No. 1795

INSTRUCTIONS

FOR THE CARE, PRESERVATION, REPAIR AND ADJUSTMENT OF

INSTRUMENTS FOR THE FIRE-CONTROL SYSTEMS

FOR COAST AND FIELD ARTILLERY

(TWELVE PLATES)

DECEMBER 18, 1906
REVISED NOVEMBER 1, 1909
REVISED OCTOBER 9, 1912
REVISED JANUARY 4, 1916

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

No. 1795

INSTRUCTIONS

FOR THE CARE, PRESERVATION, REPAIR AND ADJUSTMENT OF

INSTRUMENTS FOR THE FIRE-CONTROL SYSTEMS

FOR COAST AND FIELD ARTILLERY

(TWELVE PLATES)

DECEMBER 18, 1906
REVISED NOVEMBER 1, 1909
REVISED OCTOBER 9, 1912
REVISED JANUARY 4, 1916

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

War Department,
Office of the Chief of Ordnance,
Washington, January 4, 1916.

This manual is published for the information and government of the Regular Army and Organized Militia of the United States.

By order of the Secretary of War:

William Crozier,
Brigadier General, Chief of Ordnance.

INSTRUCTIONS FOR THE CARE, PRESERVATION, REPAIR, AND ADJUSTMENT OF INSTRUMENTS FOR THE FIRE-CONTROL SYSTEMS FOR COAST AND FIELD ARTILLERY.

INSTRUMENTS.

1. The instruments used in the fire-control and direction system of the Coast Artillery include the following:

Swasey depression position finder, types A and AII.
Lewis depression position finder, types A and B.
Lewis depression position finder, model of 1907.
Rafferty depression position finder, type B.
Barr and Stroud horizontal base range finder.
Azimuth instrument, models of 1900, 1900 MI, and 1910.
Telescopic sight, models of 1896 M, 1897, 1898, 1898 M, 1899, 1902, and for 14-inch gun turret.
Two-inch telescopic sight, models of 1906 and 1909.
Three-inch telescopic sight, models of 1904, 1910, and 1912.
Observation telescope, seacoast, model of 1908.
Periscope for 14-inch gun turret.
Gunner's quadrant, model of 1898.
Elevation quadrant, model of 1906.
Elevation quadrant for 12-inch mortar carriages, models of 1891 and 1908.
Fire commander's plotting board, model of 1906.
Whistler-Hearn plotting board, model of 1904.
Mortar plotting board, models of 1906 and 1906 MI.
Three hundred and sixty degree mortar plotting board, model of 1911.
Submarine plotting board, model of 1906.
Pratt range board, model of 1905.
Range board, model of 1909.
Deflection board, model of 1905, for guns.
Deflection board, model of 1906, for 12-inch mortar.
Wind-component indicator.
Set-forward ruler.
Prediction scale.
Predicter.
Mine-prediction ruler.
Time-interval recorder.

Drawing boards, battle charts, harbor charts, and difference boards.

Scale arms for harbor charts, and for difference boards.

2. The instruments used in the fire-control and direction system for the Field Artillery include the following:

Weldon range finder.

Field Artillery range finder, 1 meter base.

Aiming circle, model of 1916.

Sextant telemeter, type A, model of 1911.

Battery commander's telescope, models of 1904, 1905, and 1915.

Panoramic sight, models of 1904 and 1915.

Telescopic sight, models of 1896, 1896 M, and 1897.

Rear sight of various designs for different carriages.

Front sight of various designs for different carriages.

Observation telescope, field, model of 1908.

Range quadrant of various designs for different carriages.

Gunner's quadrant, models of 1892, 1897, and 1898.

Plotting board for mobile artillery, models of 1905 and 1906.

Field Artillery plotter, model of 1907.

Battery commander's ruler.

One-hundred-foot steel measuring tape.

3. Other instruments include:

Telescopic musket sight, models of 1908 and 1913.

Sixty-foot steel measuring tape for Weldon range finders.

4. In preparing instructions for the care, preservation, repair, and adjustment of the above instruments, it is found most convenient to group the instruments in the following general classes:

(*a*) Optical instruments proper, including the telescopes of the various depression position finders, azimuth instruments, telescopic sights, panoramic sights, observation instruments, etc., and Weldon range finders.

(*b*) Geared instruments, including the mechanical features of all instruments, designed to measure accurately angles of azimuth, of elevation, or of depression, as the azimuth and the elevation and depression gears of the various depression position finders and the azimuth gears and features of the various plotting boards.

(*c*) Scale arms, including all parts of instruments provided with scales and straight fiducial edges.

(*d*) Wooden parts of instruments, as the board proper of the plotting boards, of the Pratt range boards, of the time range board, of the deflection boards, of the drawing board, etc.

(*e*) Special parts of instruments, not falling in any of the above groups, as the canvas chart of the Pratt range board, the rubber covering of the mobile artillery plotting board, etc.

5. All persons using any of the instruments referred to above should be thoroughly familiar with the various descriptive pamphlets issued by the Ordnance Department relating to these instruments. In addition thereto, all persons, including especially armament foremen and machinists, called upon to inspect, repair, or adjust any of the above instruments should provide themselves with the working drawings of the instruments in question by application through the proper channels, if not already supplied with the drawings by armament officers. Before attempting to disassemble, adjust, or repair instruments, the drawings should be carefully studied and a thorough familiarity thus obtained with the component parts of any mechanism and with the function of each part in the train of movements producing any given result. Complicated groups of gear wheels, for instance, should never be separated without special attention to the arrangement of the group and to the sequence of the various disassembling operations with a view to reversing the above operations in proper order in reassembling. No forcing of parts together should ever be tolerated. When such forcing seems necessary, the indication is that the parts already assembled are incorrectly put together.

CARE AND PRESERVATION OF INSTRUMENTS.

6. The care and preservation of instruments is properly the function of those who use the instruments. Cleanliness, freedom from moisture, dust, dirt, and grit, and proper oiling are of first importance. By proper oiling is meant the supply of the lubricating oil specified in the pamphlets in proper amounts and at proper times. For instance, heavy oil, as the vaseline used in the azimuth-circle gear of the panoramic sight, should last 12 months after a proper application. Machine oil used on the panoramic-sight stem needs frequent renewal, with the cleaning of the parts daily or oftener. Clock oil used on the finer gears of the gun center of the Whistler-Hearn board will last ordinarily from four to six months without renewing, depending on the amount of use received by the board. In this latter case, frequent or excessive oiling actually will do harm, as the excess amount will flow away from the bearings to the surrounding parts and serve to catch dust and ultimately to clog up the parts concerned.

When special chests or cases are issued with instruments, the instruments should habitually be placed in them when not in use; where chests or cases are not issued, as, for instance, in the case of the wind-component indicator, the removal of dust, excess oil, or of the moisture which collects on metal surfaces during high humidity, should be daily attended to by the regular caretaker.

HUMIDITY.

7. One of the most important points to be observed with reference to the care and preservation of all classes of instruments is the prevention *as much as possible* of the deposit of moisture from the atmosphere. The humidity of the atmosphere is one of the most potent agents in producing the patina or film on the lenses and prisms of optical instruments, and its continuous presence on the surfaces of the optical glass will render them unfit for use; its action in warping the wooden base of the Whistler-Hearn and other plotting boards, drawing boards, deflection boards, and Pratt range boards is productive of trouble and frequently necessitates a readjustment of parts, as, for instance, by means of the slotted screw holes in the scales of the gun deflection board; its action on steel parts is to accelerate rusting, and thus not only to mar the appearance of instruments, but also, in the case of gears, pinions, racks, etc., to destroy accuracy and prevent easy functioning. It is not always possible absolutely to avoid difficulty from this source, but careful covering and oiling, the selection where possible of warm, dry places for the storage of optical and other instruments when not in use, and the prompt removal of deposited moisture wherever discovered will reduce the effect of humidity. Especially telescopic sights and optical parts of instruments should be stored in warm, dry places.

The condensation of atmospheric moisture on the lenses or prisms occurs when the temperature of these parts is lower than the dew point. The evaporation of this moisture may be hastened by turning on the lights mounted in telescopes. Heat from other sources should not be applied directly, as it may result in unequal expansion of the metal parts or of the optical parts of the instrument and cause considerable errors of observation.

REPAIR AND ADJUSTMENT OF INSTRUMENTS.

8. Whenever from wear due to long service, from accident, or from any other cause, an instrument is rendered unfit for service, a report of the case, as directed in the following extract from General Orders, No. 47, War Department, March 24, 1905, should be received by the armament officer.

(1) The prisms and lenses in the telescopes of position finders, azimuth instruments, and sights are not arranged for adjustment by those using them. The taking apart of telescopes for any purpose and the making of any adjustments other than those provided for in their construction and described in the pamphlets issued by the Ordnance Department, except under the supervision of district armament officers, are therefore forbidden.

(2) When telescopes or any instruments of the range-finding and fire-control system for mobile and coast artillery issued by the Ordnance Department require repair, a report describing the character and extent of the injuries or defects will be made to the armament officer of the district. In case the repairs or adjustment required by telescopes and other delicate instruments of precision are of such a nature that they can not be made at the post, as above specified, the instruments will be shipped by express to such arsenal as may be designated by the district armament-officer.

9. The armament officer of the district in which the repair is called for will, either personally or through his proper ordnance foreman or machinist, make an inspection of the instrument reported in need of repair or adjustment. From the inspection he will decide whether the telescope or other delicate instrument of precision can be repaired at the post, by instrument makers or watchmakers in the vicinity, or must be shippped by express to such arsenal as he may designate. In general, in shipping instruments away from posts for repair, only such parts should be shipped as are absolutely necessary to a proper repair. Thus, frequently only the telescope of depression position finders, azimuth instruments, etc., need be shipped when they only are in need of repair; but, on the other hand, if, for instance, tide-scale or height-scale parts of depression position finders are in need of repair or regraduation, the entire instrument must be shipped, as all parts, including base and telescope, will then be required for the final adjustment after regraduation.

10. The regraduation of instruments should be done only at an arsenal or at a manufacturing plant equipped with accurate graduating machines. All other repairs of an extensive nature involving a considerable outlay of money, including the obtaining of new prisms and lenses or of new castings to replace broken parts, should be made at an arsenal.

11. *Who may disassemble and repair instruments.*—Paragraphs marked with an asterisk (*) are added for the use of instrument makers in the adjustment of instruments or parts of instruments. It is not intended that these adjustments shall be made at the forts, but only at those places such as arsenals where special facilities are provided.

12. The parts of sights and fire control instruments for the 3-inch Field Artillery which may be disassembled by the battery, are specified in the Handbook for 3-inch Field Artillery Matériel. The disassembling of other parts will be performed by skilled workmen only.

Prisms of sights and other telescopes will not be removed from their holders except by skilled workmen. As a general rule the disassembling and adjustment of sights and instruments requiring tools

other than those issued with each instrument will be performed only by skilled mechanics.

13. *Screw threads.*—A number of different standards of screw threads below ¼-inch diameter have been used on sights and fire control instruments. They are: the F. A., the V thread, the U. S., the A. S. M. E., and the British Association. The F. A. standard thread is a round 60° thread. Taps and dies for this standard are made at the Frankford Arsenal only. This standard is used on instrument of models dated prior to 1905, when it was superseded for new design by the V thread standard. The V thread is a sharp 60° thread. Taps and dies of this standard are procured by Frankford Arsenal to special gauges. The V thread standard was superseded for new design in September, 1909, by the A. S. M. E. standard thread which was recommended for adoption in 1907 by the American Society of Mechanical Engineers. This thread is now the standard thread for new designs for all screws below ¼-inch diameter. The U. S. standard form of thread is on screws of cap screw sizes (varying in diameter by $\frac{1}{32}$ inch) used in the manufacture of the azimuth instrument, model of 1900, and the Swasey depression position finder. An independent system of screws with U. S. standard form of threads is used on the Lewis depression position finder, model of 1907. Special screws with U. S. standard threads are found in other instances. The British Association screw thread, a round thread with a thread angle of 47½°, is used on Barr and Stroud range finders.

No holes should be retapped without first consulting the detailed drawing to ascertain the diameter, pitch and type of screw thread used. In case the proper taps are not on hand, they should be requisitioned for. Screws for the various instruments are kept in stock at Frankford Arsenal, Benicia Arsenal, and Manila Ordnance Depot. In ordering screws, use the nomenclature given in the pamphlet descriptive of the instruments or on the detailed drawings. In ordering taps state the standard, the diameter, and the pitch.

14. In describing the method of repair and adjustment of the instruments already listed in paragraphs 1 and 2 of this pamphlet, repairs or adjustments of instruments will be taken up in proper order, according as they may fall under one or more of the five groups mentioned in paragraph 4.

TOOLS AND FIXTURES FOR OPTICAL REPAIR WORK.

(See Plates F, G, and H herewith and drawings 15–17–1 to 11, inclusive.)

15. A kit of tools for use in connection with optical repair work is furnished for both Coast and Field Artillery. The list of tools and fixtures comprising these sets will be found on Plate H herewith. Only a few of these tools will require description. The use of several

tools and fixtures will be described below under the instructions for repair of various models of instruments. Before using pedestal No. 85, carefully level it so that its axis is vertical.

16. *Collimating telescope for Field Artillery.*—The collimating telescope (No. 90) furnished with tools for Field Artillery work, is an ordinary nonerecting type. It is adjusted for parallax by the usual means of focusing the eyepiece on the cross wires and then removing parallax by focusing the objective. To collimate the telescope use the horizontal fixture (No. 86) mounted in pedestal (No. 85), holding the telescope against the guide on the side of the fixture and sight on a target having both horizontal and vertical lines. Rotate the telescope on its axis 180° and if the cross wires do not coincide with the target, correct half the error by adjusting the reticule by the reticule screws and half the error by shifting the telescope. Repeat until the adjustment is found to be correct. Whenever other telescopes can be collimated in this manner, it should be done.

17. *Collimating telescope for Seacoast Artillery.*—The collimating telescope (No. 98) furnished with tools for Seacoast Artillery work is the ordinary nonerecting (astronomical) type with Ramsden eyepiece. The aperture of its objective is 1 inch. The power is 8 and the field of view is 3°. The draw tube, operated by a focusing ring, provides for the removal of parallax between the image and the reticule. The eyepiece is adjustable for focusing on the reticule. The cross-wire ring is held in position by four screws and washers. The collimation adjustment for this telescope is similar to that described above in paragraph 16.

To disassemble the draw tube, remove the screw holding the focusing ring cap to the focusing ring (see drawing 15–17–10), unscrew the cap and pull out the draw tube. The eyepiece is retained in the draw tube by a retaining screw. The objective cell is also locked in the tube by a retaining screw.

With the telescope is a bracket for use in collimating telescopic sight, model of 1899, and rings which fit the outside bearing surfaces of the tube and which adapt the collimating telescope for use in the telescope seats of the telescopic sight, model of 1902, the 3-inch telescopic sight, model of 1904, and the 2-inch telescopic sight, model of 1906.

CLINOMETER, MODEL OF 1909.

18. *Use.*—This instrument is provided for the checking of elevation scales. To use it, set up the clinometer on a clinometer rest. Level the cross level using the adjusting screw. Do not clamp the adjusting screws too tightly. Level the elevation level by means of the elevation mechanism of the gun or mortar on which the clinometer is used. Reverse the clinometer and relevel the cross level, if necessary. In

case the elevation level vial bubble is not central as before, correct half the error by adjusting the vernier by means of the vernier adjusting screw and half the error by means of the elevating mechanism of the gun or mortar. Repeat the operation to verify the adjustment. Care should be taken to loosen the vernier clamping screw before adjusting the vernier and to tighten it after adjusting it.

To set the clinometer to a given elevation, unclamp the slow-motion clamp, grasp the carriage on a surface as near as possible to the T guide surface of the support and slide the carriage to the approximate position desired. Then clamp the slow-motion clamp and make final adjustment by means of the slow-motion screw.

The least reading of the clinometer is 1 minute. A movement of the bubble of the elevation level of 0.1 inch corresponds to 30 seconds of arc.

19. *Adjustment.*—The elevation level is adjusted by means of the horizontal adjusting screws so that if the elevation level is set level, the clinometer may be rotated several degrees on the clinometer rest without being moved out of its level position. The elevation level is adjusted by means of the vertical adjusting screws to allow for setting the 0 mark of the vernier correctly.

The cross-level bubble should be central when the support is vertical, and it should remain central while the gun or mortar is elevated a few degrees, or the carriage is slid over the support a few degrees. A test of the correctness of the adjustment of the cross level should preferably be made when the elevation level is approximately level. The vertical adjusting screws are adjusted so that the cross level indicates level when an accurate machinist's level laid across the top surface of the support at right angles to it indicates level. The horizontal adjusting screws are adjusted so that the bubble of the cross level remains central as the gun or mortar is elevated.

OPTICAL INSTRUMENTS (Group a).

GENERAL CONSTRUCTION.

20. The construction of optical systems of service instruments vary from that of the simple Gallilean and astronomical telescopes to the intricate systems of the periscope and the horizontal base range finders. The larger number of telescope systems, however, consist of an objective, an erecting system, and an eyepiece. In some telescopes, as the battery commander's telescope, for example, additional prisms are used for the deflection of the entrance pencil 90°, in order that the axis of the telescope may be made vertical. The periscope systems include a combination of prisms so mounted that the image remains erect and the eyepiece in a fixed position during the rotation of the periscope head through a complete circle.

In horizontal base range finders special prism systems for accomplishing a sharp division of the field as well as the erection of the image are employed.

21. *Objectives.*—The objectives of service telescopes consist of combinations of two or three lenses which are, with few exceptions, combined to prevent spherical aberration and are, with the exception of the larger objectives, cemented. When two lenses or a doublet is used it consists of a crown-glass convergent lens and a flint-glass divergent lens. The crown or the flint may be in front, depending upon the optical characteristics of the glass. When three lenses or a triplet is used it consists either of two collective crown-glass lenses and a flint-glass dispersive lens, the flint being the central lens, or of two flints and a crown, the crown being on the inside. In some telescopes, as that for the Swasey depression position finder, the objective is centered in the tube by means of collimating screws, but ordinarily the optical axis of an objective is not adjustable in respect to the axis of the tube. In the latter class of instruments the telescope is collimated by adjusting the cross wires to bring their intersection into the optical axis of the objective.

22. *Erecting systems.*—Erecting systems are of various types consisting of lenses or of prisms. The lens-erecting system consists of two or more lenses inserted in the telescope system in the rear of the focal plane of the objective, usually in the eyepiece, and so constructed as to form a positive image of the image formed by the objective. By it the inverted image of the objective is reinverted. In the simpler form the system, together with the eyepiece, is known as the Fraunhofer eyepiece or terrestrial eyepiece. This system is used in the telescopic sight, model of 1899. In a modified form of this system, such as used in the telescopic sight for 14-inch turret mount, the simple lenses are replaced by cemented combinations in order to secure improved optical qualities.

23. The earlier prism-erecting system used in service telescopes is the Brashear Hastings erecting prism shown on Plate A. This prism consists of two 30° triangular prisms cemented to the base of a prism of pentagonal section with 90° roof angle. The path of the axial ray is shown on Plate A. The efficacy of this group of prisms depends not only on the correct angular relation of the various surfaces but also upon the proper assembling of the components. In it the roof angle is required to be ground within an extremely small angular error.

The Porro system of erecting prisms is shown in Plate C. The system consists of two right-angled triangular prisms mounted with their axes at right angles to each other and with the half of the hypothenuse faces of each overlapping. The path of the rays being bent back upon itself permits a shortening of the telescope. For

these reasons the Porro system has superseded the Brashear Hastings system in service telescope construction.

A Porro erecting system, modified for a telescope with a vertical axis, is shown in Plate E.

24. The periscope prism system consists of three prisms. See Plate E. The right-angled deflecting prism is connected with the erecting prism so that during the revolution of the former through a complete circle the latter rotates with half the angular velocity of the former. The optical effect of the system is the inversion of the image and the nonrotation of the image during the rotation of the system. The image which, however, is reversed right for left is corrected by means of an additional prism.

25. *Eyepieces.*—Among the numerous types of eyepieces found in service telescopes are:

The negative, consisting of a divergent lens as used in the telescope of the sextant telemeter.

The Ramsden, consisting of two simple convergent lenses of equal focal length and separated by a distance equal to two-thirds of the focal length of a lens.

The Kellner, a modified form of the Ramsden eyepiece, in which a single eye lens is replaced by a cemented doublet with plane face; for example see Plate A. This class is largely used.

The Steinheil, consisting of a cemented triplet with the crown collective element inside. This, for example, is found in the musket sight.

A special development of the Ramsden, the orthoscopic in which the field lens consists of a triplet and the eye lens of a plano-convex lens with small separation. For example, that used with the observation telescope, seacoast, model of 1908.

The terrestrial or Fraunhofer eyepiece, in which an erecting system is combined with the eyepiece proper.

With the exception of the telescope in which the first-mentioned divergent class of eyepieces is used all have fields in which a reticule may be placed.

26. *Adjustment.*—Each lens of an optical system is designed to reduce the aberrations of the system to a minimum. This design is based upon calculations in which is considered, among other things, the optical qualities of the glass used, the direction in which light traverses the system, the separation of lenses and the curvature of each surface. Due to the numerous conditions involved, the curvature of each surface is special. After test of the elements of a system they are assembled and the system is adjusted for the best results. Thus for the proper performance of an optical system there is but *one* way in which the components of a compound lens or system may be assembled, and but one distance at which the elements of a system

may be spaced. Thus the importance of the instructions given below to mark each element to indicate the direction in which light traverses the system and the relation of components to each other. Failure to observe these instructions will cause imperfect definition by an increase in the spherical aberrations and in many cases increased errors in curvature of the field and distortion. In some cases the impairment in definition may not be noted except by an experienced observer, but it will be sufficient to cause eye strains.

OPTICAL DEFECTS.

27. Chemical disintegration of optical glass is caused by the action of moisture, dust, and acid. Water is taken into composition in the surface layers of the glass and the alkaline contents of the glass set free. The resistance of glass to decomposition depends upon its chemical composition. Dust causes what is known as lead spotting—the formation of brown spots of irregular outlines or, in the more advanced stages, the covering of the whole surface with a brown film. Flint glasses used in the divergent elements of lenses are especially sensitive to attacks of this nature. The decomposition is due to the action of the weak organic acids present in dust. Among acids which decompose optical glass is acetic acid, which is present in the perspiration of the body. Thus the caution against the leaving of finger-marks on optical surfaces.

The decomposition of optical glass by weathering is due to the action of both water and acids present in dust or elsewhere. The form of decomposition ordinarily observed is lead spotting. The rate of decomposition increases with the temperature. It is especially rapid in the warm moist climate of the Tropics. Thus greater precautions are required in warm climates than in the cooler regions.

Decomposition first appears ordinarily on the flint of objectives and the exposed plane surface of the flint of the eye lens. The crowns of some objectives are also subject to attack. The glass used in prisms is comparatively not subject to decomposition.

To examine an optical surface for evidences of decomposition hold the piece so that the light of bright daylight is reflected by it nto the eye. Focus the eye on the glass surface. It is seldom that any surface defects will be apparent in light transmitted by the piece.

The surface decomposition detracts from the efficiency of any optical element by reducing the amount of light transmitted by the system. To remove the affected surface repolishing is necessary. This work should be done only at an arsenal or a properly equipped optical shop.

28. The balsam used in cementing compound lenses or prisms sometimes dries and cracks, the effect being observed in a delicately

formed tracery somewhat resembling frost markings in shape in the case of prisms, and small bright disks in the case of achromatic lenses. Whenever this becomes sufficiently pronounced to observe the image, the telescope of the instrument affected should be sent to an arsenal for overhauling. In no case should the recementing of prisms and lenses be attempted at posts.

CLEANING AND READJUSTING.

29. *Cleaning.*—For cleaning optical surfaces use the cloth and the special lens paper furnished for that purpose. An old soft linen handkerchief is also good. Under no circumstances use dirty cloths, dirty chamois skins, cotton waste, or similar materials. A camel hair brush is excellent for removing dust or lint. In case a solvent is required in cleaning, alcohol should be used. It is permissible to breathe upon the surface, but not to spit upon it. Saliva causes deterioration of lenses. Water, as explained above, is also harmful. It is preferable that it be not used except in very small quantities, as from the condensation of the breath.

In cleaning take care to remove with a brush all particles which might scratch the surface. Then moisten the surface with alcohol or the breath and wipe it carefully. Then dry it with a clean cloth or paper and wipe off any remaining lint with a soft brush. While cleaning take care that the fingers do not come in contact with a polished surface. Also do not allow any oil to reach the glass.

30. *Cleaning lenses.*—In disassembling compound objectives for cleaning, unscrew the cell retaining ring and carefully push the objective from its cell, noting which surface is the front surface and without disturbing the relative position of the component lenses. Mark an arrow ($\wedge$) across the periphery of the lens, the point of the arrow toward the front surface. While cleaning do not wipe off the marks. With the aid of the arrow in reassembling, preserve the original relation of all the optical surfaces. The elements of a compound lens should be separated by a ring of thin, preferably black, paper. In case a ring is not available stick three small narrow pieces of paper near the edge of each surface to prevent the glass surfaces from coming into contact with each other. Reassemble the compound lens in its cell with the same surface to the front as originally found.

