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SCIENTIFIC INSTRUMENTS

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Not for the first time is Germany sending a collection of scientific instruments to an International Exposition in the United States; in Chicago in 1893 the apparatus, pertaining to the branches of mathematics and natural science, were shown in the "Deutsche Universitäts-Ausstellung", arranged in the different departments.

At that time special weight was laid on showing apparatus of historical interest and original construction with which the German scientists had made important and, in part, memorable advances in the exact sciences. It is enough to mention under physics the air pump of Otto von Guericke, the instruments of Gauss and Weber, the Kirchhoff spectrometer and the instruments of Helmholtz. Independently of this part of the Universitäts-Ausstellung, the "Deutsche Gesellschaft für Mechanik und Optik" exhibited a large collection of scientific instruments which bore eloquent witness to the progress in the work of the German mechanicians during the last decades of the century.

In preparing the present exhibit, it seemed clear that in the line of physics and related departments no stress should be laid on the historical side, to prevent a repetition of what was shown in Chicago. In this group we have also not attempted to systematically demonstrate the scientific advances in Germany by means of the apparatus used by scientists during the last ten years, since in many cases this apparatus is still in use in other investigations or has been already altered for the purpose of attacking new problems.

It was, therefore, determined to invite the German mechanicians and opticians to show in the "Deutsche Unterrichts-Ausstellung" the instruments which they have placed at the disposal of astronomy, geodesy, meteorology, and pure and applied physics, special stress being laid on the exhibition of *fine measuring instruments.*

While many establishments accepted this invitation with remarkable readiness, a complete representation was hardly to be expected. The prominent manufacturers are by no means all represented, and the exhibits do not always give a correct impression of the many sided products of their shops. Those costly productions of the mechanician and optician, which are made only to order, can in but few cases be procured for exhibition. They can not be removed for so long a time from the scientific institutions to which they belong, and the transportation of delicate apparatus over so great a distance is a matter for hesitation. That, in spite of these difficulties, so large a number of the finest instruments can be shown in St. Louis, is due to the generous support of the Imperial and State authorities.

The exhibition of scientific instruments is (neglecting for the present the Entrance Hall) arranged in four Rooms, A, B, C, D. In general the arrangement is as follows:

A. Astronomical and Geodetic Instruments; Balances; Apparatus for the Measurement of Length;

B. Optical Instruments;

C. Electrical Apparatus;

D. Thermometric and Meteorological Instruments; Scientific Glass Apparatus.

We will take the opportunity to glance over the contents of the different Rooms, and note the more important advances, which have been made in this line of work in Germany since the Chicago Exposition. In special cases it will be necessary to mention objects not shown at all, or of which we have only photographs. On the other hand it is not possible in this cursory survey to mention everything of importance; many interesting new forms of construction or improvements in detail will be evident to the specialist only through an examination of the catalogue itself.

A. Astronomical and Geodetic Instruments; Balances; Apparatus for the Measurement of Length.

Astronomical Instruments. In the department of astronomical instruments the first place must be given to the successful construction in 1899 of the double refractor, made according to the plans of H. C. Vogel for the "Kgl. Preussische Astrophysikalische Observatorium" in Potsdam. A clear photograph gives the visitor a good representation of the instrument. Both of the objectives of 80 and 50 *cm.* diameter are from the glass manufactory of Schott & Gen. (Jena) and were ground by C. A. Steinheil Söhne (München).

It was in this case proved for the first time that for objectives of these dimensions the most careful construction of the theoretically correct spherical surfaces is not sufficient to reduce the aberrations to a minimum, but that a *retouching, carried out according to scientific principles,* is necessary. We will consider the basis of this process more particularly in discussing the optical instruments.

The mechanical portions of the refractor were most satisfactorily constructed by the firm A. Repsold & Söhne (Hamburg). The excellent photograph of the Orion nebula, taken by J. Hartmann, will excite the interest of the specialist, as proof of the capabilities of the instrument. A refractor of the same form as the Potsdam instrument, but in smaller dimensions, was built in 1899 by the same firms for the observatory in Bonn.

Among *photometers* for astronomical use, attention must be called to a *wedge photometer* from Toepfer & Sohn for the observation of bright stars. It is mounted according to the suggestion of Müller and Kempf in the manner of an *équatorial coudé.* The same establishment shows a *microphotometer* according to Hartmann for the measurement of the surface luminosity of very small light emitting surfaces, which has also been found to be useful in the investigation of the sensitiveness of photographic plates.

Instruments for Astronomical Measurement and Geodesy. The most important instrument for astronomical measurement, a meridian circle, is exhibited by Bamberg. A transit instrument from the same maker, furnished as is the meridian circle with a Repsold registering micrometer for diminishing the error of the personal equation of the observer, represents the type of instruments especially developed in the "Kgl. Preussische Geodätische Institut" in Potsdam, and which are used as transit instruments for astronomical time determinations.

The remaining collection of instruments for accurate astro-geodetic measurements, exhibited by Bamberg, Tesdorpf and Wanschaff, and the geodetic instruments of Rosenberg and Tesdorpf can not be considered at all complete, since in this line of mechanical construction Germany has a large number of well known establishments, only a few of which have here exhibited the products of their skill. Among these instruments are the zenit camera, according to Schnauder, which makes use of photography for the determination of time and longitude, and which enables accurate results to be obtained by travellers even when unskilled observers.

A new system of measurement, adapted to many purposes, which is made use of in the Pulfrich *stereo-comparator*, made by Zeiss, promises to be of great importance, especially for geodesy and astronomy. In this the stereoscopic observation and measurement method is used to determine the distribution in space of distant objects, to measure their size or to compare their differences (for example, star photographs of the same portion of the heavens, taken at different times). In the first place, this method is much more economical of time than the ordinary methods, and further, yields a far greater degree of accuracy, especially when the objects to be measured are not sharply defined. The stereo-comparator has already been used in geodesy and astronomy with the greatest success, and it is especially to be noticed that in photogrammetric topography excellent results have been obtained. Great advancement will be made by means of this measurement method, worked out in recent years, in the solution of a large series of problems in the line of measurements of length (as for example, the rapid comparison of graduations), in meteorology (the measurement of the height of clouds), and also in several other lines. Other instruments, making use of the principle of stereoscopic vision, are discussed in the Department of Optics.

Geophysical Instruments. The *pendulum apparatus* with invariable pendulums, which was first used by v. Sterneck in Vienna in this form, for the relative determination of gravity in different places, is of the greatest importance for gravitational measurements. Recently this apparatus has been improved by allowing several pendulums to swing in vacuum. These can be observed during the whole interval between two astronomically determined points of time, so that clock errors are entirely eliminated. An apparatus of this sort, according to Helmert, having four quarter seconds pendulums swinging in vacuum, is exhibited by Fechner. The decrease in amplitude is so small that the pendulum observations can be continued for eight hours.

For the *determination of gravity at sea*, by the comparison of mercury barometers and boiling point thermometers, the ordinary *marine barometer* has been improved by Hecker, so that a symmetrical motion of the mercury in the barometer tubes is attained during the movements of the ship. Such a barometer according to Hecker, arranged for optical readings, is exhibited by Fuess. A similar barometer with continuous photographic registration of the mercury meniscus, which is also in use, can not be shown.

On account of the important advances in thermometry, especially the introduction of Jena borosilicate glass 59^{III}, the use of the *boiling point thermometer* for the determination of air pressures has gained an increased importance. It is especially useful in scientific expeditions for controlling aneroid barometers, for barometric altitude determinations, etc. Two instruments of this kind are shown in Room D, as is also the marine barometer.

A special department of geophysics, *seismology*, has in recent years attracted increased attention in Germany. Among the instruments for this work, the *horizontal pendulum* must be first mentioned. Two such instruments with the pendulums supported on points, according to the construction of v. Rebeur-Paschwitz, are exhibited. One is a complete instrument with registering apparatus according to Ehlert (constructed by Bosch) and is intended especially for earthquake observations; the other is a *model* of a horizontal pendulum, according to Hecker.

The Wiechert *astatic pendulum seismometer* is a new instrument of extraordinary sensitiveness. The pendulum mass itself consists of a weight of 1000 *kg.*, made up of iron plates, which is supported from below by gimbal spring supports. The upper portion of the weights and the whole registering mechanism are exhibited by Bartels. The earth movements are registered with a stylus on smoked paper and have a magnification of 200 times.

Only two pieces of *nautical apparatus* are to be mentioned, but both are of new and interesting construction: the Mensing *deep sea tidal gauge,* and the *compass-reading transmission* from Siemens & Halske. Both are fully explained in the catalogue.

Balances; Apparatus for the Measurement of Length, etc. A large number of German firms are engaged in the manufacture of *balances.* Among those exhibiting are Bekel, Brunnée, Bunge, Hasemann, Schopper, Spoerhase, and Stückrath. The most important instrument in this line is the standard balance for loads of 20 *kg.* (Stadthagen), exhibited by the "Kaiserliche Normal-Eichungs-Kommission", the highest German authority in weights and measures. This instrument, made by Stückrath, enables a mass of 20 *kg.* to be weighed with an accuracy of 1 *mg.* (that is with an accuracy of $^1/_{20\,000\,000}$).

The new large *comparator* of this institution (Weinstein and Kösters), constructed by Heele, serves for the comparison of specimens one, two, and four meters in length. It can be shown here only in photograph (see Appendix). A kind of turn-table is made use of in the moving and interchanging of the troughs in which the rods to be compared rest. The comparison can be made automatically by photographic process. In addition to the illustrations, showing the comparator room, a series of photographs is exhibited, illustrating the principal lines of work in the Normal-Eichungs-Kommission.

Besides balances, a number of large measuring instruments are exhibited. Among these, a *thickness meter*, belonging to the Normal-Eichungs-Kommission, a *cathetometer* from Heele, and a *dividing engine* from Sommer & Runge, both intended for the Physical Institute of the newly established "Technische Hochschule" in Danzig. The model of a Riefler standard clock with nickel-steel pendulum is also shown. The original of this can be seen in the exhibit of the Washington Naval Observatory.

In addition to the purely scientific instruments there are several collections (Riefler, Schoenner) of *drawing instruments*, the manufacture of which in Germany has assumed large proportions; also, of *instruments for accurate measurement in shop work* according to the metric system (Bieling, Hommel); one of the types of calculating machines (Burkhardt); also, photographs of the calculating machines of Leibniz (designed during the years 1640—1672) and that made by the clergyman Hahn (1770—1776), are exhibited.

In connection with this Room, we must not neglect to mention the extremely interesting photographs of the heavens, made by Max Wolf, Heidelberg.

B. Optical Instruments.

Photometric Apparatus. Improvements in the methods of photometry have of necessity accompanied the remarkable advances in methods of lighting during the last decades. The work of the Physikalisch-Technische Reichsanstalt in Charlottenburg (Brodhun, Liebenthal, Lummer), which has produced improvements in the *photometer bench,* in the *photometer* itself and in the ordinary German *light standard* (Hefnerkerze), are shown in part in the exhibits of Krüss and of Schmidt & Haensch. The many varieties of light sources have made necessary the construction of simple apparatus for determining the light intensity in different directions, and also the mean spherical candle power, or light flux, by means of a few observations. The method, used in the Reichsanstalt for photometry at different angles, can be shown only in photographs (see Appendix). A new instrument for the determination of surface luminosity is exhibited by Krüss.

Optical Glass. A portion of the improvements in optical apparatus is due to the work of the Jena glass manufacturers, Schott & Gen., who exhibit the results of their work in this line. The new varieties of glass, made by this firm, have led to the construction of the Zeiss apochromatic objectives which have made possible a more complete suppression of chromatic aberration in microscopes and telescopes than could before be attained. The glass has been long enough in use to show that it is not inferior to the old varieties in durability.

Recently the above glass manufacturers have succeeded in producing a variety of glass *transparent for ultra-violet light*: formerly, as is well known, it was necessary to use quartz or fluor spar. This new success of the Jena glass manufacturers will be of great importance in many lines, to mention only one: a photograph of the heavens, made with an objective of the new ultra-violet transparent glass, shows many more stars and finer details, for the same time of exposure, than one taken with objectives of the old varieties of glass. We also call attention to the exhibit of colored glasses, transmitting only light in a very limited portion of the spectrum.

Methods for Testing Objectives. A remarkable advance in German optics has been produced by the introduction of new and exact methods for the testing of objectives. Formerly the only standard of judgement for the goodness of an objective lay in the comparison of its work with that of similar instruments; for example, in ordering the 36 inch objective for the Lick observatory, comparison was made with the 26 inch instrument of the Naval Observatory in Washington.

By means of the process of *extra-focal* measurements, introduced by J. Hartmann of Potsdam in 1899, it is now possible to make accurate determination of the properties of lenses, mirrors, and compound optical apparatus. The first result, shown by this method of testing, was the already mentioned fact that, especially in very large lenses, it was not enough to give them the theoretically correct form, which could be accurately regulated by means of testing glasses. It was found that it was also necessary, probably on account of the lack of homogeneity in the glass, to correct remaining zonal errors by a *process of retouching*. This retouching, which was formerly an art known to only a few opticians, was thus placed on a scientific basis. The firm C. A. Steinheil Söhne (München) has devoted great energy to the development of this scientific process, so that it is now able to produce objectives of the most accurate finish. The curves, shown in Room A, which represent the zonal errors of the 80 *cm*. objective for the Astrophysikalische Observatorium in Potsdam, *before* and *after* the retouching by Steinheil, are ample proof of the perfection attained.

While the examination of large telescope objectives can be carried out after they are mounted, smaller objectives, especially those intended for photography, can be better investigated on a special *optical bench*. A form of bench, differing materially from the ordinary form, is exhibited by Toepfer & Sohn, and was built according to the plans of Hartmann. In the old method, the image of an object on the bench, or a distant test object, was formed by the objective to be tested, and examined by means of a lens or microscope. In the new method, this arrangement is reversed: the testing object, either a small opening or a system of lines, is placed nearly in the focus of the objective to be tested, and the image is observed by means of a telescopic system. In this way the advantage is gained, that each objective can be tested for that object distance, for which it is intended, even when this distance is infinite, without demanding an excessively long base line. In addition, since the objective of the observing telescope has a longer focus than that of the objective being tested, all aberrations (in proportion to the squares of the focal lengths) are magnified and can therefore be very accurately measured.

Stereoscopic Instruments. Remarkable advances have been made during the last ten years by Zeiss, through making use of the theory of sterescopic vision and by developing the Helmholtz telestereoscope. We have already mentioned the importance of the *stereo-comparator* which represents the most recent development in this line. The *binoculars*, with reversing prisms and with increased stereoscopic effect (prism- and stereo-binoculars), are already widely used. These binoculars and the interesting *stereoscopic distance meter* are shown in the Optical Room.

The study of *interference phenomena* has shown a series of advances, which are largely due to the existence of spectrum lamps of great power, especially the Arons mercury arc lamp in its different forms. We will here mention only the *interference spectroscope*, according to Lummer and Gehrcke, made by Schmidt & Haensch. The apparatus makes use of the interference of the multiple reflections of a ray of light in the interior of a plane parallel plate for analysing the finest components of spectrum lines.

In the field of *polarimetry* there are no special discoveries to be noted. The Exposition shows however (Peters, Schmidt & Haensch), that instrument construction along this line has not been stationary. It is mainly due to the work of Lippich of Prague, the inventor of the widely known half prism polariser, bearing his name, which is used in most of the instruments exhibited, that the polarimeter is now made in accordance with strict scientific principles. The Reichsanstalt, by improving the methods for investigating quartz, has increased the reliability of the instruments for saccharimetric determinations (Brodhun, Gumlich, Schönrock).

Under *microscopy* we must mention in addition to microscopes for different uses (Brunnée, Fuess, Leitz, Toepfer, Zeiss) and microscopic specimens (especially the unique collections of diatoms from Möller), the highly interesting experiments which have led Siedentopf and Zsigmondy to a method of making visible ultra-microscopic particles. This apparatus, exhibited by Zeiss, enables the observer with the help of a peculiar system of lighting to detect particles too small to be seen by ordinary methods.

The *spectrum apparatus,* the *optical measuring instruments,* and the various *articles of Iceland spar etc.* (Halle) are described in the catalogue, as are also the beautiful photographs by Hauswaldt, and his atlas of interference figures of crystals in polarised light.

We must not fail to mention the numerous and extensive researches in *radiation,* a part of which have been pursued along optical lines and have advanced our knowledge of optics. Several "*black bodies*" are exhibited which were used in these investigations. The spectrophotometer, according to Lummer and Brodhun, the rotating sector, and the strip bolometer, form a part of the collection of apparatus used by Lummer and Pringsheim in their researches in the Reichsanstalt. An *optical pyrometer,* which has been produced as a result of the researches on radiation (Holborn and Kurlbaum), we find in a new and interesting use among the electrical measuring instruments exhibited by the Reichsanstalt.

Projection Apparatus. These most essential auxiliaries of modern teaching are represented by several small instruments from Schmidt & Haensch but more especially by the two large pieces of apparatus, shown in the Lecture Room, the *epidiascope* from Zeiss, and the *three color projection apparatus* according to Miethe, made by C. P. Goerz A.-G., Friedenau, Berlin. The visitor will be given an opportunity to judge of the capabilities of these last.

C. Electrical Apparatus.

In Room C the equipment of physical and technical laboratories in the line of the most important electrical and magnetic measuring instruments is shown. Instruments of purely technical interest, such as electric meters, switch board instruments of ordinary form, etc. are not exhibited, since they lie outside the limits of our subject.

In order to better show their methods of use, the instruments are grouped on a series of tables with their necessary auxiliaries, ready for use.

The mirror instruments are exhibited on two shelves, and the other instruments are placed partly in cases, and partly on two switch boards.

Apparatus for Direct Current. We will especially mention here those instruments, which lie at the foundation of direct current measurements and which indicate the work of the Physikalisch-Technische Reichsanstalt in this field. Ed. Weston of Newark, N. J., has given a special impetus to work in this direction: A patent taken out by him has led the Reichsanstalt (Feußner and Lindeck) to the investigation of alloys containing manganese, resulting in the adoption of manganin for standard resistances. The numerous researches of this institution in the construction and constancy of standard manganin resistances, and methods for their exact measurement, especially in the case of very small resistances (Diesselhorst, Feussner, Jaeger, Lindeck) has resulted in the adoption of their instruments and methods very widely in other countries, particularly in the United States. This apparatus is exhibited principally by O. Wolff.

A further important service, which Weston has performed for electrical measurements, is the discovery of the *standard cell* bearing his name. The Weston cadmium element, which is analogous to the Clark element in composition, has been most thoroughly studied in the Reichsanstalt (Jaeger, Kahle, Lindeck, Wachsmuth). As a result of this work in Germany during recent years, the element has come more and more into general use, so that soon, at least in practical work, it will have displaced the Clark element. The development of the Poggendorff compensation method (potentiometer) (Feussner) stands in close relationship with the work on standard cells. Several models of potentiometers are shown.

In addition to this standard apparatus for the measurement of resistance, electromotive force and current (as the quotient of potential difference and resistance), the instruments of the

Deprez-d'Arsonval type for the direct reading of current, voltage, etc. play an important role in direct current measurements at the present time. The construction of instruments of this form here exhibited is again primarily due to Weston. In Germany these instruments are now made in many forms and ranges, and have received various small improvements. In regard to these we must refer to the exhibits of Hartmann & Braun and Siemens & Halske.

The general use of the above instruments is principally due to their insensibility to external magnetic fields. In accurate measurements, which demand the use of mirror instruments, the disturbances in the ordinary form of needle galvanometer from neighboring heavy currents, especially electric railways, have been found to be extremely troublesome. Attempts have been made in two directions to nullify these disturbances, first, by using *needle galvanometers, protected by iron shields* (du Bois and Rubens), and second, by developing the *moving coil galvanometer* according to Deprez-d'Arsonval. Both types of galvanometers are exhibited.

Alternating Current Apparatus. During recent years a marked advance has been made in *alternating current measurements.* Previously, voltage, current, and energy could be measured only by means of the well known torsion instruments, or by current balances which, in addition to their awkwardness in use, were subject to many sources of error. The attempt to produce direct reading instruments, giving correct results for any curve form and any ordinary frequency, has led to the production of apparatus for the measurement of voltage, current and energy, based on the *electrodynamic principle.* Hartmann & Braun and Siemens & Halske both exhibit well damped standard instruments of this sort. Their chief advantage is that a calibration with direct current holds good also for alternating current.

For the measurement of high alternating voltage and heavy alternating currents, *transformers* are now used to advantage in connection with the above instruments. These transformers completely take the place of the series and shunt resistances of direct current apparatus. Since some of the German porcelain factories have been able to produce good insulating porcelain for this purpose, transformers can be made (Siemens & Halske) which permit the highest voltages to be measured without danger by means of low voltage apparatus. In this method the advantage of calibration with direct current is of course lost. This is also the case in the *instruments which rest on the principle of induction*, which have recently been constructed in great numbers. To these belong the Ferraris rotating field instruments, exhibited by Siemens & Halske.

The activity of the Reichsanstalt in this subject has been mainly directed to the development of instruments and methods for testing alternating current apparatus. A double three phase machine, a photograph of which is exhibited, is used as a source of energy. One of the armatures can be rotated in respect to the other by means of a worm gear even when in motion, so that currents with any desired difference in phase can be produced. For the measurements of voltage and energy, electrometric methods have been found most satisfactory, and have been thoroughly investigated (Orlich). A very convenient electrometer, due to Dolezalek, suitable for this kind of work, is exhibited.

Recently an optical method of testing current meters (shown in Room C) has been introduced (Orlich) which makes use of the Holborn-Kurlbaum pyrometer.

In many investigations with alternating currents it is extremely important to know the form of the current curve. The apparatus, intended for this purpose, can be divided into two groups. In one, a dotted curve is constructed, using the Joubert contact disc, with more or less modification in construction. An example of this is the Franke curve indicator (not exhibited). In the other method, the movable portion of the apparatus follows the momentary values of the current and voltage. In this group belong the Braun tube and the Blondel oscillograph. In the Braun tubes (exhibited by Gundelach, Müller-Uri), the deviation of a pencil of cathode rays by means of a coil, traversed by the alternating current, is used to make the current curve visible. The Blondel oscillograph is essentially a galvanometer in which the natural period of vibration is very high in comparison with the frequency of the alternating current. An instrument of this sort is shown by Siemens & Halske.

Instruments for measuring the frequency are important auxiliaries in alternating current measurement. For this purpose vibrating tuned reeds, excited by electromagnets, have been found satisfactory. Such are exhibited by Hartmann & Braun and Lux.

Special attention has been given recently to the apparatus and methods for the measurement of *self induction* and *capacity* in response to the demands of modern telephone and telegraph work (especially wireless telegraphy), and of cable construction. The fundamental researches on the measurement of self induction have been made by Max Wien. The Exhibition shows several pieces of apparatus, resting on his method, from the Reichsanstalt (Orlich) and from Siemens & Halske. Self induction coils, exhibited by this firm for the Pupin system, will excite special interest in the telephone engineer. The different forms of apparatus for producing currents of any desired frequency must be noticed. Among these are the vibrating wire interrupter, the microphone buzzer and the alternating current generator. Of importance are also the standards of self induction, and the self induction variometer. In connection with these, as zero instruments, belong the ordinary telephone, the optical telephone, and the vibration galvanometers. These last are especially valuable for absolute measurements, since they respond only to the frequency for which they are tuned.

For absolute measurements of capacity, a method due to Maxwell and J. J. Thomson has been used in the Reichsanstalt; the combination of instruments necessary for this is exhibited.

For the *magnetic investigation of iron* several forms of measuring apparatus have been constructed during the last ten years which give the magnetisation curve *directly* according to the static method (Koepsel apparatus, du Bois balance, magnetisation apparatus according to Hartmann & Braun). Recently, however, the tendency seems to be to prefer *alternating currents for iron testing*. The improvements in alternating current apparatus, especially in wattmeters, have aided this tendency. In addition, the "Verband Deutscher Elektrotechniker" have fixed their attention on this method for the purpose of establishing a uniform system of iron testing, satisfying the demands of technical work. Two sets of apparatus of this sort, according to Möllinger and to Richter, are exhibited.

Improved apparatus for the *measurement of electrolytic resistance* and for the determination of the conductivity of liquids, according to F. Kohlrausch, which are of especial interest to electro-chemists, are exhibited by Hartmann & Braun.

The electrical methods of temperature determination are described in the following section.

D. Thermometric and Meteorological Instruments; Scientific Glass Apparatus.

Thermometry. The advance in the line of thermometry in Germany during the last ten years is shown with considerable completeness in Room D. The new researches in this direction, which are principally due to the Physikalisch-Technische Reichsanstalt, have had the important object of establishing a well defined temperature scale from -200^0 to $+2000^0$ C. Especially worthy of notice is the development of electrical and optical methods of temperature measurement, which are the only ones suitable for an accurate determination of high temperatures, that is above 750^0 C., while the electrical methods are also becoming more and more important in scientific work for the lower ranges, from 750^0 to the lowest temperatures attainable.

Naturally, the most convenient instruments are *thermometers containing liquids*, since they indicate the temperature directly.

When we enter the region of lowest temperature, the measurement of which has become so important since Linde's discovery of a rational method of liquefying air, we must first mention the *liquid thermometers for very low temperatures*, worked out in the Reichsanstalt. The liquid best suited for this purpose has proved to be commercial pentane (Rothe). These thermometers are exhibited by several firms (Burger, Richter, Siebert & Kühn). Concerning the improvements in the manufacture of mercury thermometers, for the ranges ordinarily covered by these instruments, we must refer to the extensive collections shown by the two last mentioned manufacturers (especially thermometers for deep sea investigation) and also to the exhibits of Fuess, Götze, Greiner, Niehls, and Schultze. The so called "high reading thermometers" (up to about $+570^0$ C.), in which the mercury column is under high pressure, have been developed during the last ten years and have undergone many improvements in detail very recently. *Quartz thermometers,* exhibited by Siebert & Kühn, are worthy of particular attention. These are distinguished by remarkable insensibility to extremely violent temperature changes, are not attacked by most chemical reagents, and can be used for temperatures still higher than can thermometers of the most heat resisting Jena glass, that is to about 750^0 C.

Above this limit, as we have already mentioned, electrical and optical methods of temperature measurement must be used.

Among these, the general use attained by the Le Chatelier *thermoelement* as a result of the researches in the Reichsanstalt (Day, Holborn, Lindeck, Rothe, Wien) is worthy of notice. This thermoelement, consisting of a combination of pure platinum and a 10% platinum-rhodium alloy, suitable for temperatures from $+300^0$ to $+1600^0$ C., is exhibited by Heraeus. In connection with these there is an exhibit of electrical furnaces for scientific use, and of the electrical measuring apparatus, used with the thermoelements, which is shown by Hartmann & Braun and by Siemens & Halske in this department. Recently, registering instruments for thermoelectric measurements have been constructed, which permit the course of thermal operations to be followed conveniently and with certainty.

Another method of electrical temperature measurement rests, as is well known, on the change of resistance in pure metals with changing temperature. *Resistance thermometers* of this type are here represented, first by two *platinum thermometers*, exhibited by the Reichsanstalt, one of which, according to Jaeger and v. Steinwehr, is especially intended for the most accurate measurement of small temperature differences in calorimetry, while the other is a form of Callendar instrument, modified by Rothe, and is to be used especially at low temperatures. For industrial purposes, resistance thermometers of iron wire are much used, especially for temperatures which do not differ materially from the ordinary room temperature. Hartmann & Braun, who have developed the necessary apparatus for this line of work, exhibit several pieces.

Above 1600° C. temperature measurements by the electric methods cease to be practicable, principally because the fire resisting porcelain (for insulating the wires) becomes soft and ceases to insulate. The experimental study of radiation made in Germany recently, especially in the Reichsanstalt, has produced as a side result several forms of *optical pyrometers* (Holborn and Kurlbaum, Lummer, Wanner). These are capable of measuring the highest temperatures, since they do not depend on changes in the physical properties of any material with the temperature, but measure it *photometrically*, using the law of radiation, by viewing the radiating body from a distance. The Holborn-Kurlbaum instrument we have already mentioned in connection with Room C. The two pyrometers of Lummer and of Wanner are not exhibited.

Scientific Glass Apparatus. In close connection with the production of mercury thermometers stands the manufacture of other scientific glass instruments, such as *areometers, chemical graduates, etc.* This industry, in Germany, is carried on principally in Thuringia. Through the work of the Normal-Eichungs-Kommission, these manufacturers have been placed in a position to produce accurate graduates, answering all scientific requirements. Articles of this class are exhibited by Greiner and by Schultze. Other manufacturers are engaged in the production of *vacuum tubes* of all kinds. Röntgen's epoch making discovery has naturally proved a great spur to the scientific glass industry in Germany. Not only is there a great demand in Röntgen tubes to be met, but the older forms of apparatus, according to Plücker, Hittorf and Crookes, have attained a new importance for investigation and instruction, and consequently a whole series of new forms of similar apparatus has been produced. Closely related to these, on the technical side, are the *Dewar flasks* for storing and manipulating liquid air. Both lines of work are well represented by the exhibits of Burger, Gundelach, and Müller-Uri. Especial attention is called to a series of Gundelach vacuum tubes which are to be seen in action, showing beautiful fluorescence phenomena on the enclosed minerals, excited by cathode or Röntgen rays.

A new branch has recently been developed from the scientific glass industry in Germany, that is the already briefly mentioned manufacture of *vessels and instruments of quartz.* The homely but, for scientific purposes, exceedingly interesting quartz vessels, exhibited by Siebert & Kühn and Heraeus, will certainly receive the attention of specialists.

Calorimetry etc. Especial small groups represent in Room D the apparatus for *calorimetry* (for the determination of the heat of combustion of solid, liquid or gaseous bodies), exhibited by Peters and Junkers & Co.; also *apparatus for the measurement of high pressures*, among these a pressure balance (Stückrath), pressure pump for testing manometers (Schäffer & Budenberg), *apparatus for indicator testing* (Dreyer, Rosenkranz & Droop), and lastly a photographic registering *furnace gas analyser* (Schultze).

Meteorology. The last ten years have brought to meteorology, besides a series of improvements and amplifications of the ordinary instruments for station observations, an advance in the study of the upper atmosphere. In contrast to the former method of employing mountain stations for this purpose, the investigations are now carried in the "free" atmosphere by means of kites and balloons. This work, which has been laid aside since the 28 celebrated ascensions of Glaisher between the years 1862 and 1866, has received a new impetus from the discovery of the Assmann aspiration thermometer, in as much as this instrument has shown the considerable errors in the early experiments, due to the action of the sun's rays on the thermometer, and affords a means for preventing such errors.

The apparatus for scientific study of the atmosphere, as used at the present time in Germany, is shown in Room D. It consists of kites, rubber balloons, kite balloons, and their accessories, and the instruments for registering meteorological data. A very complete exhibit is made by the "Aeronautisches Observatorium des Kgl. Meteorologischen Instituts zu Berlin-Tegel", assisted by the firms Bosch, Continental-Caoutchouc & Guttapercha Co., Felten & Guilleaume, Fuess, Riedinger and Rosenberg.

The aspiration principle now lies at the foundation of all instruments, made for temperature observation in balloon experiments; in fact, the International Aeronautical Commission in 1898 prescribed the use of aspiration thermometers for observations, made in international simultaneous balloon ascensions.

The French scientists Hermite and Besançon first introduced the use of small free balloons (*ballons-sondes*) for carrying up registering apparatus to heights inaccessible to men, that is, above 11 *km.* (Berson and Süring in the year 1902 reached the greatest height, 10800 *m.*). By arrangements for screening off radiation, and making use of the natural ventilation during the ascent and descent, this method has been improved in a marked degree. The Assmann rubber balloons of from 2 to 3 $m.^3$ capacity, whose velocity increases until the greatest height is reached, have repeatedly lifted registering apparatus to a height of 20000 *m.* and have yielded almost completely radiation-free records of the air temperature. The especially light and sensitive registering apparatus necessary for this purpose, designed by Assmann and by Hergesell, is exhibited by Fuess and by Bosch.

The method introduced by Rotch of using kites for raising registering apparatus has been copied everywhere and has resulted in the construction of many forms of such apparatus. Among these, one has recently been introduced by Assmann, which has several advantages over the former instruments of Richard of Paris and Marvin of Washington. In calm weather, which makes the use of kites impossible, the kite balloon, designed by von Sigsfeld and von Parseval, is used to advantage. With the above mentioned apparatus, the Aeronautisches Observatorium has found it possible to make daily ascensions, without a break and in all kinds of weather, since October 1902. The results of these ascensions are shown in 12 large diagrams, giving a representation of the vertical distribution of temperature above Berlin for the year 1903, up to a height of 5500 *m*. A complete account of the ascensions made from Berlin between the years 1891 and 1898 through the generosity of Kaiser Wilhelm II., are contained in the three volume report of Assmann and Berson, here exhibited. The Aeronautisches Observatorium exhibits also both of its publications.

Apparatus for the Study of Atmospheric Electricity. After the numerous theories concerning atmospheric electricity, which have been advanced in recent years, had led to no satisfactory conclusion, Elster and Geitel of Wolfenbüttel introduced a new method of investigation. They attempted to apply the ionic theory to the problem and made observations in balloons and on mountain peaks. Among the pieces of apparatus, designed for this work and exhibited by Günther & Tegetmeyer, the aspiration apparatus for the measurement of the electrical conductivity of air, designed by Ebert of Munich, is of especial interest. In this the number of free ions in the air is determined. For this purpose a measured quantity of air is drawn between the plates of a charged cylinder condenser so that all the ions, contained in the air, are deposited on the plates. A modification of this instrument due to Gerdien is shown in a photograph (see Appendix).

Terrestrial Magnetic Instruments and Meteorological Apparatus (in the narrower sense). Recent improvements in terrestrial magnetic instruments have been due largely to the late Prof. Eschenhagen of Potsdam. Especially good results have been obtained in the "Magnetische Observatorium" in Potsdam from his registering declination variometer, his highly sensitive magnetic balance and accurate registering apparatus. Several of these instruments are exhibited by Toepfer. In addition, the standard magnetic theodolite of the above mentioned observatory, made by Bamberg, an inclinatorium from Tesdorpf, as well as a small instrument designed by Ebert, which is principally intended for magnetic orientation during balloon ascensions, are all worthy of notice.

Among the *meteorological instruments proper*, the Sprung photographic "Wolkenautomat" for determining the height of clouds and the velocity and direction of their motion, is shown only in a photograph. Among the other Sprung-Fuess designs an apparatus for registering precipitation and evaporation, made on the principle of the sliding weight balance, is exhibited, also a wind gauge for remote stations that registers the velocity and direction of the wind for one year. A rain meter, designed by Hellmann and constructed by Fuess, in which the float is connected with a registering pen, is also of interest. This apparatus has found an extensive use in the numerous Prussian rain stations, especially along the river bottoms subject to floods.

Apparatus for Instructional Purposes. Besides the instruments shown in Rooms A—D, there are a number of cases, containing demonstration apparatus for use in the higher institutions of learning, arranged in the Entrance Hall (Hartmann & Braun, Kohl, Leppin & Masche). This branch of the manufacture of physical instruments has especially shown a marked development during the last ten years in Germany. If this is not made evident from the size of the exhibit, it must not be forgotten that the chief object of this Section was to show *instruments for measurement*. Moreover, it is difficult to draw a sharp line of demarkation between the two varieties of apparatus, many of the pieces shown in the Rooms A—D might just as properly have been counted as demonstration instruments. All the glass demonstration apparatus was intentionally placed with the other scientific glass instruments in Room D.

Other material for instruction in physics, especially for use in the public schools, is to be found in the "Section of Elementary and Advanced Education."

In this connection we would call attention to the equipment of the Lecture Room, exhibited by M. Kohl. This is of interest as representing the type of equipment found in our "Hochschulen". The two large pieces of projection apparatus shown in this room have been already mentioned.

Photographs. To complete the picture of the present condition of the scientific instrument industry in Germany, presented by the apparatus exhibited, a large number of photographs of various scientific institutions are shown. 64 pictures of single instruments, collections of apparatus, laboratories etc. from seven different state institutions, are mounted on a revolving stand.

Especially interesting are the large photographs of some of the buildings of these institutions, taken by the "Königl. Messbild-Anstalt" of Berlin. These, in connection with the water color of the Physikalisch-Technische Reichsanstalt, decorate the walls of our Section.

The "Appendix" to this catalogue contains a complete list of these pictures.

In order to obtain a more complete view of the activities of Germany in the manufacture of scientific instruments, it will be necessary to take account of the exhibits in other German Sections, especially those of "Chemistry" and "Medicine", since it is not possible, and has not been attempted, to draw a sharp line between these many sided subjects.

The careful observer will everywhere perceive the close connection and interaction between science and the production of scientific apparatus. We here refer only to the impetus which the manufacture of instruments has continually received from the scientific state institutions often mentioned above, as well as from the numerous universities and "Technische Hochschulen". On the other hand, several of the manufacturers, exhibiting in our Section, have shown how such manufactories, conducted in a scientific spirit, can advance the cause of science.

It is to be hoped that the exhibit of scientific instruments in the German Educational Exhibit in St. Louis 1904 will show many new things even to those visitors who had the opportunity of studying this branch of German industry in Paris in 1900, and will confirm the impression that science and the manufacture of scientific instruments are showing gratifying further development in Germany.

The organization of the "Section of Scientific Instruments" was placed by the "Reichskommissar" for the Worlds Fair in St. Louis and the "Königlich Preussische Unterrichtsverwaltung" in the hands of the undersigned.

Able assistance has been rendered by the following commission:

Geh. Regierungsrat Prof. Dr. Assmann (Berlin), Prof. Dr. Brodhun (Charlottenburg), M. Fischer (Jena), W. Haensch (Berlin), Prof. Dr. Hartmann (Potsdam), Prof. Dr. Hecker (Potsdam), Dr. H. Krüss (Hamburg), Dr. Orlich (Charlottenburg), Prof. Dr. Raps (Berlin), Regierungsrat Dr. Stadthagen (Charlottenburg), Geh. Regierungsrat Prof. Dr. Warburg (Berlin), Prof. Dr. Westphal (Berlin), Prof. Dr. Wiebe (Charlottenburg).

A special working committee, which was of the greatest assistance in the preparation work and especially in preparing this introduction, consisted of the following:

Assmann, Brodhun, Hartmann, Hecker, Orlich, Stadthagen, Wiebe.

Dr. H. A. Krüss has charge of the Section in St. Louis.

St. Lindeck,
Professor at the Physikalisch-Technische Reichsanstalt.

Description of Instruments,

arranged alphabetically

according to the Exhibitors.

Aeronautisches Observatorium
des Königl. Meteorologischen Instituts in Berlin.

No. 1—15 in D.*

1. Five folding Kites for Carrying Registering Apparatus, made in the Aeronautical Observatory.

a) Curved surface Hargrave kite, area 7 m^2., model from the Blue Hill Observatory, Boston, Mass. Curved surface of magnalium; elastic bridle according to Helm-Clayton.

b) Flat surface Hargrave kite, area 6 m^2., for stormy winds, with opening above for attaching the registering apparatus.

c) Flat surface Hargrave kite, area 4 m^2.

d) Flat surface Hargrave kite, area 2 m^2., built of aluminium tubing.

e) **X** kite, area 5 m^2.

The upper numbers on the kites denote kite area, under these, weight of the kite, and at the bottom weight per *sq. m.*

2. Model of a Kite-Balloon, volume 5 m^3., according to v. Parseval and v. Sigsfeld, exhibited by the balloon manufactory of A. Riedinger in Augsburg.

The volume of the kite-balloon used in the Aeronautical Observatory is 68 m^3., and it is filled with hydrogen. The rear third of the cylindrical balloon which is made of rubber-filled cotton stuff is separated from the rest of the balloon by a ballonet which is filled with air by the wind through an opening in its lower surface. A valve of cloth prevents the air from escaping. The pressure of the air thus forced in is communicated to the gas and gives the balloon a rigidity that enables it to act as a kite. Even in very stormy winds it is

* Concerning the different rooms, see introduction.

hardly ever forced below an angle of 30—35°. The steering sack, which is also automatically filled with air, and the tail, which is composed of wind funnels, serve to diminish side motions.

3. Model of a Kite Windlass, designed and made by C. Staamann jun., Reinickendorf-West.

The steel wire or cable, before being wound on the drum, passes in four turns around two connected pulleys, arranged to relieve the strain. Power is furnished by an electric motor with a variable resistance in its circuit. In the Aeronautical Observatory a 6 horse-power direct current shunt motor is used.

4. Five Rubber Balloons, according to Assmann, for carrying registering apparatus to a height of 20000 *m.* Manufactured and exhibited by the Continental-Caoutchouc- & Guttapercha-Company in Hannover. Also 2 silk parachutes and 2 balloon valves.

The balloons, of from 1200 to 2000 *mm.* diameter, are made of Para-rubber; the weight is from 1365 to 3230 *g.*; the volume 1 to 4 m^3. They are filled with pure hydrogen and closed. A rubber balloon filled in this way and allowed to rise increases its volume until it bursts. This happens, in general, when its natural diameter is increased about 2·5 times which corresponds to an increase in volume of 15·6 times. The corresponding air pressure is 50 *mm.* which is attained at a height of about 20 *km.* The apparatus falls unharmed to earth, supported by a parachute, which is spread above the balloon. These are made in bright colors that they may be more easily found.

For ascensions up to 8000 *m.* a light spring valve is inserted in the filling tube, which is opened automatically by means of a cord in the interior of the balloon when the balloon has expanded until its diameter is equal to the length of the cord. The gas escapes under the elastic pressure of the rubber only until the balloon has reached its natural diameter, and the balloon then sinks slowly to earth. Since the balloon does not burst a parachute is not necessary, and it can be used for four or five ascensions as the rubber is not overstrained. The great advantage of the rubber balloon over others is that it never reaches a position of equilibrium in which the natural ventilation due to the vertical motion ceases so that the thermometer is affected by the solar radiation. The average velocity in ascending and descending is about 5 *m.* per sec., thus an ascension of 15 *km.* is finished in 1 hour and 40 minutes. This prevents the balloon from falling at any great distance from the point of departure.

At times two balloons, filled to different degrees with gas, are connected in "tandem" so that after the bursting of the larger balloon the other serves to bring the apparatus down and is of use as a signal in its recovery. It also serves as a float if it falls in the water. Accompanying these advantages are the disadvantages that the descent is much slower, and consequently the apparatus may be carried a long distance horizontally and in windy weather injured by being dragged along the earth. It is also possible that *both* balloons may burst in which case of course the apparatus is ruined.

5. Registering Apparatus for Kites, with new Anemometer, according to Assmann, designed in the workshop of the Aeronautical Observatory, made and exhibited by R. Fuess, Steglitz.

A vertical tube of polished aluminium, bent forward above against the wind, and backward below, contains a circular thermometer element, made by soldering a strip of Guillaume nickel steel (mark "Invar") to a similar strip of copper. The large difference in expansion of the two metals produces a considerable motion of the free end of the open ring. This motion is enlarged by a nickel steel lever and transmitted to a registering pen which is held by a silk thread stretched between two pulleys. In the same way the motions of a hair hygrometer, situated in the same tube, and of a set of three aneroids are recorded. A powerful clock-work draws the thinnest possible register-paper from a magazine-roller above and winds it on a roller below. The length of the paper is 1·5 *m.* The registering pens stand one above another, so that almost the whole width of the paper is used. The coordinates of the curves are at right angles. The temperature is registered in red, the pressure in violet and the moisture in green ink. A blotting roller prevents the blotting of the curves. At one edge of the paper 10 minute time marks (1 min. = 1 *mm.*) are recorded, on the other edge the wind velocity is recorded, a mark being made after every 9800 revolutions of the Woltmann fan in the anemometer. This corresponds to 3·21 *km.* The anemometer is situated in the upper part of the protecting tube. A magnalium case prevents the entrance of rain and serves to fasten the apparatus in the front part of the kite. The back wall is open to prevent wind resistance. The weight of the apparatus, which according to the length of the registering paper permits of ascensions of 24 hours or more, is 1200 *g*.

6. **Registering Apparatus for Rubber Balloons,** according to Assmann, designed in the workshop of the Aeronautical-Observatory and made and exhibited by R. Fuess, Steglitz.

The arrangement and transmission of the copper-Invar thermometer element, as well as the support of the recording pens on stretched silk threads are the same as in apparatus No. 5. The motion of the registering paper is not produced by clock-work but by the aneroids themselves on account of the change in the air pressure. The recording paper in the form of an endless rouleau is covered with lamp black and is held stretched between two rollers. A third pen, driven by a light clock-work, draws a line across the whole width of the paper every 2 hours. Each of the three curves contains the air pressure as a second element. As it is important to differentiate the curves of ascent and descent, the recording pens are automatically lifted from the paper when the air pressure during the latter reaches 600 *mm*. This also prevents a blotting of the paper in landing and in the transportation of the apparatus. The funnel-like openings of the protecting tube above and below allow a free circulation of the air in ascending and descending. In this way the thermometer and hygrometer are protected from the influence of the rays of the sun. An ascension velocity of 3—4 *m*. per sec. is sufficient to prevent errors from radiation, and the velocity becomes greater than this as the balloon ascends. The time-pressure curve indicates the velocity of vertical motion, and if it is pointed at the greatest height indicates that the balloon has burst. In other cases there is a gradual change of direction. A light magnalium case, provided with a lock and protected against danger in landing by two wicker rings, serves as a protection against rain and careless handling of the finder. An envelope contains a despatch form and the information that a reward will be paid if the case is returned unopened.

The apparatus ready for use weighs 620 *g*.

7. **Balloon Theodolite** (Goniograph), according to Wurtzel, designed and exhibited by Th. Rosenberg, Berlin.

The apparatus is used to follow the flight of balloons whose angular height and azimuth are measured. On account of its large field of vision it can be successfully used also in kite ascensions, especially as the field is very bright.

For further particulars of the construction, see Rosenberg.

8. **Triple Balloon Aspiration Psychrometer,** according to Assmann, designed by R. Fuess, Steglitz.

The rapid changes of temperature and humidity during the vertical movements of the balloon make the observation of the psychrometer over any length of time unreliable on account of the difficulty of keeping the wet thermometer bulbs supplied with water. To obviate this difficulty, the balloon instrument is supplied with *two* wet bulb thermometers which can be read alternately. For very low temperatures (under -20^{0} C.), where the psychrometer becomes unreliable, a hair hygrometer protected from radiation is used. In order to prevent errors a metal plate is placed over the scale of the thermometer last moistened. This plate serves also to reflect light on to the scale when it stands in shadow. The psychrometer, which is hung on a swinging arm at a distance of 1.6 *m.* from the edge of the car to protect it from temperature disturbances due to the observers, is read with a telescope. A balloon car arranged as described is shown in the exhibit of the "Berliner Verein für Luftschiffahrt" in the Transportation Building.

9. **Two Spools of Kite-Balloon Cable and three Spools of Kite-Wire,** from Felten & Guillaume, Karlswerk, Mülheim a. Rh.

The thicker balloon cable consists of 4×4 zinc-plated cast steel wires 0·4 *mm.* in diameter, with a breaking strength of 400 *kg.*; 1000 *m.* weigh 17 *kg.* In the thinner cable, the wires have a diameter of 0·3 *mm.*, and the breaking strength of the cable is 250 *kg.*; 1000 *m.* weigh 11 *kg.*

The kite wire (piano wire) is not zinc-plated. The wire with a diameter of 0·8 *mm.* has a breaking strength of 120—125 *kg.* and a weight of 4·2 *kg.* per 1000 *m.* The 0·9 *mm.* wire has the corresponding values 150—155 *kg.* and 5·3 *kg.*, the 1·0 *mm.* wire 180—190 *kg.* and 6·6 *kg.*

10. **Wire Clamp for Auxiliary Kite,** according to O. Knopp, made in the workshop of the Aeronautical Observatory.

The kite wire passes through a serpentine conical nut. The pull of the auxiliary kite produces so much friction that the clamp will not slip. This clamp offers the great advantage that it can be very quickly put on or taken off, as it is fastened with one screw.

11. Safety-Catch for Kites, according to O. Knopp.

To prevent the breaking of the wire when several kites are fastened to it, some of the auxiliary kites are fastened by means of safety catches. When a certain before-determined maximum stress is reached, the rubber bands stretch so that the movable part of the eye unlatches and sets the kite free.

12. Twelve Sheets of Curves, showing the isotherms above Berlin during the year 1903.

The isotherms are drawn from the unbroken series of observations made in the ascensions from the Aeronautical Observatory. The temperatures above 0^0 C. are represented in red, below -10^0 C., in blue; in addition, the heights of the clouds as far as they were reached in the ascensions are represented by W. ("Wolken"), or cu (cumuli).

13. Reduced Reproductions of the above Curve Sheets, covering 15 months of daily ascensions, with explanatory text. Temperature above 0^0 C. is represented in red.

14. Six Photographs (see Appendix).

15. Variometer for Magnetic Observation in Balloons, designed by Prof. H. Ebert, München.

Two magnet systems are hung, one above the other, on points and have independent arrestments. Under the action of their own forces and the earth's field they stand at an angle with each other which is smaller in proportion to the strength of the horizontal component of the earth's magnetism. The lower needle carries a scale divided in degrees, and the upper a sight, the observation of which in respect to the scale below gives the increase or decrease of the horizontal intensity and in this way indicates the motion of the balloon in respect to the isodynamics. The lower scale serves also as a compass.

Carl Bamberg

Friedenau bei Berlin, Kaiserallee 87/88.

Mechanical and Optical Works.

No. 1—3 in A, No. 4 and 5 in D.

1. Meridian circle on solid Pillars.

Two vertical circles of the same size are firmly attached to the horizontal axis, accurately graduated to $^1/_{30}{}^0$, read by 4 micrometer-microscopes in any position. The circles of this instrument are 650 *mm.* in diameter. Readings are made directly to 1″ by the graduations on the micrometer-head and may be estimated to 0·1″.

The telescope, having a focal length of 1·14 *m.* and a clear aperture of 81 *mm.*, is fitted with a registering micrometer according to Repsold and with movable eyepiece. The achromatic-aplanatic eyepiece magnifies 114 times. The objective and ocular of the telescope may be interchanged without disturbing the illumination of field and cross hairs. The illumination is gained by light thrown into the interior of the telescope through the axis and reflected towards the cross hairs by a mirror in the central cube.

The bearings of the axis may be adjusted horizontally and vertically and are firmly attached to frames supported on the solid pillars. The reading microscopes are carried upon the same frames. The counterpoises, acting at points very near the circles, reduce the pressure on the bearings to a few kilograms. The reversal of the axis is effected quickly and without danger by means of the reversal carriage.

2. Portable Transit-Instrument with Elbow-Telescope (Fig. 1).

The instrument, having a focal length of 0·65 *m.* and a clear aperture of 68 *mm.*, is fitted with a registering micrometer with motion of the eyepiece which may be replaced by a micrometer capable of rotation through 90° (for Horrebow-Talcott observations). A revolution of the micrometer-screw corresponds to 80″. The three eyepieces supplied with the instrument have magnifying powers of 44, 65 and 86. The field is illuminated by means of an electric incandescent lamp or by an oil-lamp; the light is thrown into the interior of the telescope through the hollow rotation axis.

The eyepiece end of the horizontal axis is fitted with two juxtaposed levels for Horrebow-Talcott observations which can be finely adjusted in relation to each other, and whose carriage can be firmly clamped to the axis. The finding circle of 136 *mm.* diameter is graduated to $^1/_6{}^0$ and may be read to 1′. It is fitted with an alidade level.

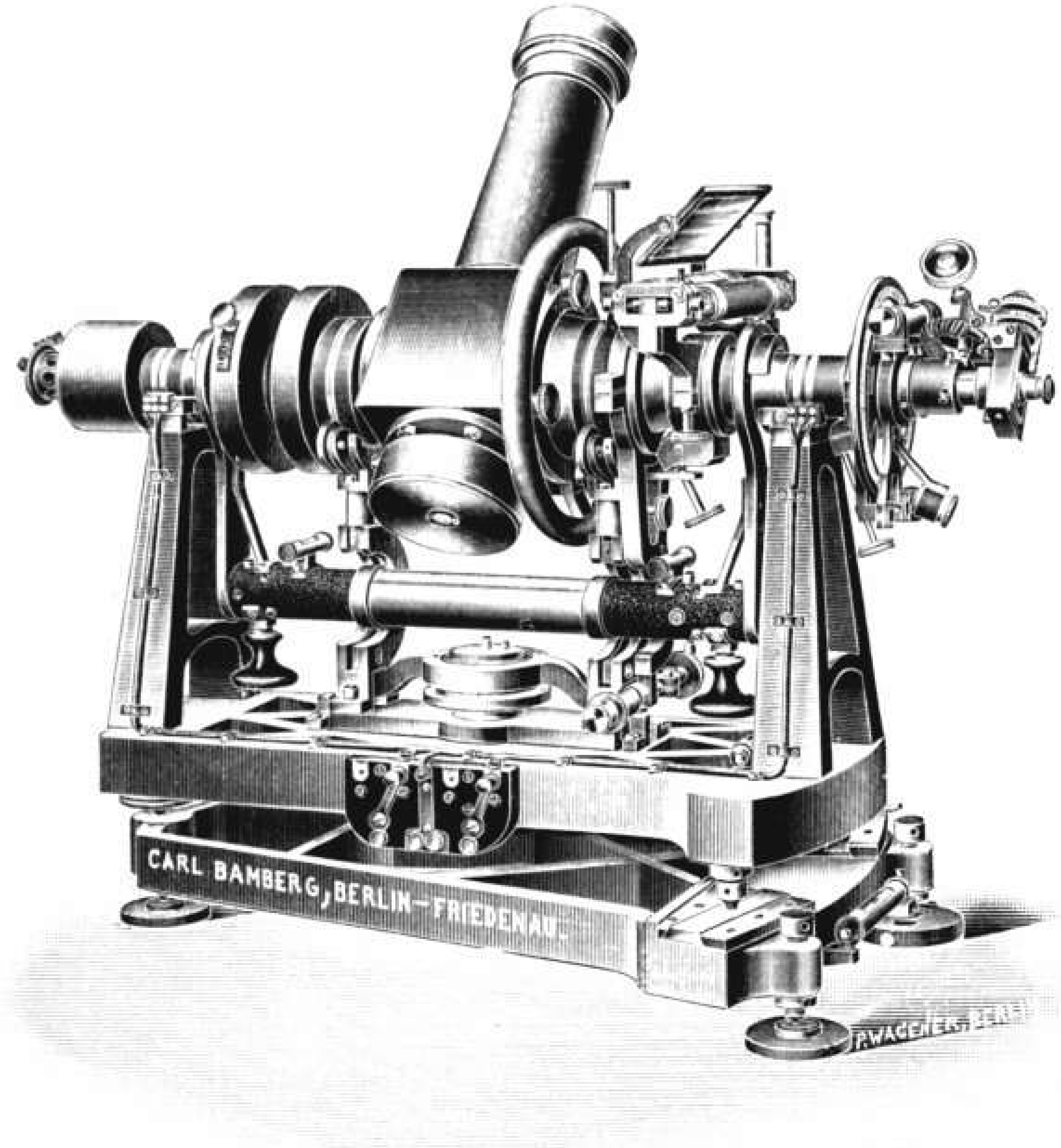


Fig. 1.

The axis can be easily reversed within a few seconds and without danger of disturbing the instrument, the suspended level being left in place. The relief of the axis-bearings is effected by the pressure of a central spring. All the clamps of this instrument are flange-clamps preventing any strain on the axis. This instrument rests on a stand with adjustment in azimuth. The instrument exhibited is made to the order of the "Kgl. Geodätische Institut" at Potsdam.

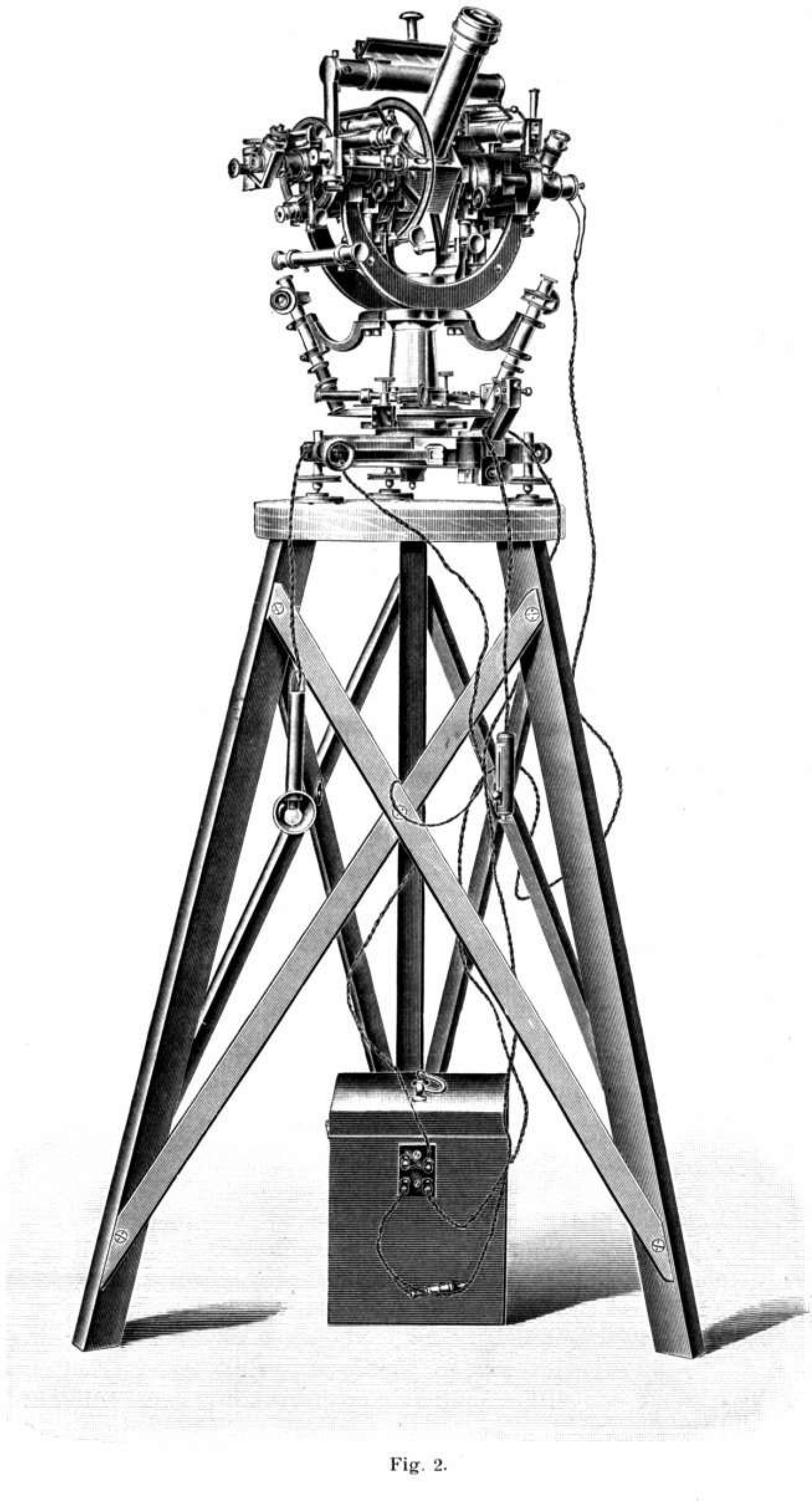


Fig. 2.

3. Universal-Instrument with Elbow-Telescope (Fig. 2).

The telescope, having a focal length 0·43 *m.* and a clear aperture of 40 *mm.*, magnifies 66 times. The horizontal circle has a diameter of 206 *mm.*, the vertical circle of 175 *mm.*

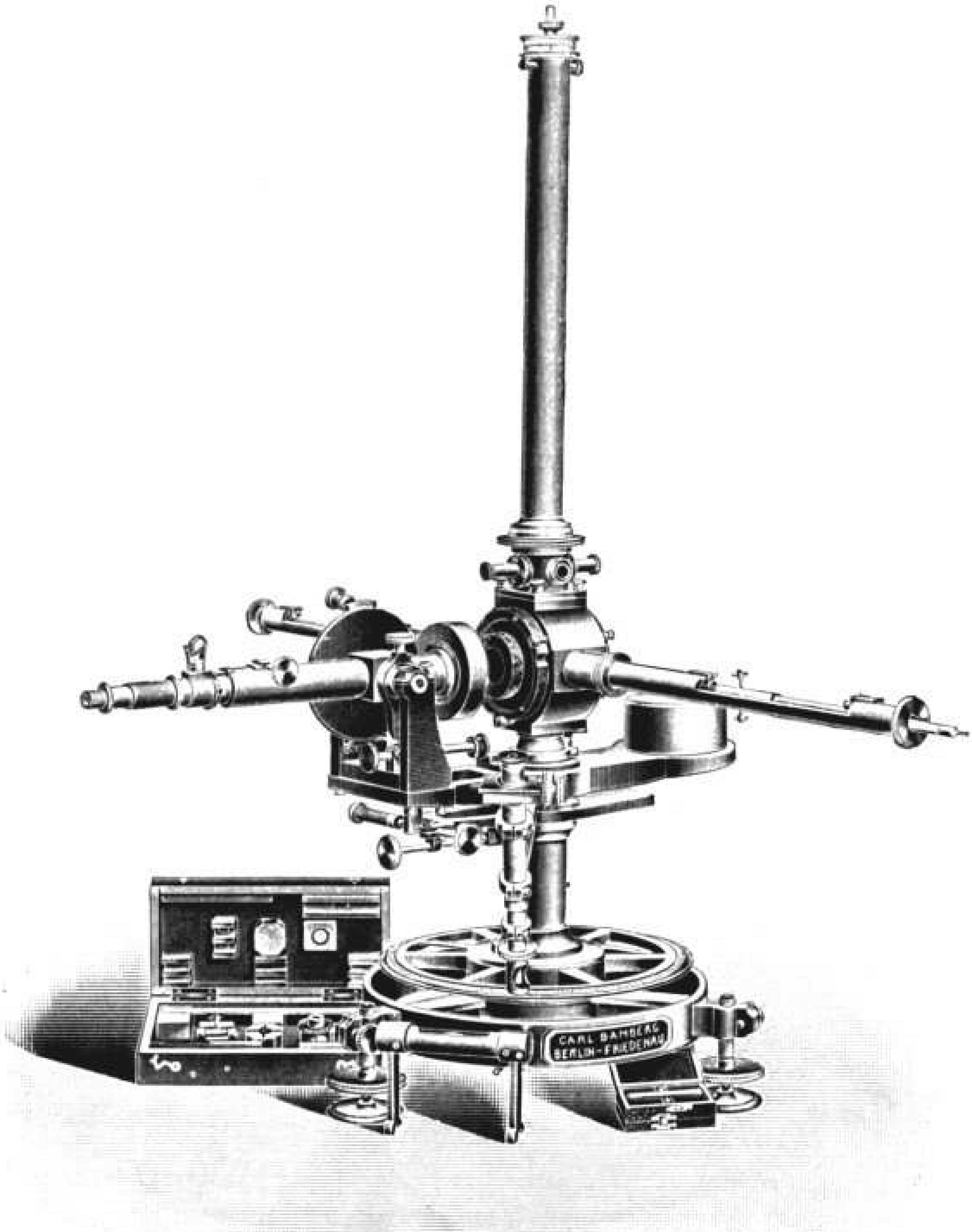


Fig. 3.

Both circles are read by microscopes directly to 5″ and by estimation to 1″. The vertical finder circle of 112 *mm.* diameter allows readings of 1′ by means of a vernier. The finely graduated horizontal circle is fitted also with a rough graduation for quickly revolving the circle to any angle desired. The microscopes reading the vertical circle are carried upon a frame, which is centred upon the rotation axis itself. This frame is furnished with a delicate level and adjustment. For Horrebow-Talcott observations the instrument is fitted with a sensitive level, clamped to the axis and eyepiece micrometer capable of rotation through 90°. A small finder

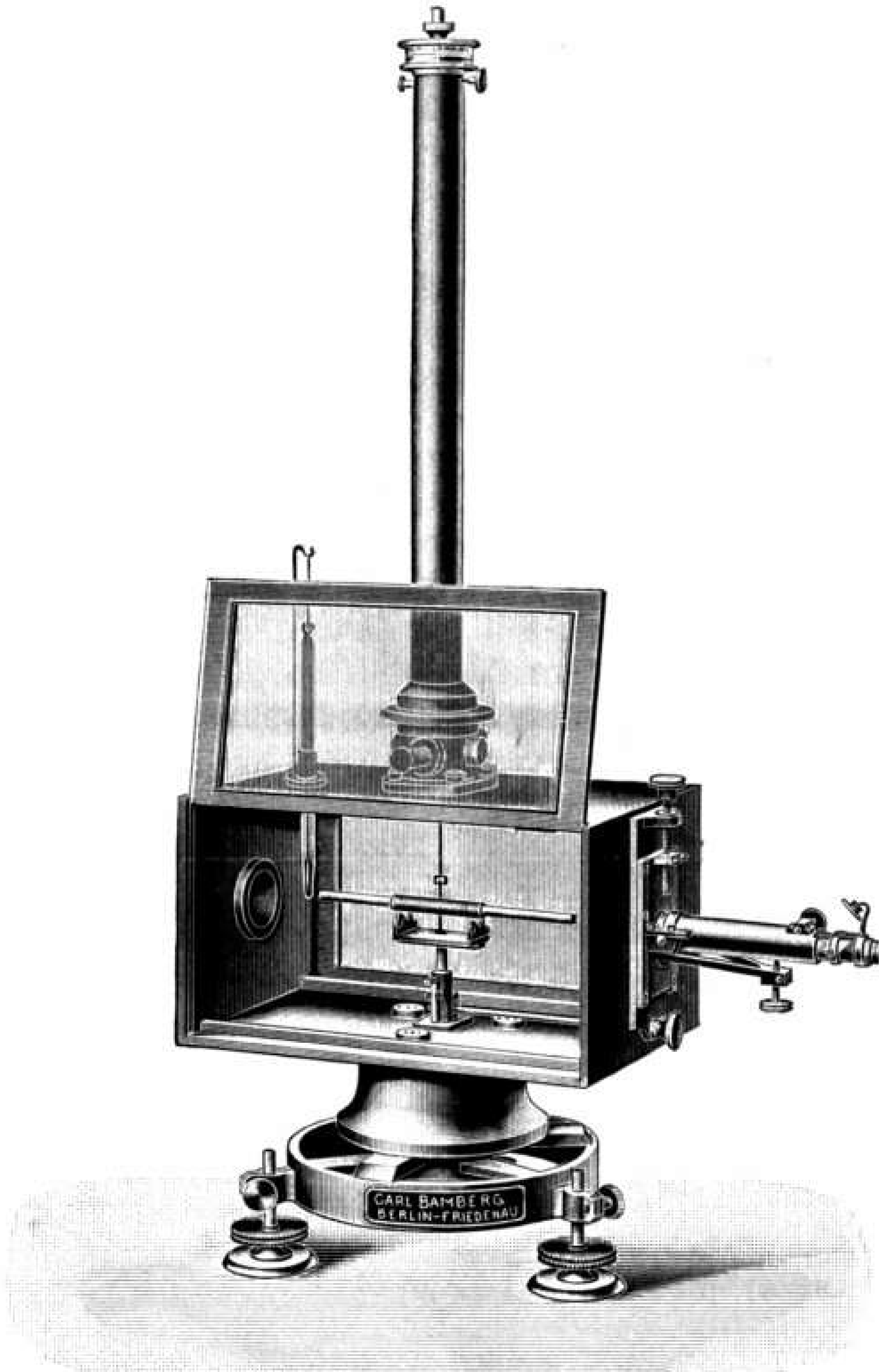


Fig. 4.

is attached to the end of the axis. The field is illuminated by means of oil or an electric incandescent lamp. The horizontal axis is counterpoised by springs. A lever mechanism allows a convenient reversal of the axis in its bearings.

The instrument exhibited is made to the order of the "Kaiserl. Reichsmarineamt" at Berlin.

4. Magnetic Theodolite and large Oscillation-Case for Observatories (Figs. 3 and 4).

The horizontal circle, having a diameter of 270 *mm.*, is read by microscopes directly to 5″ and by estimation to 1″. The circle may be turned. The eccentric collimator telescope of 32 *mm.* aperture and 275 *mm.* focus is fitted with an achromatic microscope-eyepiece with Gauss-System for illuminating the cross-threads. It magnifies 36 times. The vertical circle, having a diameter of 116 *mm.*, is read to 1′.

The magnetometer is in the centre of the instrument and is fitted with two deflecting magnet-rails for sine readings in E.-W.-and N.-S.-positions and with a suspension-tube and arrangement for lifting the deflection-magnet off its suspension and inverting it. The rails which are divided in millimeters have a circular section of 24 *mm.* diameter. There is also a third arm provided with a rotating magnet carriage with a graduated circle. The distance from the center of the deflecting magnet to the center of the instrument may be either 372·4 or 270 *mm.* (Hence the ratio of the distances is 1·33.) The deflection-magnet has a unifilar suspension capable of adjustment in its length. The suspension is attached to a torsion-head. The deflection-magnet has a length of 32·7 *mm.* and is fitted with reflecting surfaces at the ends. The rotating magnet carriage serves for the observation of the action of the magnet in different positions, serving for the determination of its general potential. This makes it possible to make an accurate determination of the horizontal intensity through declination observations at one moderate distance.

The oscillation-case is fitted with suspension-tube with torsion-head and arrangement for inverting the oscillating magnet. An eccentric collimator-telescope, having a focal length of 120 *mm.* and an aperture of 16 *mm.*, fitted with a Gauss-eyepiece is used for observation of very small oscillations (Fig. 4).

The instrument exhibited is made to the order of the Kgl. Meteorologisches Institut at Potsdam.

5. Declinatorium for Land observations (Fig. 5).

The horizontal circle of 130 *mm.* diameter is read by means of two opposite verniers reading to 30″. The declination-system oscillates on pivots and is reversible. The oscillations are observed by an eccentric collimator-telescope and a mirror attached to the magnet-system. The telescope is fitted with the Gauss-arrangement for illuminating the cross-threads.

The instrument exhibited is made to the order of the "Kgl. Institut für Meereskunde" at Berlin.

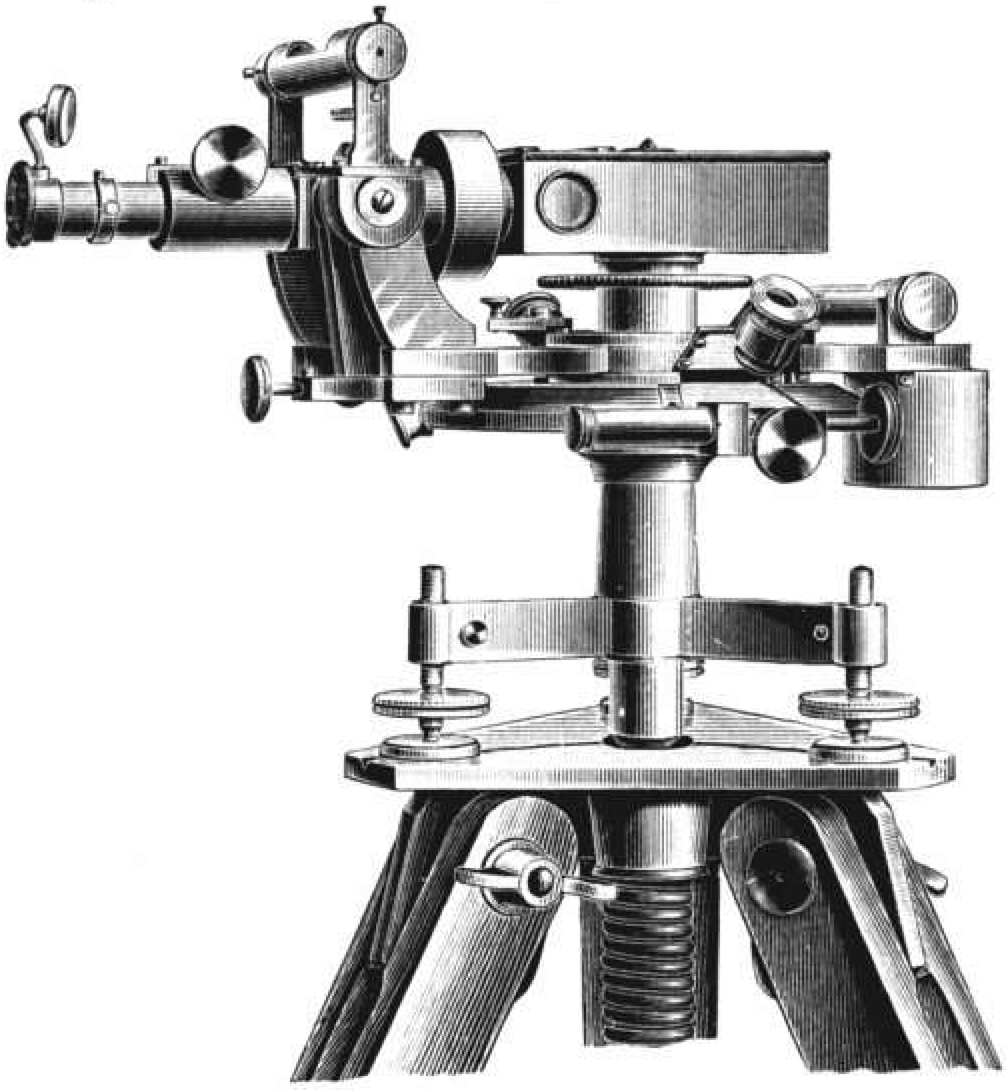


Fig. 5.

Georg Bartels

Göttingen.

Mechanician.

No. 1 in A, No. 2 in C.

1. Seismometer, according to E. Wiechert.

This instrument registers the horizontal earth motions in two components at right angles to each other and gives the greatest possible sensitiveness by means of its mechanical registration on paper covered with lamp black. It is possible to attain an "equivalent indicator lenght" of 10000 *m.* (equivalent to an angular sensitiveness of 50 *mm.* for a second of arc) and a magnification (in the case of rapid motions) of 300 times.

The space occupied is comparatively small as the apparatus is contained in a case 138×176 *cm.* and 186 *cm.* high. The stationary mass is formed by an iron weight of 1000 *kg.* The parts are so connected by means of springs or pivots that the friction is practically zero. A powerful variable air damping makes the vibration of the weight of no account. The ordinary velocity of the registering apparatus is 15 *mm.* per min. For further description, see: *Gerlands Beiträge zur Geophysik **6**. p. 435. 1903; Phys. Zeitschr. **4**. p. 821. 1903.*

The whole registering mechanism is exhibited but only the upper part of the stationary mass of iron, modelled in wood, is shown. Photographs show the appearance of the complete instrument and also the curves registered by it.

2. **Very Sensitive Quadrant Electrometer,** according to F. Dolezalek.
See: *Zeitschr. f. Instrkde. **21**. p. 345. 1901.*

Hugo Bieling

Steglitz bei Berlin, Florastrasse 2.

Mechanician.

No. 1–3 in A.

1. **Screw-cutting Tools** for metric (Loewenherz-), micrometer and steep pitch threads.
2. **Spirally cut counter-sinks.**
3. **Phonometer** (own design).

J. & A. Bosch

Strassburg i. Elsass, Münstergasse 15.

Manufacturers of Scientific Instruments.

No. 1—3 in D, No. 4 in A.

Registering Apparatus for Scientific Investigation of the Upper Atmosphere.

The following pieces of apparatus, designed in accordance with the plans of Prof. Hergesell in Strassburg, are remarkable for their great accuracy and sensitiveness as well as for their lightness. Their thermal capacity is so small that even when the temperature changes are very great they indicate the correct value within a few seconds.

1. Baro-Thermograph for Exploring Balloons *(Ballons sondes).*

This apparatus (Fig. 1) registers continuously the pressure and the temperature on the same drum. The thermometer is more than sufficiently ventilated and protected from radiation by the motion of the balloon itself. The driving mechanism is enclosed in a case for protection against cold. Weight with protecting case 630 *g*. The apparatus can be raised by means of a rubber balloon of 1·5 *m*. in diameter (see *p. 2*, No. 4), to a height of 20000 *m*.

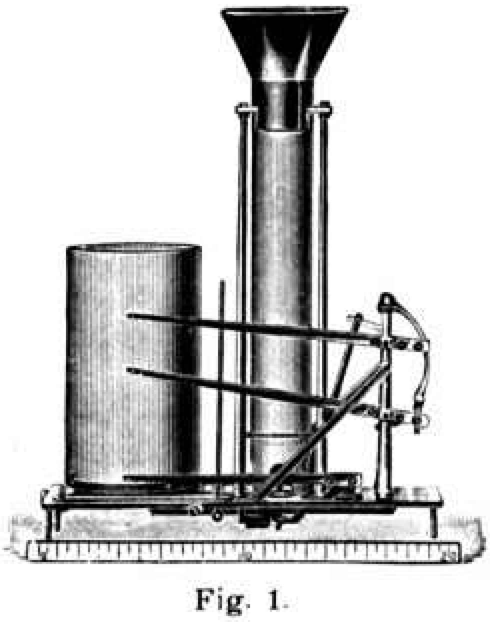


Fig. 1.

2. Baro-Thermo-Hygrograph for Balloon Ascensions.

The apparatus registers the air temperature, pressure and moisture continuously on the same drum. By means of artificial ventilation and protection against radiation the thermometer registers the correct temperature even in the strongest sunshine. The hygrometer is also artificially ventilated. The ventilation may be kept in action for several hours by means of a few galvanic cells or accumulators of small weight. Weight of the whole apparatus 1·6 *kg.* The energy required for the production of artificial ventilation for a year costs only about 50 marks.

The instrument is also constructed without a barometer for use in meteorological stations.

3. Baro-Thermo-Hygrograph for Kites.

This instrument is noteworthy on account of its extreme lightness (weight with protecting case 375 *g.*). The stiffness of the registering springs is great enough so that the curves are not disturbed or made indistinct even by violent motions of the kite. The instrument floats on water in its case. If desired, an apparatus according to our own plans for continuous registrations of wind velocity will be added.

4. Horizontal Pendulum with Photographic Registration.

The photographic registering horizontal pendulums are the most sensitive of all existing instruments for detecting changes of level, since they can be supported almost without friction. They are therefore unsurpassed as seismographs both for distant disturbances and those in the immediate vicinity.

In a small case of only 18 *kg.* total weight a pendulum is hung. Two such cases with a pendulum in each are set up at right angles to each other whereby the direction from which the disturbance comes can

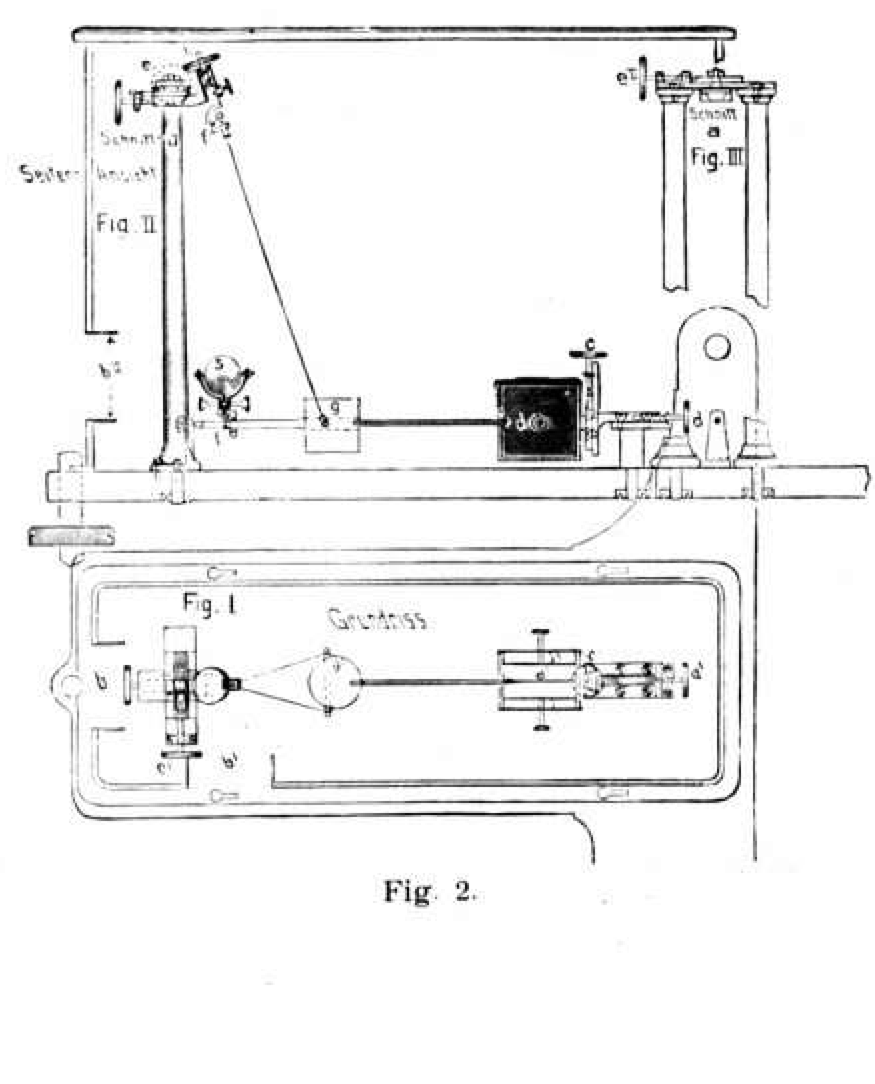


Fig. 2.

be very approximately determined. The motion is recorded with a magnification of 120 times. The registering apparatus runs with a velocity of either 6, 36 or 90 *cm*. per hour. It is to be observed that, even at 90 *cm*. per hour, the amount of bromide paper used is not greater than was formerly the case with a velocity of 12 *cm*., that is, at a cost of about 1 mark per day. This instrument is especially adapted for travelling and for use in mines etc., on account of its convenience and small weight as well as its simple and rapid adjustment. (Fig. 2.)

R. Brunnée (vormals Voigt & Hochgesang)

Göttingen, Untere Maschstr. 26.

Mechanician and Optician.

No. 1—6 in B, No. 7 in A.

1. **Large Microscope No. 1 A,** as designed by Prof. C. Klein, furnished with the best and newest arrangements for careful mineralogical and petrographic investigations. The circular stage is divided to $^1/_2{}^0$ and the vernier reads to 1′. The cross slides which serve for exact adjustment or measurement of the specimens lie enclosed in the circle.
2. **Microscope No. 5,** our own construction after an english model. This microscope is furnished with rotating Nicol prisms instead of a rotating stage.
3. **Chemical Microscope,** as designed by Prof. O. Lehmann. This is intended for the examination of minerals, chemical preparations and organic bodies by direct parallel polarised illumination, and is available for any temperature up to incandescence and also for electrolysis.
4. **Collection of 115 Sections of Petrographically Important Minerals,** as arranged by Prof. C. Klein. These sections are cut according to the crystallographic form.
5. **Collection of 347 Sections of Volcanic Rocks,** systematically arranged according to Prof. Rosenbuschs "Mikroskopische Physiographie der massigen Gesteine, 1896". The preparation of this collection is due to the

kindness of Messrs. Brögger, Chelius, Diller, Hibsch, von Kraatz-Koschlau, Osann, Ramsay and Rosenbusch.

6. **Two Large Sections of Fossil Woods.**

7. **Analytical Balance** (U. S. A. Pat. No. 634495).

The beam of this balance is insured against all deformation by a roof shaped frame. By a new and peculiar arrestment, the middle and end knife edges are simultaneously brought into position, thus preventing large swings.

Paul Bunge

Hamburg, Ottostrasse 13.

Mechanician.

No. 1—6 in A.

1. **Analytical Balance for Maximum Load of 5 *kg*.**

Magnalium beam; axis, bearings, and all the contacts of the beam and the stirrups made of the best agate. Length of beam 32 *cm*., pan space 22 × 45 *cm*. With average loads, 0·5 *mg*. gives a displacement of one division. (No. 5 in price list.)

2. **Physical Balance for Maximum Load of 500 *g*.**

Mechanical arrangement for placing and removing the weights without opening the case. Fractions of a milligramme are read by means of a collimator telescope. Beam of argentan; axis and bearings and all the contacts of the beam, stirrups and pans of the best quality of agate. Length of beam 17 *cm*. pan space 16 × 30 *cm*. Swings are rapid and accurate. 0·1 *mg*. corresponds to one division of the telescope. (No. 2c in price list.)

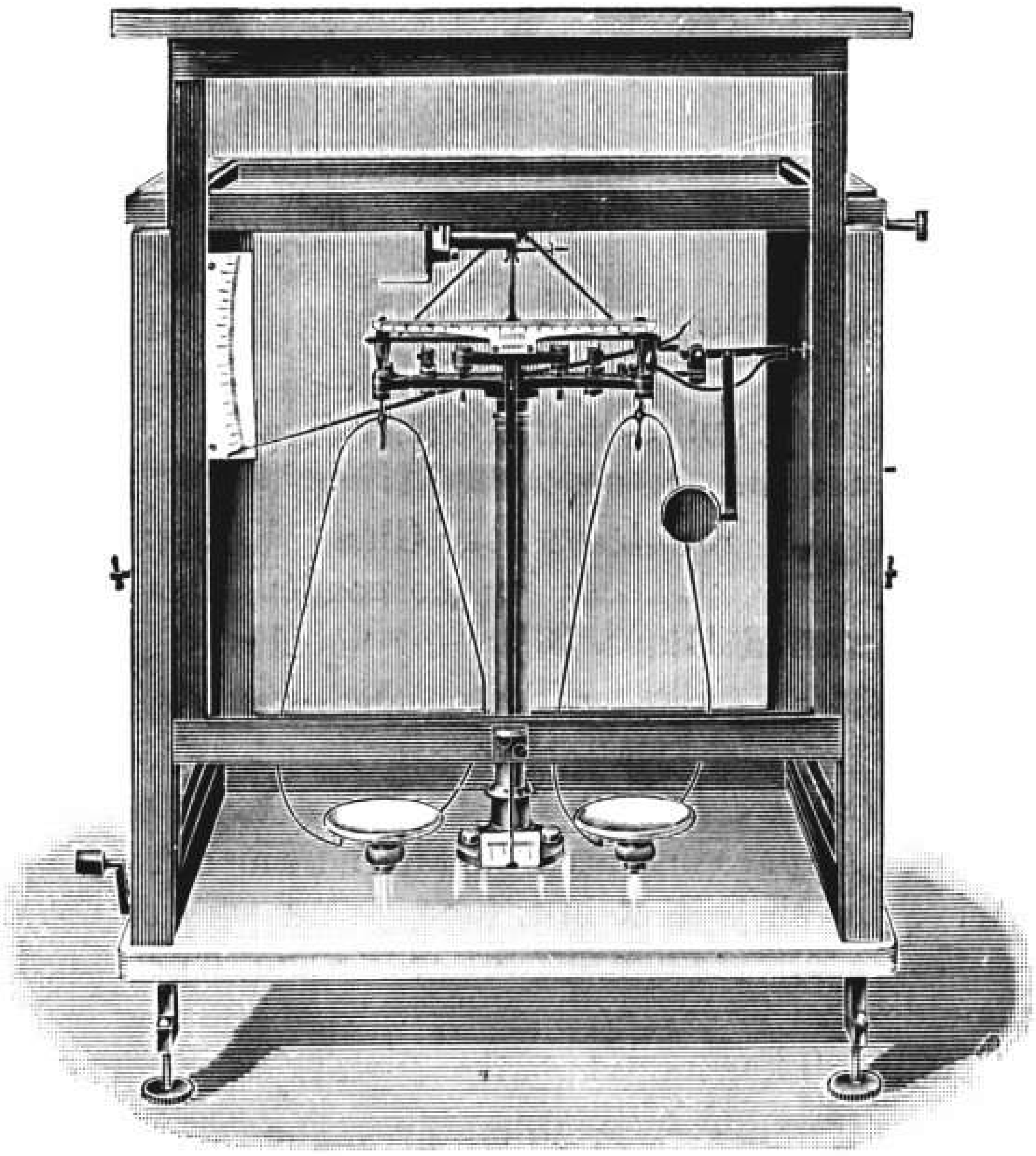
3. **Analytical Balance for Maximum Load of 500 *g*.**

Microscope reading and arrangements for placing fractions of a gramme in the pan without opening the case. Beam, length of beam and pan space same as above. Axis and bearings as well as contact points of beam and stirrups of agate. (No. 2 in price list.)

4. Analytical Balance for Maximum Load of 200 *g*.

Beam of argentan; axis and bearings as well as the contacts of the beam, stirrups and pans of agate. Length of beam 13 *cm.*, pan space 11 × 20 *cm.* The pointer is triangular to prevent vibration. 0·1 *mg.* gives a displacement of one division with all loads. (No. 1a in price list.)

5. Analytical Balance for Maximum Load of 200 *g* with Device for Direct Reading of the Weight in Grammes.



This device may be connected to the beam by means of a small arrestment. The long pointer then shows directly the weight of the object in the left pan in grammes. The direct reading device is then disconnected, and the weighing proceeds as usual. (See Fig.)

6. Assay Balance for the Precious Metals, for Load of 20 *g*.

Beam of hard rolled sheet argentan. Axis and bearings as well as the contacts of the beam, stirrups and pans of the best quality of agate. Length of beam 7 *cm.*, pan space 4·5 × 10 *cm.*; 0·01 *mg.* gives a displacement of one division for all loads. (No. 6 in price list.)

Reinhold Burger

Berlin N., Chausseestr. 2 E.

Chemical and Physical Glass Apparatus and Instruments of Precision.

No. 1—11 in D.

1. **Automatic Double-acting Mercury Pump,** according to F. Neesen. The pump acts continously and rapidly. It may be driven either by oil or water vacuum pump.
2. **Spherical, Double-walled, Exhausted Glass Flasks.** The silvered flasks are suitable for storing liquid air.
3. **Cylindrical, Double-walled Glass Flasks** for experiments with liquid air.
4. **Cylindrical, Double-walled Glass Vessel,** with outlet, cooling tube and stand for the condensation of gases.
5. **Double-walled Glass Dish,** for liquid air.
6. **Set of Glass Floats** for determining the temperature of liquid air, according to U. Behn and F. Kiebitz (*Ann. d. Physik* ***12****. p. 421. 1903*).
7. **Lecture Apparatus,** according to H. Lange. This apparatus serves to show that in a tube, filled with carbonic acid, a Geissler vacuum is formed when it is dipped into liquid air.
8. **Standard Thermometer,** filled with pentane, to —200° C.
9. **Three Standard Thermometers,** made of Jena standard thermometer glass, for temperatures between 0 and 100° C.
10. **Vessel for Maintaining Foods and Drinks at Constant High or Low Temperatures** (U. S. A. Pat. applied for). This is especially useful for travelling or hunting and in the household.
11. **Thermostat for Low Temperatures,** according to Rothe.

   This apparatus serves for producing constant low temperatures to about —150° C. It consists of two concentric, double-walled, exhausted vessels, the outer one filled with liquid air, the inner with commercial pentane or petroleum ether. To attain a constant temperature, the heat given up by the bath to the liquid air is compensated by an electrically heated coil, attached to the stirrer. The stirrer may be driven by a small motor. The apparatus may be regulated so that the temperature variations are not greater than from 0.01° to 0.02° per min. (See Rothe, *Zeitschr. f. Instrkde.* 22. *p.* 14. 1902.)

Arth. Burkhardt

Glashütte, Sachsen.

First German Manufacturer of Calculating Machines.

No. 1 and 2 in A.

1. **Calculating Machine** with the latest improvements: warning bell, removable spring box etc., for addition, subtraction, multiplication, division and the calculation of powers and roots. The machine offers a convenient means of numerical calculation of every sort. Exhibited in three sizes:

   a) Six places, 6×7 place factors and 12 place products;
   b) Eight places, 8×9 place factors and 16 place products;
   c) Ten places, 10×11 place factors and 20 place products.

   General agents: Denis Amster, Berlin W., Leipzigerstrasse 29; for America: Keuffel & Esser Co., New York.

2. **Photographs of the Calculating Machines** of Leibniz (invented 1640—1672) and Hahn (1770—1776).

Continental-Caoutchouc- und Guttapercha-Compagnie

Hannover.

Five Rubber Balloons according to Assmann.
(See Aeronautisches Observatorium *p. 2.*)

Dreyer, Rosenkranz & Droop

Hannover.

Exhibited in D.

Indicator Testing Apparatus.

The former arrangement for testing indicators, in which the springs were calibrated by the direct application of weights with

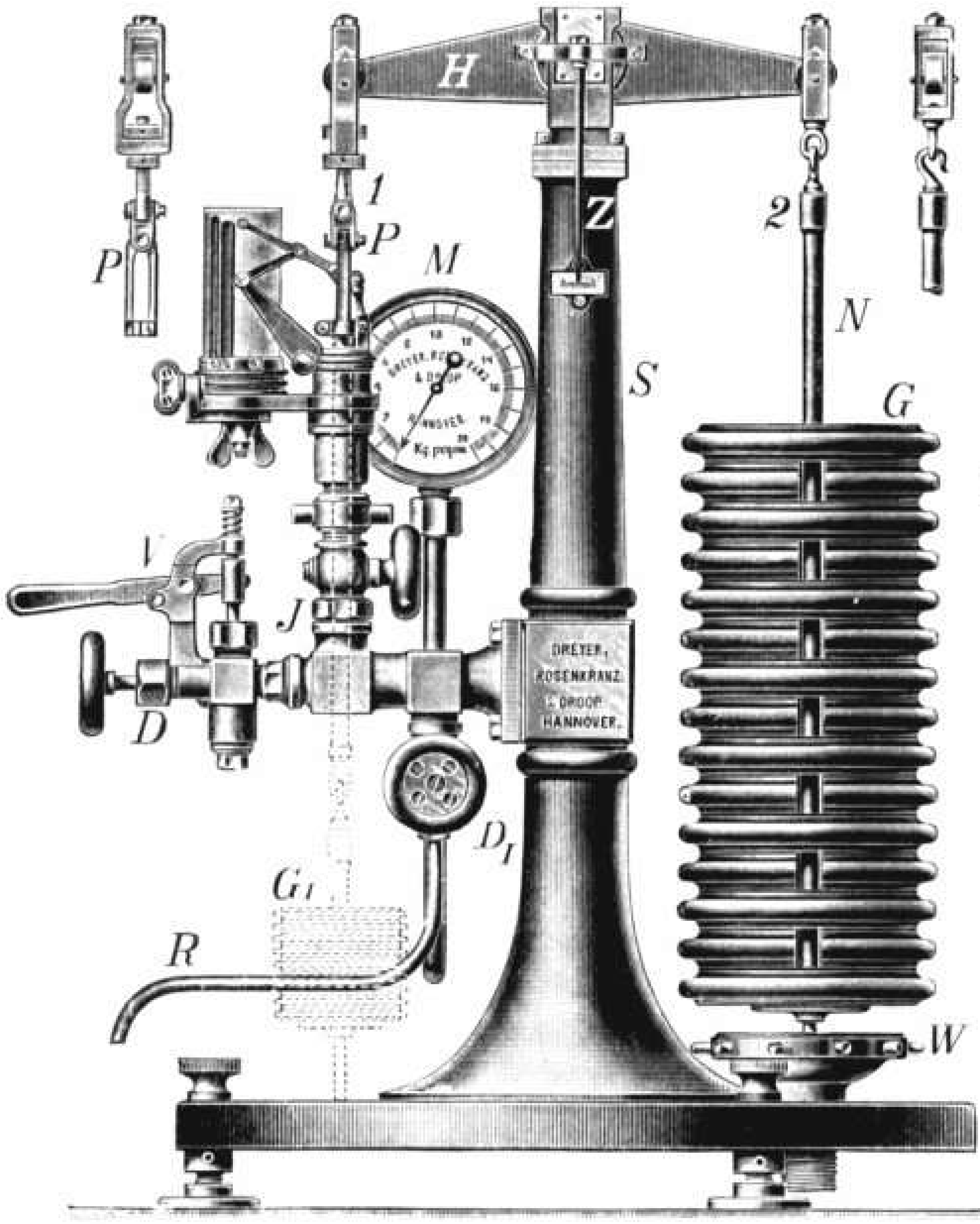


Fig. 2

Fig. 1.

or without steam heating, consisted in general of a cross-piece, supported on two pillars, on which the indicators for vacuum were screwed on above, and for pressure, below. The indicator in practice is not used in this inverted position, and in the testing it produces numerous inconveniences and causes of error.

