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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

GERMAN SCIENTIFIC APPARATUS.

TO THE EDITOR OF SCIENCE: At the International Exposition, Paris, 1900, the jury having in charge Group III., Class 15, Instruments of Precision, Moneys and Medals, were very much impressed with the German exhibit. This exhibit was arranged in a different way from that used by any other nation. Germany made a joint exhibition of mechanicians and opticians, and arranged their apparatus in sections embracing certain classes of instruments, and thus departed from the usual custom of arranging the exhibits under various firms. This enabled the jury to see at once all instruments of the same kind grouped together in one case.

The German Association printed complete catalogues describing and illustrating the apparatus exhibited, and these catalogues and descriptions were of very great assistance to the jurors in making awards.

The catalogues printed an introduction, which gave in a very condensed form the history of the work done in Germany in improving the manufacture of instruments of precision. I enclose an English translation of this introduction furnished by the German Association, and suggest that it be published in full in SCIENCE, inasmuch as it shows by what methods the German mechanicians have been able to produce such splendid results.

J. K. REES,
Member of the Jury, Group III., Class 15.

On this auspicious occasion, when the great French nation has invited the peoples of the world to inaugurate the 20th century by joining together under her hospitable sky in a brilliant exhibition of the works of peaceful competition, it would not seem irrelevant to glance back upon the departed century. It has been essentially an age of scientific and technical development and, naturally, the mechanical and optical trades claim a prominent share in the progress of mankind within the last hundred years. If we compare our present fundamental basis of all scientific measurements, our weights and measures, in their present perfection, with those existing a hundred years ago; if we place our finest astronomical and surveying instruments side by side with the to us almost primeval forms as they existed at the beginning of the century; or if we glance at our present sensitive physical and electrical measurements, remembering that a hundred years ago these were undreamt-of things, or in existence only in the crudest form, we cannot escape from a gladdening appreciation of the enormous progress made within the last century in the construction of philosophical instruments, as well as their reaction upon the progress of scientific investigations by dint of improved methods. A prominent share in this development of the aids of science is due to the German mechanicians and opticians.

At the commencement of the 19th century the French and English makers of scientific instruments were far in advance of the Germans. True, the 18th century knew of prominent mechanicians, and at the very beginning of the 19th century Fraunhofer and Reichenbach and their disciples, Repsold, of Hamburg, Pistor, of Berlin, and others, had secured general respect, in the scientific world, for German mechanical skill; yet the French and English makers took the lead at that time, so as to almost supply the world's entire demand in scientific instruments. This predominance had the further consequence of causing young Germans to emigrate to France or England in order to thoroughly master their subject. Many a German mechanician of the present day owes to French or English masters a substantial portion of his knowledge, and even in these days it is the aspiration of many a Teuton to widen his practical knowledge in France or England. The prominent position of the French and English instrument-makers was mainly due to the support which in both countries the State bestowed upon technical art. In England, the interests of the navy and merchant service gave rise to the assiduous development of astronomical and nautical measuring instruments, more particularly of astronomical chronometers, so as to ensure in these branches an absolute supremacy, which German mechanicians have only within the last ten or twenty years been able to contest. France owed her prominent position to the great geometrical survey of Cassini and his followers and, in a still greater degree, the admirable comprehensive labors leading to the establishment of the metrical system of weights and measures, which in its turn resulted in far-reaching improvements in the construction of appliances for weighing and measuring, astronomical and surveying, physical and chemical instruments.

In Germany, it is only within the last twenty or twenty-five years that the State has espoused the interests of the home industry in scientific instruments, but such have been the efforts and results that the position has, at a blow, as it were, changed in favor of Germany. Every possible encouragement was offered and great problems were created by the expenditure of the German governments, within the last thirty years, on art and science, the establishment of numerous large physical and chemical laboratories, the erection of new and the ex-

pansion of old observatories, the requisition of greatly improved surveying and astronomical instruments. Great progress resulted from the introduction of the metric system in the construction of exact weights and delicate balances, and, in compliance with the requirements of modern meteorology, led to vast improvements in thermometry and barometry. The development of the German navy created a great demand for nautical instruments. All these influences roused the productive powers of the nation and success has not been wanting.

