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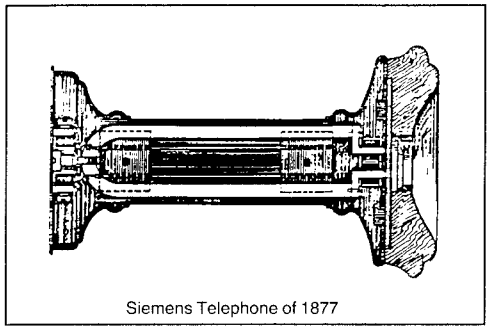
Audio Technology in Berlin to 1943: Microphones

Ernst Weiss, Georg Neumann GmbH, Berlin

In the seventies of the last century, Berlin was the scene of activities in all the spheres of life which were typical of the period - the years immediately following the founding of the Reich in 1871, by which Berlin became the German capital, as it has recently become once again. The Goldmark was the only legal currency; enterprise was booming, industry flourishing. Adolf Menzel was painting here, Ullstein established his newspaper empire and Siemens & Halske demonstrated the world's first electric locomotive on the tracks of the Lehrter railway station. And finally, on April 1st, 1881, the Berlin city telephone system was inaugurated. This trailblazing telephone network was a product of the initiative of the then Postmaster-General, Heinrich von Stephan.

First Telephone Microphone from the House of Siemens



Siemens Telephone of 1877

It was through him also that Werner Siemens received two Bell telephones in 1877. Siemens improved the design by replacing the bar magnets by horseshoe types, at the free ends of which he attached soft iron brackets for the mounting of coils. This caused the magnetism of both poles to be applied to the centre of the diaphragm.

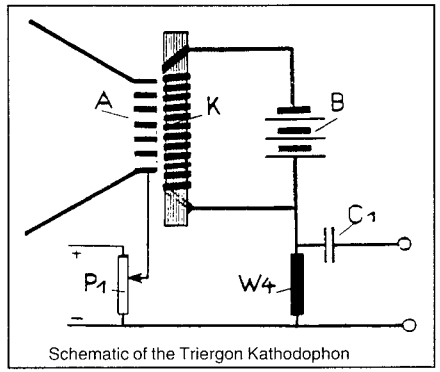
Towards the end of 1877, Siemens submitted a patent application with the title, "Telephone and Signalling Apparatus with Magnetic Equilibrium of the Oscillating Components". In it he described a transducer with a diaphragm placed as a south pole between two magnetized steel rings and the sockets which acted as the south pole. The pipe carry the coils through which the voice current flows. The magnetic field thus flows through the diaphragm without causing the latter to bend to either side - in other words, it is in a state of equilibrium. Distortion caused by unilateral bending is thus avoided. Siemens was awarded the DRP (Deutsches Reichspatent) No. 2355.

The immediate success of the Postmaster-General with the establishment of the Berlin telephone network was at first very moderate. Four years after the first technichal trials, only 48 subscribers were connected. Well, this situation has changed mightily in the meantime.

The Triergon Cathodophone

The years have passed, and now we are in the year 1919. World War I is over. Germany has become a republic. The Spartacus rebellion in January and the General Strike in March bear witness to the turbulent times. An event of great technical significance is the commencement of assembly belt production of filament lamps in the Osram factory in Berlin.

Likewise in Berlin, Hans Vogt, Dr. J. Engl and K. Massolle applied for a patent with the title, "A Method for the Control of Electric Currents by the Forces of Sound". This patent was granted on March 22, 1922 under DRP No.350 500. The patent included the microphone which later became known as the Triergon Cathodophone. It had been developed with aim of obtaining relief from the inadequacies of the carbon microphones of the period. It is worthy of mention in this connection that the three inventors, Vogt, Engl and Massolle were also the inventors of the sound-on-film recording method. It was thus only to be expected that they would be keen to develop an appropriate transducer for the sound they wished to record.



Schematic of the Triergon Kathodophon

This idea was based on the following deliberation on the part of Vogt: "It must be possible to derive an electric current from the ionised surface of an incandescent body in free air when this is approached with a charged probe. If sound were introduced into the gap between these two electrodes, the fluctuations in air pressure in the gap thereby generated must modulate the flow of electrons escaping from the incandescent body inertialessly in cadence with the sound oscillations". A corresponding experimental set-up then provided the anticipated results.

