June 21, 1966 O. HULTGREEN 3,257,542

INFRARED HEATING SYSTEM

Filed Aug. 13, 1963 2 Sheets-Sheet 1

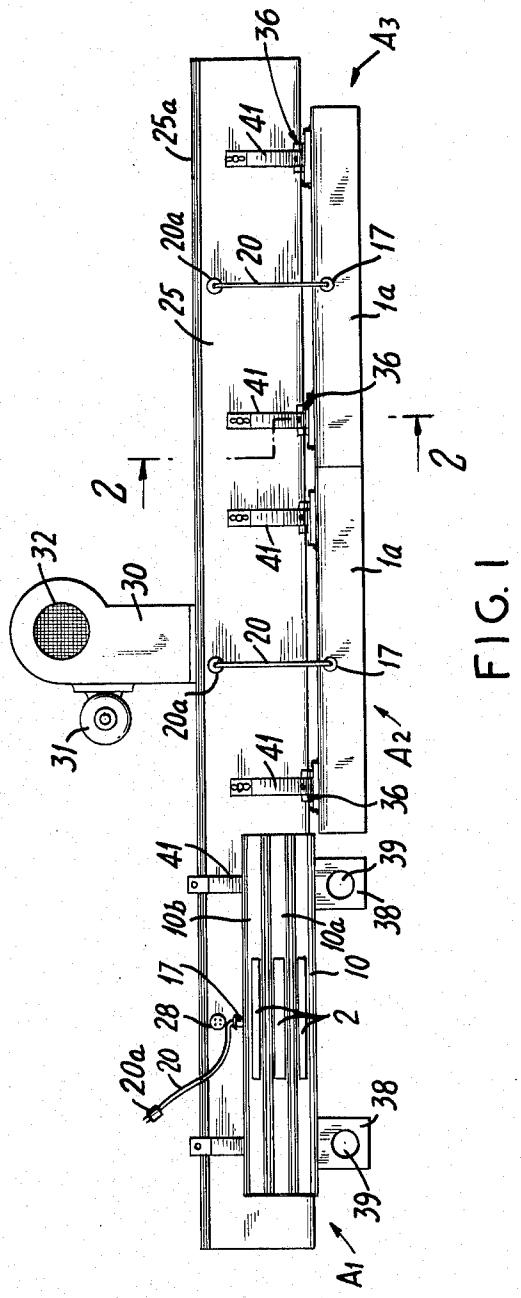


FIG. 1

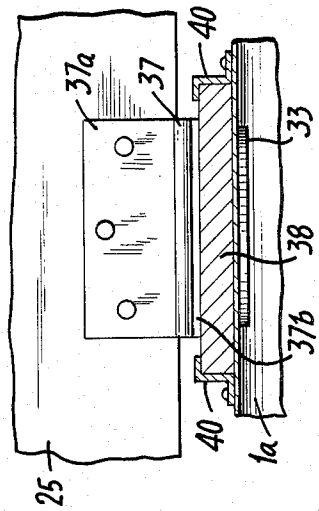


FIG. 3

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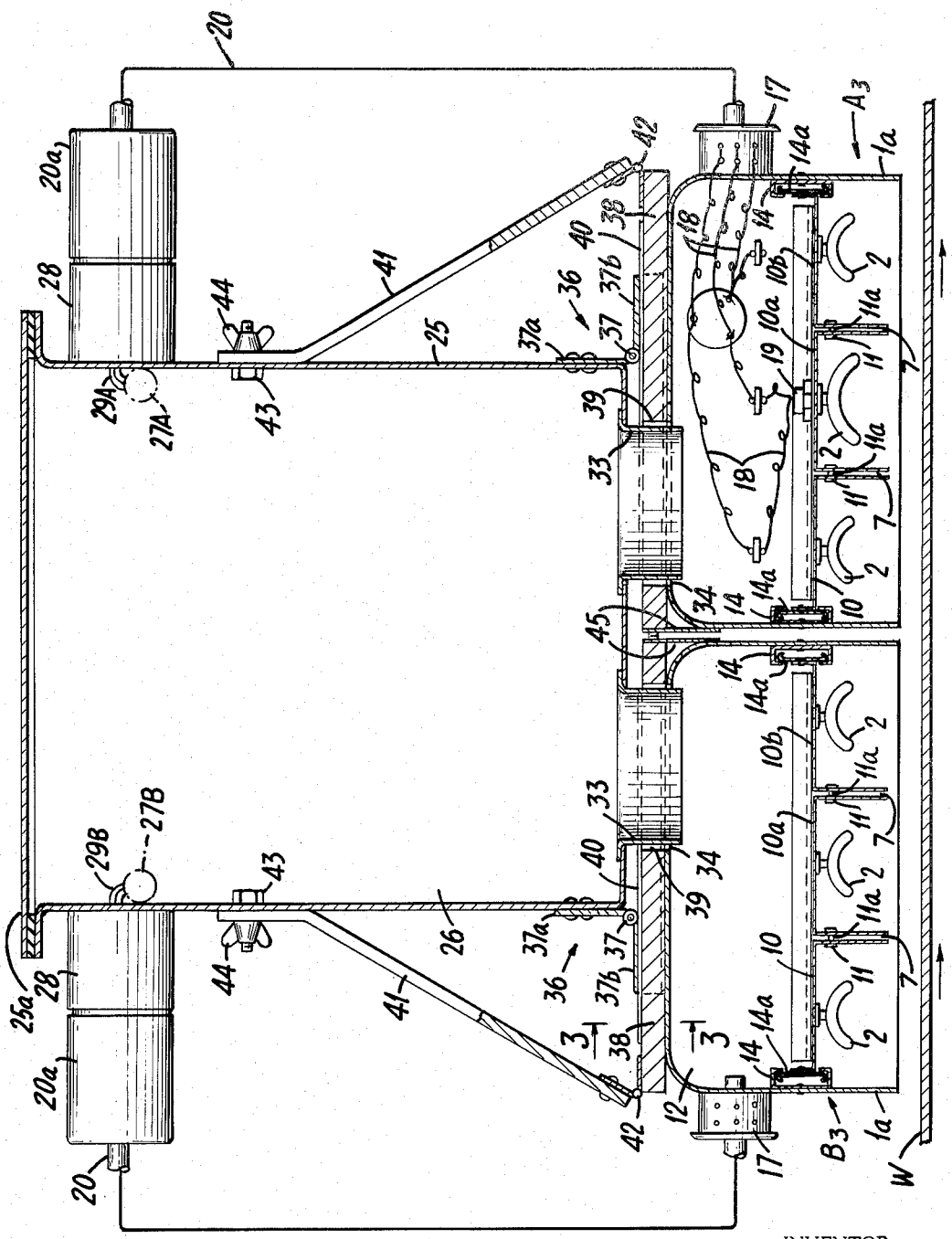


FIG. 2

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3,257,542

INFRARED HEATING SYSTEM

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10 Claims. (Cl. 219—352)

This application is a continuation-in-part of my copending application, Serial Number 107,399 field May 3, 1961, now Patent Number 3,141,089 granted July 14, 1964, entitled, "Infrared Heater."

This invention relates to infrared heating systems and more particularly to an improved apparatus of this type adapted for efficient high-speed drying of moving webs of large width, and which is of a rugged construction adapted for extended operation with a minimum of system shut-down time.

Infrared heating systems have many industrial uses, including for example the drying of lacquer, varnish and clay coatings, and the drying and curing involved in printing and papermaking. The heating units embodied within an infrared heating system generally consist of an infrared emitter, a housing supporting the emitter, and wiring connections for electrically energizing the emitter. The housing also acts as a reflector to redirect the energy from the emitter element toward the surface of the moving web or other article to be treated. The housing may have the shape of an inverted receptacle with an open bottom, the infared emitter being supported in the housing and connected to bus bars leading into the housing. The entire drying unit may be suspended above the moving web so that the latter passes opposite the open end through which the radiation is directed.