Soon also the necessity was recognized of the close cooperation of the scientists and practical men. Accordingly, in 1879, several scientists, mechanicians and opticians united in Berlin and formed the nucleus of the German Association of Mechanicians and Opticians, which was formed in 1881 and embraced the whole German Empire, having for its object the scientific, technical and commercial development of philosophical instrument-making. The official organ of this Society, the *Zeitschrift für Instrumentenkunde*, was likewise founded in 1881 and is devoted to the theoretical and practical development of scientific instruments. Specialized schools were established, first in Berlin, then in Frankfort-on-the-Main and subsequently in many other towns, where savants and practical men are combined in training the rising generation in the theoretical departments of the subject. As a result of these serious scientific aims, German mechanicians and opticians sought in their laboratories and workshops the assistance of scientists, and at the present time the majority of the leading German firms retain one or more experienced mathematicians or physicists in their permanent service.

The greatest share of the impetus given to the manufacture of scientific instruments, however, is due to the Imperial Physical and Technical Institute, which was established in 1887. The first, or scientific, department of this important institution is devoted to purely physical research, whilst the second, or technical, department deals with matters concerning the construction of philosophical instruments. This institution has already done great service, and a large proportion of recent progress is due to its stimulating and helpful influence.

Seeing how comprehensive and systematic are the efforts brought to bear upon the art and science of instrument construction, it is not surprising that in this department Germany occupies now a foremost position. This fact was already apparent on the occasion of the Universal Exhibition of 1888 at Brussels, even more strikingly so at the World's Columbian Exhibition at Chicago in 1893, and remarkable achievements were shown by the combined members of the German Association of Mechanicians and Opticians at the Berlin Trades Exhibition of 1896.

After witnessing this steady development of our mechanical and optical trade, we cannot but look with confidence and gratification upon the practical demonstration at the Paris Centenary Exhibition of the flourishing state of the scientific instrument trade in Germany, and a characteristic feature of the latter is the unity of its aims, which is traceable to the history of its development and its intimate connection with pure science. It appeared, therefore, desirable to depart from the usual custom of grouping the exhibits under various firms, and rather to place them in sections embracing certain classes of instruments, so as to demonstrate on broad lines and as a whole, within a well-arranged though condensed area, the present position of German mechanical and optical art.

The Joint Exhibition of German Mechanicians and Opticians is, accordingly, subdivided into the following sections:

I. Metrological and Standardizing Instruments.
II. Astronomical Instruments.

III. Surveying and Nautical Instruments: — a. Geometric Instruments, b. Surveying, Mining and exploring Instruments, c. Nautical Instruments.

IV. Meteorological, Geo-magnetic, Thermometric and Calorimetric Instruments.

V. Optical Instruments: —a. Photometrical Appliances; b. Spectroscopes and Optical Measuring Instruments; c. Microscopes and their auxiliaries; d. Photomicrography and Projection; e. Photographic Ojectives; f. Hand Telescopes and Terrestrial Telescopes; g. Crystaloptics, Appliances for demonstrating and observing the Phenomena of Light.

VI. Electrical Measuring Instruments for Scientific Purposes.

VII. Electro-medical, Physiological and Biological Instruments.

VIII. Appliances for Chemical and Chemico-physical Research, Laboratory and Educational Apparatus.

IX. Drawing and Calculating Appliances.

X. Appliances for the Examination of Materials and for Special Purposes, Special Tools and Auxiliaries.

Following the plan of grouping the exhibits into sections according to subjects of applied science, it may be profitable to append a short sketch of the present position of philosophical instrument-making in Germany.

