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THE NEWSPAPER FOR THE HOBBYIST OF VINTAGE ELECTRONICS AND SOUND

# THE HORN SPEAKER

# Horn Contour

## AN INTERVIEW WITH P. G. A. H. VOIGT

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Background

In April 1980 I sent a letter to P. G. A. H. Voigt, a British audio pioneer, about details on his tractrix horns. His name had come up in a conversation I had with Ed Dell about horn loudspeakers. Ed kindly supplied his address in Canada. I heard nothing for several months until August when a letter from Voigt's wife arrived. Since the letter covered none of my questions, I gave him a long distance call which turned out to be the start of many letter and telephone exchanges. Ed Dell and I approached Voigt about doing an interview for Speaker Builder. Voigt at first refused because he said that he had too many projects and immediate worries that had to be dealt with. Then as our letter and telephone conversations progressed, he gradually relented and told me that we could do the interview in January, 1981.

However, over Christmas Voigt developed a painful hernia which would require surgery and put off any interview. But during January, since he was confined to sitting position to lessen the pain, he typed several long letters on many speaker subjects which I had been asking about. Voigt went into surgery on February 3, 1981 and came home on February 8, to recuperate after an apparently successful operation. But on February 9, Voigt suffered a heart attack and died suddenly at the age of 79.

Mrs. Voigt sent me a package of all the letters that he had been working on. The length and breadth of the material indicates to me that Voigt knew that his time was running out and this was the time "to set the record straight". It is from these letters and other sources that I have edited to give the interview that Voigt in person never gave us.

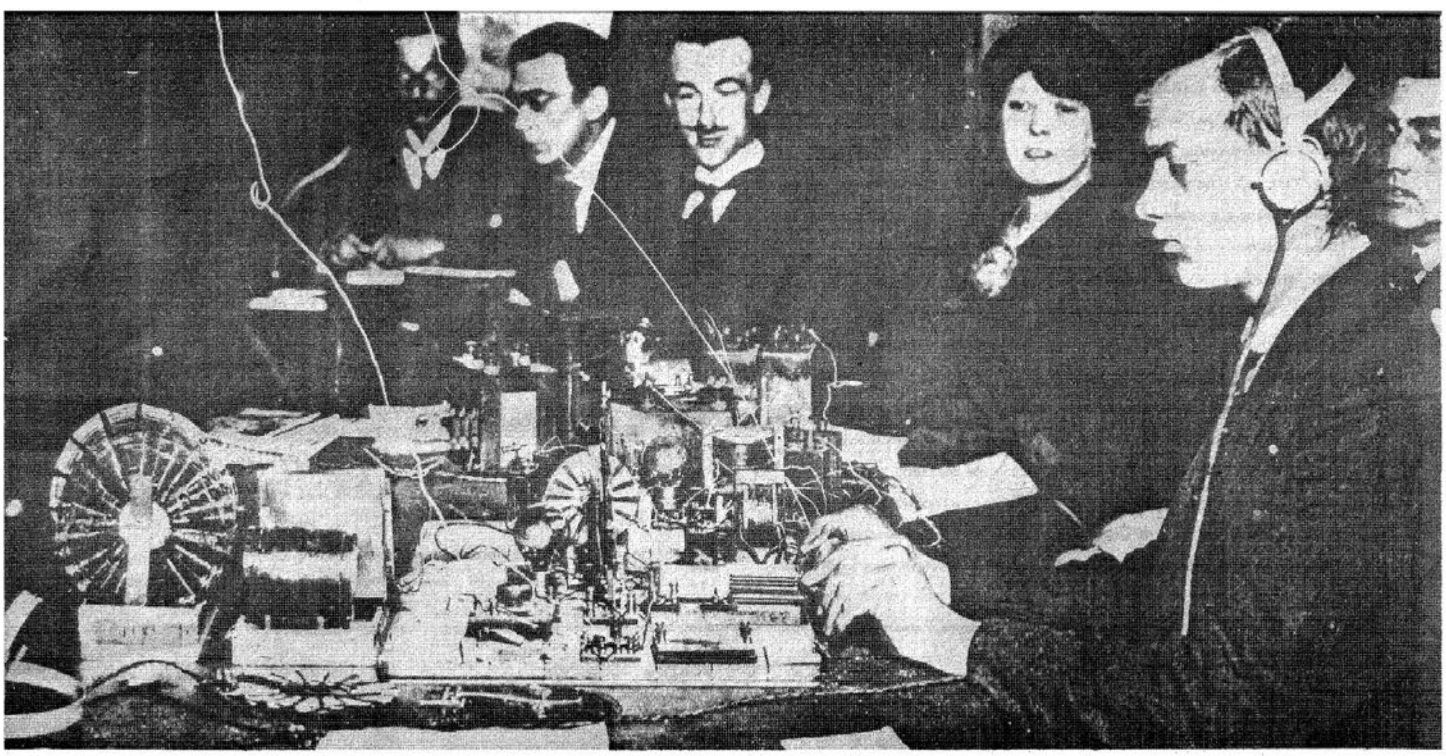

Figure 1 A young Paul Voigt (with earphones) is seen here demonstrating a reflex ( dual high and low frequency) amplifier circuit for the "Wireless and Experimental Association" of Peckham in 1922.

Introduction

Paul Gustavus Adolphus Helmuth Voigt was born on December 9, 1901 in London, England. His parents were originally from Germany who immigrated to England in the late 1800's and became naturalized English citizens. His father was an importer of buckram material which was used in ladies' hats. According to Ida Voigt, Paul Voigt's wife, his mother had the "real brains of the family", and was a constant source of encouragement. Voigt's mother lived to be 103, and Voigt expected to follow her example.

Paul Voigt came from an age of gentlemen which will never be seen again. His approach to loudspeaker design was to use intuitive physical reasoning which apparently was the style of many researchers of the early 1900's. He was also a loner, though he had many friends, who persisted towards a goal of audio perfection in the face of contrary contemporary thought and wisdom. Peter Baxandall said of Voigt (TAA 4/79), "He was a splendid chap...He demonstrated his corner loudspeaker. I heard that evening a standard of music reproduction I'd never heard before". He was a hero to many British audiophiles of the first half of this century but a relative unknown in the U.S. I hope this interview will correct the latter situation.

Paul Voigt was an audio "systems" engineer before the term was invented. He developed and/or invented velocity and capacitor microphones, amplifiers, transformers, moving coil cutters and pickups, and horn loudspeakers, all for the quality reproduction of sound. At the end of his career, he held 32 patents. In many areas he was ahead of his time, and by the time the world caught up with him, his contributions were either ignored or forgotten. So as you read this interview, see how many modern concepts and ideas of hifi had precursers in Voigt's work.

SB: What was the nature of your education?

Voigt: I was born on the 9th Dec 1901. I was a "born" inventor and, for that reason wanted to learn engineering. My parents could afford to send me to Dulwich College, 2 miles from home (in London, England). It had an engineering side. And so, during the first world war, from the age of 13, I was learning the basics of engineering. In 1922, I graduated in Electrical Engineering from University College, London.

By then, that war was over and radio was permitted again. I was experimenting on the subject, and my first article appeared in the Wireless World, publishing date 10th Dec 1921, i.e. before I ceased being a student at University College or having any degree. It would have been written while I was 19. (See Figure 1).

SB: What was your first job?

Voigt: My first paid employment was at J. E. Hough, Ltd., Edison Bell works in 1922, where gramophone records were made and plastic mouldings for the radio and other trades. The firm was afraid that the advent of the B. B. C. would damage the record market and caused them (sensibly) to decide to enter that market themselves. I was one of those taken on to get the radio side started.

However, knowing that I was an inventor and that there was no way, ahead of time, of knowing how valuable my ideas might be, (and that it was normal for employees to be obligated to sign away their patent rights), I insisted that that not be the case with me, that my patents remain my property, (I to pay the costs of patenting), and that THEY HAD PREFERENTIAL RIGHTS AS REGARDS LICENSING.

There never was a better incentive to invent things of direct use to the company.

Apart from my work designing radios and test gear etc., by late 1926, I had developed the first British designed electric recording system to last for years under practical working conditions. Our competitors were ahead of us, but only because they were using U.S. designed equipment, and since I used a moving coil cutter I had designed, my records did not have the hysteresis distortion natural to moving iron devices.

I had not been there for long before I realized that if the artists and musicians played and sang into a mike (a la B.B.C.) whose output was amplified and fed into some kind of electric cutter, that a better master should result than from the use of an assortment of large trumpets. I was encouraged. And before the end of 1926, my system (which used a moving coil cutter) was in commercial use and, with minor improvements, remained in use until Edison Bell, Ltd. (the later name of the Company) died in the slump (April, 1933).

SB: Describe your early experiments with microphones.

