and there at once arose a crop of various species of *phones*, such as the *audiphone*, the *dentiphone*, and so forth.

They have one and all failed in their purpose, being quite inefficient compared with the ear trumpet. The reasons for the failures will be plain to one who considers what the physical conditions must necessarily be.

Whenever a sound is produced in free air, the latter immediately diffuses it in every direction, the sound wave assuming a spherical form and traveling outward with a velocity, generally upward, of eleven hundred feet in a second.

Now, the strength of the sound, or in other words its energy, is proportional to the square of the amplitude of vibration, and as diffusion goes on the energy is proportionally spread, so that at a double distance the intensity is but one-fourth the original intensity. Secondly, whenever a sound wave strikes upon any surface whatever it is reflected in part as an echo and in part is absorbed; that is the body presenting the surface is itself made to vibrate, and generally the loss by reflection is as much as one-half of the energy.

Now, what is specially wanted is to bring the vibrations with their utmost energy into the ear so as to shake the appropriate bones there. In a normal ear there is energy enough in the small part of the spherical sound wave that reaches the membrana tympani to make hearing easy; but if for some such reason as a thickened membrane more energy is required to make it vibrate properly, the way to do it is either to bring the source of sound nearer to the ear, so that it shall receive the largest possible part of the spherical wave, which will be when the source of sound, say the mouth, is immediately at the conch of the ear—nothing will likely surpass that for intensity—or else, by some special device, prevent the sound from spreading in the air, and directing the wave with all its intensity into the ear, as though the mouth were at the ear.

In the light of these principles how is it with the audiphone? A more or less elastic surface is held by its edges between the teeth and hand, and some tension given to it by curvature. Of sound vibrations made in its neighborhood it receives its proportionate part of the spherical wave, of which, certainly, half will be reflected, another part will be received by the hand and lost, while the remainder will be distributed, first, to the teeth, and from them to the whole skeleton, the ear getting but a small part. Still, as the ear, even a defective one, is a marvelously sensitive organ, there may be energy enough in the vibrations that are made in this abnormal and roundabout way to enable one to hear what is said.

Any device for getting sound vibrations to the ear by the way of the bones must necessarily have these diffusive defects. None of them can bring to the ear the sound vibrations with their maximum amplitude. The ear trumpet comes nearer to the necessary conditions than anything that can be proposed; for, first, if the bell be spoken into there is no appreciable loss by reflection nor from scattering, that is, the spherical wave is not formed as it is in free air; and, second, the tube opens near to the membrana tympani, and the whole energy of the sound is spent on that.

If, however, the passage to the tympanic membrane be nearly or quite closed by the thickening of the mucous membrane, then the ear trumpet will be nearly or quite useless, as it would also be in the case of a tympanic membrane that was either too thick to respond or too flabby. In the former case nothing would be heard, and in the latter articulation would be very defective; but in general, when these abnormal conditions are not present and one cannot hear with an ear trumpet, other devices will be of no service, for the trouble is with the auditory nerve, and the judgment of a skillful aurist should be obtained in any case. When the nerve is unimpaired and the passage to the tympanic membrane is closed, it is possible for one to get some help from some form of the dentiphone; but for reasons already given one must hope but for small service from any of them. In most cases of deafness the ear trumpet is much the most efficient.

Many persons, however, are only slightly deaf, who need some aid, to whom an ear trumpet would be highly objectionable, and who would be glad of some substitute. For such persons it is well to know that the common string telephone answers well.

Theoretically it fulfills the conditions. The transmitter prevents the formation of the spherical wave to any extent, the string prevents the scattering, while the receiver fits close to the ear, and it may have an appropriate tube to enter the tympanum, in which case there is really but a very little loss. The common ones of the market costing but ten cents a pair answer every purpose. The thread need not be but two or three feet long, and the whole may be carried in the pocket. I have personally experimented with these upon deaf persons, and am assured by them that they are much helped by their use. One may talk with such a deaf person with ordinary loudness and be easily understood, when, without it, what is said must be said so loud as to be heard in distant parts of the house. A year or two ago I tried to induce a manufacturer in Boston to make for the market some of these instruments specially adapted to the wants of deaf persons, but the reply was that if made so small they could ask but a small price for them, and the demand was not enough to make it a profitable investment; but larger ones (for a show of cost) were made for business purposes, and five dollars a pair was asked. But, as said before, cheap ones are just as efficient and much more portable.