These heating units operate at high temperature, sometimes as high as 4000° F. As a result, difficulties have been encountered in providing proper insulation and in dissipating the heat absorbed by the supporting structure, particularly in the areas surrounding the power connectors of the energy source. It has been found that the region of the junction of the power lead-in wiring and the ceramic infrared emitter is critical in this respect, and failure of the unit often occurs here under excessive temperatures. It has also been found that the supporting structure, which also acts as a reflector, will not give constant reflection of the infrared energy from the emitter element if allowed to overheat, and may be damaged due to the high energy concentrations if not adequately cooled.

Heat insulation has proved insufficient to solve the temperature problem for infrared heating units. Generally, such insulation costs are high and constitute a substantial portion of the unit cost. In addition, the weight and physical size of the heater is increased by the addition of an effective amount of insulation material. Also, insulation of the housing chamber containing the electrical connections above the emitter results in a higher temperature in the chamber and consequently creates problems of design in respect to expansion and contraction. Finally, insulation fails to solve the problem of protecting the power connections and the ceramic emitters.

In the extended use of these heating units, a wide range of emitter wavelengths are needed to best perform different heating applications. As a result, difficulties have also arisen in providing apparatus wherein the infrared emitters may be readily and quickly detached from their supporting structure and interchanged with emitters which will produce the desired wavelengths of radiated energy. In prior units, heating operations would have to be stopped for a considerable shut-down period to permit the heating units to be demounted from their supporting frame in order to carry out the interchange. This resulted in loss of valuable time during which the heating

units could be in operation, and also involved a cumbersome manual operation. The same problem was also encountered when repairs were needed on the heating units, and failure of the units during a heating operation often resulted in a lengthy shut-down period causing poorer quality, or the outright loss, of the material undergoing heating treatment. These disadvantages became particularly acute when several heating units were joined together to heat moving webs of wide width, since each unit would have to be demounted whenever it was necessary to interchange the infrared emitters.

The principal object of the present invention is, therefore, to provide a more efficient and versatile heating apparatus of this type which overcomes the above-noted problems.

In a heating system made according to the invention, a member forming a closed manifold chamber serves as a frame to support infrared heating units suspended from it by hinges, the manifold member having an inlet for introducing a gaseous cooling medium (normally air and hereinafter referred to as air) into the system. The electrical power connections used to energize the infrared emitters in the heating units are in part placed in the manifold chamber to prevent damage and wear, and the cooling air circulates past and around the electrical connections. Heat is thereby absorbed from the connections so as to reduce their operating temperature and prolong their life. The air thus heated is then caused to flow from the manifold through air ducts into chambers in the upper portions of housings for the energized infrared emitters of the respective heating units. These housing chambers contain the remainder of the electrical power connections, and the air introduced through the air ducts serves to absorb heat from these remaining connections as well as from a reflecting plate means supporting the infrared emitters. The air thus heated in each housing chamber is directed upon the web surface by a slot at least partly defined by such plate means. In other words, after the air has been heated incident to its cooling action on the electrical connectors and the respective housings for the infrared emitters, it is used to assist in the drying operation by acting as a source of additional heat and providing an air draft which reduces the energy-absorbing vapor barrier over the surface of the web. The cooling effects of the air also allow the use of materials such as aluminum in the housings of the heating units.

Since it is hinged to the overlying manifold member, the housing of each heating unit can be swung from an operating position, wherein its infrared emitters face the web through the open bottom of the housing, to an inoperative position wherein the emitters face generally laterally of the manifold member and therefore are readily accessible for replacement or repair. In moving from one position to the other, each heating unit swings through a path such as not to interfere with the moving web, and the heating elements of particular heating units may thus be repaired or replaced while the remainder of the heating units of the system are still in operation. This feature is particularly desirable where double rows of heating units are suspended from the manifold member.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIG. 1 is a side elevational view of a preferred form of the invention, showing one of the heating units tilted to its inoperative position relative to the common manifold supporting member;

FIG. 2 is an enlarged sectional view on the line 2—2 in FIG. 1, showing also the web to be dried, and

FIG. 3 is a sectional view on line 3—3 in FIG. 2.