In removing lenses from their cells and in inserting them do not bring too much pressure to bear upon them. The flint element is especially liable to be broken. The cells are made of slightly larger diameter than the lens and if not wedged by tilting the lens should freely seat itself. Chipping the edges should be avoided.

A compound lens should not be removed from its cell unless, after cleaning the exposed surfaces, it is found that the interior surfaces

also require cleaning. This will be seldom. Under no circumstances attempt to remove a lens that is burnished or crimped in its cell. Such lenses are cemented.

The lenses of eyepieces are ordinarily burnished in cells which are screwed into an eyepiece tube. For cleaning, unscrew the cells but do not remove the lens from its cell. If the cells are of the same diameter note before disassembling the order in which the lenses are assembled and reassemble in the same order.

31. *Cleaning Brashear-Hastings prisms.*—The Brashear-Hastings erecting prism is supported in a metal holder by a crossbar and two screws (see Plate B) for adjustment of the line of collimation. The prism may be rocked on the cross bar by means of the screws. In adjusting care should be taken to bring a slight pressure to bear on each screw but not to strain the prism. On gun sights after adjustment the space between the prism and its holder is filled in with plaster of paris. In time the plaster will crumble and require replacement. Examine the plaster of paris once a year and without straining them test the prism adjusting screws to see that they have not loosened. Do not remove the prism from its holder for cleaning. All surfaces may readily be cleaned without removal. Take especial care not to chip the edge of the roof of the prism. After cleaning look through the prism to detect any trace of the deterioration of the balsam.

When reassembling the prism holder in its seat take especial care to seat properly the dowel pins and to screw up tightly the prism holder screws.

32. *Cleaning Porro prisms.*—Porro prisms are ordinarily held in milled seats by springs as shown in Plate C. Generally it will be sufficient to clean only the exposed surfaces, in which case do not remove the prisms from their seats. In case it is necessary to remove the prisms, carefully mark each prism so that it may be assembled in the same seat and without turning it end for end. Sometimes notches are cut in prisms as an aid in assembling, but this is not always the case. To avoid interchanging it is advisable to disassemble but one prism at a time. These precautions are necessary, as it is impracticable to grind the angles of a prism without appreciable error, and interchange or reversal when assembling will change the position of the opticle axis of the instrument.

33. *Tests.*—The correctness of assembling and the accuracy of adjustment of an optical system may be tested by noting its definition and its freedom from errors. Ordinarily a test for definition, or the cleanless and distinctness with which objects appear, is sufficient. Make the test on clearly defined, distinct, distant objects, preferably on objects which stand out in sharp relief against a light background,

9950—17——2

such as lighthouses, stacks, poles, etc. Observe the sharpness with which the details of the objects are brought out in all parts of the field of view. The quality of a telescope may best be determined by comparison with other telescopes, preferably with those of the same power.

No telescope image is entirely free from errors, but in all systems the residual errors should not be sufficient to impair good definition or to interfere with the efficient use of the telescope.

In all telescope images it will be observed that a color fringe borders the outlines of well-defined objects. If the fringes are of yellow or purple color they are due to a residual chromatic aberration which it is not practicable to remove in manufacture. If, however, a fringe of a distinct red or blue color is visible in the center of the field some part of the optical system is out of adjustment or the elements are not properly corrected. Faults of this nature will most likely be found in terrestrial eyepieces.

Practically all objectives contain small errors known as spherical aberration, but in no objective should the amount be large. It may be increased by the reversal of lenses, especially of objectives. An appreciable increase will impair the definition of the telescope. To measure the spherical aberration, cover all of the objective except a small circle about ½ inch diameter at its center. Remove parallax from the telescope and note the position of the draw tube. Then cover all the objective except a narrow ring near its periphery and again remove parallax. Measure the difference in the position of the reticule under the two conditions named. This is the spherical aberration.

The images of straight lines in the central and outer zones of the field are sometimes curved either inward or outward. This error, known as distortion, should be small in any service telescope. It may, however, be greatly increased, especially by the reversal of an objective or of a field lens of an eyepiece.

Poorness of illumination may be due to dirt or moisture on the surfaces of some optical element or in rarer cases to the surface decomposition of the glass or to the breaking away of the cement.

The condition of the interior surfaces of a telescope may be examined without removing the eyepiece by a magnifying glass held in rear of the eyepiece and moved to bring the desired surfaces into view.

If double images of well-defined lines near the center of the field appear the fault is probably due to errors in the roof angle of the prisms.

Errors in the adjustment of prisms may be detected by testing the collimation of the telescope.

34. *Mounting of cross wires.*—Wires are mounted on a frame or holder in shallow grooves. Before assembling see that the ends of

these grooves are free from sharp edges. Especially see that the end of the groove from which the wire emerges before passing under a clamp is slightly rounded. The lower surface of the clamp or clip should be smooth and its edges slightly rounded to avoid cutting the wire. Unless these precautions are observed in mounting cross wires in gun sights, the wire may be broken by the shock of firing.

In mounting platinum wire 0.001 inch in diameter, clamp the free end of the wire under the clamp of the holder in line with the slot. Place a weight on the other end of wire, grasp the holder with one hand, slide the wire under the clamp, guide it into the groove, use a slight pressure on the holder to draw the wire taut, and then clamp the wire.

35. Platinum wire 0.0005 inch in diameter is silver coated. To remove the silver coating, bend a U-shaped frame of wire, preferably aluminum, of $\frac{1}{16}$ inch or smaller diameter. The length of the U should be about 3 inches and the distance between prongs $\frac{1}{2}$ inch to $\frac{3}{4}$ inch greater than the length of cross wire required. Cover the frame with beeswax for a distance of 1 inch from the open end. Mount the wire loosely on the frame, protecting the ends by the wax. Then hold the wire mounted on the frame in a concentrated solution of nitric acid for 5 or 10 minutes. Examine it carefully with a magnifying glass to see that all silver has been removed. Then wash by gently moving the wire through water.

The wire, still mounted on the frame, should be slipped under the clamps and guided into the grooves of the holder. Before clamping bring the wire taut by permitting the U frame to be supported by the wire. After clamping cut the wire from the frame.

36. In mounting wire 0.0005 inch in diameter or finer without clamps, use a solution of ordinary brown shellac dissolved in alcohol to the consistency of cream. Follow the same method as described above except that after the wire is located in its groove apply a drop of shellac with a sharp pointed piece of wood or other sharp tool. Allow the shellac to dry from 1 to 2 hours before cutting the wire from the frame.

37. *Plastering prisms in their holders.*—After adjusting the prism in its holder for collimation of the horizontal cross wire, set up the prism adjusting screws lightly and set the lock nut for the prism adjusting screw against the holder. Then remove the holder with the prism from the telescope and fill the space between the prism and the holder with plaster of paris and water mixed to the consistency of thick paste. Work the plaster in the space between the prism and holder, using a knife, piece of wood, or any other instrument, pack the plaster tightly and completely fill the space. Remove the surplus plaster and set aside to harden for two or three hours.

Use a good grade of dental plaster of paris, which will set in from 5 to 10 minutes.

38. *Directions for preparing a silvering paste and for applying it.*—In case the silvering on metallic parts of instruments becomes worn and unsightly, a moderately thin paste should be made by mixing 1 part of silver chloride, 15 parts of cream of tartar, and 5 parts of salt (NaCl) and enough water added to the mixture to form a paste. Let the silver stand over night to remove impurities.

Clean the surface to be silvered with fine emery or crocus cloth. All grease, dirt, etc., should be removed in order to get good results. Then rub the surface thoroughly with salt and a little water. Apply the paste with the finger, rubbing until a good white surface appears, then wash over the surface with cream of tartar and water. Wipe the surface and allow to stand until thoroughly dry. It will be preferable if the silvered surface is warmed before lacquering, but this may be found impracticable in many cases. The paste should be used shortly after preparation.

Then lacquer with white lacquer, using two coats. The white lacquer is prepared as follows: Dissolve 1 pound of kiln-dried white shellac in one-half gallon of alcohol, allow it to stand 24 hours, then run it twice through filter paper. It may be obtained ready for use by requisition in the usual manner.

39. *Litharge cement.*—The litharge cement used in sealing panoramic sights is manufactured as follows: Boil raw linseed oil in a pan until it smokes. Then set it on fire and let it burn for a few minutes. Cover the pan to extinguish the blaze and pour while warm into a receptacle containing red lead and litharge in the proportions of 1 ounce of each to a quart of oil. Keep at a temperature of 70° F. for 10 days and agitate once a day. Apply the cement in a thin coating to the parts to be cemented and allow it to dry at the ordinary temperature. Only a very small quantity of cement is required. It dries very slowly. It is not affected by either water or alcohol.

This cement is used for sealing the interior chambers of instruments. To obtain a sealed joint, careful fitting of plane surfaces is required. The cement will not compensate for poor fitting. Litharge cement may be dissolved by turpentine.

40. *Silvering of mirrors.*—A silvering solution may be prepared as follows: Make separately two solutions—one to be designated solution No. 1 and the other solution No. 2.

Solution No. 1. Mix 49.6 grams of nitrate of silver (dry in crystals) and 113.4 cubic centimeters of distilled water. After the silver nitrate has been dissolved, add ammonia drop by drop until the brown precipitate falls. Stop adding ammonia just before the solution clears.

Solution No. 2. Mix 35.43 grams of Rochelle salts (dry in crystal) and 85.05 cubic centimeters of distilled water.

Take one part of solution No. 1, one part solution No. 2, and two parts distilled water in a small vessel just large enough to hold the piece to be silvered. First carefully clean the surfaces to be silvered with grain alcohol. Suspend the piece in the vessel with the face to be silvered downward and immersed a little below the surface of the solution.

Place the vessel with suspended piece on a receptacle containing white sand and heat over a gas flame until the temperature of the solution is brought nearly to the boiling point. Extinguish the flame and allow to cool. When cold remove the silvered piece and wash with distilled water. Remove any superfluous silvering by rubbing with a small pine stick previously wet with 50 per cent solution of nitric acid. Wash the piece in water and then in alcohol and allow to dry for two or three hours, when it will be ready for a protecting cover, preferably two coats of shellac varnish.

For large mirrors use a covering of paraffin backed with tin foil. The mirror is gently heated and the melted paraffin is poured in a thin film over the entire silvered surface. For large mirrors great care must be taken in heating the mirror and in applying the hot paraffin, as extremes of temperature may cause the glass to crack after the paraffin has flowed evenly over the entire silvered surface and the tin-foil backing is applied. The paraffin prevents the action of the atmosphere on the silvered surfaces and the tin-foil backing prevents the paraffin from being rubbed or scratched off. For small work, as, for instance, the prisms of the Weldon range finders, however, either of the following mixtures may be used:

(*a*) A mixture of beeswax and resin—equal parts. The beeswax is sliced in small pieces and boiled so as to get rid of all free acid, and the resin is selected as pure as possible. The mixture is put on quite hot. It is well to have the prisms warm before applying the mixture.

(*b*) The method given in (*a*) may be improved upon by using the best shellac, if this can be obtained free from impurities. Shellac may be prepared by dissolving out the impurities in absolute alcohol, which should not contain more than 0.2 per cent of water. After dissolving, filter the varnish through three thicknesses of cheese-cloth. After silvering, heat the prisms to about 160° F. and apply two coats of varnish.

41. *Cementing of optical elements.*—When the conditions described in paragraph 28 become sufficiently pronounced to obscure the image, the lenses of prisms affected should be removed and placed in an alcohol bath to dissolve out the balsam. It frequently takes from two days to two weeks, or over, to separate the parts of lenses. In

refractory cases the alcohol may be heated gradually over a water bath at 150° F. to accelerate the operation. The parts should not be removed from a hot bath, but should be left to cool off gradually. After separating the parts, remove all trace of the old balsam and clean and dry thoroughly preparatory to recementing. Absolute cleanliness of the surface is necessary. The room in which the operation is conducted should be as free from dust as possible. The balsam should always be the best obtainable quality of paper-filtered Canada balsam. In cementing, spread a thin film of balsam over the surfaces to be cemented; be sure that the film entirely covers each surface and that no air bubbles occur, then bring the parts carefully together and place in a receptacle free from dust for the preliminary setting. By the preliminary setting is meant the first stage of the cementing process, in which the balsam gradually draws the two surfaces closer and closer together and holds them fairly tight, but still adjustable. The time for the preliminary setting varies from one to two days, the interval being less as the temperature increases. When it is found by actual trying that the surfaces are held fairly tight together, the final close adjustment by hand should be made. For lenses, this consists in getting the mechanical and optical axes of the group into coincidence.

42. *Cementing lenses.*—Compound lenses when issued in instruments have already been properly assembled. Before separating such lenses, therefore, a soft-pencil arrow (∧) should be placed across the circumferential rim of the lenses, crossing all in the direction of the optical axis. This pencil arrow should be carefully preserved, for in reassembling these same lenses, if the pencil mark on each lens is brought into proper relation with the marks on the other lenses, the original relative position will be exactly reproduced. If for any reason one part of the group has had to be changed the entire group will have to be tested again for correct relation and then assembled.

To determine whether the lenses of a group are properly ground for assembling, take them carefully by the rims and assemble them without balsam in the position which they should occupy. For properly ground surfaces, a series of color rings symmetrically placed about the optical axis will be observed when two adjoining lenses of a group are brought together. Should the surfaces, however, be too high or too low in spots, then at these spots either absence of color rings, or color rings appearing which have their center out of the optical axis of the group, will be observed, depending on the extent of the incorrect surface. When this color test shows the surfaces are not in proper contact, the parts should be returned for regrinding and repolishing. Where good results are obtained, the best position should be marked with an arrow (∧) across the rim and the group then assembled with balsam.

43. *Cementing prisms.*—Compound prisms are more difficult to cement than lenses. For prisms a target must be constructed and a fixture for holding the prisms during adjustment must be arranged, depending on the shapes of the prisms. In preparing fixtures or in inserting prisms into the fixtures do not scratch the glass. All grit, chips, and dirt must be carefully avoided.

The following method should be followed in adjusting and assembling the parts of a Brashear-Hastings erecting prism, assuming that each of the parts is correct in itself: Consult first the drawings of the instrument to which the prism belongs, and determine from them the amount of overhang each of the 30° prisms has over the ends of the 90° prism. Cement the two 30° prisms to the 90° prism with balsam, taking care to get each in the proper relation as to overhang, parallelism of sides, etc. Then put the group aside for the balsam to set. As the balsam sets it gradually draws the prism surfaces closer and closer together. After a few days (one or two if the process is aided by gentle baking in a properly constructed oven) it will be found that the prisms require a little effort to move them from one position to another. This is the time for final adjustment. Place the prisms, 90° prism down, in a previously prepared Y-shaped steel block, of which the sides of the Y make an exact right angle, carefully cut and ground to receive the 90° prism. The lowest element of the Y in the block should be so placed as to make the upper plane surface of the 90° prism, on which the two 30° prisms are assembled, horizontal when the block is placed in a horizontal position. Place a target containing fine vertical and horizontal axes at a convenient distance (20 to 30 feet) and at a height corresponding to the height of the center of the 30° prisms, when the entire group is placed in the Y block. Adjust a collimating telescope or some proper mount behind the Y block, so that when the telescope is horizontal in looking through the telescope at the axes of the target, the prism being temporarily removed from the Y block, the cross hairs of the telescope shall coincide with the axes of the target. Now place the Brashear-Hastings prism in the Y block and look through the telescope at the axes of the target. In the general case the cross hairs of the telescope and the axes of the target will not coincide. To bring about coincidence move the Y block carefully on its horizontal plate until the axes of the target as seen through the prism coincide with the cross hairs of the telescope. Having attained this position, be sure that the Y block and the telescope are not altered in position during the subsequent operations. Now lift the Brashear-Hastings prism out of the Y block and turn it 180° in a horizontal plane and replace in the Y block. This will result in bringing what originally had been the far 30° prism

next to the telescope and in moving the 30° prism that had been next to the telescope to the target side. Again look through the telescope. If the prisms are correctly adjusted the axes of the target as seen through the prisms in their new position will still coincide with the cross hairs of the telescope. If the axes and cross hairs do not coincide, correct for half the error by *moving each of the 30° prisms equal amounts.* Correct for the remaining half error by moving the block. Note that in moving the 30° prisms the position of these prisms, overhang, parallelism of sides, central distance, etc., remain as laid down in the drawings. Having obtained coincidence by the methods just outlined, reverse the prism again and continue correcting for half the observed error by moving the prisms and for the other half by moving the block, until the axes and cross hairs do not lose coincidence after reversing the prisms. The prisms are now adjusted and should be put aside to allow the balsam fully to set. After the balsam has fully set, the small end pieces should be cemented to the group and the group then assembled in the prism holder and then in the optical tube, as described in connection with special instruments, the adjustments of which are given in this pamphlet.

44. *Illumination of reticule.*—The intensity of illumination of reticules is varied by withdrawing the lamp from the aperture which admits the entrance cone of rays to the reticule chamber, as in the case of the azimuth instrument models of 1900 and 1900 MI, or by varying the diameter of the entrance cone of rays by means of a fixed and movable diaphragm, as in the case of the telescope for all models of depression position finders and 2-inch and 3-inch telescopic sights.

In order not to obscure the field of view the intensity of illumination of the reticule should be reduced as much as possible on both the horizontal and vertical wires. For the 2-inch and 3-inch telescopes but one lamp is provided, and in order to reduce the amount of light entering the reticule chamber, the lower mirror on the lamp bracket (see paragraph 10, pamphlets Nos. 1955 and 1956) should be rotated to secure the maximum intensity of illumination and the upper mirror should be rotated to secure an equal degree of illumination. The intensity of illumination of both wires should then be reduced as much as possible by turning the finger grip which operates the moving diaphragm.

Mirrors are used in the reticule illumination devices of the telescopes of the Lewis depression position finder Type A and the 2-inch and 3-inch telescopic sights. In case the necessary intensity of illumination can not be secured, the mirror holders should be removed and the mirrors polished with a dry cloth.

For night observation the best results will be obtained by the use of the low-power eyepiece furnished with instruments. The

diameter of the eye ring is greater with the low-power eyepieces and more nearly equals that of the pupil of the eye. Hence the field of view is better illuminated.

45. The following examples are given as directions for removal of optical parts, for cleaning, and for readjusting. The methods of making adjustments, etc., will not be described for all instruments, but only for the various types of instruments.

TELESCOPIC SIGHT, MODEL OF 1899.

(See Handbook of Sights for Cannon and Drawings 15–2A22, 1, 2, and 3.)

46. *To remove the erecting system.*—Remove the objective and cell, the erecting system clamp ring screw, the tube cap, deflection slide, and lower deflection scale. Enter teat wrench No. 29 through the objective end of telescope, engage it in the teat holes in the first diaphragm and screw the erecting system completely out through the eyepiece end of telescope.

Scratch a short line across all joints as an aid in assembling each piece in the correct order and in tightening up screw threads. Some of the parts have similar threads on both ends and care must be taken not to reverse the piece end for end. Do not remove any lens from its cell.

Unscrew the first lens cell. Do not remove the first diaphragm. Grasp the erecting system in a chuck and unscrew the second lens cell. Clean and replace both cells. Remove the third lens cell, clean, and reassemble.

47. *To assemble the erecting system.*—Insert the erecting system threaded and rearmost, through the reticule chamber and screw into place, using teat wrench No. 29. Align the hole in the wall of the front erecting system tube with the seat of erecting system clamp ring screw. Assemble the objective, the reticule, and the eyepiece and test to determine whether parallax can be removed from the cross wires. If not, remove the objective and revolve the erecting system tube in the proper direction until parallax may be removed and the clamp ring screw assembled. Replace erecting system clamp ring screw.

Little dirt works into the erecting system of this telescope. It will not therefore be necessary to remove the erecting system except at long intervals.

48. *To collimate the telescope.*—Mount bracket No. 102 of optical repair kit on fixture No. 86, and pedestal No. 85. Level the pedestal. Insert collimating telescope No. 98 in bracket No. 102 and bring the image of the crosslines of a target into coincidence with the reticule to collimating telescope. Test the collimation of the collimating telescope and correct it if necessary. Then remove bracket No. 102

and collimating telescope from fixture No. 86 and place the telescope to be collimated upon the fixture without changing the position or adjustment of fixture. Loosen the four reticule holder screws and adjust reticule holder so that the horizontal wire coincides with horizontal wire of target and so that the vertical wire is plumb. Turn the deflection knob until vertical wire coincides with vertical line of target. Loosen the upper deflection scale screws and reset the upper deflection scale if necessary. Loosen the two deflection knob screws and set the deflection micrometer to 0. Reset the lower deflection scale and test adjustment by the eyepiece.

This telescope may also be collimated by using bracket No. 102 on the telescope seat of the gun carriage. The method of adjusting is the same as described above. Collimating the telescope on the gun carriage will probably be found preferable.

TELESCOPES WITH BRASHEAR-HASTINGS ERECTING PRISMS.

49. The telescopes of the following instruments are equipped with this kind of prisms:

Telescopic sight, models of 1896 MI, 1897, 1898, 1898 M, and 1902.
Lewis depression position finder, types A and B.
Swasey depression position finder, type A.
Azimuth instrument, model of 1900.
Three-inch telescopic sight, model of 1904, Nos. 1–26, inclusive.

TELESCOPIC SIGHTS, MODELS OF 1896 MI, 1897, 1898, AND 1899 M.

(See Handbook of Sights for Cannon and Drawings 15-2A19, 1 to 4, inclusive.)

50. For adjusting telescopic sights, models of 1896 MI, 1897, 1898, and 1898 M, a trunnion bracket (No. 87) is furnished with the optical repair kit. The following examples of its use will be given, which is applicable to either of these models of sights. Attention is also invited to "Handbook of Sights for Field and Seacoast Carriages not covered by other Pamphlets" (Form No. 1952). The fixtures and tools mentioned by numbers pertain to the optical repair kit.

51. Prepare a target on which is one horizontal line and two vertical lines, the distance between which is equal to twice the horizontal distance from the axis of the telescope to the axis of the telescope trunnions. The horizontal line of target should lie as near as practicable to the horizontal plane which includes the optical axis of the telescope. One leveling screw of the pedestal should lie in the vertical plane of the trunnions of the sight.

Level the trunnion bracket (Fixture No. 87) in the pedestal (Fixture No. 85) with a striding level (No. 74). Set the telescope without the prisms assembled in the trunnion bracket; adjust the telescope level to make the bubble central in level vial by changing the elevation

of the telescope. Set the micrometer elevation dial and vernier to read 0. (The setting of level should be tested in the usual way.) Insert the cross-wire frame (if not already assembled) and adjust the horizontal wire to coincide with the horizontal line on the target. Remove the telescope from the fixture. Rotate the swivel of trunnion bracket 180° from its former position against the stop. Replace the telescope in the bracket bottom side up. If the horizontal cross wire is not in the plane of the optical axis, correct for half the error by moving the cross-wire frame by the small adjusting screws in the top of the frame, and for half the error by moving that leveling screw of the pedestal which lies in the same vertical plane as the axis of the trunnions of the sight; without changing the level of the pedestal, reverse the telescope and recorrect if necessary.

52. If the horizontal cross wire can not be adjusted due to error in adjustment of the telescope level, the cross-wire frame should be left in an intermediate position and the adjustment for collimation made as closely as practicable by adjusting the prisms (see below) and corrected as described above after the prisms are adjusted.

53. For adjusting the vertical cross wire move the vertical wire to near the center of the diaphragm and the micrometer deflection dial to zero for trial. (It is assumed that the prisms are disassembled.) Put the telescope in the bracket. First adjust the cross level so that the bubble of level vial remains central throughout the entire arc of elevation of the telescope (for the models of 1898 and 1898 M sights). If adjustment of the level vial is necessary, remove the cap from cross level and adjust it by the internal adjusting screws (see paragraph 172). If the adjustment is made correctly, the vertical cross wire should follow a plumb line during elevation of the telescope.

54. In adjusting the cross levels of the models of 1896 MI and 1897 sights, set the telescopic sight trunnions approximately level in the trunnion bracket and the cross wire at 0° deflection and level the cross level. Align the vertical wire on a plumb line without changing the deflection setting. Then elevate the telescope through the greatest possible range of elevation scale. If the vertical wire does not follow the plumb line, correct the error by the adjusting screw of the telescopic sight holder to bring the vertical wire into coincidence with the plumb line. Then adjust the cross level by moving its axis in a plane perpendicular to the surface of the base of the level case until the bubble is central. Repeat the test to verify the setting.

