AUDIO

THE GRAMOPHONE
APRIL 1973

BY JOHN BORWICK, P. E. GOSLING AND JOHN GILBERT

MY FIFTY YEARS WITH GRAMOPHONE RECORDS

By PERCY WILSON

PART 1. THE EARLY DAYS

ONE sunny afternoon in 1923, my wife and I walked down Oxford Street, just looking at shop windows.

In a music shop, I saw a copy of the third issue of THE GRAMOPHONE, edited by Compton Mackenzie. This intrigued me because I had recently bought what was to me an expensive table gramophone. So I bought a copy, and was enthralled, particularly by the discussion that was going on about "Needle-Track-Alignment".

I promptly applied my mathematical mind to the problem of "tracking error", as we now call it, and found two lovely formulae for reducing the error to less than 2° (for a 9-inch tone-arm) at all points across the record. It was the "overlap" and "offset" principle, though I then called it "vector" and "divergence". This pleased me very much as a mathematical exercise.

Early in 1924 I went to THE GRAMOPHONE office in Newman Street in order to get Numbers 1 and 2, and there I met Christopher Stone, the London Editor. This was one of the major turning points of my life. When I told him that I had a mathematical solution of the alignment problem, he immediately said: "Why not write me an article about it?"

I wrote two which were published in the September and October issues, and created a considerable reaction, both in the industry but more particularly in gramophone societies. I recall that I was promptly invited to talk on the subject to both the Brixton and the Wandsworth societies and, since I myself lived in South London, I readily accepted.

Percy Wilson first contributed to THE GRAMOPHONE *in 1924 and, but for a break during the war years, served as Technical Adviser and latterly as Technical Editor until 1966*

It was at Brixton that I met G. W. Webb and H. F. V. Little who later joined me in the foundation of The Gramophone Expert Committee. Webb was the head of a building firm in Sutton, Surrey, but his hobby for many years had been phonographs and gramophones. He had a wonderful collection, including an early Edison and a large array of sound-boxes. He also had a mechanical workshop with precision lathes and other tools which helped us tremendously when we joined together in research.

Early friends

Little was an industrial chemist with a mathematical-cum-scientific training at London University. He was Chief Chemist, and later Managing Director as well, of Thorium Limited, which owned the Monazite Sands in Ceylon, from which the company extracted various rare elements. I recall going with him to the National Chemical Laboratory at Teddington, where he offered Professor Morgan a supply of Monazite sand, resulting in a paper to the Royal Society which broke the American stranglehold on the production of helium.

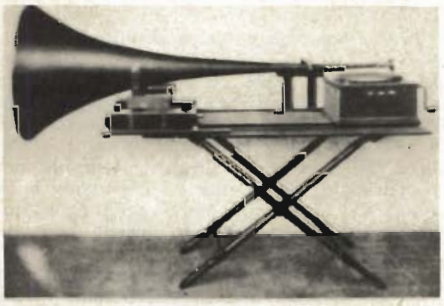
Little's hobby was opera. He always travelled in Europe during his summer vacation, and always stayed at places where there was an opera house. His knowledge of opera and the artists was encyclopaedic. I shall always be grateful to him, for it was he who created my own love of opera. Perhaps the reason in both our cases was that opera provides an escape into an imaginary, yet romantic and sentimental world for those of us whose mundane affairs are concerned with technological or even purely scientific activities.

Anyway, Little and I became close personal friends, and joined together later in the twenties at Covent Garden as well as in gramophone circles. I became Technical Adviser to the magazine, and he, under the pseudonym of "Piccolo", became the orginator of "Collectors' Corner", where he was able to display his extensive knowledge both of operatic artists and of the recordings they had made. Later, after the retirement of Herman Klein, that supreme impressario of operatic singing, Little became the reviewer of operatic records. He had not Klein's expertise on the techniques of singing, but he certainly had an outstanding experience of artists and operatic productions.

Moreover, he was a real expert on the technical aspects of sound reproduction. I took my hat off to him on this, many and many a time. So, naturally, he became one of the members of the Expert Committee when Christopher Stone invited me to form one after my articles in September and October 1924 had made their significant impact.

Another member, nominated in fact by Compton Mackenzie himself, was C. L. Balmain who had invented a gramophone consisting of a conical horn plus sound-box, which travelled radially across the record, supported by floats on two mercury baths. This for many years was Compton Mackenzie's favourite instrument.

Balmain was Deputy Controller of HM Stationery Office. This became significant because, when I had designed the exponential horn and had had a "former" made for it (at my own personal expense), he arranged for one of the Stationery Office contractors to build up a horn on my "former", by sticking on parcel tape! Later we arranged for papier mâché horns to be made on the same "former" by a firm (Scientific Supply Stores) in South London, whose premises, alas, were blitzed in the Second World War.



