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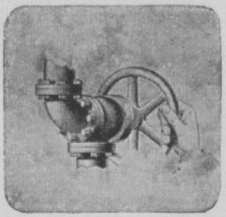

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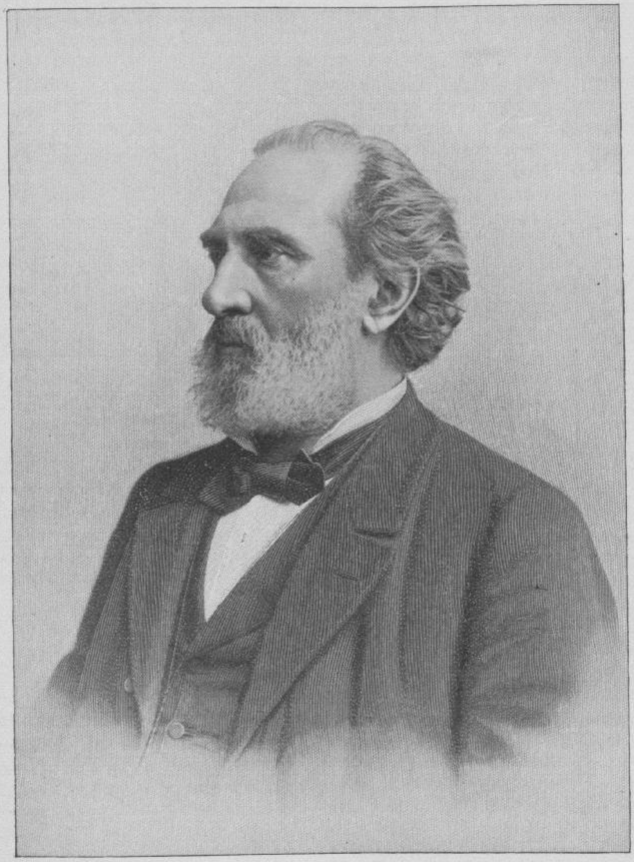

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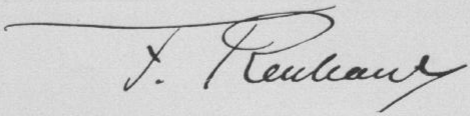

CASSIER'S MAGAZINE.

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GRIST FOR THE MILL.

THE MODERN SAW MILL.

By W. H. Trout.

IT requires only the most superficial consideration of the great extent of building and manufacturing investments to see that somewhere there must be an immense amount of lumber and timber sawn. The products are in evidence all the time, but where are the mills?

There are lumber yards in every town, and immense yards in the great cities. These we see. We also see and hear the carpenters' clatter which is continually going on. Where does all this nicely prepared material come from? Where is the home of the saw log and the place of its transformation? The general public knows as little about this as it knows where its coffee is

PROFESSOR FRANZ REULEAUX.

A Biographical Sketch.

By Professor Hans Zopke, Royal Prussian State Engineer.

I wish to express my gratitude to my friends and colleagues, in The Columbian University, Washington, D. C., Professor Hermann Schoenfeld, Ph. D., and Professor E. S. Farwell, C. E., for kind assistance in the preparation of this sketch. To Professor Reuleaux I am especially indebted for unprinted and original sources placed at my disposal, which materially supplemented my views, acquired during a long personal co-operation with, and under, him.

IT was England that gave to the world, in its very first monument of invention, the steam engine, that brilliant product of human creative genius which was to become the starting point of a revolution of the material and social conditions of mankind. But while England was the cradle of modern practical machine construction, it is, nevertheless, in France that the scientific treatment of mechanical engineering began with the foundation of L'École Polytechnique in Paris.

To the German scholars, however, belongs principally the distinction of having developed, deepened, and brought to a climax the mechanical sciences introduced by the French. The brilliant spirit of investigation and the thorough methods of the German scientists insure to them still the first rank in the various branches of the science of machines. The life and work of one of these creative and pioneer spirits, the greatest machine philosopher, Franz Reuleaux, the results of whose investigations have become common international property and have taken the firmest roots in the English and American worlds, will be here briefly presented.

Franz Reuleaux was born on September 30, 1829, the fourth son of Johann Josef Reuleaux, who had founded one of the first machine shops in Germany, at Eschweiler, near Aix-la-Chapelle. After a thorough preparation in the natural sciences, and considerable practical experience, he studied mechanical engineering at the Polytechnic school at Carlsruhe.