The condensed water collects in the indicator in front of and behind the piston, hindering its free motion and preventing a sufficiently exact determination of the temperature in the space, occupied by the spring. Further, the hot water runs down on the piston rod and through the opening, intended for the escape of steam, and wets the weights as well as the indicator paper. Also, the change of position for the testing for vacuum and pressure is likely to produce errors.

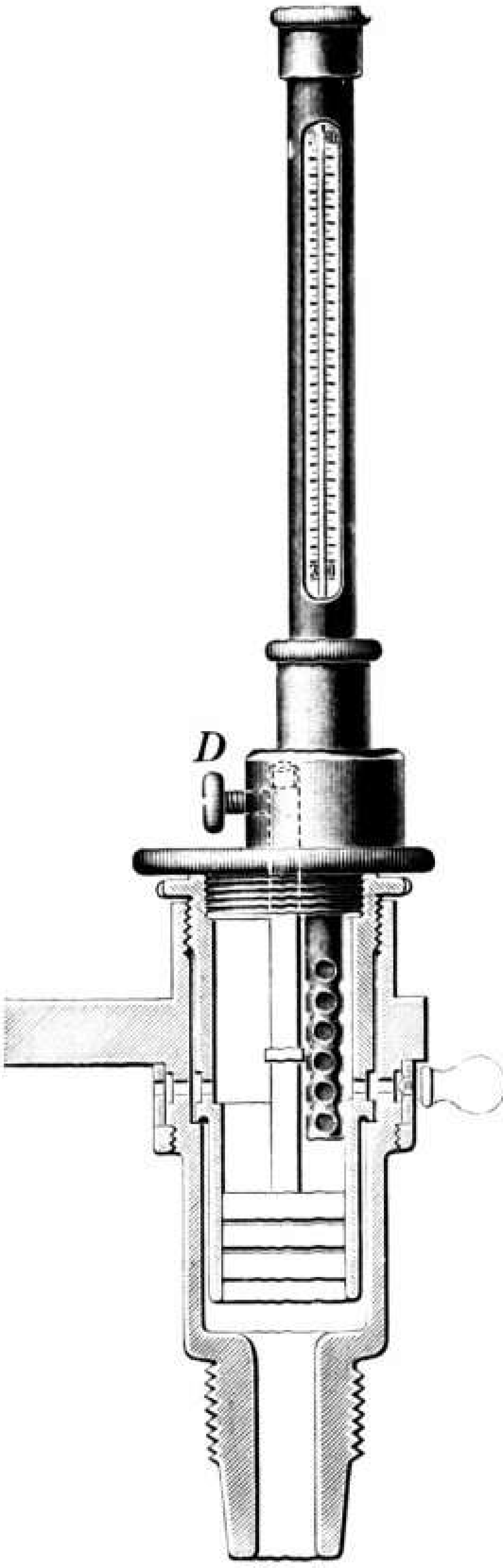


Fig. 3.

The new testing apparatus (Fig. 1) does away with these evils and offers the advantages mentioned below. The central pillar *S*, which may be made exactly vertical by means of the levelling screws and the plumb line, carries on a knife edge at the top a beam *H*. The indicator is screwed on at *J*. If desired, steam may be introduced at D_1 through the valve *V* that lies behind the valve *D*. Before the steam enters the valve *V* it passes through a water separator that collects all the condensed water from the connecting tubes, which can then be drawn off. For the purpose of allowing free passage of the steam, the lever of the valve *V* is held in position by means of a stop. The regulation of the temperature in the indicator is accomplished by means of the two valves *D* and D_1 and the manometer *M*. The excess steam as well as the condensed water escape through the tube *R*.

The length of the pointer *Z* is half that of the beam *H*. This makes it possible to so adjust the apparatus by means of screws in the stirrups, that the lever arm *1* lies as much below the horizontal as it will lie above it after the weights have been applied, thus doing away with the extra friction, which would be produced by a non-vertical pull.

The weights *G* are hung at point *2* of the lever arm. Each of these corresponds to a pressure of 1 *kg./sq. cm.*, calculated for a piston diameter of 20 *mm.* The first weight with the supporting rod *N* equals this pressure. In addition, weights G_1, each corresponding to 0·1 *kg./sq. cm.*, are furnished, which at the same time serve for the calibration of vacuum indicators (Fig. 2). The weights have slits, running to the center, are rounded on the edges and are furnished with centering rings so as to make them convenient for use. To prevent overloading when the spring is being tested with the weights and at the same time being heated by steam under pressure, the movable plate *W* having a leather ring, is provided. On this the weights are caught in their downward motion while the supporting rod *N* swings free.

In this way the indicator may be tested with the weights alone, that is, cold, or with steam, for the production of which a small boiler heated by gas is provided. It is also possible by using a thermometer, mounted according to Wiebe and Schwirkus (Fig. 3), to heat it to a given temperature. The apparatus thus permits tests of every sort which are necessary in the calibration of indicator springs, allowing the indicator to stand upright and preventing the condensed water from influencing the results.

Max Fechner

Potsdam.

Mechanician for the Königl. Geodätische Institut und Central-Bureau der Internationalen Erdmessung in Potsdam.

No. 1—3 in A.

1. A Quarter-seconds Pendulum Apparatus for the Relative Determination of Gravity.

This apparatus, built according to the plans of Prof. Helmert, Director of the Geodätische Institut in Potsdam, consists of a supporting case, four invariable pendulums, a pendulum level, a pendulum thermometer, which externally has the same form as a pendulum, and a manometer. The case is arranged to receive at the same time the four pendulums as well as the thermometer and manometer.

The pendulums swing at the same level, the two opposite each other in the same direction, so that the amount of vibration of the support can be easily and accurately determined. By means of three levelling screws, the apparatus is adjusted according to the two outer levels. The accuracy of level of the supporting shelfs can be tested by means of the pendulum level. When the vessel is closed by means of the cover, and is pumped out to a vacuum, the decrease in the damping due to the air allows the motion of the pendulums to be observed for about eight hours. By means of mirrors and prisms which are mounted on a shelf inside the case, it is possible to observe all four pendulums with *one* telescope. The observations of the coincidences with the clock pendulum and of the amplitudes are made by means of a coincidence apparatus.

2. Model of a Horizontal Pendulum.

This is the model of an instrument designed by v. Rebeur-Paschwitz and Hecker, having for its object the observation of the deviations of the plumb line, as well as of earthquakes and other motions of the earth's crust.

The pendulum frame is supported at three points without strain and rests upon a heavy iron plate, which is adjusted by means of three levelling screws. Two of the points of support are formed by steel balls, lying in depressions in the iron plate, the third point is the spherical end of a fine threaded steel screw, which projects through the supporting plate and to which is imparted a slow motion by means of a worm gear. This forms a very sensitive means of regulating the level of the plate supporting the pendulum frame. The pendulum itself is furnished with two sapphire plates, which rest upon two fine steel points, attached above and below to the pendulum frame. The direction of these points is so chosen that there is no binding of the pendulum during the swing. To protect the points from injury, a special arrangement is made for placing the pendulum in position without the use of the hands.

3. Zenit Camera for Determining Geographical Position.

This apparatus is constructed according to the plans of Prof. Schnauder. It consists of a photographic camera whose objective points to the zenit and which is capable of a rotation on a vertical axis between two stops 180° apart. A second pair of stops at right angles to the first allow a rotation of 90°. The vertical axis can be adjusted by means of two levels at right angles to each other, und the rotation is measured by means of a pair of microscopes on four circular scales 2° in length and having divisions of $^1/_6$°. With this arrangement 0·1′ can be read. The photographic plate is introduced into the camera in a metallic plate holder, and then, by means of an eccentric and springs, pushed against a frame at right angles to the axis of the objective. The size of the plates is 16×16 *cm.* By means of the accompanying telescope the instrument can be brought into the meridian. The objective is an orthostigmatic lens of 24 *cm.* focal length, from Steinheil in Munich.

The above pieces of apparatus are the property of the Königl. Geodätische Institut in Potsdam.

R. Fuess (vorm. J. G. Greiner jr. & Geissler)

Steglitz bei Berlin, Düntherstr. 8.

Mechanician and Optician.

No. 1—10 and 16—24 in D, No. 11—13 in B, No. 14 and 15 in A.

I. Section for Meteorology.

1. **Stand with Psychrometer and Psychro-Aspirator** according to Assmann, a maximum and a minimum thermometer.

   The psychro-aspirator ensures: 1. constant ventilation of the wet bulb thermometer, the air current having a velocity of 2 *m.* per sec.; 2. shortening of the time required for the observation, since the muslin is moistened *after* the last observation and the evaporation of the water is prevented by closing the ends of the tubes with corks. A few minutes before the new observation the corks are removed and connection is made to the aspirator. Even in very frosty and foggy weather five minutes is sufficient to establish constant readings.

2. **Registering Balance with Sliding Weight, for Precipitation and Evaporation.** With automatic device for sliding back the weight.

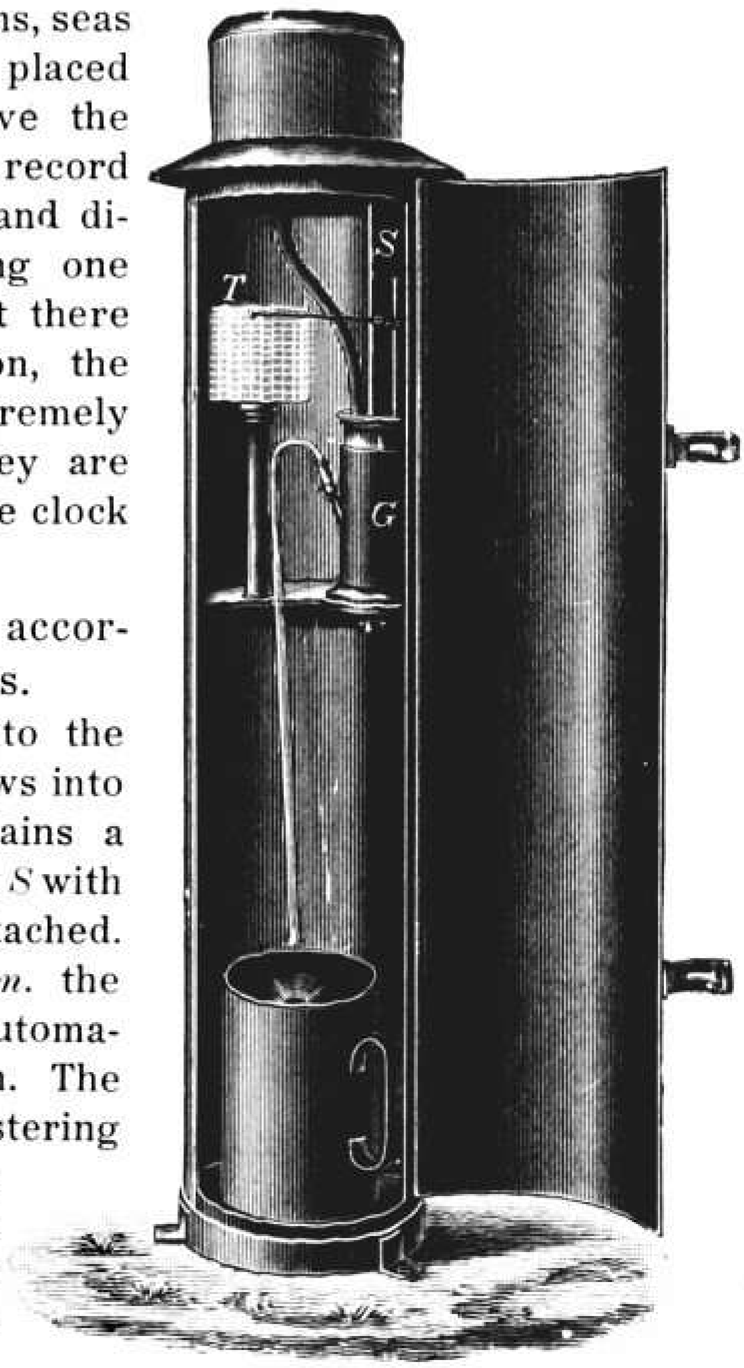
The apparatus consists of a sliding weight barograph the mercury tube of which is replaced by a vessel for receiving precipitation. The amount of rainfall is registered, magnified 20 times. The magnification ensures fine evaporation curves, especially in summer. The sensibility can be easily increased for winter use.

Since 1903 an arrangement has been introduced for sliding back the weight when, on account of heavy rain, it has reached the edge of the registering paper.

Comp. A. Sprung, Über die Registrierung der winterlichen Niederschläge. *Ergebnisse der meteorol. Beob. in Potsdam 1898*; A. Sprung, *Sur les appareils à balance romaine, qui se trouvent à l'exposition. Rapports presentés au congrès.* Paris 1901. *p. 187.*

3. Registering Anemometer for Remote Stations.

This portable instrument is intended to be used at a distance from houses, mountains, seas etc. It is arranged to be placed at a height of 10 *m.* above the surface of the earth, and to record the daily range of velocity and direction of the wind during one year. Notwithstanding that there is no electric transmission, the anemometer cups are extremely small and light, since they are required only to release the clock work.



4. Registering Rain Gauge according to Hellmann-Fuess.

The rain water falls into the funnel (200 *sq. cm.*) and flows into the cylinder *G*. This contains a float, to which a vertical arm *S* with the recording pen *T* is attached. After a rain fall of 10 *mm.* the cylinder *G* empties itself automatically by means of a siphon. The magnification of the registering apparatus is large, 8·2 *mm.* corresponding to 1 *mm.* of rain. The paper moves with a velocity of 16 *mm.* per hour.

5. **Registering Apparatus for Rubber Balloons** according to Assmann, for recording the variations of air pressure, temperature and relative humidity. (See *p. 4.*)

6. **Registering Apparatus for Kites,** recording air pressure, temperature, relative humidity, wind velocity and time. (See *p. 3.*)

7. **Aspiration Thermograph,** according to Assmann-Fuess. With electric motor and Invar-copper thermometer element.

8. **Standard Aspiration Psychrometer,** according to Assmann. With arrangement for use in the tropics.

   Two mercury or alcohol thermometers with small cylindrical bulbs are each placed in two short concentric, highly polished protecting tubes, thermally insulated from each other. These protect the thermometer from radiation. A centrifugal aspirator, run by clock work (25 turns per sec.) draws an air current of from 2 to 3 *m.* per sec. past the thermometers inside the protecting tubes. This removes the radiation heat, which has not been reflected by the protecting tubes, so that even in the strongest sunshine (at great heights, on mountains, in balloons, as well as in the tropics) the true air temperature is measured. One of the thermometer bulbs is wrapped in muslin and from time to time moistened with water. The vapor tension is calculated from Sprung's formula $f = f' - \frac{1}{2} (t - t') \, b/755$. For use in the tropics, two extra springs and thermometers and a moistening apparatus are furnished.

9. **Pocket Aspiration Thermometer.**

   In all respects like the standard apparatus No. 8, but in smaller size for carrying in the pocket.

10. **Triple Balloon Aspiration Psychrometer with Hair Hygrometer,** according to Assmann. (See *p. 5.*)

II. Section for Physics and Mineralogy.

11. **Large Microscope** for Mineralogical and Petrographic Investigation, with Nicols rotating together. Modell VI. (See C. Klein, *Sitzungsber. d. Berliner Akad. 1895. p. 93*; C. Leiss, Die optischen Instrumente der Firma R. Fuess. Leipzig 1898. *p. 199.*)

12. Clock Work Heliostat, according to A. M. Mayer (see C. Leiss, *Zeitschr. f. Instrkde.* **18**. *p. 276. 1898*).

The chief difference between this heliostat, proposed by A. M. Mayer (*Amer. Journ. of Science* **4**. *p. 306. 1897;* Abstract: *Zeitschr. f. Instrkde.* **18**. *p. 56. 1898*), and the ordinary form is that the mirror, which is ordinarily driven by the clock work, is replaced by a combination of lenses, giving a beam of parallel light. The advantages of this heliostat over those provided with a mirror are considerable. The ordinary heliostat, even when provided with a large mirror, in our latitude and especially during the winter months furnishes only a relatively small beam of parallel light. The new heliostat, since the light rays always fall normally on its collecting lens, furnishes the same quantity of light in all latitudes. In addition, the intensity of the light is considerably increased through its concentration in the large collecting lens.

The use of this instrument is to be recommended for high latitudes especially, when the greatest possible illumination (microphotography, spectrophotography, projection etc.) is required.

13. Crystal Polymeter according to C. Klein. (See C. Klein, *Sitzungsber. d. Berliner Akad. 1900. p. 248;* C. Leiss, *Zeitschr. f. Instrkde.* **22**. *p. 331. 1902.*)

This instrument, developed from the triple circle goniometer according to G. J. H. Smith, may be used for the following varieties of work:

a) as single circle, double circle or triple circle goniometer;
b) as an instrument for determining the index of refraction by the method of prismatic deviation;
c) for determining the indices of refraction of liquids;
d) as instrument for determining the indices of refraction of crystals by the method of total reflection;
e) for the investigation of crystals in media of the same refractive power, for measuring the angles of the axes etc.;
f) for investigating minerals in thin sections or in thicker plates.

III. Section for Measurement of Length and Volume.

14. New Cathetometer for Accurate Measurements, constructed according to the plans of the Kaiserl. Normal-Eichungs-Kommission, Charlottenburg.

Horizontal motion (not measurable) 300 *mm.* Measurable vertical motion 200 *mm.* Scale divided in $^1/_2$ *mm.* The filar micrometer of the reading microscope reads to 0·01 *mm.* The weight of the sliding telescope frame is counterbalanced by a movable counterpoise in the interior of the column. Furnished with micrometer adjustment. Telescope is reversible and may be focussed for all distances between 5 and 0·3 *m.* Magnification about 24 times.

15. Volumenometer, modified form of the Overbeck apparatus, for the determination of the volume of bodies, which can not be immersed in liquids.

The method rests on the Boyle-Mariotte law. The body to be measured is placed in one of the two receivers of equal size, which are closed air tight by means of glass plates. The volume of the receivers is then increased by lowering the mercury reservoirs and withdrawing the mercury in the capillaries. From the known volume of the receivers and the position of the two mercury meniscusses in the graduated capillary tubes, the volume of the body is calculated. The apparatus differs from the older form in having enlargements below the receivers by means of which the effective length of the capillary tubes is increased 5 times. By a somewhat modified method the exhibited apparatus can be used for the determination of the volumes of bodies from 1 *ccm.* to 120 *ccm.* with an accuracy of 0·001 *ccm.* The apparatus is intended for the Kaiserl. Normal-Eichungs-Kommission in Charlottenburg.

IV. Section for Heat and Air Pressure.

16. Boiling Point Apparatus (Hypsometer); including
a) thermometer divided in $^1/_{100}{}^0$;
b) thermometer divided from 2 : 2 *mm.* air pressure;
c) thermometer divided from 1 : 1 *mm.* air pressure.

17. Standard Thermometer from — 2 to + 102^0 ($^1/_{10}{}^0$).

18. Standard Thermometer from — 30 to + 50^0 and from 90 to 102^0 ($^1/_{10}{}^0$).

19. Standard Thermometer, diameter of about 7 *mm.*, from 0 to 30^0 ($^1/_{10}{}^0$).

20. Freezing Point Thermometer, graduated in $^1/_{100}{}^0$.

21. Solar Radiation Thermometer.

22. Thermometer for Measuring the temperature of springs.

23. Ground Thermometer from —12 to 30° ($^1/_{10}$°).

24. Sea Barometer according to Hecker.

F. O. R. Goetze

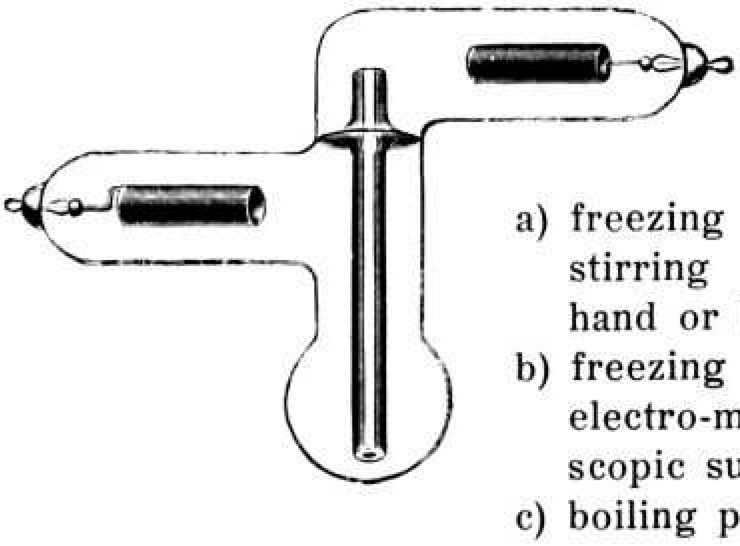
Leipzig, Härtelstrasse 4.

Manufacturer of Glass Instruments.

No. 1—3 in D.

1. Collection of Thermometers, some of which have been tested in the Physikalisch-Technische Reichsanstalt in Charlottenburg:

a) Beckmann Thermometer graduated in $^1/_{500}$ degrees,
b) Beckmann Thermometer graduated in $^1/_{100}$ degrees,
c) Beckmann Thermometer graduated in $^1/_{50}$ degrees,
d) Heidenhain Thermometer graduated in $^1/_{100}$ degrees, with fixed zero point,
e) Thermometer graduated in $^1/_{100}$ degrees in the intervals + 16 to 18°, + 28 to 30° and + 52 to 55°,
f) Boiling point Thermometer for measurements of altitude, graduated in $^1/_{100}$ degrees from + 96 to 102°, with freezing point,
g) Arago-Davy Thermometers for measurement of solar radiation.



2. Three Pieces of Apparatus for Determining Molecular Weights, according to Beckmann:

a) freezing point method with exposed stirring apparatus, to be driven by hand or by means of a motor,
b) freezing point method with enclosed electro-magnetic stirrer, for hygroscopic substances,
c) boiling point method, latest form.

3. Spectrum Tubes, Our Own Construction (see the figure) for accurate measurements, especially for the rare gases, argon, helium etc. The tubes give very brilliant spectra.

Ephraim Greiner (Proprietors: Bieler, Greiner & Kühn)

Stützerbach, Thüringen.

Manufacturer of Glass Apparatus.

No. I—III in D.

I. Thermometers.

Thermometer for chemical work, -20 to 101^{0}. Made of Jena normal glass, carefully cooled.

Standard thermometer with milk glass scale, -10 to 101^{0} C. Made of Jena normal glass, carefully cooled, graduated in $^{1}/_{10}{}^{0}$, with official certificate.

A set of standard thermometers, No. 1—7, according to Graebe-Anschütz. For accurate chemical work, made of Jena normal glass, carefully cooled. No. 4—7 filled with nitrogen, graduated from -10 to 50^{0}; $+40$ to 110^{0}; $+90$ to 160^{0}; $+150$ to 220^{0}; $+200$ to 265^{0}; $+250$ to 310^{0} and $+300$ to 360^{0} in $^{1}/_{5}{}^{0}$ C.

Thermometer with three scales on polished black board.

II. Areometers.

United States Custom-house hydrometer with thermometer.

A set of seven areometers for specific gravity determination. 0·700 to 0·850; 0·850 to 1·000; 1·000 to 1·200; 1·200 to 1·400; 1·400 to 1·600; 1·600 to 1·800; 1·800 to 2·000. With thermometer and cylinder in brass foot. All packed in a polished mahagony case with lock.

Also various areometers, saccharimeters and milk testers.

III. Various Articles of Glass.

Gas manometer, air velocity meter, standard graduates with official certificate, and others according to Dr. Mohr, automatic overflow pipette, digestion and polarisation flasks, patent cooling apparatus for simultaneous internal and external cooling etc.

Several pieces of glass apparatus for use in instruction are exhibited in the Section of Elementary and Advanced Education.

Emil Gundelach

Gehlberg, Thüringen.

Manufacturer of Glass Apparatus for Physical and Technical Use.

No. 1—32 in D.

I. Vacuum Apparatus.

In a special dark room the following vacuum tubes are in action:

1. Vacuum tube, according to Crookes, with pectolite. (Fig. 1.)
2. „ „ of blue phosphorescent glass with hexagonite. (Fig. 2.)
3. „ „ of yellow phosphorescent glass with sheelite.
4. „ „ according to Crookes, with double spar. (Fig. 1.)
5. „ „ of blue phosphorescent glass with three different minerals, which light up under the Röntgen rays. (Fig. 3.)

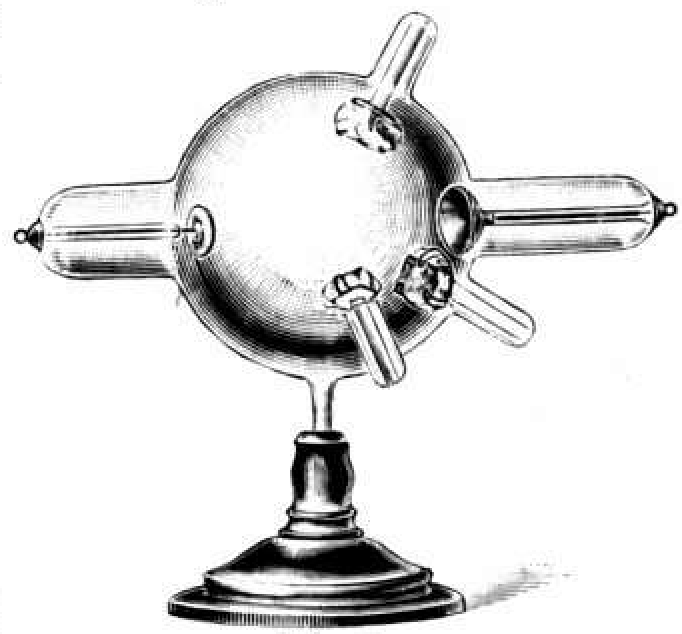
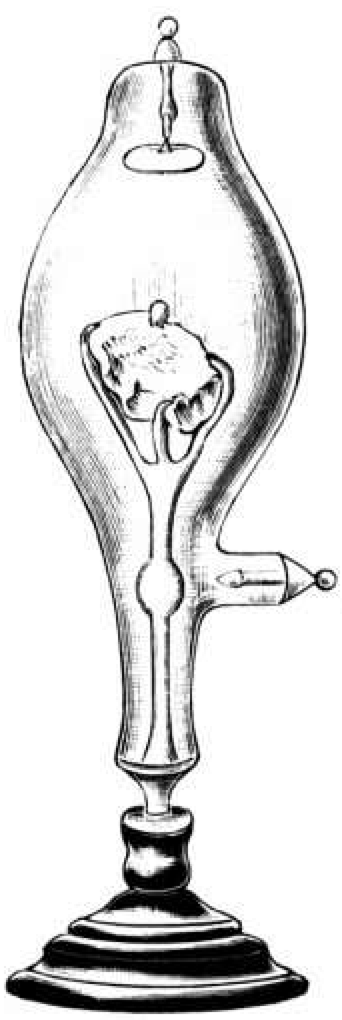


Fig. 3.



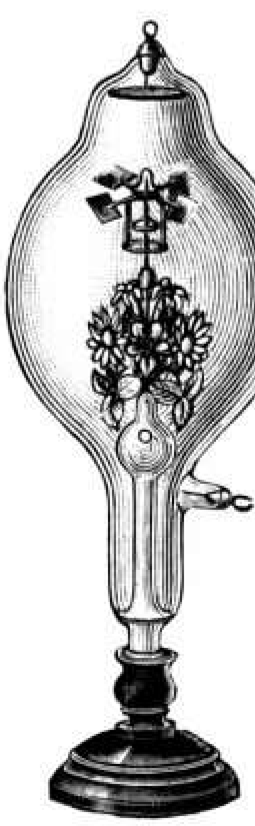


Fig. 2. Fig. 4. Fig. 1.

6. Vacuum tube of green phosphorescent glass with dolomite.
7. „ „ with radiometer and bouquet. (Fig. 4.)
8. „ „ of red phosphorescent glass.
9. „ „ „ „ „ „ with willemite.

10. Vacuum tube of green phosphorescent glass with artificial ruby mass, made in Fletcher furnace. (Fig. 2.)
11. Vacuum tube, according to Crookes, with argillaceous earth. (Fig. 1.)
12. Vacuum tube, according to Crookes, with slag from argillaceous earth. (Fig. 1.)
    Also in case outside
13. Shadow cross tube, according to Crookes, very large.
14. Deviation tube „ „ „ „ „ .
15. Phosphorescence lamp, according to Puluj. (Fig. 5.)
16. Circuitous discharge tube, according to Hittorf. (Fig. 6.)
17. Phosphorescence lamp, according to Ebert, for Tesla transformer. (Fig. 7.)

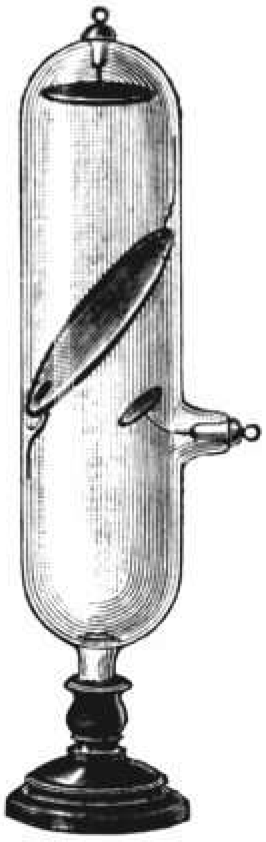


Fig. 5.

Fig. 6.

Fig. 7.

18. Phosphorescent bouquet, for Tesla transformer.
19. „ mineral „ „ „ .

Fig. 8.

20. Vacuum tube, according to Braun, for showing current curves. (Fig. 8.)

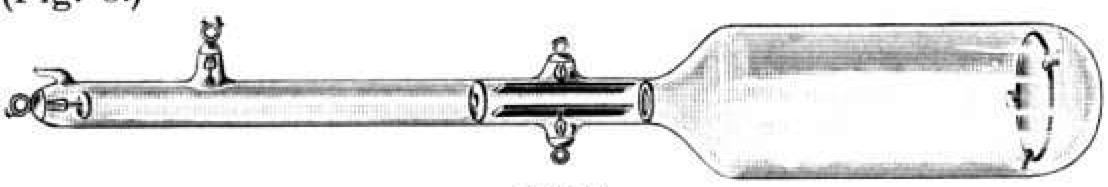


Fig. 9.

21. Vacuum tube, according to Braun-Wehnelt, for electrostatic deviation. (Fig. 9.)

22. A series of various Röntgen tubes. (Fig. 10.) Also a valve tube for suppressing the closing spark.

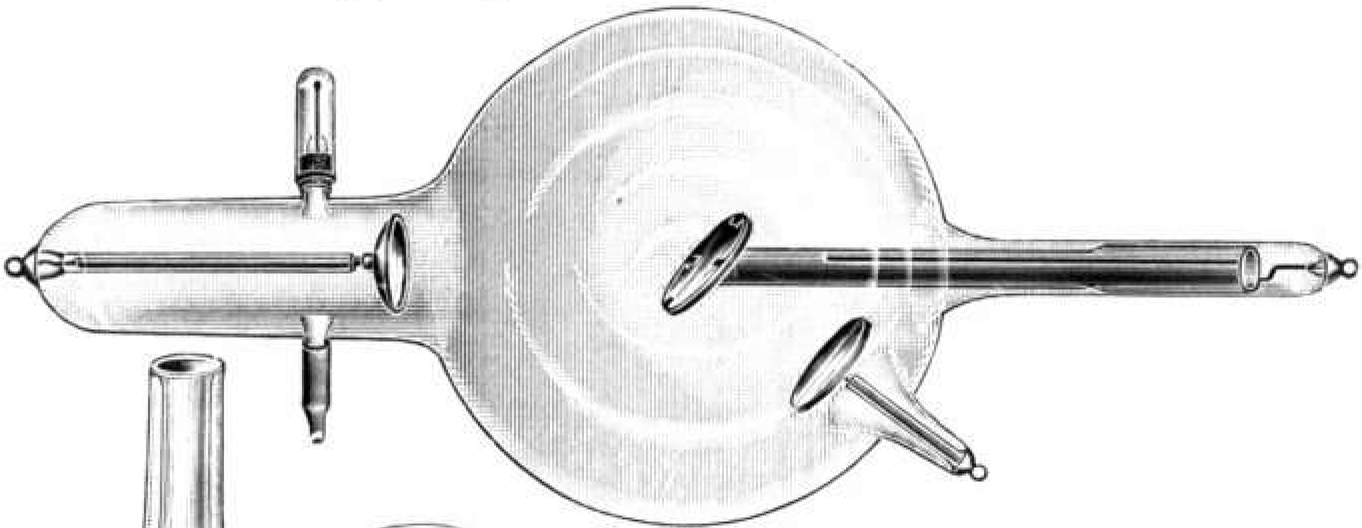


Fig. 10.

Fig 11.

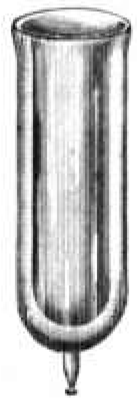


Fig. 12.

Fig. 13.

II. Dewar Flasks.

23. A series of double and triple walled vessels, according to Dewar, for keeping liquid air. (Fig. 11—13.)

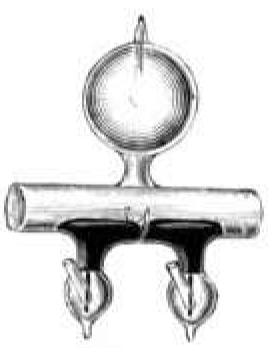


Fig. 14.

Fig. 16.

Fig. 15.

III. Apparatus for Optical Work.

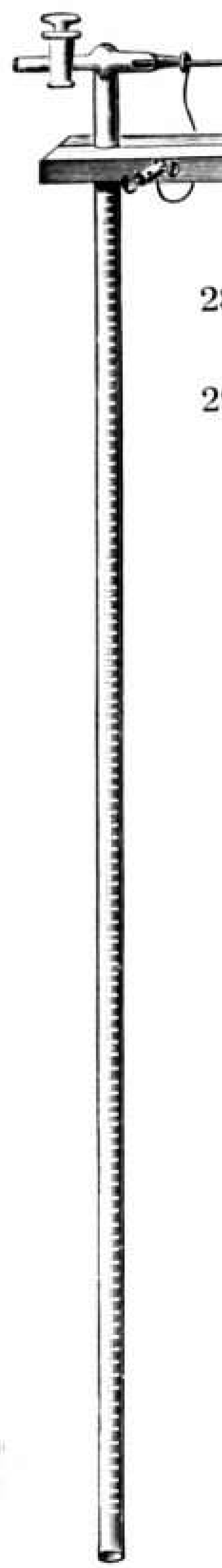
24. Mercury arc lamp, according to Lummer-Straubel, without water cooling bath. (Fig. 14.)

25. The same lamp complete in water bath. (Fig. 15.)

26. Carbondisulphide prism of crystal glass. (Fig. 16.)

27. Carbondisulphide prism of black glass. (Fig. 16.)

IV. Various Pieces of Apparatus.



28. Ozone tube, made of two combined Geissler tubes. (Fig. 17.)
29. Apparatus for demonstrating the diffusion of hydrogen through glowing platinum, according to Winkelmann. (Fig. 18.)

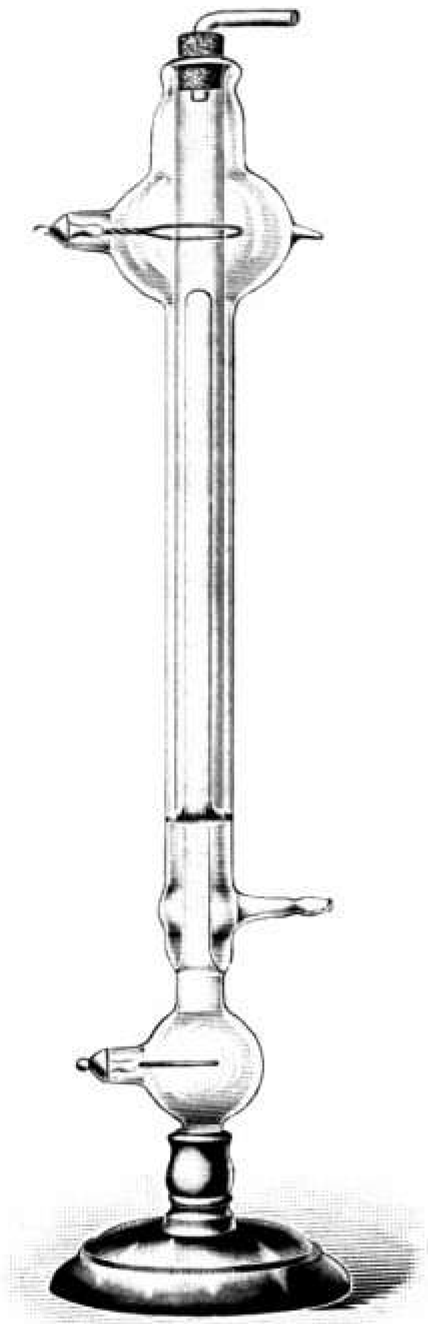


Fig. 17.

Fig. 18.

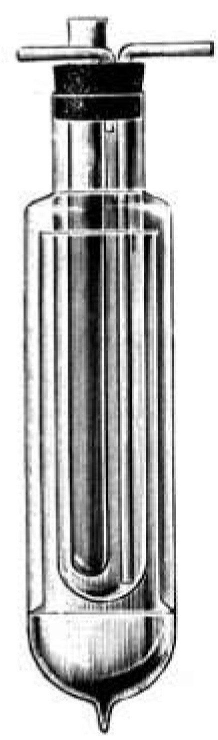


Fig. 19.

Fig. 20.

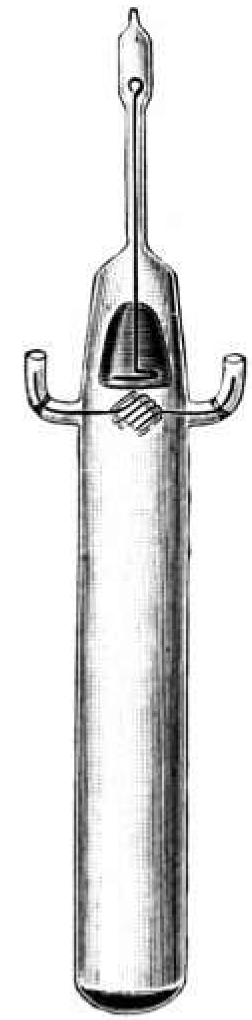


Fig. 21.

30. Apparatus for producing low temperatures by means of liquid sulphurous acid, according to Weinhold. (Fig. 19.)
31. Apparatus for the vaporization of ice without platinum wire, according to Weinhold. (Fig. 20.)
32. The same apparatus with platinum wire, which can be brought electrically to incandescence. (Fig. 21.)

Günther & Tegetmeyer

Braunschweig, Höfenstrasse 12.

No. 1—4 in D.

1. **Aluminium-leaf Electroscope** (Exner form) with internal amber insulation, mirror scale and sodium drying apparatus, according to Elster and Geitel (*Physikal. Zeitschr.* **4.** *p. 137. 1902*).

   The carrier of the leaves is insulated by means of an amber stopper in the bottom of the case. The image of the movable milk-glass scale in front of the instrument is projected on the plane of the leaves so that parallax in the readings is prevented. For use in damp places the interior of the electroscope may be kept dry by means of a piece of metallic sodium, introduced through the side tube. When the instrument is closed, the leak of electricity amounts to only 0·4 volt per hour.

2. **Apparatus for Measuring the Leakage of Electricity,** according to Elster and Geitel (*Physikal. Zeitschr.* **1.** *p. 11. 1899* and *Terrestrial Magnetism* **4.** *p. 217. 1899*).

   This apparatus serves for the determination of the electric leakage in the free air. The protecting roof screens the cylindrical discharging conductor from the influence of the earth's electrical field. By means of the accompanying wire net cylinder and the insulated metal support, the fundamental experiments, showing the existence of free ions in the air, may be repeated.

3. **Zinc Sphere Photometer for the Photoelectric Determination of the Ultraviolet Rays from the Sun,** according to Elster and Geitel.

   Latest form of the instrument described in the *Sitzungsber. d. Wiener Akad.* **101,** *IIa. p. 788. 1892.* The sensitive body is an amalgamated zinc sphere. The old form of Exner electroscope is replaced by one with mirror and scale, and the ebonite condenser by an air condenser, according to Gockel. Change in the capacity of the charged system during the adjustment of the instrument is impossible. Amber is used throughout as the insulating material.

4. Aspiration Apparatus for the Determination of the Ionization of the Atmosphere in Absolute Units, according to H. Ebert (*Physikal. Zeitschr. 2. p. 662. 1900* and *Aeronaut. Mitteil. Oktober 1902*).

An aspirator, driven by clock work, sucks the air to be investigated through a cylindrical condenser, whose fall of potential is observed during 15 minutes. The amount of electricity in 1 *cbm.* air is calculated from the capacity of the charged system and the amount of air drawn through the aspirator. The insulating material is amber and is entirely enclosed. This convenient apparatus has been found especially useful in balloon ascensions.

B. Halle

Steglitz bei Berlin, Hubertusstrasse 11.

Manufacturer of Optical Apparatus.

No. 1—3 in B.

1. Articles of Iceland Spar.

a) Nicol prisms of different constructions; including
one Nicol prism of 40 *mm.* length,
one Glan-Thompson of 103 *mm.* length,
one Foucault of 62 *mm.*;

b) sphere of 52 *mm.* diameter;

c) production of Nicol prisms in quantities, according to the method invented by the exhibitor, also photographs of the sawing machine, constructed and used in his shop.

2. Articles of Quartz.

Including
one Cornu prism of 40 *mm.* aperture, and
two spheres 55 *mm.* in diameter.

3. Articles of Glass.

Prisms of various sorts.

Hartmann & Braun A.-G.

Frankfurt am Main.

Manufacturers of Instruments for Electrical Measurements.

No. I—IX, XI—XIII in C, No. X in D.

I. Magnetic Instruments.

1. Large Half Ring Electromagnet, according to du Bois. (Fig. 1.)

The two cores of the magnet are fastened with screws to a heavy iron plate, forming the yoke. By loosening the screws the distance between them can be adjusted so that the space between the poles can be extended to 200 *mm*. The cylindrical or conical pole pieces are fastened by means of a kind

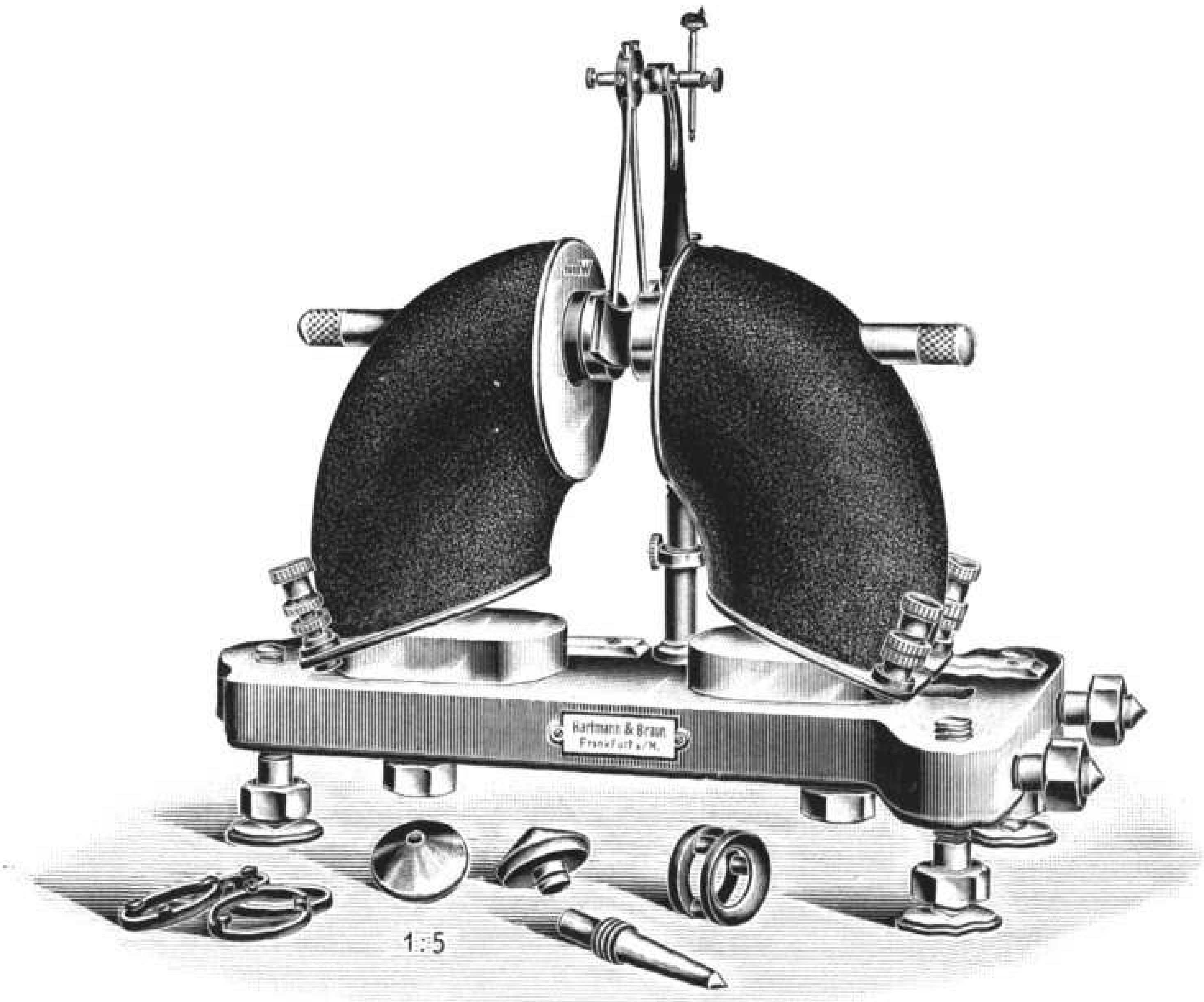


Fig. 1.

of bayonet joint and can be easily removed or changed. The small table between the poles may be rotated and has a vertical adjustment. There are cylindrical openings through the poles, intended for optical experiments, closed with removable iron cylinders.

The coils have a total resistance of 3·3 ohms and 2500 turns and are intended for a maximum current of 20 amp. Using the conical pole pieces, a field is produced in a space 1 *mm.* long and 30 *sq. mm.* in section of 39000 *C. G. S.* with 2500 amp. turns. With 50000 amp. turns, the strength of field is over 41000 *C. G. S.* Weight about 150 *kg.*

2. Small Half Ring Magnet. Of construction similar to the one above, but with all linear dimensions reduced one half. By using suitable conical pole pieces, a field of 30000 *C. G. S.* is produced with 16000 amp. turns in a space 1 *mm.* long and 30 *sq. mm.* cross section. Weight about 25 *kg.* By tipping the magnet through 90°, the line between the poles can be brought into vertical position.

3. Bismuth Spiral, according to Lenard, for measuring the intensity of magnetic fields. A thin wire of chemically pure bismuth and properly insulated is wound into a flat spiral and protected from injury by mica plates. The thickness of the spiral is only 1 *mm.* so that it can be introduced into very narrow fields; for example, between the armature and magnet of a dynamo. The change of resistance measures the number of lines of force in the field to be investigated. On an average, 1000 lines of force produce a change of 5% in the resistance. Besides spirals of the ordinary size 20 *mm.* in diameter, smaller ones, 5—6 *mm.* in diameter, can be furnished.

4. Rotating Disk Magnetometer, according to Fischer, for the measurement of weak magnetic fields. The apparatus consists of a copper disk 3 *cm.* in diameter, which is rotated mechanically with a uniform velocity. It is only necessary to know the number n of turns of the disk and the difference of potential e between the axis and the periphery of the disk as read on a voltmeter: $\mathfrak{H} = (e/n) \cdot const.$ where the constant depends on the dimensions of the disk. If a millivoltmeter is used, fields of a few hundred gauss can be measured with accuracy, while the bismuth spiral is only moderately accurate for fields of 2000 gauss.

5. Apparatus for Determining the Magnetic Qualities of Iron, especially of determining the $\mathfrak{H}$- and $\mathfrak{B}$-curve. This consists of a yoke for receiving the cylindrical test pieces, which is separated in the middle, and between the surfaces there is a small space where the field is constant, and in this a bismuth spiral is imbedded. The test piece and bismuth spiral are surrounded by a magnetising coil, which even with a weak current produces a relatively strong field. A peculiarly arranged bridge (Fig. 2) with two stretched wires and two sliding contacts permits the strength of field to be directly read upon the scale, correction being made for the temperature of the bismuth spiral.

The apparatus is so made that tests can be carried out, for instance in iron works, by persons unacquainted with electrical measurements.

Fig. 2.

II. Self Induction Standards.

6. Standard of Induction. (Fig 3.) Consists of a hard rubber rod of accurately determined geometric dimensions, on which is wound a primary coil for a maximum current strength of 10 amp. A short secondary coil of 1000 turns can be pushed

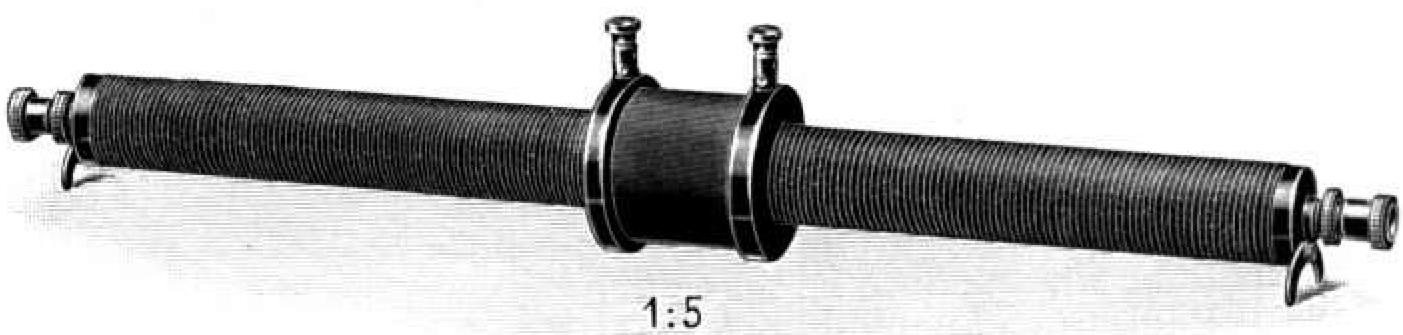


Fig. 3.

over it. From the strength of current the field of the primary coil can be calculated. The apparatus is especially suitable for the calibration of ballistic galvanometers.

7. **Self Induction Standard,** according to M. Wien, consisting of wire coils of invariable geometric form, wound on marble cylinders, adjusted so that the self inductions are equal to 10^5, 10^6, 10^7, 10^8, 10^9 *cm.* or 0·0001, 0·001, 0·01, 0·1, 1 henry.

8. **Apparatus for Varying Self Induction,** according to M. Wien.

This apparatus, which is entirely free from metal, consists of two hard rubber coils one inside the other and so arranged that the smaller can be rotated out of the plane of the larger through an angle of 155^0. The last contains four and the first two different systems of windings, which can be used either singly or in series. By different connections and by the rotation of the inner coil in respect to the outer, a continuous variation of the coefficient of self induction is possible. A rotating system of switches allows the coils to be combined in every possible way, the connection being directly indicated by a pointer. The apparatus itself is entirely free from metal, the screws being of ivory.

III. Galvanometers and Reading Appliances.

9. **Aperiodic Pointer Galvanometer** (Fig. 4), with a powerfully damped bell magnet on cocoon suspension, coils wound with two separate wires in parallel, and case free to rotate in metal foot. Sensibility: with lower resistance, about 50 ohms, $1^0 =$ 0·00008 amp.; with higher resistance, about 1000 ohms, $1^0 = 0·000005$ amp.

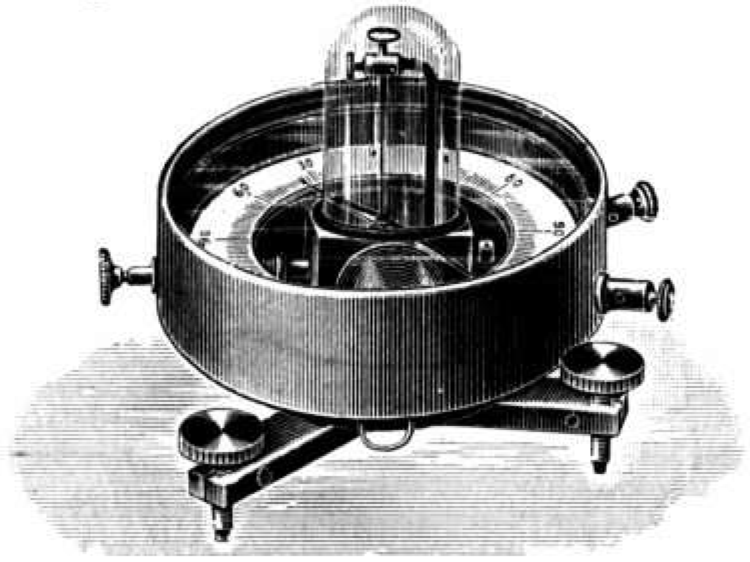


Fig. 4.

10. **Portable Aperiodic Reflecting Galvanometer** with telescope (Fig. 5). Bell magnet in flat copper damper;

secure arrestment of the magnets for transportation; can be quickly adjusted by means of the level; the whole apparatus capable of rotation and may be clamped to the supporting plate. Each of the coils has two windings of the same resistance. They may be moved to or from the needle and may be interchanged, which allows a large variation of sensibility. Adjustable magnets may be used to render the instrument astatic and so increase the sensitiveness.

Sensibility: not astatic, with lower resistance, about 100 ohms, 1 *mm.* = 0·0000009 amp.; with higher resistance, about 4000 ohms, 1 *mm.* = 0·0000003 amp.

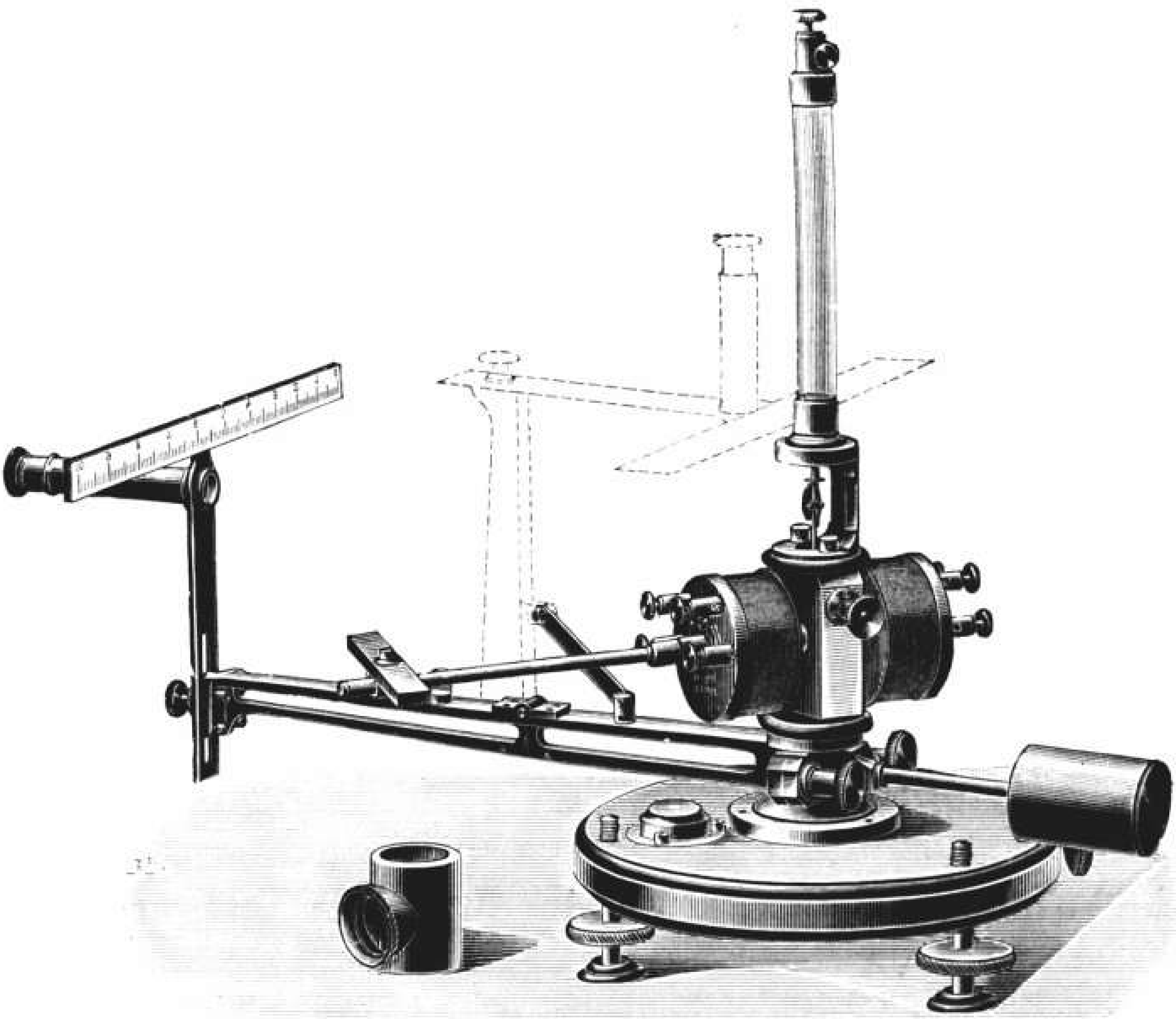


Fig. 5.

11. Moving Coil Pointer Galvanometer.

With coil on pivots or suspended by a short wire; scale divided in degrees with mirror to prevent parallax; secure arrestment. Sensibility with 50 ohms resistance: on pivots, 1^{0} = 0·000014 amp.; suspended, 1^{0} = 0·000005 amp.

12. Moving Coil Reflecting Galvanometer. (Fig. 6.)

Easily transportable on account of the solid fastening of the glass cylinder and a secure arrestment of the coil. This arrestment also relieves the suspension strip. Simple adjustment by means of a level. The coil has two windings, one of which is closed through a small resistance to supply damping. This last is adjustable.

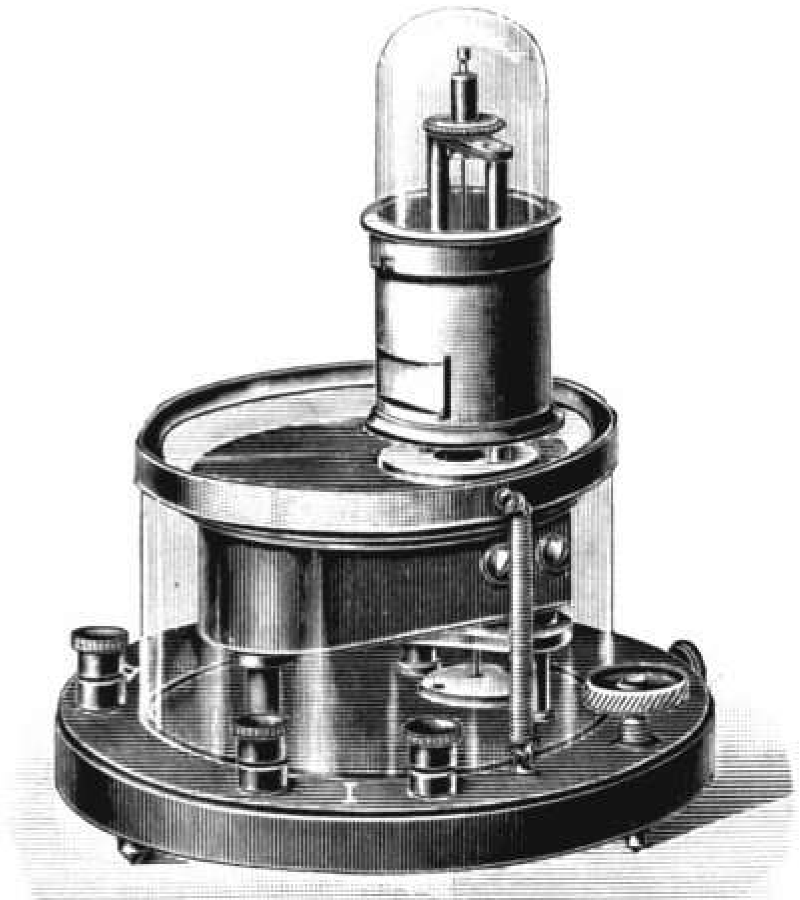


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Fig. 6.

Sensibility: with about 50 ohms resistance in coil, 1 *mm.* on a scale 1 *m.* distant = 4×10^{-9} amp.; with 700 ohms, 1 *mm.* = $1{\cdot}5 \times 10^{-9}$ amp. With finer supporting strip, higher resistance and a coil connected in series, making a total of 10 000 ohms, the sensibility attained with a constant point of rest is 1 *mm.* = 7×10^{-10} amp.

For ballistic measurements the coil is provided with a double arm for carrying spherical weights. The ballistic sensibility, with 700 ohms resistance in the coil and a time of swing of 10 sec., amounts to 200 *mm.* deflection for one microcoulomb.

13. Moving Coil Galvanometer with Reversible Telescope Arm.

The arm consists of two parts, which telescope into each other, one of which can be drawn out so as to give a scale distance of $^1/_2$ *m.* This easily transportable instrument can be set up ready for use in one minute.

14. Telescope and Scale for Reflecting Instruments.

Free from iron; powerful objective; euryscopic micrometer eye piece; sensitive adjustment in vertical or horizontal directions; large angle of elevation so that other observations may be taken if necessary.

Scales accurately divided, of wood, covered with paper, milk glass or mirror glass, with convenient arrangement for either horizontal or vertical use.

Wooden stand which can be rapidly raised or lowered. The instrument itself has a vertical rack and pinion adjustment.

The instrument is made in three sizes with telescopes of 55, 40 and 30 *mm.* opening.

15. Wall Arm with Telescope and Scale.

A vertical tube is fastened to the wall and to this is attached an aluminium arm 1 *m.* long capable of horizontal rotation, of being pushed up out of the way, and of being clamped in position. The free end of the arm carries a telescope with horizontal and vertical adjustment. Movable scale, lighted by a tube lamp. The whole is supported by a cord, running over a pulley, connected to a counterpoise in the interior of the brass tube.

A similar arrangement is made for attachment to the ceiling.

16. Scale Lantern, of sheet brass with heavy foot. The ventilated case has adjustable tube with collecting lenses, with fine adjustment in both horizontal and vertical directions. The scale is movable. A diaphragm, crossed by a fine wire illuminated by petroleum or Auer burner, is used for projection, or the incandescent filament of a tube lamp may be used.

17. Vibration-free Suspension for Mirror Instruments, according to Julius. A three armed support is fastened to the ceiling so as to be capable of rotation. Thin suspension wires with screw adjustment are attached to the ends. These support a shelf arranged to receive any mirror instrument desired. The suspension hooks are adjustable and are brought into the horizontal plane passing through the center of the mirror. Before the suspension is set free, the instrument is balanced on its shelf by means of the adjustable counterpoises. Dampers, dipping in oil, protect the apparatus from the effects of air currents.

IV. Standards for the Measurement of Current and Electromotive Force.

18. Potentiometer with Sliding Contacts. (Fig. 7.)

This consists essentially of four sets of resistances the sum of which is equal to 9999 ohms, which may be increased to 10000 ohms by means of the double slide wire resistance. Two of the dials are arranged as usual, while the two others are so made that their resistances, arranged in a circle, can be divided into two separate series by means of sliding contact pieces. It is thus possible to vary at will by means of the sliding contacts the resistance in the potentiometer circuit, between 0 and 10 000 ohms. This resistance can be read directly. By the use of sliding contacts the accuracy of the measurements is in no wise decreased.

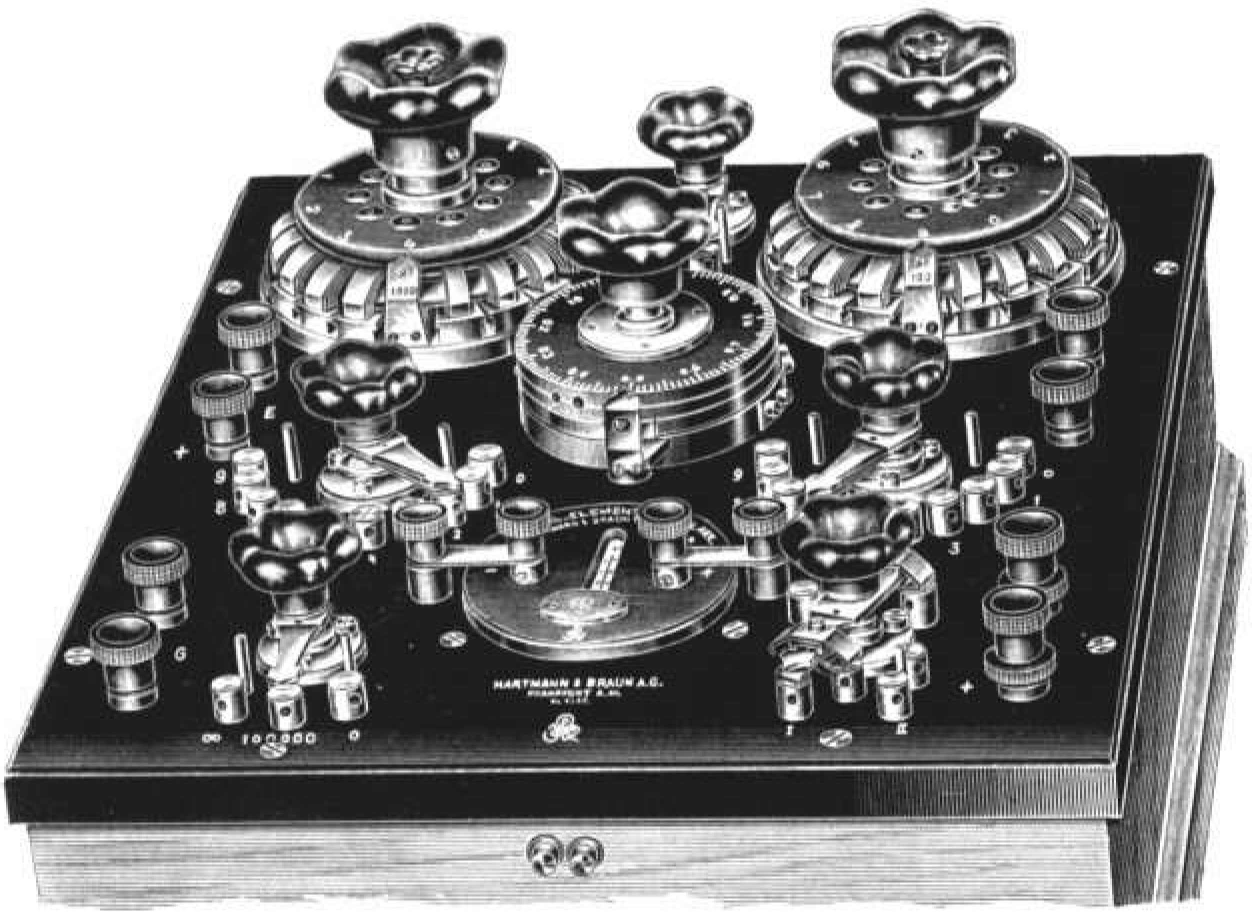


Fig. 7.

19. Plug Resistance Box of Precision.

Auxiliary apparatus for the potentiometer with the resistance of 1, 2, 3, 4, 10, 20 etc. to 40000 ohms. Total resistance 111111 ohms.

20. Standard Resistances of manganin, after the models of the Physikalisch-Technische Reichsanstalt.

The resistances are enclosed in metal cases with perforated bottoms so that petroleum baths with stirrers can be used for measurements at constant temperature. The current is introduced in some cases from mercury cups, and in some cases by means of binding screws. Resistances of 100 000, 10 000, 1000, 100, 10, 1, 0·1, 0·01, 0·001 and 0·0001 ohm are made. The two last, intended for current strength of 500 and 2000 amp., are furnished in metal baths provided with cooling tubes for flowing water and stirrers. All the resistances below 10 ohms are furnished with binding posts for fall of potential.

21. **Standard Cells,** according to Clark and according to Weston.

V. Direct Reading Electrodynamic Measuring Instruments

for scientific use.

In the construction of these instruments, intended especially for alternating currents, special stress is put on the avoidance of disturbances due to induction and external fields, on the independence of the frequency, and on the greatest possible uniformity of scale. By the method of suspension of the movable coil a high degree of sensibility is attained, and by air damping the motion is made aperiodic.

22. **Standard Astatic Electrodynamometer** for currents up to 25 amp. By the use of a stationary auxiliary coil the initial sensibility is so increased that, from 5 % of the maximum value on, the scale divisions are uniform.

23. **Standard Astatic Electrodynamometer** (Fig. 8) for weak currents, also may be used as voltmeter. Current, producing the maximum deflection of 90°, about 50 milliamp.; series resistance for use to 200 volts in instrument; pointer and mirror reading.

24. **Standard Astatic Wattmeter.** Movable system of flat oval coil, bent in ᒣ form, which gives a torsional moment independent of the position, hence the scale is uniform from the beginning. Maximum current as desired from 1 to 25 amp., maximum voltage as desired from 25 to 200 volts.

25. Small Electrodynamic Milliamperemeter with uniform scale to 60 milliamperes, with 500 ohms resistance. Coefficient of self induction 0·02 to 0·04 henry.

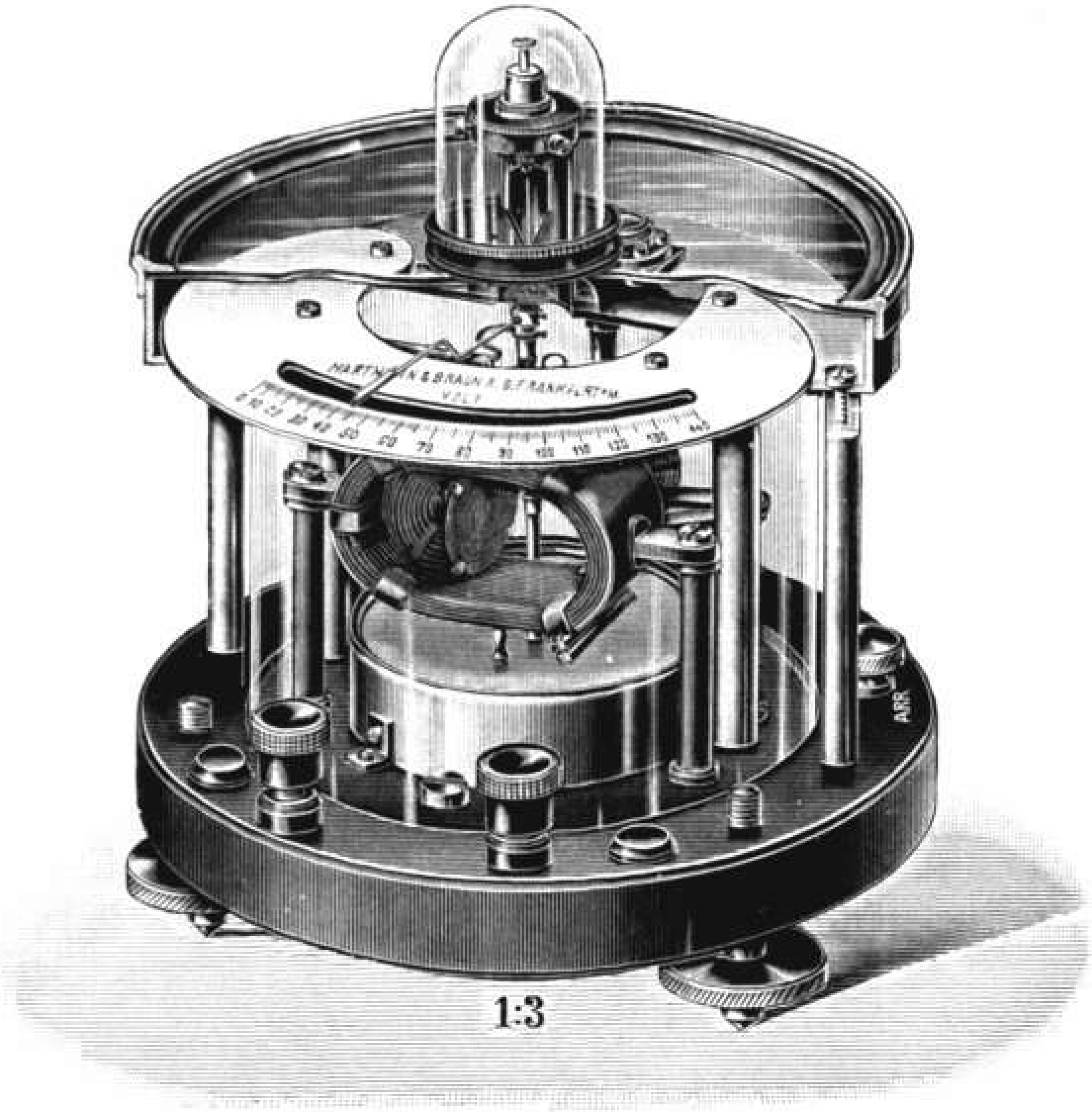


Fig. 8.

26. Phasemeter, indicating directly difference in phase. It is in principle a double wattmeter with two crossed movable coils, connected in parallel, which act partly in opposition. The reading of the pointer depends only on the action of the two electrodynamic directive forces. The movable system has therefore no point of rest when no current passes. The readings are theoretically independent of the current and of the voltage. The phasemeter is also furnished as a switchboard instrument.

VI. Apparatus for Measuring Resistance.

27. Bridge with Plug Connections, with interchangeable ratio arms. (Fig. 9.) The interchange is accomplished by means of two connected plugs by one motion. The resistances above

300 ohms are not only free from induction but also from capacity, being wound according to Chaperon. In addition to the ordinary plug connections, plugs may be put in at the sides for isolating any single resistance. A special tool is provided for cleaning the holes for the plugs. All the parts which are to be touched with the hand are covered with hard rubber to prevent thermo-currents.

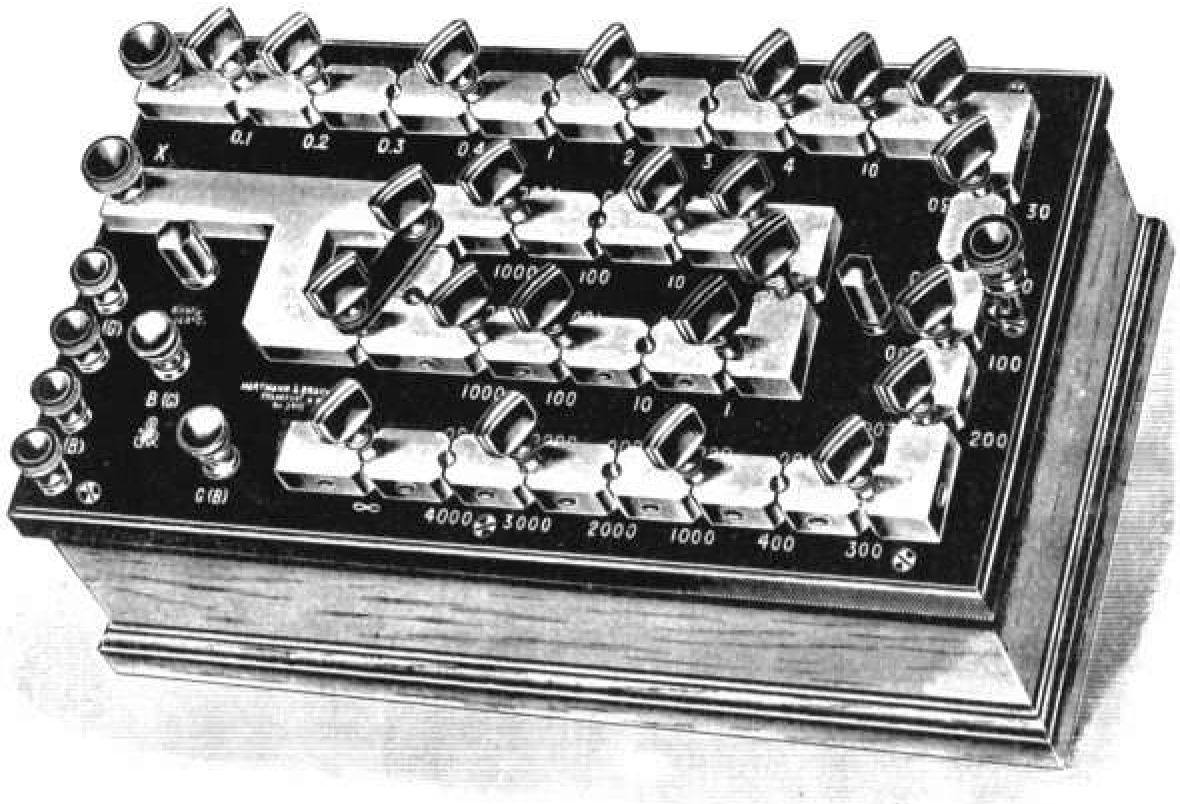


Fig. 9.

28. Simple Bridge with Plug Connections, made up of several rows with four resistances in each which when connected in series form a decade. Also four pairs of ratio resistances, all mounted on the same base.

29. Plug Rheostats connected in series and in decades.

30. Bridge with Sliding Contacts, consisting of single decades, which with pairs of ratio resistances and a double key are mounted on the same base.

31. Roller Bridge, according to Kohlrausch (Fig. 10), with two additional resistances, each having 4·5 times the resistance of the 3 *m*. long bridge wire. By means of plugs these may be connected together at either end of the wire, or placed one at each end.

In addition, *induction coil* with water covered mercury break as generator of alternating currents for the measurement of the resistance of electrolytes. Also different forms of *glass resistance-cells* with platinised platinum electrodes, partly according to Kohlrausch, partly according to Arrhenius.

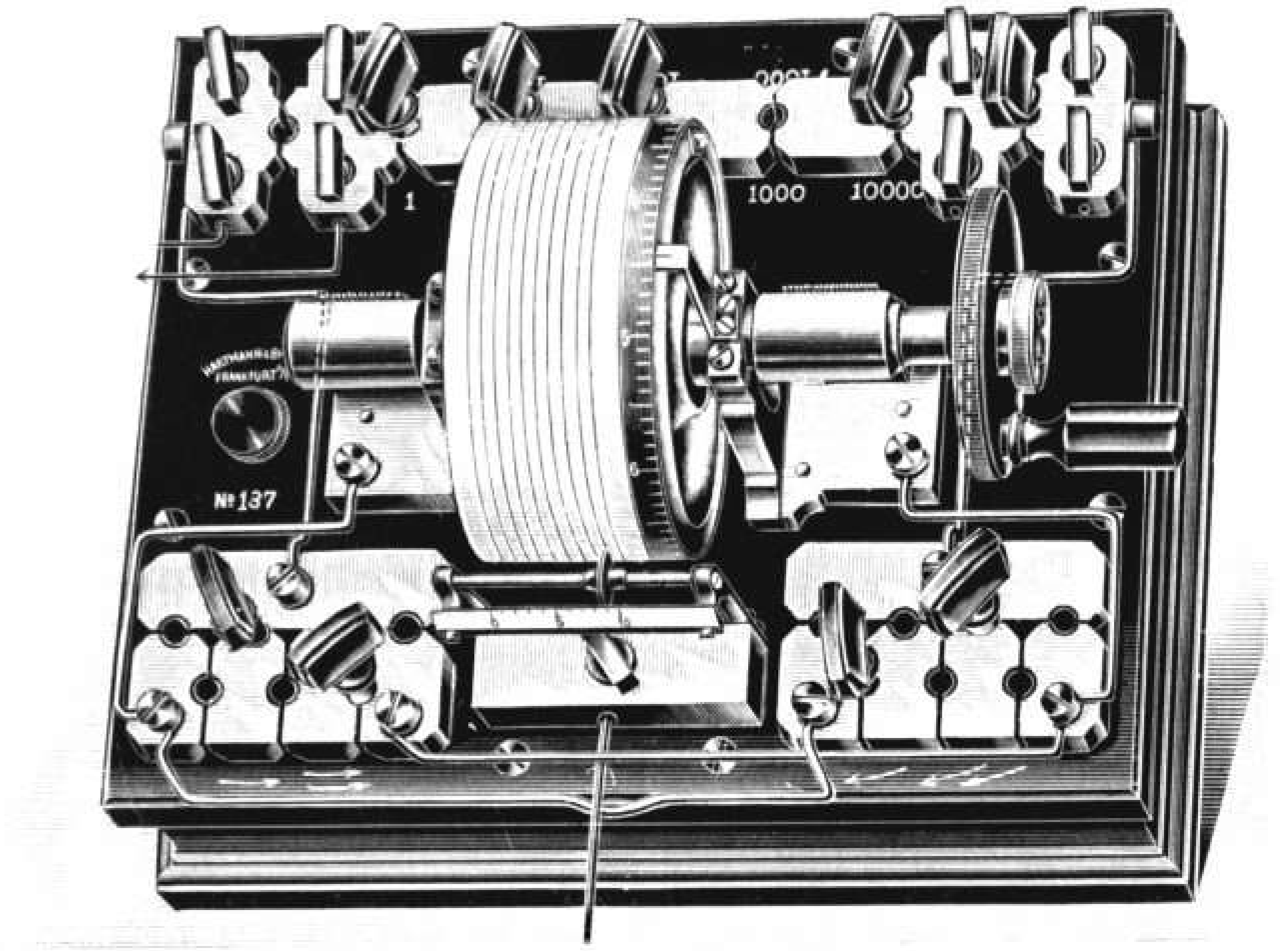


Fig. 10.

32. Universal Bridge, according to Kohlrausch (Fig. 11), for the direct reading of resistances in ohms, arranged for the measurement of the resistance of electrolytes with alternating currents (generated by a small induction coil) and telephone. Also intended for the measurement of metallic resistances with moving coil galvanometer. A shunt and a series resistance permit the measurements of current and voltage.

33. Telephone Bridge, according to Nippoldt, for the measurement of the *resistance of earth connections.* A bridge wire in round form is attached to a watch case telephone; the sliding contact is attached to a graduated dial on the back of the telephone. For manipulating the apparatus only three fingers are necessary. The alternating current is supplied by a small induction coil, and it is so arranged that direct current for the measurement of metallic resistances may be used with a galvanometer.

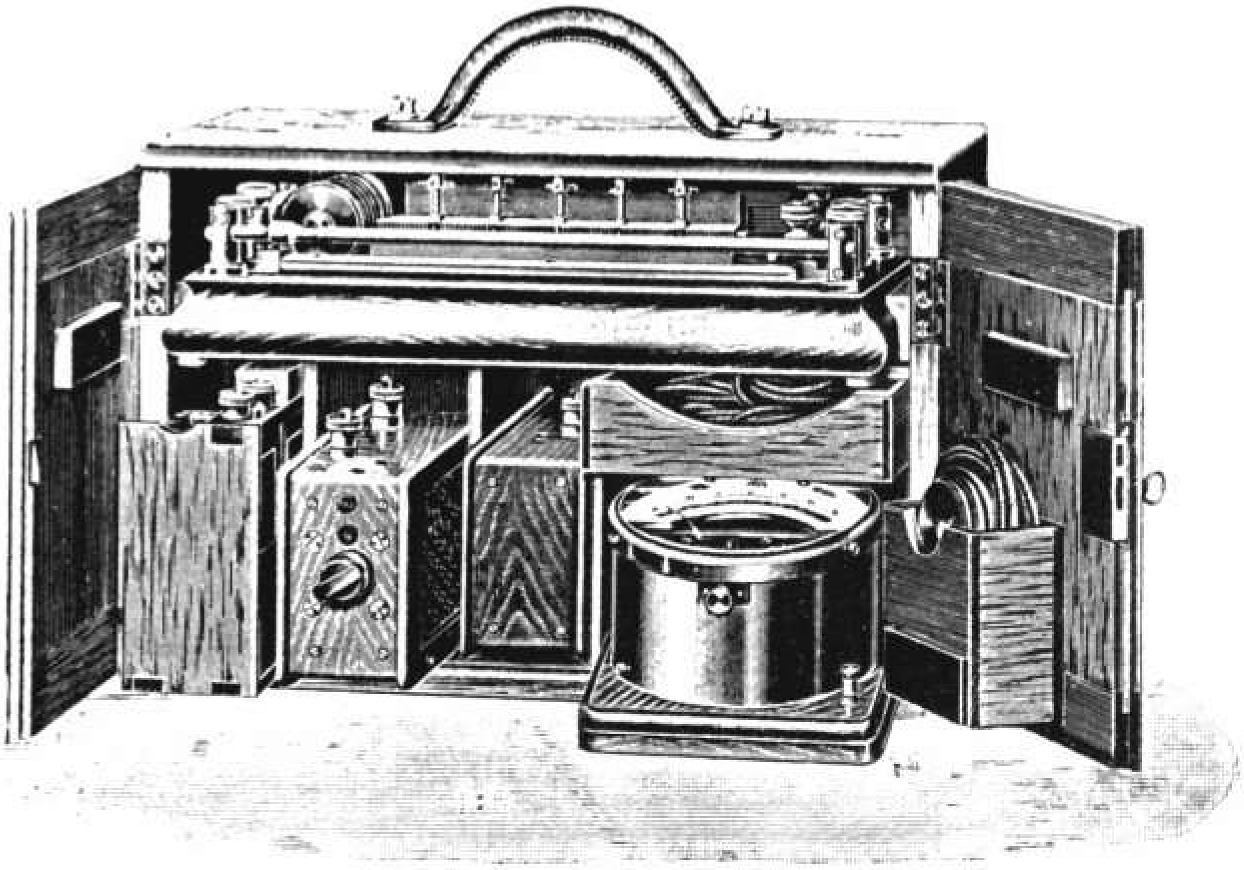


Fig. 11.

34. Sliding Contact Rheostat for heavy measuring currents. To be used lying flat or hanging on the wall. Each decade is fitted for the consumption of 100 watts and is accurately adjusted.

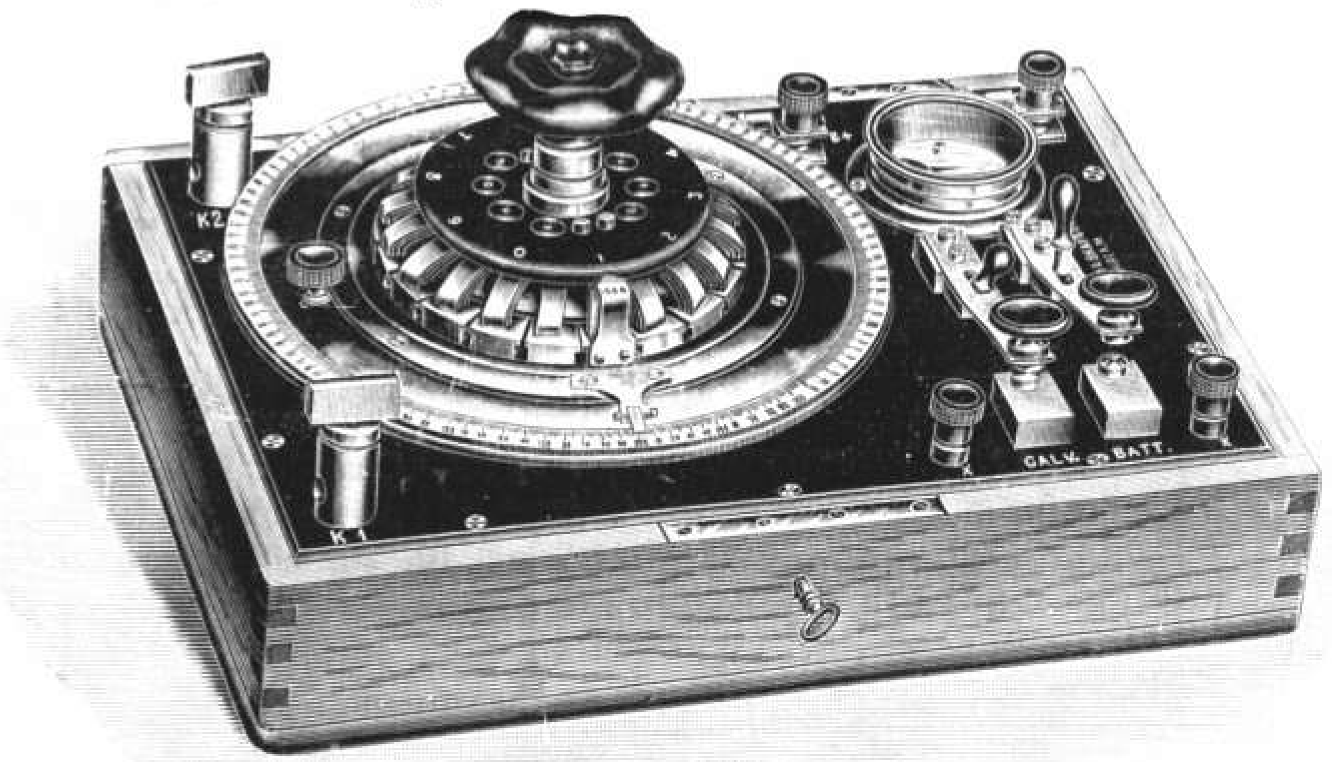
VII. Cable Testing Apparatus.

35. Thomson Double Bridge for small resistances, especially for the determination of the conductivity of linear conducting materials. The apparatus consists of two portions in the same case, the arrangement for clamping with test piece and the measuring apparatus. Two heavy clamps serve for introducing the current and for holding test pieces of any cross section, the resistance of an accurately measured length of which, lying between the clips, is determined. The slide wire is directly calibrated in thousandths of an ohm. Two comparison rheostats, each containing 10, 10, 10, 100 and 1000 ohms, and a key complete the convenient apparatus. It is possible with this apparatus to read resistances from 0·00001 ohm to 10 ohms without further calculation.

It is also suitable for the determination of non-linear resistances, for example, armature coils.

36. Apparatus for the Determination of Insulation and Capacity, according to the methods of direct deflection or of comparison. Connected ready for use and mounted on a marble slab. Consists of an accurate comparison resistance of 2 × 100000 ohms; an accurate shunt rheostat with short circuiting arrangement which reduces the sensibility of the galvanometer to $^1/_{10}$, $^1/_{100}$, $^1/_{1000}$ and $^1/_{10000}$; a divided condenser with 0·5, 0·2, 0·2 and 0·1 microfarad; a spring commutator; two cable keys and a switch for rapidly interchanging the object being tested and the standard. Also a double poled switch for changing the two methods of measurement. The connecting conductors are stiff and stand out free so that the best possible insulation is assured.

37. Slide Wire Bridge with Sliding Contact Auxiliary Resistance. (Fig. 12.) Especially for the *determination of the position of leaks in cables.* It contains, in addition to a fixed comparison resistance of 10 ohms, a slide wire fastened about a hard rubber disk, and nine resistances each of which is equal to the resistance of this wire. These may be connected in any proportion at the ends of the slide wire by means of sliding contacts. There is therefore always a resistance in the circuit equal to ten times the resistance in the slide wire, and as the wire is divided into a thousand parts, one ten thousandth of the total resistance can be read. For portable use the apparatus is put up in a convenient case with small d'Arsonval galvanometer and a battery.



1:4

Fig. 12.

38. Induction Clip, according to Dietze (Fig. 13), for the determination of faults in insulation by means of the telephone, or with a hot wire amperemeter for current measurement in alternating current conductors. The apparatus consists of a double iron core the two halves of which are jointed so that they may be opened like tongs to receive the conductor to be tested. This forms the primary circuit of a transformer whose secondary coil is connected to the telephone or the hot wire instrument. The instrument is made in two sizes, the larger is intended to receive the ordinary high potential fuses. The range of current measurements is determined by the size of the secondary coil.

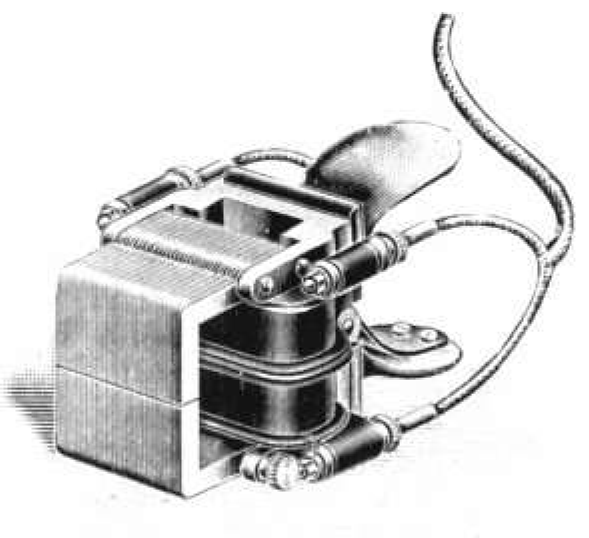


Fig. 13.

VIII. Calibrated Standard Instruments.

The form of instrument of this kind has become typical. These instruments of precision are enclosed in walnut cases with hinged tops, which also serve for transportation. A mirror is fixed below the scale and the pointer is of the knife form. The divisions are fine and of the same thickness so that the estimation of tenths is easily possible. The motion of the pointer is aperiodic.

39. Moving Coil Standard Millivoltmeter. (Fig. 14.) With system balanced so that it may be used in horizontal or vertical position. Also series and shunt resistances, fitting it for all ranges of measurement. Perfect temperature compensation.

40. Combined Moving Coil Ampere and Voltmeter. (Fig. 15.) For ranges of current and voltage measurements up to 200 amp. and 300 volts. Also contains a bridge for the direct reading of resistances from 0·01 to 10000 ohms.

