The physical properties of dental amalgams / by the late Thomas B. Hitchcock. The physical properties and pathological action of dental amalgams ; by E.A. Bogue. Read before the New York Odontological Society at the special meeting, December 14th, 15th, 16th, 1874 : and the discussions which followed.

THE PHYSICAL PROPERTIES

OF

DENTAL AMALGAMS.

BY THE LATE

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THE PHYSICAL PROPERTIES

AND

PATHOLOGICAL ACTION

OF

DENTAL AMALGAMS.

BY

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(READ BEFORE THE NEW YORK ODONTOLOGICAL SOCIETY AT THE SPECIAL MEETING, DECEMBER 14TH, 15TH, 16TH, 1874.)

AND THE DISCUSSIONS WHICH FOLLOWED.

1875.

DENTAL AMALGAMS.

DR. T. H. CHANDLER, of Boston, read the following paper by the late Prof. Thos. B. Hitchcock, making the following introductory remarks:

I would state before commencing to read this paper that I have not added a word to it myself. It is just in the condition in which it was left by Prof. Hitchcock, with the exception of the matter of some of the experiments. I found them on detached pieces of paper, and I simply copied them off. The first part of the paper was entirely completed and written out. The last work of his life was the writing of this paper, and as he had given so much time and labor, and finally his life, to these investigations, I thought it ought not to be lost, so I volunteered my services, took the matter in hand, and carried it to completion as far as I have been able.

THE PHYSICAL PROPERTIES OF DENTAL AMALGAMS.

While in Europe, during the summer of 1871, my attention was called to certain amalgams for filling teeth. For several years previous I had, in my practice, entirely discarded the use of all alloys with mercury.

Although I occasionally saw plugs which had preserved teeth many years, experience taught me that the results obtained in the great majority of cases were decidedly poor, and in many instances entirely worthless. I felt that my experience had not been sufficient to justify me, in the face of the approbation of others, in the condemnation of all "amalgams," inasmuch as I had not really investigated them; and my opinion might, after all, be but prejudice. Therefore, after my return home, I began the study of the subject, the first attempts being made that winter in New York, in company with Dr. Bogue. Since then I have continued the investigations by a series of carefully conducted experiments. I found that, as there are many different alloys in use, and as many different ways of using them, there must necessarily be a diversity in the results obtained. Nor can these results be accidental, but must be the same in each instance with each alloy, provided the conditions be the same. Having reached this conclusion, it remained, first, to consider under what conditions we obtained the most favorable results; and next, to inquire if these conditions are such

that we may readily obtain and make use of them; or, in other words, can we obtain uniform results of a desirable nature?

In considering the subject, let us look first to the condition in which we find teeth which have been filled with amalgam.

Examination of a considerable number of teeth filled with amalgam, proves that their further decay may often be prevented by its use, though oftener we shall find a defective joint between the filling and the enamel, sometimes limited to one or two places, at others extending entirely around the filling. If, in these cases, we remove the filling, the cavity is generally found discolored and carious throughout. This could not occur, provided the cavity was properly packed, if the filling was moisture-tight, and we are obliged to conclude, that either the filling was improperly introduced, or, what is more probable, its shape has changed after being placed in the cavity.

It has for some years been well known that many of the dental amalgams contracted while hardening, and the statement has also been made that some expand. Until recently, however, no attempt has been made to ascertain the relative amount of change which occurred in the several preparations. The first experiments in this direction of which I find the record were in 1861, by Mr. John Tomes.* These consisted in making fillings in holes in slips of ivory, similar to the glass slides which are used for mounting microscopical objects. When used, the ivory slips were clamped firmly upon another piece of ivory, so that a well-shaped cavity was formed. After introducing the amalgam, and allowing it to harden, the clamp was removed, and the slip, with the filling in it, was put under the microscope. Of seven experiments with various alloys, six showed contraction of the amalgam, while the remaining one, which was a compound of pure copper and mercury, was very much superior to any of the others. Two of the six were of Sullivan's cement, which is said to be largely composed of copper. One of the simplest experiments, and one which we can all try, was first suggested to me by Mr. Thos. Fletcher, of Warrington, England. It consists in making a filling in one end of a glass tube, care being taken not to touch the end of the tube holding the plugs, for fear of false results from the action of the heat of the hand. After the filling is completed, partially fill the tube with a colored fluid,—blue ink is very suitable for the purpose. If the filling contracts, the ink will penetrate between it and the wall of the tube, and can readily be observed. Experiments made in this manner show that nearly all the amalgams contract. The same change in bulk has been shown by Mr. Chas. Tomes,† by means of the specific gravity tests. The amalgam