It was just at this time that the famous Redtenbacher occupied the first German chair of machine construction, and it was his influence and work that for many years gave to the school at Carlsruhe a powerful advantage over the other technical schools of Germany. Redtenbacher recognised immediately in his pupil a nature congenial and equal to his own, in which was the harmonious blending of all the intellectual gifts necessary for the scholar in engineering and from which the world might expect creative activity.

The result of his studies had shown Reuleaux the engineering sciences, then fragmentarily arranged as to their phenomena and purposes, in a narrow view, and this did not satisfy his philosophical mind; hence, he wavered for a time in his resolution to follow mechanical engineering as a profession.

At this time there was no separate science of machines. Out of the chaos of the existing conceptions, Redtenbacher was the first to attempt the creation of a science of mechanical engineering which would exist only for the sake of the machine and machine problems. Reuleaux studied the philosophical branches at the University of Berlin

(1852-3) and at the University of Bonn (1853-54). At Bonn, assisted by the mechanical engineer Moll, he edited his first work "Strength of Materials."

Before its advent, all calculations relating to the resistance of materials were referred to the limit of rupture fixed by experiment, and, according to the character and use of the constructive part under consideration, various factors of safety were employed.

These conditions were entirely done away with by Reuleaux's principle that we must introduce the internal molecular forces, or the alterations of form, which, in every case, indicate whether the limit of elasticity is passed or not, and which define precisely how near one is to this limit. In place of the obscure and insignificant factors of safety, appeared the important molecular stresses and elastic changes which disclose the real character of internal strain.

In 1854 Reuleaux, again assisted by Moll, began to edit his work on "Theory of Construction of Machines," which he, alone, completed at Zurich, in 1861. The methods originated by Reuleaux in his first work were adopted by him also in the calculation of springs which could not be calculated till that time. The work published by Reuleaux in 1857, on "Theory of Springs Used in Machine Construction" (Wurster & Co., Winterthur, Switzerland), is still in use and is much employed in America. It may be remarked here, as characteristic of Reuleaux's greatness, that many of his ideas have spread so rapidly that already the originator has been forgotten.

It happened with his ideas what happens with the most beautiful melodies of composers and the profoundest truths of poets,– they become "winged words" whose originators are forgotten. They have found their way to every individual and pervade the intellectual life of whole nations. The influence upon the whole world is so deeply rooted, that it is apparently impossible that they should have been planted by one man.

By virtue of his scientific work the young scholar was called, in 1856, as full professor of mechanical engineering to the newly founded Polytechnic School of Zurich where he and Gustav Zeuner together in a short time brought the mechanical department to such an ideal development and fame that students repaired to Zurich from all parts of the world.

It is a remarkable act of Providence that these two bright stars should have found the starting point for their careers at the same time and at the same place. The Zurich polytechnic school has, moreover, the glory of having had, during the comparatively briet period of its existence, more technical men of first rank as members of its faculty than any polytechnic school of Germany. Zurich was for Reuleaux the starting point for all his researches—even the latest. It is a remarkable fact that the sum of Reuleaux's researches are comparable to a powerful stream from the waters of which the strongly characteristic colours of the source cannot be wiped out or destroyed. The very elements of his scientific works are so peculiar that they can be traced in their further development and in the result, and ever again fixed as essential constituents.

After Reuleaux's philosophical treatment had fixed "the machine as a combination of resistant bodies, so arranged that by their means the mechanical forces of nature could be compelled to do work, accompanied by certain determinate motions," he inferred from this definition the necessity of the division of the science of machines into four classes, characteristic of the nature of machines. Each of these four classes is treated as a special science which is to be developed independently in its particular domain. All the four special sciences have a common object,—to elucidate the casual connections of machine phenomena.

They comprise, first, the study of machinery in general which treats descriptively of all actual machines as an entity.

Second, the theoretical study of machinery, which treats of the machine known according to its purpose and

construction and which teaches what quality is to be imparted to it, in order that it may best fulfill its purpose. It occupies itself primarily with prime movers.

The third science is that of machine design, the object of which is to teach how capacity for resisting alteration of form is to be given to the pieces constituting the machine.

The fourth science is that of kinematics. It is the science of that particular arrangement of the machine by virtue of which the motions of its members, considered as changes of position solely, are to be determined. The complete solution of machine problems is accomplished only by the unification of all the four sciences. Reuleaux is the creator of the fourth special domain. Science has surnamed him "Father of Kinematics," while Gustav Zeuner's great merit lies in the domain of the theoretical study of machines which owes to him the building up of the theory of caloric engines upon the principle of the conservation of energy, discovered by the German physician Robert Mayer.

