July 5, 1966 M. LOCQUIN 3,259,012

MICROSCOPE HAVING BRIDGE TYPE SUPPORT ARM FOR BODY TUBE AND FOCUSING MECHANISM

Filed Sept. 12, 1960 4 Sheets-Sheet 1

FIG. 1

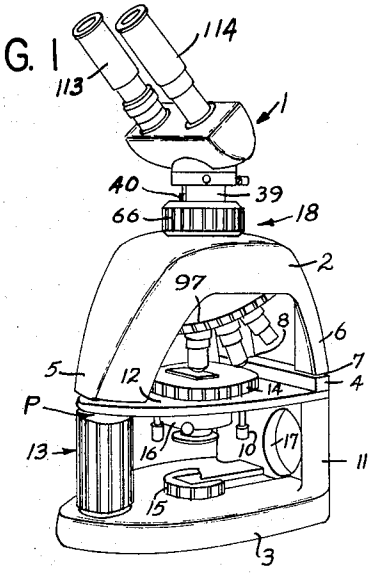


FIG. 2

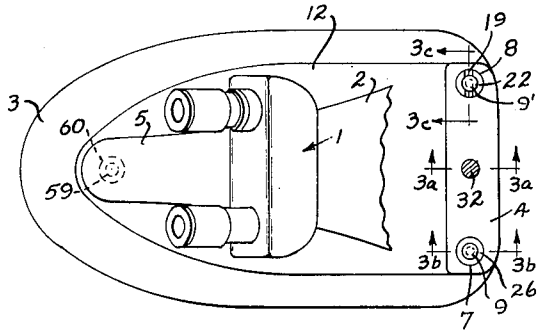


FIG. 3a

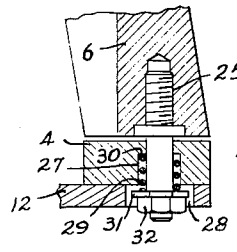


FIG. 3b

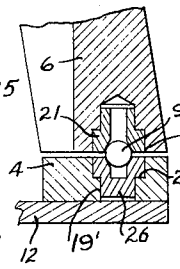


FIG. 3c

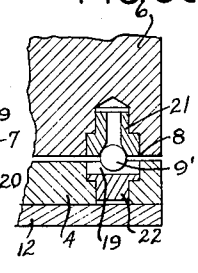
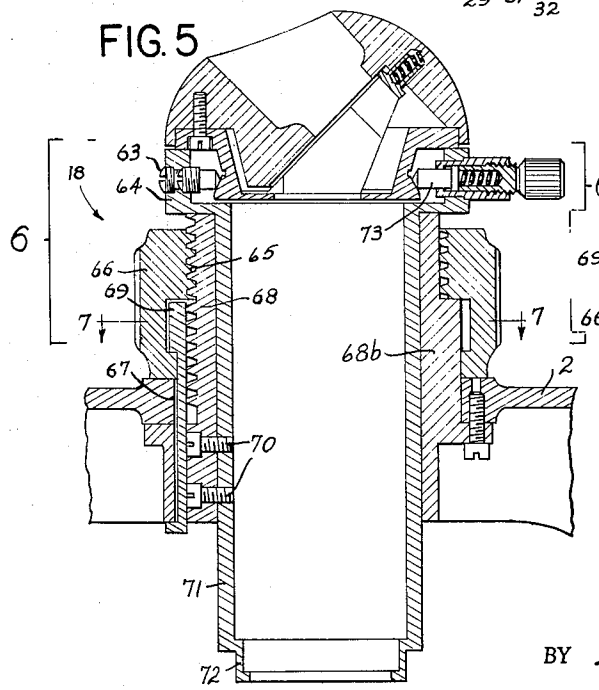


FIG. 5



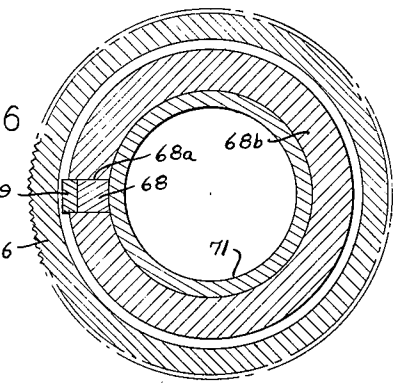


FIG. 7

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FIG. 4

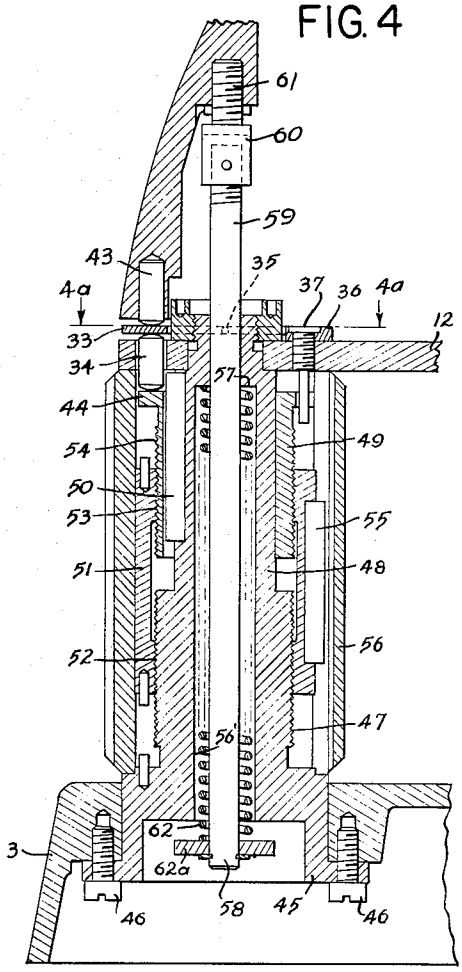


FIG. 4a

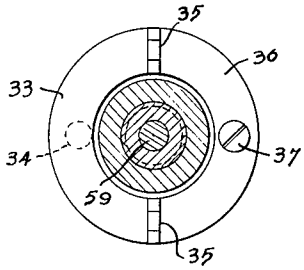
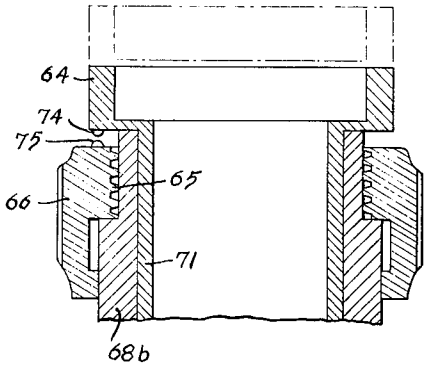