41. Hot Wire Voltmeter for ranges between 0·5 and 260 volts.

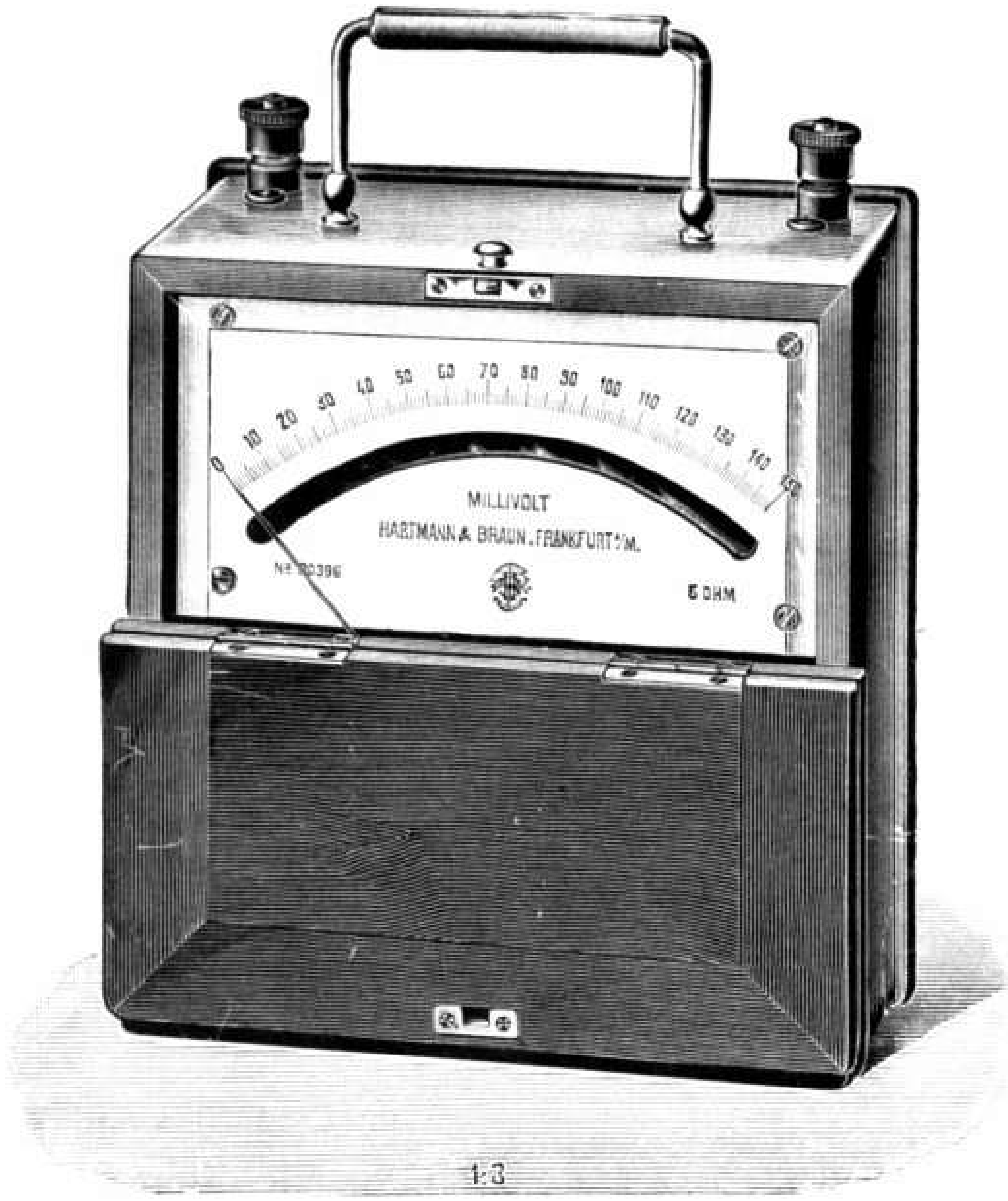

MILLIVOLT
HARTMANN & BRAUN. FRANKFURT a/M.
6 OHM
1:3

Fig. 14.

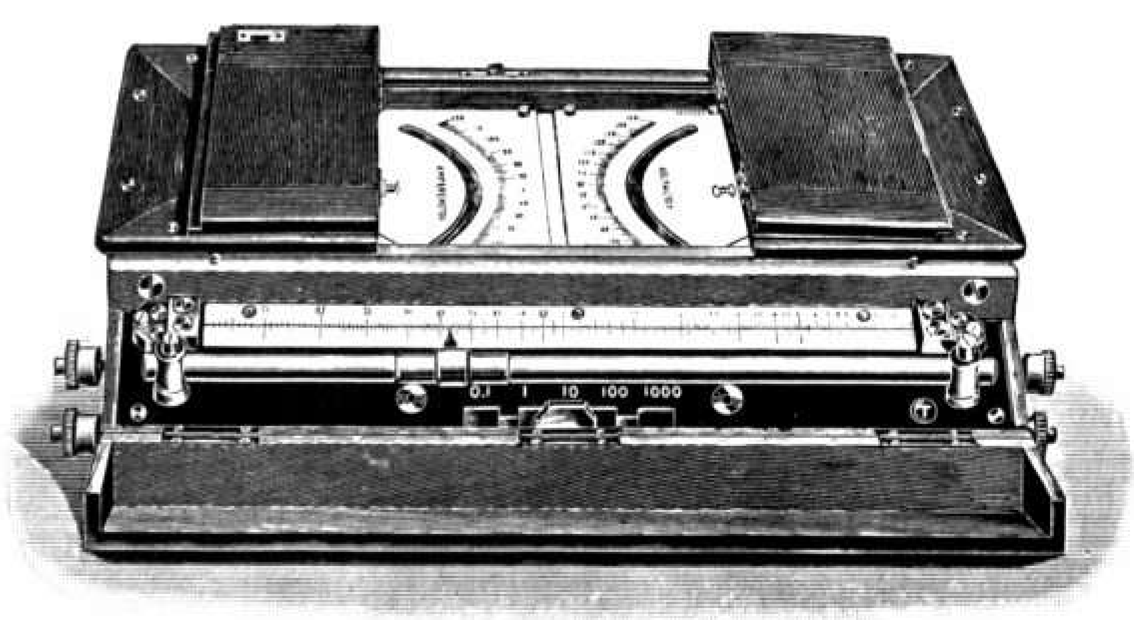

0,1 1 10 100 1000

Fig. 15.

42. Combined Hot Wire Ampere and Voltmeter for ranges of current and voltage measurements up to 50 amp. and 260 volts. The wire is protected from danger of burning out by removable fuses.

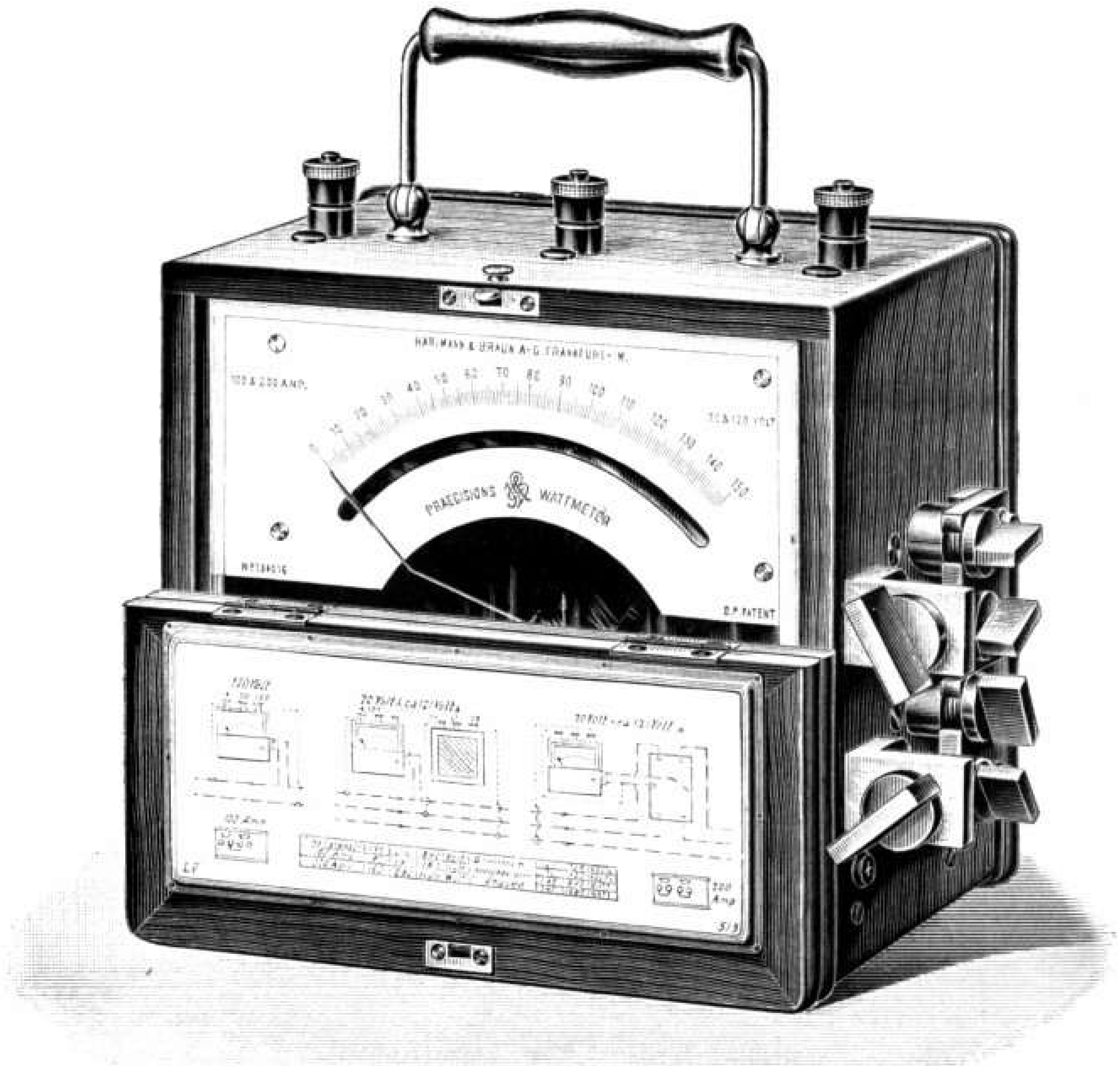


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Fig. 16.

43. Standard Electrodynamic Wattmeter (Fig. 16), with almost perfectly uniform scale. Independent of changes of temperature and of the self induction of the moving coil. Two ranges of measurement up to 400 amp. Series resistance for voltages to 150 volts contained in the case.

44. Electrodynamic Phasemeter for the direct reading of difference of phase for currents up to 150 amp. Exact readings of the pointer above $30^{0}/_{0}$ of the maximum current.

45. Ohmmeter with crossed moving coils in non homogeneous magnetic field. Accuracy independent of the voltage over a wide range. This last is best furnished by a direct current inductor. For all ranges up to ten million ohms.

46. Direct Reading Moving Coil Insulation Meter, containing battery, the variations in voltage of which can be corrected by means of a magnetic shunt on the instrument.

IX. Resonance Instruments

according to Hartmann-Kempf.

These instruments contain a number of accurately tuned steel reeds of invariable time of vibration, arranged so as to form a scale. Under the influence of the pulsating forces of laminated magnets, excited by alternating currents or broken direct currents, those reeds are set in motion whose frequencies correspond to the frequency of the exciting current. The strength of the exciting current has no influence on the accuracy, nor has the form of the current curve. The reeds can be tuned from 20 to 150 vibrations per sec. They can also be used for double vibrations by means of a transposing arrangement.

47. Electro-acoustic Frequency Meter. Consists of 32 reeds, provided with sounding boards, arranged in a circle so as to be capable of rotation. These are excited by a double magnet which is to be pulled apart by the width of 3 or 5 reeds. The circle of reeds is then rotated until the one in resonance lies in the middle between the two magnets. No sound is then heard, but any change in the frequency is indicated by the sounding of the neighbouring reeds.

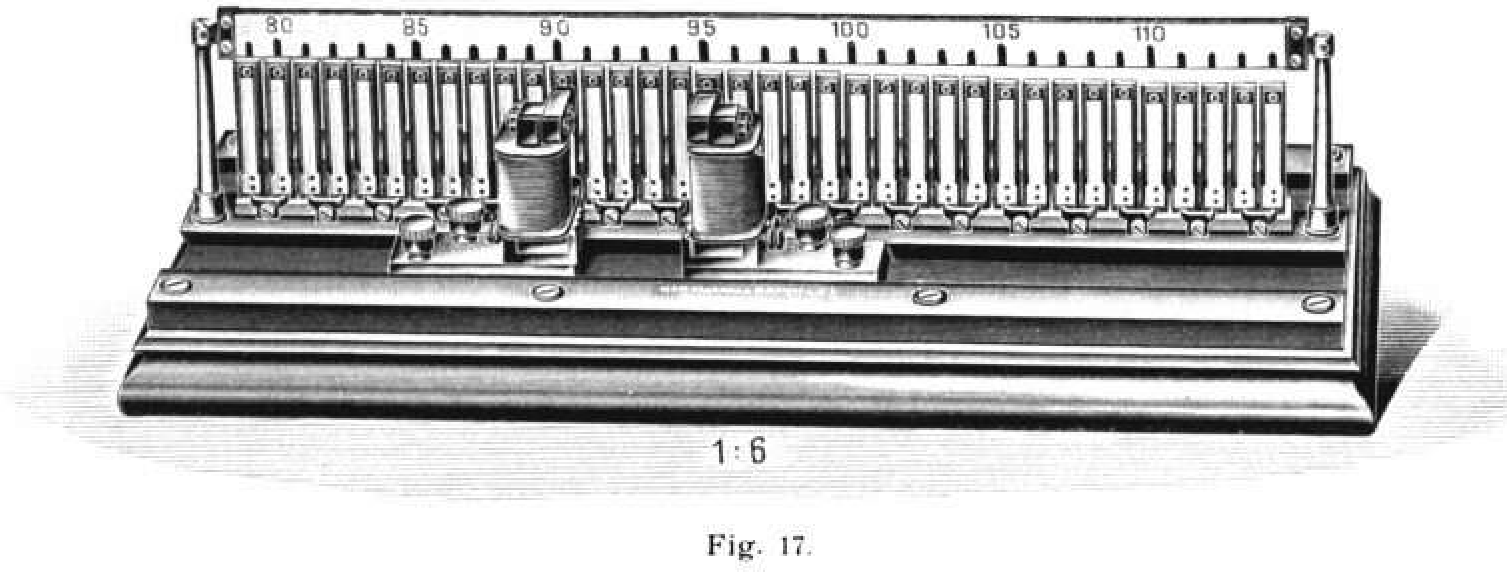

Fig. 17.

48. Electro-acoustic Tonometer (Fig. 17), with a scale of 36 tuned reeds in a row, before which on each side exciting magnets can be moved. This arrangement is especially suitable for demonstration purposes. In connection with a circuit breaker, provided with a friction point to apply to the motor axle, it may be used to demonstrate "slip" and make accurate "slip" measurements.

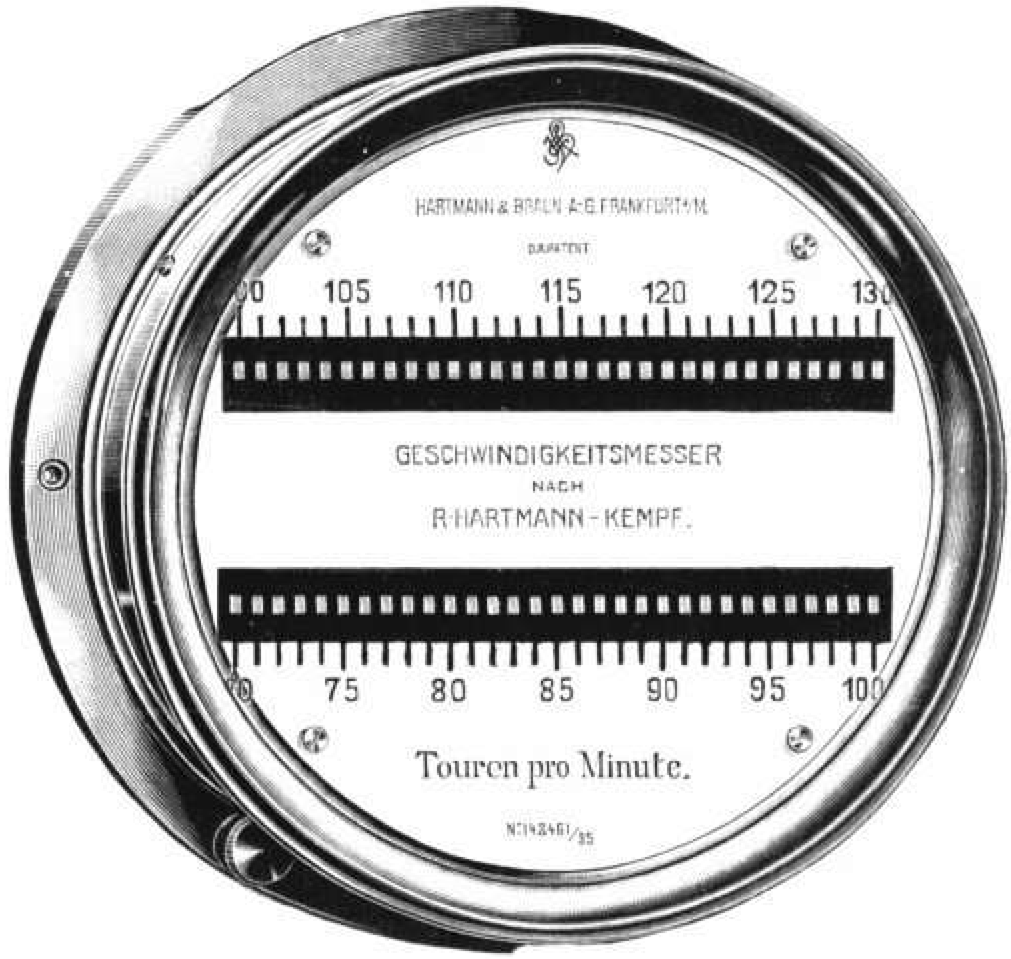

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Fig 18.

49. Double Frequency Meter with Synchronism and Similar Phase Indicator. The apparatus consists of two separate frequency meters, each with three reeds above and three below the normal frequency, and a third meter with three reeds tuned in smaller intervals, the middle one giving the normal frequency. This is excited by means of an electro-magnet provided with two separate windings, and shows accurately the beginning of synchronism and similarity of phase on the two dynamos for whose parallel connection the apparatus is primarily intended.

50. Speed Counter (Fig. 18), with 62 tuned reeds, for determining the velocity of rotation of axles which directly or indirectly, by means of circuit breakers or small generators, produce wave like current impulses. Can be arranged to register turns per minute for machines, kilometers per hour for conveyances, or meters per sec. for cable velocity on hoisting engines, etc.

X. Electric Apparatus for Reading Temperatures at a Distance.

51. Electric Resistance Thermometer. The measuring apparatus contains in a flat metal sheath a platinum resistance of accurately determined temperature coefficient. The ends of the resistance project from the sheath and are to be soldered to the connections. Resistances are furnished suitable for all purposes, for very low as well as for high temperatures up to 400° C. Also for measuring the pressure in boilers.

52. Temperature Indicator for use at a distance (Fig. 19). Can be furnished as fixed, portable or as registering instrument. These are made on the principle of the moving coil instruments but like the ohmmeter (No. 45) have two crossed coils in a non-homogeneous magnetic field so as to form a kind of differential galvanometer. The sensibility can be so adjusted that the whole scale can be used for a few degrees or for a large temperature interval. By means of switches, a single temperature indicator can be used for reading several thermometers, one after the other.

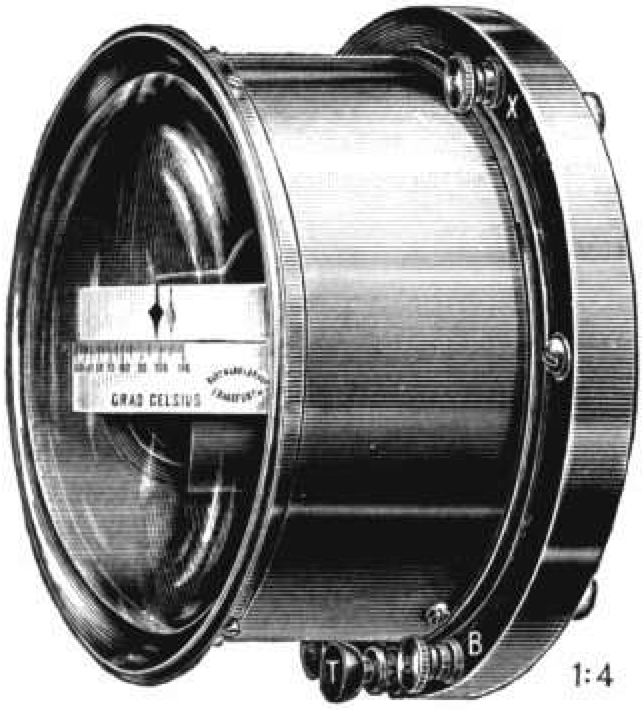

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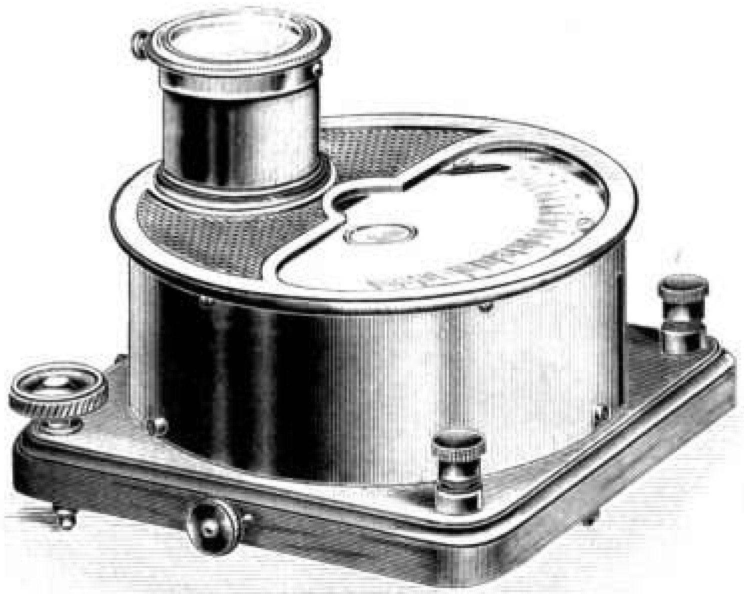
Fig. 19.

53. Thermoelectric Pyrometer for High Temperatures. The thermoelements for temperatures up to 1600° C are made according to Le Chatelier, of platinum platinum-rhodium, up to 800° of platinum platinum-nickel. This last has double sensibility. For lower temperatures iron constantan is used. The elements have a special mounting in a fire clay cylinder, contained in a platinum tube so that it will not fall apart if it cracks. The two last named thermoelements, well insulated, are contained in flat steel tubes.

54. Thermogalvanometers (Fig. 20), may be used as direct reading instruments for high temperatures, or for reading temperatures at a distance. Millivoltmeter on the moving coil principle, strongly built, suitable for all technical purposes. They are made as portable or fixed instruments, the last are arranged as switch board instruments. Also made for automatic registration. The curve is a broken one, but the intervals are so short that even in the case of large temperature variations, a connected curve is produced.



1:4

Fig. 20.

XI. Direct Reading Technical Instruments for Current, Voltage and Energy Measurements etc.

These instruments are made according to a uniform model and in different sizes from 5 to 50 *cm.* in diameter according to their method of use. The pointer and scale are arranged so as to give the greatest possible certainty of reading. The thickness of the division lines is everywhere the same and the length is proportional to the width of the interval. The movement of the pointer is aperiodic.

55. Electromagnetic Ampere and Voltmeter with air damping, for direct and alternating currents. In the interior of a coil are situated two concentric thin segments of a cylindrical shell, one nearly covering the other. One of these is stationary, and the other is rotated when the current flows. The readings are nearly the same for direct or alternating currents, the curve form and frequency having practically no influence A soft iron ring shields the instrument from the action of external fields. For current strengths up to 1000 amp. and voltages up to 800 volts, without auxiliary apparatus.

56. **Standard Ampere and Voltmeter** with moving coil in permanent magnetic field, for direct currents. In distinction from soft iron instruments, these are completely independent of position and of external magnetic influences. Have a more uniform scale and absolutely aperiodic damping. The energy consumption of the voltmeter is much smaller and they are therefore just as advantageous for very low voltages as for higher. For currents above 100 amp. shunts are used which are furnished for currents up to 20000 amp.

57. **Hot Wire Ampere and Voltmeter** with magnetic damping (Fig 21). Short, horizontal stretched wire whose bending is transmitted to the axis of the pointer by a peculiar but very simple tension arrangement. In the amperemeters, for the sake of diminishing the voltage loss, current is introduced into the wire at several points. The wire is protected against too large currents. The instrument is equally suitable for direct or alternating currents. It is especially suitable for the latter on account of its complete independence of frequency and the absence of self induction. With suitable shunts it may be used for currents up to 20000 amp.

58. **Electrodynamic Standard Ampere and Voltmeter.** By a suitable arrangement of the fixed and movable coils in series, it is possible to obtain a practically uniform scale for all readings above 20% of the maximum. The instruments are furnished with air damping and are especially suitable for alternating currents. As the maximum current strength for which they are made is 0·5 amp., for larger currents they are connected to a transformer.

59. **Induction Instruments** on the Ferraris principle. To be used for alternating currents. These are often preferred on

account of their strong construction, made possible by the large forces involved. They are however dependent upon the frequency.

Fig. 21.

60. Electrostatic Voltmeter for high potentials. A light vane which is suspended as in a Gauss balance, is repelled by a fixed vane, having a charge of the same kind, and attracted by a second more distant vane of opposite charge. The small displacement of the middle vane is transmitted to a pointer, provided with magnetic damping, by an elastic connection. The insulation is sufficient for a difference of potential of 20000 volts. Lowest range from 900 to 1500 volts. Higher ranges up to 100000 volts are attained by the connection of condensers in series with the instrument.

61. Multicellular Electrostatic Voltmeter, according to Lord Kelvin. Suitable for voltages from 50 to 100 volts as a lower range and up to 1000 volts as a maximum, according to the number of needles hung on the short suspension strip.

The original oil damping has been replaced by a magnetic damping. It is used especially for the measurement of voltages in the feeders of direct and alternating current systems.

62. **Standard Electrodynamic Wattmeter** for direct and alternating currents. Independent of the curve form, frequency and difference of phase, in the last case, since the self induction of the movable coil is very small. The scale is uniform from the beginning. Maximum current 400 amp. Higher ranges in alternating currents, and three phase currents can be secured by means of transformers. The motion of the pointer is made aperiodic by air damping.

63. **Frequency Meter on the Resonance Principle,** with 6 reeds above and 6 below the normal frequency, in intervals of 0·5 or 1 alternation.

64. **Direct Reading Phasemeter** for the determination of the difference in phase between an alternating current and its accompanying E. M. F. Electrodynamic principle with crossed moving coils. Almost uniform scale for differences of phase from 0 to 90^{0}. For currents up to 150 amp. and voltages of 200 volts. For higher voltages series resistances are used. Readings accurate above 30% of the maximum current strength.

XII. Registering Current, Potential and Energy Meters.

In the construction of the following registering instruments it is desirable to have a rectangular coordinate system. It is therefore necessary that the recording pen connected with the moving systems should be given a rectilinear motion. The clock works are constructed for different velocities, two or three, as desired. They are furnished with paper strips 15 m. long.

65. **Electromagnetic Registering Current and Voltage Meters** (Fig. 22). If desired, both record on one drum in the same case. Different colored inks may be used. Con-

structed on the principle of the Kohlrausch galvanometers. A soft iron core is hung on a spiral spring inside a solenoid. The iron core is guided by a thin stretched wire. Powerful air damping. Especially for recording the charge and discharge curves of accumulators. For currents up to 1500 amp. and voltages of 600 volts. For direct and alternating currents, in the last case taking the frequency into account.

66. Moving Coil Registering Instrument. The rotational motion of the coil is transmitted by means of a wheel and a band wound about it to a recording pen which thus receives a rectilinear motion. Arranged either for deflection in one direction, or with a zero in the middle of the scale. By the use of shunts or series resistances, any range desired may be secured. Suitable only for direct currents.

67. Hot Wire Registering Instrument. Similar transformation of rotational into rectilinear motion. Especially suitable for alternating currents. Any desired range.

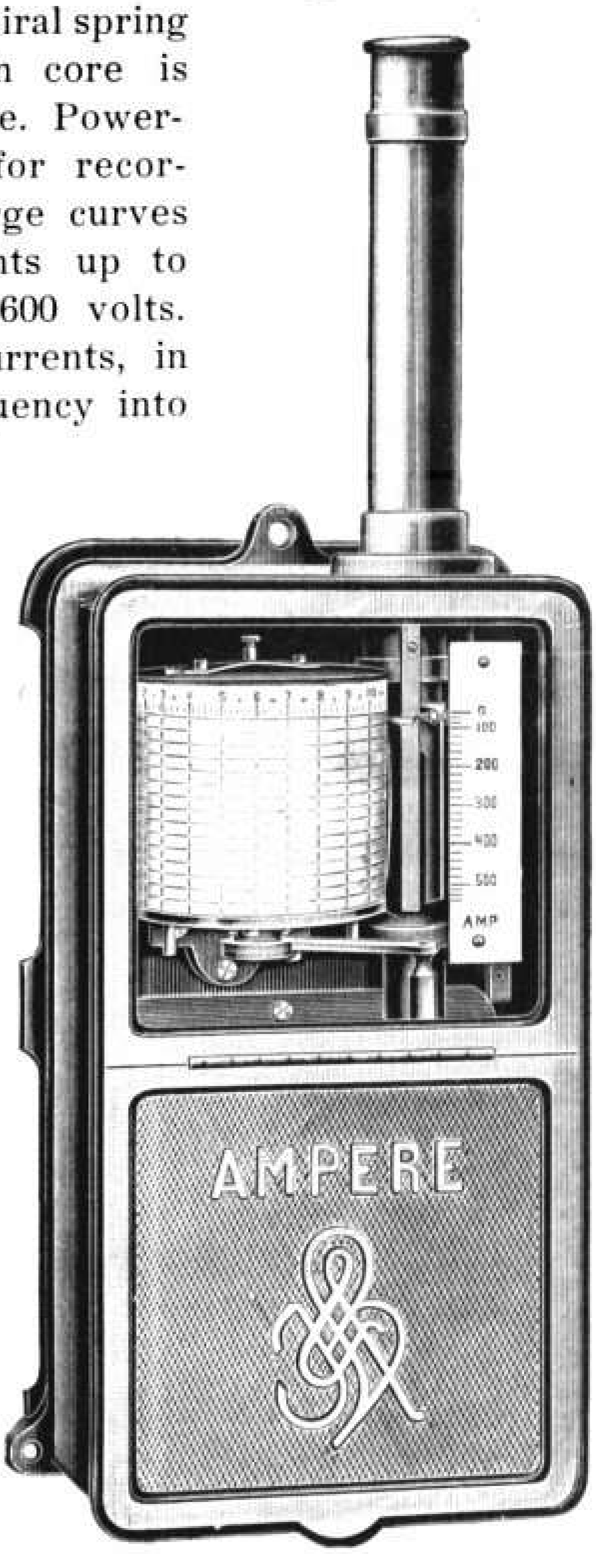


Fig. 22.

68. Registering Wattmeter. Induction instrument on the Ferraris principle, only for alternating currents. Powerful damping. For currents up to 200 amp. and voltages up to 200 volts. Higher ranges by using transformers or resistances.

Registering instruments for steam, water, and gas pressure, and for measurements of temperature, are made in form similar to the electrical instruments.

XIII. Electrical Demonstration Measurement Apparatus for Schools.

A collection of apparatus so constructed that all the important parts, especially the divisions of the scales can be seen by students from a distance. Special scale with finer divisions are so placed that they may be conveniently seen by the teacher.

69. Galvanometer. Can be taken completely apart. May be used as a simple compass or magnetometer, or as astatic galvanometer, with or without copper damper. With movable coils which may be connected in series, in parallel, or differentially.

70. Tangent Galvanometer, making use of the last mentioned galvanometer.

71. Bridge Wire with Sliding Contact. For making a Wheatstone bridge with the help of comparison resistances of 0·1, 1 and 10 ohms. In the form of wire pieces of same length and thickness, but of different materials. Also for the comparison of their conductivities.

72. Magnetometer using the galvanometer and the scale of the bridge as a track on which rests a carriage for receiving a suitable bar magnet.

73. Sliding Contact Rheostat. Three decades containing 1110 ohms. Also a slide wire resistance of 1 ohm for completing the fractional measurements, tenths and hundredths ohms. The arrangement of the resistances is visible at the back.

74. Electromagnetic Current and Voltage Indicator with a soft iron core in a coil. With two ranges up to 2 or 10 amp. and to 3 or 30 volts. Only for direct currents. Aperiodic air damping.

75. Electromagnetic School Instruments, with moving soft iron cores. Only one sensibility, but for any current strength or voltage. Powerfully damped by air vanes. Suitable for direct or alternating currents.

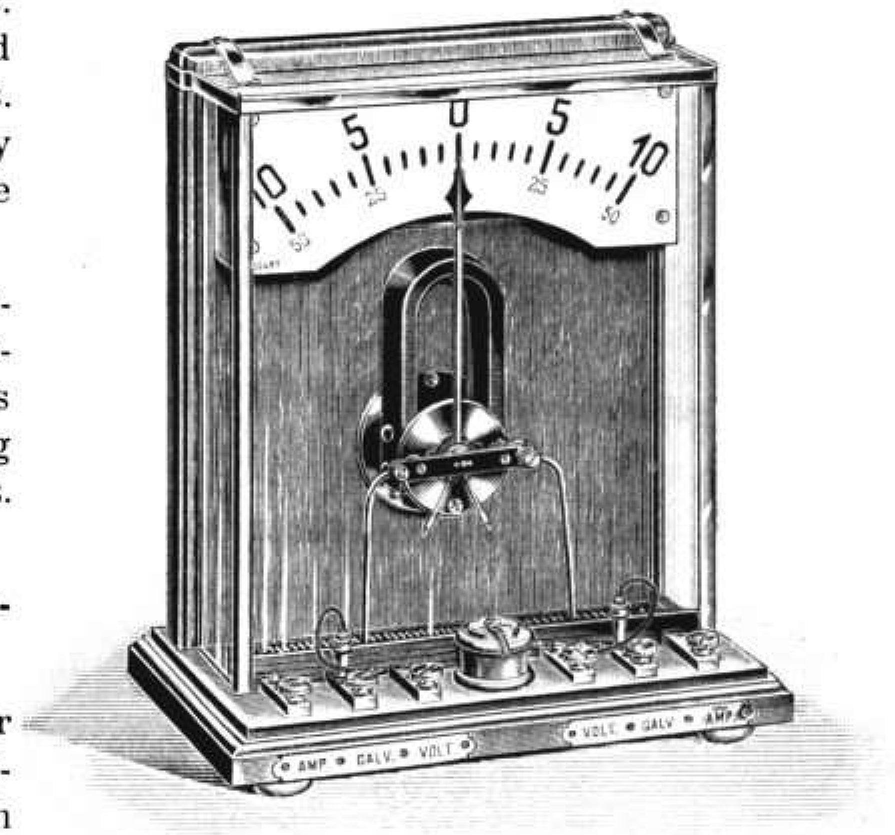
76. Electrostatic Demonstration Voltmeter. Like a quadrant electrometer, but with pointer moving in vertical plane.

77. Hot Wire Ampere and Voltmeter for Schools. For any range. Especially suitable for alternating currents, also for direct currents. All important parts visible.

78. Moving Coil Galvanometer (Fig. 23), ampere and voltmeter for schools. May be connected for different ranges. The moving coil may be removed from the magnetic field.

The two last instruments are furnished with scales 40 and 50 *cm.* long for lecture purposes.

79. Electrodynamic Demonstration Wattmeter. For direct and alternating currents, with two ranges. Connections visible.



1:6
Fig. 23.

A. Hasemann

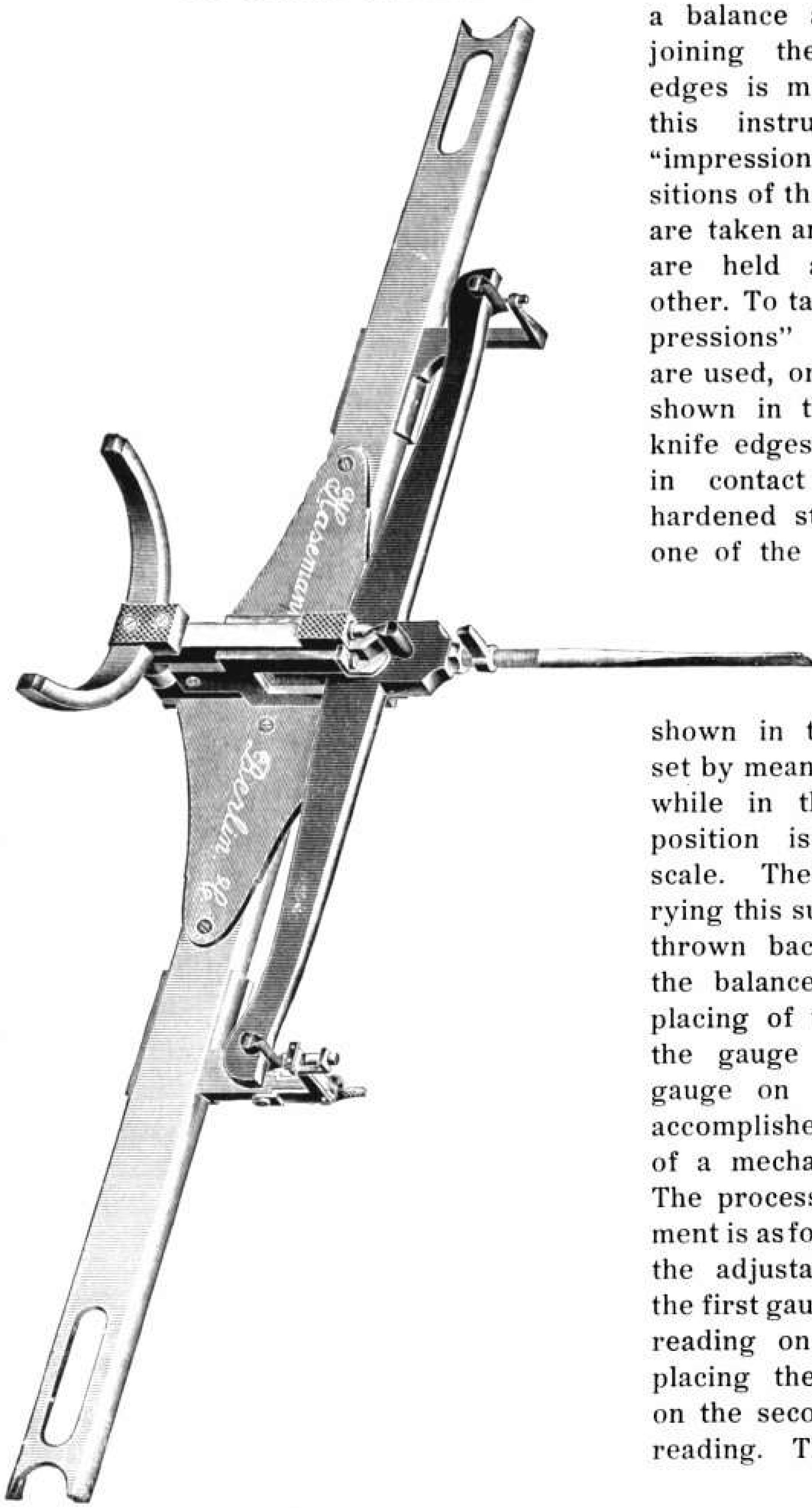
Berlin C., Nikolaikirchplatz 7/8.

No. 1—3 in A.

1. Large Standard Balance.

For loads up to 10 *kg.*, perfect arrestment, enclosed in glass case, sensibility 10 *mg.* Property of the Kaiserl. Normal-Eichungs-Kommission in Charlottenburg.

2. Apparatus for Measuring Difference in Height of Balance Beam Knife Edges.



The vertical distance between the central knife edge of a balance and the line joining the end knife edges is measured with this instrument. Two "impressions" of the positions of the knife edges are taken and then these are held against each other. To take these "impressions" two gauges are used, one of which is shown in the cut. The knife edges are brought in contact with small hardened steel surfaces, one of the latter is movable in a vertical direction. In the gauge shown in the cut it is set by means of a screw, while in the other its position is read on a scale. The frame carrying this surface can be thrown back to receive the balance beam. The placing of the beam on the gauge and of one gauge on the other is accomplished by means of a mechanical device. The process of measurement is as follows: setting the adjustable plane of the first gauge, taking the reading on the second, placing the first gauge on the second and again reading. The difference in the two readings is equal to four times the difference in height desired. In the case of the gauge which is reversed, the bending due to its own weight must be avoided, it is therefore made perfectly rigid notwithstanding its small weight.

3. Portable Decimal Balance.

For loads from 1 *g.* to 50 *kg.* (the small loads are to be weighed on the long arm); sensibility the same as in the balances of the standardizing bureaus. Arrestment of the beam and of the stirrup of the short arm. Made of steel tubing.

Hans Hauswaldt, Dr. phil. h. c.,

Magdeburg-Neustadt.

No. 1—3 in B.

1. Two Double Panels (front and back) each with sixteen original photographs of interference phenomena in plates of double refracting crystals, in convergent polarised light.

These panels contain a part of the original photographs from which Atlas I is taken.

2. Atlas I, made in the years 1897—1902, containing a systematically arranged collection of such phenomena.

3. Supplement I of this Atlas, contains interference phenomena in convergent and polarised light.

Atlas I and Supplement I were published in the printing establishment of the factory of Joh. Gottl. Hauswaldt in Magdeburg-Neustadt, under the direction of the exhibitor, in an edition of 300 copies. They were distributed without cost exclusively to universities and specialists interested in the subject. The edition is at present exhausted.

At the close of the year 1904 a new edition of 100 copies of each will appear.

Hans Heele

Berlin O., Grüner Weg 104.

Optician and Mechanician.

No. 1 and 3 in A, No. 2 in B.

The firm is especially engaged in the manufacture of spectroscopes, spectrometers, photometers and polarisation apparatus, as well as the building of large astronomical instruments.

1. **Apparatus for the Determination of Thickness** of areometers, wedges, cylinders etc. The apparatus made by C. Reichel and H. Heele is primarily intended for the accurate determination of the cross sections of areometers at various points, but can be used for many other purposes.

   A sliding piece is attached to a cylindrical column, rotation being prevented by a parallel column. On this piece rest two contact cylinders, easily movable at right angles to the direction of motion. These have edges of sapphire and micrometer scales. The scales coincide when the edges are in contact and are displaced in relation to each other when the areometer is placed between the edges. The amount of the displacement is equal to the diameter of the areometer. By means of the scales and the microscope, fastened to the sliding piece, readings may be taken to 0·0001 *mm*. The areometer is held in place so that it may be rotated around its own axis. The arrangement, intended for this purpose and which is adjustable in each direction, is situated on the end of the stand. The frictionless movement of each of the contact cylinders by means of four agate balls, each of which rolls on the side of two cylinders, is new and original. Three cylinders of steel serve as guides for all the balls. The cylinders are exactly parallel and are fastened in the sliding piece at right angles to the direction of motion.

   The instrument is the property of the Kaiserliche Normal-Eichungs-Kommission in Charlottenburg.

2. **Rotating Sector,** made according to special plans for the Physikalisch-Technische Reichsanstalt in Charlottenburg.

3. **Large Cathetometer** for the Technische Hochschule in Danzig.

Carefully and accurately ground cylinder 120 *cm.* in length, rotating in accurate ball bearings. The telescope 26 *mm.* in diameter and 23·4 *cm.* focus may be focussed from 6 times its focal length to infinity, and is reversible in its carriage. For accurate horizontal adjustment the telescope carries a level, which may be adjusted by means of micrometer screws. The scale is graduated on silver in millimeters.

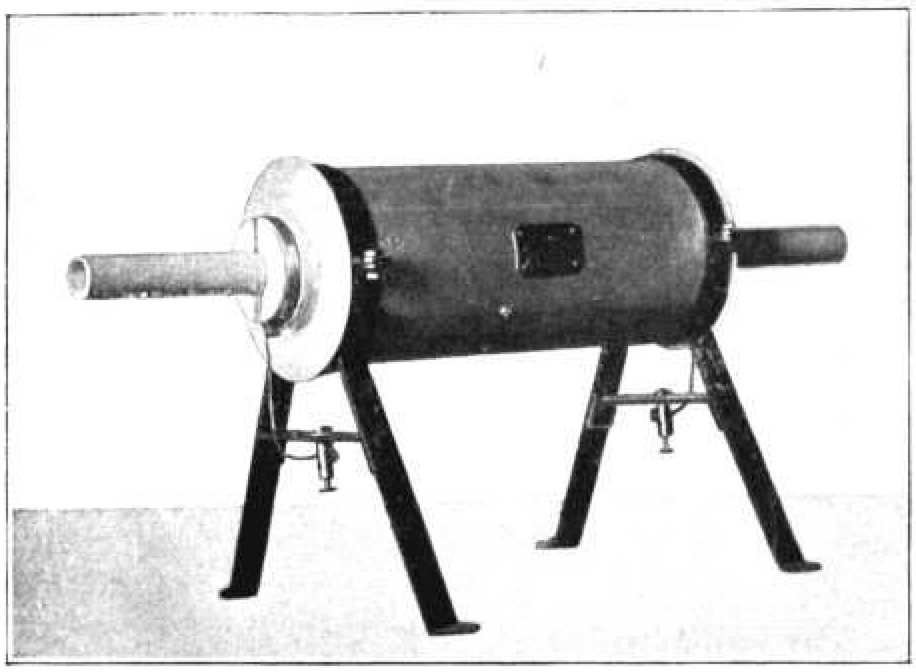
W. C. Heraeus

Hanau a. M.

Platinum Smelter.

No. 1—5 in D, No. 6 in B.

1. Electrically Heated Laboratory Ovens for High Temperatures. (U. S. Pat. No. 749204.)



The ovens (see Fig.) contain a tube, made of a great heat resisting composition, which is wound spirally with very thin platinum foil. With a current of moderate voltage it can be heated to over 1500°. Rapid attainment of the high temperatures and rapid and convenient regulation are characteristic of these ovens. Of the many models only two are exhibited.

2. Thermoelement of Platinum and Platinum-Rhodium, according to Le Chatelier, for the measurement of temperatures to 1600°.

3. **A Pair of Tubes of Fused Quartz,** for the protection of thermoelements against injurious gases.

Fused quartz is remarkable for its absolute insensibility to the most violent temperature changes; it remains unchanged up to temperatures of more than 1200° C.

4. **Iridium Oven,** as used by Prof. Nernst in his vapour density determination at temperatures of 2000°.

This consists essentially of a tube of pure iridium, which can be heated by means of a suitable electric current to a temperature of about 2200°.

5. **Thermoelement of Iridium and Iridium-Ruthenium** for measuring temperatures up to more than 2000°.

6. **Mercury-arc Lamp of Quartz,** especially suitable for the investigation of ultra-violet rays. Normal size for 110 volts and 2 amperes.

The firm also exhibits in the Section of Chemistry.

H. Hommel

Mainz; Factory: Idarwerk in Oberstein a. d. Nahe.

Tool Manufacturer.

No. 1—22 in A.

I. Vernier Calipers.

1. Vernier caliper with dividers. Jaws for inside measurements. Length of blade 250 *mm.*, length of jaws 60 *mm.*
2. Vernier caliper with points for measuring the bottom diameter of screw threads. Jaws for inside measurements. Length of blade 250 *mm.*, length of jaws 60 *mm.*
3. Vernier caliper with caliper points and dividers. Length of blade 250 *mm.*

No. 1—3 made of cast steel. One side graduated to read to $^1/_{10}$ *mm.* and to $^1/_{128}$ *inch*; other side graduated to take depth measurements. Accurate setting by means of fine adjusting screw.

4. Standard vernier caliper with micrometer screw. Vernier reads to $^1/_{50}$ *mm.* and to $^1/_{1000}$ *inch.* Between jaws 350 *mm.* respt. 14 *inch.* Length of jaws 60 *mm.* This caliper will also take inside measurements, for which a special mark is provided.

II. Micrometer Calipers.

Standard Micrometers for exact measurements with graduations, reading to $^1/_{100}$ *mm.*

5. Micrometer caliper, 0—25 *mm.*, with automatic stop.
6. Micrometer caliper, 25—50 *mm.*, with automatic stop.
   For No. 5 and 6 also a standard measuring disc 25 *mm* diam.
7. Micrometer caliper, 40—100 *mm.*, with automatic stop.
   The spindle is 20 *mm.* in diameter and bored out to reduce wear and weight and to reduce temperature effects. Also a standard measuring disc 40 *mm.* diam.

III. Standard Gauges.

Made of cast steel, hardened and ground with an accuracy of $^1/_{500}$ *mm.* For testing tools or work pieces.

8. Set of standard cylindrical gauges, consisting of plug and ring. 20 *mm.* diam.
9. Set of standard cylindrical gauges, consisting of plug and ring. 100 *mm.* diam.
10. Standard measuring disc, 25 *mm.* diam., with handle.
11. „ „ „ 50 *mm.* diam., with handle.
12. „ „ „ 100 *mm.* diam., with handle.
    No. 8—12 for setting micrometer and vernier calipers and similar tools.
13. Standard end measuring gauge with spherical ends. Length 100 *mm.*
14. Standard end measuring gauge with spherical ends. Length 300 *mm.*
    Handle for above gauges; used in testing cylindrical holes at some distance from end, or the distance between parallel surfaces and in the setting of gauges etc.
15. Set of standard caliper gauges, consisting of internal and external gauges for 50 *mm.* diam.
16. Set of standard caliper gauges, consisting of internal and external gauges for 100 *mm.* diam.

Used in all cases where cylindrical gauges cannot be applied on account of projecting parts, such as collars on side of bearings etc. Construction of handle diminishes the influence of the warmth of the hand in use.

IV. Limit Gauges.

Made of cast steel, hardened and ground with an accuracy of $^1/_{500}$ *mm.*, for fitting cylindrical joints.

17. Set of gauges for tight fitting joints, consisting of
limit plug gauge 28 *mm.* nominal diameter.
Real diam. of + end = 28·01 *mm.*
Real diam. of — end = 27·99 „
limit caliper gauge 28 *mm.* nominal width.
Real width of + side = 28·03 *mm.*
Real width of — side = 28·01 „
The smallest diameter of shaft obtained in working with this gauge will be larger than 28·01 *mm.*, while the hole will be smaller than 28·01 *mm.*

18. Set of gauges for loose fitting joints, consisting of
limit plug gauge 70 *mm.* nominal diameter.
Real diam. of + end = 70·01 *mm.*
Real diam. of — end = 69·99 „
limit caliper gauge 70 *mm.* nominal width.
Real width of + side = 69·99 *mm.*
Real width of — side = 69·97 „
The diameter of the shaft will thus be smaller than the diameter of hole.

V. Measures.

19. Standard Meter, made of tempered special cast steel; 20 *mm.* square section. Graduated into 1000 *mm.* Accuracy of total length 0·01 *mm.* or 0·00039 *inch.*

20. Caliper limit gauge. Greatest width between jaws 1000 *mm.* Used for setting calipers or testing gauges and work pieces. Jaws adapted for inside and outside measurements. Micrometer graduated to read $^1/_{100}$ *mm.*; jaw set by adjusting screw.
Real width on + side of jaws = nominal width + 0·01 *mm.*
Real width on — side of jaws = nominal width — 0·01 *mm.*

21. Caliper end rule with *mm.* graduation on either side and vernier to read $^1/_{10}$ *mm.*; width between jaws 100 *mm.* For finishing gauges and for testing, marking and graduating.

VI. Apparatus for Testing Parallelism.

22. Apparatus for testing parallelism of rollers or cylinders on papermaking or printing machinery. The apparatus consists of a most sensitive level, fitted with fine adjusting screw and mounted on a steel square. When applied at different places the bubble remains in the same position, if the rollers are parallel and cylindrical. Long arm 250 *mm.*, short arm 85 *mm.*

Junkers & Co.

Dessau in Anhalt.

No. 1—3 in D.

1. Calorimeter, according to Junkers, for accurate and exact determination of the combustion values of gaseous (Fig. 1) and liquid (Fig. 2) fuels. Patented in all countries.

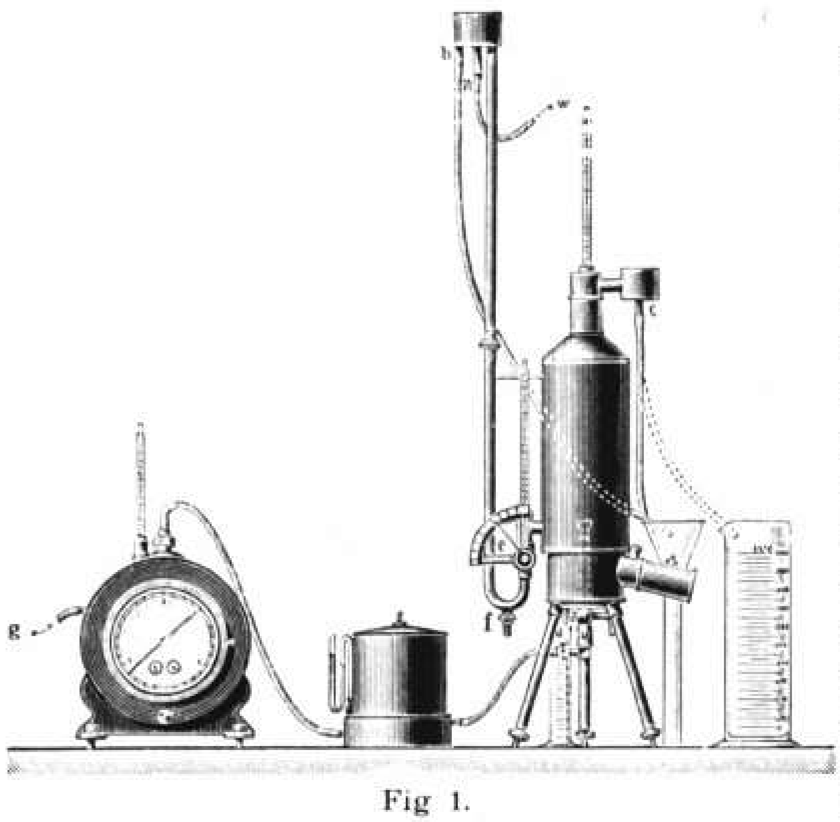


Fig 1.

A continuously burning flame communicates all its heat to a stream of water. The combustion value is determined from the quantity of water and its rise in temperature. It is necessary to measure only the amount of fuel consumed and the quantity of water and to read two thermometers, with no inconvenient water equivalent to determine or anything of the kind. Time of observation two minutes. In spite of its simplicity the apparatus is extremely accurate, as is shown by the measurements, made with it in the Physikalisch-Technische Reichsanstalt and by Prof. Slaby and others. The calorimeter can be used for the determination of the combustion value of coal and water gas, acetylene, generator-, Dawson- and blast furnace-gases; petroleum, naphtha, ligroine, benzine, benzol, alcohol etc.

Supplementary apparatus for gaseous fuels:
Accurate gas meter and *pressure regulator* (Fig. 1) also *apparatus for calibrating gas meters* in the simplest and most accurate manner (Fig. 3), *balance with lamp* for liquid fuels (Fig. 2).

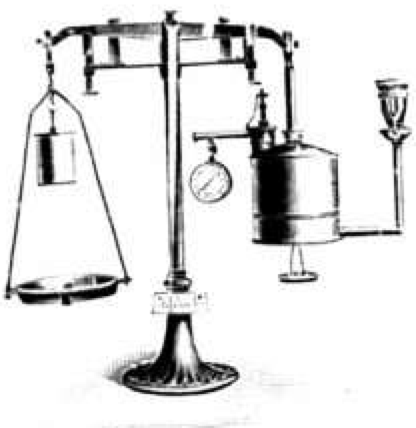


Fig 2.

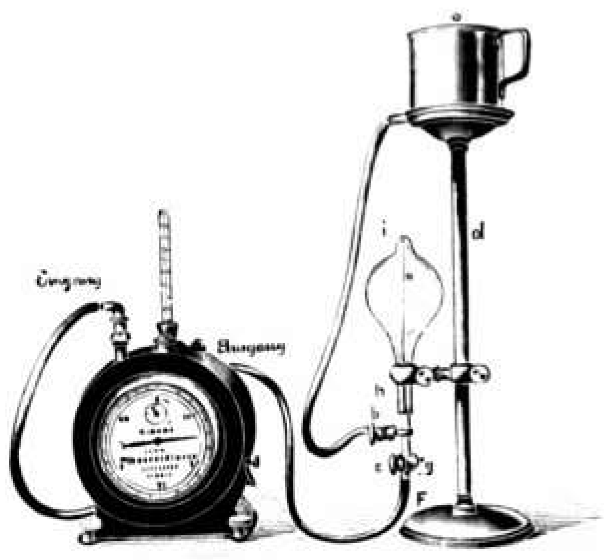


Fig. 3.

2. **Automatic Calorimeter,** according to Junkers. Determines and registers automatically and continuously the combustion values.

The combustion values can be read directly without any other observation, measurement or calculation. It is therefore important for gas works, motor manufactories, coke manufactories, generator gas establishments, blast furnaces etc.

3. **Vaporimeter,** according to Junkers. For the exact determination of the steam used in all kinds of steam engines when running. To be used instead of the awkward and troublesome determinations of the quantity of the feed water. Length of observation 5 minutes.

Max Kohl

Chemnitz (Sachsen), Adorferstr. 20.

No. 1—15 in Entrance Hall.

1. **Vocal Apparatus** according to Helmholtz, for the representation of the different qualities of sound, especially vowels. (Fig. 1.)

The apparatus consists of eight electro-magnetically driven tuning forks, giving the first harmonics of the fundamental c_0. The electromagnets are excited by a current, which is made intermittent by a tuning fork of 128 double vibrations per sec., which acts as a circuit breaker. Each tuning fork is provided with a resonator, which may be opened to a greater or less degree by means of keys. The current can be regulated by a variable resistance. The contacts of the circuit breaker are of heavy platinum. The different electromagnets can be thrown out of circuit at will, a corresponding resistance being introduced so that there is no variation in the current.

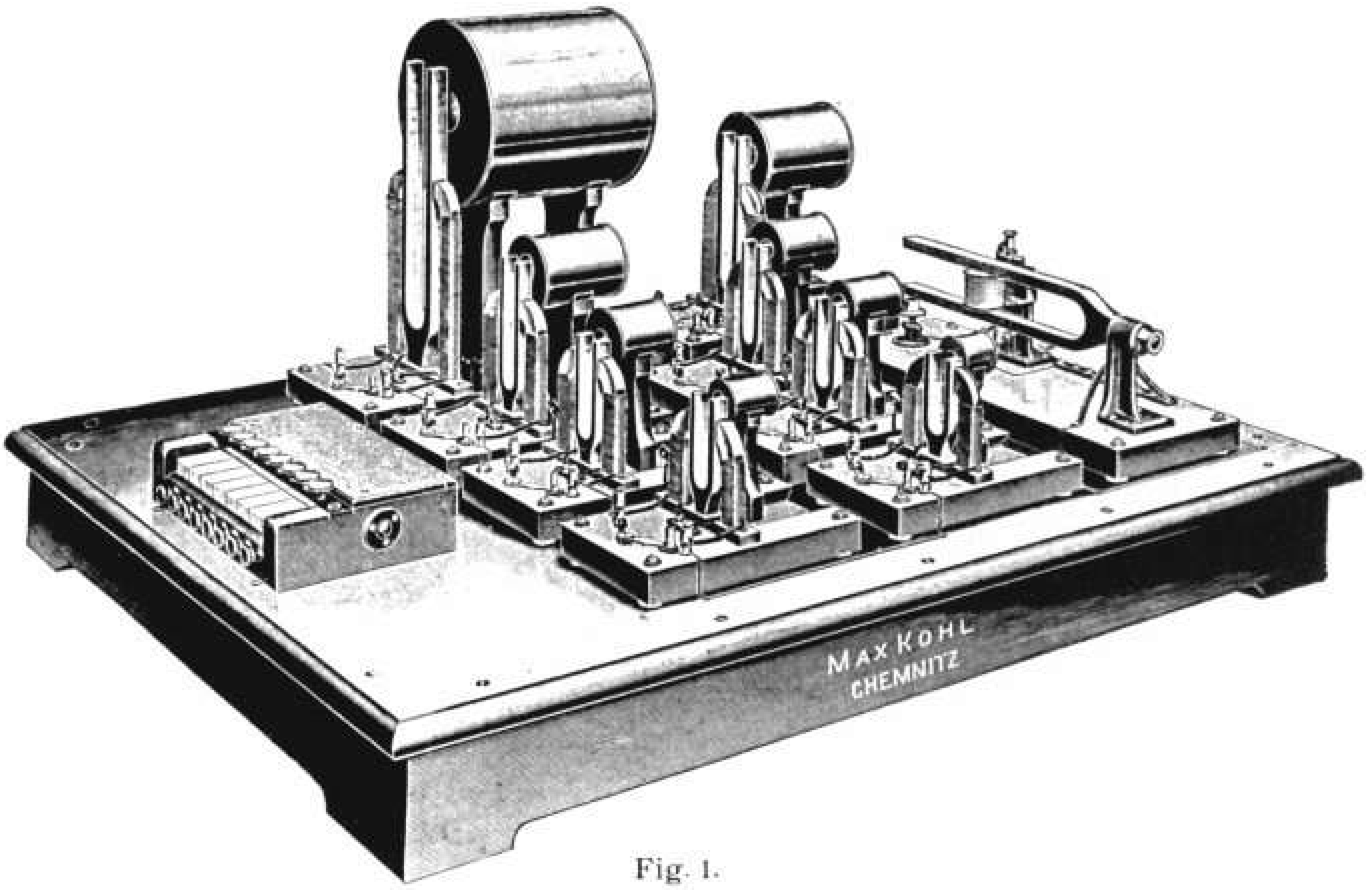


Fig. 1.

2. Projection Lantern for Electric Light.

This lantern is fitted with an automatically regulated arc lamp for continuous or alternating currents. The luminous point can be brought into the optical axis by the screw with a hand wheel, attached to the lantern. There is an optical bench for the projection head and the objects to be projected. This bench can be removed and replaced by a longer one for polarisation and interference experiments. The lower carbon holder is movable so that the carbon can be placed at the angle which will give the greatest intensity of light.

3. Electrometer according to Bruno Kolbe. (Fig. 2.)

The electrometer has a mica scale divided in degrees, which may be replaced by one calibrated in volts. The case is made of metal and can be connected to earth. The front and back are of glass so that the electrometer can be used for projection. The method of attaching the aluminium leaf gives the electrometer a high sensibility. A hollow ball can be screwed on instead of the condenser; the ebonite stopper with the aluminium leaf can be exchanged for one with a leaf of paper. The insulation of the electrometer is excellent.

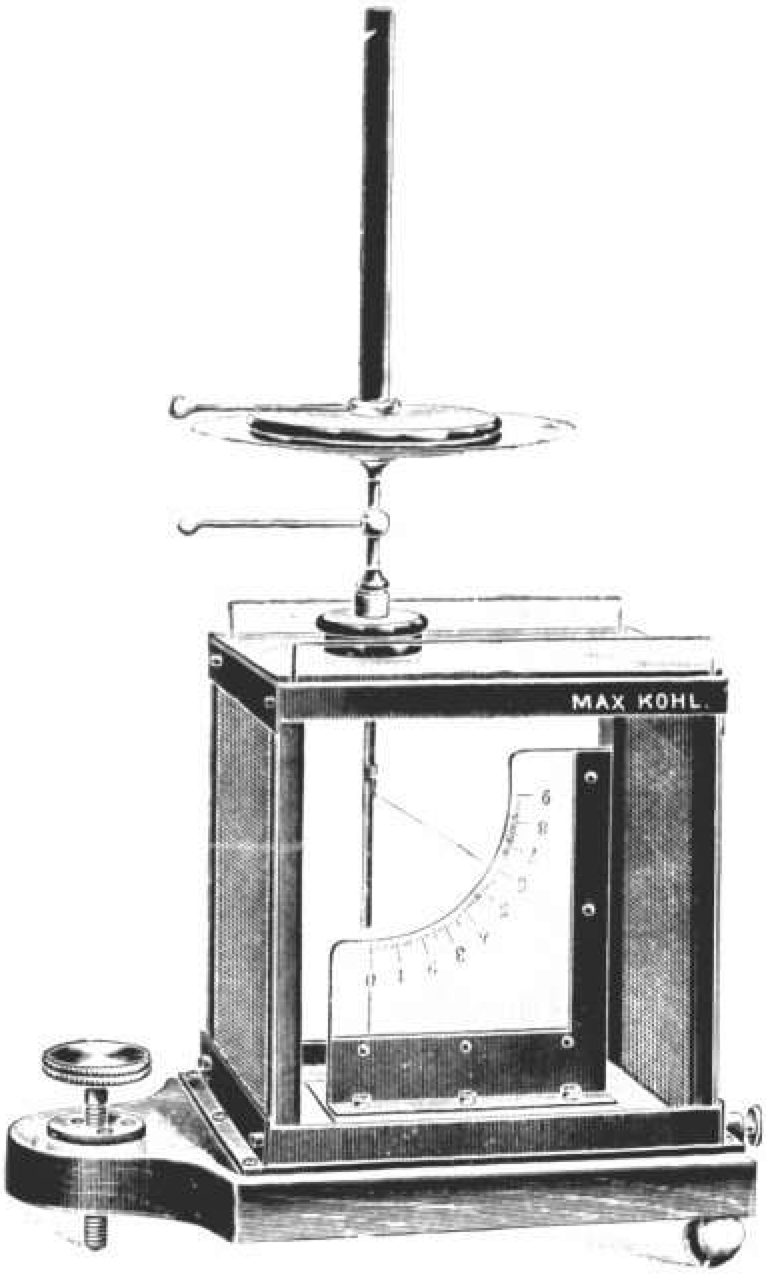


Fig. 2.

4. Astatic Mirror Galvanometer according to du Bois and Rubens. (Fig. 3.)

This galvanometer of extraordinary sensibility is arranged for four coils. The coils of 20 ohms resistance can be replaced by coils of 200 ohms. Three magnet systems of different weights, 1·05 *g.*, 0·25 *g.* and 0·09 *g.*,

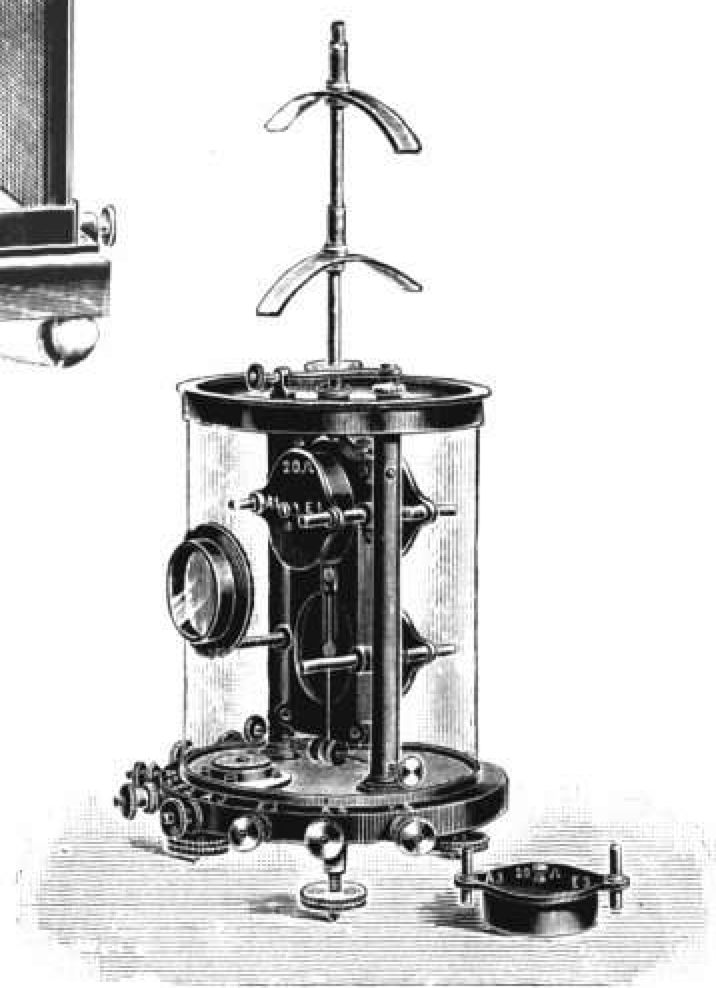


Fig. 3. 1/5 nat. size.

hung on quartz fibers, are provided. These different systems, with the help of the different methods of connecting the coils, permit change of sensibility over a wide range.

5. **Mirror Galvanometer** according to E. Wiedemann. (Fig. 4.)

This galvanometer is made according to the Deprez-d'Arsonval system. Its case is formed by the magnet and two mirror-glass plates which may be easily removed for changing the coils. One coil of 100 ohms resistance is made of 0·1 *mm.* wire, the second of 20 ohms resistance of 0·15 *mm.* wire, and the third coil, which is used for measuring high potentials, consists of 3·5 turns of 1 *mm.* wire well insulated with gutta-percha. The sensibility with the coil of finest wire is such that a current of 3×10^{-8} amp. gives a deflection of 1 *mm.* on a scale 1 *m.* distant.

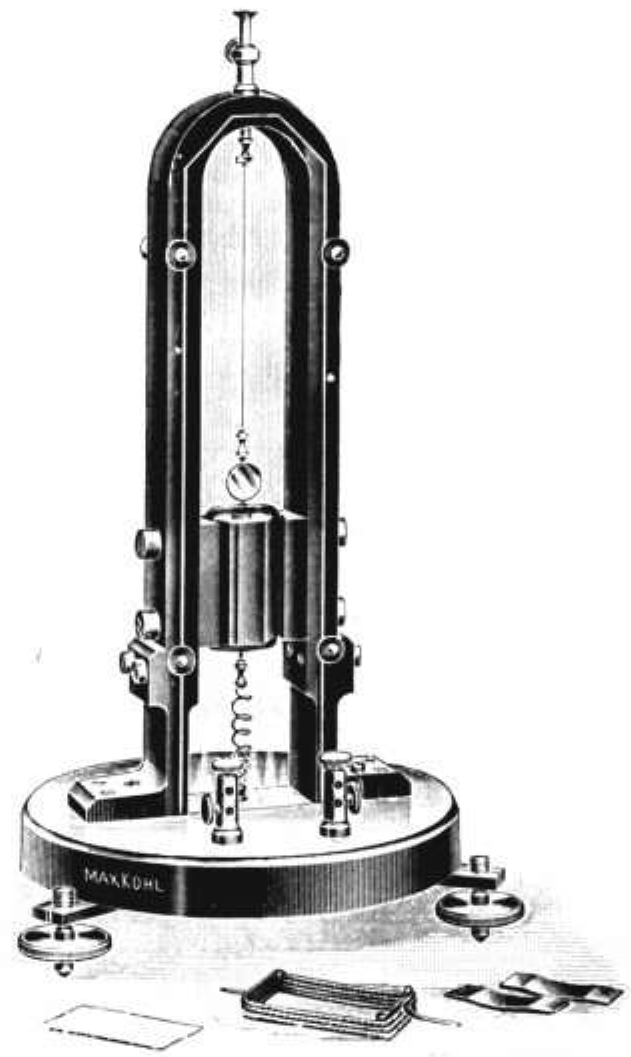


Fig. 4. ¼ nat. size.

6. **Spectrometer** with Rutherford prism.

The telescope, which can be adjusted by means of rack and pinion, has an opening of 27 *mm.*, a focus of 234 *mm.* and magnifies 8 times. The collimator has the same dimensions. The circle is divided to $\frac{1}{6}^{0}$, the vernier reads to 30″.

7. **Apparatus for the Analysis of Sound** according to König, with 14 universal resonators and variable fundamental tone. (Fig. 5.)

The apparatus is supported in a strong frame and provided with a rotating mirror, to be driven by hand. The mechanism of this is so arranged that it is entirely noiseless. The 14 universal resonators are chosen so that the highest tone of the larger corresponds to the deepest tone of the smaller. It is therefore possible to adjust them for any desired fundamental. The deepest fundamental attainable is g_{-1}. The resonators are in connection with manometric flames, which are protected from flaring due to air currents by strips of mica; these also protect the resonators from the heat of the flames.

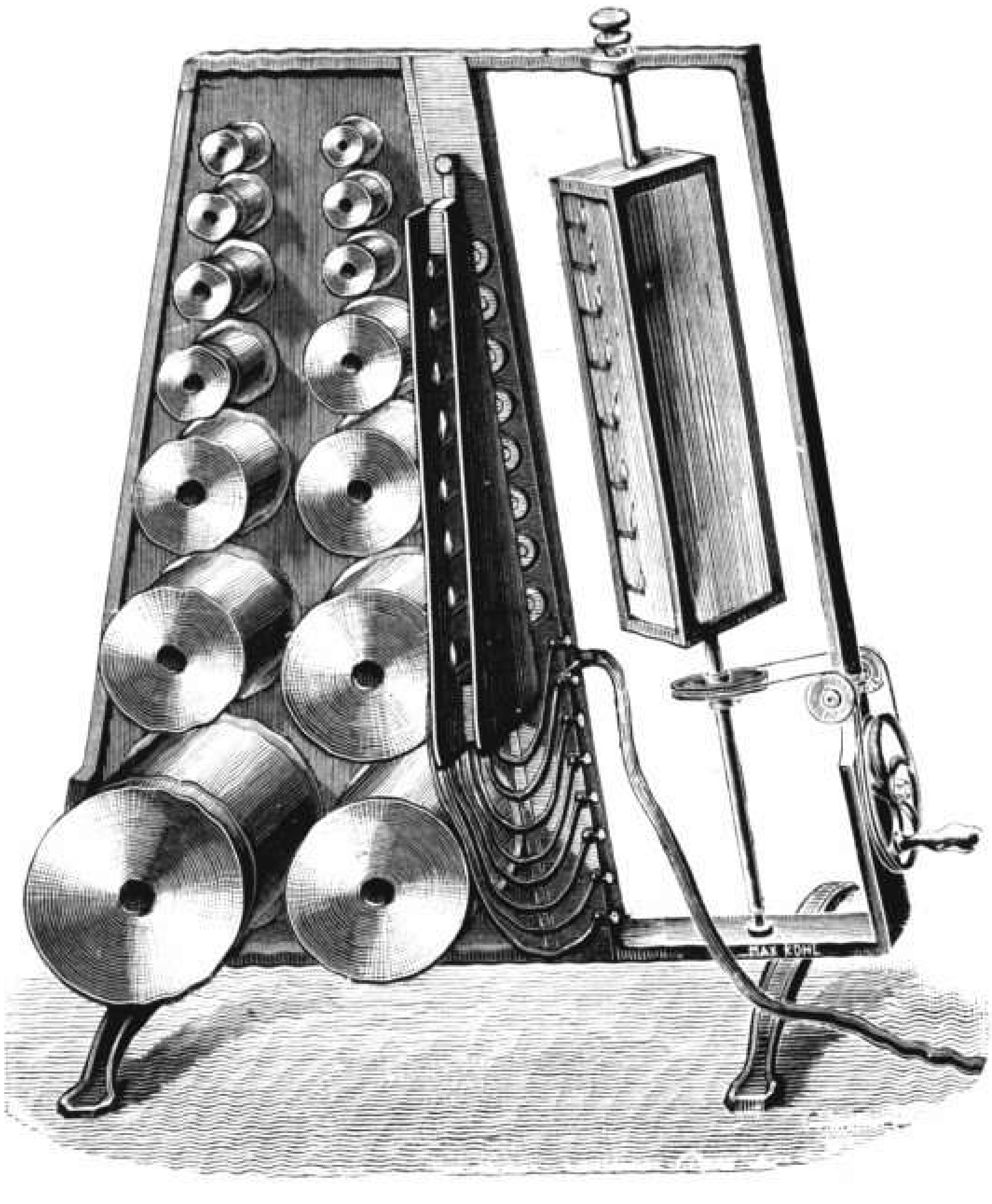


Fig. 5. $^1/_{11}$ nat. size.

8. Differential and Double Thermoscope according to Bruno Kolbe.

The thermoscope consists of two manometric tubes, attached to an upright stand, which are connected by rubber tubes to the receivers. The sources of heat, receivers, screens etc. are movable along a horizontal track. A large number of experiments on the absorption and emission of heat rays, and on diathermancy can be performed with this apparatus.

9. Gravitation Apparatus for Showing the Attraction between Masses. (Fig. 6.)

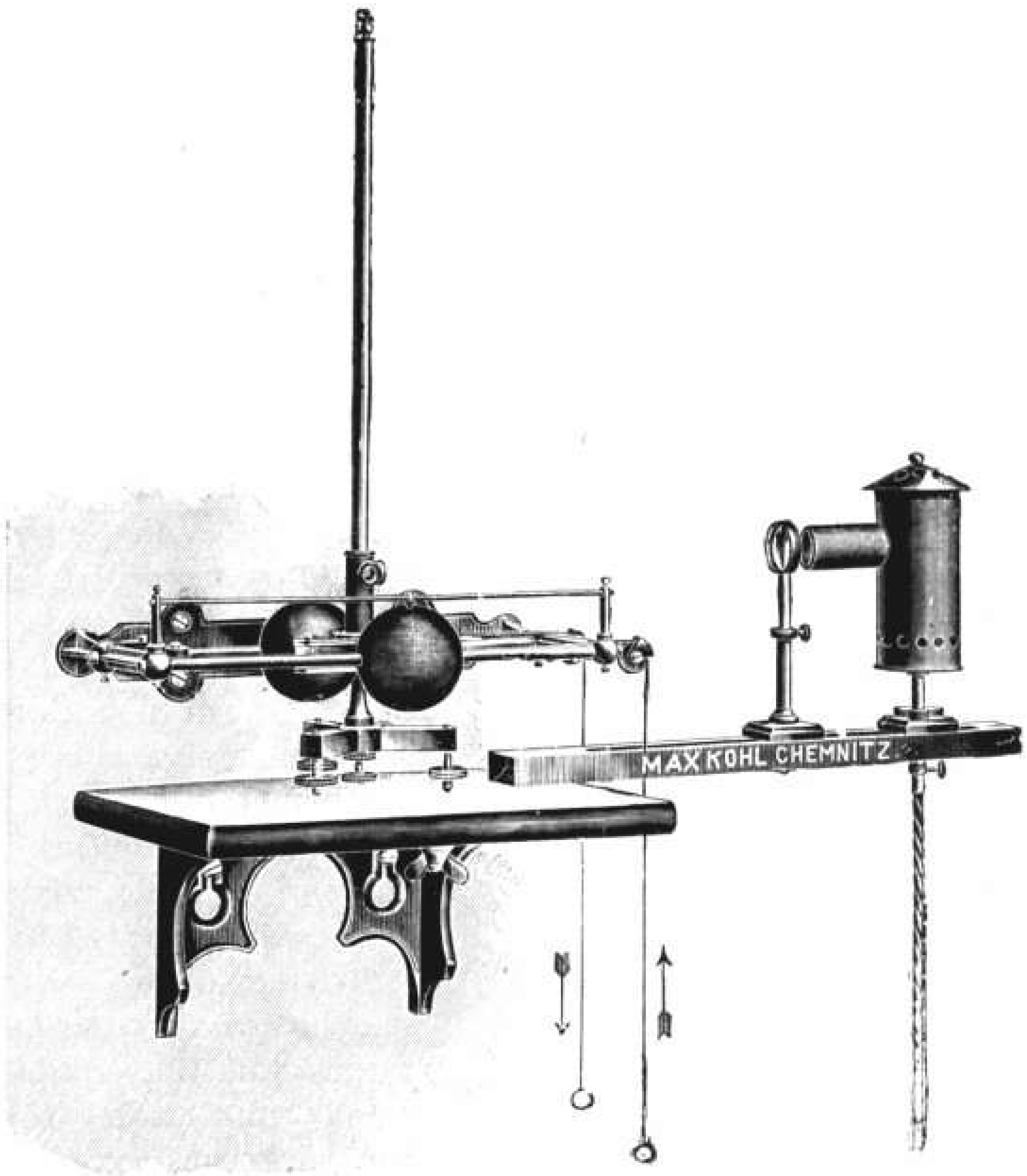


Fig. 6. 1/9 nat. size.

This apparatus, according to Boys, may be used for repeating the Cavendish experiment on the attraction of masses. Two small silver balls, each weighing 0·75 *g.*, are hung from the ends of a light arm, suspended on an exceedingly thin quartz fiber. The whole is hung in a double walled glass case for protection against air currents and temperature disturbances. The apparatus is provided with a perfect arrestment so that it can be moved from place to place and shipped without danger of injury. The small balls are attracted by large lead balls, 80 *mm.* in diameter, which may be pulled on the frame by cords from one position into the other. In order to show the motion to a large audience, the image of an illuminated slit is reflected from a light mirror, attached to the movable system, and by means of a double convex lens it is projected on a scale, fastened to the wall. The quartz fiber is so fine that the time of swing of the beam is about 18 minutes. The deviation of the image from its point of rest on a scale 2·25 *m.* distant amounts to about 21 *cm.* To secure perfect results only material entirely free from iron and which has been most thoroughly tested is used.

10. Pendulum Apparatus according to Hillig, Toledo, Ohio. (Fig. 7.)

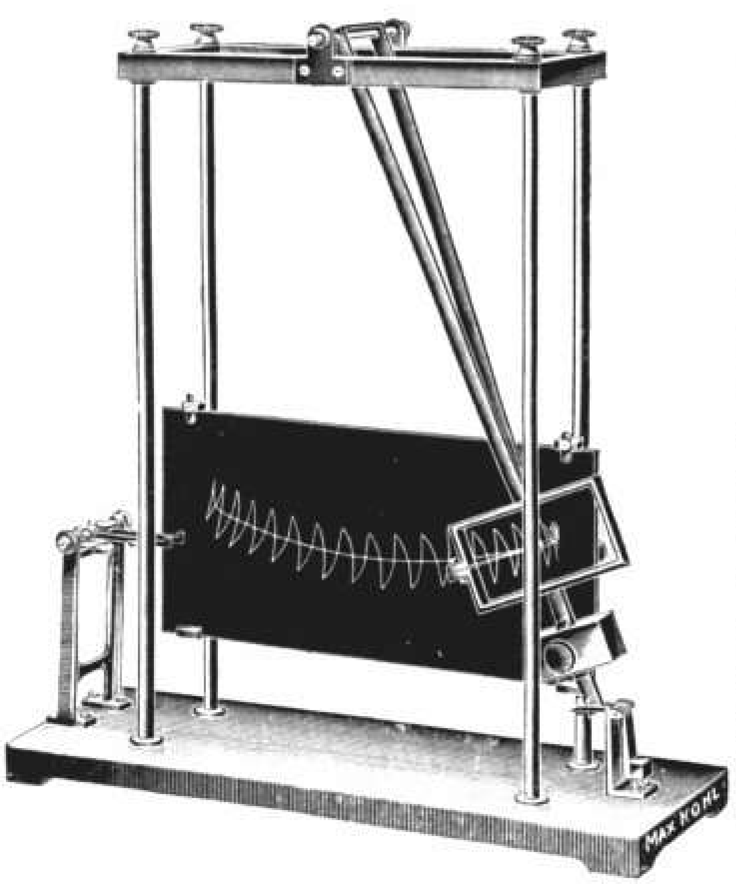


Fig. 7. $^1/_8$ nat. size.

The pendulum apparatus is intended for the demonstration of the laws of the pendulum. When the pendulum is set free, a recording stylus is at the same moment set in motion, which draws a sine curve on the blackened glass. When at rest the stylus describes the arc of a circle, which cuts the sine curve. The single divisions of this arc are the distances traversed by the pendulum in equal times, and therefore represent the different pendulum velocities.

11. Section Model of a Compound Steam Engine.

The model may be turned by means of a crank. High pressure and low pressure cylinders, the simple valve gear and the receiver are represented in section.

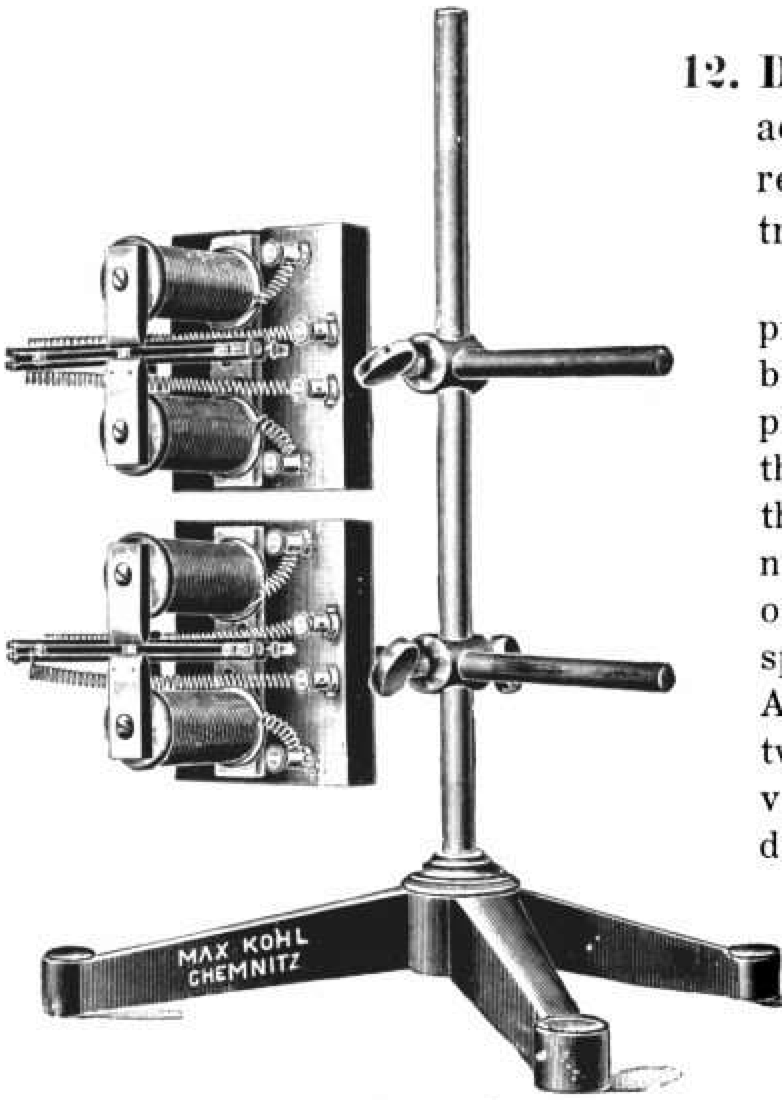


Fig. 8. $^1/_6$ nat. size.

12. Double Oscillograph, according to Wehnelt, for representing periodic electrical processes. (Fig. 8.)

The apparatus works on the principle that the current to be investigated produces displacements in the metal strips, through which it flows between the poles of a powerful magnet. This motion is projected on a screen by means of a spot of light and a mirror. As the apparatus is double, two processes may be observed and compared, for example, differences of phase, and alternating currents of different periods and curve forms.

13. Vibration Microscope, according to Helmholtz. (Fig. 9.)

The vibration microscope is provided with a powerful electrically driven tuning fork, $c_0 = 128$ vibrations. The instrument is mounted on an adjustable stand.

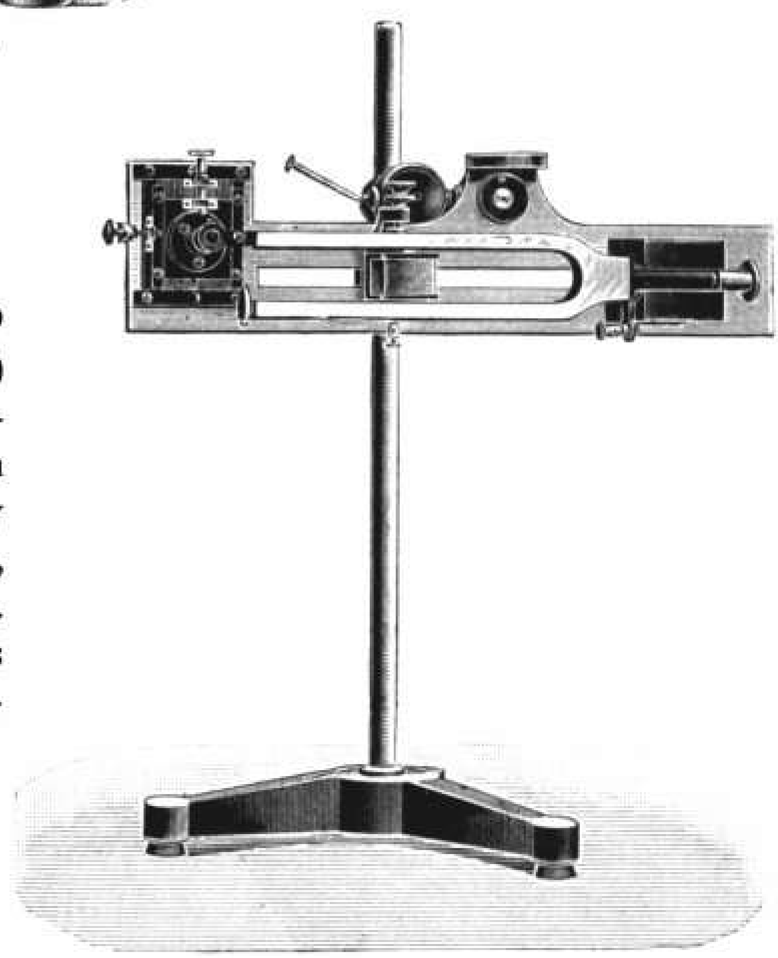


Fig. 9.

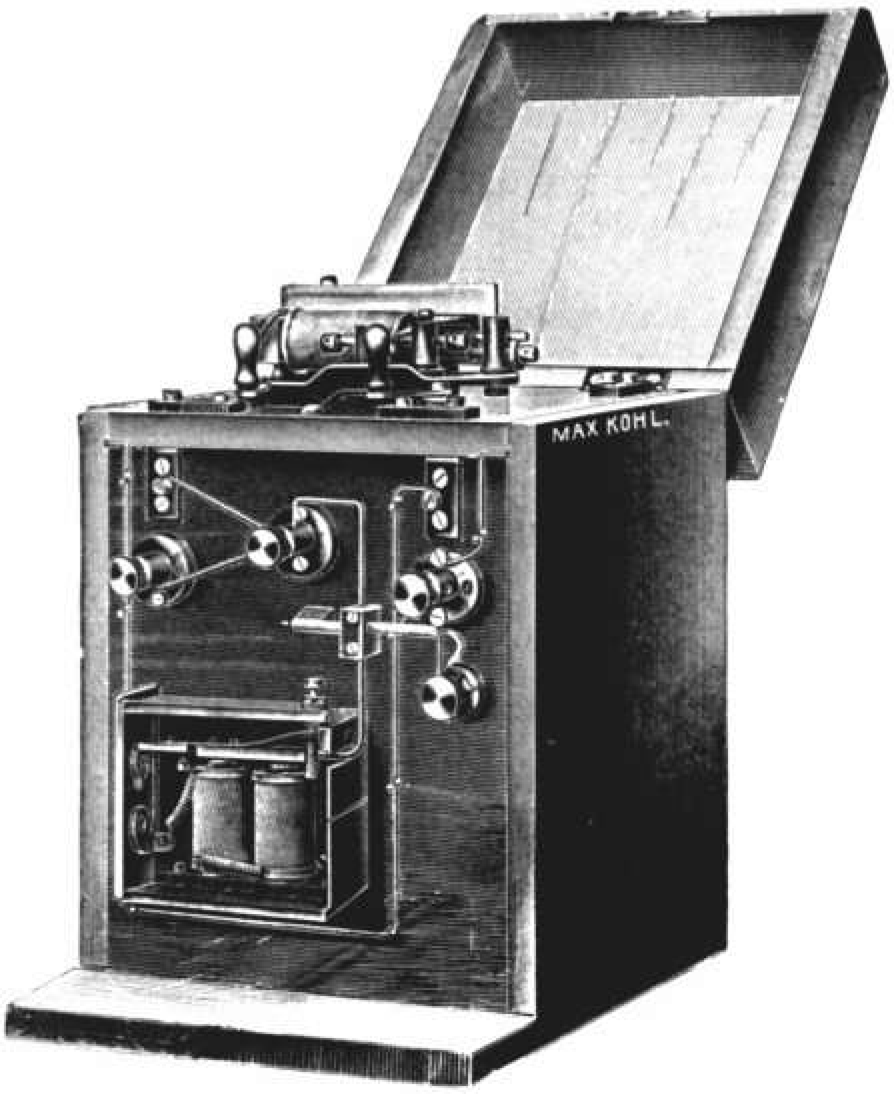


Fig. 10. 1/4 nat. size.

14. Demonstration Apparatus for Wireless Telegraphy, according to Marconi. (Fig. 10.)

The sending apparatus consists of a Righi radiator, the receiver of a sensitive coherer, a battery of four dry cells, a polarised relay and a tapper. The sender as well as the receiver are contained in a portable case, which may be opened at the top and in front when the apparatus is to be used.

15. Portable Induction Coil for Wireless Telegraphy and Röntgen Rays. 300 *mm.* spark length and adjustable discharging balls.

A. Krüss (Dr. Hugo Krüss, proprietor).

Hamburg, Adolphsbrücke 7.

Optical Instruments.

No. 1—10 in B.

1. Universal Spectroscope (Fig. 1), own construction, for spectro-photometry and qualitative and quantitative analysis, with symmetrical slits.

