Aug. 11, 1964 J. W. RUSSELL 3,143,921

PHOTOGRAPHIC ENLARGER SYSTEM

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FIG. 1.

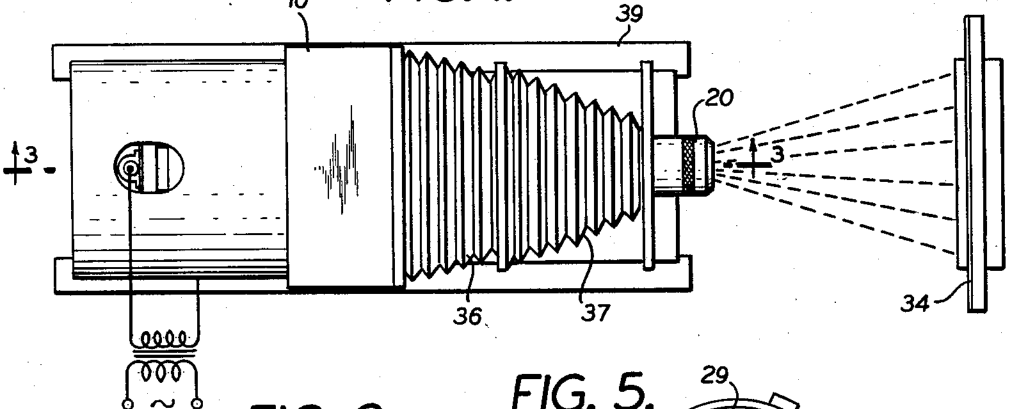


FIG. 2.

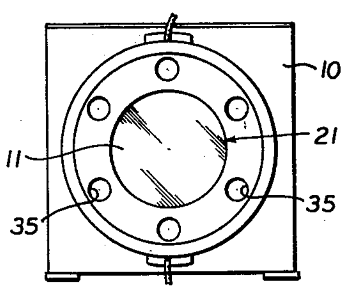


FIG. 5.

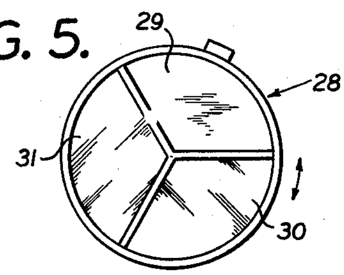


FIG. 4.

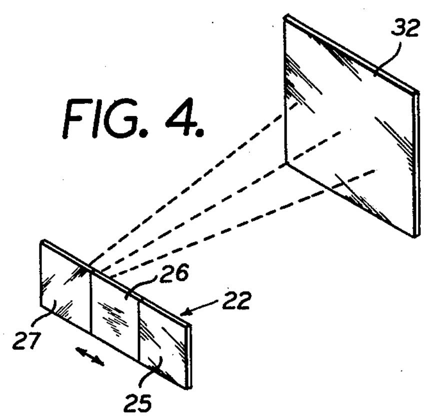
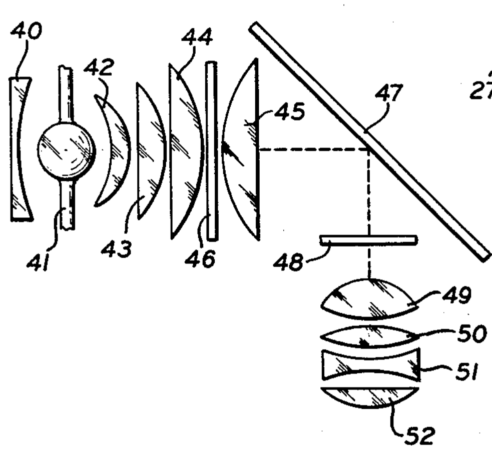


FIG. 6.



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PHOTOGRAPHIC ENLARGER SYSTEM

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FIG. 3.

