THE SMALL ORIGINAL EÖTVÖS TORSION BALANCE

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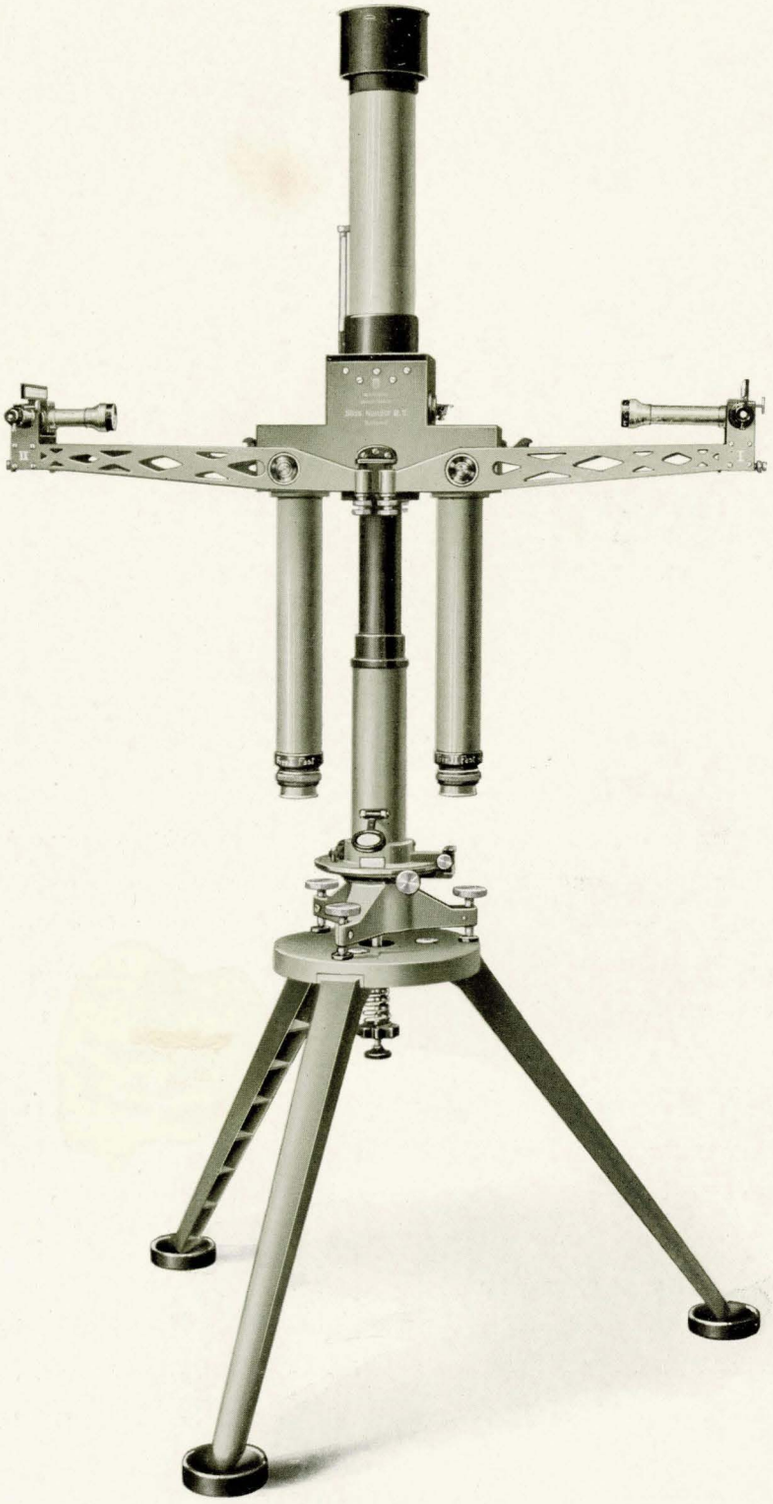
(Hungary)