I. German mechanicians found themselves for the first time in their history face to face with a task of some magnitude when called upon, some seventy years ago, to construct metrological and standardizing appliances for the purpose of determining, under the direction of the great astronomer Bessel, the standards of the old Prussian system of measures. Subsequently, the mechanical arts received an important impetus through the introduction of the metric system in general and the influence and requirements of the Standardizing Commission in particular. The numerous inducements and hints which German mechanicians have received from the Standardizing Commission have enabled them to effectually cooperate in the introduction of the metric system both in and outside Germany. Opportunities presented themselves for the construction of very exact comparators, dividing engines, terminal and divided measures, balances of the highest degree of precision, etc.; and while acquitting themselves of these tasks, German mechanicians have both learned and accomplished much. A considerable portion of the equipment of the 'Bureau international des poids et mesures' has proceeded from German workshops. The achievements of Germany in the department of metrological instruments and appliances are prominently demonstrated within the Joint Exhibition of Mechanicians and Opticians by the Special Exhibits of the Imperial Normal-Aichungs-Kommission [Office of Standards].

II. From the measures, the indispensable fundament of all exact research, we proceed to the astronomical instruments. This department is necessarily at a disadvantage inasmuch as the largest and most costly instruments, the large refractors, can only be exhibited under very special circumstances. Hitherto German telescope-makers have supplied large refractors almost exclusively to countries outside Germany, but in this respect they have actively competed with other makers. Recently they have been given an opportunity of proving their powers in the construction of the new Potsdam refractor, which is not only one of the largest instruments in Europe, but also the first large telescope built for a German observatory, and the results have been brilliant indeed. In the main, the German makers have devoted their attention to the construction of medium-sized and small astronomical instruments, refractors, transit-circles, altitude circles, heliometers, etc., but with such success that, as regards the precision and delicacy of the individual parts of the instrument, Germany stands now unrivaled. Recently great progress has been made in the construction of astronomical objectives. The first optician who broke the ice in the important department of

optical glass smelting was a German, to wit Fraunhofer. His untimely death was followed by a long period of stagnation, and the limits of the possible were soon reached when attempts were made to construct very large objectives, at least as far as the optician's art was concerned. About twenty years ago, Professor Abbe and Dr. Schott, of Jena, resumed the thread where Fraunhofer had left off, and they succeeded in producing the old crown and flint-glasses in such perfection that the chromatic differences of spherical aberration can be compensated almost completely. This led to great improvements in telescope lenses, and at the same time the Jena Glass Works have become so productive as to enable German opticians to cover their entire demand in Germany. Great progress has also been made in such an important branch of manufacture as that of spirit-levels. Not only are the finest spirit-levels incontestably made in Germany, but, in addition, the Imperal Physical and Technical Institute has successfully investigated the causes of the formation of deposits within the levels. Mechanicians possess now a ready means of detecting glass liable to deterioration and have no difficulty in securing suitable glasses.

III. The third section, comprising geometric and nautical instruments, includes also those instruments which form a connecting link between astronomy proper and the land-surveyor's art, *i. e.*, those astronomical instruments which are employed for geodetic measurements. Many improvements in this group of instruments have emanated from German workshops and have had their origin in the requirements of the International Survey and especially the influence of the Geodetic Institute and its present director, Dr. Helmert. We may here mention the conversion of the friction-rollers of transit instruments into a balance beam, so as to completely compensate the errors of collimation. We may also refer to Repsold's mode of fitting transit instruments so as to neutralize almost entirely the personal equation, and equally important are the improvements in zenith-telescopes and spirit-level testing appliances. The geophysical investigations of the International Survey have given birth to the most sensitive instrument of our times, the horizontal pendulum, which owes its origin and development to German scientists and mechanicians. The study of the movements of the oceans has recently been facilitated by greatly improved instruments, the most perfect of which are those of Seibt-Fuess. Remarkable progress has in late years been made in the construction of surveying instruments. The requirements of surveyors and engineers have reached such a high stage of development that they could not fail to beneficially affect the construction of theodolites, leveling instruments and tacheometers. The manufacture of surveying instruments is carried on in Germany on a very extensive scale, and the reputation of these instruments has obtained for them a wide market all over the world. Considerable improvements have also been made in small compactly built surveying instruments, which have been requisitioned by numerous German explorers. As the natural outcome of the developments of the merchant service and the creation of a powerful navy, considerable attention is paid to the manufacture of nautical instruments. Whereas formerly Germany depended for these accessories of navigation upon other countries, England in particular, at the present time all nautical instruments are manufactured at home equally well, in some respects even better than abroad.

