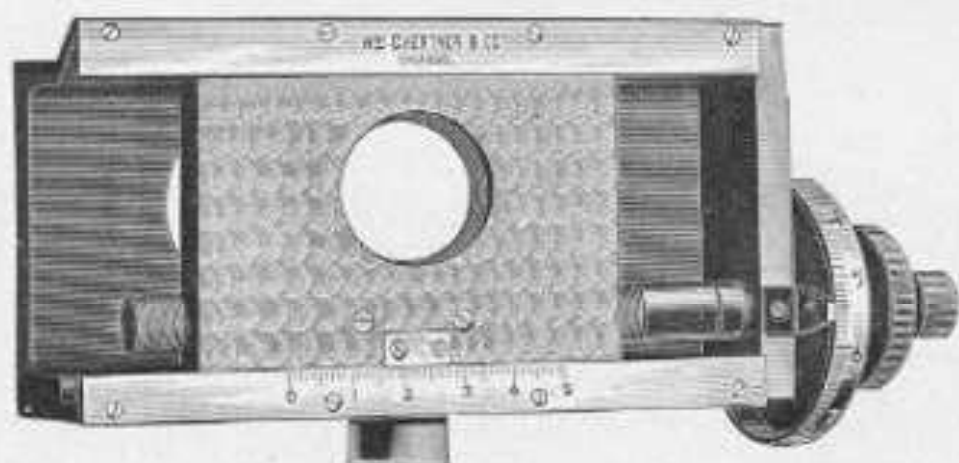


**Instruments of Precision
Laboratory Apparatus
Astronomical Apparatus**



Wm. Gaertner & Co.

**Astronomical, Physical and Physiological
Apparatus**

5347-5349 LAKE AVENUE
CHICAGO



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NOTICE.

This catalog supersedes former editions.

In ordering please give catalog number and state shipping directions.

Packing will be done with the greatest care and no charge will be made except on transoceanic shipments, or when special great care will be required.

All apparatus listed in this catalog is of our own manufacture, and most of the pieces are kept in stock. Our manufacturing facilities have been largely increased during the last year, and with more perfect organization we expect to be able to fill all orders promptly.

Everything that leaves our establishment is carefully inspected and we can guarantee our apparatus to be, in every respect, fully as represented. Any piece found defective will always be promptly replaced within a reasonable time.

We shall be glad to give careful attention to desired changes, additions or new designs of any of our apparatus, and solicit correspondence.

Thanking our customers and friends for the confidence they have bestowed on us in the past, and soliciting their further patronage, we are,

Very respectfully,

WM. GAERTNER & CO.

INSTRUMENTS OF PRECISION.

MEASURING MICROSCOPES.

The following microscopes have been designed to meet the demand for an instrument adapted to the many cases of physical and mechanical measurements requiring a microscope—such as the examination of lines and surfaces, comparison of length and other instances in which the ordinary microscope is not at all suited, or convenient to use. The optical parts are the same for each style of instrument; the tube is fixed in length to avoid unnecessary joints and secure rigidity, but, if desired, we can furnish any of our microscopes with extra draw tube to vary the magnifying power, or fit the same with rack and pinion motion for more convenient focusing. Each microscope is fitted with a clamp collar, the screw of which is standard, and will fit any of the various supports or instruments of our make requiring a measuring microscope. If not otherwise specified we furnish the optical parts to give a magnifying power of about twenty-five diameters, which for the general work has proven to be most useful.

The objective end of our microscope is threaded to fit the society standard microscope screw.



Fig. M 101

- Cat. No. M101. Microscope—Plain.** (Fig. M101.) A plain microscope without micrometer, consisting of objective, eye piece fitted with stationary cross-wires, tube and clamp collar. Price\$10.00
- Cat. No. M101a.** Same as M101, but fitted with rack and pinion. Price\$14.50
- Cat. No. M102. Microscope—With Simple Micrometer.** Consisting of objective, eye piece, simple micrometer M201, tube and clamp collar. Price.....\$16.50
- Cat. No. M103. Microscope—With Micrometer.** Consisting of objective, eye piece micrometer of best construction M202, tube and clamp collar. Price.....\$23.50

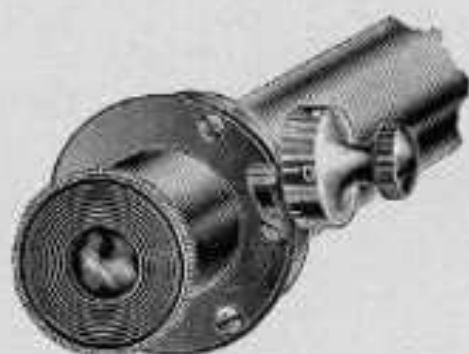


Fig. M 201



Fig. M 202

For the convenience of those wishing to purchase micrometers separate from other parts of apparatus, those used on our microscopes and telescopes are listed below:

Cat. No. M201. Simple Micrometer. (Fig. M201.) This micrometer has been especially designed as an instrument suitable for all but the most accurate work, and reasonable in price. The micrometer screw has a pitch of 0.25 mm. and a range of 6 mm., index reading 0.005 mm.
 Price\$8.50

Cat. No. M303. Micrometer. (Fig. M202.) A micrometer of new design and guaranteed to be of the highest order of workmanship and accuracy. Pitch of screw 0.25 mm., range, 10 mm., reading direct to 0.0025 mm.
 Price\$15.50



Fig. M 301

Cat. No. M301. Micrometer Slide. (Fig. M301.) The micrometer slide has a range of 50 mm. The carriage is carefully fitted in the brass bed plate. The guides are scraped true. The micrometer screw has a diameter of 10 mm., pitch of .5 mm., and is cut with great care and of the highest accuracy obtainable. The micrometer head has a diameter of 50 mm. and is divided in 100 parts, each division

reading to .005 mm. As the divisions are large .001 mm. can easily be estimated. Any of our standard microscopes will fit this slide. The supporting arm has a length of 150 mm. and diameter of 19 mm. The slide may be tapped on either end so as to make it more convenient in different positions. Price\$23.00

Cat. No. M302. Micrometer Microscope Support—With Joint. The same as M301, but with arm jointed, in order that the slide may be set at any angle with it. Price..\$26.00

Cat. No. M303. The same as M301, but with 10 cm. motion. Price\$33.00

Cat. M304. Adaptor. To hold the microscope parallel to slide; useful for determining the index of refraction of liquids. Price\$1.75

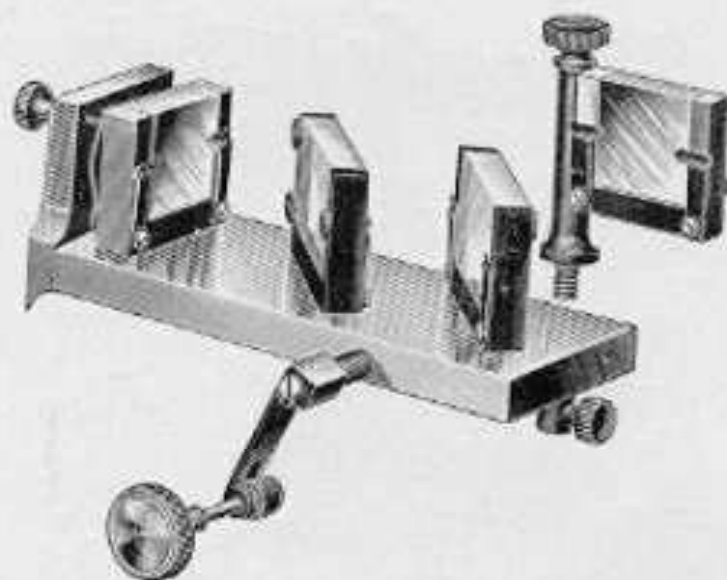


Fig. M 305

Cat. M305. Interferometer Attachment. (Fig. M305.) This attachment will fit our micrometer slides M301, M302 and M303. One mirror is readily attached by a milled head screw to the microscope carriage. The parallel plates, fixed mirror with fine adjustment, and slow motion head are mounted on a brass plate which, by means of a milled head screw, is clamped across the head end of the bed plate. The slow motion of the slide is given by a very small steel pinion engaging in the finely knurled edge of the micrometer head. The plates are 15 by 22.5 mm. For further details see our circular "I" 1902. Price.....\$35.00

Cat. No. M306. Dividing Attachment. The dividing head will fit on any of our micrometer slides and will be found very convenient for dividing small scales on glass or metal,

such as may be used for the measuring of magnifying power of microscopes and telescopes. The scale to be divided is fastened to a small stage which is held on the carriage.
 Price\$25.00

NOTE—This attachment can be used in connection with interferometer attachment Cat. No. M305, thus permitting graduations in wave length of light.

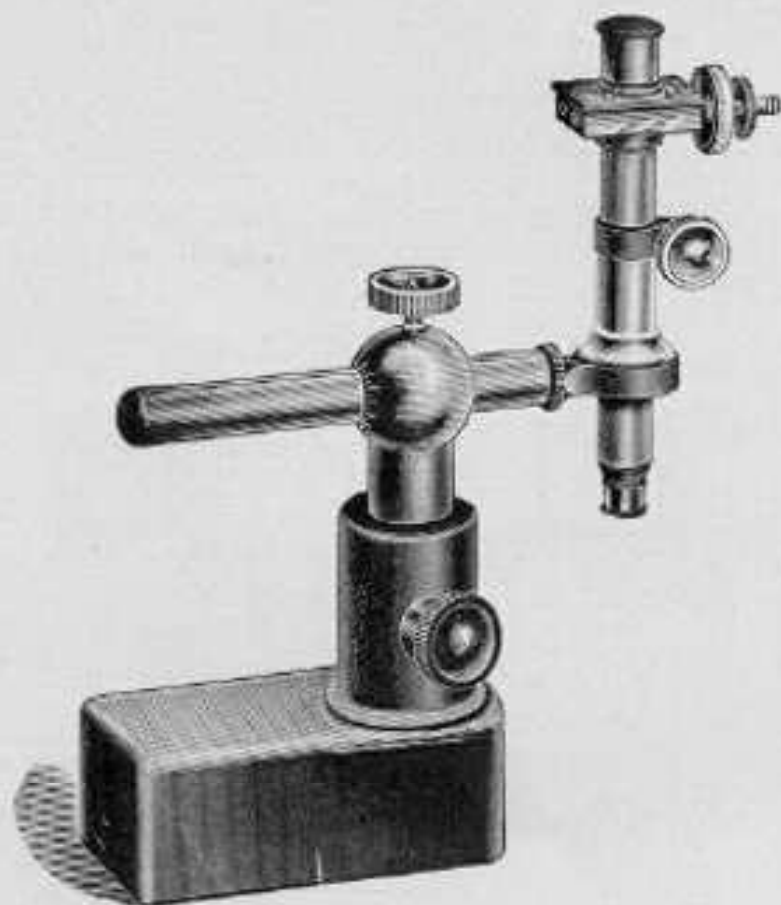


Fig. M 310

Cat. No. M310. Microscope Support. (Fig. M310.) A heavy adjustable support for measuring microscopes. The microscope may be rigidly held in any position, as all joints can be tightly clamped. The base has sufficient weight to insure the steadiness required in microscope used for accurate measurement. The size of the opening in the horizontal arm will be kept standard and the collars of the different microscopes will be threaded to fit this opening. The top of the base is machined so as to enable the easy attaching of stages or other arrangements. Price.....\$6.50

NOTE.—We can furnish this support with different sizes of collars so as to adopt other microscopes of different diameters.

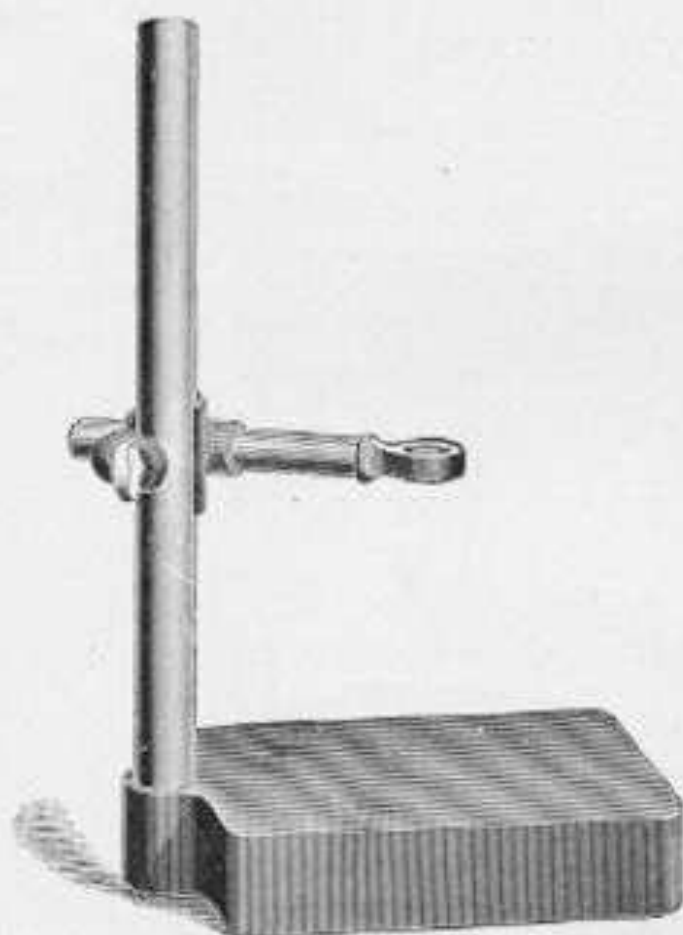


Fig. M 320

Cat. No. M320. Microscope Support. (Fig. M320)
 A heavy base into which is screwed an upright rod 30 mm. diameter and 40cm. high. This support will be found convenient in many cases when a tripod support cannot be used. The top surface is planed. Price including clamp, rod and screw collar.....\$5.50

SPHEROMETERS.

These instruments are of the best workmanship and improved design. Larger sizes than those listed will be made to order.

Cat. No. M401. A Small Spherometer for student use. (Fig. M401.) Length of screw 5 cm., diameter 6 mm., pitch 0.5 mm., head divided into 100 parts, base circle 5 cm. diameter. Price \$10.00



Fig. M 401

Cat. No. M402. Spherometer. Length of screw 10 cm., diameter 10 mm., pitch 0.5 mm., head divided into 200 parts, base circle 10 cm. diameter. Price.....\$18.00

Cat. No. M403. The same as M402, but with lever contact and head divided into 500 parts. Price.....\$26.00

MICROMETER SCREWS.

In setting up laboratory experiments and special apparatus it is frequently necessary to use micrometer screws. The screws listed below are fitted with a divided head and index. The mounting shown permits of the use of the micrometer in a variety of positions, and will be found very convenient. Other styles of mounting will be furnished to order at a reasonable price.

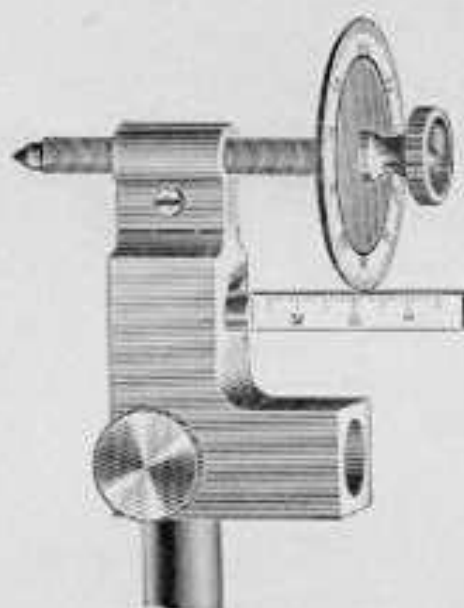


Fig. M 411

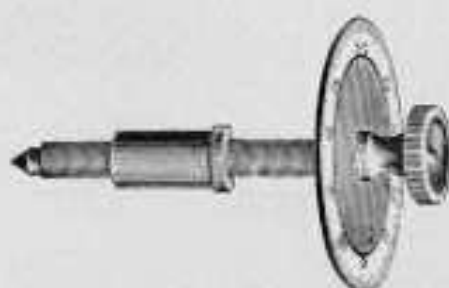


Fig. M 415

Cat. No. M411. Micrometer Screw. (Fig. M411.) Length 5 cm., pitch, 0.5 mm., diameter of head, 5 cm., head divided in 100 parts, diameter of hole of mounting 13 mm.
Price\$8.00

Cat. No. M412. Micrometer Screw. Length of screw 10 cm., pitch 0.5 mm., diameter of head 10 cm., head divided in 200 parts, diameter of hole of mounting 19 mm. Price...\$15.00

NOTE.—The screws used in our spherometer M401 and our micrometer screw M411 are interchangeable with their nuts, and may be easily taken from one instrument and used in the other by simply unloosening one screw. This feature will be found desirable where economy is needed.

Cat. M415. Micrometer Screw and Nut, without mounting (fig. M415), screw and divided head of the same dimension as used in spherometer M401 and micrometer screw M411. Outside diameter of nut 8 mm., length 18 mm.
Price\$4.50

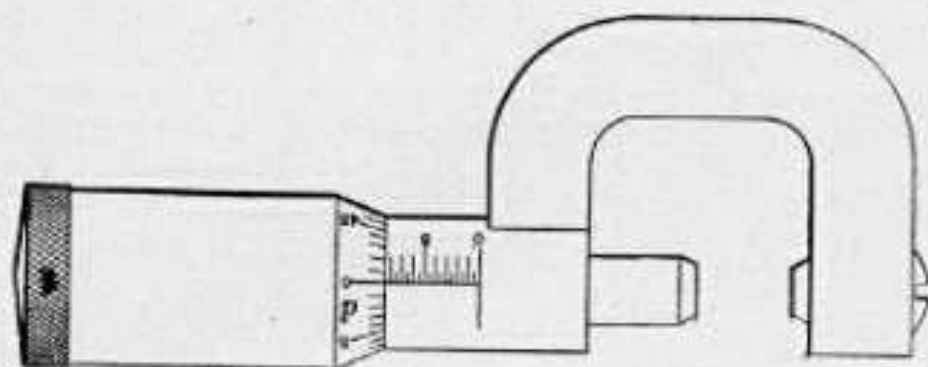


Fig. M 430

MICROMETER CALIPERS.

Cat. No. M430. Micrometer Caliper. Measuring from 0 to 25 and reading to .01 mm. Price.....\$5.50
Price in case.....\$6.00

Cat. No. M431. Micrometer Caliper. Measuring from 0 to 50 mm. reading to .01 mm. Price.....\$8.00
Price in case.....\$8.75

Ratchet stop fitted to these calipers, 50c. extra.

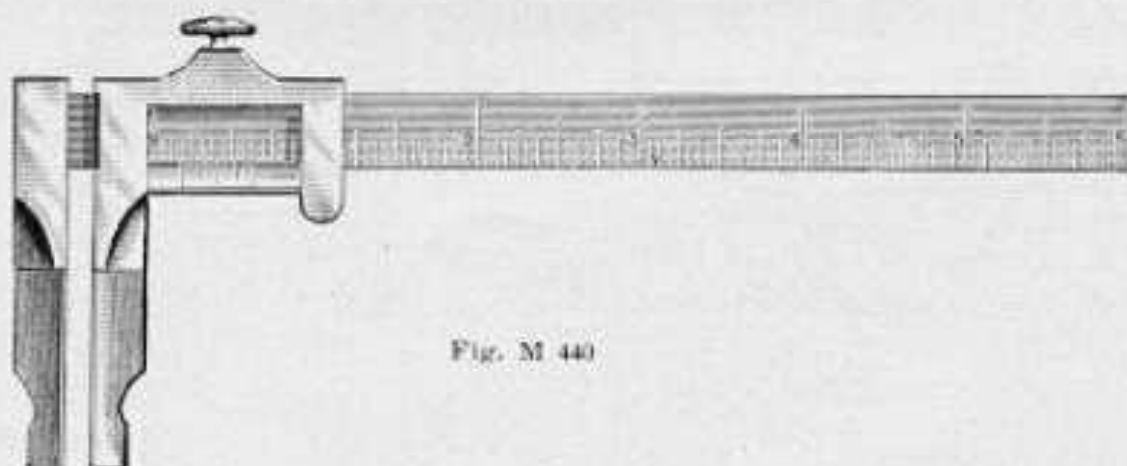


Fig. M 440

VERNIER CALIPERS.

Cat. No. M440. Vernier Caliper, 100 mm. long, opening 80 mm., graduated on one side in mm. reading to 0.1 mm. on the other side in .05 of an inch and 1-16 of an inch, reading to .01 and 1-128 of an inch. Price.....\$2.50

Cat. No. M441. Same as M440, but 150 mm. long.
Price\$3.00

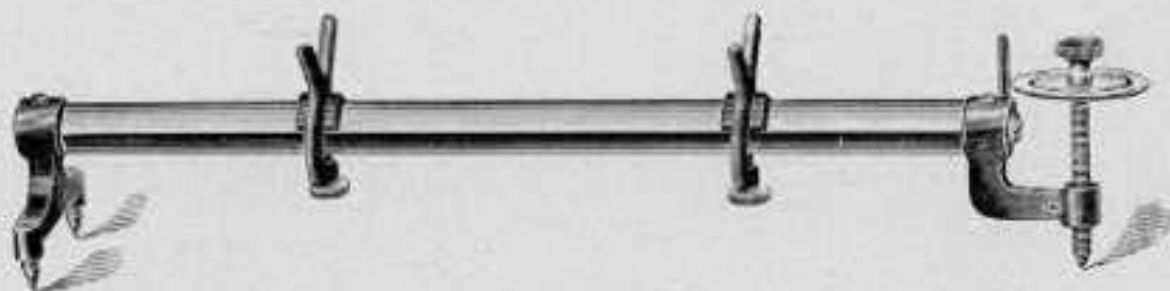


Fig. M 450

LEVEL TESTERS.

Cat. No. M450. Level Tester. (Fig. M450.) An instrument for the calibration and testing of levels. It is also suitable for laboratory experiments in connection with levels. (Fig. M450.) The length of the base is such that one division of the divided head corresponds to 3 sec. of arc. The instrument may be used in connection with our S1203, or S901a and small mirror S3301 as an optical lever. Price....\$16.00

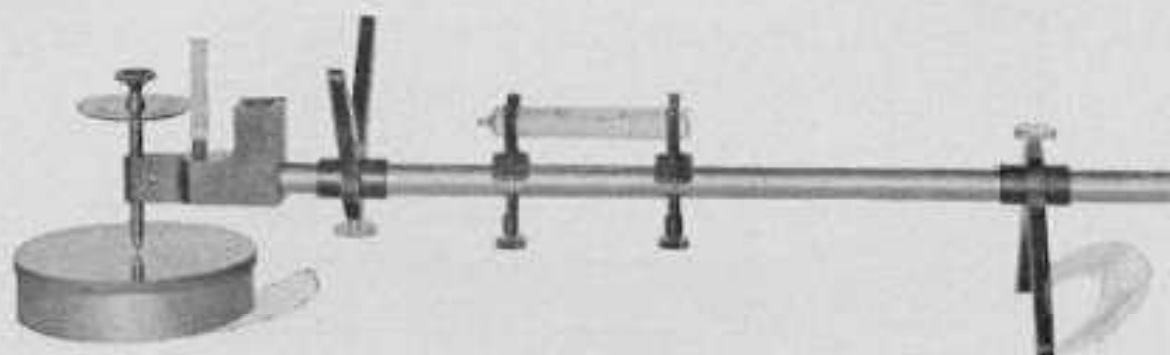


Fig. M 451

Cat. No. M451. Level Tester. (Fig. M451.) Built up from micrometer screw M411, rods S203, V support S3402b and two V supports S3401a. Price.....\$10.60



Fig. M 460

Cat. No. M460. Mounted Laboratory Level. (Fig M460.) Base 20 cm. long, level 12 cm. long, reading to 30 sec. Price\$6.50

Cat. No. M461. Same as above, but with 15 cm. base, level 7 cm. and reading to 30 sec. Price.....\$4.50

Cat. No. M470. Unmounted Spirit Levels (Accurately Ground and Graduated).

"a"	5 to 6 cm. long, reading from 60 to 30 sec.	Price \$0.50
"b"	5 to 6 cm. long, reading from 30 to 20 sec.	Price .65
"c"	5 to 6 cm. long, reading from 20 to 10 sec.	Price .90
"d"	7 to 9 cm. long, reading from 60 to 30 sec.	Price .60
"e"	7 to 9 cm. long, reading from 30 to 20 sec.	Price .80
"f"	7 to 9 cm. long, reading from 20 to 10 sec.	Price 1.15
"g"	10 to 12 cm. long, reading from 60 to 30 sec.	Price .85
"h"	10 to 12 cm. long, reading from 30 to 20 sec.	Price 1.35
"i"	10 to 12 cm. long, reading from 20 to 10 sec.	Price 1.65

Spirit levels of any description made to order.

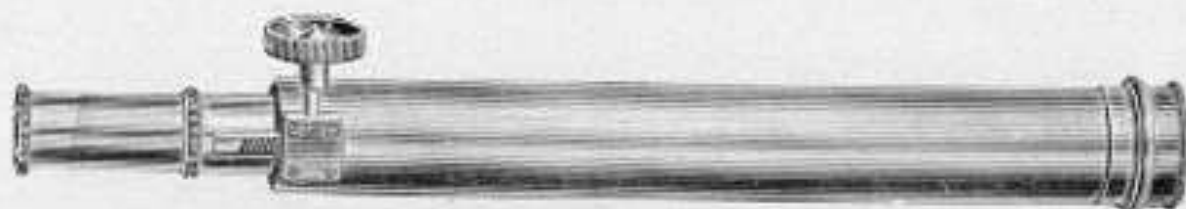


Fig. M 522

LABORATORY TELESCOPES.

The telescopes listed below are designed as reading and observing telescopes. The optical parts are of excellent quality. The telescopes are unmounted, thus permitting of any desired mounting or use, a feature which will be appreciated by those wishing a good telescope available for all kinds of work.

The eye pieces of all the telescopes except M511 are interchangeable. The micrometers M201 and M202 and our small slit M711 will fit in place of the eye pieces.

Cat. No. M511. Telescope Without Rack and Pinion: eye piece fitted with cross wires and draw tube will focus sufficiently close for galvanometer work. Objective 20 mm. in diameter, focus 125 mm. Price.....\$6.00

Cat. No. M512. Same as above. Objective 25 mm. in diameter, focus 150 mm. Price.....\$7.50

Cat. No. M513. Same as above. Objective 30 mm. in diameter, focus 250 mm. Price.....\$9.50

- Cat. No. M522. Telescope, With Rack and Pinion.** (Fig. M522.) Eye piece fitted with cross wires and draw tube, with rack and pinion for focusing; will focus sufficiently close for galvanometer work. Objective 25 mm. in diameter, focus 150 mm. Price.....\$12.00
- Cat. No. M523.** The same as above. Objective 30 mm. in diameter, focus 250 mm. Price.....\$16.00
- Cat. No. M524.** The same as above. Objective 40 mm. in diameter, and fitted with objective draw tube (for short focus). Price.....\$26.00
- Cat. No. M530. Telescope of Low Power.** A short focus telescope of low power, magnifying from three to four diameters, suitable for interferometer and other work requiring a low power. Objective 25 mm. diameter, fitted with rack and pinions and cross wires. Price.....\$12.00

NOTE.—The cross wires in our eye pieces are placed on an angle of about 30 degrees. We have adapted this form of cross as it will enable a closer setting on a single line. If desired we will furnish the eye piece with cross hairs placed at right angles.