Balmain gramophone with 5 ft. exponential horn tracking radially on floats in baths of mercury

Papier mache

As a digression from my main historical theme, perhaps I may be allowed at this stage to describe the papier mâché technique. This was built up by pasting blue sugar-bag absorbent paper, layer by layer, on the "former". A thickness of about $\frac{3}{16}$in was thereby secured. The whole thing was then allowed to dry. In drying, the papier mâché horn lifted itself from the "former". This was indeed fortunate, because I later found that this very process converted the crude exponential formula adopted in the construction of the "former" into the modified form as deduced later in the Appendix to the chapter on Horns in my (and George Webb's) book *Modern Gramophones and Electrical Reproducers*. The conversion was as accurate as one could have wished. After the horn had dried out, it was sprayed internally with varnish and externally with a peculiar preparation for stiffening.

Our success led other firms to have their designs made up by the Scientific Supply

This series of three articles is based on Percy Wilson's contribution to the *Jubilee Book*.

Stores. Instances were the EMG, the Expert and the Bond models.

The other two original members of the Expert Committee were Lionel Gilman and W. S. Wild. Neither had any special technological qualifications, but both were devoted gramophiles and had written forceful letters to THE GRAMOPHONE about playing records, particularly with bamboo fibre needles, Gilman under his own name, and Wild under the pseudonym "Indicator".

The EMG external horn gramophone

Later, when electronic methods of recording had been adopted, we co-opted four other members. All were on the staff of the National Physical Laboratory at Teddington and all became heads of their respective departments: Heat, Electricity, Metrology and Acoustics. In that way we secured the highest possible expertise at minimum cost! For we were all unpaid, even as to our personal expenses.

We elect a chairman

I recall one vivid incident at our first meeting. Lionel Gilman accidentally knocked over a box of Christopher Stone's steel needles. They scattered themselves over the carpet. George Webb promptly produced a large magnet from his pocket and gathered them all up. We wondered what other mysteries his pockets contained. Anyhow, we thereupon made him chairman. I also recall that one of our earliest discussions was about the superiority of external horn gramophones over even the most expensive cabinet models. Balmain, of course, had his own patented machine (Patent 177215/20). I had the table model which had cost me more than I could really afford at the time. The others had the HMV "Schools" model which had an external "flower" horn and 4-spring motor. As this was remarkably cheap, I sold my table model and bought a "Schools" model with the proceeds.

It was at this meeting too that I was stimulated to study the properties of horns. Fortunately I was adept in Hydrodynamics and the Theory of Sound which, along with Electricity, had been my special subjects when I took my degree at Oxford. So I proceeded to extend Lord Rayleigh's analysis for conical horns into a general horn theory. This was in 1925-6. Later I discovered that precisely the same solution had been found by A. G. Webster in America in 1919. But his work had just remained filed away for many years. Thanks to the Expert Committee, and particularly to Balmain, mine was put into production within a few months.

Skating force

Before that, however, I had been interested in a feature, arising out of my October 1924 article, which had been drawn to my attention by the letter of a correspondent in THE GRAMOPHONE. I mention this because it has been the subject of a good deal of notice in recent years. This was that the friction of the record on the stylus created an inward "skating force". So I drew attention to it in a note published in the March 1925 issue, and indicated a method of correction which was simple with the conventional tone-arms of those days since they had their full mass in front of the vertical axis, but which no longer applies to modern pickup arms, where counter-weights are used behind the axis so as to reduce the playing weight. However, other methods have been found for these.

It is intriguing to note that, whilst we were only 20 years ahead of America in the matter of "needle-track-alignment", we were 40 years ahead in reference to "skating force". The effect of this force was not easy to observe when steel needles were used, but it was highly significant for fibre needles. Gilman and Wild always used fibres; Balmain used steel; Little, Webb and I normally used fibres but occasionally used steel. We soon found that the fibre points broke down more readily when the "skating force" had not been corrected, and therefore concluded that even with steel needles the skating force would place a substantial stress on the groove walls.

Sound-boxes

Of course all this led to debate on the virtue or otherwise of fibre needles, and this set us off into much research on construction of sound-boxes and, to carry this out, we had to learn what the functions of the various items were. We were fortunate in that George Webb had made a special study of the history of phonographs and gramophones, and could direct our attention to many significant patents. We were also fortunate that both Wild and Little were friendly with a working jeweller, named Virtz, who made superb sound-boxes, and before long each of us was the proud possessor of one or more of them.

So we gradually acquired both deeper knowledge and authority, and became justified in the title of the articles we wrote month after month: *Crede Experto*—put your trust in one who has been through the mill!

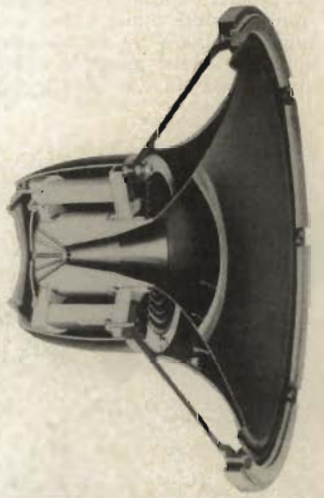
MEET THE MANUFACTURER

No. 10. TANNOY PRODUCTS LTD. By ROGER DRISCOLL

I was very pleased to visit Tannoy recently and have explained to me the many interesting production techniques which go into their audio products. Tannoy are respected throughout the world for the contributions they have made in the field of communication acoustics, and particularly for their loudspeaker systems of high quality and consistency of performance. In the case of public address, of course, Tannoy has become a generic term like Hoover or Thermos.