* Transactions of Odontological Society of Great Britain, vol. iii.

† "On the Chemical and Physical Properties of Amalgams," Transactions of Odontological Society of Great Britain, March, 1871–2, vol. iv., New Series.

to be tested is weighed in water; after it has hardened, it is again weighed in water. If it has expanded, it is buoyed up by the greater quantity of water which it displaces, while if it has contracted, it weighs more than at first. He found that in one hundred parts of the following amalgams the weight gained by each was as follows: Palladium, .037; Sullivan, .07; Ash, .14; Smale, .14; tin and silver (55 to 45), .35; tin and silver, equal quantities, .38. In each of them only enough mercury was used to render the mass sufficiently cohesive to form a solid lump by the fingers.

It is seen that those amalgams composed entirely of silver and tin have contracted the most, while Ash's and Smale's, the former of which is said to be largely composed of these metals, show a less degree of contraction. Palladium, of which I shall again speak, stands at the head. The action of the copper in Sullivan's is seen in the small amount which it gained in weight. It also makes quite satisfactory fillings in glass tubes. "Watts's Dictionary of Chemistry" states that the specific gravity of pure copper amalgam is the same after hardening as before. It seems to be fully proven that the presence of copper in an amalgam lessens the amount of its contraction.

It seems also proven that, besides the contraction of the entire mass of amalgam, another change is experienced, and one which is of great importance. I allude to the tendency of the filling to assume, when hardening, a spheroidal shape. Mr. Fletcher* says "there is little doubt that shrinkage is not the only nor worst evil, and that it is of little consequence, as compared with the tendency of many—I might, perhaps, say all amalgams—to spring away from the shape they were packed in, and to assume a globular or spheroidal form. This is a very difficult matter to test absolutely, as the measurements are exceedingly small, and a test with a large plug is not a fair one, as it may, for some not understood cause, give a false result. The reason why I have come to this conclusion, is that some of the worst amalgams, as a rule, shrink around the top edge only, remaining perfectly tight in the middle of the plug, and that the shrinkage is greatest nearest the surface. If this were shrinkage *only*, it would be equal, but a spheroidal surface would give exactly this appearance. I have been testing in tubes with sharp angles, three- and four-sided, and find that it is only with the greatest difficulty that any amalgam can be made tight.

"Of quite a number of experiments which I have made by filling three- and four-sided tubes with various amalgams of American make, and subjecting them to the ink test, all but two were found to be deficient in this respect. They all were packed dry, with a small proportion of mercury, and particular attention was paid to the corners, yet nearly all showed this tendency to assume the spheroidal or rounded shape."

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* Letter, October 28th, 1873.

In some instances we find the amalgam projecting beyond the edge of the cavity, forming an angle or groove which serves to retain mucus and particles of food. At first, one would suppose the amalgam had expanded, but, as we have seen, most of them contract. There are a few, however, which, when subjected to the proper tests, show expansion.

In 1868, Mr. Mummery* stated that "some kinds of amalgam expand in hardening, and when the enamel presents a certain angle to the surface of the stopping, the marginal fibers are often split off by the mechanical force."

Mr. Fletcher† states that amalgams composed of silver and mercury alone expand, and sometimes sufficient to split the tooth.