VOIGT: Although my initial function was to develope radio components and sets for manufacture, it was not long before I became interested in electric recording. Just when that interest crystallized I can not say without my notes, but in a brochure entitled "The History of Edison Bell" there is a picture of the recording studio in which there is clearly to be seen a swan neck horn Browns loudspeaker. I had it fixed there and was using it it as a "backwards" mike. The electrical people had put in a connecting (phone type) circuit to where my lab was at that time, and there I had a similar loudspeaker used in the right way. No amplification was needed, and while the speaker mike (perhaps the 120 ohm winding) may not have matched the connecting circuit, that was short and the mike certainly matched the output speaker. At one time I tried carbon mikes, but the amplitude distortion made me scrap the idea.

SB: How did you build and set up your first good microphone?

VOIGT: I had a portion of the wall between the studio and the lab removed and a shelf put across the opening. On that shelf I put a specially designed mike (description to follow) and hid the opening with thin silk or something. The mike had a square frame which however did not happen to fit the opening, so strips of carpet were fitted to close the space around the mike frame. The face of the mike was in the plane of the partition wall, simulating a closed window.

From what I learned from the excursion requirements, it was obvious that any velocity operated mike (moving iron or moving coil) had to be free to move about without any appreciable restraint. The ordinary arrangement of a diaphragm clamped around its edge was out.

The diaphragm of the special mike was spun of very thin aluminum and was the size and shape of a saucer. From its edge there were tangential spokes meeting at the hub on the convex side. The curved diaphragm

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was suspended in a circular hole in a square frame with about 1/8" clearance around its periphery. The main suspension was on two threads about 1 1/2" long spaced about 45° either side of the vertical center line. To stop it from flopping about there were two rubber threads pulling down, each at about 45° on either side of the lower part of the center line. There may have been cotton stuffed into the clearance between the diaphragm and the frame.

The transducer part consisted of a flat elongated coil mounted with its plane vertical and on an extrapolation of the diaphragm spin axis. Using magnets (at first it was permanent magnets out of a magneto, but later it was an electro-magnet) fitted with poles that provided a plane vertical air gap . the end of the coil was located within the pole piece jaws and free to move. Thus as the diaphragm vibrated, the coil vibrated, and that part of its coil within the magnetic field had a voltage induced in them. This arrangement was not efficient, but as a mike it was easier to put in some amplification than to devise a freely supported circular coil and magnet system.

SB: How did you become interested in loudspeakers?

Voigt: There was a great need for a good speaker to use in the studio. Musicians wasted much time in the recording studio because they could not tell from the gramophones in use at the time just how good or bad the recording was.

For laboratory test purposes, I wanted a perfect loudspeaker, or at least as close as possible. In 1924, on the 30th of April, when the B. B. C. was about 18 months old, Capt. P. P. Eckersley, an ex Marconi Engineer, and then chief Engineer of the B. B. C. gave the Radio Society of Great Britain a lecture on the early problems of the B. B. C. and how they coped with them. I had already considered what perfect (mono) sound should be like if ever we could produce it and in the discussion which followed the lecture was able to "ventilate" my "HOLE IN THE WALL" theory. The lecture (which took place in the I. E. E. lecture theatre) was reported in the Wireless World for 28th May, and the discussion in the W. W. for 4th June, 1924.

SB: Can you give a brief description of your hole in the wall theory?

Voigt: In those early days, I had done a mental preliminary survey, not of what bits and pieces should be put together to get good audio, but more fundamentally WHAT WOULD GOOD AUDIO BE LIKE IF WE EVER GOT IT.

My 1924 answer to that was my "hole in the wall theory. My hole-in-the-wall theory was controversial for a long time. Some people thought that perfect reproduction should sound as though the sould originated IN THE ROOM YOU WERE IN. That overlooks that your room has one set of reverberations and the studio or concert hall a totally different one. The latter can easily be made negligible by having the announcer come right up to his side of the wall where the hole is and, as it were, be talking direct to you through that hole. That theory and consequent understanding of what to aim for has been fundamental to my outlook. Incidentally a non-technical musical expert,visiting a friend who was having a demonstration in my corner horn days, wrote up his experience for some musical journal did not use the word "hole". He described his listening experience as listening through a WINDOW!

SB: What was the "state of the art" of gramophones and loudspeakers in the early '20's?

Voigt: When I asked leading gramophone designers what would the perfect sound reproduction sound like, I found that the "forward" tone was apparently the ideal.

Now having some scientific knowledge, I could not quite understand how a mechanical instrument could be expected to produce a tone which would appear to originate at some point 6 inches or so in front of the mouth of the horn, unless this effect were achieved by resonance or some form of forward reflection which would give a focal point there.

One of the firm's (Edison Bell) slogans at the time was "It rings out loud and clear", and so we have a clue to the ideas of perfect reproducti of the 1920's.[1]

In the 1920's loudspeakers for radio , etc. mostly began with an enlarged headphone mechanism coupled to a horn. The general idea had dev that the horn was the reason why the audio quality was so poor. I myself looked upon horns as an unknown quantity with the introduction of extra resonances into the system as a most probable disadvantage. (Editor's note: This attitude changed rather drastically later.)

With my "hole in the wall" concept in mind, it was obvious to me that for bass it was necessary to provide for the free oscillation of air volume through any such (real or imaginary) hole, and therefore the standard type of reproducer based upon the idea of a "blown up" earphone with trumpet attached would not meet the end requirements. Even the so-called hornless devices, with large diaphragms, were driven by some electromagnetic mechanism which,if adjustable and adjusted to be well clear of the pole pieces, would be inefficient and,if too close, would collapse onto the pole pieces. To prevent either occurrence, the diaphragms had to be stiff, i. e. no freedom of movement. Now I had seen a Magnavox with a 20" or so horn after World War I with a moving coil drive. But it sounded like the flat bottom of a white enammelled army mug of those days. I do not suppose for a moment that its diaphragm was made out of a mug, but that is what it sounded like and with an iron diaphragm clamped around its edge that is just about what you can expect.

SB: What was your normal approach to research?

Voigt: To get to grips with a problem and work out the answer is my normal way of trying to achieve progress. Having worked out the answer, it is my normal way to compare that answer with the ESTABLISHED ideas when such already exist. If my answer fits the established ideas, then what I have found is that I can safely use those ideas. IF, on the contrary, my result does not fit the established ones then, arises the question WHICH IS CORRECT or are BOTH WRONG.

Since I am rotten at maths, my approach is rarely the mathematical one. The usefulness of maths depends upon the accuracy of the ASSUMPTIONS on which that maths is based.

SB: How did you start designing moving coil loudspeakers?

Voigt: At Edison Bell I was experimenting with moving coil systems and using my knowledge, I designed the moving coil cutter for the recording system. I was familiar with the consequence of applying various field strengths (magnetic) to current carrying conductors.

One major result is that the greater the field strength, the greater is the electro-magnetic force for a given current. In those days, undistorted audio watts were expensive, that was one reason for pushing up the flux density. Another was that the greater the flux density, the greater was the electro-magnetic damping on the moving coil (other things being unchanged). AND, there was a more subtle one, theoretical, but partly imaginary.

Suppose you could make the field strength so high that the electro-acoustic efficiency would average 100% over the whole audio scale, would it not have a flat energy response curve with no peaks or troughs?

While 100% efficiency is unattainable in practice, there was no question in my mind that the nearer you could get in that direction the better would be the ratio of average to peak. For example, if the average was 1/4 of 100%, i.e. 25%, any energy peak beyond 6 dB would provide the missing part for a perpetual motion machine!

The fact that in my lab, I had both d.c. and a.c. mains, meant that if I designed a huge magnet with electrical excitation, in those days when valve rectifiers were still unreliable, providing the excitation presented no difficulties.

(To be continued)

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1. Voigt, P.G.A.H., A Controversial Idea from England, Audio Engineering, 24, pp 40-41, Oct. 1950.

THE INTERVIEWER

Dr. Bruce C. Edgar is a Space Scientist for The Aerospace Corporation and is interested in the history of loudspeakers.

# Horn Contour

continued *by* BRUCE C. EDGAR

SB: What did your first designs of loudspeakers look like?

Voigt: I designed for high flux density on the electro-magnetic moving coil drive. The company blacksmith provided a U-shaped soft iron core, bent, (from memory) out of 2 inch diameter bar. Onto its straight portions went 4 separate coils, each with a carbon lamp across it to take care of the "splash" when switching off, and so, for my earliest high power magnet experiments, I had a 1/4 KW excited field U magnet to experiment with. In due time, I arranged for a pole-tip system suitable for a cylindrical coil. (NOTE, in my school text book at Dulwich, such coils were called Solenoids. Nowadays that word is used to describe such a coil plus iron cores to operate switches, etc.)

