Feb. 17, 1948. L. B. CHUBB 2,436,096

APPARATUS FOR TESTING THE STATIC BALANCE OF PROPELLER BLADES

Filed May 14, 1943 3 Sheets-Sheet 1

Fig. 1

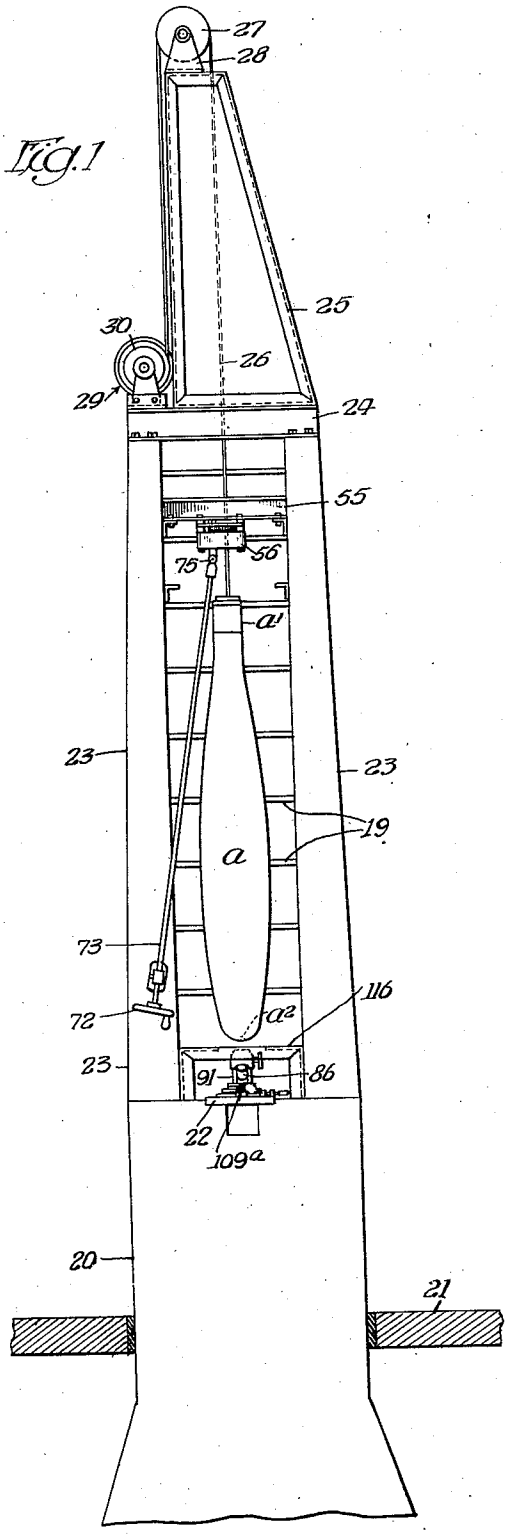
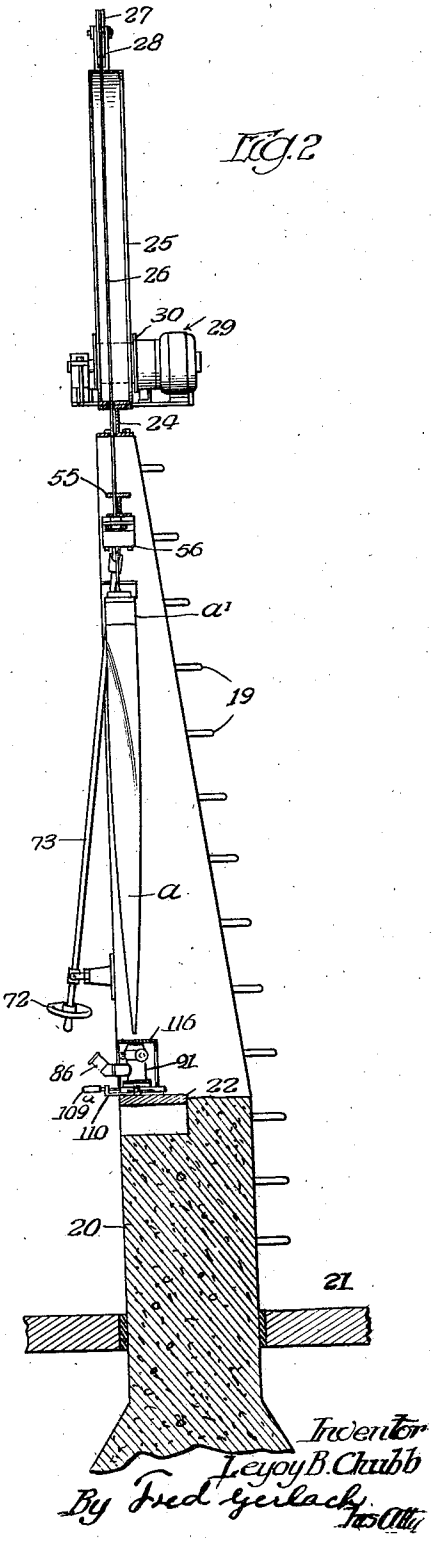



