METHOD OF CORRECTING FAULTY ACOUSTIC PROPERTIES OF PUBLIC HALLS.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

M. Gustave Lyon, who is at the head of the well-known Pleyel piano manufacturing firm of Paris, has devised a method for remedying the faulty acoustic properties of public halls. One of the largest and at the same time the worst public hall in the city is that of the Trocadero, which seats 5,000 persons. By his method he succeeded in correcting the surfaces to such an extent that about ninety per cent of the disturbances are suppressed. He divides the stage into a number of ruled squares each about 5 feet square. Standing on one of them he makes a loud sound by clapping two pieces of wood together. Auditors are placed in various seats, and when one of them hears the first sound and then a second one or echo reflected by the walls, he raises a large numbered cardboard from which his number is noted. From each point of the stage in turn we thus make a note of the seat numbers.

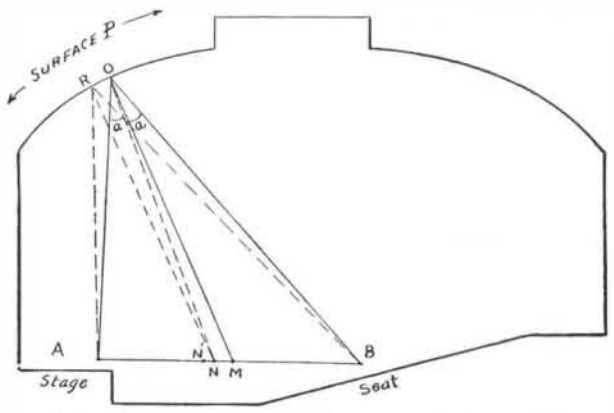
Taking a given case where stage square No. 8 causes the echo in seat No. 25, we must find what points on the wall surfaces reflect the echo. This is done by drawing a line on the plan from the stage to the seat, and then from the middle point of the line a perpendicular to any wall surface *P* of known curvature. From this point as a base we can geometrically locate the spot on the wall which throws the echo to seat 25.

Referring to the diagram, we draw a line from point 8 on the stage to the seat No. 25, on the longitudinal cross-section of the building, which gives the line *A B*. We bisect this line and obtain point *M*. From *M* we draw a perpendicular to any of the large wall surfaces such as the surface *P*, and thus obtain the point *O*. We draw the lines *A O*, *O B* which form the angle *A O B*, and then bisect this angle by the line *O N*. This line intersects the line *A B* at the point *N*. From *N* we draw another perpendicular to the reflecting surface at the point *R* and draw the lines *A R*, *R B*, when it is found for practical purposes that the point *R* is the one which throws the echo, inasmuch as the angle *A R N* nearly equals *N R B*. A closer approximation can be made by repeating the same operation, bisecting the angle *A R B* and finding thus a third point *N'* on the line *A B*, etc. Many of the points fall where they could produce no echo for a given surface, while others are too near to give an echo. An interval of one-tenth second is needed for the ear to perceive the echo after the direct sound, and as sound travels at about 1,000 feet per second, the sound must travel at least 100 feet in order to be heard one-tenth second afterward. Otherwise the direct and reflected sounds will be confounded with each other. Thus the wall point must be one-half of 100 or 50 feet off in order to give an echo, and all points under this value can be discarded.

After plotting on the elevation and plan views of the hall the points which give the reflections as we have just seen and finding the faulty surfaces, it is desired to check up these results by an experimental method, and for this purpose M. Lyon devised a novel acoustic apparatus. It consists of a long metal tube which serves the purpose of a speaking trumpet, and the tube is connected by a rubber hose with a box about two feet cube in which an audible signal can be produced. Such a sound is sent from the tube and is projected along one general direction. For giving the adjustment and measuring the angles of the tube there is used a graduated dial around which a pointer travels mounted on the tube shaft. The whole device is mounted on a circular base. This can be turned around on a pivot after the manner of a surveying instrument.