Tannoy is a private company in Norwood, South East London, founded 48 years ago by Guy R. Fountain, who is the Chairman. The name Tannoy is derived from 'Tantalum Alloy', a material on which Guy Fountain worked as an electronics engineer in designing rectifiers. The company is also established in the United States: it has manufacturing facilities there and servicing facilities in Canada. There is also a distribution centre in Ireland and, in all cases, the policy is to distribute through appointed dealers. In some cases, for the public address equipment, commercial firms deal with Tannoy direct. At the Norwood site, a total of around 500 people are employed, and a number of new buildings have been acquired over the years, mainly for the expanding production of loudspeakers.

I was shown round the London factory by Mr Terry Livingstone, the Sales Director, and J. J. Bunt who assists him. First we saw a new wing which was opened only last August, where the basic assembly of speaker units is carried out. The Tannoy Dual Concentric Monitor speaker has a worldwide reputation as a system of the highest quality. A single full-range transducer, it incorporates a special concentric high frequency radiator which is independently driven and has an aluminium diaphragm, coupled to an acoustic horn, at the centre of the bass cone. The system was designed and first made more than twenty years ago. Important changes have been made more recently to allow adjustment of the high frequency energy and roll-off by controls in the crossover, which is an integral part of the speaker. Known today as the 'Monitor Gold', it is one of the most familiar products in the audio industry.



Cut-away model showing the unique construction of the Tannoy Dual Concentric speaker

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PART 3. MODERN DEVELOPMENTS

THE other development between 1926 and 1939 to which I wish to draw special attention was that of the moving-coil loudspeaker. This mechanism along with many others had been described in a Siemens Patent 4685 of 1877. It had been used in a number of scientific instruments, but the significant development for loudspeaker work started with a paper read to the American Institute of Electrical Engineers in September 1925, by Rice and Kellogg. The design soon outpaced all others. An alternative electrostatic device had a come-back in about 1953, and is still strongly favoured by some enthusiasts. But for both performance and price the moving-coil loudspeaker still holds an unassailable position in public favour.

However, let us come back to 1953 and my return to THE GRAMOPHONE as Technical Editor. Much had happened in the Audio world between the end of the war and then but, thanks to my pre-war contacts, I had been able to keep track. It was an exciting experience.

In the previous five years, not only had the German tape recorder idea been developed, but the long-playing record was with us. Moreover, there was a new, almost silent, record material, and both steel needles and fibres or thorn needles were dead. Sapphire and diamond styli took their place, as I had forecast in November 1934, and there were rumours of even further intriguing things.

The advent of tape

I remember my visit in 1963 to the Ampex plant near San Francisco and talking to its Director, Mr Poniatoff, about his courage, when he was first shown the Telefunken Magnetophone in 1946, in deciding to devote the whole of the resources of his small firm, and even mortgaging his home, in order to develop tape recording. He himself told the story in that fascinating book by Gilbert Briggs, *Audio Biographies*, so I will not repeat it here. I will only remark that Poniatoff's enterprise has been one of the most important contributions to Audio since the war. It is not so much the domestic use that is significant: that has not been carried to the full extent of its capability at present. Its real value lies in the way it has transformed the process of recording. Every recording is now made on tape, and is then transferred at leisure to disc—or, in more recent practice, to cassettes or cartridges. This, of course, is to facilitate editing. By this process the final version as put on the market may be a conglomerate of several 'takes', and not necessarily a continuous performance.

Of course, there can be two opinions as to whether this facility of editing and splicing is really desirable or not. In some circumstances, as I pointed out to *The Times* newspaper in February 1966, during the course of a controversy on the legitimacy of editing films and interviews, particularly for television, it can be a menace. I instanced a tape recording I had listened to in October 1961, ostensibly of a speech by Herbert Morrison condemning the conduct of the war by Winston Churchill. This had been built up word for word from Morrison's speeches, so skilfully pieced together that no gap could be distinguished. The voice was accurate, the intonations were accurate. After the built-up tape had been copied on to fresh tape, there were no signs of physical joins. Yet the whole thing was a fraud.

Are the recordings we now hear to be classed as frauds too? It is a delicate question but I think we can say that, thanks to the skill and integrity of today's record producers, the facility of editing and splicing is being used to the benefit of all concerned.

Long-playing records

Still, no doubts like this can be held about the value of LP records. They are a boon and a blessing to men and in fact could not be economically produced without the facilities of tape recording. Their inception was largely due to experiments carried out at the CBS Laboratory in Stamford, Connecticut, by Peter Goldmark, its Director, who had had his previous technological training at Cambridge, England. That development culminated in 1947 and immediately made a tremendous impact, particularly as a new record material became available at about the same time.