In Zurich was also laid the foundation of a thorough and systematic treatment of the elements of machines and the details of machinery. The fruit of this effort appeared in 1861 in his practical hand-book of machine design, "The Constructor," which grew, in the fourth edition, to a voluminous work and has been translated into French, English, Swedish, and Russian.

The conception of scientifically differentiating the elements of machinery was first formed by Reuleaux. The excellent and very painstaking English translation of the fourth edition of "The Constructor" was made by Henry Harrison Supplee, of Philadelphia. In the domain of details of machinery also, Reuleaux has done original work and enriched the subject with numerous new views and methods.

His investigations into the inner nature of the machine led, after long preliminary work, to kinematics, which he placed on an entirely new foundation. Kinematics is the science of the constrained or machine motions which can be produced only in one and the same predetermined manner. These principles are universally recognised at present.

The kinematic laws discovered by Reuleaux were disclosed by him for the first time in 1864 before the Society of Swiss Scholars of Natural History and its German guests. At the occasion of the 150th anniversary of its existence the society made Reuleaux and Zeuner honorary members.

Reuleaux discovered, and proved, in 1864, that all machines consisted not of single elements but of kinematic pairs of elements, as for instance the shaft and the bearing, the screw and the nut, etc., which can be determined with mathematic accuracy and combined to form what are called kinematic chains. A kinematic chain becomes a mechanism, when one of its links is fixed in position relatively to the surrounding space, according to which principle every kinematic chain furnishes as many mechanisms as it has links. By this process a very remarkable simplicity of facts was reached, inasmuch as different and distant mechanisms were recognised as closely related, old things were connected with new, order and law were put into a wide domain of supposed-to-be different things, or were proven to exist at the bottom of things.

Reuleaux showed further that the number of the elements forming a pair was not unlimited, as heretofore considered, but was limited to some twenty, while their combinations into kinematic chains, it is true, can be widened to an immense, but definite, number of possibilities.

The solitary theories of Poinsot on relative motion, which, up to Reuleaux's time, were quite strange to machine construction, he incorporated as geometrical principles into the science of machine motion and assigned to them thereby a practical use not dreamed of before.

Reuleaux laid down his kinematic principles in his fundamental work on "The Kinematics of Machinery," in 1875, a work which was soon translated

into Italian, French and English. The classical English translation is by Professor Alex. B. W. Kennedy, of London. The work has bestowed upon Reuleaux's name an international fame and insures to him an imperishable monument in the history of science.

Shortly after the publication of his kinematic laws, Reuleaux received an honourable, as well as enticing, call to Riga to found a new Imperial Institute of Technology,—a call which he, however, did not accept. But soon afterwards, in consequence of his reformation of the science of machines, he was called to the Royal Technical Academy of Berlin, as professor of mechanical engineering and kinematics. In 1868 he was appointed president of that institute and honoured with the title of royal privy councillor.

For the illustration of his kinematic idea, Reuleaux had begun, while at Zurich, to sketch and elaborate kinematic models which form an unconditional necessity for the successful instruction and study of kinematics. But in Berlin, Reuleaux, provided by the Prussian government with very ample means for the building up of his science, created an entirely original collection of models,—the kinematic cabinet,—which is an ornament to the Royal School of Technology in Berlin and an attraction for technical scholars everywhere.

The collection embraces about seven hundred models which represent the kinematic pairs of elements and all the kinematic chains as far as they are in practical use, in simple construction and systematic order. These chains are then combined as mechanisms in all the various applications for the formation of machines. A complete reproduction of the Berlin collection is to be found at McGill University of Montreal; Cornell University in the United States possesses more than one-half of the models.

The instructive value of these models is almost inestimable, provided that they are used in Reuleaux's sense, and the many fine points of the invention are understood and wisely used. A slight alteration of the model, a different view of the same, leads to a new kinematic idea and unveils often in the simplest and clearest manner the genesis of the most complicated machine phenomena which, without this preliminary step, are incomprehensible. In Berlin this collection is not only used for instruction, but is also much studied and consulted by inventors.

Very frequently it happens that the inventor, after a correct kinematic study of his own invention, discovers by virtue of the Reuleaux models, that the motion discovered has been known for a long time, but that it appeared veiled in its nature owing to an odd design of the moving parts. It is, moreover, remarkable that certain problems of motion for which all kinematic possibilities of solution have already been exhausted, still have a never-ceasing attraction for inventive genius.