Fig. 2




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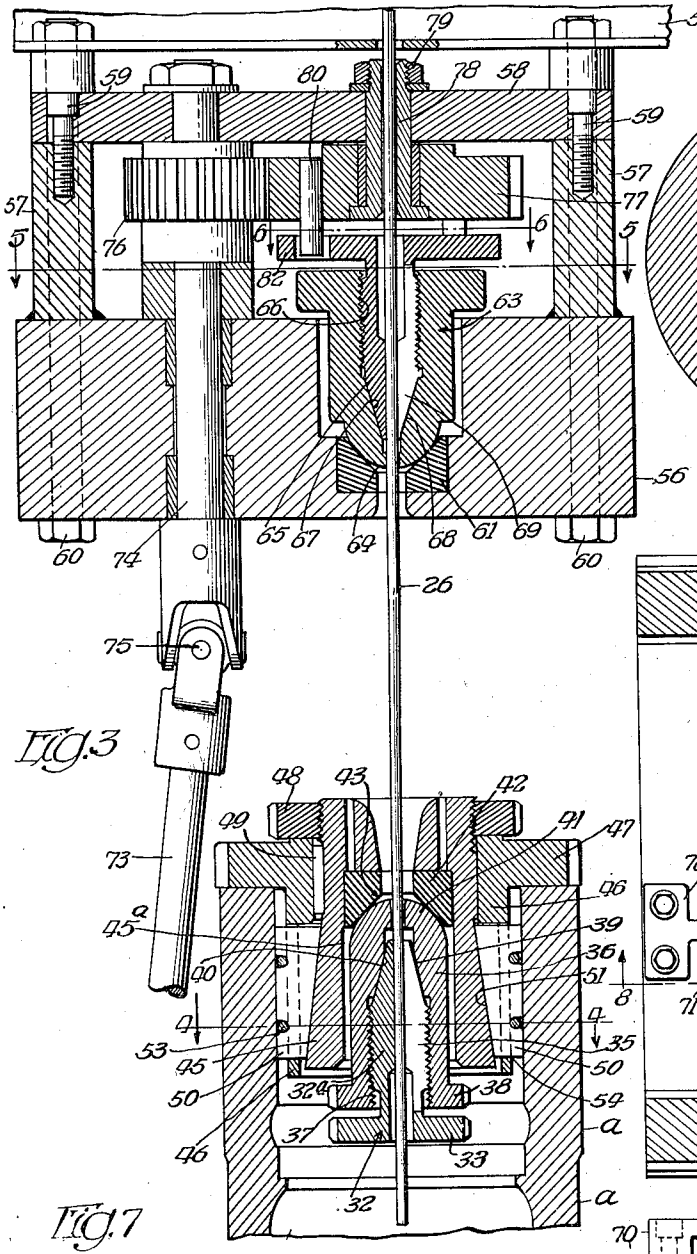