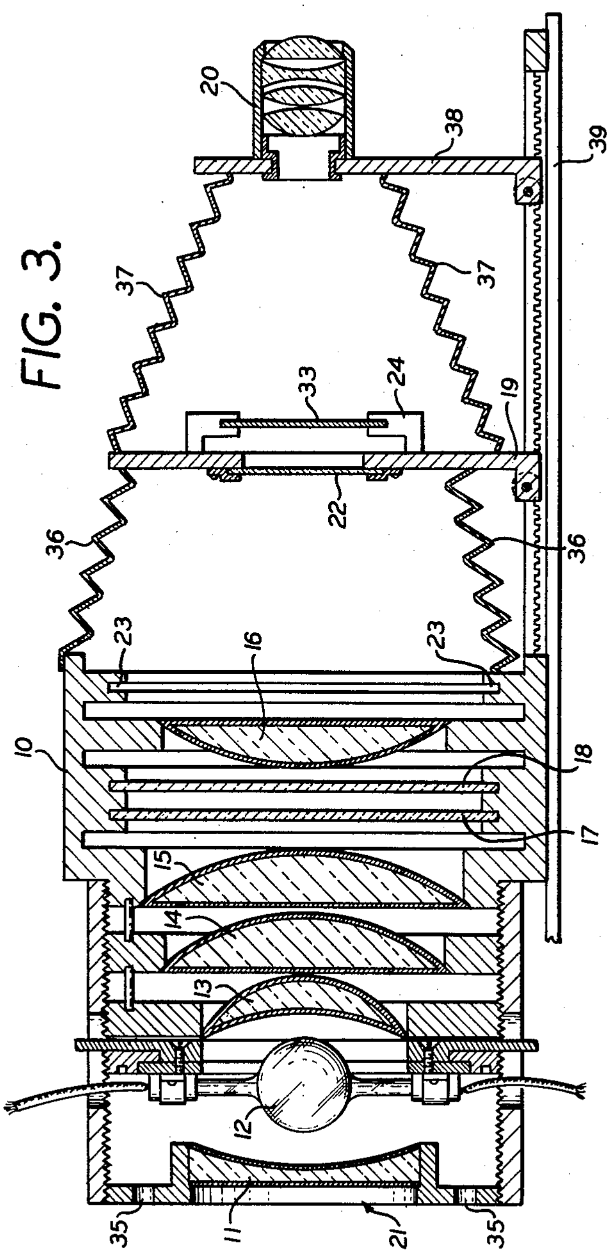
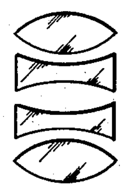


FIG. 7.



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PHOTOGRAPHIC ENLARGER SYSTEM

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6 Claims. (Cl. 88—24)

The present invention relates to a photographic enlarger system for high speed enlarging, especially adapted for use with slow speed photosensitive materials such as diazos.

From the standpoint of speed, sharpness and definition, conventional enlarger systems have not produced satisfactory results with the use of anything but the more expensive non-contact grade papers, such as silver emulsions. It has not been possible, or practicable, to enlarge or reduce with the use of the less expensive contact grade materials, such as diazo, which have been largely, if not exclusively, confined to size-to-size reproduction. Even when non-contact papers were utilized, it has not always been possible to obtain the maximum sharpness and definition at the minimum speed.

The defects just described are due in large part to the failure of existing systems to utilize a maximum amount of usable light from the light source provided. That is to say, conventional systems utilize less than approximately 25% of the effective light available from the enlarger lamp, in that portion of the spectrum to which the material is sensitive. Moreover, they permit the admittance of unusable light—those portions of the spectrum to which the materials are insensitive, such as infra-red, and which are actually harmful, in that they cause overheating of the housing and distortion of the negative. Therefore, to obtain the optimum result, it has often been necessary to provide elaborate and cumbersome means for cooling the housing and film.

An object of the present invention is to provide a simple and effective photographic enlarger system which admits the maximum amount of light in that portion of the spectrum to which printing papers are sensitive, and which admits the minimum amount of light in those portions of the spectrum to which such papers are insensitive.