Then put the sight in the trunnion bracket of gun at 0° elevation and level the cross level. Elevate the gun through as great an arc as possible. If the bubble of cross level does not remain central, slightly loosen the screws of the level case and adjust the level so that the bubble is central at this position. In this adjustment the axis of the

level is moved in a plane parallel to the base of the level case. Repeat test and after adjustment is satisfactory, readjust the level for movement of telescope in elevation as directed in preceding paragraph.

55. After the cross level is adjusted align the telescope on the right-hand vertical line of target. Take out the telescope and replace it bottom side up, turning the swivel of bracket as before. If the vertical wire does not coincide with the left-hand vertical line of target, determine the amount of the error by means of the micrometer deflection dial, and turn back the micrometer toward the first position by one-half of the measured error. Reset the telescope on the target, with the vertical wire in this new position. Reverse the telescope and proceed as before to correct the adjustment of the vertical wire. The micrometer deflection dial should be set at 0 and the internal scale adjusted for this position.

56. Collimate the prisms as described below for 3-inch telescopic sights, model of 1904, Nos. 1–26, inclusive. Then remove prism and holder from the telescope tube, fill the space around the two adjusting screws between the prism and the holder with plaster of paris and allow the plaster to set. Carefully clean the prisms and replace them and the holder in the telescope. Set the telescope with the vertical cross wire on a vertical line of target. Insert the holder screws into the telescope body and align the prism holder so that the coincidence of the vertical cross wire with a line on the target is not disturbed. Test the adjustment by reversing the telescope as described above. Then tighten the prism holder screws and replace the prism box cover. The horizontal and vertical axis should then be tested for collimation and collimated if necessary, as described above.

57. After a workman has become familiar with the adjustment of sights in the manner described above, it will be sufficient if prisms are located centrally in telescope tube before the cross wires are collimated. Then set the horizontal cross wire in an intermediate position and collimate by adjusting the screws between the prism and holder, moving the axis of the prisms in a vertical plane only. Remove the prism and the holder and fill the space between them with plaster of paris. Then complete the collimation of the horizontal wire by adjusting the cross-wire frame. Adjust the vertical wire as described above. In this case, test the location of prisms in the tube by looking through the telescope and observing that neither edge of prism is seen within the diaphragm or that both edges are seen equally spaced from the sides of diaphragm.

58. After a telescopic sight is adjusted in this manner, it should be tested for parallelism with the axis of the bore of the gun. If the line of collimation of the sight is not parallel with the axis of the bore at 0° deflection and 0° elevation, the sight brackets on the gun car-

riage should be adjusted, or the V's of the trunnion bracket should be filed or scraped to make the line of collimation parallel to the axis of the bore under the conditions stated.

TELLESCOPIC SIGHT, MODEL OF 1902.

(See Drawings 15–2A18, 1, 2, and 3.)

59. To collimate this telescope, use collimating telescope No. 98 with rings Nos. 101, pertaining to the optical repair kit, in the cradle of sight. Point the gun at a given object and adjust the prisms by the prism-adjusting screws so that the line of collimation of sight agrees with that of collimating telescope. The erecting prism holder is located in the telescope tube by dowel pins. Relocation of these pins will not be required except to compensate for errors in cementing the elements of the erecting prism. After adjustment of the horizontal plane containing the line of collimation, set up the prism-adjusting screws so that they just come in contact with the glass surface, set the lock nuts and fill in with plaster of paris as described in paragraph 37 above.

3-INCH TELESCOPIC SIGHTS, MODEL 1904, NOS. 1–26, INCLUSIVE.

(See Plate A.)

60. *To dismount the eyepiece and prism.*—To remove the prism holder, unscrew the four screws (1) on cover (2); unscrew (3) and lay aside with washer (4); unscrew (5), and the whole prism, with holder, can be taken from the telescope body. To remove the prism from its holder, unscrew (6), take out piece (7), and the whole prism is now ready to be removed. Great care must be taken to replace the prism in exactly the same position in the holder. Plate A shows clearly the method of dismounting the eyepiece. No attempt should be made to remove the lenses of the eyepiece from their cells.

61. The lenses of the objective of this telescope are secured in the holder by crimping, and should not be removed for cleaning or any other purpose, except by an expert instrument maker.

62. *To assemble and adjust the telescope.*—Assemble and insert the eyepiece, but not the prism, as the telescope must be adjusted without the latter. Place the collimating telescope No. 98, using rings No. 103 in the telescope bearings of the sight cradle. Select a target at least 300 yards' distance and bisect it with the cross wire. Then revolve the collimating telescope 180°, and if the cross wires bisect the same target exactly then the adjustment of the collimating telescope is correct. Remove the collimating telescope and without changing the pointing of the sight, insert the 3″ telescope in its bearing in the cradle. If the cross wires are to one side, or up or down

from the target selected, then the whole error must be corrected with the cross-wire adjusting screws (9). Check the correctness of the adjustment. Then with the telescope in position and carefully aligned on the target, insert the prism and screw down tight screw (5) and also screw (3). If the telescope does not bisect the target exactly as before, then the correction up or down must be made wholly with the screws (3) and (10); (3) holds the prism holder to the telescope body, and (10) are pushing screws, which raise and lower the image of the objective in relation to the cross wires. The adjusting sideways is done by screws (11), and to do this the screw (3) must be unscrewed and the whole prism holder, with the prism hinged on screw (5), raised enough to reach the screws (11) and then dropped.

Great care must be taken that both the screws (10) are turned exactly the same amount and touch the telescope body at the same time, otherwise, by screwing down the screw (3), the whole holder will be twisted and the prism may be broken or strained sufficiently to destroy good definition.

After inserting and adjusting the prism, the telescope should point to exactly the same point as without the prism. All adjusting with screws must be done carefully and in such a way as not to put any strain on the metal, because if the screws are too tight the adjustment will change rapidly. As a general rule, it is always advisable to tighten each screw just enough to secure a firm contact between the two parts without any strain whatever.

SWASEY DEPRESSION POSITION FINDER, TYPE A.

(See Plates B and C.)

63. *To dismount the eyepiece.*—Plate C indicates clearly the construction and method of dismounting the eyepiece. No attempt should be made to remove the lenses of the eyepiece from their rings.

64. *To dismount the objective* (Plate C).—Unscrew objective shade (45-46), then unscrew the objective cell (91), unscrew the ring (93) which holds the objective in the cell, and put a clean piece of linen on a table and take out the objective (92) from the cell (91). To do this it is best to unscrew first ring (93) and lay the cell of the table with the ring (93) end up. Then put a clean piece of linen over the left hand; put left hand covered with linen on top of cell and lenses, and reverse, so that the left hand is on the bottom and the right hand on the top. Now raise the cell slowly and both lenses will come out of the cell easily. Should the lenses fit a little snugly, especially in cold weather, bring the whole cell into a warm room and let it stand for about one hour; the lenses should then be readily removed from the cell. Before separating the lenses, place a soft-pencil arrow (∧) across the circumference. Clean carefully and put back in the

same position. There are three small pieces of paper pasted on one of the lenses of the objective, exactly 120° apart and at the egde, to separate the two lenses.

65. *To dismount, replace, and readjust prism* (Plate B).—Remove cover by unscrewing the screws.

Unscrew the two screws (1) and take out the prism with its holder, loosen (4) a trifle, take out screws (2), and remove crossbar (3). Then the prisms will come off from the holder easily.

Clean prisms carefully, insert in holder, put in place piece (3); put in screw (2) and tighten screws (3); then slowly tighten screws (4).

This telescope, with the Brashear-Hastings prism removed, is adjusted exactly as described for the telescope of Type A1 below. After this is done, the Brashear-Hastings prism must be inserted with screws (1), Plate B, and if the image now on the target is too high or too low, then this must be corrected with screws (4) by loosening one screw a trifle and tightening the other one. If the image is to one side, loosen slightly one of the screws (1) and move prism holder in desired direction. This is best done by wedging a screw driver between the opening of the telescope body and the prism frame. In case the prism holder can not be moved to one side correct the error by changing the collimation of the objective. After adjusting, put the cover on top of the telescope and secure with screws (5).

In this telescope no adjustment of the reticule is provided.

ADJUSTMENT OF PRISMS OF LEWIS DEPRESSION POSITION FINDER, TYPE A.

(See Pamphlet No. 1873.)

66. The vertical adjustment of the prisms of the Type A position finder should be made in reference to the tide scale in order to minimize the error of the range scale for various heights of tide. In making this adjustment, set the range scale at infinity (if not practicable set at maximum range on scale) and the tide slide at either extreme of the scale. Set up a target with horizontal line in the horizontal plane of the axis of the trunnions of telescope. Direct the telescope on the target and by turning the refraction screw bring the horizontal cross wire of the telescope to coincide with the horizontal line of the target. Then translate the tide slide to the other extreme end of the scale. If the horizontal cross wire still remains on the horizontal line of the target, the prism is correctly adjusted vertically. If the coincidence of the cross wire and the horizontal line is disturbed, correct half the error by rotating the prisms in a vertical plane by means of the prism holder screws and half the error by rotating the telescope on the trunnions by the refraction screw. Repeat until the adjustment is found to be correct.

67. In the telescopes for the following instruments Porro prisms are used for erecting the image:

Swasey depression position finder, type AII.
Lewis depression position finder, model of 1907.
Azimuth instrument, models of 1900 MI and 1910.
Three-inch telescopic sight, models of 1904 (after No. 26) and 1910.
Two-inch telescopic sight, models of 1906 and 1909.
Observation telescope, seacoast, model of 1908.
Observation telescope, field, model of 1908.
Battery commander's telescope, models of 1904, 1905, and 1915.
Telescopic musket sight, models of 1908 and 1913.

68. Porro prisms of all telescopes mentioned above are fixed in position in a holder and do not permit of adjustment as in the case of Brashear-Hastings prisms. Each telescope is tested for adjustment of prisms before it leaves the manufacturer and no change should be found necessary. Telescopes with Porro prisms are ordinarily collimated by moving the cross-wire holder. In a few telescopes the objective can be adjusted as in the case of the telescope for the Swasey depression position finder, types AI and AII.

3-INCH TELESCOPIC SIGHT, MODEL OF 1904 AFTER NO. 26.

(See Plate III, Pamphlet No. 1955.)

69. *To dismount eyepiece.*—Plate III, Form No. 1955, indicates clearly the construction and method of dismounting the eyepiece. No attempt should be made to remove the lenses of the eyepiece from their cells.

70. *To dismount the prisms.*—To take off the prism holder, unscrew all screws and remove the holder from the telescope body by simply raising the holder from the telescope body; push down one end of the prism spring to disengage the recess or receiver and pull or turn the spring sideways. If this is done, and the spring removed, the prism is ready to be taken out. Care must be taken after cleaning the prism that it is mounted in the same position as before.

71. The prism holders on sights after No. 297 differ somewhat from those that preceded. The holder is separate from the cover and is secured to the tube by five screws, three entered from the outside of the tube on the right hand and two entered inside the cover through a shoulder on the prism holder. The cover is in two pieces, the smaller of which is secured to the right-hand side of the prism holder by three screws. The larger is secured to the smaller by three screws and to the prism holder on the left side by two screws; in addition, one screw secures it to the rear flange of the prism-holder seat and one to the front flange. In dismounting, first remove the larger piece of the cover and then the smaller, when the prism holder

may be taken out. The parts should be assembled in reverse order. The method of removing the prisms from the holder, cleaning, and reassembling is the same as that described in preceding paragraph.

72. *To dismount the objective.*—Unscrew the objective holder and lay it on a clean table covered with fine white paper. Then unscrew the ring securing the three lenses (56) in the holder. Be careful that the two black paper rings which separate the lenses are not lost. Before taking the lenses apart, put a soft-pencil arrow (>) across the periphery and in line with the optical axis of the objective, the point of the > toward the outside surface of the objective. This will serve to indicate that the three lenses must be put in the same position as before cleaning; with the indicated arrow lines, the position of the lenses can not be changed, because there is only one position where the lines of the arrow will match.

73. *To adjust the telescope.*—Place the collimating telescope No. 98 with rings No. 99 in the cradle bearing and sight on an object. Test and adjust collimating telescope if necessary. Remove the collimating telescope, and without disturbing the position of the bearings insert the telescope to be adjusted, and by means of the cross-wire holder screw collimate it to agree with collimating telescope. (See paragraph 62.)

74. Make the vertical wire parallel with a plumb line. The holes through the focusing sleeve and draw tube for reaching the cross-wire ring screws are slotted for this purpose. Before this adjustment make sure that the focusing sleeve (51) is screwed tightly into the tube. If the focusing sleeve can be screwed in too far, its flange should be packed up with a thin piece of metal, paper, or other suitable material.

SWASEY DEPRESSION POSITION FINDER, TYPE AII.

(See Plate C herewith and Plates I and II, Form No. 1875.)

75. The eyepiece and objective of this telescope are the same as in the type A instrument and should be dismounted as described in paragraphs 29 and 30.

76. *To dismount and replace the prism* (Plate C).—Take off screw (81) and turn focusing nut (50), holding the eye end (53) until the thread of the focusing nut is disengaged with the thread of the eye end, and then slide out the whole eye end. Remove screw (86) and spring (87) and the prism (88) can be lifted out, cleaned, and replaced in position. Take off eyepiece and micrometer box by unscrewing screws (82), then unscrew (83), remove the spring (84), and the prism (85) can be removed, cleaned, and placed in position as before. Insert spring (84) and screw in screw (83), assemble micrometer box and eyepiece to prism holder with screws (82), put into telescope, and see that screw (81) fits in the slot of the prism holder.

77. *To adjust the telescope for level and collimation (Plates I and II, Form No. 1875).*—Set the striding level on top of the telescope, turn the range crank on range drum, and bring the level bubble in the center of the glass scale; then reverse the striding level, and if the bubble is not exactly in the center of the divided glass scale, correct half the error with the adjusting screws of the striding level, and the other half with the range crank (71). Repeat this several times until the level bubble remains in the center.

78. Set the azimuth index at 0 and bring the striding level bubble to the center of the glass scale by turning the range crank, then revolve the whole telescope and cradle 180° on the vertical spindle, so that the azimuth index reads 180°. If the level bubble should happen to be in the center of the glass scale, the axis is perfectly plumb in this position; but if the level bubble is not in the center then half of this error must be corrected on the leveling screws (47) and the other half by turning the range crank (71). Repeat these readings several times and at the end set in azimuth every 90°—first 0°—180° and 180°—0°, and then 90°—270° and 270°—90°. If the level bubble remains exactly in the center, then the instrument is correctly leveled and all that is necessary is to open the door (74) in front of the range-drum cover, loosen a trifle the three screws on the range drum and set the range drum so that telescope level on the drum corresponds with the index line of the range pointer (78). Next point the telescope to some distant object and find some point or target bisected by the cross wires. Then take off the striding level (46), open the two caps (66) on the telescope trunnion, take the telescope out of the bearings and reverse the trunnion axis with the whole telescope, close the two trunnion caps, set the striding level on top of the telescope, and turn the range crank so that the level bubble is again in the center of the glass scale. The cross wires should exactly bisect the same target as before; if they do not they are either too high or too low or to the right or to the left. In either case only half the amount of this error is to be corrected by shifting the objective. Loosen slightly the screws (89), Plate C, and by using the screws (90), Plate C, always in opposite directions, loosen one and tighten the other either up or down or sideways until the telescope is adjusted correctly. This operation must be repeated several times to insure correct adjustment. Note that the horizontal wire may be moved in a vertical plane and that before collimating the horizontal wire should be moved to bisect the field of view.

79. *To adjust the vertical wire, type AII, serial numbers after No. 219 only.*—In case the vertical wire is not parallel to a plumb line loosen the four screws holding the wire ring in the micrometer slide and rotate the wire ring in the micrometer slide until wire is plumb. Then set up screws.

LEWIS DEPRESSION POSITION FINDER, MODEL OF 1907.

(See pamphlet No. 1876, Description of Lewis D. P. F., Model of 1907.)

80. *To replace and to adjust the cross wires of telescope.*—Remove the eyepiece adapter (21) from the prism case back. Unscrew the cross-wire adjusting screws (15) and remove the cell for spider lines. Insert the cross wires (platinum wire 0.0005 inch diameter or spider web) and replace the cell for spider line in the eyepiece adapter, taking care that the cell for spider lines is concentric with the bore of the eyepiece adapter. Replace the eyepiece adapter and in case the vertical cross wire does not appear to bisect the field of view adjust the position of the cell for spider lines by means of the two cross-wire adjusting screws (15) on the sides of the eyepiece adapter.

Make the vertical wire parallel with a plumb line set up at a distance for which parallax may be removed from the telescope. It will be noted that the holes through which the cross-wire adjusting screws (15) pass are slotted to permit this adjustment. This operation may well be combined with the next, the target described being made of sufficient length for making the vertical line plumb.

81. Use fixture No. 86, or any other surface plate, on pedestal No. 85, and level with bench level No. 73. Using collimating telescope No. 98, with a convenient set of rings or guides, lay off on a target a horizontal line whose image is coincident with the horizontal cross wire. If the target is near, make the necessary allowance for the difference in heights of the center of the collimating telescope and of the objective of the Lewis depression position finder and lay off a second line to represent the height of center of Lewis depression position-finder telescope. Screw the counterweight of telescope to be collimated to a position nearest the center of the trunnion yoke (53). Clamp the telescope to the surface plate so that the bar (51) bears uniformly on it, or lay the telescope on the surface plate with the bar in uniform contact and support the outer end of the telescope. Adjust the two cross-wire adjusting screws (15) on the top and bottom of the eyepiece adapter (21) so that the horizontal cross wire coincides with the image of the horizontal line of target. Verify the adjustment of the vertical wire. Assemble the telescope.

On instruments Nos. 154 and higher, remove the angles piece attached to the side of bar (51) before placing the telescope on a surface plate.

82. On instruments of serial numbers 154 and above the objective is mounted in an adjustable collar, the axis of which is adjustable in respect to the axis of the tube of the telescope. This adjustment is to compensate errors in manufacture and should not need be made in the field. If the parts are disassembled, center the adjustable collar in the tube so that about equal movement of the objective

may be made in any direction. Make the collimation adjustment by the cross-wire adjusting screws. If the collimation adjustment can not be made correctly by those screws, loosen the four screws clamping the adjustable collar to the flange of the tube and by means of the radial screws in the adjustable collar make the necessary correction of the line of sight. Repeat the test and tighten all screws.

83. *Alternate method.*—Set up a transit or level so that the center of the telescope of transit or level is in the same horizontal plane as the center of the telescope of the Lewis depression position finder (or make the necessary allowance for difference in height). Before measuring to obtain the center of the telescope make the bar (51) parallel to the tangent screw rail as described in succeeding paragraph. Lay off a permanent target to indicate the position of the horizontal plane through the axis of the objective of the position finder.

Level the position finder. Set the range dial at some range, greater than 1,500 yards but less than the maximum range, for which the compensating bar (14) and the tangent screw rail (46) are parallel. (After releasing the clamp screw (12), no movement of the compensating screw (11) should occur during translation of the slide block (42) even if the compensating bar and tangent screw rail are not parallel. The setting of the bar and rail, however, guards against accidental disturbance of the compensating screw.) Release the clamp screw (12). Adjust the compensating screw (11) so that as the slide block (42) is moved along the tangent screw rail (46), the horizontal cross wire remains aligned on the same external object. Then adjust the horizontal cross wire to bisect the line previously laid off.

In case a permanent target for telescope level is laid off, measure the distance between body (8) and pedestal cap (33) and when collimating the telescope see that the distance between these parts is not appreciably changed. In case the target is at least 100 feet distant, a variation of one thirty-second of an inch in the distance between body and pedestal cap may be neglected.

84. To lay off a target at the height of the axis of telescope without the aid of a transit collimate the telescope on a surface plate as described above, and mount the telescope in its yoke and level the table. Set the range dial at some range greater than 1,500 yards and less than the maximum reading for which the compensating bar (14) and the tangent screw rail (46) are parallel. Release the clamp screw (12). Adjust the compensating screw (11) so that, after unclamping the nut block (30), as the slide block (42) is moved along the tangent screw rail (46), the horizontal cross wire remains aligned on the same internal object. Then lay off a target whose image coincides with

the cross wires and use this target for future collimation of the instrument.

85. The telescope may be collimated approximately by adjusting the horizontal wire in the same manner as described in paragraph 80 for the vertical wire—that is, to bisect the field of view.

BATTERY COMMANDER'S TELESCOPE, MODELS OF 1904 AND 1905.

(See Plate E, herewith, pamphlet No. 1796, and drawings 22–17–1 to 6, inclusive, for model of 1905, and drawings, 22–2–1, 6, 7, 8, 9, and 10 for model of 1904 instrument.)

(The symbols given apply to the model of 1905 instruments only.)

86. For a description of the operations of disassembling and cleaning the battery commander's telescope which are permitted in the field, see pamphlet No. 1796 (Handbook of Battalion and Regimental Equipment of Field Artillery and of Fire Control Equipment of Field Artillery Batteries, with instructions for its care). A description of the operations of disassembling the base of the instrument will be found in paragraphs 174–176 below.

87. *To clean the objective prism* (6V).—Remove the telescope from the mount, take out the four objective prism box cover screws (5P) from the front face of the objective prism box cover (5J), remove the cover (5J), turn the telescope over, and gently tap against the hand and withdraw the objective prism (6V). Before removing the prism mark the top, in order that it may be reassembled in the same manner as originally adjusted. The three polished surfaces of the prism should be carefully cleaned. Reassemble parts in the reversed order.

The objective prism base (5G) should not be removed from the objective prism box (5H).

88. *To remove the objective.*—Unscrew the four objective prism base screws (5M) on the circumferential surface of the objective prism base (5G) and draw off the objective prism box (5H) and the objective prism base (5G) together. Do not separate the base from the box. Unscrew the objective cell (5E), clean the objective lens (6W), and replace. Do not attempt to remove the objective from its cell.

89. *To clean the focusing mechanism.*—The objective prism and box and the objective cell should be removed. Then take out the focusing pinion sleeve screw (5DA) and pull out the focusing pinion (5U) and the focusing pinion sleeve (5CA). The draw tube (5B) may now be removed. Carefully clean all parts, put a little vaseline on the focusing rack (5S), and lightly oil the draw tube (5B) with clock oil. Insert the draw tube with a downward spiral motion, align the focusing rack, and assemble the focusing pinion (5U). The objective cell holder (5D) is soldered to the draw tube and should not be removed.

90. *To disassemble the focusing pinion* (5U).—Loosen the focusing pinion nut screw (5AA), unscrew, gently tap to allow the focusing pinion knob washer (5X) to drop out, pull off the focusing pinion knob (5W), noting that it is keyed to the shaft, and take off the focusing pinion sleeve (5CA). Clean, lightly oil with clock oil, and assemble in the reversed manner.

91. *For cleaning the Porro prisms.*—It will be necessary to take out the three prism cover screws (2KA) in the axis prism cover (2LA) and to remove the cover. Then unscrew the four prism holder screws (2FA) and remove the axis prism holder (2MA). Loosen the prism holder spring screw (2GA) and take out the upper (small) prism. The lower prism may be taken out as soon as the prism holder is removed. Carefully mark the prisms before removal, in order to reassemble them in the position for which they were originally adjusted. If these precautions are taken, no difficulty should be experienced in reassembling.

92. *To disassemble the eyepiece.*—Take out the eyepiece screw (5GA) and pull the eyepiece from the eyepiece adapter (5EA). The field lens cell (5HA) and the eye lens cell (5JA) may be unscrewed from the eyepiece tube (5FA). Do not attempt to remove the lenses from their cells.

93. *To remove the reticule* (6H).—For cleaning, it will be necessary to unscrew the eyepiece adapter (5EA) from the axis (2PA). But first mark the position of the eyepiece adapter (5EA) as assembled in the axis (2PA) by drawing or scratching a line across the top surface of the eyepiece end of the axis and the end of the adapter. Then unscrew the eyepiece adapter (5EA), take out three of the reticule holder screws (6C), hold the reticule holder (6A) by the finger, and remove the fourth reticule holder screw and allow the reticule holder to drop out onto the palm of the hand. Keep the reticule holder screws (6C) and washers (6B) together, and reassemble them in the same hole from which removed. Also note the position of the reticule before disassembling, in order to put it back in the same position.

In reassembling, place the reticule holder (6A) in the eyepiece adapter (5EA) in the proper position, insert the reticule holder screws (6C) in the same holes from which removed. Tighten opposite screws and adjust the reticule holder concentric with the bore of the adapter. Test this position with inside calipers. Reassemble the eyepiece adapter (5EA) in the axis (2PA), so that the marks made on the adapter and the axis come opposite each other. Then assemble the Porro prisms (if not in place), the eyepiece, and the objective (if not already in place).

94. *Adjustment.*—After assembling all the parts except the objective prism and prism box, the telescope will now be adjusted. For this purpose carefully level the base of the instrument on a stable mount or plate. Put the telescope in the trunnion bearings so that the axis of the objective lies in a horizontal plane. Adjust the reticule holder (6A) by the reticule holder screws (6C) so that the vertical line on the reticule is parallel to a plumb line. In making this adjustment do not disturb the concentricity of the reticule holder and the eyepiece adapter.