The cathode K of refractory ceramic material is wrapped in a platinum ribbon coated with barium oxide, which acts as the ion source. A few tenths of a millimetre in front of the cathode is the anode A, which has the form of a funnel tip. The cathode is heated by the battery B. Between the anode and the cathode lies the anode potential of several hundred volts, adjustable by means of the potentiometer P. The sound captured by the funnel arrives via the open end of the funnel tip in the region of the hot cathode, where it modulates the flow of ions between A and K, which effects a corresponding voltage drop at the resistor W4, which is fed to the grid of the first amplifier valve via the capacitor C1.

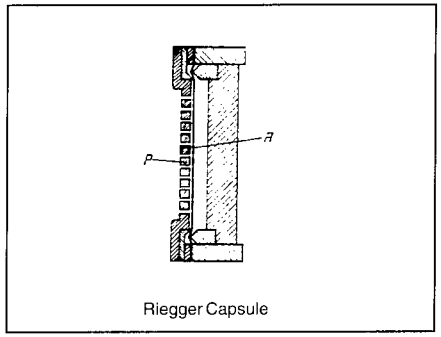
Triergon Kathodophon

The cathodophone made something of a name for itself in sound film recording. Vogt writes in retrospect: "After all, almost all Triergon sound film recordings were made with the Cathodophone".

High-frequency Condenser Microphone

Time marched on; in 1923, the Tempelhof Airport Berlin was opened for civil aviation; in the Vox House on the Potsdamer Platz, the first commercial broadcast took place on October 29 from the "Funkstunde", and the catastrophic inflation period came to an end with the introduction of the Rentenmark. In the years that followed, certain activities on the sector of microphone development proceeded in Berlin almost on parallel lines.

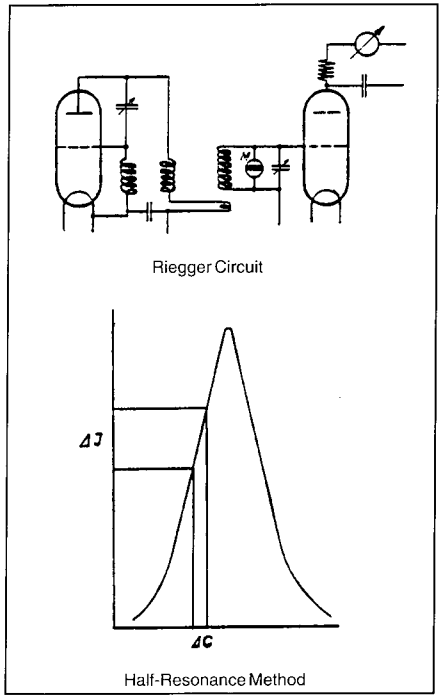
The year 1923 saw an interesting experiment take place in the Siemens research laboratory in Berlin. Hans Riegger arranged a silver paper foil over a tin plate with a layer of mantle gauze in between. This formed a capacitor, which he incorporated in a high-frequency circuit. Already this most simple of arrangements was capable of being used as a microphone, for the trial which was made immediately enabled the word "Hallo" to be transmitted to the next room, where it was plainly audible. The Rieggers condenser microphone was born - it worked in a high-frequency circuit!



Riegger Capsule

The professional version of the microphone capsule consisted subsequently of a baseplate turned out of the centrepiece, with a projecting tapered outer ring. On this is placed an aluminium diaphragm, the mechanical tension of which can be adjusted by appropriate mounting in such a way that its natural resonance is as high as required. It is mounted by means of a slotted pole plate forming the sound reception side of the capsule. Handling protection is provided by a layer of porous silk between the pole plate and the diaphragm.

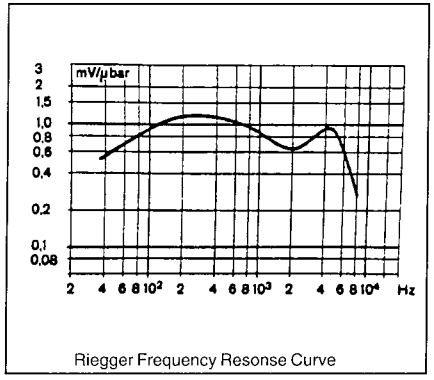
Riegger called the operating mode of this circuit "the half-resonance curve method". Here the microphone constitutes the capacity in a high-frequency resonant circuit. When the selected frequency in the quiescent condition is at half the height of the resonance curve, the anode current of the connected rectifier valve changes in cadence with the change in capacity, i.e. the alternating pressure of the sound arriving at the microphone capsule. As far as the straight part of the resonance curve is concerned, this relationship is linear.