Of course, a controversy arose at once about the best speed and size for the LP record, and a compromise was eventually reached that there should be two speeds, 33⅓ rpm and 45 rpm, and three possible record sizes, 7, 10 and 12 inches. But it took much longer for a standard frequency response characteristic to be agreed. For a few years each recording company, whether in America or in Europe, had its own characteristic, and amplifier manufacturers had to include a variety of corrective circuits in their control units. All that is now past history, however. Unfortunately, a similar contretemps is arising again in relation to the new 'quadraphonic' (*i.e.* four-channel) records.

The rumours I mentioned earlier concerned the possibility of obtaining stereophonic sound from the modulations imposed upon a single groove. Blumlein had forecast this in his fascinating British Patent 394,325, applied for in 1931 and granted in 1933. He concluded that there were two possible systems: a combination of the Edison vertical indentation of the groove with the Berliner lateral; or a system in which the indentations for one channel should be on one wall of a V-shaped groove and those for a second channel on the other wall. His patent works out the requirements for each type, and shows that they are compatible by a simple, so-called matrixing, system. Another system, entirely different, was later proposed by Livy (British Patent 612,163/1946-8) whereby a high frequency carrier signal was modulated up to a frequency of, say, 15,000Hz by one audio channel and from 15,000 to 30,000Hz by the second channel. Rumour had it that Decca in conjunction with Telefunken (the consortium being called Teldec) were busy developing all three systems. For once Rumour proved not to be a lying jade. All three were in fact carried to the production stage between 1952 and 1954. In the meantime, EMI in 1954 had introduced "Stereo-sonic" tapes following Blumlein's philosophy, while in America twin-channel tapes became available following a parallel philosophy of the Bell Telephone Laboratories.

Decca, however, decided to keep their proposed system in abeyance until the commercial market was ripe for it. This occurred in 1957 when Westrex announced that their engineers had developed a 45/45 recording system and that they were preparing to produce the appropriate record-cutting machines for sale to recording companies.

The problem then arose as to which of the two systems, vertical/lateral or 45/45, should be standard. An agreement was reached in Europe in November 1957 and in America in March 1958, that the standard should be the 45/45 arrangement.

Stereo records began to appear in the summer of 1958 and, notwithstanding the fact that they demanded for their full exploitation both twin amplifiers and twin loudspeakers, they have rapidly found favour and displaced mono recordings from the market. Fortunately, they can also be played on mono reproducing systems provided a pickup with adequate vertical compliance is used, and these are now available. They must not, however, be played with the older type of pickup in which the stylus assembly was stiff in the vertical direction, for that would destroy the stereo modulations.

The new pickups

From 1958 to 1970 the major developments have been in the design of improved loudspeakers and pickup cartridges. Some really tremendous achievements have been made in both respects, but especially in respect of cartridges. We used to play our 78 rpm records with sound-boxes at a playing weight (or, in America, tracking force) of 5 oz. or so (about 150 grams). In 1950, the pickups for LP records had a playing weight of 10 grams or so. In 1958, a playing weight of 3 grams became feasible. Now, some of the most advanced designs can operate at a playing weight of 0·5 grams. Record wear has become negligible. The

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This is the last of three articles based on Percy Wilson's contribution to THE GRAMOPHONE *Jubilee Book*.

modern bugbear has become the intrusion "pops and crackles" due to the deposit on the records not only of fluff and dust, but also of a sticky substance derived from smog, tobacco smoke, household fumes and the like, which float about in the atmosphere and are drawn down to the rotating disc by a sort of vortex action. This substance entraps the particles of grit and gradually hardens, so creating semi-permanent pops. Methods have now been devised for removing it, as well as the loose fluff and dust.

This can be highly important in view of the demands which the new quadraphonic recordings are bound to make on groove cleanliness. For, whatever the particular recording system, and I have heard seven and am told that there may be several more coming along, cleanliness of groove will be an absolute "must".

At the time this account is being written, it is too early to forecast which of the various proposed systems is likely to succeed in preference to the others; or indeed whether the public as a whole will submit to buying four amplifiers and four loudspeakers, and to having the latter disposed in a square in the living-room with chairs for listeners in the middle.

I am sure that my wife will not. But perhaps ours is an exceptional household. The framed motto, given to me in America, and put up in our hall just inside the front door, says:

"The opinions expressed by the husband in this house are not necessarily those of the Management".

Percy Wilson first contributed to THE GRAMOPHONE *in* 1924 *and, but for a break during the war years, served as Technical Adviser and latterly as Technical Editor until* 1966.

BEGINNER'S GUIDE TO UNIT AUDIO

By P. E. GOSLING

PART FIVE: FITTING IT INTO THE ROOM

ONCE you have purchased your equipment, you are then faced with the task of fitting it into the general arrangement of a room. The encouragement and co-operation of a loving wife is of prime necessity at this stage of the game, as it can be quite a ticklish job to fit in a deck, amplifier and loudspeakers with the existing decor in such a way that good sound is gained without too much of a major upheaval. It is the siting of the loudspeakers which needs the greatest amount of care and thought. If they are large, and of the bass reflex type, they are probably going to give of their best when placed in or across the corners of the room. In the position shown in Fig. 1a, such loudspeakers will have their bass response improved.