FIG. 6



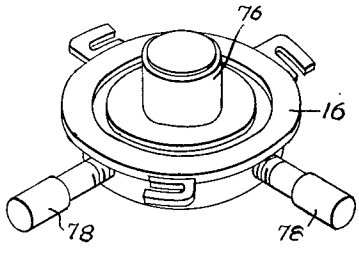


FIG. 8

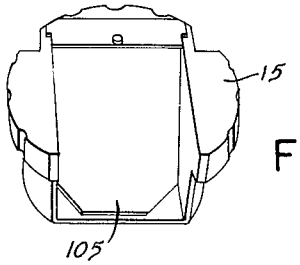


FIG. 16

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MICROSCOPE HAVING BRIDGE TYPE SUPPORT ARM FOR BODY TUBE AND FOCUSING MECHANISM

Filed Sept. 12, 1960 4 Sheets-Sheet 3

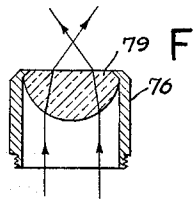

FIG. 9

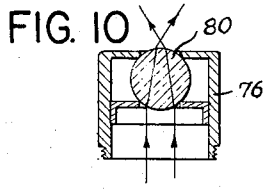

FIG. 10

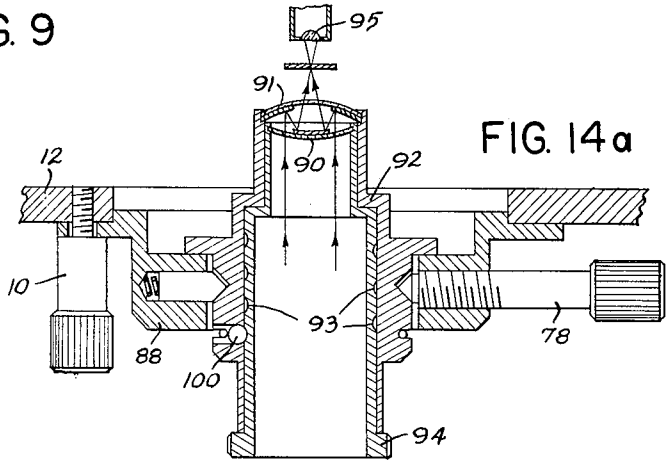

FIG. 14a

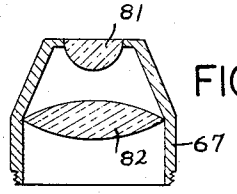

FIG. 11

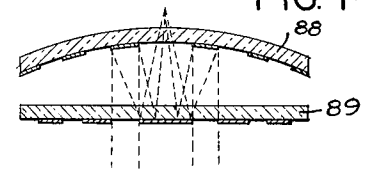

FIG. 14b

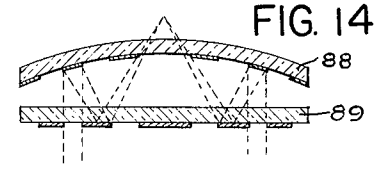

FIG. 14c

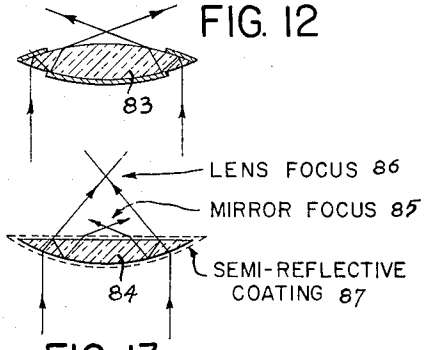

FIG. 12

FIG. 13

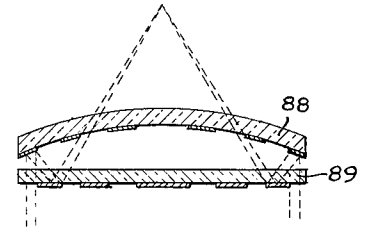

FIG. 14d

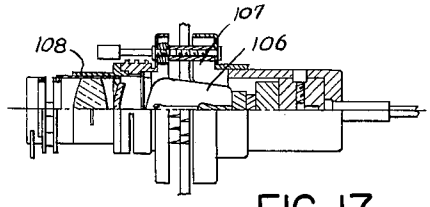

FIG. 17

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MICROSCOPE HAVING BRIDGE TYPE SUPPORT ARM FOR BODY TUBE AND FOCUSING MECHANISM