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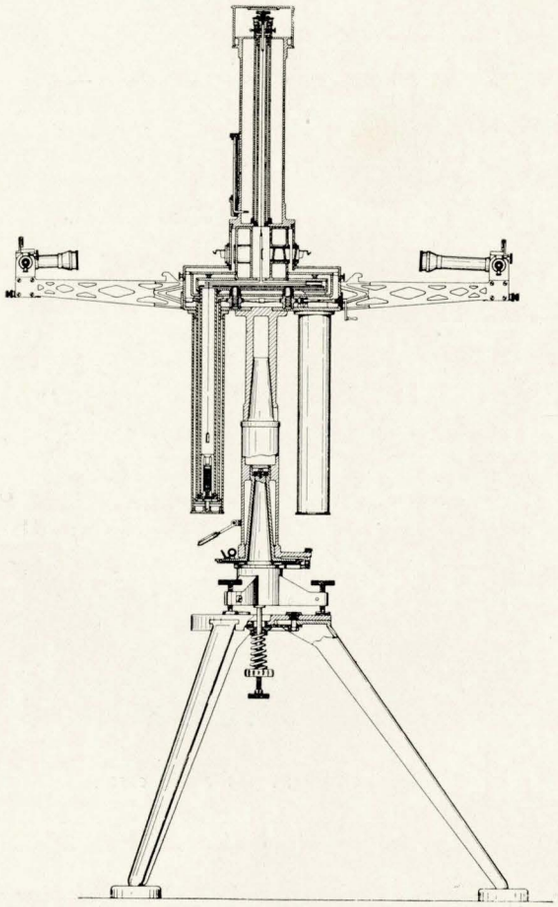
The eminent Hungarian scientist Baron Roland Eötvös, late professor of Physics at the Budapest University devoted nearly the whole of his life to the study of gravitation. During his researches he invented a quite new and ingenious method, worked out its detailed mathematical theory and in order to carry out the necessary measurements, he constructed suitable instruments the gravitational Torsion Balances which were of an almost incredible sensitiveness. With the aid of this instrument we can determine the variations of gravity in space, first of all the Gradients i. e. the extent and direction of the greatest increase of gravity in the horizontal plane. Further we can determine the Horizontal Directing Tendencies by which we are informed

about the form of the Earth's surface, i. e. to a certain extent about the curvature data of the gravitational level surface. With the help of the Gradients the value of gravity for all observation stations may be computed. Further on basis of these values the lines of equal gravity i. e. Isogams may be determined. The most suitable way of presenting the results of observation is to sum them up graphically in maps by which the gravitational disturbances are illustrated in detail. These disturbances are caused by the attraction of both the visible masses on the Earth's surface, and the invisible subterranean masses of various density and configuration. As the characteristic datum of attraction i. e. the Gravitational Constant has only the value of $66{,}3.10^{-9}$ CGS. these disturbances are of a similar insignificant order. For that very reason the measurements made by the Torsion Balance must be carried out with an accuracy of 1.10^{-9} CGS which value is now internationally called »Eötvös« and marked by »E«.

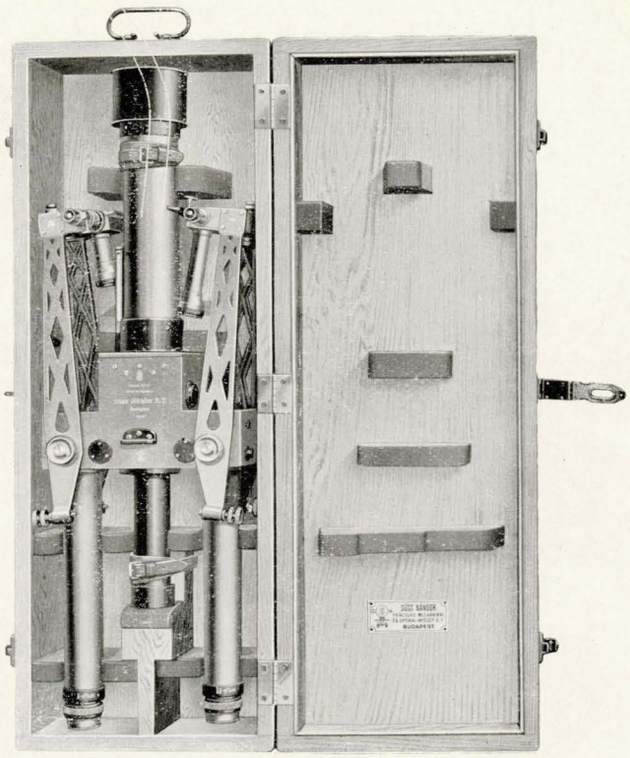
Therefore the Torsion Balance, as an instrument of exceedingly great sensitiveness, can be used both for various scientific investigations and for practical purposes. Thus the Eötvös Balance enables us to carry out very interesting and useful researches in Physics, Geophysics, Seismology and especially in Geodesy, where immediate data may be obtained as to the real form of the Earth's surface. In Geology, on basis of the gravitational observations very important conclusions can be drawn as to the subterranean strata and their configuration.