FIG. 3

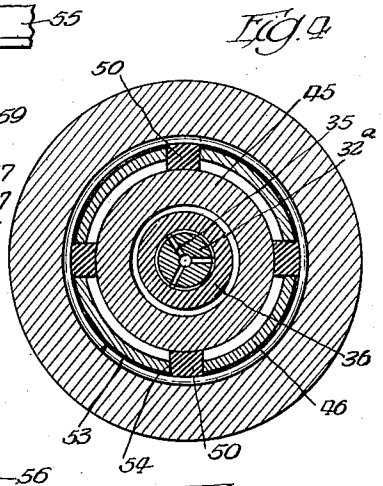



FIG. 4

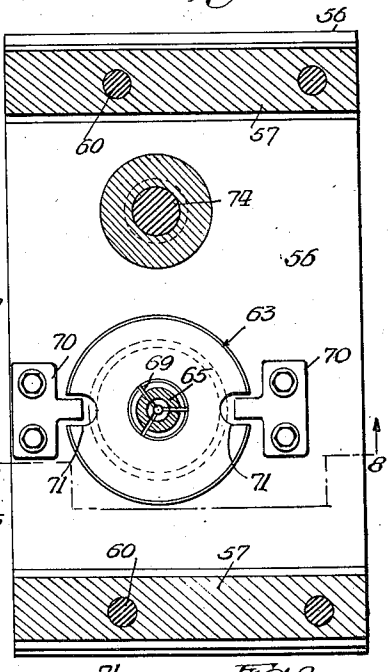



FIG. 5




FIG. 7

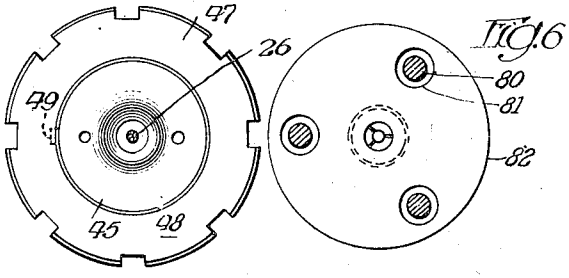



FIG. 6

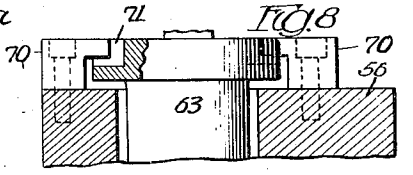



FIG. 8

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APPARATUS FOR TESTING THE STATIC BALANCE OF PROPELLER BLADES

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Fig. 9

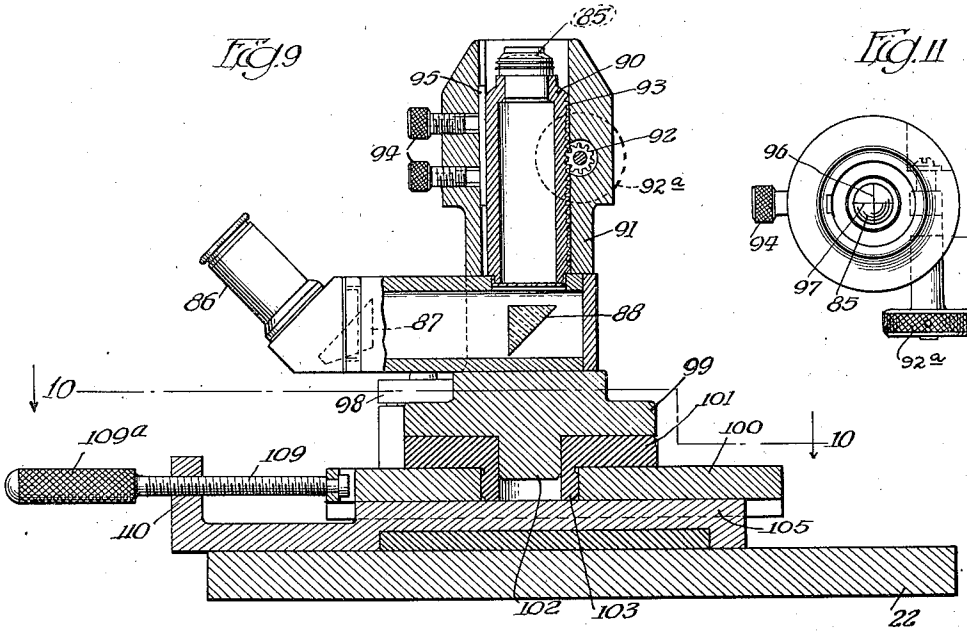



Fig. 11




Fig. 10

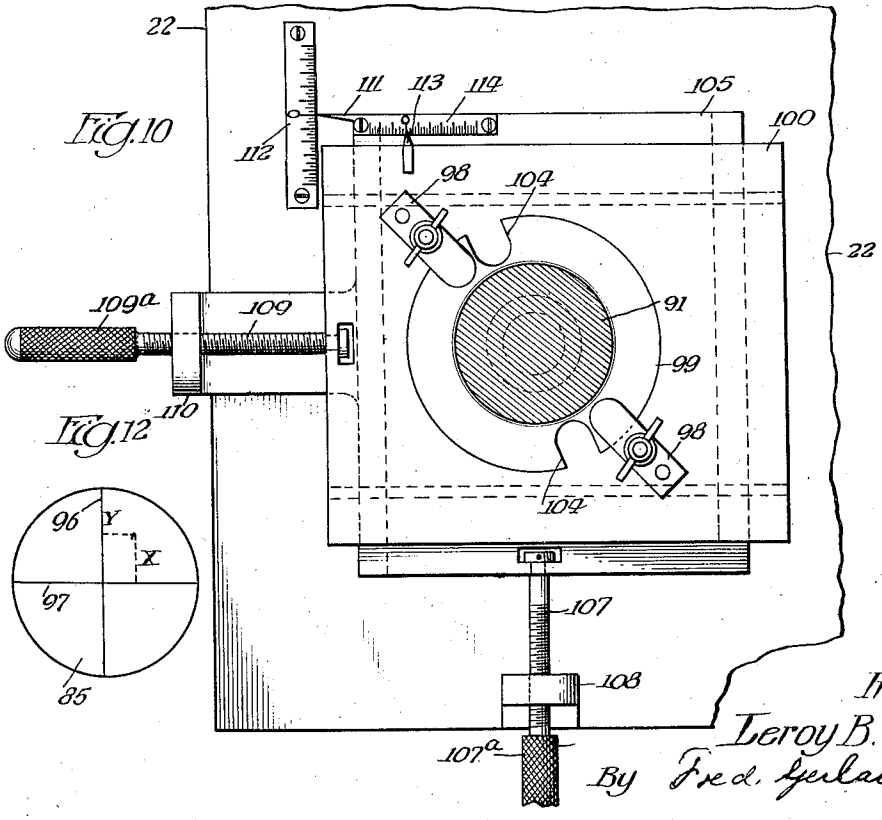



Fig. 12




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# UNITED STATES PATENT OFFICE

2,436,096

## APPARATUS FOR TESTING THE STATIC BALANCE OF PROPELLER BLADES

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Application May 14, 1943, Serial No. 487,000

20 Claims. (Cl. 73—66)

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The invention relates to apparatus for use in making propeller blades.

In the fabrication of hollow steel propeller blades it is desirable and important for the proper performance of the blade to finish the tubular shank end of the blade, which is usually rotatably confined in a radial socket in the hub for pitch variation, according to the hanging vertical center line of the blade when it is suspended in vertical hanging balance rather than according to its physical longitudinal axis. In the fabrication of these blades in production equipment discrepancies between said axis and said hanging center line are practically unavoidable and this renders it necessary to machine the shank for its proper performance in the hub.

One object of the invention is to provide improved apparatus for measuring the variation at the tip of the blade between the physical longitudinal axis and the hanging vertical center line for use in machining the internal and external peripheries of the shank so that the axis of the shank, when installed in a hub, will be coincident with the true vertical center line of gravity or hanging vertical center line of the blade.

Another object of the invention is to provide improved apparatus for expediting the manipulation of the propeller blades for determining the variation between the physical longitudinal axis and the true hanging vertical center line.

Another object of the invention is to provide a simple, efficient and quickly attachable and detachable device for internally gripping the shank of the blade for hanging the blade on an abutment on the flexible suspension element.

Another object of the invention is to provide a device which is adapted to grip and is quickly attachable to and detachable from the flexible suspension element such as a wire, for hanging the blade from its shank while making measurements at the tip.

Other objects of the invention will appear from the detailed description.