Another object of the invention is to provide such a photographic enlarger system which enables the use of inexpensive materials to obtain enlargements of a sharpness and definition heretofore obtainable only with expensive papers, and at comparable or improved increased speeds.

The manner in which the foregoing and other objects of the invention are accomplished will be understood from the detailed description which follows when considered in connection with the accompanying drawing, in which:

FIG. 1 is a top plan view of a photographic enlarger system embodying my invention;

FIG. 2 is a rear elevational view of the enlarger system shown in FIG. 1;

FIG. 3 is a section taken along the plane of the line 3—3 of FIG. 1;

FIG. 4 is a perspective view showing the shutter strip of the enlarger system, in relation to a screen;

FIG. 5 is a plan view of a shutter circle for use in the invention;

FIG. 6 is a diagrammatic section of one modified form of the invention; and

FIG. 7 is a diagrammatic section of a modified form of enlarger lens.

Referring to the drawing, the device comprises a housing **10** in which are mounter a rear mirror **11**, a lamp **12**, a condenser system comprised of lenses **13**, **14**, **15** and **16**, filters **17** and **18**, a film and shutter mounting bracket **19**, and an enlarging lens **20**.

The light source, or lamp **12** is preferably a high pressure short arc mercury vapor lamp, although other comparable lamps may be utilized. The lamp **12** may range from as low as 85 watts to 500 watts, or more, although with the present invention it is not necessary to increase the intensity of the light source to the point where cooling means must be provided, since, as noted above, one of the principal objects of the invention is the selection and admittance of the maximum amount of usable light, and thus to obtain the maximum effectiveness from a given light source.

The lamp **12** may be mounted vertically—the normal burning position of the lamp—in the housing **10** in any suitable manner. To the rear of the lamp **12** there is mounted a dichroic mirror **11**, having a concave first surface. The first surface of this concave mirror will be calculated to complement the design of the condenser system and will be generated by a portion of a conic section (circle, ellipse, or parabola) rotated about a major axis. This mirror **11** as illustrated is spherical having a radius of 1½ inches to the front surface. Its front surface is coated, e.g. with alternate layers of magnesium fluoride and titanium dioxide, to reflect the usable portion of the mercury spectrum and pass as much of the rest as possible. The base is preferably quartz, although any one of a number of well-known quartz substitutes, such as Pyrex, may be utilized; and such other materials as will readily transmit as much of the non-reflected energy as possible and will not be destroyed, or unduly distorted, by the heat of the lamp.

For best results in this system, the diameter of the mirror should be about 2½ times the diameter of the lamp bulb. This mirror reflects 80% or more of a band about 1000 A. wide, or less—and preferably as narrow as possible, matching material sensitivity. Diazo contact papers, for example, are most sensitive in the range around 3800 A., and the mirror **11** should be so coated that the reflection at the 3650 A. line and other usable portions of the mercury spectrum will be as high as possible. The mirror transmits more than 80% of the entire spectrum, outside the range of reflection referred to above, including infra-red rays, which, if reflected back through the lamp and thence into the condenser system, could result in overheating, shorten considerably the useful life of the lamp **12**, and cause distortion or wrinkling of the film. The mirror transmits these unusable portions of the spectrum through the opening indicated at **21**, provided for that purpose in the housing **10**. The use of such a mirror results in a reduction of 10 to 15% in exposure time.