Riegger Circuit

Half-Resonance Method

Due to the relatively low diaphragm mass and the high resilience of the air cushion, the tuning of the heavily damped diaphragm is relatively high. This resulted in an excellent frequency response for that day and age.



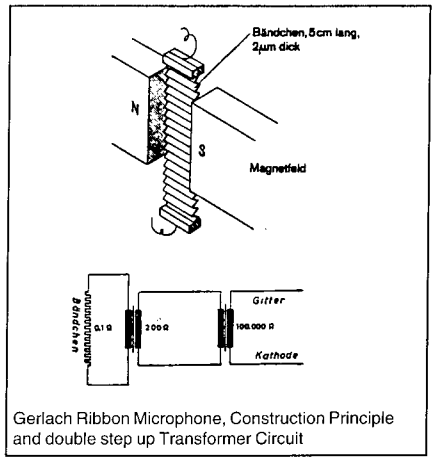
Riegger Frequency Resonse Curve

The microphone was demonstrated at the Physicists Convention 1924 in Innsbruck, In 1925 it was used with great success for speech amplification and music relays at the inauguration of the Deutsche Museum in Munich. This event was of such importance that in the following year a detailed report of it appeared in the "Elektrotechnische Zeitschrift", a Julius Springer publication.

The microphone was used again between 1926 and 1928 for the amplification of the sermons in the Cologne cathedral and in 1928 in Den Haag for the Dutch princess Juliane's Declaration of Majority. Many honours for such a new and intricate product. The Riegger microphone is in all probability the first condenser microphone to be used successfully in Europe. Nevertheless, it was not able to hold and consolidate its position.

The Ribbon Microphone

A new development was announced by Messrs Gerlach and Schottky, in which the electroacoustic transducer was designed on the electrodynamic principle in such a way that the electric conductor simultaneously formed the diaphragm. For this purpose, a ribbon of corrugated aluminium 50 mm long, 4 mm wide and 2 µm thick was stretched between the pole shoes of a magnet. The incoming sound moves the ribbon in the magnetic field, and at the ends of the ribbon the induced alternating voltage - which is proportional to the movement velocity of the ribbon and thus to the sound waves - can be tapped.



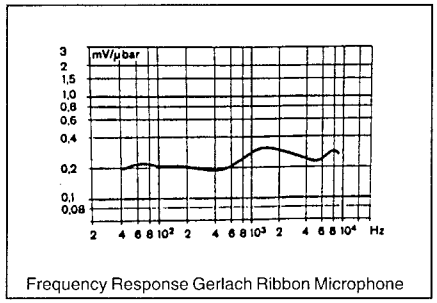
Gerlach Ribbon Microphone, Construction Principle and double step up Transformer Circuit

It is obvious that, with the slight internal resistance (0.1 ohm) of the ribbon, the output voltage will be extremely low. This makes a double step-up transformer necessary.

The first transformer is resident in the microphone, where it increases the impedance to 200 ohms, so that longer microphone cables can be used between microphone and consumer. The second transformer is located in the input of the follow-on amplifier.

In experimental setups, the magnetic field was still generated by a battery-powered electromagnet. In regular production, which commenced in 1928, this was replaced by a cobalt annular magnet.

The acoustic properties are shown in the diagram - the technical world called it an outstanding frequency response.
The characteristics really were outstanding in that day and age. A wide field of application opened up for the microphone - it came into regular use in broadcasting, sound films and gramophone record studios.



Frequency Response Gerlach Ribbon Microphone

The success of the ribbon microphone can be attributed to a number of factors. For one, the relatively unproblematic wiring technique, for another its exellent acoustic properties made it so popular. One of its inventors, Prof. Schottky, stated at the Physicists Convention in Innsbruck in 1924: "The basic conception from which we started out at the beginning of our experiments in the autumn of 1920 was a diaphragm as light as air". That was when the term "light-as-air diaphragm" was coined. Certainly this is one of the main characteristics of a high-quality microphone!

