

[54] **APPARATUS FOR CURING SOLVENT-FREE PRINTING MATERIAL**

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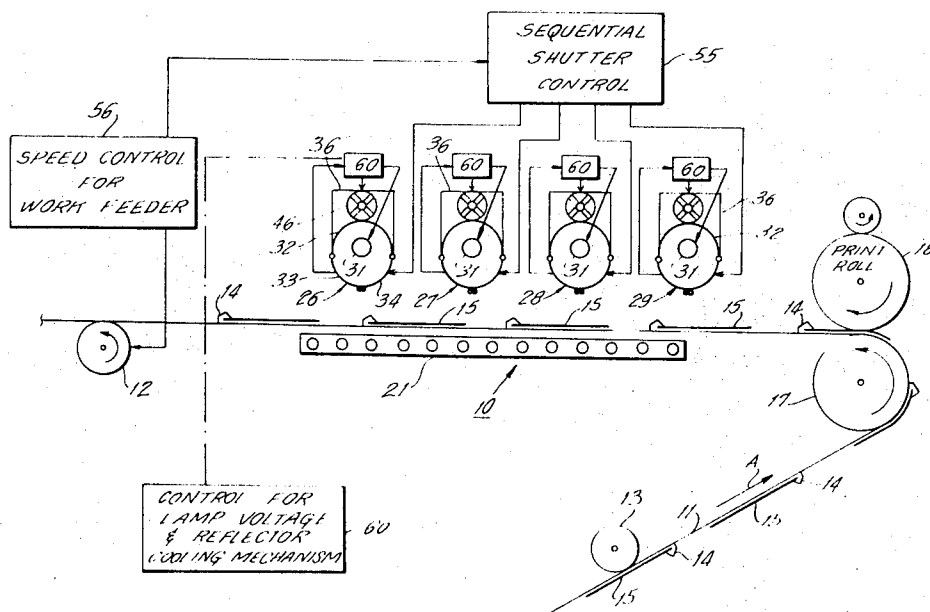
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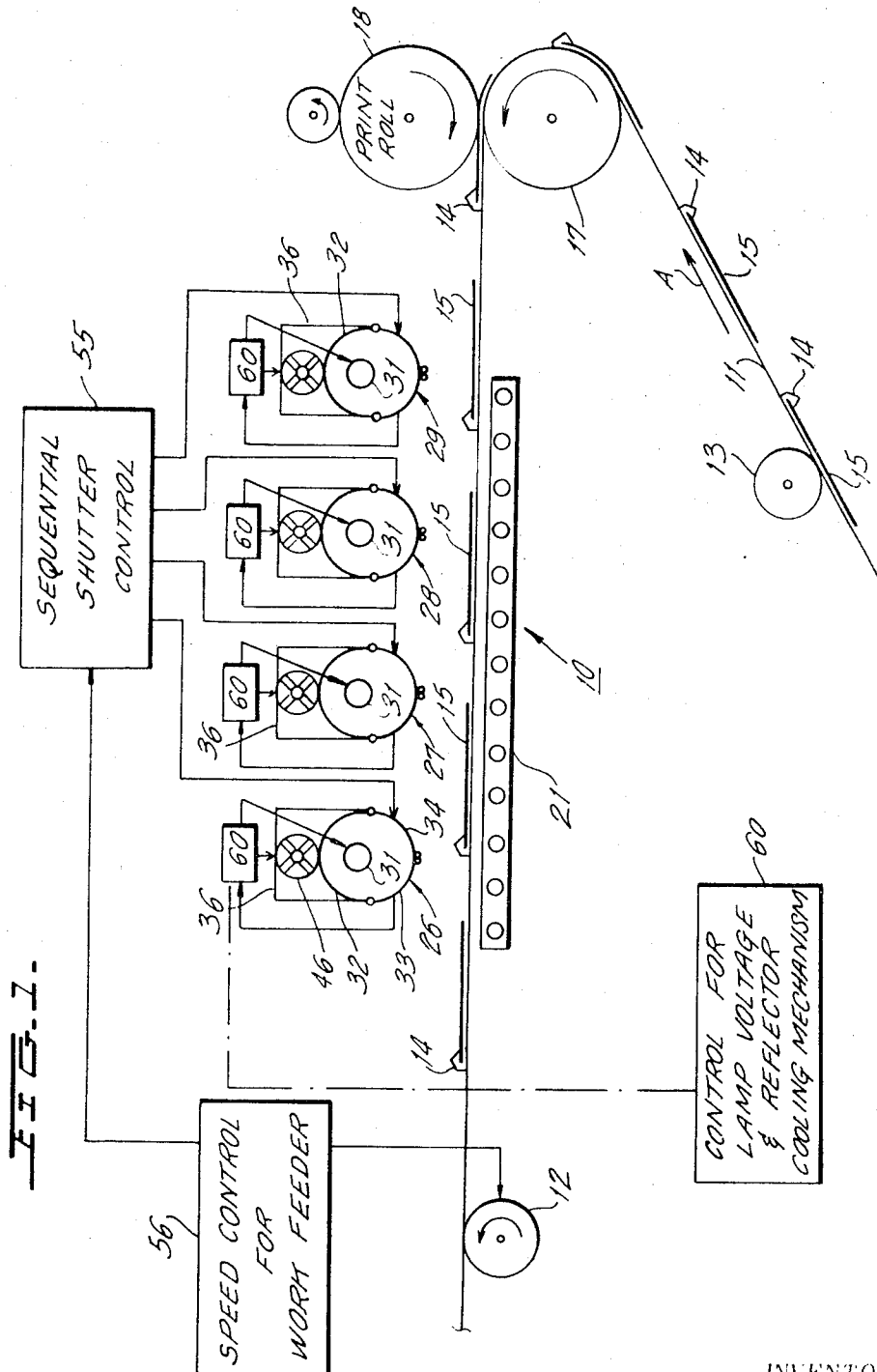
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[57] **ABSTRACT**