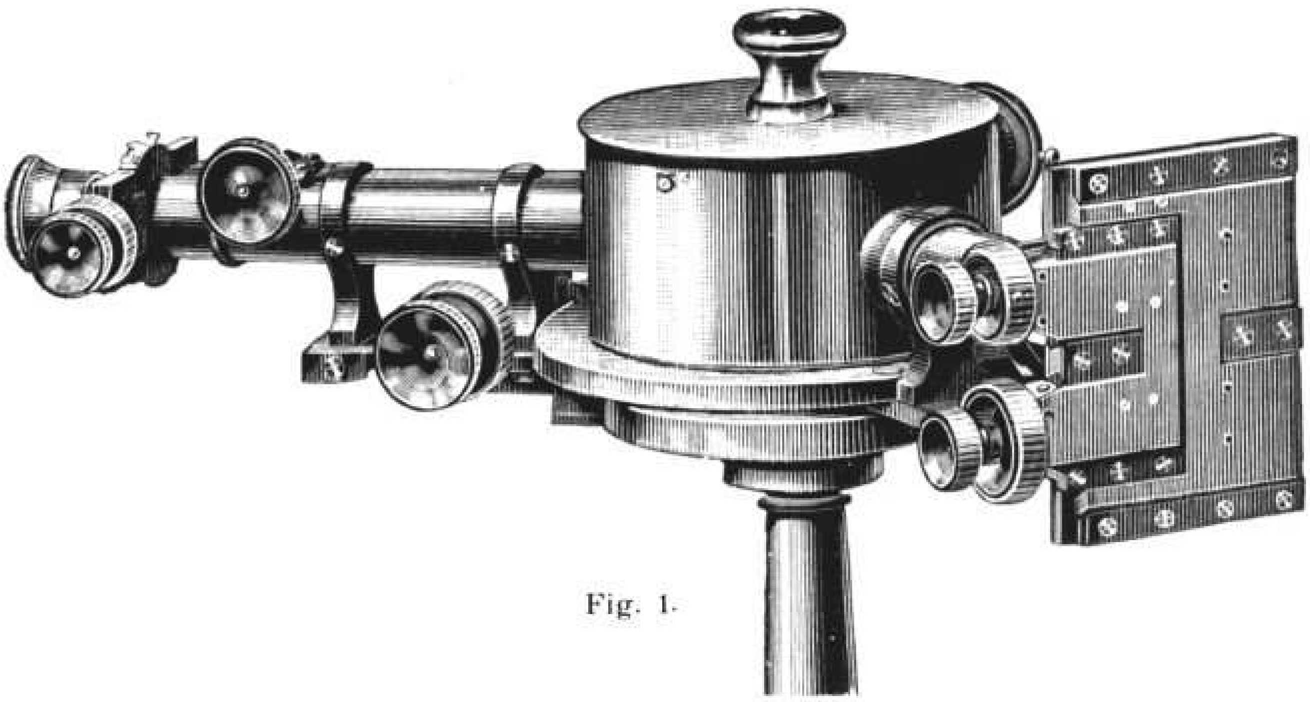


Fig. 1.

2. Spectrometer, according to V. v. Lang. (Fig. 2.)

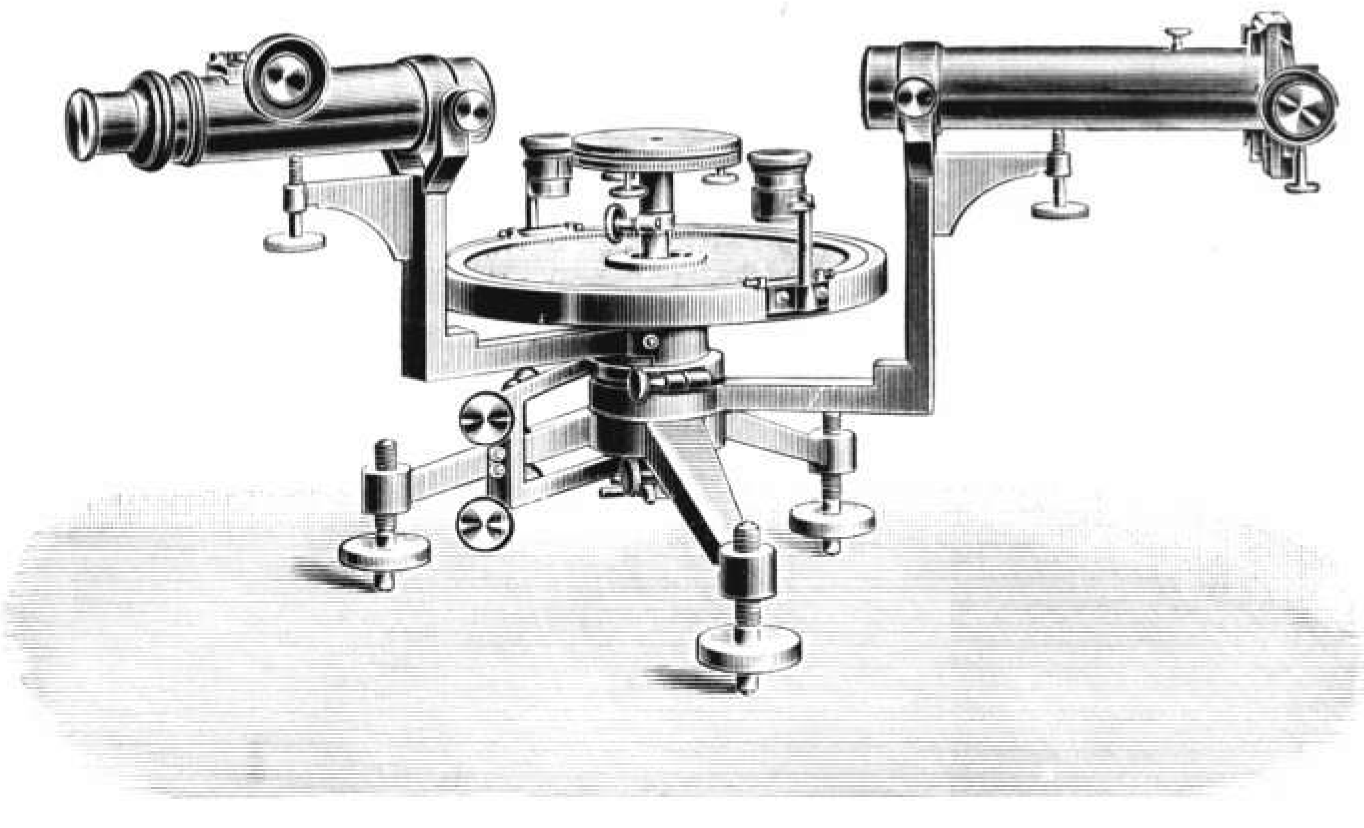


Fig. 2.

3. Colorimeter, according to C. H. Wolff, for the determination of the concentration of colored liquids by means of comparison with a standard solution.

4. Colorimeter with Lummer-Brodhun prisms.

5. Photometer Stand, for gas burners.

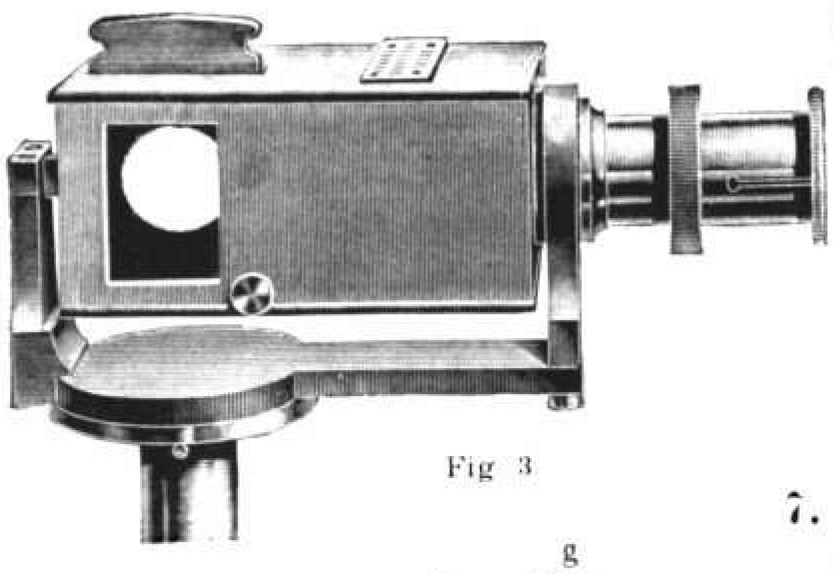


Fig. 3

6. Photometer Head, according to Lummer and Brodhun (Fig. 3), with telescope in the axis;
a) for similarity, with graduated arc,
b) for contrast.

7. Photometer, according to L. Weber.

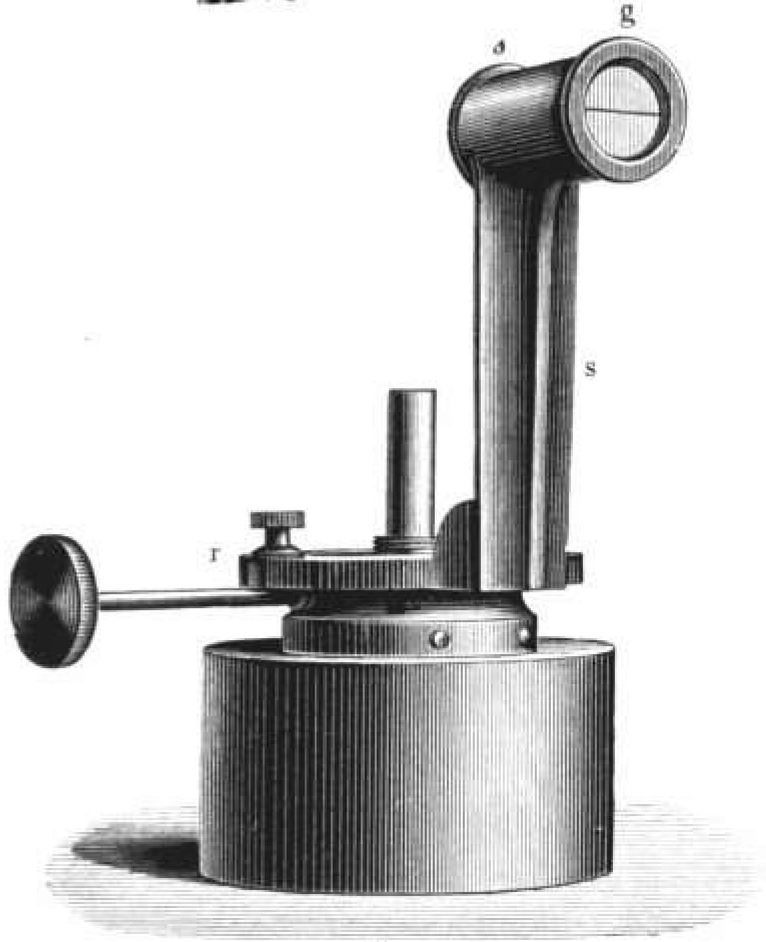


Fig. 4.

8. Hefner Lamp (Fig. 4), with optical flame measurer, according to Krüss.

9. Photometer Stand for incandescent lights.

10. Apparatus for Determining the Brightness of Surfaces, according to Krüss. (Street photometer.)

E. Leitz
Wetzlar.

Manufacturer of Optical Instruments.

No. 1–6 in B.

1. New Stand A. (Fig. 1.)

Universal microscope with large draw-tube and fitted with round revolving centering stage, *new* fine adjustment (each division = $^1/_{1000}$ *mm.*), large illuminating apparatus with swing-out condenser and cylinder iris-diaphragm, large movable stage. Quadruple nose-piece, objectives 2, 4, 6; oil-immersion $^1/_{12}$, eye-piece 3.

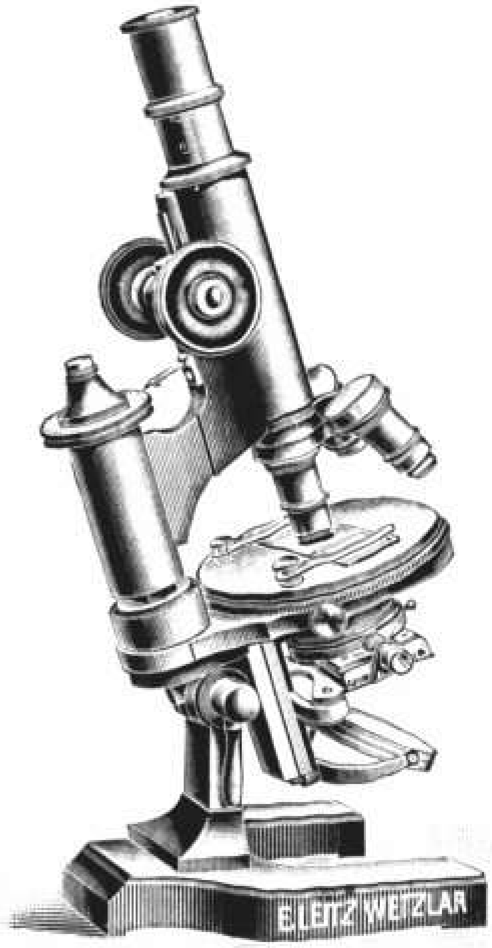


Fig. 2. Stand Ia.

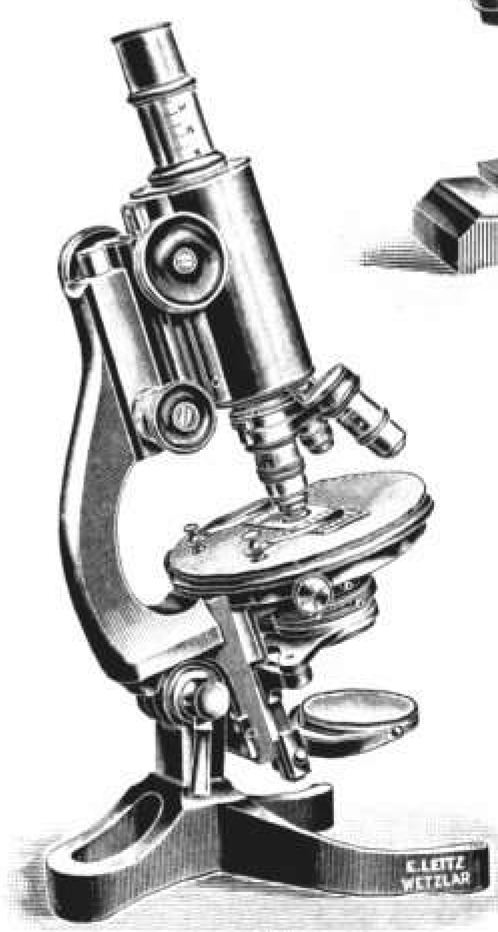


Fig. 1. Stand A.

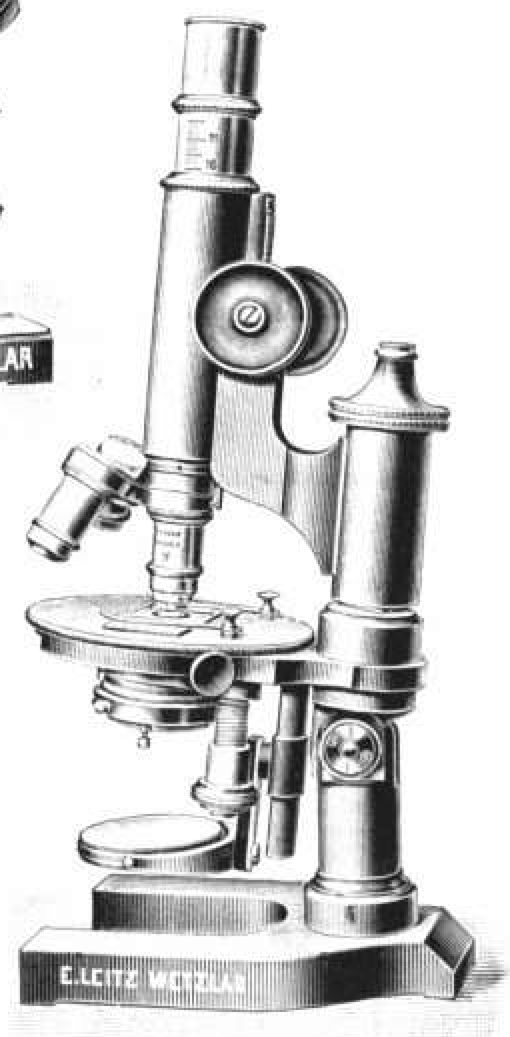


Fig. 3. Stand II.

2. Stand I.

With revolving centering stage, *new* fine adjustment, large illuminating apparatus with swing-out condenser and cylinder iris-diaphragm, movable stage, triple nose-piece, objectives 3, 6a, oil-immersion $^1/_{12}$, eye-piece 3.

3. Stand Ia. (Fig. 2.)

With swing-out condenser and cylinder iris-diaphragm, triple nose-piece, objectives 2, 5, 7, eye-piece 4.

4. Stand IIc.

With medium size condenser, iris-diaphragm, movable stage 99a, triple nose-piece, objectives 2, 4, 6, eye-piece 2.

5. Stand IId.

With medium size condenser, iris-diaphragm, double nose-piece, objectives 3, 7, eye-piece 3.

6. Stand Ib.

Condenser, iris-diaphragm, double nose-piece, objectives 3, 6, eye-piece 2.

The above stands can be provided if desired with any other objectives and eye-pieces of my make.

Branch houses: New-York, 411 W. 59th Str. and Chicago, 32—38 Clark Str.

Leppin & Masche

Berlin SO., Engelufer 17.

Manufacturers of Scientific Instruments.

No. 1—26 in Entrance Hall.

1. **Jolly Balance** for determination of density.

2. **Electric Centrifugal Machine,** to be driven from the lighting circuit. (Fig. 1.)

The apparatus is provided with a starting rheostat so that it may be connected directly to the lighting circuit. The velocity of rotation is regulated by means of this resistance and incandescent lamps, which may be thrown into the circuit. The motor can be used in any position, and since it is furnished with a

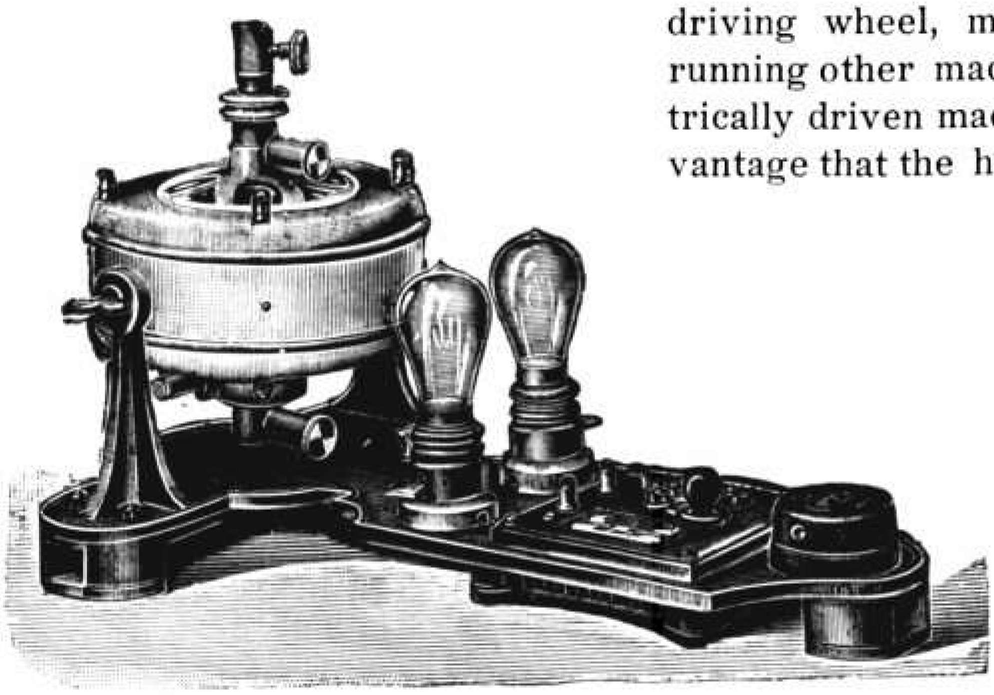


Fig. 1.

driving wheel, may be used for running other machines. This electrically driven machine has the advantage that the hands of the operator are free, the velocity of rotation is constant and can be measured and on this account experiments, which would not be possible with other machines, can be carried out.

3. **Cubes** of 12 different metals.
4. **Rods** of 12 different metals.
5. **Hydraulic Press** of iron.
6. **Wind Chest** for experiments in sound, arranged for use with compressed gas. (Fig. 2.)

The use of compressed gas in place of the ordinary blower or old fashioned wind chest has the advantages: first, that the pressure may be regulated and kept constant, and second, that both hands are free. The wind chest is to be connected with a steel gas tank, provided with a reducing valve.

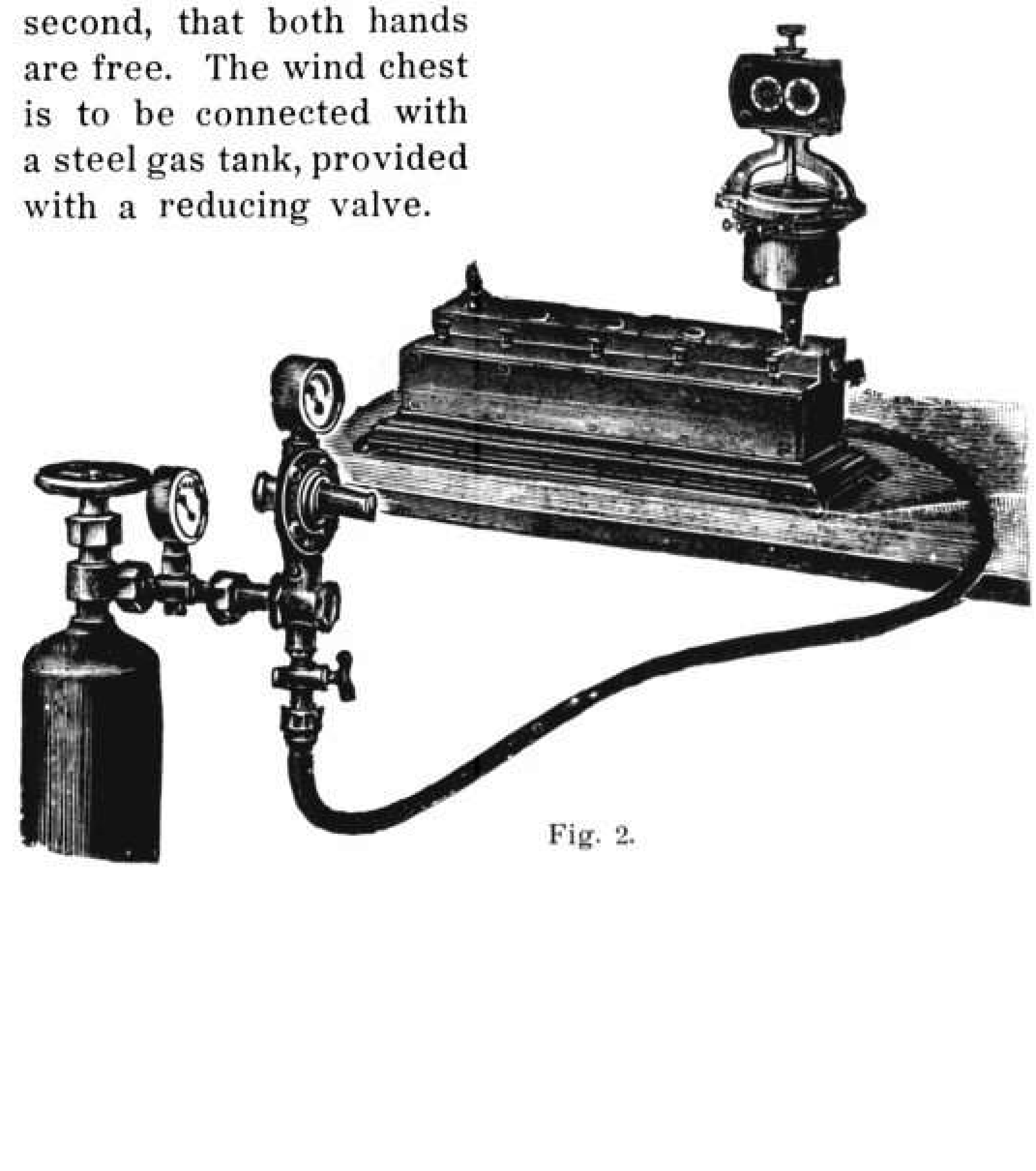


Fig. 2.

7. **Reed Pipe,** C = 64 double vibrations.

8. **Resonators,** according to Helmholtz. Set of five (g, c_1, e_1, g_1, c_2).

9. **Accord Sirene,** according to Dove.

10. **Double Sirene,** according to Helmholtz.

11. **Standard Tuning Fork,** small size ($a_1 = 435$ double vibrations), with certificate.

12. **Rotating Mirror** for experiments in sound.

13. **Heliostat with Clock Work.**

14. **Carbondisulphide Prism.**

15. **School Spectroscope,** flint glass prism 28 *mm.* in height, telescope, collimator, comparison prism and scale.

16. **Pocket Spectroscope** with adjustable slit.

17. **Horizontal Dark Room Lamp,** to be connected to the electric circuit, on jointed stand.

18. **Linear Expansion Apparatus,** according to Blümel. (Fig. 3.)

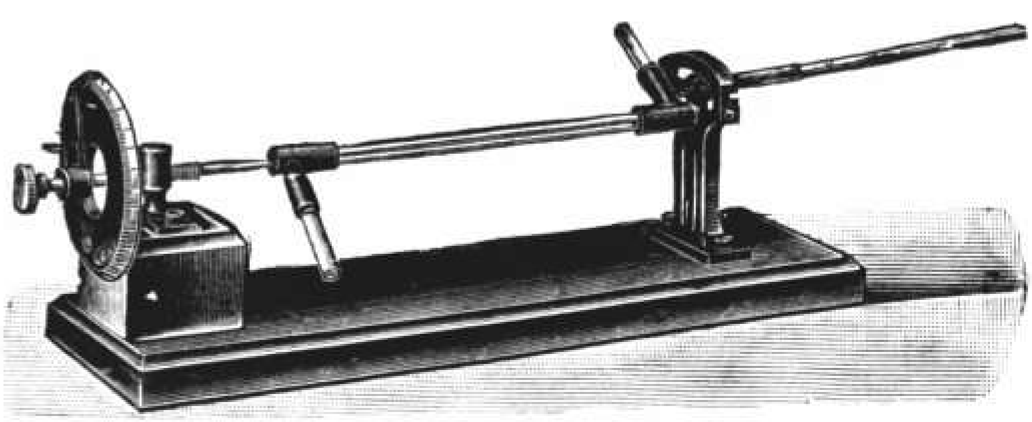


Fig. 3

The pieces, to be measured, are in the form of metal rods exactly 200 *mm.* long. The rods are placed in glass tubes, which are closed at each end with rubber tubes. In making the measurements, water at room temperature is first sent through the tubes, and afterward steam. The index is movable on the micrometer screw so that it may be brought to zero. A mirror, provided with a mark, is used for fixing the height of the point of the long lever arm. From the observations and the known difference in temperature the coefficient of expansion can be accurately calculated.

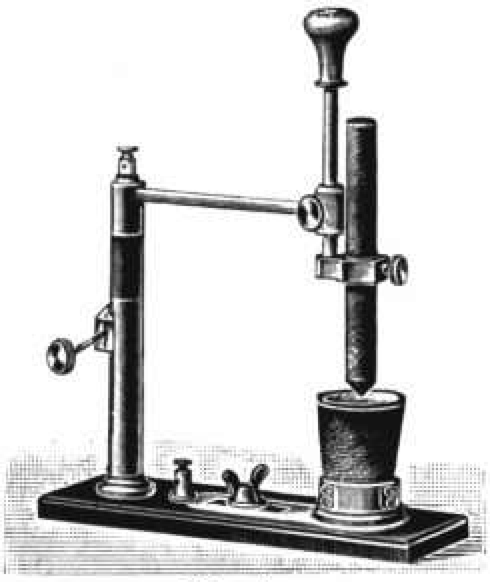


Fig. 4.

19. Quadrant Electrometer, according to Thomson-Mascart.

20. Electric Furnace for heavy currents. (Fig. 4.)

The furnace is provided with double insulation so that, when in use, short circuiting is impossible. The apparatus has a rack and pinion movement and an arrangement for centering the crucible. The support of the crucible has movable sections so that the crucible may be at once removed after use.

21. Astatic Mirror Galvanometer with shelf and switch board. (Fig. 5.)

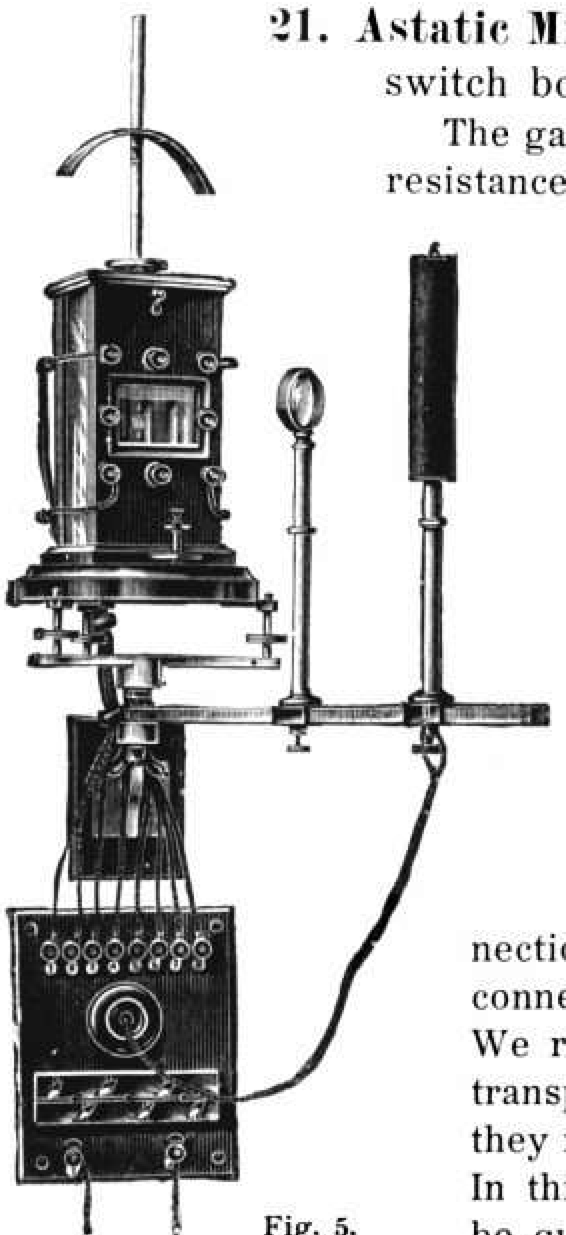


Fig. 5.

The galvanometer has four coils of four ohms resistance each. It stands on an aluminium support, which rests on an aluminium shelf. A movable arm carries a lamp and lens. The fact that the movable arm, the aluminium support and the galvanometer mirror all have a common axis of rotation, makes the adjustment of the galvanometer very simple. As it is important in different experiments to change the resistance of the galvanometer, the terminals of the coils are connected by means of flexible conductors to the switch board. The binding screws, to which the wires run, are in connection with the brass plates, which may be connected in various ways by means of plugs. We recommend further for this apparatus transparent scales, which are hung so that they may be moved along a stretched wire. In this way the correction of the zero can be quickly made by moving the scale.

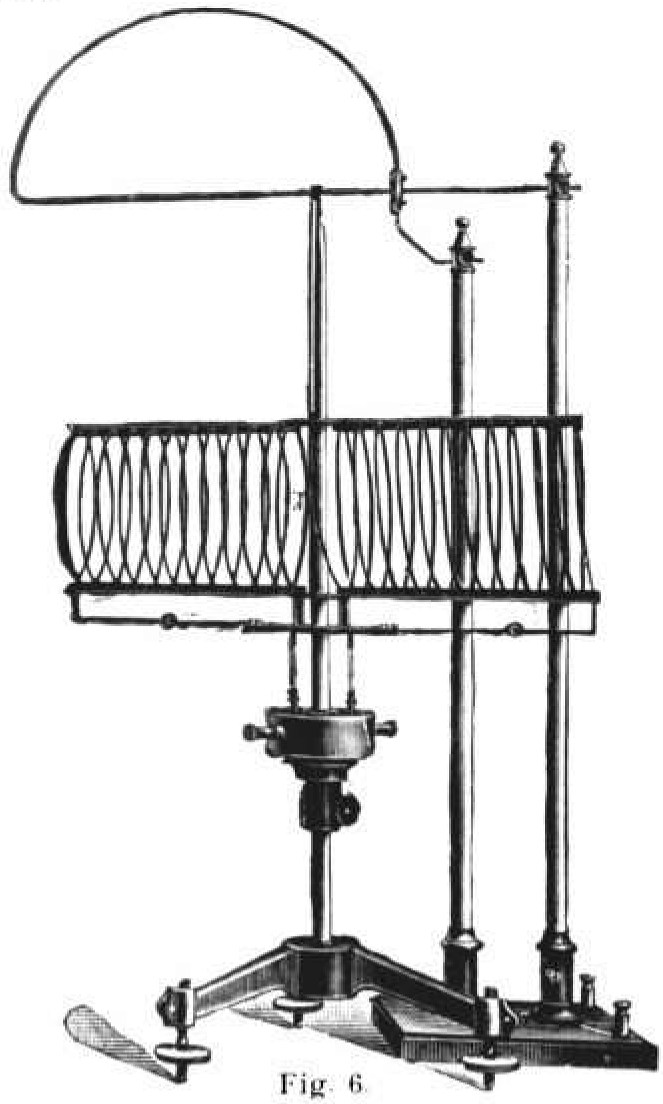


Fig. 6.

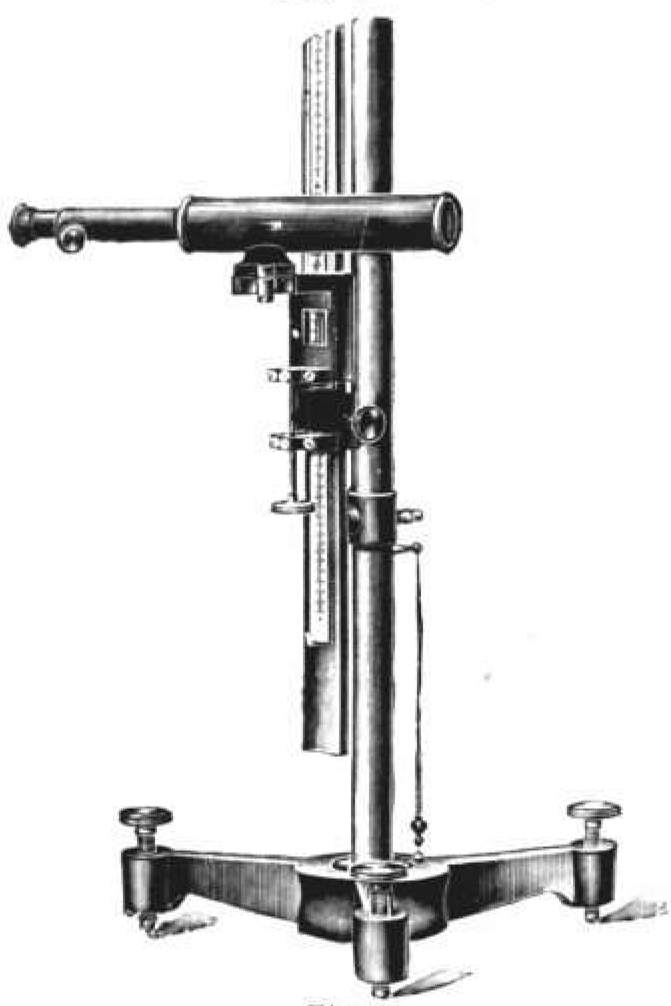


Fig. 7.

22. Ampère Apparatus for heavy currents. (Fig. 6.)

The pieces are of large size, made of aluminium wire, and are provided with sliding balls to assist in the adjustment. Two mercury cups of serpentine are supplied with the apparatus. One is intended for the experiment showing the directive action and the other for the rotations. A second stand accompanies the apparatus for the experiments, showing the action of one current upon another.

23. Thermopile, according to Nobili. 63 elements, conical receiving tube, mounted on a stand with joint.

24. Cathetometer of simple construction. (Fig. 7.)

The telescope has rack and pinion motion and turns on ball bearings, making the rotation smooth and accurate. The cathetometer has a micrometer adjustment and a vernier for reading to one tenth of a millimeter.

25. Spherometer, simple form, for schools.

26. **Spherometer** for exact measurement, reading to 0.001 *mm.*, with lens for accurate readings. Distance between the feet 4 *cm.*

See also the exhibit of the firm in the "Section of Elementary and Advanced Education".

Friedrich Lux

Ludwigshafen.

Exhibited in C.

Velocity Meter, according to Frahm.

Adolf Mensing

Captain in the Imperial Navy (Retired).

Berlin W., Kurfürstenstrasse 99.

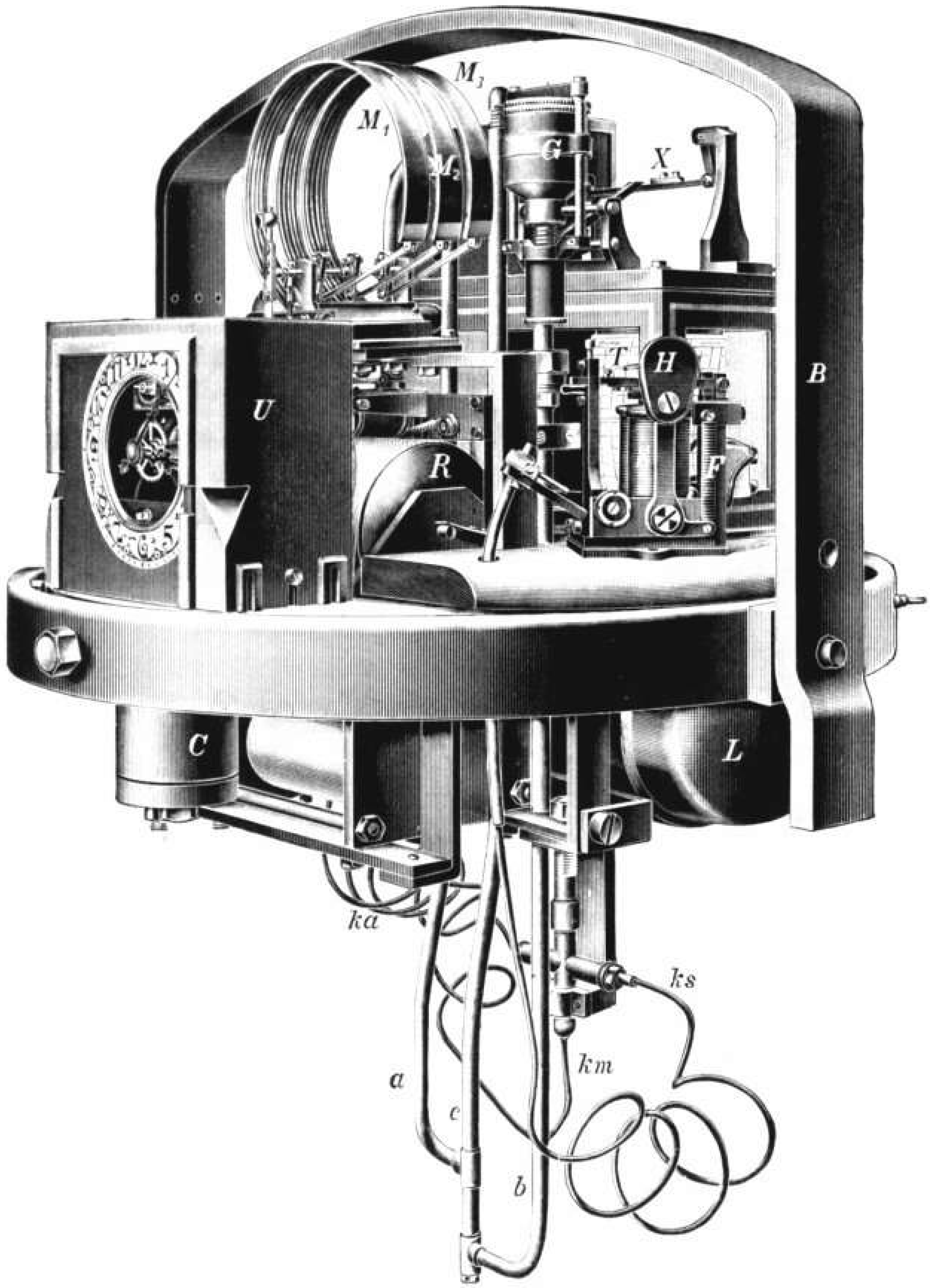
Exhibited in A.

Deep-sea Tidal Gauge.

This instrument is designed to automatically register the ebb and flow of the tides in the open sea. (See *Zeitschr. f. Instrkde.* ***23.*** *p. 334. 1903.*)

The instrument here exhibited is, when in use, enclosed in an iron case and lowered to the sea bottom. The interior of the case is in communication with the surrounding sea water so that the hydrostatic pressure is communicated to the air in the interior. Through the method of construction and suitable precautions water is prevented from entering the space, in which the apparatus is placed, and the gauge itself is almost entirely prevented from sinking into sandy bottoms.

The gauge is now arranged for use in the North Sea, that is, for depths up to 200 *m.*, but by changes in the outer case it would be possible to use it at much greater depths.



The rise and fall of the ocean surface is represented on a scale of 1 : 100. *This ratio remains invariable even for the greatest depths.* Surface motions of short periods, such as ordinary waves, are not shown upon the curve. The normal time of submersion is 30 days, but the safety of the apparatus is not endangered if left one or two weeks longer.

The main portion of the apparatus consists of a manometer $M_1\ M_2\ M_3$, the interior of which is connected with a closed steel cylinder *L* and three siphon shaped tubes *a*, *b*, *c*. So long as the tubes are open, the registering lever remains at rest. When the tubes are filled with mercury the cylinder and tubes are hermetically closed, and the air pressure (p_i) in the interior remains almost unchanged. If the pressure of the external air (p_a) is changed, the registering lever marks the difference in pressure $p_a - p_i$. The mercury is introduced from *G*, which is opened by means of clock work *U* at any desired time after the apparatus is lowered.

The registering apparatus is driven electrically with a velocity of 1 *cm.* per hour. The record is almost entirely freed from disturbing influences through the peculiar arrangement of the apparatus. The record strip is 15 *cm.* wide and 7·5 *m.* long. An arrangement is added to the registering apparatus, by means of which a mark is made each hour near both edges of the strip. These serve for drawing the hour curves and are used as base lines and make possible the determination of the expansion of the paper from moisture. Observations accurate to 0·2 *mm.* can be easily made. The maximum error of an observation amounts therefore to 2 *cm.* = $^3/_4$ *inch* in the height of the water. The clock *U* has a minute and an hour contact, by which the circuits of the driving mechanism and the marking apparatus are closed. The arrangement *H S F* has for its object the opening of the steel cylinder, when the air pressure in the interior reaches a certain value as the apparatus is raised toward the surface. The lever *H* is released and drives a steel point through a copper cap *z*, which closes the end of the tube *ks*, which is connected with the steel cylinder.

When the greatest possible accuracy is demanded, it is necessary to apply certain corrections to the readings: 1. for the variations of the barometer, 2. for the amount, that the apparatus has sunk into the sea bottom, 3. for the movement of the mercury in the tubes and the height of the water in the case, 4. for the thermal expansion and contraction of the enclosed air.

In order to be able to calculate the last corrections, a thermograph *T* is added, which at the same time gives a record of the temperature on the sea bottom.

Prof. A. Miethe

Director of the Photochemical Laboratory at the "Königl. Techn. Hochschule" in Berlin.

Exhibited in the Lecture Room.

Three Color Projection Apparatus, according to the exhibitors own system. Made by the firm C. P. Goerz, A. G., Opticians, Friedenau; with series of pictures.

The projection apparatus consists of a massive supporting stand with levelling screws, on which are arranged three parallel optical benches, which carry the three similar three color projection objectives, made especially for this purpose. On the optical benches the objectives have a horizontal and vertical motion, controlled by micrometer screws without losing the parallelism of their axes. In this way the three partial images may be superposed upon the screen to form the picture in its natural colors. The objectives are furnished with color filters, consisting of plane parallel plates with a sheet of pure colored substance between, whose absorption spectra are so chosen that the red filter allows waves from 700 to 600 $\mu\mu$ to pass, the green filter from 600 to 500 $\mu\mu$ and the blue filter from 500 to 400 $\mu\mu$. The arrangement for illuminating the slides consists of three hand-regulating arc lamps with the necessary controlling resistances for varying the current between 15 and 30 amp. Plates of hard glass are placed before the arc lamps for the protection of the triple condensers. These are especially intended for their purpose and consist of one double concave and two plano-convex lenses. Between the two plano-convex lenses there is a cooling cell, and at the proper distance frames for receiving the slides. These last are mounted in aluminium. For adjusting the slides, there is a special apparatus, consisting of an optical bench and two adjusting microscopes, by means of which corresponding points on the three slides are placed in the proper positions in respect to each other. After exact adjustment, the three slides are held in their positions by springs. The projection apparatus for pictures up to 6 *sq.m.* uses 15 amp. per lamp, up to 20 *sq.m.* 25 to 30 amp.

The pictures (Series: German state vineyards on the Moselle and Rhine, German village, German forest, pictures from the Dolomites and Lake Garda) are taken with the exhibitors three color camera on his ethyl-red plates (patented in all countries). The time of exposure for the three partial pictures is remarkably short, and the changing of the color filter in the camera is produced automatically. During the Exposition, lectures, illustrated with the apparatus, will be given.

J. D. Möller

Wedel in Holstein.

Institute for Microscopic Work.

No. 1–18 in B.

I. Slides of Diatom Types.

These microscopic preparations were made according to a process, discovered by the exhibitor in the year 1867, between the years 1886 and 1890. They form a complete whole and contain in 73 preparations about 30000 diatoms.

1. **Universum Diatomacearum Moellerianum.** This main slide consists of a systematically arranged group of diatoms, 6 *mm.* wide and 7 *mm.* long, which in 9 divisions of 133 rows contains 4036 single diatoms. The catalogue with description and a number of enlarged photographic reproductions explain the collection. The slide is exhibited under a Leitz universal microscope and will be shown, if desired.

2. **25 Slides Showing Diatom Types** of the flora of different regions. Also a catalogue with description and enlarged illustrations:

Fresh water, western hemisphere	197	Diat.
Fresh water, western hemisphere, foss.	174	„
Fresh water, eastern hemisphere	286	„
Fresh water, eastern hemisphere, foss. .	199	„
North Sea	178	„
Baltic	138	„
Mediterranean	207	„
Indian Ocean	122	„
Atlantic Ocean	293	„
Gulf of Mexico . . .	304	„
North Pacific	299	„
South Pacific	302	„
Polycystinae marl from Barbadoes .	274	„
Earth from Moron, Spain	87	„
Polycystinae marl from Jérémy, Hayti	122	Diat.
Sand from Charkow, Russia	53	„
Tripoli from Mejillones, Bolivia	109	„
Stone from Santa Monica, Cal.	284	„
Cement stone from Sendai, Japan	286	„
Cement stone from Mors, Jutland	120	„
Polishing Slate from Simbirsk, Russia . . .	243	„
Argillaceous slate from Oamaru, New Zealand	291	„
Argillaceous marl from St. Peter, Hungary . .	264	„
Earth from Nottingham, Maryland	253	„
Guano, South America .	140	„

3. **30 Slides of Diatom Types** of flora of different regions, on circular surfaces 3 *mm.* in diameter, arranged in natural order. Each slide contains about 400 diatoms.

4. **8 Diatom Slides,** arranged in stars. Each slide contains about 200 specimens.

5. **8 Diatom Types and Experimental Slides,** showing the historical development of the method of preparation, with about 2000 diatoms.

6. **Triceratium Favus Ehr. in 48 Sections.**

7. **Preparation Microscope** with the necessary devices for arranging, fastening and the imbedding of the diatoms, as used by the exhibitor.

II. Microscopic Reduction of Photographs,

showing the method, invented by the exhibitor.

8. **Carrier Pigeon Photographs.**
   a) Sheet of a carrier pigeon despatch 50×50 *cm.*, covered with written and printed matter as well as drawings, and containing about 20000 letters.
   b) The same sheet reduced 25 times, 2×2 *cm.*, on a thin membrane, weighing 0·01 *g.*, for sending in an aluminium case by carrier pigeon.
   c) The same sheet, at its place of destination laid on a glass plate for the purpose of enlargement.
   d) The same sheet photographically enlarged, 45×45 *cm.*

9. **Micrometer Photography.**
   a) Microphotographic graduations, cross threads, gratings, micrometers, for the different instruments of precision, on glass.
   b) Enlarged prints on paper, of the above.
   c) General staff map on glass, size 1×1 *cm.*

III. Glass Silvering.

The silvered surfaces, made by the exhibitor according to his new method, have a reflection coefficient of 96 to 97%.

10. **Parabolic Mirror,** 420 *mm.* in diameter. Silvered and coppered on the back.

11. **Plane Mirror,** 400 *mm.* square. Silvered on the back.

12. **Plane Parallel Plate,** silvered on the back, as substitute for total reflecting right angled prism.

13. **Four Plane Mirrors** in frame under glass.
   a) Silvered on the front.
   b) Silvered on the front, covered with a very thin plating of gold to protect the polish.
   c) Silvered on the front, with heavier gold plating.
   d) Gilded on the front.

14. **Different Forms of Prisms,** silvered on the back, for various optical instruments.

15. **Various Forms of Concave and Plane Mirrors,** for microscopes, opthalmoscopes, laryngoscopes etc., larynx, mouth and tooth mirrors.

16. **Six Glass Plates** with silvering of different thickness, varying from transparent to opaque and showing the peculiar series of colors in the new process.

IV. Optical Work of Precision.

17. **Plane Parallel Plates** of great accuracy.

18. **Accurate Prisms of Different Construction** for optical instruments.

Richard Müller-Uri

Braunschweig, Schleinitz-Strasse 19.

No. 1—19 in D.

I. Apparatus for Thermometry.

1. **Four-Walled Cylindrical Flask** for liquid air, with double neck. Capacity 75 *ccm.* Graduated in 0·1 *ccm.*, on wooden stand, according to Weinhold.

2. **Set of Four Crystal Thermometers** for projection, with oval section external tubes, according to Schering. a) b) c) graduated in 1·0° and 0·1° respectively, d) large freezing point thermometer with round external tube. The projected images of the instruments with oval tubes are clearer and less distorted than with round tubes.

3. **Set of Thermometers for High and Low Temperatures,** three pieces, made of Jena normal glass, graduated on tube; a) filled with petrol ether, reading from —200° C., graduated in 1·0°, b) filled with toluol, from —100° C., graduated in 1·0°, c) borosilicate glass, filled with nitrogen under pressure. Scale from +100 to 550° C., graduated in 5·0°.

II. Electrical Apparatus.

4. Photoelectric Apparatus, according to Elster and Geitel, for the discharge by sunlight or day light, in case with window. The apparatus includes a sodium cell in metal stand with dark chamber and calibrated electroscope, according to Exner, in case. Also dry pile, according to Elster and Geitel, stands for both, cell with sodium amalgam and stand for latter with screw clamp.

5. Photoelectric Cell with Quartz Window, according to O. J. Lodge. Pure metallic potassium contained in dark chamber cell, ready mounted.

6. Exner Electroscope with improved insulation.

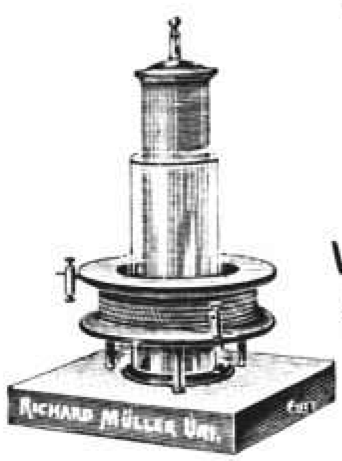


Fig. 1.

7. Tesla Transformer with air insulation, increased by strong cylinder of Leyden-jar glass. This construction allows strong currents in coils and is almost perfectly safe from danger of sparking through. (Fig. 1.)

8. Vacuum Transformer, according to R. Franke. Square tube similar to the Holtz funnel tubes, by means of which alternating currents of small quantity but high potential are changed into direct currents.

III. Vacuum Tubes of Different Kinds.

9. Original Vacuum Scale, according to Chas. R. Cross, Boston. On new form of stand with arrangement for lighting the tubes in succession. (Fig. 2.)

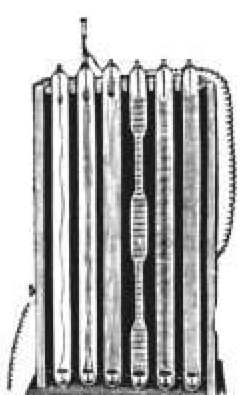


Fig. 2.

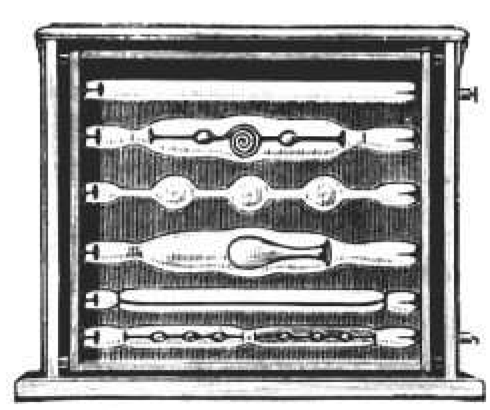


Fig. 3.

10. Series of Geissler Tubes ("Compendium"). In dust proof case with glass. Includes six examples of the chief forms of Geissler tubes. (Fig. 3.)

11. Collection of High Vacuum Tubes, on stand. Including a large spherical Crookes tube with five different brilliantly phosphorescent minerals, held in glass claws, (hexagonite, double spar, pectolite, sheelite, artificial ruby).

12. Vacuum Break and Lighting Tube, according to Mac Farlan-Moore, mounted with all connections exposed for use in the lecture room.

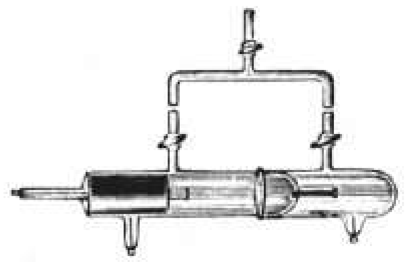


Fig. 4.

13. Lenard Tube for showing the action of cathode rays. Observation tube, which can also be exhausted, connected to the first with ground glass joint. (Fig. 4.)

14. Canal Ray Tube, according to W. Wien. With wire net cathode. These tubes show the positive and negative charges of the canal and cathode rays.

Fig. 5.

15. Lupus Tube, according to Röntgen. Own modification with reflector close to the tube wall, and vacuum regenerator. On account of its form the efficiency of the Röntgen rays is very high, since the reflecting surface lies so near the tube wall. Requires only an induction coil of about 10 *cm.* spark length. With 1 amp. and 10 volts the results are excellent. (Fig. 5.)

16. Braun Tube of large size, modification according to Harris J. Ryan. The narrow part of the tube is made as small as possible so that the magnetising coils can be brought close together. (Fig. 6.)

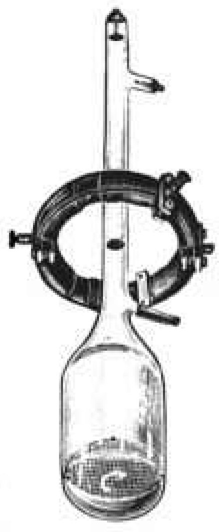


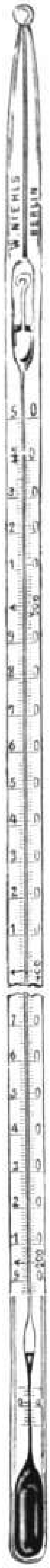
Fig. 6.

IV. Spectrum Tubes.

17. Mercury Arc Lamps, according to Fabry-Perot, and modifications.

18. Mercury Spectrum Lamps. In the form of the Monckhoven end-on spectrum tubes. Gives a very bright spot of light. For many purposes may be used instead of the expensive and sensitive mercury arc lamp.

19. Set of Spectrum Tubes (two stands and a velvet lined case). a) Spectrum tube, according to Plücker, filled with $Si\ Fl_4$, on improved metal stand with spiral spring and glass ebonite insulation; b) **H** form spectrum tube, filled with helium, on wooden stand; c) Old form Plücker tube (Geissler) with argon; d) Absorption spectrum tube, according to Schellen, with Na in H; e) Absorption spectrum tube, according to Dvořak, with three bulbs of hard glass, containing K in H; f) Absorption spectrum tube, filled with NO_2; g) Spark spectrum tube, according to Delachanal-Mermet.



W. Niehls

Berlin N., Schönhauser Allee 171.

Maker of Glass Scientific Apparatus and Instruments of Precision.

No. 1—11 in D.

I. Thermometers.

1. Thermometers for high temperatures to 540⁰ and 583⁰ C. for scientific and technical use, with certificates from the Physik.-Techn. Reichsanstalt.

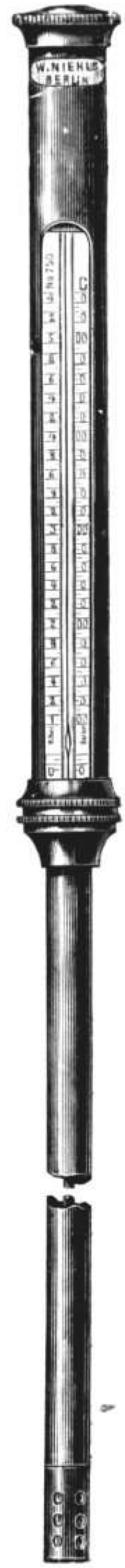
   All the thermometers are well cooled. The scales of the thermometers, graduated on the tube, are burned in by a special process.

   The factory thermometers are so arranged that greater or less immersion has little influence on the readings.

   All the thermometers are furnished with protection against particles falling into the capillary.
2. Contact thermometer, giving contact at 522⁰ C.
3. Mercury thread thermometer, according to Dr. Mahlke.
4. Thermometer for low temperatures to —200⁰ C.
5. Boiling point thermometer.
6. Minimum thermometer.
7. Deep sea thermometer.
8. Metallic thermometer, according to Breguet, with upright scale and arrangement for showing the cooling due to rarifying the air.

II. Different Kinds of Glass Apparatus.

9. Calibrated mineral oil testers.
10. Glass cocks with safety devices.
11. Scale of hardness for glass with testing pieces for use in the laboratory, in teaching and in trade.



Kaiserliche Normal-Eichungs-Kommission

Charlottenburg.

No. 1—6 in A.

1. **Balance of Precision for Load of 20 *kg.*,** with automatic arrangement for changing the weights, from P. Stückrath, Friedenau, Berlin.

The movable portions of the balance are made of partinium, a metal of small density, in order to attain a high sensibility, combined with a moderate time of oscillation.

The balance with its accessories stands, in the Normal-Eichungs-Kommission, on a pier free from the floor of the observation room, the top of which is formed by a large sandstone slab.

The end planes of the balance as well as the middle plane are made of agate. On account of the variation of this material with different atmospheric conditions, they were carefully tested before being used in the instrument, as to whether the variations would be nearly the same in all.

The balance pans are made in the form of a grating so that all the combinations of weights, used in weighing 1, 2, 5 and 10 *kg.* up to the sum of 20 *kg.*, can be placed on the pans and exchanged from one side to the other by means of a carrier of corresponding grating form.

The balance can be used without opening the case, by an observer sitting $1^1/_2$ *m.* away. The carrier with the gratings, on which the weights rest, is lowered until the weights are caught on the grating of the pans, and by a further movement, the arrestment is released so that first the middle knife edge rests on its plane and almost at the same moment the stirrups rest on their knife edges.

On account of the heavy weights, which are to be moved, the lowering and raising of the weight carrier and the action of the arrestment are produced by the motion of a wedge, which is moved forward or back by a triple threaded screw, attached to the arrestment shaft. The movable portion of the arrestment rests on rollers on the sloping surface of the wedge.

The riders, used for the determination of sensibility and for compensating small differences in weight, consist of a combination of 1, 3, 9, 27, 81 *mg.* on each side of the balance. These hang on short levers and are placed on the balance beam by means of five arms, each of which is connected with one of five concentric tubes, whose motion is transmitted by levers to five other corresponding concentric tubes in the balance, and these in turn move the levers carrying the riders.

In order to simplify the placing and centering of the large weights, these are placed in forms of cardboard, bound with brass, on two carriages, the upper parts of which are formed by gratings of nickel plated brass rods. These forms are so situated that when the weights are transferred to the carrier and then are lowered to the pans, their center of gravity comes directly below the end knife edge of the balance.

The sensibility for a load of 20 *kg.* amounts to 0·24, with 10 *kg.* to about 0·28 divisions per 1 *mg.* This sensibility can be easily doubled, but naturally at the cost of constancy and time of swing. With the above sensibility a weight of 20 *kg.* can be weighed with an error of about $\pm$ 1·0 *mg.*, and of 10 *kg.* with an error of $\pm$ 0·3 *mg.* This implies an accuracy in weighing of 5×10^{-8} and 3×10^{-8} respectively.

In addition the following instruments, belonging to the Kaiserliche Normal-Eichungs-Kommission and made according to their own plans, are exhibited by the makers.

2. **Balance of Precision** for load of 250 *g.* With automatic arrangement for interchanging the weights, to be read with a telescope. From P. Stückrath. (See Stückrath.)

3. **Balance of Precision,** for standardizing weights or volume measures up to 10 *kg.* From A. Hasemann. (See *p. 65.*)

4. **Apparatus for Measurement of Thickness,** especially for determining the diameter of areometers. From C. Reichel and H. Heele. (See *p. 68.*)

5. **Cathetometer** for the measurement of differences in height up to 20 *cm.* at distances of from 30 *cm.* to 5 *m.* From R. Fuess. (See *p. 29.*)

6. **Volumenometer** for measuring the volume of weights in air. From R. Fuess. (See *p. 30.*)

In addition, 16 photographs of instruments and apparatus are exhibited, concerning which see appendix to this catalogue.

Julius Peters

Berlin NW., Turmstrasse 4.

Manufacturer of Scientific and Technical Apparatus.

No. 1—4, 6 and 7 in B, No. 5 in D.

1. **Half Shadow Apparatus,** according to Landolt (Fig. 1). Own construction, upon trestle stand with covered circle; reading to 0·01°. Polariser, according to Lippich. Telescope aplanatic and with strong magnification. In addition: a gas

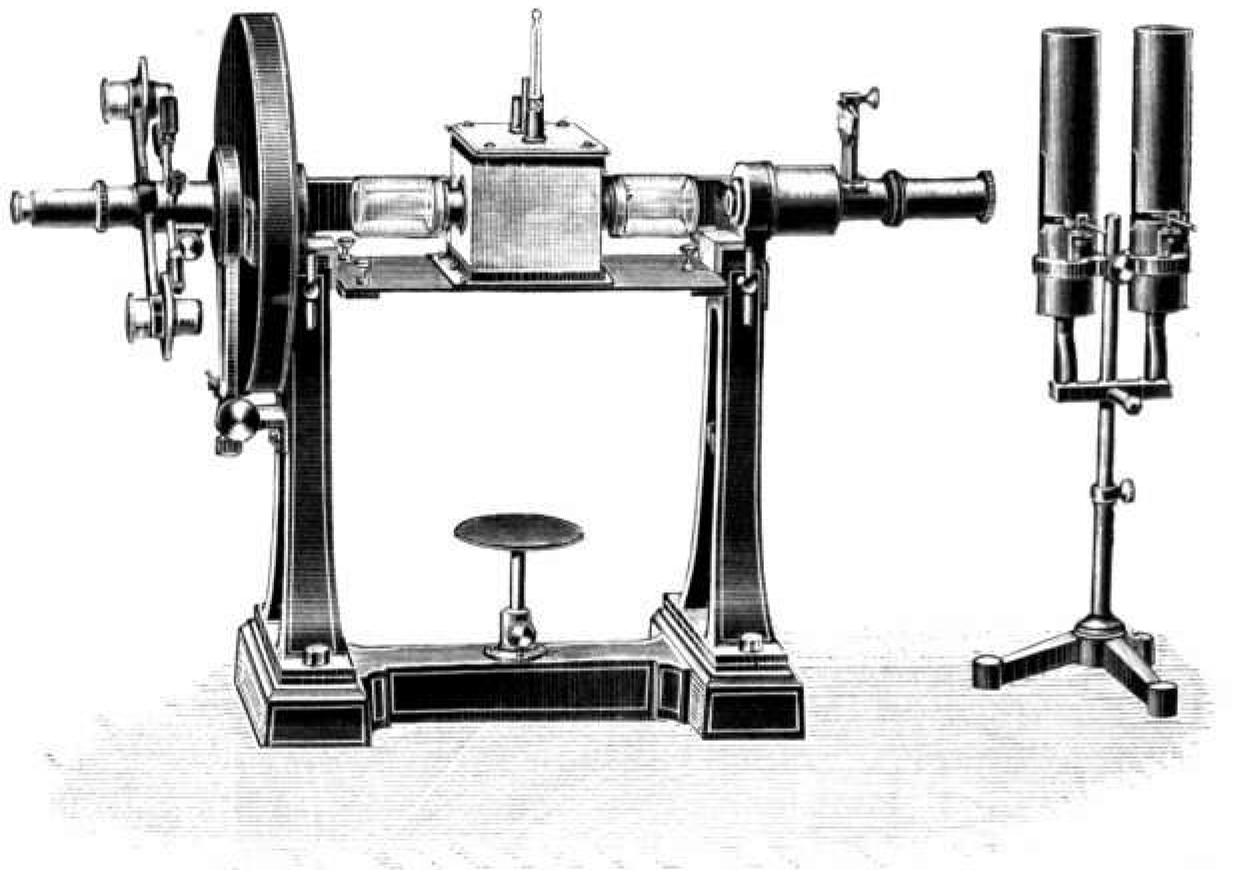


Fig. 1.

sodium lamp of our own construction with double burner; box with observation tubes, gilded on the inside for observations at high and low temperatures. This apparatus is especially fitted for scientific investigations. (Comp. *Chem. Ber.* **28**. *p. 3102. 1895.*)

2. **Half Shadow Saccharimeter** (Fig. 2), own construction, on trestle stand with wedge compensation for white light; with Lippich polariser, strong magnifying aplanatic telescope, and quartz wedges, held in their settings without pressure. The quartz wedges and the scale are situated in an air tight case.
3. **Observation Lamps** for petroleum, gas and electricity.

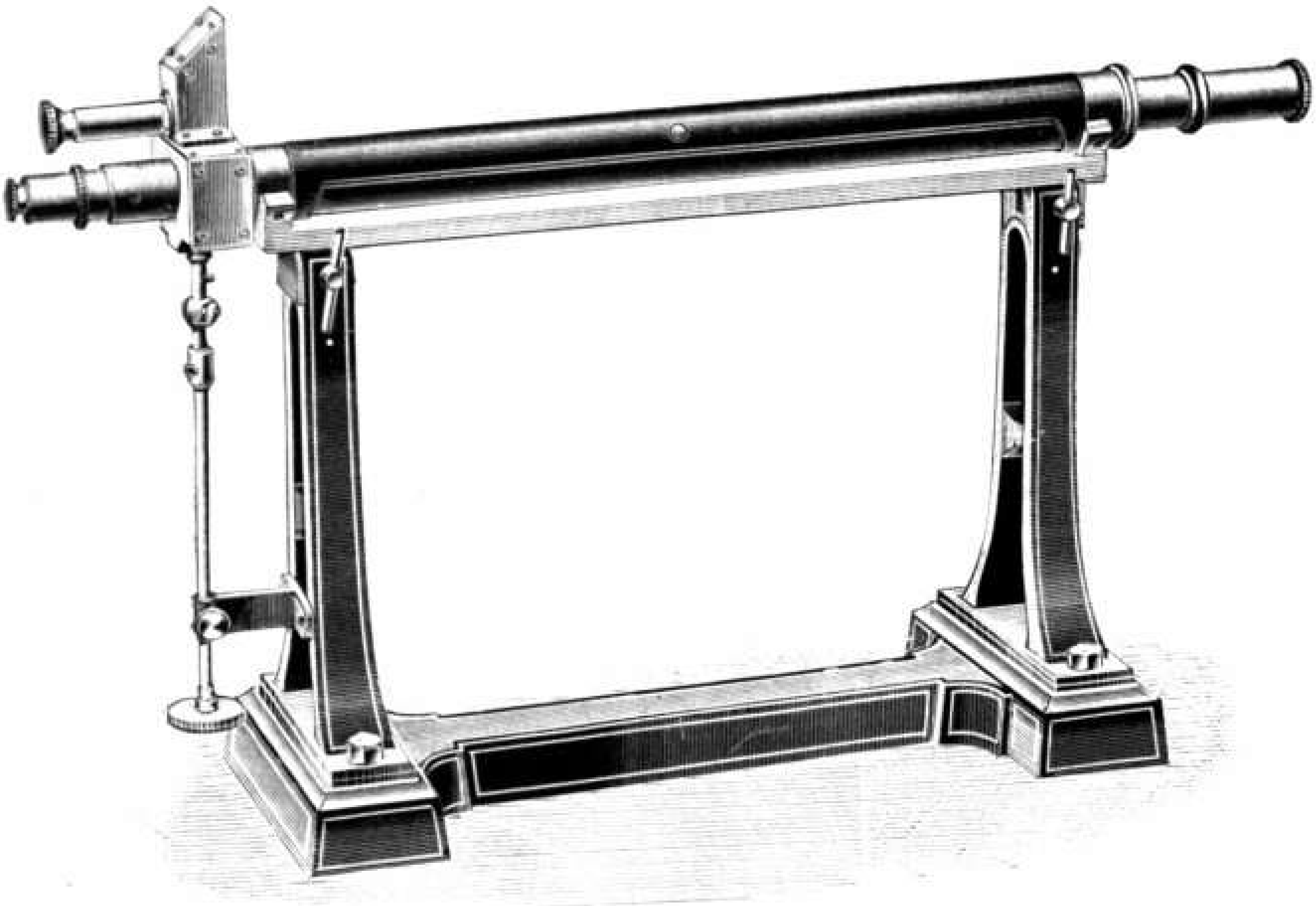


Fig. 2.

4. **Observation Tubes** of various forms, some with tube in the middle, for convenience in filling and for preventing possible air bubbles in the field of view.

5. **Calorimeter,** according to Berthelot-Mahler, improved by Kroeker. By means of an arrangement in the combustion bomb, the amounts of water and of carbonic acid, formed in the combustion of carbon, can be determined at the same time. The apparatus is also used to advantage in the study of the heat development in physiological researches.

Photographs.

6. **Large Standard Half Shadow Saccharimeter,** according to Herzfeld, furnished to the newly erected "Institut der deutschen Zucker-Industrie". The instrument is arranged for receiving 12 observation tubes at the same time and provided with the most valuable transparent crystals.

7. **Set of Standard Quartz Plates.** Made to the order of the "International Commission for uniform methods of measurement". The essential requirements were that the quartz should be absolutely optically pure, the surfaces plane and parallel, and that these should be cut exactly at right angles to the axes.

Physikalisch-Technische Reichsanstalt

Charlottenburg.

No. I in D, No. II in B, No. III in C.

I. Heat.

1. Liquid Thermostat with electric heating, for the comparison of thermometers.

The copper bath, containing the liquid, is surrounded by a brass cylinder, from which it is separated by an air space and to which it is connected by a metal ring. In the bath there are three small ship screws in a brass cylinder, on which the heating arrangement is held. This arrangement consists of constantan wire, insulated in glass tubing, the ends of which terminate in binding screws. Melted palmin is used as the bath liquid. The strength of the current is regulated by means of sliding contact constantan resistances in series.

The thermometers are held in corks in the aluminium cover. They are read with exposed mercury threads, the temperature of which is determined by means of a Mahlke mercury thread thermometer. The constancy of temperature at 200° is about 0·02°, and the energy consumed about 350 watts.

2. Sulphur Boiling Point Apparatus.

The apparatus is used for the standardization of thermometers, thermoelements and platinum thermometers, with the help of the boiling point of sulpnur. The sulphur, which is contained in a movable glass tube, is heated electrically. The current is so regulated that the vapor just reaches the lower asbestos disc, a point which is important in the case of mercury thermometers on account of the correction for the exposed mercury thread. The upper part of the tube can be heated by a separate electric circuit, which is disconnected during the measurements themselves. (See R. Rothe, *Zeitschr. f. Instrkde.* ***23.*** *p. 364 1903.*)

3. Smelting Furnace for accurate determination of melting points and for the standardization of thermoelements.

The heating arrangement of the furnace consists of a fire clay cylinder, covered with a tube of platinum foil 0·007 *mm.* thick, which is provided with connections above and below. Through this currents up to 200 amp. at 10 volts can be sent. It is protected from the influence of the hot gases by a cylinder of quartz, in which the crucible is placed. The upper auxiliary furnace is heated to approximately the melting temperature so that a greater depth of nearly uniform temperature is attained, which is important in the calibration of thermoelements.

4. **Platinum Thermometer** of small thermal inertia, for calorimetry.

The thermometer consists of a silk insulated platinum wire of 0·01 *sq. mm.* cross section and about 30 *cm.* long (resistance 5 ohms), inclosed in a U-shaped metal tube of 1 *mm.* internal diameter. The junctions of the fall of potential wires are at the temperature, which is being measured. There are two pairs of binding posts for the introduction of the current and for the fall of potential. (See W. Jaeger and H. v. Steinwehr, *Verhandl. d. Deutsch. Physikal. Gesellsch.* ***5.*** *p. 353. 1903; Zeitschr. f. Instrkde.* ***24.*** *p. 28. 1904.*)

5. **Platinum Thermometers** for temperatures below +600° C.

For the prevention of deposits of moisture in the interior of the thermometers with long use at low temperatures, a drying arrangement in the handle is introduced. The binding posts are protected from the influence of radiation and air currents by means of a brass cap. (See R. Rothe, *Zeitschr. f. Instrkde.* ***24.*** *p. 52. 1904.*)

The Reichsanstalt has also been connected with the production of the following pieces of apparatus, exhibited in the department for the measurement of temperature and pressure:

a) **Thermostat for Low Temperatures**, exhibited by R. Burger, Berlin. (See R. Rothe, *Zeitschr. f. Instrkde.* ***22.*** *p. 14, 33. 1902.*)

b) **Potentiometer for Pyrometer Measurements,** according to Lindeck, exhibited by Siemens & Halske, Berlin. (See St. Lindeck and R. Rothe, *Zeitschr. f. Instrkde.* ***20.*** *p. 285. 1900.*)

c) **Arrangement for Indicator Testing,** exhibited by Dreyer, Rosenkranz & Droop, Hannover.

d) **Pressure Balance for the Measurement of High Pressures,** with piston, which can be rotated, exhibited by P. Stückrath, Friedenau.

II. Optics.

6. Two Electrically Glowed "Black Bodies".

In the derivation of his celebrated law of the absorption and emission of light, G. Kirchhoff has defined the "absolutely black body" as a radiating body which absorbs all waves, neither reflecting nor transmitting. Such a body, which does not actually exist, is of great importance, not only for spectrum analysis, but for the whole process of radiation, since by it all radiating bodies may be brought into a close relationship. Of all radiating bodies of the same temperature, the black body is the one, which emits the maximum energy for all wave lengths, hence its energy curves envelop those of all other radiating bodies. In order to realize this black body, a cavity of uniform temperature (according to Lummer and Wien) is used, whose radiation is emitted through a small opening.

Two "electrically glowed black bodies" are exhibited, in one of which the cavity is heated by a *platinum cylinder*, and in the other the cavity is formed by an electrically heated *carbon tube*.

7. Bolometric Apparatus for the Measurement of the Total Radiation.

In order to measure the radiation from a glowing body, which it sends out to its environment in the form of ether waves, a very sensitive instrument is required, which transforms the energy of the oncoming waves into heat, and by means of its rise in temperature allows this energy to be measured.

The bolometer, according to Lummer-Kurlbaum, consists of platinum foil 0·001 *mm.* in thickness, covered with spongy platinum, in order that all wave lengths may be absorbed equally. The four arms of the bolometer are combined into a Wheatstone bridge. These are all as much alike as possible in order that the balance of the bridge shall not be affected in any appreciable degree by the variations of the room temperature or the variations in strength of the measuring current. In consequence of this and on account of the small thermal inertia and extraordinary thinness of the strips, a radiation, which produces a heating in the bolometer of only 0·00001^{0} C., can be measured with an accuracy of a few per cent. In addition to the bolometer, the stand holds a blending apparatus and a shutter, provided with water cooling.

8. **Mercury Arc Lamp,** according to Arons-Lummer, made by Dr. R. Muencke, Berlin NW., Luisenstr. 58. (See O. Lummer, *Zeitschr. f. Instrkde.* ***21.*** *p. 201. 1901.*)

The Reichsanstalt has also been connected with the production of the following pieces of optical apparatus, exhibited in the department of optics:

a) **Photometer Bench** with photometer for similarity and contrast, according to Lummer and Brodhun, exhibited by Franz Schmidt & Haensch, Berlin. (See *Zeitschr. f. Instrkde.* ***12.*** *p. 41. 1892.*)

b) **Spectrophotometer,** according to Lummer and Brodhun, exhibited by Franz Schmidt & Haensch, Berlin. (See *Zeitschr. f. Instrkde.* ***12.*** *p. 132. 1892.*)

c) **Rotating Sector,** in which the size of the sector can be varied and measured during the rotation, exhibited by H. Heele, Berlin. (See O. Lummer and E. Brodhun, *Zeitschr. f. Instrkde.* ***16.*** *p. 299. 1896.*; E. Brodhun, *Zeitschr. f. Instrkde.* ***17.*** *p. 10. 1897.*)

d) **Interference Spectroscope,** according to Lummer and Gehrcke, exhibited by Franz Schmidt & Haensch, Berlin. (See *Drudes Ann. d. Physik* ***10.*** *p. 457. 1903.*)

III. Electricity.

9. **Optical Method of Measuring Large Alternating Currents.**

The following apparatus is employed:

a) platinum glower (made by W. Meyerling, Halensee, Berlin). In order to secure constant cooling by conduction, the conductors introducing the current are hollow and are cooled by a stream of water;

b) optical pyrometer, according to Holborn and Kurlbaum (see *Drudes Ann. d. Physik.* ***10.*** *p. 225. 1903*), made by W. Meyerling;

c) standard direct current amperemeter (exhibited by Siemens & Halske, Berlin) for the measurement of the current in the incandescent lamp of the pyrometer.

d) continuously variable regulating resistance (made by W. Meyerling) for regulating the lamp current.

The alternating current to be measured is sent through a suitable platinum strip in the glower so that it is brought to incandescence. The optical pyrometer is directed toward the incandescent strip and the lamp current varied, until the lamp filament seems to disappear against the incandescent strip. The platinum strip is then heated by a direct current of such strength that the lamp filament, traversed by a current of the same strength as before, disappears. The direct current used for the heating is then equal to the alternating current to be measured. (See E. Orlich, *Zeitschr. f. Instrkde.* ***24.*** *S. 65. 1904.*)

10. Apparatus for the Measurement of Induction Coefficients.

The apparatus consists of the following pieces:

a) a vibrating wire interrupter, according to M. Wien and L. Arons, as improved in the Reichsanstalt. (See E. Orlich, *Elektrotechn. Zeitschr.* ***24.*** *p. 503. 1903.*) Frequency variable within wide limits up to 1000 periods per sec.;

b) a small transformer, which converts a direct current, interrupted by the vibrating interrupter, into an alternating current;

c) a Wheatstone bridge, in which the unknown self induction is compared with a known variable self induction (see M. Wien, *Wied. Ann* ***44.*** *p. 689. 1891;* ***58.*** *p. 553. 1896*). Two of the arms of the bridge are formed by a slide wire, at the ends of which resistances can be introduced, which are multiples of the resistance of the slide wire itself. Between the other two arms a set of resistances, free from induction and capacity, are connected (made by Otto Wolff, Berlin);

d) a self induction variometer, similar to the variometer of M. Wien (*Wied. Ann.* ***57.*** *p. 249. 1896*), made in the Reichsanstalt. The movable coil contains three, the fixed coil five turns. Range from 0·00065 to 0·8 Henry.

In connection with the bridge may be used either an ordinary telephone or an optical telephone, according to M. Wien (see *Wied. Ann.* ***42.*** *p. 593. 1891*, made by W. Oehmke, Berlin NW., Dorotheenstr. 35), or a vibration galvanometer, according to Rubens (see *Wied. Ann.* ***56.*** *p. 27. 1895*, also made by Oehmke), or a vibration galvanometer, according to M. Wien (see *Drudes Ann. d. Physik* ***4.*** *p. 425. 1901*, made by the Instituts-Mechaniker Feldhausen, Aachen).

The optical telephone and the two vibration galvanometers are exhibited on the same galvanometer shelf.

11. Absolute Measurement of Capacity, according to the Maxwell-Thomson method (see J. J. Thomson, *Phil. Trans.* ***174.*** *p. 707. 1883*).

Three of the arms of a Wheatstone bridge consist of resistances, free from capacity and induction. The capacity to be measured and a rotating interrupter are connected in the fourth arm. By means of this last, the capacity is alternately charged and short circuited, while the resistance of the bridge arms is varied until the constant current, flowing through the galvanometer, is compensated. When the number of times per sec. that the capacity is charged lies between 30 and 250, the charging current acts on the galvanometer like a direct current. By means of a worm wheel transmission with arrangement for making contact and a chronograph, the frequency is accurately determined.

The rotating interrupter, according to Jaeger and Kurlbaum, is made by O. Wolff, and the arrangement for varying the speed, connected between the interrupter and the driving motor, is made by W. Meyerling.

Two of the arms of the bridge are contained in a case and consist of Kundt resistances. These are made of extremely thin films of a platinum gold alloy, which are burned into a glazed porcelain tube. In order to produce the highest possible resistance, the film is cut in the form of a spiral of gradual pitch. The process of production of this new form of high resistance has been worked out in the Reichsanstalt in connection with the Chemische Fabrik auf Aktien (formerly E. Schering), Berlin. The third arm consists of a resistance box from O. Wolff, Berlin.

The work of the Reichsanstalt in the line of standard resistances (single resistances, resistance boxes, petroleum baths for the comparison of standard resistances, Thomson bridge and potentiometer) is exhibited by O. Wolff, Berlin; in part also by Hartmann & Braun, Frankfurt a. M. and by Siemens & Halske, Berlin.

The water color general view of the Reichsanstalt and various photographs of the institution, which are on exhibition, are described in the appendix.

C. Richter

Berlin N., Johannisstrasse 14/15.

Glass Apparatus and Instruments of Precision.

No. 1—52 in D.

I. Standard Thermometers.

Thermometers of this kind may have their fixed points determined and be calibrated in the usual way. The enlargements in the capillary take up the mercury not required for the temperature measurement and also allow an accurate calibration.

	Range		Graduations	Variety of glass
1. With scale on tube . . .	— 5	+102⁰	0·1⁰	Jena Borosilicate Glass 59 III
2. " " " " . . .	— 5	+ 55⁰	0·1⁰	
3. " " " " . . .	+ 45	+102⁰	0·1⁰	
4. Universal thermometer, according to Pernet . .	— 40	+150⁰	0·1⁰	
5. Scale enclosed	— 5	+102⁰	0·1⁰	
6. " "	— 35	+ 2⁰	0·2⁰	
7. " " for measurement of altitude	+ 75	+102⁰	0·1⁰	
8. Scale enclosed	+ 95	+155⁰	0·1⁰	
9. " "	+145	+205⁰	0·1⁰	
10. " "	+195	+255⁰	0·1⁰	

II. Thermometer Sets for Large Temperature Intervals.

	Range		Graduations
11. Set of three	— 10	+300⁰	0·5⁰
12. Set of four	— 10	+400⁰	1·0⁰

11. The interval 0—300⁰ is divided among the three thermometers. Each may have its fixed points determined and be calibrated by itself.

12. The interval 0—400⁰ is divided among four thermometers, each with a zero point. The capellaris of the last three are filled with dry gas.

III. Mercury Thread Thermometers, according to Mahlke.

These serve to determine the correction due to the exposed mercury thread.

	Range		Graduations	Variety of glass
13. Length of bulb 100 *mm.* .	−10	+300°	1.0°	
14. „ „ „ 200 *mm.* .	−10	+300°	1.0°	

IV. Thermometers for Molecular Weight Determinations, according to Beckmann.

	Range		Graduations	Variety of glass
15. Covering	3°		0.01°	
16. „	5°		0.02°	
17. „	8°		0.05°	

V. Thermometers for High Temperatures.

These instruments are filled with dry gas under a pressure of 20 atm., with zero point.

	Range		Graduations	Variety of glass
18. Thermometer	+250	+550°	1.0°	59 III
19. Set of two	+350 +450	+450° +550°	1.0°	59 III

VI. Pentane Thermometers for Low Temperatures.

On the thermometers, having the scale on the tube, each tenth div. is drawn clear around, to prevent errors of parallax.

	Range		Graduations
20. Scale on tube	−200 −175°; −81 −74°; −5	+ 5°	0.1°
21. Scale on tube	−200 −175°; −100	+10°	0.5°
22. Scale on tube	−200	+20°	1.0°
23. Scale enclosed	−200	+20°	1.0°

VII. Thermometers for Calorimetry.

	Range		Graduations	Variety of glass
24. For calorimeter, according to Kroeker	+15	+22°	0.01°	
25. For calorimeter, according to Kroeker	+14	+24°	0.02°	
26. For calorimeter, according to Berthelot-Mahler, scale on tube, weight of mercury and glass given.			0.02°	59 III
27. For calorimeter, according to Berthelot-Mahler, scale on tube, weight of mercury and glass given.			0.02°	59 III

VIII. Thermometers for Meteorology and Marine Investigation.

	Range		Graduations
28. Deep-sea thermometer, according to Nansen. Set of three	−2	+17°	0.1°
29. Reversing thermometer, *own design*	−2	+22°	0.2°
30. Set of two with reversing arrangement	−2	+22°	0.1°

31. Thermometer for surface water temperatures.
32. Light ship thermometer.
33. Psychrometer, according to Schubert, with whirling arrangement.
34. Aspiration psychrometer, according to Assmann.
35. Solar radiation thermometer.
36. Solar radiation maximum thermometer.
37. Boiling point thermometer, millimeter divisions.
38. Boiling point thermometer, centigrade and millimeter divisions.
39. Hypsometer, according to Grützmacher.
40. Earth thermometer.
41. Pendulum thermometer.
42. Stand with psychrometer thermometers, according to August.
43. Maximum thermometer.
44. Minimum thermometer.

IX. Miscellaneous Glass Apparatus.

45. Burette with stop cock, according to Knudsen, for the examination of sea water.
46. Pipette with stop cock, according to Knudsen, for the examination of sea water.
47. Pyknometer, according to Nansen.
48. Pyknometer, according to Kohlrausch.
49. Three Resistance cells of different forms, according to Kohlrausch. (Comp. Kohlrausch and Holborn, Leitvermögen der Elektrolyte. Leipzig 1898. *p. 12.*)
50. Stand with four double walled Dewar flasks.
51. Water-jet pump with back pressure valve.
52. Large and small glass stop cock.

August Riedinger

Augsburg.

Balloon Manufacturer.

Model of a Kite-Balloon, according to von Parseval and von Sigsfeld.

(See Aeronautisches Observatorium *p. 1.*)

Clemens Riefler

Nesselwang und München (Bayern).

Manufacturer of Mathematical Instruments.

No. 1 and 2 in A.

1. **Drawing Instruments of Precision** and instruments used in technical designing.

The compasses (Figs. 1, 2, 3) of the mathematical instruments of the Riefler Company are made on the so-called round system, which was designed by Dr. S. Riefler. This system on account of its many advantages has very largely superseded the older patterns of compasses with their angular form and three cornered points, and is now, after the expiration of the patents, used by most other manufacturers of drawing instruments. Of the numerous instruments, which the firm has newly designed or improved, are exhibited:

Dividers with changeable points (Fig. 2), compasses, drawing pens with adjusting screw and nib, opening to the side without disturbing the thickness of the lines (Fig. 4), road pens, curve pens, double curve pens, drawing fountain pens for drawing many lines with one filling (Fig. 5), map gauge, kilometer gauge (according to Oberst Heller) (Fig. 6), spring bows for small circles with point, falling by its own weight (Fig. 7), spring bows with micrometer screw between the legs (Fig. 8), proportional compasses, six beam compasses of different styles, three triangular compasses, two pieces of hatching apparatus, two ellipsographs, three dotting pens for drawing broken lines and circles (Fig. 9), angle divider and several other similar instruments.

2. **Model of Astronomical Clock Work.**

The astronomical clocks*, built by the exhibitor during the last 15 years, possess a perfectly *free escapement* and *mercury* or *nickel-steel compensated pendulums.*

* *Astronom. Nachr.* **133** *and* **134**; *Zeitschr. f. Instrkde.* **13**. *p. 88. 1893;* **14**. *p. 346. 1894.* S. Riefler, Die Präzisionsuhren mit vollkommen freiem Echappement und Quecksilber-Kompensationspendel. München 1894; S. Riefler Nickelstahl-Kompensationspendel. München 1902.

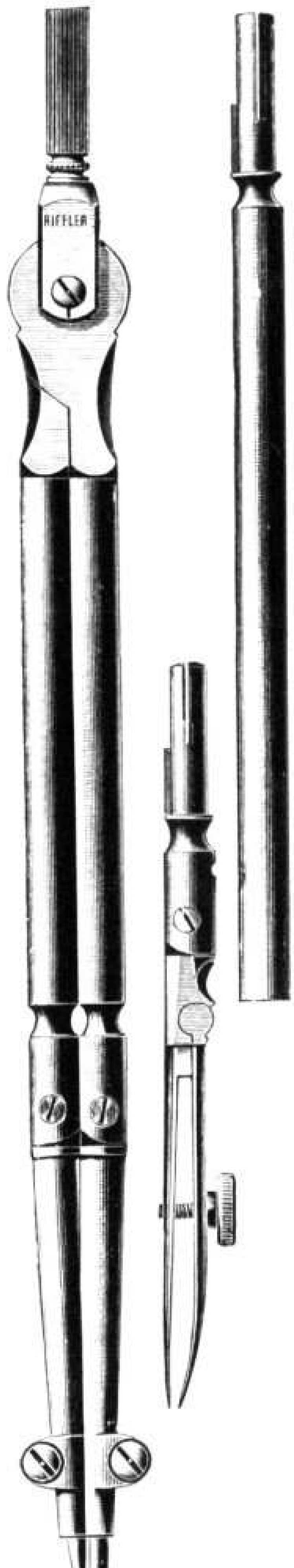


Fig. 1.

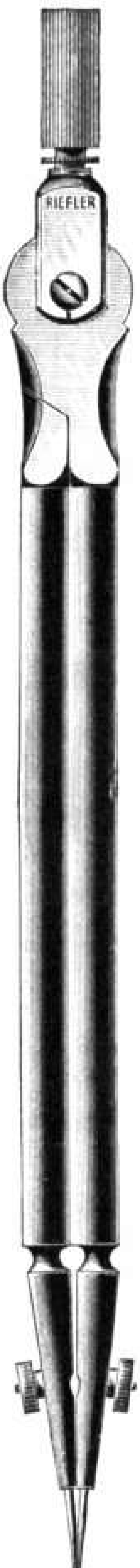


Fig. 2.

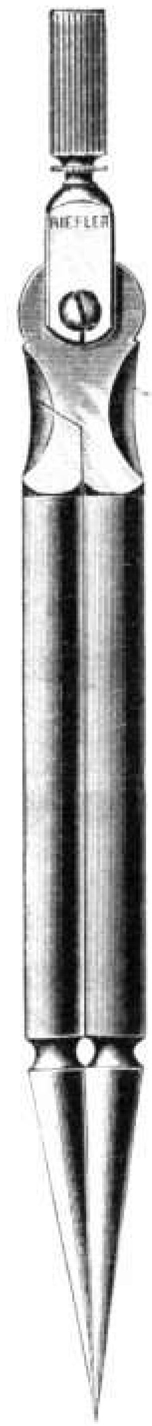


Fig. 3.

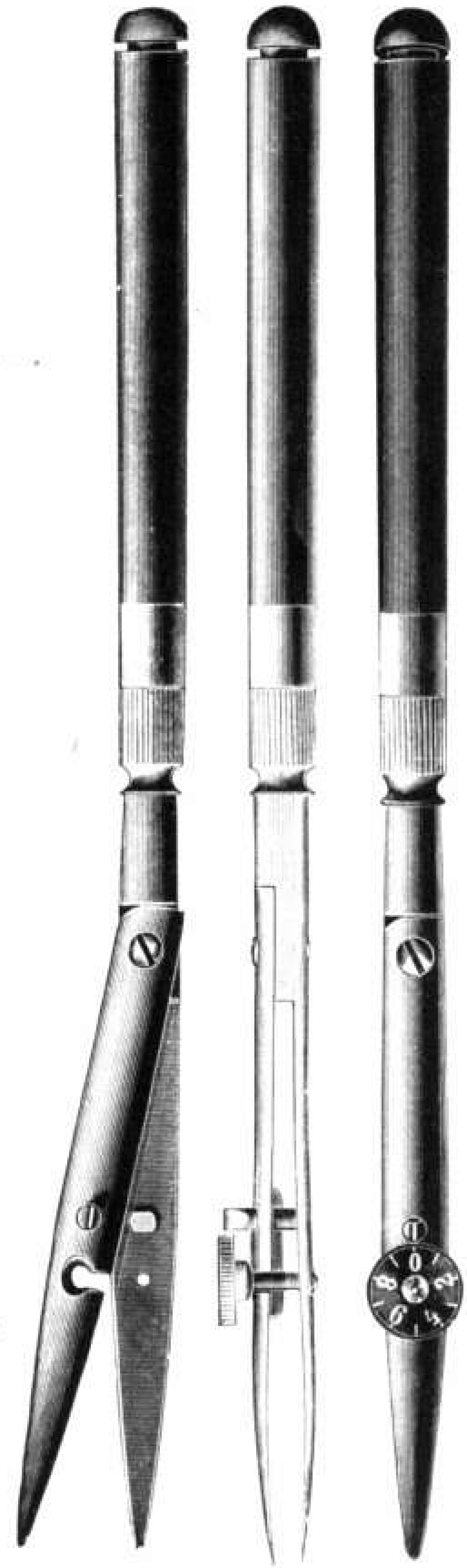


Fig. 4.

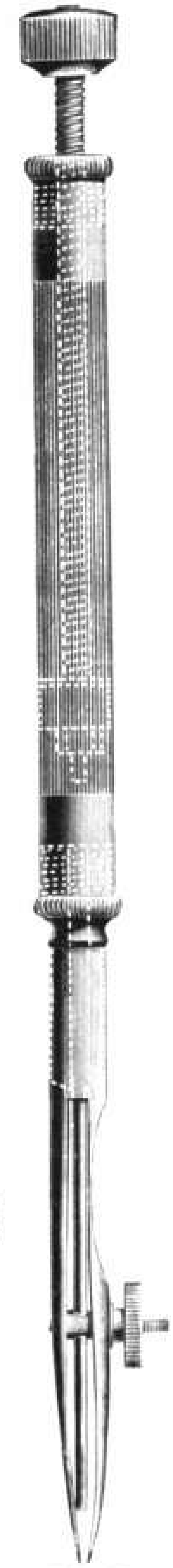


Fig. 5.

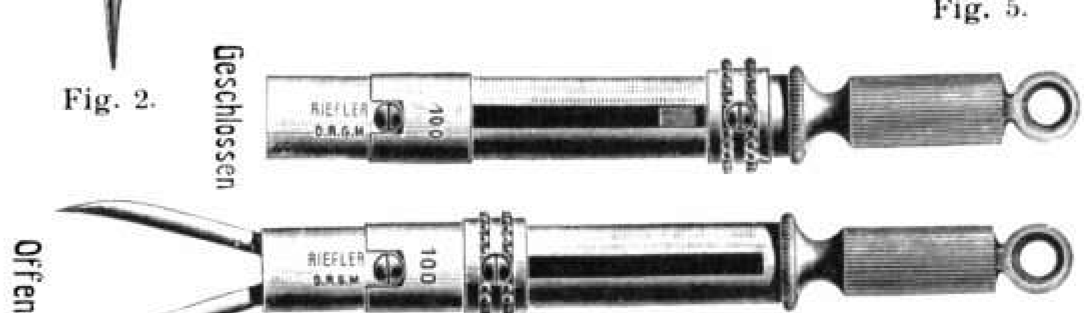


Fig. 6.

