

Mysteries of Sound.

BY JOHN M. BACON.



SOME curious experiences with regard to the trickery of sound occurred to me during undergraduate days at Cambridge, to which I attribute an early predilection for the science and study of acoustics.

While yet an out-college man, I was unexpectedly offered a set of rooms in the Old Court of Trinity, which rooms had been somewhat hurriedly vacated by a man of uncertain health and nervous temperament, who assigned no satisfactory reasons for suddenly going into lodgings. It was the commencement of a dull October term, and I remember well how the bedmaker warned me against the rooms, which she characterized as "dreadful dismal." The cause, however, of this forbidding description was not revealed to me till some weeks afterwards, when boisterous winds chanced to set in with gloomy November weather, about which period, when sitting up reading, I used frequently to hear low, moaning sounds, as if some creature were in distress somewhere in the lane outside. No one could explain the phenomenon, and it was not until months afterwards that I myself searched for the cause, and after some little difficulty discovered it. It was commonplace enough. In a side room a piece of wall-paper pasted across a chink had developed a crack, leaving two jagged or toothed edges, which, under certain conditions of draught, vibrated rapidly together, forming, as it were, a reed, and thus producing the sound above described.

That ghost, like all others in my experience, was readily laid; but another uncanny and more noteworthy occurrence shortly afterwards taught me yet more clearly how capricious sounds may become, and how hard to locate or explain.

In a neighbouring staircase there lived (I beg pardon, "kept") another friend of mine, a man of much tougher fibre, who was reading—and over-reading—for a medical exam., and once, through a sleepless night, he was driven to distraction by what, in the morning, he described as mysterious voices apparently in the court outside, accompanied by rappings on a tin tray or the like; yet, often as he rose and went to the window, there was nothing to be seen, and at last his

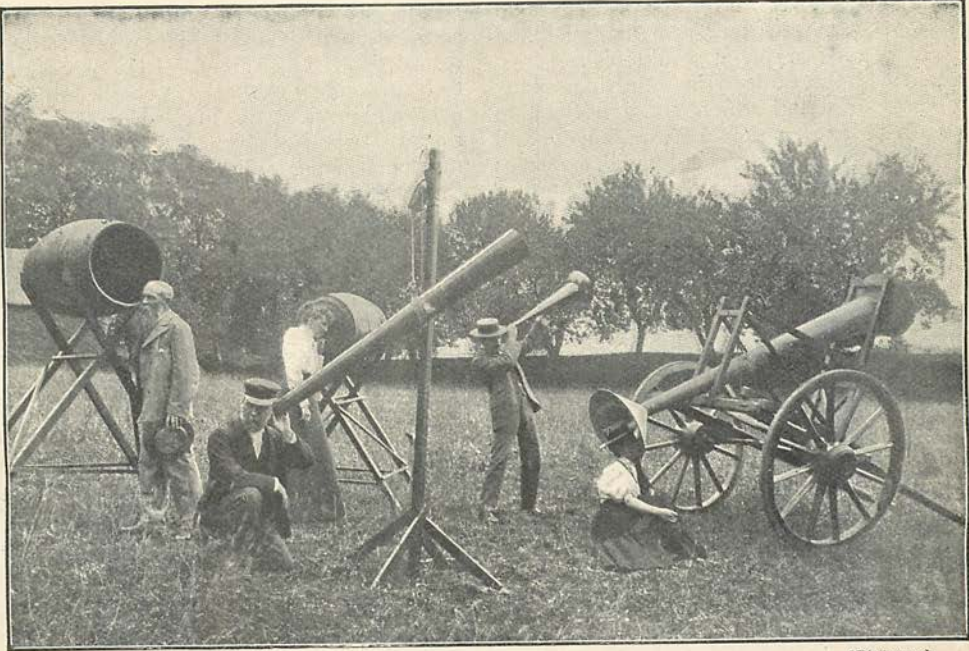
over-wrought nerves gave way, and were not to be relieved until some of his friends succeeded in finding the cause of his disturbance, which was this: Over the way, in Caius College, where building was going on, an engine had broken down and workmen had been employed through the night in tinkering it up. This was the sole and sufficient explanation. It satisfactorily accounted for the existence of midnight voices and for the weird tappings, excited imagination supplying all the rest. The instructive fact, however, brought home to my own mind was how unaccountably sounds may seem to behave themselves when the mind fails to interpret them aright, and how strangely different even a familiar noise may sound when heard amid dead silence. It has been my good fortune more than once since then to dispel idle imaginings that had been causing real disturbance and distress.*

