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ACOUSTIC PROPERTIES AND RESONANCE OF BUILDINGS.

The pleasurable enjoyment of a public discourse, a debate or a concert may be largely interfered with or destroyed by the acoustic or resonant conditions of a public hall—not that the entire audience is so afflicted, but almost every public hall not expressly arranged or dressed for the purpose has some local points or nodes in which the direct and reflected pulsations of sound meet at unequal times, arising from the difference in distance traversed by their direct and reflected courses.

The laws in regard to the reflection and refraction of sound are the same as for light, and the nodes and acoustic curves of condensation of vibratory effect may be as graphically laid down for sound as for light. They are practically illustrated in large whispering galleries and domes, such as the whispering gallery of St. Paul's, London, the sculpture dome in the Capitol at Washington, and to a limited extent in many large public halls and domes. A most remarkable building for excessive acoustic and resonant properties is the Mormon teehive temple, Salt Lake City, having a capacity for 14,000 people; the drop of a pin on a plate at one end can be distinctly heard at the other, and the resonance or reverberation from a speaker is so intense and confusing that leafy branches of trees have been suspended from the ceiling to diminish it.

An example of a lecture hall free from acoustic echo is found in the Smithsonian Institution in Washington, which was originally designed with the purpose in view of perfect freedom from acoustic defect.

To find a remedy for acoustic echo and resonance in halls and lecture rooms already built, and to avoid these properties in new constructions, is a much desired need with architects and builders, as well as with lecturers and hearers. It is conceded by those who have examined the details of the reflective and nodal points in the transmission of sound, and its similarity to the reflective and refractive properties of light, that if the reflective properties of walls and ceiling can be neutralized without destroying or materially interfering with the architectural harmony of large public rooms, the point most desired for an oratorical or a music room will be attained.

In an architectural point of view, the breaking up of long and high walls and ceilings into a system of panel work is a move in the right direction; but a more severe treatment than plain surfaces is needed to make a success.

Plain, hard-finished walls and ceiling are powerful reflectors of sound, and when a speaker stands at a nodal point, the reflected sound vibrations are repeated many times, resulting in a confusing resonance.

Not only do the walls and ceiling contribute to a repetition of sound waves, but uneven temperature and the presence of gases in large halls contribute to the confusion of the voice and to destroy the purity of musical tones by the unequal degree of sound refraction, from the varying densities of different portions of the air; hence a plea, other than hygienic, for uniform temperature and ventilation, without strong draughts, in large halls.

The sound of a syllable moves through the normal atmosphere at mean temperature at the rate of 1110 feet per second; so that a hearer in a node of reflected sound, near to and listening to a speaker uttering five syllables per second, with a reflecting wall at a distance of 112 feet, will hear the echo of one syllable exactly overlapping the next direct syllable; thus making a complete resonance, most annoying to healthy ears, and a pandemonium to the nervous.

A voice uttering syllables at the rate of three per second will have a return of one syllable to meet the next from a wall at 186 feet distance, and a return exactly between syllables from a wall 93 feet distant, and overlapping in a confusing degree at less distances.

If the rostrum is at the end center of an oblong room, the resonance will be cumulative, and return to the speaker with increased force, while, if placed at the center of a side, the resonance is dispersive, and does not strongly focalize on the speaker.

Corner rostrums in square rooms are favorable to a dispersive resonance; but wherever it is convenient to place a rostrum, or for any position of a speaker in a debating hall, a proper treatment of the walls and ceiling will largely if not totally neutralize acoustic resonance.

Smooth hard-finished and continuous walls in rooms designed for lectures and music should be avoided in new structures and so changed in rooms already finished as to produce the least acoustic resonance with the least cost in the required work.

