HANS REISSNER

profiles in engineering science

HANS REISSNER, Engineer, Physicist and Engineering Scientist

by Eric Reissner

It is probably appropriate to say, with all due apologies for a possible bias on the part of the writer, that Hans Reissner was one of the world's leading engineering scientists of the first third of this century. What distinguished H.R. from other engineering scientists of his generation, aside from the special tasks which he chose to undertake during his long active life, was the breadth of his interests. He started out as a civil engineer, then studied to become a theoretical physicist, and soon thereafter, at the very beginning of the era opened up by the Wright brothers, became an aeronautical engineer and scientist, with these three lines of endeavor remaining intertwined throughout most of a professional career of more than fifty years' duration.

H.R. was born in January 1874 in Berlin, Germany the second of seven sons in a well-to-do businessman's family. The financial resources of this family were significantly enhanced during the childhood years of H.R. by an inheritance from an uncle of his mother who had been successful in the wool trade. It was part of the family tradition that not only financial but also intellectual acumen originated on his mother's side. Part of the evidence for this was seen in the fact that two of his cousins on this side, the Danzig organic chemistry professor Alfred Wohl, and the onetime President of the Reichsfinanzhof Herbert Dorn had similarly distinguished careers.

After graduation from the Friedrichs-Gymnasium in Berlin (the curriculum of which included nine years of Latin and six years of ancient Greek), H.R. enrolled in 1892 at the Technische Hochschule of Berlin, with the intention of becoming a civil engineer. By the year 1897 he had received the degree of Diplom-Ingenieur and the beginning civil service rank of Regierungsbauführer. He then made the decision, presumably remarkable for a young engineer in those days, to spend a year in the United States, holding structural draftsman's positions with firms in New York, Philadelphia, Pittsburgh and Chicago. (It is one of many regrets of a similar nature that I never asked my father, when there was time to do so, for the circumstances which led to his decision to undertake this first of his American journeys and for his feelings about it afterwards).

Upon his return, H.R. enrolled at Berlin University, for a period of two years, with the evident intention of becoming a physicist rather than an engineer. Being on the way towards writing a Ph.D. dissertation under Max Planck, in the field of electromagnetics of moving media, he once again in 1900 changed plans to become Assistant and doctoral student to Heinrich Muller-Breslau at the Technische Hochschule, completing one of the first, if not the very first, Dr.-Ing. dissertation at this institution, in 1902, on the subject of

vibrations of framed structures. He remained at the T.H. as Chief Assistant to Muller-Breslau, becoming Privat-Dozent soon thereafter, and holding outside part-time jobs as well, including a period as structural analyst for Count Zeppelin. In 1904, he once again visited the U.S., as recipient of a Boissonet travelling fellowship, with an assignment *die bisher. wenig bekannten Eisenhochbaukonstruktionen neuerer Stadtbahnen, moderner industrieller Anlagen und hoher Wohngebaude Nordamerika's näher zu untersuchen and durch einen eingehenden Bericht darzu-stellen.*

Two years after his return, in 1906, he was called to become Professor of Mechanics in Aachen, as successor to Arnold Sommer-field, who soon thereafter, in München, would be one of Germany's leading physicists.

In reviewing this period of the life of H.R., I think it is of interest to quote from an early and from a late communication of his teacher Müller-Breslau. In 1897 M.-B. wrote *"Herr* H.R. *hat meine. Vorträge über Statik der Baukonstruktionen und Eiserne* Brücken *mit grossem Fleiss und* <u>*ausgezeichnetem*</u> *Erfolge gehört. Besonders hervorzuheben ist, dass Herr* R. sich *night auf das Studium landläufiger Fälle beschränkt hat, sondern dass er. auch schwierigere Aufgaben, die neue theoretische Untersuchungen erforderten selbständig gelöst hat. Ich mag daher Herrn R. für die Fächer Statik und Eisenkonstruktionen auf das wärmste zu empfehlen".* A personal letter in 1906 would say: "*.... So ungerne ich Si*e sche*iden sehe, so drängt es mich doch, Ihnen meine grosse Freude über ehrenvolle Berufung and* meine herztlishten *Glück-wünsche auszusprechen. Aachen kann sich gratulieren, für ein wich-tiges Fach eine so tüchtige Kraft gewonnen zu haben".*