The Torsion Balance is very extensively and variously used for the purposes of practical prospecting. With



Cross-section of the instrument.

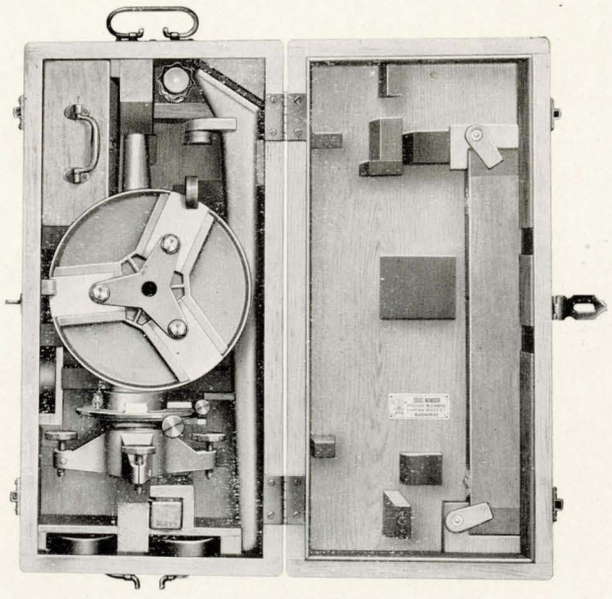
the aid of this instrument can be determined the subterranean slopes, the deepest and highest spots of the layers, i. e. the synclines and anticlines or domes, the steplike configurations, the faults etc. knowledge of which is often of a great practical importance. Thus in coal mines in Hungary the faults were detected, where mining in general stops. In other cases in the limestone surrounding the coal, the subterranean holes were determined through which the penetration of water constantly



The instrument packed in cases.

endangers mining and the imminent disaster can be avoided by plugging these holes with cement. The Tor≈sion Balance rendered good services also in other sub≈terranean work.

Further valuable mineral products may be prospected by a direct or indirect method. Materials to be found by the direct method are those which cause gravitational disturbances, because their den≈sity their specific gravity differs from that of the sur≈roundings. On one hand materials of greater density may be detected, as for instance different deposits of ore, on the other hand materials of lesser density like coal



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and especially salt bodies, as has been proved in the Torsion Balance Surveys carried out in Hungary. Materials to be found indirectly are those which do not cause gravitational disturbances, but occur in connexion with certain subterranean configurations discoverable with the aid of the Eötvös Balance. There are many possible ways of applying this indirect method. Often the course of the subterranean layers containing water can be detected. But as it is customary all over the world of the greatest importance is the search for oil and natural gas. According to geological experiences the oil can be found on the slopes of salt bodies, on the boundaries of igneous rocks or magmatic intrusions, in the neighbourhood of faults and on the subterranean elevations, on the anticlines, especially on the domes which configurations may safely and exactly be determined by the Torsion Balance.

Transport of the equipment on elephant back.
(Upper Assam expedition of the Eötvös Institute in India.)

This method of prospecting is especially useful and important in the plains where the commonly used geological methods fail and where up to now reliable information could only be secured by the very expensive test-borings.