Occasions also have arisen which have stimulated me to construct sound instruments which, in performing certain novel functions, should attain objects of practical value. For example, on the occasion of an annual flower show held in my grounds, it has been necessary to summon visitors, many hundreds in number, and scattered over a large area, to certain side-shows. A horn or bell conveyed nothing in particular, but a specially-made trumpet, rigged on a scaffold 30ft. high, commanded the whole ground, and a polite invitation gently spoken to the four winds has been easily heard by all. In the accompanying illustration the instrument referred to is that in the foreground, and its efficiency and due proportions were only tentatively arrived at.

Some ten years ago my attention was accidentally directed towards kindred acoustical problems by circumstances which again may be considered as outside common experience.

By the kindness and courtesy of the late Dean Church, I had been granted the privilege of making use of St. Paul's Cathedral for carrying out certain experiments dealing with terrestrial magnetism. I had chosen for my purpose a quiet summer's night, and all due arrangements having been made, I commenced a long vigil, sitting alone for

* Once in 1895, in the case of the famous Ham ghost, near Hungerford.



From a)

INSTRUMENTS FOR TESTING SOUNDS.

[Photograph.]

hours in the loftiest chamber of the building watching the readings of an instrument, while a colleague watched a similar instrument in the crypt 400ft. below. It was while occupying this elevated position, with attention well braced, and in that night silence which falls even over our great Metropolis, that I learned how remarkably certain sounds can be recorded over vast distances. The measured tramp of the policeman rang as sharp or sharper than if I had been on the pavement beside him. The fog-horn of the bicycle—then in vogue—could be heard streets away, and railway whistles on distant lines and hooters on the shipping far down the river seemed unearthy in their carrying power and clearness.

The experiences of that night were further confirmed on yet another occasion when, about the same period, I chanced to make my first balloon voyage, and when, by rare fortune, our balloon drifted over the very heart of London and almost directly over St. Paul's Cathedral, at an elevation of 3,000ft. above its golden cross. It was a noteworthy voyage, and deeply impressed upon my mind afterwards by the fact that it was one of the last conducted by the late Captain Dale, who shortly afterwards lost his life while ascending from the Crystal Palace grounds. It was while we were maintaining a high elevation that we made out Kennington

Oval immediately below us, and we could actually watch a game of cricket in progress. Soon, however, it became apparent that play was suspended, and then, manifestly in our honour, a ringing cheer came up with a distinctness that I was wholly unprepared for. I learned, then, that an English cheer is a very arousing, and may become a very astonishing, sound; but my wonder grew as we swept on and presently caught the gathering rattle of the streets below, which soon increased and grew to a deafening roar positively painful by its harshness and intensity.

So far, these experiences were but proofs of the great carrying power aloft of loud and familiar natural noises, but I was now to be impressed quite equally with the penetration into upper air of Nature's softer music. It was squally weather that day, and, as evening approached, the wind grew rough with gathering storm. We were at that time scudding fast over Hertfordshire, where the country was well timbered, and ever as we passed high over woods, then in full foliage, a soft murmur would fill our ears, and it seemed almost incredible that this was but the tossing trees singing to us half a mile below. There were other sounds, of course. Anon would come the bark of a dog from—where? Or the whistle of a train scarcely yet visible in the distance deep down.

Altogether it was firmly impressed upon me from that time onwards that a balloon ascent properly arranged would offer an exceptional opportunity for studying many problems in sound which could not fail to repay fresh investigation and experiment; and it is not a little curious that, although acoustics have occupied the special attention of many scientists, no one has come forward to systematically utilize the balloon in the service of that all-important branch of science.