It also seems appropriate to give a brief account of H.R.'s published work prior to his first professorial appointment. After two short notes of an elementary nature, "Eine neue Fahrbahnanordnung für eiserne Strassenbrücken" and "Über Fahrbahnüberhöhung"*,

> *The latter note, written in 1899, is the first item in the publication list in Ref. [4]. The former, which appeared in 1897 in the *Centralblatt der Bauverwaltung, <u>17</u>*, 190-91, is not included in this list.

we find three papers, including the printed Dissertation, dealing with vibrations of framed structures. Then there are a number of publications at the interface of mechanics and physics, including a substantial paper entitled "Anwendung der Statik und Dynamik monocyklischer Systeme auf die Elastizitätstheorie", which appeared in the *Annalen der Physik* in 1902 and 1906. Also worthy of note is a brief paper on lateral stability of beams, where it is shown that the earlier results by Prandtl and Michell may be deduced more simply as a consequence of the general Kirchhoff-theory of space-curved beams. The list of this period is completed by a series of articles, as well as by a book, containing the required report on his observations of American construction practices, during his tenure of the Boissonet fellowship.

Succession to Sommerfeld's chair was not the only important happening in H.R.'s life in 1906. In this same year he married Josephine Reichenberger, a young lady from

Vienna, nearly ten years his junior. It was destined to become a happy and harmonious union, blessed after a childless interval of seven years by altogether four children, all of whom were to feel a strong and friendly attachment to their parents. Under the influence of the young wife the Reissners house would be known for its spirit of hospitality, to old friends as well as to young ones, throughout the more than forty years that fate decreed for the duration of this marriage.

The years in Aachen from 1906 to 1913 unquestionably were the most productive in the life of H.R. In the first place, he continues his contributions to what at that time was the forefront of research in applied elasticity. A paper in 1907 on frameworks of cyclical symmetry through use of finite trigonometric series is followed by a paper on symmetric bending of cylindrical shells of linearly varying thickness in 1908. The author recognizes the possibility of a solution in terms of Bessel functions but, since no appropriate tables were in existence, proceeds instead to a direct use of power series, with the examples chosen in such a way as to obviate the necessity of considering logarithmic portions of the solution. In 1909, a paper appears on buckling of rectangular plates with two opposite edges simply supported. It turns out that this work overlaps with work published by Timoshenko in Russian in 1907 (and republished in a German periodical in 1910). In 1912 appears what is probably the most important contribution of H.R. in the field of applied elasticity, his article in the Müller-Breslau *Festschrift*, on rotationally-symmetric bending and on non-rotationally-symmetric membrane deformations of spherical shells. The paper presents the crucial reduction of the sixth-order bending problem to a fourth-order problem through the use of two first integrals and recognizes the fact that bending effects for thin spherical shells are, just as for circular cylindrical shells, confined to narrow edge zones, making possible the use of an asymptotic integration procedure. For help with the mathematics of the asymptotic expansion H.R. expresses his appreciation to his colleague Otto Blumenthal, who himself then publishes papers on ramifications, of the problem.

It would seem that foremost in H.R.'s mind, beginning in about 1906, was the new field of aviation. His first publication on the subject is the text of a lecture held at the Annual Meeting in 1908 of the German Naturforscherverein describing the comtemporary state of knowledge of the basic subjects of airplane stability, control and propulsion.*

Subsequent to this, in 1910, H.R. obtains original results on the subject of lateral stability and control of aeroplanes, supplemented by a further paper in 1912. At the same time, he publishes a detailed and comprehensive study on propeller analysis and experimentation. We note that in his own mind, as expressed in an unpublished lecture on aviation technology in 1943, he saw his contribution to the science of the propeller as follows: "I found that two rational theories had been developed, mainly by English naval engineers and I succeeded in a certain way to bring them into agreement. The one was the reaction analysis based on the dynamic theorems on the creation of fluid momentum by propeller thrust and of fluid moment of momentum by engine torque. This theory, correct as it is, gives no indication of how to choose the shape of the propeller blades. The second theory treats the blade as a rotating wing and derives thrust and torque as projections of the lift and drag of these wings. The unification of

these theories allowed new results about the suction inflow and about the appropriate blade width and propeller diameter."