As we know the position of any of the noted points on the wall on the vertical and horizontal plans of the building, it is an easy matter to calculate the position for setting the angles of the "acoustic theodolite" so as to direct the tube to this particular point. Finding thus from the drawings the angles needed for the point number 32, for instance, we direct the tube to this point by the two graduated scales, and then find whether this is actually the point which gave the echo at say seat number 25, from the square number 8 of the stage. We have only to make the acoustic signal in the box which is mounted on the stage at the proper square, and the hearer finds whether the echo is noted at this seat. By carrying out a series of observations in this way we are able to find the exact points and in consequence the wall surfaces which need to be corrected.

M. Lyon devised another instrument of a larger size which is intended to demonstrate his method in a more striking manner. A small cabin is used which

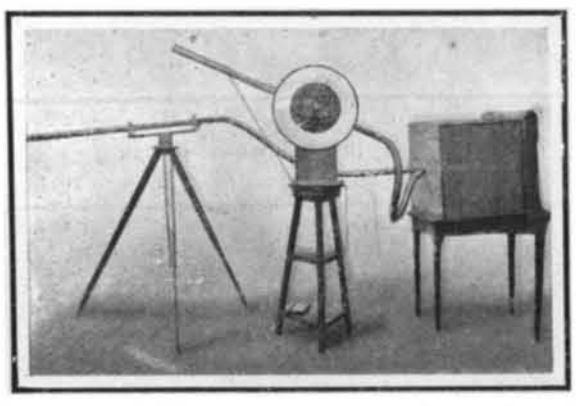


How the reflecting spot on a wall is found.

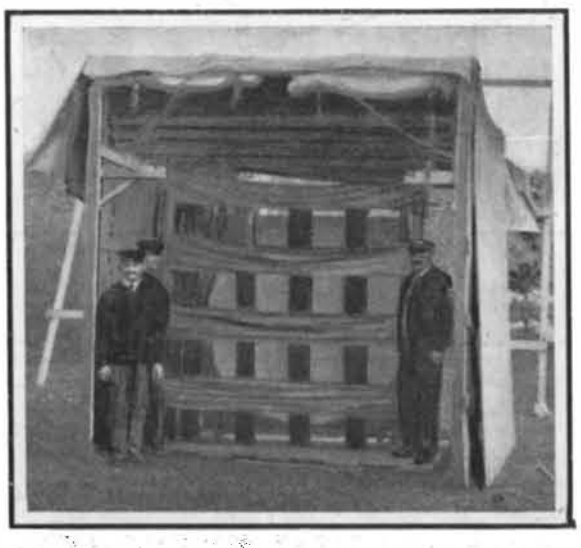
is soundproof, and made so as just to cover one of the squares of the stage. On the sides are openings through which can be inserted two acoustic tubes of large size, as will be noticed. The operator is stationed inside the box. The sound is produced between the two ends of the tubes so that it is given out from each tube. Above the cabin is a support which carries a graduated beam. This holds the tubes at a given angle by wires with which the tubes are hung from the ends of the beam. Previous to this we have already located the points by the "acoustic theodolite" and noted the place of each one by referring to certain details of the ornamentation of the walls. Accordingly we are able to direct one of the present tubes, the rear one, to the same point by means of cross-wires placed at each end of the tube by sighting from the inside of the cabin. In the same way the front tube is directed to the seat in question. Were the front tube to be used alone, the hearer in the seat could perceive only the principal sound given by the operator, but when the rear tube is used, he hears first the principal sound and then the reflected sound. Should the front tube be stopped off, he will hear only the reflected sound. Placing an auditor in the President's box, for instance, we find that the concave part of the wall lying over the organ is the principal cause of the echoes in the hall, and we can explore this region and the other walls so as to make this evident. According to the data which he thus obtained, M. Lyon was able to demonstrate very clearly that 90 per cent of the echoes of the Trocadero hall were produced by this concave surface, and that if it were properly corrected, the hall would have its acoustic properties radically changed. This was in fact the case.