Mental labour and money is again and again bestowed upon them, while the result can give only old and well known results. For cases of this kind nothing is more convincing than kinematic models which show systematically how one and the same kinematic thought can be worked out and put into different forms.

The models can be studied in motion, and are so constructed that from each individual mechanism, whatever constructive forms its single members may present, the fundamental kinematic thought shines forth clearly and convincingly. As a science, Reuleaux's kinematics is treated conspicuously in McGill University, Montreal; Cornell University, Ithaca, N. Y., and Lehigh, South Bethlehem, Pa. In Germany the most prominent representative of kinematics is Reuleaux's pupil, Professor Wilhelm Hartmann, of Berlin.

To his theoretical kinematics Reuleaux adds applied kinematics, to which the former serves as a scientific basis. While theoretical kinematics is occupied with solving the questions, "what is machine motion," and "by what means can it be produced," applied kinematics treats of the question, "what purposes do given machine motions serve?" This point of view leads not only to separating the machine into

its kinematic elements, as theoretical kinematics proves it to be possible, but to separation into higher units or mechanisms, from the combination of which the machine has arisen for a special object.

Reuleaux calls a mechanism which, as a unit, forms a part of a machine, a train; consequently a machine consists of a combination of trains. From the standpoint of applied kinematics, therefore, machines are distinguished only through the method of combining the trains contained in them. The number of all the trains which have been used for the purpose of machine construction, is, in spite of the broad extent of modern mechanical engineering, comparatively small and has been accurately fixed by Reuleaux. All the trains out of which machines have heretofore been built, and are daily being built, can be exemplified by the models of his kinematic cabinet.

Each individual train in machine construction may be given a great variety of applications, serving different objects, which can also be shown, to a certain degree, by the models. The numerous purposes of trains can, however, be reduced to four principal functions characteristic of controlled motions, viz., guiding, storing, driving and forming. In the fourth edition of "The Constructor" the study of machine construction has, for the first time, been based upon a kinematic foundation and the four functions of the machine just mentioned. This was a Herculean task possible only to a genius.

Reuleaux belongs to the most prolific technical authors and it is, therefore, impossible in a limited space to enumerate his many scientific and technical works. All of them bear the stamp of the great philosophical thinker; everywhere the law is put in the foreground, or, where it is not known, he endeavours to evolve it, searching out the general element in the great mass of special things. Afterwards the individual phenomenon is logically deduced from the law of the general case.

Still, I cannot leave unmentioned his address on "Culture and Technics," delivered in 1884 in Vienna, before the Trade Association of Lower Austria. This belongs to his finest works. The fundamental thought of all his writings, extending from his special profession, of the science of mechanical engineering to the outward world, is expressed in the most brilliant way,—namely, mechanical engineering in organic union with universal culture. He expresses in this oration in an admirable manner the difference between the great civilised nations and the rest of the nations of the present and the past, a difference which rests mainly upon scientific technics, based upon scientific knowledge of natural laws.

Since Reuleaux's appointment as president of the Royal Technical Academy of Berlin, it was possible for him to realise his plans of organisation for technical instruction. These plans tended to prevent a one-sided professional training by the introduction of many scientific branches of a philosophical nature to extend the student's horizon and raise his intellectual standard. For instruction he required everywhere the highest form that would place the creating of new matter upon the basis of the scientific knowledge of what had been already done.

Collections of a technical and artistic character were increased under his guidance, and made accessible to the community at large. He also endeavoured to introduce scientific laboratory work in the department for mechanical engineering, but was unable to obtain adequate means for this purpose. This scientific work in laboratory instruction has meanwhile been largely developed in the United States, especially by Professor R. H. Thurston, of Cornell University, with the idea that experiment and independent investigation must alternate and be connected in adequate manner with the purely intellectual means of education in engineering instruction.

Reuleaux developed the institute entrusted to him, in a short time, to a considerable degree by steadily increasing the number of lectures and professors. He receded from the presidency

in 1879 when the combination of the Royal Academy of Architecture and the Royal Technical Academy into the Royal Institute of Technology (Kgl.-Technische Hochschule) was effected. The customary arrangements in the German universities were adopted and the rector (president) was annually elected from the professors.

For the academic year 1890-1 Reuleaux was elected rector of the Royal Institute of Technology which is, at present, the greatest technical university in the world. It comprises a school of architecture, a school of civil engineering, a school of mechanical and electrical engineering, a school of naval architecture and ship machinery, a school of technical chemistry and metallurgy, and a school of auxiliaries of engineering sciences as mathematics, natural sciences, political economy, philosophy, language, literature and law and has a staff of 330 professors and assistants. There are about 3000 students.