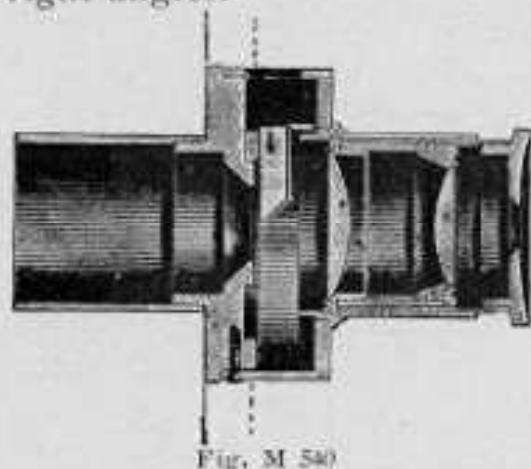


Fig. M 540

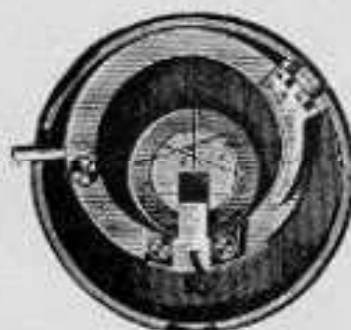


Fig. M 540

- Cat. No. M540. Auto Collimating Eye Piece (Lamont & Abbe).** (Fig. M540.) A small total reflecting prism illuminates from the side the cross hairs of the eye piece and the reflected image of the cross hairs appears between the two parallel wires. The prism can be thrown out of the field by means of a small lever. The focus of the eye piece is 25 mm. Price.....\$10.50
- Cat. No. M550. Reversing Eye Piece.** This eye piece is made to fit our standard microscopes and its use is strongly recommended on length comparators to eliminate the personal equation which may often amount to more than 0.01 mm. Focus 25 mm. Price.....\$8.00

- Cat. No. M560. Objective Prism to be used on reading telescopes Cat. No. M512 and M522. Price.....\$8.00
 Cat. No. M561. The same to fit telescopes Cat. No. M513-M523. Price\$10.00

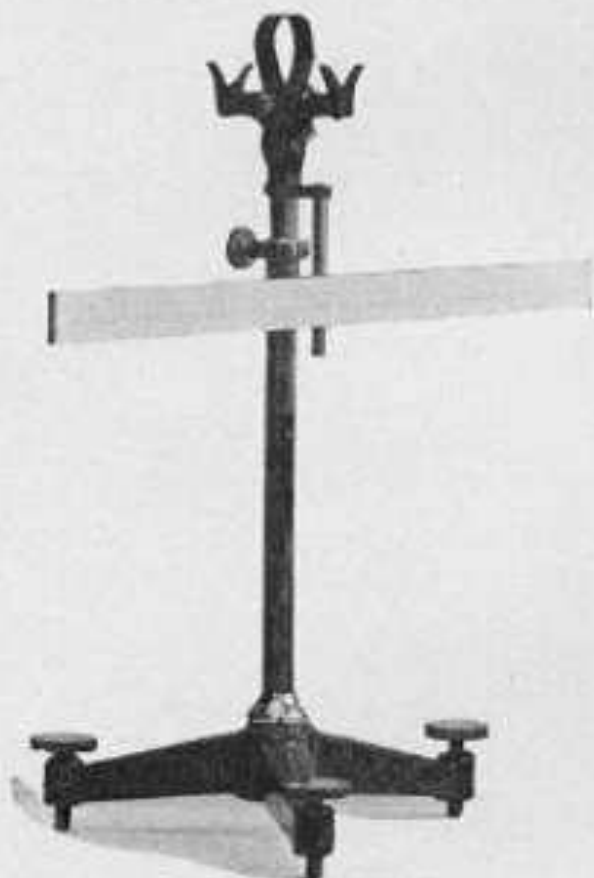


Fig. M 601 to M 604



Fig. M 610

TELESCOPE SUPPORTS.

- Cat. No. M601. Telescope Support. (Fig. M601.) A convenient, well-made support suitable for galvanometer and other reading telescopes. Will carry telescopes up to 5 cm. in diameter. Price includes paper scale, upright tube 3 dm. long, tripod with leveling screws. Price.....\$10.00
 Cat. No. M602. The same, but constructed of non-magnetic materials. Price\$11.25
 Cat. No. M603. The same as Cat. No. M601, but with upright tube, 4 dm. long and heavier tripod. Price.....\$10.50
 Cat. No. M604. The same as Cat. No. M603, but constructed of non-magnetic materials. Price.....\$12.50
 Cat. No. M610. Reading Telescope Support, built up from our laboratory support pieces. (Fig. M610.) This support will carry telescopes up to 5 cm. in diameter and allow adjustment of the telescope and scale in every direction. Price, complete with scale.....\$4.50

Cat. No. M611. Reading Telescope Support. Same as Cat. No. M610, but of non-magnetic materials. Price.....\$7.25

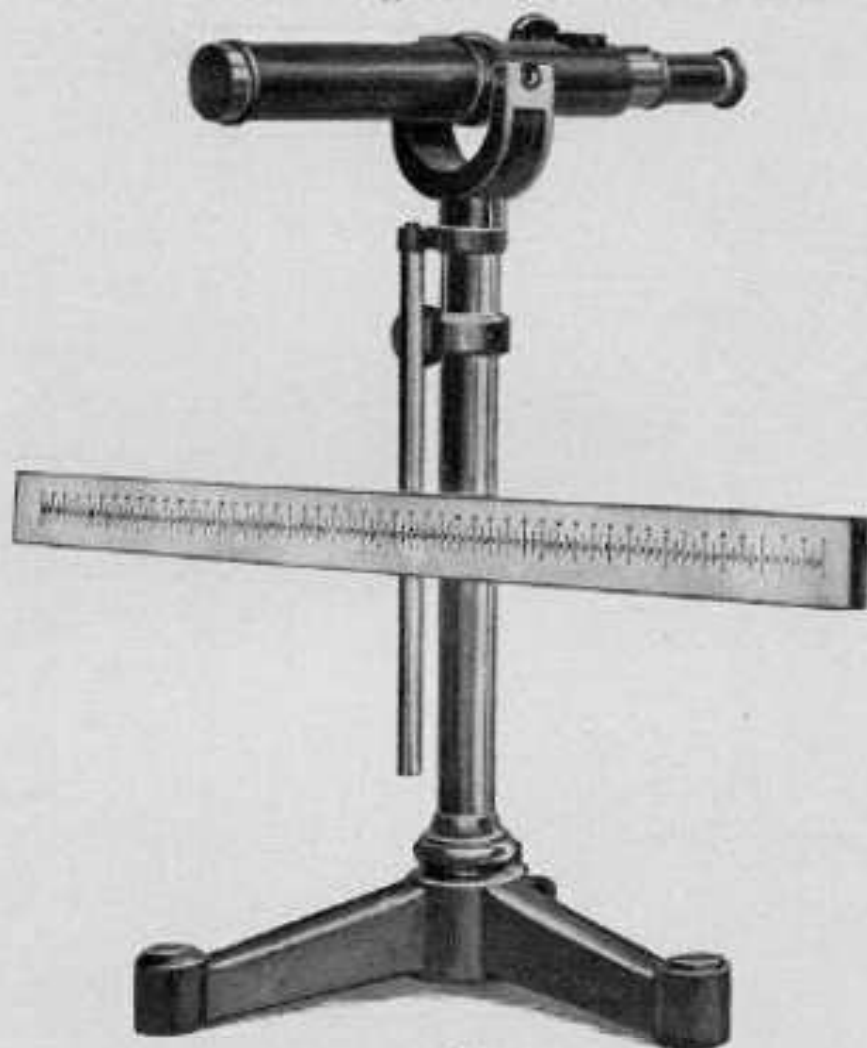


Fig. M 620

Cat. No. M620. Reading Telescope. (Fig. M620.) With fixed telescope of 25 mm. aperture, fitted with rack and pinion; constructed entirely of non-magnetic materials, tripod with leveling screws. Scale can be shifted and inclined horizontally. Price\$25.00

Cat. No. M621. The same as M620, but telescope of 30 mm. aperture. Price\$31.00

SLITS.

These slits are fitted with adaptor to fit our telescopes, Cat. Nos. M512, 513, 523 and 524, so as to serve as collimators. They have a holder to attach to our laboratory support rods and in this form are very suitable for experiments in projecting, interference, diffraction and other optical work. They are adjustable about an axis perpendicular to plane of the slit.

Cat. No. M701. Plain Slit. (Fig. M701.) Jaws 2 cm. long of German silver. Price.....\$5.50

Cat. No. M702. The same as above; jaws 2 cm. long to screw on 10 mm. rod. Price.....\$6.00

Cat. No. M703. The same as above; jaws 4 cm. long to screw on 13 mm. rod. Price.....\$8.50

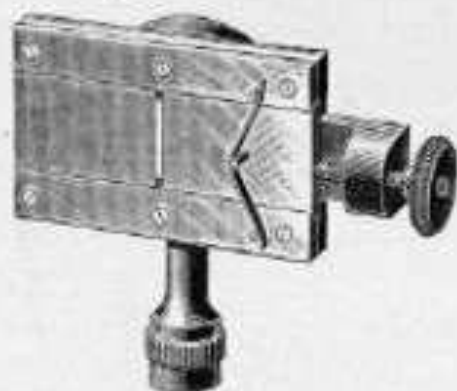


Fig. M 701

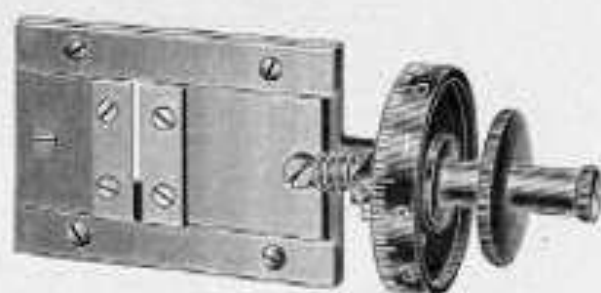


Fig. M 710

Cat. No. M710. Micrometer Slit. (Fig. M710.) The same as M701, but fitted with micrometer head for measuring width of slit to 0.0025 mm. Price.....\$12.00

Cat. No. M711. The same as M702, but with micrometer head. Price.....\$12.50

Cat. No. M712. The same as M703, but with micrometer head. Price.....\$16.00



Fig. M 730

Cat. No. M730. Bilateral Slit. (After design of Prof. F. L. O. Wadsworth) (Fig. M730.) The slit jaws have a length of 2 cm., the micrometer head reads to, 0.0025 mm. Price.....\$21.00

NOTE: All our slits are so constructed that the jaws are kept together by pressure, thus avoiding any injury through too much pressure of the micrometer screw.

Any of the slits listed above can be fitted with comparison prism at an extra cost of \$3.00.

Cat. No. M801. Optical Lever. (Fig. M801.) Plane mirror 25 mm., square, length of lever 75 mm. Price \$3.50

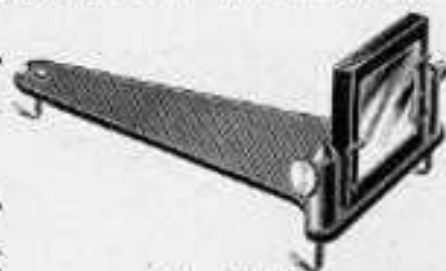


Fig. M. 801

CATHETOMETERS.

Cat. No. M901. Cathetometer. (Fig. M901.)

The base of the instrument is of considerable weight and is fitted with leveling screws which can be clamped after adjustment has been made. The central upright support consists of a heavy steel rod with conical bearings on top. The rotating motion of the telescope is limited by means of two stop screws attached to the base circle. The circle also carries a level which serves to bring the instrument in vertical adjustment. The rod on which the telescope slides is 90 cm. long and divided in mm., for a length of 70 cm. The vernier reads to 0.1 of a m. m. The slide supporting the telescope is long and carefully fitted to the square rod. A micrometer screw gives the slow motion to this slide.

The telescope has an aperture of 25 m. m. The eye-end is provided with rack and pinion, and allows a focusing from about 1 meter to infinity. A sensitive level is at-

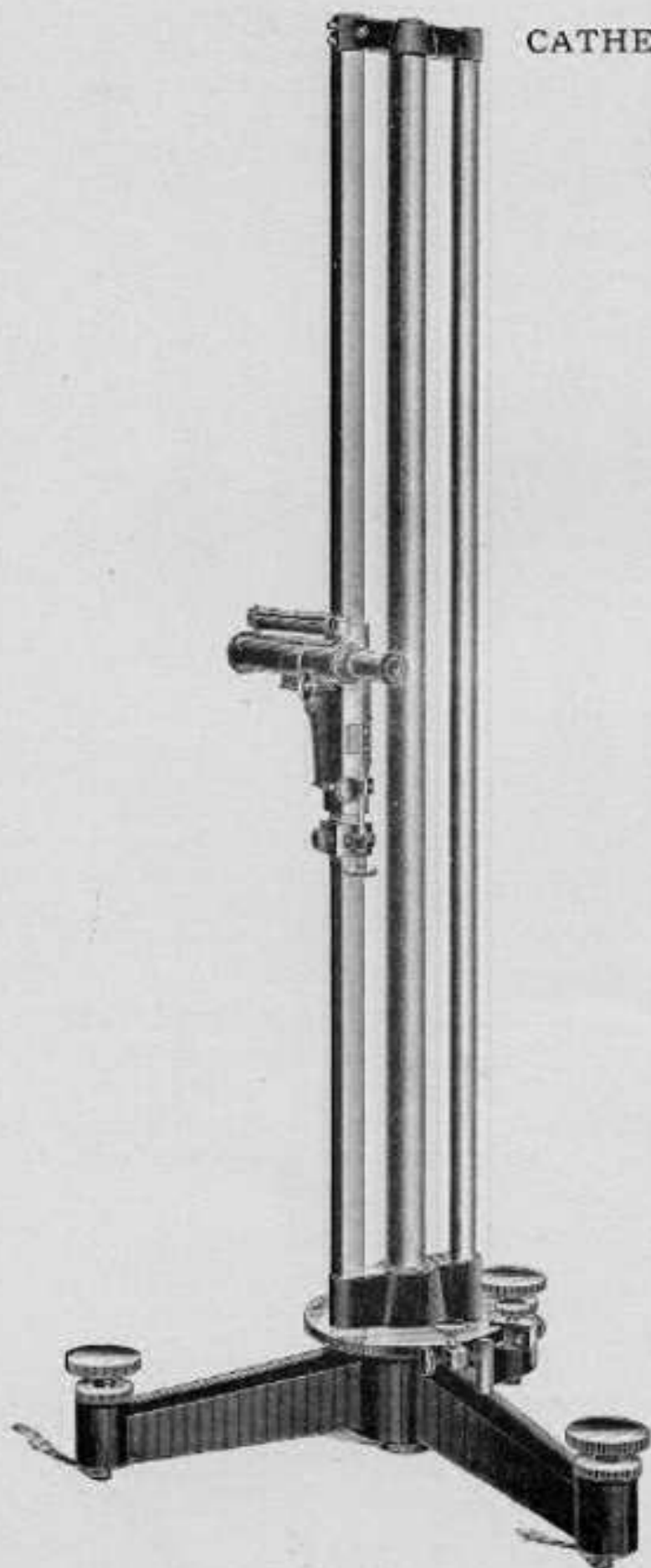


Fig. M 901

tached to the telescope. The eye end of the telescope is of our standard size, and micrometer eye pieces Cat. No. M201 and M202, will fit the same

The instrument is nicely finished, all steel parts nickel plated and brass parts lacquered or oxidized. Price, \$85.00

Cat. No. M903. (Fig. M903.) Cathetometer of 1 meter vertical motion. This instrument is very heavy and substantially constructed and intended for measurements of highest accuracy. The supporting frame consists of two heavy pillars which carry the steel column on which the telescope slides. The telescope is mounted in Y's, reversible and fitted with spirit level and micrometer adjustment. The whole instrument swivels at the tripod base. The tripod spreads over a circle of 50 cm. diameter. Total height of instrument 160 cm., total weight 150 kg. Price \$190.00

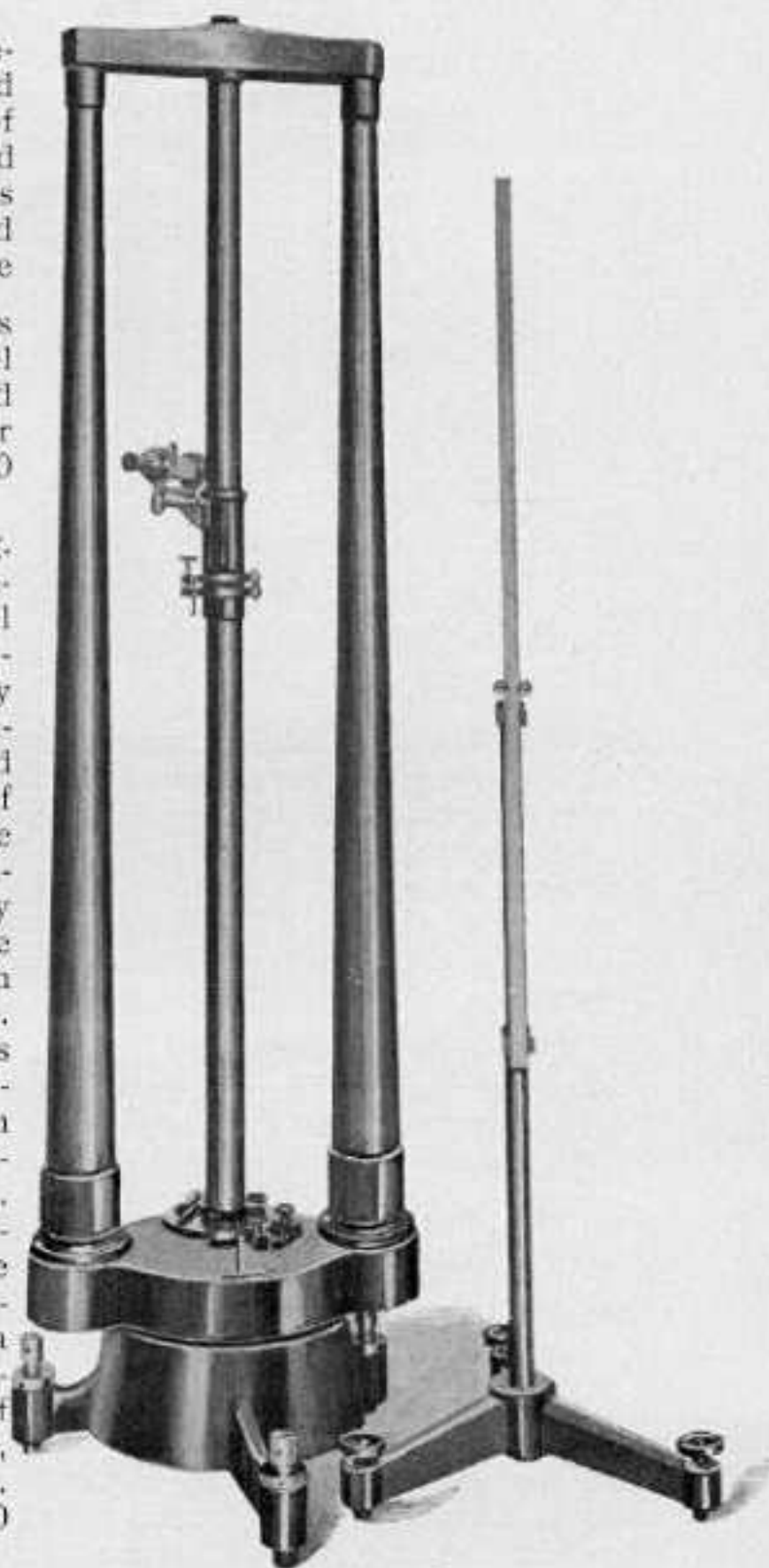


Fig. M 903

Cat. No. M904. The same as above, but with two telescopes.
Price \$255.00

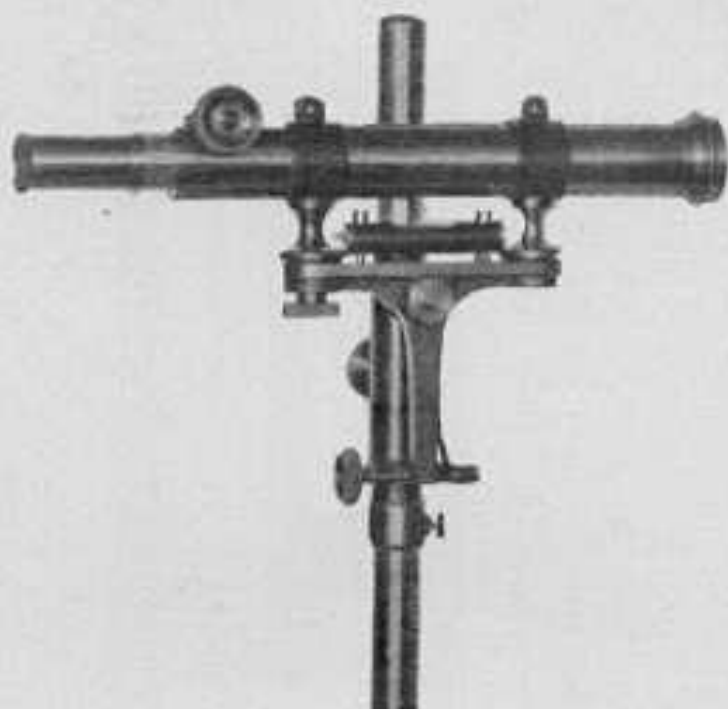


Fig. M. 910

Cat. No. M910. Simple Cathetometer. (Fig. M910.) The sleeve carrying the telescope is fitted to our standard 30 mm. support rod. It is made of considerable length, slides easily by hand and is kept in position by a collar on which it rotates accurately. The telescope has an aperture of 25 mm., 200 mm. focus, and is mounted on an arm which is fitted with spirit level and tangent screw for vertical adjustment.

This Cathetometer is suitable for any except the most accurate work. The telescope may be used on any length of support rod and may serve as well as reading telescope, collimator, etc. Price, with support rod one meter...\$33.00

Cat. No. M911. The same as M910, but with 30 mm. telescope. Price\$36.00

Cat. No. M1001. Standard Meter Scale, made of brass, divided in mm., last mm. divided in 1-5 mm. on solid silver strip. For use with cathetometer or comparator. Price\$26.00

Cat. No. M1002. Standard Meter Scale, made of brass. H form, divided in mm. on solid silver. The first and last mm. subdivided in 0.1 mm. Price.....\$35.00

Cat. No. M1000. Meter Scale, divided on rectangular steel bar, 25 mm.x12 mm., divided in single millimeters. Price\$12.00

Cat. No. M1101. Support for holding scale M1001 or M1002 in vertical position. Tripod with leveling screws and adjustment is provided for slight vertical motion of the scale. Price.....\$22.00

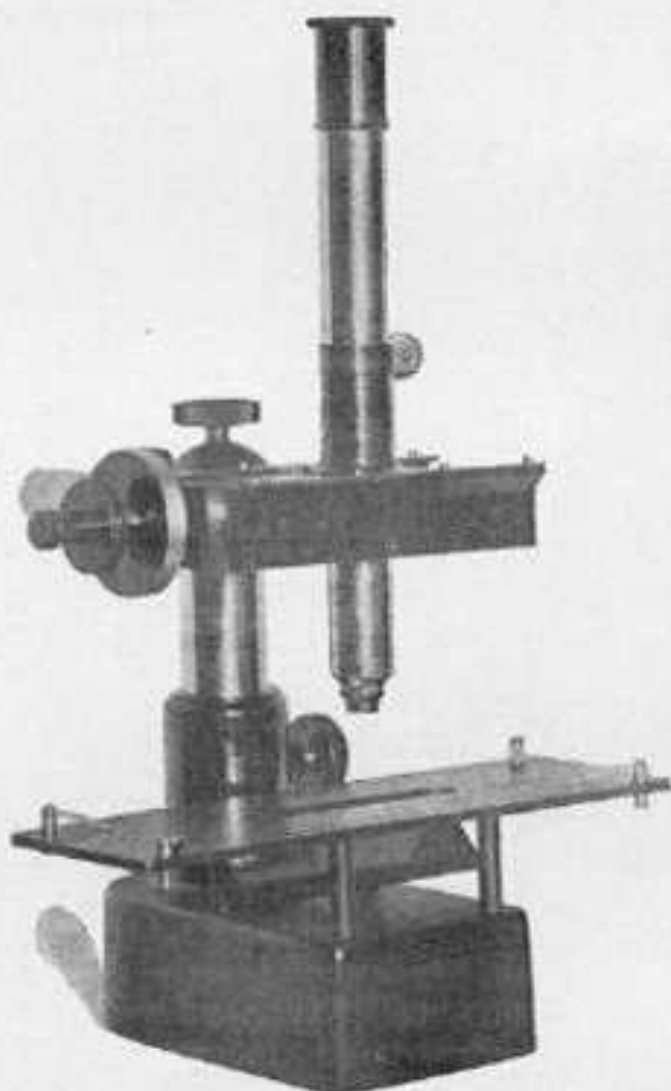


Fig. M 1200

COMPARATORS.