It was thought advisable to cover the wall with cloth or similar covering so as to deaden the echo. In order to find out how to do this, M. Lyon made experiments with a large circular reflecting mirror. The reflector is made of stucco which gives a very smooth surface. It has about 200 feet radius. In the middle is mounted a sighting tube for directing the reflector. At the proper distance in front of the mirror is a closed cabin having a small front window of two feet square, and by making a sound by striking on a suspended steel bar with an electric tapper with the bar placed well back of the window, we send out the sound on a general straight line. It falls on the mirror, being reflected from it to a point lying close to the cabin. There are three hearers placed at this point. When the operator makes the signal in the cabin it is perceived by the hearers directly, and afterward there comes a second sound reflected from the mirror, this being also a strong sound. What is desired is to suspend some kind of screen before the reflector (representing the wall) so as to shut off the sound. Various screens were tried, and one which is seen here is made of crossed strips of cloth. This cut down 50 per cent of the echo, but strange to say, a full cloth covering scarcely cut down the echo at all. On the other hand, it was found that a double cloth with a few inches space between the two, would almost completely suppress the reflected sound. We no doubt have interference phenomena which are not as yet very clear, but the practical effect is certain.

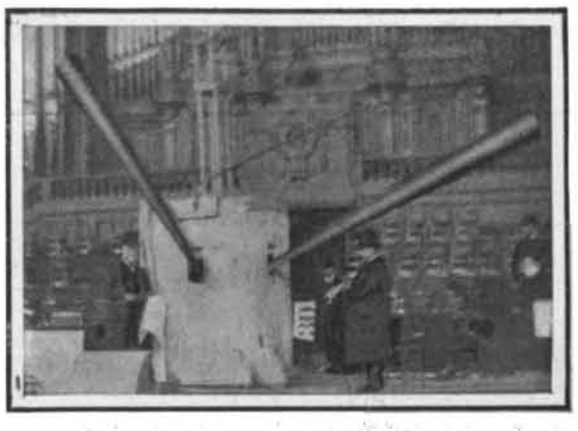
Accordingly, such a double cloth covering was placed over the concave surface of the Trocadero wall above the organ, this being simply hung between two flat pieces of wood strip, leaving a space of a few inches between the two cloths. A fabric of the nature of Canton flannel is found to be best. A very small expense is needed for this work, and in the present case it did not exceed $5,000. At the same time the result is striking, and the acoustic properties of the Trocadero are vastly improved, as 90 per cent of the echoes have disappeared. M. Lyon, who had carried out all work at his own expense, was congratulated for his results by the Secretary of Beaux-Arts, and other officials, who were present at the tests.



Lyon's small apparatus for ascertaining the position of acoustic reflecting points.



A cloth screen with a sound-reflecting mirror behind it.



Lyon's large apparatus employed in correcting the acoustics of the "Trocadero."

Maisine: A New Corn Product.

Some time since we had occasion to speak of a product known as "maisine," which is obtained from corn. In fact, it is found that corn flour contains a gluten which is analogous to the gluten of wheat, but differs from it by its solubility in the alcohols, especially in amylic alcohol. The present name was given to the product by Messrs. Donard and Labbé, who studied its leading properties. It is now found that it has a commercial value, and its solutions in alcohol and acetone give upon evaporation a transparent substance which can be used as a plastic material. Maisine is now produced in France on an industrial scale at the Trystram works at Grande Synthe, as a by-product of the corn industry. It can be incorporated with celluloid in the proportion of 20 to 75 per cent, and it thus lowers the price of the celluloid and renders it less combustible. When used above 20 per cent proportion, the product can be heated for 3 minutes at 155 deg. C. without showing decomposition. Maisine has various uses as a plastic material, and either alone or with camphor, and it can also be employed as a food product. Like caseine, it can be treated with alkalies and will thus give glue and sizing products. Thus the new substance w ll be an advantage in the corn industry, as besides the corn starch and the oil, we can now utilize the albuminous portions of the corn. To prepare maisine, corn flour is exhausted with amylic alcohol. The flour is previously dried, and then freed from fatty matter by treatment with benzine. The amyl alcohol solution is mixed with three parts of benzine, when the maisine is thrown down as a woolly precipitate. It is collected by filtering and dried *in vacuo*. Some 13 per cent of maisine is obtained from corn flour in this way. Messrs. Donard and Labbé find that this product is a mixture of several different albuminous substances which have varying solubilities in alcohol.

The Radium Institute of Heidelberg will be the first of its kind to commence actual work, as an endowment has been secured for it. It is to be opened for work before the end of the year.