95. To more perfectly collimate the telescope, set the azimuth scale at 0 and accurately align the vertical line of reticule on a plumb line. Reverse the base 180° so that the azimuth scale reads 32. Take out the telescope from its bearing, turn it around, and replace it in the trunnion bearing. Correct half the error of the vertical line of reticule from the plumb line by readjusting the reticule holder, taking care to keep the vertical line parallel to the plumb line. Correct the remainder of the error by rotating the platen (4R) by the slow motion screw. Repeat until the adjustment of the reticule is made satisfactory.

96. Then assemble the telescope in its normal position, align the vertical line of reticule on a plumb line, and rotate the telescope on its trunnions until the axis of the telescope tube is vertical. Carefully maintain the position of the telescope for direction. Assemble the objective prism box (5H) with prism mounted therein, and tighten the four objective prism base screws (5M) for the position of the prism box in which the vertical wire is aligned on the plumb line. Note that the prism box can be rotated slightly to secure this adjustment.

97. Lay off on a target a horizontal line in the same horizontal plane as the axis of the objective prism. Release the platen, so that it can revolve freely. Set the telescope by turning the elevation micrometer head (4WA) so that the telescope will rotate on a fixed vertical axis. Change the adjustment of the reticule, if necessary, to bring the horizontal line of reticule onto the horizontal line of target. Repeat to test adjustment. Set the elevation dial (4HA) and the elevation scale (2S) to read 0 for this position of telescope. In case the horizontal line of reticule can not be aligned on the target in this manner, it will be necessary to change slightly the elevation of the telescope by turning the elevation micrometer head.

98. Ordinarily the reticule of the telescope may be adjusted satisfactorily by carrying out the instructions of paragraphs 95 and 97 above. The elevation scale and the elevation dial should then be set to read 0 when the horizontal line of the reticule is aligned on a line in the same horizontal plane as the axis of the objective prism.

BATTERY COMMANDER'S TELESCOPE, MODEL OF 1915.

(See Plate J herewith, pamphlet No. 1796, and drawings 22–39–1 to 13, inclusive.)

99. *To clean the objective prism.*—Take out the prism shield cell screws, unscrew the prism shield cell, release lock nuts, and withdraw objective prism. The three polished surfaces of the prism should be carefully cleaned. Reassemble parts in the reversed order. The prism adjusting ring should not be disturbed.

100. *To remove the objective.*—Take out the telescope tube screw (upper), remove the objective prism holder, take out objective cell retaining screws, and withdraw the objective in its cell. Do not attempt to remove the objective from its cell. Clean the objective and replace.

101. *To remove the eye lens.*—Take out hood retaining screw, remove the hood, take off the focusing nut sleeve, take out the three focusing nut retaining screws, then remove the focusing nut; the eye lens and its cell may now be unscrewed. Do not remove the eye lens from its cell.

102. *To disassemble the eyepiece.*—Take out reticule adjusting ring screw, remove the reticule adjusting ring, take out eyepiece tube retaining screw, and unscrew the eyepiece. The reticule may now be removed for cleaning Reassemble the parts in the reversed order.

103. *To disassemble the elevation worm mechanism.*—Take out the two eye distance scale screws, remove the eye distance scale, unscrew end bearing lock nut, and remove the elevation worm end bearing and elevation worm washer. By next driving out steel pin the elevation worm knob can be removed and the elevation worm withdrawn.

OBSERVATION TELESCOPE, FIELD, MODEL OF 1908.

(See Pamphlet No. 1796.)

104. The lenses forming the objective of this telescope are cemented and the objective should not be removed from its cell for cleaning.

105. *To clean the prisms.*—Remove the cover; but unless after cleaning the exposed surfaces dirt or moisture is seen on the unexposed surfaces, the holder should not be removed from the cover nor the prisms from the holder. If it is found necessary to clean the unexposed surfaces, remove the screws which hold the holder to the cover and then pull the holder and cover apart. Then remove a prism-retaining spring and take out one prism. Only one prism need be removed from the holder. The prism should be marked before disassembling, in order that it may be replaced in exactly the same manner. Do not reverse the prism, as it has been adjusted by

the manufacturer and tested for the adjustment in which it is issued to the service. In reassembling, note that the prism holder is located on the cover by two dowel pins.

TELESCOPIC MUSKET SIGHT, MODEL OF 1908.

(See Pamphlet No. 1957.)

106. As stated in pamphlet No. 1957, the body of this telescope and its objective must remain intact and the prism holder should never be opened except by a competent person. In case moisture collects on the interior optical surfaces, it may be evaporated by imparting a gentle warmth to the telescope.

107. *Removal of prisms.*—The prism holder is tightly fitted to the body to prevent the access of dust, moisture, etc., into the interior and is held to the body by five body screws. After removal of these screws the prism holder may be withdrawn from the body. Carefully clean the polished surfaces of the prisms without removing them from their holder. The prisms should be withdrawn from their holder for repairs or for adjustment of the telescope by an instrument maker only. Replace the holder so that the prisms are in the same relation to the lenses as before removed.

108. *Removal of lenses.*—The objective and cell may be removed for cleaning by unscrewing, the cell being held only by the screw thread on its periphery. The reticule holder is adjusted by special tests by the manufacturer and should not be disturbed. The objective, reticule, and eyepiece are crimped in their cells and should never be removed.

109. If the objective cell is removed, care should be taken to screw it in tightly when assembling, as in this sight the location of the objective in respect to the reticule is made for a medium range and should not be varied. Aside from the adjustment permitted for focusing the eyepiece, the construction of the telescope admits of no adjustment except by an experienced instrument maker. In case parallax can not be removed for medium ranges the sight should be shipped to an arsenal for overhauling.

TELESCOPIC MUSKET SIGHT, MODEL OF 1913.

(See Pamphlet No. 1957.)

110. This instrument is identical with the model of 1908, except that the objective is mounted in the objective cell and held in place by the objective retaining nut.

PANORAMIC SIGHT, MODEL OF 1904.

(See Plate D herewith, Pamphlet No. 1659, and Drawings 15–2AII–1 to 6, inclusive.)

111. *Sealing of sights.*—In all panoramic sights in which the shutter window (5K) is inserted in the eyepiece elbow (6E) and in those sights having the shutter window burnished in the shutter, which have been issued from Frankford Arsenal later than May 1, 1912, all exposed optical elements and machined joints leading to the interior chambers of the sight which contain optical elements, are sealed with litharge cement. No parts of such sights except the worm box mechanism and the movable index cover will be removed except at an arsenal or other establishment equipped for repairing panoramic sights. The parts of the sight which may be removed in the field are specified by pamphlet No. 1659 (Handbook of the 3-inch Field Artillery Matériel).

112. The optical parts of the panoramic sight should be removed only in case of necessity. This sight is a delicate instrument and is difficult to adjust accurately. In case moisture condenses on the optical parts of unsealed sights it may be evaporated by allowing the sight to stand in a warm, dry room. No part of the sight should be disassembled for which specific directions are not given below, and then only after careful study of the following paragraphs and the pamphlet referred to above. In case the method of reassembling is not given it should be done in the reversed order to which the parts are disassembled.

113. *To clean the rotating head window* (5D).—Unscrew the window cell in rotating head (2P). Do not remove the window from the cell.

114. *To disassemble the eyepiece.*—Remove the set screw from the underside of the eyepiece elbow (6E) and unscrew the field lens cell (6N). For cleaning the lenses, remove the set screw (3Z) on underside of field lens cell (6N) and unscrew the eye lens cell (6L). The field lens (5M) is held in place by the field lens retaining spring (6R) both of which may drop out as soon as the eye lens cell is disassembled. In reassembling note that the field lens should be assembled with its flat surface toward the reticule (5K).

115. *Disassembling of azimuth circle mechanism.*—If it is necessary to disassemble the azimuth circle mechanism, throw out the worm-box eccentric lever (4A), disengaging the worm (4J) from the worm gear on the azimuth circle (2E). Insert a pin in the radial hole in the spring-box pin for worm box (4B). Throw the eccentric lever (4A) back and engage the worm in the azimuth circle (2E). Push the spring box (4R) toward the worm knob (4N) about $\frac{3}{8}$ inch and then pull the spring box straight out. Take out the stud (3M) from worm-box eccentric lever (4A) and remove the worm-box eccentric lever (4A). Pull out the dowel for worm-box pin (4G) with a pair of

pliers and drive out the worm-box pin (4F). Then pull out the worm box (4B) and the worm (4J) complete.

116. To clean the worm (4J) remove the worm knob (4N) and draw the worm (4J) from the worm box (4B). Do not remove the worm index (4E) from the worm (4J), in order not to change the adjustment of the azimuth mechanism.

117. *To disassemble the azimuth circle, etc.*—Remove the five radial screws from the hood for azimuth circle (2F) and unscrew it from the azimuth-circle support (5C). Remove the window cell in totating head (2N) if it is not already disassembled. Then lift the hood for azimuth circle (2F) from the sight.

118. Before removing the azimuth circle (2E), the rotating head (2N), etc., turn those parts until the 0 on the azimuth circle (2E) is opposite the center of the supporting lug on the eyepiece end of the shank. Then pull the azimuth circle (2E) and the rotating head (2N) straight off without rotating the gears by the least amount. Mark the tooth on the large pinion (2LA) which is opposite the nearest corner of the rotating prism (5B). Then make a mark on the rotating prism holder (4Q) directly opposite the marked tooth of the pinion. Drive out the pinion shaft (2MA) from the underside of the azimuth-circle support (5C). Move the pinions opposite the opening in the azimuth-circle support (5C) and withdraw by inverting the sight. Grasp the rotating prism holder (4Q) and withdraw the rotating prism (5B) and the rotating prism holder (4Q) and the supporting sleeve for rotating prism (5A) from their seat in the shank (5L).

119. Do not remove the covers for rotating head (2M) and do not disassemble the rotating head (2N) and the azimuth circle (2E) from the azimuth-circle hub and gear (2D); also do not remove the rotating prism (5B) from the rotating prism holder (4Q) nor the rotating prism holder (4Q) from the supporting sleeve for rotating prism (5A). Also do not disturb the adjustment of the lower reflecting prism (5J). These parts may be disassembled only by an expert instrument maker with proper facilities for readjusting, etc.

120. *Cleaning and oiling.*—Carefully clean all gears and exposed surfaces of metal parts. Benzine may be used in cleaning the worm and gear teeth. Apply it with a toothbrush or similar brush. After thoroughly cleaning, put a little vaseline on the worm and gear teeth and a little clock oil on the inside circumferential and lower surfaces of the azimuth circle (2E) and the outside surface of the supporting sleeve for rotating prism (5A). Two drops of clock oil on each of the parts is sufficient for proper lubrication. Never use emery cloth, crocus cloth, or any abrasive on any part of the panoramic sight. Be careful not to allow any oil to drop on the glass surfaces. Leave no free oil to run down onto glass surfaces after reassembling.

121. Clean the exposed surfaces of the rotating head prism (5E) and the rotating prism (5B). Use a soft cloth free from lint on a stick to reach such surfaces as can not be otherwise reached for cleaning. After carefully wiping the optical surfaces, brush them with a camel hair brush. Do not in any manner change the adjustment of these prisms.

122. *In reassembling,* insert the rotating prism holder (4Q) and the parts assembled thereto and bring the mark made on the rotating prism holder (4Q) opposite the pinion shaft (2MA) seat. Insert the pinions for rotating prism (2LA) and rotating head (2N) through the opening in the azimuth-circle support (5C) and engage the teeth of pinion and gear so that the mark made on a tooth of the pinion comes opposite the mark made on the holder. Insert the pinion shaft (2MA). Place the azimuth circle (2E) and the attached parts over the azimuth-circle support (5C) without engaging any teeth, and rotate the azimuth circle (2E) so that the 0 of scale comes opposite the supporting lug on the front face of the shank (5L). Then drop the azimuth circle (2E) in place and reassemble other parts.

123. *To remove the objective lens* (5H).—Special tools not furnished with sights are required. For this purpose take out the four radial screws in the lower part of the shank (5L). First note whether opposing marks are on the upper surface of the eyepiece elbow (6E) and the lower surface of the shank. If not, scratch a light mark on these two surfaces, in order that the parts may be reassembled in exactly the same position as originally adjusted. Then put the eyepiece elbow (6E) in a vise. Use spanner wrench and block No. 34 (furnished with tools and fixtures for optical repair work) and unscrew the elbow from the shank (5L). Remove the set screw in the upper end of the eyepiece elbow (6E). Use spanner wrench No. 32 and unscrew the objective lens cell (6A). Do not remove the lens from its cell.

124. *To disassemble the reticule* (5K).—Remove the two screws in the adjusting block for reticule cell (6H) and gently shake out the reticule cell (6G). The reticule should not be disturbed in its cell. In cleaning the reticule (6G), use cloth as free as possible from lint. After cleaning it, examine its surface with a magnifier (the eyepiece may be used for this purpose), and if not perfectly clean reclean it. Use a camel hair brush for wiping off dust and lint. This special precaution is necessary, as the reticule is in the focal plane of the eyepiece and any dust thereon will be magnified.

125. *Lower reflecting prism.*—With the objective lens cell (6A) and the reticule cell (6H) removed, the lower reflecting prism (5J) may be cleaned. For this purpose remove also the eyepiece elbow covers (6B) and clean the back surfaces as well as the faces of this prism. In this connection note paragraphs 119 and 121 above.

126. *Adjustment of reticule.*—When reassembling the reticule cell (6G), insert the adjustable block for reticule cell (6H), but do not tighten the screws. After all other parts of the sight are assembled adjust the reticule cell (6G) so that the vertical line is parallel to a plumb line. The reticule cell (6G) and the adjustable block for reticule cell (6H) may be slightly rotated for this purpose. Also adjust the reticule cell (6G) by translating it longitudinally until it is in the focal plane of the eyepiece and there is no parallax when observing objects at least 1 mile distant. To secure this adjustment, the objective lens cell (6A) must have been replaced in exactly the same position as before disassembling. In order that the field may be vertical, the eyepiece elbow (6E) must be screwed up so that the marks on it and the shank (5L) come opposite each other and the eyepiece elbow (6E) is entered by the same number of threads. Great care must be taken in reassembling the sight.

127. If the field is not vertical, either the rotating prism (5B) has been wrongly assembled or the eyepiece elbow (6E) has not been properly screwed up. If parallax can not be removed, either the objective lens cell (6A) or the field lens cell (6N) or the reticule cell (6G) has been incorrectly assembled. For adjusting the reticule cell (6G) the panoramic sight may be mounted in its seat on the rear sight or it may be mounted in vertical fixture No. 89 (furnished with tools and fixtures for optical repair work). Fixture No. 89 is used on round surface plate No. 88, which should be centered and leveled on pedestal No. 85.

128. *Adjustment of azimuth circle.*—Ordinarily the azimuth circle (2E) will be set with the panoramic sight in its seat on the rear sight as described in pamphlet No. 1659. It will be corrected for errors in the rear sight or its support. It may, however, be adjusted independently of the rear sight as follows: Mount horizontal fixture No. 86 in pedestal No. 85 and carefully level. Screw guide for collimating telescope No. 90 in horizontal fixture No. 86 and align collimating telescope No. 90 on a plumb line. Clamp the fixture in place, remove the collimating telescope and guides, and secure the panoramic sight shank clamp to the horizontal fixture. Set panoramic sight at the azimuth of 48 and insert it in the seat prepared for it on the horizontal fixture, turn the worm knob (4N), and align the line on the reticule with a plumb line without changing the setting of the fixture. Then adjust the azimuth circle to read 48 when the line on the reticule (5K) coincides with a plumb line. For adjusting the azimuth circle, note that the movable index cover (2UA) may be moved and that the worm index (4E) on the worm (4J) may be adjusted.

129. The azimuth circle of a panoramic sight must be adjusted for a particular gun and for a particular rear sight. The adjustment

of the worm index (4E), the movable index cover (2UA), and the worm (4J), as made by the manufacturer of the panoramic sight, will probably not be found correct for a particular gun. It is intended that the final adjustment of the azimuth circle (2E) of a panoramic sight be made by the battery commander by making the line of sight of the panoramic sight parallel to the axis of the bore of the gun and setting the scales accordingly.

130.* *Special notes on adjusting panoramic sights.*—The larger rectangular surface of the rotating prism is polished and is known as the "base."

To adjust the rotating prism in its holder, put shank with elbow and eyepiece assembled in horizontal fixture No. 86 with eyepiece up. Direct telescope at a plumb line. Insert the rotating prism wrapped with paper as described below into the holder and the holder into the supporting sleeve for rotating prism and assemble them in the shank without the gearing. Turn the prism so that the end surfaces lie in vertical planes and a plumb line appears parallel to the vertical line of the reticule. Move the fixture if necessary to make the image of the plumb line coincide with the vertical line of reticule. Then turn the rotating prism 180° until plumb line again appears parallel to the vertical line of the reticule. Correct half the error of deviation of the vertical line on the reticule from a plumb line by slightly filing off and slightly bending over the supporting walls of the upper and lower ends of the prism holders. Note that if the upper surface is bent toward the axis of the holder the lower surface on the same side of holder should be filed by an equal amount, as the prism should be rotated on one of its shorter axes. The filing or bending of holder should be only on the surface prepared for the base of the prism and the opposite surface. Do not touch the other two surfaces of the prism holder. The amount of metal to be taken off will be only a few thousandths of an inch. Then rotate the fixture to again bring the vertical line of the reticule on the plumb line and repeat the test. Before assembling the prism in its holder for test or final adjustment partially wrap the prism with a sheet of dull black paper 0.005 inch thick of the length of the bearing surface of the holder. For this purpose turn back one edge of the paper $\frac{3}{32}$ inch against the polished surface of the base, then wrap the paper over the three unpolished surfaces and turn it over the other edge of the base and cut so that it extends $\frac{3}{32}$ inch beyond the edge of the base. After final adjustment of rotating prism insert the set screw in prism holder. Note that the set screw should not bottom in the notch in the rotating prism.

131.* In adjusting the prisms of this sight the following intructions should be followed: It is assumed that the lenses and mountings, the rotating prism, the pinions and pinion shaft, the azimuth circle,

* See paragraph 11.

and the rotating head are assembled. Use vertical fixture No. 89 on pedestal No. 85, with round surface plate No. 88. Carefully level and place the panoramic sight in the socket of vertical fixture No. 89. Now look through the eyepiece. If the field of view seems to incline either to the right or left, it will be necessary to remove the rotating head and the azimuth circle and change the relation of the prism to the larger gears. This change is made by removing the pinion shaft and turning the pinion until those teeth are in mesh, which bring the field of view into a vertical position. This operation usually requires much care and time. If it be found after long trial that one position of the teeth gives better results than any other position, but that the results are not yet satisfactory as to verticality of the field, it will then be necessary, having determined this best position of the teeth, to make the ultimate adjustment for verticality of the field on the rotating prism and rotating prism holder. To do this, unscrew the rotating prism holder screw, securing the rotating prism holder to the supporting sleeve for rotating prism. The rotating prism holder with rotating prism may then be revolved in the supporting sleeve by hand until the field assumes the correct vertical position. Having obtained the position, clamp the rotating prism holder and the supporting sleeve carefully together and drill and tap a new hole for the set screw. The field adjustment should now be satisfactory. The pinion and gear teeth which are in mesh to give verticality of field should be spot marked for future adjustment. These marks are readily recognized by any machinist or instrument maker and no difficulty should be experienced in at once bringing the field into proper adjustment. Also note that the portion of the above description relating to the removal of the set screw securing rotating prism holder and supporting sleeve together is intended to be applied only in extreme cases, when from violent accident great injury to the parts of the panoramic sight has been produced. In such cases the adjustment must, of course, proceed on the same lines as if the parts had never been assembled together. In the general case, however, no need will be found for removing the set screw and redrilling. It may occasionally be necessary to loosen the set screw slightly, and then push, by the merest hair the rotating prism holder in one direction or the other, again tightening the screw. But caution is enjoined for any such operation.

132.* Replace rotating head, azimuth circle, etc. The sight still mounted in the vertical fixture is then directed toward a target at the same height as the center of the window cell. Such a target should be laid out carefully, using an accurate transit or Y level. Now look through the eyepiece of the panoramic sight. The horizontal line of the reticule from end to end should appear at the same

*See paragraph 11.

height as the fixed target selected. If the cross line appears above or below the target, correction should be made on the lower reflecting prism and *not on the reticule.* The necessary correction should be made by filing carefully the brass bearings of the seat for the lower reflecting prism in such a way as to make the prism lean forward or backward, as the case may be, an amount sufficient to correct for the full error. This operation is extremely delicate, and the filing or scraping should be proceeded with most carefully. The bearing surfaces of the prism seat must be cut away to produce a change in the position of the prism from front to rear, or the reverse only, but lateral tilting produced by leaving the seat higher on one side than the other must be avoided.

PANORAMIC SIGHT, MODEL OF 1915.

(See Plate K herewith, Pamphlet No. 1659, and Drawings 15–15G–1 to 10, inclusive.)

133. The optical parts of the panoramic sight should be removed only in case of necessity and then by order of an officer of the Ordnance Department. All the joints are sealed when they leave the manufacturer and any disassembling will break this seal and allow dust and moisture to enter. In case moisture condenses on the optical parts of unsealed sights, it may be evaporated by allowing the sight to stand in a warm, dry room. This sight is a delicate instrument and is difficult to adjust accurately. Reassembling should be done in the reversed order to which the parts were disassembled.

134. *To disassemble the eyepiece.*—Take out the eye lens cell retaining screw, remove the eye lens cell and reticule cell. To clear the lenses, take out the reticule cell retaining screw, unscrew reticule cell in which the reticule is permanently fastened, take out field lens retaining ring screw and unscrew the field lens retaining ring which permits the field lens and eye lens to be removed. In reassembling note that the eye lens and field lens be assembled with their curved surfaces toward each other.

135. *To disassemble the rotating head mechanism with the elevation device from the instrument.*—Remove the four azimuth scale retaining ring screws and unscrew the rotating head from the upper end of the azimuth worm wheel. The azimuth scale with azimuth scale retaining ring can now be removed. To disassemble the elevation device, loosen the locking screw, remove the elevation worm micrometer head, loosen the elevation worm retaining nut screw, and then remove the elevation worm retaining nut. The elevation worm can now be removed by turning. To unscrew the rotating head cover, remove the rotating head cover screw. Remove the prism holder cover screw and unscrew the prism holder screw. Remove the two elevation index retaining screws and then elevation index can be

lifted from the elevation index support. Remove the support retaining ring screw and unscrew the support retaining ring. Remove the elevation index support screw and unscrew the elevation index support. Drive out the segment lock pin and the elevation segment will drop from its seat to the interior of the head. Unscrew the rotating head prism holder stop screw and then withdraw the rotating head prism holder. The elevation segment can now be removed by using the fingers. To remove the elevation worm bushing loosen the bushing clamp plug screw which releases the elevation worm bushing clamp plug. Remove the rotating head spring which releases the prism support back, and then remove the rotating head prism. The prism shield can be removed by unscrewing the two prism shield retaining piece screws and removing the prism shield retaining piece.

136. *To disassemble the azimuth mechanism.*—Loosen the locking screw, remove the azimuth micrometer, drive out the taper pin from the worm knob, unscrew the worm knob and remove the lever spring, take out azimuth worm lever screw and remove the azimuth worm lever. The azimuth worm may now be withdrawn by turning and the azimuth worm bushing and bushing spring can now be removed. Remove the three deflection worm wheel and support ring screws, then unscrew and dismount the azimuth worm wheel cover. Remove the azimuth worm wheel support spring and azimuth worm wheel. Disassemble the azimuth worm wheel support with interior mechanism. Drive out the pinion shaft which will allow the rotating head pinion to slide into the slot in the azimuth worm wheel support in such a manner that the rotating prism supporting sleeve with rotating holder can be removed. The rotating prism pinion with rotating head pinion can now be removed. Do not remove the rotating prism from the rotating prism holder.

137. *To disassemble the deflection mechanism.*—Remove the deflection dial by loosening the locking screw, drive out the taper pin from the worm knob, unscrew the worm knob from the end of the deflection worm; the compensating spring can now be removed. The deflection worm can be withdrawn by turning. Remove the two deflection worm wheel support screws which release the deflection worm-wheel support, remove the deflection worm-wheel and supporting ring and deflection worm-wheel support from the upper end of the shank, loosen the deflection worm bushing clamp plug screw which releases the deflection worm bushing clamp plug, and remove the deflection worm bushing.

138. *To remove the objective lens.*—Take out four elbow retaining screws, unscrew the elbow from the shank, take out two objective cell retaining screws, and unscrew the objective lens cell. Do not attempt to remove the lens from its cell. With the objective lens

cell and the eyepiece removed, the lower reflecting prism may be cleaned. For this purpose the elbow covers should be removed and the back surfaces as well as the faces of this prism should be cleaned.