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FIG. 15

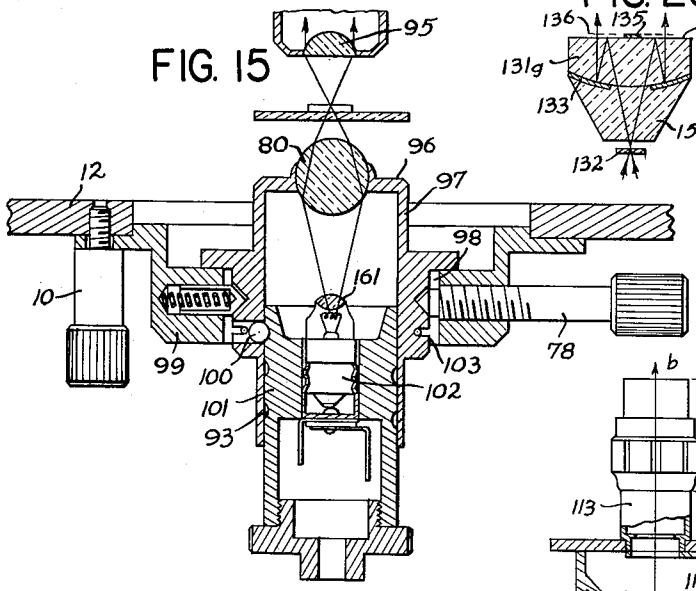


FIG. 20h

FIG. 20i

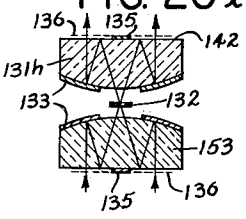


FIG. 18

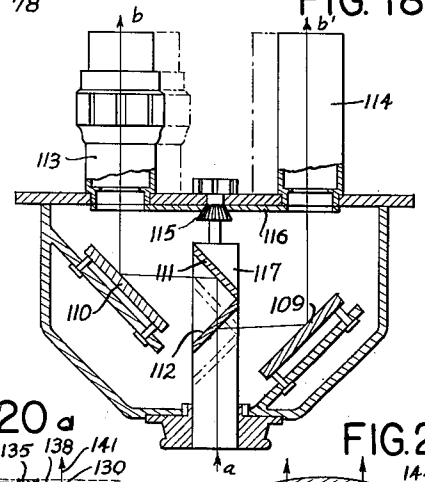


FIG. 19

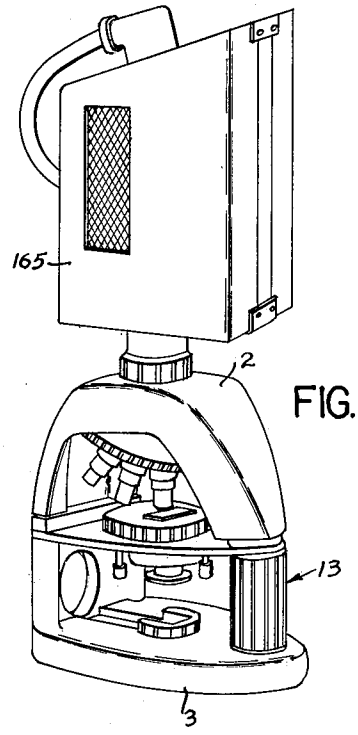


FIG. 20a

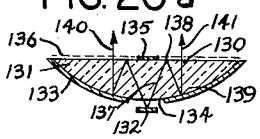


FIG. 20b

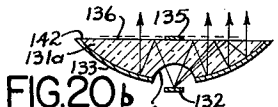
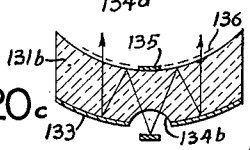


FIG. 20c



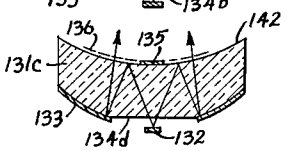


FIG. 20d

FIG. 20e

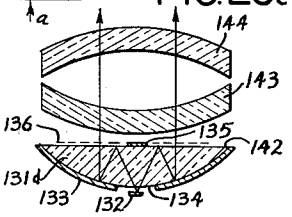
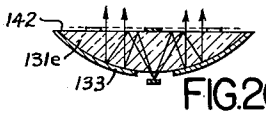


FIG. 20f



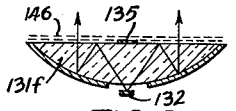


FIG. 20g

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United States Patent Office

3,259,012

Patented July 5, 1966

3,259,012

MICROSCOPE HAVING BRIDGE TYPE SUPPORT ARM FOR BODY TUBE AND FOCUSING MECHANISM

Marcel Locquin, Montreuil, France, assignor, by mesne assignments, to Inventions Finance Corporation, a corporation of Delaware

Filed Sept. 12, 1960, Ser. No. 55,340
10 Claims. (Cl. 88—39)

This invention relates to microscopes and more particularly to an improved microscope in which the body tube is carried by a bridgelike arm spanning the base, the body tube being provided with a coarse adjustment focusing mechanism and the arm with a fine adjustment focusing mechanism so arranged as to provide extreme precision and stability of focus. Further improvements and numerous other advantages will be pointed out hereinafter.

In conventional microscopes, the optical system is carried by a stand customarily consisting of an arm mounted on a supporting base through the medium of one or more adjusting devices such as a rack and pinion, or a lever, making it possible to adjust the position of the objective in relation to the object under examination, the latter being carried by a stage rigidly affixed to the stand, under which there is located the source of illumination and the optical system which concentrates the light on the subject.

The movements of the objective and its support arm must be able to be precisely controlled; consequently, the adjusting system, such as the rack and pinion or lever, has to be made with very great precision. This precision machining generally requires a truing operation which is very expensive, and with use the adjust mechanism can easily get out of adjustment due to wear.

In French Patent No. 1,162,627, the applicant has proposed replacing the above-mentioned device with a new system having no overhang, in which the optical system is coupled to an arm resting at both ends on the base of the stand, one of these being connected to an elastic hinge associated with the base of the stand, and the other being connected to a device making it possible to act upon this hinge, which is placed under spring bias so as to bring about the vertical movement of the objective or objectives in relation to the base supporting the object.

This arrangement affords numerous advantages over the rack and pinion system. However, when in use, the tension resulting from the presence of an elastic hinge, and which is necessary to the movements of the piece supporting the lens, causes deformations of the assembly containing this piece, which are detrimental to the stability of focus.

Accordingly, it is a primary object of the present invention to provide a microscope structure which will remedy the above-cited defect and obviate the disadvantages of microscopes of conventional construction.

Another object of the invention is to provide a microscope having a base and a bridgelike body tube carrying arm, the body tube being provided with a coarse focusing mechanism and the arm with a fine adjustment focusing mechanism, whereby to provide precise and stable focus adjustments and exceptional precision.

Yet another object of the invention is to provide a microscope having the constructional features outlined above in which automatic focusing to accommodate change of slides regardless of their thickness is also provided.

Still another object of the invention is to provide a microscope having the constructional features outlined above which is simple of construction, easy to operate and economical to produce.

A further object of the invention is to provide a microscope of the character indicated in which is incorporated an improved illumination system combined with improved objectives comprising the optical system.

Yet a further object of the invention is to provide a microscope of the construction indicated above which is susceptible to use with a great variety of accessory devices to enable semimicroprojection, macrography, microdissection, photomicrography, cinemicrography, tomophotometry and similar functions.

Still another object of the invention is to provide a microscope of the type outlined above whose center of gravity is always in the optical axis even when equipped with heavy accessory devices whereby to permit a more precise and stable functioning in any of its universal applications.