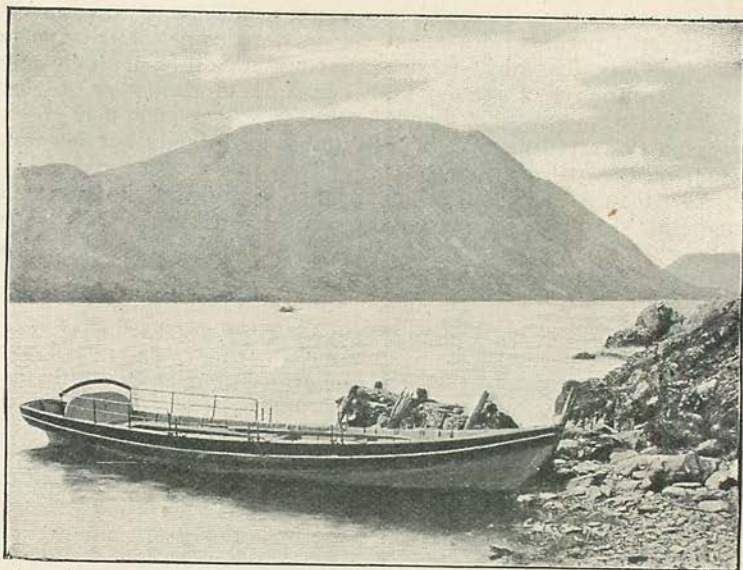
I am confident, however, that the subject here broached is likely to become a popular one, and considering how important a part sound signals play—and always must play—on our railways, and yet more especially in navigation round our coasts, any inquiry that may lead to further knowledge and improvement in this direction cannot fail to possess interest.

The results of former investigation have been instructive, in many ways, and I may be pardoned for a brief retrospect.

On scientific matters our grandfathers, apparently, were easily satisfied with such plausible theories as seemed fairly convincing and intelligible, and it was with reluctance that they admitted any facts tending to upset preconceived opinions. This statement is

the passage of light, so must rain or fog, of sorts, deaden sound. This was formerly regarded as self-evident. It is now known to be absolutely untrue. It has been proved over and over again that when the sky is thickest, when all view is lost and danger may be at hand, and unsuspected, then it is that Nature comes to our aid in her own way. It is just then that sounds lend us their readiest warning; that the approaching train may be heard a mile farther than usual; that the horse's footfall, the rattle of the wheels, the shout of a human voice—all such sounds ring out with unwonted clearness.

And Nature in another mood will sometimes give other utterance to her secrets, and in mysterious echoes mock our words and taunt us as it were for our lack of knowledge of her laws. A symmetrical building, or courtyard, rigidly four-square, will give us an echo the elements of which common sense can assign and calculate. But if we hunt for them, we can pick up other echoes unaccountable enough to set mere theory well-nigh at defiance. Killarney is the home of such echoes, but you may find a like natural magic in any woodland or rocky district. Take the Cumberland lake country, where



From a]

CRUMMOCK WATER.

[Photograph.

at least true with regard to the science of sound, and we can easily support it.

For example, we find it accepted as a fact, not to be challenged, that as rain and mist and haze of any kind obviously interfere with

not only will the cliff rising bluff from Crummock return your voice across the silent lake, but at times even down the slant of Lodore amid the plash of water, and where all around is but broken rock and dense



From a

THE FALLS OF LODORE.

[Photograph.]

foliage, you may clap your hand and hear the spirit of the stream reply.