Eötvös constructed his first instruments for laboratory use in the early eighties of the last century. These as well as all the later types of Eötvös Balances* were made in our factory, including the instruments already suitable for field measurements, which were exhibited in Budapest in

* The development of the Original Eötvös Instruments is described and properly illustrated in the following article: D. Pekár, Entwicklung der Eötvösschen Originaldrehwagen, Die Naturwissenschaften **16,** 1079—1088. Berlin, 1928.

Taking down of the observation huts from elephant back.
(Upper Assam expedition of the Eötvös Institute in India.)

1896 and in Paris in 1900. In order to reduce the time required for observation, Eötvös constructed in 1902 his first double instrument which actually consists of two separate torsion balances mounted parallelly, but in opposite direction, on a common pedestal. Since then double instruments were used exclusively in field measurements and they have since been improved upon by Eötvös himself.

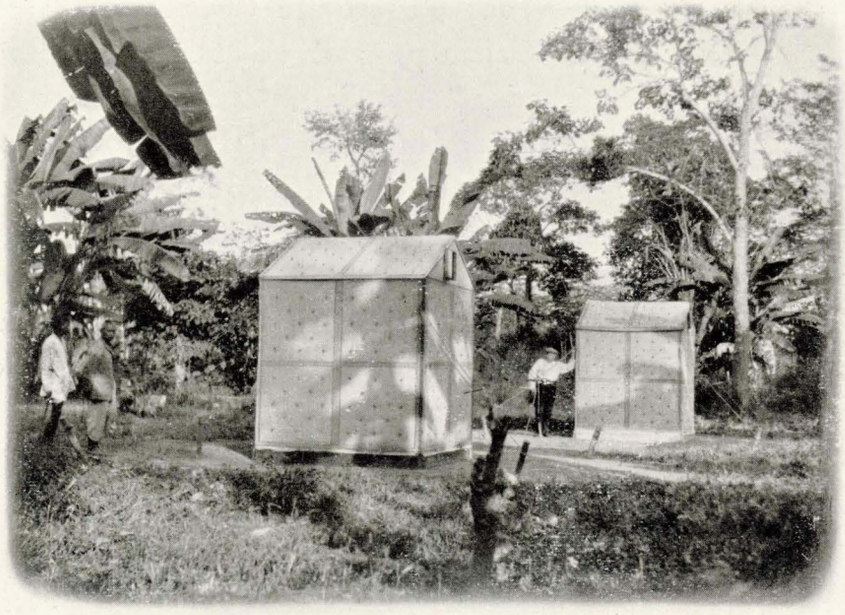
After the death of Eötvös in 1919 a special institute The Baron Roland Eötvös Geophysical Institute, was founded in Budapest, for the purposes of continuing the scientific geophysical researches both in field and laboratory. The institute is directed by Dr. D. Pekár, member of the Hungarian Academy of Sciences, who was the collaborator of Eötvös for a quarter of a cen-

tury and since their beginning all Torsion Balance measurements in Hungary were conducted and supervised by him. All our instruments are made according to the instructions of the Eötvös Institute whereby their continuous improvement and perfection is secured. In the construction of the new models constant use was made of all experiences gathered by this Institute during their measurements carried out over a long period under the most varied circumstances as in the tropics in India. In this way many improvements were introduced without changing the principle of the instrument and the original conception of Eötvös. Just therefore these instruments too may justly be called »Original Eötvös«.

Readings with these instruments are carried out exclusively by telescope and scale in a visual way, corresponding to the original point of view of Eötvös*.

The instruments were manufactered for a time in the original large dimensions with torsion beams of 40 cm length. But very soon to meet practical requirements we introduced instruments of a considerably smaller size. In the Small Original Eötvös of the newest construction the torsion beams have a length of but 20 cm. The instrument is so light that packed in two small cases it can easily be transported over the roughest ground in case of necessity even by coolie porterage.

* The advantages of the instruments are thorougly discussed in the following articles: D. Pekár, Die bei Feldmessungen angewendete Drehwage des Baron Roland v. Eötvös, Z. Instrumentenkunde **42,** 173–178 (1922); Die Anwendbarkeit der Eötvösschen Drehwage im Felde. Z. Instrumentenkunde **43,** 187–195 (1923); Die Entwickelung, Empfindlichkeit und Verlässlichkeit der Eötvösschen Original–Drehwagen. Z. Instrumentenkunde **45,** 486–493 (1925). Berlin.