WELDON RANGE FINDERS.

(See Pamphlet No. 1908 and Drawing 22–1–41.)

139. In the Weldon range finder, accurately ground and polished prisms are held in a metal frame. The prisms should not be removed for any purpose, and care should be taken not to disturb them in their mounting, as with the range finder rigidly held vertical the prisms are so located by optical tests as not to displace the image from the horizontal plane of the object. In case adjustment of prisms is required, it should be done only by an experienced workman with a complete set of working fixtures and tools.

140. In order to secure the maximum intensity of illumination, the refracting surfaces should be kept clean and free from moisture, finger prints, etc. The silvered surface of a prism requires no attention. In case after careful cleaning the image is poorly illuminated, the range finder should be sent to an arsenal for resilvering the prisms or for other repairs.

141.* *Methods of assembling prisms.*—The Weldon range finders at present in the service have been obtained from various sources and at different times, and they differ slightly in dimensions, means of securing prisms, and in other minor points. There have been used three general methods of securing prisms in place:

(*a*) By cement.

(*b*) By pins or plugs let into the prisms.

(*c*) By clips bent over edges of the prisms when their presence does not affect the field of view.

(*a*) Where cement has been used, as for instance, either sodium silicate or sealing wax, immersing the range finder complete in cold water and gradually raising the temperature to the boiling point will ultimately loosen the cement and allow removal of the prism. The time required by this process depends upon the quality and condition of the cement used. Frequently an hour or more is required to loosen the prisms.

(*b*) Where pins or screws have been let into the prisms, cement may also have been used to aid in securing these. When screws have been used it will frequently be found that the screw head has been filed away. It will, therefore, be necessary in this case to make a new slot in the remaining part of the screw. Then loosen all cement as above described and, using a small screw driver, turn the screw out. This sometimes proves to be a very difficult operation.

* See paragraph 11.

(*c*) Where clips are used the screws securing the lower clips should be removed. The prisms may then be removed from their seats without trouble. The upper clips, soldered to the projecting rings, need not be removed.

142. No special tools, other than small screw drivers, pinchers, etc., are needed. The prisms should be handled carefully and inserted and removed by the fingers, except in extreme cases, when a wooden wedge or stick, carefully used, may be needed to remove tightly fitted prisms.

143. The latest method adopted for securing prisms in the Weldon range finder is by clips and is shown in the plate. This method is believed superior to any other yet devised and is simple in application. Cement is no longer used, as it is liable to deterioration, with loss of prism.

144.* Having removed the prisms from the case for resilvering or other repair, to reassemble, proceed as follows: Prepare the prism seat so that it will receive the prism snugly. Three small steel blocks, cut accurately to the dimensions of the prism, should be prepared. These small steel blocks are used in adjusting the clips, as they will sustain the pressure required in bending or otherwise fitting the clips, whereas the prisms would crack or chip under this pressure. The upper clips shown on the plate are first soldered to the case. They should then be bent over the steel blocks to give a snug fit. The lower clips shown are secured by screws after the upper clips have been adjusted and the prisms seated. A thin piece of paper under each prism will be found useful as a buffer for the silvered face in fitting the prism securely in its seat.

By a snug fit is meant a fit so close that any looseness or shaking is prevented, and yet not so close that undue pressure is brought to bear on the prism by the clips. If undue pressure is brought to bear on the prism, the effect will be to warp the transmitted rays slightly and thus slightly blur the target seen through the prism.

145.* The tolerance permitted in the angles of prisms for Weldon range finders is $\pm$ three minutes measured as the error of the angle through which a ray is deflected from the specified angle. By careful grouping of such prisms, range finders are made in which the range error for either the first two prisms grouped together, or the last two grouped, does not exceed $\pm$ 1 per cent of the range. In testing and adjusting, a prism must be held or located so as not to displace the image from the horizontal plane of the object.

Although of apparently simple construction great care is required in the testing and adjusting of prisms of this range finder. If prisms are removed for resilvering or other repairs, a fixture should be provided to hold the range finder vertically, and a telescope should be

* See paragraph 11.

used in locating the prisms. Each prism should be so adjusted that for the range finder held vertically the object and image are in the same horizontal plane. Care should be taken not to mix the prisms originally assembled in a given range finder, as they are not interchangeable with similar prisms from other range finders.

FIELD ARTILLERY RANGE FINDER, 1-METER BASE.

(See pamphlet No. 1796.)

146. Under no circumstances shall this instrument be disassembled or adjusted except by the manufacturer or by an arsenal especially equipped for instrument work.

AIMING CIRCLE, MODEL OF 1916.

(See Plate L herewith, Pamphlet No. 1796 and Drawings 22–41–1 to 7, inclusive.)

147. The optical parts of the aiming circle should not be removed unless it is absolutely necessary. When the instrument leaves the manufacturer all the joints are sealed, and the breaking of this seal allows dust and moisture to enter. In case disassembling is necessary, reassembling should be done in the reversed order.

148. *To disassemble the eyepiece.*—Take out the eyepiece retaining screw, unscrew the eyepiece, which carries with it when assembled the eye lens, the field lens, and the reticule. Unscrew the reticule cell but do not disturb the reticule. Unscrew the eyepiece cell which contains the eye lens and the field lens. To remove the lenses from the cell, unscrew the lens nut, remove the field lens, take out the lens separator, and remove the eye lens.

149. *To clean the elbow prism and erecting prism.*—Take out the elbow cover retaining screw, unscrew the elbow cover, take out the two erecting prism holder screws, and withdraw the erecting prism holder. Care should be taken not to disturb the prisms when cleaning.

150. *To clean the objective prism or the objective.*—The telescope must be dismantled.

151. *To disassemble the elevation mechanism.*—Drive out taper pin from worm knob, remove worm knob and take out bearing cap retaining screw, unscrew bearing cap, and withdraw elevation worm by turning. This allows the telescope elbow to be removed after the five objective prism housing screws have been unscrewed. Take out the six shutter guide screws, slide the shutter guides with the shutter to the left-hand side and take out five objective prism housing screws; withdraw the angle of site mechanism which allows the objective prism housing to be removed. Do not attempt to remove the prism from the housing.

152. *To remove the objective.*—Unscrew the objective lens cell nut. Scratch a line on the eccentric washer and objective lens cell before removing them. Do not remove the objective from its cell.

153. *To disassemble the angle of site mechanism.*—Loosen angle of site dial locking screw, drive out taper pin from worm knob, remove worm knob and take out bearing cap retaining screw, unscrew bearing cap, and withdraw the angle of site worm by turning. Take out the three level vial holder screws, remove the level vial holder, take out the three worm wheel holding disk screws, and remove the worm wheel holding disk and angle of site worm wheel.

154. *To disassemble the azimuth worm mechanism.*—Loosen the azimuth worm knob locking screw and remove the azimuth worm knob and the lever spring; take out the azimuth worm lever screw and remove the azimuth worm lever. The azimuth worm may now be withdrawn by turning, then remove the azimuth worm bushing and bushing spring.

155. *To disassemble the compass mechanism.*—Unscrew the cover ring and lift the glass cover with parts assembled thereto from the instrument. Take out the three level housing screws and remove the level housing. Take out the three needle release guide plate screws and remove the needle release guide plate (lower), unscrew the needle release button and remove the spring. The needle release guide plate (upper) and the needle release guide plate (lower) may now be separated and removed from the glass cover. Do not attempt to disassemble the level unless the fluid has leaked out to such an extent as to require refilling.

156. *To remove the compass needle from the needle release guide plate (lower).*—Unscrew the needle release collar.

SEXTANT TELEMETER, MODEL OF 1911, TYPE A.

(See pamphlet No. 1796.)

(See Plate I.)

157. *To disassemble the worm.*—If for any purpose it is necessary to remove the worm, rotate the worm until the worm wheel is brought up to the stop plunger, draw back the stop plunger, and continue rotation of the worm wheel until it and the movable mirror are clear of the worm box. Then unscrew the four worm-box cap screws and draw out the worm-box cap with worm, etc. To disassemble, loosen the worm locking screw, unscrew the retaining nut, using teat wrench No. 105, and draw off the micrometer head and worm box cap. To remove the worm from the worm box, first remove the worm plunger screw and then the worm plunger and worm plunger spring. Then push the worm and worm bearing out of the worm box, applying slight pressure on the end from which the micrometer was removed, clean,

lightly oil with clock oil all bearing surfaces, except the worm teeth, which should be lightly coated with vaseline. Reassemble in the reversed order. Take special care that no dirt or grit remains on any bearing surface. Adjust the retaining nut to remove all longitudinal play and readjust the micrometer scale of the micrometer.

158. *To disassemble the cover.*—Remove the two fixed mirror-holder screws holding the fixed mirror holder to the cover. Rotate the worm until the clinometer scale registers 6, draw back the stop plunger and continue rotation of the worm wheel a few revolutions in the same direction. Remove the optical square body from its seat in the cover. Move the pendulum until its toe is about $\frac{3}{4}$ inch from the post opposite the pendulum lock. Unscrew the four cover screws and lift the cover. Revolve the worm wheel until disengaged from the worm and remove worm wheel and pendulum assembled. Then slip the pendulum arms over the worm wheel and remove the index dial.

159. *To disassemble the pendulum.*—Bend the pendulum arm inward to release the spring lock and push the arm through the undercut groove of pendulum weight. After removal of both arms the pendulum prism and prism spring may be pushed from their seat. To remove the pendulum lens cell, take out the pendulum lens screw and unscrew the cell. As all its joints are sealed with litharge cement the pendulum weight should be disassembled only when repairs are required.

160.* *Notes on adjustment.*—The pendulum lens is adjusted so that its focal plane lies in the exposed surface of the pendulum prism on which is etched a reference line. The telescope, which is focused for an object about a mile distant, is placed in the axes of the pendulum lens and the lens cell is screwed in or out until the reference line on the prism is seen sharply defined by the telescope. This position is noted and a ring is made to fit between the upper surface of the pendulum weight and the flange of eye lens cell. A set screw is also inserted in the cell. In final assembling all exposed joints of the parts are lightly coated with litharge cement for sealing.

Before assembling in the instrument the pendulum is suspended by its arms and the position of the balancing screw in the pendulum weight is adjusted until the front face of the pendulum is inclined 11° 15′ from the plumb.

161.* A coating of litharge cement is placed on the back of the movable mirror after silvering. The mirror is then placed in the movable mirror holder and the ends of the holder are burnished over the mirror. The mirror and the holder are assembled in the worm wheel and secured by burnishing the worm wheel lightly over the sides of the mirror. In this operation care must be taken not to

* See paragraph 11.

strain the mirror, otherwise the definition of the optical system will be impaired. The space between the mirror holder and the worm wheel is then filled with a mixture of litharge cement, whiting, and lamp black mixed to the consistency of soft putty.

162.* After the optical systems are assembled the telemeter is placed on a plane horizontal surface, cover up, the movable mirror is set for vertical coincidence of the images formed by direct and reflected pencils, and the fixed mirror holder is rocked on a horizontal axis by means of the four fixed mirror screws which enter the frame and the two fixed mirror adjusting screws which bear against the frame until horizontal lines of the two images are coincident. Either the upper or the lower bearing surface of the mirror holder should be in contact throughout its length with the fixed mirror seat of the frame. The index is then adjusted so that while the two images of objects about a mile distant are in coincidence, the reference line on the index is opposite the 0 graduation of the index dial. The micrometer scale is then set to register 0. The telemeter is then placed on end on a horizontal surface with the micrometer above, the movable mirror is rotated to register 3 centièmes elevation, and the telescope is directed on a target at any distance in the same horizontal plane as the axis of the telescope. The pendulum is then released by throwing the pendulum lock, and the adjusting screw in the pendulum weight is adjusted so that the image of the reference line is superposed upon the image of a horizontal line ½ mil above the target. The telemeter is then disassembled, a dowel pin is added to hold the index in its proper place, and a hole is drilled and a pin driven through the adjusting screw and pendulum weight. The allowance made in the adjustment of the pendulum weight compensates for the loss of weight resulting from the insertion of the pin. The telemeter is then reassembled for final adjustment of the fixed mirror for coincidence of horizontal lines and for the setting of the scale at 0 when the images formed by the direct and the reflected pencils from distant objects are coincident.

163. In subsequent adjustments after repairs the fixed mirror may be rotated on its vertical axis to bring the images of a distant object into coincidence when the index registers 0 on the index dial. After setting the fixed mirror the final adjustment for coincidence of vertical lines of images is made by rotating the movable mirror for coincidence of images and then adjusting the micrometer scale to register 0. In this case a rebalancing of the pendulum will be required. The accuracy of both the telemeter and the clinometer systems are tested by comparisons with graduated circles.

* See paragraph 11.

GEARED INSTRUMENTS (Group b).

164. *Gearing.*—Loss of adjustment and lack of accuracy due to gearing is ordinarily made apparent by what is known as backlash, lost motion, or looseness. This looseness develops either from the actual wear of the parts which mesh together or from the loss of position and looseness of surrounding parts, which should keep the gears in close contact. Thus, taking the range quadrant and rear sight of the 3-inch field matériel as examples, the pinions, quadrant-arm racks, and scroll gear, worms, etc., are from the very nature of their service subjected not only to constant wear, but to constant wear under the severest conditions of weather, dust, grit, etc. The close mesh and fit of these parts will deteriorate, and this deterioration sometimes proceeds very rapidly. When possible, if new parts are not available and the demands of the service prevent the return of the part affected for repair, a thin washer, an added bushing, or other similar slight repair will tide over the difficulty. But when the looseness developed is so great as to destroy the value of the instrument, new gears, worms, etc., must be cut, and the parts refitted and adjusted. For service in the field it should be remembered that instruments issued from the Frankford Arsenal have corresponding parts of the same model interchangeable. Thus a good part of one otherwise unserviceable instrument may be taken and used for another instrument, when such exchange is necessary. Rear-sight brackets, shank sockets, shank, etc., may thus be interchanged.

165. Where the looseness has developed from the loss of position of surrounding parts which should keep the gears in close contact, as, for instance, in the case of the gun azimuth subdial mechanism in the Whistler-Hearn plotting board, the dial box in which the mechanism is housed should be moved closer up to the movable limb and resecured by the screws provided. If backlash exceeding 0.03° is still found, the gears themselves or their bearings should be examined for dust or dirt. Careful cleaning of such parts will frequently remove a cause of error in the readings obtained. The worm stand of plotting boards may be similarly adjusted.

166. On those instruments in which a worm and worm gear are employed to obtain rotation in horizontal or vertical planes, adjustments are provided to remove longitudinal play between the worm and worm bearing and to remove backlash between the worm and worm gear. To remove longitudinal play, turn up the screw or nut on the end of the worm until there is no longitudinal shake of the worm, but the worm should revolve freely when disengaged from the worm gear. The worm is ordinarily held in mesh with the gear by a flat spring. The pressure of the worm on the gear is regulated by an adjusting screw. This adjusting screw should be set at the critical

position at which there is no backlash between worm and gear and the pressure of the worm against the spindle is a minimum for no backlash.

167. Care should be taken to keep the gears of instruments *clean* and lightly oiled. The cutting of worms and gear sufficiently accurate for instrument use is a difficult machine operation, and the accuracy of such parts can be preserved only by careful handling, cleaning, and adjusting these parts in service.

168. *Test of levels.*—Levels furnished with instruments are ordinarily adjustable, although the open sights and range quadrants for mobile artillery and the mortar quadrants contain nonadjustable levels, which are rigidly held in a metal casing or tube and are accurately adjusted and tested by the manufacturer and do not require adjustment by the service. Adjustable levels are of two types—one adjusted by exposed adjusting screws as the levels on the base of an azimuth instrument or of a battery commander's telescope; the other adjusted by internal screws, to reach which a cap must be removed from the level box, as in the case of the cross level on the range quadrant and the elevation level on the rear sight for 3-inch field matériel. Both types of adjustable levels are accurately adjusted and tested by the manufacturer, but these levels are designed for and will require adjustment by the service.

169. In case of breakage or looseness of level vials belonging to instruments, the metal case surrounding the level vial must be opened, and in case of a broken vial the broken parts and old packing must be removed. A level of the same degree of sensitiveness as that originally in the instrument should be obtained. The level vial mixture should be specified as 60 per cent alcohol and 40 per cent ether. Levels differ in sensitiveness, depending upon the accuracy demanded in the instruments with which they are used. Thus the large striding level for the Swasey depression position finders shows a movement of the bubble of $\frac{1}{10}$ inch for a variation in level of 15 seconds of arc; the level for the gunner's quadrant shows a movement of the bubble of $\frac{1}{10}$ inch for a variation in level of 5 minutes of arc; the Weldon range-finder level is simply a general leveling device for an instrument held in the hand, subject to constant vibration, and hence is not sensitive; any good commercial vial of the size needed, not specially ground, but in which the highest point for bubbles is easily determined and symmetrically placed, will do for this use. Levels in which the $\frac{1}{10}$-inch graduation is to show a certain variation in minutes or seconds of arc must have the interior surface of the vial specially ground to the correct radius of curvature Such levels before acceptance should be tested on a regular level-testing machine. If one of them is not available, a Y block properly mounted to receive the level, terminating in standards which can be

raised or lowered definite amounts by screw action, and from which, knowing the pitch of the screw, etc., the angle to which the Y block is tilted may be determined, can be used in ascertaining the movement of level bubbles corresponding to a certain angular displacement. Levels must be ground so that the movement of the bubble over the length of the graduations on the vial is uniform.

170. *Adjustment of levels.*—Having tested the level vial for sensitiveness and uniformity, place paper or cotton packing in the bottom of the metal level holder, so that the level will fit snugly. Care must be taken not to pack the level too tightly, as a very tightly packed level vial, exposed to extreme variations of temperature, will probably crack. On the other hand, when the level is not packed sufficiently, it will readily change in position and thus not remain true. Having determined the proper amount of packing, by inserting and removing the level frequently until the right fit is found, pack the ends of the level to prevent longitudinal motion in the case, using cotton or a slight amount of plaster of paris (dental plaster which will set in from 5 to 10 minutes), then screw on the level holder end caps or top, as the case may be. As an example illustrating the principles of level adjustment, take the striding level of the Swasey depression-position finder, Type A1. Prepare a carefully turned cylindrical block, mounted on a small pedestal or base provided with a leveling attachment, as three screws at the vertices of an isosceles triangle. Place the striding level on the cylindrical block and bring the bubble to the center of the scale by means of the leveling screws of the pedestal of the cylindrical block. Then lift the level from the cylindrical block and turn it around so that the former right end will become the left end, and place again on the cylindrical block. If the level is properly adjusted, the bubble will still be in the center of the scale. If the level is not properly adjusted, correct for half of the bubble error by the small screws at either end of the level vial case, and for the other half of the error by the leveling screws of the pedestal. Then reverse the striding level as before, and continue this process until the bubble shows no variation after reversal, when the striding level will be properly adjusted.

171. The following additional examples of special cases are given as containing such remaining information on the principles of level adjustment as may be necessary. The adjustment of the elevation or angle of site level for the range quadrant of the 3-inch field matériel is made as follows: After carefully packing the level and closing vial holder, the zero mark on the holder is brought opposite the reference number (3) on the level scale by means of the clinometer level screw. (See plate and description of "Range quadrant" in pamphlet No. 1659, "Handbook of the 3-inch Field Artillery Matériel.") The micrometer disk is then loosened, by releasing its

retaining screw, and is turned until the zero mark on the scale is brought opposite the zero or index mark on the quadrant body. The retaining screw is then tightened, when these parts will be in adjustment for range.

172. The transverse or cross level of the range quadrant is adjusted as follows: The cross-level vial is first secured in its tube and then inserted in the level holder. One end of the tube containing the level vial fits snugly in the level holder. The other end of the tube is somewhat smaller and contains four radial adjusting screws. The verticality of the rocker arm should be determined by the testing level or by a steel square projecting from a horizontal plate in such manner that the base of the square will rest on the plate when the vertical edge is in contact with the planed surface of the rocker arm or parallel to it. The level should be adjusted by means of the upper and lower radial screws for this position of the rocker arm. Then by means of the two side radial screws the level vial and tube should be adjusted in the level holder, so that the bubble remains central, while either the quadrant or the body is moved in a vertical plane.

173. The following detailed instructions for the disassembling of bases of some of the more complex instruments are given below. No instrument should be disassembled except when required.

BATTERY COMMANDER'S TELESCOPE, MODEL OF 1905.

(See Plate E.)

174. *To disassemble the center and the worm mechanism.*—Remove the platen caps (4DA) and lift out the telescope. *Do not remove the four spindle screws* (2B). *The spindle should not be removed from the platen.* Remove the one spindle-nut screw (2C) and the spindle nut (2J), using teat wrench No. 41. Throw the azimuth worm out of mesh, loosen the slow-motion screw, and lift the platen (4R) with spindle (2A) and the horizontal limb (4B) from the fixed limb (2W) carefully, to avoid bruising. Unclamp the slow motion clamp screw and remove the slow-motion arm (3E). Remove the platen cover (4FA). After taking off the worm box stud nut (4AA) and unscrewing the azimuth worm box stud (4M), lift the azimuth worm mechanism from the platen (4R). Remove the azimuth worm adjusting screw (4U), loosen the dial nut screw (4JA), and remove the dial nut (4Y), the two azimuth dial screws (4SA), and washers (4UA). Remove the azimuth micrometer head (4K) and the azimuth dial (4NA) and push the azimuth worm from its bearing.

Drive out the eccentric crank pin (2V) and drive in eccentric (2T). The eccentric crank (2U) will then drop off. Reassemble all parts in the reversed order. Use clock oil on the spindle bearing.

175. *To disassemble the leveling screws, etc.*—Screw the four leveling screws (3CA) into the fixed limb to remove friction between the leveling plate (3A) and the fixed limb nut (2X). Take out the fixed limb-nut screw (2M), unscrew the fixed limb nut (2X), using adjustable key wrench No. 37. Lift off the leveling plate (3A) and the screw collar (3D). The four leveling screws (3CA) may then be removed from the fixed limb (2W) and the shoes driven off with a light blow of a mallet.

Remove the plunger sleeve screw (3S), unscrew the slow-motion plunger sleeve (3L) from the fixed limb. The slow-motion plunger (3K) and slow-motion plunger spring (3M) may then be separated from the slow-motion plunger sleeve.

176. *To remove the elvation worm mechanism.*—Remove the two elevation worm-box studs (4GA) and lift off the worm box. Loosen the dial-nut screw (4JA), remove the dial nut (4Y), the two elevation-dial screws (4TA) and the screw washers (4UA). Lift off the elevation dial (4HA), drive out the elevation worm (4Z) by tapping lightly on the threaded end of the worm, thereby forcing out the plug (4X) and releasing the elevation micrometer head (4WA).

AZIMUTH INSTRUMENT, MODEL OF 1910.

(See Pamphlet No. 1656 and drawings 22–30–1 to 14, inclusive.)

177.[1] *To disassemble the base.*—Remove the azimuth stop (11T), unscrew the spindle-washer screw (9F) and lift off the spindle washer (11D). Lift off the body (9A) and yoke (10A) assembled from the azimuth circle (9B). Remove the spindle-nut lock screw (11AA) and, using adjustable key wrench No. 36, unscrew the spindle nut (11C). The azimuth circle may then be lifted from the leveling plate (10P).

To remove yoke (10A) from body (9A) take out the yoke-washer screws (10T), draw off yoke washer (11K) and separate yoke from body and azimuth slow-motion arm (9D).

178. *To disassemble worm.*—Remove the yoke and the body from the azimuth circle. Take off the worm-box cover (9C). Remove the worm-shaft screw (10V). Draw off the drum crank (10L), the azimuth drum (10G), the drum adjusting clamp (10J), and drum adjusting sleeve (10K) assembled. Loosen the azimuth-drum cover, set screw (10Y) and pull off the azimuth drum cover (10B). Unscrew partially the worm-box adjusting screw (8AC). Remove the worm-box support screws (10Z) and draw out the worm-box support (10R). Unscrew the worm-box pivot (8X) and draw out the worm screw (10F) and the worm box (10H) assembled. Unscrew

[1] These instructions also apply to the azimuth instruments, models of 1900 and 1900 Mi.

the worm-screw bearing screw (10AA), pull out the worm-screw bearing (10Q) and slip out the worm screw (10F).

Use clock oil on all internal bearing surfaces. Assemble all parts in the reversed order. In case the felt strip (1F) becomes unserviceable replace it by a good grade of soft felt $\frac{1}{8}$ inch thick.

SWASEY DEPRESSION POSITION FINDER.[1]

(See pamphlet No. 1875 and drawings 22–22–1 to 15, inclusive.)

179. *To disassemble the azimuth worm mechanism.*—Loosen the azimuth drum lamp-bracket screw (14FB) and rotate the azimuth-drum lamp bracket slightly. Loosen the worm-box pivot screw (14YA) and unscrew the worm-box pivot (8Z). Throw the worm out of mesh and pull the worm box assembled down out of its seat. Remove the azimuth-drum screw (14M) and pull off the azimuth drum (8S). Loosen the azimuth drum-cover screw (14P) and remove the azimuth drum cover (8Q). The azimuth drum lamp bracket may also be disassembled. Take out the worm-box adjusting screw (14U) and the worm-box oil tube (8DA). Push out the worm screw (8B) and the worm-box bush (8C).