The *escapement* of these clocks rests on a practically new principle, which was worked out by Dr. S. Riefler in the year 1869. It was only by means of extensive experiments that a practical solution of the problem was reached (1889).

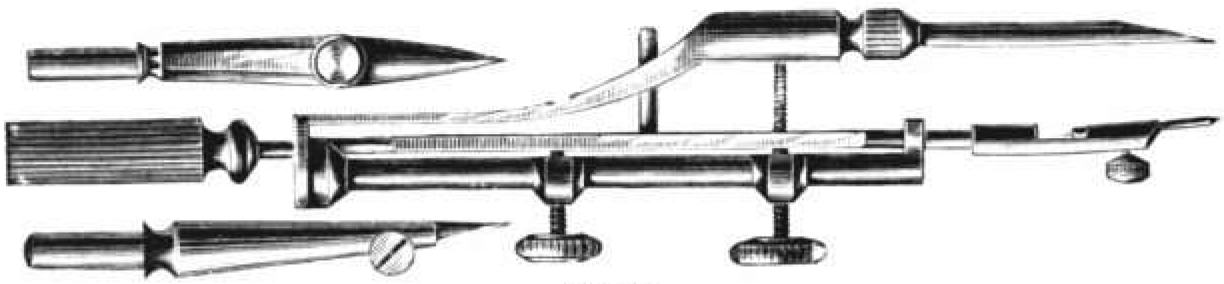


Fig. 7

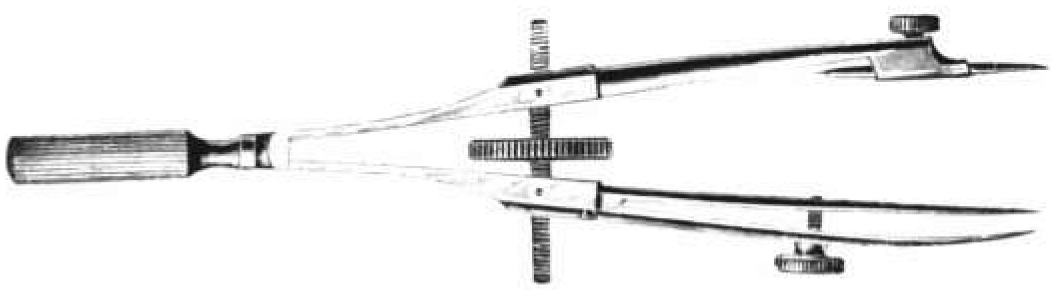


Fig. 8.

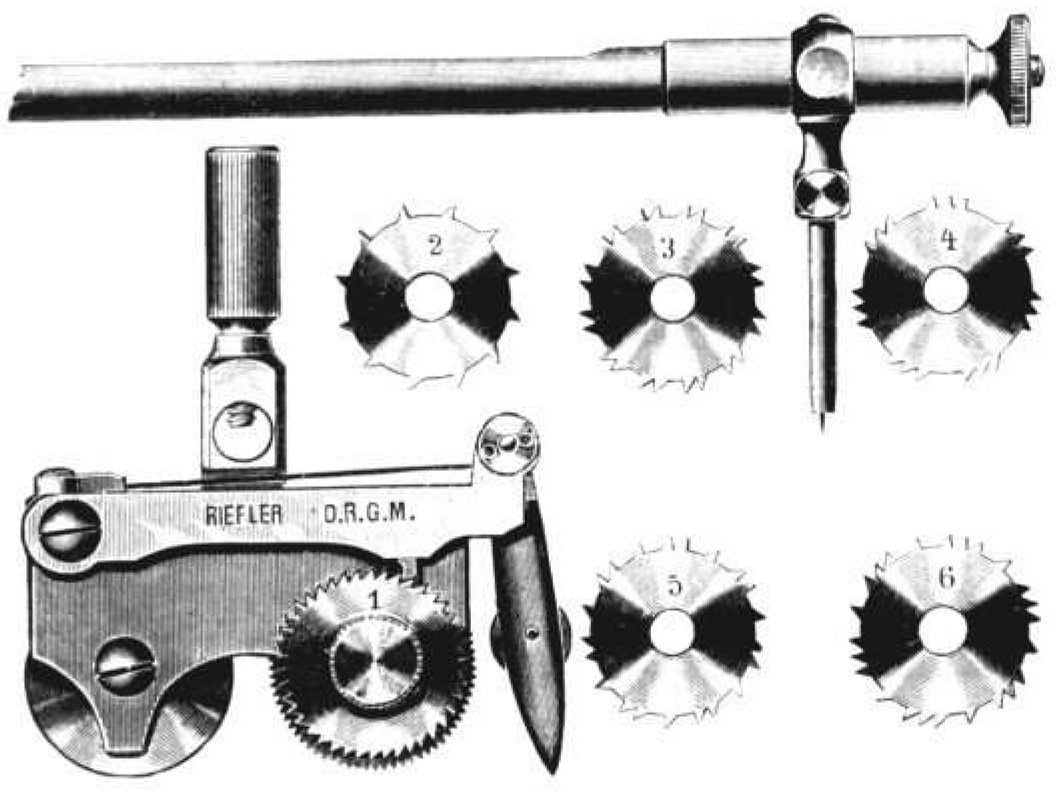


Fig. 9

The pendulum is not driven by an anchor escapement, which is entirely lacking, but by the pendulum spring itself, which is slightly bent at each oscillation and the resulting elastic force imparts the necessary motion. The introduction of this completely free escapement has produced an accuracy in the clocks not before known.

An additional important advance in this direction was in the introduction of the *mercury compensation pendulum* in the year 1891. This consists of a thin walled Mannesmann steel tube, filled to two thirds its height with mercury.


Fig. 10.

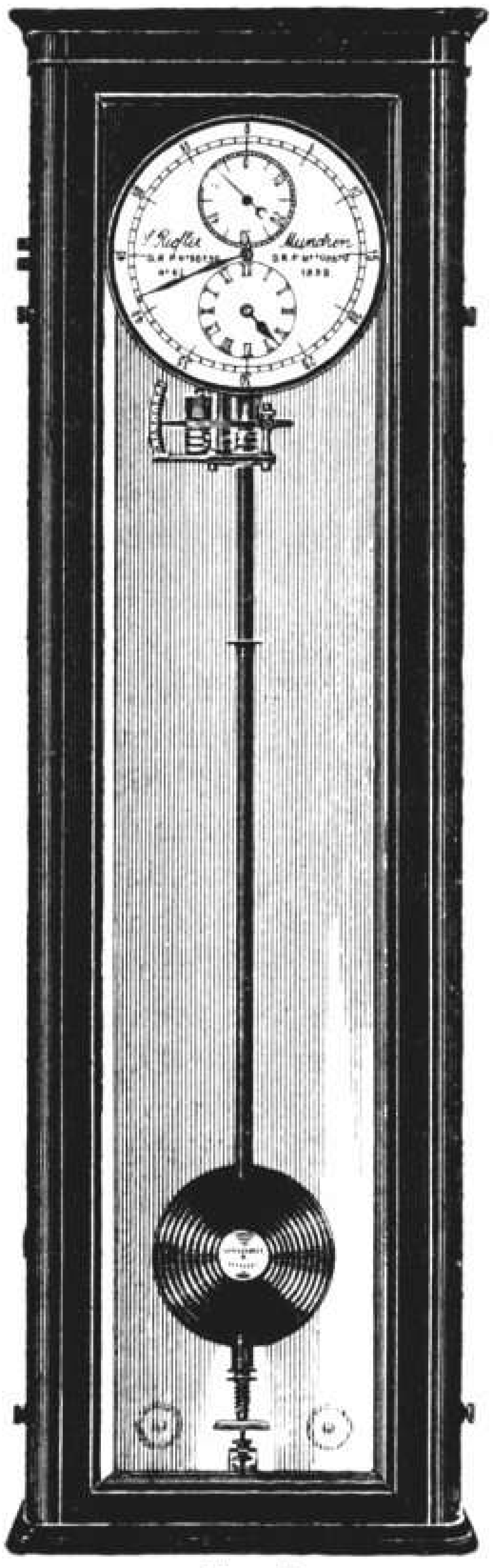


Fig. 11.

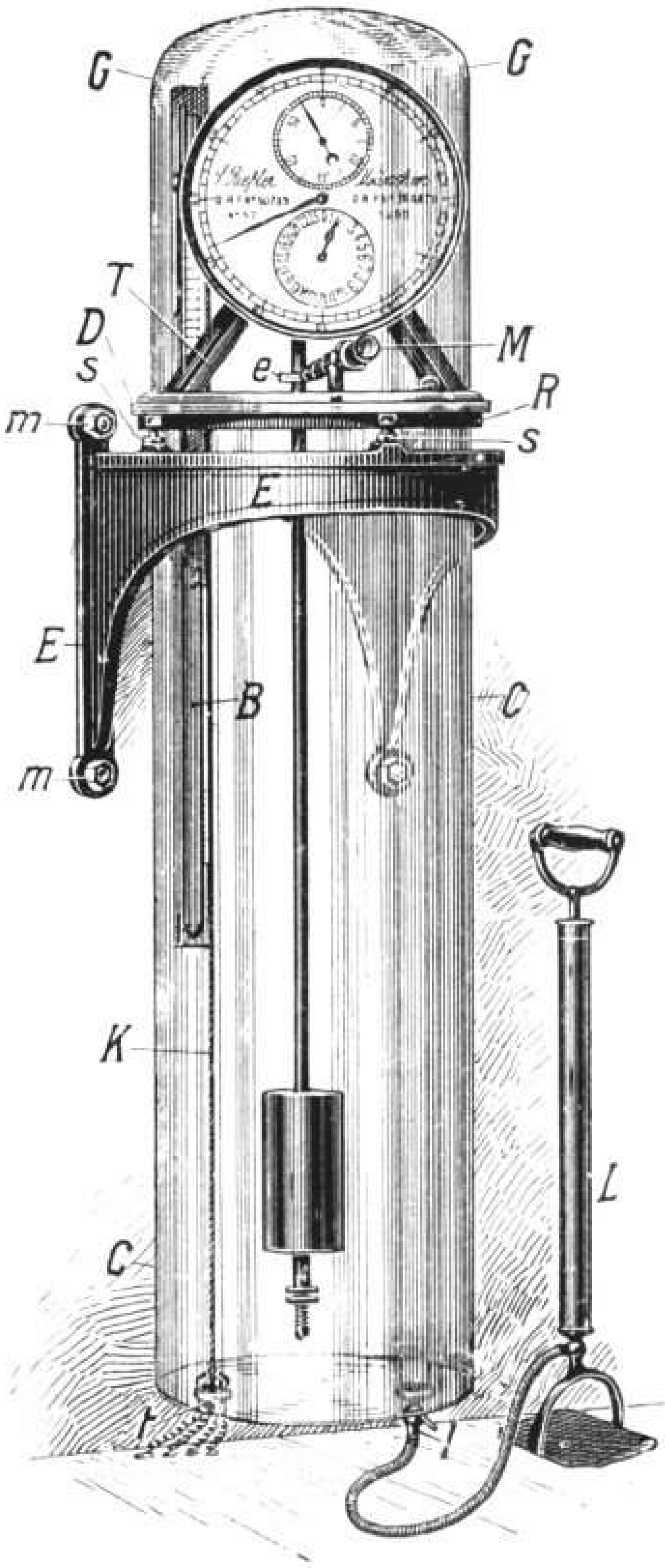


Fig. 12.

This successful construction was followed in 1898 by the *nickel-steel compensation pendulum* (Fig. 10), which resulted from the discovery of Guillaume in Paris, that a nickel steel alloy with 35·7% nickel possessed an extraordinarily small expansion coefficient. The temperature compensation of this pendulum has been calculated by Dr. Riefler by his own special method in accordance with the expansion coefficient, measured in the Physikalisch-Technische Reichsanstalt and later in the *Bureau international des poids et mesures* at Sèvres. The average error, remaining in the compensation of the pendulums, amounts to only 0·005 sec. per 1° C. per day.

The time of swing of a pendulum is also dependent upon the air pressure. The air pressure constant of a seconds pendulum varies according to the shape of the ball, whether flat or cylindrical, between 0·012 and 0·018 seconds; that is, the pendulum loses daily this amount when the air pressure increases 1 *mm*. The values have been established by experiments on several pendulums. The exhibitor therefore built (in 1895) a clock in an air tight glass case, consisting of a glass cylinder for receiving the clock work and a ground bell glass, in this way making it independent of the air pressure. In 1899, Riefler applied an *air pressure compensator* (Fig. 13) to clocks, used in the air (Fig. 11). This consisted of an aneroid of peculiar construction, attached to the pendulum.

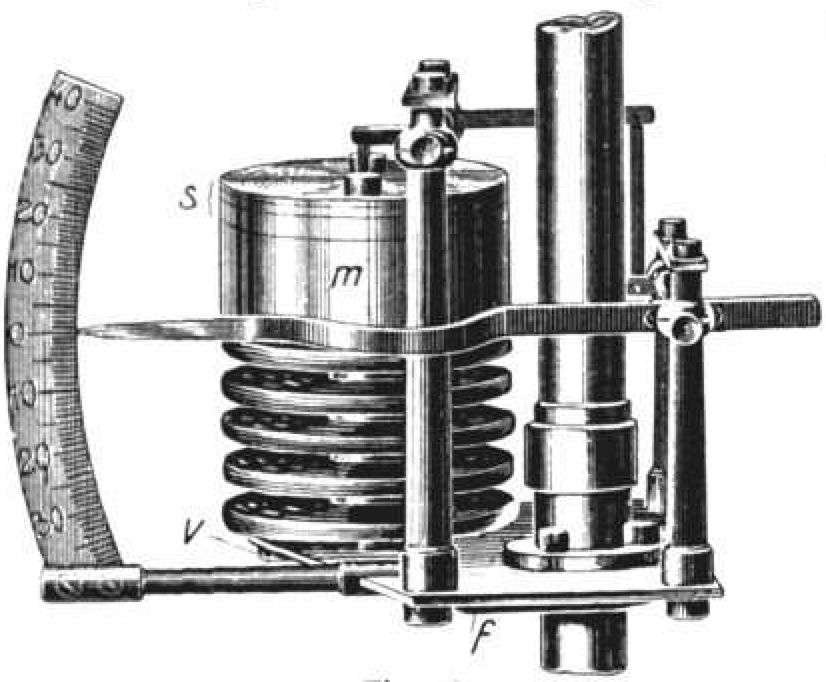


Fig. 13.

For chronographic comparison, the clocks are furnished with *electrical seconds contacts*. During the last year and a half, the firm has also furnished clocks with a new *electric winding apparatus*. Fig. 12 shows such a clock with air tight case, nickel-steel pendulum, electric winding apparatus and an air pump to exhaust the case.

Among the time records of these clocks, which we have received from different observatories, we will mention only the ones, published on the 11th of August 1902 by Prof. Howe in the *Astronom. Journ. No. 524*, concerning the "Riefler clock No. 56", provided with an air tight case, nickel-steel pendulum and electric winder, which is installed at the observatory in Cleveland, Ohio. According to this, the average daily variation of this clock is 0·015 sec. and the largest during the whole course of the observations, covering several months, was 0·022 sec. This is the best record of a clock known up to the present time, and it must be remembered that this is the actually observed record subject to no corrections on account of length of swing, temperature etc.

One of the five clocks (Fig. 12), which the Riefler Company has provided for the U. S. Naval Observatory, is exhibited in the *Time Service department* of that institution. This has air tight case, nickel-steel pendulum, electric seconds contact and electric winder.

In addition, there is in the Belgian division of the exhibition a description of a plan of the time service of the royal Belgian observatory in Uccle, accompanied by diagrams, which has been worked out by Dr. S. Riefler. This plan contains in two groups (stellar time group and mean time group) 4 standard clocks of the 1st order and 2 standard clocks of the 2nd order, to which 11 other electrically synchronised clocks are connected.

Th. Rosenberg

Berlin N., Chausseestrasse 95.

Manufacturer of Geodetic Instruments.

No. 1–6 in A.

1. **Repeating Theodolite.** No. 24 in the price list, including auxiliaries a, b, c, f, g.

2. **Tachymetric Theodolite.** No. 27 in the price list, including auxiliary d.

3. **Tachymeter Level** with clinometer screw, according to Howgrewe, for the measurement of directions, distances and elevations, according to Lorber and Sickler, for moderately inclined sighting. *Telescope in rings* with objective of 325 *mm.* focus, magnifying 28 times with an orthoscopic eye piece, showing the divisions of the surveyor's rod clearly at 250 *m.* distance. The telescope is provided with a *reversible level,* reading to 20″, which is read by means of a mirror from the eye piece. Circular level on the alidade. *Horizontal circle,*

divided in $^1/_2{}^0$, two verniers reading to 1′, vernier A having an auxiliary pointer for preventing gross errors. Circle graduated on silver, covered, and read by movable lenses. An *orientation compass* can be easily fastened above the telescope.

4. **Simple Levelling Instrument** with clinometer screw, according to Howgrewe. For levelling points, when the horizontal line of vision meets the ground or passes above the staff, also when necessary, for the measurement of distances. *Telescope* with objective of 325 *mm.* focus, magnifying 28 times, shows the divisions on the rod clearly at 200 *m.* *Level* reading to 20″, attached to the telescope. Circular level for setting the axis perpendicular.

5. **Tachymetric Plane Table,** as suggested by Ch. A. Vogler. The elevation angles are rendered independent of the inclination of the table by the alidade level, the horizontal angles by a cross level, the axis of rotation of which constitutes the ruler. The telescope is of the transit type, has a focus of 300 *mm.* and magnifies 25 times, with an orthoscopic eye piece, fitted with three cross wires for distance measurements. The altitude arcs, divided on silver to $^1/_6{}^0$, are read to 30″ by verniers, which can be accurately set by means of the alidade level. One of these is fitted with an auxiliary pointer to prevent gross errors. The *cross level*, mounted on the ruler, is parallel to the transit axis and can be set horizontally by means of a screw with large milled head. An *orientation compass* can be attached to the ruler. The equipment of this instrument includes a small level, to be placed above the transit axis, and a circular level for the plane table.

6. **Instrument for Registering Angular Measurements** (goniograph, balloon theodolite) (see R. Wurtzel, *Mitteil. d. Ver. v. Freunden d. Astron. u. kosm. Physik 1894. p. 51*).

With this instrument it is possible to carry out rapidly a large number of angular measurements, one after the other, and it is therefore especially fitted for the determination of the paths of rapidly moving objects, balloons, clouds, meteors etc. During the observations the observer can remain at the telescope, since the readings of the settings can be made later. The registration of the settings is made by means of hardened steel points on black lacquered metal discs or drums, by means of which great accuracy is attained. From 100 to 120 observations can be registered without interruption.

The registering discs etc. can be easily and rapidly changed, no artificial light is required in night observations. The results can be read to 1′. The telescope is a comet finder with large field.

The instrument exhibited is the property of the "Aeronautisches Observatorium des Kgl. Preußischen Meteorologischen Instituts" in Berlin.

Schaeffer & Budenberg, G. m. b. H.

Magdeburg-Buckau.

Manufacturers of Engine and Boiler Fittings.

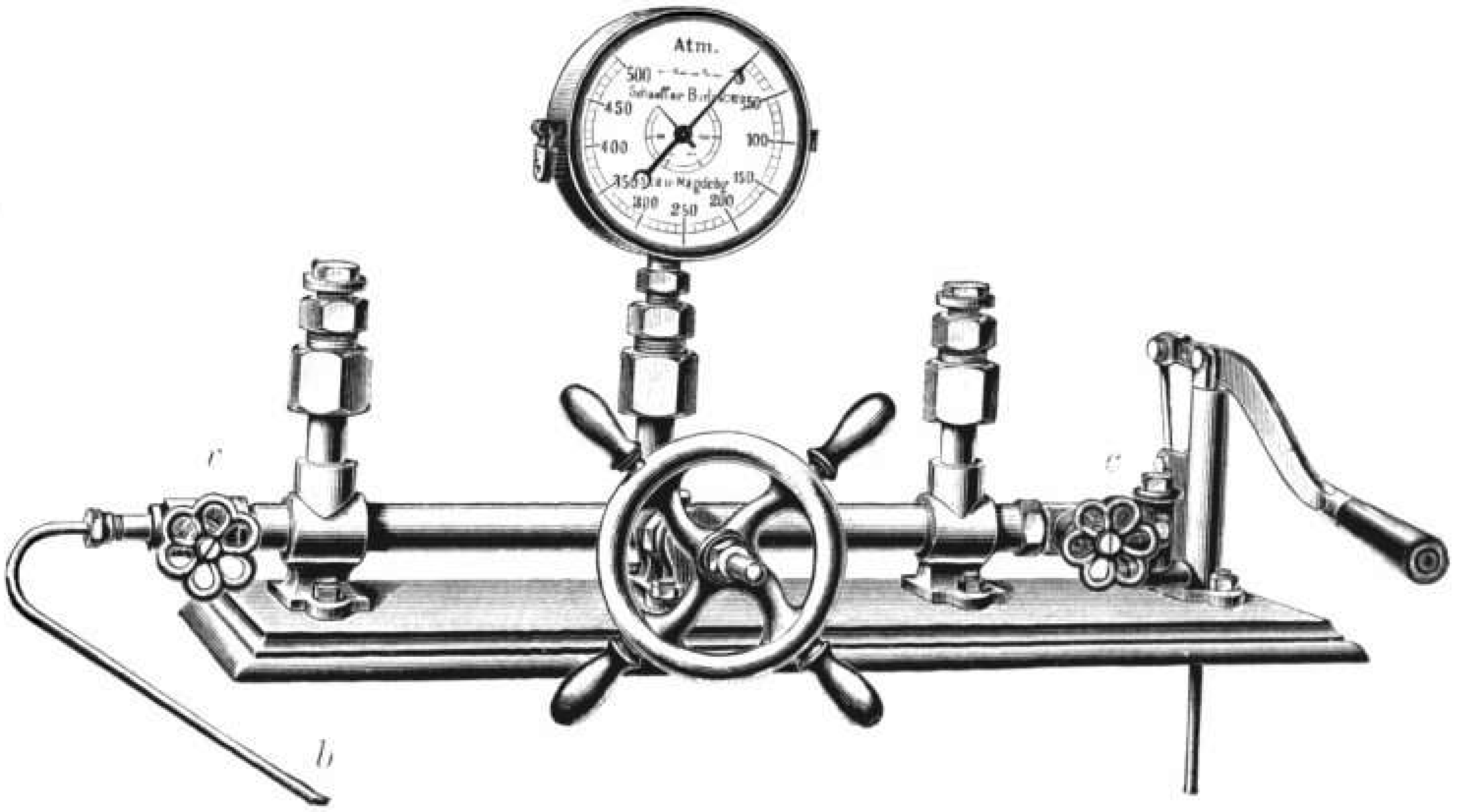
Exhibited in D.

Hydraulic Pressure Pump for testing manometers etc. Made in two forms:

a) *strong*, for pressure up to 1000 atm.;

b) *especially strong*, for pressure up to 2000 atm.

The pump is used as follows. The piston is withdrawn as far as possible from the cylinder by turning the wheel. The cylinder and the connecting tubes of the pressure pump are then filled with oil or glycerine by means of the pump at the side. The valve *c*



is then closed and by screwing down the spindle the manometer is placed under pressure.

The oil or glycerine holder, from which the feed pump draws, is brought under the latter, and the escape pipe *b* so bent that, when the escape valve *r* is opened, the oil or glycerine flows back into the receptacle.

The connections for receiving the manometers to be tested are provided with valves for cutting off the pressure.

The exhibitor has the following specialties: *manometers* and *vacuum meters* of different forms; *counters* for reciprocating and rotational motions; counters for automatic balances, for milk centrifuges, for hydraulic lifts, for street rollers, for cable roads, for linen weaving machinery, paper and wood planing machines; also with graphic speed registration etc.; *indicators; tachometers;* tachographs; dynanometers; air velocity meters etc.; *mercury thermometers;* mercury thermometers with spring and pyrometers; thermometers and pyrometers for superheated steam; thermometers for reading at a distance up to 50 *m.*, the same with automatic registration of the temperature etc.; collection of *large and small fittings* for engines and boilers, in metal, cast iron and cast steel.

Branch factories and *branches* in New-York-Brooklyn, Chicago, Manchester, London, Glasgow, Paris, Lille, Milan, Liege, Zürich, Aussig, Vienna, Prague, Stockholm, St. Petersburg, Hamburg, Berlin.

Franz Schmidt & Haensch

Berlin S., Prinzessinnenstr. 16.

Mechanicians and Opticians.

No. 1—16 in B.

1. Large Standard Spectrometer with six flint glass prisms with automatic motion. Fixed circle of 28·6 *cm.* diameter, divided in $^1/_{12}$°, reading to 1″. With objectives of 430 *mm.* focus and 42 *mm.* opening. Rotating telescope with horizontal reading microscopes. The telescope carriage is supported by a roller, running on the ring of the tripod, doing away with the necessity of a counterpoise.

Possible displacements of the telescope, due to the motion in respect to the vertical axis of the apparatus, are prevented by correcting the ring surface on which the roller runs, or by correcting by optical methods. This arrangement allows the telescope carriage to carry a photographic camera, concave mirror, according to Rubens etc., without any danger of bending or other variation. Telescope and collimator can be rotated about two axes and clamped in place.

If desired, the instrument will be furnished with a table with Rutherford prisms, having automatic motion. The prisms are mounted so as to be easily removable, so that one, two or more can be easily used.

2. **Spectrometer** (Fig. 1), according to Victor von Lang. Intermediate model with covered circle of 170 *mm.* diameter, graduated in $^1/_3{}^0$, reading by means of lenses to 30″; with

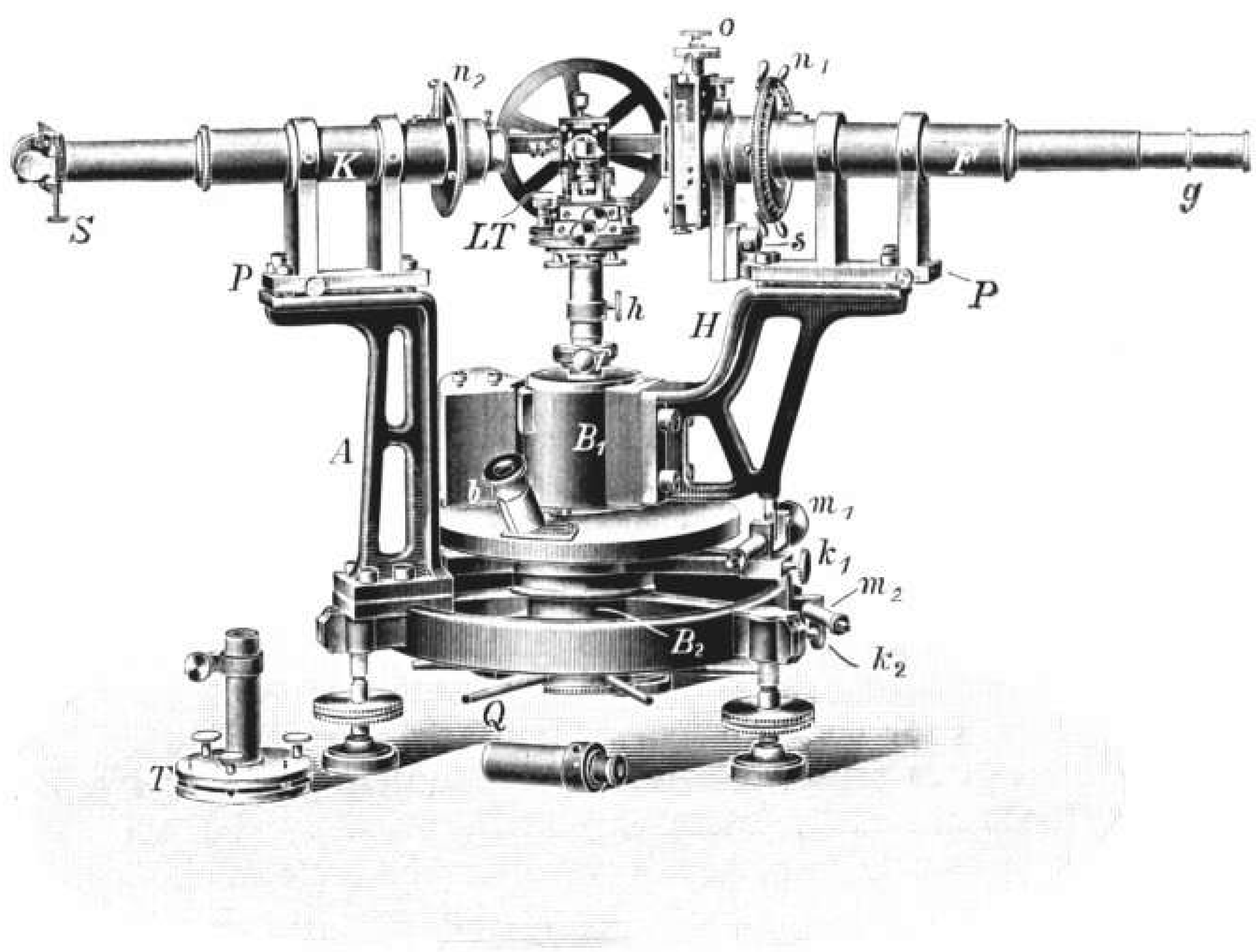


Fig. 1.

objectives of 240 *mm.* focus and 26 *mm.* diam. Collimator tube on ring support; telescope counterbalanced, with verniers movable about the circle; circle with table arranged to be rotated about the vertical axis by means of *Q* (see Fig. 1); circle and telescope provided with micrometer screw adjustment. Adjustable table to be placed on the vertical axis, capable of rotation independently of circle and telescope.

The spectrometer, shown in Fig. 1, is furnished with a Liebisch *total reflectometer*, Babinet *compensator*, and *polarisation apparatus*. On account of the mounting of the Liebisch total reflectometer, the frame of the telescope is higher than usual.

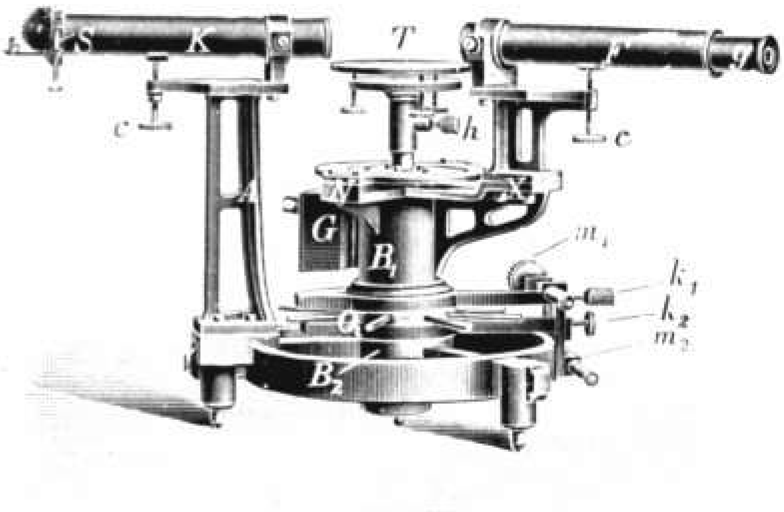


Fig. 2

3. Spectrometer (Fig. 2), according to Victor von Lang. Small model, circle of 110 *mm.* diameter, graduated in $^1/_2{}^0$, reading to 1′; objectives of 150 *mm.* focus and 17 *mm.* diameter. Otherwise the same as the intermediate model.

4. Small Spectrometer, according to Martens, for laboratory practice. Objectives of 150 *mm.* focus and 17 *mm.* opening; fixed circle, divided in 1⁰, reading by means of a vernier to 6′; collimator removable so that the instrument can be used as a goniometer; telescope can be rotated about the circle; table with removable and adjustable top capable of rotation about the vertical axis.

5. Large Spectroscope, according to Kirchhoff-Bunsen, with objectives of 240 *mm.* focus and 26 *mm.* opening. A micrometer screw with graduated head, which moves the telescope, is used for measurements. The instrument is furnished with flint glass prism, or with Rutherford prism or with both. These are easily interchanged. In place of the orientation scale usually furnished, a wave lengths scale can be supplied, if desired. The latter to be used only with a Rutherford prism.

6. Large Spectroscope (Fig. 3), according to Kirchhoff-Bunsen for photographing spectra. Adjustment of the position and angle of the ground glass by means of rack and pinion. The plate holder can be moved downward so that several spectra can be taken one above another. Size of plates 9 × 12 *cm.* The photographic apparatus can easily be removed by taking out *K*, the telescope *F* can then be inserted in its place.

7. Interference Spectroscope, according to Lummer and Gehrcke. The apparatus rests on a new principle, using the Lummer interference rings of "equal inclination", which occur in a plane parallel glass plate. Its action is comparable with that of the Michelson echelon spectroscope, but the desired effect is obtained in a much simpler way. By means of multiple reflection in the interior of a narrow plane parallel glass strip, a great number of parallel rays are produced, which interfere with a large difference in path.

By interchanging some of the parts of the apparatus, it can be used for testing the plane parallelism of a plate by means of the interference rings, produced by light at normal incidence.

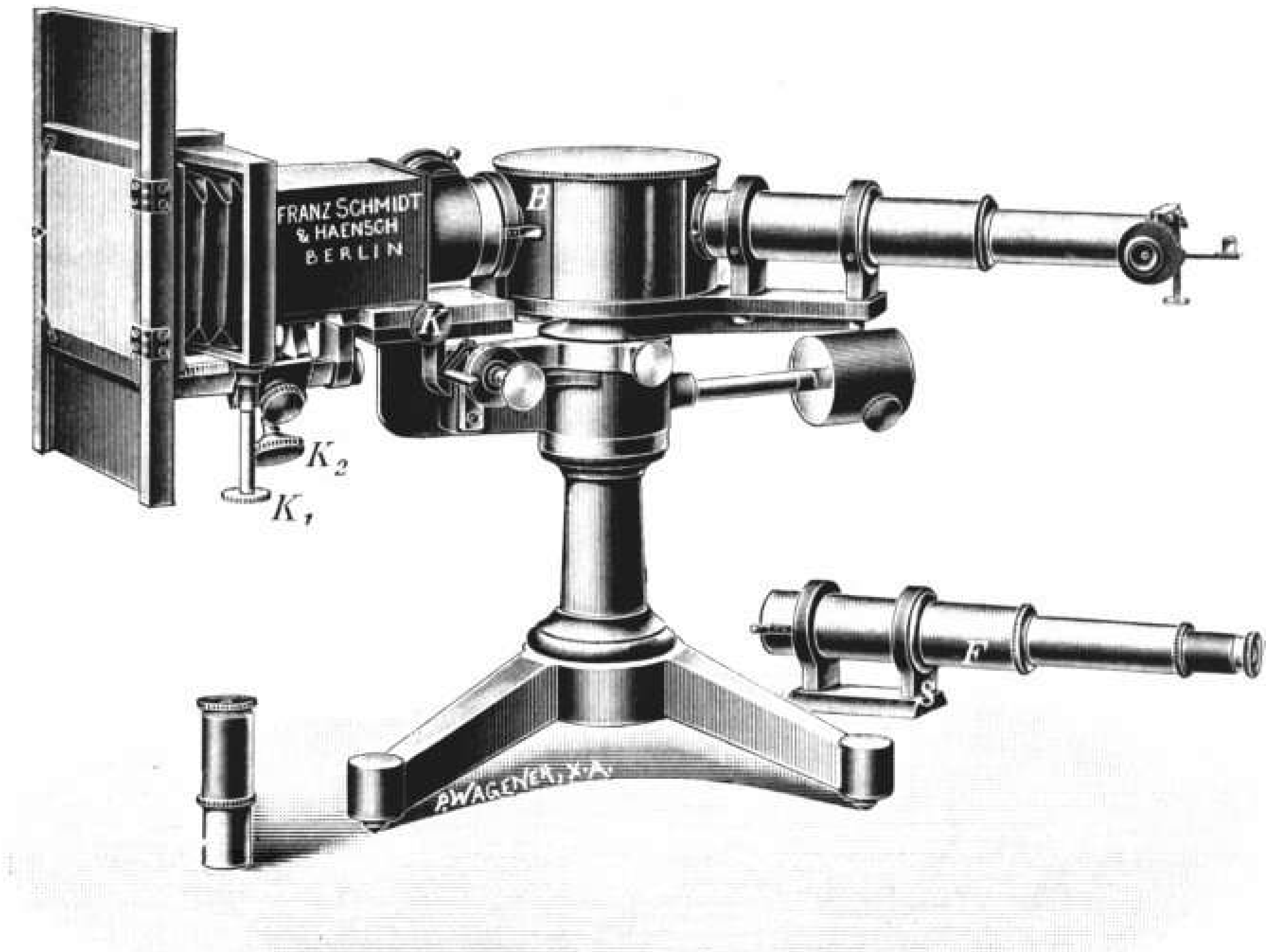


Fig. 3.

8. Spectrophotometer (Fig. 4), according to Arthur König, improved construction, according to Martens. With measurable micrometer motion of the observation tube about its horizontal axis. The photometer is entirely free from reflection. The dividing line between the two illuminated surfaces disappears entirely, when the illumination of both is equal, which is important for the rapidity and sensitiveness of the setting. The measurements are made by means of a rotating Nicol with graduated circle, which is placed above the slit of eye piece.

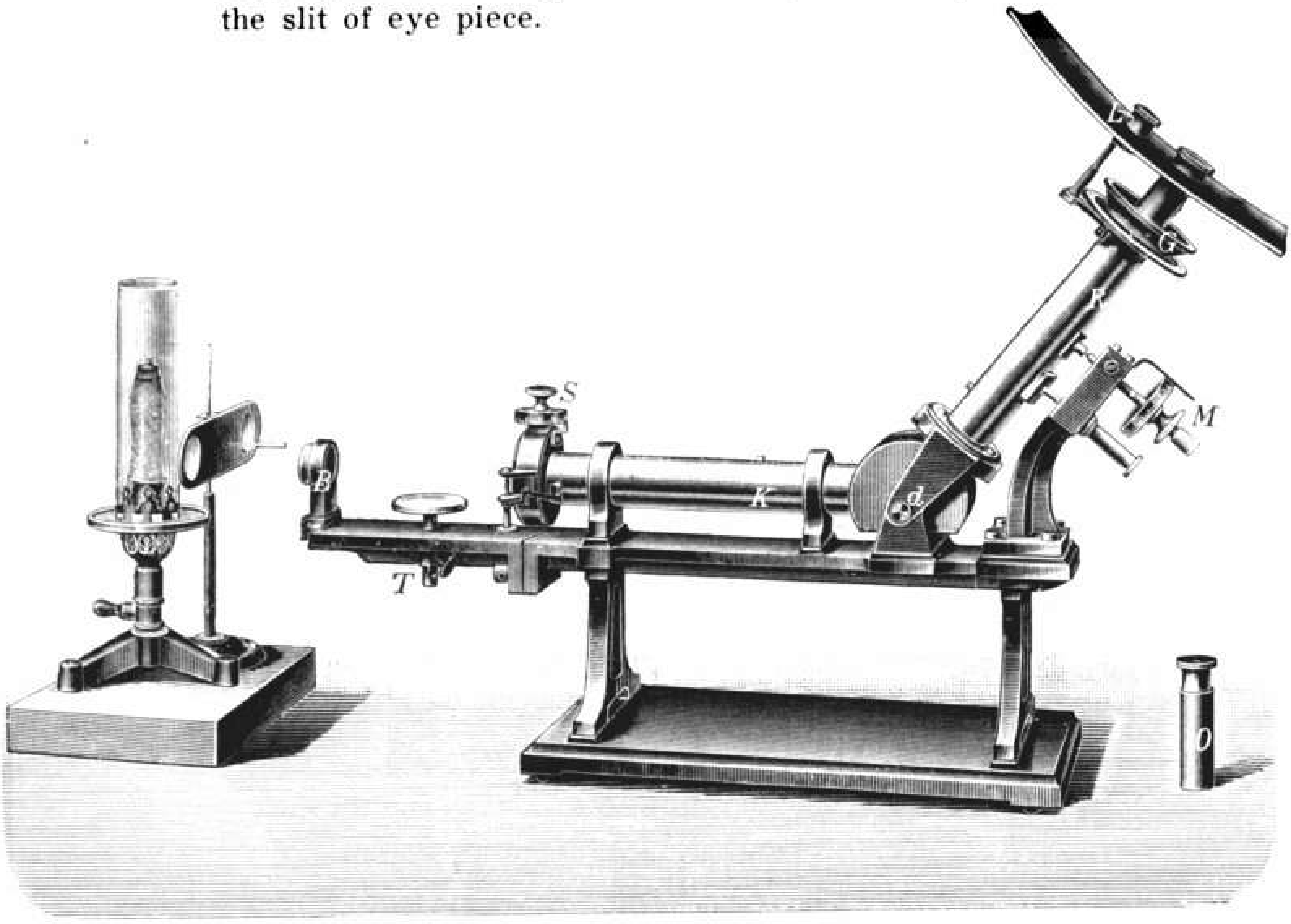


Fig. 4.

9. Spectrophotometer, according to Lummer-Brodhun. With two collimators, having bilateral slits, at right angles to each other; illuminating apparatus and light diminishing apparatus; collimator tubes interchangeable, one of them being furnished with a half circular hollow cap between the slit and objective, for receiving a rotating sector, which is used for measurement; Lummer-Brodhun photometer cube. The telescope can be rotated about the vertical axis of the apparatus by means of a micrometer screw with graduated head. It has objectives of 240 *mm.* focus and 26 *mm.* opening.

10. Large Standard Photometer Bench, according to the specifications of the Physikalisch-Technische Reichsanstalt in Charlottenburg, with two blackened steel tubes

250 *cm.* long, three carriages, each running on three wheels, millimeter divisions and candle scale. Lummer-Brodhun photometer head to be used for equal illumination or equal contrast, with graduated circle and shadow casting arrangement for the measurement of sources of light at different radiation angles (Fig. 5). Arrangement for cutting off any

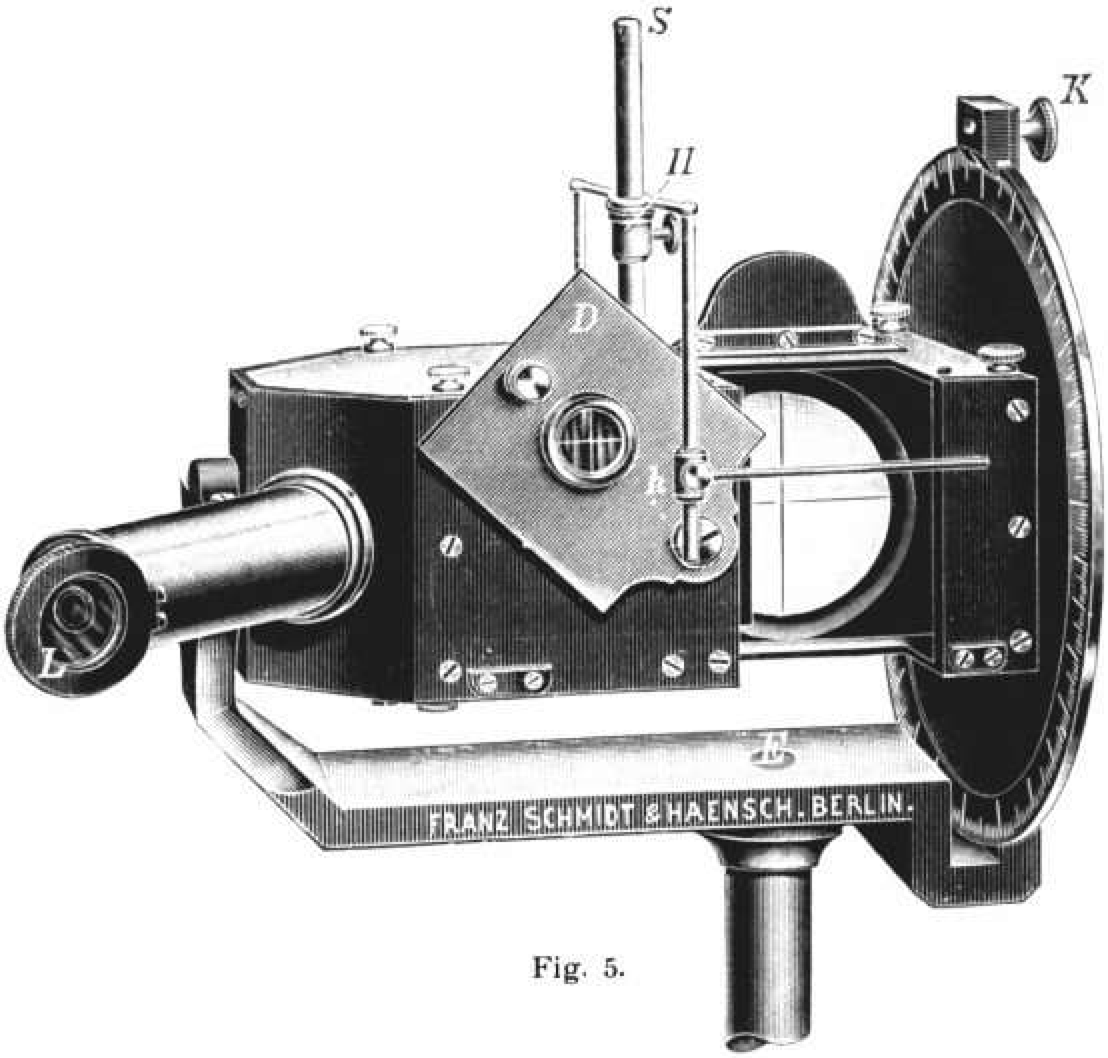


Fig. 5.

possible external light, consisting of eight velvet covered aluminium screens, of which four are held in wooden clamps and four in angle pieces for setting in a brass frame, connecting the central carriage and one of the side carriages. Arrangement for the photometry of incandescent lamps, consisting of two fixed mirrors, inclosing an angle of 120°.

Under photometric apparatus, the firm makes also (see price list "Photometry"): a) apparatus for the determination of the spherical candle power, according to Brodhun, a photograph of which is exhibited by the Physikalisch-Technische Reichsanstalt (see Appendix); b) photometer, according to Leonhard Weber, original construction, constants determined by the inventor; c) new universal photometer for white light, according to Martens.

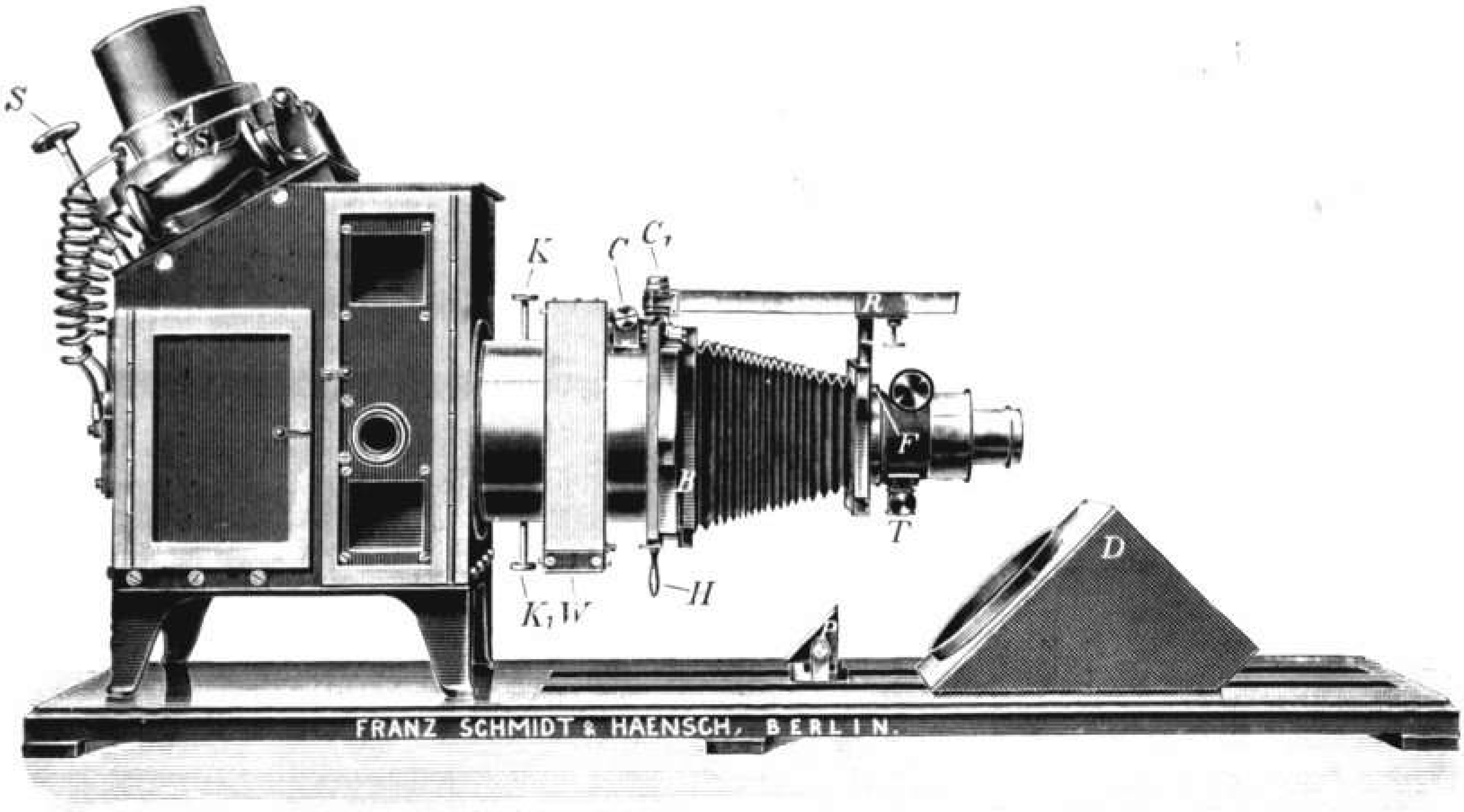


Fig. 6.

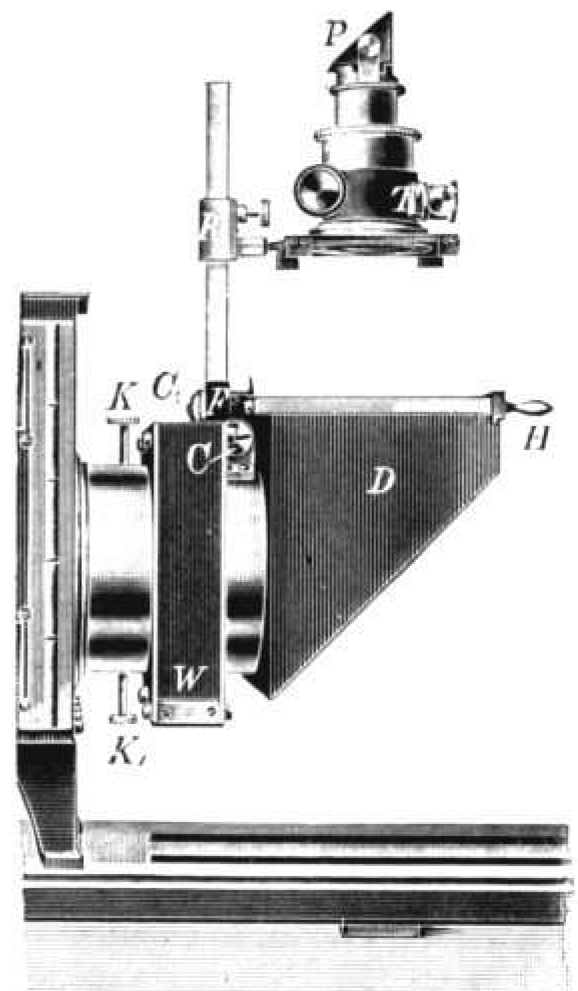


Fig. 7.

11. Projection Apparatus for Lecture Rooms (Fig. 6). Consists of a heavy lantern with an automatically regulating direct current arc lamp, having diagonal carbons (Schuckert system); bellows attached to the objective; for use in the projection of slides; also vertical arrangement of the objective (see Fig. 7) for the projection of horizontal objects; a black base 1·5 *m.* in length, having two flush brass rails, with four stands adjustable in height and with heavy iron bases, to slide on them; two large plano-convex lenses for projection with parallel light; a reversing prism in frame; and a stand for the projection of vertical transparent objects, also for showing the phenomena of spectrum analysis with slit, collimator lens and liquid prism, according to Wernicke.

12. Projection Apparatus for Schools (Fig. 8). Consists of a steel plate lantern, fitted for different light sources, on black base; bellows for the objective; for the projection of slides and horizontal and vertical objects.

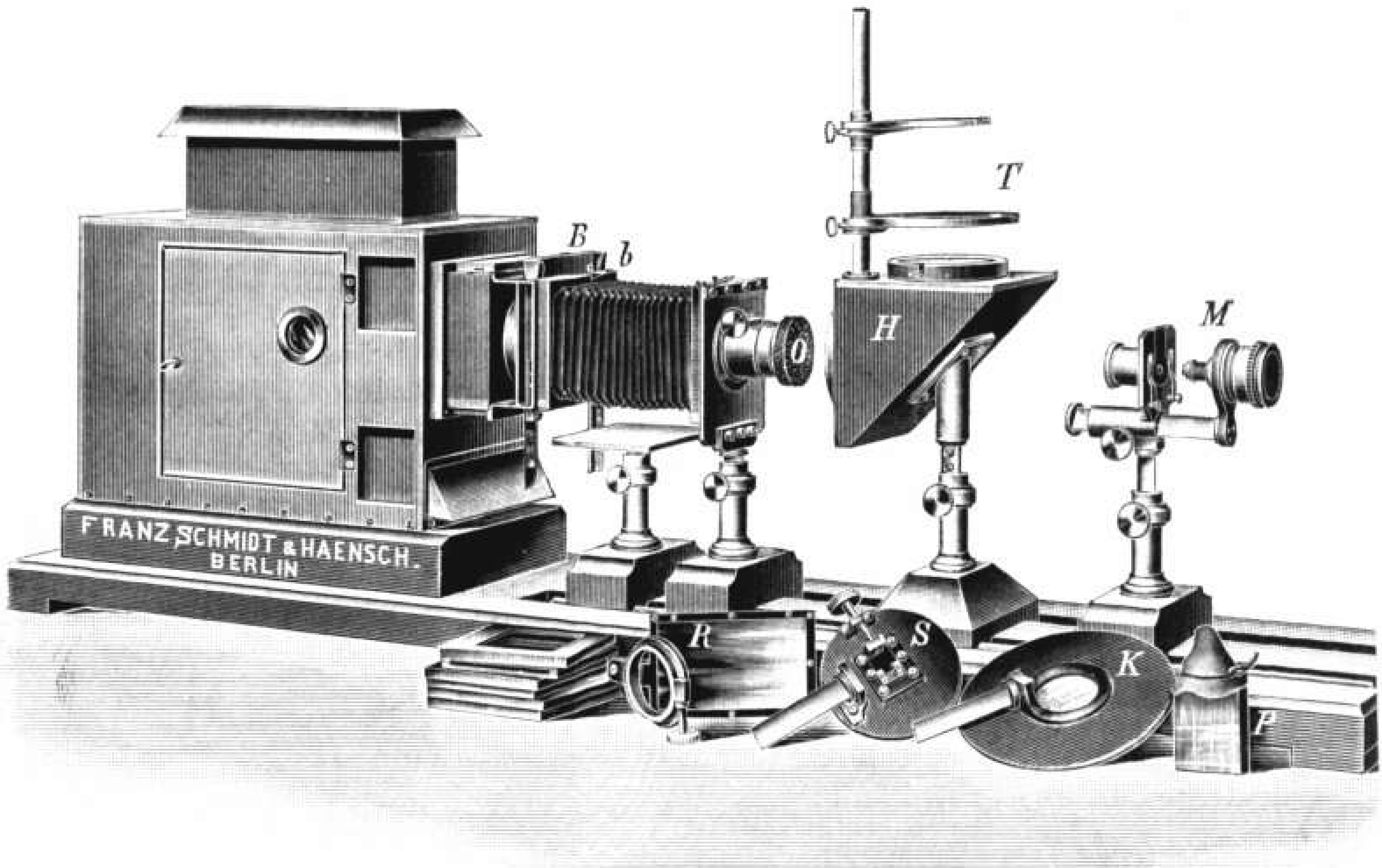
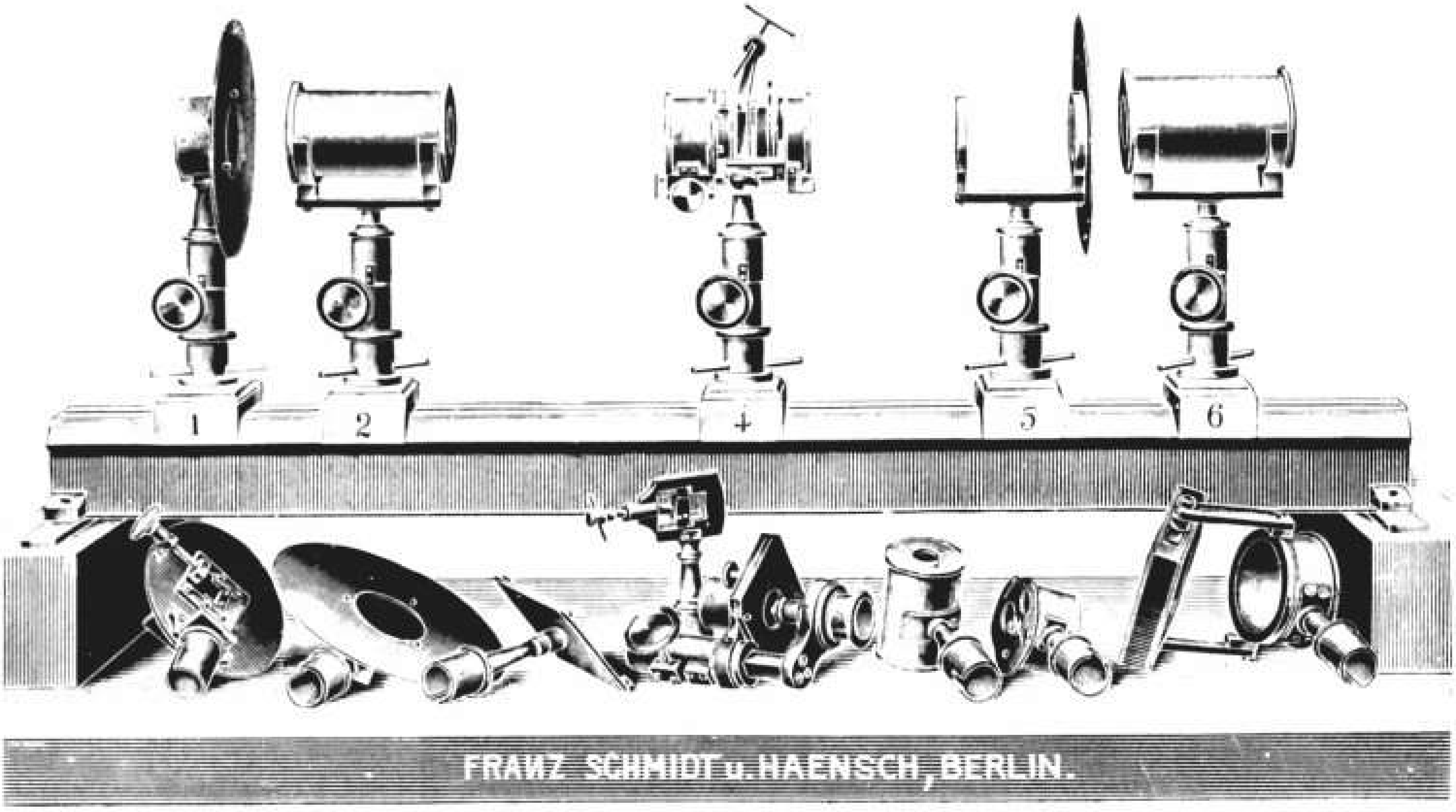


Fig. 8.

13. Large Optical Bench (Fig. 9), according to Paalzow, for the projection of the polarisation phenomena with parallel and convergent light, also for spectrum analysis and microscopy.

14. Polarisation Apparatus (Fig. 10), according to Lippich, on trestle stand. With adjustable half shadow angle; double or triple field of view; diameter of the circle 174 *mm.*, graduated in $^1/_4{}^0$, reading by means of lenses and verniers to $0{\cdot}01^0$; for tubes of 220, 400 or 600 *mm.* length; circle settings made by means of lever and micrometer screw. The apparatus is also furnished mounted on tripod with central column.

15. Polarisation Apparatus (Fig. 11), according to Landolt, on trestle stand. Suitable for various experiments (influence of temperature on the specific rotation, electromagnetic rotation etc.); reading of the analysing Nicol to $0{\cdot}01^0$; other fittings as for No. 14.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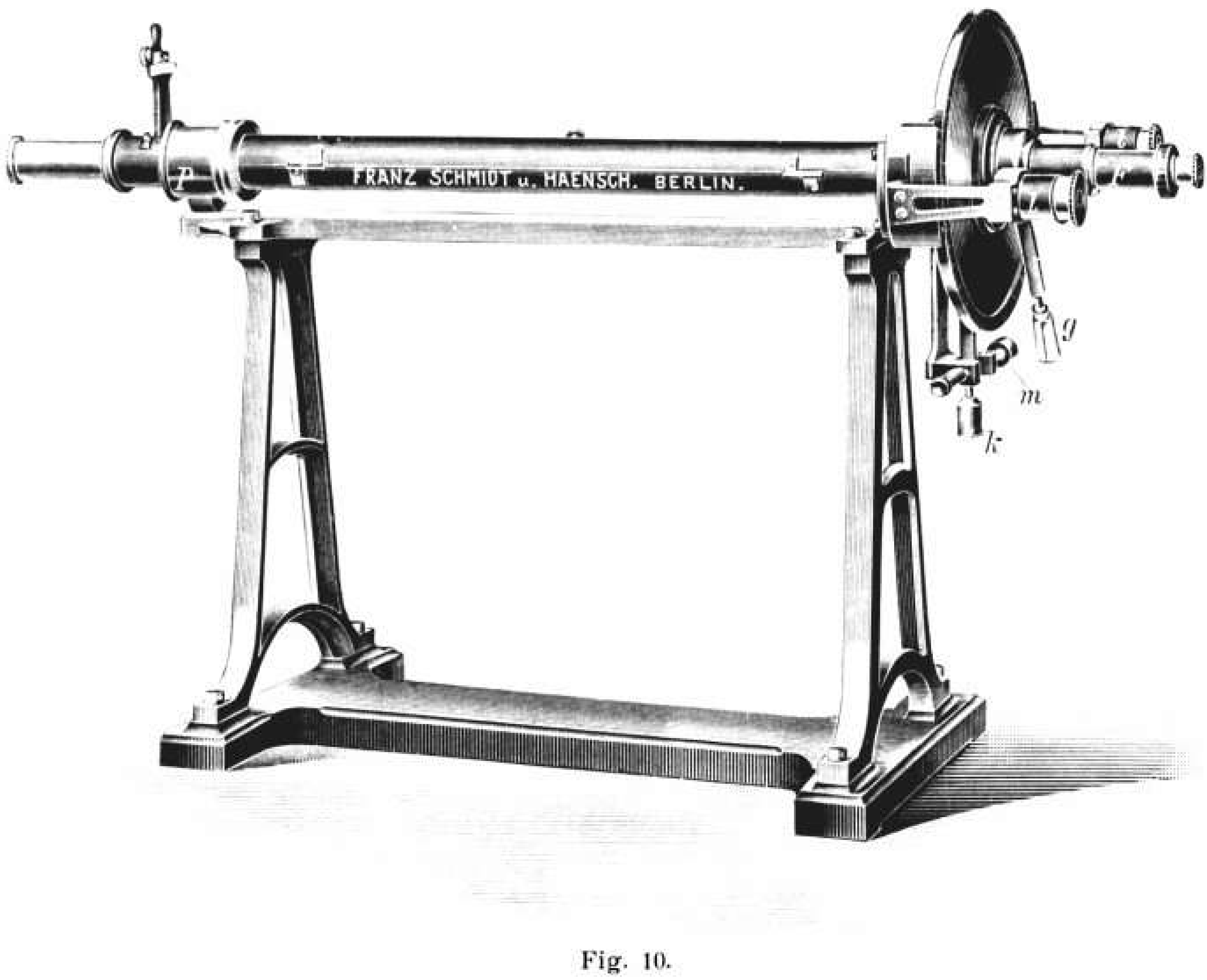
FRANZ SCHMIDT u. HAENSCH, BERLIN.

Fig. 9.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FRANZ SCHMIDT u. HAENSCH. BERLIN.
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Fig. 10.

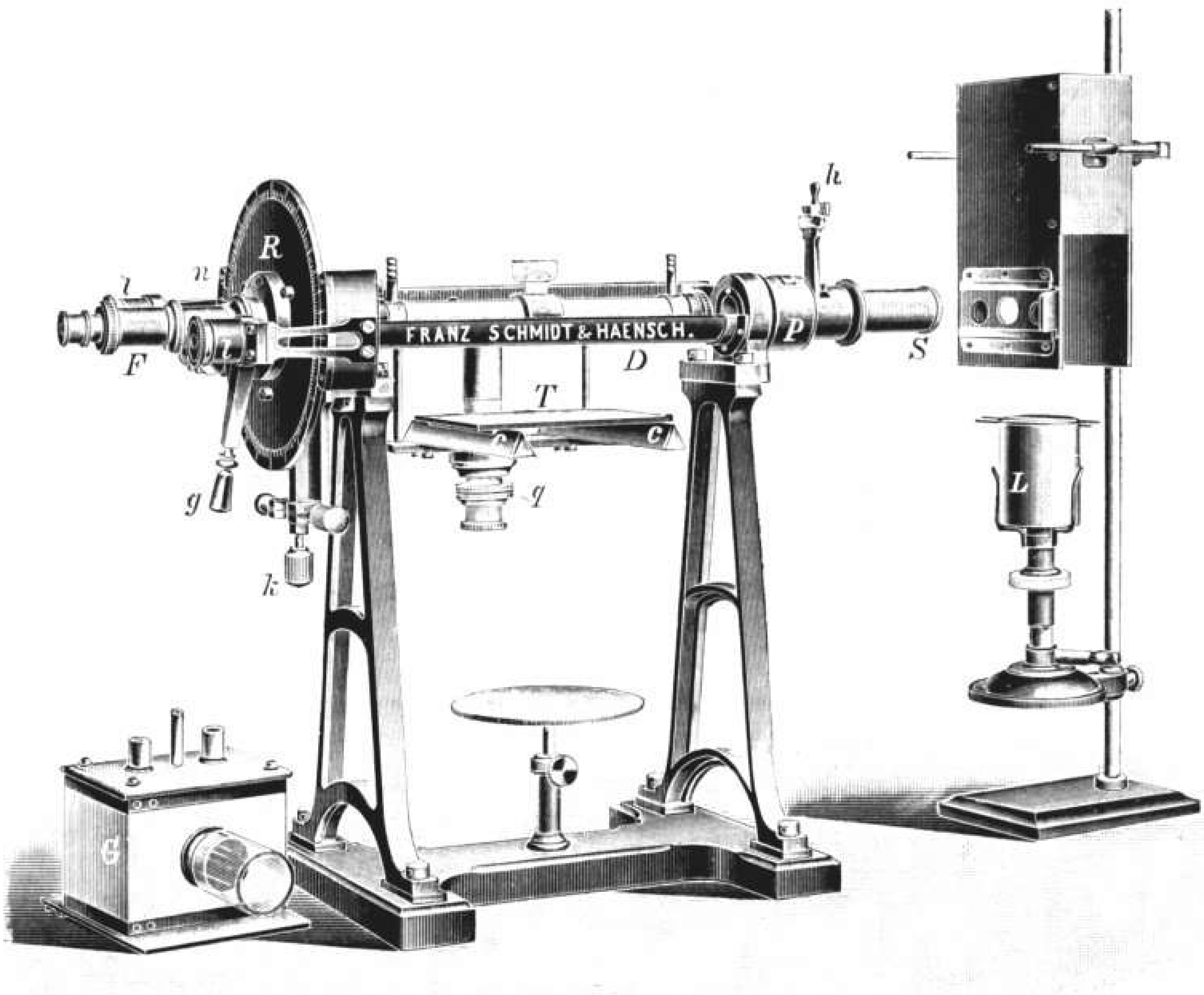


Fig. 11.

16. Large Universal Polarisation Apparatus, according to Lippich. On iron free brass frame, 1·5 *m.* long; with fixed analyser and movable polariser, for using observation tubes of any length; for the investigation of electromagnetic rotation etc. Covered silver circle 270 *mm.* in diameter, graduated in $^1/_{10}{}^0$, reading directly to 0·001° by means of two microscopes. The polariser is peculiar in that the half prisms can be conveniently adjusted from without by means of micrometer screws, and a worm screw motion changes the triple into a double field of vision. Polariser and analyser both have especially large Nicol prisms so that, even when observation tubes 1 *m* long are used, sufficient luminosity and sensitiveness are obtained.

Georg Schoenner

Nürnberg.

Manufacturer of Drawing Instruments.

Exhibited in A.

Drawing Instruments for technical and school use.

The latest improvements of this maker are: guide for the compass handle, patent lever for cleaning the drawing pen without disturbing the adjustment for width of line, patent needle point regulator for compass, improvement of head joint.

Louis Schopper

Leipzig, Arndtstrasse 27.

Manufacturer of Fine Mechanical Apparatus.

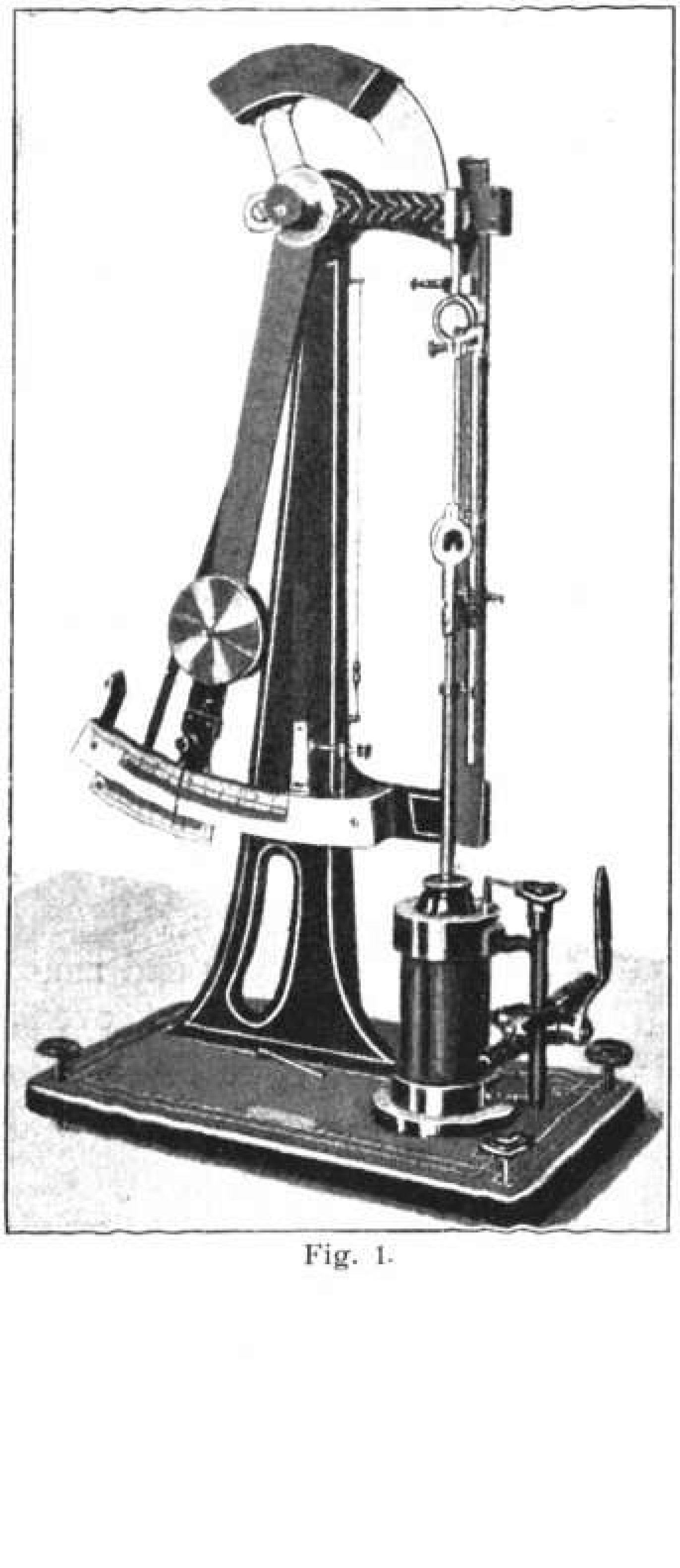


Fig. 1.

No. 1—5 in A.

The firm is especially engaged in the manufacture of testing apparatus and testing balances for the paper, textile and cement industries, as well as grain testing apparatus and balances for determining the quality of grain, etc.

1. Patent Strength Tester (Fig. 1) for wool and cotton fibers etc., to be driven by hand or water power. Serves for the determination of the tenacity and stretching of wool, cotton or other fibers, either collectively or singly, etc.

Reversing gear, according to A. Martens. Capacity 1 *kg*. Sensibility $^1/_{50}$ *g*. Several forms are in use in the Kgl. Material-Prüfungsamt in Dahlem, Berlin.

2. Paper Tester, own patented construction (Fig. 2)

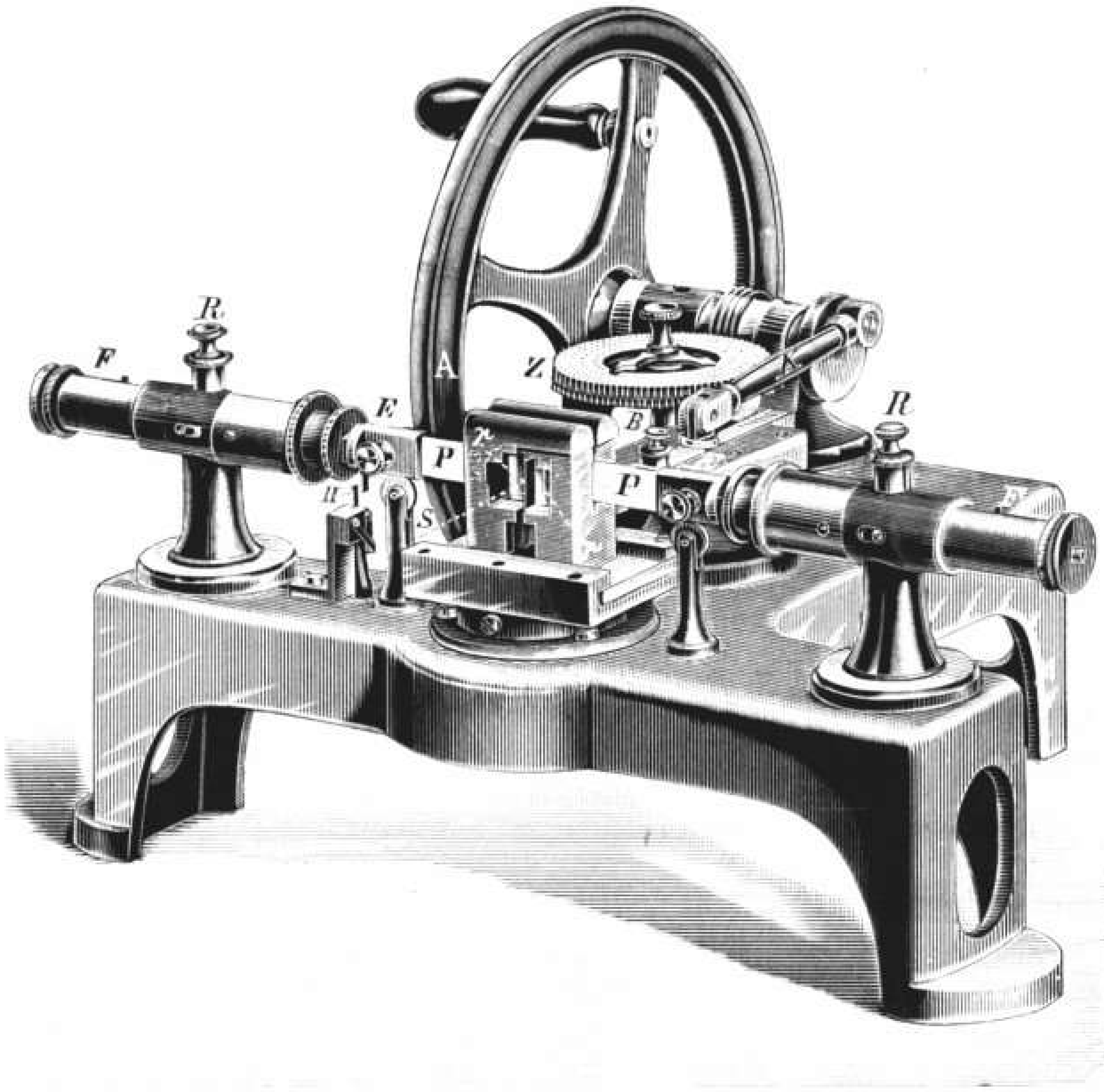


Fig. 2.

for quantitative determination of the resistance of paper to repeated bendings. The apparatus is intended to be driven either by hand or by a motor. Its use is simple and rapid, and it gives satisfactory results. At the moment of tearing the value attained remains fixed, even when the wheel continues in motion.

The apparatus is in use at the Kgl. Material-Prüfungsamt in Dahlem, Berlin, and has been introduced in the Prussian State paper testing work.

The quality of grain is determined by the weight of a stated volume. This is called the *grain test.*

3. Grain Tester, system of the Kaiserl. Normal-Eichungs-Kommission, stationary form, capacity 1 Liter. (Fig. 3.)

The apparatus consists of a balance of precision and brass cylinders with covers, mounted on a fine polished wooden base. With drawer for holding the different parts.

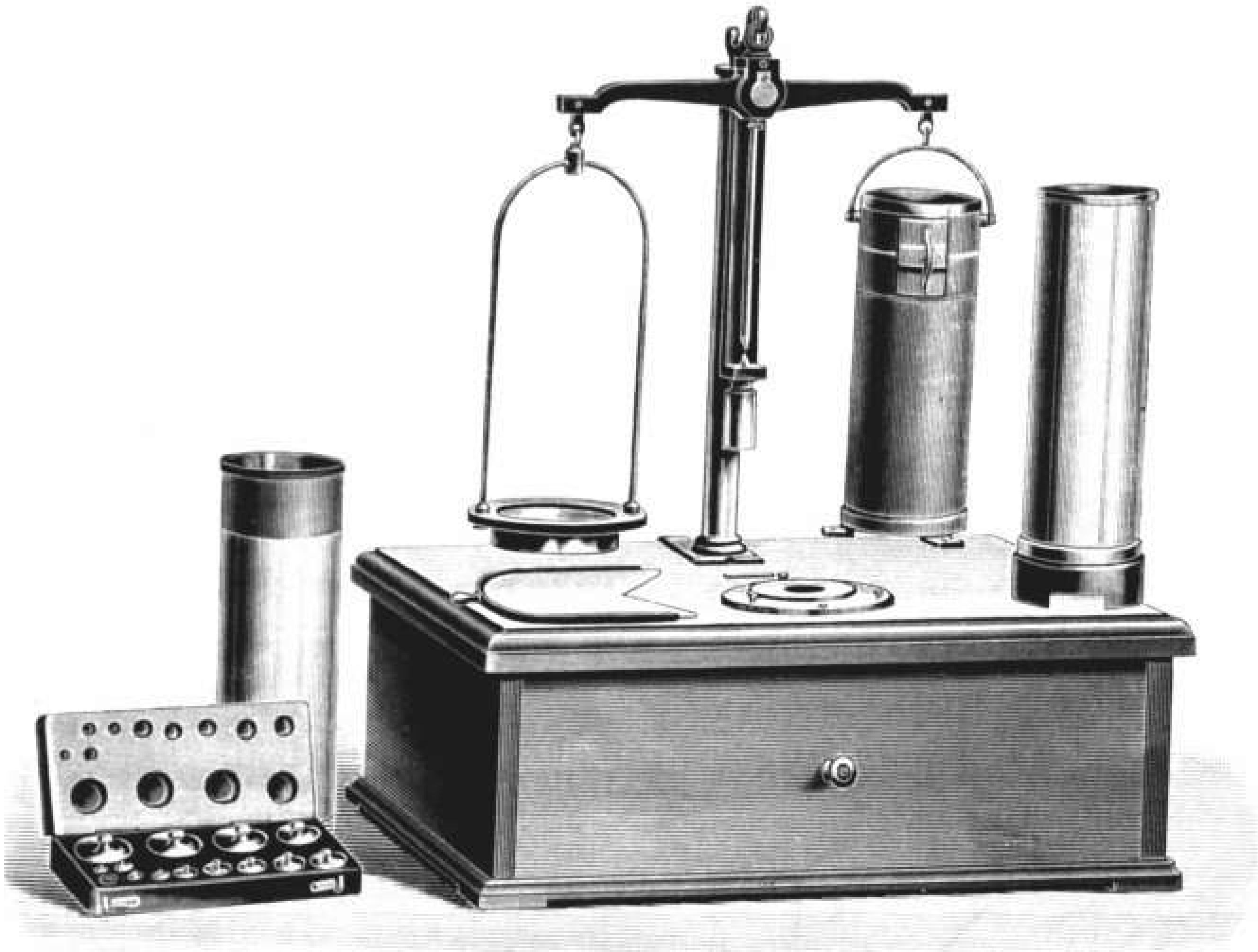


Fig. 3.

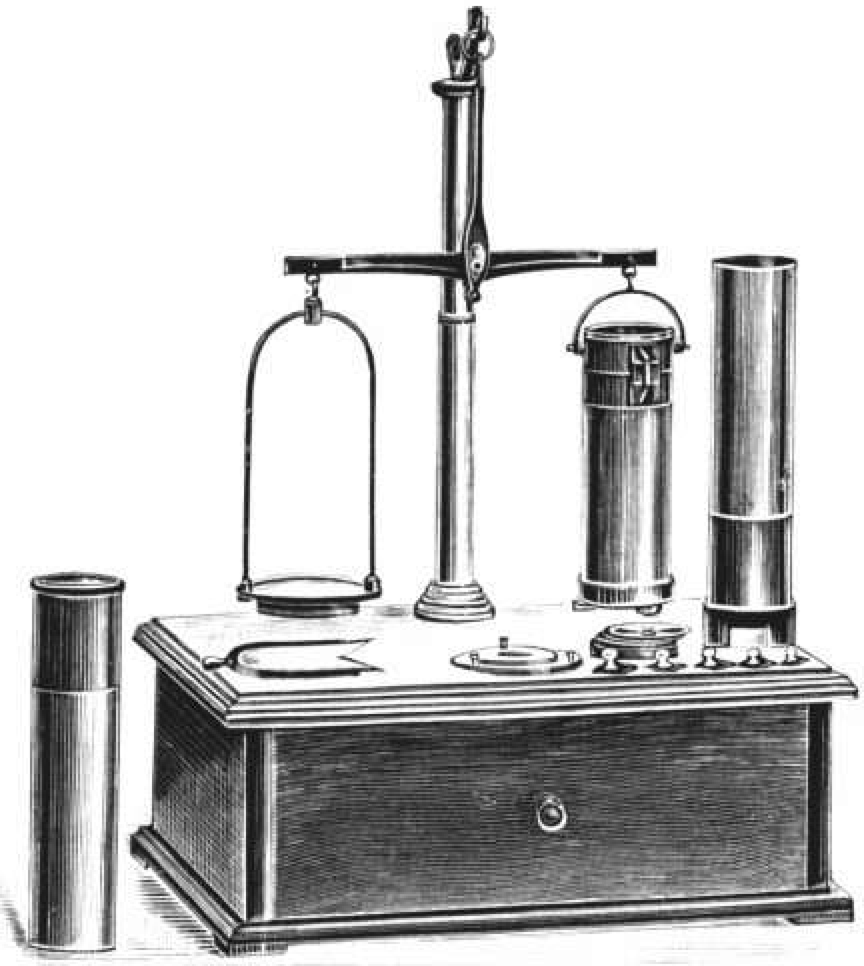
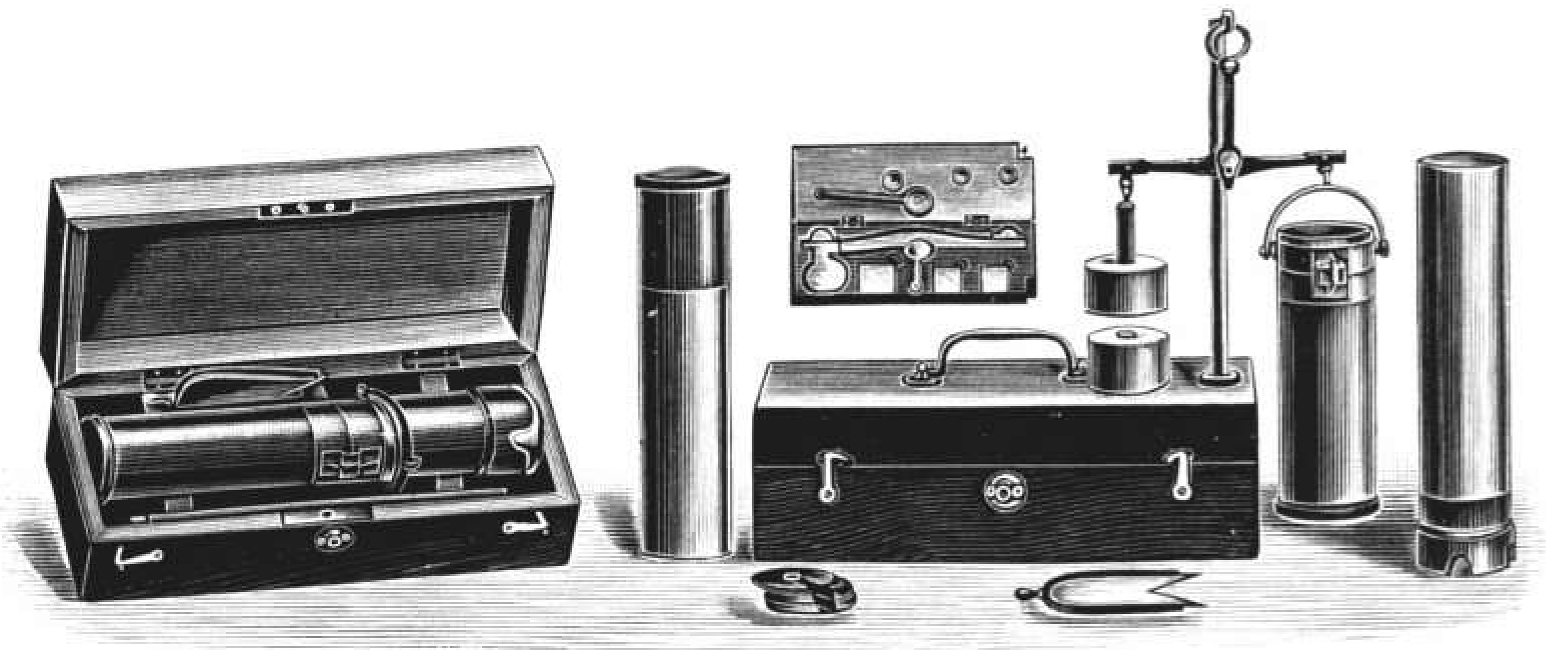


Fig. 4.

4. Grain Tester, system of the Kaiserl. Normal-Eichungs-Kommission, stationary form, capacity $1/4$ liter. (Fig. 4.)

5. Grain Tester, portable form, capacity $1/4$ liter. (Fig. 5.)



packed in case. Fig. 5. ready for use.

Schott & Genossen

Jena.

Glass Works.

No. 1—9 in B.

Glass for Scientific and Industrial Purposes.

Apart from the ordinary crown and flint glasses, the regular manufacture includes a series of new glasses, such as *borate* and *baryta, crown* and *flint glasses*, which are extensively used by all leading manufacturing opticians and have furnished the means for many improvements in the construction of optical instruments. We may mention among these: Improved achromatic microscope objectives, apochromatic microscope lenses, anastigmatic lenses for photographic objectives, telescope lenses without secondary spectrum, new Zeiss prism binoculars (with the aid of colourless prism glass). Recently, to the foregoing has been added the manufacture of *tinted glasses for optical purposes*, similar to optical glasses, *crown* and *flint glasses permeable*, in a high degree, *to ultra-violet rays*. Optical glasses free from internal tension are produced by a new annealing process.

In the course of time, the manufacture was made to include other glasses, so as to satisfy higher requirements than the usual commercial glasses. Among these may be named:

Jena standard glass 16 III (registered trade-mark: a red longitudinal line), and *borosilicate glass 59 III*, for thermometers with diminished secondary depression and an almost unchangeable zero-point. The latter glass (59 III) resists fusion to such a degree as to make it adapted for the manufacture of high temperature thermometers, registering up to 550° C. In addition, *combustion tubing-glass* is now being used for the manufacture of mercury thermometers up to 575° C.

For laboratory use: *Jena laboratory glass*, capable of resisting sudden changes of temperature and chemical action in an extraordinary degree. Flasks, beakers, retorts, burettes and measuring vessels for precise titration, reagent bottles, washing bottles, evaporating dishes, glass-tubes for explosion furnaces, combustion tubes, tubes made of laboratory glass, of non-alkaline glass and free from arsenic for judicial tests.

Water gauge glasses made of *compound-glass* (German Patent No. 61573) and *Durax-glass*, capable of resisting in a high degree sudden changes of temperature and the solvent action of hot water and steam. *Jena chimneys for incandescent gas-lights* and for *petroleum-lamps*, resisting sudden changes of temperature in a hitherto unknown degree. These chimneys will stand, almost without exception, sprinkling with cold water, while the lamp is burning.

The glasses made by the Jena Glass Works, in so far as they are finished commercial articles, bear, for the protection of the public, the firm's stamp.

The *optical department* exhibits:

1. **Optical Glass in Slabs** for ordinary optical purposes. Regular manufacture on a large scale of about *100 types* (for particulars see special catalogue) of glasses, varying in refraction and dispersion. This glass is supplied, in a fine annealed state, in the shape of rectangular plates, having two opposite facets polished, to allow of their being tested as regards homogeneity.

2. **Objective Discs,** measuring up to 1 *m*. in diameter, and above, for telescopes and larger photographic objectives,

made of ordinary crowns and flints, borosilicate crown, baryta flint etc.

3. **Objective Discs** of *telescope crown* and *telescope flint*, for objectives with an almost annulled secondary spectrum. The *telescope flint* is made in sizes up to 1 *m.* in diameter and above, the *telescope crown* — for the time being — up to about 300 *mm.*

4. **Objective Prisms,** up to 1 *m.* diameter and upwards for spectrographs.

5. **Reflecting Prisms** (inverting prisms) for photographic work, with bases up to 200 *mm.* × 200 *mm.* and above.

6. **Boro-Silicate Crown in Slabs** of sizes to order, *approximately plane-parallel,* for *field-glass-prisms,* especially colorless.

7. **Crown- and Flint-Glasses** capable, in a high degree, of *transmitting the ultra-violet rays*: for *astrophotographic objectives, spectrographs* etc., in the shape of *plates, objective discs* and *prisms,* of any size desired.

8. **Optical Tinted Glasses,** in the shape of slabs, same as optical glass. By means of these glasses, serving as ray-filters, certain parts of the spectrum may be absorbed. *Yellow* discs for photographic work, besides: *red, green* and *blue filters. Neutral glass. "Violet U.V. glass"*, as filter for violet and ultra-violet rays. *Didym-* and *Cerium glass.*

9. **Fluorescent glass,** of strong fluorescence, particularly so, when exposed to ultra-violet rays, in slabs and discs of any size desired, same as optical glass.

The firm also exhibits in the Section of Chemistry.

G. A. Schultze

Berlin SW., Schönebergerstrasse 4.

Manufacturer of Glass Instruments of Precision.

No. 1—5 in D.

The firm is especially engaged in the manufacture of signal thermometers and thermometers for use at a distance, and of control apparatus for furnace firing.

1. 29 Different Glass Instruments of Precision, such as calibrated thermo-alcoholometers, thermo-saccharometers, thermo-areometers, standard thermometers etc.

2. Micromanometer with Pneumometer.

This apparatus is intended for the measurement of the velocity of air and gas currents. It consists of a manometer bulb with a measuring tube, ending in the interior, which is arranged at different slopes according to its use, the least being 1 : 400. The exhibited micromanometer is intended for the determination of high air velocities (blowers etc.); the measuring tube has the form of an accurately calculated curve. The pneumometer, which is connected to the micromanometer by means of a stop cock stand and two connecting tubes, consists of a small round cavity divided into two parts ("Stauscheibe"), which is so placed in the air or gas current that one of the small openings in the chambers is turned toward and the other away from the current.

The difference in pressure in the two chambers produces a deflection in the micromanometer so that the velocity can be directly read, when the temperature and density of the gas are taken into account.

In all cases, where anemometer measurements can not be made and where direct readings of the velocity are desired, this apparatus is essential.

3. Signal Thermometer and Thermometer for Use at a Distance.

Two thermometers are exhibited, one for living rooms, schools, hospitals, theaters etc., and one for measurement of temperature in liquids etc., contained in tubes and tanks. Both instruments are mercury thermometers, having platinum contacts sealed into the tubes at the divisions to be indicated. The reading apparatus is a voltmeter, which can be placed at any distance and by means of switches can be used to read a number of thermometers. The peculiarities of the new system are that by the reading at a distance of any number of points on the thermometer scale only two wires per thermometer are necessary, and that the indicated temperature is read at once without any manipulation of the reading apparatus. The height of water, pressure etc., as well as temperature can be read at a distance by this system.

4. Registering Furnace Gas Analyser. (Fig 1.)

This apparatus serves for the continuous determination of the amount of CO_2 in the gases from boiler furnaces etc. A column of furnace gas and an air column act upon the two arms of a sensitive liquid micromanometer.