IV. The development of the meteorological instruments and the appliances for measuring temperatures presents a typical illustration of the close connection be-

tween theoretical science and manufacture in Germany. This applies in particular to thermometers. About twenty years ago the manufacture of thermometers had come to a dead stop in Germany, thermometers being then invested with a defect, their liability to periodic changes, which seriously endangered German manufacture. Comprehensive investigations were then carried on by the Normal-Aichungs-Kommission, the Imperial Physical and Technical Institute and the Jena Glass Works, and after much labor brought the desired reward. Chemical analysis in conjunction with carefully managed glass smeltings and practical tests showed that pure potassic and pure sodic glasses possess these defects in the least degree, whereas glasses containing both alkalis are subject to periodic changes to such an extent as to render them useless for thermometric purposes. The last outcome of these investigations was the production, at the Jena Glass Works, of an excellent sodium glass which shows depressions of not more than 0.1° per 100°. Recently a boro-silicate glass has been prepared which shows a maximum depression of only 0.05° and possesses, moreover, the important property of excellently agreeing with the hydrogen thermometer. The advantages which may result from these discoveries to meteorology as well as the physical, chemical and medical sciences, are obvious. The technical arts too have benefited by discovery. With the aid of the new glasses and the invention of a process by which mercury is kept in the thermometer under a pressure of from 20 to 25 atmospheres, thermometers have been constructed for temperatures up to and beyond 550° C., as far as the region of incipient red heat, and reading accurately to $\frac{1}{10}$°. In consequence of these systematic efforts the manufacture of thermometers has reached in Germany an unprecedented level, and now governs the market of the world. German thermometers are purchased everywhere with particular confidence, as they can be supplied with official certificates. The Thermometer Testing Institute of Ilmenau examine annually about 40,000, and 16,000 are annually tested by the Imperial Physical and Technical Institute. German barometers, mercurial as well as aneroid, enjoy a high reputation and are everywhere esteemed for their delicate workmanship and reliability. The aneroid-barometers, which have obtained increased importance through the requirements of explorers, are tested by the Imperial Physical and Technical Institute with respect to their liability to periodic changes. The merits of the German self-registering instruments of the Sprung-Fuess type, thermographs and barographs, anemometers and rain-gauges are so well known that they need no further comment. These excellent instruments are used in all the meteorological observatories of the world. Finally, attention should be drawn to the pyrometers and calorimeters, which have also been considerably improved in recent years.

V. Like the mechanical arts, optical construction has made great and rapid progress in Germany. In this connection it is our gratifying duty to mention the name of Abbe, whose master-mind has had a profound influence upon the development of German optical science and manufacture. Abbe's earliest great merit is the elucidation of the theory of the microscope, by which he has placed microscopical optics upon an entirely new basis. It is also due to his efforts, in conjunction with those of Dr. Schott, the head of the Jena Glass Works, that numerous optically valuable glasses have been rendered available for the purposes of optical construction and that many difficult problems have now been solved. The new Jena phosphate and baryte glasses have led to many improvements in microscopical optics. We need only refer to the