In assembling, tighten the azimuth drum screw (14M) so that the worm screw may revolve in the worm box without great friction and without longitudinal play. Adjust the worm-box adjusting screw (14U) so that the worm screw comes just to bearing with the azimuth circle and operates without appreciable backlash.

180. *To remove the range pointer arm* (9T).—Remove the range pointer cover (6P) and the curvature attachment guard (6F). Unscrew the two range pointer screws (14GA) in the forks of the range pointer arm (9T). Remove the screws from the range pointer guides (9W) and (9X). Pull out the range pointer (9U) and the range pointer guides (9W) and (9X). Take out the four pointer bracket cap screws (14AB) and remove the range pointer bracket (9N). Loosen the pointer arm screw (14B) and push out the range pointer-arm shaft (9Y). When reassembling, note that a flat is machined on the range pointer-arm shaft (9Y) for the set screw.

181. *To remove the bell crank lever* (6D).—Remove the curvature attachment guard (6F). Scribe a line across the rack on the bell crank lever and the worm sleeve (4AA) for reference in assembling. If no other parts are to be disassembled, take care that the range drum is not moved while the bell crank lever is disassembled. If other parts are to be disassembled, the instrument should be set for telescope level and the range drum removed before the bell crank lever is taken off. Remove the lever post caps (7B). Lift off bell crank lever assembled.

[1] The nomenclature given is for the type AII instrument. The parts of this instrument will be disassembled only in case of necessity for making repairs or correcting errors, etc.

182. *To remove the range drum.*—If the range pointer arm (9T) is to be removed, set the instrument at a short range and remove the pointer arm screw (14B) from the hub of the arm (9T). Then revolve the drum until it indicates telescope level. Note that in this position the cam crank pin (6E) bears on the flat of the cam (6T). Remove the range pointer cover (6P). Take out the two range pointer screws (14GA) from the fork of the range pointer arm (9T) and the screws from the range pointer guides (9W) and (9X). Pull out the range pointer (9U) and the range pointer guides. Remove the screws holding together the two sections of the range drum cover (10D) and (10E). Remove from the cradle the range crank (9K), the oiler for oiling the range crank shaft (9H), and the oiler for lubrication of the azimuth circle. Take out the large drum-cover screws (14S) holding the drum covers to the cradle (7D). Pull off the drum covers. Take out the three screws from the slotted holes in the range drum (9L) and remove the range drum (9L). Unscrew the drum gear screw (14A) and pull off the range drum gear (9E). The range crank pinion (9D) and range crank shaft (9H) may now be removed. No attempt, however, should be made to remove these parts until after the range drum gear is removed.

183. *To remove the cam of the curvature attachment.*—Remove the range drum and gear complete. Note instructions in paragraph 159 above regarding setting of range drum before it is removed. Mark the opposite teeth of the worm shaft pinion (5T) and the cam shaft gear (5U). These teeth may already be spot marked. Remove the cam bracket caps (5Q) and pull out the cam shaft (4V), cam (6T), and cam shaft gear (5U) assembled. The cam and cam shaft gear are located on the cam shaft (4V) by paper pins. The cam, cam shaft, and cam shaft gear may be removed after the curvature attachment guard (6F) is taken off, provided that a bent wire is used in removing the capstan head screws holding the cam bracket caps (5Q). If, however, other parts are to be disassembled, it will be preferable to remove the range drum, etc., first.

184. *To remove the range drum shaft.*—Remove the range drum (9L), the range pointer arm (9T), the range pointer bracket (9N), the bell crank lever (6D), and cam shaft with cam and gear. Note instructions above for setting of the range drum before its removal and for marking the opposite teeth of the worm shaft pinion (5T) and the cam shaft gear (5U), and for marking the bell crank lever and the worm sleeve. Drive out the taper pin and remove the worm shaft pinion (5T). Loosen the cam bracket screw (5N). Remove the two capstan head screws holding the worm sleeve (4AA) in the cam bracket (5L), the filister head screw holding the cam bracket (5L) to the cradle (7D), the one headless locating screw locating the worm sleeve (4AA) in the cradle (7D), and the clamp screw (14BB)

from the cradle. Pull worm sleeve (4AA) to the rear, slipping from it the cam bracket (5L). Loosen the set screw holding the worm sleeve bush (6C) in the worm sleeve (4AA), pull out the range drum shaft (4Q), and remove the worm sleeve bush (6C).

Reassemble in reversed order, taking care to mesh gearing to the teeth previously marked, to locate the flat on the smaller end of the cam uppermost, and to assemble the bell crank lever according to the mark previously scribed.

185. *To remove the cradle, etc., from the base.*—Take out the oil cup from spindle washer. Remove the brush block (13W). Use teat wrench No. 43 and unscrew spindle washer (11SA). Then lift off the cradle (7D). Four men are required for this work. The cradle must be lifted directly up about 12 inches. The vertical spindle (11JA) is driven in the azimuth circle (8F) and should not be removed. To remove the azimuth circle (8F) and the azimuth plate (7C) loosen the azimuth drum set screws (14CB) and lift the two parts off the base (7E). Remove the spindle nut screw (14ZA) from the spindle nut, unscrew the spindle nut (11RA) and lift the azimuth circle from the azimuth plate (7C).

One leveling shoe (8K) is made with a tongue. The position of this shoe may be changed without disassembling the azimuth circle (8F) from the azimuth plate (7C).

186. *Notes on assembling.*—Assemble the range drum shaft and the worm sleeve bush, etc., in the worm sleeve (4AA). Slide the worm sleeve and cam bracket (5L) in their seats, locating the worm sleeve by the headless locating screw, and put in the screws which hold the cam bracket and clamp the worm sleeve. Assemble in the cam bracket (5L) with flat of cam uppermost, the cam shaft (4V) with cam (6T) and cam shaft gear (5U) assembled. Place in position the crank lever noting the marks previously scribed. If no marks are scribed on it, assemble it so that its rear end just clears the rear lug of cradle. While placing the bell crank lever in its bearing hold up the cam crank (5V) so that the cam crank pin (6E) does not touch the cam. In this position of the cam and the bell crank lever, the cam crank pin (6E) should rest on the flat of the cam. Assemble the range crank pinion (9D) and range crank shaft (9H).

Then assemble the range drum gear, the range drum at telescope level, and the pointer mechanism. The range pointer arm (9T) should be meshed in the range drum shaft so that the pointer indicates telescope level. Assemble the worm shaft pinion as marked (if not marked assemble for trial). Rotate parts by the range crank to prove that the range drum may be revolved from telescope level to the shortest range. If the full movement can not be obtained, loosen the four pointer bracket cap screws (14AB) and shift the pointer

bracket on the worm sleeve to obtain it. Assemble the pointer arm screw (14B) with the range drum set for a short range.

187. *To test adjustment.*[1]—Level the cradle, set the range drum at telescope level, assemble the telescope and the striding level. Adjust the striding level. Set the telescope level. Adjust the cam crank screw (5W) if necessary so that the top surface of the carriage crank (5P) is perpendicular to the height scale. Slide the height slide (4E) assembled along the rail and by the telescope observe any external object. If, during movement of the height slide, the image shifts in respect to the cross wires, remove the plunger (4P) and adjust the plunger screw (4U) in the plunger. Replace the plunger for trial and readjust it until the image remains stationary. Level the telescope by the range crank. If the cam crank pin (6E) does not rest on the flat of the cam (6T), remove the worm shaft pinion (5T), turn the cam shaft until the pin rests there and reassemble the pinion. Now the movement of the range crank has thrown the guide (12G) out of parallelism with the rail of the bell crank lever. Readjust the plunger (4P) until there is no movement of the image over the cross wires when the height slide is moved, readjust the level of the telescope by the range crank until the striding level indicates level. Repeat until when the telescope is level and the height slide may be moved without changing its level. Then set the range drum to indicate telescope level.

This adjustment may be made with the use of the Testing Instrument described in Pamphlet No. 1875. In this case observe the rotation of the telescope by means of the testing instrument instead of by the telescope.

188. *To set the height scale.*—After adjusting the telescope, the height slide, the curvature mechanism, and the range drum, set the drum at telescope level (the telescope being level) and adjust the testing instrument[2] to register 0. With the height scale set for the proper height, measure the angular rotation of the telescope for various setting of the range drum. In case the angles measured are greater than the calculated angles, move the height slide to register a slightly smaller height of site. Repeat the readings and readjust until the measured angles agree with the calculated angles. Then adjust the height scale pointer screw (6V) until the height scale pointer (11N) registers the correct height. Loosen the screws in the pointer stop (11P) and set the index line of the pointer strip opposite the line on the height scale pointer. Make this adjustment for the mean height at which the instrument is to be used.

---

[1] For instructions for collimation and leveling by means of the striding level see paragraph 78.

[2] For description of the testing instrument and instructions for its use see Pamphlet No. 1875 (Description of the Swasey Depression Position Finders).

189. To determine the angular error of the instrument, bring the range drum to register the specified range and read the angle of rotation by the testing instrument. Subtract the observed reading from the calculated angle to obtain the error. If it is desired to obtain the error in yards, set the testing instrument to the calculated angle and read the range from the drum. The range error is the measured range subtracted from the calculated range. The following are calculated values of the angular rotation of the telescope from telescope level to the range specified for the stated heights of site:

Range.	Angle of rotation in minutes for height of instrument of—					
	60 feet.	81 feet.	126 feet.	210 feet.	282 feet.	396 feet.
Telescope level	0	0	0	0	0	0
11,000	8.576	10.764	15.451	24.202	31.702	43.576
9,000	9.542	12.216	17.945	28.640	37.806	52.319
8,000	10.286	13.294	19.739	31.771	42.083	58.409
6,000	12.727	16.738	25.332	41.374	55.122	76.886
4,000	18.034	24.501	39.582	61.000	81.617	114.249
3,000	23.552	31.573	48.760	80.833	108.314	151.796
2,000	34.799	46.830	72.605	120.694	161.877	226.984

LEWIS DEPRESSION POSITION FINDER, MODEL OF 1907.

(See drawings Class 22, Division 21, drawings 1 to 10, inclusive, and pamphlet No. 1876.)

190. *To disassemble the internal mechanism.*—Take off the telescope by loosening the trunnion center screws (4E) and pulling trunnion centers (4T) out gradually to prevent the telescope from jarring. Remove the table clamp (4C) by driving out the taper pin (4P) and unscrewing the head (4Q) and taking out the clamp screw (4R) (left hand thread). Take off the gear guard ring (5D), first removing the 12 screws holding same to table. Remove the 5 screws holding the gear case (5M) to the table (5A), being careful to note position of long and short screws and take off the gear case (5M). Unscrew the small headless screw in the gear (5H) and drive out the pinion (5J) from the gear (5H) with a small stick and hammer. Loosen the three table center screws (4L) and (4Z) in the body about 1½ turns and lift off the table (5A) (2 men required), by raising on opposite sides with equal force, taking care not to force parts or to injure the center. Mark one slot of table center (4G) and one table center screw so that the table may be put back in same position.

191. *To dismantle the range gearing.*—Set the range scale at 1,500 yards and mark the position of the range dial gear (3Q), the rack gear (3S), and the lower worm shaft gear (2W). Remove the range dial gear plate (3E). Mark the position of the range pointer (3TA). Remove the lower worm shaft gear (2W), holding the rack gear (3S)

to prevent its rotation. Remove the rack gear plate (3F) and the rack gear (3S). Assemble in the reversed order.

192. *To disassemble the azimuth gearing.*—Remove the trunnion yoke screw (4B) and pull out the trunnion yoke (4F). Unscrew the screw located directly under the trunnion yoke screw which holds the table (5A) to the tabel center (4G). Drive out the table center (4G) by tapping lightly on the head of the center screw (4H). Do not remove the azimuth circle (6P) and holder (6Q) unless it is necessary. Never attempt to remove these parts until after the table has been removed from the body (6B).

Remove the screw for table (6G) and the small headless screw in the screw for azimuth dial pinion (4M) and unscrew the screw for azimuth dial pinion (4M). The azimuth dial assembled (4X) will then drop out. Remove the screws for azimuth dial block (6E) [these are the first and fourth screws in the table extending in a line outward from the azimuth circle window (5B)] and slide out the azimuth dial block (6R) and $\frac{1}{100}$ degree scale (6S) assembled. The screw for azimuth dial pinion (4M) and the eccentric for azimuth dial block (6D) may now fall out. Assemble in the reversed order. Make sure that the pin which is located half in the azimuth dial pinion (4D) and half in the azimuth dial center (4N) is driven home. Otherwise backlash may be found in the $\frac{1}{100}$ degree scale (6S).

193. *To remove the compensating mechanism.*—Set the range scale at 1,500 yards and note the position of the cam (2Z) and the pin for bar (3D). Take off the worm shaft nut (2P). Mark the position of the lower worm shaft gear (2W) in reference to the range dial gear (3Q). Remove the lower worm shaft gear (2W). Take out the four screws holding the screw and gear case (2A) and lift it from the table.

194. *To change the class of an instrument.*—Remove the compensating mechanism and the range dial as described above. The range dial gear and the compensating mechanism of class required may then be assembled in the reversed order specified above. Take care to set all parts in the same manner in respect to each other as those removed; that is, the range dial and the range pointer should be at 1,500 yards, the rack gear (3S) at the position marked and the cam (2Z) and pin for bar (3D) should be in same position as on compensating mechanism taken off. (The position of the cam and pin for bar is that shown on Plate IV of pamphlet No. 1876—Description of the Lewis Depression Position Finder, Model of 1907.)

It is possible that the hole through the center of trunnion yoke (4F) will needs be elongated to obtain short-range readings at the extreme readings on the tide scale. Test to see that the lug on the trunnion of the telescope tube does not come in contact with the sides of this clearance hole.

195.* *To disassemble the compensating mechanism.*—After removal of the compensating mechanism which has previously been set at 1,500 yards, remove the two intermediate gear plates (2BA). Take out the two screws holding the worm wheel shaft bracket (2B) to the screw and gear case (2A). Unscrew the screws holding the worm shaft plate (2R) and draw out the worm shaft plate (2R) the worm shaft (2N) and the upper worm shaft gear (2G) assembled. To disassemble the upper worm shaft gear (2G) remove the set screw from it and draw off the gear from the worm shaft. If the bevel gear (2D) and the worm wheel (2C) are to be disassembled, first drive out the taper pins (2E) and (2YA) from the bevel gear (2D) and the collar (2ZA). Remove the set screw from the cam and drive out the taper pin (2J) from the cam (2Z). Then drive the cam shaft (2L) into the screw and gear case (2A). If the cam is to be removed loosen the screw holding the pin for bar (3D) and push out the pin for bar (3D). The cam may then be slipped out. Note that the tangent screw gears (2HA) are marked for assembling in a particular position on the inner sleeve nut (2EB) and the outer sleeve nut (2DB). If removed, these gears should be carefully assembled in the same manner. The parts disassembled may then be assembled without readjustment of the compensating mechanism, provided that the outer sleeve nut and the inner sleeve nut have not been changed in position.

196.* If the tangent screw rail is to be removed, measure and record the distance from the bottom of the screw and gear case (2A) to the top of tangent screw rail (3UA). After the removal of screws holding the tangent screw gear (2HA) to the inner sleeve nut (2EB) and the outer sleeve nut (2DB), the tangent screw rail (3UA) with sleeve nuts assembled may be withdrawn from the screw and gear case (2A). The inner sleeve nut (2EB) and the outer sleeve nut (2DB) may then be removed and later the tangent screws (2AA). Clean all gears and all bearing surfaces before assembling and oil all parts. Examine small pieces for burrs and remove them if found on bearing surfaces. Be exceedingly careful in cleaning the threads of tangent screw and sleeve nut Oil these threads with clock oil. In instruments of classes A and AA the screws have 210 threads per inch, and any dirt or grit in the threads will interfere with the smoothness of operation and the accuracy of these parts.

197.* *Assembly of compensating mechanism.*—Reassemble in the reverse order, noting that the lower numbers on the tide scale on the tangent screw rail (3UA) should be over the outside end of the screw and gear case. Adjust the inner and outer sleeve nuts on the tangent screws until the tangent screw rail is *exactly* parallel with the

* See paragraph 11.

bottom surface of the screw and gear case. Locate the cam (2Z) so that the pin for bar (3D) is in the left end of cam groove (see note on drawing 22–21–8). Locate the intermediate gear plates (2BA) so that the intermediate gears (2U) mesh the pinion and tangent screw gears (2HA) without backlash and so that the outer sleeve nut (2DB) operates smoothly and without backlash. The assembled height from the surface of the tangent screw rail to the axis of the telescope (axis of trunnion centers) is specified on drawing 22–21–8. If the height of rail from base of screw and gear case is made the same as measured before disassembling, the rail should be located correctly from the axis of the telescope. It may be noted that the surface of the table to which the compensating mechanism is fitted is accurately scraped in reference to the lower surface of the inner hub of the table.

198. *To test correctness of assembly.*[1]—After assembling the table test by operating the outer sleeve nut to see that the range scale may be operated throughout the limits of range. In case the range pointer is not correctly set, keep the range scale at 1,500 yards, remove the table, take off the lower worm shaft gear (2W) and move the rack gear and pinion (3U) to the desired position, and reassemble. If the range dial gear (3Q) is limited in movement, lift and block up the table, and, if the desired additional movement is small, spring the range dial gear (3Q) sufficiently to throw it out of mesh with the lower worm shaft gear (2W) and move it in the desired direction. If the required additional movement is considerable, disassemble and reassemble all parts, setting the range dial gear (3Q) and the range pointer (3TA) at 1,500 yards and the cam (2Z) so that the pin for bar (3D) is in the left end of slot.

199. *Accuracy tests.*—The accuracy of readings may be measured by comparison with a bar scale graduated in inches and fractional parts. Set the height for the given height of site and the range scale at a range of about 8,000 yards for instruments whose range scales are graduated to 12,000 yards and of about 4,500 yards for other instruments. Set up the bar scale vertically at exactly 100 feet distance from the telescope (trunnion center) axis, so that the bar scale reading given in table below for the range setting specified is intersected by the horizontal cross wire. This is calculated so that the 0 of scale corresponds to the "telescope level" position of the telescope. Then by moving the range mechanism, without disturbing the compensating screw, bring the telescope successively to the bar scale readings and read the range registered on the range scale. To obtain the range error, subtract the measured range from the calculated range.

[1] Collimate the telescope as described in paragraphs 80–85.

200. *Data for accuracy tests.*—

Range.	Bar scale reading in inches for a height of instrument of—						
	24 feet.	60 feet.	81 feet.	126 feet.	210 feet.	282 feet.	396 feet.
8°	0	0	0	0	0	0	0
11,000	1.684	2.994	3.757	5.394	8.448	11.066	15.212
9,000	1.731	3.331	4.264	6.264	9.997	13.198	18.264
8,000	1.790	3.590	4.640	6.890	11.090	14.690	20.390
6,000	2.043	4.443	5.843	8.843	14.443	19.243	26.843
4,000	2.695	6.295	8.395	13.817	21.295	28.495	39.895
3,000	3.421	8.221	11.021	17.021	28.221	37.822	53.021
2,000	4.948	12.148	16.348	25.348	42.148	56.548	79.348

If desired, the target may be set up at a shorter distance, provided that the bar scale readings are proportionally reduced.

SCALE ARMS (Group c).

201. Scale arms and all graduated surfaces give incorrect results if their fiducial edges for any reason lose the form they properly should have. Thus, the long plotting arms for a Whistler-Hearn plotting board, if handled roughly, or if bent too much, become warped in one direction or another, giving readings too great or too small, depending on the direction of warping. Such arms must be removed from the board, and by careful reverse, bending, peening, and testing with a straightedge, returned to their original condition. In tapping such arms, tap very lightly and carefully, for otherwise the tapping will result in broadening out the distance between graduations, and thus in destroying the accuracy of the arm. Where circular scales are bent out of shape and become eccentric, a gage must be made for testing the edge after correction. Spoiled scales may ordinarily be replaced by new ones obtainable from the Frankford Arsenal. If time, cost of transportation, or other reason prevents, new pieces must be prepared according to the drawings, and graduated carefully. The index head of a milling machine may be used if no circular graduating machine for circular scales is available. For straight scales, if no rectilinear graduating machine, least reading 0.001 inch, is available, use the best vernier gage obtainable for the purpose. Lettering, numbering, and index marks will in such cases ordinarily have to be stamped in. The stamping increases the length of the scales; hence the stamping must be done before the final graduation, the position of the various numbers being determined as closely as possible. If an engraving machine is available, the graduating should be done first and the engraving second.

WOODEN PARTS (Group d).

202. Wooden parts of instruments, if destroyed or damaged so as to interfere with the action of the other parts of the same instrument, should be replaced when possible by the same material as that originally used. The various drawings specify the material and its method of preparation, including the linseed oil and varnish treatment. Warping can only be provided for by increasing clearances already allowed. Slotted instead of round screw holes, etc., are suggested as means of overcoming difficulties in the adjustment of metal parts to a wooden base which expands or shrinks unduly with change of moisture in the air. No absolute method can be given for such cases, and readjustment of all metal parts frequently will be found necessary.

SPECIAL PARTS (Group e).

203. The canvas charts, with the blue-print chart attached, for Pratt range board should be kept habitually flat when not stretched in the board. If it is desired to prepare new charts, obtain the canvas of the size necessary and sew over a stretching form corresponding to the frame of the board. While stretched tight paste on the blue print in its proper position, giving careful attention to the eyehole. Sew edges of blue print down after pasting, as they will otherwise curl up and tear off.

204. The rubber covering of the mobile artillery board may be rubbed up and in a measure improved as to elasticity by the use of powdered sulphur. Keep the rubber out of the sun when practicable.

205. The steel tapes issued with Weldon range finders should be kept clean and well oiled when not in use. When using, avoid getting kinks in the steel ribbon. Never drag the tape over rough or broken ground. Before winding up, clean the steel ribbon as it comes in of all grit and dirt, for, if not, after once entering the case, the parts will be rapidly clogged, scratched, and otherwise injured. Should a tape break, repair the break by an extra piece soldered on, or attached by suitable rivets, and of such length as to keep the readings of the tape on either side of the break correct.

206. Time-interval recorders may be repaired and adjusted by any competent watch repairer.

ADDITIONAL TESTS.

207. For testing of plotting boards, if data for observation points is not at hand, hypothetical points should be located in the field of fire at long ranges, and the azimuth and distances of these points from the primary and secondary stations and from the directing point of the battery should be calculated. To test a plotting board, set the primary and secondary arms at the calculated azimuths, note errors

in the ranges from these stations and errors in gun arm range and azimuth from the calculated values.

208. In case it is desired to report the condition of a plotting board to an armament officer or to Frankford Arsenal, it will be of great assistance if a complete test of the board be made and reported in accordance with the following form, in each case reporting the model and serial number: Tested for right (or left) base line ------ yards long with ranges from ------ yards to ------ yards from the gun center. The errors of ------ readings were: Primary arms, maximum, ------ yards; mean, ------ yards. Secondary arm, maximum, ------ yards; mean, ------ yards. Gun arm, maximum, ------ yards; mean, ------ yards. Gun arm azimuth circle, maximum, ------ °; mean, ------ °. The maximum error in gun azimuth if the gun arm is moved from 1,500 through intermediate positions to 2,500 is ------ °. The gun arm set at the azimuth of the normal is parallel to the primary arm set at the same azimuth; error, ------ °. The error in azimuth of the gun arm due to moving the longitudinal slide through the full extent of its movements is ------°; the error due to moving the lateral slide similarly is ------°. The primary (or secondary) arm set at the azimuth of the base line is parallel to the base line arm with an error of ------°. The backlash of the gun azimuth mechanism is ------°; that of the azimuth correction mechanism is ------°; that of the primary index box is ------°; that of the secondary index box is ------°. The base line arm vernier is located correctly; error, ------°. With the gun arm center over the primary arm center the maximum error of the gun arm azimuth circle compared with the main azimuth circle is ------°. The fiducial edges of the arms (naming them) vary from a straight edge by ------ inches.

209. The following problems and results are furnished for testing other instruments of the fire-control systems. The instrument should be set at the given data of the problem and the results obtained on the instrument compared with the calculated results.

Deflection board, model of 1905, for guns.

[For capped projectiles, short points.]

	Service.						Subcaliber.	
Given:								
Interval—seconds	15			30			15	30
Wind scale	10			90			35	65
Platen scale	16			11			16	11
Range—yards	10,000			6,000			2,000	2,000
Gun.	8 in.	10 in.	12 in.	8 in.	10 in.	12 in.	Subcaliber.	Subcaliber.
Result:								
Deflection scale	3.219	3.323	3.416	1.834	1.854	1.847	2.643	2.635
Azimuth correction scale	16.219	16.323	16.416	9.834	9.854	9.847	15.643	10.635

Deflection board, model of 1906, for 12-inch mortars.