Printing apparatus utilizing lamps generating ultraviolet light to cure solvent-free ink by photopolymerization is provided with lamp reflectors having shutters to permit the lamps to remain energized while the printed work conveyor is stopped or is moving at a slow rate. A plurality of such lamps, each with an individual shutter, are arranged in parallel rows extending transverse to direction of movement of the work. The number of reflectors having open shutters is automatically coordinated with work conveyor speed, with an increase in conveyor speed being accompanied by an increase in the number of reflectors having open shutters. As each shutter is closed, the lamp voltage is reduced to a standby point where the lamp remains fired and at the same time increased air circulation is provided for cooling of the associated reflector. A liquid cooled plate is positioned behind the work feed path to shield other elements of the apparatus from lamp radiation.

10 Claims, 6 Drawing Figures





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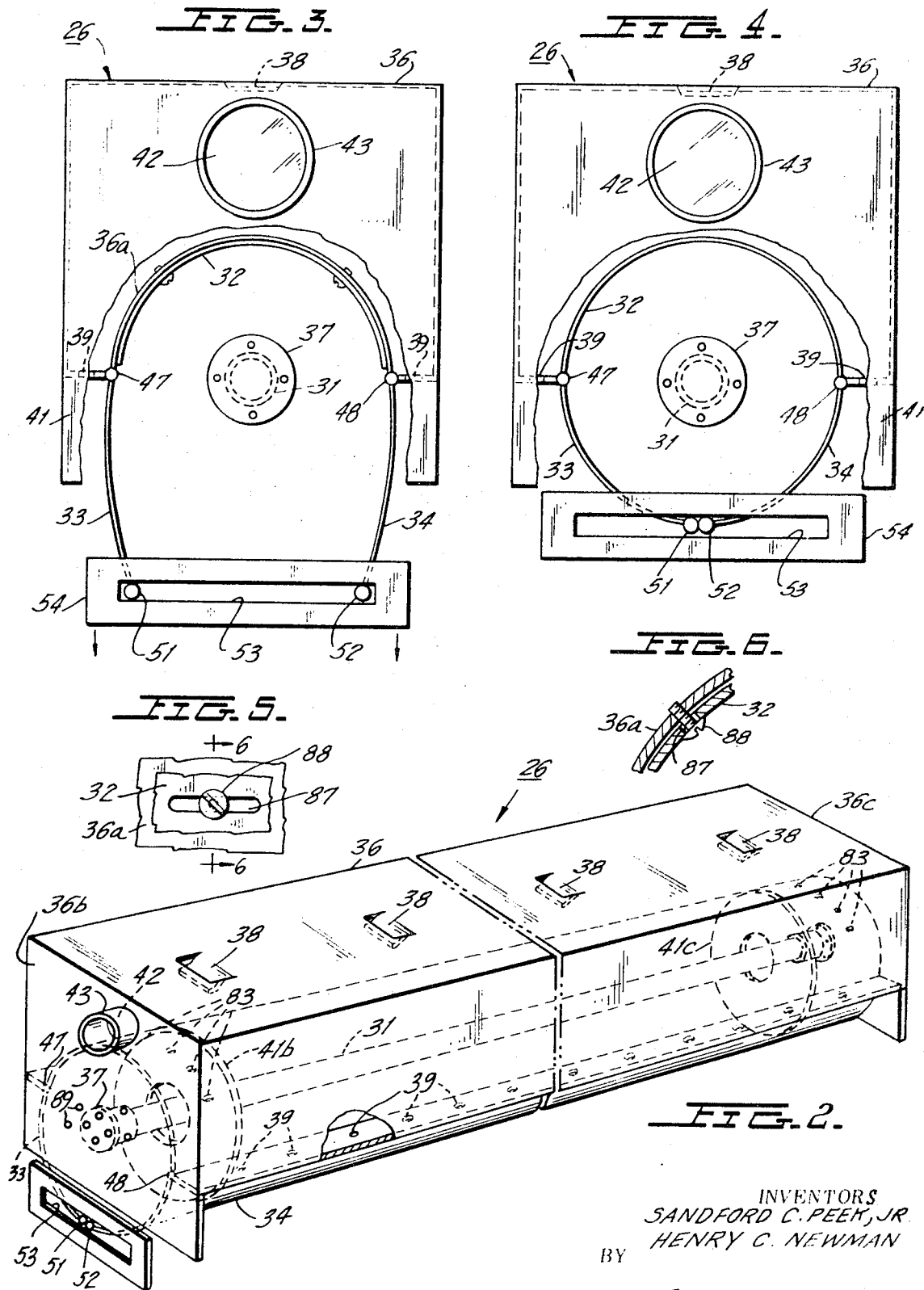
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APPARATUS FOR CURING SOLVENT-FREE PRINTING MATERIAL

This invention relates to printing apparatus in general, and more particularly relates to means for curing solvent-free inks, and is an improvement over the apparatus disclosed in U.S. Pat. No. 3,159,464 issued Dec. 1, 1964, to H. C. Early et al. for a Method of Drying Printed Webs.

Solvent-free inks and other solvent-free coatings are finding increased utilization in industry, particularly in view of the fact that use of such materials greatly lowers or completely eliminates air pollution of the type that results from the curing of solvent-bearing inks and coatings. High-speed curing of solvent-free materials is accomplished by utilizing high-power ultraviolet radiation which is directed at the material immediately after application thereof.

In accordance with the instant invention, in printing apparatus ultraviolet radiation is produced by a plurality of parallel elongated tubes extending transverse to the direction of movement of the printed material. Associated with each lamp is an elliptical reflector means for concentrating the ultraviolet radiation in narrow bands impinging upon the printed material as the latter leaves the printing station of the apparatus. The reflector is force-cooled by air circulation primarily at the rear of the reflector, since excessive cooling on the lamp side of the reflector would cause the lamp to cool excessively and extinguish. Shutter means having reflector properties are operable to a closed position to block light from impinging upon the printed material without the necessity of extinguishing the lamp.

Shutter operation is coordinated with speed of travel of the printed material past the lamps, with a decrease of speed automatically being accompanied by a decrease in the amount of ultraviolet light impinging instantaneously on the printed matter, such automatic control being accomplished by closing the shutters for the required number of lamps.

Since the refiring time for the lamps in question is usually in the neighborhood of ten to twelve minutes, in order to conserve press time, the lamps should not be extinguished. Thus, in order to prevent excessive heating of the reflector when its shutter is closed, the lamp is operated at reduced or standby power, with firing maintained, and increased air circulation is applied for cooling of the reflector.