Zeiss Apochromatic objectives, which, in conjunction with the compensating eye-pieces, yield a much more perfect correction of the chromatic and spherical aberrations than was previously attainable. We believe that we are not going too far by saying that to Professor Abbe is due the world-wide fame of German microscope construction. This reputation is not limited to the microscope itself, but to all its accessories, and embraces also microtomes, photo-micrographic and projection appliances and, in particular, photographic objectives, the construction of which has undergone wonderful changes since the introduction of the Jena glasses. The enormous exigencies of modern artificial illumination has given rise to many improvements in photometry. In this department the path has been smoothed by the efforts of the Imperial Physical and Technical Institute, and photometers are now made by which the intensity of a luminary can be measured with a degree of accuracy within $\frac{1}{2}$ per cent. The result is that German photometers enjoy a predominant popularity.—Germany, the cradle of spectrum analysis, occupies naturally an important position in the manufacture of spectrum appliances. The construction of these instruments, varying from the largest and finest spectrometers for astronomical, physical and chemical research, to the smallest hand spectroscopes, employs a large number of establishments. The same applies to the manufacture of polariscopic appliances, which have a wide reputation and command a particularly large market in the sugar trade.—No less importance attaches to the optical measuring instruments designed for the special requirements of physicists, chemists, mineralogists, etc., which are made with astronomical precision, so as to satisfy the highest exigencies of modern research. Among these we may mention the crystaloptic instruments and those for studying the theory of the nature of light.—In the construction of telescopes Germany has, in addition to general improvements, achieved a triumph, which has given her a great advantage. We are referring to the new form of binocular telescopes, in which, by the interposition of prisms, the dimensions of terrestrial telescopes are reduced to their lowest limits, while, at the same time, the defining power, light-gathering power and the stereoscopic effect are greatly increased as compared with the old types. The invention of these telescopes has created a wide demand in the army and navy. Very considerable, too, is the industry in optical auxiliaries, prisms, quartz and calc-spar preparations, etc., in which Germany excels both in quality and productiveness.

VI. The manufacture of electrical measuring instruments for scientific purposes has, in Germany, kept pace with the great strides made in electrical engineering. A number of prominent firms apply themselves to this technical branch and have made themselves a good name. This industry has likewise profited by the fundamental labors of the Imperial Physical and Technical Institute, in particular by the establishment of standards and by important investigations. We may here mention the introduction of new resistance materials, called manganine and constantan, which are not affected by changes of temperature and are now introduced by nearly all German firms occupied with the manufacture of electrical measuring instruments. Mention should also be made of the work accomplished in standard cells, which facilitate the application of the so-called methods of compensation for accurately measuring the strength and E.M.F. of electrical currents. This is, therefore, another department where the influence of scientific research has been felt in practical manufacture.

VII. Electro-medical appliances are also

made in Germany and exported abroad in very large numbers. The growing application of the electric current as a curative agent in operations and for the illumination of internal cavities of the human body has caused this department of industry to develop considerably both technically and commercially. To this group of appliances belong the various kinds of Röntgen ray apparatus, which are made and exported in stupendous numbers. Great importance attaches also to the manufacture of physiological and biological instruments, which engages the attention of several prominent firms.

VIII. The manufacture of educational appliances has grown in proportion to the development of the methods of practical demonstration in elementary as well as intermediate schools and technical colleges. The German output of educational appliances has at present reached a truly astounding magnitude. This is mainly due to their cheapness, simplicity and their suitable size. The laboratory appliances required for scientific investigations comprise naturally the finest and costliest instruments made.

IX. The manufacture of drawing and calculating instruments employs a large number of German mechanicians. Excellent drawing instruments and other appliances for drawing, cartography, etc., are exported to all parts of the world. German mechanicians have likewise succeeded in considerably improving Thomas's old calculating machine.

X. In addition to purely scientific instruments, a very large number of appliances are in constant requisition for special industrial purposes, and many a mechanician finds constant employment in this department. Besides, much thought and skill is brought to bear upon the needs of mechanical workshops. Formerly every mechanician made his own tools, and in many instances this is still done. Many changes have, however, been wrought in this respect by the influence of the American system of manufacture, in which, it should be added, Germans have a considerable share. Prominent mechanicians and engineers began to devote themselves more or less exclusively to the manufacture of special tools for philosophical instrument-making, and now form an important independent branch of industry.

