GERMAN EDUCATIONAL EXHIBITION: WORLD'S FAIR, ST. LOUIS, 1904. SCIENTIFIC INSTRUMENTS

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German Educational Exhibition: World's Fair, St. Louis, 1904. Scientific Instruments by Various

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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 $^1/_{20000000}$).

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