When the printed matter passes in front of the ultraviolet producing lamps, such printed matter is closely spaced from a cooling plate means upon which the ultraviolet rays would impinge in the absence of printed matter, as when sheets, rather than a web, are being printed. The presence of the cooling plate means protects other components of the apparatus from heat damage and prevents heating of any components that could be contacted by paper from being heated to the kindling point of paper.

Accordingly, a primary object of the instant invention is to provide improved photopolymerization means to cure solvent-free inks and coatings.

Another object is to provide means for automatically regulating lamp energy applied to moving work as a function of the speed thereof.

Still another object is to provide improved coordinated operation between a lamp, cooling means for the lamp reflector, and shutter means to selectively block energy from the sheet.

A further object is to provide novel means to protect printing apparatus elements from excessive heating as a result of lamp energy provided for curing of ink.

These objects as well as other objects of this invention will become readily apparent after reading the following description of the accompanying drawings, in which:

FIG. 1 is a schematic illustrating a portion of printing apparatus constructed in accordance with teachings of the instant invention.

FIG. 2 is a perspective of a lamp reflector assembly for the apparatus of FIG. 1.

FIGS. 3 and 4 are end views of the lamp reflector assembly, looking from left to right, with respect to FIG. 2. In FIG. 3 the reflector-shutter is opened and in FIG. 4 the shutter is closed.

FIG. 5 is an elevation showing a fragment of the reflector sheet and its loose connection to the reflector housing.

FIG. 6 is a cross-section taken through line 6-6 of FIG. 5, looking in the direction of arrows 6-6.

Now referring to the figures. Printing apparatus 10, illustrated schematically in FIG. 1, includes feed chain 11 driven in the direction of arrow A by feed sprocket 12 and guided by idler 13 and additional idlers (not shown). A plurality of releasable grippers 14 carried by feed chain 11 hold individual sheets 15 for conveyance by chain 11 along a feed path that extends between pressure cylinder 17 and print cylinder 18.

After printing is applied to sheets 15, they pass over water-cooled plate 21, being spaced thereabove by approximately 1 inch. While sheets 15 pass over cooling plate 21, they pass beneath radiant energy source lamp-reflector assemblies 26-29 to cure by photopolymerization the solvent-free ink applied to sheets 15 by print cylinder 18. As will hereinafter be seen, each assembly 26-29 causes a high intensity radiant image to be formed on work surface or feed path traveled by sheets 15. Since each of the assemblies 26-29 is identical, only the essential details of assembly 26 will be hereinafter described by particular reference to FIGS. 2-5.

Assembly 26 includes elongated tubular ultraviolet-producing lamp 31 and stationary hood-like elliptical reflector sheet 32 positioned to the rear of lamp 31 to focus energy near peak intensity from lamp 31, so that such energy is concentrated over a short distance along the feed path for chain 11 and housing 36 to the rear of reflector sheet 32 provides a support for sheet 32 and lamp sockets 37. Reflector extensions 33, 34 are hinged to housing 36 along the lower edges of concave bottom wall section 36a and constitute a shutter means operable between the open position of FIG. 3 and the closed position of FIG. 4. Typically, lamp 31 is a quartz, medium pressure, mercury discharge tube, in the power range of 50 to 400 watts per inch.

Housing 36 is constructed of structurally strong metal, whereas reflector 32 is of relatively thin stock, typically 0.005 to 0.150 inch thick. Preferably, the latter is constructed of a lightweight metal that retains reflective properties by resisting oxidation even in an oxidizing atmosphere accompanied by heat and ultraviolet radiation. Suitable metals are sold under the trademarks Lurium and Alzak. Reflector 32 is mounted to concave housing wall 36a by a plurality of screws 88 (FIGS. 5 and 6) that pass through longitudinally extending slots 87 in reflector 32. This type of mounting

permits reflector 32 to expand and contract independently of housing 36 when temperature differentials are present. Relative movement between reflector 32 and housing wall 36a is also facilitated by having the threaded body of screw 88 of a diameter substantially less than the width of slot 87.

Housing 36 is shaped to provide a conduit to guide flow of cooling air over the rear surface of housing wall 36a which is in contact, or heat conducting relationship, with reflector sheet 32. In particular, lamp tube 31 is positioned at the focus of elliptical reflector 32, which extends along the full length of lamp 31.