The usable portion of the spectrum is reflected by the mirror **12** back through the lamp **11** and into the condenser system, which consists of lenses **13**, **14**, **15** and **16**, and filters **17** and **18**. The lenses, as well as the mirror **11**, are preferably of quartz, although quartz substitutes, and many other optical glasses which transmit readily the 3500 to 4100 A. range may be utilized. These four lenses must be coated to reduce reflection and to give maximum admittance to the usable portion of the mercury spectrum. For example, they may be coated with a single thickness of magnesium fluoride specifically calculated to be an optical thickness of one quarter wave at 3800 A. (a yellow-brown reflectance coating), or any of a number of other well-known and widely used reflection-reducing coating materials which reduce total reflection and transmit the usable portion of the mercury spectrum, ranging from about 3500 to 4100 A. One object of the combination of condenser lenses is to obtain a wide angle of acceptance with the first lens. While the characteristics and arrangement of the lenses may be varied, the exemplary combination illustrated in the accompanying drawings and described just below has been found to be particularly effective. The lens **13** nearest to the lamp **12** is a meniscus lens having radii of +50,120 mm., and having a diameter of 78 mm. and a thickness of 13 mm. at its center. The second lens **14** is a plano convex lens having a radius of 85 mm., a diameter of 112 mm., and a thickness at its center of 23 mm. The third lens **15** is a plano convex lens having a radius of approximately 115 mm., a diameter of 134 mm., thickness at the center of 23 mm. The fourth lens **16** is a plano convex lens having the same radius, diameter and thickness as the third lens **15**.

In the form illustrated in FIGS. 1, 2 and 3, the first three lenses, **13**, **14** and **15** should be mounted as closely as possible to each other without actual contact. The lenses in the condenser system are placed in line, and the third and fourth lenses, **15** and **16**, are separated by filters **17** and **18**. Filter **17** is a Furnace Door Blue, a cobalt glass, which filters out a large percentage of the non-usable portion of the visible spectrum not filtered out by filter **18**. Filter **18** is an infra-red absorbing filter. Like the condenser lenses, they are coated, e.g. with a single thickness of magnesium fluoride specifically calculated to be an optical thickness of one quarter wave at 3800 A., to reduce total reflection and to transmit the usable portion of the spectrum.

Although for optimum results, the condenser lenses and the filters must be coated, as described above, it will be apparent that when less than optimum results are usable in a particular case, one or more of the filters, or lenses, or both, may be uncoated.

Together, these filters transmit more than 80% of the usable portion of the spectrum, and less than 10% of the non-usable portion.

The number, type and placement of the filters may be varied. For example, it is possible to reverse the position of the filters **17** and **18** or to place one of the filters, **17** or **18**, between the third and fourth lenses **15** and **16**, and the other filter after the fourth lens **16**. Another alternative arrangement is that in which either one of the filters is placed in the shutter strip **22**, as described below and illustrated in FIG. 4. While best results are obtained with the use of the flat filters, described above, the filters may be incorporated into the condenser lenses. In certain cases where there is high absorption in the film strip, more than one infra-red filter, making a total of three filters, may be desirable. Again, the filters are interchangeable. One possible placement of these three filters is to have the first two mounted between lenses **15** and **16** as shown in FIG. 3; the third filter may be mounted in the slots **23** provided for that purpose, FIG. 3, or, alternatively, it may be mounted in the shutter strip **22**. The filters utilized should, in any event, transmit a maximum amount of light in the usable portion of the spectrum, and a minimum of that in the non-usable portion.

In front of the condenser system are a shutter strip **22** and a film holder **24**, both of which may be conveniently mounted on the film and shutter mounting bracket **19**, illustrated in FIG. 3. The shutter strip **22** is mounted on the bracket **19**, to the rear of the film holder **24**. The shutter strip **22**, FIG. 4, is slidably mounted on the film and shutter mounting bracket **19**. The shutter strip **22** is in three parts, FIG. 4, one section **25** of the shutter strip being opaque, a second section **26** being an ultra-violet transmitting filter eliminating as completely as possible all visible light, and a third section **27**, being one of the infra-red or cobalt blue filters described above, whichever is not already present in the system (if only one type is already present) or it may be blank, if the two types of filters are already present.

Instead of the shutter strip **22** described above, a shutter circle **28**, FIG. 5, may be rotatably mounted on the bracket **19**. The shutter circle **28** is also comprised of three parts: a first, opaque section **29**, a second section **30** being an ultra-violet transmitting filter, and a third section **31** being one of the infra-red or cobalt filters described above, whichever is not already present in the system (if only one type is already present) or it may be blank, if the two types of filters are already present.