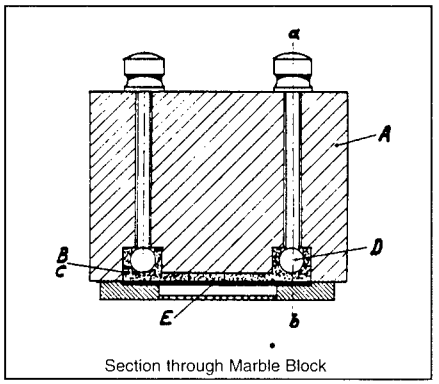
Reisz Microphone

The conductivity of carbon granules for sound conversion was utilised quite early, although it must be said that the quality of transmission was not of the best.

In the laboratory of Eugen Reisz, an interesting experiment was undertaken. Reisz's colleague, who conducted it, was Georg Neumann. He gave an account of the work he was engaged on in a conversation with Lützkendorf and myself in 1968. He had shaken some carbon granules on to a marble slab which was lying more or less by accident on the laboratory bench and applied two electrodes, through which direct current was flowing. He spoke into this arrangement, and the expected response was heard from a connected loudspeaker. It was a thin response, as Neumann reported. He then took a thin rubber film and stretched it over the carbon granules, pressing them together. Again he spoke into the setup. And the result? "The low frequencies were also there!" Neumann reported. That was how the Reisz microphone was born - a great advance in comparison with the other carbon microphones of the time!

As the housing for the new microphone, Neumann used a marble block, for, as he himself said, all the "usual sheet metal capsules" had some inherent resonance or other. The Reisz microphone was to have no resonance. The mechanical design is shown in the drawing.

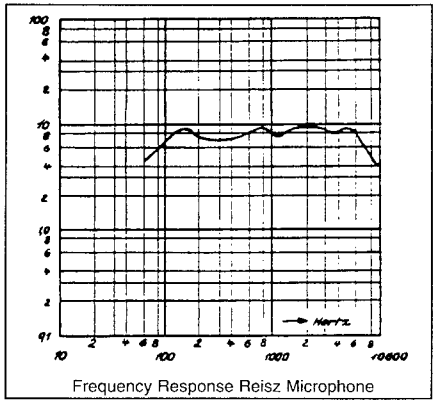
A is the marble block, B the chamber with C the carbon granule filling. The current is routed via the electrodes D in such a way that it passes through the carbon granules in a parallel path to the diaphragm. The diaphragm movement caused by the impingement of sound produces changes in the resistance within the granule mass, which affects the corresponding alternating voltages at an external transformer.



Section through Marble Block

The frequency response between 60 and 10,000 Hz is described in a 1931 publication as virtually linear. The diagram represents the frequency response.

The Reisz microphone earned high praise for its "very good quality" in all relevant publications of the period. Its sphere of application ranged from the new art of broadcasting (many of us still remember Alfred Braun's announcement "This is Berlin on 400 metres"), to sound film recording and sound amplification for public address loudspeakers. The first trials in the Vox house in Berlin had demonstrated that the Reisz microphone was plainly superior to the Triergon Cathodophone. Georg Neumann also reported in the previously mentioned conversation how successfully Reisz had marketed this microphone. Its price at that time was a remarkable 600 Marks!.



Frequency Response Reisz Microphone

Here is an interesting instruction from that period: it was recommended, in order to achieve a constant alternating voltage, to switch on the Reisz microphone some 15 minutes before the start of recording. Also it was advised to avoid excessively loud sounds, as these would lead to non-linear distortion, causing noticeable interference.