Mr. Kirby‡ states that amalgams of pure silver, either the precipitate or filings, expand greatly. By making plugs in glass tubes, he found that some of them were split by the expansion, while in other cases the amalgam projected from the ends of the tubes. By the use of a V-shaped trough and micrometer screw for measurement, Mr. Kirby was able to determine the change in bulk of some of the amalgams. He states that precipitated silver expanded "to the extent of $\frac{1}{40}$ diameter or more." In order to determine for myself the change in bulk of amalgams, I had a steel V-shaped trough, an inch long, made, one end being fixed, the other so arranged that after the amalgam had been packed, any expansion or contraction would be communicated to the short arm of a lever, the long arm serving as an index upon a scale made to record the thousandth of an inch. With an amalgam of precipitated silver, after fifteen hours, the expansion recorded was $\frac{2}{1000}$ of an inch; after twenty-four hours, $\frac{3}{1000}$ of an inch; after thirty-nine hours, $\frac{4}{1000}$, or $\frac{1}{250}$, of an inch, after which time there was no perceptible change. It might thence be concluded that some of these projecting fillings are caused by the expansion of the amalgam, but as very little pure silver amalgam is at present used, some other cause must be looked for.

Mr. Fletcher§ states that he has found this appearance almost entirely in cases where silver and tin, or silver, tin, and gold amalgams have been used, and he has not found it with pure silver or Sullivan's amalgam. As he has found it only with those amalgams which are known to shrink, he suggests that the plug may be raised or forced out by the "decomposition of tooth-substance and formation of gas under

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* Transactions of Odontological Society of Great Britain, vol. i., New Series, p. 26, 1868–9.

† British Journal of Dental Science, 1872, p. 392.

‡ Transactions Odontological Society of Great Britain, 1871–72, vol. iv., New Series, p. 189.

§ B. J. D. S., 1872, p. 391.

the loosened plug, the driving down and accumulation of food underneath, or some similar cause."

Another reason for this appearance, and one which I think is often the case, is because the amalgam filling, when made, is left extending over the margin of the cavity, upon the sound tooth-substance; as the filling is subjected to wear, these projecting edges break away, and this appearance is the result. Mr. C. Tomes* also recognizes this cause.

Another feature which we notice in examining amalgam fillings is their discoloration. Thus, the tissue of the tooth often shows in some cases dark or black, and often of a yellow color.

Although it is a very difficult matter to prevent this discoloration, on account of the affinity of the sulphur compounds of the mouth for the mercury, still by using this metal pure, and in as small a proportion as possible, so that it shall be entirely combined with the other metals, we may obtain the least objectionable results. But there is a great difference in the amount of discoloration of these plugs, depending upon the alloys used, the manner of using them, and the quality of the mercury with which they are combined. The test suggested by Mr. Fletcher, for determining the relative tendency of different alloys to discolor, is to nicely polish the plug and subject it to the action of sulphur in a solution of sulphuretted hydrogen.

The affinity of sulphur for silver is well known,—the result being a black sulphuret of silver. Tin alone is not acted upon by sulphur, but sulphur acts upon a silver and tin alloy, the amount of discoloration being determined by the relative proportions of silver and tin. If gold, or platinum, be added, the amount of discoloration is said to be still less. With copper it is increased. Sullivan's cement presents a very black surface. Amalgams containing copper, besides becoming black, usually stain the teeth. Mr. Tomes† states that examination of a large number of teeth which were stained by amalgams showed uniformly the presence of metallic sulphides. In regard to the deep stain from copper, he is inclined to attribute it to the following cause: "The sulphide of copper, under the influence of exposure to air and moisture, readily becomes oxidized, and forms the sulphate. Hence it is almost certain we shall have sulphate of copper formed upon the exposed surface of the filling; now this sulphate is freely soluble, and hence is likely to permeate the dentine, when it will again be converted into sulphide, whilst the sulphides of other metals, not being so readily converted into soluble salts, will not so thoroughly permeate the tooth."