HARVEST FIGURES.

A good many curious calculations have been made in connection with the enormous crops of wheat produced by the Dalrymple farm in Dakota. A correspondent of the Chicago *Inter-Ocean* has been indulging in some new ones relative to the last harvest. From the speed of the harvester and the length of the cutting-bar he calculated that there would be 900 bundles to the acre, or seventy-five shooks of twelve bundles each. As there were 18,000 acres in the field the shooks numbered 1,350,000, and the bundles 16,200,000. Allowing thirty inches of wire to the bundle, over 7,670 miles of wire were needed for binding the crop—almost enough to reach through the earth.

PROFESSOR GAMGEE'S ICE MACHINE.

A press dispatch from Washington, dated December 22, gives a very amusing report of an exhibition of an ice machine at the Navy Yard the day before. The report states that "the great novelty of the apparatus consists in the utilizing of heat which all others waste, and the liquefaction of ammonia by expansion. Almost immediately after the machine was started a temperature of nearly zero was obtained. Chief Engineer B. F. Isherwood, in an interview with Professor Gamgee, recognized the correctness of the principle, which had now been demonstrated to be sound by actual test. The heat of southern climes, the Professor maintains, will henceforth prove no obstacle to cheap ice making, since where there is most heat, by his new system, there is most available energy wherewith to drive the machine. The consumption of coal is thus reduced to a minimum. This fact was recognized by the Board of Naval Engineers, who reported favorably on Prof. Gamgee's plans for the refrigerating ship."

Heretofore it has been held to be established, both in theory and in practice, that it costs more to freeze warm water than cold water. Given water at 32° Fah., a certain amount of heat has to be withdrawn before the water will congeal. To withdraw this heat artificially costs money, both for power and for water to carry off the heat withdrawn. With every degree of heat which the water shows above 32° Fah., more heat must obviously be withdrawn, and a larger volume of waste water will be required to carry it away before the water operated on can be frozen. Thus, even if the waste water costs nothing, the increased power required in freezing the warmer water must increase by so much the cost of the ice. This is as certain and plain as the familiar fact that it costs more to draw a load up hill than on a level. The report claims that where the heat is greatest there is the most available energy for ice making, which is equivalent to saying that he can use the load on his wagon to propel the wagon up hill.

How Far Does the Sound of Cannon Travel?

To the Editor of the Scientific American:

The battle of Bunker Hill was fought June 17, 1775. The sound of the cannon used in the engagement was distinctly heard by persons on the Deerfield River on the east side of Hoosick Mountain, where now is the town of Charlemont, Mass., the distance being one hundred and twenty miles. This is asserted in "The Memoirs of Capt. Lemuel Roberts," a rare work, printed at Bennington, Vt., 1809. Capt. Roberts was an officer in the army of the revolution. He says: "We were surprised at the hearing of a heavy cannonade from a great distance, which proved to be the battle of Bunker Hill." P. 27.

On July 29, 1812, a naval engagement, with a cannonade, lasting an hour and a half, occurred between the United States Flotilla of Delaware, Lieut. Samuel Angus commanding, and some British ships that were in the bay. The conflict transpired near Cape May, not far from a place called Crows Shoals. The firing of the cannon was heard by many persons at Washington city, the distance of which from the scene of action in a direct line is one hundred and twenty miles. This is recorded as "A Curious Fact" in Vol. 2, No. 9, page 40, of *The War*, published weekly at New York, 1812–13.

These cases are well authenticated. The cannon could not have been so large as those now in use. Are there similar instances on record? And how far distant can the report of the heaviest cannon be heard? D. T. TAYLOR.

Hyde Park, Mass.

ELECTRO-METALLURGY.

COPPER DEPOSITS.

Where it is intended to simply coat or plate another metal or alloy, the electro-deposit of copper is usually obtained by the decomposition of a double salt, such as the cyanide of copper and potassium. This process is adapted to most metals, and affords a fine uniform deposit. The following is a good bath of this description:

Water (soft)	1	gall.
Acetate of copper (cryst.)	3½	oz.
Carbonate of soda (cryst.)	3½	"
Bisulphite of soda	3	"
Cyanide of potassium (pure)	7½	"

Moisten the copper salt with water to form a paste (otherwise it is apt to float on the liquid); stir in next the carbonate of soda with a little more water, then the bisulphite, and finally the cyanide with the rest of the water. When solution is complete the liquid should be colorless. If not, add cyanide until it is.