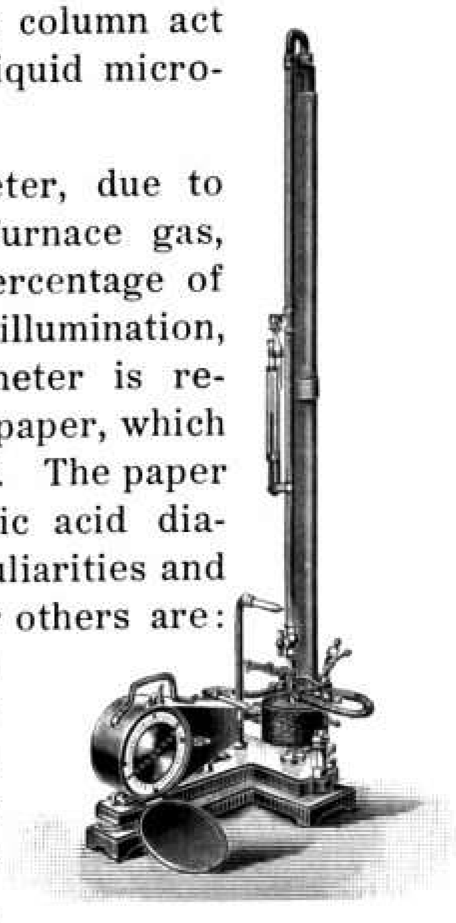


Fig. 1.

The displacement of the manometer, due to the heavier carbonic acid in the furnace gas, indicates on a scale the volume percentage of carbonic acid. By means of suitable illumination, the changing height of the manometer is registered on a strip of photographic paper, which is moved in a camera by clock work. The paper after development shows the carbonic acid diagram (Fig. 2). The characteristic peculiarities and advantages of this gas analyser over others are: a) amount of carbonic acid can be read at any moment; b) the results of the combustion can be measured in from one to one and one half minutes; c) the amount of carbonic acid is measured not discontinuously, but in a continuous curve; d) with the exception of the clock work, the apparatus has no movable parts; e) the apparatus is not sensitive to dust or moisture.

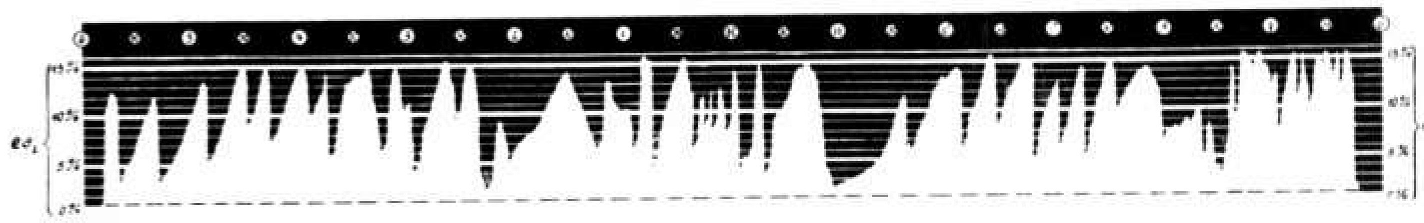


Fig. 2.

5. Mercury Thermometer, reading to 550° C., (filled with nitrogen) for the measurement of furnace gas temperatures.

Dr. Siebert & Kühn

Kassel.

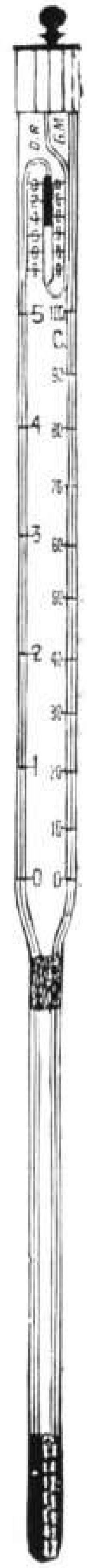
No. 1—42 in D.

I. Glass Thermometers.

1. Set of standard thermometers, graduated in 0·1°, milk glass scale, from — 5 to + 150° C., three pieces.
2. Set of standard thermometers, graduated in 0·1°, milk glass scale, from — 30 to + 200° C., with zero and boiling points on each, four pieces.
3. Set of standard thermometers, graduated in 0·1° on the tube (4 *mm.* in diameter), from — 50 to + 250° C., with auxiliary graduations at 0 and 100°, eight pieces.
4. Set of standard thermometers, according to Anschütz, graduated in 1·0° on the tube (3·5 *mm.* diam.), from — 5 to + 360° C., with auxiliary graduations from 15 to 25° C., seven pieces.
5. Set of standard thermometers, according to Anschütz, graduated in 0·2°, milk glass scale, from — 5 to 360° C., with auxiliary graduations from 15 to 25° C., seven pieces.

		Range	Graduations
6.	Standard thermometer, with milk glass scale	0—50°	1·0°
7.	,, ,, ,, ,, ,, ,,	0—50°	0·5°
8.	,, ,, ,, ,, ,, ,,	0—50°	0·2°
9.	,, ,, ,, ,, ,, ,,	0—50°	0·1°
10.	,, ,, ,, ,, ,, ,,	0—100°	1·0°
11.	,, ,, ,, ,, ,, ,,	0—100°	0·5°
12.	,, ,, ,, ,, ,, ,,	0—100°	0·2°
13.	,, ,, ,, ,, ,, ,,	0—100°	0·1°
14.	,, ,, graduated on tube	0—50°	1·0°
15.	,, ,, ,, ,, ,,	0—50°	0·5°
16.	,, ,, ,, ,, ,,	0—50°	0·2°
17.	,, ,, ,, ,, ,,	0—50°	0·1°
18.	,, ,, ,, ,, ,,	0—100°	1·0°
19.	,, ,, ,, ,, ,,	0—100°	0·5°
20.	,, ,, ,, ,, ,,	0—100°	0·2°
21.	,, ,, ,, ,, ,,	0—200°	0·5°
22.	,, ,, ,, ,, ,,	0—200°	0·2°

23. High temperature thermometer of Jena boro-silicate glass, filled with nitrogen under a pressure of 20 atm. With freezing point, +180 to +550° C., graduated in 1·0°.
24. High temperature thermometer of Jena combustion tube glass, filled with nitrogen under 25 atm. From +200 to +575° C., graduated in 1·0°.
25. Thermometer, according to Rothe, for low temperatures, filled with pentane, from +30 to −200° C., milk glass scale.
26. The same, graduated on the tube.
27. Thermometer, according to Beckmann, old form. Range 5—6°, graduated in 0·01°.
28. Thermometer, according to Beckmann, new form, graduated in 0·01°.
29. Thermometer, according to Beckmann, with auxiliary scale, according to Kühn.
30. Latest differential thermometer, according to Beckmann, containing absolute thermometer, according to Kühn. (See Fig.)
31. Calorimeter thermometer, from +10 to +25° C. Graduated on tube in 0·02°.



II. Vessels and Thermometers of Quartz, manufactured in connection with the firm W. C. Heraeus, Hanau.

32. Crucible.
33. Small flask.
34. Distillation flask.
35. Air thermometer bulb.
36. Geissler tube with quartz and ground glass connections, according to Elster and Geitel.
37. Dilatometer, according to Tammann.
38. Set of standard thermometers, 0 to 300° C., graduated in 0·5°, three pieces.
39. High temperature mercury thermometer, 0 to 700° C., filled with nitrogen under a pressure of 60 atm.

40. Pyknometer with sealed in thermometer.
41. Pyrometer protecting tube.
42. Vacuum tube radiator for medical use, according to Strebel.

Siemens & Halske A.-G.

Berliner Werk.

Berlin SW., Markgrafenstr. 94.

No. Ia—g, II and III in C, No. Ih in D, No. IV in A.

I. **Complete Collections of Measuring Instruments** for scientific and technical purposes. Arranged on tables under glass. *p. 142 to 158.*

II. **Typical Measuring Instruments** for scientific and technical use. Exhibited in glass cases or on shelves. *p. 159 to 174.*

III. **Switch Board Instruments** for different varieties of current. Fastened to a switch board. *p. 175 to 181.*

IV. **Apparatus for Reading Ship Compasses at a Distance.** *p. 182 to 185.*

I. Complete Collections of Measuring Instruments.

a) Apparatus for the Measurement of Electro-Motive Force and Current.

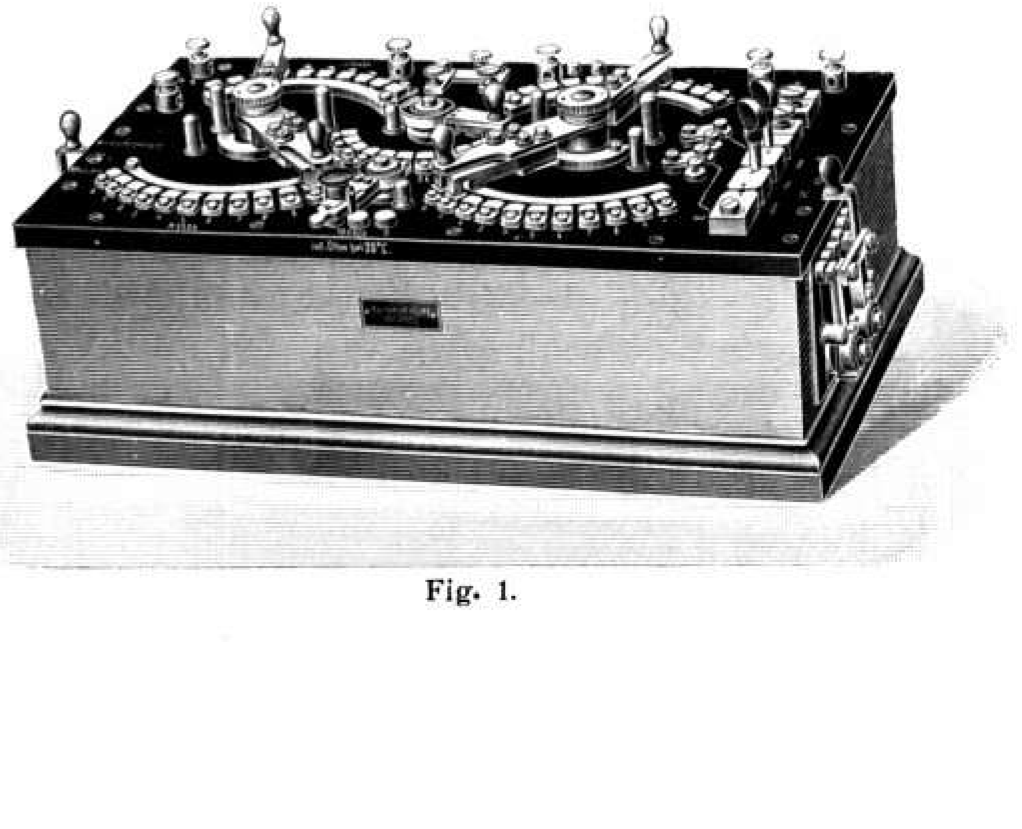


Fig. 1.

Including:

1. Potentiometer (Fig. 1). For exact current and voltage measurements, according to the Poggendorff and Dubois-Reymond compensation method.

The measurements are made by a comparison with the E. M. F. of a standard cadmium cell, which requires no temperature correction; any other standard cell may be used (Clark cell), taking into account the corrections for temperature. The connection of the apparatus has the advantage that the contact resistances have only one tenth of the effect of that in the ordinary method of connection. In addition, the sliding contacts are in the form of brushes so that in this apparatus appreciable contact resistances do not occur at all.

2. Sliding Contact Resistance Box of Precision (Fig. 2), necessary auxiliary for the full range of the potentiometer, from 0·0001 to 1600 volts; distinguished for its freedom from

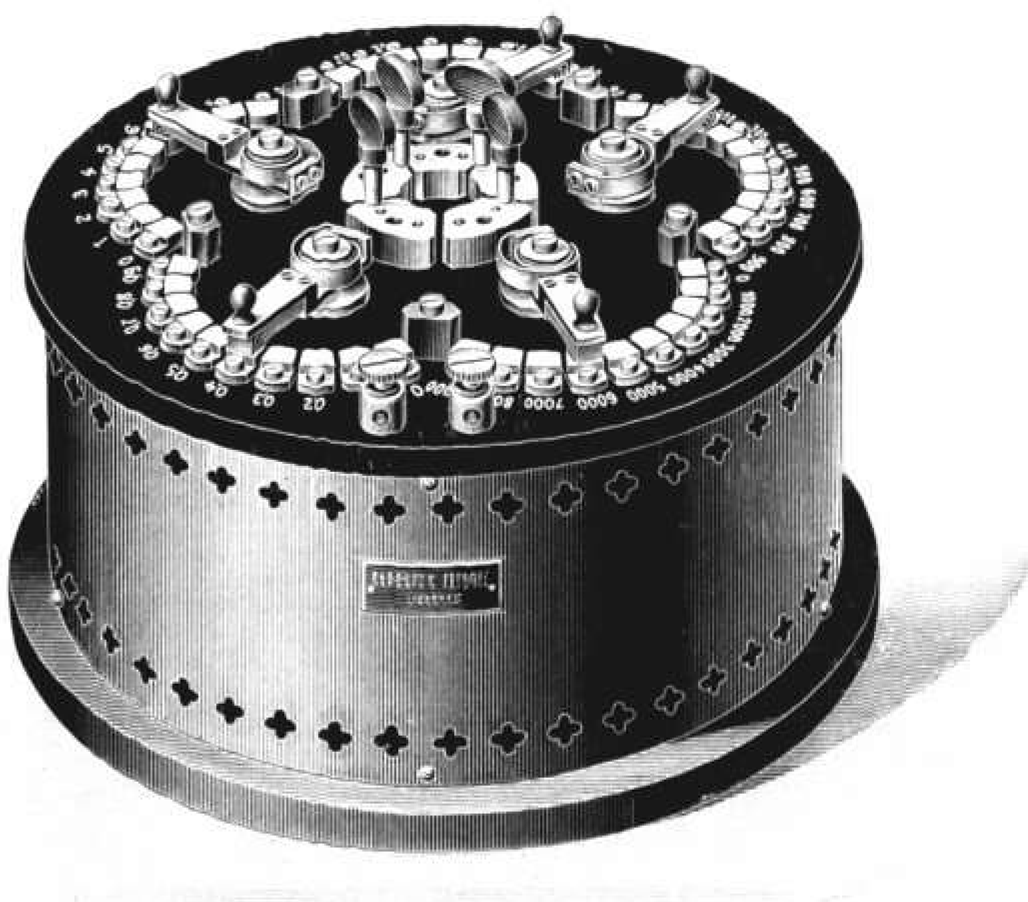


Fig. 2.

variable contact resistance in the axes of the contact arms. For measurements under 10 volts, a small plug resistance box (Fig. 7) is sufficient, or an equivalent sliding contact regulating resistance (Fig. 6).

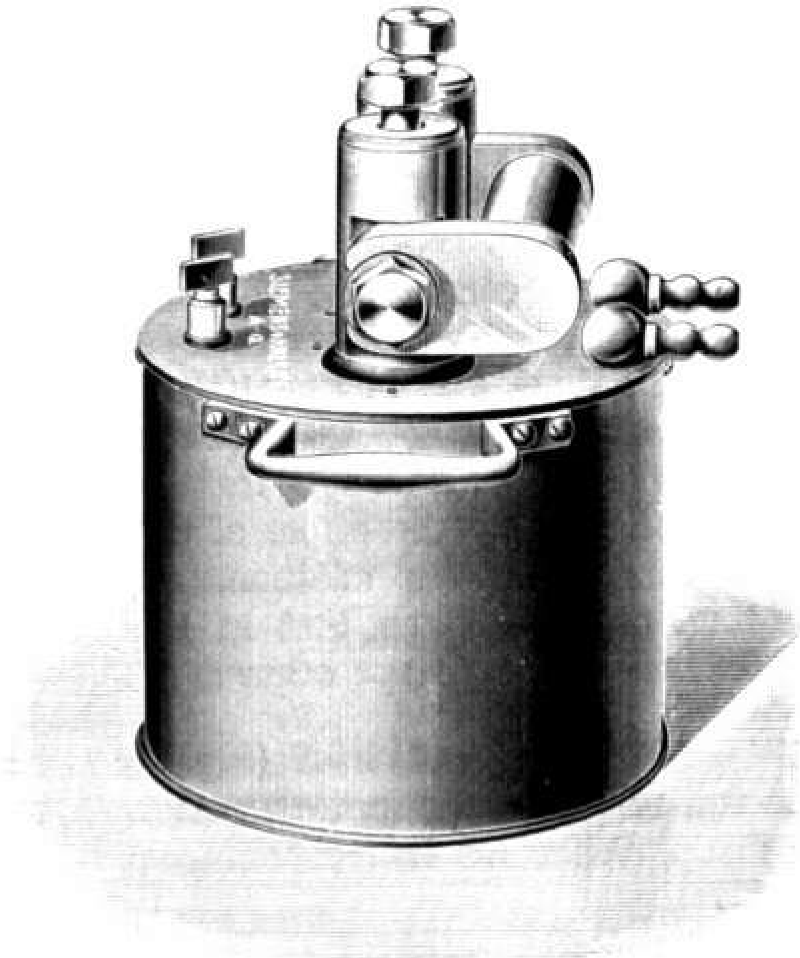


Fig. 3.

Fig. 4.

Current measurements are made with the potentiometer by measuring the fall of potential over standard resistances.

As such serve:

3. Standard Resistance (Fig. 3) with water cooling. For currents up to 3000 amp.

Fig. 5.

4. Standard Resistance (Fig. 4) with strap connections. For currents up to 200 amp.

5. Standard Resistance (Fig. 5) with mercury connections. Also

6. Petroleum Bath, capable of receiving five standard resistances.

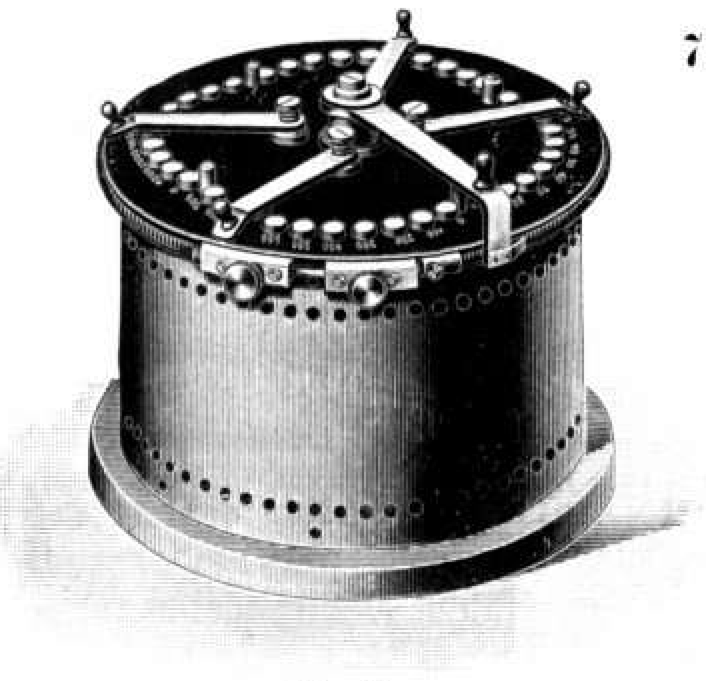


Fig. 6.

7. Sliding Contact Regulating Resistance (Fig. 6), for regulating the voltage. The total resistance is 100000 ohms. These are connected by means of four contact arms in four divisions of 9×10, 9×100, 9×1000, 9×10000 ohms and by means of a fifth arm, a slide wire of 10 ohms resistance.

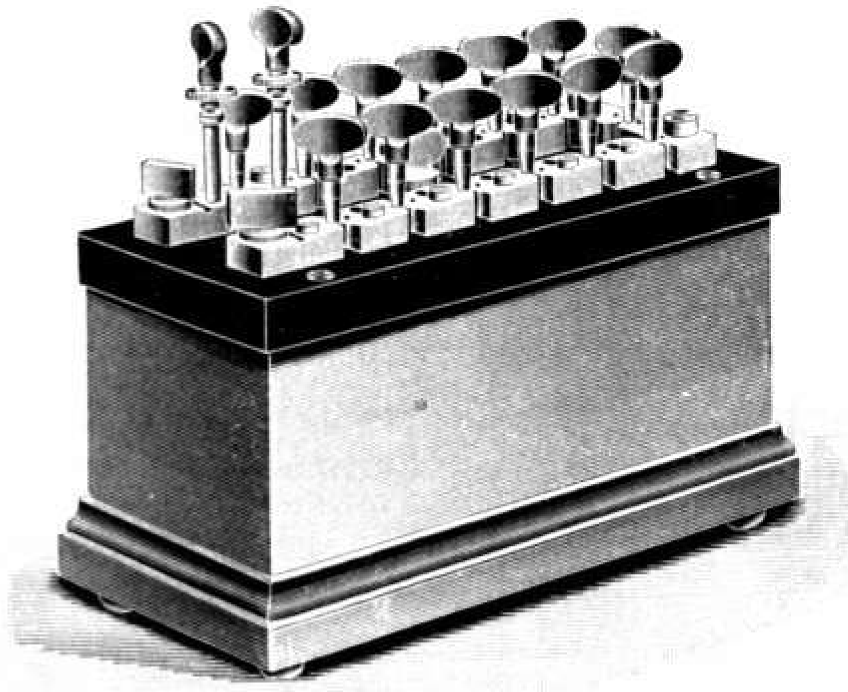


Fig. 7.

8. Plug Resistance Box (Fig. 7). Can be used in connection with the potentiometer and also for other laboratory purposes.

The *mirror galvanometer*, according to Deprez-d'Arsonval (for further description see under No. 68), is especially fitted for use as a current indicator.

b) Measuring Apparatus for the Determination of Resistances.

For the measurement of *small resistances* are used:

9. Double Sliding Contact Bridge (Fig. 8), for resistance measurements by the Thomson method, from 1—0·000001 ohm with the help of standard resistances (see No. 4), especially those with binding post connections. The bridge has two sets of contacts each of 9×0·1, 9×1, 9×10, 9×100, and two

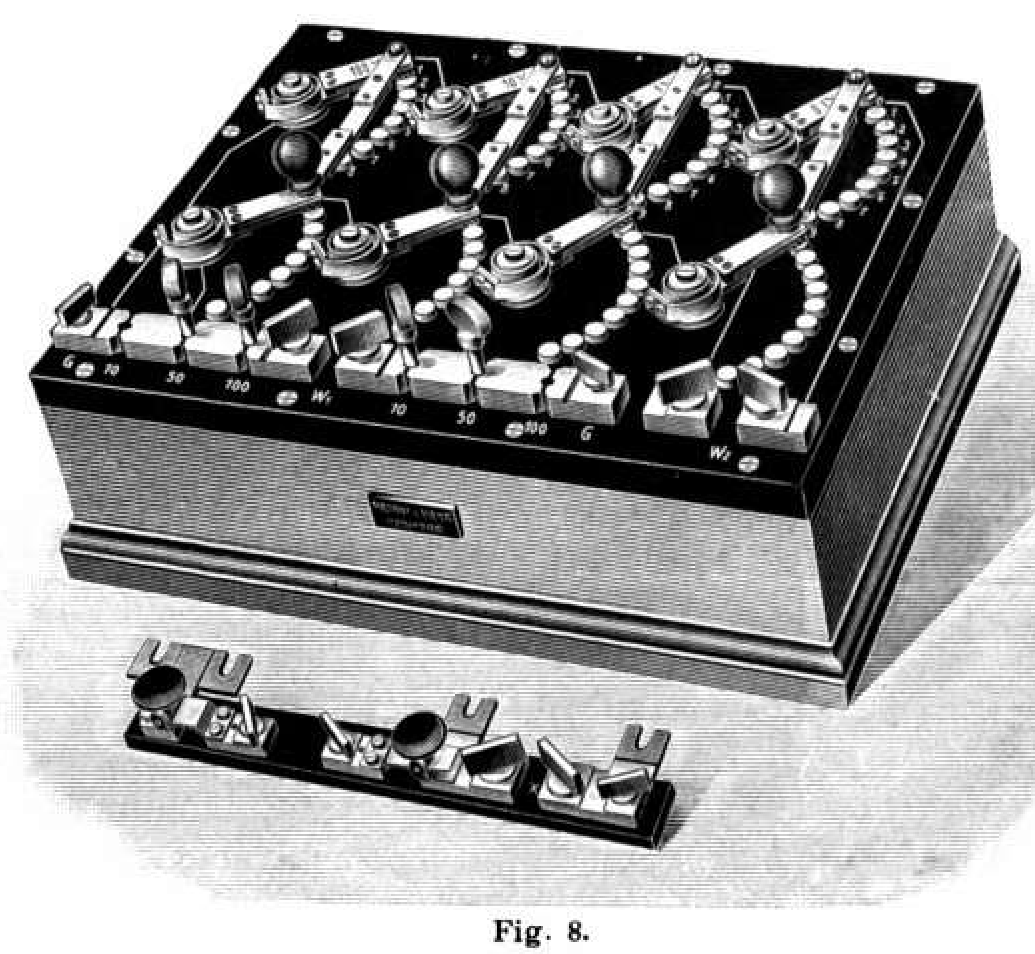


Fig. 8.

sets of comparison resistances, each of 10, 50 and 100 ohms. By means of the connection piece, represented beside the bridge, which carries binding posts and keys for the battery and galvanometer, the bridge can be used for measuring resistance from 0·1 to 10000 ohms, according to the Wheatstone method.

10. Thomson Bridge (Fig. 9), intended especially for rapid measurements for factory use, easily transportable.

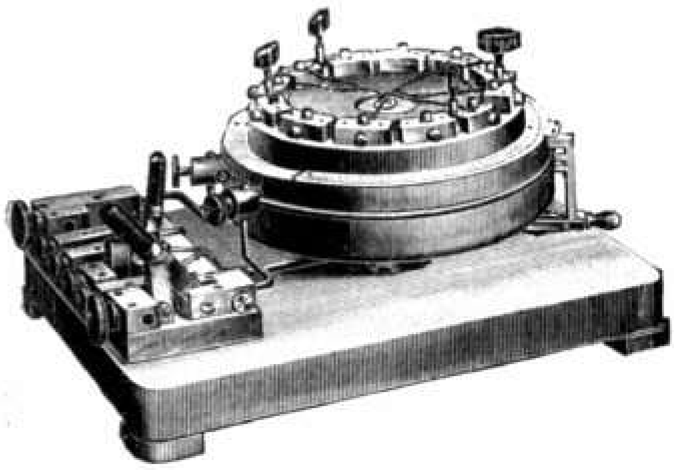


Fig. 9.

For measuring off lengths of wire of 1 *m.* a peculiar *clamping arrangement* for wires from 1—10 *mm.* in diameter is used.

Either the Deprez-d'Arsonval *mirror galvanometer* or the *spherical armored galvanometer*, according to du Bois-Rubens (see Nos. 68 and 73) may be used.

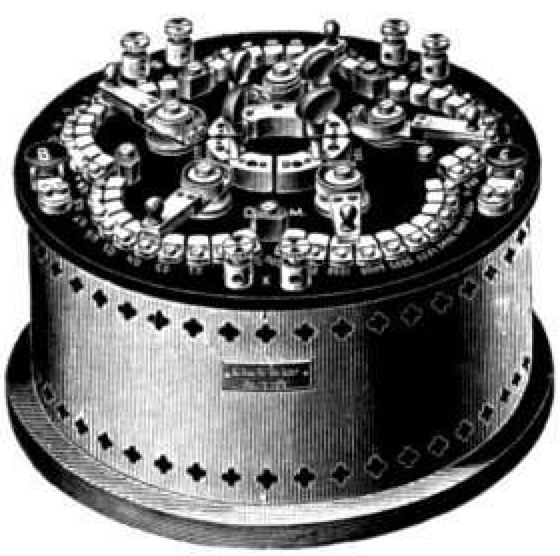


Fig. 10.

For the measurement of *resistances above 0·1 ohm*, apparatus Nos. 11—17 is used.

11. Standard Sliding Contact Bridge (Fig. 10). This, like the sliding contact resistance box No. 2, is remarkable for its freedom from contact resistances in the contact arm axes.

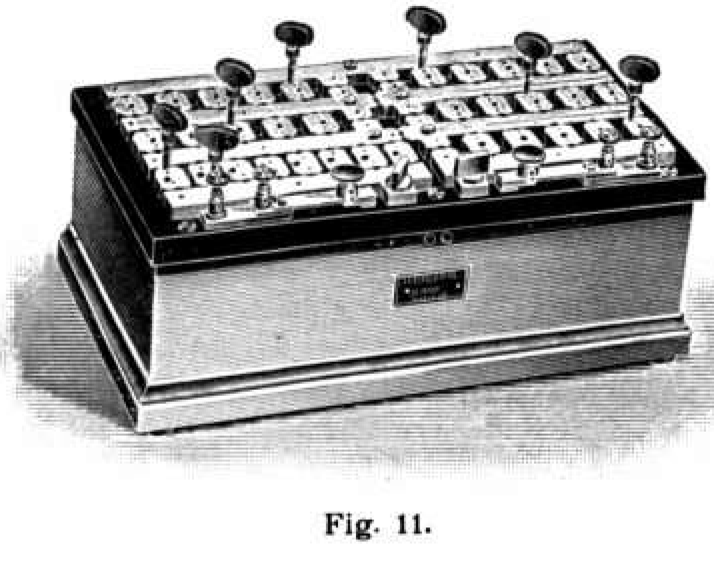


Fig. 11.

12. Decade Bridge (Fig. 11) for very accurate measurements. This consists of a comparison resistance from 0·1 to 11111 ohms in five decades, two reversible ratio arms, two keys and binding posts for galvanometer and battery.

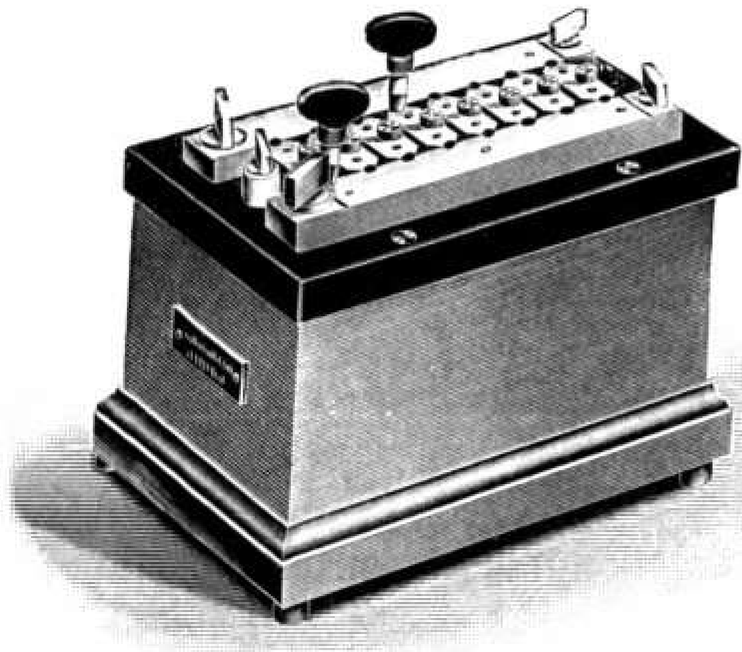


Fig. 12.

13. Bridge Ratio Arms (Fig. 12), containing two arms of 1, 10, 100 and 1000 ohms, which can be connected at will on either side. In connection with the sliding contact regulating resistance No. 7 or plug resistance box No. 8, it forms a Wheatstone bridge.

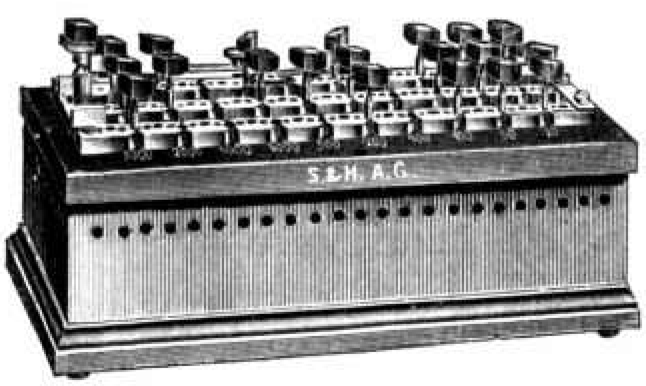


Fig. 13.

14. Standard Plug Contact Bridge (Fig. 13) with special arrangement of the resistances for widest possible use.

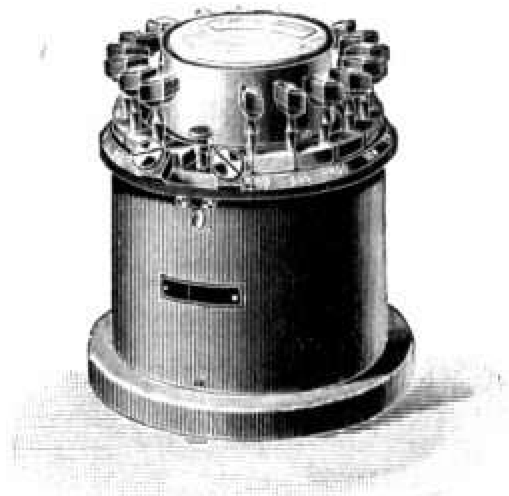


Fig. 14.

15. Installation Bridge (Fig. 14) for rough measurements from 0·1 to 100000 ohms.

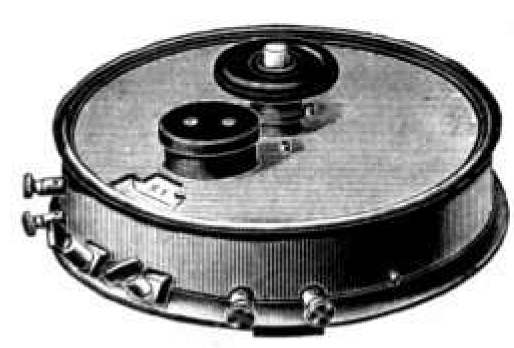


Fig. 15.

16. Slide Wire Bridge (Fig. 15) for rapid measurements of resistance. The value of the resistance is read directly on the slide wire, while the comparison resistance of 0·1, 1, 10, 100 or 1000 ohms is introduced by means of a switch. In addition, the bridge is furnished with double key and binding screws for the galvanometer and battery.

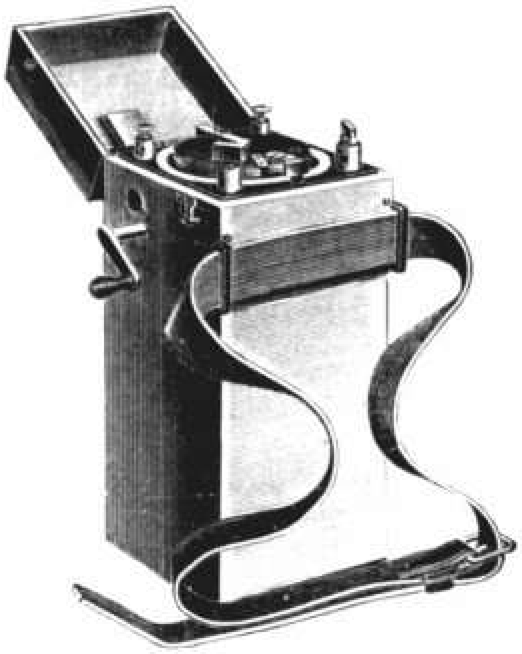


Fig. 16.

17. Telephone Bridge (Fig. 16), especially for the examination of lightning conductors. The direct current, furnished by the two dry cells inclosed in the instrument, is made intermittent by means of a contact wheel.

c) Measurement Apparatus for the Determination of Induction Coefficients and the Energy Loss in Alternating Current Apparatus.

The principle of the method of measurement is briefly as follows: If an alternating current of definite voltage is sent through a piece of apparatus whose coil is free from self induction or capacity, the effective current strength may be determined according to Ohm's law; if the coil has self induction in addition to resistance, the inductive resistance is added to the ohmic resistance.

This is true only as long as the coil contains no iron core. If it contains iron or if energy is supplied to an external system of conductors by induction, the induced current (Foucault current) produces a displacement of the phase of the field in reference to that of the exciting current and decreases in this way the self induction. In addition, a certain amount of heat is produced in the secondary circuit, which must of course be supplied from the primary circuit, so that the energy consuming resistance of the coil appears to be increased.

If there is no loss of energy in the apparatus under consideration except that due to resistance in the windings, the conditions of balance of the bridge are the same as for a direct current; if however there are Foucault and hysteresis losses, the conditions of balance are no longer the same as for direct current. If after balancing the bridge for an alternating current, a direct current be sent through and the telephone replaced by a galvanometer, the latter will show a deflection. By changing the resistance the bridge can be balanced for the direct current. This last change in resistance is the alternating current loss resistance.

18. Bridge for Direct and Alternating Current (Fig. 17). With this alternating current bridge, self inductions down to 0·001 Henry (10^6 *cm.*) may be determined.

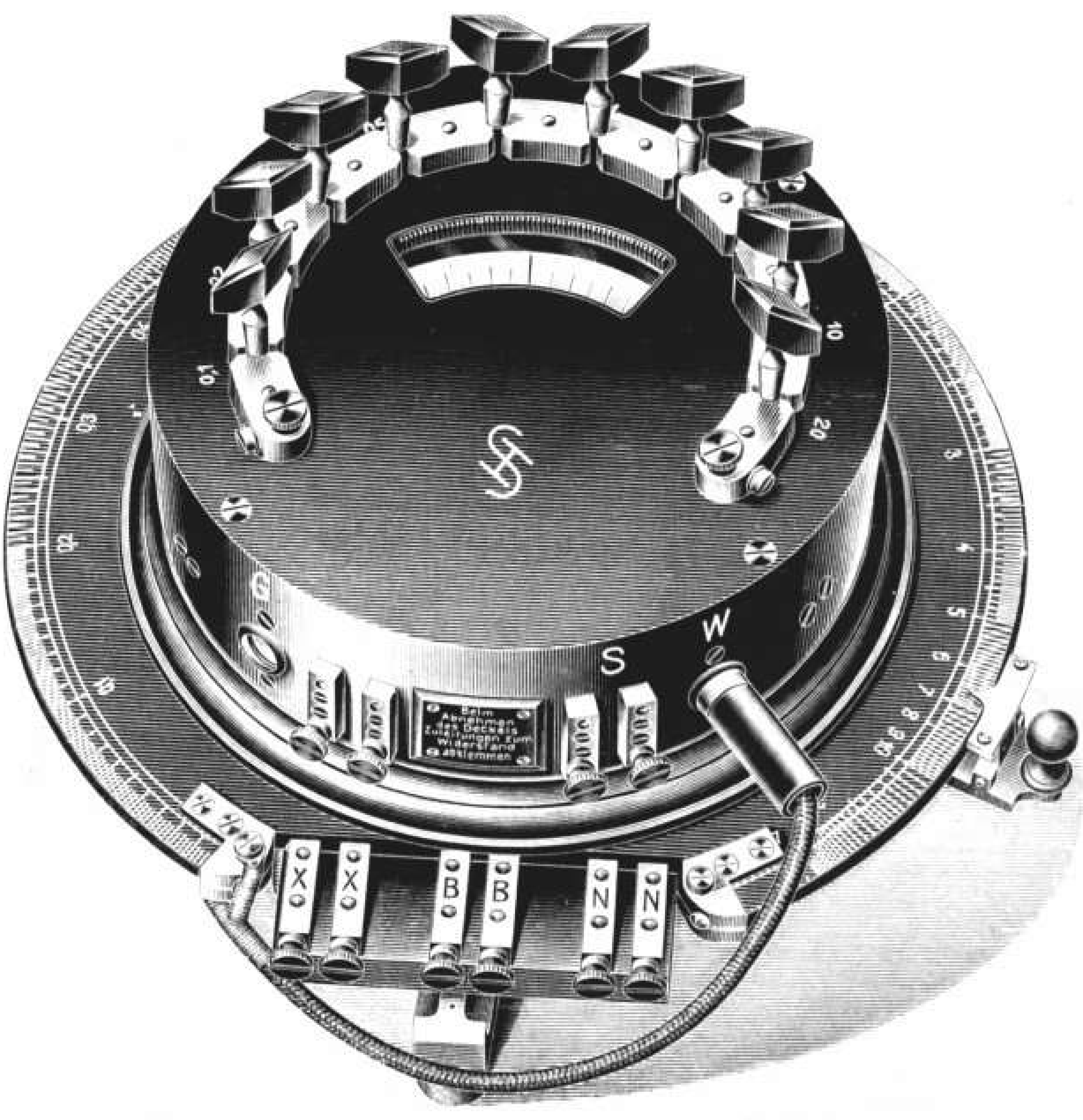


Fig. 17.

19. Bridge for the Determination of Small Self Inductions (Fig. 18). The bridge wire is straight and only 10 *cm.* in length, in order to prevent errors due to mutual induction; as comparison resistance serves a 2 *cm.* long manganin wire, on which a contact slides with sensitive adjustment.

With this bridge it is possible to measure even the smallest self inductions down to 10^{-7} Henry (100 *cm.*) with an accuracy of from 1 to 2 %. The self induction of a few

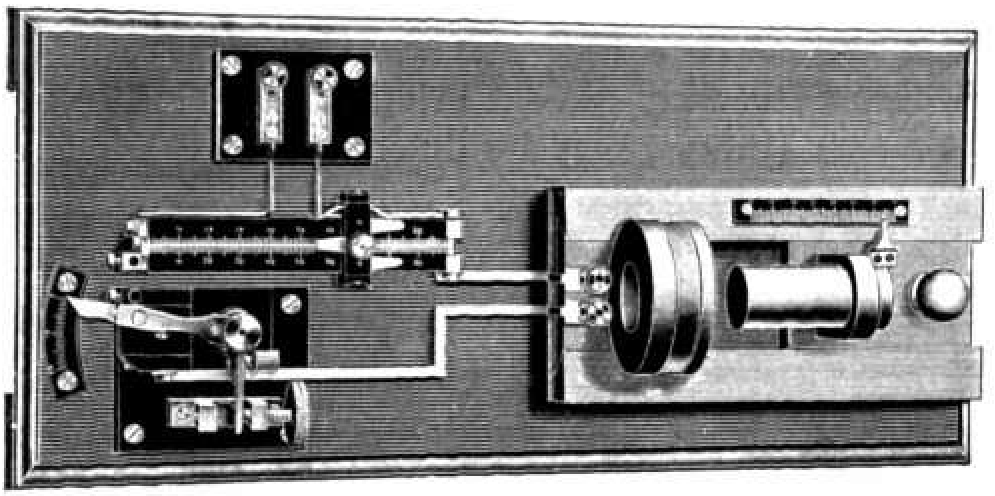


Fig. 18.

turns of thick copper wire can be determined with sufficient accuracy to make the bridge a convenient means of investigating rapid electrical oscillations.

The two bridges are also suitable for the *measurement of mutual induction coefficients* and the *absolute determination of self induction*, according to the method of M. Wien.

For the production of alternating currents of high frequency is used:

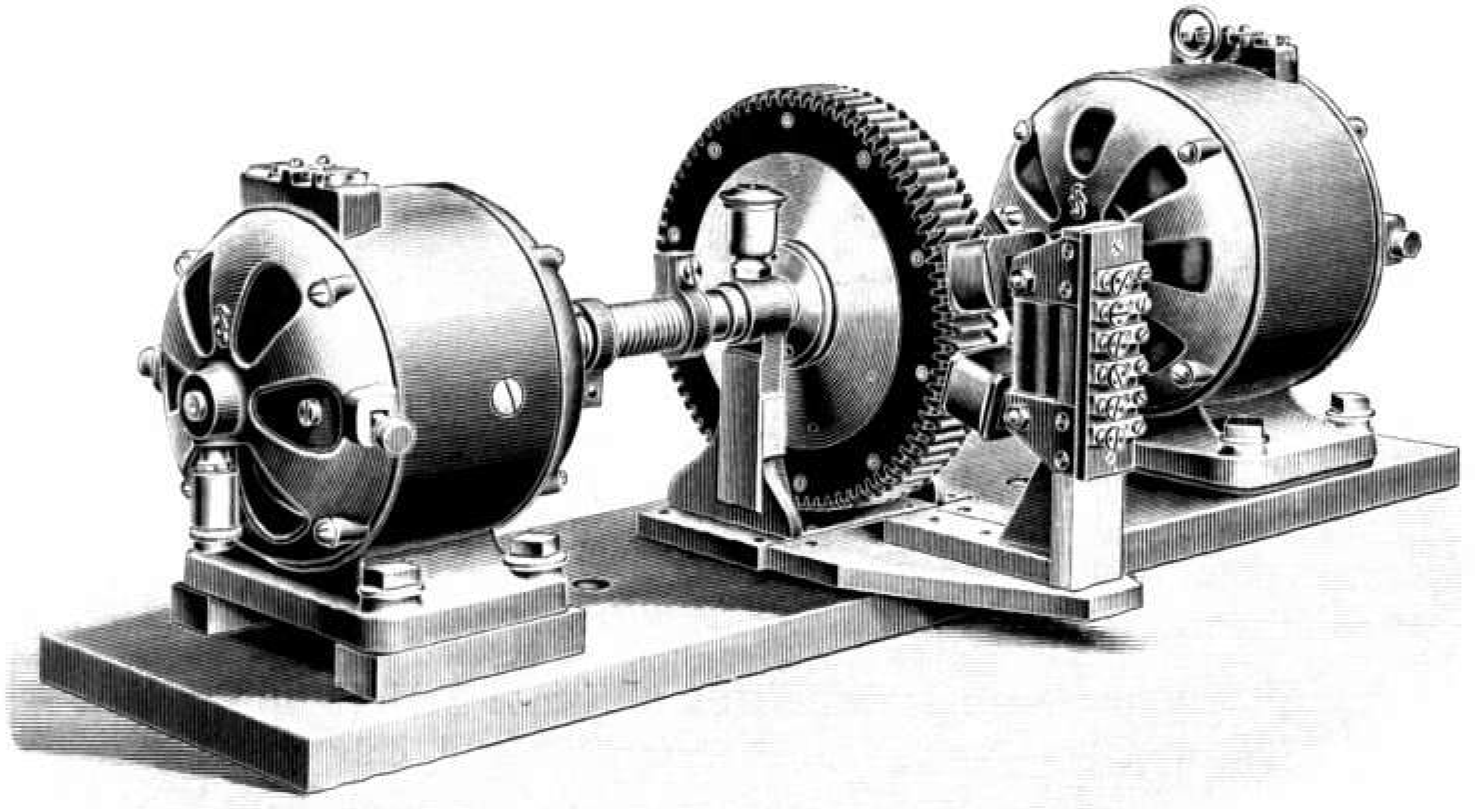


Fig. 19.

20. Alternating Current Generator (Fig. 19). The essential part of the generator consists of a toothed iron disc. Close to and opposite the teeth of the disc are situated the poles of a horse-shoe electromagnet with three sets of windings. The poles are narrowed to an edge so that the magnetic circuit is closed through the iron disc as soon as the teeth come into a position opposite the poles. When the electromagnet is excited by means of a direct current in its middle winding and the iron disc is set in rapid rotation by means of a motor, the continual approaching and receding of the teeth produce powerful magnetic fluctuations, which generate an alternating current in the secondary windings. With this machine alternating currents up to 10000 periods per sec. can be produced. The second motor, seen at the left in Fig. 19, is short circuited through an adjustable resistance and serves to give the driving motor a constant load so that small variations in the friction in the axes etc. will produce no variations in the speed.

Fig. 20.

21. Buzzer Transformer (Fig. 20) for the generation of pure sine currents. This furnishes alternating currents with periods from 300 to 650; with a thicker diaphragm, for a short time, currents of 900 periods per sec.

22. Standard of Self Induction (Fig. 21). In these the dependence of the resistance and self induction on the frequency of the alternating current is entirely prevented.

Fig. 21.

d) Self Induction Coils for the Pupin Telephone System.

The self induction coils are connected at definite distances in the cable lines or on free telephone wires and serve to diminish the damping of the speaking currents. By using Prof. Pupin's theory, the dimensions and distances of the coils can

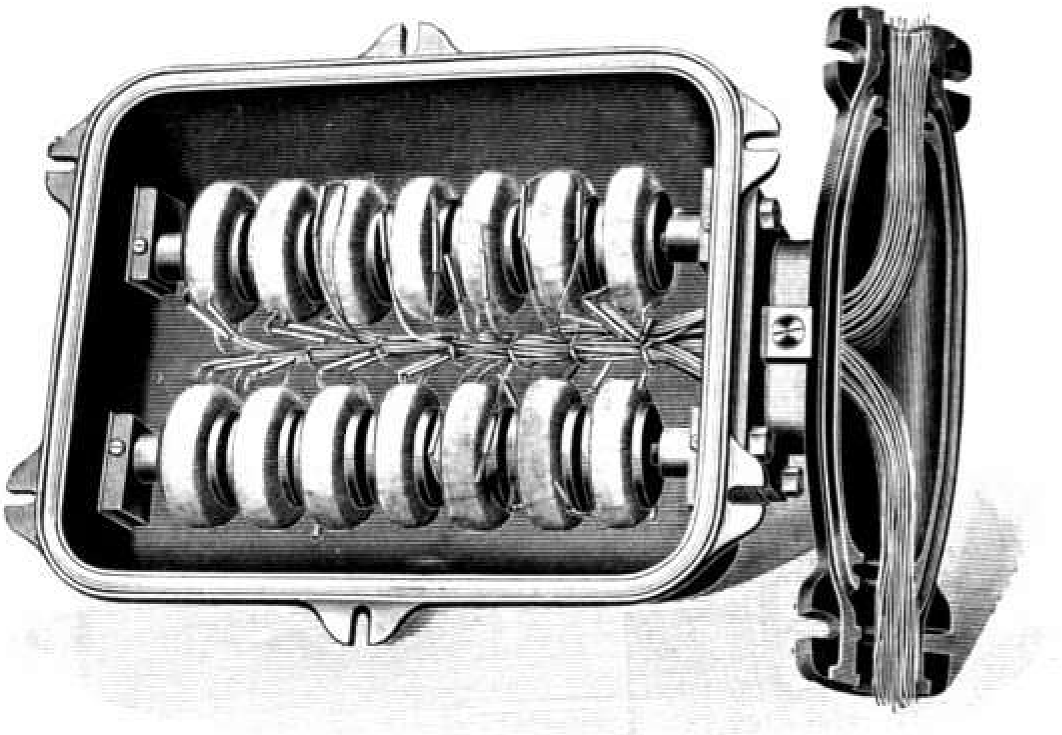


Fig. 22.

be so chosen that a definite and considerable decrease of the damping is produced, and a marked increase in the strength

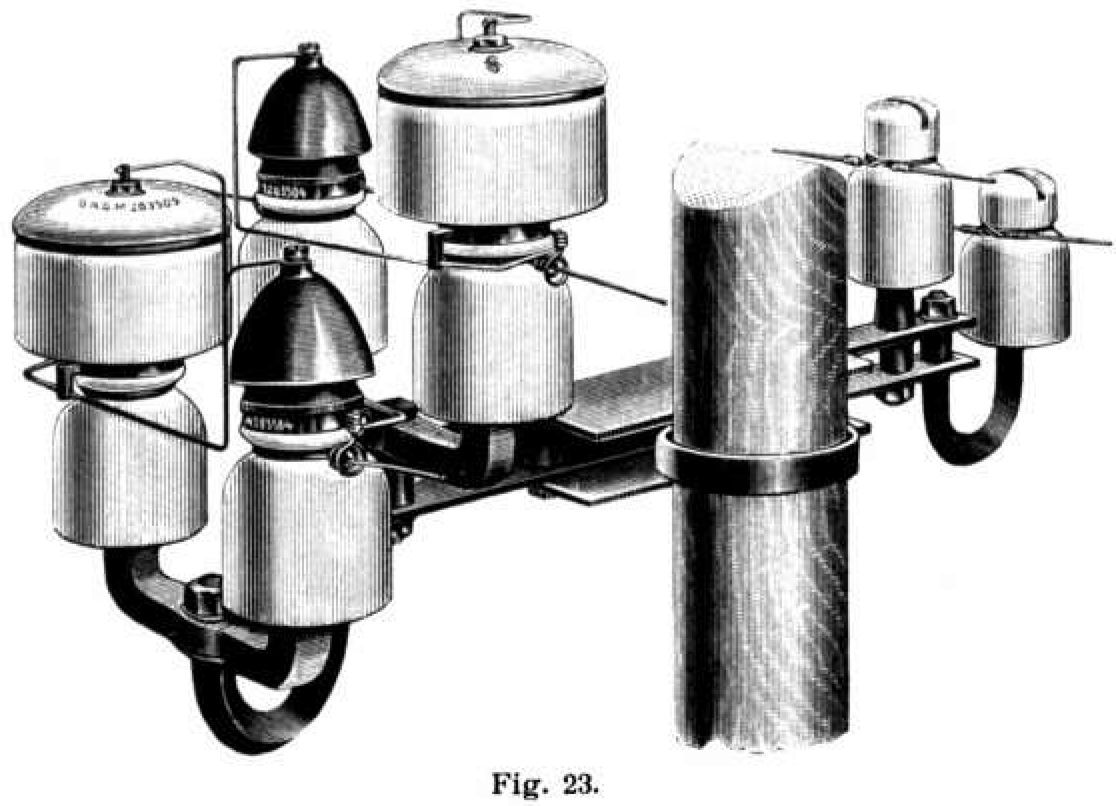


Fig. 23.

of tone is attained. On cable lines, the self induction coils are wound on the same circular iron core. In air lines, the coils for the wires in the two directions are separated. To guard against danger from lightning the coils on the air lines are connected by means of a lightning arrester. The coils and lightning arrester are mounted on insulators.

23. **Case with Self Induction Coils** (Fig. 22) for telephone cables, according to the Pupin system.

24. **Telephone Pole with Self Induction Coils** (Fig. 23) for telephone air lines, according to the Pupin system.

e) Apparatus for Drawing Curves of Magnetisation.

These pieces of apparatus are intended for the investigation of the magnetic properties of iron or steel. The test pieces are in the form of rods or bundles of strips of definite dimensions.

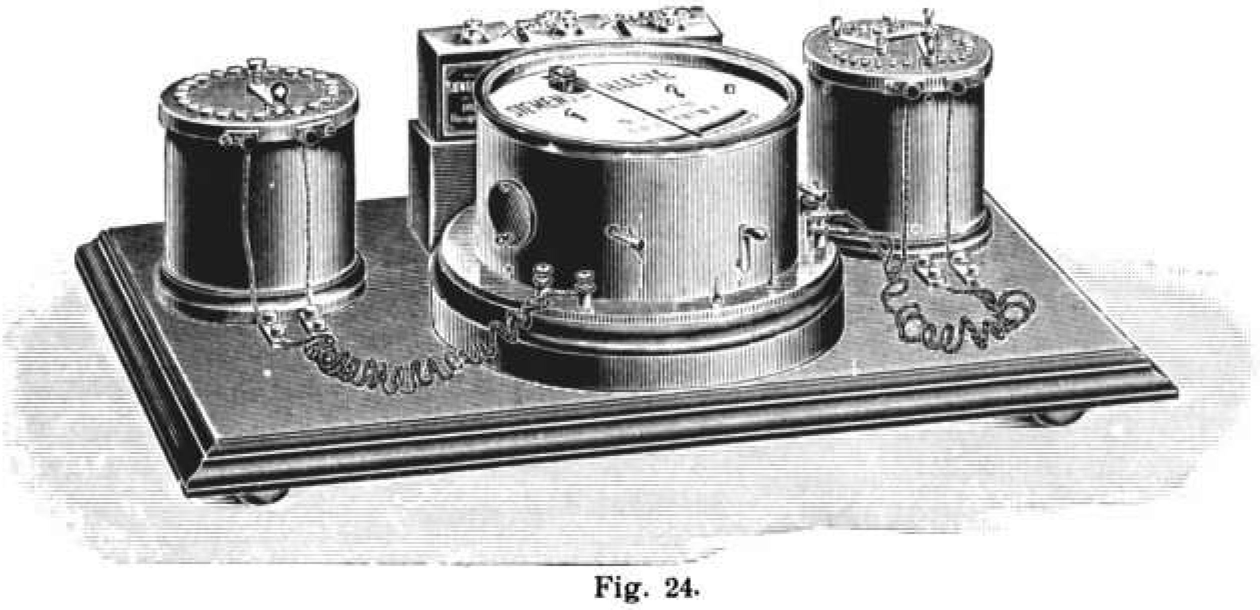


Fig. 24.

25. **Magnetic Apparatus** (Fig. 24). Indicates the magnetic induction per *sq. cm.* in the test piece directly by means of a pointer. This apparatus makes use of the principle of the Deprez-d'Arsonval galvanometer. The test piece is surrounded by a magnetizing coil and closes an iron yoke. A coil, which is traversed by a known auxiliary current, swings in a narrow air space in the yoke. It is deflected by an amount, corresponding to the magnetic induction, which is read directly on the scale.

26. Standard Magnetic Balance (Fig. 25), according to du Bois. For testing magnetic materials with great accuracy. The magnetizing coil, with correction windings, surrounds the test rod or strip. The strong yoke piece, made of cast steel of great permeability, forms an unequal armed balance beam. The unequal attraction of the beam, produced by the magnetisation of the whole system, is compensated by means of a sliding weight. The amount of displacement of the weight measures the induction attained. The *roller rheostat*, exhibited beside the balance, serves for continuous regulation of the magnetizing current.

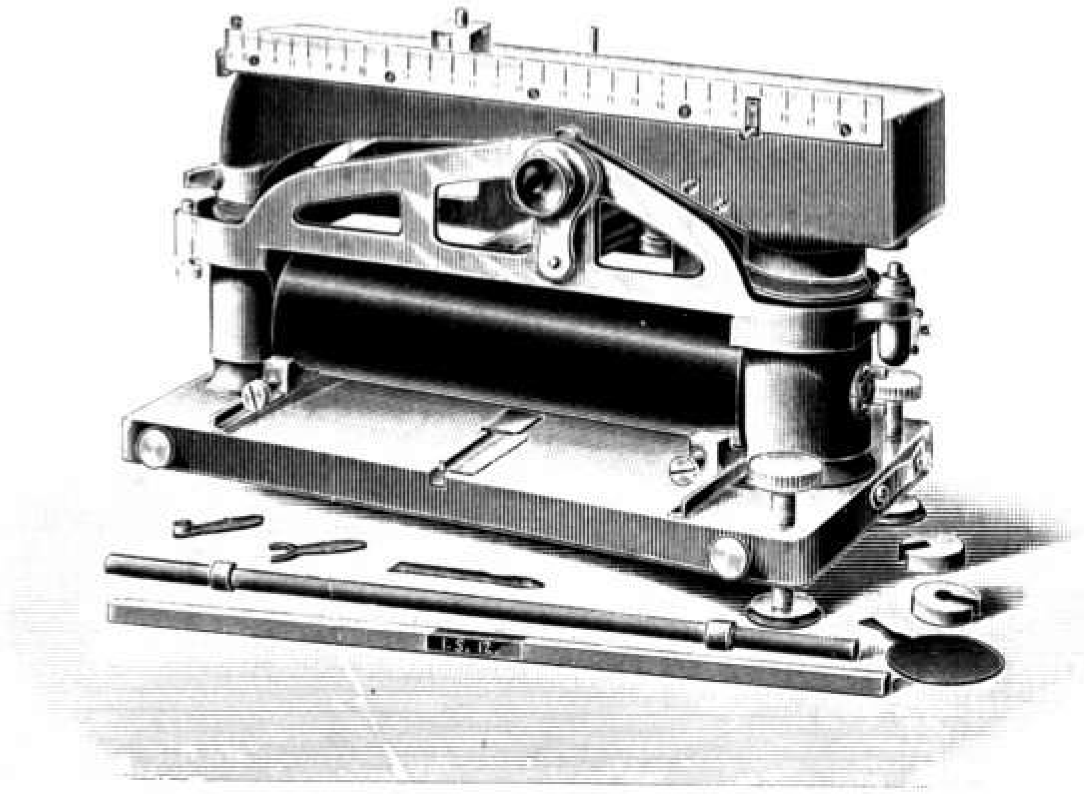


Fig. 25.

f) Pieces of Apparatus for Determining the Coefficient of Magnetisation Loss in Iron.

The method for determining the magnetisation losses due to hysteresis and Foucault currents is as follows: the strips are formed into a closed yoke and surrounded by a magnetizing coil, which is traversed by an alternating current of 50 periods per sec. The difference of potential on the terminals of the coil is so adjusted that the iron core shows a maximum induction of $\mathfrak{B} = 10\,000$. Then the loss coefficient is equal to the magnetizing energy, divided by the weight of the iron.

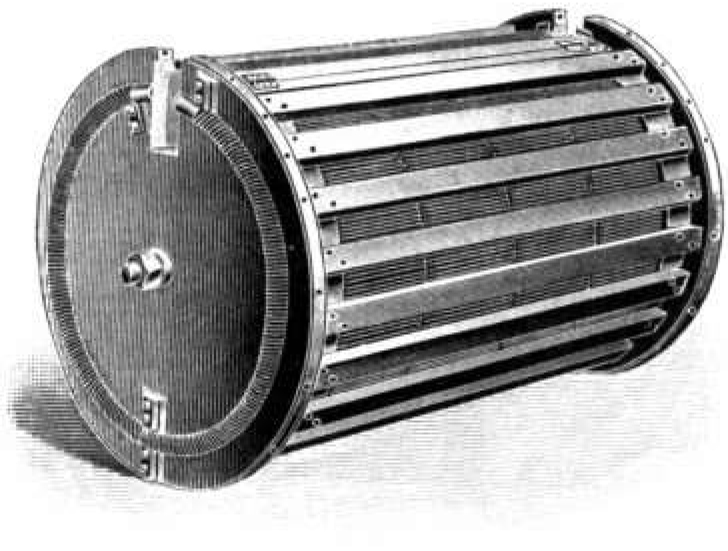


Fig. 26.

27. Iron Testing Apparatus, according to Richter (Fig. 26). This is so arranged that special test pieces are not necessary, but the test can be made on complete sheets of metal.

As auxiliary apparatus are used: a *standard wattmeter* (see No. 50) with series resistance, an *alternating current standard amperemeter* (see No. 48) and an *alternating current standard voltmeter* (see No. 49). The corresponding portable aperiodic instruments (see Nos. 56—58) can be used if desired.

28. Iron Testing Apparatus, according to Möllinger (Fig. 27) for testing stamped sheet iron discs of definite sizes for dynamos, motors and transformers. A definite number of sheets are laid one upon another and placed in the apparatus. The windings *A* can be opened singly and consist therefore of flexible cable with plug contacts. Fig. 27 shows the whole apparatus; the auxiliary apparatus is the same as in No. 27.

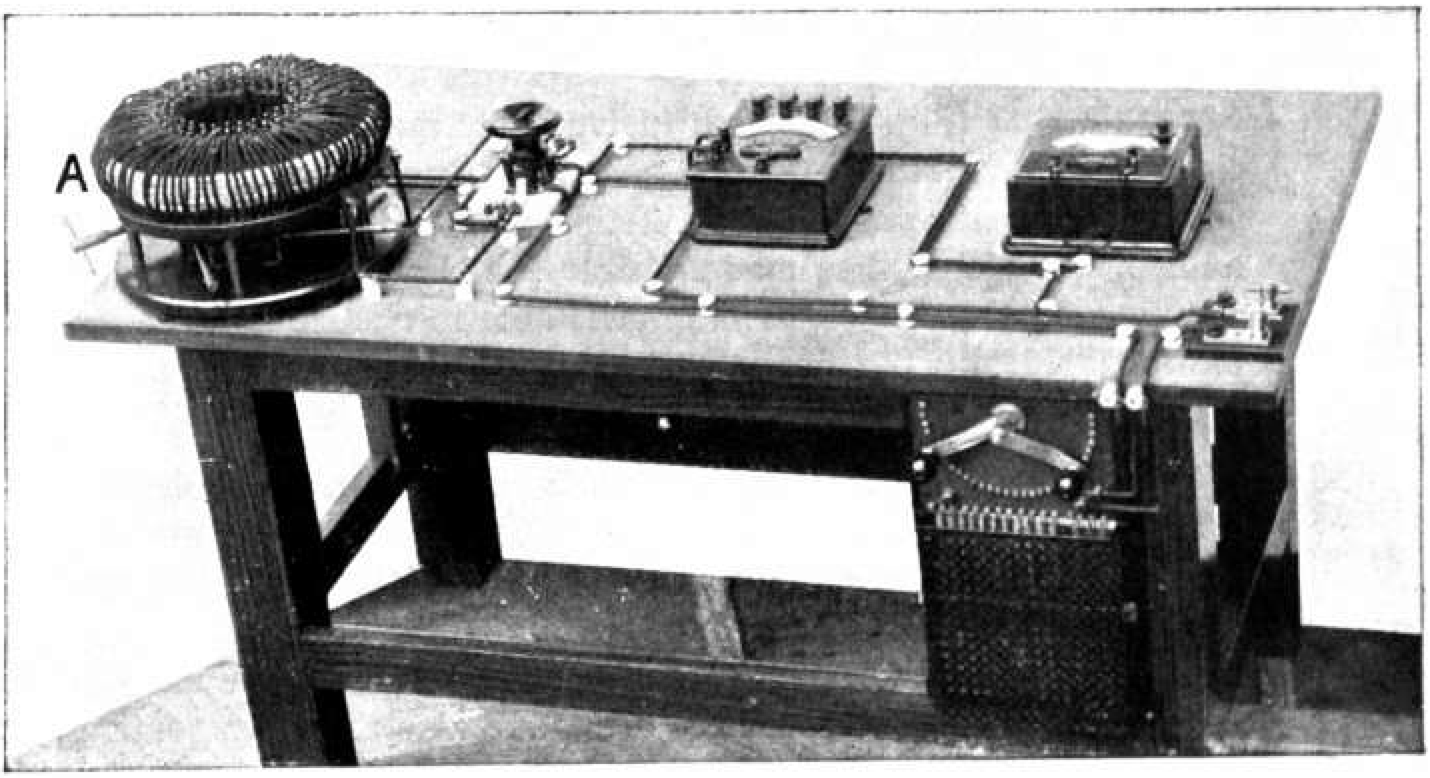


Fig. 27.

g) Apparatus for Drawing Alternating Current Curves.

Just as an indicator diagram is necessary for giving an insight into the mode of working of a steam engine, it has recently become necessary in the field of electricity to have an apparatus, which will rapidly and easily graphically register the variations of the two main elements of the circuit, namely the current and the voltage.

For this purpose is used:

Fig. 28.

29. Oscillograph (Fig. 28). This instrument, made on the principle of the Blondel oscillograph in its essential parts, accomplishes its purpose completely. By using an ingenious device, the diagram is made visible just before it is photographed so that the experimenter is able to choose and record photographically the particularly interesting portion of the process.

The operation of the apparatus is as follows: the oscillograph, which is in principle only a d'Arsonval galvanometer reduced to its simplest form according to Blondel, records the curve form on a drum, covered with photographic paper, by means of a moving ray of light, reflected from the mirror. A *synchronous motor* drives the drum and also the arrangement for making the curve visible. Between the oscillograph and the photographic drum a mirror is placed, which reflects the light onto a rotating apparatus on which the curve appears. By pressing a button, the mirror is thrown back and the ray of light records on the drum.

h) Apparatus for Pyrometric Measurements.

The range, over which thermoelectric measurements are generally made, extends from —190° C. to +1600° C. The scales of the single pieces of apparatus can be made shorter if desired. For temperatures between —190° C. and +600° C., thermoelements of *copper constantan,* for higher temperatures up to +1600° C. elements of *platinum platinum-rhodium,* according to Le Chatelier are used. All thermoelements are tested in the Physikalisch-Technische Reichsanstalt and are provided with seals and certificates. In order to protect them from injury in use they must be properly mounted. One of the different forms, made by the firm, is exhibited.

30. Thermoelement with a double tube of special fire resisting material, which is protected from mechanical injury by a tube of pure nickel. The following instruments are used for measuring the E. M. F.:

31. Sensitive Pointer Galvanometer (Fig. 29) with millivolt and temperature scale.

32. Registering Pyrometer (Fig. 30, *p. 158*), fitted with automatic switch by means of which the curves of five different elements can be registered simultaneously but without risk of confusion. The pointer, connected to the switch, shows at each instant which of the elements is in connection with the apparatus.

Fig. 29.

33. Potentiometer for Accurate Pyrometric Measurements, according to Lindeck (Fig. 31). In this the unknown E. M. F.

of the thermoelement is balanced against a known variable difference of potential. This instrument is used to advantage

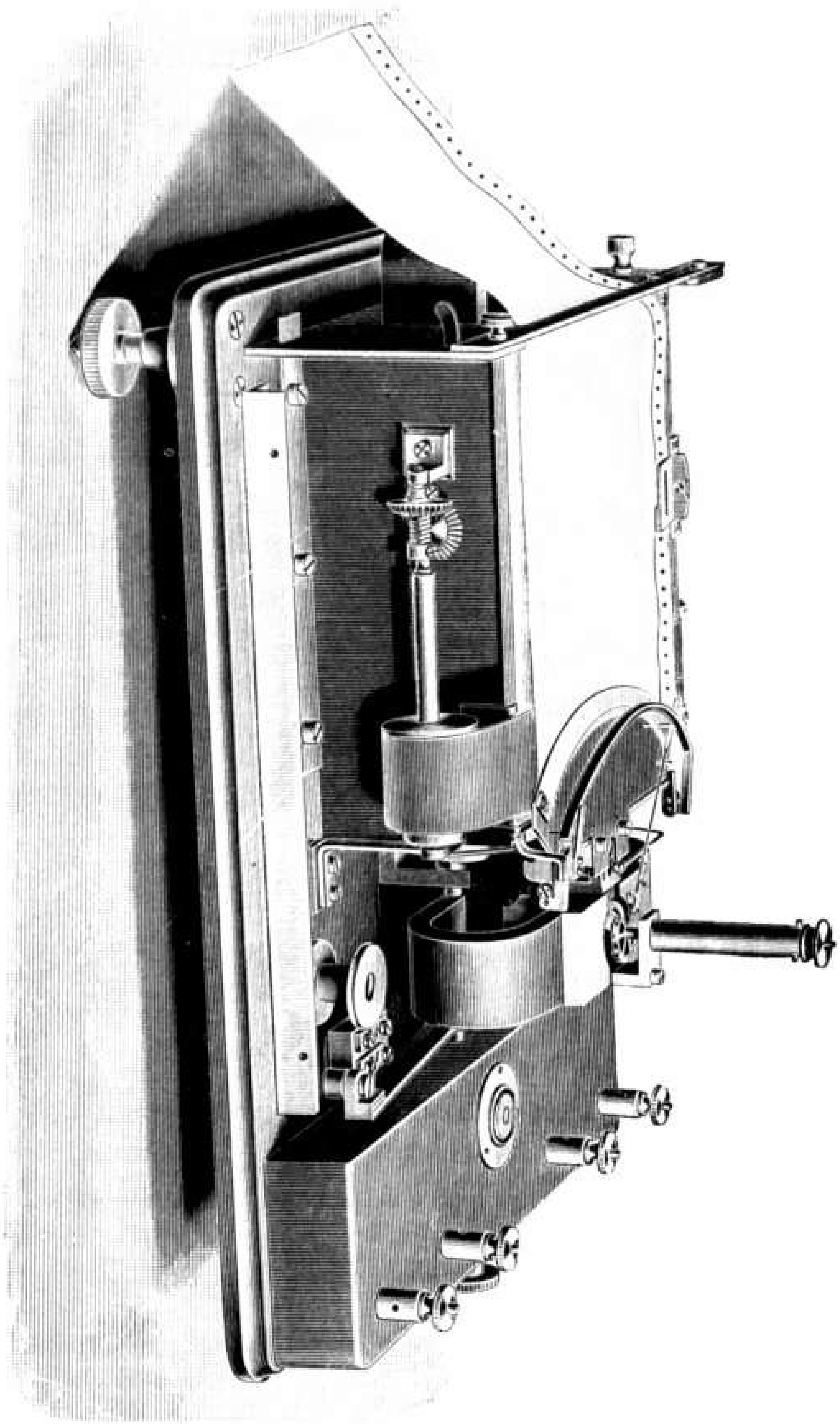


Fig. 30.

whenever the ordinary method of measuring thermoelements by means of a sensitive voltmeter is not sufficiently accurate.

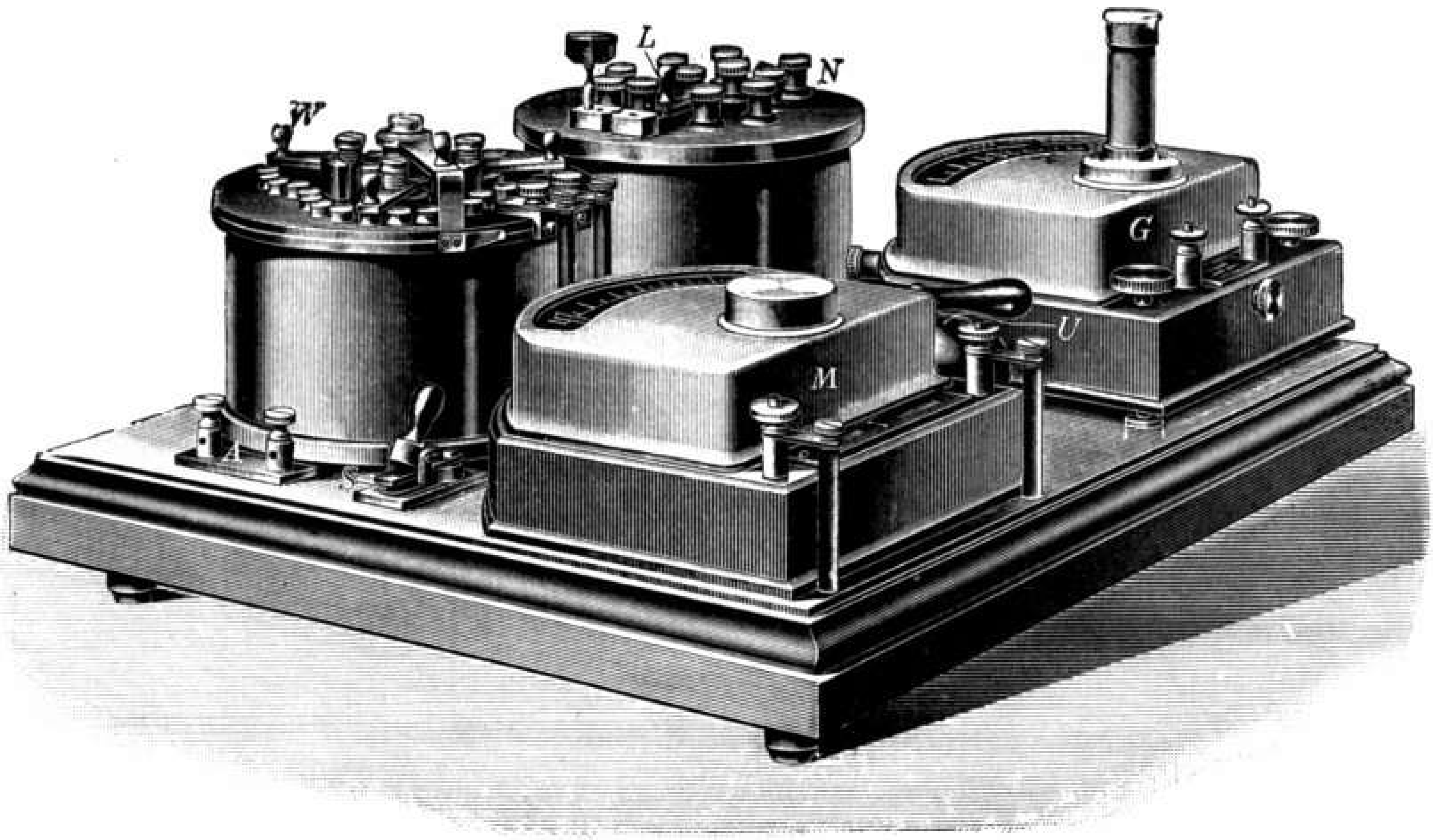


Fig. 31.

II. Typical Measuring Instruments for Lecture Rooms, Laboratories and Technical Use.

a) Standard Deprez-d'Arsonval Instruments for Direct Current.

The following instruments, made according to the principle first suggested by Lord Kelvin and Deprez-d'Arsonval and afterward improved by Weston, are exhibited:

34. Standard Millivolt- and Amperemeter (Fig. 32) of 1 ohm resistance; range 0 to 0·15 amp. and 0 to 0·15 volt. Also manganin *shunt* to be directly connected to the instrument or a manganin *series resistance* for increasing the voltage range. For currents over 150 amp. the shunts are not connected directly, but portable shunts with connecting wires 0·75 *m.* long are made.

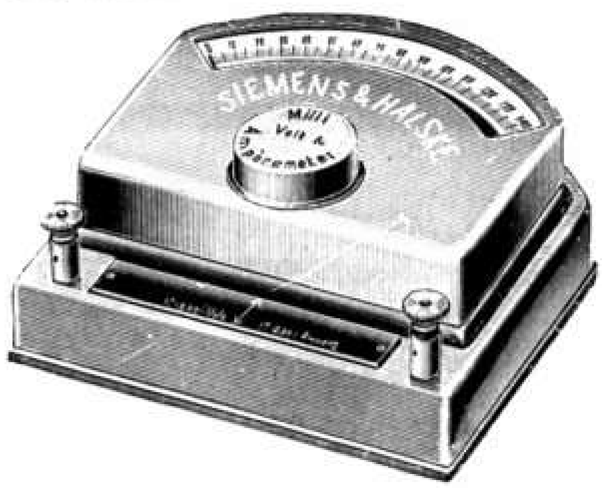


Fig. 32.

35. Portable Shunt for use up to 300 amp.

36. Portable Shunt (Fig. 33) for use up to 750 amp.

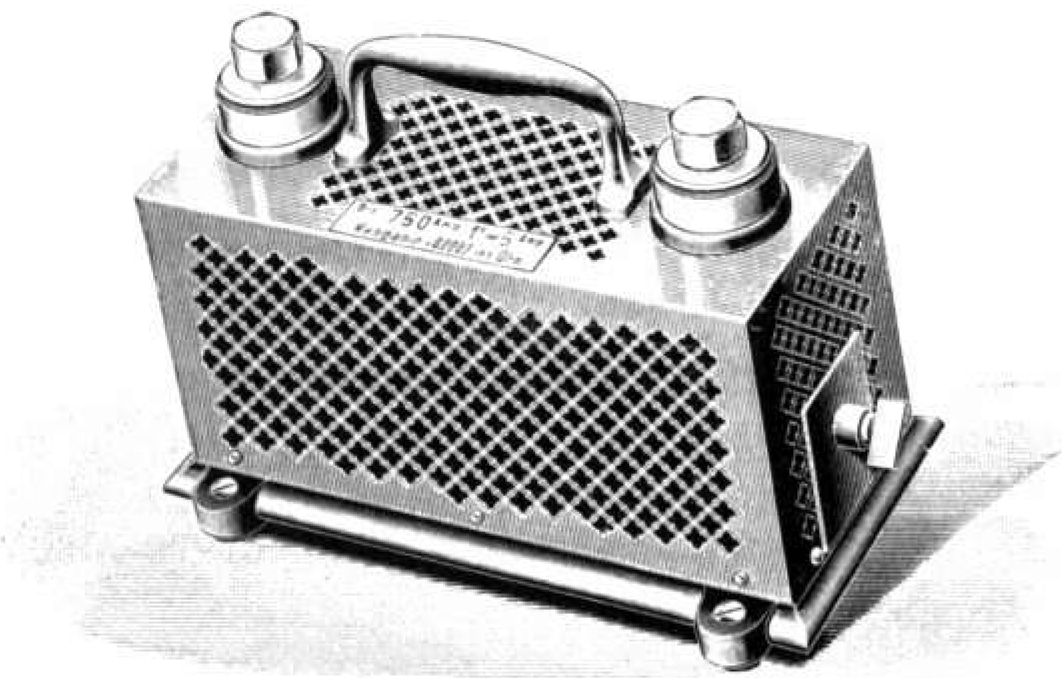


Fig. 33.

37. Shunt Resistance, according to Feussner (Fig. 34). Forms in connection with a millivoltmeter (for example with the

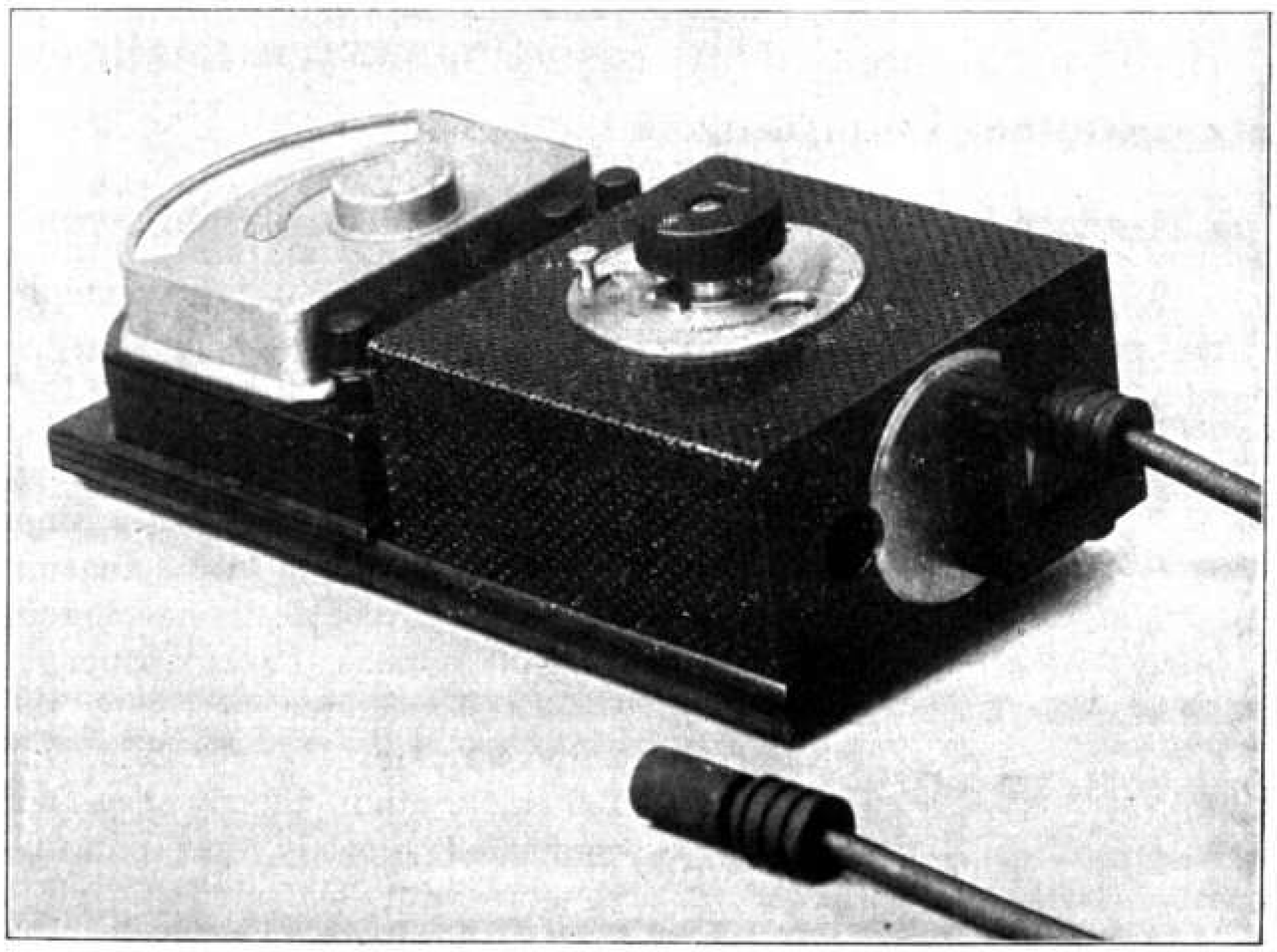


Fig. 34.

standard instrument No. 34) a current measuring apparatus of several ranges, and permits changing from one to another of the seven ranges, or short circuiting without breaking the connections. It is therefore possible to read all strengths of current on the upper part of the scale of the millivoltmeter, thereby increasing the accuracy of the reading. The scale factor at each moment appears in large figures in an opening in the case. The sliding contact is mechanically connected with a circuit breaker in the instrument so that the passage of too large a current is prevented. The fact that the resistances of the different sections are whole multiples of ohms makes it possible to use it in connection with a millivoltmeter of any resistance.

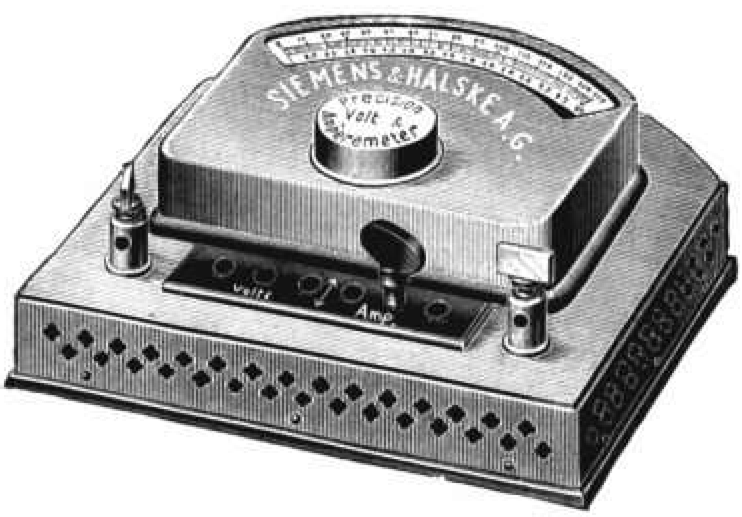


Fig. 35.

38. Standard Volt- and Amperemeter (Fig. 35) with six ranges of measurement. The shunt and series resistances are inclosed in the instrument.

39. Standard Amperemeter (see No. 34) of 2 ohms resistance. Zero temperature coefficient. Also manganin shunt to be directly connected to the instrument.

40. Combined Standard Volt- and Amperemeter (Fig. 36, *p. 162*), for simultaneous measurements of current and voltage. The instrument contains a voltmeter and an amperemeter with zero temperature coefficients, mounted on a common hard rubber base. With connections for four ranges of voltage up to 3, 150, 300 and 600 volts, and four current ranges up to 3, 7·5, 15 and 30 amp. In addition the instrument contains arrangements for connecting special shunts.

Simpler forms of instruments of this kind are:

41. Battery Tester (Fig. 37, *p. 163*).

Fig. 36.

42. Portable Installation Standard Voltage Indicator.

43. Installation Standard Current and Voltage Indicator (Fig. 38).

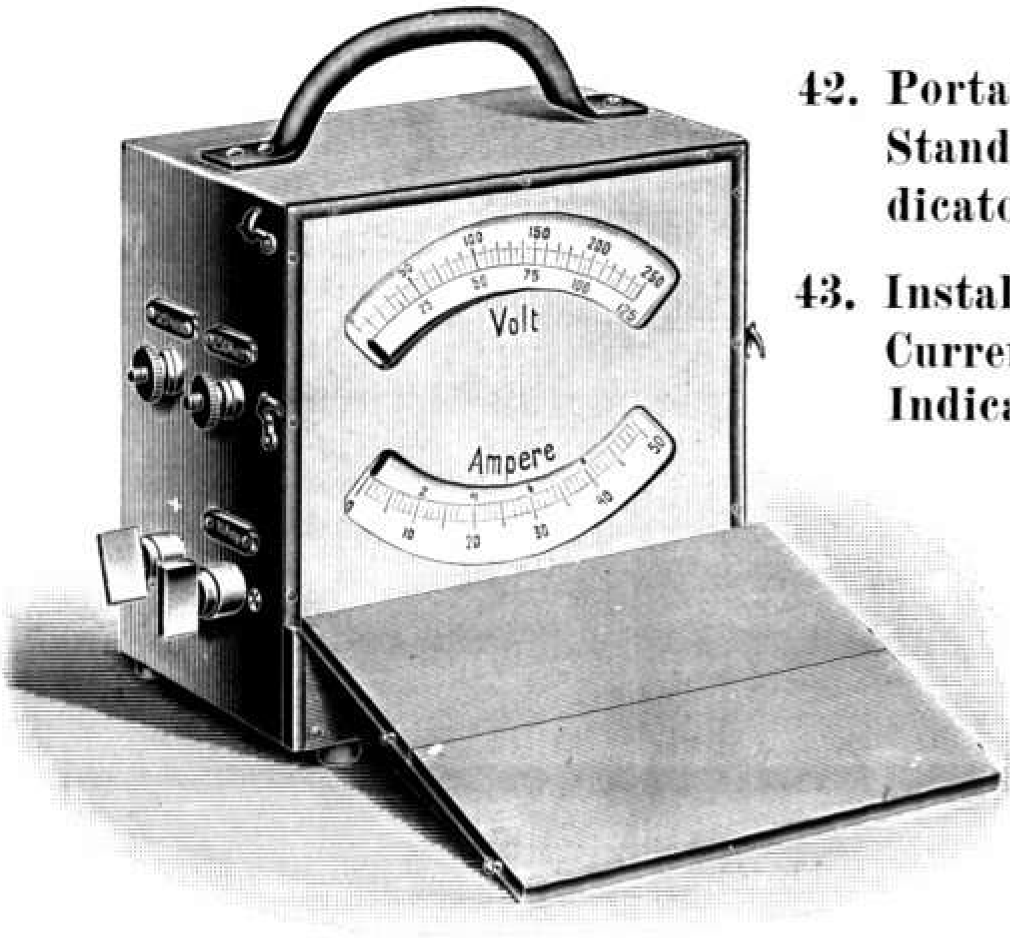


Fig. 38.

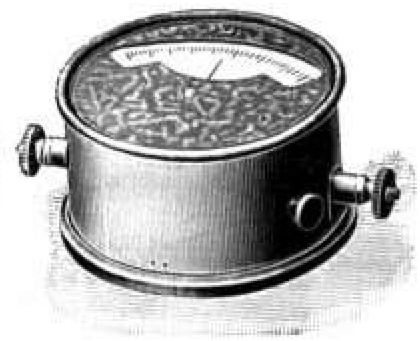


Fig. 37.

44. Current and Voltage Indicator. Circular form with three ranges of current and voltage measurements.

Especial attention is called to

45. Universal Galvanometer (Fig. 39). This unites a moving coil instrument with a Wheatstone bridge and permits the direct measurement of current, voltage, E. M. F., battery and wire resistance up to about 30000 ohms, and the finding of faults in conductors. The bridge can also be used with alternating currents for determining the resistance of electrolytes, using the telephone.

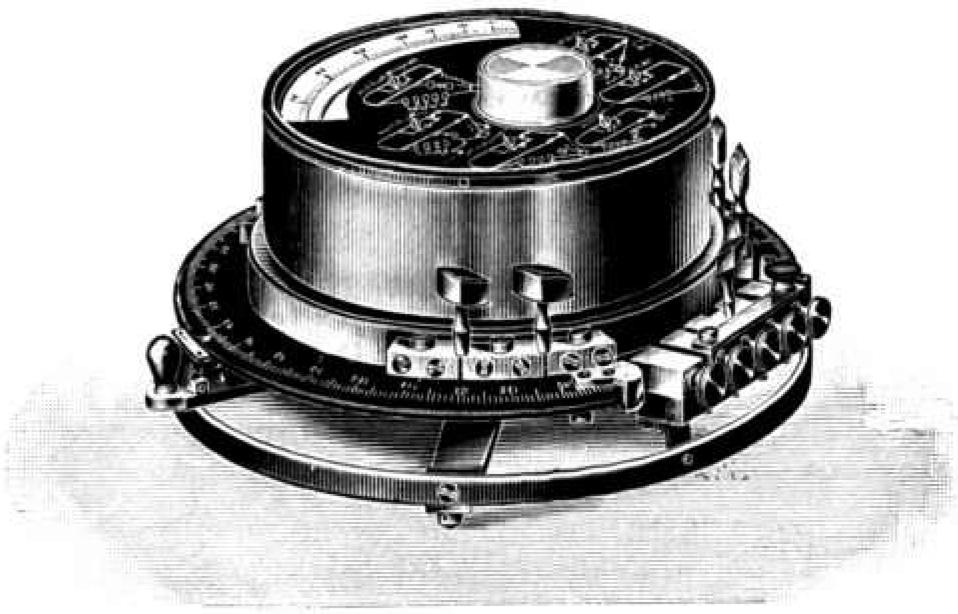


Fig. 39.

Telephone and its accompanying *induction coil* are exhibited with the instrument.

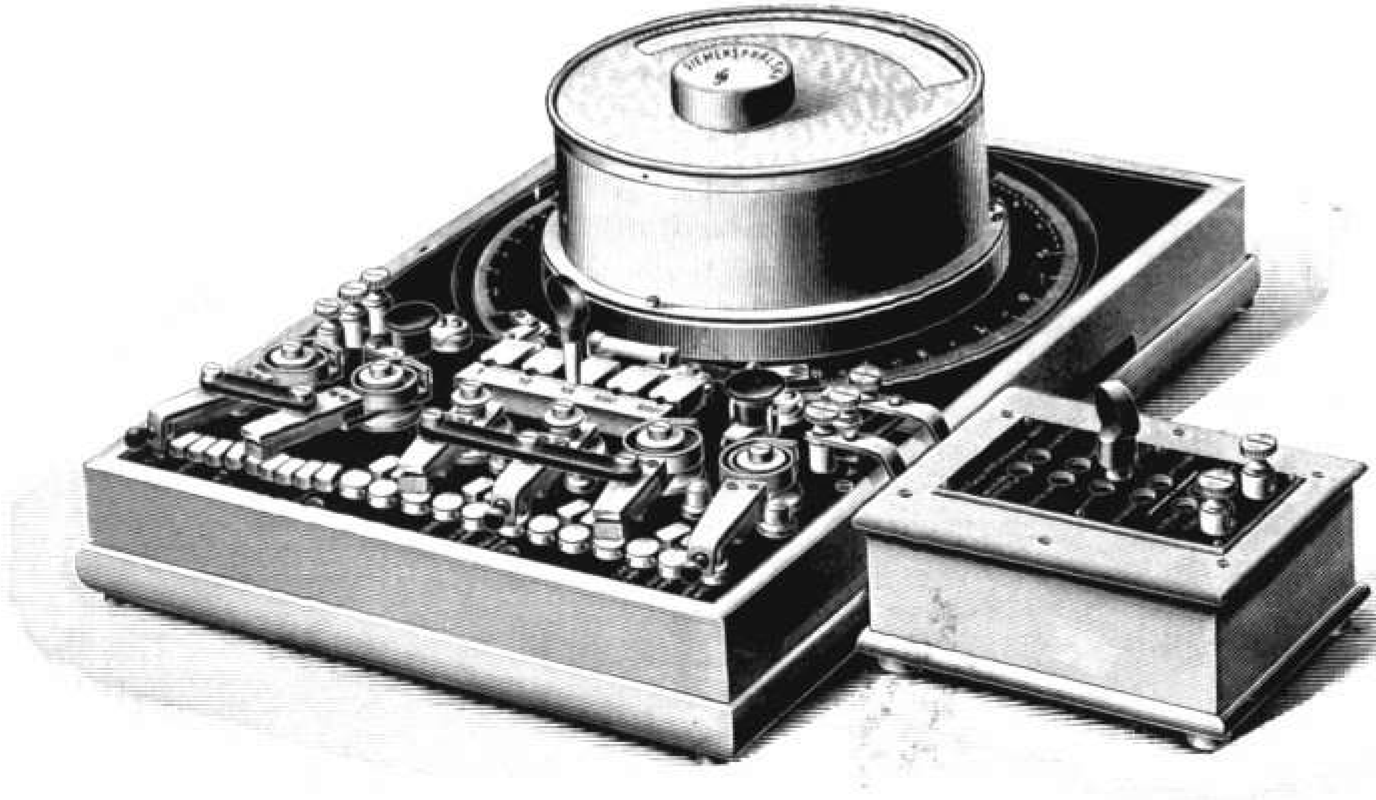


Fig. 40.