Loudspeaker positioning

If the loudspeakers are of the smaller, infinite baffle type, not only will they be very vulnerable to damage, when placed on the floor, but they are very likely to discharge their music into the back of an armchair. It is therefore preferable to place the speakers so that the treble units are at about the height of the listener's ears. If the speakers are sufficiently small, they can be accommodated in convenient bookshelves or on brackets firmly fixed to the wall. There is then less chance of the high notes being absorbed by soft furnishings on their journey to your ears. The choice of exactly where in the room the speakers are to be fixed is often a matter for experiment but, in general, it is better to place them so that they are pointing down the long axis of the room, rather than across it. One reason for this is that the room itself, and its furnishings, can considerably modify the quality of the sound due to the formation of what are called 'standing waves'.

The sound waves which leave a loudspeaker travel at a speed of about 340 metres per second and in straight lines towards the facing wall. As most walls have a hard surface, most of the sound energy will be reflected back to the opposite end of the room where it will be reflected again, and so on. The result is that the room will tend to resonate rather like the stretched string of a violin. There is a formula by which we can calculate the frequency of a standing wave, if we know the distance between the walls which reflect the sound. For a room which is L metres long, the fundamental frequency of the standing waves set up is given by:

$$\frac{170}{L} \text{ Hz.}$$

In other words, if a room is 5 metres long, a note of approximately 34 Hz given out from the loudspeaker will resonate in the room and so, incidentally, will notes of multiples of this frequency, but not to the same extent. I have heard the most diabolical results from apparently good and expensive equipment which has been set up with the loudspeakers facing *across* the room, rather than along it. In any case, if one has the speakers facing across the room, the listener will have to sit too close to them. In order to minimise the effects of standing waves in a room, the wall facing the speakers should be curtained if possible. We very often have windows in such a position, and so such a situation should not be difficult to achieve.

Another way to break up standing waves is to choose a room which is not regular in shape; an alcove or some sort of recess is a very good feature to exploit in this context. The acoustic difference between a room with a very few soft furnishings and one with plenty of velvet curtains and a fitted carpet is very great. On the one hand, we tend to get a greater likelihood of standing waves being set up and, on the other, there is the lack of a reasonable period of reverberation. We want to have a little 'life' in the sound, so too much plush is not always a good thing, acoustically speaking. A reverberation time of around 0·5 second is usually recommended.

Having finally decided just where the loudspeakers are to be placed, there is another factor to be considered, the speaker spacing. In general, a pair of stereo loudspeakers should be placed about six to eight feet apart. If the speakers are too far apart, there is the tendency towards a 'hole in the middle' effect and, if they are too close together, the stereo spread is lost. With modern loudspeakers, the pinpoint type of stereo image no longer applies, but the size of the area where the stereo effect shows itself can be altered considerably by adjusting the direction faced by the speakers.

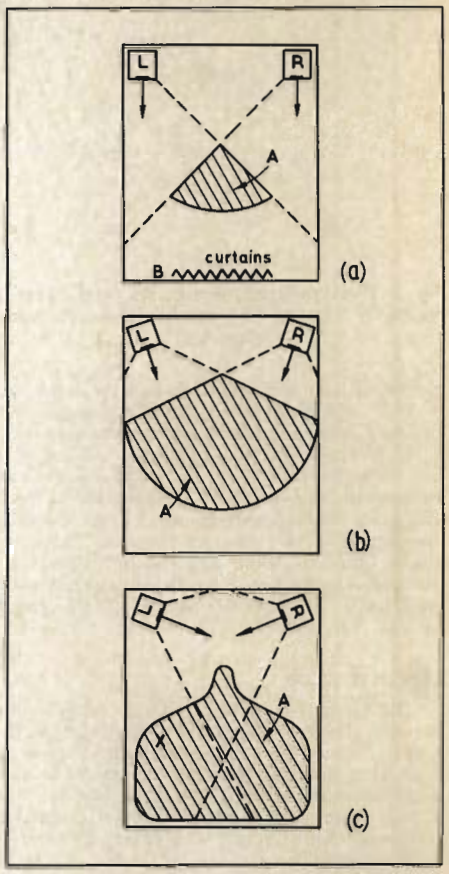

Fig. 1. Speakers can be angled (a) straight down the room, (b) slightly inwards or (c) sharply inwards (to give enlarged listening area for stereo)

If they face straight down the room as in Fig. 1a, the image tends to be restricted to the area A indicated. If they are slightly angled towards each other, as in Fig. 1b, the image is spread over a larger area. The size of the angle needed to produce a widely spread stereo image depends on the design of the loudspeaker and, in particular, its dispersion of sound. A polar diagram gives a very good idea of the all round dispersion—see Fig. 2. Some of the more modern, and expensive, loudspeakers have special elements within them to aid the wide spread of the high notes, as these are the ones which are most directional and convey the stereo information—see Fig. 4.

A good test of the overall quality of the sound you are getting from your equipment is to leave the door open and listen in another part of the house, say from the top of the stairs. It may sound silly, but this often gives a very good guide to the results you are achieving. If you can convince yourself that Janet Baker is singing in your living room, then you are getting somewhere.