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawing, wherein like reference characters indicate like parts throughout the several figures and in which:

FIG. 1 is a perspective view of a microscope stand constructed in accordance with the invention fitted with optics and binocular observation tubes;

FIG. 2 is a plan view of the microscope with certain parts broken away to reveal sectional details;

FIG. 3*a* is a cross sectional view taken along line 3*a*—3*a*, FIG. 2, and looking in the direction of the arrows;

FIG. 3*b* is a cross sectional view taken along line 3*b*—3*b*, FIG. 2;

FIG. 3*c* is a cross-sectional view taken along line 3*c*—3*c* of FIG. 2;

FIG. 4 is an enlarged sectional view taken axially of the fine focusing mechanism for the microscope.

FIG. 4*a* is a plan view of a structural element taken from line 4*a*—4*a* of FIG. 4;

FIG. 5 is a cross sectional view taken axially of the coarse focusing mechanism for the microscope;

FIG. 6 is a fragmentary diagrammatical cross section of the prefocusing mechanism taken along plane 6—6 of FIG. 5 and showing its upper level position in broken lines;

FIG. 7 is a sectional view taken along line 7—7 of FIG. 5;

FIG. 8 is a perspective view of the microscope condenser holder;

FIG. 9 is a cross sectional view of a hemispherical condenser lens;

FIG. 10 is a cross sectional view of a spherical condenser lens;

FIG. 11 is a cross sectional view of a double lens condenser;

FIG. 12 is a cross sectional view of a dark ground catadioptric Cassegrain condenser;

FIG. 13 is a cross sectional view of a bifocal catadioptric condenser;

FIG. 14*a* is a cross sectional view of a phase contrast condenser;

FIG. 14*b*–*d* are cross sectional diagrammatic views of a modified phase contrast condenser showing the paths of rays when one of the lens segments is moved axially with respect to the other lens segment;

FIG. 15 is a cross sectional view of a self-illuminating condenser;

FIG. 16 is a perspective view of the mirror holder and mirror;

FIG. 17 is an axial cross sectional view of an external light source with cooling device;

FIG. 18 is a diagrammatical view of the binocular tubes and support in section;

FIG. 19 is a perspective view of the microscope with television camera fitted on the body tube; and

FIGS. 20*a–i* are cross sectional views of various catadioptric objectives.

The microscope stand

The stand according to the present invention is of the type in which the body tube is carried by an arm overspanning its base, and it is characterized principally by the fact that the arm is in the form of a bridge resting on the base, or on an element mounted on the latter, according to the system which shall be called a "plane-line-point" support in this application.

The advantages of this "plane-line-point" system are its great simplicity of construction, requiring no precision or truing, and its insensitivity to shocks and to accidental or thermal deformations.

According to one particular embodiment, the "plane-line-point" support is achieved by causing the narrow end, or nose, of the bridge to be supported by a movable adjusting member connected to the stage support or, more simply, to the base, whereas the broad end of the said bridge rests upon the base or upon an element mounted on the latter through the medium of two balls, one of which is lodged in a hollow conical recess and the other is engaged in a V-groove.

Referring now to the drawings and more particularly to FIGS. 1, 2, 3*a*–3*c*, a preferred embodiment of the stand according to the invention is constituted by a base **3** bearing an upright **11** constituting a holder for the stage support **12** which rests, at its other extremity, on the central fixed column of the fine focusing mechanism designated by the general reference **13**. On the stage support **12**, on the side opposite mechanism **13**, there is mounted an insert **4** upon which rests the upper portion of the stand which has the general form of a bridge designated by reference number **2**. In the upper part of this bridge is mounted the optical device designated by the reference number **1**.

The nose portion **5** of bridge **2** overspanning the stage support assembly **12**, rests upon that portion of the stage support which overlies the fine focusing mechanism **13**. The nose portion **6** of the arm or bridge **2** rests upon the insert **4** by means of a "point" disposed substantially at the place near one end designated as **7** and, near the other end, by means of a "line" support located substantially at the position marked **8**. The nose portion **5** reposes on the stage support **12** by means of a "plane" support located at the position indicated by the arrow P.

The insert **4** at position **7** is provided with an opening **19'** having a shoulder **20** (FIG. 3*b*). A socket **26** provided with a corresponding shoulder is lodged in opening **19'**. Socket **26** comprises a frusto-conical recess in which a ball **7** is seated. The ball is retained by a socket **21** lodged in corresponding part of the bridge portion **6**. Socket **21** also comprises a frustoconical recess. The assembly of the two sockets with frustoconical recesses constitutes, with ball **9**, the "point" support centered on the center of the ball which is provided between insert **4** and bridge **6**.

At the are designated as **8** in FIG. 1, the "line" support is created between the inserted piece **4** and portion **6** of the bridge. The construction is illustrated in FIG. 3*c*. This support also comprises a socket **22** of exterior form substantially similar to that of the socket **20**, but in which the frustoconical recess for the ball **9'** is replaced by a V-groove **19**. Ball **9'** is capped by another socket **21** lodged in the corresponding location of the bridge portion **6**.

Between the point and line supports, the insert **4**, which is affixed in an appropriate manner, not shown, to the stage support, is fastened in an elastic fashion, to bridge **6**, for example, by means of a bolt **32**, FIG. 3*a*, screwed into a tapped hole **25** provided in the bridge. The bolt **32** passes through holes **27** and **28** provided in the insert **4** and the stage support plate and bears a spring **29**, one extremity of which rests against a step **30** in hole **27**, and the other against a washer **31**, placed under the head of bolt **32**. This retaining assembly has the purpose simply of preventing bridge extremity **6** from being accidentally pulled away from the base, and it may be dispensed with without impeding the operation of the assembly.

Rough focusing mechanism

In the upper horizontal portion of bridge **2**, an opening **67** is provided, in which the rough focusing mechanism is engaged, FIG. 5. The driving member of this mechanism consists of a knurled nut **66** that can rotate about its axis but cannot shift axially by reason of engagement of shoulders carried in the nut and part **69**. The internal thread **65** of nut **66** meshes with the external thread of a strip **68** that is affixed by means of screws **70** to the body tube **71**. The strip **68** slides in the vertical groove **68***a* formed in the sleeve **68***b* which is firmly fixed to the bridge arm **2**.