The system of stringing wires across a room below the ceiling has been tried in England and found expensive and uncouth, and in an architectural point of view not to be tolerated. Draperies for walls already finished are a most ready means for temporary relief. The draping of windows with suitable curtains and the intervening walls with festoons of bunting will almost relieve the reverberation; but the accumulation of dust on draperies and consequent depreciation of the freshness and beauty of a public room is a bar

to their permanent use. Wherever it is found expedient to drape walls for temporary use only, those in front of the speaker and only partially at the sides need be draped. A rear hard-finished wall is an advantage, for its nearness increases the strength of the voice by reflection in the right direction, and without materially overlapping the vibrations. The acoustic condition of rooms now in use having smooth-finished walls and ceilings can be much improved if not entirely corrected by the application of roughfaced or embossed wall paper, of which the Anaglypta and Lincrusta-Walton are types. For future construction the rough plastering now much in vogue is recommended. The stipple plaster with deep-figured dado borders has proved a most valuable agent in deafening the acoustic resonance of public rooms.

The Real Estate Exchange in New York is an excellent example of a non-resonant room by this treatment.

Explosion of Twenty-seven Steam Boilers.

At Shamokin, Pa., on Oct. 11, twenty-seven of a nest of thirty-six boilers at the Henry Clay Colliery exploded about 7:30 o'clock in the morning, completely destroying the boiler house, killing five men, seriously injuring two, and slightly injuring four.

Without warning the last boiler on the west side of the nest went up, and it was followed by the others in rapid succession. The workmen were knocked in every direction, and what had been a strong corrugated iron building disappeared as if by magic. All that remained was a mass of bricks and timbers, pieces of twisted pipe, and battered boiler iron.

The nine remaining boilers were so injured that they can never be used. Pieces of heavy steel were carried hundreds of yards, while a half of a boiler was found over a quarter of a mile away up the mountain. The report was heard for miles.

The explosion occurred just after the colliery had started work for the day. It was a very cold morning, and the men who were killed and injured were standing around the boilers getting warm.

One cause given for the explosion is that the boilers had become weakened by the mine water that was used during the long drought in the summer. Lime was used to neutralize the acids in the mine water, but the boilers are said to be quickly eaten away by this water.

The colliery is operated by the Philadelphia and Reading Coal and Iron Company. The pecuniary loss is \$100,000. Sixteen hundred men and boys are thrown out of employment. The shaft payroll amounted to \$40,000 per month. It will take six weeks before the plant will be able to resume.

Science.

A lucid statement concerning the exact nature of scientific verity has been given to the public by the president of the American Association for the Advancement of Science, Dr. Daniel G. Brinton. Dr. Brinton is a citizen whom Philadelphia delights to honor; he is perhaps without a rival among all the American scientists of to-day as a scholar of versatile culture. Speaking as one with authority, he declares:

"The one test of scientific truth is that it shall bear unlimited and untrammelled investigation. It must be not only verified, but always verifiable. It welcomes every trial; it recoils from no criticism, higher or lower; from no analysis, from no skepticism. It challenges them all. It asks no aid from faith; it appeals to no authority; it relies on the dictum of no master. The evidence, and the only evidence, to which it appeals or which it admits is that which it is in the power of every one to judge, that which is furnished directly by the senses. It deals with the actual world about us, its objective realities and present activities. It does not relegate the inquirer to dusty precedents or the mouldy maxims of commentators. The only conditions that it enjoins are that the imperfections of the senses shall be corrected as far as possible, and that their observations shall be interpreted by the laws of logical induction."

This dictum should be remembered as the sworn affidavit of a society which numbers over 2,000 scientists among its adherents and embraces all the prominent lines of scientific research; a society which presents in its forty-two volumes of transactions an abstract and epitome of the scientific work of the United States for nearly half a century. This definition really defines. It makes an exact survey of the farthest boundaries and utmost limits of the domain of science. From this map of its scope, the precise value of its discoveries can be determined.—Philadelphia Record.

Paper Making Materials.

There are many patents relating to the manufacture of paper. Some of the patents provide for the making of paper from the leaves of trees, from hop plants, bean stalks, pea vines; from the trunks and stems of Indian corn and every variety of grain; from moss, hay and more than one hundred kinds of grasses; from straw and coconut fiber; from fresh water weeds and sea weeds; from sawdust, shavings and asbestos.