Depending on one's bank balance and the ability of one's wife to take the current madness in her stride, the deck and amplifier units need to be placed where they are accessible, but out of reach of grasping juvenile hands. At the same time, a mass of wires and obviously

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PART 2. THE ELECTRICAL ERA

THEN came Electrical Recording. It was first demonstrated in this country by Herbert Ridout of the Columbia Graphophone Company at the Congress which THE GRAMOPHONE organized at Caxton Hall, London, in July 1925. The record was of a choir with 4,850 voices singing *Adeste Fideles* on Columbia 9048, and made a sensation on the Balmain machine which was then on view. Mind you, it was not revealed at this stage that the recording was by an electrical process. That would have prejudiced the whole existing acoustic catalogues of the recording companies. But, later, records crept out in the companies' lists which were obviously different, and then the secret had to be revealed.

Another revelation at this Congress was of a pickup and a loudspeaker system, invented by two young British amateurs, which was operated through piezo-electric Rochelle Salt elements. Later, their patents were taken up by Mr Brush of Ohio, who had recently retired from his huge electric corporation in America and was searching for a new hobby. I told the story about this in THE GRAMOPHONE in November 1934, and more recently (1970) in a paper I presented to the Audio Engineering Society of America. It is a really romantic story. Historically, it had a crucial effect on the production of inexpensive, yet acceptable, electric radiograms in subsequent years.

It must be admitted at once that the early electric records were something of a disappointment, particularly in respect of voices. Yet we of the Expert Committee were convinced that, once the trial stages were over, they would supersede the records made by the older acoustical system. We proceeded to modify our sound-box technique so as to neutralise the somewhat nasal quality which was the subject of so much criticism.

We go to Jethou

It was just at this time that I completed my design of the 5-foot exponential horn for the Balmain machine, and arranged that all six members of the Expert Committee should spend a weekend at Jethou in the Channel Islands, where Compton Mackenzie lived, and demonstrate to him the new techniques. We took a skeleton Balmain machine with us as well as the parcel-tape model, described earlier, of the exponential horn, and a number of sound-boxes, all of which, however, had been designed for fibre needles. It took us about an hour to set it up in Compton's library. The first record we played was a Sousa march. It knocked us all, Compton included, endwise. By the end of the day he was so bilious as to be positively green. He had to remain in bed for the rest of our stay, during which we set about 'tuning' one of the sound-boxes to match the new system and for use with steel needles. (Steel needles had smaller 'needle-point compliance' than fibres, both laterally and vertically.)

After that I modified the "former" for the horn by designing a cast-iron elbow to go with it so as to make it suitable for the HMV "Schools" model. This combination gave us satisfaction for a number of years. It was placed on the market by the Scientific Supply Stores under the title "The Wilson Panharmonic Horn". But foolishly, as I see now, I did not bargain for any royalty or other payment!

Electrical reproduction

Then, inevitably, came electrical reproduction, with pickup, amplifier and loudspeaker. We knew for sure that it must in time supersede the sound-box system: it was so much more flexible and controllable. Yet again, to start with, it was something of a disappointment in its commercial application, though radiograms began to dominate the market. It was at this stage that the burden on the Expert Committee became too onerous for efficiency, particularly in keeping track of new developments and in reviewing new products. So Christopher Stone decided to have a full-time Technical Editor, and my younger brother, Gilbert, was appointed in 1929. I remained as unpaid Technical Adviser, but Gilbert did all the donkey work, including the keeping of Christopher's HMV Electrical Reproducer in order.

This was important for THE GRAMOPHONE for, by this time, Christopher Stone had built up a superb reputation as a Disc Jockey both for the BBC and later for Radio Luxembourg. I recall with some joy his first broadcast for the BBC from the Savoy Hill studio, for I accompanied him. He was decidedly nervous, and this must have been effective with listeners, for they never regarded him as any kind of superior person. Nor was he, but always modest and helpful. Perhaps what intrigued me most about his broadcast was that the pickup used by the BBC at that time virtually destroyed the disc at its first playing!

Happily for my brother, I had by 1929 just completed, in collaboration with George Webb, my first book on *Modern Gramophones and Electrical Reproducers* which described the results of our researches as well as those of Maxwell and Harrison of the Bell Telephone Laboratories in America. It was published by Cassell but has long been out of print. I still have a real affection for it, and it had some rave reviews, particularly as it was the first book to be published about the new techniques. Its chapter on "Horns" is still regarded as a classic.

As described below, the moving-coil loudspeaker superseded all other types during the decade preceding the Second World War, principally because of its impressive response in the bass. Indeed, the slogan "Listen to the bass" became commonplace in advertising. But it was soon realised that, in the methods of construction then largely adopted, the bass reproduction was apt to be boomy and lumpy. Cabinet resonances were prominent and added a quality which one could not live with for long in one's own home.