The body tube is disposed perpendicularly to the stage support **12** and is equipped at **72** with classical means for the locking of the objective turret, which are not illustrated. The upper portion of tubular element **71** comprises a cylindrical flange **64** in which an elastic click detent mechanism **63**, **73** of known type is provided for the mounting of an inclined and interchangeable binocular tube **1**, which is desired, can also be a monocular tube or a photographic tube, or a combination of a binocular tube with a tube for photography.

The rackless rough focusing movement **18** is based on the nut and screw system and has a travel of about 25 mm. It is irreversible even under the heaviest load. Therefore, the microscope will support the heaviest of equipment. An end-of-travel stop is located opposite the prefocusing stop **74** and is made adjustable in any suitable manner.

Neither grease nor oil nor graphite need be used in the movements. Lubrication is assured for the life of the instrument by an antifriction substance impregnating the metal, which in this case is molbdenum bisulfide applied in aerosol form. This type of movement, furthermore, is self-adjusting for wear, like the fine focusing system to be described.

The threaded strip **68** is an element that is different from a rack. This sleeve permits vertical movement and guides it, while preventing any transverse play; it furthermore permits the achievement of a much less rapid movement than would be provided by a classical rack and pinion movement. During assembly, if the microscope is focused on an object, and the relative position of the stops **74** and **75** is adjusted to the thickness of the slide, a useful prefocusing device is obtained. This prefocusing (FIG. 6) can be adjustably set according to the type of objective used; makes it possible for the operator, by placing the slide between the two nylon stops, to obtain automatic compensation for the thickness of slides. To do this, the operator brings the stops into light contact with the slide by means of the rough focusing mechanism **18**.

Fine focusing mechanism

The fine focusing movement **13** acts on the nose of the bridge, and the bridge displacement resulting therefrom is on an arc which always coincides with the tangent in the depth of field of the object under examination, no matter what the magnification might be. The theoretical lateral movement is thus always less than the power of resolution of the instrument, and consequently is imperceptible. The mechanism of the movement, is differential, and therefore practically impossible to wear out. Its speed is approximately 120 microns per turn; its travel is 2.5 mm., and it is accurate to within 0.1 micron without backlash. Furthermore, take-up for any wear is

automatic since the thrust is always against the same side of the threads.

In FIG. 4, the mechanism of the fine focusing movement is represented in axial section, and this figure illustrates the "plane" support (indicated by the arrow P in FIG. 1) between the base and the nose of the bridge. This "plane" support is provided more particularly between the nose **5** of the bridge and an abutment **43** which comes to bear on a flange **44** which will be described in connection with the mechanism for operating the fine focusing system. The latter comprises an elongated tubular core **48** screwed at **46** to the base **3** of the stand. The core **48** is equipped on the lower portion of its periphery with a thread **47**. On the upper portion of the core periphery, which has a smaller diameter than the portion bearing thread **47**, there is placed a sleeve **49**, the upper end of which terminates in the flange **44** mentioned above. Sleeve **49** is prevented by a key **50** from turning in relation to the tubular core **48**.

Around the assembly which has just been described, there is mounted a differential nut **51** comprising at its lower portion a thread **52** in engagement with thread **47**, and at its upper part an internal thread **53** in engagement with the external thread **54** provided on the periphery of the sliding sleeve **49**.

By means of a key **55**, the differential nut **51** is made to rotate with a knurled cylinder **56** constituting the operating member of the device.

The pitch of thread **54** is smaller than the pitch of thread **47**, so that a large rotation of the knurled cylinder **56** and consequently of the differential nut, corresponds to a small axial displacement of sleeve **49** and a small movement of abutment **43** and consequently of bridge nose **5**.

The core **48** has a longitudinal bore **56** with a shoulder **57**, and in this bore is lodged a rod **58**, whose upper extremity **59** is yoked to a fork **60** borne by the screw **61** screwed into the nose **5** of the bridge. On its lower extremity, rod **58** bears a washer **62***a* which constitutes an abutment for a spring **63** mounted around rod **58**. The other extremity of this spring bears on the step **57**. The spring **63** may be dispensed with because it has no effect on the operation of the mechanism other than to provide a cushioning means.

To improve the stability of the bridge, it is expedient to separate the plane support of the plane-line-point system from the fine focusing movement. To accomplish this, a washer half **33** hinged at **35** to the other half washer **36** is inserted between abutments **43** and **34**, the latter resting on the movable sleeve flange **44**. Washer portion **36** is firmly affixed to the stage support **12** by screw **37**. The hinged washer assembly enables only part **33** to flex vertically. By its presence and its great horizontal rigidity, it prevents any reaction of the possible play in the movement on the nose of the bridge.

The stages

The stage holder **12** can support in addition to the stage **14**, FIG. 1, of the microscope, such accessories as electrode holders, microdissectors, micromanipulators and thermometer probes. It is oval in its simplest form, and circular when it is necessary, to provide room for bulky accessories, such as micromanipulators.

The stages mentioned above may be either fixed stages, stages that are movable by greasy friction, stages with built-in carriages, or independent-carriage stages, or lastly, movable stages driven automatically for the automatic exploration of the object, particularly for the purpose of counting.

The simplest fixed stage is square, rectangular or round.

The "greasy friction" stages **14** are constituted by two pieces with perfectly flat and lightly lubricated surfaces in contact. When the two pieces are placed on one another, atmospheric pressure opposes their free movement and retards the movements of the hand of the operator, thus demultiplying his control action. The object in this case is advantageously held by magnetic clamps constituted by springs affixed to a magnetized cube of metal, the assembly being affixed to the stage made of steel or soft iron.

Other stages, such as independent-carriage or built-in carriage stages of a classical type, may be used.

The optical system

The optical system with which the stand is equipped is of a new type, utlizing the objectives illustrated in FIGS. 20*a*–20*i*. The objectives of FIGS. 20*d*–20*i* operate when the object is in air or in an immersion liquid, whereaes the objectives in FIGS. 20*b* and *c* operate only when an air space is interposed between the object and the objective. The microscope thus equipped with mirror optics in this new form presents, in relation to other microscopes, the following advantages: operation possible in ultraviolet, infrared aberration, spherical aberration reduced to the minimum, and low cost.