It will be understood that the thickness of the two filters **26** and **27**, in the case of shutter strip **22**, or **30** and **31**, in the case of shutter circle **28**, should be adjusted, for critical results, according to the relative indices of refraction. The three-section shutter strip **22**, or circle **28**, is unique, in that it is placed to the rear of the film holder **24** and is extremely useful in focusing the enlarger lens. The second section **26**, or **30**, which transmits the 3650 A. line is used in connection with a fluorescent screen **32** or other material, and conveniently, the same type of diazo contact paper which is to be used in making the exposure. Such paper is fluorescent under the 3650 A. line, even after it has been bleached, and can therefore be used, in connection with the second section **26**, or **30**, for focusing.

Since the second section **26**, or **30**, used for focusing, as described above, transmits only about 55% of the 3650 A. line, when the exposure is made the shutter strip **22**, or circle **28**, is moved so that the light transmitted by the condenser system passes through the third section **27**, or **31**. This third section transmits a much higher percentage of the usable portion of the spectrum, thereby accomplishing the exposure.

The enlarger lens **20**, illustrated in FIGS. 1 and 3 is a commercialy available *f*4–80 mm. or *f*5.6–80 mm. enlarger lens, the Schneider Componon. It has a transmission factor, in the usable portion of the spectrum, of about 60%.

Another lens which might be utilized consists of four elements, FIG. 7. The first and fourth, placed symmetrically to the stop, are positive. The second and third, also placed symmetrically to the stop, are negative. A most effective lens of this type is one which combines sapphire as the positive elements with quartz or other lower index of refraction material, such as the borosilicates, as the negative elements, so as to utilize the relatively low dispersion of the sapphire with the relatively high dispersion of some other high ultra-violet transmitting material.

While object lenses are not commercially available at the present time, coated specifically for high admittance of the usable portion of the spectrum, lenses so coated or recoated will increase the efficiency of this enlarger.

The film **33** may be a silver emulsion on an acetate base. It may be mounted in a suitable holder **24**. Since there is usually some movement or expansion of the film as a result of the radiation absorbed within the film base, some allowance should be made for the expansion of the film, for example, by mounting in an aperture card.

The lamp **12** should be adjusted so that the arc is centrally located with respect to the central axis of the system, since the arcs of such lamps are not uniformly placed in relation to the envelope or the terminals. A prefocus base on the lamp or a frame may be used to simplify such adjustment.

The mirror **11** should be so adjusted that the image of the arc, as reflected by the mirror **11**, falls just in front of the arc itself, i.e., in the direction of the condenser.

For focusing the system, a bellows arrangement as illustrated in FIGS. 1 and 3, may be utilized, the first bellows **36** extending from the forward portion of the housing to the film and shutter mounting bracket **19**, and a second bellows **37** extending from the film and shutter mounting bracket to the enlarger lens **20** which may also be mounted on a suitable support **38**. Bracket **19** and support **38** may be movably mounted on a suitable frame **39**, as illustrated in FIG. 3. It will be understood that the adjustment of the bracket **19** will remain fixed for any given enlarger lens, and that the support **38** will be moved forwardly or rearwardly in focusing.

When an exposure is to be made, the shutter strip **22** is first adjusted so that the opaque section **25** is in the path of the light transmitted by the condenser system. The film **33** is then placed in the film holder **24**. The shutter strip **22** is adjusted so that the second section **26**, which is the ultra-violet transmitting filter, is in the path of the light, and the enlarger is focused with the aid of a screen **32** having a fluorescent surface; instead of such screen, diazo contact paper may conveniently be utilized, mounted on a suitable copy board or other surface. The shutter strip **22** is then moved back to opaque, and a fresh, unexposed photosensitive paper is placed on the screen **32** or other surface. The shutter strip **22** is adjusted so that the third section **27** is in place. The exposure is timed, the opaque section **25** of the shutter strip **22** is moved back into place, and the paper may be removed and developed.