Alongside the foregoing there were three other activities of H.R. during the period 1906-12 which must be mentioned. The first of these was his concern with the structure and safety of aircraft, as reported in a substantial paper in the first volume of the yearbook of the newly founded Wissenschaftliche Gesellschaft für Luftfahrt(WGL)**

> *0ne of his concluding sentences seems particularly quotable: "Wenn *auch nicht bestritten werden soll, dass vieles Vortreffliches aus dynamischem Gefüll, Geschlicklichkeit und instinktiver Beobachtung geschaffen worden ist, so ist doch zu betonen, dass Leute wie 0. und W. Wright und G. Voisin mit mehr wissenschaftlicher, plan-mässiger and geduldiger Technik anbeiten als die Welt annimmt."*
> **A contemporary newspaper report (8. *2. am Mittag,* Nov. 26, 1912) on the founding session of the WGL begins with the exclamation: *"Ein wichtiger Abschnitt deutscher Geschichte wissenschaftlicher Luftfart ist heute zum würdigen Abschluss gekommen'."* and further on in the story includes these remarks: *"Hierauf wurden die Satzangen angenommen, die Geschäftssitzung geschlossen and Prof. Reissner nahm das Wort zum ersten wissenschaftlichen Vortrag: "Beanspruchungen und Sicherheit im Flugzeugbau". Der Vortragende ging zunächst auf die Kräfte ein, die ein Flugzeug wärhend des Fluges beeinflussen, gab verschiedene Methoden an, diese Kräfte rechnerisch festzulegen, and wandte sich dann dem Fall zu, dass ein Flugzeug nach steilem Gleitflug schnell duren* eine järe *Steuerbewegung abgefangen und zu sanftem Horizontalflug gezwungen wird, weil hierbei die grössten Beanspruchungen auftreten. Dann wurden die Konstruktionsteile besprochen, die grundsätzlichen Unterschiede zwischen Ein- and Doppel- decker skizziert, und endlich die Materialprüfung erwähnt. Prof. R. schloss mit dem Wunsche, dass es recht bald gelingen möge, die Rechnungsmethoden durch Versuche so auszubilden, dass eine rechnerische Nachprüfung auch für die Praxis möglich* wäre." .... *"Nach einer kur*zen *Pause, während welcher in den anschliessenden Räumen ein Frühstück. eingenommen wurde, setzte die Diskussion zum Vortrag Reissner ein, die sich recht lebhaft gestaltete. Wissenschaft und Militär, Flieger and Konstrukteure beteiligten sich an ihr und förderten eine Unmenge wissenswerter Daten und Ansichten zutage."*

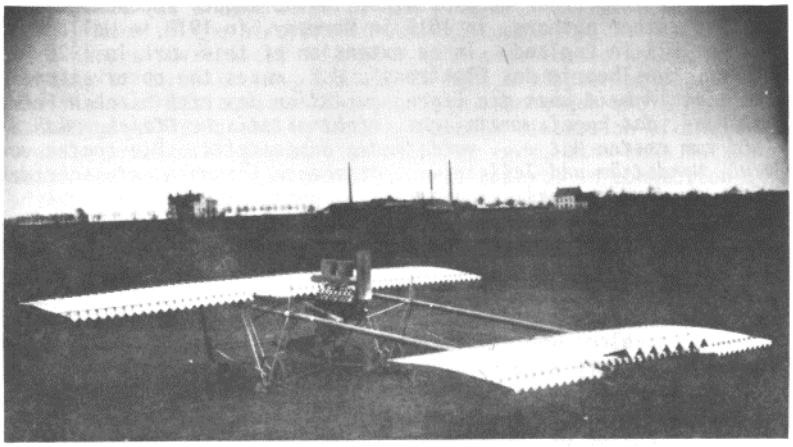
> A much briefer report on the second session includes this sentence: *"Es wurde eine Resolution angenommen, die Festigkeits-betec-knang der Luftfahrtzeuge auf wissenschaftlicher Grundlage. aufzubauen, zu welchem Zweck die Gesellschaft den gesetzgeberi-schen Körperschaften sich zur Mitaribeit zur Verfügung stellt."*

The various activities mentioned, alongside a normal amount of lecturing obligations, were not sufficient to fill the time of the newly appointed Mechanics professor. Some of H.R.'s time during his Aachen period was devoted to two other tasks of a more practical nature. The first of these was the design and construction of a tail-first aeroplane,

Ente, with the additional distinction of being the first aircraft with wings and tail surfaces of all-metal construction.* After many successful flights of this aircraft an avoidable accident resulted in the death of the test pilot and the work on this project did not come to its expected fruition.**

*Both wings and tail were made of corrugated aluminum sheet, a method of construction which subsequently achieved much success in the Junkers transport planes and the Ford Trimotor craft.