Cat. No. M1200. Simple Comparator. (Fig. M1200). Built up of Micrometer Slide M301 and Microscope M101, with Support M310 Fitted with Stage. The stage is 150 mm. long and provided with clips for holding objects, such as spectrum photographs, scales, etc., and is fitted with illuminating mirror. Price.....\$44.00

Cat. No. M1201. Small Comparator. (Fig. M1201.) The instrument is intended for measuring spectra photographs, gratings, divided scales, or such objects which can be focused by the microscope and will allow rapid measurements of the highest possible accuracy. The measurement de-

depends on the accuracy of the micrometer screw, which is cut with an apparatus especially devised for this purpose and which we correct by using the best known methods of screw correcting. The screw has a pitch of .5 mm. and diameter of 15 mm. The index head attached to the screw is of considerable diameter so as to allow the direct reading

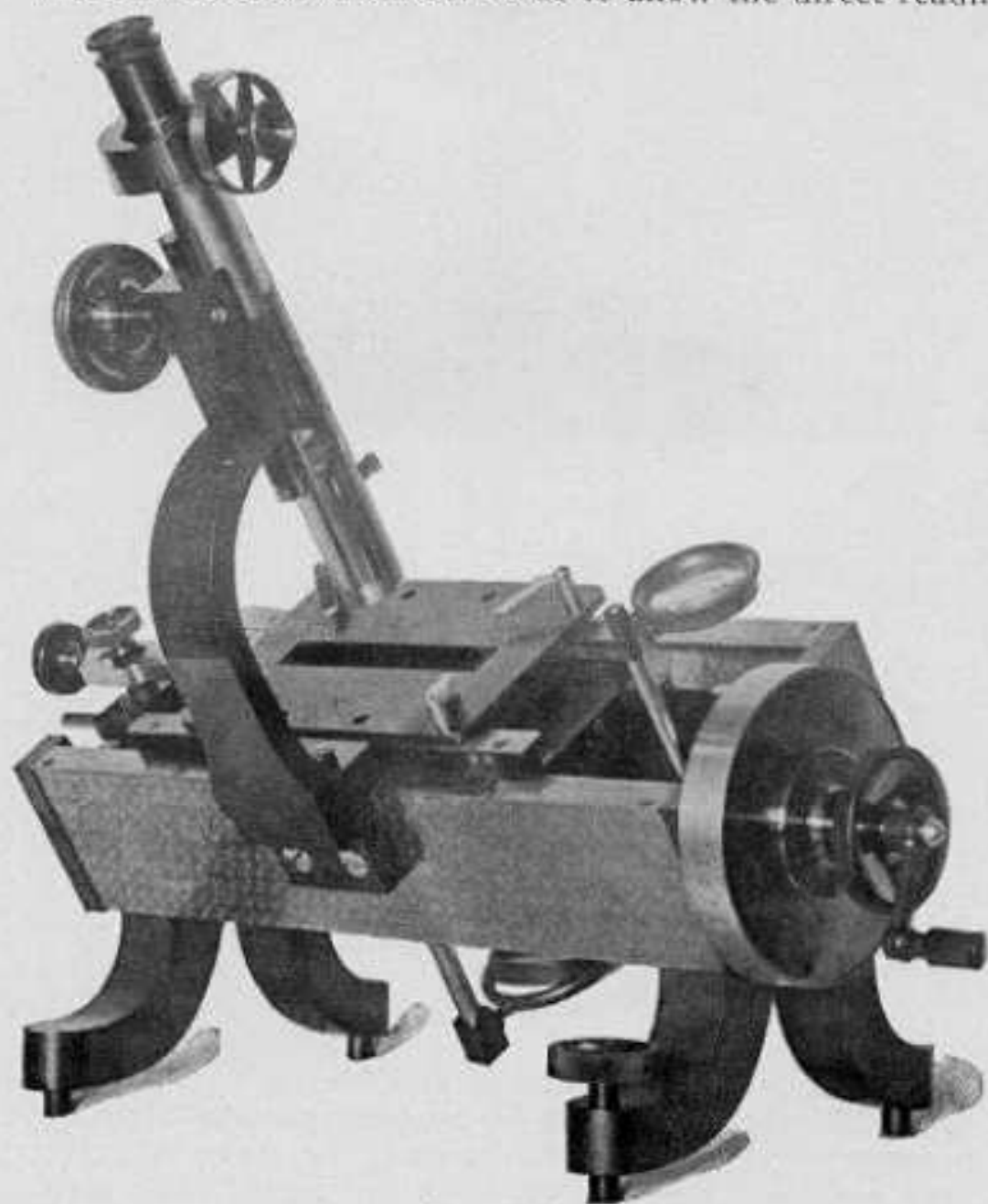


Fig. M 1201

of .001 of a mm. The head is divided on solid silver in 500 parts, and carries two rows of figures indicating the first and second half of the mm. The full mm. are read by means of a scale in front of the instrument. The bed plate is heavy, made of cast iron, and the guides are carefully scraped true within 0.001 mm. The carriage has a move-

ment of 80 mm., is made of gun metal and fitted exactly to the bearing; it is provided with a second carriage with 40 mm. motion. This top carriage can be moved by hand and accurately set by means of micrometer screw. The microscope is of variable magnifying power, focused by rack and pinion. Illumination for transparent objects is given from below by means of plane mirror. For opaque objects the microscope can be fitted with illumination on the objective end. The instrument is mounted on heavy brass supports, under an angle to make it convenient for the observer. The instrument is finished in first class manner, and the iron bed-plate heavy copper and nickel plated.

The design of this machine was suggested by Prof. Edwin Frost of the Yerkes Observatory, where a number of these machines have been in use in the last years and have proven very satisfactory and convenient. Careful tests have shown the screw accurate within .001 of a mm. through the full length. Price.....\$165.00

This machine may be fitted with dividing attachment M306 and stage to the top carriage.

Cat. No. M1202. Measuring Machine for Star Photographs. measure in one direction 80 mm. and under right angle 60 mm. The lower part is constructed similar to our Comparator M1201. The top slide carries a divided scale for measuring position angles. The circle is arranged similar to a position micrometer. It is fitted with quick gear motion and tangent screw and the two verniers read to 1-100 degree. The microscope has variable magnifying power and is provided with reversing eye piece.

This machine is in use at Yerkes and Lick Observatories. Price\$365.00

Cat. No. M1203. Measuring Machine for Plates 8x10 inches. (Fig. M1203.) This machine was constructed after plans furnished by Dr. Frank Schlesinger of the Yerkes Observatory. It is built entirely of cast iron. The bed of the machine is inclined at an angle of 35 degrees. The ways are carefully straightened within 0.002 millimeter. The carriage moves by two racks and pinions and has one large handle on each side. Two concentric circles are fitted to the carriage, the inner circle carries the plate with the film in a fixed plane, no matter what the thickness of the glass. The plate can be very easily fastened to the machine. Both circles are provided with clamps and tangent screws, so that each one may be clamped and adjusted independently. The outside circle carries four nicely marked index points 90 degrees apart. One of these marks

is made adjustable. These four marks serve to turn the plate exactly 90 degrees so as to measure rectangular coordinates. The microscope is used for bisecting these four marks. The guide carrying the measuring microscope is adjusted exactly at right angle to the ways of the bed plate. The carriage supporting the microscope is moved by rack

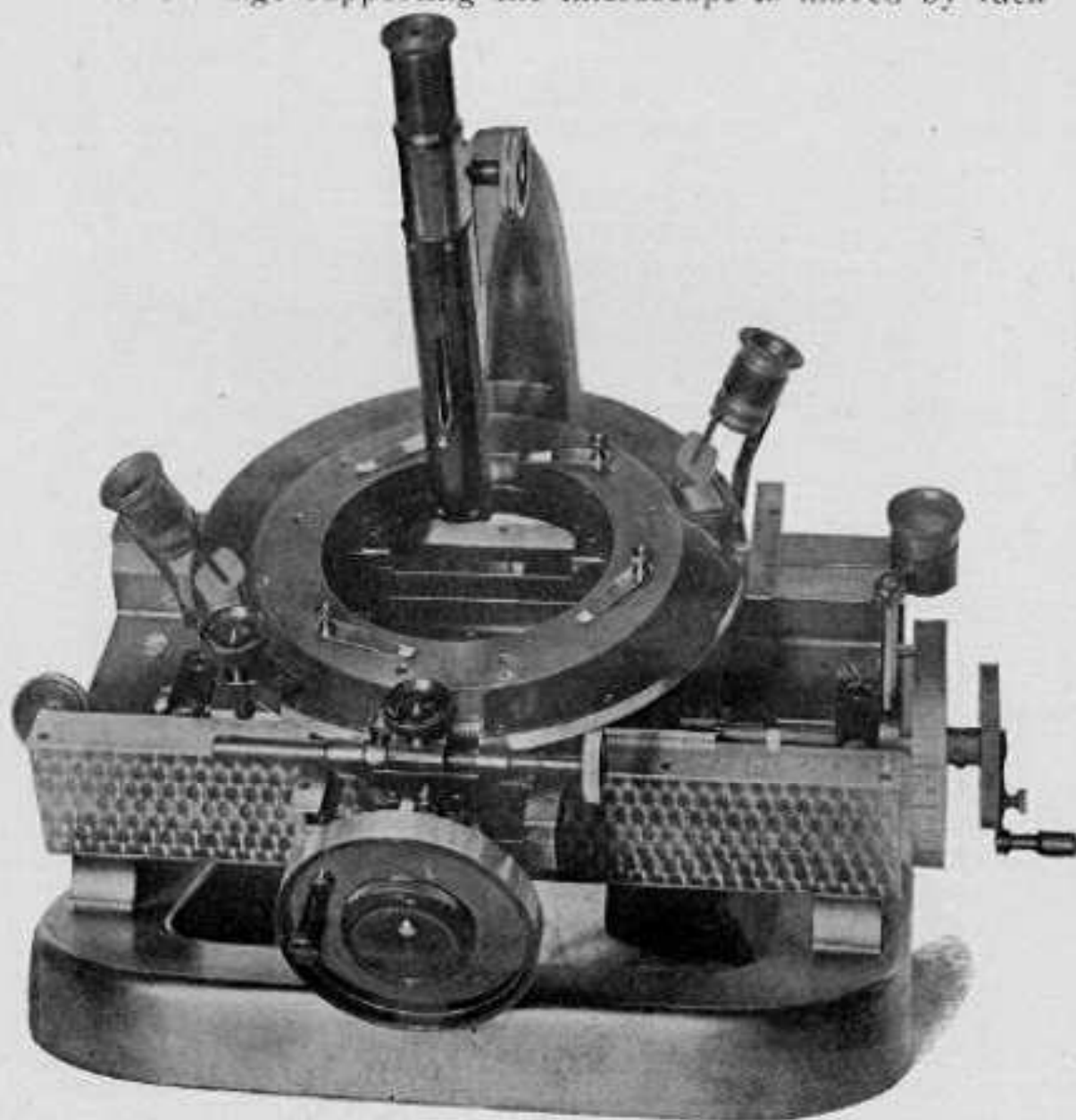


Fig. M 1202

and pinion, one turn of the head being equal to about 25 mm. The microscope is arranged to tilt, so as to view either the plate or the scale above. The lever for this purpose is attached on the left side of the microscope and adjustable stops for this tilting motion are provided. The eye piece is provided with a reversing prism. Measurements are made on the scale divided in millimeters. The smaller measurements, to 1-4000 of a mm., are made by the

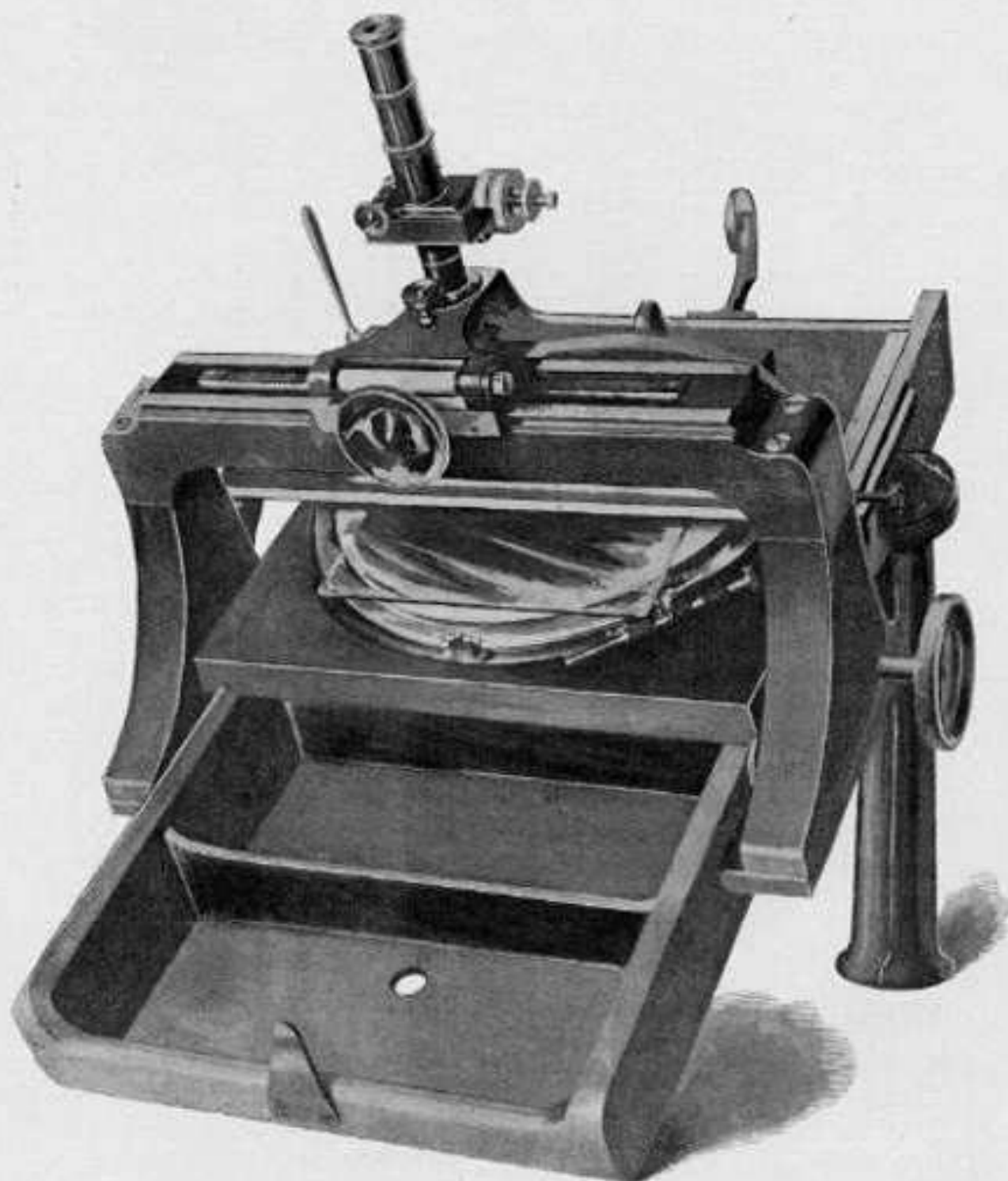


Fig. M 1203

micrometer. The micrometer is fitted with sliding eyepiece and counter for full revolutions. The scale is not marked in the usual way with single lines, but each millimeter is marked with a double line. This double line, about 15-100 of a mm. apart, allows the use of one single spider thread, which is preferable to use for bisecting the star, and the double line on the scale allows a clear setting with the single spider thread. The scale is divided on silver and is adjustable lengthwise, by means of a small screw shown on the right side of the cut. The objective has a focal

length of about 50 mm. and the eye piece has an equivalent focus of 65 mm. The stage is fitted with an adaptor for holding plates 4x5 inches. Price.....\$450.00

This machine has been in use during the last year at the Yerkes Observatory and has been found very convenient and satisfactory in every way.

A graduated circle can be provided if desirable. Such division, on solid silver, with verniers reading to 1-100 of a degree, will increase the cost \$50.00.

Cat. No. M1204. Measuring Machine for plates 4x5 inches, of the same design as M1203. Price.....\$300.00

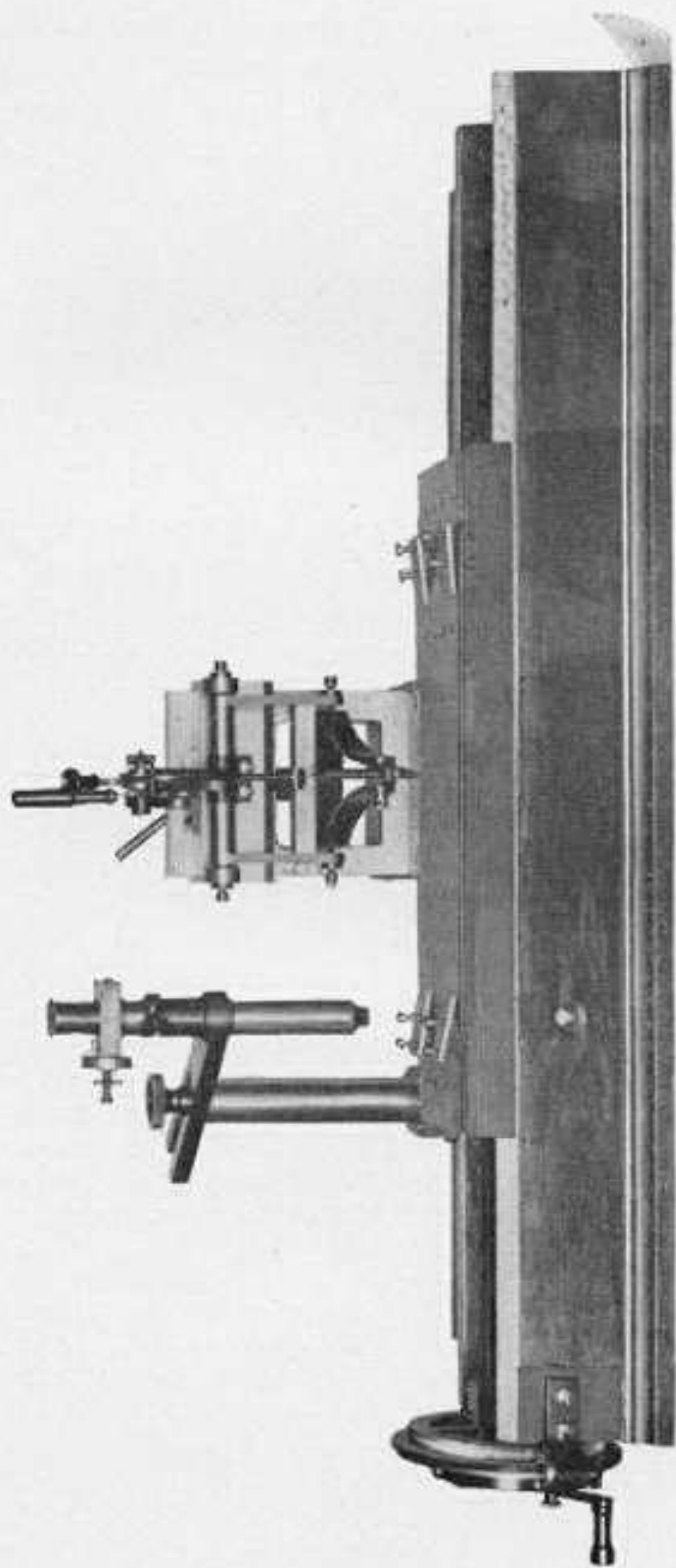
DIVIDING MACHINES.

Cat. No. M1301. Linear Dividing Machine, of simple construction. Range of screw 20 cm., pitch 1 mm., length of bed 42 cm. The head of the drum is divided in 100 parts. The dividing head is fixed and not arranged for automatically changing the length of lines. The carriage is provided with grooves for graduating tubes. Price.....\$83.00

Cat. No. M1301a. Attachment for Dividing Circles, up to 13 cm. diameter, to fit above machine, consisting of worm wheel with 180 teeth, and worm screw with head divided in 60 parts. Price.....\$35.00

Cat. No. M1301b. Glass Case for above machine.
Price \$4.50

Cat. No. M1302. Linear Dividing Machine for Laboratory Use. (Fig. M1302.) The total length of the machine is 82 cm. and the carriage has a range of 35 cm. The screw has millimeter pitch and is carefully corrected to about 0.01 mm. The nut has considerable length, is carefully fitted to the screw, and provided with adjustment for wear. It is guided on a bar which may be inclined for length correction, or can be shaped to a curve for correcting of local errors of screw. The indexing arrangement is automatic and permits graduations from 5 mm. to 0.005 mm. The dividing head may be fastened on any part of the bed, it is very solidly constructed and is easily adjustable in every direction. Provision is made for the automatic changing of length of lines, and a counterbalance is fitted to the arm holding the dividing tool, to permit the tracing of very light lines with a diamond on glass, etc. The carriage has



Cat. No. M1302 LINEAR DIVIDING MACHINE FOR LABORATORY USE. Fig. M 1302

- a length of 41 cm. and is fitted on top with V groove for holding glass tubes, etc. The machine is carefully constructed and well and durably finished. Price.....\$185.00
- Cat. No. M1302a. Glass Case for machine. Price.....\$7.50
- Cat. No. M1303. Linear Dividing Machine. The same as preceding one, but having range of screw of 55 cm.
Price\$265.00
- Cat. No. M1303a. Glass Case for machine. Price.....\$9.00
- Cat. No. M1304. Linear Dividing Machine. The same as Cat. No. M1302, but arranged entirely automatic.
Price\$345.00
- Cat. No. M1310. Micrometer Microscope and Support to clamp on bed plate of machine. Price.....\$35.00
- Cat. No. M1311. Attachment for Dividing of Circles to fit machine Cat. No. M1302 or M1303. Largest circle that may be divided 20 cm.; worm wheel 180 teeth; index head on worm screw 60 parts, accuracy 30 sec. With this attachment is furnished a set of suitable stop wheels to the dividing head for changing length of lines. Price.....\$50.00
- Cat. No. M. 1312. Mounted diamond point to fit dividing head.
Price\$3.50

NOTE.—Experience in the use of precision screws for measuring or dividing machines has decided us to use on all our machines, wherever possible, a solid nut in preference to the releasable split nut. The time which is apparently saved through the releasable nut in returning the carriage, is often sacrificed by imperfect rulings. A simple mechanism which we fit to the ratchet wheel allows the backward motion of the carriage without its removal.

We are prepared to undertake the construction of dividing and ruling machines for laboratory or commercial use of any size and shall be glad to correspond with interested parties.



LABORATORY APPARATUS

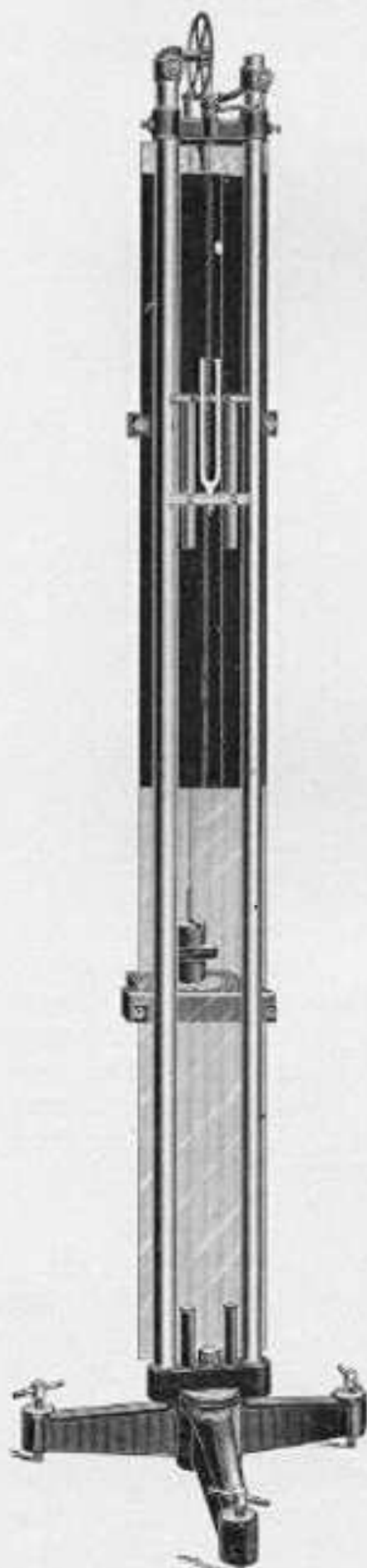


Fig. L 1001

Cat. No. L1001. Acceleration Apparatus. Millikan Physics, p. 11 (Fig. L1001.) The instrument is used to verify the laws governing acceleration of falling bodies.

The falling piece is very freely guided between two highly polished and nickel plated steel rods, and carries a tuning fork of known rate of vibration. The prongs of the fork are spread slightly apart by means of an eccentric on top of the frame. This eccentric can be drawn up in the frame by turning a lever, and thus the fork is released and set in vibration. A light metal stylus attached to one of the prongs records the vibrations on the smoked glass plate, while the fork is falling. The heavy glass plate is held parallel to the rods, and can easily be shifted sidewise so that a number of curves can be traced with one smoking of the plate. Two dash pots at the base of the instrument catch the falling piece and take up the jar. For measuring the curves on the plate, the same is taken from the frame and laid on a table and the measurements are made with a pair of dividers, or by directly applying a scale.

In using the apparatus as an Atwood Machine, a light aluminum wheel is attached to the top of the frame. This wheel runs very free of friction in light ball bearings. The falling piece is attached to a cord passing over this wheel and holding on its other end the counterbalance weight. The counterbalance weights can be picked up from adjustable platforms attached to the back of the glass plate, and are so adjusted that when all weights are

in use the falling piece will be exactly counterbalanced and drop without acceleration.

The apparatus stands one and one-half meter high. It is mounted on a heavy tripod with leveling screws, and is provided with a plumb bob for the easy vertical adjustment of the rods. The cut shows the smoke removed from the lower part of the glass, in order that the platforms on the back may be seen.

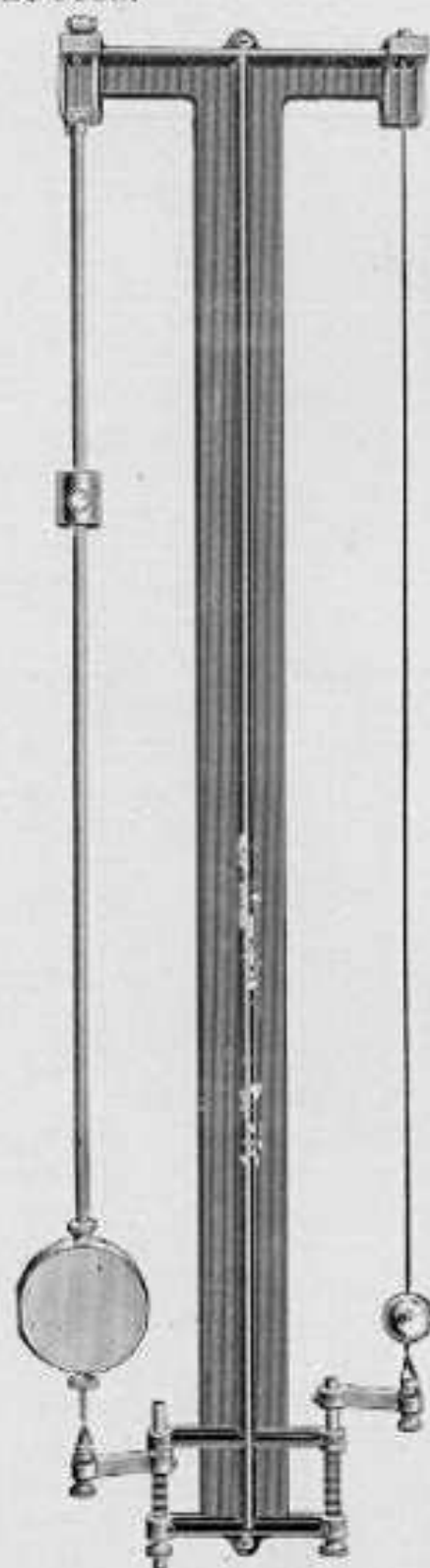


Fig. L 1010

We have furnished this apparatus to many leading universities and colleges, and have received very satisfactory testimonials in regard to the same. The value of "G" has been obtained with an accuracy of from 1 to 1½ per cent., which error is due to the friction in the rods.