The image of the arc of the lamp **12**, is reflected by the mirror **11** so that it falls just in front of the arc. Thus the intensity of the light source is greatly increased, while at the same time a large part of the non-usable portion of the spectrum is transmitted by the mirror **11**. The condenser system illustrated in and described above gives a wide angle of acceptance with the first two lenses **13** and **14**, and the beams emerge nearly parallel. Coating the condenser lenses **13**, **14**, **15** and **16**, and the filters **17** and **18**, reduces total reflection and greatly increases transmission of the usable portions of the spectrum. The use of the shutter strip **22**, or circle **28**, provides a simple and efficient means for focusing the enlarger.

The enlarger system described above makes practicable for the first time the use of contact papers in enlarging. It has been found, for example, using a 500 watt lamp and an f5.6–80 mm. Schneider Componon lens in the system described above and illustrated in FIG. 3, that exposures of 50 to 55 seconds can be obtained with enlargements of 14 diameters, using "14" speed blue diazo paper. Proportionate exposures can be obtained on other photosensitive materials in accordance with their respective sensitivities to the light band used. The same system, using a conventional, first surface aluminized mirror of the same radii and size in place of the mirror **11**, results in severe damage to the lamp; the same system utilizing the mirror **11** but with uncoated condenser lenses and filters requires longer than four minutes for each exposure. The conventional system, without a rear mirror, without the filters, and with uncoated condenser lenses, results in destruction of the film, so that it is impossible to obtain any exposure.

With the enlarger system of this invention, no elaborate cooling means are necessary. Normally, sufficient cooling will be provided by openings **35** in the rear of the housing **10**, as illustrated in FIG. 2.

One modification of this invention is illustrated in diagrammatic section, in FIG. 6 where the rear mirror **40**, the lamp **41**, condenser lenses **42**, **43**, **44** and **45** and filter **46**, which may be either of the cobalt or infra-red filters described above, are placed in line. A conventional mirror **47** is placed in front of and at a 45° angle with respect to the fourth condenser lens **45** or the central axis of the system. A second filter **48**, which should be the infra-red filter, described above, if filter **46** is the cobalt filter, or vice versa, and the enlarger lens consisting of the elements **49**, **50**, **51** and **52** are placed at a similar angle with respect to the mirror **47**, so that their axis is perpendicular to and coincides with the axis of the condenser lenses. It will be understood that other variations may be made including, for example, the use of two mirrors, in place of the single mirror **47**, and placed in various positions.

From the foregoing detailed description it will be appreciated that I have provided a simple, efficient photographic enlarger system especially adapted for use with slow speed photosensitive materials such as diazos, and although I have shown a preferred embodiment of my invention, it is to be understood that changes in details or construction and arrangement of parts disclosed may be resorted to without departing from the spirit of the invention, as claimed.

What I claim is:

1. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a lamp, a condenser system comprising a plurality of condenser lenses, a dichroic rear mirror having a concave first surface positioned to reflect a substantial percentage of that portion of the spectrum, about 1000 A. wide centered at about 3800 A., to which the said material is sensitive, through said lamp and into said condenser system, means for filtering out a substantial percentage of the non-usable portion of the spectrum, at least a majority of the lens and filter surfaces being coated for low reflection and for maximum admittance of said portion of the spectrum to which the said material is sensitive, and an enlarger lens positioned to receive the light band transmitted by both said condenser system and said means for filtering.

2. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a lamp, a condenser system comprising a plurality of condenser lenses, a dichroic rear mirror having a concave first surface positioned to reflect a substantial percentage of that portion of the spectrum, about 1000 A. wide centered at about 3800 A., to which the said material is sensitive, through said lamp and into said condenser system, means for filtering out a substantial percentage of the non-usable portion of the spectrum, at least a majority of the lens and filter surfaces being coated for low reflection and for maximum admittance of said portion of the spectrum to which the said material is sensitive, a film holder, an enlarger lens and means including a shutter element disposed rearwardly of the said film holder and comprising a section consisting of an ultra-violet transmitting filter for focusing prior to exposure upon a surface sensitive to the light transmitted by such filter, and another section consisting of a filter transmitting for exposure said portion of the spectrum to which the said material is sensitive.

3. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a dichroic rear mirror having a concave first surface, a lamp having an arc, a condenser system in front of said lamp comprising a plurality of condenser lenses coated to reduce reflection and for maximum admittance of that portion of the spectrum to which the said material is sensitive, ranging from about 3500 A. to 4100 A., filtering means coated to reduce reflection and for maximum admittance of a substantial percentage of said portion of the spectrum to which the said material is sensitive, and an enlarger lens positioned to receive the light band transmitted by the said condenser system and filtering means, said lamp having a relatively high output in said portion of the spectrum to which the said material is sensitive, said mirror being disposed to the rear of said lamp and adjusted to reflect the image of the arc of said lamp to a position immediately forward thereof, which mirror reflects substantially the said portion of the spectrum to which the material is sensitive and transmits substantially all other portions of the spectrum.

4. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a lamp having an arc with a relatively high output in that portion of the spectrum, about 1000 A. wide centered at about 3800 A., to which the said material is sensitive, a dichroic mirror having a concave first surface, and having a diameter approximately twice the diameter of the said lamp and placed to the rear of the said lamp, whereby the image of the arc of said lamp is reflected by the said mirror to a position immediately in front of the said arc, which mirror reflects substantially only said portion of the spectrum to which the material is sensitive and transmits those portions of the spectrum to which the material is insensitive, a plurality of condenser lenses disposed forwardly of said lamp, a plurality of filters, of which at least one is a cobalt filter and of which one is an infra-red filter, at least a majority of the lens and filter surfaces being coated for low reflection and for maximum ad-

mittance of said portion of the spectrum to which the said material is sensitive, and an enlarger lens positioned to receive the light band transmitted by both said condenser system and said filtering means.

5. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a short-arc mercury vapor lamp of at least 85 watts, a dichroic mirror having a concave first surface coated with alternate layers of magnesium fluoride and titanium dioxide and having a diameter approximately twice the diameter of the said lamp and placed to the rear of the said lamp, whereby the image of the arc of said lamp is reflected by the said mirror to a position immediately in front of the said arc, which mirror reflects at least about 80% of substantially only that portion of the spectrum, about 1000 A. wide centered at about 3800 A., to which the material is sensitive and transmits those portions of the spectrum to which the material is insensitive, a first, meniscus lens, a second, plano-convex lens, and a third, plano-convex lens, said lenses being disposed in line forwardly of said lamp, at least one filter coated for low reflection and for maximum admittance of said portion of the spectrum, to which the said material is sensitive, a fourth, plano-convex lens, said lenses being coated for low reflection and for maximum admittance of said portion of the spectrum, to which the said material is sensitive, and an enlarger lens positioned to receive the light band transmitted by the said lenses and filter, and which transmits said portion of the spectrum to which the material is sensitive.

6. A photographic enlarger system adapted for use with low-speed photosensitive material comprising a lamp having an arc with a relatively high output in that portion of the spectrum, about 1000 A. wide centered at about 3800 A., to which the said material is sensitive, a dichroic mirror having a concave first surface and having a diameter approximately twice the diameter of the said lamp and placed to the rear of the said lamp, whereby the image of the arc of said lamp is reflected by the said mirror to a position immediately in front of the said arc, a plurality of condenser lenses disposed forwardly of said lamp and coated for low reflection and maximum admittance of the said portion of the spectrum which lenses transmit said portion of the spectrum to which the said material is sensitive, a plurality of filters coated for low reflection and for maximum admittance of said portion of the spectrum, of which at least one is a cobalt and of which at least one is an infra-red filter, which filters transmit said portion of the spectrum to which the material is sensitive, a film holder, a shutter element mounted to the rear of said film holder and comprising an opaque section, an ultra-violet transmitting filter for focusing prior to exposure upon a surface sensitive to the light transmitted by such filter in connection with a fluorescent surface, and a filter for exposure, and an enlarger lens in front of said film holder which enlarger lens transmits said portion of the spectrum to which the material is sensitive.

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