**Much later, in 1930, H.R. described his feelings in this matter in an article written on the occasion of still another design, by Focke, of a tail-first plane. "*Wenn ich sagen soll was mich dazu gebracht hat, die Kopfdeckerbauart nicht weiter zu fördern, so war es nicht der schmerzliche Unglücksfall von Hild, nach so vielen erfolgreichen Flügen* von *Gsell, als vielmehr die Erkenntnis (von) .... konstruktiven Schwierigkeiten in bezug auf die aerodynamisch günstige Rumpfgestaltung, die Vertikalflossen, die Propelleranord-nung and die Längsstabitat. "*



The *Ente*, an early model of the *tail-first* airplane

The second practical task was the conception and the initial steps in the development of the Aachen Aerodynamic Institute.*

In 1913, after seven fruitful years in Aachen, H.R. was invited by his alma mater to be the Professor of Mechanics in the department of civil engineering, the same department in which he had begun his studies. I do not know how easy or how difficult it was for him to accept this call, I can only report the simple fact of his acceptance.

It appears that the move to Berlin revived in H.R. his original interests in pure physics. The first results of this were two papers in 1914 and 1915 entitled "Über die Relativitat der Beschleu-nigungen in der Mechanik" and "Über eine Möglichkeit die Gravitation als unmittelbare Folge der Relativitat der Trägheit abzu-leiten". It is an indication of the significance of these two papers that ten years later similar results were published inde-pendently by E. Schrödinger.**

In 1916, H.R. publishes a contribution to the general theory of relativity, entitled "Über die Eigengravitation des elektri-schen Feldes nach der Einstein'schen Theorie".

Remarkably, the results of this paper were obtained in the sequel independently by three other authors, in 1917 in Germany, in 1918 in Holland and in 1921 in England. In an extension of this work in 1925, "Beitrag zur Theorie des Elektrons", H.R. makes the observation: *"In einer Arbeit über die Eigengravitation des elektrischen Feldes hat Verf. das kugelsymmetrische, elektrostatische Gleichgewichts-feld zum ersten Mal ... vollständig dargestellt. Die später von Weyl, Nordström und Jeffery .... gegebenen Lösungen unterscheiden sich von der des Verf. einerseits nur durch die Ableitung aus einem Variationsprinzip ...., andererseits, aber durch die Unter-drückung einer ... wesentlichen lntegrationskonstante, die auf die Festsetzung hinauskommt, welche natürliche Länge man dm Kreisumfang im Mittelpunkt zuschreibt."*

H.R.'s principal efforts during the years 1914-18 were devoted to those problems where his competence and the needs of his country coincided. There were relatively few publications in connection with these efforts, his most noteworthy aeronautical paper being "Die Festigkeitsberechnung der Flugzeugholme". Other than this, he was in charge of the structural analysis of the Staaken four-engine bomberplanes (then called *"Riesenflugzeuge")* and he also designed, for these planes, the first controllable-pitch propellers

> *The founding of the Institute has often been credited to T. von Karman who became H.R.'s successor in 1913. According to the 25th Anniversary publication of the Institute, Ref. [1], "*Das Aero-dynamische Institut an der T. H. Aachen entstand auf Anregung und unter der Leitung von H. R. in 1912 - 14." "... von Kármán konnte den Bau des Institutes and die Windkanalanlagen fertigstellen."*
> **"Die Erfüllbarkeit der Relativitätsforderung in der klassischen Mechanik". *Ann. der Pkysik* (4) 77, 325, 1925. The manuscript of a *Bemerkung,* on this paper, evidently intended for publication, in which Schrödinger acknowledges H.R.'s priority and describes some differences in point of view, was found in H.R.'s papers but I am not certain that it was in fact published.

which were actually used in flight. His contributions to the national effort were acknowledged by an award of the Iron Cross for civilians.