A circular giving information as to setting up and adjusting the apparatus, as well as suggestions as to the experiments for which it is adapted, and methods of smoking the glass and measuring the vibrations will be sent with the apparatus.

Price of apparatus, with At-wood Attachment \$40.00

Cat. No. L1002, without At-wood Attachment. Price, \$25.00

Extra glass plates, each \$1.50

Cat. No. L1010. Coincidence-Pendulum. Millikan Physics p. 97. (Fig. L1010.) This apparatus is used for the determination of "G" by the method of coincidences. One pendulum is adjusted to one second of a vibration; the length of the other can readily be found by adding the distance from the knife edge to the top of the ball, as read by the cathetometer, to the radius of the ball. The platinum points at the ends of the pendulums make contact with the adjustable mercury cups, insulated from the frame. When both touch the mercury at the same time the circuit is completed and the sounder

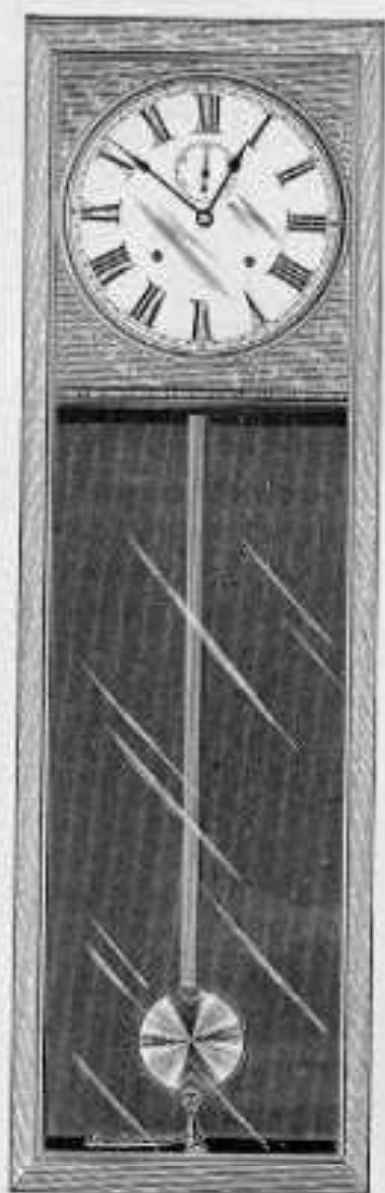


Fig. L 1013

inches in diameter and has hour, minute and second hands. Pendulum beats seconds and makes electric contact by means of an adjustable mercury cup. It is mounted in a hardwood case with glass door. Price.....\$27.00

Cat. No. L1013. Laboratory Clock. The same as preceding one, but with better clock movement, gravity driven. Price\$35.00

Cat. No. L1014. Seconds Pendulum, similar in construction to Pendulum L1010, mounted on board with mercury contact. The bob is very heavy and will oscillate sufficiently long for most laboratory experiments. Price\$12.50

Cat. No. L1020. Ballistic Pendulum. Millikan Physics, p. 62. (Fig. L1020.) This apparatus is designed to demonstrate Newton's laws of motion. Two elastic, or inelastic bodies are suspended from a frame 150 cm. high. The impact is given by holding one ball by means of a thread at the desired height and relaxing it by burning the thread. A sliding in-

clicks. Owing to the finite width of the mercury globule several clicks will be heard and the mean time of these is taken as the true time of coincidence. By observing the coincidence over a period of thirty minutes the time can be accurately found, and knowing the length of pendulum, "G" is easily calculated. Price of the apparatus with sounder....\$25.00

Cat. No. L1011. Single Pendulum, with adjustable mercury contact, mounted on knife edge, the same as used on the coincidence pendulum, but mounted separately on a board to fasten against the wall. This pendulum may be used in connection with a laboratory clock, or second's pendulum for the same experiments as the coincidence pendulum. Price\$10.00

Cat. No. L1012. Laboratory Clock. (Fig. L1012.) This is an eight-day clock; has a movement of the best workmanship, is driven by two strong springs, and keeps accurate time. The dial is 12

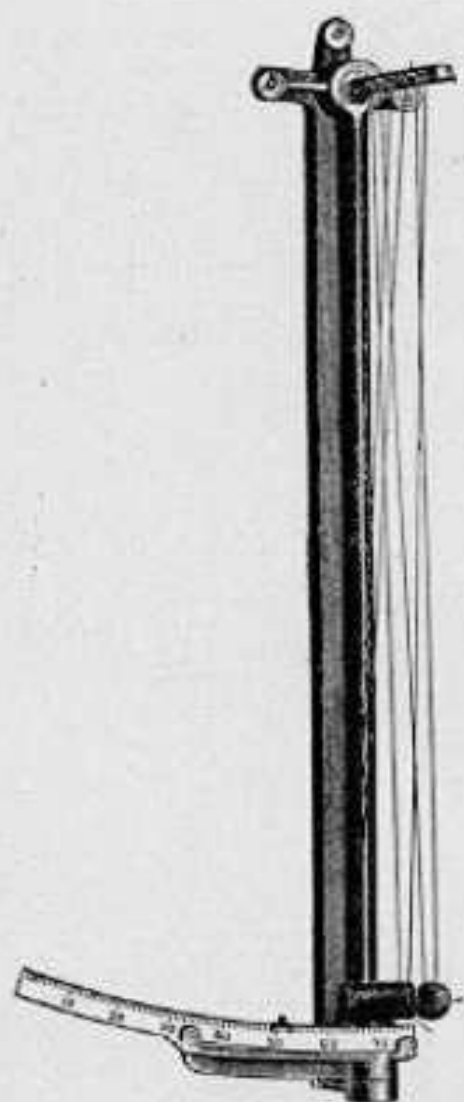


Fig. L 1025

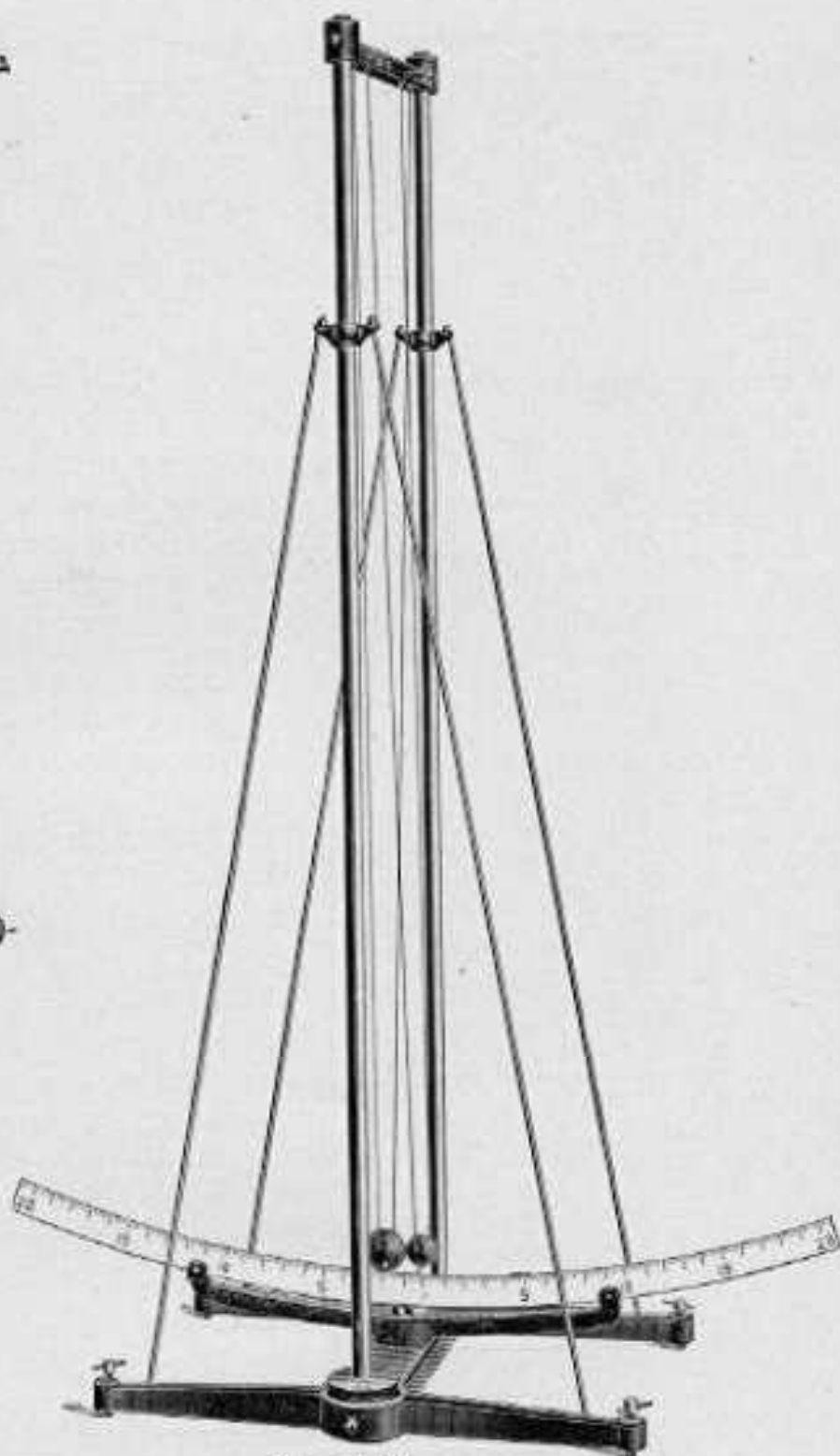


Fig. L 1020

dex indicates on the divided arc, the height to which the second body is driven. The arc is divided for a length of 20 degrees on each side from the centre. The smallest divisions read to 6 minutes, and are about 2.5 mm. wide, which will easily allow to estimate single minutes. The frame is built of heavy, well-braced steel rods, nickel plated and mounted on a large cast iron base with four leveling screws.

Price, with elastic weights.....\$33.50

- Cat. No. L1022. Ballistic Pendulum, with inelastic weights.
 Price\$32.50
- Cat. No. L1023. Set of Weights, elastic or inelastic...\$2.50



Cat. No. L1025. Wall Ballistic Pendulum. (Millikan, p. 54.) (Fig. L1025.) The same apparatus as above but arranged to fasten to the wall.

This form has the advantage that it allows a full view of the scale.

With elastic weights.....\$27.00

Cat. No. L1026. Wall Ballistic Pendulum. With inelastic weights\$26.00

Note.—The Ballistic Pendulums with elastic weights may be used with inelastic weights.

Cat. No. L1030 Inclined Pendulum. The pendulum swings very freely in cone bearings and is of adjustable length. The support shank of the Pendulum is 10 mm. in diameter, so as to fit out Universal Laboratory supports. Price, including support\$3.50

Without support\$2.50

Cat. No. L1040. Kater Pendulum, with support. (Fig. L1040.) The instrument is designed to meet a demand for a simple laboratory instrument. All essential parts are carefully constructed, while the other parts are plainly finished. The rod is made of steel, and the knife edges are fastened at a fixed distance, but fitted with adjustments to make them parallel. The weights are of brass, the wall support is iron, and fitted with necessary adjustments. The ends of the pendulum bar are provided with platinum points. Price\$22.00

Cat. No. L1048. Adjustable Mercury Contact, to be used in connection with Kater Pendulum.
 Price\$6.00

Fig. L. 1040

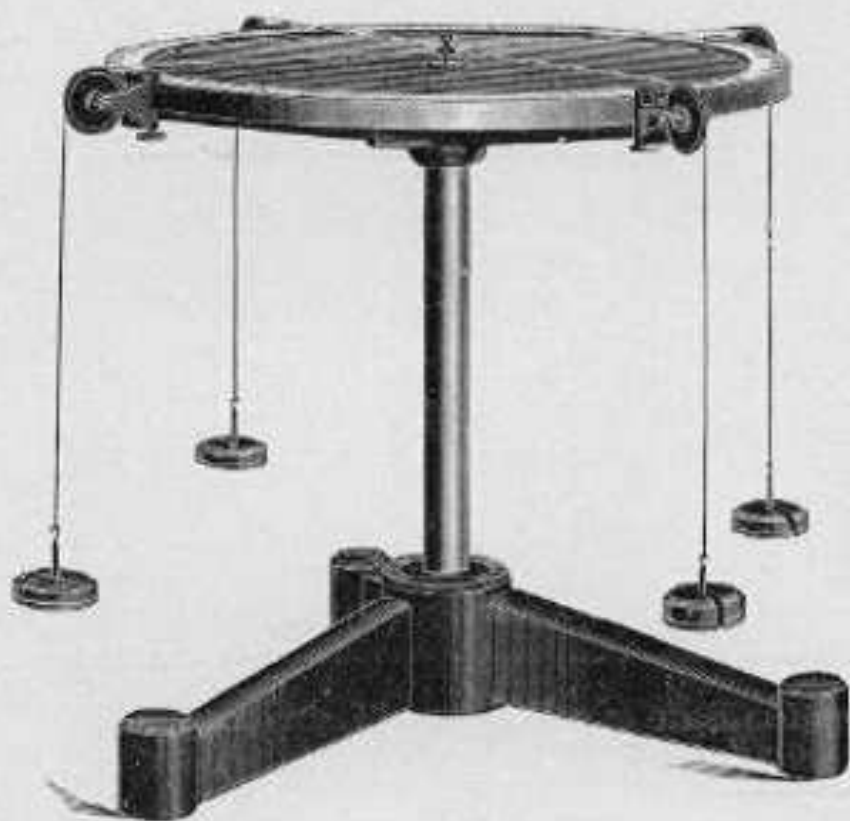


Fig. L 1050

Cat. No. L1050. Force Table, Millikan Physics, p. 26. (Fig. L1050.) The apparatus is used to demonstrate the composition and resolution of forces. The table top is constructed of cast iron, it has a diameter of 40 cm. and is divided in degrees. The top is mounted on our 30 mm. support rod and heavy tripod. Light pulleys running very free of friction, in carefully made cone bearings, can be clamped to any part of the rim of the table. The cords are attached to a small ring, which can be held in the center of the table by a pin, in order to easily adjust the weights. Price of the apparatus complete as in cut, including four pulley clamps and two sets of weights and holders.....\$20.00

Cat. No. L1051. Force Table, as described above, but fitted with support rod 1 meter long and tripod with leveling screws. The long support rod will be found most desirable as it permits the use of the force table direct on the floor and allows easy access from every side. Price.....\$25.00

Note.—The graduated circle of the force table may be made use of for many other experiments and our Universal Laboratory Supports will be found very helpful in this connection. The table may be used for laying off simple graduations on paper or for building up demonstrating spectrometers with telescope holders, etc. Simple attachments may be clamped to the table to demonstrate the laws of reflection and refraction of light, composition of harmonic motion, reflection of elastic bodies, etc.

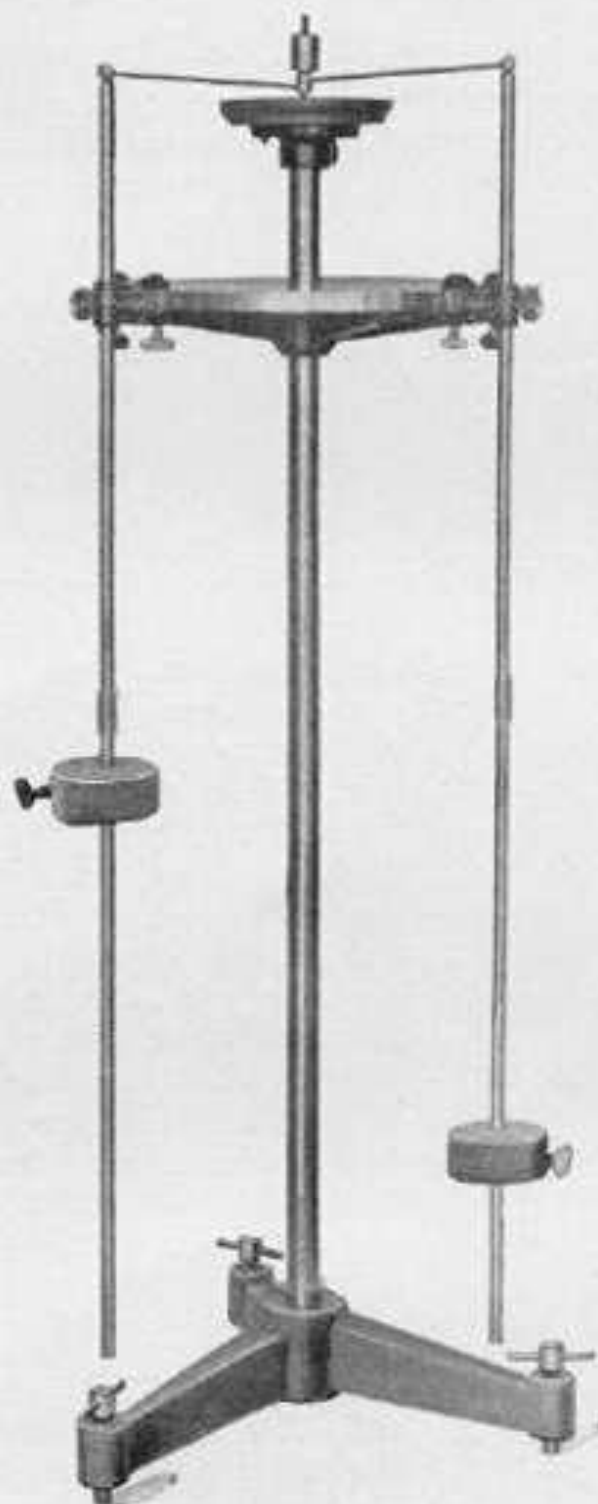


Fig. L-1052

Cat. No. L1052. Tisley's Harmonograph Attachment. (Fig. L1052.) Two clamps with pendulums adjustable to various lengths, and connected by universal joint at the center of the table; variable in period, phase and amplitude
Price\$18.00

Cat. No. L1053. Attachments for Showing the Reflection of Elastic Bodies, consisting of spring pistol, ivory ball, pocket for catching the ball, and reflecting plate attachable to center of the table. Price.....\$6.00

Cat. No. L1054. **Attachment for Demonstrating the Reflection of Light**, consisting of plane mirror attached to the center of the table, fitted with arm and index point and two slits with screws which can be clamped to the rim of the table. Price\$8.00

Cat. No. L1055. **Bisulphate of Carbon Prism**. Prism consisting of brass frame, fitted with plate glass sides, 6 cm. aperture. Price\$3.00

We can furnish these prism with optical surfaces at a reasonable cost.

For prices of flint glass prisms see Circular "I," page 22.

Cat. No. L1060. **Young's Modulus Apparatus**. Millikan Physics, p. 67. (Fig. L1060.) Used for the determination

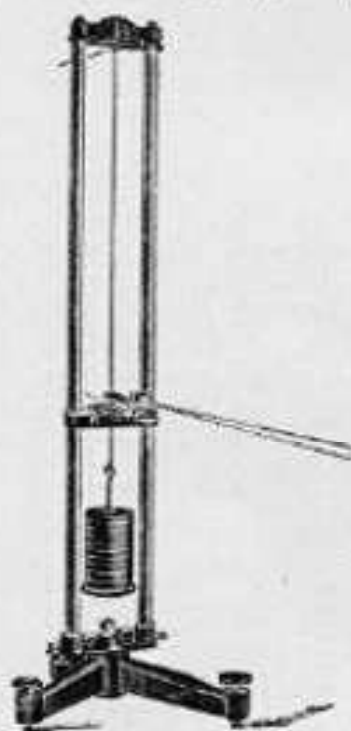


Fig. L 1060

of Young's modulus and Hooke's law. The supporting frame consists of two heavy steel rods 90 cm. high, mounted on tripod with leveling screws, and fitted with strong steel clamp on top of rods for holding the wire. A small bushing is clamped near the end of the wire, and on this, one leg of the optical lever rests. The other two legs rest on an adjustable platform attached to the support rods. The stretch is measured by a telescope and scale. Price, including optical lever, four 2 kilo and two 1 kilo weights, \$19.00

Cat. No. L1060a. **Torsion Pendulum Attachment to the Young's Modulus Apparatus**, consisting of disc and ring of 10 cm. diameter. The top clamp of the Young's

Modulus Apparatus serving as upper support for the pendulum. Price\$7.50

Cat. No. L1065. **Block of Pulleys**, consisting of two sets of triple pulleys mounted side by side. The pulleys are made of brass and have a diameter of 36 mm.

Price, per set.....\$3.00

Cat. No. L1066. **Block of Pulleys**. Two sets of triple pulleys mounted in tandem. Price, per set.....\$4.50

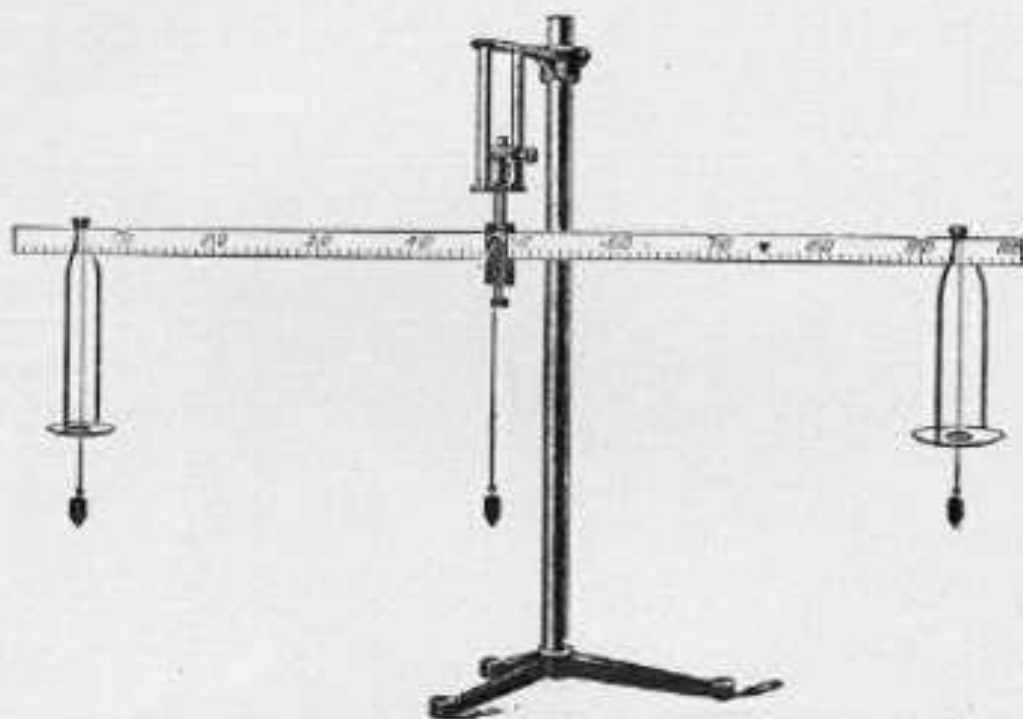


Fig. L 1070

Cat. No. L1070. Apparatus for Demonstrating the Principle of Balance. Millikan Physics, p. 36. (Fig. L1070.) The apparatus consists of a meter stick to which is clamped the supporting knife edge, and to which the pans are directly hung. The support for the knife edge is fitted with 13 mm. shank, to fit our laboratory supports. Price.....\$7.50

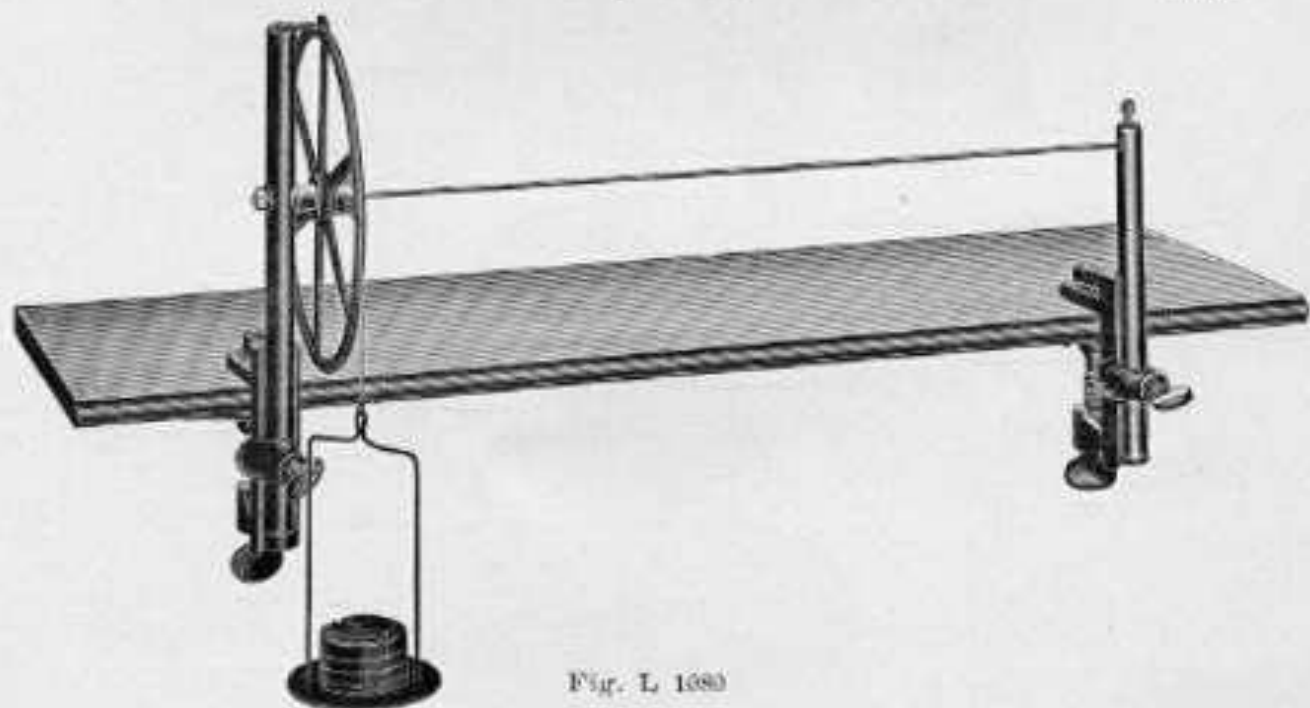


Fig. L 1080

Cat. No. L1080. Torsion Apparatus. Millikan's Physics, p. 75. (Fig. L1080.) The apparatus is used to investigate the laws of torsion, and to determine the movements of torsion of rods of different diameters, lengths and materials. It is designed to be used horizontally, being held to the labora-



Fig. L1081

tory table by means of clamps. One end of the rod is rigidly held, while the other end is attached to the twisting axis. This axis rotates very free of friction in specially constructed ball bearings, and to it is attached a light wheel 200 mm. in diameter, grooved on the rim. The face of the wheel is graduated through 180 degrees into single degrees. The rods may be adjusted to different lengths by sliding the table clamps. Weights applied to the end of the cone passing over the wheel give the desired revolution and twist to the rod. The index attached to the support gives the angle of twist directly in degrees and tenths can easily be estimated. With the apparatus are furnished four rods of different diameters.