Various expedients were tried to mitigate the effect. The most successful was undoubtedly the Voigt Corner Horn. A schematic drawing and a photograph are reproduced here (Figs. 1 and 2). I confidently assert that this system will bear comparison with even the most

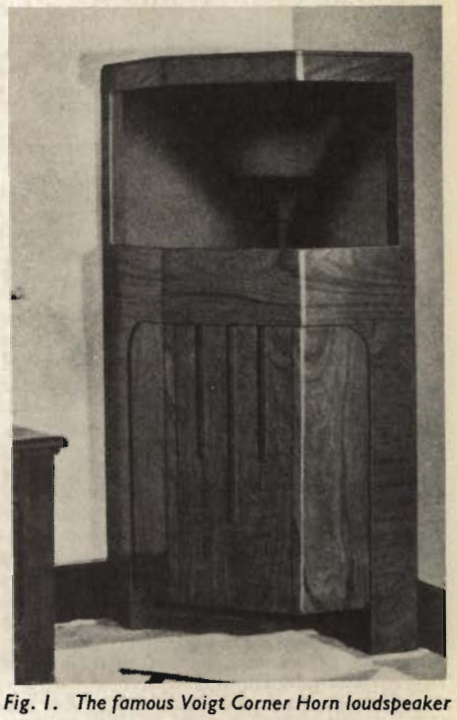

Fig. 1. The famous Voigt Corner Horn loudspeaker

sophisticated modern designs both in its efficiency (acoustic output/electrical input) and in the quality of its acoustic response.

Other successful applications of horn loading have since appeared. Some of the Olson designs for RCA as well as the Klipsch enclosure in America are cases in point. So also, in Britain, are the Autograph and GRF enclosures designed for Tannoy by Mordaunt. All these are still in the forefront of loudspeaker designs, but they are so complicated in construction as to be expensive.

Naturally, other less expensive methods were tried out, and several significant solutions emerged. The first was the "bass-reflex"

This series of three articles is based on Percy Wilson's contribution to the *Jubilee Book*. The final article will appear next month.

system originally proposed by Thuras in a USA patent in 1932 (No. 1,869,178). But he died in 1945 and it was left to others to develop the principle which he had ingeniously established. This development, indeed, dominated most designs up to about 1955, and still has a large impact. It was much more efficient than the second type of design which was then known as the "infinite baffle" system.

To understand this, one needs to appreciate that the sound waves from the rear of a speaker diaphragm are of opposite polarity (sometimes wrongly called "opposite phase") from those of the front. So the two streams, if allowed to interfere, will tend to cancel, particularly in the bass frequencies.

To avoid this, it was originally proposed to mount the speaker unit on a large "baffle"; but this was soon seen to be inadequate, unless

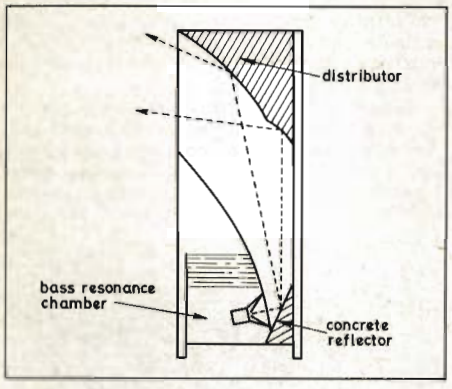

Fig. 2. Schematic of the Voigt Domestic Horn

the baffle itself were mounted in the wall between two rooms, so completely separating the two streams. That, in fact, was what I myself did with conspicuous success.

Just before the War, a new solution was found by two British Post Office engineers—West and Macmillan. This was fully developed after the War by Villchur and Kloss of Acoustic Research Inc. in America under the description "Acoustic Suspension". This makes use of the elasticity of the air in a completely enclosed box to control the motion of the diaphragm. The system is tricky but is successful provided the designer appreciates what the appropriate parameters are. Its major disability is that it is very inefficient as compared with either the horn-loading or the bass-reflex system. A larger output from the power amplifier is therefore needed to drive the diaphragm. Fortunately, modern solid state (transistor) amplifiers can be designed at moderate cost to give the required power.

Other relatively efficient systems have also been developed by the use of multiple drive units. In the case of what is known as a "line-source" speaker, a large number of separate units are linked together in an elongated cabinet, and are so disposed and fed from the amplifier that the combination has a highly directional effect. This is most useful for public address work and for sound reinforcement in large auditoria.

Another multiple unit system has also become popular. This divides the sound spectrum into two or more ranges and provides a separate unit for each particular range. These have come to be known as "woofers", "squawkers" and "tweeters", and are fed from the amplifier output via a filter circuit known as a "cross-over".

Since 1955, electrostatic driving systems have begun to compete with the moving-coil units. Their advantage is that the driving force is distributed over the whole face of the diaphragm, rather than being concentrated in a small coil in the middle. Claims have been made that this method is more "transparent", i.e. that it gives a closer approach to the original sound. But similar claims have been made for systems in which a moving-coil drives a stiff, flat, polystyrene diaphragm rather than a cone.

Experiment still goes on, for it is generally admitted that even now the loudspeaker is the weakest link in the reproducing chain. Microphones, pickups, amplifiers, tuners are all nearing perfection.