Again, it seems to have been pretty generally taken for granted that the sounds which most strikingly assail the ear at close range must also be those that reach the farthest. This, however, is far from the truth, as, indeed, might have been easily proved. We listen with charmed ears to the varied sounds of a military band passing us on the march at short distance. Our ears are invaded by a tumultuous ocean of sound waves which none the less are perfectly agreeable to our sense of hearing. All is not only harmonious, but well balanced. The reeds easily hold their own against the brass. The cymbals now and again pleasantly startle us with their crash, and ever and anon the shrill little piccolo trills out high above all the rest. Yet as the troops move on into the distance, these more piercing but thinner voices may be the first to fade, presently passing out of hearing altogether and leaving the horns alone in competition, and when all else is lost, prob-

ably the vast waves put in motion by the membrane of the drum will be the last to reach the ear.

There is another familiar experience which our grandfathers left without notice, or at least without explanation. Thunder is the voice of Jove; the loudest sound in Nature, awakening echoes that will respond to nothing else on earth. Yet the loudest peals of thunder are heard comparatively speaking but a very little distance. We shall be easily convinced that this is so if we think it out. If only eight or ten seconds' silence elapse after a lightning flash, the thunder that then follows is only just heard as a subdued rumbling. Yet the uproar is but two miles away, across which short range even the bark of a dog may be distinctly heard, and a steam hooter three times as far.

We could cite many other examples of the apparent ignorance of everyday acoustical facts prevailing only a generation or two ago; yet Nature herself has been frank enough, and old-fashioned mis-

conceptions have arisen in direct defiance of her teaching. We may watch the lark rising into space and singing as it rises; singing on while mounting, till it hangs as a speck in the sky, and then passes out of sight altogether. It has but a tiny pipe, and yet its notes ring sweet and clear out of the empty air. So with certain other high-pitched sounds of Nature's own devising. On a still night a cricket may be heard not only all over the house but outside the house and 80yds. away. In like manner the shrill voices of children may penetrate to astonishingly great distances. These and other lessons of Nature form an integral part of everyday life, yet they have received far from due attention. We may note again the seeming anomaly that a whisper will often arrest attention where ordinary speech is unheeded. A discordant note will jar the ear, while a purer though far louder sound passes unnoticed. Again, vibrations deemed quite inaudible because beyond the reach of human ears

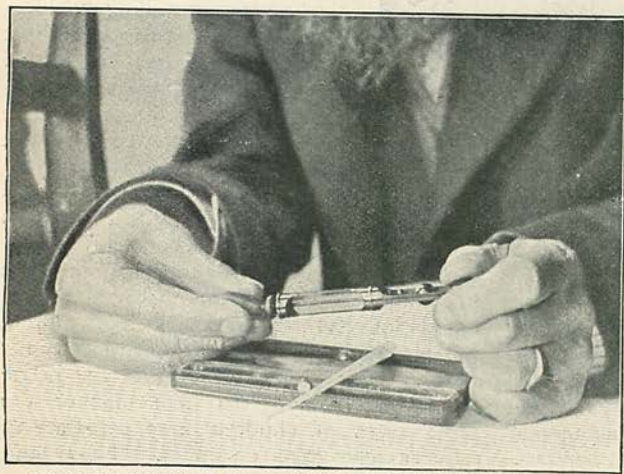
may be sounds of much penetration as interpreted by the hearing faculty of other creatures. A curious illustration of this fact is to be noticed near my own home in Berkshire. I have often gone out on my lawn just before nine o'clock on a still night, when the wind was either dead calm or else blowing softly from the south, and having accurate time, have listened with all my ears for the report of the evening gun at Portsmouth, forty miles away, but neither myself nor any friends who have been with me have ever succeeded in catching even the slightest suspicion of the sound. Yet you may go to the neighbouring preserves, and, precisely after the hour, the pheasants will give a startled flutter. Unquestionably, the birds detect the sound that, too feeble to affect ourselves, yet conveys alarm to their more sensitive hearing. The same may also be said of other vibrations which are not feeble, but on the contrary intense and rapid—in fact, so rapid as to be just beyond the human auditory scale. Mr. F. Galton, the famous anthropologist, has invented a little whistle with an adjustable plug, by which it can be rendered more and more shrill until it ceases to give any true note at all to our ears; yet a little dog may clearly hear it as a whistle still, and respond readily