The bath may be employed hot or cold, and requires a moderately strong circuit of electricity. A copper plate forms the anode, and it should expose surface enough to supply the loss of copper—at least a surface equal to that of the work. It must be removed when the bath is not in use.

If the liquid becomes colored, more cyanide must be added.

Large pieces are generally kept hanging motionless in the bath while the plating is in progress; small articles are moved about as much as possible, especially if the bath is warm.

The formula for the bath given above requires pure cyanide of potassium, and where the commercial article, which is often very impure, is used instead considerable allowance must be made. The following formulæ require a cyanide containing 70 to 75 per cent (a good average) of pure potassium cyanide:

COLD BATH FOR IRON AND STEEL.

Acetate of copper	3	oz
Carbonate of soda	6 1/5	"
Bisulphite of soda	3 1/5	"
Cyanide of potassium	3¼	"
Water	1	gall.
Aquaammonia	2 1/5	fl. oz.

Prepare as before.

WARM BATH.

Acetate of copper	3 1/5	oz.
Carbonate of soda	3 1/5	"
Bisulphite of soda	1 1/5	"
Cyanide of potassium	4½	"
Water	1	gall.
Aqua ammonia	1 4/5	fl. oz.

HOT OR COLD BATH FOR TIN, CAST IRON, OR LARGE ZINC PIECES.

Acetate of copper	12½	oz.
Bisulphite of soda	10	"
Cyanide of potassium	18	"
Water	5 1/5	gall.
Ammonia (aqua)	7	fl. oz.

For small articles of zinc, which are coppered in a perforated ladle and in nearly boiling baths:

Acetate of copper	16	oz.
Bisulphite of soda	3½	"
Cyanide of potassium	25	"
Aqua ammonia	5½	"
Water	4 to 5½	galls.

In the preparation of these baths the salts are all dissolved together, except the copper acetate and ammonia, which are added after dissolving together in a small quantity of the water.

The deep blue color of the ammonio-copper solution should entirely disappear on mixing it with the other solution; otherwise, it becomes necessary to add more cyanide.

The cold bath is put into well joined tanks of oak or fir wood, coated inside with gutta percha or asphaltum (genuine). The vertical sides are also covered with sheets of copper, all connected with the last carbon or copper of the battery by a stout copper wire with well-cleaned ends, the other pole of the battery being in similar connection with a stout brass rod extending the length of the tank (without any point of contact with the anodes), and from which the work is suspended by hooks or trusses in the bath.

With a thin deposit the coating is sufficiently bright to be considered finished after being rinsed and dried, but if the operation is more protracted the deposit has a dead luster on account of its thickness, and if a bright luster is desired it is necessary to use the scratch brush.

The hot baths are usually put into stoneware vessels heated by a water or steam bath, or into an enameled cast iron kettle placed directly over a fire. The vessels are lined inside with copper, the edges of the vessels being varnished or support a wooden ring upon which rests a brass circle connected with the zinc pole of the battery. The objects to be electroplated are suspended from this ring.

The hot process it more rapid than the cold, and is especially adapted to those articles which are difficult to cleanse. The articles are kept in continual agitation, which permits of the employment of a strong current of electricity. Small articles of zinc are placed in a perforated stoneware or enameled ladle, at the bottom of which is attached a copper wire which is wound up around the handle and connected with the zinc pole of the battery. It is sufficient that one of the small articles touches the wire for all to be affected by the current, as they are in contact with each other. The ladle must be continually agitated, so as to change the points of contact of the objects. What has been said in regard to strength of battery, in the article on electro-brass plating, will apply here.

COPPER DEPOSITS BY DIPPING.

This is seldom practiced except upon iron, as deposits thus obtained are generally wanting in lasting qualities, since, from the thinness of the coating, the iron is but imperfectly protected from atmospheric influences. If the iron is dipped in a solution of—

Sulphate of copper	3½	oz.
Sulphuric acid	3½	"
Water	1 to 2	galls.,

it becomes covered with a coating of pure copper, having a certain adhesion; but should it remain there a few minutes the deposit becomes thick and muddy, and does not stand any rubbing. Small articles, such as pins, hooks, and nails, are thus coppered by tumbling them for a few moments in sand, bran, or sawdust impregnated with the above solution diluted with three or four volumes of water.

ELECTRIC EXHIBITION, PARIS.—It is proposed to hold an International Exhibition and Congress at Paris in 1881.