Referring to the drawings, the system as shown comprises a row of three heating units A1, A2, and A3, and

a second parallel row of three heating units of which only the unit B–3 is illustrated (FIG. 2). The various heating units are identical and have their corresponding parts indicated by the same reference numbers. Each unit includes a metallic housing **1***a* in the form of an elongated box which is open at the bottom. Each housing **1***a* contains horizontal plate means made up of flanged metal plates **10**, **10***a* and **10***b* supporting ceramic heating elements **2** which are infrared emitters. The supporting plates **10–10***a***–10***b* and their underlying infrared emitters **2** extend lengthwise of the housing **1***a*, and the emitters of the three heating units in each row extend over the entire width of the web W to be dried. While I have shown three plates **10**, **10***a* and **10***b* in each heating unit supporting corresponding heating elements **2**, any other desired number may be employed.

Secured to opposite side walls of each housing **1***a* are longitudinal brackets **14** containing slides **14***a* secured to the outer edge portions of plates **10** and **10***b*. Since the plates **10**, **10***a* and **10***b* are interconnected (as described in more detail presently), the entire assembly of plates and heating elements in each housing **1***a* may be slid as a unit on brackets **14** from the housing through an open end thereof. By making the slides **14***a* in the form of tensioned strips as shown in FIG. 2, they accommodate relative movements of the heating unit parts incident to thermal expansion or contraction, thereby preventing the creation of internal stresses in the supporting structure. Alternatively, longitudinal angle brackets may be secured to the side walls of the housings **1***a*, as described in the parent application identified above, to slidably support the outer edge portions of plates **10** and **10***b*.

The plates **10–10***a***–10***b* supporting the heater elements **2** are joined by releasable connecting means **11**. Spacers **11***a* are provided between opposed vertical flanges of adjacent plates to form slots **7** leading downward from an upper chamber **12** of each heating unit to points above the surface of web W.

The emitters **2** in each housing **1***a* are electrically energized through a wiring network including wires **18** in chamber **12** extending downward through an insulating collar **19** of the corresponding emitter **2**, this collar projecting upward through an opening in the overlying plate of assembly **10–10***a***–10***b*. The wiring **18** from the several emitters **2** is connected to terminals in an insulating member **17** in the outer side wall of housing **1***a*, and these terminals are connected through a flexible connector cable **20** to a pronged plug **20***a*.

A hollow, elongated member **25** forms an air manifold chamber **26** and also serves to support the two rows of heating units A and B located below this member. Within the manifold chamber **26** are two electrical supply cables **27**A and **27**B extending along opposite sides of this chamber and connected to an electric current source (not shown). An insulating socket **28** is secured to the outer face of each side wall of supporting member **25** directly above each of the six heating units A and B. Each socket **28** overlying a heating unit A is electrically connected to cable **27**A through a tap-off **29**A, and each socket **28** overlying a heating unit B is electrically connected to cable **27**B through a tap-off **29**B. The flexible connector cable **20** from each of the heating units A and B has its plug **20***a* inserted in the overlying socket **28** on supporting member **25**. Thus, the emitters **2** of each of these heating units are electrically connected to the supply cable **27**A or **27**B through the wiring network (including wires **18**) in the corresponding housing chamber **12** and through the corresponding cable connector **20** and tap-off **29**A or **29**B.

The top of the hollow supporting member **25** is formed by a cover plate **25***a* secured to the main body of this member by suitable releasable means (not shown), so that cover plate **25***a* may be readily removed to provide access to manifold chamber **26** and the electrical connections therein.

A blower **30** is mounted on cover plate **25***a* directly over an opening therein and serves to force air into manifold chamber **26**. As shown in FIG. 1, the blower **30** is driven by an electric motor **31** and has an intake opening **32** through which air is drawn into the blower and blown downwardly into chamber **26** of supporting member **25**. The bottom of the latter is provided with short ducts **33** leading downwardly from manifold chamber **6**. At least one duct **33** projects through the top of each housing **1***a* by way of an aligned opening **34** in the top, the opening **34** receiving the duct **33** with a slight clearance. Thus, air from blower **30** is forced through ducts **33** by way of manifold chamber **26** and enters the upper chambers **12** in the housings **1***a* of the respective heating units. As it is blown through manifold chamber **26**, the air serves to cool the electrical connections in that chamber.