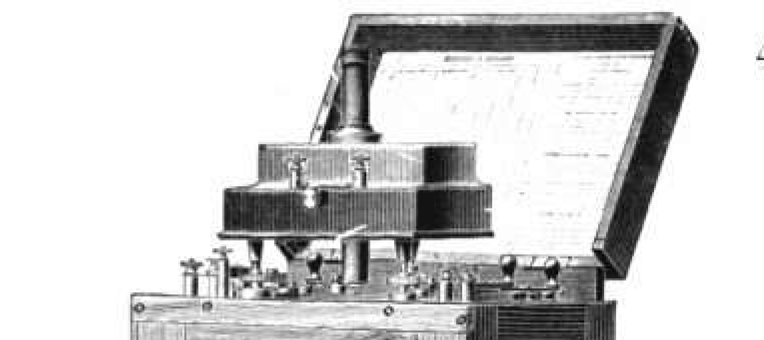


Fig. 41.

46. Universal Measuring Instrument for Telegraph and Telephone Conductors (Fig. 40). Similar to the above. Has been widely introduced by the post and telegraph authorities in different countries. The following measurements can be made with this universal instrument: 1. resistance measurements on single and double conductors, 2. insulation measurements between single conductors and the earth, and between double conductors, 3. measurements of stray current in single conductors, 4. current and voltage measurements. If the apparatus is to be used for installations or inspections, it is furnished with a suitable battery in a case with the necessary switches.

47. Portable Testing Set (Fig. 41). This contains a very sensitive moving coil galvanometer, in which a high sensibility is attained by introducing the current through the suspension strip or spiral between which the coil hangs, instead of through the torsion spring. This set contains all the necessary apparatus for determining at any place insulation, capacity, resistance and the position of faults.

b) Standard Instruments for Direct, Alternating and Three Phase Currents.

The electrodynamic principle has proved itself free from objection for all measurements in which the effective values of current, voltage and energy are to be determined independently of frequency and curve form. According to this, a movable coil, carrying a current, is deflected in the magnetic field of the fixed coil, this field being made as homogeneous as possible. To prevent Foucault currents, the cases of these instruments are made of wood. Air damping secures almost aperiodic motion of the pointers. According to the connections of the coils or by using shunts, current, voltage or energy indicators are obtained.


Fig. 42.

48. Standard Amperemeter with two ranges, and

49. Standard Voltmeter with two ranges. Correspond in external form with

50. Standard Wattmeter (Fig. 42). This has two current ranges and three voltage ranges. These instruments are noteworthy in that their readings are independent of the length of time of connection. For high voltages, *voltage transformers* are used, or a

51. Series Resistance.

For large currents use is made of a

Fig. 43.

52. Current Transformer (Fig. 43).

For alternating current measurements also the rotating field instrument has been introduced.

53. Portable Ferraris Energy Indicator (Fig. 44).

54. Portable Ferraris Current Indicator, externally similar to No. 53.

55. Portable Ferraris Voltage Indicator, externally similar to No. 53.

There are in addition the electromagnetic instruments, in which a soft iron core is drawn into a coil.

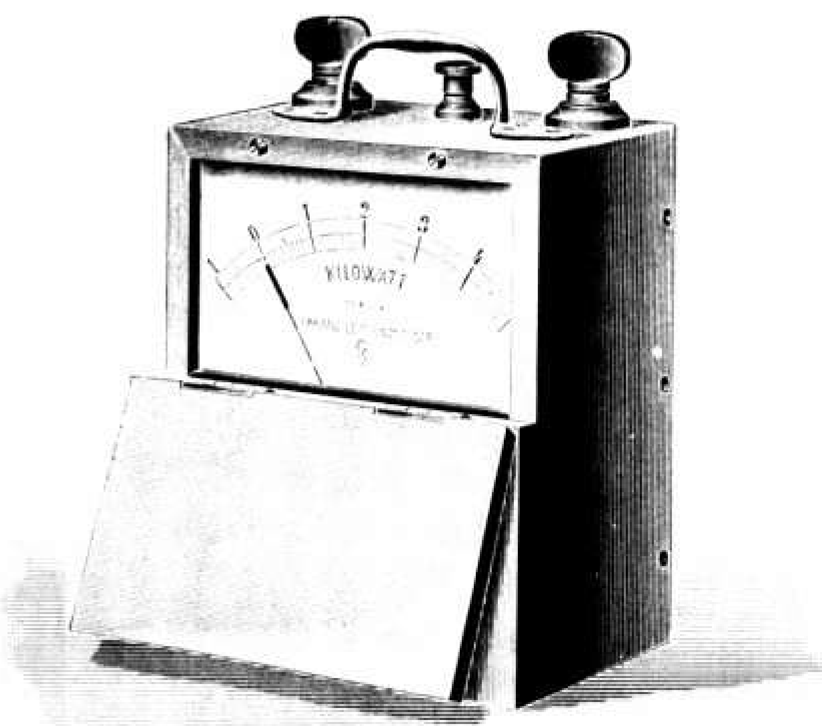


Fig. 44.

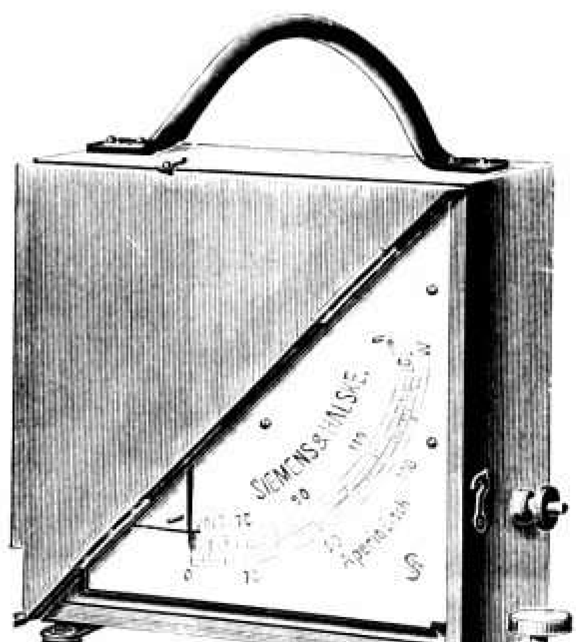


Fig. 45.

56. Portable Aperiodic Voltage Indicator (Fig. 45).

57. Portable Aperiodic Current Indicator } externally similar to No. 56.

58. Portable Aperiodic Energy Indicator }

c) Insulation Testers and Complete Apparatus for Measuring Insulation and Capacity.

The firm has constructed several pieces of apparatus for the preliminary insulation testing of the different parts of an installation and for testing it while it is being put in place.

Fig 46.

59. Insulation Tester with volt and ohm scale. Contains a moving coil galvanometer and allows insulation measurements to be made by means of a magnetic inductor, contained in the instrument, which furnishes an intermittent direct current, or by means of direct current, taken from the mains at 110 or 220 volts.

60. Insulation Tester (Fig. 46). With battery of 20 volts, contained in the instrument. Measurements up to 1 megohm can be made with this battery or up to 10 or 20 megohms with the current from the mains at 110 or 220 volts.

61. Resistance Meter for Blast Igniters. Similar in form to the above. Permits direct measurement of electric resistance of igniters.

62. Ferraris Insulation Meter (Fig. 47) for alternating currents. The voltage of the lighting mains can be used in the measurements.

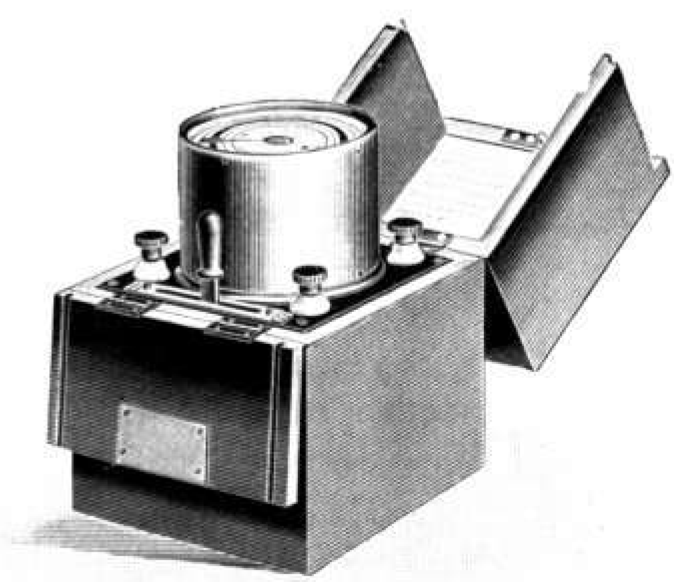


Fig. 47.

Fig. 48.

63. Insulation Meter (Fig. 48), used as control instrument. Has no source of current of its own but uses a special battery in case the measurements are not made with the voltage from the mains. By using a special battery, measurements can be made on alternating and three phase current lines while they are in use.

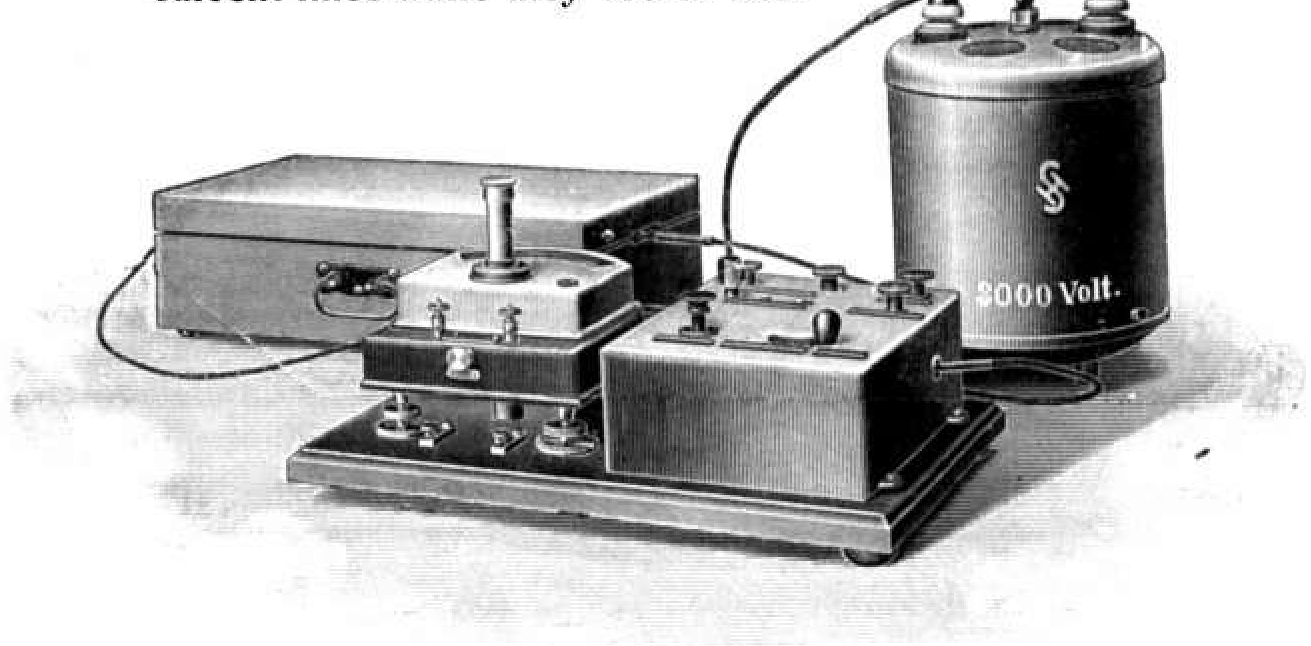


Fig. 49.

64. Apparatus for Insulation Testing (Fig. 49). For the measurement of insulation resistances in high potential circuits up to 1000 megohms, while in use; and for testing the insulation of cables, carrying high tension currents (for use in cable manufactories, etc.).

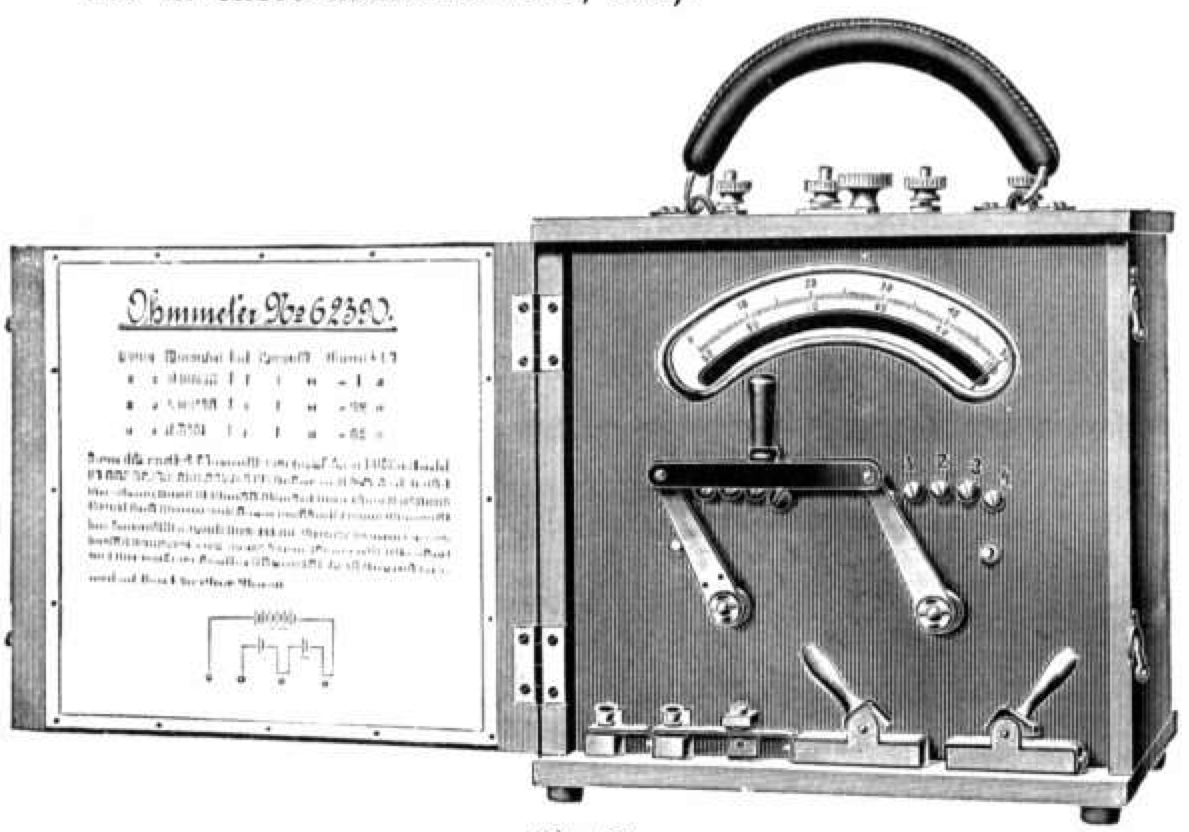


Fig. 50.

65. Ohmmeter (Fig. 50). For reading resistance directly. To be connected to a constant source of potential, 2—10 volts. With adjustable magnetic shunt, by means of which divergences from the propeı potential can be compensated.

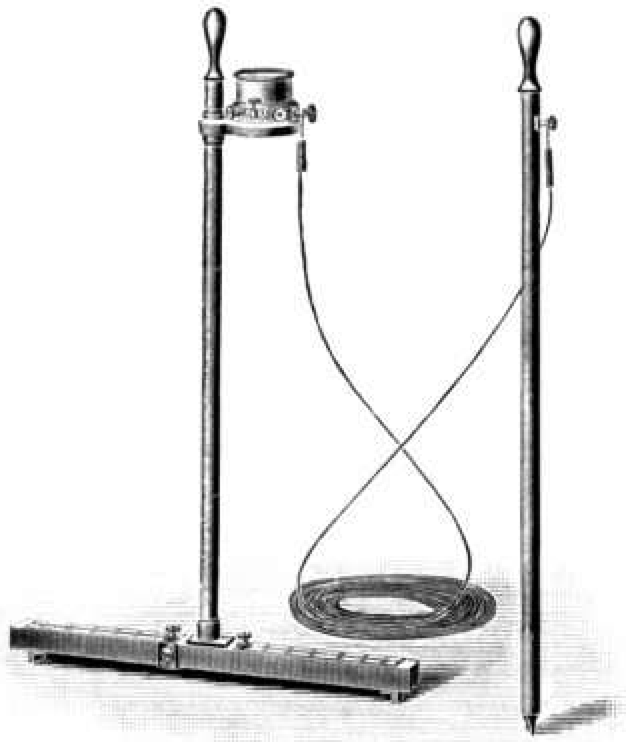


Fig. 51.

66. Apparatus for Measuring the Resistance of Rail Joints in Electric Railways (Fig. 51). This does not permit the measurement of the resistance directly in ohms but gives a comparison of the resistance of the joint with a portion of the rail itself. By simple calculation the resistance can be reduced to ohms.

67. Apparatus for Measurement of Insulation and Capacity (Fig. 52), to be connected to a Deprez-d'Arsonval mirror galvanometer. Insulation range 0 to 150000 megohms, capacity range down to 0·0001 microfarad, with 110 volts.

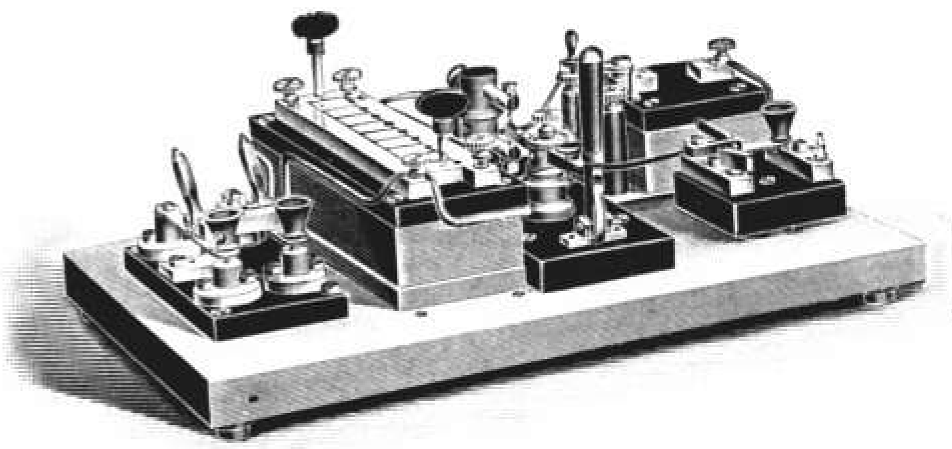


Fig. 52.

Auxiliary apparatus: a) *condenser* of 0·1 microfarad; b) divided *condenser*, in twelve divisions, giving from 0·001 to 1 microfarad; c) *resistance* with shunt binding posts (1 megohm in ten divisions of 100000 ohms each), to be used for high potentials in place of the 100000 ohms resistance contained in the instrument.

d) Mirror Galvanometers, Electrodynamometers and Electrometers.

68. Mirror Galvanometer, according to Deprez-d'Arsonval (Fig. 53). These instruments, as is well known, consist of a moving coil in a powerful magnetic field. Their special advantages are:

The galvanometer readings are over a wide range proportional to the current on account of the completely homogeneous magnetic field. The coils are light and easily interchangeable. It is therefore possible, while using the same base, to use the coil, which is best suited to the measurement which is to be made. The coils are furnished with damping resistances. For special purposes (ballistic measurements) the moving system can be weighted so as to ensure a longer time of swing with little damping. By means of a magnetic shunt, the sensibility can be changed over a range of about 35%. The principal parts of the instrument are shown in Fig. 54.

The following pieces are used as auxiliary apparatus:

69. **Shunt** (Fig. 55). So arranged that the damping of the galvanometer is independent of the shunt resistance.

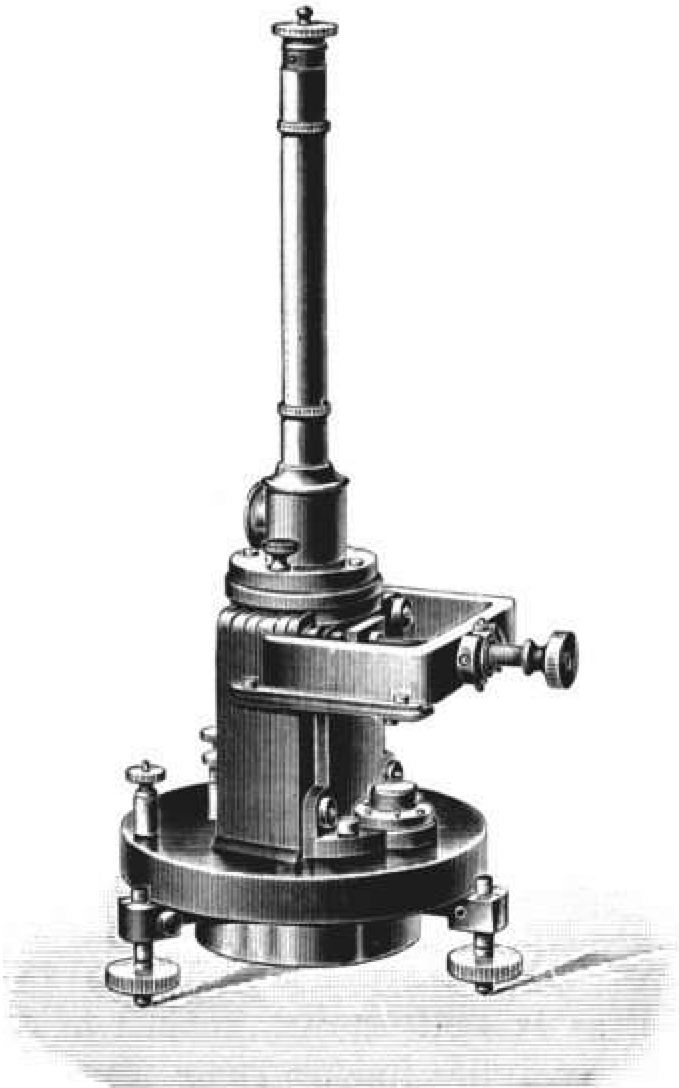


Fig. 53.

Fig. 54.

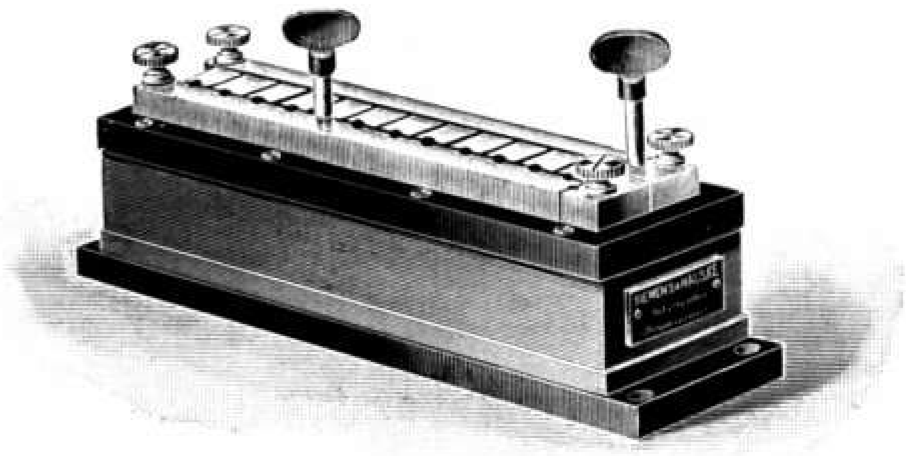
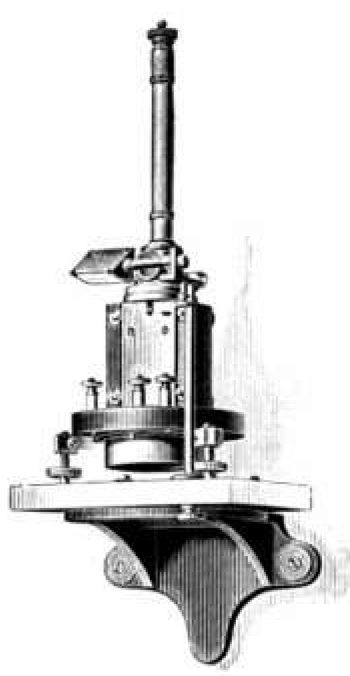


Fig. 55.



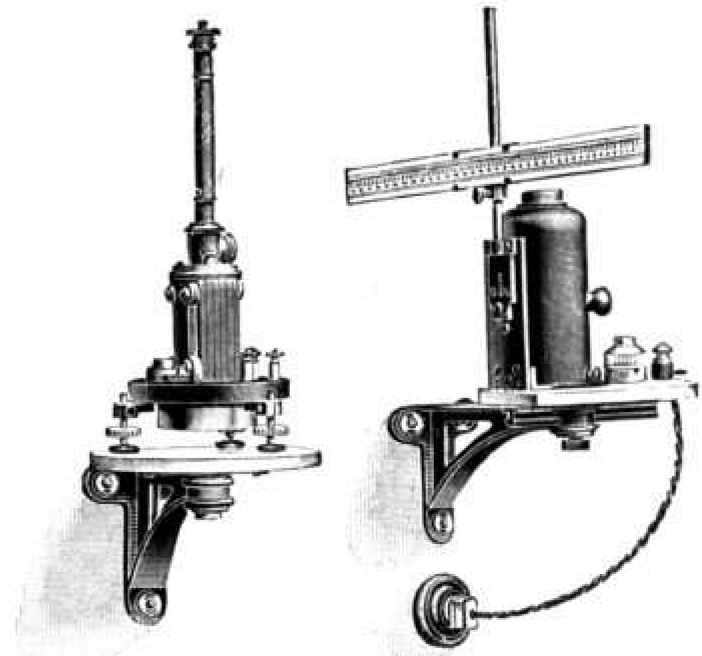


Fig. 57.

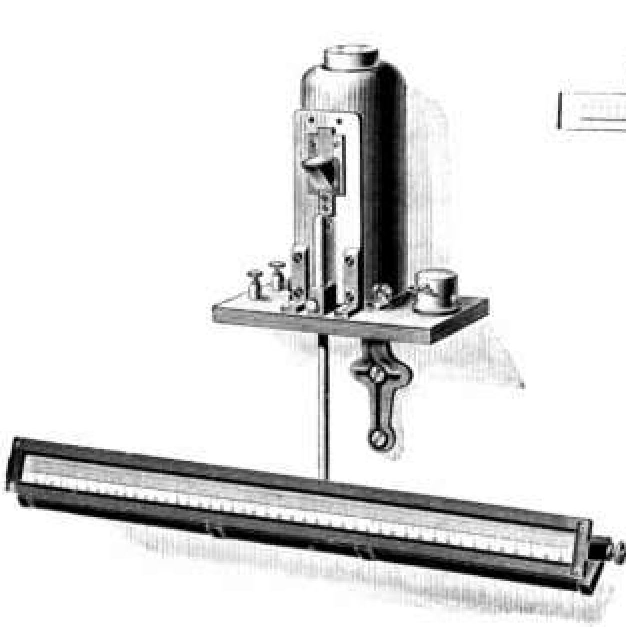


Fig. 53.

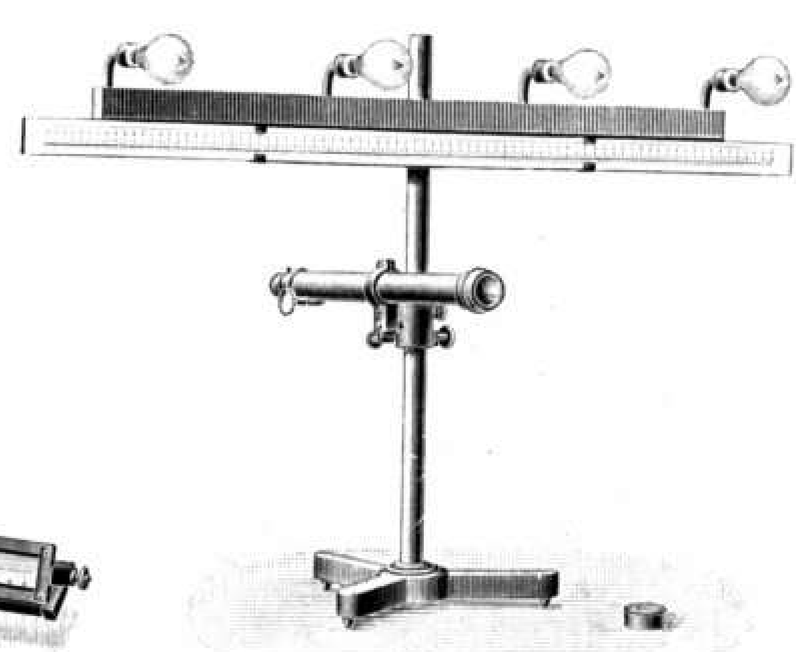


Fig. 58.

70. Vertical Reading Apparatus (Fig. 56). The advantage in this consists in the small amount of space required, in the convenient position of the scale for the observer, and the great intensity of the spot of light so that readings can be made even in well lighted rooms. Especially intended for zero methods.

71. Horizontal Reading Apparatus (Fig. 57) for deflection methods.

72. Telescope (Fig. 58). For reading scales with a distance between instrument and scale of over 2 *m*. Magnification 40 times. The smaller form of this telescope has a magnification of 20 times.

73. Spherical Armored Galvanometer, according to du Bois and Rubens (Fig. 59).

This "needle galvanometer" differs from the moving coil galvanometers in having fixed coils and a movable magnetic system. By means of the two concentric spherical iron shells and a cylindrical iron shell serving as a case, external magnetic disturbances are reduced to about 0·001. It can be used to advantage in all cases where there are magnetic disturbances from car lines etc., and where the sensibility of the Deprez-d'Arsonval galvanometer is not sufficient.

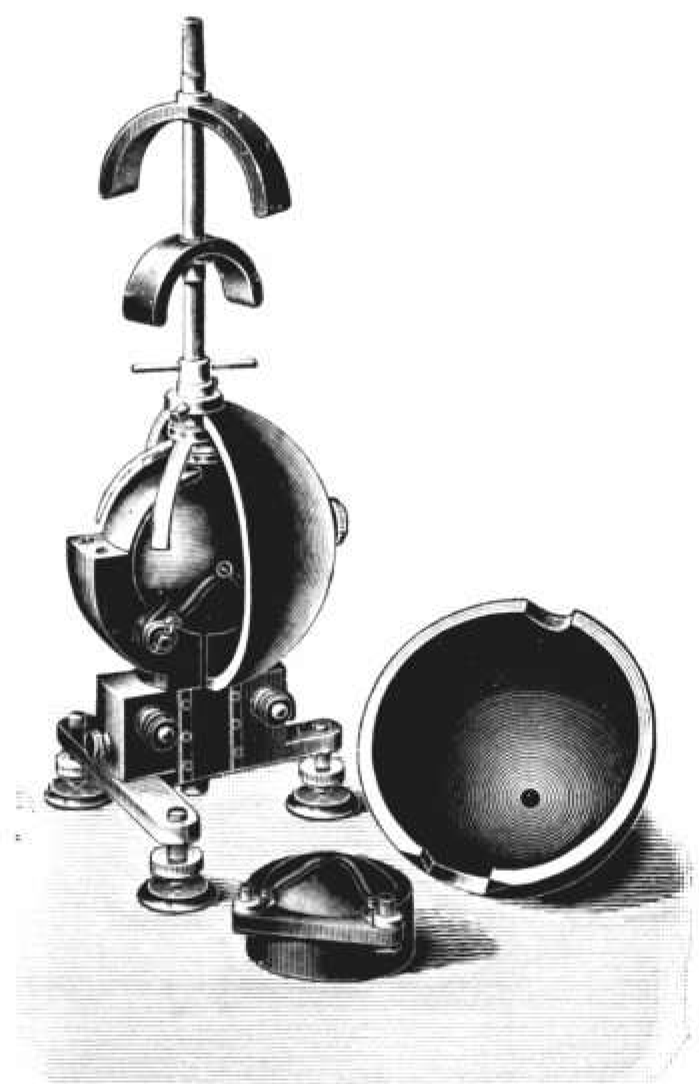


Fig. 59.

74. Suspension, according to Julius.

For the prevention of mechanical disturbances mirror galvanometers are placed on special suspensions. Fig. 60 shows a special construction for a disturbance free suspension of the armored galvanometer. The readings are made with telescope No. 72.

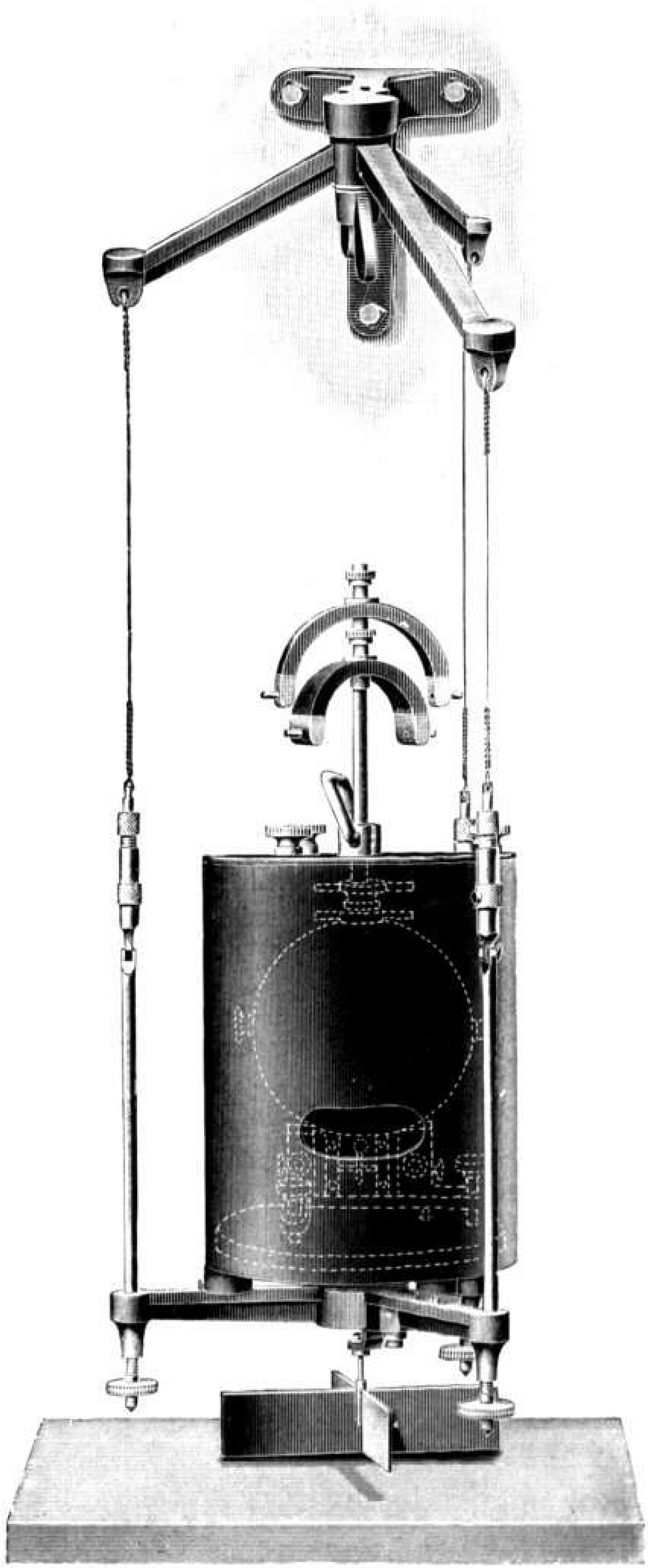


Fig. 60.

75. Mirror Electrodynamometer, free from Foucault Currents (Fig. 61), for the measurement of weak alternating currents. Like all dynamometers this instrument consists of a fixed and a moving coil. In its construction no metal not necessary for the conduction of the current is used. The instrument, which is entirely free from Foucault currents, can be used for accurate energy measurements, with or without difference of phase. It is provided with an air damper, made as far as possible of insulating material.

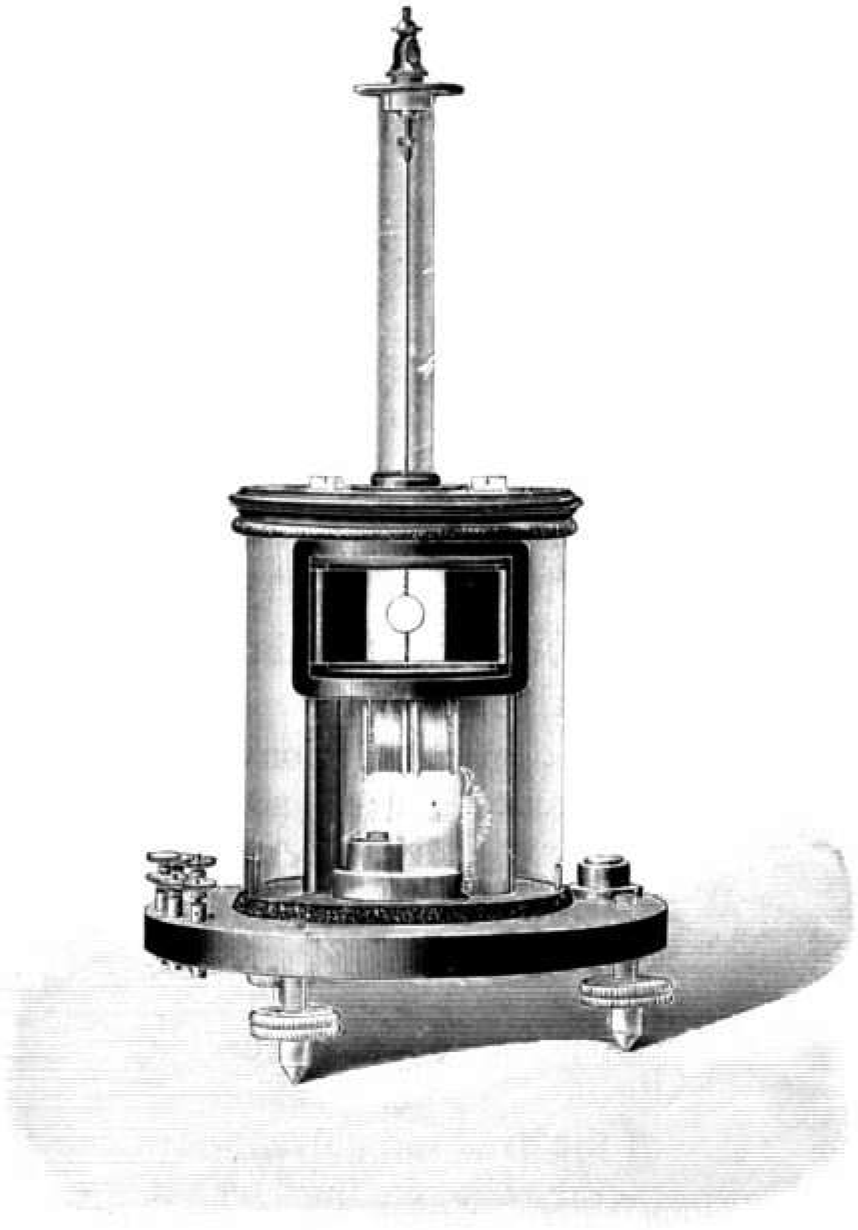


Fig. 61.

76. Electrometer, according to Beggerow (Fig. 62) with two adjustable electrodes and a movable needle, the latter consisting of a very thin metal band of small capacity. Readings are made with a microscope and ocular micrometer. Enclosed in metal case with amber and quartz insulation. The air is dried by means of metallic sodium. Range 0·1 to 50 volts with auxiliary potential of 300 volts.

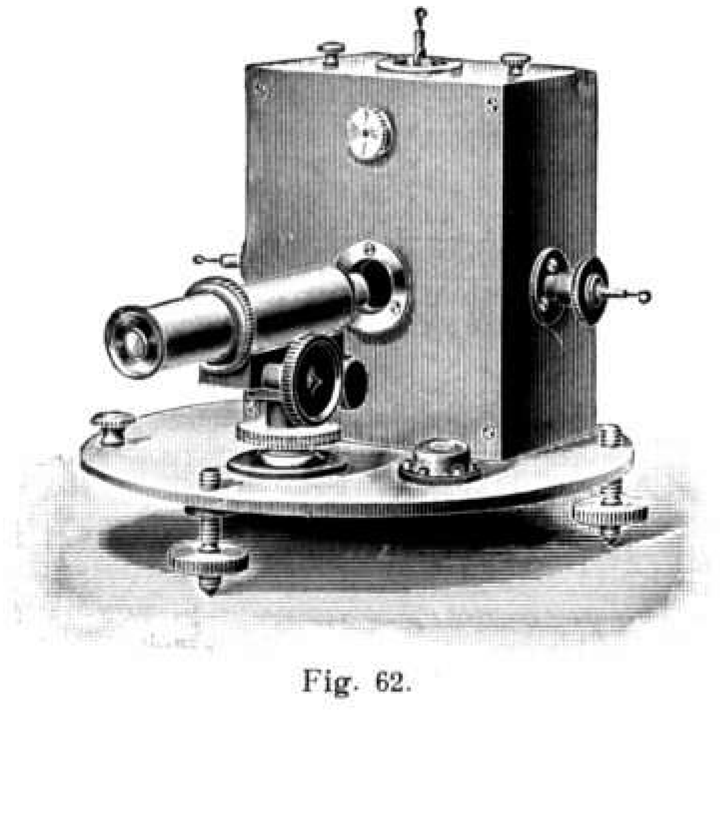


Fig. 62.

III. Switch Board Instruments for Different Varieties of Current.

a) Registering Apparatus.

77. Registering Apparatus with Intermittent Registration (Fig. 63). For the registration of the variations of current, voltage and energy in electrical laboratories, this firm has constructed registering apparatus on the principle of intermittent registration. In these a paper strip 45 *m.* long is drawn under the pointer with a definite velocity by means of an accurate clock work. At equal intervals the pointer is depressed by an arm against the paper strip, and with the help of a printing ribbon registers the current, voltage, or energy curve in the form of a row of dots. For *direct currents* the apparatus is supplied with standard instruments of the Deprez-d'Arsonval type for current and voltage registration; or one instrument may serve both purposes by using shunt or series resistances, thus forming an universal registering apparatus. For *alternating currents*, electro-magnetic current and voltage indicators are chosen with damping as nearly aperiodic as possible. In *high voltage circuits* and for registering *heavy currents*, the apparatus is used in connection with current and voltage transformers. By means of proper switches a registering apparatus may be used in connection with several transformers. The *energy registering apparatus* for direct and alternating currents makes use of the same system as the standard wattmeter No. 50.

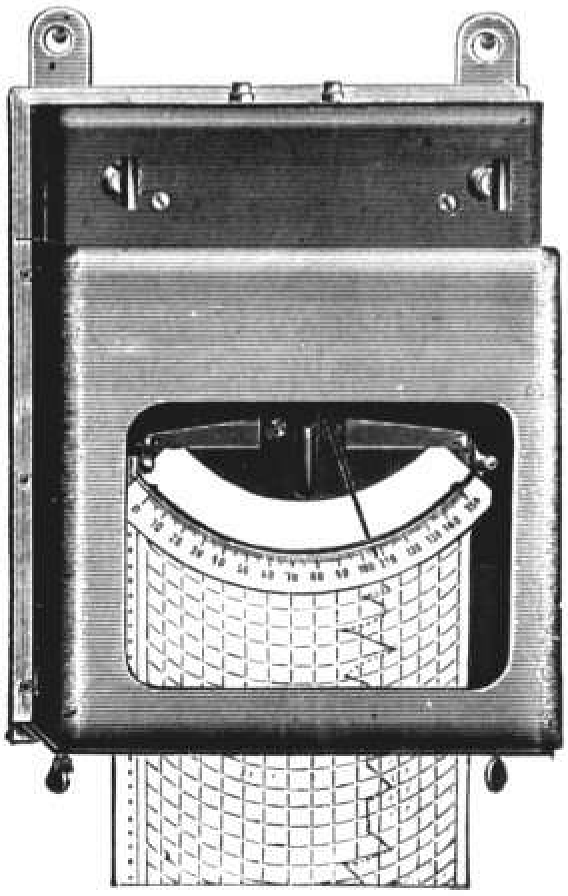


Fig. 63.

78. Voltage Transformer (Fig. 64).

79. Current Transformer (Fig. 65).

80. Registering Apparatus with Spark Registration. Instruments have lately been introduced with spark registration for recording rapidly varying electrical processes, as for example, showing the change in the current and energy in starting an electric car or in connecting or disconnecting an electric crane. These instruments have almost aperiodic damping, and light, rapidly swinging systems, so that the pointer readings actually correspond with the values of the electric quantities at the given moment. The position of the pointer is marked continuously on the registering paper by the perforating sparks. Registering apparatus of this sort is now made for current and voltage indicators for direct current, and as energy indicators for direct, alternating and three phase currents.

Fig. 64.

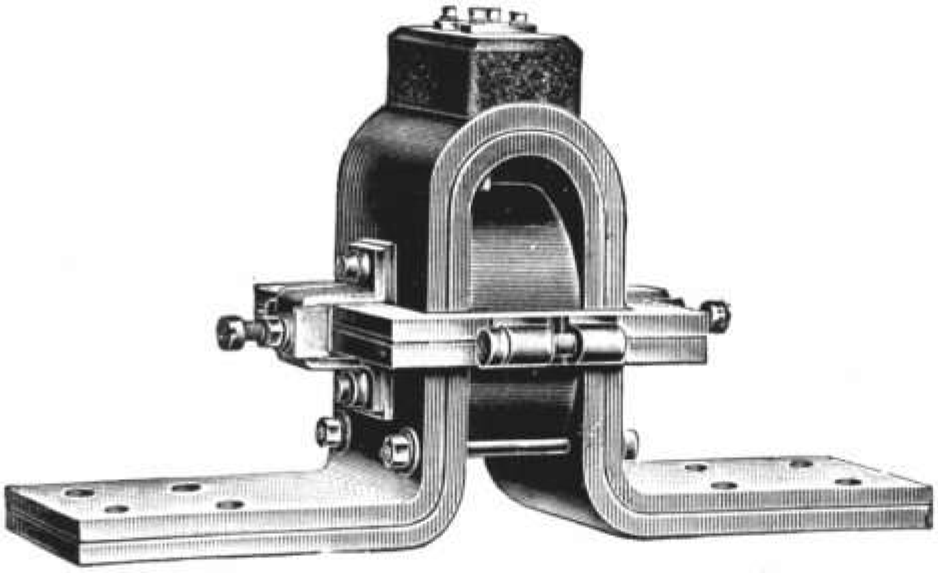


Fig. 65.

Fig. 66 shows a copy of a registration strip in one half natural size, on which is registered the starting current of a 150 horse power motor, connected with a three phase machine without load.

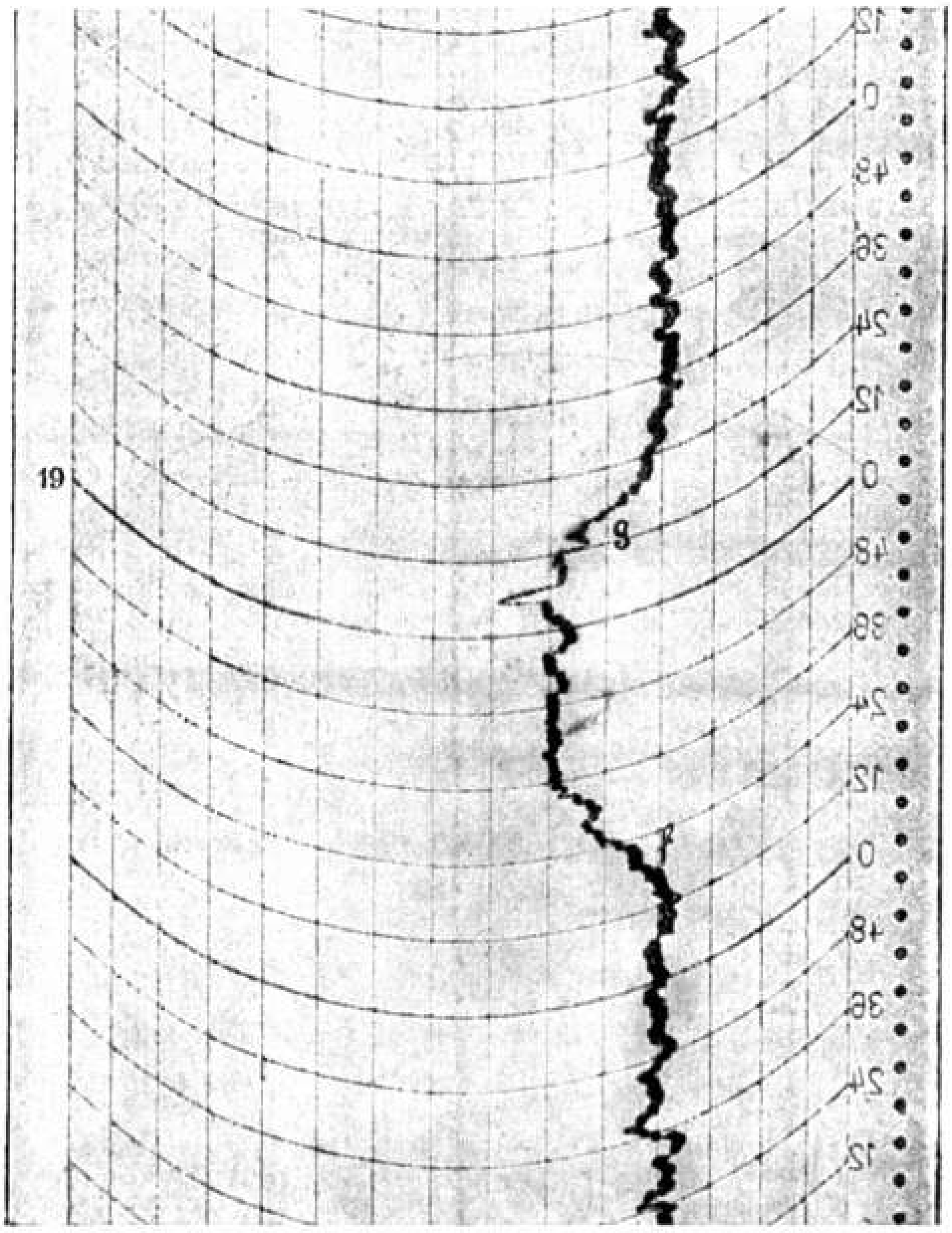


Fig. 66.

b) Ferraris Instruments.

The advantages of the Ferraris instruments, made by this firm, are: large rotational moment of the moving system, resulting in certainty of reading; invariable zero; excellent damping even in instruments with long pointer; scale easily read, being 120 degrees of arc in length, can be made uniform if desired, giving great accuracy of reading; independence of neighboring currents. By using current and voltage transformers in the case of large currents and high voltages, the use of the instruments is rendered free from danger.

For three phase currents it is sometimes best to arrange the necessary instruments upon a pillar, instead of on a switch board.

81. Universal Indicator (Fig. 67). Current, voltage and energy indicators are in the same case which is possible, since they do not influence each other. The energy indicator and cur-

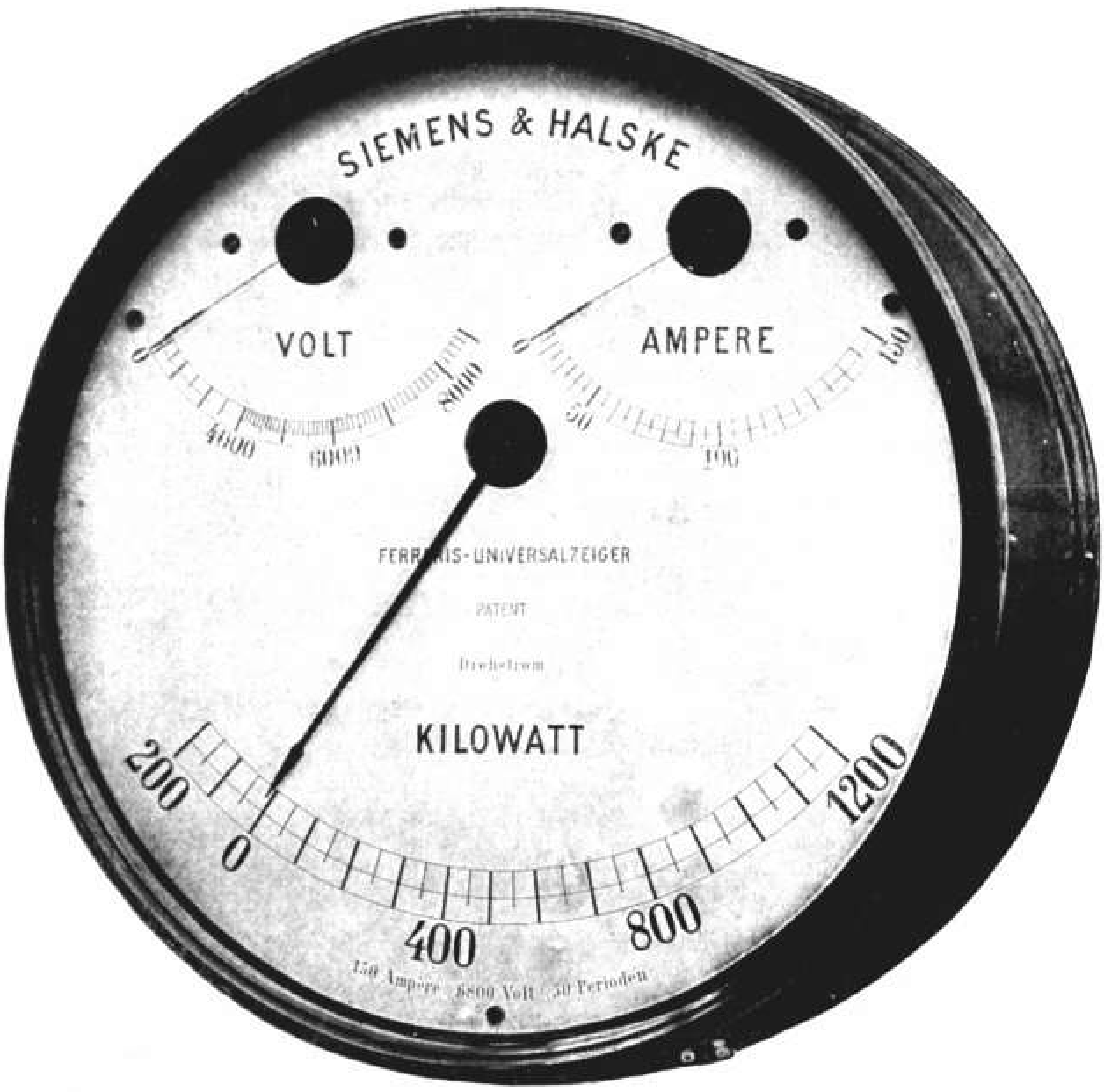


Fig. 67.

rent indicator are connected to a common current transformer, and energy indicator and voltage indicator to a common voltage transformer.

82. Current Transformer (Fig. 68). Arranged for 200 amp. at 20000 volts. These transformers are also furnished for currents up to 200 amp. and 30000 volts.

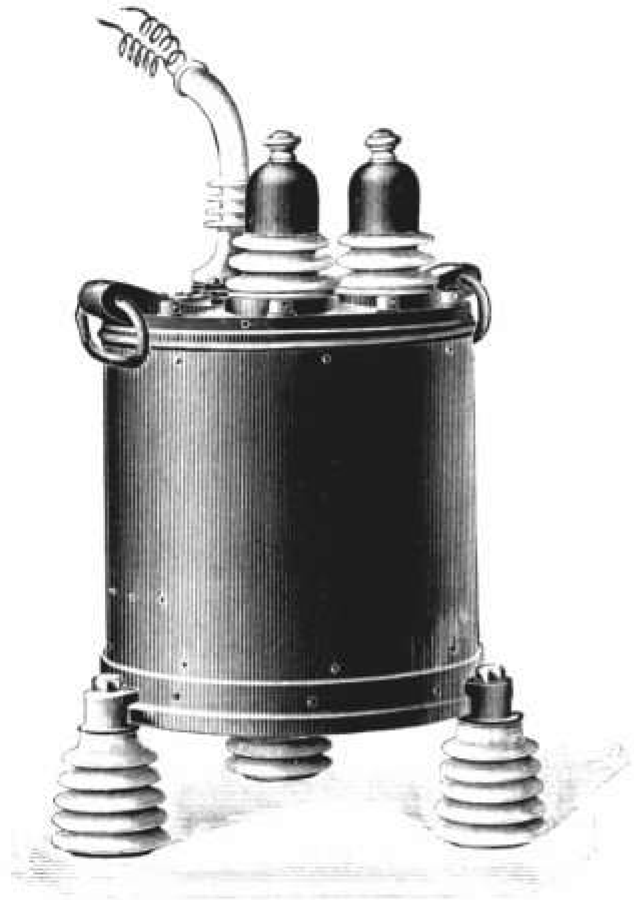


Fig. 68.

83. Voltage Transformer for regular use at 20000 volts, also built for 30000 volts.

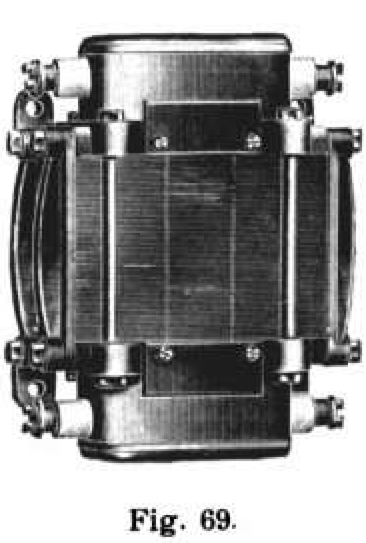


Fig. 69.

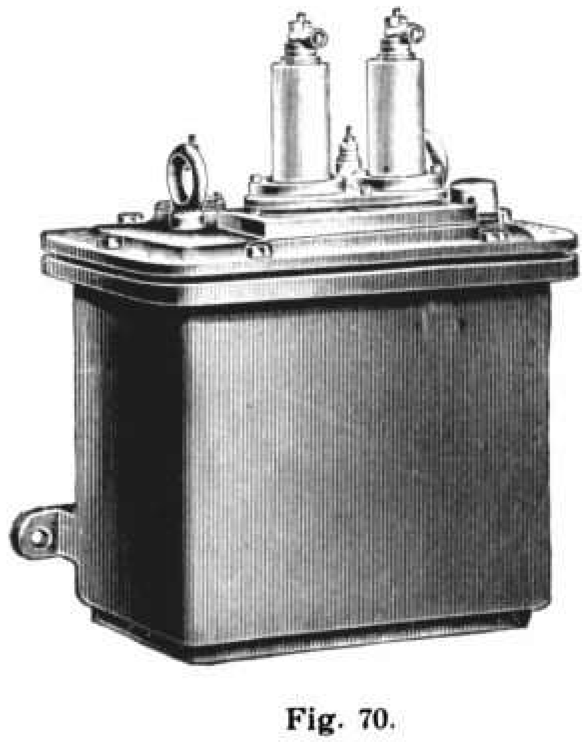


Fig. 70.

84. Current Transformer (Fig. 69) for continuous use with 100 amp. at 20000 volts.

85. Voltage Transformer (Fig. 70) for continuous use at 6000 volts.

86. Ferraris Voltage Indicator, arranged as switch board instrument. In current and voltage indicators, which are used over the whole range of the scale, an almost uniform arrangement of the divisions can be attained by means of a patented spring device. Externally similar to No. 87.

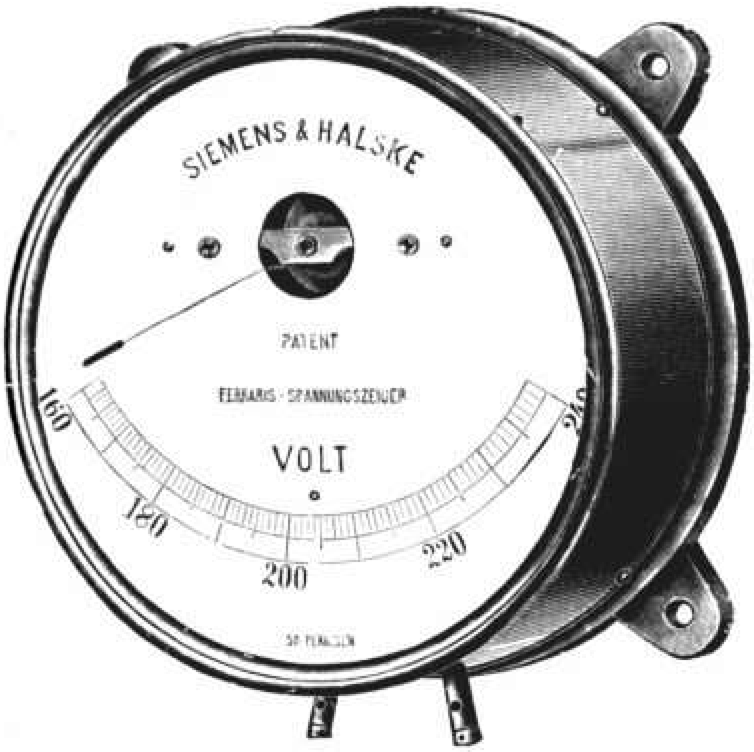


Fig. 71.

87. Ferraris Voltage Indicator (Fig. 71), reading only the upper range of the scale.

88. Ferraris Current Indicator, externally similar to No. 87.


Fig. 72.

89. Controlling Apparatus (Fig. 72), made on the Ferraris rotating field principle. For procuring constancy of voltage in alternating and three phase circuits. It sets in action a mechanical or electromagnetic arrangement, which then attends to the regulation of the voltage. In small establishment it is sufficient to set in action an acoustic or optic signal.

90. Phase Indicator with Lamp Case (Fig. 73). For determining the equality of phase in bringing three phase generators into parallel. The apparatus is here represented with aperiodic voltage indicators, but for establishments, which possess Ferraris instruments, will be furnished with these. Beside the voltage indicator, which shows the voltage on the terminals of the dynamos, there is a lamp case with three incandescent lamps so connected that they light up one after the other, and the order in which they light indicates whether the driving dynamo runs too rapidly or too slowly. A second voltage indicator is connected in parallel with one of the lamps and indicates the exact moment of equality of phase more accurately than the lamp.

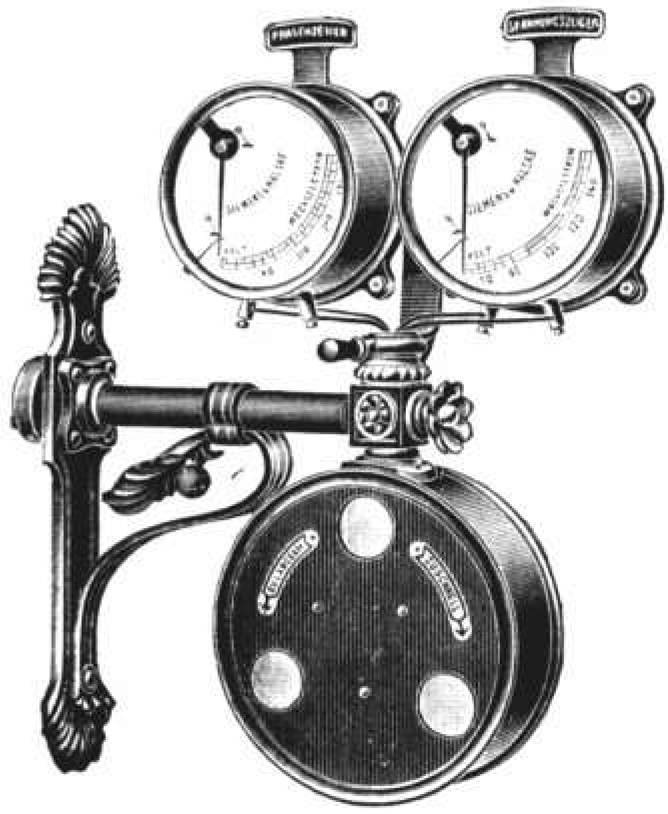


Fig. 73.

91. Standard Energy Indicator (Fig. 74) on the dynamometer principle. Especially for alternating and three phase currents, using the system of the standard wattmeter No. 50.

Fig. 74.

IV. Apparatus for Reading Ship Compasses at a Distance.

On modern war ships the strength of the earth's field is not only greatly diminished in most places, where compasses are to be used, by the great masses of iron and steel, but it is possible that the movement of these large magnetic bodies (turrets and guns) can produce a change in the direction of the field. For a long time, therefore, there has been great necessity for a reliable method of compass-reading transmission. This must consist of a primary compass (transmitter) which is placed in a magnetically favorable portion of the ship, where the above mentioned disturbances are infinitesimal, and of one or more secondary compasses (receivers) which are independent of external magnetic disturbances and which at each moment indicate the exact position of the card of the primary compass. The exhibited compass-transmission system fulfills these conditions most completely. It rests on the bolometric principle and works without relays.

92. **Primary Compass** (Fig. 75). This has the same form and auxiliary parts as the compasses, usually found on board German ships. The card used is of the so called "Kaiser" form, which is especially suitable for this purpose on account of the magnets on the periphery. A mica disc, covered with tin foil, is connected with the card. The tin foil has a horn shaped opening through which the rays of a powerful incandescent lamp fall on the stationary system of bolometers below the card. Different portions of this system, in which the bolometers are arranged in a radial grating form, are illuminated, according to the position of the compass card. The radiation produces changes in resistance, which in turn produce current variations in the circuits containing the bolometers. These cause the cards of the secondary compasses to exactly follow the movements of the primary compass card. The electromagnets of the secondary compasses, the incandescent lamp and the system of bolometers all receive their current from the direct current lighting system of the ship. Changes of voltage in this system have no influence on the accuracy of the transmission.

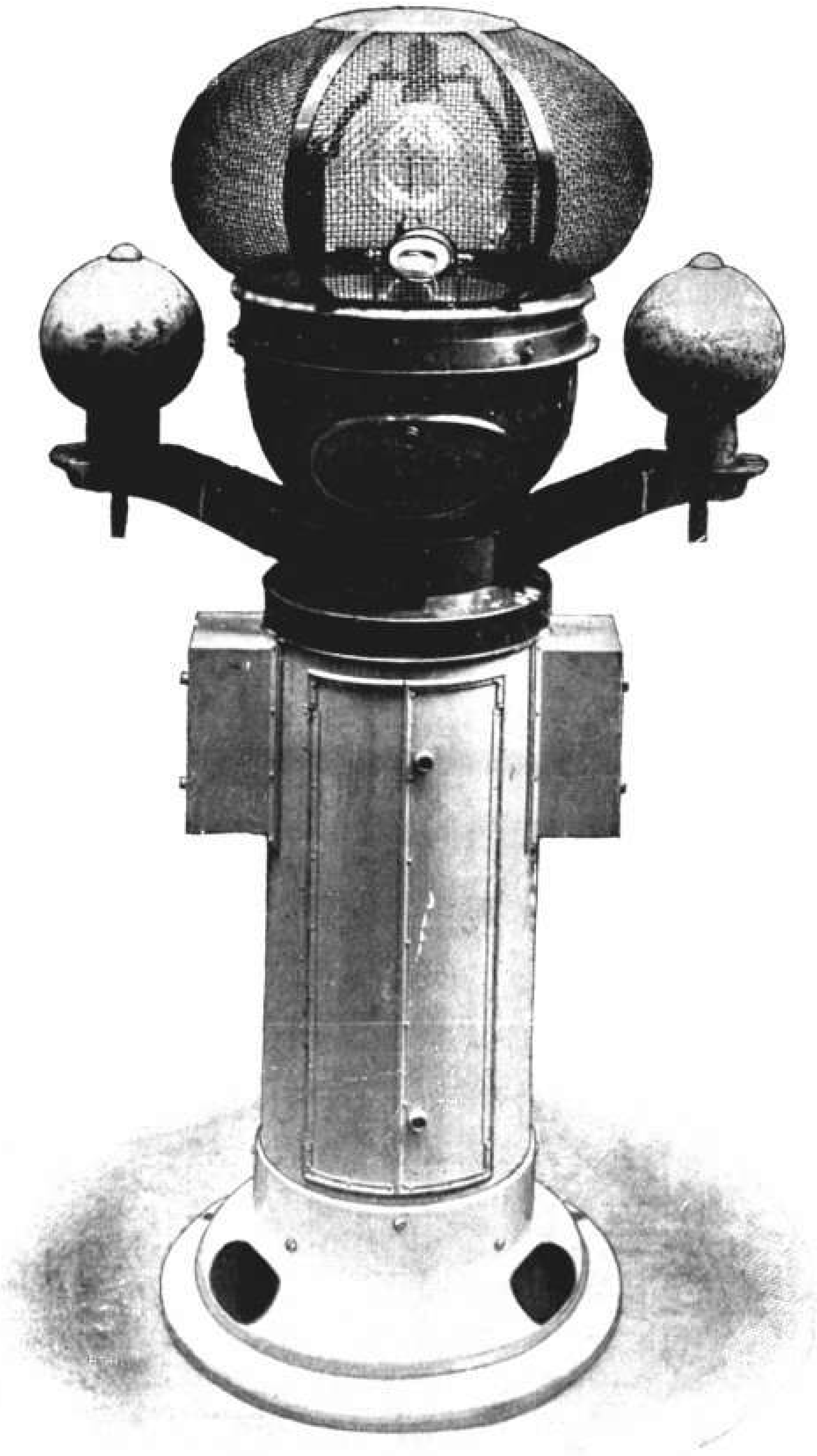


Fig. 75.

93. Secondary Compass (Fig. 76). This consists of an instrument of the Deprez-d'Arsonval type with a horse-shoe electro-magnet (see No. 34). The moving coil contains two differential sets of windings. These are traversed by currents whose intensities are varied by the changes in resistance of the bolometers in the primary compass. The card of the secondary compass is attached to the moving coil.

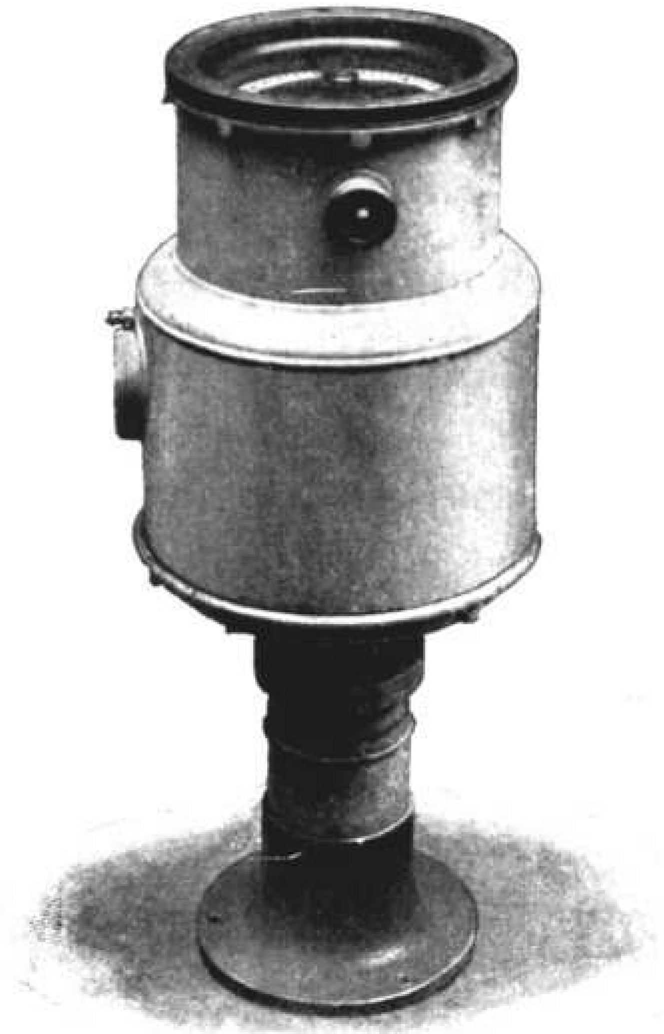


Fig. 76.

A special arrangement allows the card to make complete revolutions without injury to the spirals introducing the current. In addition to the secondary compass, shown in Fig. 76, a second smaller and lighter form of secondary compass is exhibited.

94. Switch Board, carrying the necessary safety fuses, switches, measuring instruments and connections (for the sources of current, transmitter and receivers).

This system of compass transmission possesses several advantages: the receiver card, as soon as connected with the transmitter, indicates at once the same course as the primary card without any preliminary adjustment; the moving parts of the secondary compass are so completely damped that as soon as the current flows the position of the card corresponds at each moment with that of the primary compass; the secondary card follows the motions of the primary continuously, not intermittently; the motions of the primary compass are entirely free as there are no contacts; it acts with sufficient certainty even when the horizontal intensity is reduced one half; one adjustment of the apparatus is sufficient for a long time, for example, experiments undertaken on board *S. M. S. Württemberg*, extending over several months, showed no change in the adjustment to be necessary; the apparatus works without relays and there are no parts, essential to the accuracy of transmission, which are subject to deterioration; the large incandescent lamp for lighting the bolometer system can be changed for another without causing errors.

A transmission system of this kind, in which the transmitter simultaneously controls several receivers, was installed for trial on the Dutch iron clads *Piet Hein* and *Kortenaer* several years ago. The results were very encouraging although they were the first instruments of this sort. Since then the system has been revised and several important improvements in principle and construction have been introduced. During the year 1903 very satisfactory results were obtained with the improved apparatus, in the experiments already mentioned on board *S. M. S. Württemberg*; even when the large guns close to the apparatus were fired it was not disturbed.

Sommer & Runge

Berlin SW., Wilhelmstrasse 122.

Mechanicians.

No. 1 in A, No. 2—5 in D.

1. **Dividing Engine,** also comparator.
   The dividing engine is provided with a screw, having an easily removable nut. It has two microscopes. Free length 1 *m*. Reading directly to 0·001 *mm*.
2. **Petroleum Tester,** according to Abel, with essential parts duplicated.
3. **Igniting Point Tester,** according to Pensky-Martens.
4. **Viscosimeter,** according to Engler.
5. **Boiling Apparatus** for the investigation of mineral oils. For use in custom houses.

Wilh. Spoerhase (vorm. C. Staudinger & Co.)

Giessen (Hessen).

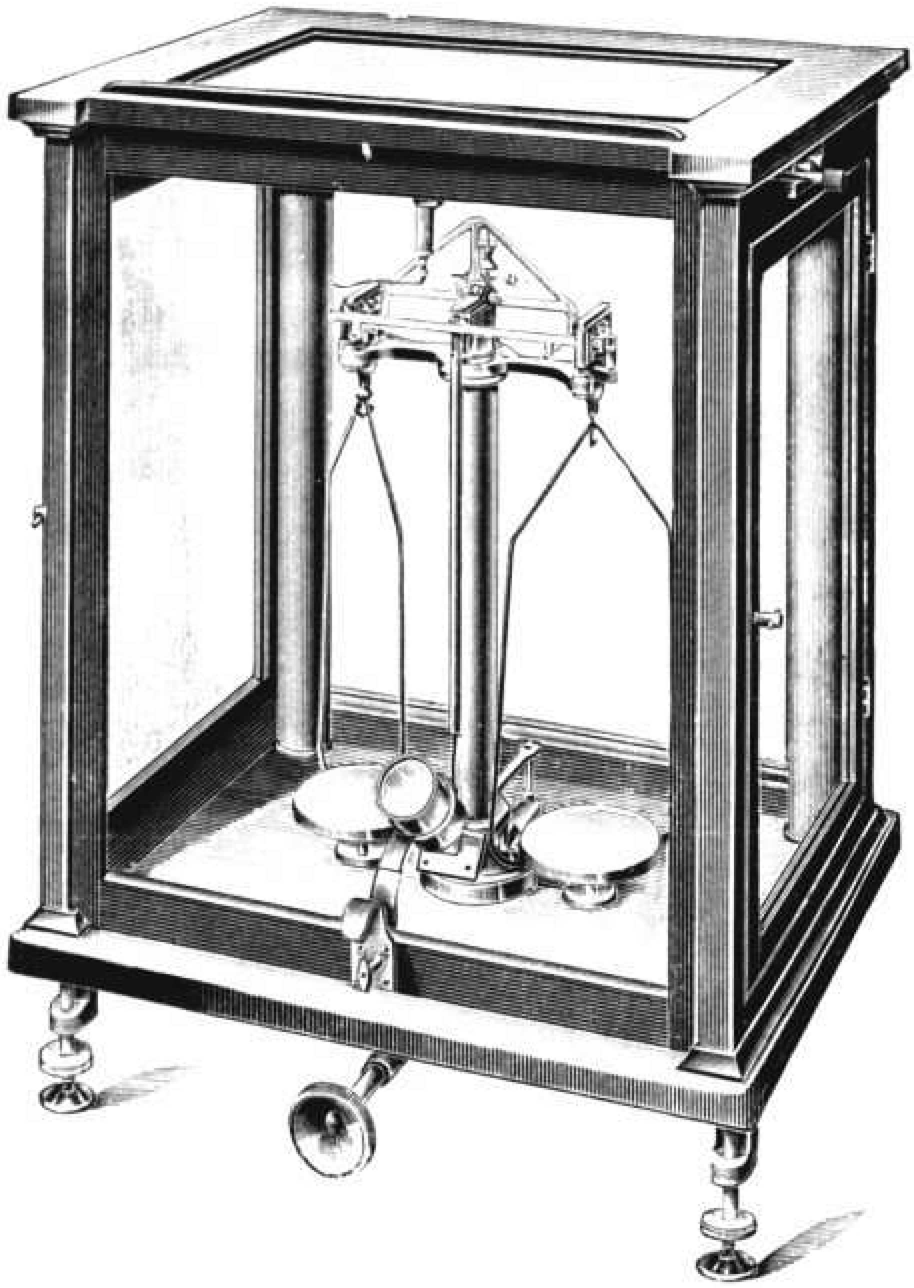
Manufacturer of Fine Balances and Weights for Physical, Technical and Chemical Use.

No. 1—4 in A.

1. **Analytical Balance No. 1a** (see Fig.). Maximum load 200 *g*. Sensibility 0·01—0·05 *mg*. For accurate analytical weighing. With arrangement for accurate reading of the scale. Completely protected from oxydation. Axes and bearings as well

as the contact points of the stirrups and arrestment of agate. Argentan beam. Accurately working rider adjustment and perfect arrestment.

2. **Analytical Balance No. 2.** Maximum load 200 *g*. Sensibility 0·1 *mg*. The balance is arranged like No. 1a and is especially intended for university laboratories.



3. **Analytical Balance No. 3.** Maximum load 200 *g*. Sensibility 0·1 *mg*. For factory and commercial laboratories. Axes and bearings and the contact points of the stirrup and arrestment of agate.

4. **Analytical Balance No. 3b.** Maximum load 200 *g*. Sensibility 0·2 *mg*. Axes and bearings and the contact points of the stirrups of agate. This balance is especially intended for laboratory practice.

P. Stückrath

Friedenau bei Berlin, Albestr. 11.

No. 1 and 2 in A.

1. 200 Gramme Balance.

This balance, made in the year 1903, serves for the comparison of the masses of weights between 200 *g.* and 10 *g.* The beam is of bronze, the stirrups and pans of an aluminium alloy (B-metal from C. Zeiß, Jena), the bearings are of agate, and the middle and end knife edges of the best steel. The scale is intended later to be read by means of a telescope. All the motions of the arrestment and the carrier for the automatic interchange of the loads are made by means of two handles. The carrier moves on ball bearings. Six auxiliary weights, in the form of riders, can be hung on each side of the beam without opening the case. This last is made of light metal. Sensibility of the balance, with the greatest load, at least five divisions per 1 *mg.*

2. Pressure Balance for the Measurement of High Pressures, up to 1000 *kg./sq.cm.*

The apparatus consists of a balance with unequal arms (ratio 1 : 10). The longer arm is loaded with weights, while a movable piston presses on the stirrup of the shorter arm. The piston is made tight in the cylinder, which contains the pressure liquid (diluted glycerine), by means of a collar of gold-beater's skin. To prevent friction of the collar, an arrangement is introduced for rotating this piston, so that the difference between the pressure readings for increasing and decreasing weights for 200 *kg./sq.cm.* is only 0·02, and up to 400 *kg./sq.cm.* is only 0·2 *kg./sq.cm.* The relative error of the pressure measurements can be assumed to be less than one half of this difference, while the absolute error depends upon the accuracy, with which the cross section of the cylinder, in which the piston moves, can be determined. A comparison of two such pressure balances gave results agreeing within 0·1 to 0·2 at 300 *kg./sq.cm.*, and 0·5 at 400 *kg./sq.cm.* (See *Zeitschr. f. Instrkde.* **23.** *p. 176. 1903* and Wiebe, *Zeitschr. f. kompr. u. flüss. Gase* **1.** *Heft 1, 2, 5, 6. 1897.*)

Ludwig Tesdorpf

Stuttgart, Forststrasse 71.

Manufacturer of Scientific Instruments of Precision.

No. 1—19 in A, No. 20 in D.

1. Portable Transit Instrument. (Fig. 1.)

Objective of 48 *mm.* opening; two eyepieces, magnifying 36 and 52 times; finder circle 15 *cm.* in diameter, graduated in $^1/_2{}^0$, reading to 1′; vertical fine adjustment. The lower structure is made of cast iron, the level carrier and holder etc. are made entirely of magnalium and aluminium. The construction is such that no strains can occur in the single parts.

For correcting the 3·5″ box level there is a levelling screw of 0·2 *mm.* pitch. The complete rider level, including mirror, weighs only 1·250 *kg.* The instrument is intended for zenit and nadir observations.

2. Large Portable Universal Instrument. Newest construction, according to the plans of Prof. L. Ambronn, Göttingen. (Fig. 2.)

This differs from the former types especially in having a particularly heavy double armed carrier for the two vertical circle microscopes so that they take an almost invariable position. On this carrier is set a cross level, having a sensitiveness of 8″ and provided with a reservoir and mirror. By this arrangement a much greater accuracy is attained than in former types, especially in the measurements of altitude. Both levels, rider level and cross level, are enclosed in glass. Both circles can be directly read to 10″ and by estimation to 5″; telescope with two oculars, magnifying 24 and 34 times; objective of 37 *mm.* opening. Central opening in the telescope axis for illuminating the cross hairs.

3. Tachymeter, according to Wagner. With adjustable filar distance meter. (Fig. 3.)

The projection of the diagonally measured distance on the horizontal, and also the difference in height of the points observed, reduced to the position of the instrument, can be read off directly without any calculation, in the ratio 1 : 1000, with an accuracy of 0·1 *mm.* = 1 *dm.* in the distance measured. These measurements are made by means of the distance ruler parallel to the telescope, the ruler fastened below the frame, and the movable projection triangle, making use of

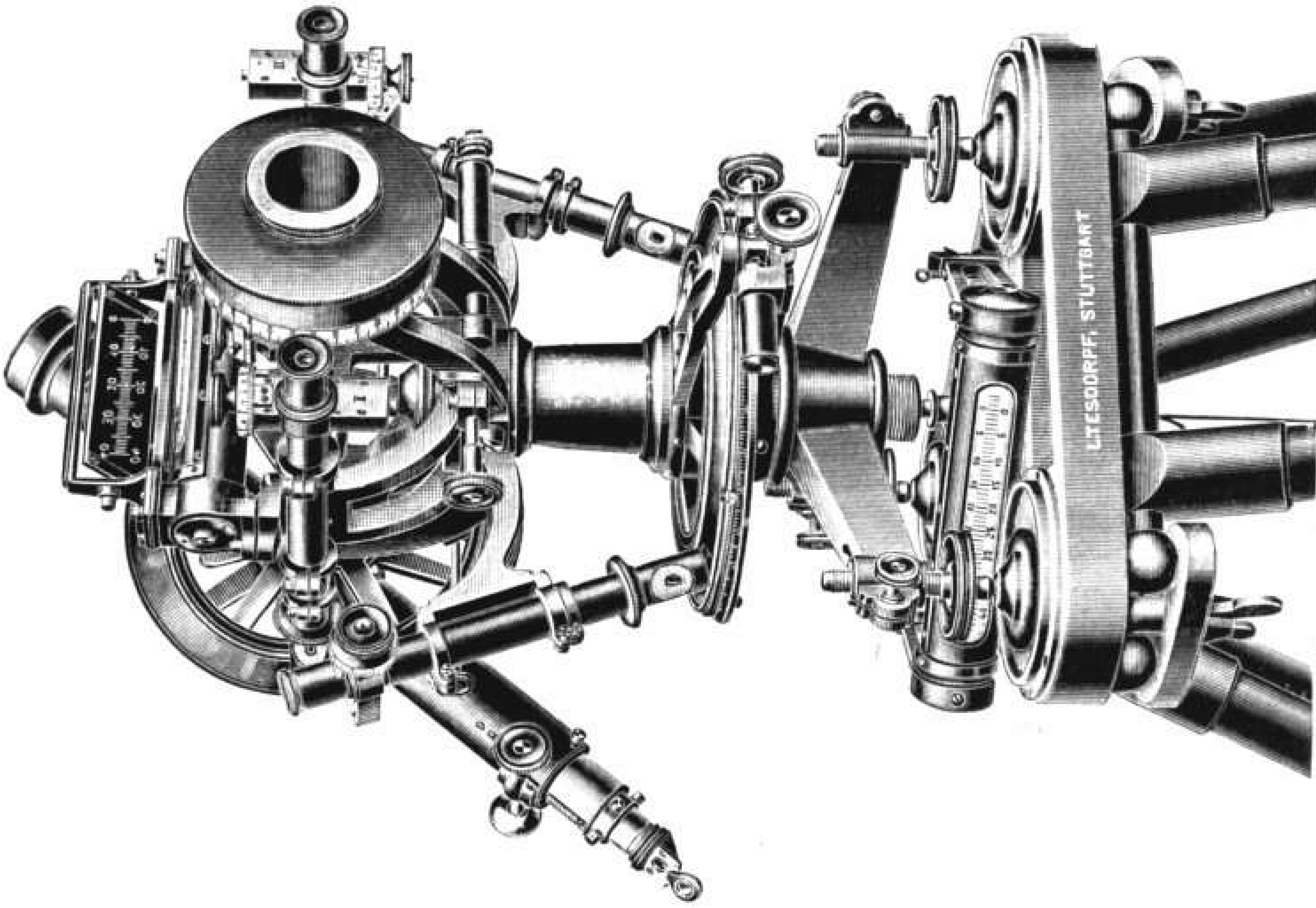


Fig. 2.

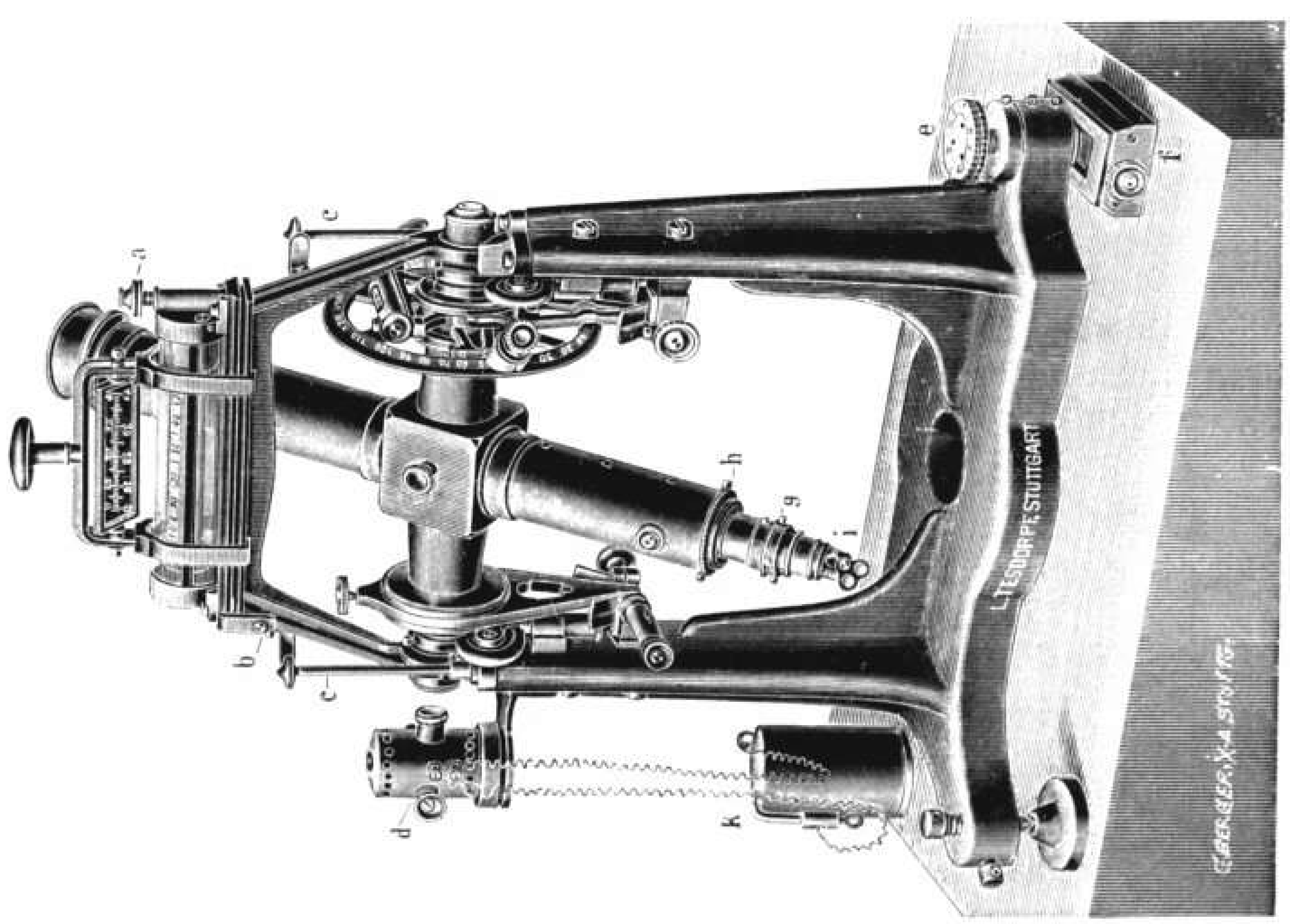


Fig. 1.

the formula $E = D \cdot \cos^2\alpha$. The graduations of the rulers can also be furnished in the ratio 1 : 2000 or 1 : 2500.

4. Orientation Instrument.

This instrument is especially intended for use in mines. It has a horizontal circle 15 *cm.* in diameter, graduated in $^1/_3{}^0$, reading to 20″. By allowing a ray of light to enter the telescope (magnifying 33 times) through the ocular, and placing an auxiliary lens in front of the objective, a much diminished point of light is produced. The North-South marks of the compass case are so adjusted by means of the correction screws that reading with equal angles (that is equal inclinations of the collimator axis) by means of the rotated telescope, this point of light is seen to be symmetrically cut by the marks. If the marks on the magnet coincide with the fixed marks, the axis of the magnet is placed parallel to the axis of collimation of the telescope with perfect accuracy. This indirect method is easier than the ordinary method of observation through the telescope and simplifies the direct observation of the marks on the needle.

5. Smallest Portable Theodolite. (Fig. 4.)

Both circles have an internal diameter of 7 *cm.*, and are graduated on silver in $^1/_2{}^0$, reading to 1′; eccentric telescope, magnifying 12 times; vertical fine adjustment; reversion level; ocular prism with two sun glasses; ocular distance meter on glass, with five vertical lines for star observations.

The bottom of the compass is perforated and covered with glass, thus rendering the level, mounted below, accessible for observation. Weight, including case, 1·90 *kg.* Weight of stand from 0·5 to 2 *kg.* as is desired.

6. Large Levelling Instrument, according to R. Wagner.

For accurate measurements at *great distances*, as well as for harbor work, bridge construction, and the determination of height above water level, when very accurate results are demanded, combined with *rapid observations*.

The telescope magnifies 60 times. The reversion level (5—6″) is protected from heat by a metal cover and is read directly from the eyepiece by reflection in the interior and by means of a lens at the side. (See also Nos. 7, 9, 10, 11.)

7. Patent Levelling Instrument.

The telescope, magnifying 24 times, rests on four cornelian prisms. Reversion level, sensibility about 10″. The accurate readings of the level are made directly from the eyepiece

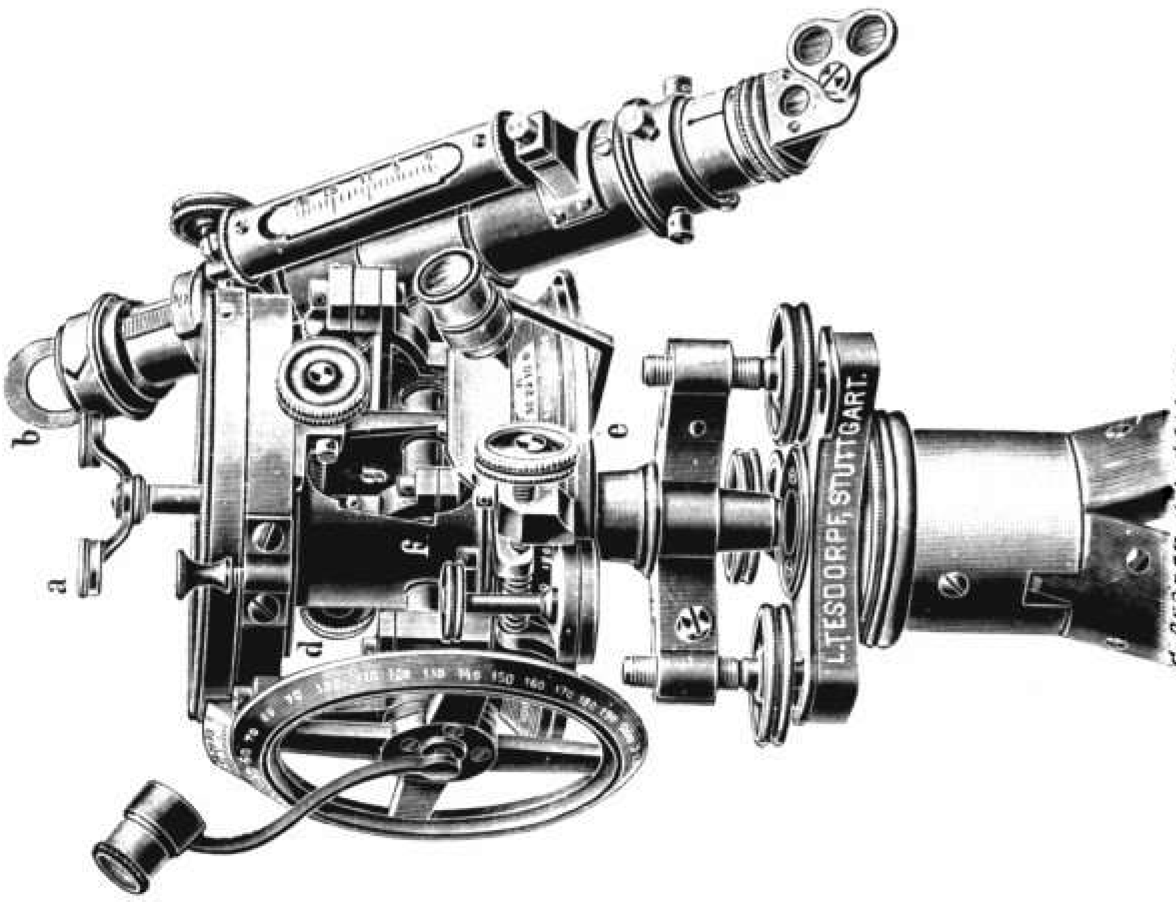


Fig. 4.