behaviour of sound was not always the same. That on some occasions horns could be heard farther than guns; on another occasion the guns would surpass the horns. In some conditions of atmosphere, irrespective of wind, sounds would penetrate much farther than at other times; while it was taken, as the result of former experiment, that sounds attain greatest audibility not down the wind, but across it. The maximum range of sound was sought out at sea and obtained, but this experiment, as then carried out, was far inferior to the same when tried from a balloon. In the case of observers at sea, there is always some extraneous sound present—the lapping of the water against the vessel's side; the breeze stirring through the rigging, and so on; while in a lofty balloon the silence is profound. Moreover, the sound must travel directly down the wind and with the farther advantage of ascent; thus a greater and surer record may be obtained. The most curious discovery, however, that the learned Professor claimed to have made was the existence of what he termed "acoustic clouds," *i.e.*, floating masses of air of different density to that of the surrounding atmosphere, and which, though wholly invisible, are incapable of reflecting sound and causing echoes out of the empty air. Indeed, it was assumed that the rolling of thunder is due to reverberations not from frowning thunder-packs, but from flocculent masses of these acoustic vapours present always around us.

Altogether the above-mentioned investigations undertaken by Professor Tyndall under the auspices of Trinity House are the most important on record, and give the valuable results of one of our most eminent experimentalists.

Facilities, however, for further observations have rapidly developed since then. Principles are better understood. New methods have been found, and instruments of extreme delicacy introduced. Even the microscope has been called upon to lend its aid, and the trace of a suitable phonograph can be made to reveal to the eye differences of sound intensities difficult to compare by ear.

It was, therefore, under most propitious circumstances that the first ascent which I



WHISTLE INVENTED BY MR. F. GALTON, WHICH A DOG CAN HEAR BUT NOT A HUMAN BEING. [Photograph.]

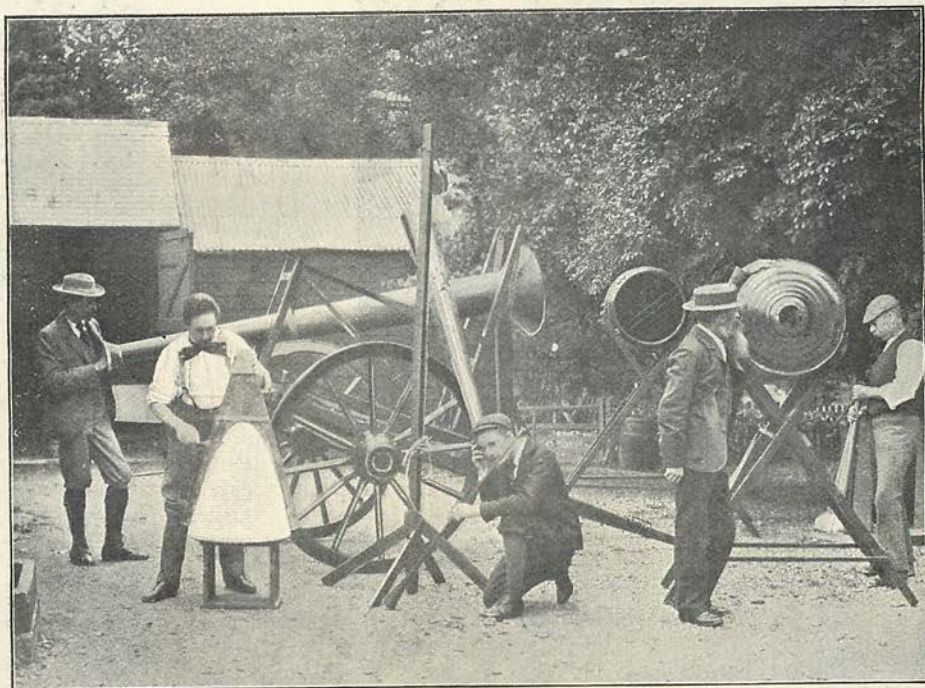
to its call. The little instrument, in use, is here pictured.