In my case the coil actuated a lightweight saucer-shaped aluminum diaphragm, driven via aluminum spokes and supported so as to be able to move very freely. It was surrounded by strips of mother's old carpets to act as a non-resonant baffle.

You will notice that the diaphragms (see Figure2) I show, are based on the "cap of a sphere" shape, with "spokes" which are tangential to the surface. This arrangement I used on the moving coil mikes I experimented with during the development of the recording system and on the early moving coil loudspeaker drives. It never went into production, as I had no satisfactory method of making the spokes adhere the spun aluminum diaphragm.

When the adhesive between the spokes and the al diaphragm gave way, it would rattle under working conditions. When I had overhauled it carefully and had my moving coil system working, I would "turn up the wick", and, alas, within 5 minutes it would be rattling again!

By the time my complete specification of my loudspeaker was under study by the patent examiners, they were aware of the work of Rice & Kellogg, and that anticipated my concept so completely that I removed from the complete spec. and the claims mentioning the moving coil system.

Such removal meant that manufacture for sale was out, but not that I had to give up my "hole in the wall" concept or that I had to give up making experiments with moving coil systems.

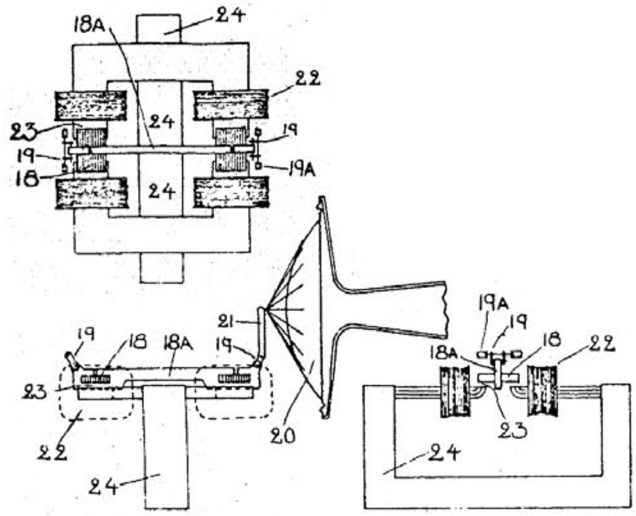
SB: Was this your first patent application?

Voigt: No, I had 6 previous patents granted to me, all on wireless devices. I was eventually granted British Patent # 238, 310 for "Improvements to Sound Reproducers". That is the one which would have anticipated Rice-Kellogg if it had been 2 months earlier. As you will see my application date May 20, 1924, so the Rice-Kellogg application should be in March of that year. I was quite unaware of the work of Rice-Kellogg at that time. The news had had not reached Britain.

(Editor's note: Rice and Kellogg were two American engineers, working for General Electric, who developed the first good electromagnetic moving coil loudspeaker.[2])

FIGURE 2

238,310 COMPLETE SPECIFICATION




Early Voigt moving coil loudspeaker portrayed in a patent drawing. ( British Patent # 238, 310)

SB: How did your first loudspeaker perform?

Voigt: When it was all ready for test, I was looking forward to hearing something vastly better than any previous loudspeaker. I was, upon switching on, very very disappointed. I had never had anything sounding so "tinny". The highs were strong and the lows very poor.

Upon thinking out why such an unexpected result was occurring, I realised that when calculating the load which the square inches of diaphragm area (piston equivalent) were assumed to be working into, I had used the mechanical ohms figure for a plane audio wavefront.

The disappointing result I was getting, I realised, was due to to that assumption being approximately right for frequencies so high that the wavelength was SMALL relative to the dimensions of the diaphragm, but totally wrong when the diaphragm dimensions were small relative to the wavelength. Under those conditions the air, when exposed to the peak pressure of low frequency sound instead of reacting with back pressure, simply ESCAPED sideways out of the compression region, and ditto all that in reverse during the suction half of the sound cycle.

Evidently, some means of PREVENTING those lateral component motions must be provided, and that is how I came to design my horn. Close to the diaphragm, the obvious way to prevent lateral motion, is to fit a large diameter pipe, but analysis of that obvious way shows that while the to and from flow of the air propagating the sound is prevented from lateral motion, it will propagate with a plane wavefront (at right angles to the inner surface of the pipe) until it reaches the end of the pipe at which the prevention of the lateral component ceases abruptly. That allows the transverse escape there and thus a coupling into an air resistance totally different to the mechanical ohms resistance at the diaphragm.

The parallel pipe thus, basically, only transfers the discontinuity which permits the lateral "escape" near the diaphragm, to a more distant location. IT DOES NOT ELIMINATE THE DISCONTINUITY.

What is worse, is that at the discontinuity, there is a reflection (analogous to that in a transmission line) which travels back to the diaphragm and tends to make the pipe behave rather like an organ pipe!

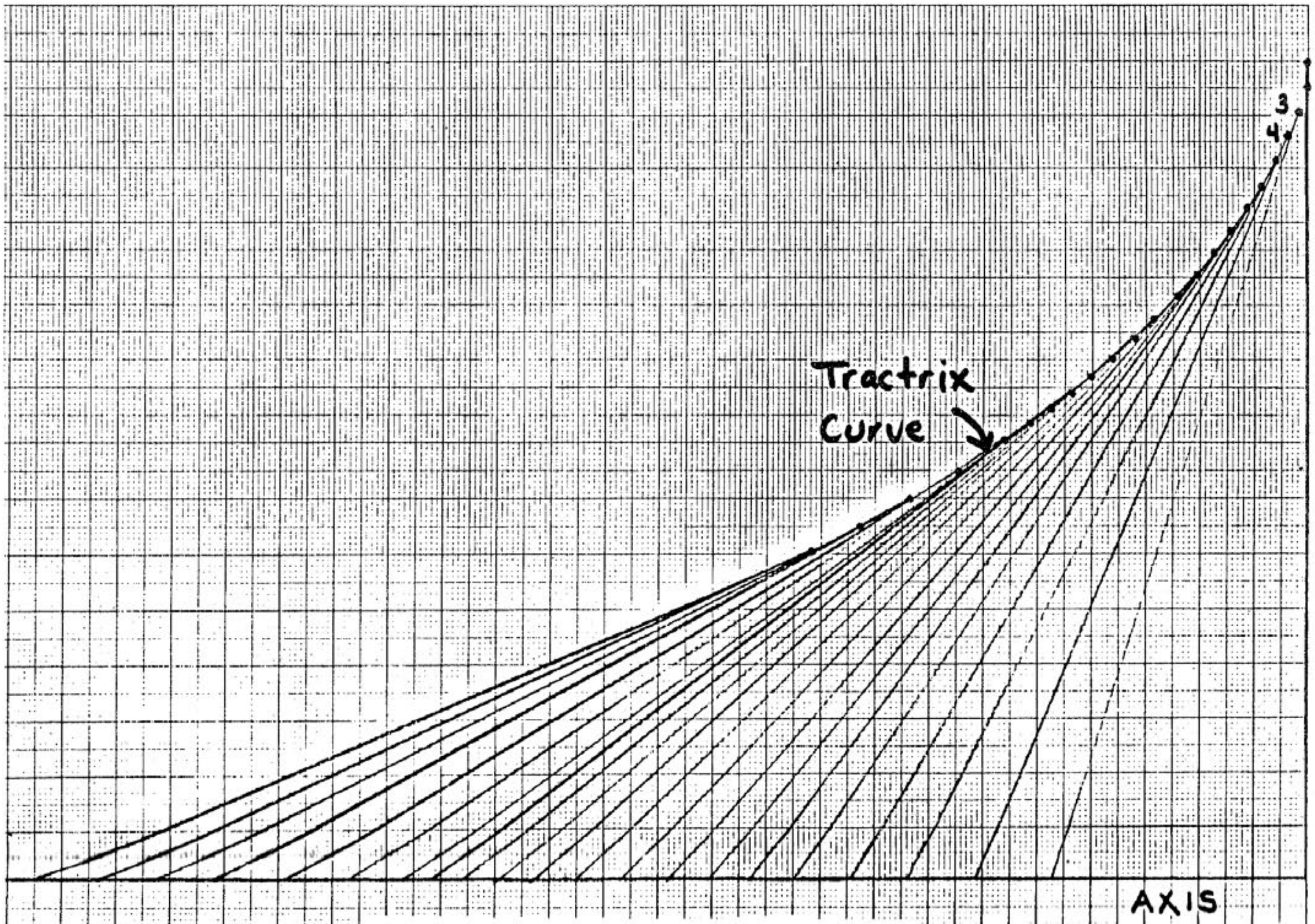



Figure 3 Drawing of the Tractrix curve from instructions of Voigt.