Soon after the end of the war a group of German engineering scientists and applied mathematicians thought that the time had come to have their own professional organization. These efforts led, in 1923, to the founding of the Gesellschaft für angewandte Mathematik und Mechanik (GAMM). In the first meeting of the new society the founding members elected Ludwig Prandtl to be president, H.R. to be vice-president and Richard von Mises to be secretary.*

During the period 1923-33, H.R. continued his labors, essentially with undiminished vigor. In addition to about ten hours per week of lecturing assignments (including the required two-year course of Mechanics for civil engineers, an advanced course on plate theory, and an elective course on propeller theory) he would carry on research on aircraft structural mechanics, including the analysis of torsion of boxbeams (which shortly there

after would be developed in greater depth by his student Hans Ebner), and including a solution of the problem torsional wing divergence (as a forerunner of the flutter work which would soon occupy much of the aircraft structural community). Then there were papers on stresses in sheets with edge-loaded holes, on bending of circular ring plates, in 1931 a pioneering paper in the field of dislocation theory, "Eigenspannungen und Eigenspannungsquellen", and in 1933 a thorough discussion of the vibration problem of pretwisted rotating rods, with this latter paper representing only one of several efforts in connection with H.R.'s continuing interest in the problem of the propeller.

Alongside this, H.R.'s original responsibility in the operation of the GAMM continued, including Chairmanship of its Berlin section, which was founded in 1926. In 1930 H.R. became Chairman of the Luftfahrzeug-Ausschuss, a committee of the Ministry of Transportation, which had the task of overseeing the state of airworthiness requirements for German aviation. In what was left of his time he continued his interests in the design problems of the controllable pitch propeller and in the improvement of patents which he held in this field.

As he approached his 60th birthday, H.R. was thus able to look back on a rewarding career as a teacher, researcher and public servant.**

> *0riginally the intent had been to call this organization German Engineering Science Association (see ZAMM 2, 478, 1922).
> **His friend and colleague Erich Trefftz would write on this occasion "... *'Reissner hat an der Entwicklung der Mechanik hervorra*-genden *Anteil gehabt ... Auf fast allen Gebieten der Technischen Meckanik verdankt man ihm bannbrechende Arbeiten ... Die* Bedeu.-tung *der Flugwissenschaften als einer der ersten erkennend, gründete R. an der T.H. Aachen das aerodynamische Laboratorium. Eine grosse Zahl von Anregungen, die die Entwicklung der Flugtechnik in Deutschland wesentlich gefördert haben, gehen auf ihn zurück .... Die Fachgenossen und zahlreichen Schüler, die R. als vornehmen Menschen ebenso schätzen wie als Wissenschaftler, werden seiner an seinem Geburtstag in Hochachtung und aufrichtiger Zuneigung gedenken."*

The political changes in the Germany of 1933 brought disillusionment and concern to H.R. He soon realized the nature of what was happening, and that there could be no peaceful reversal of the new path embarked upon. It is likely that if H.R. had been ten or fifteen years younger it would have been easier for him to decide what to do in the new circumstances. As it was, he stayed on in his post until 1936 and then, in 1938 at the age of sixty-four, he came once again to the United States, to be associated with the Illinois Institute of Technology (1938-44) and the Polytechnic Institute of Brooklyn (1944-54).

As always, he would during this new period devote himself fully to the work which he had to do. He and his wife would make new friendships and be receptive to new experiences. Still, to those who had known him earlier, a change would be apparent, a change from a positive and optimistic outlook to one of caution and some pessimism. Renewed sadness came in 1947 with the death of his wife from a then incurable heart

condition.

For seven years thereafter, he would continue to give lectures and also continue his efforts to solve new problems. Included among these were problems on the oscillations of suspension bridges, the analysis of turbo jet propulsion, as well as the dynamics of helicopter blade systems.*

In 1949 "his friends and former students" presented him with a seventy-fifth Anniversary Volume, and in 1954 the then reconstituted German Aeronautical Society (WGL) elected him as one of their early Honorary Members.

In 1954, after some serious surgery, he withdrew from professional life altogether, with his strong constitution allowing him to live on for thirteen more years. He died peacefully in October 1967, at the age of nearly ninety-four years.

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*His last paper, jointly with M. Morduchow and S. W. Yuan, on "Vibrations of a Helicopter Rotor-Fuselage System Induced by the Main Rotor Blades in Flight", J. App. Mech. 22, 355-60, 1955, just as his first paper, escaped inclusion in the publication list in Ref. [4]

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