The air entering each housing chamber **12** serves to case the electrical connections therein as well as the plate means **10–10***a***–10***b*. The bottom surfaces of the latter are reflective, causing the infrared radiation of elements **2** to be directed downward onto the web W. This tends to reduce the temperature within the upper chamber **12** of each housing **1***a* by reflecting radiational heat therefrom. However, the reflecting plate means **10–10***a***–10***b* would become overheated if no provision were made for cooling them. By circulating cooling air through the housing chambers **12**, the plate means **10–10***a***–10***b* are maintained at relatively low temperature to prevent reduced and non-uniform reflection of infrared energy from these plates to the material W being heated. Since the improved heating system is operable at a lower temperature than conventional systems of this type, the housings **1***a* of the heating units and the other metallic parts of the system may be made of aluminum or other metal having a relatively high coefficient of thermal expansion.

Under the action of blower **30**, the air thus heated in each housing chamber **12** is forced downwardly through the slots **7** formed by the corresponding plate means **10–10***a***–10***b*. The heated air streams from slots **7** impinge upon the upper surface of web W, thereby assisting in removal of energy-absorbing vapors from the web and otherwise promoting the drying of the web.

Each housing **1***a* is suspended from the supporting manifold member **25** by hinge means shown generally at **35** in FIG. 1. As shown in detail in FIGS. 2 and 3, each hinge means **36** comprises a hinge **37** having one of its plates **37***a* secured to the adjacent side wall of member **25**, the other hinge plate **37***b* being secured to a block **38** having an opening **39** vertically aligned with the underlying housing opening **34**. The block **38** has a sliding fit in a retaining track **40** secured to the top of the housing **1***a* and extending transversely thereof. Thus, each housing **1***a* is supported by its hinges **37** through the corresponding tracks **40** secured to the housing and the corresponding blocks **38** held in the tracks.

Accordingly, when each housing **1***a* is swung outwardly on its hinges **37**, the hinge blocks **38** and the underlying top of the housing are withdrawn downwardly from the corresponding ducts **33**. When the top of the housing **1***a* clears the lower ends of these ducts, the housing may be pulled outwardly (laterally) relative to supporting member **25**, since the housing tracks **40** are slidable along the hinge blocks **38** held in the tracks. The housing **1***a* may then be tilted further on its hinges **37** to an inoperative position shown at A1 in FIG. 1, without interference from or with the underlying web W. In this inoperative position of the housing, it is disposed generally vertically along the adjacent side wall of supporting member **25**, with the open bottom of the housing facing outwardly from member **25**. Thus, the emitters **2** of the corresponding heating unit A1 are readily accessible, and the entire assembly of emitters and plate means **10–10***a***–10***b* of this unit may be slid endwise though an open end of the housing **1***a* (the end adjacent heating unit A2) to obtain access to the wiring **18** in the housing chamber **12**.

It will be apparent that the heating unit A1 may be restored to its normal horizontal or operating position below the supporting member 25 by following the reverse of the above-noted procedure. Also, each of the six heating units A and B may be similarly moved between operating and inoperative positions independently of the others.

Each heating unit A or B is releasably held in its operating position by means including struts 41 secured at their lower ends through hinges 42 to the outer ends of the corresponding hinge blocks 38. At its upper end, each strut 41 is releasably secured to the adjacent side wall of supporting member 25 by a bolt 43 and a wing nut 44 threaded on the bolt. When thus secured, the struts 41 act as braces to prevent tilting of housings 1*a* from their horizontal operating positions under the supporting member 25. However, by removing the wing nuts 44 and swinging the struts outwardly on their hinges 42 to disengage the bolts 43, the housings 1*a* are free to tilt and slide laterally as previously described.