**SB: How did you make the transition from a pipe to a horn?**

**Voigt:** Part of the "trick" which is necessary to improve the situation at the output end of the straight pipe is to scrap that shape and put a slight, expanding taper at the diaphragm end. If that taper is "gentle" enough the lateral motion can be reduced so much that it is so slight as not to introduce any major loss of reaction pressure.

The sound wave will, when in a slightly (outward) tapering pipe, no longer travel with a perfectly flat wavefront. Where the wavefront travels along the surface of the taper, it will, quite naturally travel parallel to that tapered surface. On the opposite side, the tapered surface ALSO causes the wave to travel parallel to it. Thus, the wavefront edges will diverge as necessary to fit the gentle divergence of the expanding taper which encloses it. AND, the beginnings of the normal spherical expansion of a sound wave have commenced.

As the area increases, its relation to the lower frequency wavelengths improves, and, while this is beneficial from their point of view when reaching the end of the horn, they have already suffered a little because of the poorer relationship near the smaller diaphragm. AND, if the taper remains gentle, the wavefront in the horn will only expand very slowly making the horn inconveniently long if that benefit is to be preserved.

What is practical, is to increase the outward taper as the distance from the diaphragm increases. This too is desirable ; for by the time the wavefront reaches the opening, ESPECIALLY if there is a flat baffle around the opening, the taper should have increased gradually to a 90 degree angle to the axis. The abrupt discontinuity is then reduced to a rounded surface leading to the baffle, and the ill effects are greatly diminished.

**SB: How did you draw the horn curve?**

**Voigt:** The curve (see Figure 3) is easily drawn on drawing board paper by starting with the decision of the semi-mouth size at the 90° to the axis taper. Suppose that that size is to be near 30 cms. Place a rule at 90° to the axis and mark the approximate position of the mouth at 30 cms from the axis. (Point No. 1). Mark clearly the first cm from that point toward the axis. (Point No. 2). Keeping the lower end of the rule on the axis, move the lower end of the rule along the axis, keeping the 30 cm rule point near the clearly marked top cm. In fact, let the edge of the rule pass over point no. 2 (which will be 29 cms from the axis.). When point no. 2 is at 30-1/2 cms along the rule, step the motion along the axis and mark the next point, no. 3, at the 29-1/2 cm mark on the rule. Point no. 3 will be near 28 cms from the axis. Move the axis end of the rule along the axis again so that point no. 3 is at 30-1/2 cms along the rule and mark point 4 at 29-1/2 cms along the rule.

A curve will be seen to develop. Continue the above procedure. As the curve flattens out, the steps can be made longer. The wanted curve is the curved line through the points.

As I drew out this curve to make the smoothest possible transition from the nearly parallel taper near the diaphragm, to a 90° angle to the axis, I wondered if I had re-invented the standard logarithmic (exponential) curve mentioned in some advertisements, (this was in the mid twenties.). When I plotted the latter, I found that at the throat where the taper was very slight, the difference was negligible. As the mouth was approached, however, the taper increased faster than the logarithmic, and the 90°

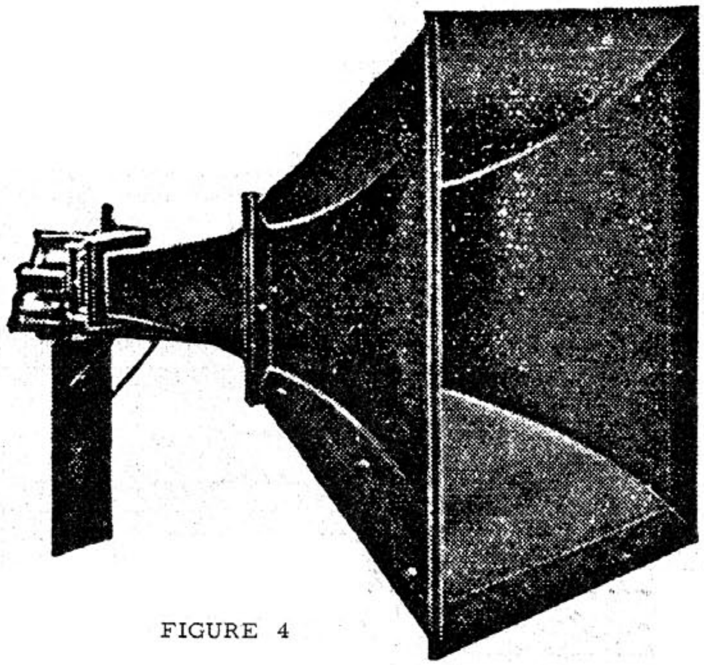


FIGURE 4

angle was reached quite soon, so that it seemed shorter. Later, I learned from our draftsman, that the curve was known in the mechanical world, and that its name was a Tractrix.

SB: How did you come to the conclusion that the wavefronts in a horn must be curved instead of flat?

Voigt: My background was that I was familiar with basic engineering principles. It follows from the most elementary of these, that where the edge of the wavefront rubs on the inside surface of the horn, the wave surface has NO ALTERNATIVE but to orient itself at right angles, i.e., normal to that surface.

Try and imagine the pressure face of a wavefront endeavouring to propagate parallel to the axis, then it will have to leave a gap between its own circumference and the expanding inner surface of the horn. The further forward that wavefront goes, the bigger will the gap become.

AUTOMATICALLY, the pressure wavefront will spread sideways to fill that gap. With such a sideway spread, the volume moving forwards is reduced and thereby slowed down. Such slowing down slows down the wavefront, the effect being greatest where the gap is being filled and least at the furthest distance from the gap. With a circular horn, the expanding gap exists all around the circle, and the furthest distance available to the wavefront is IN THE MIDDLE, i.e., on the axis. Thus, inevitably there is a forwardly bulging wavefront. With a circular horn, will that bulge be 100.000% Spherical? The answer is NO. This will be surprising to most readers, but it is not a serious matter.

So, to sum up, the difference between the tractrix and the exponential with its flat wavefront (theory) is that one was designed by a 24 year old engineer familiar with the elementary mechanics of nature, the other by a skilled mathematician, take your choice!

(Editor's note: On July 5, 1926 Voigt applied for a patent, and he was granted British Patent # 278,098 for the Tractrix Horn in 1927.)

SB: What was the size of your first tractrix horn?

Voigt: The first horn I had made for my lab had a 4 foot square mouth and a 4 inch square throat and was about 5 feet long with a monster magnet. When the 4 foot mouth tractrix was eventually finished, the speaker's frequency range (with the low frequency cut off very gentle) peaked a little before its gradual cutoff but now it was no longer "tinny" in sound, its response went down to below 100 cycles per sec (Hz!) and was still useful at 50 Hz.

My lab had a "cathederal" ceiling, and, from the previous users, (Radio set repair), an erection on to which my monsterous loudspeaker could be raised. It provided the most perfect reproduced sound I had yet heard up to that time. In those days, I did a lot of late work. So, in the evenings up to midnight when the B.B.C. dance music closed down, I had the pleasure of listening to reproduced LIVE music (with NO commercials) from London's leading hotels via the B.B.C.

What the above proved, was that my belief that IF a high average energy efficiency electricity-to-audio transducer could be produced, then the energy response curve would not only be smooth, but that the audio effect would be very satisfying ------- assuming of course, that the polar distribution diagram of the energy did not concentrate parts of the energy into compact beams with the listener located in an area of major concentration.

In my case, the erection on which my 4 foot mouth horn speaker was located ran transverse to the room. The horn's axis was about 9 foot above the floor, and, as I am only about 5 foot, 11 inches tall, my ears will have been about 3-1/2 foot BELOW the level of the axis. About 4 foot from the horn's mouth, along the axis was the wall above the entrance door. So any normal listening to which I was exposed was reflected off that wall, OR it may have come off the back of the diaphragm and been reflected in different ways.

SB: When did your tractrix horns reach public notice?

Voigt: As regards the word tractrix in connections with horns, that did not reach readers of the Gramophone till their November 1933 number when it described a visit to the inventor's exhibition at which Voigt Patents Ltd had a stand (see Figure 4).

SB: How did you construct your cinema horns?