Given.			Result.				
			Model of 1890 M.		Model of 1886.		
Azimuth	Elevation.	Deflection.	824 lbs.	1,046 lbs.	824 lbs.	1,046 lbs.	Subcaliber.
10°	45°	3	6.66	7.37	7.33	7.90	8.88
145°	65°	5.50	139.44	141.15	141.06	142.42	144.75
271°	55°	0.50	263.47	264.54	264.47	265.34	266.79

Wind component indicator.

[Problem: Azimuth of wind, 135; azimuth of target arm, 190; velocity of wind, 50.]

Result:

Range component	21.321
Deflection component	9.0425

Field-artillery plotter, model of 1907.

Observation of point settings.				Relocating readings.				
Aiming point arm.		Target arm.		Gun arm.	Aiming point arm.		Target arm.	
Mils.	Yards.	Mils.	Yards.	Yards.	Mils.	Yards.	Mils.	Yards.
56	2,000	48	2,000	2,828	40	2,000	16	2,000
56	4,000	48	4,000	5,656	40	4,000	16	4,000

Battery commander's ruler, for 2.95-inch mountain gun.

	12.5-pound projectile.		18-pound projectile.	
	First problem.	Second problem.	Third problem.	Fourth problem.
Given:				
Angle of site of target	100	−20	100	−20
Range of obstacle	600	1,000	600	1,000
Range of target	3,800	3,400	3,800	3,400
Result:				
Height of trajectory, calculated	363.4	177.3	493.8	272.7

For 3-inch field gun.

	First problem.	Second problem.	Third problem.	Fourth problem.
Given:				
Angle of site of target	+130	−15	+20	+50
Range of obstacle	1,000	200	2,400	4,000
Range of target	4,600	2,800	5,200	5,600
Result:				
Height of trajectory, calculated	282	64	164	150

For 4.7-inch gun.

	First problem.	Second problem.	Third problem.	Fourth problem.
Given:				
Angle of site of target	+130	−15	+20	+50
Range of obstacle	1,000	200	3,800	6,000
Range of target	6,000	2,800	6,700	7,800
Result:				
Height of trajectory, calculated	284.2	42.2	137.9	156.1

Sextant telemeter, Type A, model of 1911, slide ruler for solution of triangles.

	First problem.	Second problem.	Third problem.
Given:			
Angle in mils	1,600	800	500
Difference in mils	7	24	3.2
Base	65	100	36
Result:			
Range	9,458	3,001	5,402

INDEX.

All numbers refer to paragraphs.

A.

B.

C.

D.

E.

F.

G.

H.

L.

M.

O.

P.

Q.

R.

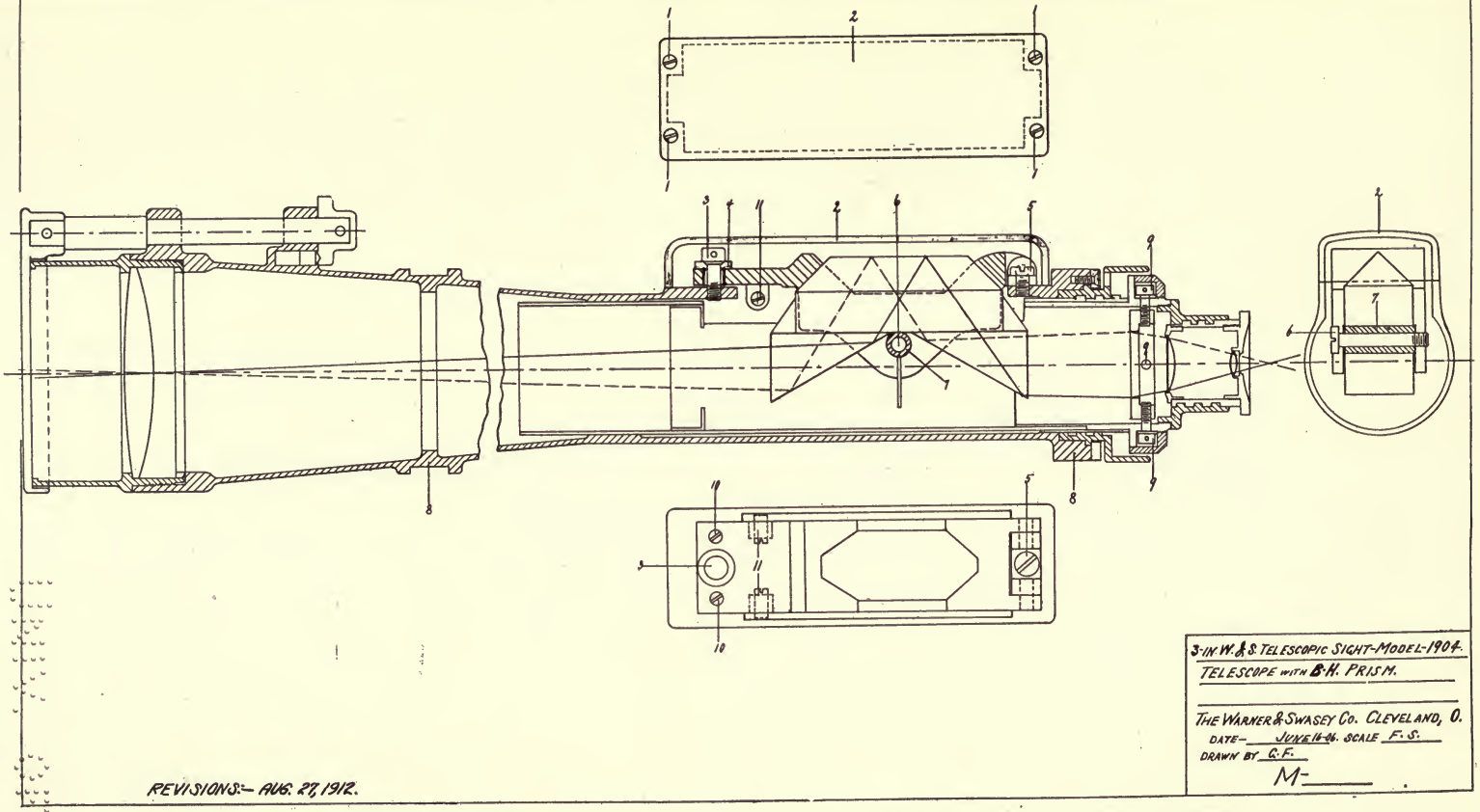
S.

T.

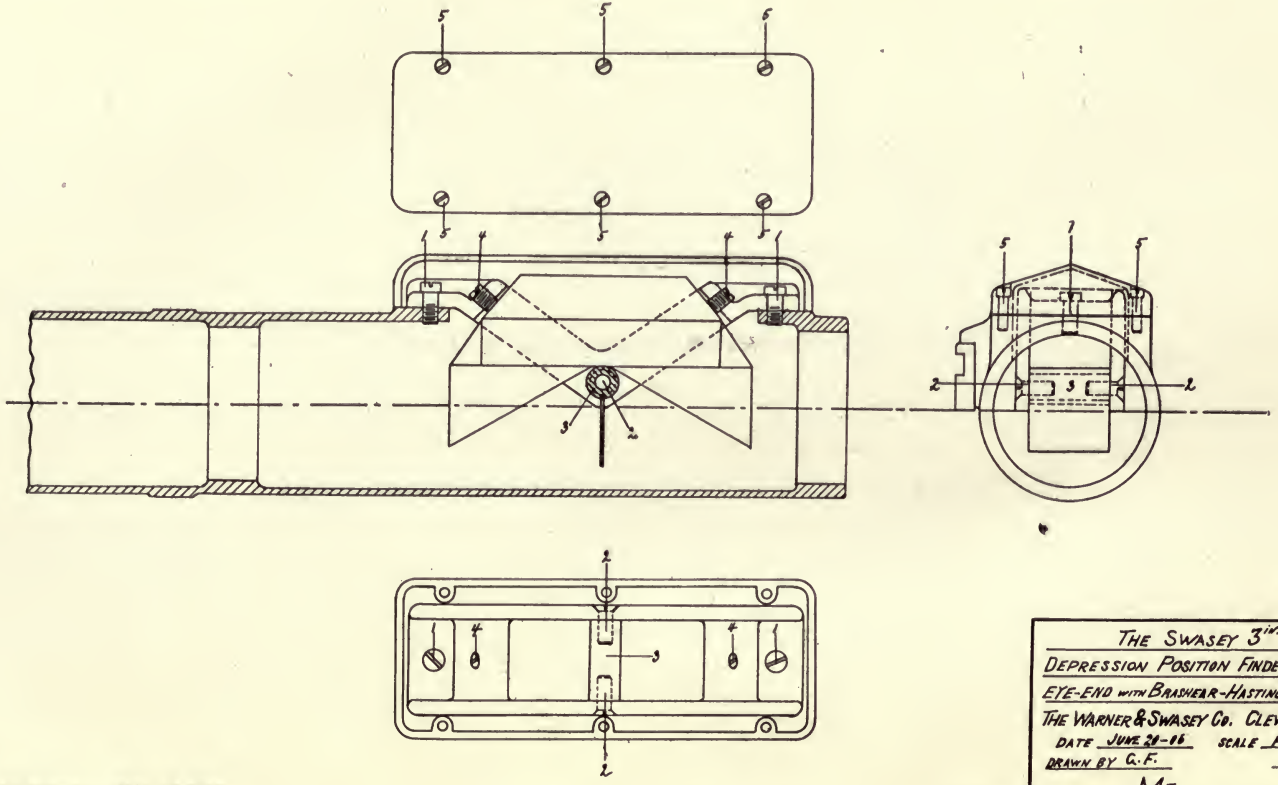
W.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, January 4, 1916.

December 18, 1906.
Revised November 1, 1909.
Revised October 9, 1912.
Revised January 4, 1916.
Form No. 1795.
Ed. Aug. 24-17—3000.
38025-2734-1.



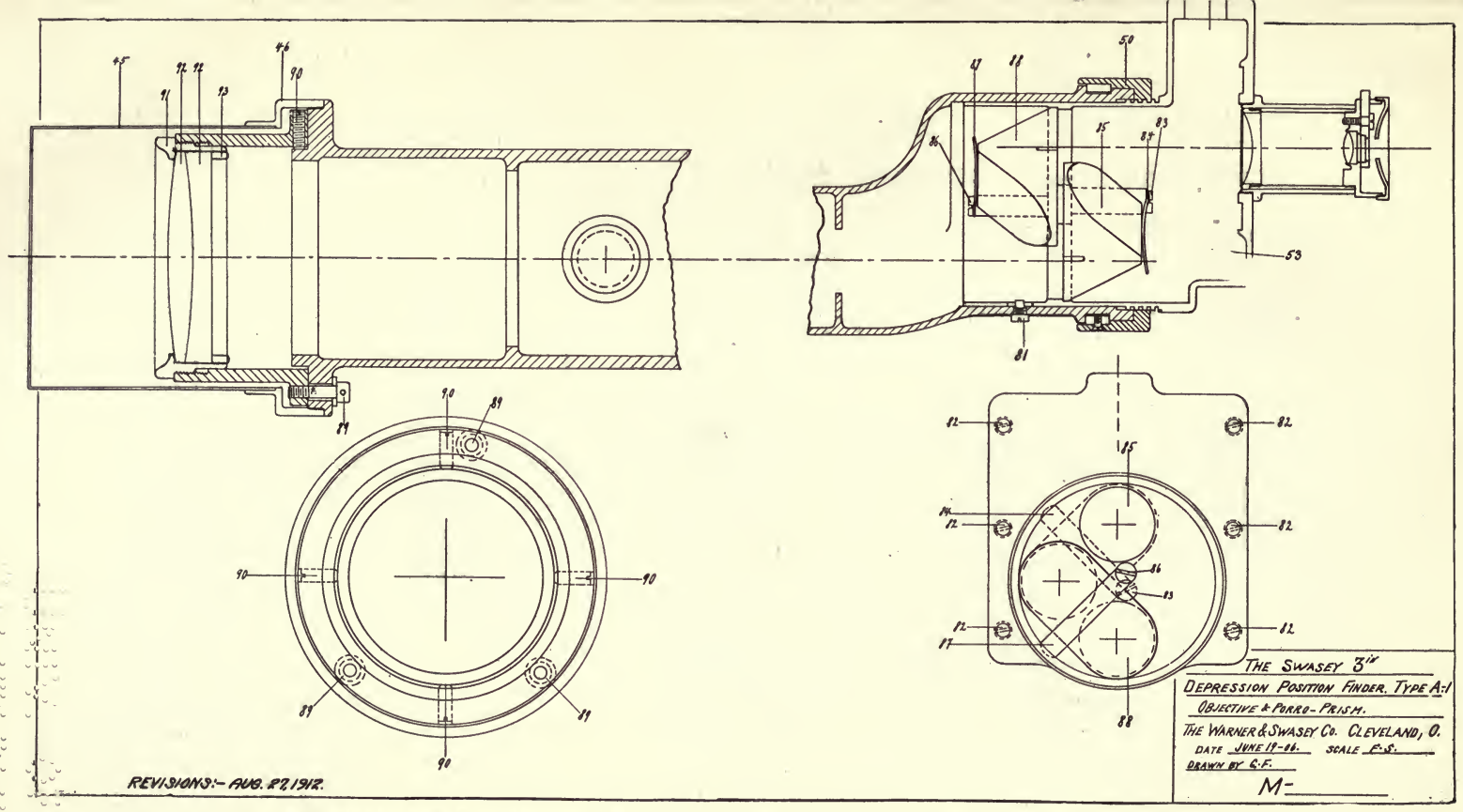
3-INCH WARNER & SWASEY TELESCOPIC SIGHT, MODEL OF 1904, TELESCOPE WITH B. H. PRISM.



THE SWASEY 3 in.
DEPRESSION POSITION FINDER.
EYE-END WITH BRASHEAR-HASTINGS PRISM.
THE WARNER & SWASEY CO. CLEVELAND, O.
DATE JUNE 28-06 SCALE F.S.
DRAWN BY G.F.
M-

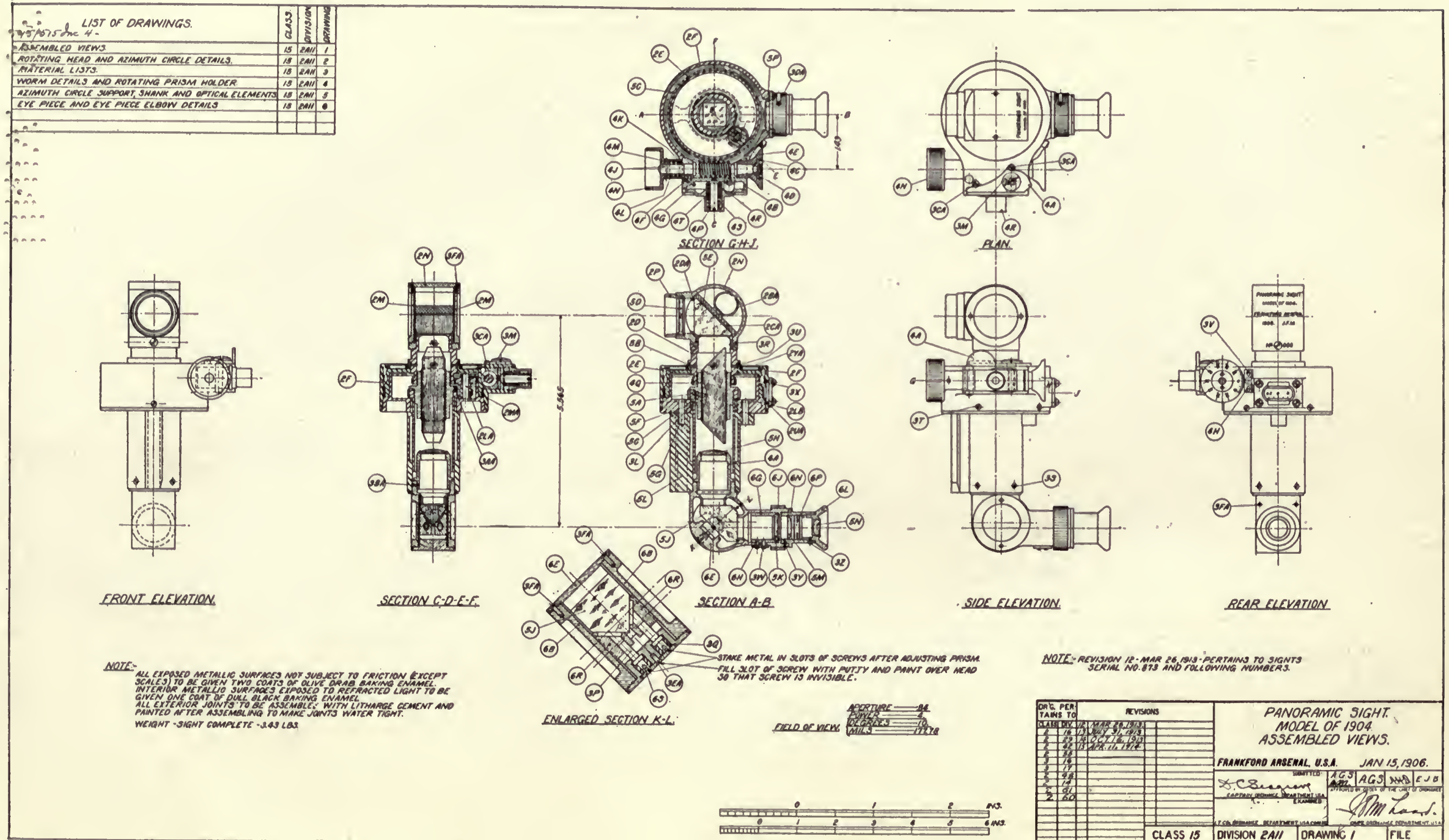
REVISIONS:- AUG. 27, 1912.

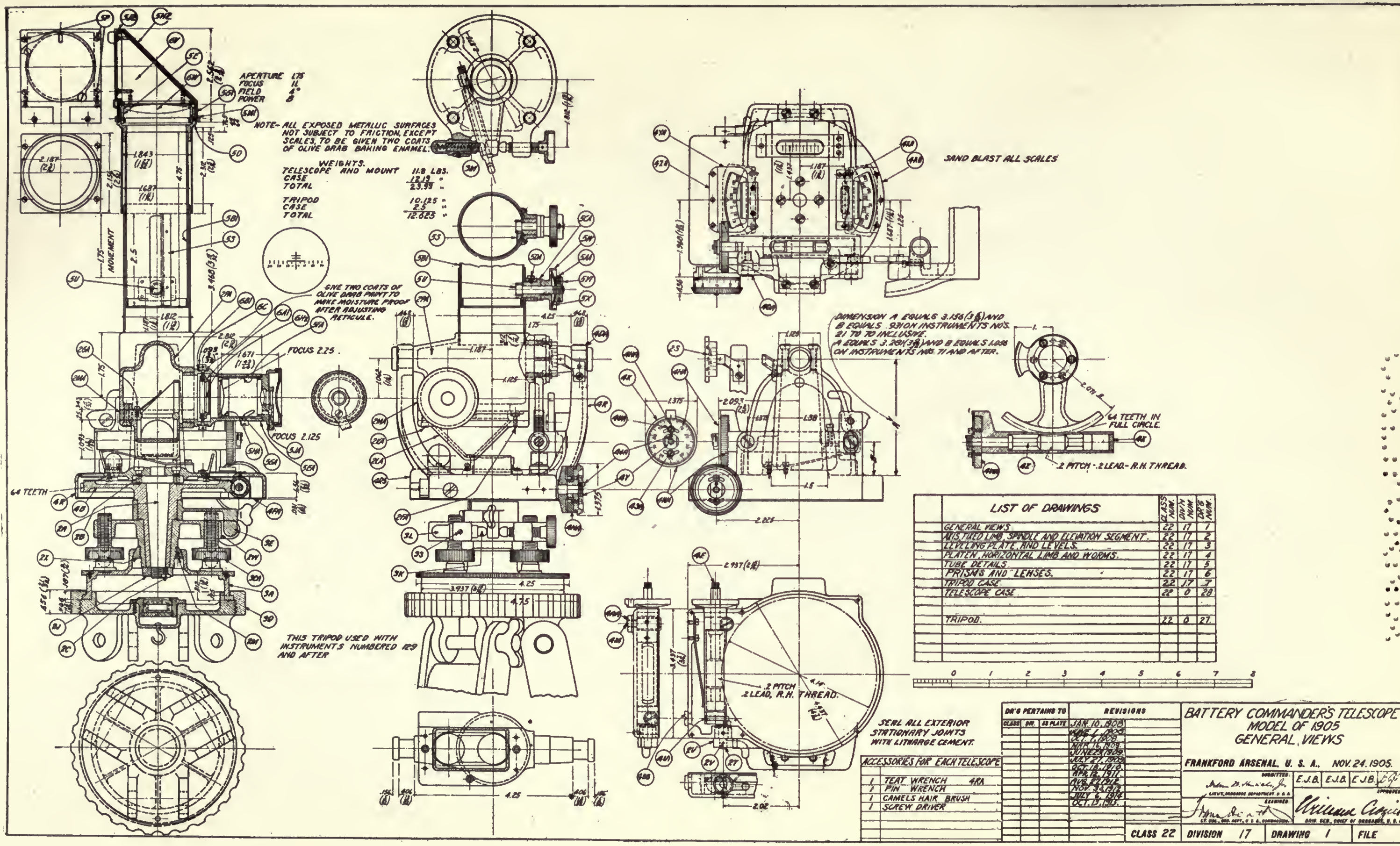
THE SWASEY 3 INCH DEPRESSION POSITION FINDER: EYE-END WITH BRASHEAR HASTINGS PRISM.



THE SWASEY 3-INCH DEPRESSION POSITION FINDER, TYPE A-1 OBJECTIVE AND PORRO PRISM.

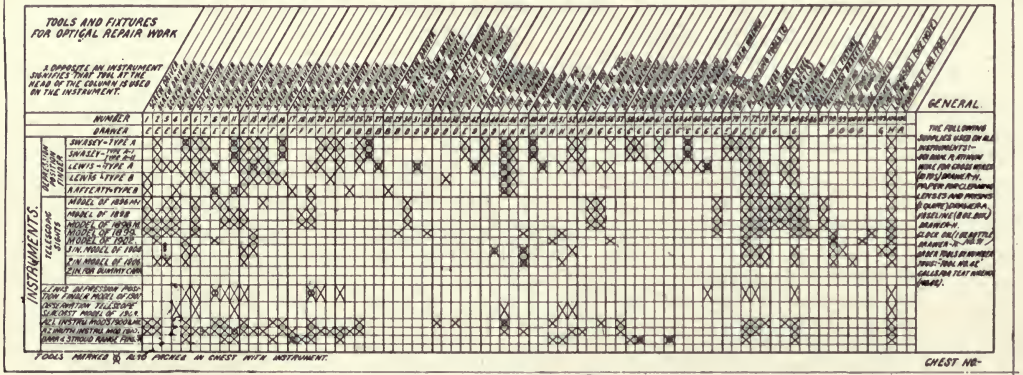
PLATE D.





BATTERY COMMANDER'S TELESCOPE, MODEL OF 1905.

TOOLS FOR INSTRUMENTS OF FIRE CONTROL SYSTEM FOR COAST ARTILLERY.



LIST OF TOOLS. (189)
ONE FOR COAST ARTILLERY ONLY - BLUE PRINT.
GLUE ON INTERIOR SURFACE OF LID OF TOOL CHEST, THEN SHELLAC.

NOTE:- THE FOLLOWING TOOLS ARE PACKED ALSO IN THE CHEST ALONG WITH THE INSTRUMENTS.
SWASEY DEPRESSION POSITION FINDER, TYPE BB.
1- SCREW DRIVER (SPECIAL), SEE ART. (1) MAR. 08 TOOLS, STS LOAN, NO. 98

LENCE DEPRESSION POSITION FINDER, MODEL OF 1907.
1- PIN WRENCH, (BR) SEE CL. 22 DIV. 31 DRAW. - NO. 93
1- PIN WRENCH, (LR) " " " " " " NO. 94
1- SCREW WRENCH, (LR), .875 (1) OPENING OF JAW. SEE CL. 22 DIV. 31 DRAWS. NO. 99

BATTERY COMMANDER'S TELESCOPE - MODELS OF 1904 AND 1908.
1- PIN WRENCH, NO. 45.

2 INCH TELESCOPIC SIGHT MODEL OF 1908.
1- SWASEY WRENCH (B.S.W.) SEE CL. 22 DIV. 31 DRAWS. 4. NO. 96.

SWASEY DEPRESSION POSITION FINDERS
- 1 OIL CAN OF ENGLISH, DRAWER 33 BOTTOM, TOY SPOUT, THE PHARMACY CO. (OR EQUAL) NO. 97.