Many of the facts just mentioned were dealt with by the late Professor Tyndall in a memorable series of experiments carried on chiefly at South Foreland. The results of that inquiry fairly took the scientific world by surprise. It went to show that the

have had the privilege of organizing, and which was designed to deal more particularly with acoustical problems, took place in the historic grounds of Shaw House, Newbury, at the end of July last. As a colleague and companion of the voyage I had the co-operation of Dr. R. Lachlan, of Cambridge, who is well known in the front rank of working mathematicians, while our plan of operations had been carefully collaborated under the ablest advice, and with the aid of practical counsel from leading experts at home and also on the Continent, where scientific ballooning has for some time been pursued. The liveliest interest was manifested in our enterprise, and the loan of instruments of value was freely offered to us by individuals and institutions.

This was a long stride towards success, but

trial. Foremost among this working party should be mentioned those two unrivalled mechanics, Mr. J. N. Maskelyne and his son, Mr. Nevil Maskelyne, F.R.A.S.; also Mr. T. H. Webb, Mus.Bac., a finished musician and enthusiastic student in his own department of acoustics. A long stretch of open country known as Bucklebury Common, near the Berkshire Downs, and remote from haunts of men, had afforded excellent practice ground, and the hush of a still July night lent the necessary element of silence. Thus, admirable opportunities had been secured for rehearsals; for testing the penetration of various sounds below; for perfecting instruments of varied construction, transmitters and receivers, and for determining maximum and minimum audibility on the earth.



From a]

INSTRUMENTS FOR TESTING SOUNDS—A REHEARSAL.

[Photograph.

one equally important requirement had rested with the observing party themselves, and had needed much development. This, of course, consisted in a series of carefully conducted preliminary experiments, and the due training of the experimenters. Of these there were naturally two sections: the aeronauts, and the working party that were to remain on the ground and combine in carrying out the very varied programme which suggested itself as suitable for a first

In the illustration showing the official party on the final day of trial in front of the fast-filling balloon, Mr. J. N. Maskelyne is holding a paraboloidal receiver of his own construction, which theory suggested as the best possible form, and the hopes respecting which were, as I shall show, fully borne out. Under the canopy of a straw hat may be recognised the Savilian Professor of Astronomy at Oxford giving his last word of advice after having presented myself with the fine



THE OFFICIAL PARTY BEFORE THE ASCENT.
From a Photograph.

marine telescope depicted. On the ground is an instrument devised by Mr. Nevil Maskelyne for recording intensities; while in the middle of the group is Captain Lynn-Smart, who, on behalf of the Cotton Powder Company, generously brought a store of the powerful fog-signals now being used in all parts of the world, the terrific discharges of which shivered the above-mentioned delicate instrument all to pieces, though far removed; and it may be, that the captain returned home chuckling—and if so pardonably—at the damage he had done.

Before proceeding any further it may be interesting to give here part of a kinematograph film which was taken as the balloon ascended into space. The eleven pictures shown in this portion of the film were taken in less than one second, yet the change of

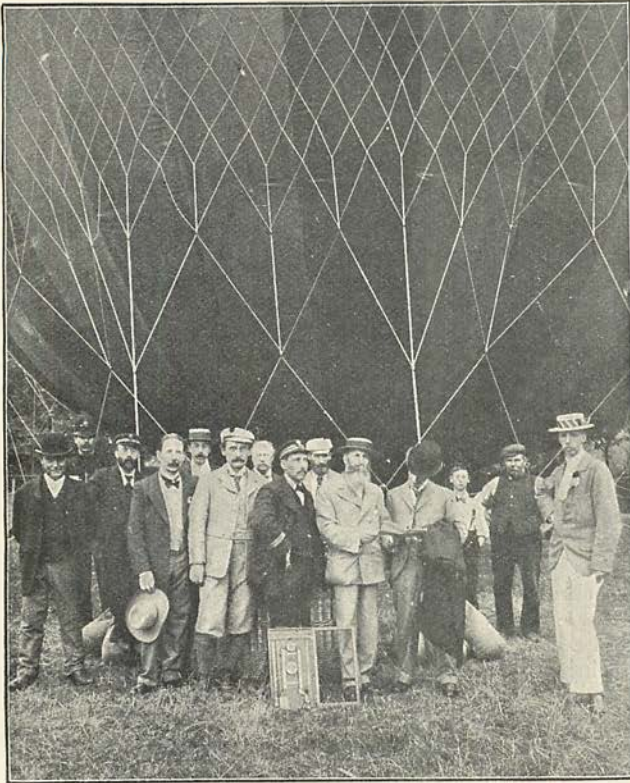
perspective in that short period of time may be easily detected.