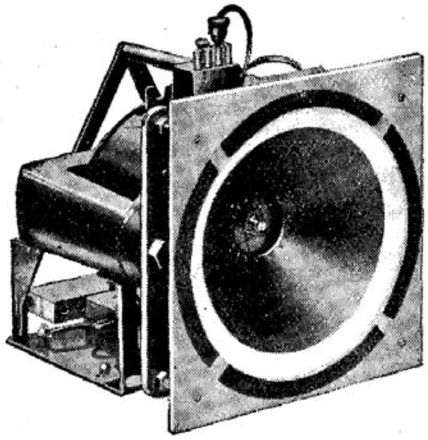
VOIGT: In the drawings I made for the carpenter, the forward flare part was in 4 pieces bolted together, plywood on frames cut to the correct shape. The front was square, and so the sections joined at an angle which from the front was 45° off the vertical. The front opening was 4 foot square while the rear opening of that assembly was 1 foot square. To that could be bolted neck pieces of the length required for their input sources. Now the angle of the ply's relative to each other was not 45°. In fact the angle varied along the length. So I figured out a jig to hold the wood at the appropriate shape and then by sawing vertically, the varying angle would come out automatically. Well, the carpenter could not see the need for that at all. Obviously the angle was 45°, and he had been in the business for many years.

Well, when people know all the answers I do not waste time arguing with them. When I have alerted them I have done my bit. He learned the hard way that horns can look like 45° joints, but they are not. He had an awful job making it fit together.

The curves of those horns were based on the tractrix across the center section. This meant that across the diagonal the tangent would

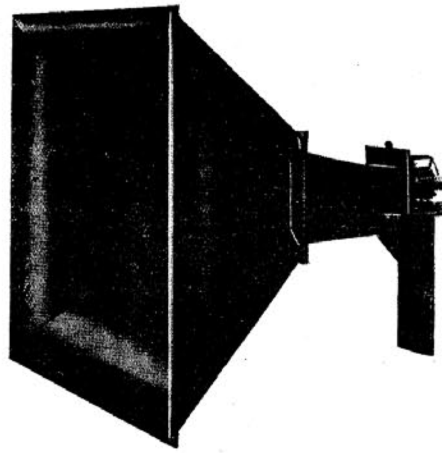
# Horn Contour

**continued** *by* Bruce C. Edgar



Voigt Excited Field Loudspeaker

Edison Bell Power Loudspeaker
(Voigt Patents)



Voigt Cinema Horn [14]

SB: What were the developments leading to the formation of Voigt Patents Ltd?

VOIGT: It was in the 1920's while at Edison-Bell that I learned enough about magnets to design high-flux-density loudspeaker magnets properly. Those design principles were discussed in detail in my British Patent number 331,209.

Excited field speakers, made under my patent by Edison-Bell, supplied with 40 to 50 watts excitation power gave a flux density of 16,000 to 17,000 gauss across a 2 mm gap, and were used for cinema work, high quality public address, etc. Edison-Bell "died" in the slump (1933), so my own business was started to keep the speaker alive.[3] (See Figure 5).

SB: How did you design your domestic corner horn? (See Figure 6).

VOIGT: The simplest way to visualize it is to imagine that my cinema square section horn is facing downward onto the floor and that it is the bottom portion of a rather distorted pyramid. Then it is sawn into four parts by sawing vertically downwards from one corner to the opposite one. Now if you place one of the quarter sections into a corner of a room, the horn's performance will be unaffected.

SB: How did the unusual reflector in the corner horn come about?

VOIGT: The next problem I faced in designing the corner horn was that of obtaining an even distribution around the room. I knew that the low frequencies coming from the horn would diverge while the higher tones would be projected more or less in a beam. The high frequency beam would tend to strike the lower concave section, and the more divergent lower frequencies would be reflected by the larger concave surface. So I aimed at a 30 degree reflection up and down, so as to cover persons either sitting or standing, and of course anywhere in between. (Editorial note: Voigt received British Patent number 404,037 in 1934 for this feature.)

**Figure 5 Voigt (left) is taking a response curve on a recorder at Voigt Patents, Ltd. in the late 1930's. From Wireless World, July 21, 1933; " Mr. P. G. A. H. Voigt, for some time chief research engineer of Edison-Bell, Ltd., has acquired the stocks of Edison-Bell-Voigt moving coil loudspeakers and electrostatic microphones and has formed a company, Voigt Patents, Ltd., to carry on the manufacture of high grade electroacoustic devices."**

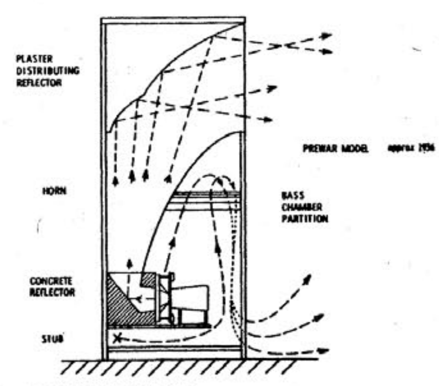



**Figure 6 (a) Cross section of the Voigt Domestic Corner Horn. The horn portion had a response down to 100 Hz, and the bass chamber used a λ/4 tapered pipe resonant at 50 Hz to supply the bass.**[15]

SB: Why did you develope the λ/4 tapered pipe loudspeaker enclosure?

VOIGT: In 1933-34, I was very much concerned with trying to increase the amount of bass you can get with a fairly small cone. That cone was already driving a short horn, but the system was inefficient below the horn cutoff. Several cubic feet of space was available in the cabinet below the horn, and the problem was to find a way to augment the lowest frequencies within the available volume. The method finally adopted used a tapered folded pipe (rather like the neck of a horn) which exhausted near the floor. I named the bass department of the system a bass chamber and would certainly not have done so had I been aware of the impending introduction of what is now called the reflex cabinet. For that has a better right to be called a chamber than my more complex tapered folded pipe system.[4]

In those days any kind of resonance was considered taboo, I refrained from suppying any details. Its main purpose was to provide bass and that covered with the name bass chamber. (Editorial note: It even fooled Percy Wilson, technical editor of Gramophone, who called it a Helmholtz chamber in his review[5] of the Voigt corner horn.)

Actually it behaves like the neck part of a very low frequency horn which stops before the flare is fitted. Technically a quarter wave length resonator will describe it. But since it exhausts at floor level in a corner it is feeding into an eighth sphere and so it is well loaded and therby highly damped. Additionally the floor and sides of the room act as a substitute flare, so the mouth reflection to be expected from a quarter wavelength pipe resonator is very much reduced therby widening the skirts of the response on each side of the peak which itself is so much damped that there is no noticable boominess.

(See figure 7 for an explanation of the λ/4 tapered pipe enclosure.)

(Editorial note: Voigt was granted British Patent number 447,749 for the above idea.)

SB: Did you have any problems with the response of the corner horn?

The corner horn in a living room setting. The base measured 2 x 2 ft. square. Although not excessively large by today's standards, Voigt must have encountered resistance from the distaff side. A 1937 ad, written by Voigt, asks " Imagine how fine it would sound in your own room..... Imagine your wife's remarks! Then write to us for details of how to get even better results as well as the approval of the ladies." A corner horn with a white finish sold for £ 32 in 1937.

VOIGT: I did have trouble with a bump with our domestic corner horns. By themselves they sounded fine, but when compared with the four foot mouth straight horns that bump could be detected easily on the comparison. I tried all kinds of things, thin ply for the back boards, saw slots etc. Every batch of horns for a year or so included some experimental ideas.

In order to help me with putting the problem on a proper footing, I started a year or so before the war on developing a tone burst test of a simple kind. I made the burst last 100 ms and the space 100 ms by switching from a shaft at rps synchronized with the mains by gearing off a Baird scanning disc motor. (Baird was an early English television experimenter.) With this I could show quite clearly a hangover at about 100 Hz. So at least I knew that our corner horns were not aperiodic around the horn limit frequency. By various experiments, I could push the hangover frequency about, but I could not get rid of it at that time. I never completed the total system or solved the problem; it was some problem that we had with Hitler that messed up further progress.

After the war I brought a double beam Cossor oscilloscope and was able to show that at the bump frequency the phase up and down the horn flare was substantially the same. This is what occurs in a Helmholtz resonator. So my belief that there was some kind of resonance was confirmed again. It could be a cavity resonance. I did start some experiments for absorbing it electrically or mechanically, but I was never able to finish them.

SB: How were your speaker diaphragms made?

VOIGT: What I used for my diaphragms was white paper as used by the draftman on his drawing boards. It was handy and available for the asking. I cut it to shape, bent the cone on the appropriate former and glued the overlap seam with celluloid cement.