In a manner well known to the art, electrical connections to lamp 31 are made through cap-type sockets 37 at opposite ends of lamp 31, with such sockets being mechanically supported at opposite ends of housing 36 on end walls 36b, 36c thereof. Additional holes 89 in walls 36b, 36c are provided for repositioning of sockets 37, depending upon the orientation of assembly 26 with respect to earth in that the arc in lamp 31 tends to rise toward the top of the lamp tube. Thus, in order to maintain the arc at the focal point of reflector sheet 32, sockets 37 must be appropriately positioned.

The top wall of housing 36 is provided with a plurality of indented louvers 38, while the inwardly turned portions at the bottom edges of housing 36 are provided with a plurality of small holes 39. Left end wall 36b of housing 36 is provided with circular exhaust opening 42, surrounded by outwardly extending cylindrical sleeve 43. A flexible conduit (not shown) from a suction blower (not shown) is adapted to be attached to sleeve 43 to draw air into housing 36 through louvers 38, with such air circulating over the rear surface wall 36a to cool reflector 32. Holes 39 along the lower edges of housing 36 are provided for drawing off of ozone, generated by ignited lamp 31, especially during warm-up thereof, into the air stream generated by the suction blower shown schematically in FIG. 1 as dual speed fan 46.

The inner surfaces of shutters 33, 34 are polished to reflect the energy from lamp 31 and cooperate with reflector sheet 32 in concentrating this energy. Baffle sheets 41b, 41c, inboard of end walls 36b, 36c respectively, are provided with reflecting surfaces to reflect energy back into the work area and assist reflector sheet 32 in preventing energy intensity drop-off at the end regions of reflector 32. Baffle sheets also serve to partially shield sockets 37 from the heating effects of lamp radiation. Concave wall 36a in the regions between baffles 41b and 41c and their respective near end walls 36b, 36c are provided with apertures 83 through which cooling air is drawn over sockets 37. Thus, fan 46 creates a suction on negative pressure, which causes air to flow in chambers 80b, 80c past the lamp ends in sockets 37 and through housing chamber 79, in such a manner that sockets 37 and reflector 32 are cooled, yet little if any air moves past the major portion of the lamp body.

Shutter sections 33, 34 are hingedly connected at 47, 48 to the free edges of concave housing wall 36a along the entire length thereof. Follower rollers 51, 52 are secured to the free edges of the respective shutter parts 33, 34 and are disposed to move within slot 53 of operating member 54. Upward movement of upper 54 is effective to force rollers 51, 52 to converge, thereby operating shutter 33, 34 from the open position of FIG. 3 to the closed position of FIG. 4.

In operation conveyor speed control 56 (FIG. 1), acting to control the speed of drive sprocket 12, feeds signals to control 55, which sequentially operates the shutters of lamp reflector assemblies 26-29. More particularly, as work conveyor 11 slows down, the number of shutters operated to close positions is increased so as to prevent overheating of the work. That is, as printed sheets 15 move at a slower rate they are in the field of radiant energy source 25 for a longer time, so that in order to maintain the total quantity of radiant energy impinging on printed sheets 15 to a desired level it is necessary to decrease the available energy from source 25 that is applied to printed sheets 15. This is accomplished by closing the shutters of those lamp reflector assemblies 26-29 that are not required.

Operation of the shutter means 33, 34 for each of the assemblies 26-29 is coordinated by control 60, so that upon closing of shutter 33, 34 lamp voltage is reduced to a point where current through lamp 31 is at a standby level, much lower than the operating current level. At the same time reflector cooling is increased, through increase of blower motor speed or operation of a damper (not shown). It is noted that standby current is at a level which will maintain lamp 31 in a fired condition. Conversely, opening of shutter 33, 34 is accompanied by an increase in lamp voltage and a decrease in the amount of cooling air impinging on stationary reflector 32. Increased cooling is required when shutter 33, 34 is closed even though lamp voltage is reduced, in that lamp 31 is in a substantially enclosed region that does not have the extensive opening that is present when shutter 33, 34 is open.