The number of students annually attending Reuleaux's lectures amounted last year to 360 in his machine elements, and 200 in kinematics. With the first of October, 1896, Reuleaux concluded his career after more than forty years of academic work. He continues, however, his membership in the Royal Technical Deputation to which he has belonged since 1864.

Reuleaux's lectures will never be forgotten by those who had the good fortune of hearing them. He, himself, bears the stamp of superiority, to the influence of which nobody can help succumbing. The shining eyes under the bushy eyebrows indicate the sharp penetrating glance of the genius; the broad, arched forehead gives testimony of his powerful creative mental activity.

But Reuleaux's name is not simply connected with the history of sciences, but also with the history of international expositions. He was vested with the honourable office of judge of awards in the expositions of London (1862) and Paris (1867), where he entered upon close and friendly relations with the first professional men of the world. His cooperation with the commissions of awards at Vienna (1873) and Philadelphia (1876) enlarged the circle of his knowledge and scientific-technical friends.

At Philadelphia, where he was Imperial German commissioner, induced by the failure of the German department, he proved the necessity of transforming the economic convictions of the time, so that in the competitions of industries the rivalry of the quality of the products must stand above that of price. The severe and harshly striking expression with which Reuleaux at that time wounded the unworthy principle of German industries to the quick, aroused a storm in the interested circles of his fatherland,—a storm which to this very day has not entirely subsided. The scholar whose name became henceforth well known to the whole world, could stand this storm with perfect equanimity.

From day to day he saw the fruit of the great service he had rendered by his frank confessions at Philadelphia. For the correct understanding of the questions hinted at, the study of Reuleaux's letters from Philadelphia, the third of which is the most important of all, is indispensable, as well as the flavour of "cheap and nasty" literature which arose in connection with it.

Reuleaux conducted the exhibits of Germany in both the Australian expositions at Sydney and Melbourne (1879 and 1881), where Germany obtained great success and began the now highly developed trade with Australia. This trade could be developed still farther by the realisation of a steamer line between Germany and Australia, which Reuleaux had recommended to his government from Sydney in 1879. Reuleaux also participated by word and script in the movement for a German patent law in close connection with his dear friend Werner von Siemens, Germany's greatest electrical scientist and engineer.

For eight years Reuleaux was a member of the imperial patent office. Owing to the rare manysidedness of his knowledge, his sagacity for the essential and characteristic in the phenomena and his understanding of the work of foreign

countries, he was better fitted for all these different positions than any one else.

His experiences at the various expositions Reuleaux depicted in a recently published pamphlet entitled, "Development of Expositions." Here, too, appears his immense ability to draw the essential and fundamental element from the multitude of single phenomena and to obtain fruitful consequences from the practice of systematic observations. German industry owes to Reuleaux not only its most valuable suggestions in the way of technics, but the art trade equally enjoyed his intelligent and fostering care.

He conducted the selection and the purchase of a great number of objects of art which can be found now in the magnificent Royal Museum of Arts in Berlin whose trustee he is to this very day. The identity of their ideal endeavours for the promotions of national art trade brought Reuleaux into the closest and warmest relation with Dr. Salvini, the reviver of the wonderful Venetian glass painting, and Sir Philip Owen, the founder of the South Kensington Museum in London. It is characteristic of Reuleaux's standing in art trade that for five years he was president of the Association of German Art Trade. If German industries have today become a power in the world's markets, whose growth is attempted to be explained abroad by the most various reasons, it must not be forgotten to remember those men who, as enlightened leaders, have shown the way, and for decades have laboured in raising the industrial standard in all domains with a clear consciousness of the aim to be attained.

Reuleaux is also one of the leaders in the movement for the purification of the German language and belonged for ten years to the board of directors of the German Language Association of Berlin, which excels all other German linguistic associations by its extraordinary activity. The beauty of the German language does not lie in euphony, but in ideal strength and depth, in vigour and fullness of expression. To fight for its purity means fighting against laziness of thought, confusion and superficiality. Reuleaux's writings, the technical as well as those on art, on travels, on the various domains of science are models of German style.

Thus Franz Reuleaux stands before us as a universal genius, epoch-making in his profession, a creator and a leader in the most important domains of human science and knowledge, interested in everything that is noble and great, appreciating all that is eminent among foreign people, a cosmopolitan in the noblest sense of the word. While he lives and works for his people, he lives and works for the world.