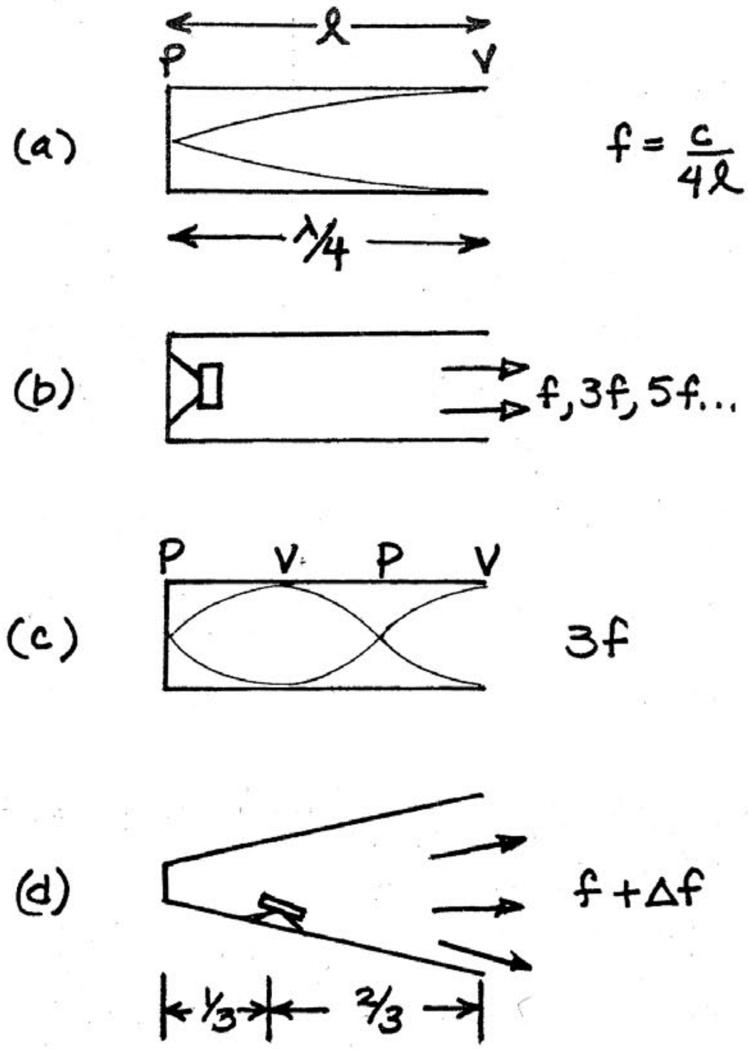
Of the techniques developed as between the paper makers and the mass production speaker makers, I have no knowledge. I imagine that the dies for forming the paper were not cheap.

Later, when diaphragms were being made for straight horn speakers for talkies, the assembled diaphragm was sprayed with mahogany coloured shellac using a hand operated "FLIT" gun sold for spraying anti-fly liquids, (also something readily obtainable.,

To start with, the frame around the diaphragms was made of wood, the outside being rectangular (almost square) while the opening (naturally) was round. In the early days, the flexible surround was of chamois leather which could be stuck on. There were two reasons for changing that. One was that it was not as elastic as I thought desirable. The other reason was that I had news that in some cinemas, the mice found it good to eat.

As things improved, the frames were made of die cast aluminum. and for surround I used a red material which I think was a form of crepe rubber. It came from the Malay States and was sold in England under the name Linatex. An aluminum ring was used to clamp the linatex to the paper diaphragm. The mice showed no interest in that material, but like rubber materials in general there was perishing with time. This was affected by the atmosphere. In most cinemas, a life of 4 or 5 years was quite usual, but in seaside towns might be only half that. In the domestic corner horns of 1934 onwards a longer life was normal. During the later fifties, while living in Toronto, I was introduced to a flexible plas-

Figure 7




The Voigt quarter wavelength bass loading enclosure relies on the fact that a $\lambda/4$ closed pipe resonates at the fundamental and odd harmonics . In (a) the fundamental standing wave has a pressure maximum (P) at the closed end and a velocity maximum (V) at the open end. A loudspeaker will be properly loaded if placed at the pressure maximum in (b), but it will radiate at the fundamental and all the odd harmonics. At the third harmonic there are two pressure and velocity maximums as shown in (c). Voigt found that if he placed a driver unit a 1/3 of the length down from the closed end (d), the speaker is near a pressure minimum of the third harmonic, reducing the third harmonic excitation. By also tapering the pipe, he was able to broaden the response about the fundamental to give an octave and a half of bass.

tic material about 0.4 mm (from memory) thick, made by DuPont under the name FAIRPRENE M5550. It was not quite as elastic as the Linatex, but for domestic work that is not as important as in a cinema. When we moved away from Ottawa, about 18 years later, it showed no signs of perishing.

(To be continued.)

3. Voigt, P. G. A. H., Letter to Editor, Radio-Electronics, 30, pp 16, 20, 22, Mar. 1959.

4. __________, All About the Reflex Enclosure, Radio-Electronics, 30, p 38, Feb. 1959.

5. Wilson, P., Cabinets for Speakers - II, Gramophone, 14, p 354, Jan. 1937

14. The Voigt Loudspeaker, Gramophone, 10, p298, Dec. 1933.

# Horn Contour

continued *by* Bruce C. Edgar

SB: When did you invent the twin cone diaphragm?

VOIGT: I discovered the advantages of using a twin cone to improve the high frequencies in 1933. But it did not improve the high frequencies as much as the light coil feature later on. The twin cone idea was probably the most "borrowed" of any of my ideas. I was able to license Wharfedale and Goodmans to use my twin cone patent in their loudspeakers, and they both paid their royalties faithfully. Because the war spoiled the high quality sound business, I was granted an extension of time of the life of the patent. However patents do not go on for ever. I did not have patents in other countries. What is the position today? Well, there is not a HiFi shop inthe world which does not have a few twin diaphragm loudspeakers in stock. And for every one in stock, how many are in use? So at least if Rice and Kellogg beat me by a few weeks for the moving voice coil loudspeaker, I contributed the twin diaphragm. (Editoral note: Voigt was granted British Patent no. 413,758 for the twin diaphragm idea in 1934.)

SB: How did you develope your Light Coil Twin (cone) version of the Voigt loudspeaker unit?

VOIGT: During the latter 30's, while driving on a long trip to Scotland, my mind returned to the field strengh consequences. My main starting point then was the 1929 design of the Voigt cinema speaker for which I had accomplished 16,000 gauss (the flux density at which iron shows signs of nearing saturation) is the same as 1500 milli Teslas. If you prefer to be strictly scientific and call it 1.6 Teslas and use that value after explaining to a customer how important it is to have the highest practical field strength, he would probably conclude that you were nuts and think you were lying. And the above flux density I had accomplished with 40 Watts dc magnetising.

Now, the only "guidance" on the subject of speech coils I had come across was in an American book by Olsen[6] in which it was proven mathematically that the optimum mass for the speech coil was that which made it equal to the mass of the diaphragm.

That may have been correct relative to the assumptions on which his math was based. But my assumption was that high flux density was important. Anyway, the mass of my aluminum wire speech coil was far less than that of my twin cone diaphragm (main cone 6" diameter). So I was already "guilty" of a major deviation from established ideas.

But, if I were to use a coil weighing as much as the diaphragm, it would be possible to squeeze it into a 2mm gap. To increase the volume of the gap sufficiently for the "established" advice, the electro-magnet would would have to be increased tremendously. My 1929 design already had 8 pounds of wire on it, took 40 Watts and weighed about 30 pounds.

SB: So what hypotheses did you reach?

VOIGT: If I reduced the mass of the speech coil still more, it would cut the moving parts, thereby improving the acceleration of the transients and the response of the high frequencies though at the loss of average power. Would there really be a loss, and if there were, would it matter? The possibilities either way produced food for cogitation.

SB: How did you go about redesigning your speaker with these hypotheses?

VOIGT: With a reduced mass of wire, I could reduce the speech coil from 6 layers to 4. That enabled a reduction of the gap from 2mm to 11/2mm. That reduction would push the flux density up further into the saturation region. In practice by about 2,000 gauss (about a 12% density gain).

With only 4 layers instead of 6 of the same wire guage, the resistance would go down 66%. There are two alternatives now. Change the output transformer from a secondary for 30 ohms to one for 20 ohms. Then the voltage would go down about 12% and the current would go up by about 12%. The disadvantage would be the change of a transformer. Were there other disadvantages?

With 2/3's the turns, the ampere-turns were down by 2/3's because of the reduced number of turns and up by about 12% because of the increased current, i.e. only down to 80% considering those two factors alone. But hold it. There is a third factor. With the narrower gap, the flux density will go up. But, by how much? Well, sitting at the steering wheel of a moving car, I had to guestimate. Getting into the iron saturation region, how much would the flux density in the gap go up when that gap was reduced from 2mm to 11/2mm? If the rest of the magnetic circuit was a perfect conductor of magnetism, one could expect the 25% gap reduction to give an approximate 33% increase in flux density. Suppose, since the iron was going into saturation at the pole tips, which were nowhere perfect, that 1/3rd of the above 33% increase would be available in practice, then the third factor would provide a 10% boost. 80% plus one tenth of 80% is 88%.

SB: So what were the ramifications of these guestimates?"