Price with clamps\$18.00

Cat. No. L1081. Torsion Pendulum. (Fig. L1081.)

The same rods as used in the Torsion apparatus may be used. The disc has a diameter of 300 mm., thickness of 12 mm., and is made of cast iron. A Ring of same weight and diameter is included.

Price\$15.00



Fig. L1085

Cat. No. L1085. Water Motor Fitted with Speed Indicator, Pressure Gauge, Prony Brake and Pulley. Millikan, p. 47. (Fig. L1085.) For the determination of efficiency of water motor. The motor is of $\frac{1}{8}$ horse power. Price\$32.00

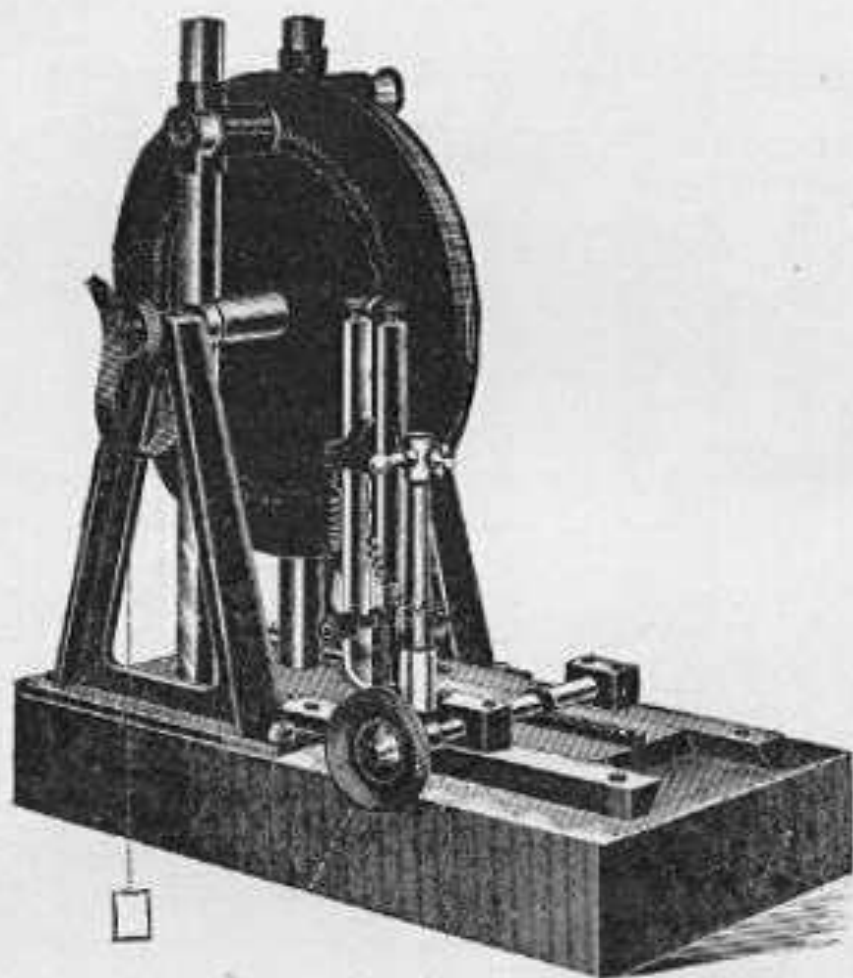


Fig. L 1087

Cat. No. L1087. Inertia Apparatus. Millikan, p. 81. (Fig. L1087.) The revolving disc has a diameter of 200 mm., a width of 15 mm. and weighs approximately 3 kilograms. It is mounted on a shaft revolving very freely in ball bearings. One side of the disc is graduated to degrees, the other side is intended to receive the tracings, which are made on the smoked surface by means of an electric driven turning fork. The fork is mounted on a slide moved by rack and pinion parallel to the face of the revolving disc. A shifting of the revolving disc at right angles to its face can be obtained by means of a milled head screw; this motion gives the necessary adjustment for the stylus. After the tracing has been made, the disc can be shifted away from the stylus and the vibrations counted by aid of a magnifying glass fitted with cross hairs; at the same time the angular readings are made on the other side. Price.....\$45.00

Cat. No. L1088. Jolly Balance. Millikan, p. 91. Price without weights\$7.00

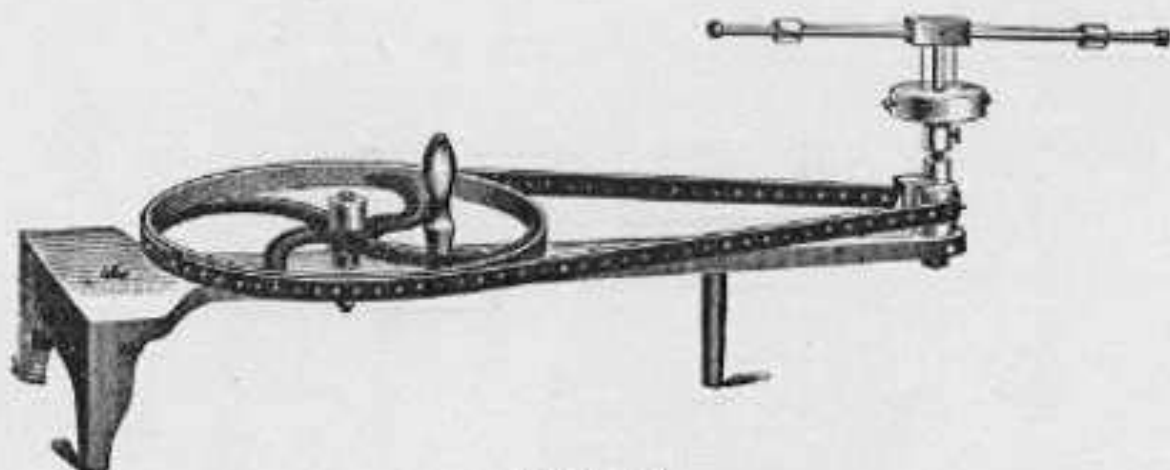


Fig. L 1098

Cat. No. L1089. Centrifugal Table with Attachment to Verify the Law of Centrifugal Force. Millikan, p. 102. (Fig. L1090.) The table is fitted with speed indicator and two sets of small weights. Price, complete\$18.00

Cat. No. L1089a. The same without speed indicator.....\$14.00

Cat. No. L1089b. Attachment same as above without centrifugal table\$8.00

Cat. No. L1090. Harmonic Motion Apparatus. Ames & Bliss, p. 115. (Fig. L1089.) The oscillation of the spiral spring can be observed on a divided circle at the base of the apparatus. The vertical shaft revolves very freely in ball bearings. Price\$18.00

Cat. No. L1101. Boyle's Law Apparatus. (Fig. L1101.) The instrument has a height of 150 cm. It is mounted on a heavy tripod fitted with leveling screws. The middle rod is square and provided with scale 130 cm. in length, divided to mm. The vernier reads to 0.1 mm. A mirror is attached behind the glass tubes which assists in reading the heights of the meniscus without parallax. The two glass tubes are connected by means of steel couplings and heavy rubber tubing. The closed tube is graduated to ccm. and fitted with stop-cock on top. This tube can easily be changed for an air ther-

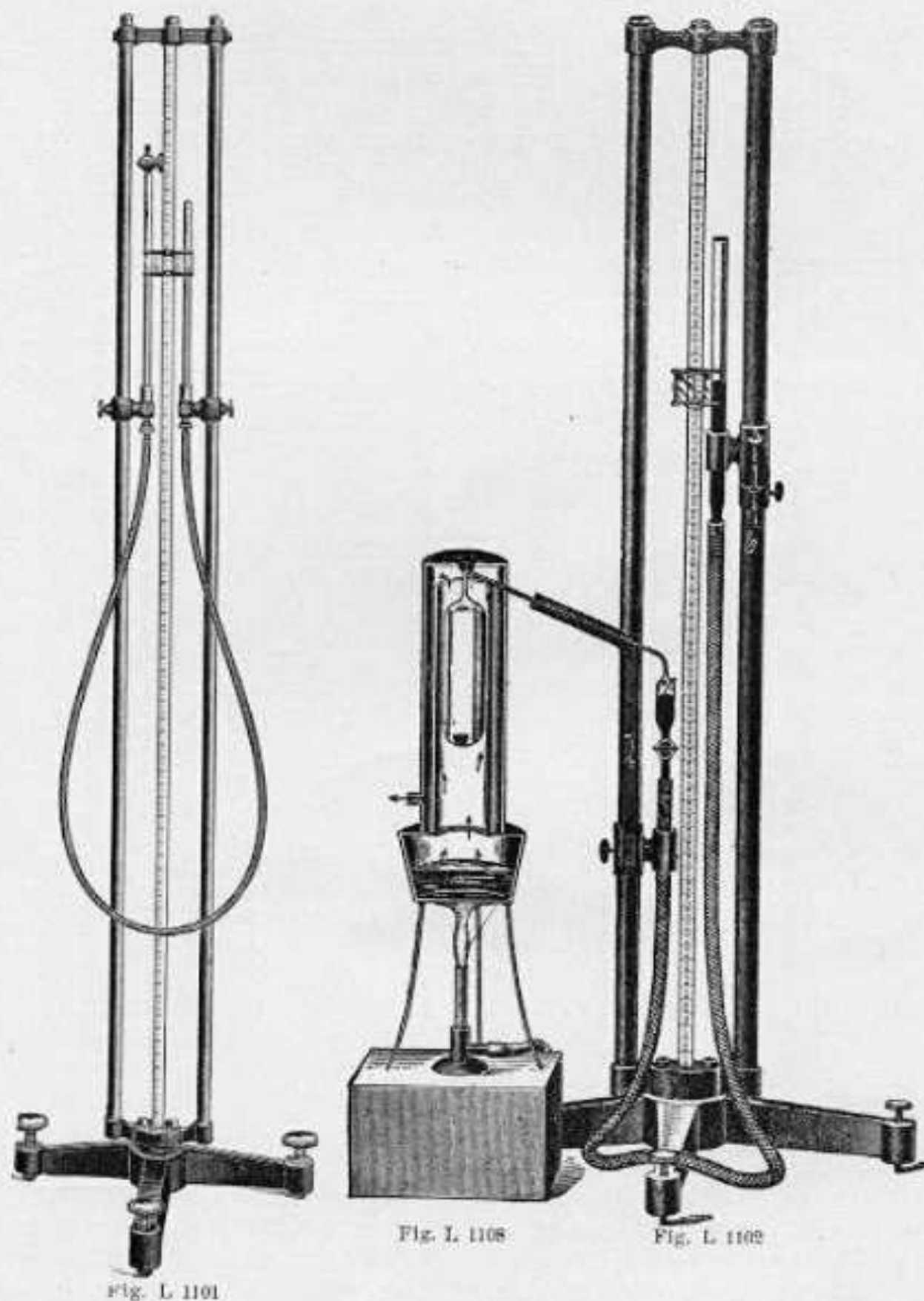


Fig. L 1090

scale 130 cm. in length, divided to mm. The vernier reads to 0.1 mm. A mirror is attached behind the glass tubes which assists in reading the heights of the meniscus without parallax. The two glass tubes are connected by means of steel couplings and heavy rubber tubing. The closed tube is graduated to ccm. and fitted with stop-cock on top. This tube can easily be changed for an air ther-

meter attachment. All steel parts are heavy nickel plated. Price, with air thermometer attachment. . . . \$34.00

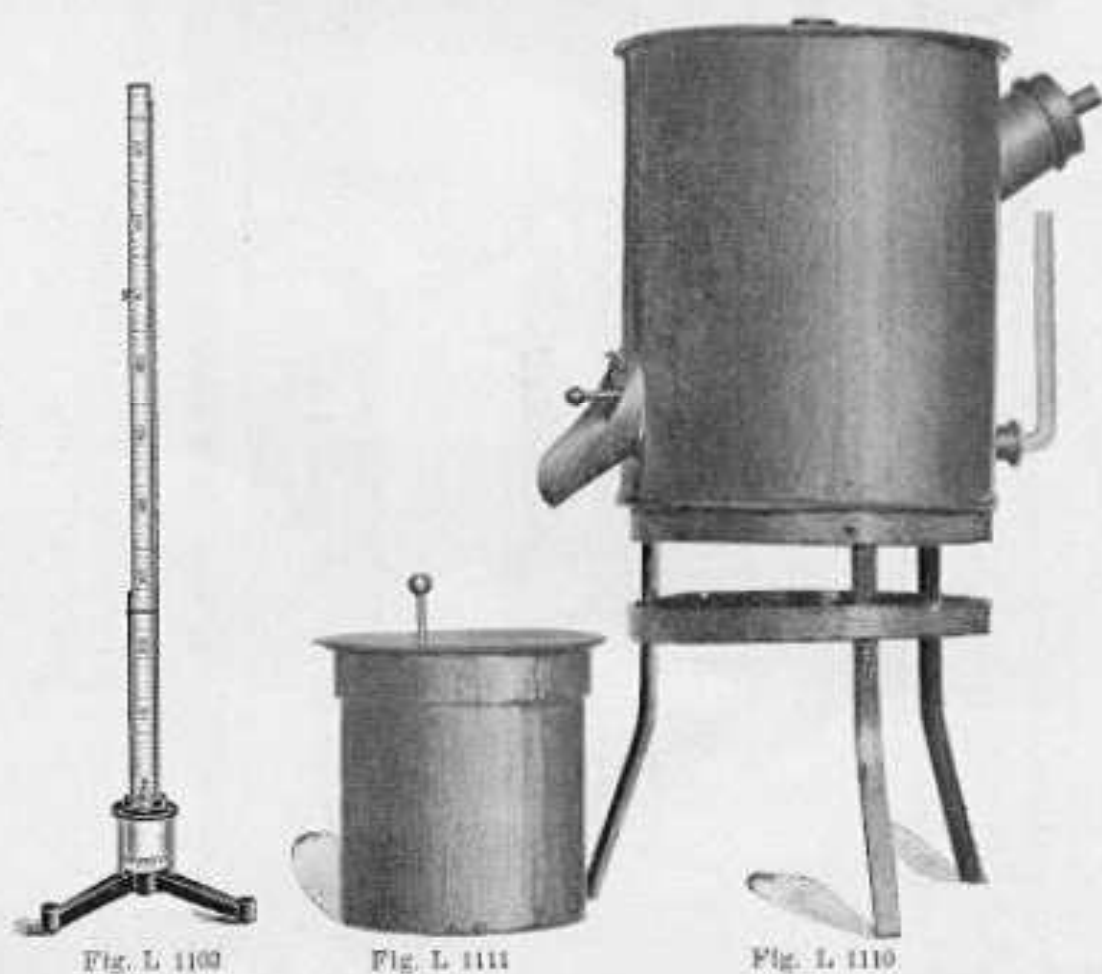
Cat. No. L1102. Air Thermometer. Millikan, p. 131. (Fig. L1102.) The size and construction of this apparatus is



similar to the Boyle's Law Apparatus, L1101, but it is provided with a fine adjustment on the right arm and the bulb is furnished with a three-way stop-cock. The instrument can be used as Boyle's Law Apparatus. Price, including tube for Boyle's Law.....\$38.00

Cat. No. L1103. Boyle's Law Apparatus, Simple Construction. (Fig. L1103.) This apparatus consists of two tubes attached to an air-tight glass vessel. The short closed tube is 30 cm. high and the longer open tube is 100 cm. and is provided with a millimeter scale. The top of the vessel is fitted with a valve connection for the pressure pump by means of which the mercury heights are obtained. Price\$8.50

Cat. No. L1104. Steam Bath. Millikan, p. 131. (Fig. L1104.) For use with air thermometer L1101 or L1102, or for testing thermometers. Price\$12.00



Cat. No. L1110. Specific Heat Apparatus. (Fig. L1110.) Used for the determination of the specific heat of solids. The steam bath is 20 cm. in diameter and made of heavy copper fitted with inclined tube for receiving the ther-

mometer and piece to be heated. The tube is fitted below with shutter which easily opens and allows the body to drop in the calorimeter. Price, including tripod.....\$8.00

Cat. No. L1111. Calorimeter. (Fig. L1111.) Consisting of inner and outer vessels made of brass and nickel plated, fitted with fiber top holding stirrer and opening for thermometer. Size of inside vessel 10 cm. diameter, 13 cm. high. Price\$5.50

Cat. No. L1112. Calorimeter. (Small Size.) Same as L1111, but inside vessel 7 cm. in diameter. Price.....\$4.00

Cat. No. L1113. Calorimeter. Millikan, p. 206. The apparatus is of the same size as No. L1111, but fitted with outside water jacket which is provided with stirrer. Price\$8.00

Cat. No. L1114. Apparatus for Showing Laws of Cooling. Millikan, p. 209. Price, without thermometer.....\$8.50

Cat. No. L1120. Alluard Dew Point Hygrometer. (Fig. L1120.) Millikan, p. 167. The polished metal surface on

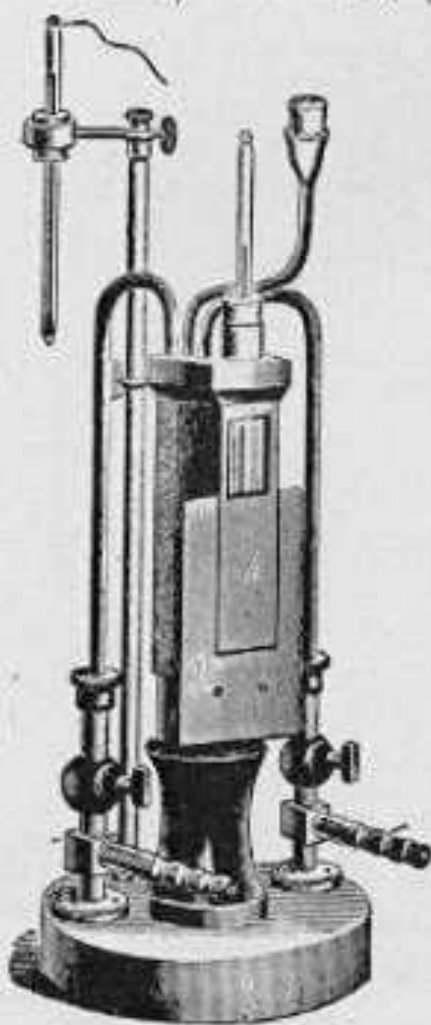


Fig. L 1120

which the dew is formed is in close proximity to an exactly similar surface which remains bright, thus making it possible to observe the dew point with great accuracy. This instrument is used as a standard in most meteorological stations. Price\$26.00

Cat. No. L1125. Pressure Tank. Millikan, p. 117. The tank is of metal fitted with manometer, drying tube and pressure pump and mounted substantially on a hardwood base. Price\$13.50

Cat. No. L1130. Mercury Cistern. (Fig. L1130.) Millikan, p. 108. For experiments upon Boyle's Law for pressure less than one atmosphere and for demonstrating the laws of pressure of saturated vapors. This instrument is especially adapted for accurate determinations, the mercury height being read with the cathetometer. Price\$20.00



Fig. L 1131

Cat. No. L1131. Glass Bulb, with one stop cock 80 mm. diameter. Price\$2.25

Cat. No. L1132. Glass Bulb, with two stop cocks, 80 mm. diameter. Price\$3.00

These bulbs are intended for use in determining density of air or gases.

Cat. No. L1133. Brass Tube. Millikan, p. 220. One meter long, covered with asbestos and felt, and fitted with steam connections; used for measuring coefficient of expansion. Price, including support \$6.50

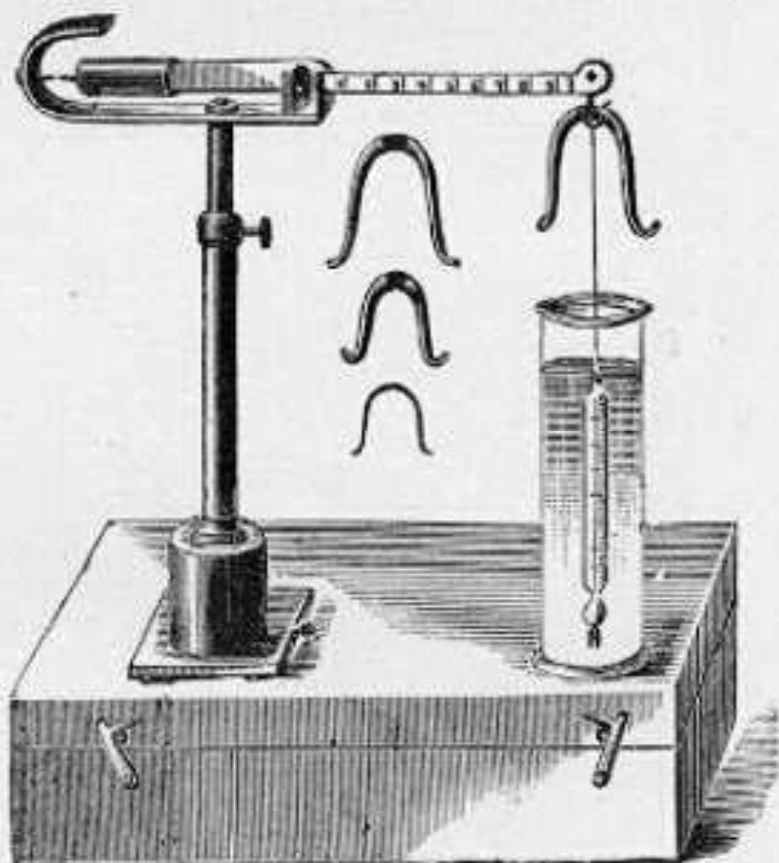


Fig. L 1134

Cat. No. L1134. Mohr's Balance. (Fig. L1134.) For determining densities of liquids, mounted on mahogany case. Price\$20.00

Cat. No. L1141. Chemical Thermometer, from 0 to 100 degrees Centigrade, divided in single degrees. Price....\$1.25

- Cat. No. L1142. Chemical Thermometer, from 0 to 100 degrees Centigrade, divided in one-half degrees.
Price\$3.20
- Cat. No. L1143. Chemical Thermometer, from 0 to 55 degrees Centigrade, divided in one-fifth degrees.
Price\$3.20
- Cat. No. L1144. Chemical Thermometer, from 10 to 55 degrees Centigrade, divided in one-tenth degrees.
Price\$4.25
- Cat. No. L1150. Wet and Dry Bulb Hygrometer. Price \$5.50
- Cat. No. L1151. Hydrometer of Glass, for liquids lighter than water. Price\$0.50
- Cat. No. L1152. Hydrometer of Glass, for liquids heavier than water. Price\$0.50
- Cat. No. L1153. Hydrometer of Glass, with Baumé and specific gravity scale, for liquids lighter than water. Price, \$1.00
- Cat. No. L1154. Hydrometer of Glass, with Baumé and specific gravity scale, for liquids heavier than water. . . \$1.00

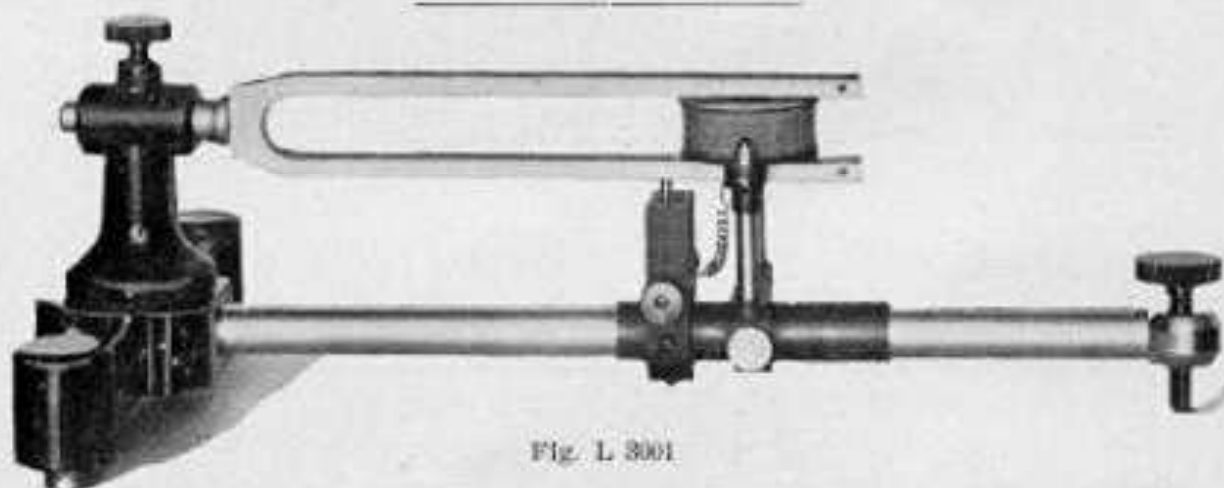


Fig. L 3001

- Cat. No. L3001. Electrical Driven Tuning Fork. (Fig. L3001.) The support is substantially constructed of iron and steel and adapted to carry forks of different lengths. The electro-magnet and mercury contact are made to slide on the horizontal bar. Forks of 50, 100 and 200 complete vibrations can be used with the apparatus. Price of apparatus, including one fork.....\$27.00
- Cat. No. L3002. Tuning Fork of 50, 100 or 200 vibrations, to fit above apparatus, provided with platinum contact pin.
Price\$8.00

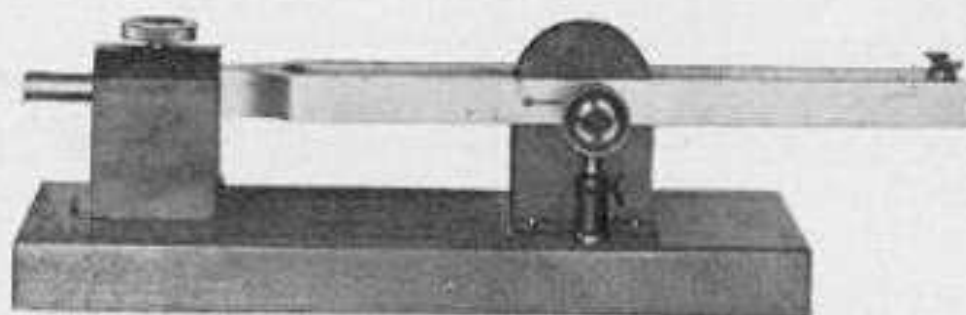


Fig. L 3003

Cat. No. L3003. Electrical Driven Tuning Fork. (Fig. L3003.) with platinum contact, mounted on hardwood base, tuning fork 50, 100 or 200 vibrations. Price.....\$22.50

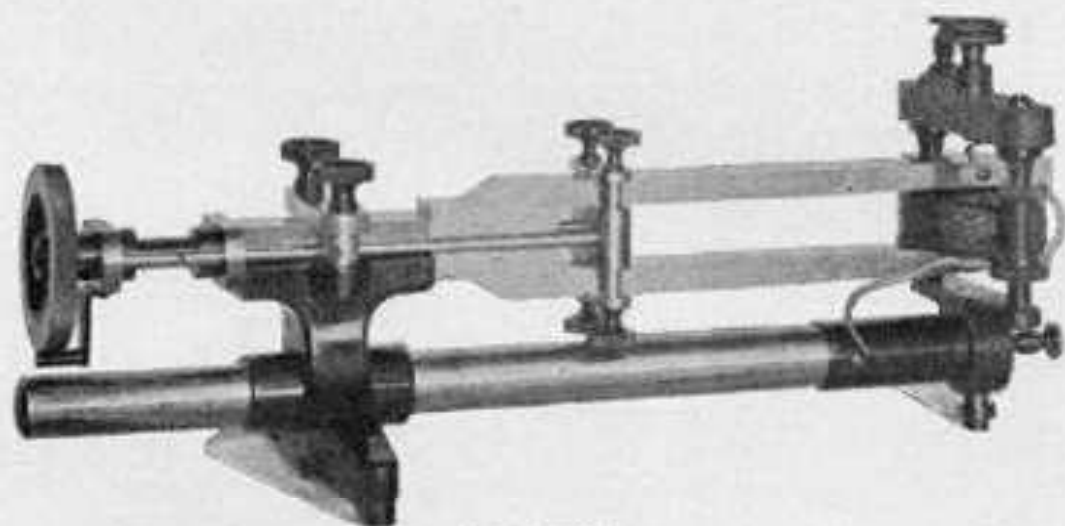


Fig. L 3004

Cat. No. L3004. Adjustable Electrical Driven Tuning Fork. (Fig. L3004.) Mounted on a substantial iron support, which will accommodate forks of different lengths. The adjusting piece is very carefully fitted between the prongs, and moved by means of micrometer screw.