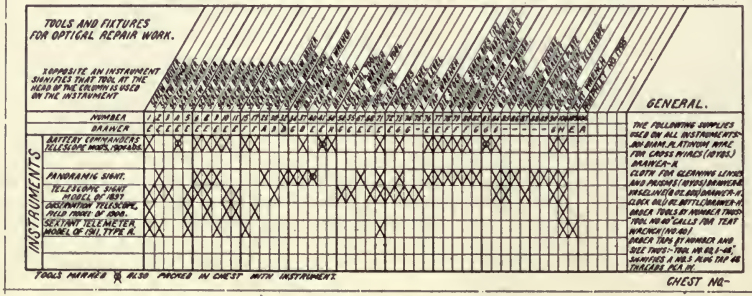
COLUMN NO. 189 TO BE ISSUED ONLY TO THOSE DISTRICTS HAVING 6-INCH TELESCOPIC SIGHTS, PROD. OF 1904, NUMBERED 1 TO 26, INCLUSIVE

WARNER & SWASEY AZIMUTH INSTRUMENT, MODEL OF 1910.
1-SCREW DRIVER (1/4 A) SEE CL. 22, DIV. 30, DR. 15, NO. 11.
1-ADJUSTING PIN. (1/4) " " " " " "

SEKTANT TELEMETER, MODEL OF 1911, TYPE A.
1-SCREW DRIVER (3/4) SEE CL. 22, DIV. 31, DR. 8.

BAUSCH & STROUD 9 FOOT HORIZONTAL BASE, SELF CONTAINED RANGE FINDER. SEE CL. 22, DIV. 26, DR. 18 FOR TOOLS ALSO PACKED IN THE CHEST.
1- SCREW DRIVER. (NO. 9)
1- SCREW DRIVER. (NO. 11)
1- SCREW WRENCH. (NO. 39)
1- SCREW WRENCH. (NO. 42)
1- COMBINATION WRENCH.
1- PENTAGONAL CARRIER STARTING PIN.

TOOLS FOR INSTRUMENTS OF FIRE CONTROL SYSTEM FOR FIELD ARTILLERY.



LIST OF TOOLS. (192)
ONE FOR FIELD ARTILLERY ONLY - BLUE PRINT.
GLUE ON INTERIOR SURFACE OF LID OF TOOL CHEST, THEN SHELLAC.

PLATE	LIST OF DRAWINGS	CLASS	DIV.	DR.
	LISTS OF TOOLS.	15	17	1
	TOOLS NOS 1 TO 38 INCLUSIVE.	15	17	2
	TOOLS NOS. 39 TO 81 INCLUSIVE.	15	17	3
	TOOLS NOS 82 TO 86 INCLUSIVE & 91.	15	17	4
	FIXTURES NOS 87 AND 88.	15	17	5
	FIXTURES NOS 89-90-92.	15	17	6
	COLLIMATING TELESCOPE NO. 20.	15	17	7
	TOOL CHEST - CHEST DETAILS.	15	17	8
	TOOL CHEST - DRAWERS.	15	17	9
	COLLIMATING TELESCOPE NO. 30	15	17	10
	COLLIMATING TEL. NO. 30 TUBE FIXTURE ETC.	15	17	11

DR'G PERTAINS TO

CLASS	DIV.	DR. PLATE

REVISIONS

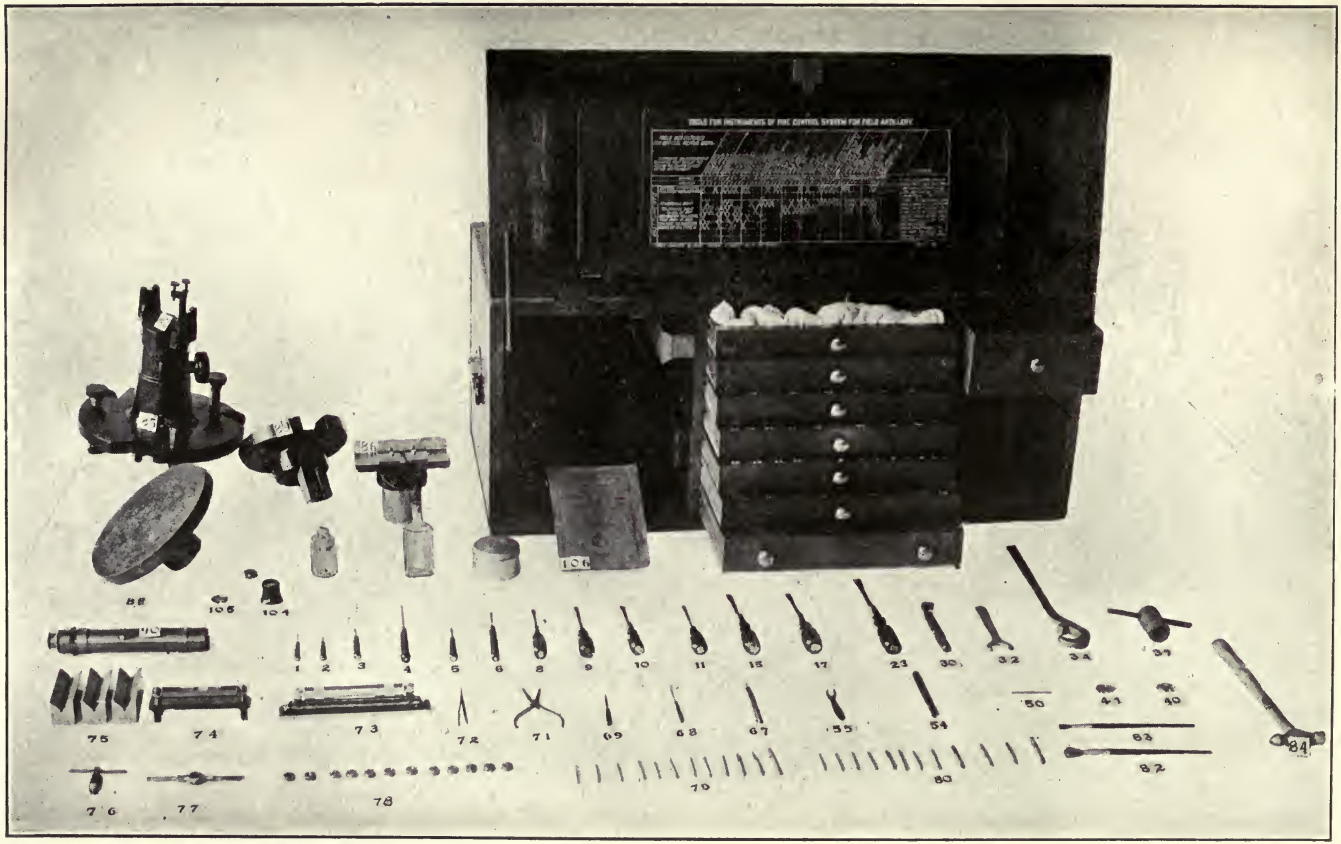
MAY 21, 1907
JUNE 3, 1908
APRIL 22, 1908
MAY 20, 1908
JULY 22, 1908
JULY 8, 1910
JULY 15, 1910
JAN. 24, 1911

TOOLS AND FIXTURES FOR OPTICAL REPAIR WORK ON INSTRUMENTS. LISTS OF TOOLS.

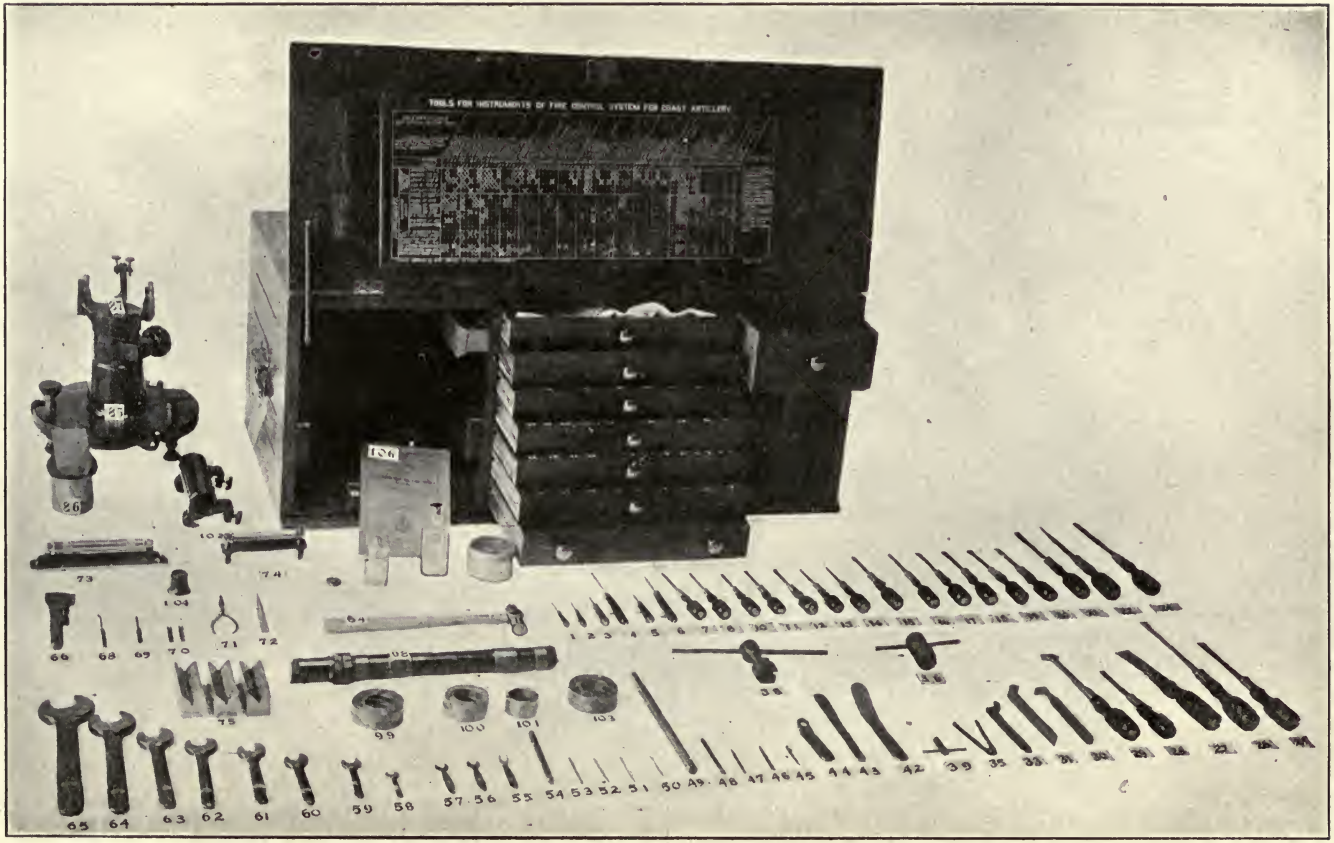
FRANKFORD ARSENAL, U. S. A., AUG. 22, 1907.

DRAWN	TRACED	CHECKED	APPROVED

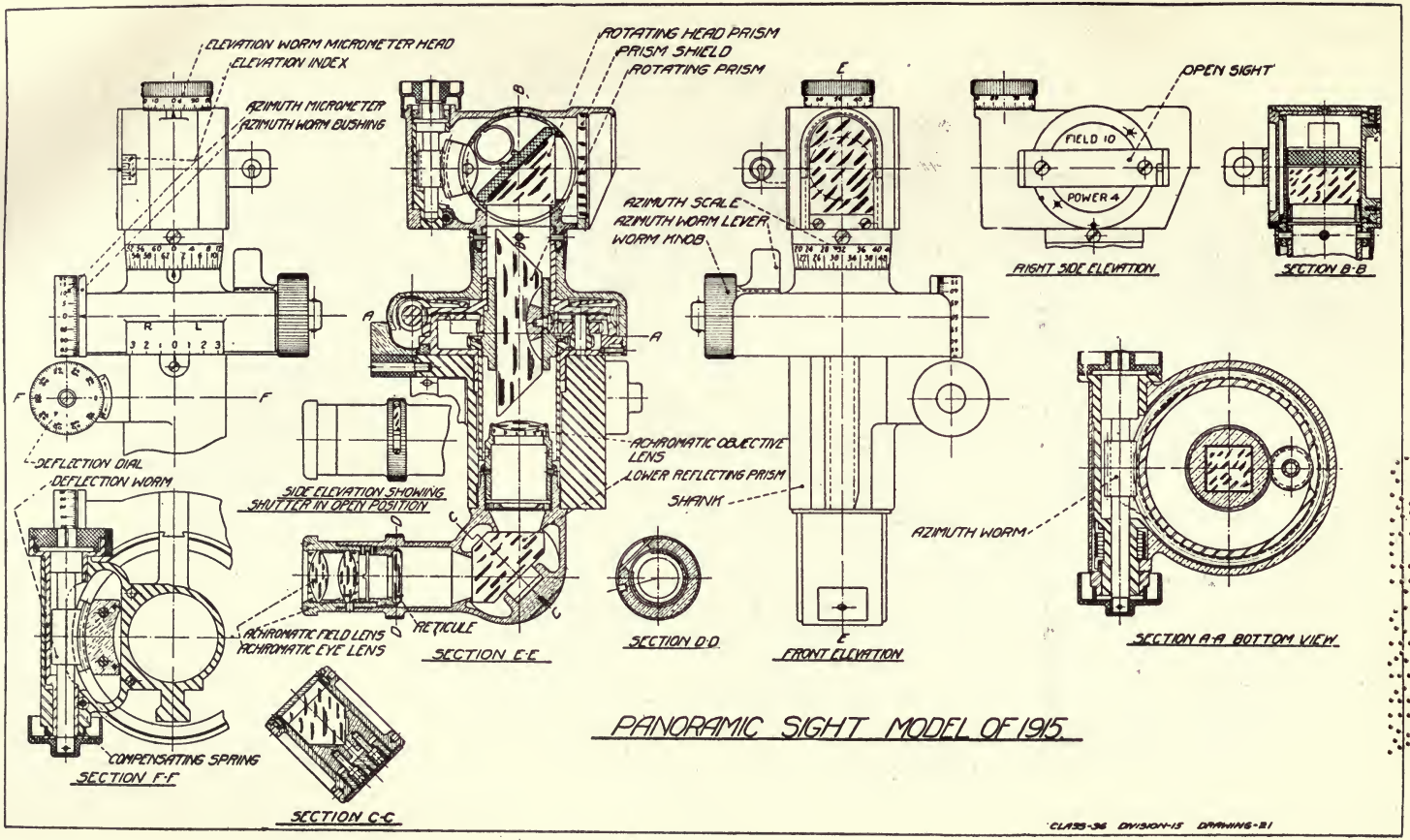
CLASS 15 | DIVISION 17 | DRAWING 1 | FILE



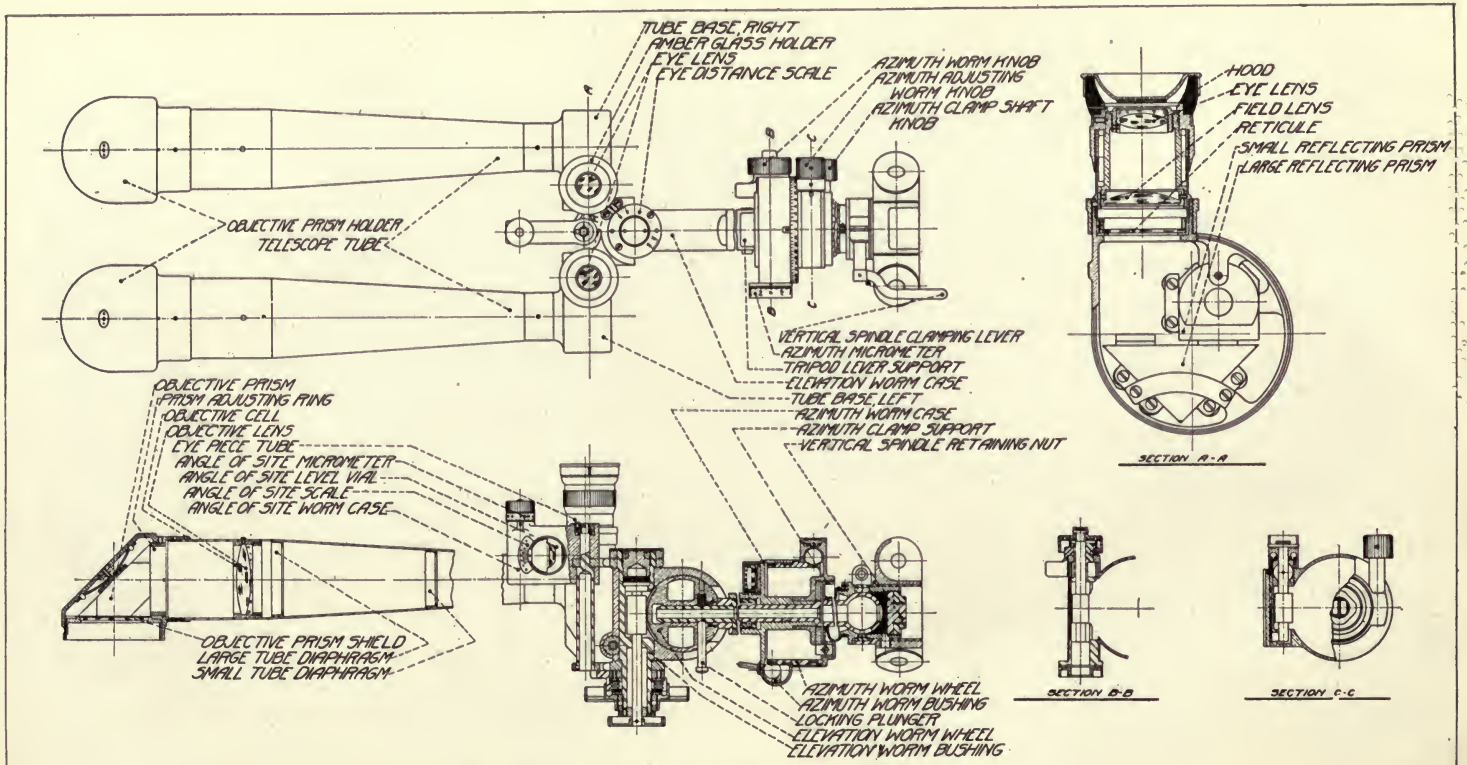
TOOLS FOR INSTRUMENTS OF FIRE-CONTROL SYSTEM FOR FIELD ARTILLERY.



TOOLS FOR INSTRUMENTS OF FIRE-CONTROL SYSTEM FOR COAST ARTILLERY.

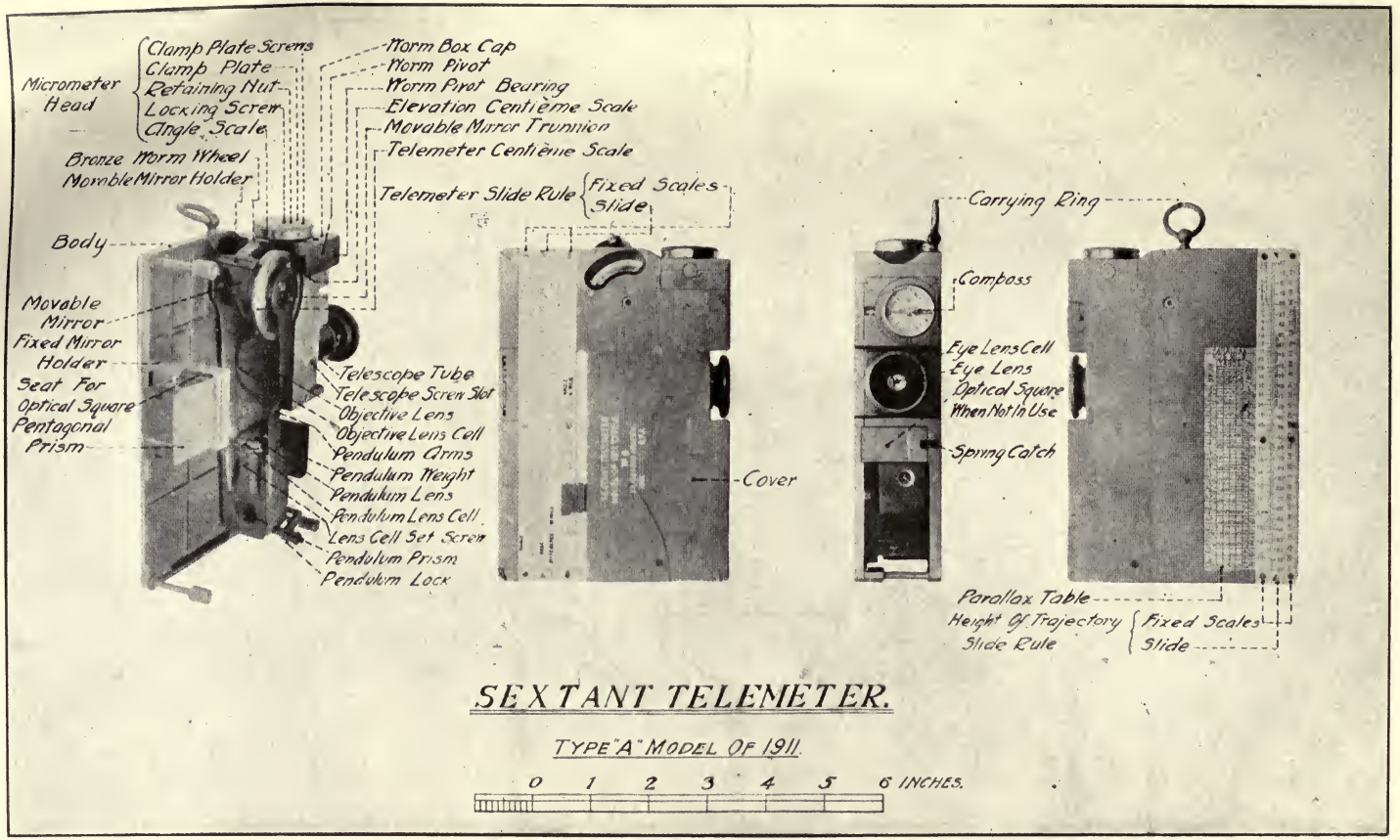


PANORAMIC SIGHT, MODEL OF 1915.



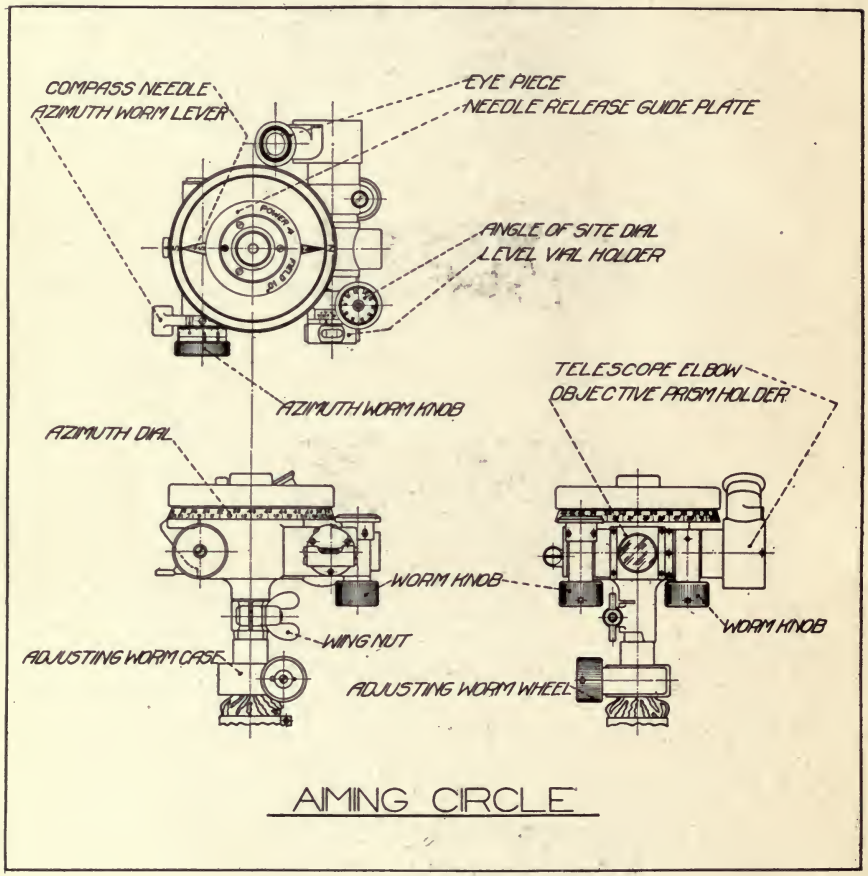
BATTERY COMMANDER'S TELESCOPE
MODEL OF 1915.

BATTERY COMMANDER'S TELESCOPE, MODEL OF 1915.



SEXTANT TELEMETER, MODEL OF 1911.

PLATE L.



AIMING CIRCLE, MODEL OF 1916.