VOIGT: First that with a coil mass reduction to 66%, the obvious consequence was that the force would also go down to 66% of the previous value. Although this is correct, it is not final. If the reduction of mass is obtained by reduction of wire length, a change of the input transformer alone helps to counteract the situation and reduces the efficiency drop to 20%. On the good side, the reduction of the coil mass has reduced the inertia loss by 33%.

What I did not mention before is that instead of changing the transformer to suit the reduced resistance load, a change in wire guage can match the load to the existing transformer. In either case, the mass reduction makes possible a reduction of the gap width. That makes possible an increase in flux density. Just by how much is guess work until you can measure it from a live example. The limits are easily imagined but are probably fairy tales. Suppose you have a magic wand that eliminated the resistance of iron to carrying magnetic flux, then a reduction of the gap width to 3/4ths of its previous width would allow the flux density to go up to 4/3rds of its previous value. We had already a force reduction to 80% before considering the benefical effect of increased flux. The 80% relative difference, if multiplied by 4/3 is 107% compared to the original 100% taken as the force. In practice such a magic wand does not operate in the saturation region, but it works much better at lower flux densities. The other imaginary limit is a lower one. Suppose that the iron circuit refuses to carry more flux, then there is no increase, and the above 80% figure holds good. Thus, until practical measurements are made with the real hardware, the consequence of reducing the coil mass will lie somewhere between a downward change to 80% and an upward change of 107%.

So, that cogitation showed that treble loss could be reduced and transient acceleration improved without any major reduction, and possibly even an increase in electromagnetic force.

To me the idea that, for good results the coil mass should equal that of the diaphragm might be OK when you could not "juggle" with the flux density. But in my case I could. Measurements in the lab showed by reducing the gap to 11/2mm, there was a flux density gain of about 2,000 gauss. Compared with the previous density of slightly over 16,000 gauss, that was a gain of 1 in 8.

SB: What was the result?

VOIGT: The result? I deliberately developed a LIGHT COIL TWIN variation of the Voigt loudspeaker. I knew I was deviating further from the established concept than before. And my title made it clear that I was doing something deliberately.

The practical result was that the extreme high frequencies were so much better, that for radio reception (a.m.) whistle frequency filters had to be put into the circuit to cut out the hetrodyne beat frequency between adjacent wavelength transmitters. For gramophone use, the filter could be cut out if desired, and by daytime it could be switched in when receiving the B.B.C.

My light coil twin corner horn speakers was submitted for review and received favorable reports, i. e. WIRELESS WORLD, March 9, 1939. (Editorial note: After WW II, Voigt consolidated many of his arguments for a low mass speech coil and diaphragm in British Patent no. 667,170 and U.S. Patent no. 2,615,995.)



6. Olson, H.F., Acoustical Engineering, D. Van Nostrand, N.Y., 1940, p 128.

# Horn Contour

**continued** *by* **Bruce C. Edgar**

SB: Tell me about your early experiments with stereo.

VOIGT: A few years before the war, I gave a lecture to the Radio Society of Great Britain on sound reproduction and demonstrated with a pair of my corner horns side by side to give 180 degree distribution. The climax to that lecture was the reproduction of a small live orchestra playing in another room there. Initially the two small speakers were connected in parallel as would be correct for mono reproduction. Then, the two speakers were separated by about the distance between the two mikes (6 feet) and their circuits were separated. As far as I know, that was the first demonstration to an audience of two channel reproduction in Britain. The meeting was reported on in WIRELESS WORLD, April 10, 1936. It is a pity that they call two channel by the name stereo these days. That is not stereo. Real stereo needs not only headphones but mike placing which has in mind that the listener will be wearing headphones.

However, in my stereo demonstrations I was following Blumlein, who in 1931 invented the stereo record groove (British Patent no. 394,325). Blumlein's brilliant idea is now incorporated in every regular stereo record made. I regarded Blumlein was head and shoulders above myself in ability. If Blumlein had not been killed during the war in a plane accident while developing a radar system, we would have had more ideas from him in addition to the ones which originated while he was alive.

SB: How did your association with Lowther begin?

VOIGT: I first met Lowther at RadiOlympia in 1934. It was young O.P. Lowther's ambition to market the best possible radiogramophone, which naturally needed the best possible speaker. This meeting developed into a very friendly alliance with the Lowther Manufacturing Company, that made excellent tuners and amplifiers. These together with Voigt speakers made up the Lowther-Voigt Radiogram, which set a very high standard of performance.3

SB: Describe the research developments in the late 30's.

VOIGT: In those days, I had set a tone burst system, and was experimenting with permanent magnets. However, I was unable to obtain magnets which provided the flux density obtainable with my excited field units. I had hoped that a P.M. unit being made in time for the 1939 annual radio exhibition period would do the trick. It was so late in coming that they had to deliver it direct to the address where we had rented space, together with Lowther, near the Olympia building. Upon comparing it to one of our excited field units it sounded poorly and was removed from view. When I measured the flux density it was not up to standard in spite of the large dimension of the magnetic overcoat.

It was on Sunday, a few days after the Radiolympia exhibition had started that Prime Minister Chamberlin announced that as Hitler's forces had invaded Poland, Britain was at war with Germany. That altered everything. On the Monday, instead of the public exhibition, everything was being dismantled. I could not resume my tone burst tests as the noise might be mistaken for some enemy action. Our sales collapsed.

SB: What were your activities during World War II?

VOIGT: With the help of my wife who did the drafting and booking chores, we kept Voigt patents alive doing maintenance work on the Voigt cinema horns. This work was deemed necessary for keeping up the home front morale. The admiralty did give us some research money, which surprised us because of my German parents. They could be quite "sticky" about such matters.

SB: Describe your postwar research efforts.

VOIGT: In 1939, when Hitler walked into Poland, Britain had sterner tasks on hand, and speaker research stopped in its tracks. by the time the war was in its last stages, newer magnetic materials, known variously as Ticonal, Alcomax and Alnico V had proved their worth and were able to provide a magnetomotive force far exceeding that obtainable with 40 to 50 watts of electrical excitation. When research could be resumed, it was with these newer materials in mind.

This time I concentrated on producing a P.M. unit with the magnetic material in the center and as a matter of policy retained the old styling as far as possible. the idea was that it might eventually be practical to convert existing excited - field speakers to P.M., thus enabling Voigt speaker owners to bring their speakers up to date at minimum expense.

Our policy on diaphragms had been similar and when the twin cone came out in 1933 they were mounted so as to make them interchangeable with earlier single cones. Again in 1938 when the light coil twin was introduced, this too was interchangeable. As that required a gap of 1 1/2 mm, liners were made which could be fitted to existing magnets. With these the flux density went up to the 18,000 - 19,000 gauss region.3

SB: What was the relationship between yours and Lowther's P.M. loudspeaker research and development?

VOIGT: In the postwar period, Mr. Chave, once Mr. Lowther's chief technician who had become owner of the firm shared my opinion that the excited - field speaker would be regarded as obsolete and that therefore a P.M. version of it was required.

Mr. Chave pushed on with experiments he had started with a P.M. version of the excited - field speaker, using the magnetic material externally, while I carried on with my experiments, using an internal magnet block. At my suggestion we worked independently and did not compare notes till completion.

The outcome of Mr. Chave's work was the Lowther P.M. series (British patent no. 618,802 and no. 628,432) and the outcome of my work was reviewed in WIRELESS WORLD, March 1949. Subsequently, the design was improved still further, but it is no longer in production as my company became dormant some years after I emigrated to Canada. (See Figure 8.)

The diaphragms used on the early Lowther P.M. speakers were supplied by my company, so the speakers were in more ways than one a true Lowther- Voigt combination and were sold as such. The diaphragms used by Lowther's even now differ but little from the genuine Voigt diaphragms of the 30's and 40's. the reason is simple. When my health started giving me trouble in 1946/47, I realized that I could no longer supervise the manufacture of

(Continued on page 9)

handmade diaphragms and that I would have to subcontract this work and that we would continue only the final test and inspection. All special tools and jigs needed were loaned to the subcontracting firm and I taught them all the special techniques involved. That subcontracting firm was the Lowther Manufacturing Company and so when I am credited with being responsible for the P.M.-2, this is partly correct. But Mr. Chave is responsible for the transition from the Voigt excited field to the Lowther P.M. His work has merit and it would not be proper for me to accept all the credit.3

(Editorial note: Part of the confusion between Lowther and Voigt was inadvertently started by George Augspurger7 in an article on horn loudspeakers where he gave Voigt credit for the Lowther P.M. speaker. See also the letter by Chave8 with a different opinion on the subject.)

SB: What was the nature of your health problems in 1946?