Prices and further information on application.

Cat. No. L3005. Electrical Driven Tuning Fork. (Fig. L3005.) This mounting is similar to our L3001. The fork is provided with platinum contact. It can be used with either the prongs horizontally or vertically, and this change is very easily made. The magnet is adjustable between the prongs so as to regulate the amplitude of vibrations. The support can be screwed to a tripod to have the fork stand vertically. Any of our standard size forks as low as 50 vibrations can be used with this apparatus.

This mounting is well adapted for demonstrating Lissajou's figures, Melde's experiments and general work in sound. It also can easily be arranged for a vibration microscope. Price with one fork of 100 to 300 vibrations. . \$34.00

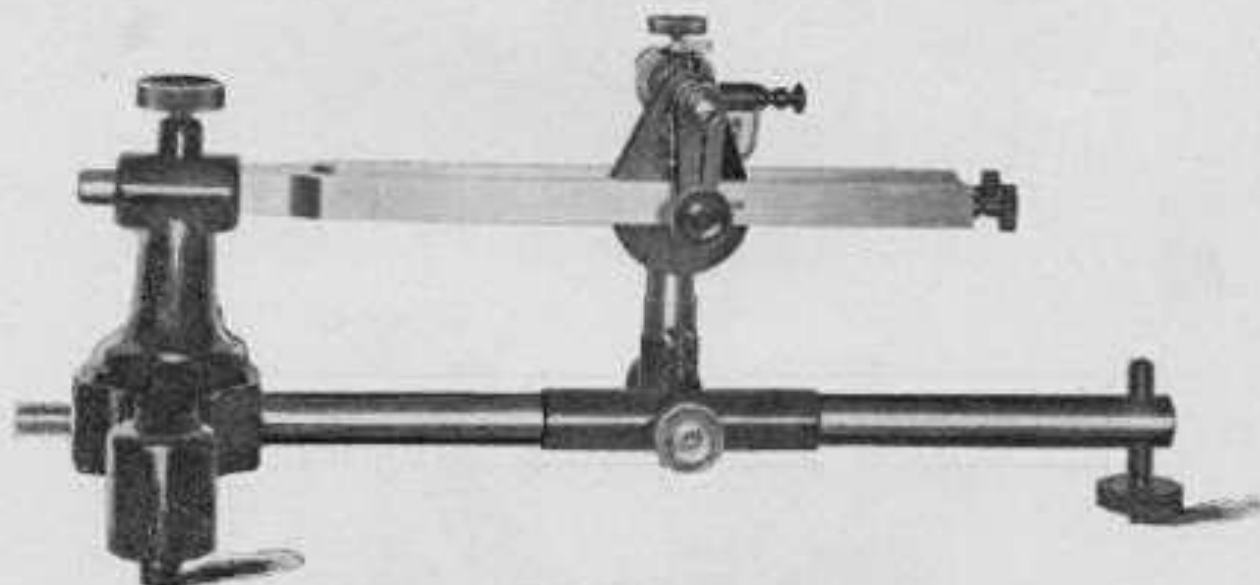


Fig. L 3005

Cat. No. L3005a. Pair of Weights to clamp on fork for changing rate. Price.....\$1.00

Cat. No. L3005b. One Glass Mirror and Counter Weight to screw on prongs. Price.....\$2.00

Cat. No. L3005c. Vibration Microscope Attachment to fit No. L3005. Price\$16.50



Fig. L 3006

Cat. No. L3006. Tuning Fork Apparatus. (Fig. L3006.) For rough calibration of tuning forks. Vibrations are recorded on a smoked glass plate which slides on a board of 90 cm. length, and on the latter are mounted the tuning fork and adjustable pendulum. Price, complete with tuning fork\$5.50



Fig. L 4001

Cat. N. L4001. Foucault Heliostat. (After design Fuess.) (Fig. L4001.) The instrument is mounted on a heavy base fitted with leveling screws. A circular level is mounted in the center of the column. The column rotates in the tripod for azimuth adjustment. The Heliostat is adjustable for different latitudes and provided with divided latitude arc. The hour circle and decl. arc are divided in degrees. The clock work is strong and fitted with jeweled escapement. The mirror is 25 by 13 cm. For convenience in adjusting, the instrument is fitted with an attachment for making use of the shadow of the sun. The beam of light is easily adjustable in every direction. The instrument is strongly constructed and nicely finished. Price.....\$140.00



Fig. L 4002

- Cat. No. L4002. Two Mirror Heliostat.** (Fig. L4002.) The mirrors of the instrument are 10 by 20 cm. The instrument is fitted with a good strong clock of best American make. The lower mirror is fitted with hour circle and decl. arc. The hour circle reads to four minutes. The instrument is mounted on a substantially heavy tripod. No latitude adjustment is provided as the instrument is furnished with a polar axis fixed for the latitude for which it is intended. Adjustment is given by leveling screws in the tripod. The fixed polar axis makes the instrument more substantial and less expensive. The mirrors are of the best selected crystal plate, silvered on the back. Price.....\$32.00
- Cat. No. L4003. Two Mirror Heliostat.** The same instrument as above, but mounted on a bracket which can be clamped to the window sill. The bracket is adjustable so as to be adaptable to different widths of sills. Price..\$34.00
- Cat. No. L4010. Plane Mirror** mounted in frame and fork, similar to the second mirror on Heliostat No. L4002. The sleeve to fit on our 19 mm. standard rod. Price.....\$5.00

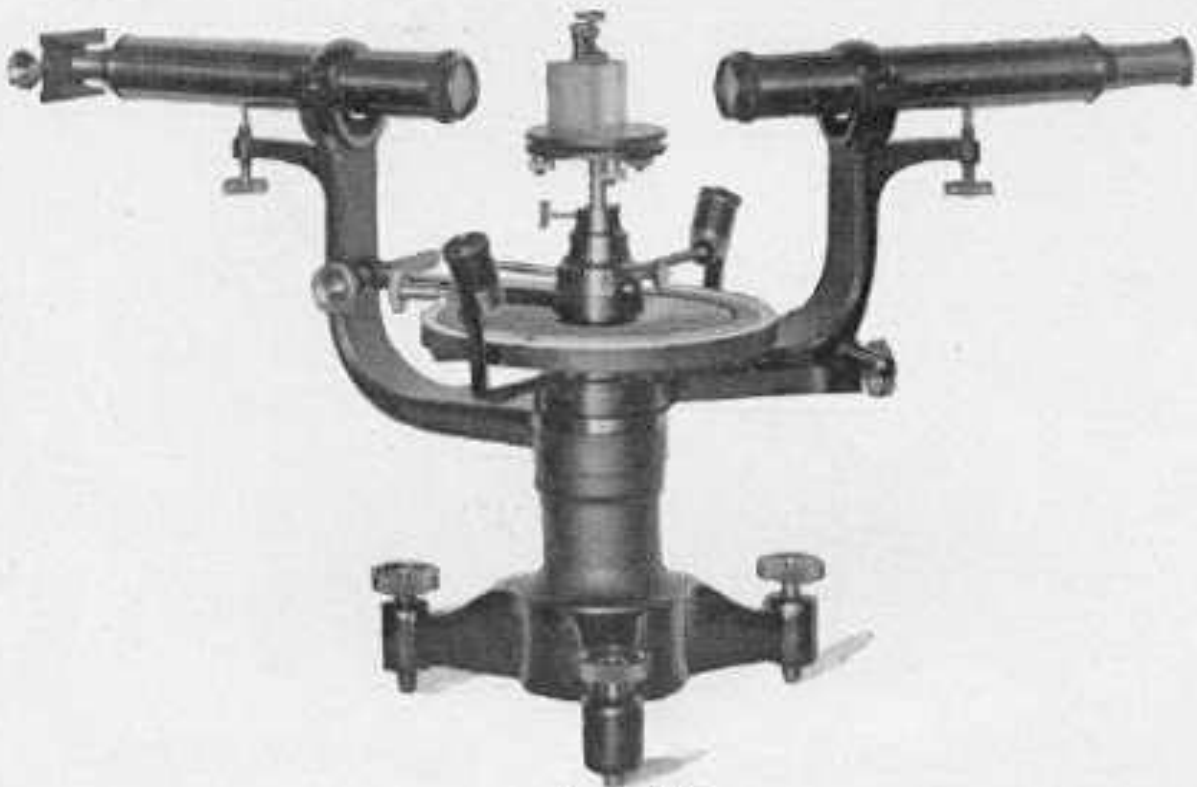


Fig. L 4020

Cat. No. L4020. Spectrometer. (Fig. L4020.) The circle has a diameter of 15 cm. and the two verniers read to 20 sec. The graduation is on solid silver. The verniers are fitted with magnifying glasses; the telescopes have an aperture of 25 mm., focal length of 200 mm. They can easily be taken out from their bearings for focusing. A horizontal adjustment for the telescopes is provided. No provision is made for radial adjustment, which correction is made before the instrument is sent out. The slit jaws are of German silver and the slit is provided with comparison prism. The eye end of the observing telescope is of standard size, so as to receive our micrometers M201 or M202. Gauss eye piece is fitted to the instrument. The prism table and observing telescope have independent movements and each are provided with clamps and tangent screw. The prism table can be clamped to any part of the vernier plate. A prism holder with convenient leveling arrangement is provided and will hold a prism up to 35 mm. in height. The instrument is substantially constructed and well finished, and is arranged to receive Fuess centering apparatus and crystal holder. A 60 degree heavy flint glass prism of best optical quality is included. Price. \$75.00

Cat. No. L4020a. Polarizing Attachments to above spectrometer consisting of two graduated circles, fitted to the objectives, and carrying Wollaston or Nicol prisms, a third circle for measuring the rotation of the Nicol in the eye piece, a Jamin compensator attached to the eye piece and used for measuring the constants of metallic reflection.

Prices and further information on application.

Cat. No. L4020b. Camera Attachment to Spectrometer L4020. The Camera tube is made to fit in place of the observing telescope and is provided with a plate-holder for $2\frac{3}{4}$ inch by $3\frac{1}{4}$ inch plates. The slit is so arranged that a number of photographs can be taken on the same plate. Price\$20.00

Cat. No. L4020c. Scale Tube, fitted to above instrument to photograph a scale alongside with the spectrum. The tube is mounted on an arm similar as the observing telescope and is adjustable in every direction. Price.....\$20.00

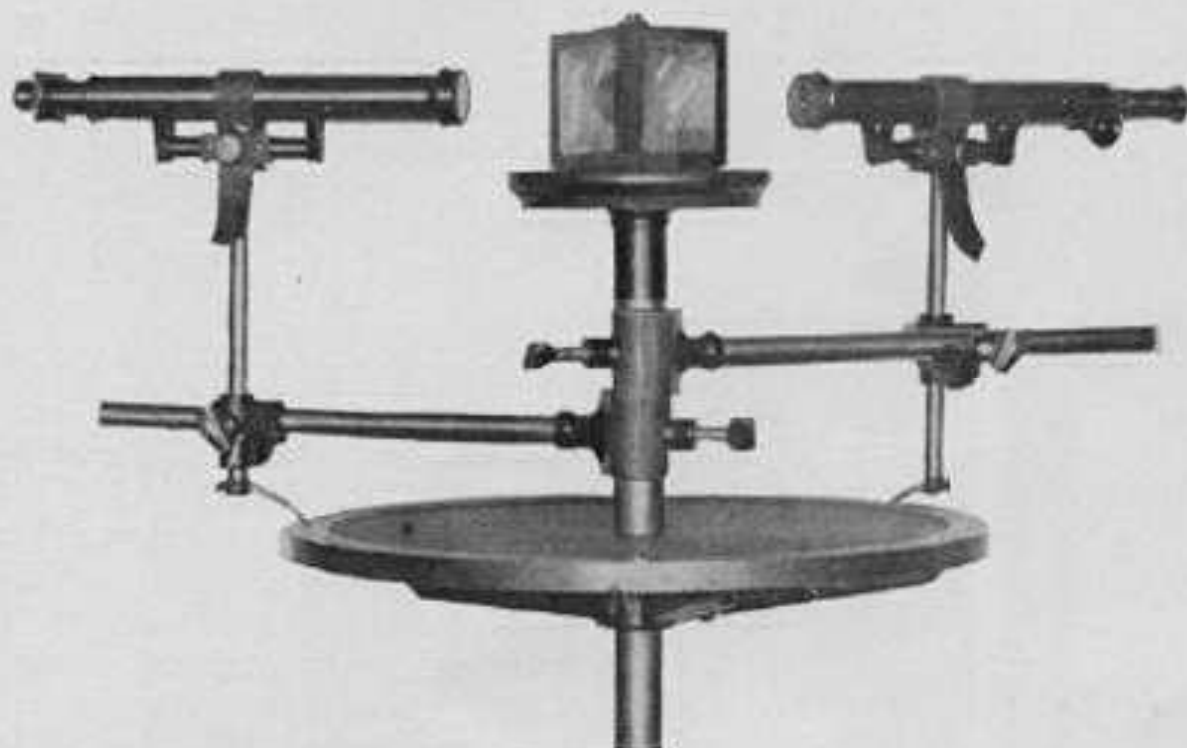


Fig. L 4021

Fig. L4021 shows a spectrometer built up from our standard laboratory pieces listed in other parts of the catalogue. The graduated force table top, Fig. L1050, serves as the divided circle. An efficient spectrometer may thus be easily constructed at small cost. For special research work, for which the ordinary spectrometer is not always suitable, this form of instrument will often do good service. It is also serviceable for demonstrating the principle of the spectrometer to elementary classes.

Cat. No. L4030. Littrow Spectroscope. (Fig. L4030.) This instrument is constructed from the design of Prof. A. A.

Michelson and is especially intended to be used in connection with his Echelon Spectroscope, or for any work where high dispersion is desired. The collimators and observing telescope have an aperture of 50 mm. and focus by rack and pinion. Two 60 degree prisms of heavy flint glass and of 75 mm. side are furnished with the instrument. The mirror may be used in two different positions, to permit the use of one or two prisms. A small right angle prism easily adjustable in every direction is placed near the slit of the first collimator and throws the light into the slit of the second collimator whence it is reflected by another right angle prism into the Echelon and to the observing telescope. The observing telescope is provided with filar micrometer. The platform on which the Echelon is placed is adjustable in two directions.

Price\$250.00



Fig. L. 4030

Cat. No. L4040. Brace Spectrophotometer. (Fig. L4040.) The instrument is designed to serve for spectrometer as well as spectrophotometer and for this purpose is provided with a graduated circle. One of the collimators is mounted fixed on the circle, the other collimator and the observing telescope are movable around a common axis. The fixed collimator can be clamped in two positions; radial, for spectrometer work, or set over at the proper angle for spectrophotometer work. The movable colli-

mator and observing telescope are mounted on arms which carry a worm and tangent screw. The arms can be clamped at any part of the circle. The fine adjustment is done with the

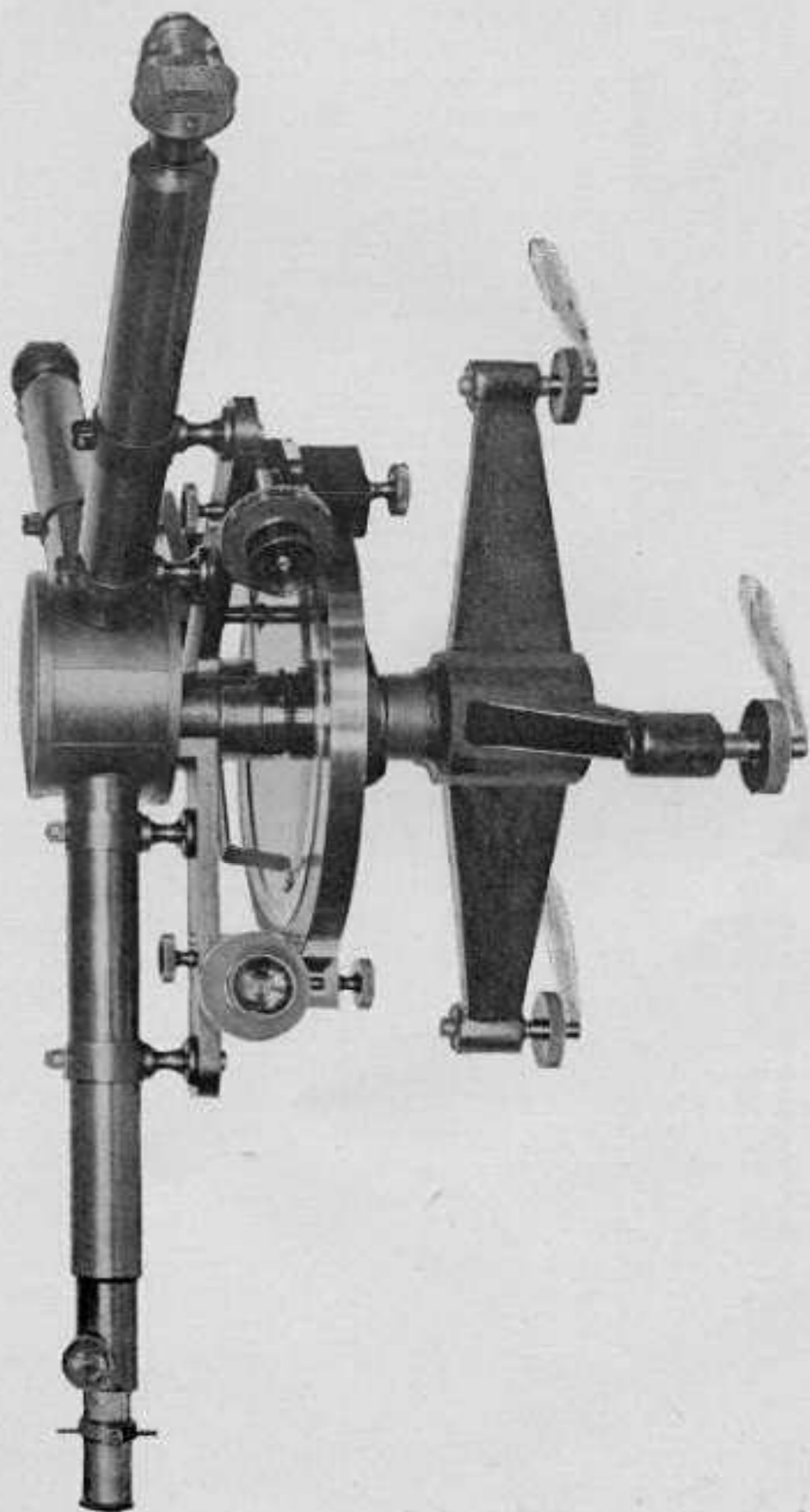


Fig. 1. 4040

tangent screw and a second clamp screw is provided for clamping the telescope after adjustment has been made. The tangent screws are fitted with large graduated heads divided in 100 parts, the graduation being in white on black so as to be easily read in the dark. The collimators are fitted with bilateral slits (design of F. O. L. Wadsworth). The opening of the slits can be read by means of large divided heads to $1/400$ of a mm. The slit jaws are made of German silver and carefully fitted. The focusing of the slits is done by hand. The observing telescope is provided with a rack and pinion and carries the eye slit. This slit consists of two sets of jaws mounted at right angles to each other. The largest opening of this slit is about 5 mm. square. The eye end is so arranged that the slit may be used with or without eye piece in front, or the slit taken off entirely and the eye piece used alone. The prism is carefully housed and mounted on an adjustable platform. The telescope objectives can be easily withdrawn from the tube for convenience in adjusting the instrument. For use as spectrometer the instrument is provided with verniers which are attached to the observing telescope and movable collimator. The circle has a diameter of 200 mm., is of solid silver and is graduated to 15 minutes, the verniers read to 15 seconds. In using the instrument as spectrometer, the fixed collimator is turned to radial position and the observing telescope used in the usual way. The movable collimator is displaced by a platform carrying the spectrometer prism. The spectrophotometer prism has a height of 30 mm. and base of 60 mm.; the telescopes have an aperture of 30 mm. and focal length of 300 mm. The circle has an outside diameter of 250 mm. The tripod is fitted with leveling screws. Price\$250.00

Cat. No. L4041. Brace Spectrophotometer. This instrument is of simple construction, the telescopes have an aperture of 30 mm., 250 mm. focus. The observing telescope only is provided with tangent screw; the collimators are adjusted by hand and clamped in position. Both slits are bilateral, but only one has micrometer head. The observing telescope is provided with rack and pinion and eye-slit. The prism is of the same size as in the preceding instrument and is mounted in the same way. Price.....\$140.00

Cat. No. L4090. Rotating Arc Apparatus. (After Crew & Tatnall, Phil. Mag., 37, p. 379; 1894.) (Fig. L4090.) The apparatus consists of an air-tight brass chamber of 12 cm. diameter which incloses two electrodes. One electrode passes through the rear of the apparatus and is rotated by

an electric motor, which will run with direct or alternating current; the other electrode passes through one side of the case, is insulated from the same and provided with screw-feed. Both electrodes are fitted with stuffing boxes. The front of the air chamber can be unscrewed so as to give access to the electrodes for the purpose of changing or renewing. Direct or alternating current may be used for

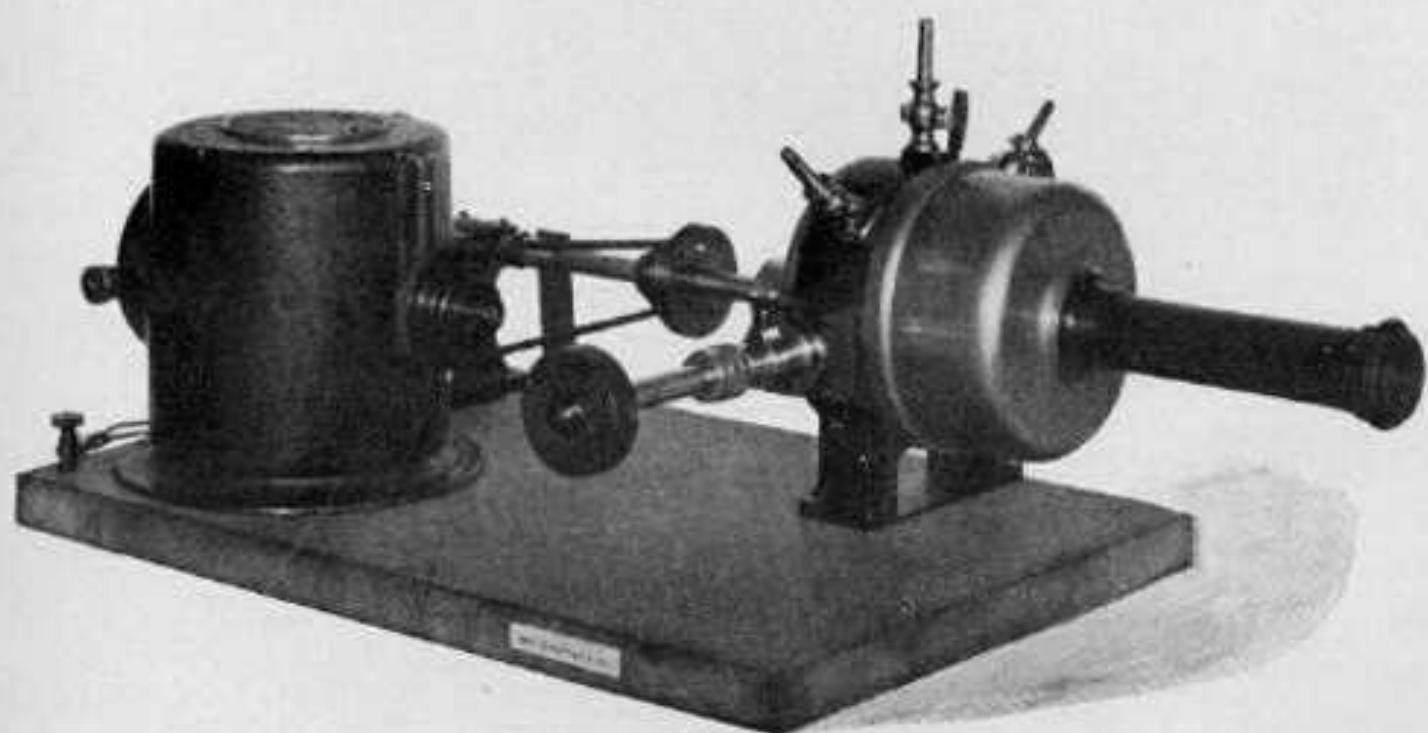


Fig. L 4090

the arc. A brass tube screwed to the front of the case carries at its forward end a quartz lens. The tube is made adjustable in length so as to allow the proper focusing of the arc. Three valves are attached to the gas chamber for admission of gasses, exhausting of air and attaching of manometer. A small window in the back of the case allows the operator to observe the arc. The apparatus is mounted on a heavy slate plate and is substantially constructed and well finished. With the apparatus are furnished electrodes of iron, copper and aluminum. The arc thus provided allows one to examine the spectrum of practically any metal in any gas. Price.....\$110.00