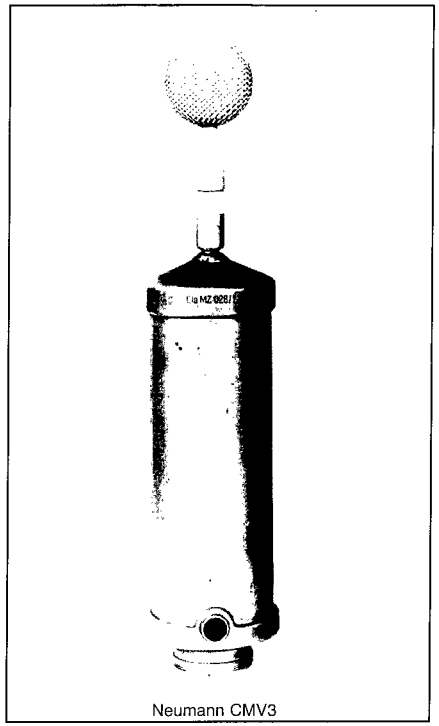
Neumann Condenser Microphone

In connection with the Reisz microphone. we mentioned the name of Georg Neumann, who had parted from Reisz, his employer, and founded his own company in partnership with Erich Rickmann in 1928. According to the report in the chronicle published to mark the 10-year anniversary of the young enterprise, the object of the company was the manufacture of sound recording and reproducing equipment. In this period, the first electrically driven disk recording machine was manufactured by Neumann - previously these had been driven only by clockwork or weights. Neumann was attracted by the idea of manufacturing microphones of high quality, in order to improve the recording of phonograph disks. Although he had designed the Reisz microphone himself, a variant was precluded for licensing reasons, and so he constructed a capacitive microphone.

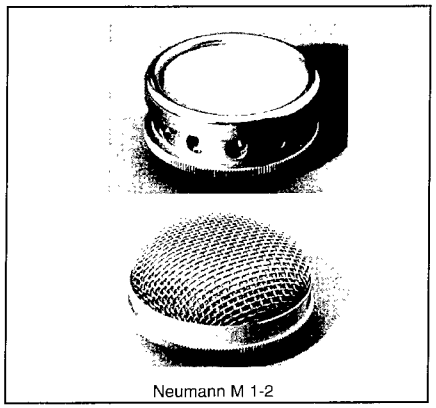
Neumann has often talked about these beginnings, mentioning the numerous difficulties he had to contend with at the outset. Of course it was out of the question at that time to purchase plastic film a few thousands of a millimeter thick. Neumann made the first diaphragms himeslf by moulding plastic foil and then gold-plating it.

The first moulding material for diaphragms consisted of resin dissolved in alcohol, later of PVC dissolved in amyl acetate. In the first moulding attempts, the material was poured on to a water surface, later on to gold-dusted glass plates.

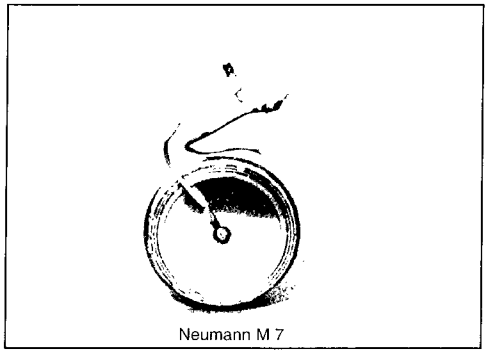
The counter-electrode was a perforated plate with blind holes, which determined the volume of air behind the diaphragm. The first Neumann condenser microphone was thus a pressure microphone. As a complete microphone, it bore the designation CMV 3.


Neumann CMV3

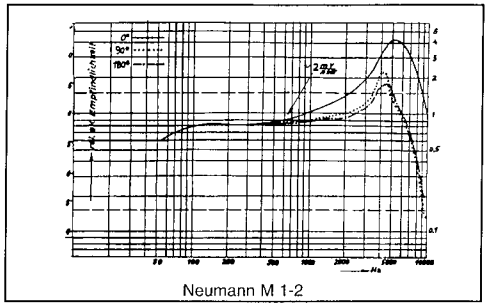
The first microphone capsule to be manufactured in quantity was designated M 1 - 2. It was manufactured before the firm of Neumann was established in 1927, and it appeared in two versions, the first of which had a silk protective gauze; later, in 1930, it was provided with a wire gauze cap.


Neumann M 1-2

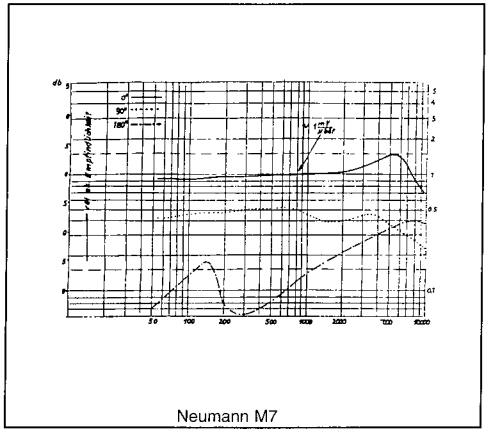
In 1932, Neumann assembled the first capsule for a pressure gradient microphone: the famous M 7 capsule.