## Days in Rome.

In connection with this place, where the old Romans made holiday, I may speak of the baths of Caracalla, where, even more than in the Coliseum, one gets a sense of the luxurious pleasure-loving life that was led under the emperors. Passing through the arch of Constantine, which stands close to the Coliseum, we are in a quarter of an hour at the entrance to this ruin. Parts of the outer walls are standing, but vineyards are growing on a considerable portion of the land they once inclosed, and a stranger might drive by without realizing that he was passing one of the most interesting places to be seen. It is hard, even upon the ground, to realize how grand a club house this was. It covered a square mile. The mosaic floors of some of the rooms are well preserved and are in pretty patterns. The partition walls are destroyed, but the ground plan has all been made out and can be easily traced. We walk around in the great swimming baths where the water could stand six feet deep; we can see arrangements for heating the water for the tepidarium and caldarium.

The great building was double, the two parts being alike. Sixteen hundred bathers could be accommodated at once. Besides the bath rooms, there were gymnasia and halls for other amusements. In what is supposed was the grand parlor, the famous Farnese Bull and statues of Hercules and Venus, now in the Naples museum, were found; in fact, no less than 200 pieces of statuary were taken away when the place was excavated. The floor of the sitting room was alabaster; the lower part of the walls was covered with porphyry and above was pink marble. There was a race course included among the attractions. Fragments of columns of granite, pieces of friezes and broken statues are standing against the broken walls. In many places the mosaic floors have sunken under the weight of the mass which rested upon them. The building was begun by Caracalla about 220, and it was only the fourth century when it was despoiled of some of the marbles and statues to ornament churches, and some were burned for lime. The steps of St. Peter's church are made of columns taken from here and split lengthwise. Adjoining this great public bath house were elegant private bath houses, of which but slight traces are in sight, but their location can be made out.

When the work of excavation began here, vineyards were growing all over the ruin.

The Forum is the part of Rome where, above all others, the traveler who knows anything of ancient history expects to feel that he is on more or less familiar ground. Under the best conditions he needs to summon all the resources of his memory and all the power of his imagination in the study of the bewildering place.

It is natural to begin the survey at the foot of the Capitoline. Here, in earliest times, there was a marsh extending to the Palatine, and it was to drain it that the famous sewer, the Cloaca Maxima, was built, probably under the fifth king, Tarquin. A sewer large enough for a load of hay to be driven through, with travertine walls laid without mortar, that, without being rebuilt, is still carrying drainage into the Tiber, surely deserves frequent mention.

This valley was the site of the Forum Boarium or cattle market, and the Comitium, and to the east and north were afterward the forums of the emperors. There were in fact, in the time of Rome's glory, eleven forums, all communicating with each other. It is, as I have said, bewildering to stand in this place, which was the center of life during the republic and the empire. The realization of a far distant past comes over one with overpowering force; the traces of power and glory are so nearly wiped out that we know they must have belonged to a remote time. What do we see?

Eight granite pillars are left to represent the Temple of Saturn, the oldest temple, built 400 B. C. This was used as a treasury; the story is that the lightning once struck it, and the gold stored there melted and ran in a stream into the Forum. Beside this temple passed the Via Sacra, upon which the tufa blocks of the old pavement still remain. Over it rises the large arch of Septimius Severus, raised 203 A. D. The bas-reliefs upon it, representing the siege and taking of Babylon, the passage of the Tigris and Euphrates, and other scenes in the career of the emperor, are worn and were at their best not fine works of art. This monument was used as a fortress in the middle ages; was partly buried, and was not uncovered until this century. Standing as it does at the foot of the hill, with high modern buildings above it, it is not an imposing object. Close to it on the right are the remains of an old stone rostrum, from which Cicero made his second speech against Catiline. It is but a few steps to the last monument of antiquity, the column of Phocas, upon which once stood the golden statue of the Byzantine usurper. On our right was the great Basilica of Julia, begun by Julius Cæsar and finished by Augustus. Low brick posts mark the places where the columns once stood; but they were used centuries ago for other buildings. The principal branch of

the Cloaca Maxima runs right along the eastern end of the foundation of this basilica. We are now on the part of the Forum associated with Julius Cæsar. It is but a few steps to the new rostrum which he built. Here Mark Antony delivered the oration over his dead body, and a pile was improvised and the body was burned. There is little left of the rostrum, and virtually nothing of the temple, afterward erected over the place by Augustus in honor of his uncle, and as a resting place for his ashes. We pass now over the foundation of the Arch of Augustus, to look at a bit of the mosaic floor of the Temple of Castor and Pollux, and the three marble columns, considered among the most beautiful that have resisted the attacks of time.