New pickups

As regards the pickup cartridges, the crystal pickup nearly ousted the magnetic pickup. It had a much higher output, so that one stage of amplification could be omitted in the valve amplifier, and this of course reduced costs appreciably. It has even been claimed that this fact saved the industry from insolvency. Yet it should be noticed in this connection that, towards the end of the period, the pendulum swung back to the magnetic pickups (of greatly improved types) to ensure sound reproduction of superior quality. Voigt had a moving-coil type, and both EMI and Decca had moving-iron (or variable reluctance) types in this country, matched only by Ortofon in Denmark for a moving coil type, and by Telefunken in Germany.

When war broke out in 1939, the Expert Committee had to be disbanded, and both my brother Gilbert and I had to leave the service of THE GRAMOPHONE. During the war, the magazine carried on but the technical aspect was virtually dormant and it was looked after by Geoffrey Howard-Sorrell.

After the war a new era dawned and, in 1953 having retired from the Civil Service, I was invited to come back as Technical Editor. We then entered on a most exciting decade. But before we come to that, and in explanation of it, mention must be made of one or two other significant things that happened in the pre-war period.

The theory on which electrical recording was developed was based on two fundamental principles which were thought to be essential for perfect reproduction.

Firstly, the apparatus, including the reproducer as well as the recorder, should uniformly deal with all sound frequencies within the normal range of hearing *i.e.*, from about 30 cycles per second (now denoted by Hz) to about 20,000Hz. Secondly, only the original components of the sound that were fed into the recorder should come out in the reproduction. That, of course, was a tall order, but fortunately the human ear is tolerant, otherwise all sound reproduction would be impossible. Thus the spectrum of the old, acoustic recording departed substantially from both criteria. The frequency range extended only from about 250Hz to 2,500Hz, and there was a huge peak between 1,500 and 2,000Hz. Moreover, the second criterion was far from being satisfied. Yet records did manage to achieve a sense of realism.

The prospect with electrical recording was much better. At first, a uniform response in the recording from 200 to 5,000Hz was aimed at, with tailing off outside those limits in a prescribed fashion. This prescription was based on a preliminary study of the tracking of a stylus in a groove: at the bass end the amplitude (that is, the distance of the side to side modulation) of the groove would be too great for the needle, in its attachment to the reproducing mechanism, whether sound-box or pickup, to manage with comfort; and in the treble, the sinuosities of the groove would have too sharp a curvature to accommodate a needle of finite dimensions.

It was therefore contemplated that corrections for the lack of uniformity should be made in the reproducing amplifier.

The idea worked tolerably well except for two things. Both recording and reproducing elements then available introduced distortion, so that the second principle was not satisfied: severe criticisms were in fact made about the "nasality" and "fair-ground quality" of the tone; and the early pickups imposed too much strain on the groove walls, so that record wear became pronounced.

Happily, these disabilities were gradually avoided with improved instrumentation. Certainly by 1945, as a result of work undertaken as part of the war effort, the possible range of recording at the treble end had been extended to 20,000Hz, though a limit of 15,000Hz was voluntarily imposed as a general rule. The art of reproducing had also been intensively studied, notably by Pierce and Hunt of Harvard University (Journal of the American Acoustical Society, July 1938), so that the distortion factor was substantially reduced. Thereafter it was no longer thought that for ideal tracking the stylus should penetrate to the bottom of the groove, as had previously been supposed.

Demand for long-play records

Round about 1926, too, there was a persistent demand for a longer-playing record. I recall that Christopher Stone specially asked me for an article in the December 1926 issue reviewing the prospects, more particularly in reference to electrical recording both on discs and on film. Luckily, I had by this time received full information about research both in Britain (*e.g.*, Voigt, Blumlein) and in America (Harvey Fletcher, Maxfield and Harrison, Rice and Kellogg, S. T. Williams). My American correspondent in those days, by the way, was David Sarnoff, who later became President of RCA. So I was able to give a persuasive account of the possibilities. But, of course, I was unaware of the promise of magnetic tape, which had not by then been invented. Poulsen had invented magnetic recording on wire, but the response by no means equalled that of disc recording. The magnetic tape development was a German invention prior to the war, and was 'appropriated' by the Allies at the war's end. I myself was one of the British representatives on the Allied Committee which decided which inventions should be seized!

The fact that long-playing records should be possible was established in 1934 when the Royal National Institute for the Blind, in conjunction with St Dunstan's, produced Talking Books for the Blind. These had 200 grooves to the inch instead of the standard 100 grooves, and played at a speed of 24 rpm instead of the standard 78 rpm. I was asked by the Director of the RNIB, who met me from time to time at the Board of Education, to cooperate with Captain Fraser (now Lord Fraser) of St Dunstan's in developing the project. The recording companies had expressed doubts about its feasibility, so we set up a recording studio at St Dunstan's in Regents Park, and proceeded to solve the various problems that were involved. We were supplied with recording waxes by HMV for the purpose and, after we had demonstrated that good speech recordings were possible, had the utmost cooperation from both HMV and Decca.