Neumann M 7

The very first Neumann condenser microphones were designed, manufactured and delivered in only one week to an English record company which had commissioned them. These were therefore prototypes, which had not even been measured and tested. Georg Neumann recounted this episode, saying, "They just sounded good, better than anything that was available at the time". The frequency response obtained appeared as shown aside:


Neumann M 1-2

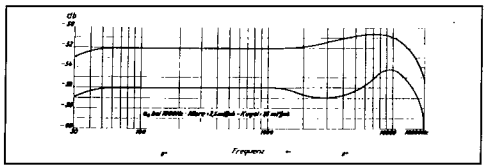
The M 7 capsule produced the frequency response shown aside:


Neumann M7

The test certificates issued by the laboratories of the inspection offices of that time took into account only the frequency range up to 10 kHz. Below is a test certificate representing the entire audible range.

Frequency Response Neumann U 47 with M 7

A frequency response which is found quite commonly in today's microphones.

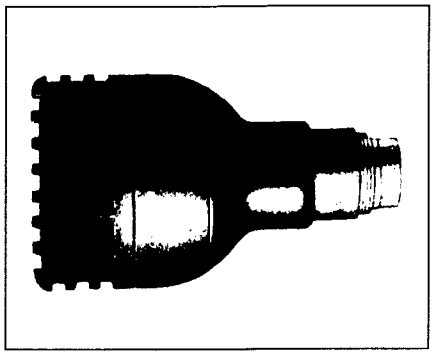


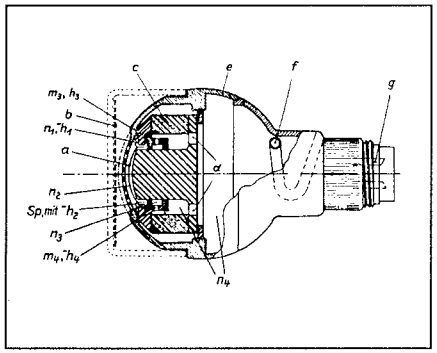
In the ensuing years, further microphone capsules were added, including the M 8 with figure-eight characteristic and the M 9, an omnidirectional model - all capsules which were interchangeable on the same microphone amplifier. A method of use still offered today by many manufacturers.

The Neumann condenser microphones were successful from the start, and were not long in dominating the market. It may be of interest that the M 7 capsule was also used in such renowned microphones as the U 47 and the M 49. It is a fact that this capsule is still being manufatured today. It certainly does not happen very often that a product is able to maintain its dominant position in the marketplace for over 60 years.

Dynamic Moving Coil Microphone by Beyer

Now last, but by no means least, we come to Eugen Beyer, who established his company in 1924 in Berlin for the development and production of cinema loudspeakers. This is where he developed in 1937 the world-famous dynamic test telephone DT 48, which is still in production today, and in 1939 a moving coil microphone with the designation M 19. The latter is a pressure microphone with an impressively linear frequency response.





Beyer M 19

Reichardt describes this microphone in his standard work: "Fundamentals of Electroacoustics", mentioning the peculiar form of the diaphragm as follows: "The sound imparts movement to a dome-shaped aluminium diaphragm, which is serrated at the edge, so that it moves easily in the manner of a piston reinforced at the centre".

There is a story told in connection with its clearance for introduction with the German broadcasting authority that it survived a fall from the 2nd floor of the Funkhaus in the Masurenallee, and even passed the functional test which followed. Perhaps the solid diaphragm construction had something to do with it...
The microphone was manufactured by Beyer until 1953, and sold all over the world.

In the last 20 minutes, we have held what we might call a spot-check review of a period spanning over half a century. From today's viewpoint, we can certainly appreciate the astounding performances of the past. Some of what we have been talking about has no doubt

been buried by progress, and is only of historical interest. Other things though bear witness to the inventive genius and far-sightedness of the engineers who performed these outstanding feats with technical means which had nothing to compare with today's sophistication. All who have been mentioned in this review are certainly worthy of the deep respect of the present-day engineering generation.

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