The objective, which may be of the dry type or of the so-called immersion type, is characterized by the fact that it is constituted, mainly, of a lens whose convex face, situated on the object side, is covered with a coating of a completely reflective material comprising an uncoated area at its apex; its plane or spherical face situated on the image side comprises an opaque central area and is covered on at least a portion of its remaining area with a simple or complex semi-reflective coating. In addition to the advantage of perfect achromatism, this objective offers the advantage over the complex objectives mentioned above, and over the classical mirror objectives, that it simplifies the mechanical mounting and provides an extremely small central obturation which is all the smaller as the magnification is greater.

The objective illustrated in FIG. 20*a* is constituted by a plano-convex lens **131**. The convex face situated on the side of the object **132** is covered with a fully reflective coating or mirror surface **133**, with the exception of area **134** situated at the apex of the convex surface facing the object. The central portion of the plane face is covered with an opaque material **135** preventing the direct passage of rays through the lens in the axial zone, the remainder of the plane face being covered with a semi-reflective material **136**.

A ray **137** issuing from the object **132** undergoes an initial reflection at **138**. The reflected ray in turn undergoes another reflection at **139** and then passes out of the objective at **130** along the line **141** parallel to the axis of the objective, the image forming at infinity.

The perfect achromatism of such an objective is due to the fact that the light rays traverse all the air-to-glass surfaces at perpendicular incidence, so that there is no refraction, and the reflections on the mirrors do not introduce any chromatic aberration.

In the embodiment according to FIG. 20*b*, the objective is again constituted by a plano-convex lens **131***a*, the convex face of which, on the object side, is provided with a reflective surface **133** except for a portion **134***a* situated at its apex, which constitutes a spherical depression, the center of which coincides substantially with the object point **132**.

With the exception of an uncoated annular peripheral area **142** and a central area bearing an opaque material **135**, the plane face is covered with a semi-reflective coating **136**. All the rays issuing from the object **132** undergo reflections on the surfaces **133** and **136** and pass out perpendicularly to the plane face to form an image at infinity.

The embodiment of the objective represented in FIG. 20*c* differs from the one in FIG. 20*b* only in the fact that the lens **131***b* is a double convex lens. The radius of the convex face comprising the opaque spot surrounded by the semi-reflective coating **136** is centered on the image plane which, in this case, is situated at a finite distance.

The convex face situated on the side of the object **132** is again covered with a reflective material **133**, with the exception of a central spherical zone **134***b* situated on the object side. In the case of an objective constituted by a biconvex lens, the magnification of the objective depends on the radius of curvature of the convex face provided with the reflective material.

The objective in FIG. 20*d* differs from that of FIG. 20*c* in that the spherical depression **134** situated on the object side is replaced by flat portion **134***d* situated at the apex of the convex face nearest the object, this flat portion being designed to be connected to the object by a drop of liquid of appropriate index equal to that of the glass forming the lens.

The objective of FIG. 20*e* is in conformity with any one of the types described above, as for example that of FIG. 20*a*, but associated with two lenses **143** and **144** designed to correct simple spherical aberration in case of large magnifications and large apertures.

The objective of FIG. 20*f* is in conformity with any one of the preceding types, but an annular phase plaque **145** of a known type is placed on the semi-reflective surface or is excavated therein.

The objective in FIG. 20*g* comprises a semi-reflective surface of an interferential nature **146** covering preferably the entire aperture, for the purpose of obtaining, in addition to reflection, a certain modulation in phase and wavelength of the light, to produce a certain color interest in the image.

The objective of FIG. 20*h* is similar to those described above except that a frustoconical glass front layer **152** has been added.

FIG. 20*i* illustrates a condenser **153** formed similar to the objective **131***i* and symmetrically disposed with respect to the object **132**.

The described mirror lenses of FIG. 20 constitute perfectly achromatic objectives, can be manufactured with the classical materials, as for example glass, fused silica, fluorine, thallium iodobromide, etc., and can be used not only with rays of the visible spectrum, but also with rays outside of this spectrum. The semi-reflective coatings can be metallic, dielectric, or interferential.

In the case of phase contrast operation, it is advantageous to make the annular phase plaque in one of the following manners:

By removal of a circular portion of the semi-metallization at **142**, FIG. 20*i*;

By superimposed dephasing dielectric and absorptive metallic deposition;

By a succession of alternate dielectric and metallic depositions to produce the appropriate dephasing when the rays are reflected.

In all cases it is advantageous to replace the metallic coatings with high-index coatings such as titanium oxide or antimonium sulfide or a combination of them so as to improve the reflectivity.

Illumination

When the object under examination is transparent, it can be illuminated in the conventional fashion by a condenser, reflecting mirror and external lamp, the lamp being able to be affixed, in this case, on the circular emplacement **17** in FIG. 1. An external source of light may be of any type, but it is advantageous (FIG. 17) to make one of small size by using direct metallic contact to cool it. This contact is made either by means of stacked elastic fins **107** or by a mat of metal wool encased between two hemispheres, one of them being the reflector of the light. The assembly is connected to the base of the stand by a metal piece fastened to a lodgment provided for this purpose.

To avoid the classical defects of mirror holders, which are great difficulty of adjustment and instability, the mirror holder in FIG. 16 has only one degree of liberty: rotation, which prevents all instability without the need for locking. The mirror **105** is surface-aluminized, which prevents any double image of the field diaphragm. It can be equipped with a "cold mirror" that reflects only visible light, this cold mirror being a multiple-layer interferential filter transparent to infrared and ultraviolet.

The condenser holder **16**, FIGS. 1 and 9, is removable by unscrewing the 3 setscrews **10** and rotating it slightly to the left. The condenser comprises a cylinder **76** in which the lens is mounted and equipped for rapid rough adjustment by pushing it upwardly or downwardly, and the fine adjustment by rotation. A ball is urged by a spring into a spiral groove; if the cylinder is pushed upward without rotating it, a rapid movement is obtained, and if it is rotated, a relatively slow movement is obtained, guided by the ball in the spiral groove. It can furthermore be centered by means of two orthogonal centering screws **78**.

