preventing an overlapping of the rays and resultant uneven temperature or "hot spots."

The oven is of the enclosed type having sides, top and bottom enclosed by a sheath **5** composed of sheets of light metal or other noninflammable material. The ends are left open and, as will be further explained hereinafter, are so constructed to permit grouping of a number of the oven units and the employment of an overhead conveyor system.

As shown in Figures 1 and 2, a perforated metal baffle plate **6** is suspended in front of the infrared ray lamps so as to be positioned between the lamps and any object passing through the oven. Installed at a uniform distance of approximately 18 inches from the infrared lamps **3**, baffle plate **6** is made of ⅛'' unpainted metal perforated with ⅛'' holes placed approximately on $\frac{3}{16}$'' centers and constitutes an inner liner covering virtually all of the interior walls of the oven, particularly those areas occupied by the infrared lamps.

The use of metal sheets perforated as described—that is, with approximately 50% of the metal removed—was found to produce the best results. The employment of too few holes, or too solid a baffle plate, results in too few of the radiations reaching the painted object; whereas, the use of a plate having too many or too large holes results in the undesirable streaking and discoloration of the paint.

To operate in conjunction with the infrared lamp and the baffle plates, the applicant has installed a forced air circulating system to provide a continuous agitation in all parts of the oven. As shown in the accompanying drawings, the air is taken from the top of the oven through a series of vents **7**, is carried downward in ducts **8**, passes through a blower unit **9**, and is forced into the inner conduits **10** which are installed on both sides of the oven along the floor. Vents **11**, extending the full length of conduit **10** on the floor of the oven, permit the escape of the agitated air inwardly on the oven floor. Streams of air from vents **11** opposed to one another, meet and converge in the middle of the oven at floor level and surge upwardly with an eddying motion. As the air rises through the oven, it is heated by the baffle plates, circulates about the object being dried and as it reaches the top of the oven is again taken out through vent **7** and the process repeated.

To provide for the escape of the fume-saturated air, ventilator **12** is installed upon the top of the oven. A fresh air intake vent **13** is provided on blower 9 to operate in conjunction with the exhaust vent 12 and to permit the intake of fresh air in the same volume as the exhaust. A simple type of suggested control is shown in the accompanying drawings and comprises the intake vent lever 14 and a cable 15 running through a system of pulleys 16 to the exhaust vent cover 17. This arrangement permits the opening of exhaust vent 12 to the same degree as intake vent 13 and insures a balanced air condition in the oven.

The combination of infrared ray lamps, perforated baffle plates and circulated air in an enclosed oven, as described here, results in a more complete utilization of the infrared radiations produced by the lamps. In the conventional type infrared ray oven, radiations not sufficiently strong to reach the object—or the painted surface of the object—placed in the oven, are dissipated in the air in the oven and generally serve no useful purpose. In the applicant's improved oven, however, quantities of the infrared rays pass through the perforations in the baffle plates 6, reach and penetrate the painted surface and begin the drying and curing cycle of the paint; the balance of the radiations is absorbed by the baffles and raises the temperature thereof. These, in turn, heat the currents of air forced through the oven by the blowers 9 and as the process continues, those portions of the painted object not reached by the direct infrared rays are heated and dried by the hot air. An even distribution of heat is attained and the uniform temperatures produced in all portions of the object being treated result in properly dried and cured surfaces, even though said surfaces are not in the direct path of the infrared radiations.

The semiportable nature of infrared ray baking equipment has increased its use to a great extent and has permitted its application in many instances where the installation of a bulky and permanent steam or gas oven was undesirable. As portrayed in the accompanying drawings, the oven has been designed to operate in conjunction with a typical overhead conveyor system 19. Figure 1 depicts the oven arranged for the accommodation of an automobile body 24, which is suspended in the conventional manner by chains 21 and carrier 22. However, in the event small objects such as fenders or wheels were to be run through the oven, it would be uneconomical and undesirable to use either the space or the electric power required for the operation of the oven constructed as shown to accommodate automobile bodies. For this reason, the size of the oven unit may be varied as the need arises.

In the event it is necessary or desirable to reduce the size or—because of the shape of the object to be processed—to alter the internal contours of the oven, studs 25 are removed and necessary adjustment made to cross members 27 and framework 2. Such adjustment may require the removal or addition of numbers of infrared ray lamps and this operation is facilitated by the known lamps mounting method shown. This method entails the mounting of the lamps in groups of seven on boxlike metal crosspieces 28, which crosspieces also contain the wiring and focusing equipment for the lamps. Mounted in this fashion, units of seven lamps may be installed or removed with ease, and if desired, with appropriate wiring arrangements, can be controlled individually without affecting other such units in the oven. This type of control—permitting the increase or decrease of the voltage under which the lamp units were operated, or the total extinguishment of blocks of the lamps—would enable the oven operator to maintain the oven at any desired temperature or to raise or lower such temperature as required.