We are now near the circular blocks indicating where stood the Temple of Vesta and the Palace of the Vestal Virgins. It was on or near this site that Numa Pompilius founded the first Temple of Vesta, when the sacred fire was brought from the shrine at Alba, and he ordered that four virgins be consecrated to the service of the goddess.

The date of the construction of these buildings is somewhat doubtful, but the plan has been carefully worked out. Pedestals with such names as Cælia Claudiana, Terentia Flavola, and Flavia Publicia were found among the ruins. The inscriptions show that they once bore statues of the vestals, erected by friends or relatives who had obtained favors by their intercession. It is only ten years since excavations on this spot were made. The uncovering of the Forum was begun by Pope Pius IX., and the present government has continued the work.

The three colossal arches of the basilica of Constantine are in the distance as we go toward the Forum of Trajan. This was the model of the basilica churches, of which so many were afterward built in Rome. St. Peter's is so far a copy of it as to have its nave of the same size.

Northeast of the old Forum were the forums of the emperors. They were all intended to show the wealth and splendor and to celebrate the victories of their founders, rather than for public assemblies, though the principal edifice in each of them was a temple. The Forum of Trajan is the most interesting one. The four rows of broken columns of Egyptian granite set up in it are to show the site of the Basilica Ulpia. The main entrance was through a triumphal arch. His column, so familiar from pictures, is, I suppose, the most interesting of the many columns in Rome. When Trajan began the great work of joining the forums of the old city with the Champ de Mars, by making another, his architect told him that the Quirinal and the Capitoline hills would have to be cut down to carry out his plans. Trajan's reply was that his column, then, must be as high as these hills and as high as the Tarpeian rock, or 138 feet, and so it was built.

It consists of 24 blocks of marble, which are now dark gray. There are 2,500 human figures upon it, besides horses, machines, etc. The top was originally surmounted by an imperial statue of Trajan holding in his hand a gold globe. In this globe, it is said, his ashes were placed. But in 1587 Sixtus V. put a statue of St. Peter on top. As early as the tenth century this forum was in ruins, and churches were built among the columns. At one time no less than fifty houses stood upon its site. The French government, in 1812 and 1814, demolished many of these buildings, and began the work of bringing Trajan's plan once more to light. It is to-day a most striking commentary upon the transitoriness of all human work which is put into material form.

In this unsatisfactory survey of the forums I have not attempted even to name the churches which stand partly or entirely upon the ruins of the pagan temples. Each has its own interesting history; each suggests the conquest of Christianity over heathenism; each leads one's thoughts from its own walls to the arena of the Coliseum, where, we read, the early Christians faced the lions so calmly that sometimes the beasts did not harm them, and because they would not do it, men put them to death.

A. D.  
Rome, 1894.

## A Bullet Proof Shield.

The Duke of Cambridge lately visited the Cyclops Works of Messrs. Charles Cammell & Company, Sheffield, and witnessed the testing of a bullet proof shield, manufactured by that firm, which was invented by Captain Boynton. The shield is simple in construction. It takes the form of a plate of specially prepared chrome steel, with a slot in the top for the soldier's rifle. The weight is less than one-half that of a life guardsman's cuirass, and the material has such powers of resistance that it is absolutely proof against the service bullet propelled by cordite through a Lee-Metford barrel at 30 yards distance. A bullet which would pass completely through an oak plank 30 inches thick is powerless to do more than make a slight indentation on Captain Boynton's plate, which is only three-sixteenths of an inch thick. Mr. Tucker, R. E., fired five shots at one plate from a Lee-Metford rifle, and at the request of the duke placed his shots as

nearly as possible in the same spot. This extreme test was also withstood by the plate. There was no indication of anything like perforation. Each bullet struck the shield with more than a foot-ton of energy. Before leaving, his royal highness expressed his satisfaction with the result of the test, inasmuch as not the slightest damage appeared to have been done to the shield.