Cat. No. L4091. Rotating Arc Apparatus, similar to the preceding one but somewhat simplified. The arc is not airtight inclosed, and no lens is provided. Price with three pair of electrodes\$50.00

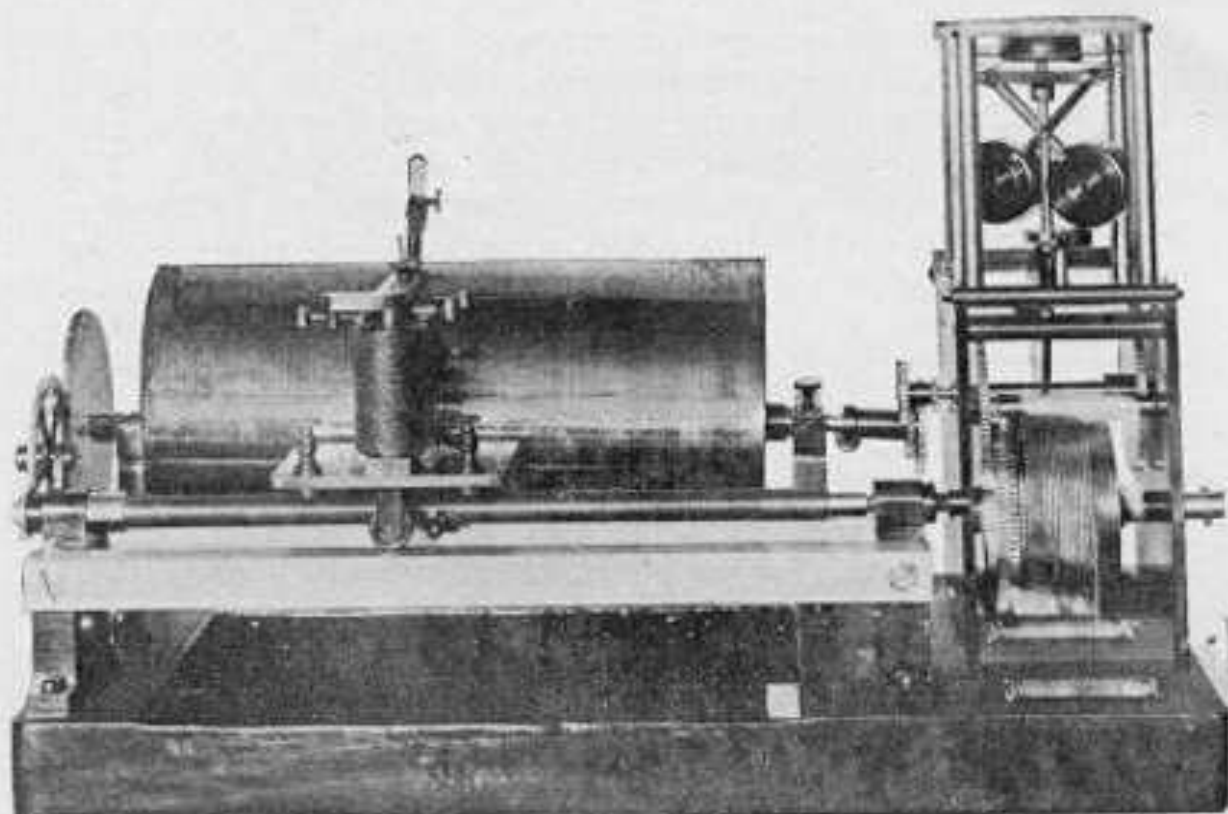


Fig. L 5001

Cat. No. L5001. Chronograph. (Fig. L5001.) For physical and astronomical work. The chronograph is designed to meet the demand for a medium-sized, well-made and accurate instrument of this kind and has given very good satisfaction. The cylinder is 15 cm. in diameter, 25 cm. long, driven by strong, carefully made clock work, fitted with friction governor. Different speeds for the cylinder can be obtained by means of change gears and the higher speeds for physical work, by changing the governor to a fan regulator. The carriage is driven by means of a screw, the nut of which is made to disengage. One or two recording pens can be provided. Price of instrument complete, with one pen and driving weights, and glass cover.....\$185.00

Cat. No. L5002. Prof. G. W. Hough's Printing Chronograph. (Fig. L5002.) The instrument consists of two carefully and accurately constructed clock movements, which are driven by gravity and controlled electrically by the sidereal clock. The movements revolve three type wheels. One of these turns once per second; its edge is divided in 50 parts and it is driven by a separate movement shown in rear of cut. The second wheel turns once per minute and the third once per hour and they will print the seconds and minutes, while the first will give the hundreds of seconds. A strip of paper 50 mm. wide is carried over these wheels and moved for-

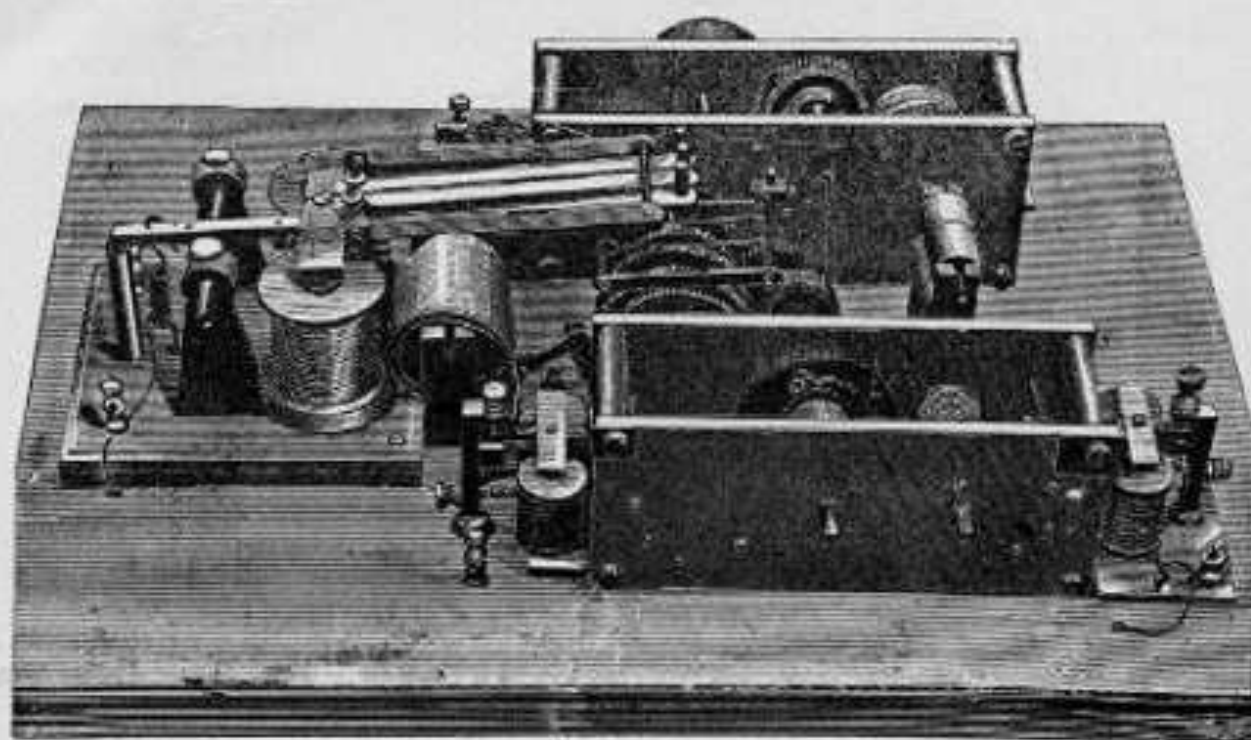


Fig. 1. 5002

ward by the same electro-magnet, which operates the printing hammers. The paper is sufficiently long for 1200 observations including spacing between records. The operation of the printing hammers is such that the uniform motion of the type wheels is not disturbed in the act of printing. The type is inked by means of a roller mounted below the wheels. The whole instrument is mounted on a heavy slate plate 45 cm. by 60 cm. and protected by a glass cover.

The manipulation of the apparatus is extremely simple and convenient and the records obtained are perfectly reliable and accurate within about 0.01 of a second. The saving of time and labor by the printing chronograph is very considerable and the filing of the records very convenient.

This printing chronograph has been in use at the Dearborn Observatory for about 20 years and during the last 5 years the following observatories have been equipped with the instrument: Amherst College Observatory; Case School of Applied Science, Cleveland; Philadelphia Observatory; Durham Observatory, Durham, Eng. the probable error 0.01 of a second.

Prof. Hough has kindly consented to inspect every chronograph before it leaves our shop. Price.....\$500.00

Cat. No. L5003. Recording Drum. (Fig. L5003.) The drum is driven by a good spring clock movement running 24 hours

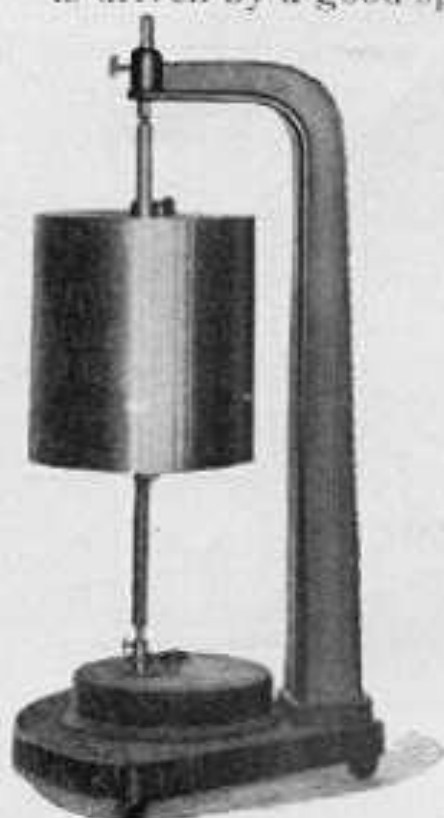


Fig. L 5003

and it may be used vertically or horizontally. Different speeds ranging from 3 hours to 24 hours per revolution can be obtained by means of change gears. The drum has a diameter of 15 cm., length of 15 cm., and can be shifted and clamped on any part of the shaft. Price\$18.50

Cat. No. L5005. Recording Drum. convenient for recording tuning fork vibrations, etc., similar to the preceding one but driven by spring motor, and giving speeds ranging from 1 revolution in two seconds to 1 revolution in two minutes.

Price\$25.00

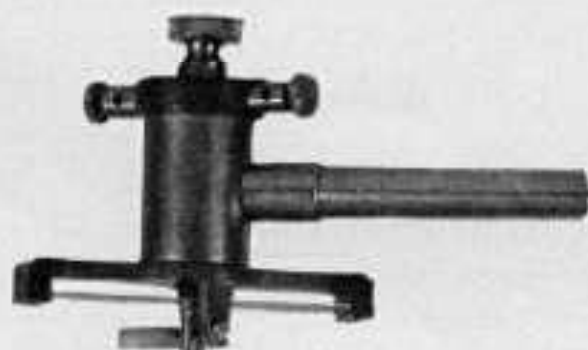


Fig. L 5006

Cat. No. L5006. Electric Time Marker. (Fig. L5006.) Convenient to use in connection with recording drums. The instrument will work satisfactorily up to 1000 vibrations per second. The support shank is 10 mm. Price.....\$7.50



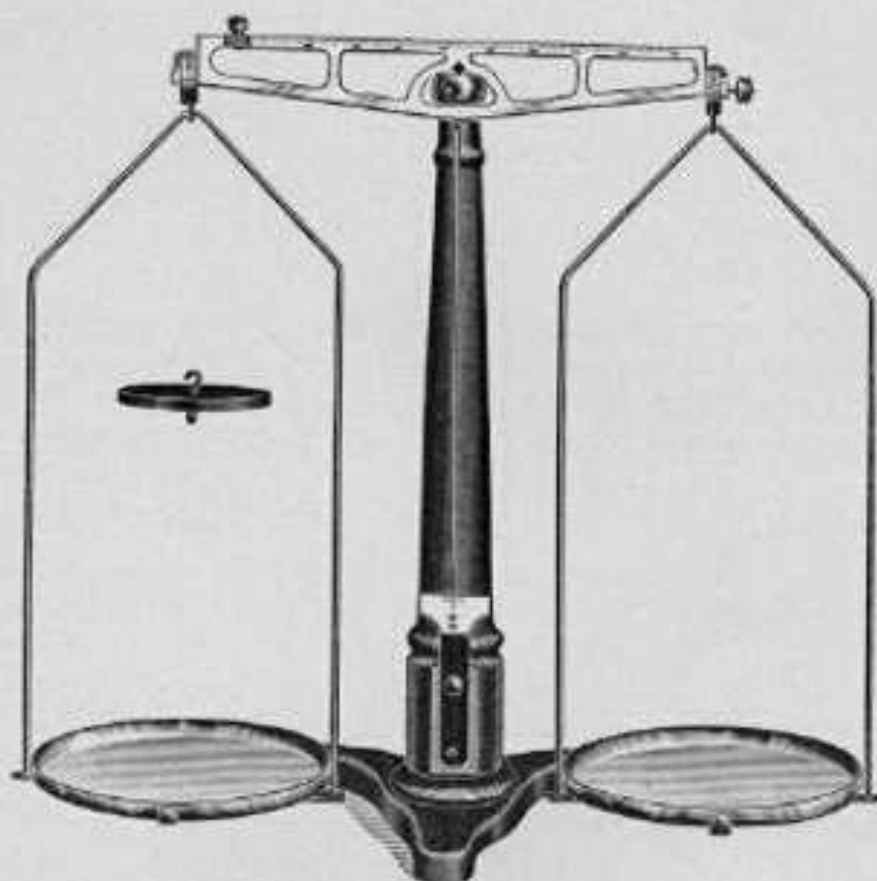


Fig. L. 6010

Cat. No. L6010. General Laboratory and Student's Balance.

(Fig. L6010.) This balance was especially designed for the University High School (University of Chicago). It meets the demand made by high schools everywhere for an inexpensive balance more reliable than trip scales and no less convenient. The points to be noticed are:

1. There are no small weights to use or to lose. All weights under 10 grams are taken care of by the rider, which travels the full length of the beam.

2. The results are not at all dependent upon the position of the weights on the pans. All forms of trip scales are subject to error from this cause, the inaccuracy often amounting to as much as 5 grams in 500.

3. The balance is provided with a convenient damping device, thus increasing speed without sacrificing accuracy.

4. By replacing one pan by the counterpoise, the instrument becomes a specific gravity balance. Height from table to counterpoise is 33 cm. (Specific gravity cannot be determined either conveniently or accurately with trip scales.)

5. The range of accuracy is greater than that of any other balance of its price. The beam is divided into tenths gram divisions, each division being 2.2 mm. long. A movement of the rider amounting to $\frac{1}{4}$ division is easily observed in the pointer. Loads up to 1000 grams are weighed with an

error not to exceed 0.05. Loads up to 2000 grams may be used without danger.

6. The pans are large, receiving objects 15 cm. in diameter. Larger objects can be hung beneath the counterpoise.

7. Both the beam and the pans are securely attached so that they cannot come off when the balance is carried about or roughly handled.

The construction and finish are first-class; the knife edges are of high-grade steel carefully hardened and polished. They rest on steel bearings. All parts are nickel-plated, the base and pillar being neatly japanned. Price.....\$10.00

Cat. No. L6015. Set of Brass Weights Nickel Plated, consisting of one 10 gr., two 20 gr., one 50 gr., one 100 gr., two 200 gr., one 500 gr. Price.....\$3.75

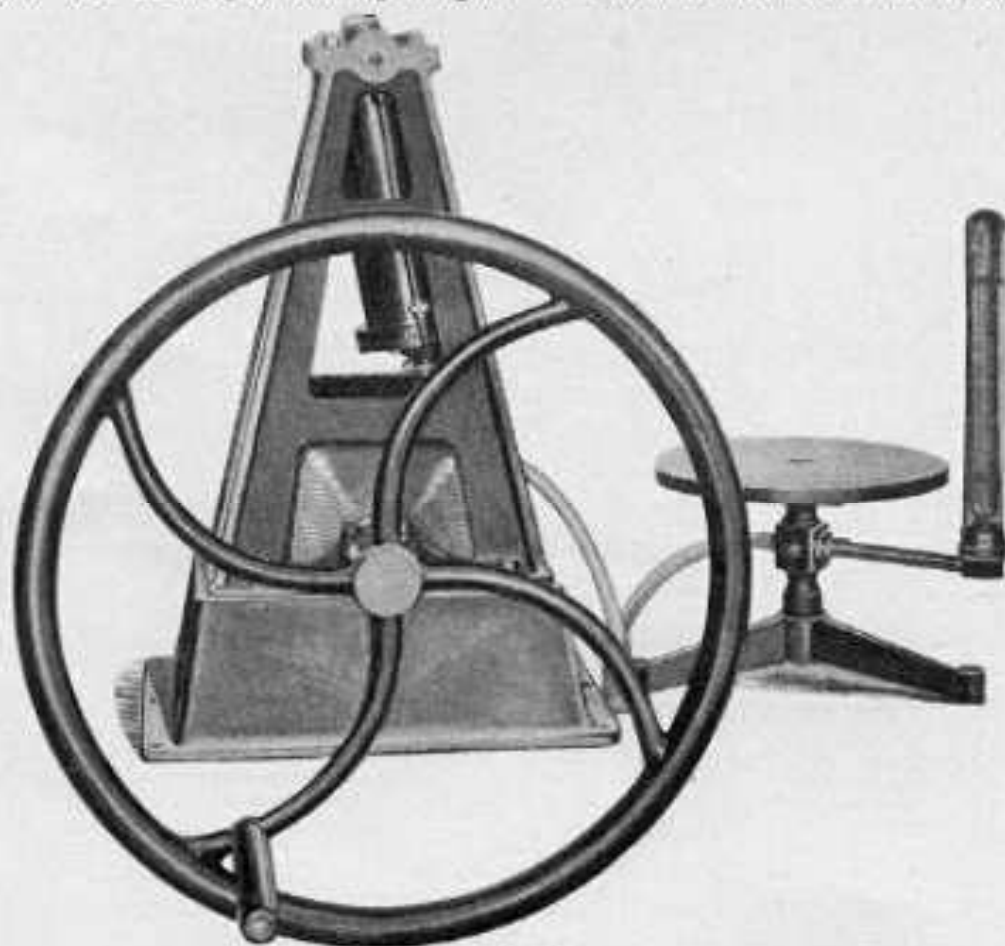


FIG. 1. 6020

Cat. No. L6020. Vacuum and Compression Pump. (Fig. L6020.) Mounted on a heavy iron frame to fasten on laboratory table. The cylinder is of brass and has a diameter of 90 mm. and a length of 280 mm. The receiver table has a diameter of 280 mm. and is fitted with Manometer of 300 mm. length. The pump will give a vacuum of 2 mm. Price.....\$150.00

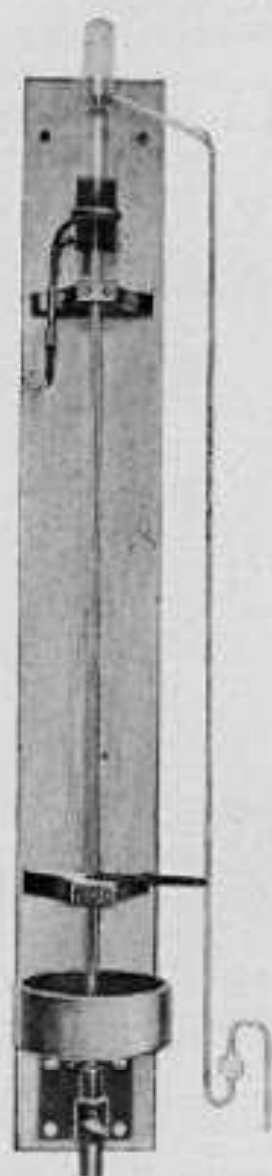


Fig. L 6030



Fig. L 6050

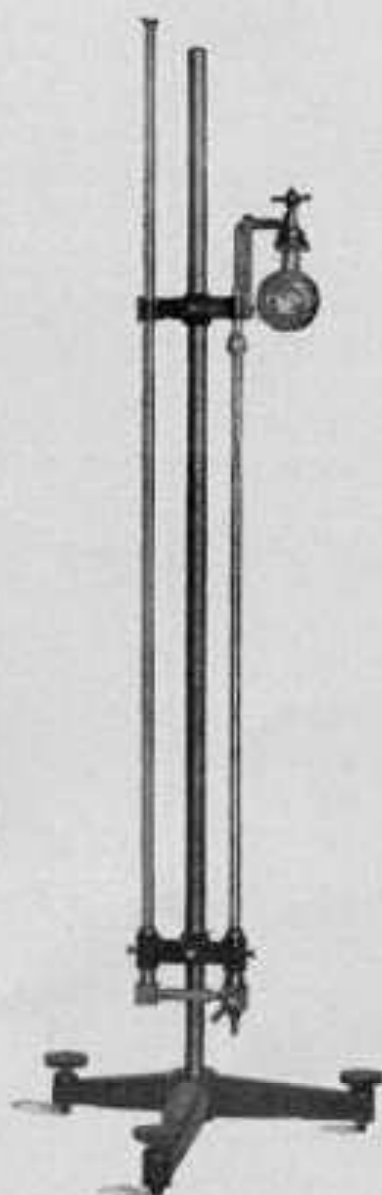


Fig. L6040

Cat. No. L6030. Mercury Distilling Apparatus. (Fig. L6030.)

The apparatus is substantially constructed, mounted on a board intended to fasten against the wall. Price.....\$16.50

Cat. No. L6040. Volumenometer. (Fig. L6040.)

Loudon & McLennan's Physics, p. 26. An instrument for determining the volumes of salts, sugar and other substances which cannot be brought into contact with water. Price....\$24.00

Cat. L6050. Glass Disc Cutting Apparatus. (Fig. L6050.)

The apparatus will cut discs from 1 to 20 cm. in diameter. The cutter arm is graduated to millimeters and provided with 6 cutters. The apparatus can also be used for cutting discs of cardboard, metal and other materials and will be found of great value in the laboratory. Price.....\$6.00

ASTRONOMICAL INSTRUMENTS

Cat. No. A101. Equatorial Mounting for 5-inch Object Glass.

(Fig. A101.) The instrument is built after modern ideas and all stationary parts are strong and rigidly constructed, while the moving parts are made light without sacrificing strength. The pillar is of rectangular cross-section, has a large base and considerable weight. The clock case is securely fastened, but with provision for adjustment in azimuth. The clock is very carefully constructed, it is amply large to supply sufficient driving power and is regulated by a friction governor (design Prof. Young). Two plate glass doors give easy access to the clock. The worm wheel has a diameter of 16 cm., is accurately cut and protected from dust and injury by a brass shield. Declination and hour circles have a diameter of 20 cm. and are provided with fine graduations on silver and coarse finding graduation. The handles for clamping and slow motion, are fastened conveniently near the eye end of the telescope, and are differently shaped so as to distinguish in the dark declination and right ascension. The finder has an aperture of 40 mm. Electric illumination for the eye end and for reading the verniers is provided. The telescope tube is of steel, the eye end fitted with strong rack and pinion, giving 15 cm. motion. Price, including 3 celestial eye pieces...\$900.00

Cat. No. A201. 3½ in. Universal Mounting. (Fig. A201.)