As contemplated by the applicant, the present improved oven unit is approximately five feet long and in the formation of a tunnel type oven for conveyor operation, numbers of these oven units are placed end-to-end until the desired length is reached. The entire tunnel may then be controlled as to temperature, air velocity, number or arrangement of lamp units, etc., as one large unit, or each of the individual ovens could be separately controlled throughout the tunnel.

Constructing the units in this manner greatly increases the range of adaptability of the equipment and permits its modification or rearrangement for use in a limitless number of paint-drying operations.

The application of one of the known types of air curtains to the improved infrared baking oven is demonstrated in Figure 2. The air curtain feature provides a current of air carried from a blower or blowers (not shown) through a system of ducts 29 which terminates in vents 20 positioned to blow a steady stream of air across the open end of the oven or tunnel. The application of the air curtain principle is well-known and need not be discussed other than to point out that its employment permits the operation of a baking tunnel on an assembly line or conveyor system, and obviates the necessity for the installation or operation of doors at the end of the oven or the tunnel.

Shown also in the accompanying drawings is a safety bar 23 which, located in the bottom of the oven, is designed to stop the overhead conveyor in the event an automobile body or other object passing through the oven on the overhead conveyor falls from the conveyor carrier 22. Not shown in detail, it is sufficient to say that the safety bar 23 is wired in conjunction with the conveyor motor (not shown) so that any object falling across the bar causes a short in the circuit and stops the conveyor system until such fallen object is removed.

I claim:

1. An infrared ray paint-baking oven comprising in combination, a framework, a housing over said framework, a series of electrically powered infrared ray sources adjustably mounted on said framework within said oven, perforated metal panels suspended within said oven in the path of said infrared rays and within a uniform distance of the sources thereof, blower means to provide a constant circulation of air in said oven, duct and vent means on the floor of said oven positioned so as to direct opposing currents of air into said oven and to result in upwardly eddying currents of air passing around and through said baffle plates, and an exhaust escape means.

2. An apparatus for drying enamel or a similar coating upon motor vehicle bodies comprising, an adjustable boxlike framework, the sides, top, and bottom, excepting the ends, of such framework being covered with heat resistant material, a plurality of infrared ray sources mounted on the inside of said boxlike framework, an inner liner in said framework, said inner liner comprising sheets of perforated metal suspended in front of said infrared sources so as to be directly exposed to the radiations emanating from the said sources, an air circulating means having a fresh air intake thereon, said air circulating means to

forcibly circulate air through said oven, ducts from said air circulating means to said oven, inlet vents of said ducts to said oven being located at the bottom of said oven and on either side thereof and disposed to discharge opposed currents of air along the floor of said oven so as to cause said air currents to eddy and flow upwardly through said oven over said infrared sources and over and through said inner liner, outlet vents from said oven to said air circulating means located in the upper portions of the side walls of said oven, outlet ducts from said exhaust vents to said air circulating means, and an exhaust vent permitting the escape of fume-saturated air from the said oven to the exterior thereof.

3. In an apparatus for drying and curing enamels or similar coatings, a combination comprising an open-ended boxlike framework having adjustable members, an outer sheath of heat-resisting material covering said boxlike framework, an inner liner in said boxlike framework, said liner comprising metal sheets uniformly perforated to effect the removal of approximately 50% of the metal therefrom, a plurality of carbon filament infrared ray lamps mounted on said framework between said outer sheath and said inner liner, said lamps positioned to permit the infra-red rays emanating therefrom to be partially intercepted by said metal sheets, an air blower system having a fresh air intake, ducts from said blower system to said apparatus, vents in said ducts, said vents positioned in said apparatus so as to create a flow of air from the bottom of said apparatus over and around said infra-red ray lamps and

said inner liner, and an exhaust vent to permit the escape of fume-saturated air from said apparatus.

4. In a paint drying apparatus, a tunnel provided with infrared sources on the interior walls, perforated metal plates placed adjacent the infrared sources and on the side of said sources remote from the wall upon which said sources are mounted so that the generated infrared radiation must pass through the perforated metal plates to reach the axis of the tunnel, means for causing air to pass toward the work through the perforations and other means to cause air to pass between the perforated plates and the work and means for conveying such work through the tunnel.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,284,218	Benjamin	Nov. 12, 1918
1,559,076	Collins	Oct. 27, 1925
1,720,678	Judelson	July 16, 1929
1,947,338	Furbush	Feb. 13, 1934
2,317,426	Wilson	Apr. 27, 1943
2,368,124	Elliott	Jan. 30, 1945
2,376,207	Tetzlaff et al.	May 15, 1945
2,391,764	Andrews	Dec. 25, 1945
2,406,494	Ferris	Aug. 27, 1946
2,439,005	Jensen	Apr. 6, 1948