## Valuable Woods.

Many of the finest woods in existence are yet unknown, or only slightly known, to the manufacturers of wood in the civilized world. The woods of Central and South America are, perhaps, the most remarkable as well as the least known. In the yet untouched forests of this continent are many woods far finer than any of those now in use. These woods range from pure white to jet black in color, and many of them are most beautifully marked and veined. Some of them are so hard that they turn the edges of axes, chisels and other tools, while the band saw cuts them only slowly. In the Columbian Exposition there were many displays of little known woods, and the finest of them were those from Argentine Republic, Brazil and other South American countries. Some of these southern woods yielded to the teeth of the band saw, not the ordinary sawdust, but fine powder, fine as the finest flour, so hard were the woods. Some of them burnt but slowly. Others possess qualities that keep them free from insects. Some of them seem to be practically indestructible by air and water. All along the eastern slopes of the Andes, up to the snow line on those great elevations, throughout all the great river valleys, and in some of the wide areas of level country in South America are great forests of fine woods that are specially fit for the finest cabinet and furniture work, and also for shipbuilding, carpentry and other industrial arts in which wood is the "raw material." These great forests are now an unknown quantity in the commercial world, but they will come rapidly into the knowledge of men and into industrial use when once the railroad has reached them. Before many years, it is safe to predict, the South American and Central American republics will be threaded by railroads, and then those wonderful woods will be drawn upon to supply the demand for new and fine woods in all the civilized countries.—The Lumber World.

## Long Passenger Trains.

In a recent issue of the Kansas City Journal it was recorded that the Kansas City, Fort Scott & Memphis R. R. had the credit of hauling the longest train of loaded passenger coaches ever drawn in the world. It was composed of twenty-three coaches, which held an average of one hundred passengers each, and was run out of Kansas City to Merriam Park, carrying the colored school children, who took a day's outing at that resort. Last year the Alton took a train of twenty-one coaches into Chicago and claimed the record on big passenger trains.

The Alton record was beaten on May 7, 1894, by the Jacksonville, St. Augustine and Indian River Railway, which ran an excursion train, consisting of twenty-two crowded coaches, from Jacksonville to St. Augustine, a distance of 38 miles, in 1 hour and 15 minutes, three minutes of which were consumed in backing out of the Jacksonville yards and six minutes in taking wood and water en route. The actual running time, therefore, was one hour and six minutes.

On Sunday, Aug. 19, 1894, however, the same line of railway actually beat the record of the Memphis route and secured the world's record for big passenger trains. The regular passenger train from Jacksonville at 8:50 that morning consisted of twenty-five loaded passenger coaches and one baggage car, besides the Schenectady locomotive, which drew the train from South Jacksonville to St. Augustine without assistance. There were about 1,500 passengers on board, and remarkably good time was made. The occasion which called out this crowd was an encampment of a portion of the Florida State troops in the ancient city, and but for some previous agitation there against Sunday excursions and military parades, it is probable that fully thirty cars would have been required to handle the business.

## The New Cunard Ships.

Recent voyages by the two new Cunard steamers Campania and Lucania, plying between New York and Liverpool, establish their records as the fastest vessels of their class now afloat. The mean speed of the Campania has been 21.5 knots per hour and the Lucania 21.65 knots. The Lucania has made 555 miles in 24 hours, being the highest known speed for that period, and equivalent to 22½ knots per hour. The round voyage of 5,598 miles has been made by the Campania in 10 days 20 hours 14 minutes. These are remarkable performances, and show how thoroughly strong and excellent the vessels must be in hulls and machinery. These ships are the greatest speeders, and, we may add, the greatest coal consumers of any of the Atlantic fleet.