The actual optical systems which may be mounted on top of the condenser holder are the following:

A hemisphere **79**, FIG. 9, a simple device but one that entails aberration;

Or a complete sphere **80**, FIG. 10, also a simple device, but better than the hemisphere;

Or a classical system of lenses comprising at least two lenses **81** and **82**, associated together to reduce the aberations (FIG. 11);

Or a dark field condenser, as for example a paraboloid or a Cassegrain device **83**, FIG. 12;

Or a phase contrast condenser (FIGS. 14*a*–14*d*) like the one to be described below;

Or a mixed catadioptric device such as a bifocal condenser **84**, FIG. 13.

This is a mixed catadioptric assembly: a mirror and lens combined into a single element. It has no chromatic aberration at the mirror focus. The mirror focus can be used for powerful objectives. The lens focus can be used for low-power objectives. The two foci always coexist, and this prevents the use of this device to form images. By shifting the condenser from one focus **85** to the other **86**, all the intermediate field and aperture adjustments are obtained, rendering unnecessary the usual iris diaphragm customarily used with condensers.

Furthermore, it will be noted that, at each of the foci, the object is illuminated by the other focus along a thin axial beam, which actually amounts to the permanent super-position of a highly diaphragmed illumination, which gives the contrast, on a wide-open illumination which provides the separating power. The fringeless contrast obtained is therefore better than that obtained with an ordinary Abbe condenser and Koehler's principle.

The operation of condenser **84** is very simple. Since it is reduced to a single axial movement, it must be perfectly centered on the optical axis, and to this end it is fitted to the centering mount.

When it is desired to combine the source and the condenser in a single element, the so-called "illuminating condenser" can be constructed as shown in FIG. 15. The stage support designated by the general reference **99**, comprising a central opening **103** into which there engages a cylindrical element **96**, in the end of which is lodged a clear or groundglass sphere or ellipsoid **80**. In the bottom of cylinder **96** is located a holding element **101** for socket **102** into which is screwed a bulb **161** having an integral convex lens. The socket-holding element **101** is capable of axial adjustment in the cylindrical element **96** by means of circular grooves **93** capable of coming into engagement with a toric element **100** forming a spring. The variation of the relative position of the spherical or ellipsoidal lens and of the lens incorporated into the bulb provides, in simple fashion, an illuminating condenser of variable focus and aperture, which is far superior to the known spherical optical systems.

Preferably, the groove **93** will be constructed in spiral form and will be engaged by a ball **100** in the tubular element **96**; rotating the socket holding element will then cause it to be displaced axially.

This assembly, which can be screwed into the greasy-friction round stage, comprises in a single unit the equivalent of a condenser and lamp with reflector. The bulb is powered at low voltage and can be fed by a flashlight battery or by a fixed power transformer that can supply several stands on the laboratory table, or by a transformer that can be controlled by a rheostat. Only bulbs with correctly centered filaments should be used.

To operate the microscope on phase contrast, a special condenser shown in FIG. 14*a* may be used. In this figure, the stage support plate **12** may be seen, and the snap locking device **99** serving to hold in place a tubular element **92** substantially similar to the tubular element **96** of FIG. 15, but in the top of which a meniscus lens **91** is inserted. In this tubular element, there is a guided sleeve **94** terminating in a meniscus lens **90**. The axial distance between the two meniscuses can be regulated by means of the spiral groove **93** provided in the periphery of the sleeve **94** and co-operating with a ball **100** carried by the tubular element. By making the sleeve **94** rotate about its axis, it is caused to shift axially, thus changing the distance between the two meniscuses, which are arranged so as to permit the light to pass in the form of an annular slot of variable thickness, so as enable the user to adjust the illumination precisely, according to the structure of the objects being examined.

An improvement of this phase contrast condenser is obtained by making two mirrors **88**, **89** with multiple concentric reflective areas (FIGS. 14*b*, 14*c*, 14*d*), the diameters of these areas being such that, by varying the distance between the two mirrors by a suitable amount, the operator can shift from the optical set-up **14***b* to *c* and then to *d*. This eliminates the need for cumbersome and costly so-called turret condensers.

Interferential filters may be placed between the light source and the condenser, particularly the rectangular "polychromatic filters," which are interferential filters that operate by multiple band transmission. Being placed in a gimbal mount which engages into grooves provided for this purpose in the mirror holder, the filter is inclinable and retractable. By tilting, the pass bands of the long wavelengths are shifted towards the short wavelengths. It is thus always possible to make a pass band of the filter coincide with one of the colors of the object and thus strengthen it in relation to all the others, without the object being illuminated with monochromatic light. Such filters are also recommended as general-purpose contrast filters on naturally or artificially colored objects.

In addition to the filter, a circular lodgement on the mirror holder accepts fixed filters or a polarizing filter. The polarizing equipment of the stand is completed, in this latter case, by an analyzer and, if desired, with compensators placed between the body tube proper of the microscope and the observation tubes.

Light conductors, viz., bundles of fine glass fibers insulated optically from one another by a substance having a weaker index of refraction than that of the glass of which they are made, can be used to conduct the light from the source to the object or from the source to the condenser. The use of such conductors is of greater interest in the case of opaque objects. The vertical illuminator of a classical type is connected to the light conductor, and the light is made to encircle the objective by means of a circular fanning of the glass fibers around it.

Temperature control

When it is desired to observe objects at constant temperature, it is useful to enclose the free space between the bridge and the stage support and heat it at constant temperature by means of a heating resistance. This heating resistance is an actual stove incorporated into the microscope, not a simple heating stage which could not assure a precise, known temperature at the level of the object.

Two transparent plastic hoods connect the bridge to the stage support, thus isolating the preparation and the objectives from the ambient air. The preparation and the objectives therefore are no longer a "cold point" close to the object. A fixed contact thermometer controls through a relay the heating resistance connected to the power line.

The nosepiece

The nosepiece is a turret **97** placed on the body tube **71** to normally carry six objectives **95**. The nose turret can be remotely controlled by a ratchet system, the control box, which is independent of the microscope, then comprising a presetting knob and a pushbutton for starting. After selecting the objective which one desires to use, one pushes the pushbutton and the turret revolves until the selected objective is facing the object.

The observation tubes

The interchangeable observation tubes may be conventional, right monocular, inclined monocular, binocular and photographic binocular eye pieces. However, the present invention contemplates the use of a new and improved binocular mirror tube. The difference in quality which is observed, between the microscope image furnished by a classical upright tube and the one obtained with an inclined binocular tube, is due to the insertion into the optical trajectory of prisms for the division and deflection of the beam.