The observation huts mounted.
(Upper Assam expedition of the Eötvös Institute in India.)

The mechanical parts of the Eötvös instruments are manufactured exclusively in our factory. The experiences of over fourty years in this particular line and our world wide reputation in the production of precision instruments are a sufficient guarantee that all instruments leaving our works fulfil the highest claims.

The making of the Eötvös Torsion Balances is scientifically supervised by D. Pekár, director of the Eötvös Institute. The precise construction of the interior parts of the instruments, the most suitable adjustment of the balances for certain particular conditions, the final and careful testing, the determination of the constants and the computation of the formulae of the instruments are made in the laboratories of the Baron Roland

Eötvös Geophysical Institute (VIII, Eszterházy-utca 7. Budapest, Hungary) and all Original Eötvös Balances are furnished with a Certificate signed by the director. Any informations in the more important matters concerning the instrument and the Surveys may be obtained also directly from this Institute.

The Eötvös Institute takes special pains in preparing the torsion wires. On basis of their experiences gathered during several decades they apply special methods for this purpose by which it has become possible to render the data of the wires really constant. Their position of equilibrium changes but slightly with the temperature and returning to the same temperature this position will again be exactly the same as before. It is especially this quality which is characteristic and important for really reliable wires. In the Small Original Eötvös of the newest type the length of the torsion wire is only 30 cm and yet of a sufficient sensitiveness.

Each instrument is tested and adjusted individually in a way that it becomes almost absolutely insensible against the external disturbing effects, against the sudden changes of temperature. Therefore it yields exact and reliable readings during the day time observations. The oscillations of the torsion balances are damped to an extent that the readings can be made at intervals of three quarters of an hour. Accordingly repeating the series of three positions once and thus taking altogether six observations, the time needed is not more than four and a half hours only which time will be suffucient to obtain quite reliable and checked data.

The internal construction of the instrument is so simple and reliable that functional troubles are almost

excluded. The precise settings by means of micrometric screws, used formerly in laboratory Balances, were discarded in the field instruments. The torsion heads, the prisms of the telescopes etc. are fixed and secured by nuts in the proper position that no shaking whatever would alter the settings. It was proved by experience that the instrument could be used immediately without any readjustment, even on return from an expedition after long railway and ocean transport.

The upper part, the Balance proper consists of one piece only. It is not necessary to open the instrument during the survey. The torsion beams and the lower hanging weights can be fastened from the outside in such a way that, packed in cases, the instrument can be transported in any position. The mounting of the apparatus is very simple and done in no time. The tripod is put together, the pedestal screwed on, upon which the Balance itself will be placed. The telescope arms are bent downwards, the turning axis set vertically, the lower hanging weights released first and then the torsion beams. Finally the instrument is turned in the magnetic meridian, placing a compass on it for this purpose and then the Torsion Balance is ready for observation. The handling of the instrument and the carrying out of the observations is so simple that it can be done by any intelligent person.

Nothing can better prove the usefulness of the instrument than the fact that a great number of Original Eötvös Balances are to be found in use all over the world as in Japan, India, Africa, America and of course in the States of Europe.

Besides the Small Original Eötvös Torsion Balances we also manufacture all the supplemantary outfit for field

measurements such as observation tents, inclinometers for terraincorrection, scales for measuring the specific gravity of the soil, theodolites, transport equipment etc. Full information re supplementary outfits may be obtained on special request.

Some of the characteristics of the Small Original Eötvös Torsion Balance:

Length of torsion wire: 300 mm.
Diameter of torsion wire: 0·02 mm.
Length of torsion arm of the beam: 100 mm.
Interval of the successive readings: 45 minutes.
Total height of instrument with pedestal and tripod: 1600 mm.
Totalweight of instrument with pedestal and tripod: 38 kg.
Totalweight of the larger box including the upper part of the instrument: 40 kg.
Totalweight of the smaller box including the pedestal and tripod of the instrument: 33 kg.

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