The entire work proposed and carried out came chiefly within the range of such problems as I have already enumerated, and produced a harvest of results of which I may here mention a few. The tick of a watch was distinctly heard at the focus of the paraboloid 60yds. away. The word "hush," gently whispered through one of the larger trumpets, carried clearly over 300yds., and "halt" would promptly bring a man up at that distance in the teeth of half a gale of wind. Over a

long range it was proved that the single toot of a horn might become the sport of any chance gust, but not so the prolonged note of two horns, which cared little for measurable distances, and less still when blown out of tune. Reeds, rattles, and whistles were shown to have their own idiosyncrasies, and monster instruments specially designed, that would do their own work well and willingly, would do nothing else save under protest. An idea of the character of some of these



SCENE FROM ALOFT.



From a]

THE CAPTIVE BALLOON.

[Photograph.

may be gathered from the first illustration of this paper, where a photograph of some of them is reproduced, and in which it may be noticed that the tapering of the longer tubes is less abrupt than in the short instrument—really made for a foreign Government. The right degree of taper was discovered only by experiment, and was found to be a most important factor in construction. The tub-like resonant receiver on the left responds to concussions by the singing of piano-wires stretched within, and the duration of their vibrations is the measure of the sound tested. Among other instruments used must here be mentioned the ubiquitous bicycle, which proved simply invaluable for rapidly and silently travelling from station to station.

Our balloon, of 4,000 cubic feet capacity, under the pilotage of Messrs. P. and A. Spencer, was first utilized as a "captive," after which it was liberated at an exact moment, and as it rose aloft the well-rehearsed programme was once more carried through, and without a hitch. At every half-minute pre-concerted signals were delivered below, and their arrival accurately timed and determined

in the steadily retreating car. First in order came simple speech, a word of command, a cry, a shout, then the blast of a horn, of two horns, of various forms of horns, of horns in unison, in harmony, and in discord. Then a rifle party formed up and fired single shots, then a roll, then a volley. After that, steam-power instruments lent their voices; and lastly the powerful fog-signals were requisitioned, and ear-splitting reports roared out at due intervals, until the voyagers had got a start of full half an hour.

Meanwhile, it had been arranged that the tenor bell of a neighbouring church should be set ringing, and guns of different calibre fired at Portsmouth, so that any exalted power of hearing aloft might be estimated. All worked well. The comparison of sounds travelling upwards was well registered, their penetration tested in calm silence, the blending of different notes, the toning-down of discord, and even the velocity of sound as

it travelled—to upper strata. This was not a difficult feat. The occupants of the car knew to a fraction of a second when each fog-signal was fired. They also knew every field and homestead over which they journeyed, and their own height. Thus, the elements of time and space were determined, and the mean of many observations could be taken. Many other problems were grappled with, and among many results perhaps none was more convincing than when at a great height we tried the effect of a trumpet upon a group of harvesters below, and put the question: "What's the time?" and after due interval the answer, gathered in our big receiver, came up with an unmistakable—"Six o'clock."

This was a record in itself, and would have given sufficient proof, if proof had been wanting, that our maiden scientific ascent has brought us excellent promise for the future. Our memorandum-books are filled with notes, and we may at least assert that of all our previous results, noticed above, none have been disproved, while we fairly feel ourselves in hot pursuit of fresh and further fact.