VOIGT: Briefly, in the latter 40's after the war, I was experiencing sensations of pressure in my left chest. These were fatigue related and slowed me down. If at an exhibition, I walked past the stands slowly, no one noticed. But, if at a restaurant, I could not follow the head waiter to my table in a normal fashion and it was extremely noticable.

I consulted a sequence of medical doctors who applied the standard tests. They could not find any reason for my trouble and assured me that there was nothing physically wrong with me. They made suggestions and eventually tried to convince me that I was imagining it all.

Finally, I found an osteopath who diagnosed the problem as being a malformation of the spine. A spinal brace was made for me and initially, produced a day to day improvement.

SB: What were the factors in deciding to move to Canada in 1950?

VOIGT: The war had reduced us to a skeleton basis and I could see no chance of recovery unless I could build up sufficient export trade on which there was no British purchase tax nor rationing of materials, which tended to reduce our British sales till they were of no consequence.

It was in April 1950 that my wife and i crossed the Atlantic, leaving my business, Voigt Patents, Ltd., running on a skeleton basis in London, England. The purpose of our crossing was to build up export sale of my corner horn loudspeaker on this continent specifically to make sure that I did not have "all my eggs in one basket."

My wife had been in Toronto for a year or so somewhere around 1926, so for her, it was not a blind shot and she had friends there. I had one helpful audio contact there and another in New York. From a general point of view Toronto is within 600 miles of 1/3 of the population of this continent and from a personal point of view I felt it would be more satisfying to operate from a part of the British dominions than from the U.S. Not only had they come in late for both world wars but that inventor Armstrong had committed suicide because of legal patent troubles had not been overlooked in the British radio journals at the time.

SB: What happened to the Canadian venture?

VOIGT: Default by a company, I thought I could trust, upset the financial situation and an almost total failure of communications ensured that my Canadian venture would be doomed. The company ran on its own momentum into the mid 1950's but without substantial export trade, it could not and did not survive.

I have two important things to be thankful for. Had the Canadian venture suceeded, there is no doubt that I would have overtaxed my strength and long ago become the "late" Mr. Voigt. Instead, I am 79 now and in better shape than when I left England in 1950.

SB: What was your latest development in loudspeaker design?

VOIGT: The week before we sailed, April 1950, I applied for something for ensuring that the spacing between the inner and outer poles of the P.M. speaker magnet would automatically be accurate upon assembly.

(To be continued)

By extensive calculations it has been demonstrated that, in order to amplify the different tones equally, there must be the same proportion of expansion for each unit of extension in length. The exponential horn fulfills these conditions, and gives a practically uniform amplification of all frequencies within the range for which it is designed.

**LIMIT OF RANGE**

It is found, however, that there is a certain point called the "cut-off," and the exponential horn will not reproduce frequencies below this point. The "cut-off" point, or lowest frequency at which the horn will reproduce, is dependent on the rate of expansion. The wider the conical angle, or the greater the rate of expansion, the higher will be the "cut-off" point. The horn illustrated will bring in notes as low as 29 cycles, and the result is that the music which it gives off creates the impression that a real orchestra, or a real singer, is present in the room. In every instance where a visitor has heard this outfit, the result has been an instant desire to obtain something similar.

(To be continued)



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3. Voigt, P.G.A.H., Letter to Editor, Radio-Electronics, 30, pp 16, 20, 22, Mar. 1959.

7. Augspurger, G.L., Horn-Type Speaker Systems, Radio-Electronics, 26, p 82-86, May 1955.

8. Chave, D.M., Letter to Editor, Radio-Electronics, 26, p 16, July 1955.

# Horn Contour

continued *by* BRUCE C. EDGAR

SB: What did you do after the failure of Voigt Patents, Ltd.?

VOIGT: I had various activities such as teaching electronics, consulting, etc. There was a period of employment while I was working in a lab of a firm that made office dictation machines using tape. This gave me the opportunity to gain first hand experience in tape recording research. Hardly Hi Fi, but very instructive all the same. I was very surprised at the distortion figures for slow tape speeds.

Unsuspected tape distortion may well explain why there are so many records which do not satisfy the ear when heard over really first class equipment. The highs are there, the lows are there, so is the mid-range, but they leave you dissatisfied. The sound of live music contains a satisfying richness which many records lack.

In my opinion, freedom from distortion is even more important than a wide frequency range. I regard a distortion free system with a range of 40 to 10,000 HZ as better than one which distorts appreciably even though its range might be 2 octaves wider and run from 20 - 20000. The target, of course, is full range without any distortion.9

Also during periods of rest and in between jobs, I started to think about the basic nature of gravity, electricity, etc., which were more than enough to keep me out of mischief.10

In 1960 I was employed with the Canadian Federal Government in radio regulations (anti-interference section). A very satisfactory time with that job was spent in the lab, developing test techniques, apparatus for direction finding, etc. This gave me a better understanding of the relationship between electricity and magnetism and the electromagnetic wave, etc. In 1970 I retired to a country dwelling in Brighton, Ontario with more time to concentrate on the riddles of the fundamentals of nature.

SB: Describe your meeting with Paul Klipsch in 1974.

VOIGT: At the 1974 Audio Engineering Society meeting in New York, I was asked whether I or Paul Klipsch were first with corner horns. As I was about to answer, the fellow with the mobile mike went over to some one in the audience section and I was saved from replying for he told the audience that "When he was applying for his patent my work was among that brought up against him." It was Paul Klipsch himself speaking.

From there I picked up and filled in details. I told the audience that after reading his first horn paper, I had sent a copy of our literature as I thought it would interest him. However I did not have his address and sent it to the organization that published the paper.

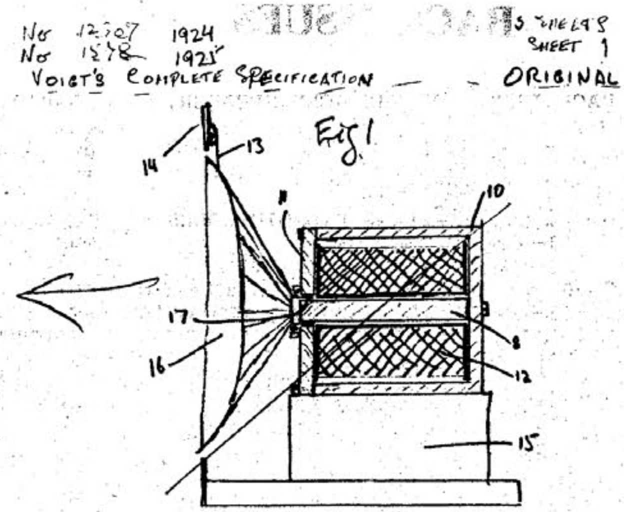
It was never acknowledged. So, I did not know if it had ever reached him and if he was very busy or simply impolite. He was able to reply that he had no recollection of receiving it, and so a question which had been in my mind for 30 years had been favorably answered. After the meeting he invited us all to lunch and later to see some slides.

Anyway Klipsch is no longer just a name to me, and the reason for not acknowledging the literature may well have been that it never reached him.

(Editorial note: Klipsch told me that he later tried to find out the exact claims that were held against him, but he said that those details could not be found in his patent papers. Also at this meeting Paul Voigt was made an honorary member of the Audio Engineering Society in recognition of his pioneering achievements in the pickup, recording and recording of sound.) 11

SB: Can you review the progress of your Voigt speakers from the 30's to the 50's?

VOIGT: The 1929 cinema speaker had a flux density of 16,000 gauss across a 2mm gap with 40-50 watts field excitation. The axial length of the gap was about 5mm. In the latter 30's for our light coil twin diaphragm as used in the domestic corner horn, the gap was reduced to 1 1/2 mm. That improved the flux to 18,000 -




19,000 gauss with the same excitation. At the end of the 40's with a new speech coil design I could go down to a 1 mm gap. By then we had a permanent magnet, but I had to design a 20,000 ampere-turn magnetiser to magnetise it. By 1950 the flux density was 22,000-23,000 gauss in prototypes. It never went into production because of the failure of Voigt Patents, Ltd.

SB: Do you have any advice for the testing of loudspeakers?

VOIGT: The final test should be the ear test. Some people are concerned with organ pedal tones, some with the clarity or edginess of cymbals and triangles. But the real test of a speaker system is male speech. If that sounds boxy, boomy or unnatural in any way, something is wrong somewhere. It may be in the studio or mike but if the same kind of unnaturalness persists on all program material the trouble is usually in the speaker or enclosure.12

And now, one more thing, go to a live concert in a hall where there is no PA gear occaisionally just to keep your ideas in line.13

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THE INTERVIEWER

Dr. Bruce Edgar is a space scientist for the Aerospace Corporation and is a contributing editor for SPEAKER BUILDER in the areas of horn design and the history of loudspeakers.

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# Horn Contour

*by* Bruce C. Edgar

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