The hinge blocks 38 are provided at their inner ends with stops 45 engagable with the respective housings 1*a* to limit their inward sliding on these blocks.

Each of the two parallel rows of heating units A and B extends transversely of the web W over its entire width. Thus, as the web is moved along its path under these heating units, it is acted upon by several rows of emitters 2 and several rows of air slots or nozzles 7, each row extending continuously over the web from one edge thereof to the other.

I claim:

1. An infrared heating system comprising a plurality of relatively movable housings each having a bottom opening for passage of infrared radiation, generally horizontal plate means in each housing defining therewith a substantially closed chamber in the upper portion of the housing, electrically operable infrared emitter means in each housing located below said plate means and supported thereby in overlying relation to said bottom opening, each said plate means forming a slot leading downward from the chamber toward said bottom opening of the corresponding housing, electrical wiring in each said chamber through which the corresponding emitter means are adapted to be energized, a hollow elongated supporting member forming a substantially closed manifold chamber for cooling air, means associated with said manifold chamber to cause the flow of cooling air therein, hinge means connecting said housings to the supporting member and through which said member tiltably suspends the housings in substantially adjacent relation along said member, each housing being tiltable from an operating position wherein its emitter means face downwardly from said member to an inoperative position wherein its emitter means face generally laterally of said member, and duct means connecting each housing chamber to the interior of the manifold chamber in said operating position of the housing, said duct means being adapted to permit free movement of said housing from said operative to said inoperative positions, whereby cooling air from said manifold chamber is adapted to pass through said duct means into the housing chamber to cool the corresponding electrical wiring and plate means, and heated air is adapted to pass from the housing chamber through said slot and housing opening.

2. A system according to claim 1, comprising also a releasable strut connecting each housing to said supporting member for holding the housing in one of said positions.

3. A system according to claim 1, comprising also blower means connected to said supporting member for forcing air through said manifold chamber.

4. A system according to claim 1, comprising also means slidably mounting each plate means in the corresponding housing.

5. A system according to claim 1, comprising also an electric supply cable extending along the manifold chamber, and releasable electrical connectors outside the manifold chamber for connecting said cable to said wiring in the respective housing chambers.

6. A system according to claim 1, in which each housing has a top opening, each said duct means including a duct extending downwardly from the manifold chamber into said top opening of the corresponding housing.

7. A system according to claim 1, in which said housings are disposed in parallel rows along the supporting member.

8. The combination of a hollow supporting member forming an air manifold chamber, means associated with said manifold chamber to cause the flow of cooling air therein, a housing having a bottom opening, infrared emitter means mounted in the housing and facing the bottom opening, plate means in the housing overlying the emitter means for reflecting radiation therefrom through said bottom opening, said plate means forming the bottom of an upper chamber in the housing and at least partly defining a nozzle for directing air from the housing chamber through said bottom opening, hinge means suspending the housing from and below said member in an operating position wherein said emitter means and plate means are disposed generally horizontally to radiate and reflect downwardly through said bottom opening, the housing being tiltable on the hinge means from said operating position to an inoperative position wherein said bottom opening faces generally laterally outward from the supporting member and wherein said emitter and plate means are disposed generally vertically, and duct means operable in said operating position of the housing to connect the manifold chamber to said housing chamber said duct means being adapted to permit free movement of said housing from said operative to said inoperative positions.

9. The combination defined in claim 8, comprising also a sliding connection through which the hinge means interconnect the housing and said supporting member, said sliding connection having a first element secured to said housing, a second element secured to said hinge means, said elements being associated so as to permit sliding movement therebetween, the housing being slidable laterally outward from said member on said sliding connection while tiltable on the hinge means.

10. The combination defined in claim 8, comprising also a sliding connection through which the hinge means interconnect the housing and said supporting member, the housing being slidable laterally outward from said member on said sliding connection while tiltable on the hinge means, said sliding connection including a track element extending laterally of the supporting member and a block element slidably retained in the track element, one of said elements being secured to the housing and the other element being secured through the hinge means to said supporting member.

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