The invention consists in the several novel features which are hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings:

Fig. 1 is a front elevation of apparatus embodying and for carrying out the invention.

Fig. 2 is a vertical central transverse section.

Fig. 3 is a vertical section of the device detachably secured in the shank of the blade and the detachable device for gripping the suspension

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wire for suspending the blade from a hanging center in the shank of the blade.

Fig. 4 is a section taken on line 4—4 of Fig. 3.

Fig. 5 is a section taken on line 5—5 of Fig. 3.

Fig. 6 is a section taken on line 6—6 of Fig. 3.

Fig. 7 is a plan view of parts of the device which are secured in the shank of the blade for suspension of the blade from the wire.

Fig. 8 is a section taken on line 8—8 of Fig. 5.

Fig. 9 is a vertical section of the viewing and measuring device.

Fig. 10 is a section taken on line 10—10 of Fig. 9.

Fig. 11 is a plan of the lens and the casing in which it is mounted.

Fig. 12 is a diagram illustrating the manner of determining the location of the hanging vertical center line at the tip of the blade from the physical longitudinal axis of the blade.

In the fabrication of the blade $a$ the working portions of the blade are finished to airfoil contour and the shank $a^1$ is rough finished. A point $a^2$ is pricked in the tip at the physical longitudinal axis for use in measuring the hanging vertical center line at the tip of the blade. The blade is then elevated and suspended so it will hang in vertical balance. While hanging in vertical balance, the tip end of the blade is viewed and the location of the hanging vertical center line is micrometrically measured from the point $a^2$. These measurements are then used in machining the interior and exterior peripheries of the shank so its axis will conform to the true hanging center line of the blade. The blade is placed in a cylindrical fixture or jig with the true hanging center line congruent with or lying along the center line in the jig. The jig is then placed in suitable equipment so that the internal and external surfaces of the hub may be machined parallel to the hanging center line of the blade. In assembling the blade into the jig the point $a^2$ is again utilized by positioning it away from the center line of the jig according to the measurements as determined by the micrometer readings taken when the blade was in hanging balance in the hanging fixture.

The apparatus exemplifying the invention comprises, generally: a flexible element such as a wire for suspending the blade in hanging balance; a detachable abutment device on the suspension wire on which the blade is free to hang in vertical balance; a device which is detachably secured in the bore of the shank of the propeller for suspending the blade in hanging balance from the abutment device; hoisting mechanism comprising a winding drum for the wire for rais-

ing and lowering the blade from its shank into its hanging position; a columnar supporting structure; an overhead device for gripping the wire above the blade for holding the latter in an elevated hanging position; a device controlled from floor level for operating the overhead gripping device; an optical unit for viewing from below the tip of the blade; and means for measuring the variation between the point indicating the physical longitudinal axis and the hanging vertical center line when the blade is suspended in hanging balance.

The supporting structure comprises a solid concrete base 20 which is usually built on a solid foundation under the shop floor 21; a pair of concrete columns 23 built on the base 20 and spaced apart to provide between them a vertically extending space in which the propeller blade *a* can be suspended; a plate 22 rigidly mounted on the base 20 at convenient working level for the operator; and I-beam 24 which rigidly connects the top of the columns 23; and a frame 25 rigidly mounted on the top of I-beam 24 for supporting a sheave 27 which is journaled in a bracket 28 which is welded to the top of the frame 25. A suspension wire 26 has a portion which depends from the sheave 27 for attachment to the propeller blade. An overhead electric hoisting mechanism 29 is mounted on the beam 24 and comprises a drum 30 on which the wire 26 is wound to hoist the blade connected to the free end of the wire 26 from the floor into suspended position between the columns 23. Rungs 19 secured in the base 20 and columns form a ladder on which an operator can climb to the upper portion of the supporting structure.

The abutment-device for supporting the shank end of the blade for vertical hanging balance from the wire 26 comprises a body or thimble 36 through which the wire 26 passes and which is provided with a notched gripping flange or wheel 38, a conical socket 39 and an internal screwthread 37. A gripping member 32 comprises a stem 32ª which is threaded to the screwthread 37 in the thimble 36 and provided with a wheel or grip 33 at its lower end, a series of longitudinally extending radial slots 35 which form contractible jaws for gripping the wire 26, and a conical portion 40 fitting in the conical socket 39 in the thimble 36. Thimble 36 and member 32 have a central opening through which the wire 26 passes. In attaching the abutment device to wire 26, the wire is threaded through thimble 36 and member 32 and the thimble 36 is then rotated around member 32 which will cause the conical socket 39 to contract the jaws on member 32 and force them into firm gripping relation with the wire. Reverse rotation of the thimble will permit the jaws on member 32 to expand and release the wire. The upper end of thimble 36 has a hemispherical bearing surface 41 for supporting the blade in hanging vertical balance. This exemplifies an abutment device which is adapted to be clamped on the wire or suspension element for supporting the blade from the suspension wire, and to be detached therefrom.