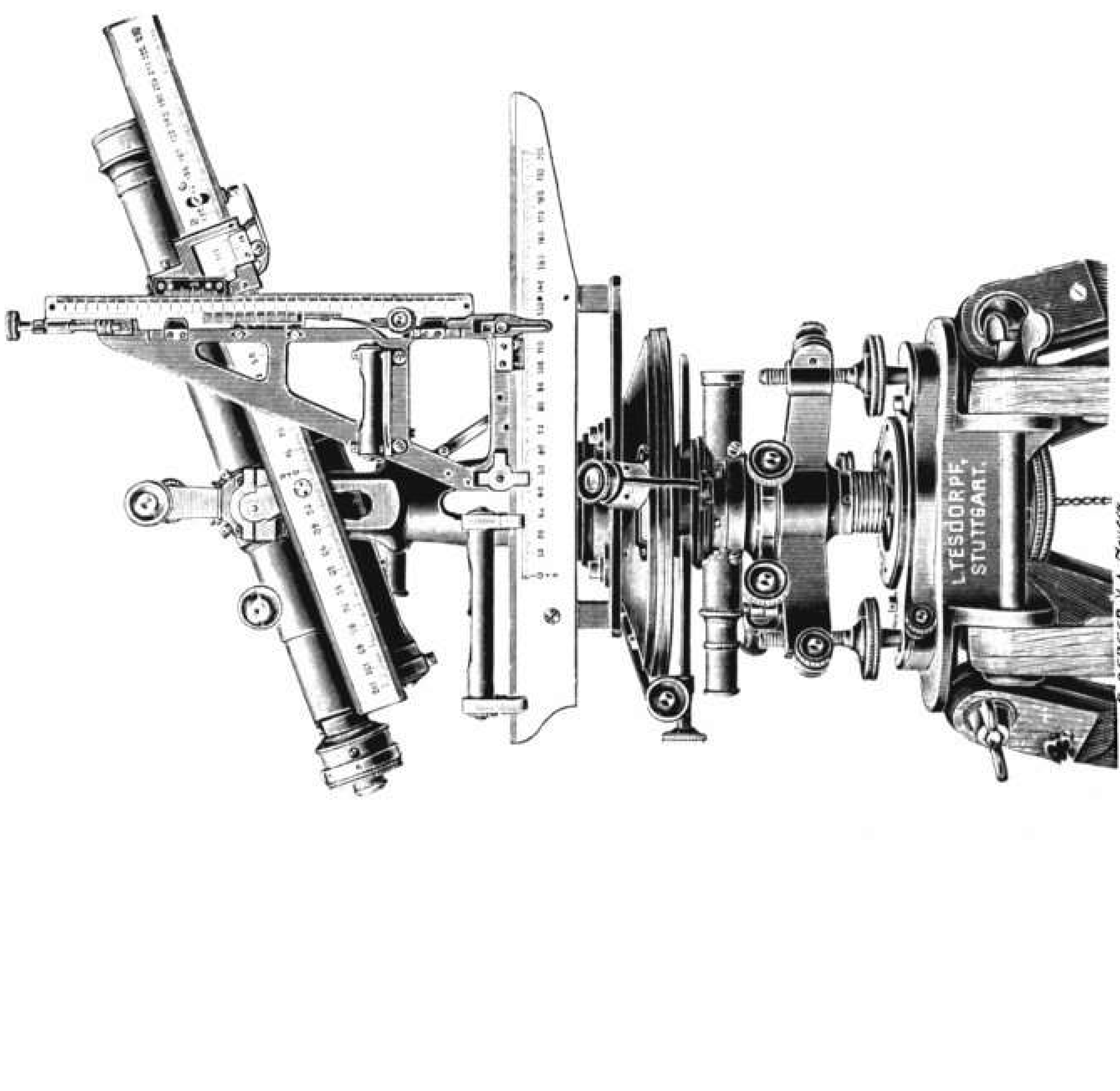


Fig. 3.

without moving the eye, which is a great convenience. The arrangements of the level are the same as in No. 6.

8. Compass Repetition Theodolite (*transit* instrument).

Fig. 5 shows a similar instrument of smaller dimensions. Telescope magnifying 33 times; horizontal circle with diameter of 20 *cm.*, divided in $^1/_6{}^0$, reading to 10″; vertical circle 17 *cm.*, divided in $^1/_6{}^0$, reading to 10″. There are also $^1/_2{}^0$ divisions on the edge for convenience in finding the stars. For terrestrial use a per cent graduation is provided. The compass is between the supports. Length of needle 120 *mm.* Lantern for illuminating the cross hairs.

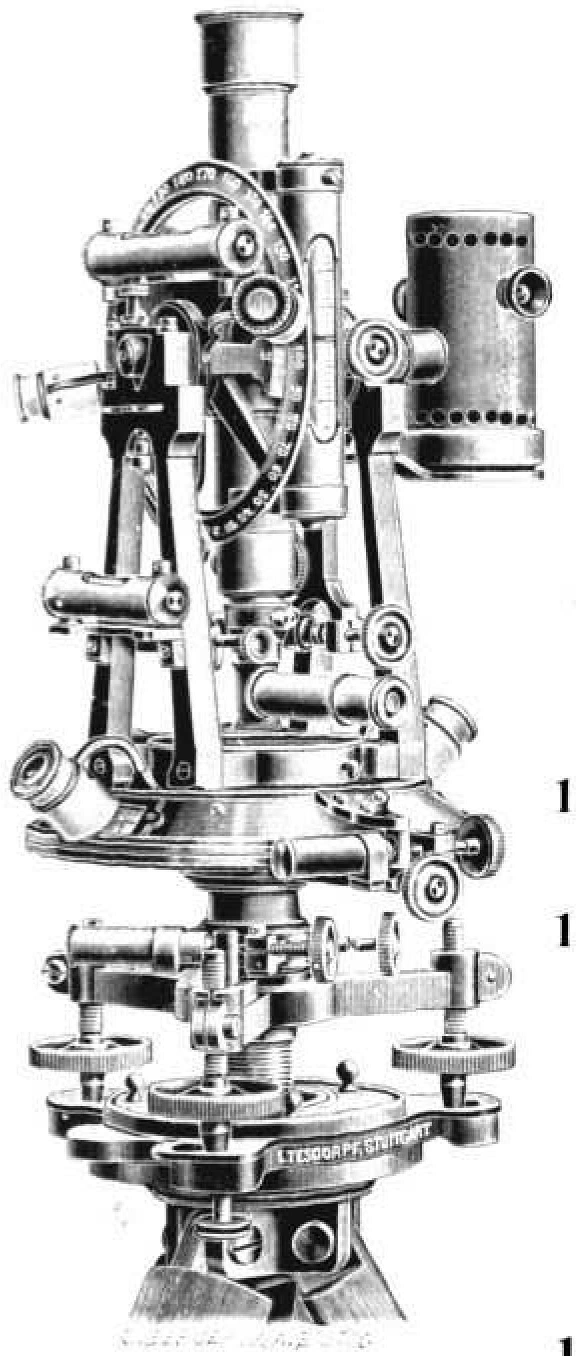


Fig. 5.

9. Patent Pocket Levelling Instrument, according to R. Wagner. Magnifying 18 times; in case.

10. The Same, magnifying 12 times; in case.

11. The Same, magnifying 12 times, telescope capable of rotation in its bearings. Diameter of horizontal circle 7 *cm.*, graduated in 1°, reading to 2′.

With this instrument 0·5 *cm.* can be easily read at a distance of 80 *m.*

12. Small Reflecting Circle, according to Wagner, pocket form.

This small and convenient instrument is suited for general surveying work, but especially for laying out curves in railroad construction.

13. Curve Rectifier (line measurer), according to Kleritj. For the accurate measurement of boundary lines.

14. Mirror Hypsometer, made of metal, especially for measuring heights of trees.

With this simple forest instrument, approximate levellings and determinations of height directly in meters can be made. By means of a table, angles of altitude and distances can be determined, and grades can be ascertained.

15a. "Schmalkalder" Patent Compass (newest form), *large model.*

The graduated circle ($^1/_2{}^0$, and 100 *mm.* in diameter) is fastened to the magnet needle and swings under a reflecting prism. With this horizontal angles are conveniently measured. A movable mirror is used in connection with the hair diopter, by means of which astronomical meridian determinations are made. From these the *declination* is quickly and easily determined.

15b. "Schmalkalder" Patent Compass, *small model,* simpler form.

16. Levelling Instrument of Precision.

The telescope, magnifying 33 times, rests on four cornelian prisms and is capable of rotation about its own axis. It has at the side an accurately ground reversion level (about 6″). Horizontal circle 10 *cm.* in diameter, reading directly to 1′. By means of the distance measuring screw, distances are conveniently measured in the ratio 1:100, also difference in height with an accuracy of 0·1 $^0/_0$.

17. Diopter Instrument (per cent grade measurer).

The vertical circle has per cent and also degree graduations, reading directly to 10′.

18. Small Rapid Topograph, according to plans of General Pauli.

The instrument (diopter) case (10×10 *cm.*) contains the viewing and measuring apparatus for measuring heights, distances, horizontal angles and slopes; also small aneroid barometer, orientation compass and scales (on the edge of the case). The case with light folding sketching table and accessories, pedometer etc. are packed in carrying case. Observations can be made on horse back or on the ground. For the latter, especially for exact measurements, a folding stand is supplied.

With the instrument are provided: instruction for use, three tables for height and distance measurements, and for corrections for the aneroid barometer, and special paper for the sketching table.

19. Small Mine Compass, according to Studer, with plate.

20. Large Portable Inclinatorium, also suited for the determination of the vertical intensity. (Figs. 6a and 6b.)

This instrument is intended for the "Institut für Meereskunde an der Königl. Universität Berlin" and is made on the same plan as the first instrument, which was constructed for the German South Pole expedition, at the order of the "Kgl. Magnetisches Observatorium in Potsdam".

The circle *F*, provided with four arms, which carry the lenses *M M*¹ for reading the position of the inclination needle *N* on the divided circle *K*, rotates on a central axis in the adjustable supporting ring *G*.

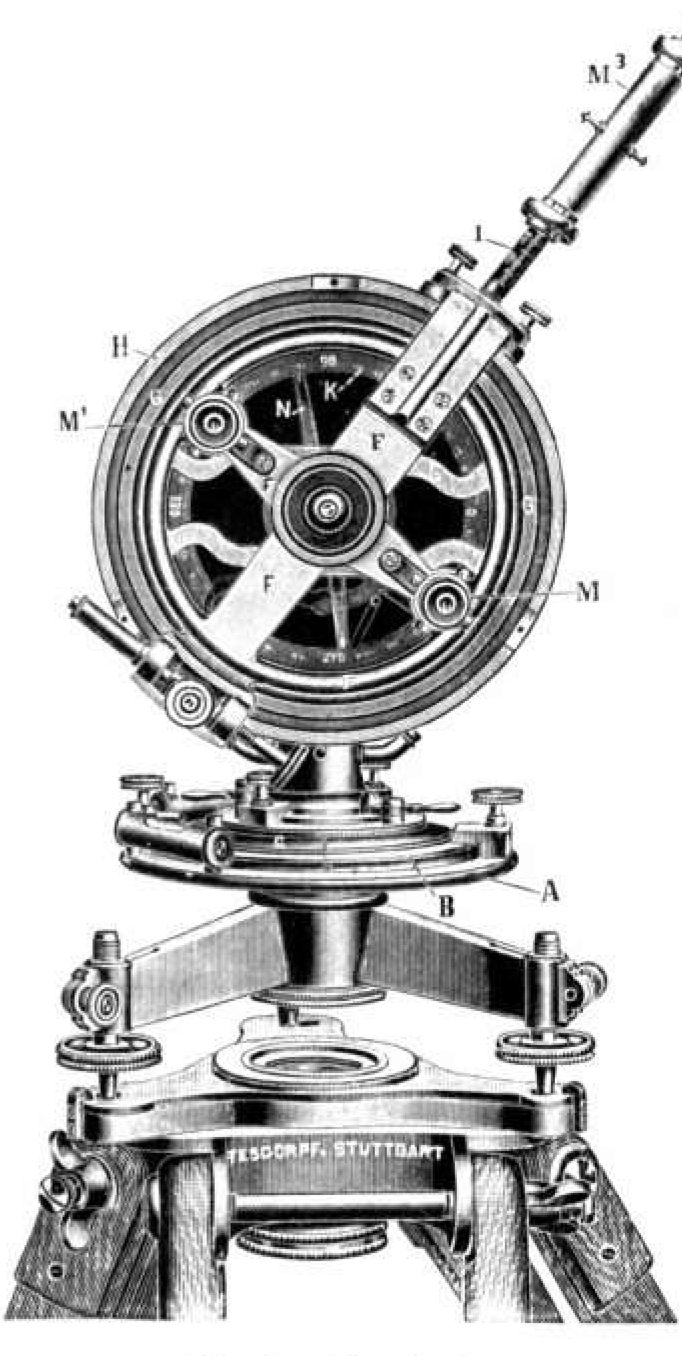


Fig. 6a. Front view.

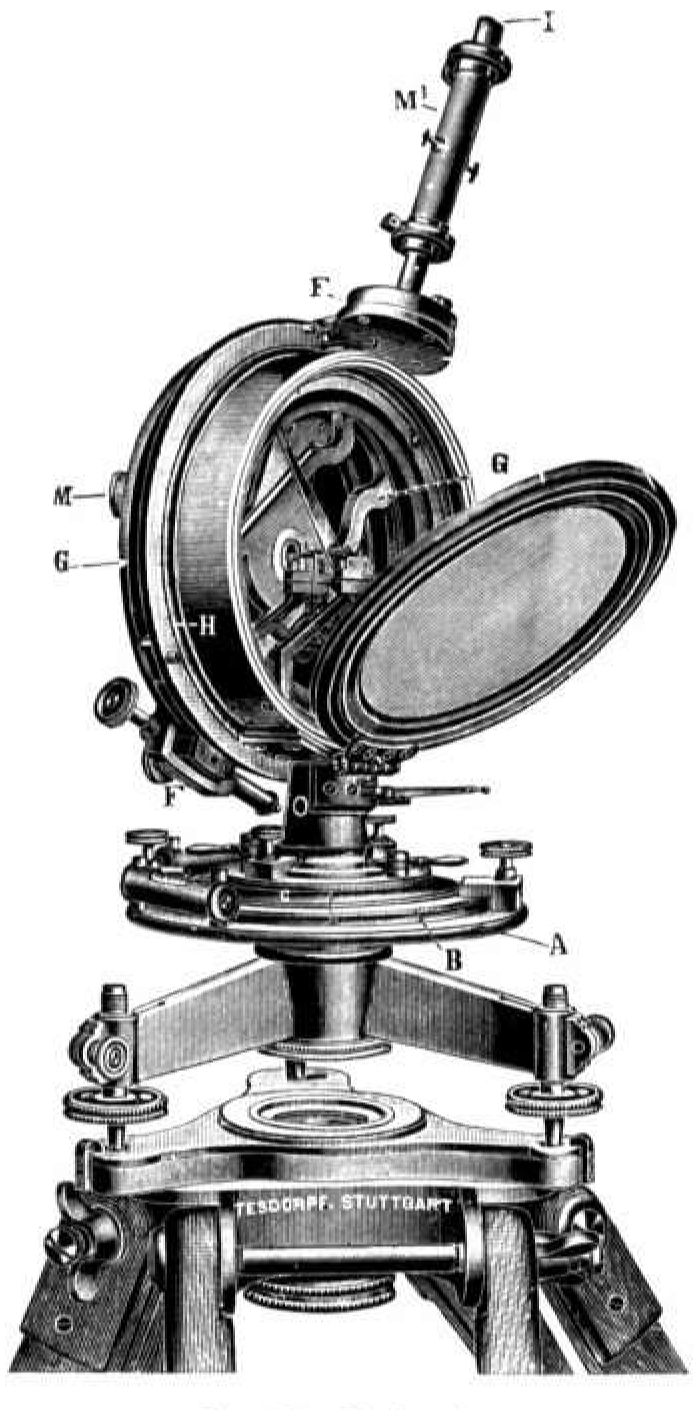


Fig. 6b. Back view.

The support F has a radial cylindrical extension for receiving the deflecting magnet M^3. The axis of this cylinder is exactly at right angles to the line joining the centres of the microscopes. F and G are both made movable so that the instrument can be used in all latitudes.

Since in the neighborhood of the poles the inclination needle takes an almost vertical position, in which its sensibility is much reduced, one of the deflecting magnets M^3, belonging to the *Portable Magnet Theodolite* (not exhibited), whose magnetic properties have been in every way tested and which has been used for measuring the horizontal intensity, can immediately afterward also be used for determining the vertical intensity.

For orientation and fixing in the magnetic meridian, a small round compass is furnished, which can easily be taken off and replaced by the instrument itself.

For the sake of reducing the weight, which is important in sledge expeditions, the instrument is made as far as possible of magnalium.

Otto Toepfer & Sohn

Potsdam, Mammonstrasse 3.

Manufacturers of Scientific Instruments.

No. 1—4 in A, No. 5 and 6 in B, No. 7—10 in D.

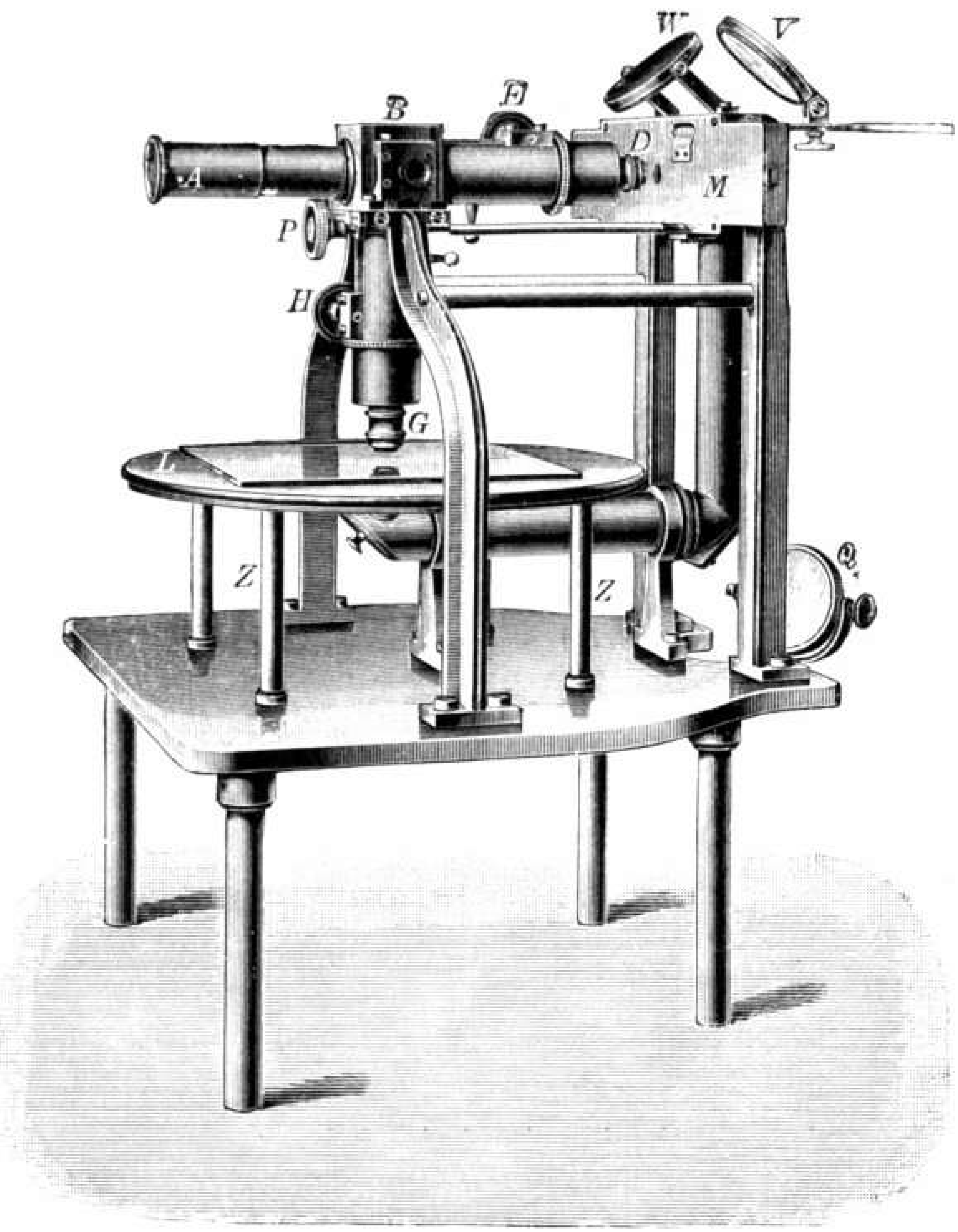
1. **Microphotometer** (see Fig.), according to J. Hartmann. For the photographic measurement of surface illumination. (See *Zeitschr. f. Instrkde.* ***19.*** *p. 97. 1899.*)

2. **Double Elbow Telescope,** according to G. Müller (*Equatorial coudé*), 55 *mm.* opening and 600 *mm.* focus. With ocular wedge photometer, adjustable for any polar altitude. Constructed for the Aetna expedition for the observation of the absorption of light in the earth's atmosphere.

3. **Large Measuring Apparatus,** according to H. C. Vogel. For the measurement of spectra. Microscope has sliding motion at right angles to the measuring screw. Free length

of the measuring screw 50 *mm.*, pitch 0·5 *mm.*, reading to 0·0005 *mm.*

4. **Zenit Camera,** portable instrument, according to Schnauder. Case serving also as stand. Level and telescope for adjustment.



5. **Optical Bench,** according to J. Hartmann. For the rational investigation of objectives. Has the following parts: small spectrograph, ocular screw micrometer with two oculars, ocular spectroscope *à vision directe*, three metal diaphragms, three inserts for the object carrier, different circular diaphragms, objective cover with centering point, objective

cap for holding different diaphragms, Bunsen burner and oil lamp for illumination etc. (See *Zeitschr. f. Instrkde.* ***24.*** *p. 97. 1904.*)

6. **Portable Microscope** (D. R. G. M. "Amicus"). Stand formed by a part of the case. Remarkable for lightness and portability. Size of instrument with case closed 24 × 11 × 9 *cm.* Weight 1·7 to 2 *kg.*

7. **Fine Registering Apparatus,** according to M. Eschenhagen. With 2 or 24 hour time of rotation. Especially suitable either as stationary or portable apparatus. With light folding case, powerful clock work, automatic time marking mechanism, electric or petroleum lamp with slit.

8. **Registering Declination Variometer,** according to M. Eschenhagen. Stationary or portable instrument, with one fixed and two movable mirrors, for registration at distances up to 172 *cm.*; with micrometric adjustable torsion head and *arrangement for rapid and secure interchange of the already tested fibers.*

9. **Registering Horizontal Intensity Variometer.** Construction same as No. 8.

10. **Registering Vertical Intensity Variometer,** according to M. Eschenhagen. For stationary and portable use. Length of magnet 100 *mm.* One fixed and one movable mirror for registration at distances up to 250 *cm.* Accurate arrestment, copper damping, adjusting magnet below, and declination track.

J. Wanschaff Sohn

Berlin S., Elisabeth-Ufer 1.

Manufacturer of Scientific Instruments.

No. 1 in B, No. 2 in A.

1. **Large Spectrometer of Precision** (Fig. 1). Reading directly to 2″. Accuracy of graduation 0·3 to 0·4″. Arranged

for all kinds of measurements. (See Müller-Pouillet's Lehrbuch der Physik. 9. Aufl. 2. Bd. *p. 230*). The first instrument of this form was made for the Physikalisch-Technische Reichsanstalt in Charlottenburg.

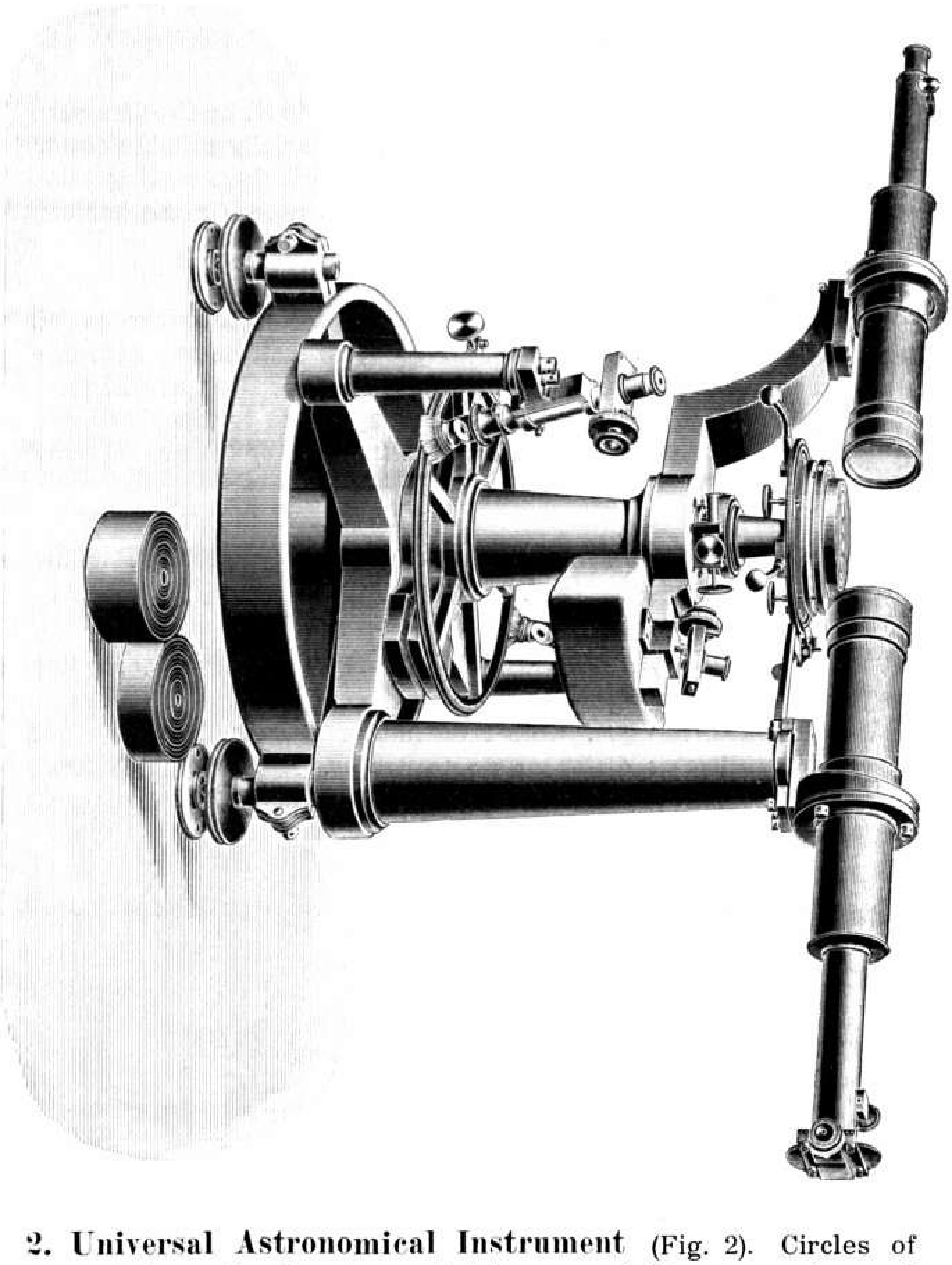


Fig. 1.

2. Universal Astronomical Instrument (Fig. 2). Circles of 14·5 *cm.* in diameter and telescope of 29 *mm.* opening and

24 *cm.* focus. Magnification 20 and 30 times. Reading directly to 10″. Accuracy of graduation 0·3 to 0·4″. With spring hook.

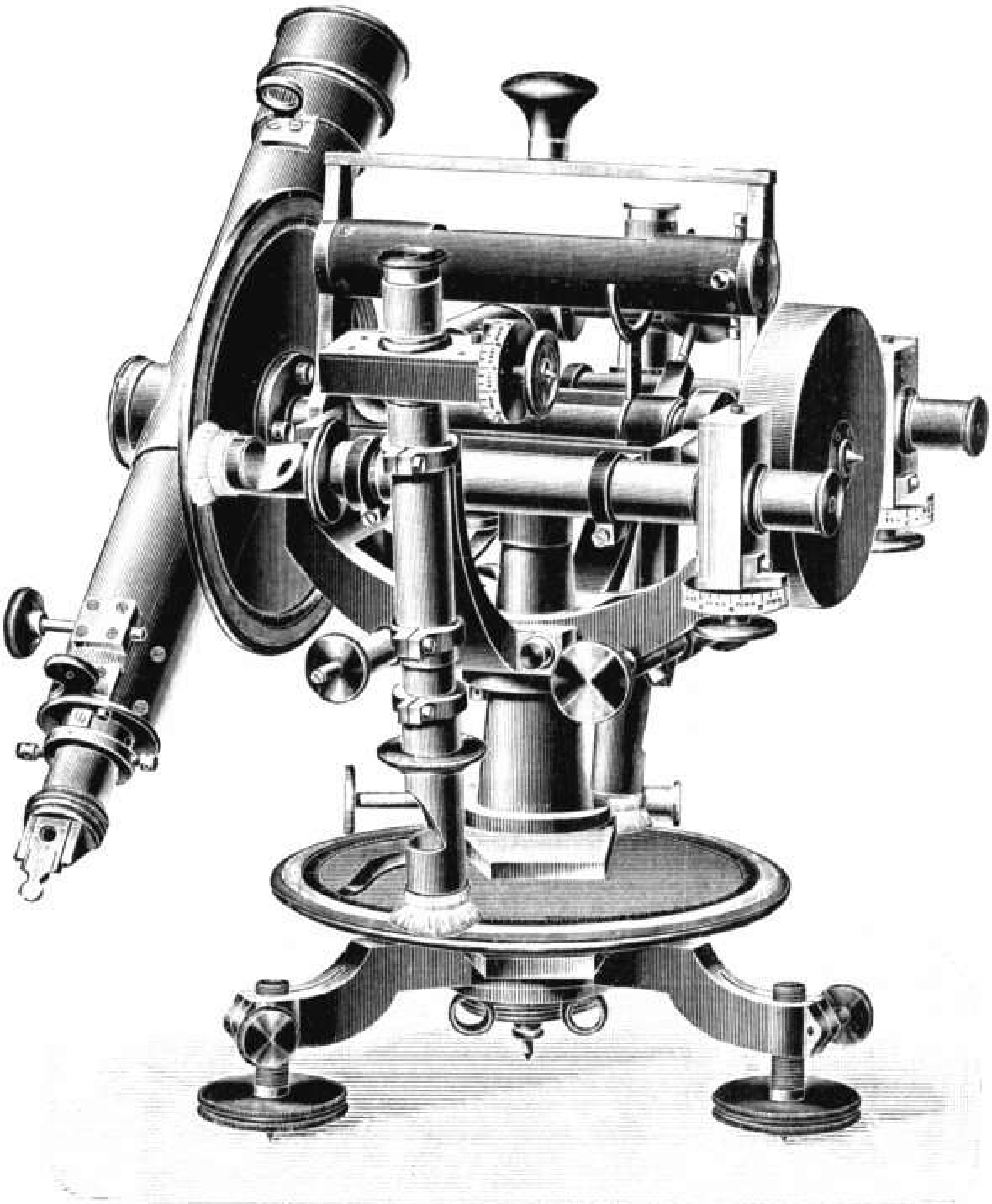


Fig. 2.

Otto Wolff

Berlin W., Karlsbad 15.

No. 1—13 in C.

1. **Standard Resistances of Manganin,** according to the specifications of the Physikalisch-Technische Reichsanstalt.

a) 100000 10000 1000 100 10 1 ohm.

All the resistances have bent copper connections, by which they may be hung in the mercury cups of a petroleum bath. Binding screw connections are also provided so that the resistances can be used without mercury cups, and also for receiving the wires for measuring the fall of potential.

b) 1 and 0·1 ohm.

In these, each of the bent copper connections is provided with two binding screws so that the current may be led in either through mercury cups, or connection may be made directly to the large binding screws, while the wires for the fall of potential are connected to the small ones.

c) 1 and 0·1 ohm.

The bent copper connections have no binding screws. The resistance is calculated from the ends of the connections so that several can be connected in series for comparison with larger resistances.

d) 0·01 and 0·001 ohm.

The bent connections for hanging the resistances in mercury cups are not provided with binding screws. There are two special fall of potential binding screws on the hard rubber cover, which connect directly with the resistance strip within, so that the contact resistance of the bent connections does not affect the measurement.

e) 1—0·1—0·01—0·001—0·0001—0·00001 ohm.

In these resistances the current connection and the fall of potential connection are made from *one* copper bar, in which the manganin wire or strip is hard soldered so that all soft soldering is done away with, except in the shunts of the 1 and 0·1 ohm resistances.

f) 0·01—0·001—0·0001 ohm.

These models are intended for heavy currents. The manganin strips are hard soldered to massive copper pieces. The case is filled with petroleum, the temperature of which is kept constant by means of a coiled tube, through which water passes, and is stirred by means of a turbine.

2. Apparatus for the Comparison of Standard Resistances and the Determination of Their Temperature Coefficients.

The apparatus serves:

a) For the comparison of two nearly equal standard resistances, either according to the Wheatstone or Thomson bridge methods. (Comp. *Zeitschr. f. Instrkde. 15. p. 428. 1895.*)

As ratio resistances or double ratio resistances respectively are used two ratio resistance boxes of 100 or 10 ohms with interpolation of $^1/_{1000}$ of these values. For the determination of temperature coefficients, one of the petroleum baths is heated by means of a wire, wound on a frame, through which is sent a current, regulated by a series resistance. A small motor drives the turbines for stirring the petroleum.

b) For the comparison of the sum of several standard resistances with one of numerically the same value. As ratio resistance a ratio box with interpolation is also in this case used. There is also a set of six standard resistances 1, 1, 2, 2, 5, 10 ohms for demonstration.

c) For comparison of unequal standard resistances, for example, 1 ohm with 0·1 ohm, either by the Wheatstone or Thomson bridge methods. As ratios suitable standard resistances are here used. Shunts are used for interpolation.

All the connections for these different methods of measurement can be quickly made with the help of the seven mercury cups and the four petroleum baths. It is only necessary to change some of the wooden supports of the mercury cups, sticking their pegs into the holes provided. A diagram explains the different methods of connecting the apparatus.

3. Plug Resistance Box, 0·1 to 50000 ohms. Sum 100000.

The resistances in this as well as in all the following apparatus are made of manganin, according to the method used in the standard resistances.

4. Sliding Contact Resistance Box, 0·1 to 1000 ohms. Four decades of 9×100, 9×10, 9×1 and 9×0·1 ohm.

5. Sliding Contact Resistance Box, 1 to 111110 ohms. Five decades of 10×10000, 10×1000, 10×100, 10×10 and 10×1 ohms.*

The resistances lie horizontally. The bottom and cover of the apparatus are formed of perforated metal for the sake of ventilation. The resistances, thrown into circuit, can be read rapidly and without error, as the corresponding numbers in the single decades appear in the openings of the slanting front of the case. The sliding contacts are protected as much as possible against dust by a movable cover. The contacts and axes can be readily removed for cleaning.

6. Decade Resistance Box with Plug Connections, 10×10000 ohms.

7. Decade Resistance Box, 10×100000 ohms.

For the sake of better insulation the contacts are mounted on hard rubber pillars. In place of plugs short-circuit bridges are used.

8. Ratio Resistance Box with Plug Connections.

There are four pairs of ratios, 10000—1000—100 and 10 ohms, each of which may be thrown into circuit by means of a plug. Between the two sets there are three interpolation resistances of 1—0·1—0·01 ohm, which may be connected at will to either of the two arms.

9. Wheatstone Bridge with Plug Connections.

The apparatus contains five pairs of ratios, 1000—100—10—1—0·1 ohms, and a set of comparison resistances, 0·1 to 50000, making in all 111111·1 ohms. There are also binding posts for connecting the resistances, to be measured, and battery and galvanometer keys for long or short contact.

10. Wheatstone Bridge with Sliding Contacts.

The ratio resistances with plug contacts are arranged as in the ratio box described in No. 8 but have in addition an arrangement for interchanging the bridge arms. The

* No. 4 and 5 are shown in the exhibition of the Physikalisch-Technische Reichsanstalt, in the apparatus, set up for showing induction and capacity measurements. (See *p. 109* and *110.*)

comparison resistances consist of six decades with sliding contacts, 10×10000, 10×1000, 10×100, 10×10, 10×1 and $10 \times 0{\cdot}1$ ohms. There are in addition binding posts for connecting the resistances, to be measured, and battery and galvanometer keys.

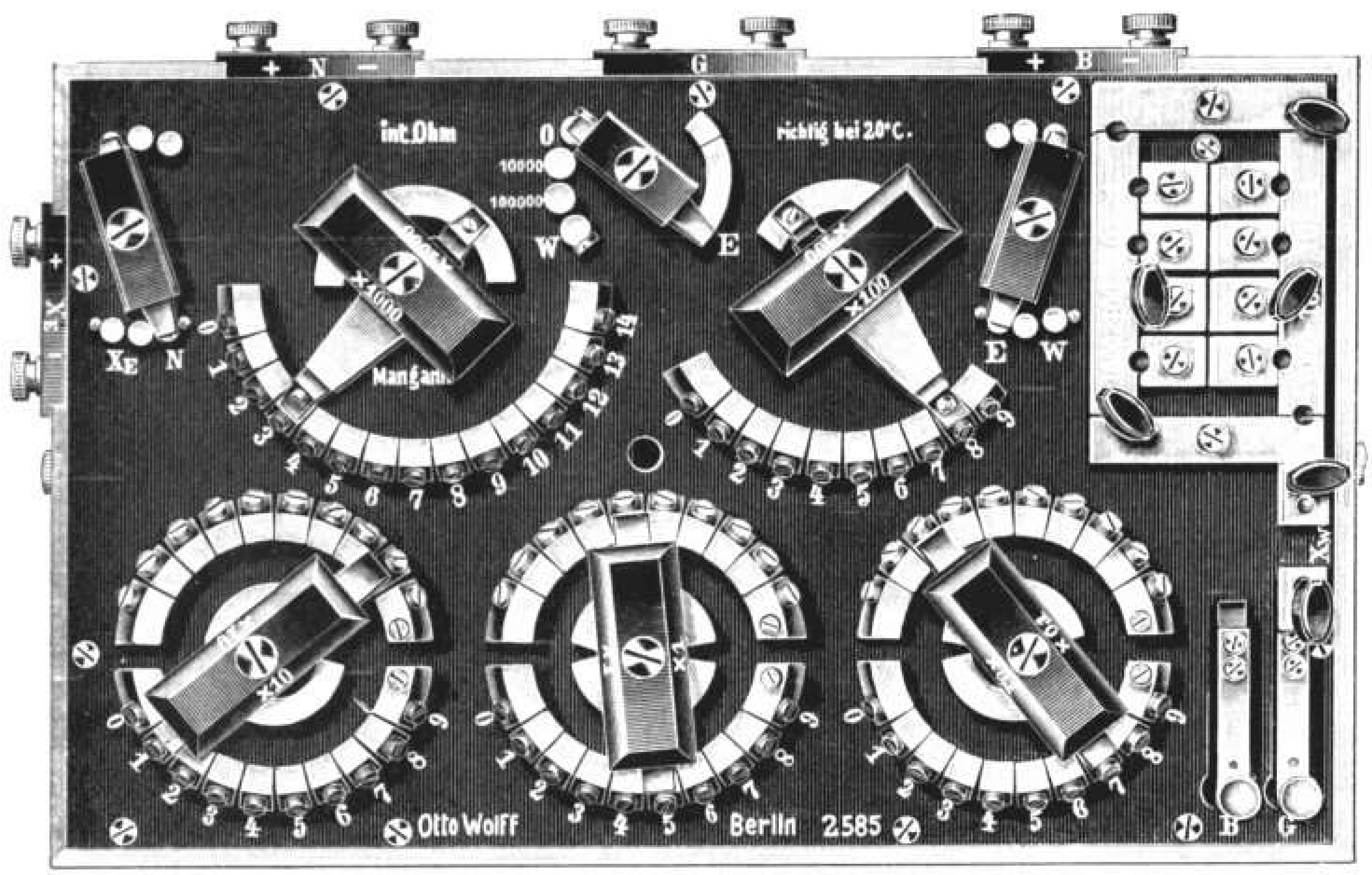
11. Thomson Double Bridge, with arrangement for the determination of specific resistance and the temperature coefficients of conductors and resistance material.

The apparatus consists of three parts: the arrangement for connecting the material to be investigated, the standard resistance for comparison, and the double ratio resistance box. The wire, to be measured, is placed in the proper clamps, and the main current flows through this and a suitable standard resistance, placed in series with it. The standard resistance hangs in a petroleum bath, provided with a cooler and a turbine stirrer. Between the two weighted knife-edges of the apparatus lies a definite, accurately measurable length of wire. From the shunt binding posts of the standard resistance connections run to the posts NN and from the movable knife-edges to the posts XX of the double ratio box. On the two arms of the latter, two corresponding plugs are drawn, for example 100 ohms, and then the four double contact pieces are so placed that the galvanometer connected at GG shows no current. The result is then known from the position of the sliding contacts without further readings, taking into account the value of the standard resistance. The advantage of this apparatus lies in the fact that *accurately adjusted standard resistances* are used for comparison instead of the ordinary slide wire. For the determination of temperature coefficients the petroleum bath can be electrically heated and stirred by means of turbines.

12. Potentiometer for the Determination of Electromotive Forces.

This apparatus is the best known form of the Feussner potentiometer. In use it is simple and trustworthy. The resistances are brought into circuit by means of sliding contacts, and the result can be read at once from the position of the contacts with an accuracy of 1/100000 volt. As standard of E. M. F. a Clark cell is furnished, or any other standard can be used, as for example the Weston cell. As auxiliary apparatus a voltage reducer is exhibited, which serves for the measurement of large E. M. F. The two shunt connections of the voltage reducer are connected with the two binding posts $+X-$ of the potentiometer. The high voltage, to be measured, is connected to the binding post $+0$ and with one of the other six binding posts of the voltage reducer. There are six ranges, giving respectively 5, 10, 50, 100, 500 and 1000 times the value, measured on the potentiometer, so that E. M. F. as high as 1500 volts can be measured accurately to five places of figures.

13. Potentiometer and Wheatstone Bridge. (See Fig.). The apparatus is the same as the last, with the addition of an



arrangement for converting it into a Wheatstone bridge. For the change from potentiometer to bridge it is only necessary to change two sliding contacts. Battery and galvanometer remain connected as before and are used in the measurement of the resistances. The standard cell and any E. M. F., connected at X, do not need to be removed, as they cannot come into the circuit. The resistances, to be measured, are fastened in the binding posts X_W. The five sliding contact decades of the potentiometer serve as comparison resistances. The ratio resistances consist of four pairs of 1000, 100, 10 and 1 ohm coils. Tne bridge arms can be reversed by changing two plugs. A complete description of the apparatus appeared in the *Zeitschr. f. Instrkde.* ***23.*** *p. 301. 1903.*

Carl Zeiss

Jena.

Manufacturer of Optical Apparatus.

Nos. 1—24 and 28 in B, 25 and 26 in A, 27 in Lecture Room.

I. Microscopes.

1. Stand Ia. Large microscope, fitted with large revolving and centering mechanical stage, the illuminating apparatus, designed

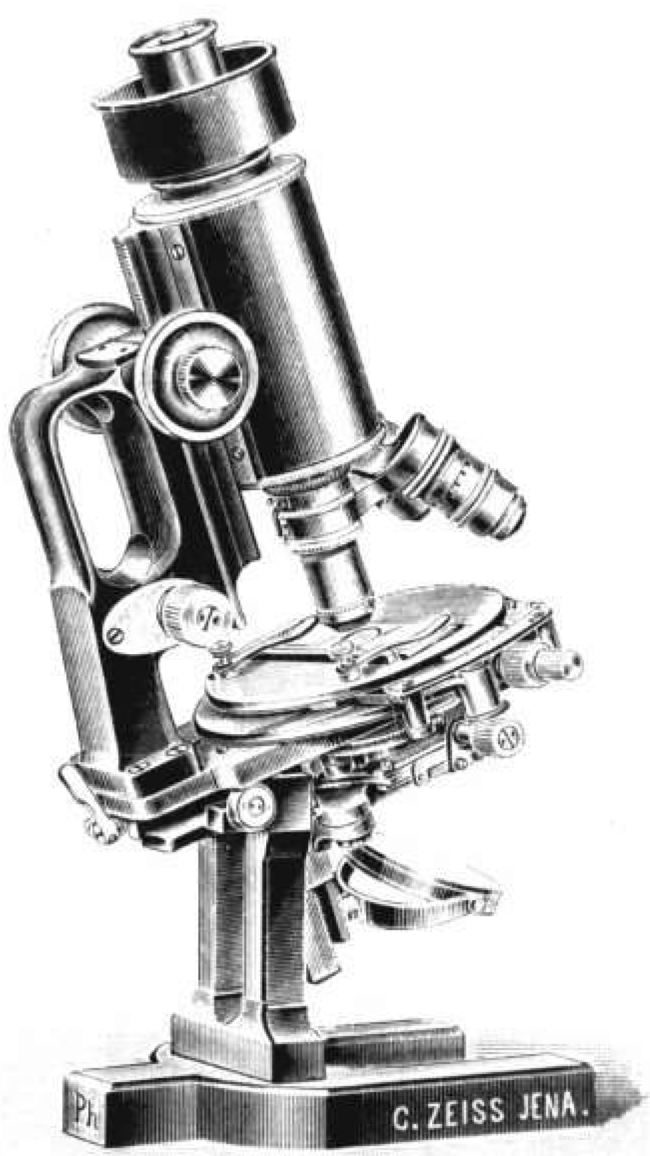


Fig. 1.

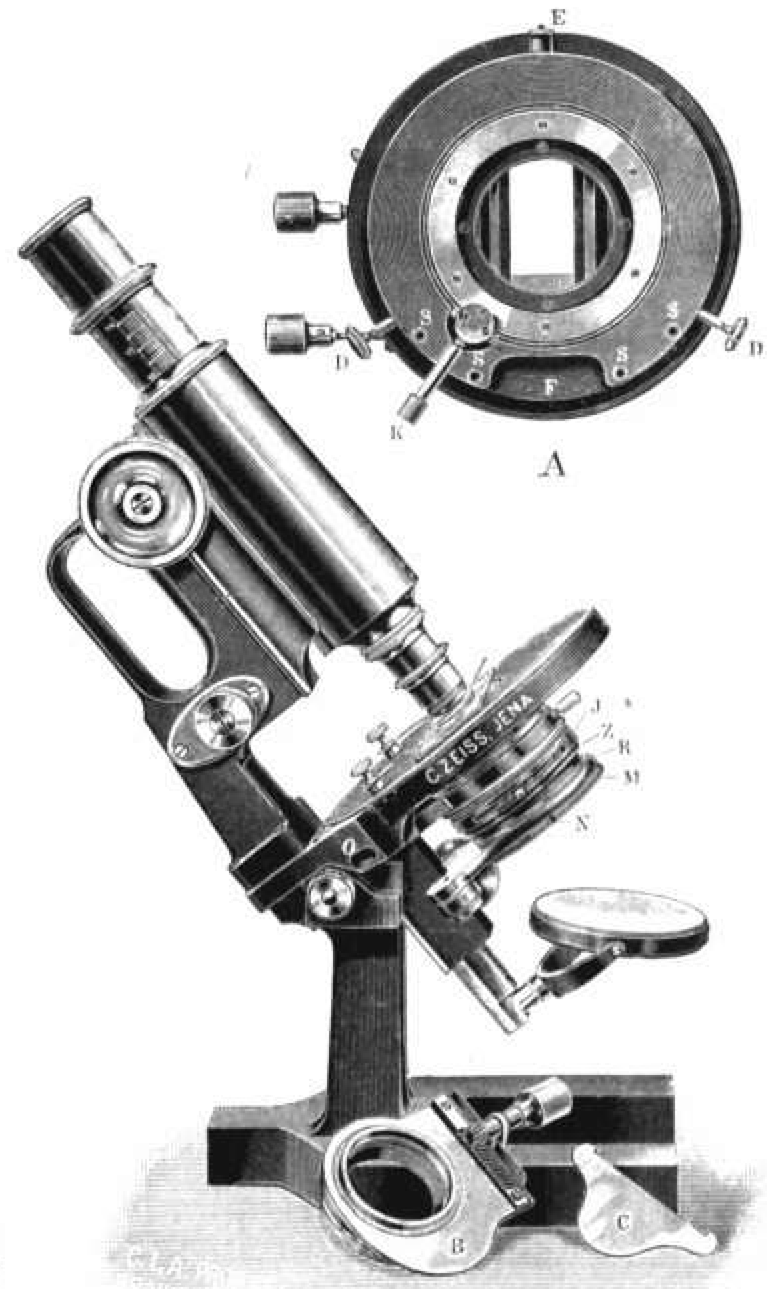


Fig. 2.

by Abbe, a swing-out condenser, num. Ap. 1·40, and an iris-cylinder diaphragm. Suitable for all classes of scientific research.

2. **Stand Ic** (Fig. 1). Large microscope, fitted with photo-micrographic stage, which facilitates a very slow and uniform movement of the specimen, the illuminating apparatus of Abbe's design, a centering achromatic condenser, num. Ap. 1·30, and Berger's micrometer movement. Specially adapted for photo-micrographic and projection purposes, but may also be used with the greatest advantage for ordinary direct observation.

3. **Stand III** (Fig. 2). Microscope, medium size, fitted with a revolving and centering vulcanite stage and Berger's micrometer movement. The construction of this stand is such as to admit of its being augmented at any time by ordering supplemental parts, thus affording all the advantages of a large stand.

Detailed particulars regarding our instruments are contained in the 32nd (1902) edition of our catalogue of microscopes, copies of which (in English, French or German) may be obtained post-free on application.

II. Optical Measuring Instruments.

4. **Immersion Refractometer** (Fig. 3) for rapidly determining the concentration of solutions (as, for instance, the extract and the alcohol in beer, sugar in the urine) and for quickly testing standard solutions.

5. **Abbe Refractometer,** with heating apparatus for the prisms, for use in chemical and technical laboratories.

6. **Butter and Milk-Fat Refractometers.**

7. **Refractometer for purposes of instruction and practice.**

8. **Abbe Spectrometer** for delicate spectrometric measurements.

9. Comparison Spectroscope, with scale of wave-lengths, for the use of colour specialists (three spectra in the field of view), for laboratory use (two spectra) (Fig. 4). *Hand spectroscope* with scale of wave-lengths.

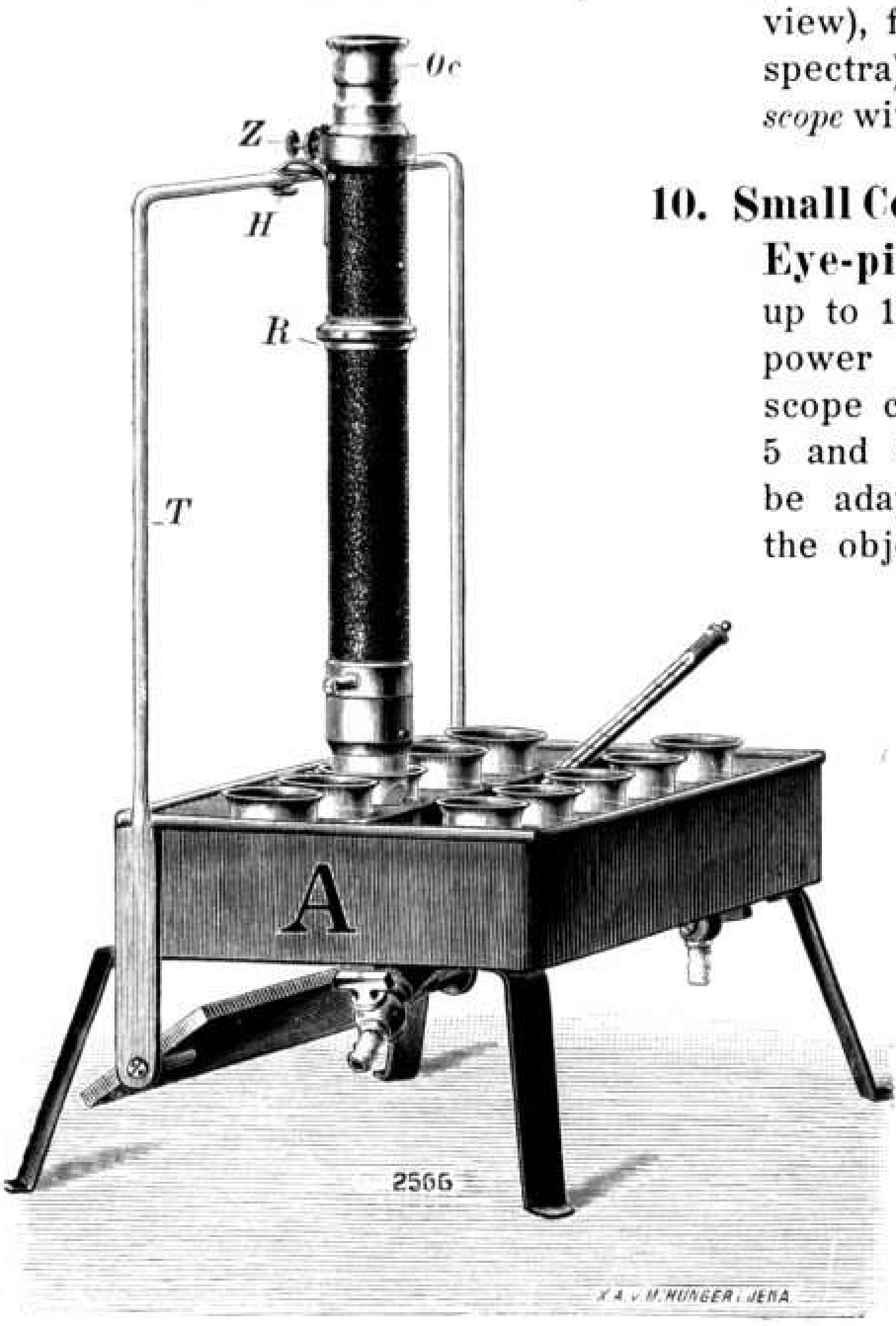


Fig. 3. 1/5 nat. size.

10. Small Comparator with Bent Eye-pieces, measuring lengths up to 100 *mm.*; the magnifying power of the object microscope can be varied between 5 and 25 diameters and thus be adapted to the nature of the object.

11. Abbe Diffraction Microscope, for teaching purposes.

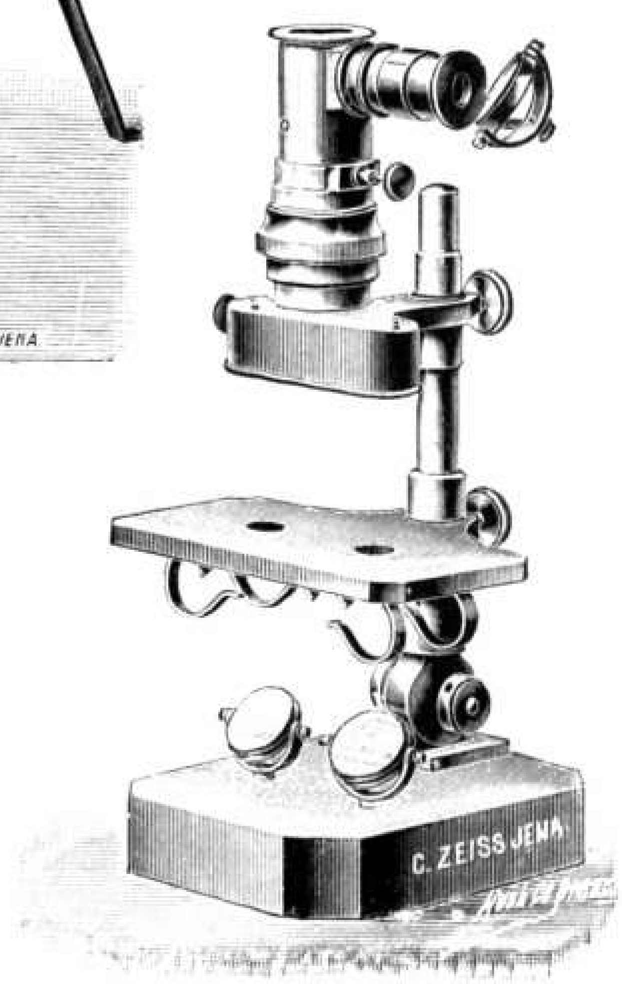


Fig. 4. 1/4 nat. size.

12. Interference Measuring Apparatus, according to Pulfrich.

13. Interference Table with variable thickness of the air stratum.

14. Apparatus for Observing Interference Curves on Plates of Glass.

III. Field-Glasses and Telescopes.

15. Prism Field Glass (Fig. 5 and 6), magnification 8 diam., distinguished above all other patterns of prism binoculars by enhanced stereoscopic power, obtained by placing the objectives farther apart than the eye-pieces.

Fig. 5.

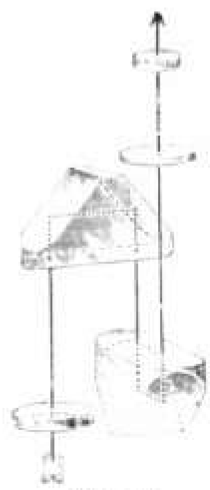


Fig. 6.

16. Hunting Glass, 5 diam., distinguished by its exceptional light gathering power.

17. Stereo-Binocular, possessing very pronounced stereoscopic power (see distances between objectives and eye-pieces).

18. Hinged-Binocular (Fig. 7), possessing a still higher degree of stereoscopic power. This instrument can be folded up

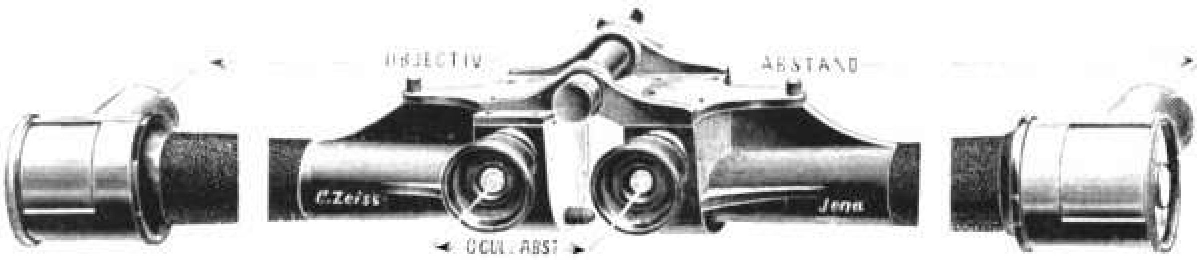


Fig. 7.

and is, therefore, handy to carry, in addition to which it admits of looking over a parapet etc., without exposing the person, by turning the arms upwards.

19. Horizontal Telescope, yielding the maximum of stereoscopic power; rigid construction (see our prospectus relating to *Stand Telescopes*).

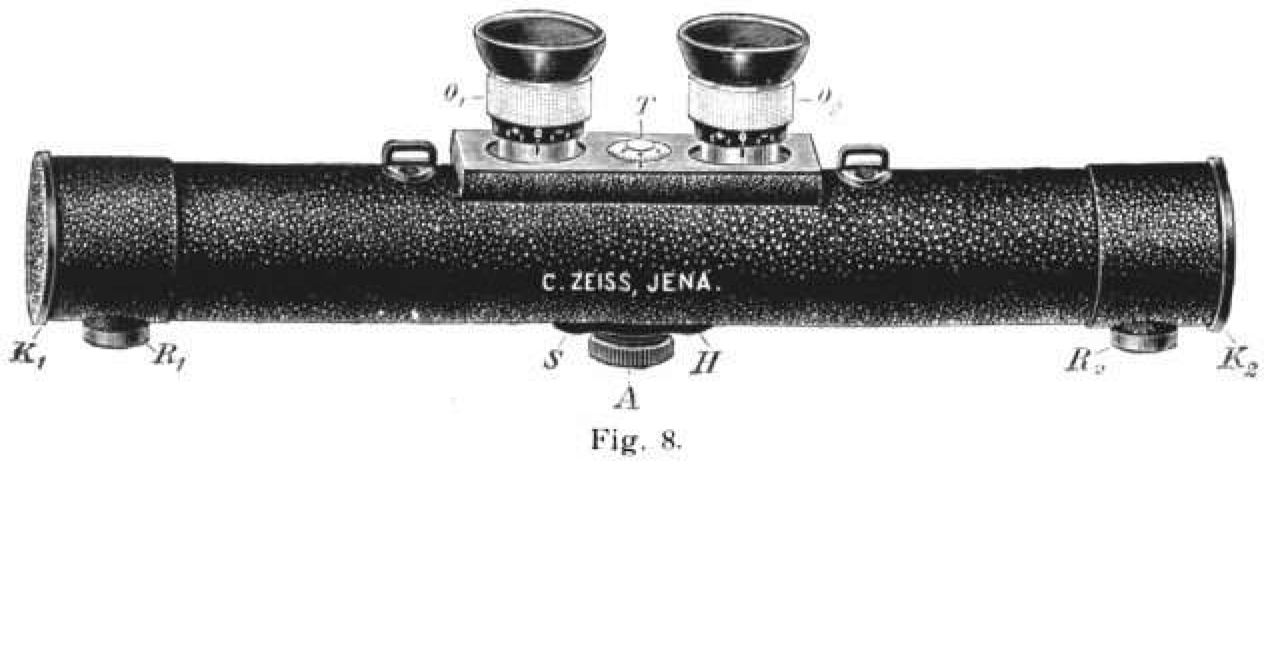


Fig. 8.

20. Stereo-Telemeter (Fig. 8). This instrument is constructed on the principle of the „horizontal telescope", the eye-pieces being provided with scales. These are seen extending in a zigzag line into space, above the stereoscopic landscape. This telemeter is distinguished from any other similar instrument by the fact that it is possible by its aid to ascertain accurately the distance of objects without sharply-defined outlines such as smoke, clouds, shrubs etc. (see special prospectus).

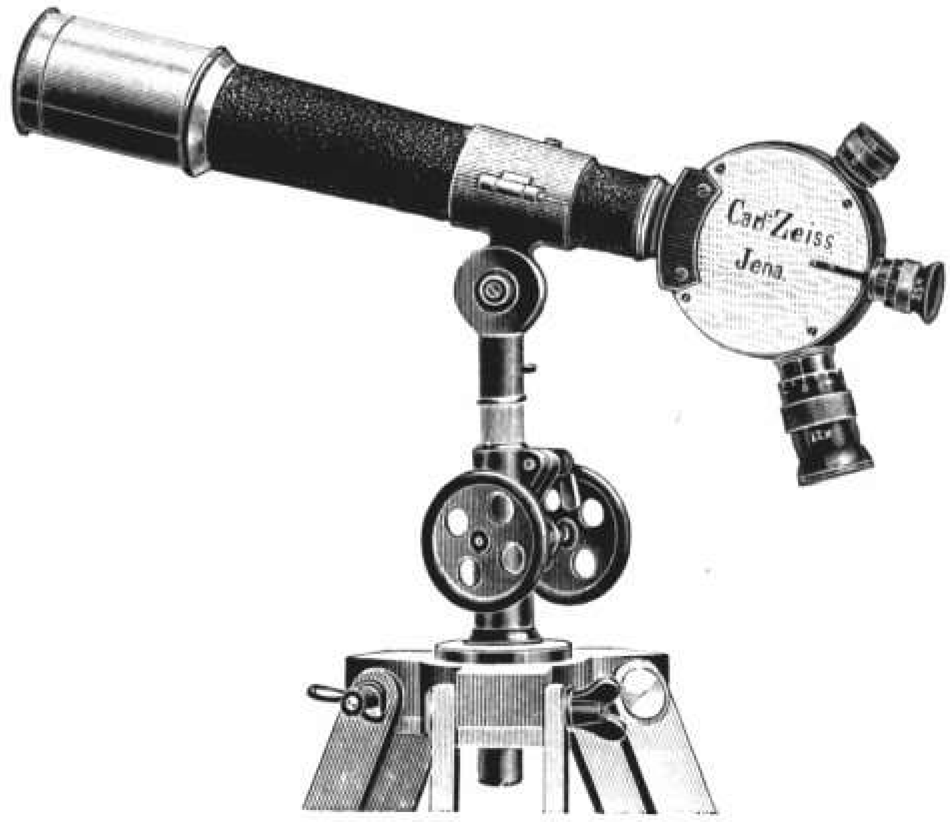


Fig. 9.

21. Revolver Telescope (Fig. 9), a short, handy monocular telescope with three different magnifications, thus available under the most varying conditions of light (see *p. 7* of our prospectus relating to *stand telescopes*).

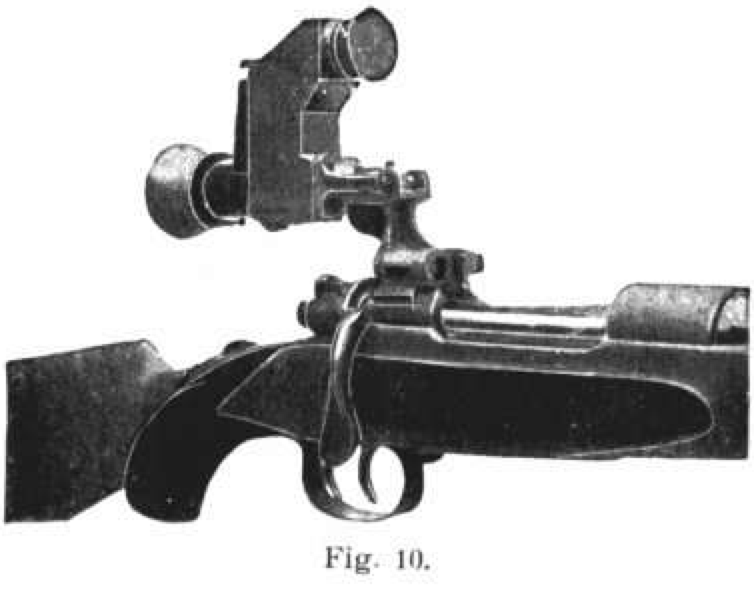


Fig. 10.

22. Telescope Sight for Rifles (Fig. 10), notable for its great brightness and exceptionally large field. The elevated position of the objective prevents the barrel of the rifle, irrespective of its size, from encroaching inconveniently on the field of view (see special prospectus).

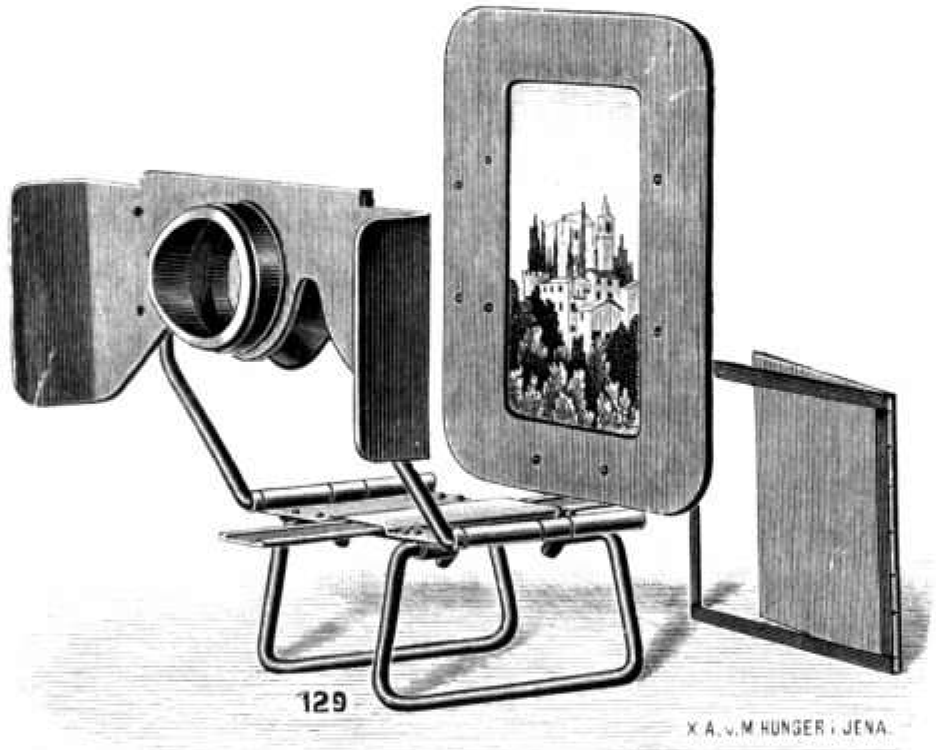


Fig. 11.

23. Verant (Fig. 11). Instrument for monocular observation of photographs, which are taken with an objective of shorter focus than the normal vision distance. Such photographs, looked at through this instrument, give an extremely natural appearance (see special prospectus).

IV. Stereoscopic Apparatus.

24. New Stereoscope, whose ocular lenses may be adjusted for individual power of vision and inter-ocular distance, accompanied by *Stereo - Diapositives* and also a *Stereo - Micrometer*, designed for studying the nature and advantages of the stereoscopic method of measurement.

25. Pulfrich's Stereo-Comparator (Fig. 12), applicable to the purposes of astronomy, meteorology and geology, of topography, photogrammetry and architecture etc. Specially useful for detecting defects in photographic plates, for locating variable stars and planets, for determining the parallaxes of fixed stars, for measuring the height of clouds, variations in mountains and coast-lines, for preparing topographic plans, for building revisions etc.

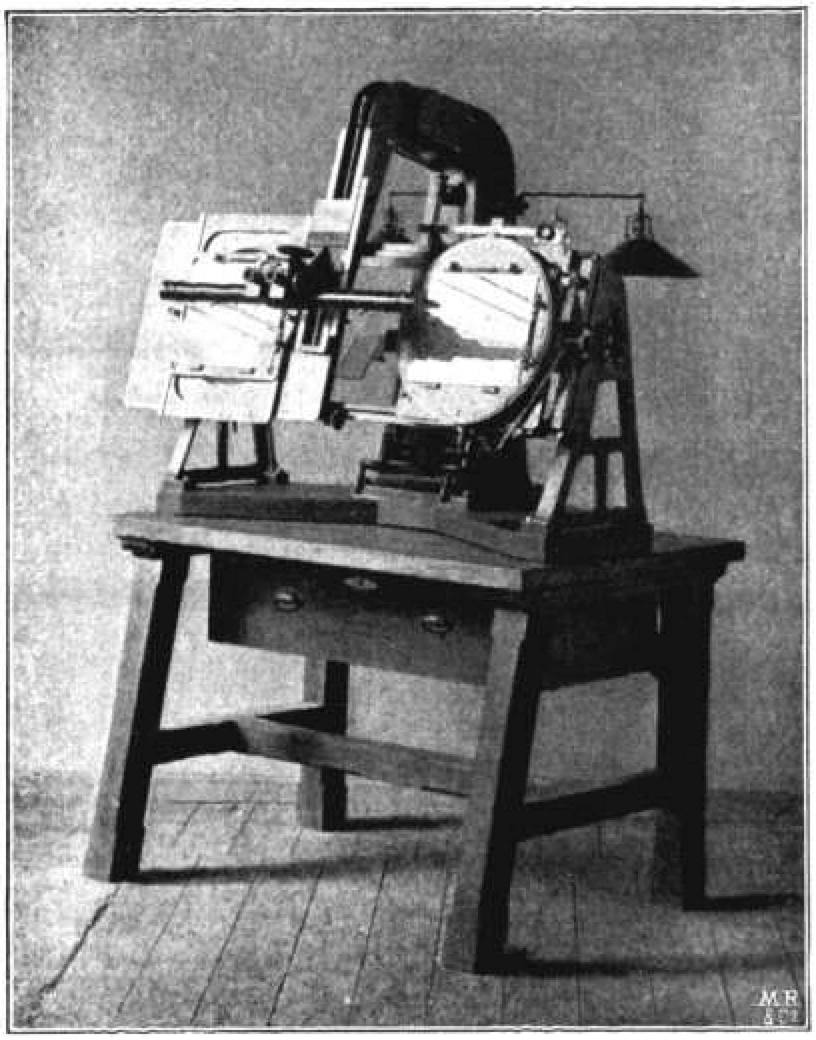


Fig. 12. $^1/_{18}$ nat. size.

26. **A map of the „Kernberge"** (mountainous region in the neighborhood of Jena) on the scale of 1 : 10 000, *produced by means of the Stereo-Comparator.*

V. Projection Apparatus.

27. **Epidiascope** (Fig. 13). An apparatus for the projection of objects lying horizontally, reflected light being employed in the case of opaque, transmitted light in that of transparent or translucent objects. The epidiascope is distinguished mainly by the following advantageous features:

1. Great latitude in the shape and size of objects;
2. A search-light being used, illumination by reflected light is highly effective.
3. Transition from reflected to transmitted light is effected with speed and ease.

4. The apparatus is readily adjusted for projection obliquely upward.
5. The several parts are protected against dust and improper usage.

The length of the epidiascope is about $1^1/_2$ *m.*, its width about $^3/_4$ *m.* and its total height about $1^1/_2$ *m.*, the latter dimension being so calculated as to enable a person, standing on the floor at the side of the apparatus, to use it conveniently.

The width of objects to be projected can not be more than 30 *cm.* and their maximum thickness must not exceed 16 *cm.*, though the construction of the apparatus does not impose arbitrary limits as to their length. Given objects of this description, the apparatus is adapted for projection over a uniformly illuminated circular area of 22 *cm.* diameter. It is essential that details, which are to be sharply defined, should lie in approximately the same horizontal plane and that the objects should transmit or, in episcopic projection, reflect sufficient light. It is thus seen that dia-

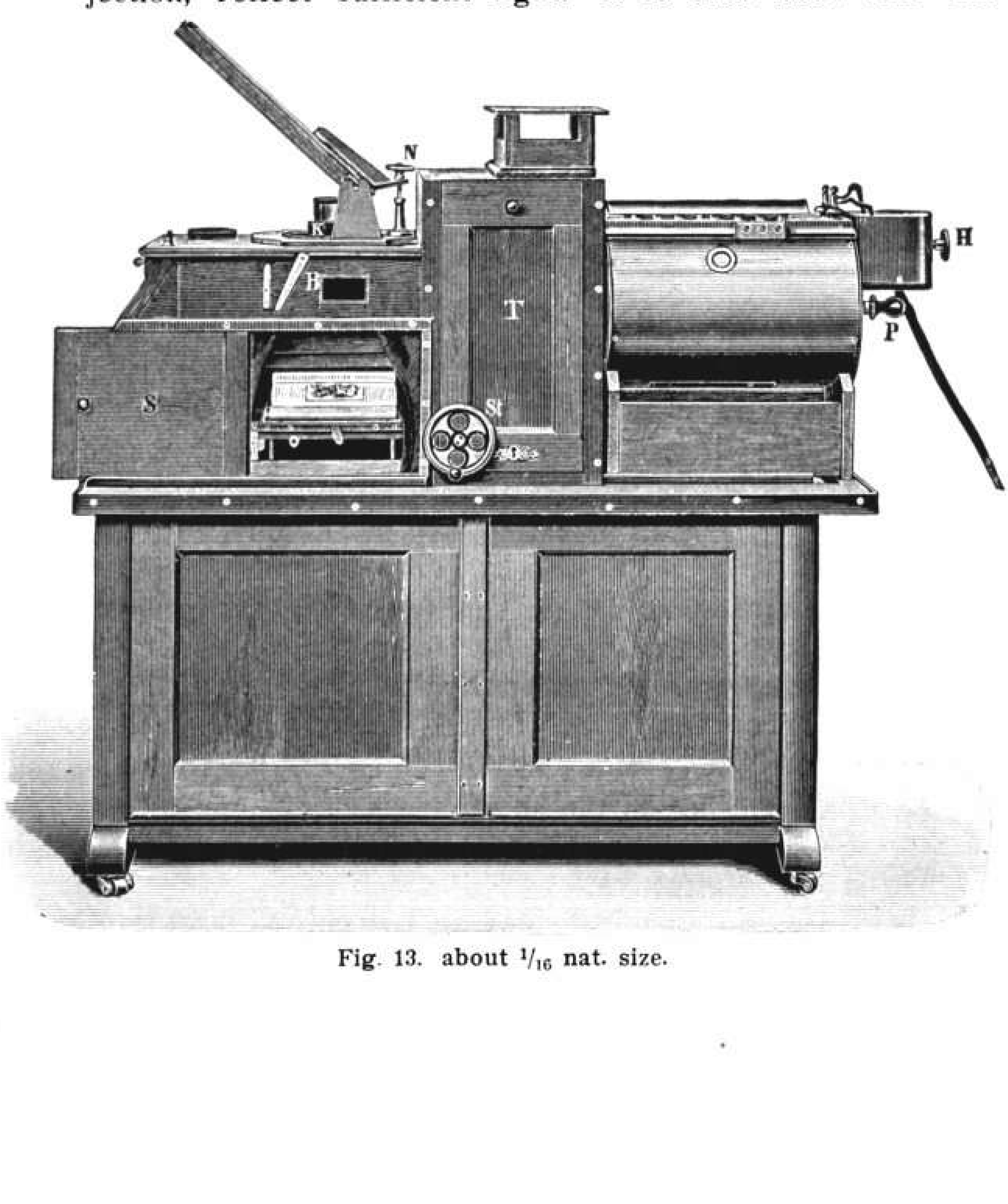


Fig. 13. about $^1/_{16}$ nat. size.

positives, a variety of physical phenomena etc. are mainly to be considered in the case of transmitted light, while pictures (including plates in books), drawings, small models, physical apparatus, small plants and animals or portions of large ones etc. are best adapted for projection by reflected light.

VI. Apparatus for Rendering Visible Ultramicroscopic Particles.

This apparatus, designed by H. Siedentopf and R. Zsigmondy, consists of

28. **Three Microscopes,** fitted with special illuminating apparatus, for rendering visible
    a) ultramicroscopic particles in glasses,
    b) ultramicroscopic particles in liquids,
    c) ultramicroscopic bacteria in preparations of ordinary form (between object carrier and cover glass).

Appendix.

The appendix contains a catalogue of the photographs and other pictures, exhibited in our section, so far as they pertain to scientific institutions.

It was desired to complete the collection of instruments shown by pictures of those which could not be exhibited. Further, we have also assumed that interest would be taken in views in the laboratories and observatories, and in pictures of the buildings of the scientific institutions frequently mentioned in this catalogue.

The photographs have been placed in part on a revolving stand, and a portion have been framed and hung on the walls of the Entrance Hall and the Rooms A—D.

I. Revolving Stand with 64 Photographs.

The photographs have been furnished by:

a) Aeronautisches Observatorium des Kgl. Meteorologischen Instituts in Berlin. 1. Kites. — 2. Balloon-hall with kite-balloon. — 3. Kite after a winter ascension. — 4. Registering apparatus, covered with ice. — 5. Room for testing registering apparatus at low temperatures and pressures. — 6. Windlass-tower and instrument-house.

b) Kgl. Astrophysikalisches Observatorium in Potsdam. 1. Spectro-heliograph. — 2. Spectrometer II. — 3. Spectrograph IV. — 4. Repsold apparatus for stellar photographs. — 5. Dividing engine. — 6. Repsold heliostat. — 7. Spectrograph I. — 8. Spectrograph III with electric heating. — 9. Small Zöllner photometer. — 10. General view of the Astrophysikalisches Observatorium while the large dome was being built.

c) Kgl. Geophysikalisches Institut und Kgl. Sternwarte in Göttingen. 1. Portable apparatus for determination of latitude and longitude. — 2. a) Zenit-camera; b) grating-photometer. — 3. Aspirator for the determination of the quantity of ions in the air, according to Gerdien. — 4. Double meteoroscope. — 5. Horizontal seismometer. — 6. Vertical seismometer.

d) Kgl. Meteorologisch - Magnetisches Observatorium in Potsdam. 1. Meteorological instruments in use in the open air and main building. — 2. Meteorological instrument room (first floor). — 3. Meteorological instrument room (tower). — 4. Meteorological registering room (tower). — 5. Observatory for absolute magnetic measurements. — 6. Observatory for absolute magnetic measurements (an other view).

e) Kaiserliche Normal-Eichungs-Kommission in Charlottenburg. 1. Universal comparator (photographic apparatus, carriages, trough). — 2. Vacuum balance, cover removed. — 3. Testing gas meters. — 4. Testing water meters. — 5. Universal comparator (microscopes, carriages, trough). — 6. Universal comparator (carriages, trough). — 7. Universal comparator (general view from above). — 8. Universal comparator (switch-board). — 9. Hydrostatic balance of precision, for loads up to 50 *kg*. — 10. Balance of precision for 1 *g*. — 11. Comparator for measuring tapes. — 12. Grain tester, for determining the quality of grain. — 13. Apparatus for the determination of capillarity by the wave method, according to Lord Kelvin. — 14. Apparatus for the determination of capillarity in capillar tubes. — 15. Apparatus for the determination of the density of liquids at different temperatures. — 16. Testing of graduates, pipettes etc.

f) Physikalisch-Technische Reichsanstalt in Charlottenburg. 1. Manometer up to 20 atmospheres. — 2. Determination of the expansion of water. — 3. Measurement of small resistances. — 4. Conductivity measurements. — 5. Gas-thermometer. — 6. Testing high-temperature thermometers. — 7. Electrically heated thermostat. — 8. Testing apparatus for aneroids. — 9. Comparator. — 10. Hydrostatic balance for 10 *kg*. — 11. Measurement of "black temperatures". — 12. Polarimetric apparatus. — 13. Photometric apparatus. — 14. Measurement of the spherical light intensity. — 15. Measurements of alternating and three-phase currents. — 16. High voltage battery (11000 volts). — 17. Electrical measurement of temperature. — 18. Electric oven with Le Chatelier thermoelements. — 19. Pyrometer room. — 20. Manometer testing.

II. Photographs and Other Framed Pictures.

As far as these photographs and pictures represent instruments or results obtained by their means, they are arranged in their respective departments in the Rooms A—D.

These have been furnished by:

a) Dr. M. Haid, Professor an der Technischen Hochschule in Karlsruhe.

Two photographs of the pendulum stand, according to Haid.

This apparatus, designed for the accurate determination of gravity (see *Zeitschr. f. Instrkde.* ***16.*** *p. 193. 1896*) is made by C. Bamberg, Friedenau, Berlin.

b) Kgl. Observatorien in Berlin-Potsdam.

1. *Eleven pictures,* taken and enlarged by the Kgl. Meß-bildanstalt in Berlin (Director: Geh. Baurat Prof. Dr. Meydenbauer):

Astrophysikalisches Observatorium: Large refractor (80 *cm.*). — Photographic refractor. — Large dome. — Two views of the observatory.

Geodätisches Institut: View of the building and of the instrument room.

Meteorologisch-Magnetisches Observatorium: Three views of the observatory.

A picture representing the entrance to the park, in which the observatories on the Telegraphenberg near Potsdam are situated.

2. *Photograph of the Orion nebula,* taken by Prof. J. Hartmann in 1901 with the 80 *cm.* refractor.

3. *Five photographs and drawings* from the Meteorologisch-Magnetisches Observatorium:

Curves of the magnetic disturbance on October 31. 1903. — Registering constant volume air thermometer, according to A. Sprung (improved form of the instrument, described in the *Zeitschr. f. Instrkde.* ***1.*** *p. 358. 1881*; see also Rep. of the Intern. Meteorol. Congress, Chicago 1893. *p. 718*). — Preliminary plan for automatic registration of the dew point, by means of a selenium cell (see A. Sprung, *Das Wetter* ***19.*** *p. 241. 1902*). — "Wolkenautomat", according to Sprung-Fuess. — Photographs of clouds made with the "Wolkenautomat".

In connection with the two last photographs there is in Room D a publication by A. Sprung and R. Süring: "Ergebnisse der

Wolkenbeobachtungen in Potsdam und an einigen Hülfsstationen in Deutschland in den Jahren 1896 und 1897". Berlin 1903, A. Asher & Co.

4. *Twelve sets of curves* from the Aeronautisches Observatorium des Meteorologischen Instituts:

The curves show the daily vertical distribution of temperature above Berlin during the year 1903, to a height of 5500 *m*.

The following publications on this subject will be found in Room D: "Ergebnissse der Arbeiten am Aeronautischen Observatorium" von R. Aßmann und A. Berson, in 2 Bänden; I. 1900 bis 1. X. 1901, II. vom 1. X. 1901 bis 31. XII. 1902. Berlin, A. Asher & Co. — "Wissenschaftliche Luftfahrten" von R. Aßmann und A. Berson, in 3 Bänden. Braunschweig 1900, Friedr. Vieweg & Sohn.

c) Physikalisch-Technische Reichsanstalt in Charlottenburg.

1. *Water color* of the buildings and grounds of the Reichsanstalt, painted by the architects Laxmann and Gerstenhauer, Charlottenburg.

2. *Three large photographs* of the Reichsanstalt, taken and enlarged by the Kgl. Meßbildanstalt, Berlin:

Front view of the Physical Division. — Rear view of the main building of the Technical Division. — Power house.

3. *Five smaller photographs* of the buildings of the Reichsanstalt:

Residence of the President. — Residence of the Director of the Technical Division. — Administration building. — Power house (from the street). — Front view of the Technical Division.

4. *Three small photographs* (hung in Room C):

Double three phase generator with driving motor. — Connections for the city three phase mains. — Three phase direct current transformer with switch board.

d) Elektrisches Prüfamt in München.

The electrotechnical laboratory of the city lighting works in München, founded and managed by Stadtbaurat F. Uppenborn, has assumed the functions of an official electrical testing bureau. Similar testing bureaus also exist in Chemnitz, Frankfurt a. M., Hamburg, Ilmenau, and Nürnberg. In accordance with the law concerning the electrical units, passed June 1. 1898, these have taken up the testing of electric meters and other commercial switch board instruments.

The testing bureau in München exhibits the following *five photographs*:

General view of the laboratory building. — Ground plan of the upper and lower stories. — View of the testing room. — View of the room used for measurements of precision. — Current distributing pillar with mercury switch for the testing room; standard switch board for electric meter testing.

e) Dr. M. Wolf, Professor an der Universität Heidelberg.

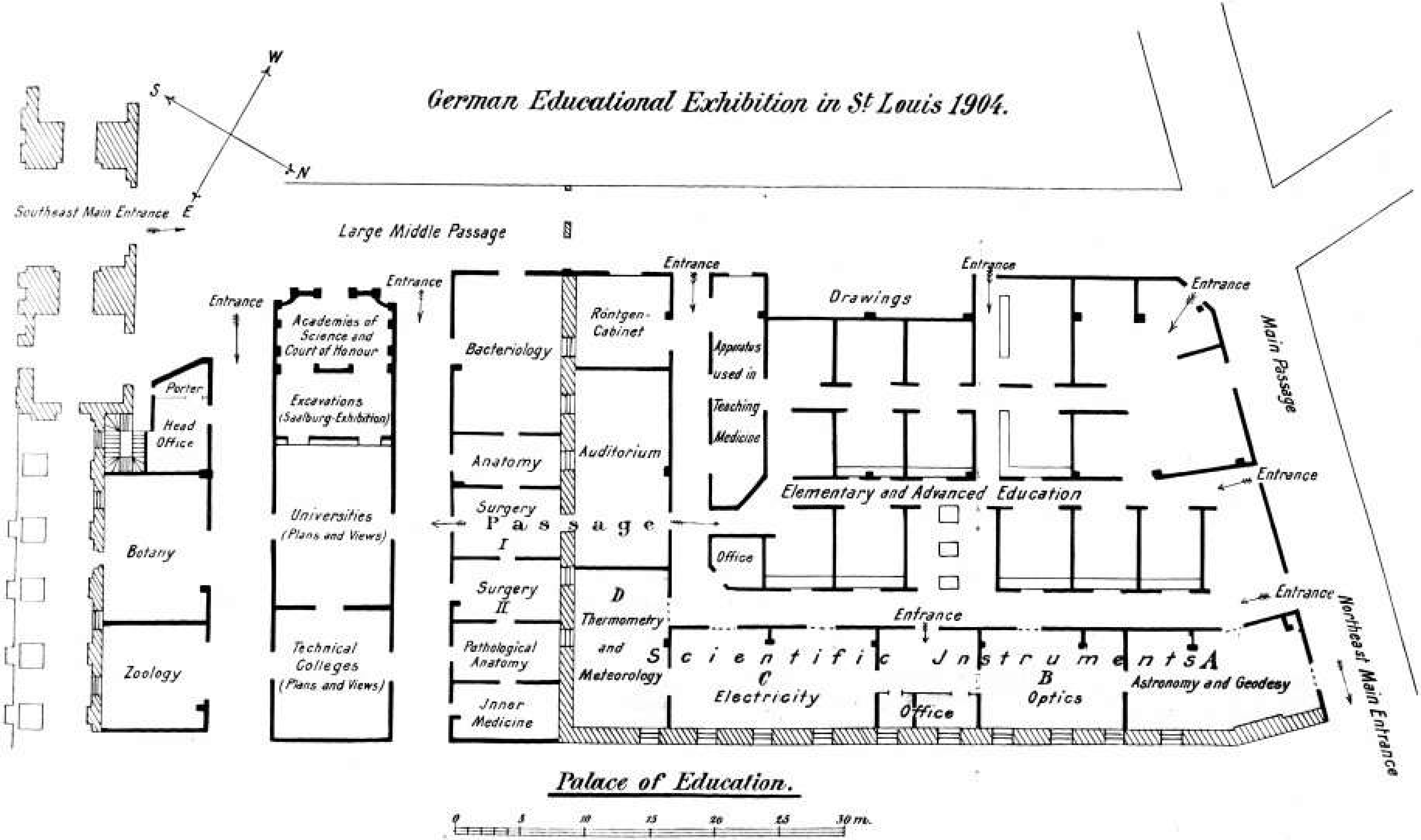
Photographs of the heavens, taken with a time of exposure of from 2—15 hours, between the years 1890 and 1903:

28 prints; 72 slides, which will be shown from time to time with the Zeiss epidiascope in the Lecture Room.

Index.

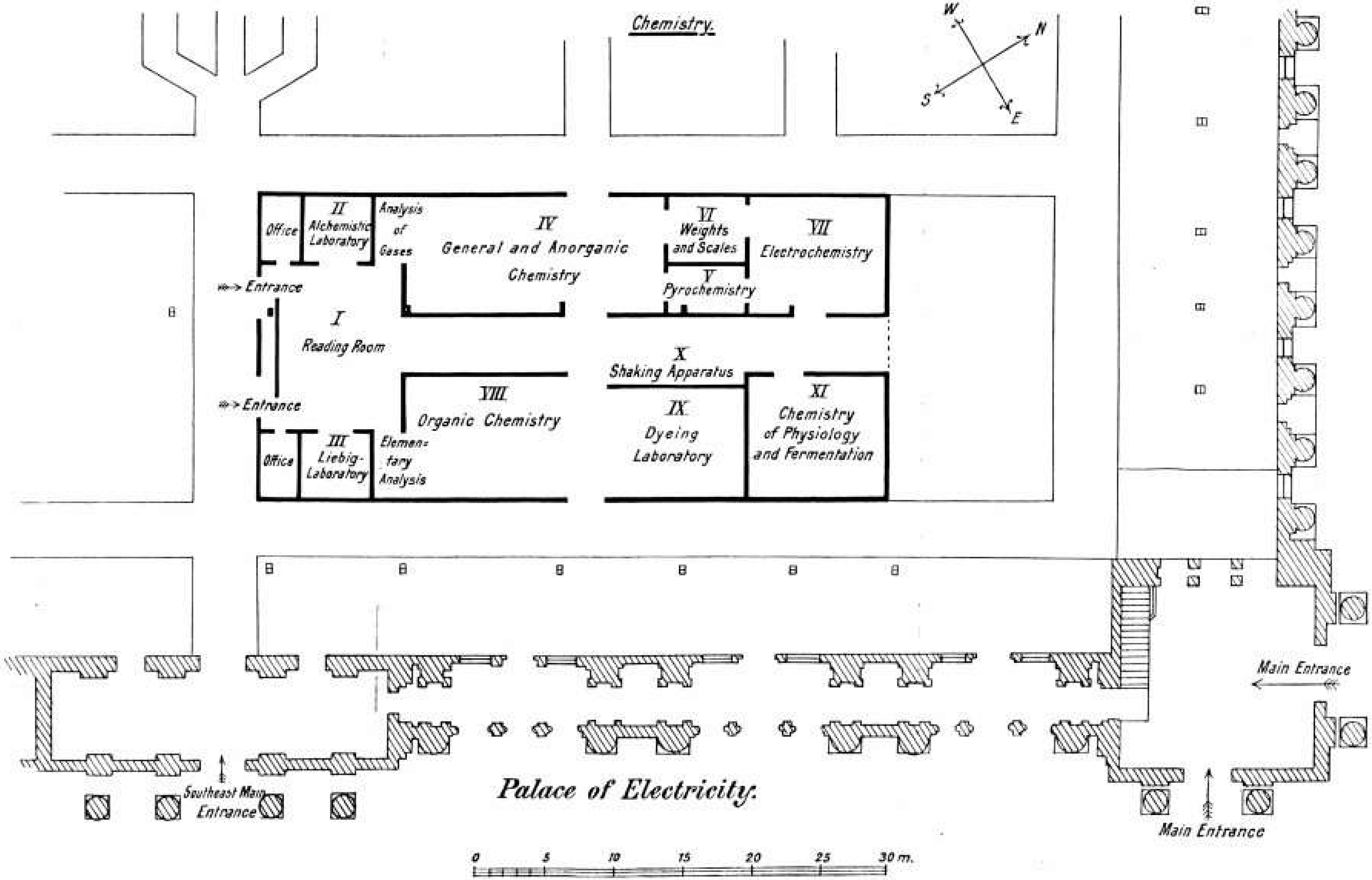
The numbers opposite the names of the exhibitors refer to the pages.

German Educational Exhibition in St Louis 1904.



Palace of Education.

German Educational Exhibition in St Louis 1904.



Palace of Electricity.