This instrument is especially designed to meet the demand of colleges and amateur astronomers for a substantial and well constructed telescope, which is easy, portable and reasonable in cost. The polar axis may be easily and quickly clamped at any angle so that the telescope can be used at any latitude and will serve as a very satisfactory alt-azimuth, if set at 90 degrees. The instrument is mounted on a strong tripod of white oak. The top casting swivels on the tripod head so that the polar axis can be easily set and clamped in the meridian. Two small levels are fitted to the tripod top. The polar and declination axes are carefully fitted to their bearings and are provided with clamp screws. The polar axis carries the worm wheel in which engages a worm for slow motion. This worm is kept in contact with the wheel by a stiff spring and can be easily disengaged in order to move the telescope by hand. The slow motion handle can be attached to either side of the worm shaft. The telescope tube is made of brass, polished and lacquered, and can be easily taken out of its cradle. A strong diagonal

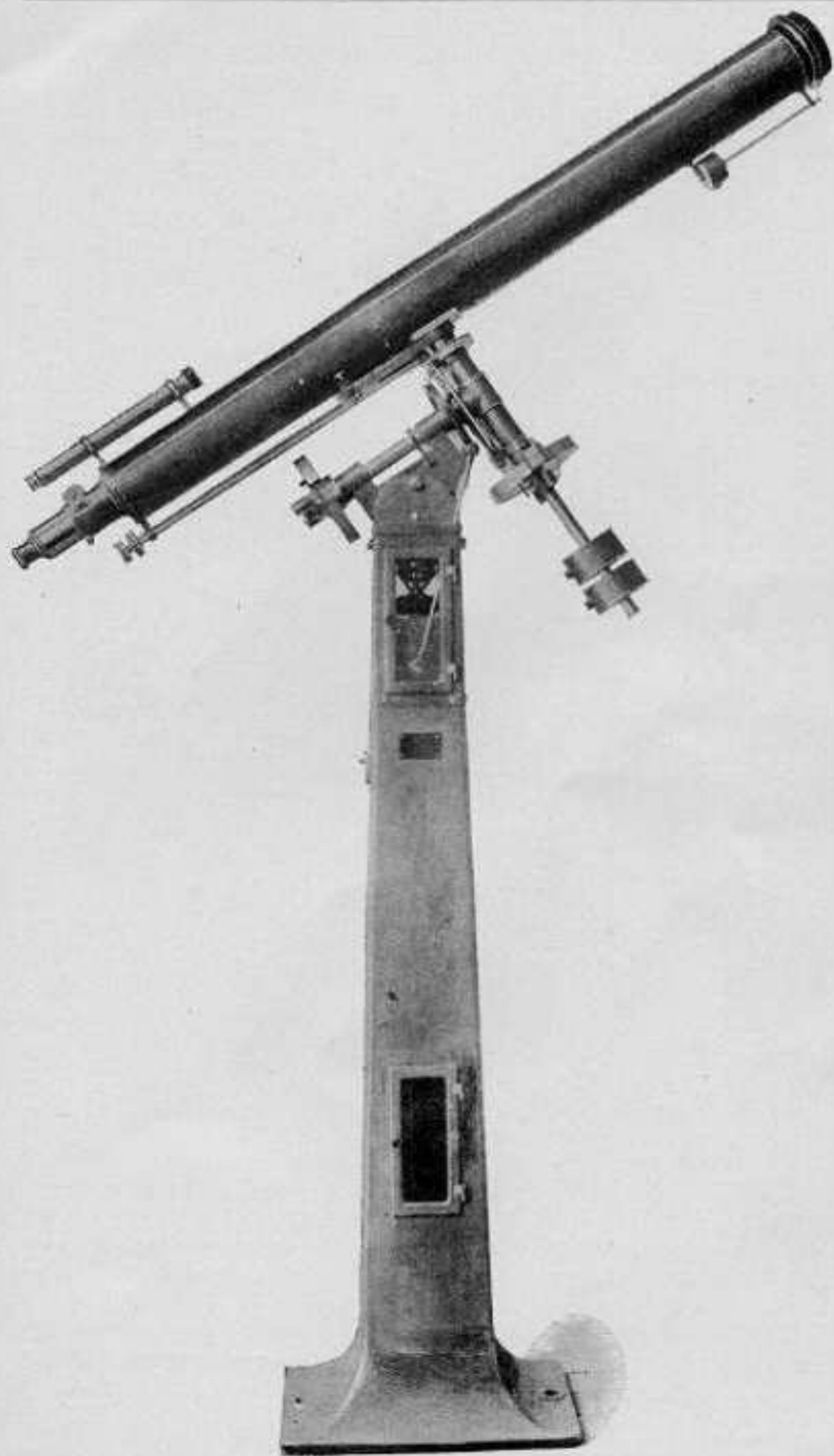


Fig. A 101

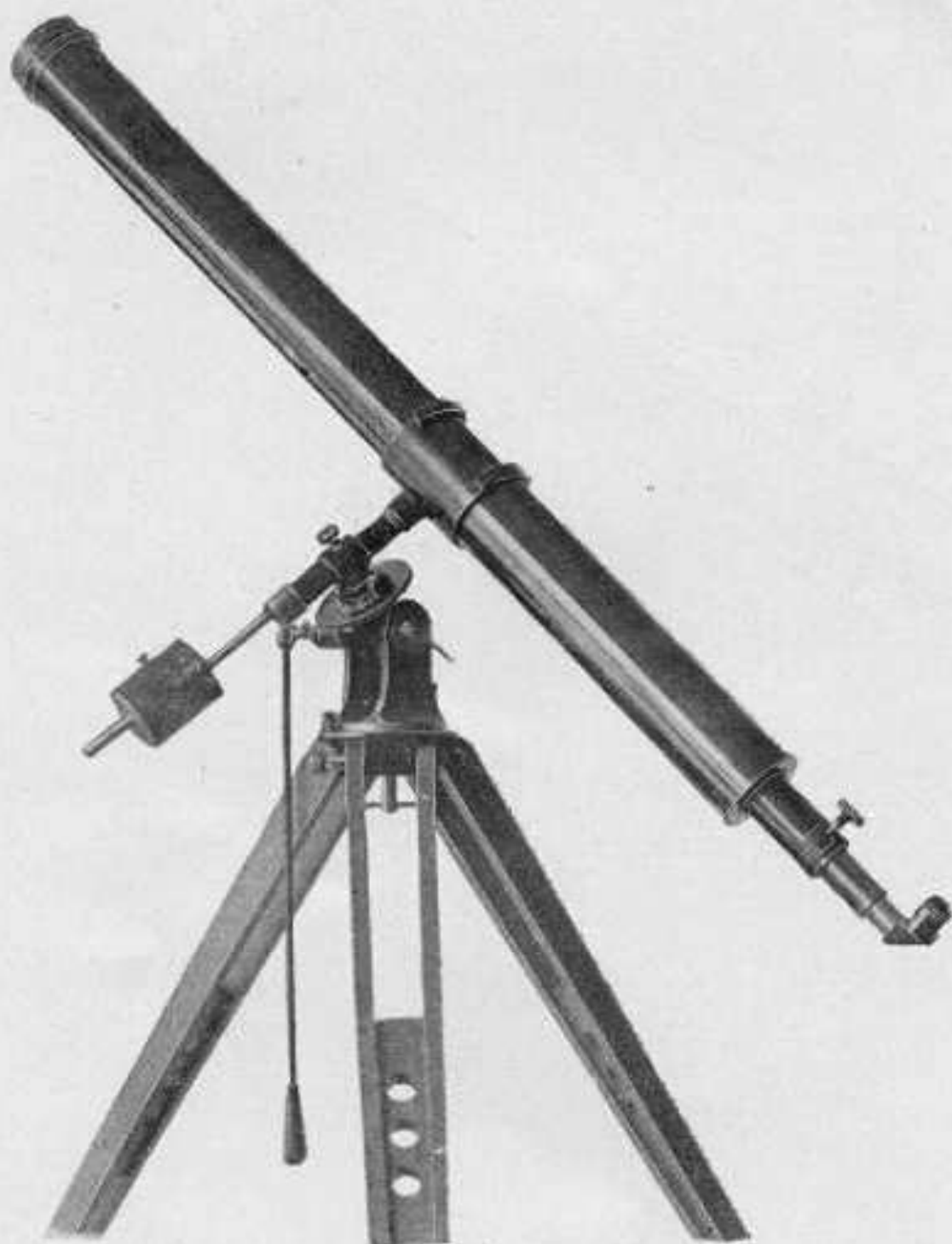


Fig. A. 201

rack and pinion is fitted to the eye end, it gives a motion of about 15 cm. The objective has a focus of 132 cm., is mounted in the most improved manner and provided with means for adjusting. All exposed steel parts are heavy nickel plated, the iron castings are nicely enameled and the brass parts lacquered. The instrument is furnished with three celestial eye pieces, giving magnification of 50, 100 and 150 diameters. All optical parts are guaranteed to be of the highest quality. Price.....\$165.00

ACCESSORIES TO 3½-INCH TELESCOPE.

- Finder to 3½-inch telescope. Price.....\$13.50
 Circle and Vernier, fitted to Polar axis, diameter 15 cm., reading to one minute. Price.....\$15.00
 Circle and Vernier, fitted to declination axis, diameter 15 cm., reading to six minutes. Price.....\$15.00
 Positive Eye Piece (Ramsden), focus 6 to 25 mm.....\$4.50
 Negative Eye Piece (Huygenian), focus 8 to 25 mm.
 Price\$4.50
 Diagonal Eye Piece. The prism of the eye piece has guaranteed optically flat surfaces and will not affect the definition of the telescope. Price.....\$12.00
 Terrestrial Eye Piece, focus 12 to 25 mm. Price.....\$12.00
 Sun Caps, to fit above eye pieces. Price.....\$1.00

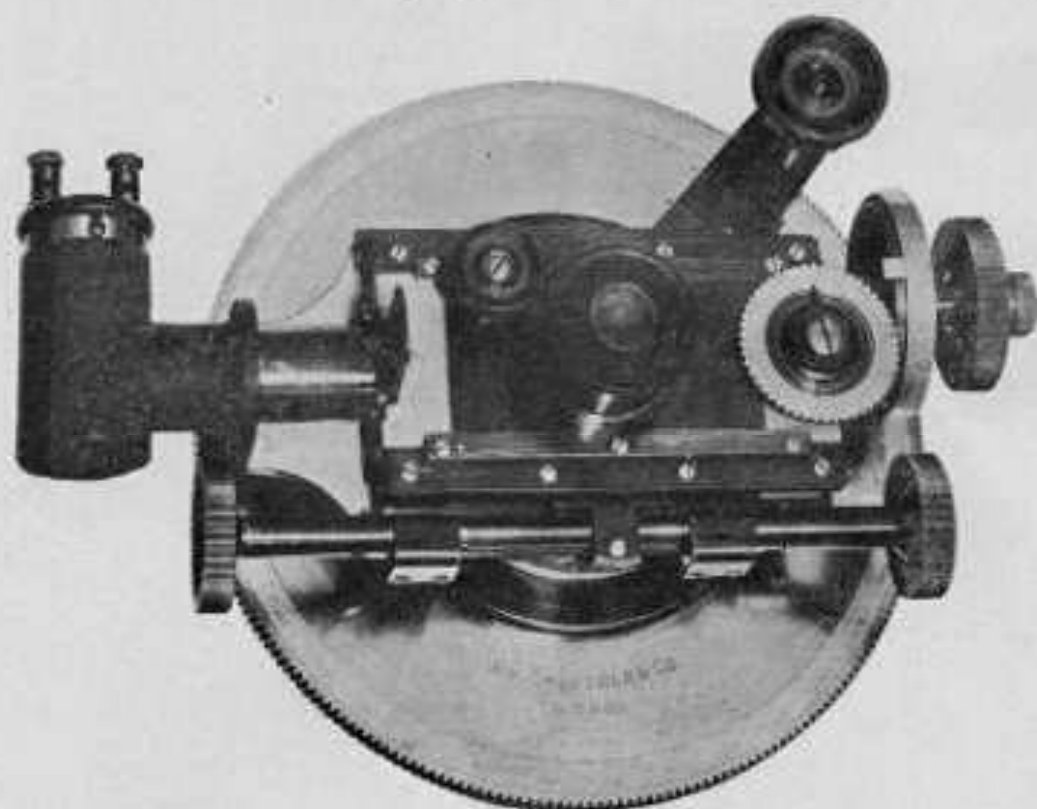


FIG. A 301

- Cat. No. A301. Position Micrometer for 5 to 8-in. Telescopes. (Fig. A301.) Circle 15 cm. diameter, verniers reading to 6 minutes; electrical illumination. (Screw of highest accuracy.) Price\$170.00
 Cat. No. A302. Small Position Micrometer for telescopes from 3 to 4½-inch aperture. Circle reading to single degrees. Price\$65.00

Fig. A450 shows a driving clock for 6-inch telescope, fitted with friction governor and maintaining gear.

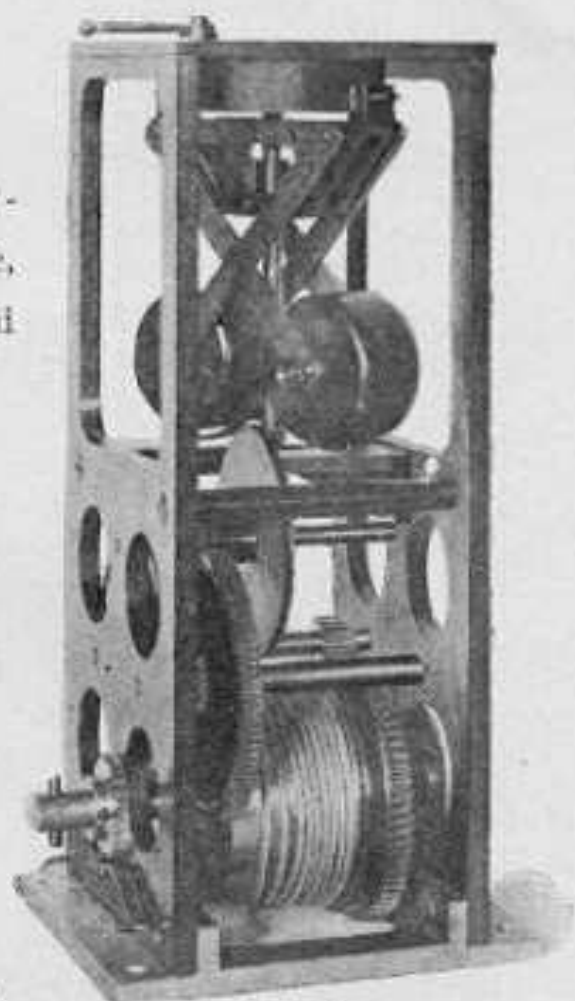


Fig. A 50

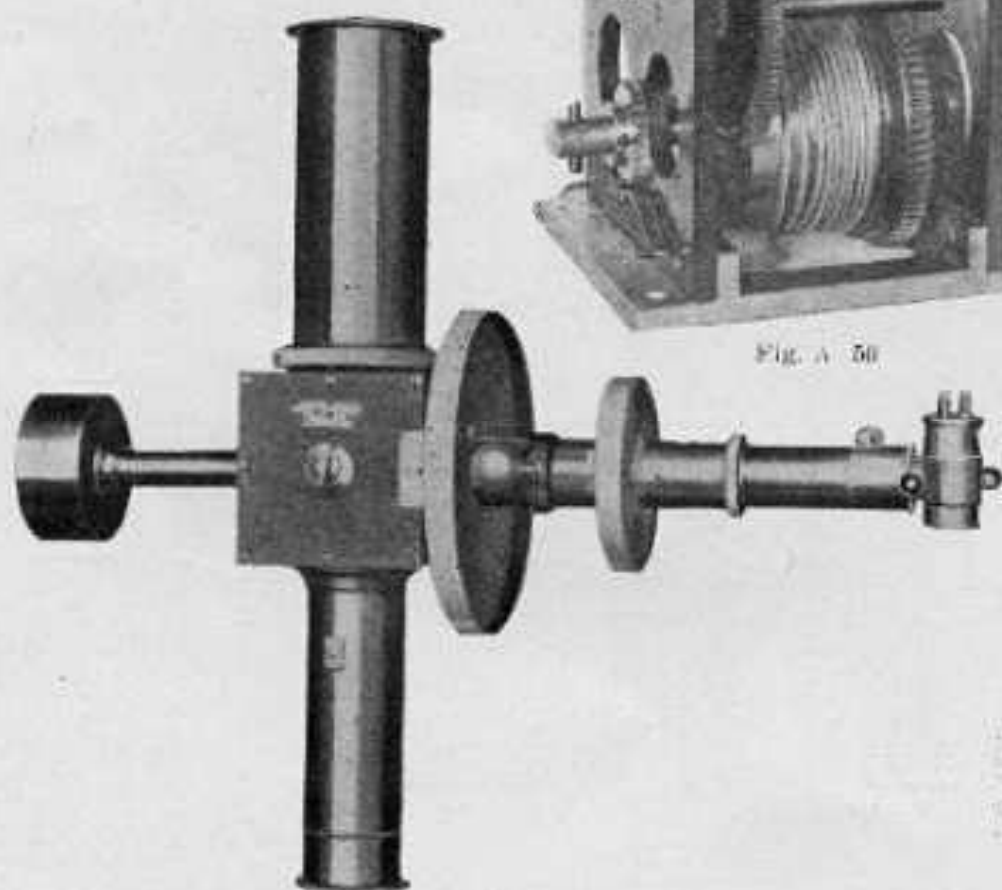


Fig. A 501

Cat. No. A501. Zoellner Astrophotometer. (Fig. A501.) The instrument is made to attach to the eye end of the telescope and may be used with any size of refractor or reflector. An axis parallel to the telescope tube allows the instrument to rotate as a whole. A clamp is provided to hold it in position. The artificial star is formed by a small incandescent

lamp which is adjustable in every direction, and in front of which is mounted a small diaphragm. The color changing device, consisting of nicol prism and quartz plate, is fitted with a divided circle reading to single degrees. The circle revolving with the nicol prism for changing the intensity of the star, has a diameter of 14 cm. and reads by means of two verniers to 6 minutes. A concave lens is mounted in the path of the artificial star to make the light diverging at the proper angle and a parallel plate is fixed adjustable in the center of the box to throw the light in the eye piece. An achromatic objective in front of the eye piece brings the two images of the real and artificial star in focus in the same plane. Price.....\$130.00



Fig. A 510



FIG. A 511

Cat. No. A510. Small Astronomical Spectroscope. (Fig. A510.) Suitable for telescopes from 3 to 6-inch aperture. The collimator and observing telescope have an aperture of 25 mm., focus of 200 mm. Both are fitted with rack and pinion. The spectroscope may be used with a grating or a 60 degree prism, and for this purpose has an opening at the proper angle, in which the observing telescope may be

screwed. A position circle of 75 mm. diameter, reading to degrees, is fitted to the instrument. The slit has German silver jaws and micrometer head for measuring width. The instrument is light, but durably constructed, and well finished. Price, without grating, but including 60 degree prism\$75.00

The spectroscope may be used on a support for laboratory work.

Support for above spectroscope. Price.....\$4.50

Cat. No. A511. Astronomical Spectroscope for larger telescopes. The spectroscope is mounted in a strong but light frame constructed of steel tubing and may be held to the telescope by means of split rings (as shown in cut), or can be fitted with screw adaptor. Collimator and observing telescope have an aperture of 40 mm. and are focused by rack and pinion. The collimator is made to slide as a whole by rack motion in order to focus the slit on the star. The slit is bilateral (Wadsworth), and the slit jaws very carefully fitted. The micrometer head reads to 0.004 mm. A diagonal eye piece is attached behind the slit in order to set the star on the slit. The observing telescope is very rigidly mounted in double bearings, and the eye-end is fitted with a filar micrometer and electric illumination. The circle has a diameter of 160 mm., is graduated on solid silver and reads by means of two verniers to single minutes. The prism is carefully housed and the prism table fitted with arrangement for minimum deviation. The spectroscope is provided with grating and cylindrical lens in front of slit. Price.....\$350.00

This spectroscope may be fitted with electric spark apparatus and camera attachment and can be fastened to a support for laboratory use.

NOTE.—We are prepared to undertake the construction of other astronomical instruments such as Transits, Zenith Telescopes, Spectroheliographs, refractor and reflecting mountings of large size, and shall be glad to correspond with interested parties.

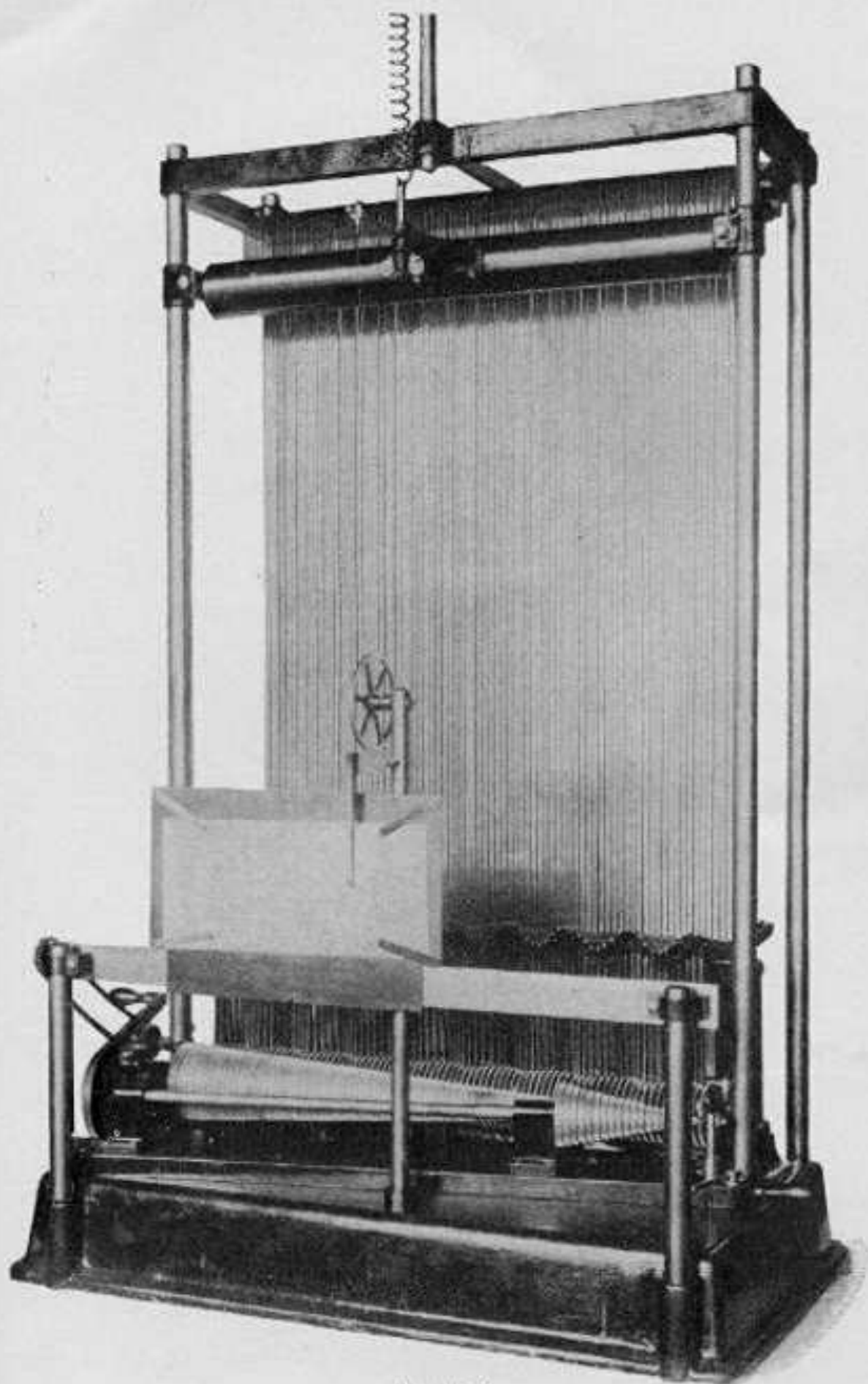


Fig. A 1001

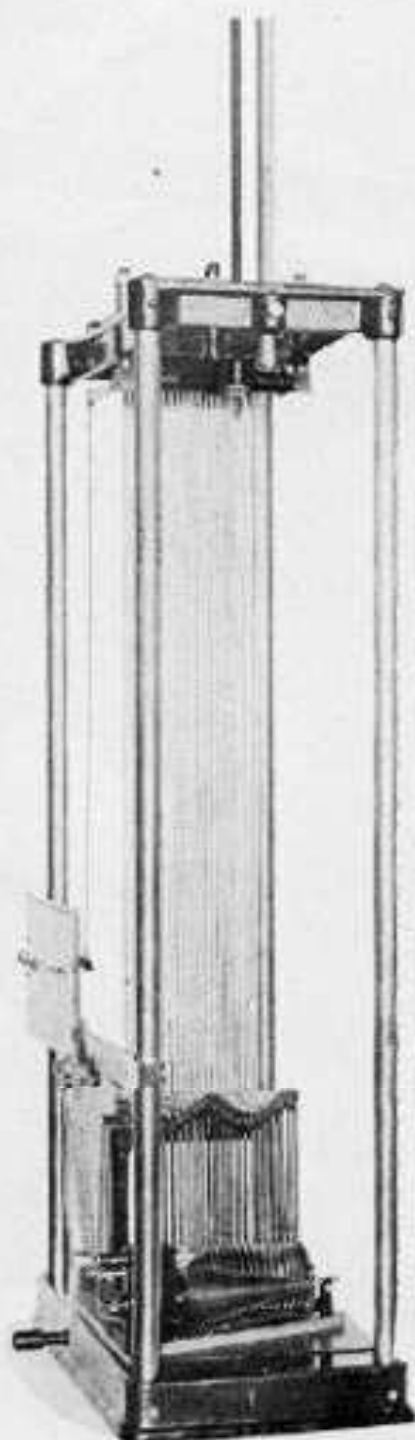
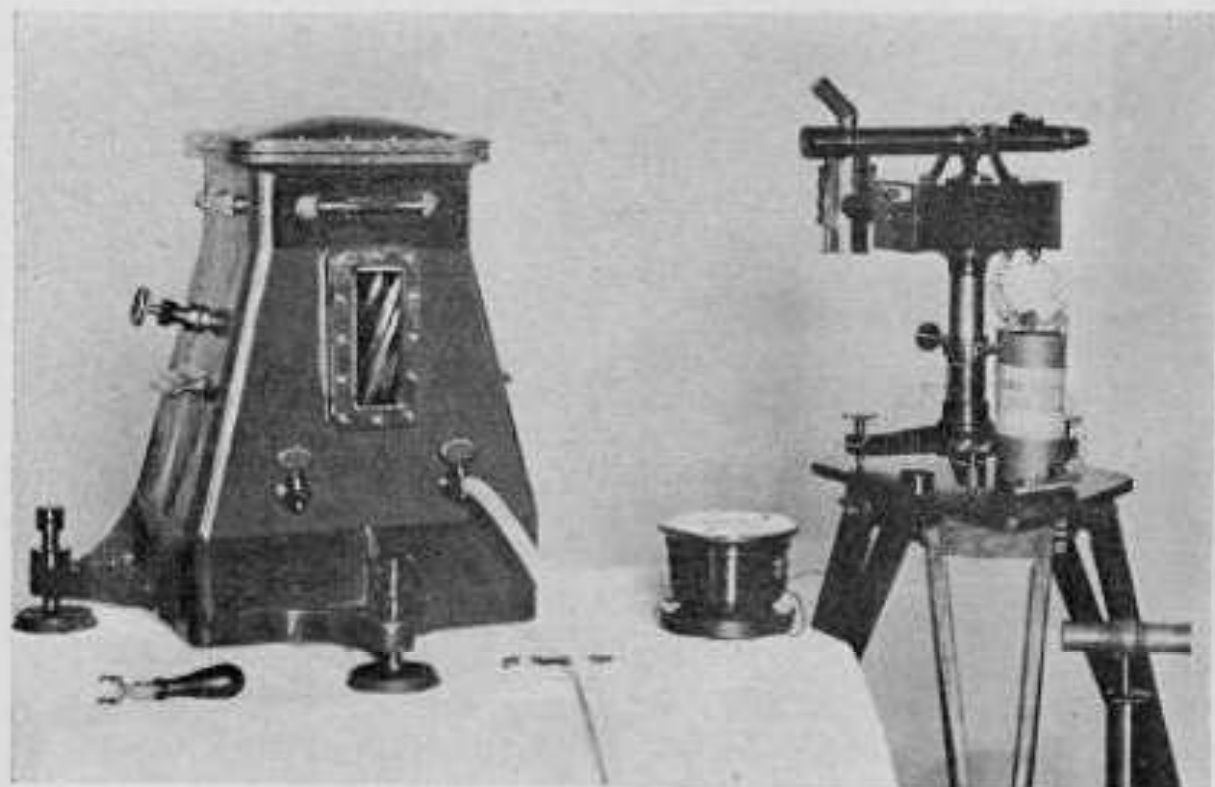


Fig. A 1002

Harmonic Analyzer, designed by Professors A. A. Michelson and S. W. Stratton, *Phil. Mag.*, May, 1898. The apparatus is capable either of drawing the curve corresponding to any Fourier Series, or of determining the coefficients of the Fourier Series, which corresponds to any given curve.

Fig. No. A1001 shows an analyzer containing 80 elements and Fig. A1002 one containing 20 elements.

PENDULUM APPARATUS.



As designed by Professor T. C. Mendenhall for the United States Coast and Geodetic Survey. For details see Coast Survey Report, 1891—Appendix No. 15.

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