The expansible device which is adapted to be secured in the bore in the shank of the blade for suspending the blade on the hemispherical abutment surface 41 of the thimble 36 comprises a cylindrical body 46 which is adapted to extend freely into the bore of the shank of the blade and is provided with a peripherally notched flange 47 adapted to abut against the end of the shank; a series of wedges 50 which are radially slidable in slots 54 in the body 46; and an expanding sleeve 45 which extends through body 46 and comprises a cone 51 which engages and is adapted to spread the wedges 50 in the bore of the blade for internally gripping the shank. Sleeve 45 is slidable in the body 46 and is connected thereto against rotation by a spline 49. A nut 48 is screw-threaded to the upper end of the expanding sleeve 45, abuts against the upper face of flange 47 on body 46, and is adapted to slide the sleeve 45 in body 46 so that cone 51 will expand the wedges 50 into internal gripping engagement with the bore of the blade. Spring rings 53 are adapted to contract the wedges 50 when the nut 48 is rotated on member 41 to release the wedges 50. A bearing block 42 is seated against the shouldered upper end of a socket 45ª in the expanding sleeve 45 and is provided with a conical surface 43 which engages the hemispherical surface 41 on the member 36 of the wire gripping device so that the blade and the device clamped in the blade are free to permit the blade to hang in vertical balance. The thimble 36 extends into the socket 45ª in sleeve 45 so that the bearing line between block 42 and said thimble will be adjacent the end of the shank. A characteristic of this device for internally gripping the shank of the blade is that its axis, when attached to the blade, remains centralized or coaxial with the shank of the blade. The abutment device is held coaxial with the wire 26. As a result the center from which the blade hangs is coincident with the axis of the shank. This expansible gripping device exemplifies one which is adapted to be clamped in the bore of the blade for freely suspending the blade from the abutment device which is clamped to the wire 26, so that the blade will pass into true vertical hanging balance.

In using the invention the shank gripping device with the bearing block 42 therein is secured in the blade while the latter is on or near the floor and after the wire 26 has been threaded therethrough and the abutment device has been secured on the wire. The drum 30 will then be operated by the hoisting device 29 to wind the wire 26 on the drum. The abutment device on the wire will engage the gripping device in the shank of the blade and elevate the blade until it is freely suspended in hanging balance with its tip $a^2$ above the base 20 of the supporting structure.

The invention comprises a device for gripping the wire 26 to support the blade in hanging balance for the determination of the discrepancy between the physical longitudinal axis and the hanging vertical center line of the blade. This device is supported above the hanging blade by an I-beam 55 which extends between the columns 23 and is secured to angle irons fixed to said columns. This gripping device is supported in a frame which comprises a block 56, bars 57 welded to the top of said block, and a bar 58 secured by screws 59 to the bars 57. The frame is supported from the I-beam 55 by bolts 60 which extend through block 56 and bars 57 and 58. A bearing block 61 is seated in a shouldered recess in block 56 and is provided with an upwardly facing conical bearing surface. The wire 26 between the sheave 27 and the end on which the blade is suspended extends through a thimble or sleeve 63. The lower end of sleeve 63 is provided with a hemispherical bearing surface 64 which engages the conical surface 62 in the block 61. A stem 65 is screw-threaded at 66 to the sleeve 63 and is

provided with a conical lower end 67 which fits in a conical bore 68 in the sleeve 63 and with longitudinal slits 69 so that the portions between the slits constitute contractible jaws for gripping the wire. The cone 67 formed on the stem 65, fits in a conical socket 68 in the sleeve 63, and is adapted to contract the jaws on said sleeve.

The stem 65 is provided at its upper end with a flange or wheel 82 for rotating the stem 65 relatively to the sleeve 63. When the stem 65 is screwed into sleeve 63, the conical bore 68 in said sleeve will contract the jaws on said stem and cause them to grip the wire 26. Reverse rotation of the stem will release said jaws to permit the wire to slide through the block 61, sleeve 63 and stem 65. Lugs 70 fixed to block 56 extend loosely into notches 71 in a flange on the upper end of sleeve 63 to hold said sleeve against rotation. Sufficient play of the lugs 70 in notches 71 is provided to permit the sleeve 63 and the stem 65 therein to tilt on the bearing block 61 so that the wire will hang truly vertical from the sleeve 63.

This cable gripping device is elevated for suspending the blade above the base 20 and mechanism is provided for operating it conveniently by an operator on the floor 21. This mechanism comprises a hand wheel 72 fixed to the lower end of a shaft 73 which is journaled in a bracket which is fixed to the front side of one of the standards 23; a vertical shaft 74 journaled in the block 56 and bar 58 and connected by a universal joint 75 to the upper end of shaft 73; a pinion 76 keyed to shaft 74 between bar 58 and block 56; a gear 77 meshing with pinion 76 and journaled on a hollow stud 78 which is secured by a nut 79 in the bar 58; and a series of pins 80 fixed in and depending from gear 77 and extending loosely into holes 81 in the flange 82 on the upper end of the stem 65. Holes 81 are enlarged to permit the sleeve 63 and the stem 65 to tilt. The wire 26 extends through the stud 78. Before the hoisting device is operated to wind wire 26 on the drum 30 for hoisting the blade to its elevated hanging position, the operator on the floor 21 will rotate the wheel 72 in one direction which will cause pinion 76 to rotate gear 77 which carries the pins 80 and the latter will rotate the stem 65 to cause the screw-thread 66 to move the stem 65 upwardly in the sleeve 63. This will cause the jaws on the stem 65 to spread so that the wire 26 will pass through the stem 65 and sleeve 63. When the blade has been elevated to its hanging position below the block 56, rotation of the hand wheel 72 in the opposite direction will rotate the stem 65 into the cone 68 in the sleeve 63 and jamb the jaws on said stem into firm gripping relation with the wire 26 so that the blade will be suspended at the fixed elevation desired. After the hanging center line of the blade has been determined as hereinafter set forth, the hand wheel 72 may be again operated to release the wire 26 so that the blade can be lowered to floor level. This exemplifies means accessible from the floor for operating the device for locking the depending portion of the wire 26.