Cooling plate 21 is preferably water-cooled, and is positioned so as to shield the other elements of apparatus 10 from the rays of radiant energy source 25. This is particularly important in a sheet printing machine, as shown, rather than in a web machine, because of the fact that there are extensive spaces between adjacent sheets. In the absence of cooling plate 21, such spaces between sheets 15 would permit rays from energy source 25 to impinge upon and heat other elements of apparatus 10, either to the point of destruction or to a point where they become so hot that contact by sheet 15 would be sufficient to cause a fire.

Although there have been described preferred embodiments of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited not by the specific disclosure herein but only by the appending claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including an ultraviolet-producing lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor

means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open.

2. Apparatus as set forth in claim 1, in which there is a cooling element closely spaced with respect to said feed path and on the side thereof remote from said radiant energy means to shield other elements of said apparatus from having said radiation impinge thereon.

3. Apparatus as set forth in claim 1, in which the lamp has a characteristic in which there is an operating current at which a normal radiation level is present, a radiation extinguishing current below said operating current, and a standby current at which a significantly reduced radiation level is present, said standby current being between said operating and extinguishing currents; another control means to automatically coordinate energization of said lamp and operation of said shutter means, whereby upon closing of said shutter means energization of said lamp is reduced from said operating current to said standby current.

4. Apparatus as set forth in claim 3, in which there is a cooling element closely spaced with respect to said feed path and on the side thereof remote from said radiant energy means to shield other elements of said apparatus from having said radiation impinge thereon.

5. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including a lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open; and a cooling element closely spaced with respect to said feed path and on the side thereof remote from said radiant energy means to shield other elements of said apparatus from having said radiation impinge thereon, said cooling element comprising a liquid-cooled plate means.

6. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including a lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open, said reflector being an elongated hood-like mem-

ber of elliptical cross-section and the shutter means comprising elongated reflecting sections connected to the reflector along opposite edges thereof.

7. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including an ultraviolet-producing lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open, said lamp having a characteristic in which there is an operating current at which a normal radiation level is present, a radiation extinguishing current below said operating current, and a standby current at which a significantly reduced radiation level is present, said standby current being between said operating and extinguishing currents; another control means to automatically coordinate energization of said lamp and operation of said shutter means, whereby upon closing of said shutter means energization of said lamp is reduced from said operating current to said standby current.

8. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including a lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open, said lamp having a characteristic in which there is an operating current at which a normal radiation level is present, a radiation extinguishing current below said operating current, and a standby current at which a significantly reduced radiation level is present, said standby current being between said operating and extinguishing currents; another control means to automatically coordinate energization of said lamp and operation of said shutter means, whereby upon closing of said shutter means energization of said lamp is reduced from said operating current to said standby current; and a cooling element closely spaced with respect to said feed path and on the side thereof remote from said radiant energy means to shield other elements of said apparatus from having said radiation impinge thereon, said cooling element comprising a liquid-cooled plate means.

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9. Apparatus including curing means for solvent-free coating and printing material, said curing means including radiant energy means, and conveyor means for moving work to which said material is applied along a feed path in front of said radiant energy means, whereby radiation therefrom impinges on said work and cures the material thereon; said radiant energy means comprising a plurality of sections each including a lamp, a reflector to direct radiation from said lamp toward said feed path, shutter means operable to a closed position to block radiation from reaching said feed path, operating means to open and close said shutter means; said first control means to automatically coordinate operation of said conveyor means and said radiant energy means, whereby an increase in speed of said conveyor means is accompanied by an increase in the number of said sections having their shutter means open, said lamp having a characteristic in which there is an operating current at which a normal radiation

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level is present, a radiation extinguishing current below said operating current, and a standby current at which a significantly reduced radiation level is present, said standby current being between said operating and extinguishing currents; another control means to automatically coordinate energization of said lamp and operation of said shutter means, whereby upon closing of said shutter means energization of said lamp is reduced from said operating current to said standby current, wherein said lamp includes an elongated envelope and the reflector is an elongated hood-like member positioned behind the envelope and extending the length thereof.

10. Apparatus as set forth in claim 9, in which the elongated hood-like member is of generally elliptical cross-section, and the shutter means comprises elongated reflecting sections connected to the reflector along opposite edges thereof.

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