In conclusion, we have to draw attention to the separate exhibition of the Imperial Physical and Technical Institute, which could not be mortised into the general plan of the Joint Exhibition. The aims of this Institute, the greatest of its kind in the world, have already been explained. The exhibits of the Institute serve to illustrate in a concise form several spheres of its activity.

The commercial importance of the mechanical and optical trade of Germany is commensurate with its reputation, as will readily be seen from the following table showing the export of scientific instruments during 1898:

	Net weight kilos.	Value in Marks.
Astronomical, optical mathematical, physical and electrical instruments	218,900	8,975,000
Raw optical glass (flint and crown)	124,900	625,000
Optical glasses (spectacles, reading-glasses, stereoscope glasses)	224,200	3,139,000
Terrestrial telescopes, field-glasses, opera-glasses, m'ntd spectacles, etc.	33,900	1,526,000
Total	601,900	14,265,000

The export has been trebled within ten years!

Another measure of the magnitude of the mechanical and optical trade of Germany may be obtained from the number of manufacturing establishments and their employés.

These are at present as follows:

Nature of manufacture.	Number of establishments.	Number of persons employed.
Astronomical, optical, mathematical, physical and electrical instruments	500	9,200
Glass-blowing, glass instruments, glass thermometers	125	1,773
Optical instruments, spectacles, reading-glasses	165	2,652
Total	790	13,625

THE FIRST SPECIES NAMED AS THE TYPE OF THE GENUS.

IN the suggestive article on 'The Method of Types in Botanical Nomenclature,' by Mr. O. F. Cook, published in SCIENCE of September 28, 1900, is an admirable statement of the meaning of type in biological taxonomy.

A species 'is a coherent or continuous group of organisms.' Its type is the first individual on which the specific name was bestowed. The type-specimen has an especial value in fixing the name and meaning of the species.

In like manner 'a genus of organisms is a species without close affinities or a group of mutually related species.' In other words, it too 'is a coherent or continuous group of organisms.' It is essential to its definition that some one of its species should constitute its type, to which the generic name should be inseparably attached. The large genera of earlier writers, subdivisions of their artificial orders, rather than groups of species, must become each associated around a special type before they can enter into modern conceptions of nomenclature.

The first essential in nomenclature is fixity. To establish permanence we must eliminate all elements of personal choice. The fixity of specific names through the law of priority is now fairly well established. Generic names are not yet similarly fixed. The method of changing the conception of an old genus from that of a mere subdivision of a higher group to that of a group of related species associated about a type species has not yet been well determined. In nomenclature, a genus must be fixed by its type, which is definite, not by its definition, which may be amended. Some writers have insisted that the first writer who subdivides a genus has the right and the duty to fix its type. Others maintain that the type must always be fixed by the process of elimination. In this process authors who eliminated unconsciously or in ignorance must be considered, as well as those who attempted to limit and define the generic parts in a group of family rank, called by its author a genus.

The method of elimination is now generally approved, but there is great variation in the application of it. Its great defect lies in the necessary uncertainty of its definition. Too often different assumptions or different points of view give different results. Any result may be vitiated by the discovery of some note or discussion—useless in itself, which may have been overlooked at the time of the first attempt at finding the type.

Inasmuch as the thought of type is inseparable in modern taxonomy from the idea of genus or species, it is most desirable to find some way of fixing the type of an author through the words of the author himself—not trusting to the mazes of subsequent delimitation and elimination.

The most convenient and most logical method of doing this, as well as the one most practically convenient, is to fix a group name to the first individual or the first species to which the name was tenably applied. If based on specimens, the species would rest with the individual actually in hand for description. If based on a series of previous records, the one of these standing first in the list of synonyms should be the type.

In the case of the genus, if no type, central species or 'chef de file' is indicated by