Before the blade is hoisted to its hanging position a point $a^2$ is pricked in the tip on the physical longitudinal axis of the blade. When the blade is elevated and suspended the wire 26 permits it to hang in vertical balance around a vertical line extending through the center of the bearing between the sleeve 63 and the bearing block 61. When the point $a^2$ on the tip of the blade in hanging balance is not coincident with the hanging vertical center line, said point will be horizontally offset from the vertical hanging center line in distance and direction according to the discrepancy between the vertical hanging center line and the physical longitudinal axis resulting from variations in the distribution of mass in or in the machining of the blade.

An optical device is provided for viewing the tip of the blade and micrometric means for measuring the variation between the point $a^2$ which indicates the physical longitudinal axis and the hanging vertical center line at the tip of the blade while it is suspended in vertical hanging balance. This optical device is mounted over the plate 22 at convenient working level for the operator and comprises a mounting or casing 91; a lens 85 carried by a tube 90; a pinion 92 which engages rack-teeth 93 on tube 90 for focusing the lens 85 on the tip of the blade; a thumb wheel $92^a$ for rotating pinion 92; screws 94 engaging a shoe 95 for securing tube 90 with its lens therein in its adjusted position; an upwardly and forwardly inclined tube 86 with a suitable lens and eye-piece; and housed prisms 87 and 88 which provide for vision from tube 86 of the tip of the blade through the lens 85. The lens 85 is provided with hair lines 96, 97 at right angles to each other which intersect in the center of lens 85 and tube 90. The optical device with the lens 85 therein is mounted for movement in planes at right angles to each other corresponding to the lines 96, 97 so that the intersection of lines 96, 97 may be shifted longitudinally and transversely into vertical alignment with the point $a^2$ on the physical longitudinal axis of the blade.

The mounting 91 is detachably and fixedly carried by a plate 100 which is slidable horizontally and transversely under the tip of the blade in a plane parallel to the line 97 on lens 85 over a plate 105 which is slidable longitudinally on the fixed plate 22, so that by compounding the movements of the plates 100 and 105 the intersection of the lines 96, 97 may be brought into vertical alignment with the point $a^2$ on the tip of the blade while the latter is viewed by the operator. A screw 107 is connected to plate 105, threaded to a lug 108 which is fixed on the plate 22, and provided with a stem $107^a$ for turning the screw to positively shift plate 105. A screw 109 is connected to plate 100, threaded to a lug 110 which is integral with the plate 105, and provided with a handle $109^a$ for turning the screw to positively adjust the plate 100 over the plate 105. The position of the plate 105 on the plate 22 is indicated by a pointer 111 and a scale 112 fixed to plate 22. The position of the plate 100 on the plate 105 is indicated by a pointer 113 on plate 100 and a scale 114 fixed to plate 105. These scales are marked to indicate when the mounting 91 is adjusted to vertically align the intersection of lines 96, 97 on lens 85 with the hanging vertical center line of the blade when it is in true vertical hanging balance and also to indicate the distance which the mounting and lens are moved horizontally in directions at right angles to each other to vertically align said intersection with the point $a^2$ on the tip of the blade. As a result, when the intersection of the lines 96, 97 is shifted horizontally into vertical alignment with the point $a^2$ on the tip of the blade, the coordinates X and Y, as illustrated in Fig. 12, will be measured on the scales 114, 112, respectively. In this manner the variation or discrepancy between the physical longitudinal

axis and the hanging vertical center line at the tip of the blade will be accurately determined and measured. The mounting 91 is provided with a base flange 99 which is detachably secured by clamping lugs 98 to plate 100. A circular plate 101 is clamped between the flange 99 and plate 100. The base flange 99 is provided with a stud 102 which fits into a hole in the plate 101 and the latter is provided with a cylindrical stud 103 which fits into a corresponding opening in plate 100. The base flange 99 is provided with notches 104 which, when the clamps 98 are loosened and the flange 99 is rotated to bring the notches into alignment with lugs 98, will permit the mounting 91 to be removed from the plate 100.

The optical device is partially enclosed in a housing 116 which is provided with an opening in its top for exposing the tip of the blade.

After the X and Y coordinates have been thus measured, the hand wheel 72 is operated to release the wire 26 and the blade is lowered. The shank gripping device is then released from the blade and left on the wire 26. The blade is then positioned in a suitable fixture or jig in accordance with the true hanging center line of the blade coincident with or lying along the center line of the jig. This jig is then placed in a suitable equipment and the internal and external surfaces of the shank are machined parallel to the hanging center line of the blade. In assembling the blade into the jig the blade is positioned from the point $a^2$ and the center line of the jig according to the measured coordinates X and Y as determined by the micrometric readings taken when the blade was in the hanging fixture.

The invention exemplifies apparatus for expeditiously and accurately determining and measuring the discrepancy between the physical longitudinal center line and the vertical center line of a propeller blade at its tip when the blade is in hanging balance for use in machining or remachining the shank of the blade in accordance with its true hanging center line to facilitate the fabrication of propeller blades within permissible tolerances for mounting the blade in a hub in accordance with the hanging vertical center line and which results in reducing the tolerance range. The invention also exemplifies: a fixture for conveniently handling the blade for hanging it in vertical balance; a conveniently operable device for controlling an overhead device for gripping the wire to support the blade in elevated position; an abutment device adapted to be clamped to the suspension wire; and a device which is adapted to internally grip the shank of the blade for suspension from the abutment device on the wire.