To completely eliminate these difficulties, a binocular mirror tube **119** is used in which the beams do not pass through any mass of glass, excepting the one of minimum thickness that splits the beam in two, the tube being sealed by flat glasses treated against reflections, see FIG. 18.

A longitudinally movable carriage **117** bears the two mirrors, one for the division **112**, and one for the deflection **111** of the beam. To this carriage there is connected a taper **115** which simultaneously separates or brings together the eyepiece tubes **113** through the medium of piece **116**. Since the two angle mirrors **109** and **110** are fixed, it is the position of the carriage **117** which determines both the separation of the two optical exit axes *b* and *b'* and the synchronized mechanical separation of the eyepiece tubes.

Accessories

Television.—The connection of a television network to the microscope is desirable for teaching and research, particularly nuclear research, see FIG. 19. The camera **165** is placed vertically on the stand by means of the intermediate piece without any ocular; the bridge form of the stand permits such mounting. The illumination of the microscope must be created by means of a lamp with an achromatic reflector and a bright bulb. The bifocal condenser is recommended, especially at low magnifications. The objectives must be of the largest possible aperture and must be devoid of spherical and chromatic aberration. It is advantageous to equip the microscope with the cold mirror already described. It is advantageous for the movements of focusing and of the changing of the objectives of the microscope to be remotely controlled. In addition to the remotely controlled stage and turret, the focusing movements can be remotely controlled by a mechanical device or by an electro-mechanical device, both of them being known and therefore not illustrated.

Measurements and counting

To measure with precision the diameters of very small objects, and to count them, automatically or not, according to their diameter, a photometric discriminator is used. This is a compensator operating by polarized light, which permits the image to be divided in a continuously variable ratio. It serves also as a micrometer of great precision

for the measurement of object diameters, and as a photometric discriminator for the counting of particles and for classifying them according to dimensions. This discriminator may be constituted of a classical Bravais compensator that is movable along the optical axis and connected to a scale for gauging its position.

It will be apparent from the above description that the improved microscope of the present invention may be utilized with many other accessory devices to accomplish such functions as microdissection, photomicrography with automatic control of light intensity, cinemicrography with automatic actuation of the movie camera, tomophotometry, and the like. In each instance, the microscope comprises a firm base with the center of gravity falling in the optical axis and the stability of the focus and ease of focusing contribute materially to successful accomplishment of the desired function.

Although certain specific embodiments of the invention have been shown and described, it is obvious that many modifications thereof are possible. The invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

What is claimed is:

1. A microscope comprising in combination a base, a body tube and a body tube carrying arm in the form of a bridge spanning the base, said arm being supported from both sides of said base in no more than three localized bearing areas, said bearing areas being localized into a point, a line, and a small area plane, said bridgelike arm resting at one end on a movable driving piece connected to the base by a fine adjustment focusing mechanism for elevating and lowering said end of the arm, and the other end of said arm resting upon two spaced ball bearings, one seated in the base in a conical opening and the other seated in a straight line channel having a V-shaped cross section, said fine adjustment focusing mechanism comprising an elongated tubular core affixed at one end to said base, the exterior of one portion of said core having threads of a selected pitch, a sleeve slidable on another portion of the core and having external threads of a slightly different pitch, an elongated nut having separate internal sections with threads of different pitches meshing with the threads of said core and sleeve, and means moved by said sleeve in engagement with said driving piece to move the latter and said arm upon turning movement of said nut.

2. A microscope according to claim 1 wherein said conical opening and V-shaped cross section channel for seating the ball bearings are provided in a separate piece fastened to said base and securing a stage support plate thereto, and additional resilient means is provided to press said arm and said separate piece toward each other to hold the ball bearings seated.

3. A microscope according to claim 1 wherein each of said ball bearings is capped by a conical retainer secured to said arm, wherein said body tube includes eye piece means and carries an objective turret defining an optical axis, a spheriodal achromatic objective lens characterized by a convex face situated on the object side and which is coated with a reflective material except for a small area surrounding the optical axis, the other face of said lens having an opaque area in its center surrounded for at least a portion of its surface with a semireflective coating, and wherein said microscope further includes means for illuminating an object placed in said axis, said illuminating means comprising a tubular support coaxial with said optical axis, a light condenser in the form of a ball secured in one open end of said support, a lamp having an integral lens formed therein supported by a socket within the said support and means for axially adjusting the lamp and its socket within the said support.

4. A microscope according to claim 1 wherein a body tube receiving opening is provided in the central portion of said arm, said body tube being supported in said opening by a rough focusing mechanism and having means for detachably coupling a turret for objectives at its lower extremity and monocular or binocular observation tubes at its upper extremity.

5. A microscope according to claim 4 wherein said rough focusing mechanism comprises an internally threaded operating ring rotatably mounted on said arm and above said opening by means preventing axial movement thereof, a sleeve in said opening and fixed to said arm slideably receiving said body tube, and a longitudinal strip having external threads meshing with the internal threads of said operating ring inset in a longitudinal groove of said sleeve and affixed to said body tube.

6. A microscope according to claim 5 wherein a pair of adjustable stops is additionally provided for mutual engagement to prefocus the microscope to compensate for differences in the thickness of the object to be viewed, said stops being respectively secured to fixed and moving parts of said rough focusing mechanism.

7. A microscope according to claim 1 wherein said fine adjustment focusing mechanism is further comprised of a fluted operating tube surrouding said nut and keyed thereto, said operating tube being supported between said base and a stage supported above the base in such manner as to permit rotation without axial movement of the operating tube.

8. A microscope according to claim 1 wherein is additionally provided resilient means urging said arm toward said base.

9. A microscope according to claim 8 wherein said resilient means comprises a shouldered opening positioned longitudinally within said core, a rod traversing said opening and secured in said core opening and surrounding said rod, said spring being comprised between the shoulder of the core opening and holding means affixed to the other end of said rod.

10. A microscope according to claim 1 wherein said bridgelike arm is centrally provided with an opening, a body tube adjustably supported in said opening to define a substanially vertical optical axis which coincides with the center of gravity of the microscope, and means for coupling accessory devices to said body tube in such manner as to coincide the centers of gravity of such devices with the optical axis of the microscope.

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