The invention is not to be understood as restricted to the details set forth since these may be modified within the scope of the appended claims without departing from the spirit and scope of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure, means adapted to be connected to the shank of the blade for suspending the blade from said structure so it is free to hang vertically with the tip at its lower end, and an optical device on said structure for viewing the tip of the blade from below, including means for measuring the deviation between the vertical line of the hanging center and a mark on the physical longitudinal axis at the tip of the blade in different angular directions.

2. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure, means adapted to be connected to the shank of the blade for suspending the blade from said structure so it is free to hang vertically with the tip at its lower end, and an optical device on said structure for viewing the tip of the blade from below including means for moving said device in horizontal planes in directions at right angles to each other, and means for measuring in said planes the deviation between the vertical line of the hanging center and a mark on the physical longitudinal axis at the tip of the blade in different angular directions.

3. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure, means adapted to be connected to the shank of the blade for suspending the blade from said structure so it is free to hang vertically with the tip at its lower end, and an optical device on said structure for viewing the tip of the blade from below comprising a lens below the blade and provided with means movable to vertical coincidence with a point on the tip of the blade, an eye-piece in offset relation to the blade, prisms between the lens and the eye-piece, and means for measuring the deviation between the vertical hanging center line and a mark on the physical longitudinal axis at the tip of the blade in different angular directions.

4. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure, means adapted to be connected to the shank of the blade for suspending the blade from said structure so it is free to hang vertically with the tip at its lower end, an optical device on said structure for viewing the tip of the blade from below including, a lens below the blade, an eye-piece in offset relation to the blade, prisms between the lens and the eye-piece, and a mounting for the lens, eye-piece and prisms, movable in horizontal planes in directions at right angles to each other to position the lens in vertical alignment with a marked physical center on the tip of the blade, and means carried by said mounting for measuring in said planes the distance between the vertical line of the hanging center and a mark on the physical longitudinal axis at the tip of the blade.

5. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a rigid columnar supporting structure, a flexible suspension element for the blade carried by the structure and having a depending end-portion, hoisting mechanism supported on the structure and connected to said element for raising the blade into a freely hanging position, means on the depending portion of the element for supporting the blade, a device on the supporting structure for gripping said element to hold the blade in a predetermined hanging position, means for operating the gripping device to secure and release said element, and means below and for determining the deviation of a mark on the physical longitudinal

axis from the vertical hanging center line at the tip of the blade.

6. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a rigid columnar supporting structure, a flexible suspension element for the blade carried by the structure and having a depending end-portion, a sheave at the top of the structure around which the element extends, elevated hoisting mechanism supported on the structure and connected to the other end of said element for raising the blade into a freely hanging position, means on the depending portion of the element for supporting the blade, a device on the supporting structure for gripping said element to hold the blade in a predetermined hanging position, means for operating the gripping device to secure and release said element, and optical means below and for determining the deviation of a mark on the physical longitudinal axis from the vertical hanging center line at the tip of the blade.

7. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a flexible element having a depending portion for a hanging connection to the shank of the blade, a device for gripping said element to support the blade in hanging position comprising a member provided with contractible jaws for gripping said element and a body to which said member is screw-threaded and provided with means for contracting the jaws to grip the element, said body and member having a central opening through which said element passes, bearing-means for supporting said body-member so the member and body tilt in any direction, means for holding the body against rotation, and means for rotating said member in the body.

8. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a flexible element having a depending portion for a hanging connection to the shank of the blade, a device for gripping said element to support the blade in hanging position comprising a member provided with contractible jaws for gripping said element and a body to which said member is screw-threaded and provided with means for contracting the jaws to grip the element, said body and member having a central opening through which said element passes, bearing-means for supporting said body-member so the member and body are free to tilt in any direction, a stationary support for the bearing-means, means between the support and body, for holding the body against rotation while permitting it to tilt, and means for rotating said member in the body.

9. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a flexible element having a depending portion for a hanging connection to the shank of the blade, a device for gripping said element to support the blade in hanging position comprising a member provided with contractible jaws for gripping said element and a body to which said member is screw-threaded and provided with means for contracting the jaws to grip the element, said body and member having a central opening through which said element passes, bearing-means for supporting said body-member so the member and body are free to tilt in any direction, a stationary support for the bearing-means, means between the support and body, for holding the body against rotation, and



gearing for rotating said member mounted on the support, and a loose driving connection between the gearing and said member which permits said member to tilt in any direction.

10. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a flexible element having a depending portion for a hanging connection to the shank of the blade, a device for gripping said element to support the blade in hanging position comprising a member provided with a screw-threaded stem having contractible jaws for gripping said element and a body member with a screw-thread for said stem and provided with means for contracting the jaws to grip the element, said stem and body having a central opening through which said element passes, bearing-means for supporting said body so the body and stem are free to tilt in any direction, means for holding the body against rotation, and means for rotating said member in the body.

11. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a flexible element having a depending portion for a hanging connection to the shank of the blade, a device for gripping said element to support the blade in hanging position comprising a member provided with contractible jaws for gripping said element and a body to which said member is screw-threaded and provided with means for contracting the jaws to grip the element, said body and member having a central opening through which the element passes, a stationary support, a bearing carried by the support which permits said body and member to tilt in any direction, means between the support and the body for holding the body against rotation while permitting such tilting movement, and gearing carried by said support for rotating said member in the body while permitting said member to tilt.

12. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure including a pair of rigid columns extended upwardly from a working floor and spaced apart laterally to provide between them space for hanging the blade, a flexible suspension element for the blade having a depending end-portion between the columns, means for detachably supporting the blade on the end of the depending portion of the element, hoisting mechanism supported on the structure and to which the element is connected for raising the blade into hanging position between the columns, an overhead device on the supporting structure for gripping the element to suspend the blade in its hanging position, means operable from a point adjacent the floor level for operating the gripping device to release and lock said element, and means below the hanging blade for measuring the variation between a mark on the physical axis and the vertical line of the hanging center at the tip of the blade.

13. Apparatus for use in making propeller blades provided with a shank for connection to a hub comprising, a supporting structure including a pair of rigid columns extended upwardly from a working floor and spaced apart laterally to provide between them space for hanging the blade, an overhead guide on the structure, a flexible suspension element for the blade extending around said guide and having a free depending portion between the columns, means for detachably supporting the blade on the end of the depending portion of the element, hoisting mecha-

nism supported on the structure and to which the element is connected for raising the blade into hanging position between the columns, an overhead device on the supporting structure for gripping the element to suspend the blade in its hanging position, means operable from a point adjacent the floor level for operating the gripping device to release and lock said element, and means below the hanging blade for measuring the variation between a mark on the physical axis and the vertical line of the hanging center at the tip of the blade.

14. Means for hanging a propeller blade with a tubular shank from a flexible suspension element comprising, a body provided with a member adapted to extend into the shank of the propeller, a flange on said body, gripping members slidably mounted in said body for internally gripping the shank, a sleeve provided with means for expanding said members and slidably mounted in said body, a nut threaded to said sleeve for shifting it to expand said gripping members, a bearing-member in the sleeve having a downwardly facing conical surface, a stem provided with contractible jaws for gripping said element and a thimble extending into the sleeve and having means at its upper end for engaging the conical surface on the bearing-member and means for contracting the jaws, the thimble and stem being connected by a screw thread, the sleeve, thimble and stem being provided with an opening through which said element passes.

15. A device for supporting a propeller blade having a tubular shank from a flexible suspension element provided with an abutment comprising, a body adapted to extend into the shank of the blade, elements mounted to slide radially in said body for internally gripping the shank, a sleeve slidably mounted in and extending through said body and provided with means for spreading the gripping elements, a nut on the sleeve for shifting the sleeve in the body, and a bearing in the sleeve for tiltably supporting the device and blade from the abutment on the suspension element.

16. A device for supporting a propeller blade having a tubular shank from a flexible suspension element provided with an abutment, comprising, a body adapted to extend into the shank of the blade, elements mounted to slide radially in said body for internally gripping the shank, a holding flange on the body on the outside of the blade, a sleeve slidably mounted in, and extending through said body and provided with means for spreading the gripping elements, a nut on the sleeve for shifting the sleeve in the body, and a bearing in the sleeve for tiltably supporting the device and blade from the abutment on the suspension element.

17. Means for hanging a propeller blade provided with a tubular shank, from a flexible suspension element so it will be free to hang vertically, comprising: a device including means for detachably gripping said element and provided with a bearing; a device including a body insertable into the shank of the blade, means carried by the body for internally gripping the shank, and a bearing fixed in said body as a support therefor having a bore which is clear of the element; said bearings being separable and provided with engaging faces for universal tilting of, and solely supporting, the blade and the blade gripping device on the element gripping device so that the blade will be free to hang vertically.



18. Means for hanging a propeller blade provided with a tubular shank, from a flexible suspension element so it will be free to hang vertically, comprising: a device including means for detachably gripping said element and provided with a bearing; a device including a body insertable into the shank of the blade, means carried by the body for internally gripping the shank, and a bearing fixed in the body as a support therefor having an opening for clearing the element; said bearings being separable and provided with conical and arcuate engaging faces for universal tilting of, and solely supporting, the blade and the blade gripping device on the element gripping device so that the blade will be free to hang vertically.

19. Means for hanging a propeller blade provided with a tubular shank, from a flexible suspension element so it will be free to hang vertically, comprising: a device including means for detachably gripping said element and provided with a bearing; a device including a tubular body insertable into the shank of the blade, expansible jaws carried by the body for gripping the shank, a member slidably mounted in the body for expanding the jaws for internally gripping the shank, and a bearing fixed in said body as a support therefor having a bore which is clear of the element; said bearings being separable and provided with engaging faces in said member for universal tilting of, and solely supporting the blade and the blade gripping device on the element gripping device so that the blade will be free to hang vertically.

20. Means for hanging a propeller blade provided with a tubular shank, from a flexible suspension element so it will be free to hang vertically, comprising: a device including means for detachably gripping said element and provided with a bearing; a device including a tubular body insertable into the shank of the blade, means in the body for internally gripping the shank, and a bearing having a bore which is clear of the element, said element gripping member being adapted to extend into the tubular body, said bearings being disposed in the tubular body, and being separable and provided with engaging faces for universal tilting of, and solely supporting the blade and the blade gripping device on the element gripping device so that the blade will be free to hang vertically.

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## REFERENCES CITED

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

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,203,782 | Hem | June 11, 1940 |
| 1,968,540 | Squires | July 31, 1934 |
| 231,751 | Bailey et al. | Aug. 31, 1880 |
| 1,331,892 | Arbon | Feb. 24, 1920 |
| 1,775,952 | Turrettini | Sept. 16, 1930 |
| 2,039,211 | Caldwell | Apr. 28, 1936 |
| 833,548 | Putnam | Oct. 16, 1906 |
| 936,263 | Young | Oct. 5, 1909 |
| 1,801,989 | Wells et al. | Apr. 21, 1931 |
| 2,172,006 | Buckner et al. | Sept. 5, 1939 |
| 2,338,057 | Petersen | Dec. 28, 1943 |