Palladium, which we have seen contracts very little, turns quite dark after being in the mouth for a few weeks; the samples I have used not remaining of a steel-gray color, as I had hoped, but becoming

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* Loc. cit.

† Loc. cit.

very black. It does not, however, stain the tooth. This is because, being moisture-tight, the fluids are unable to penetrate between it and the tooth substance.

Cadmium, either alone or combined with silver, tin, or both, has been used as a dental amalgam. In 1849, Dr. T. W. Evans,* of Paris, introduced an alloy of cadmium.

Fillings of this alloy are said to have contracted largely and become quite soft. Their surface is covered with a yellow sulphide, which extends under the filling and penetrates the dentine, which is generally carious.† As far as I am aware, the use of the metal for this purpose has been abandoned.

As a rule, those fillings which expand, or do not contract, *i.e.*, those which form a moisture-tight plug, do not stain the tooth, while those which contract undergo chemical action upon their surfaces, as a result of which soluble metallic salts are produced, which by capillary action penetrate the dentine and cause discoloration.

Consideration of the Different Metals and Alloys.

Tin alone forms an amalgam with mercury, which requires considerable time to harden, and never becomes sufficiently hard to properly protect the tooth.

In combination with silver, it hardens well, but the addition of silver not only adds to the discoloration of the mass, but nearly all amalgams of tin and silver contract, and some of them to a very marked extent. Mr. C. Tomes‡ found the weight gained, when weighed in water, by 100 parts of an alloy of silver, 45, and tin 55, to be .35. These proportions are not very unlike those of Townsend's amalgam, which, according to the *Dental Cosmos*, October, 1855, is composed of silver, 4; tin, 5. My own experiments with several amalgams of this class all show shrinking and discoloration.

The addition of copper lessens the shrinkage, but increases very greatly the discoloration. Many of the earlier amalgam fillings were made of coin silver,—thus combining silver and copper,—and although they usually discolored considerably, still the results obtained, as far as regards decay around their edges and under them, were not entirely unsatisfactory. Gold alone does not harden well with mercury. When added to an amalgam of silver and tin, however, it produces a decided effect in lessening not only the shrinkage, but also the tendency to ball up and round itself in the angles; but while it does this, it greatly retards the setting.

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* American Journal of Dental Science, October, 1849.

† John Fairbank, M.R.C.S., in B. J. D. S., 1872, p. 252.

‡ Loc. cit.

The action of gold is well shown in the paper by Mr. C. S. Tomes, before alluded to. Selecting an alloy of silver and tin, which he knew contracted largely, he added gold to it in increasing proportions, and by means of the specific gravity test obtained the following results as the relative amount of contraction of each alloy:

Silver 4.5, Tin 5.5	.33
Silver 4.5, Tin 5.5, +Gold 1	.16
Silver 4.5, Tin 5.5, +Gold 2	.086
Silver 4.5, Tin 5.5, +Gold 3	.055
Silver 4.5, Tin 5.5, +Gold 4	.037

This last kept its color well, but Mr. Tomes questions if it becomes hard enough for use in the mouth.

A larger proportion of gold did not harden well. The experiments of Mr. Fletcher, by means of the glass tubes, also show that gold lessens contraction.

Mr. Kirby* states that an amalgam of an alloy of 3 silver and 2 of tin contracts slightly at first, but finally expands about $\frac{1}{500}$; 2 parts silver, 1 of tin, and about 25 per cent. gold, expands without contraction.

Ash & Sons, London, sell an amalgam which is supposed to consist of silver, tin, and gold. An alloy of gold 1, tin 2, silver 3 parts, has been used in England. It is said that these alloys keep their color well, but do not become very hard. Gold also makes the amalgam more plastic.†

We are told by Mr. Fletcher‡ that antimony also possesses this power of controlling contraction; in fact, when added to alloys of silver and tin, it causes at first slight expansion, and reduces the total contraction in about the same proportion as when gold is used.

Platinum alone, from the difficulty with which it forms an amalgam, seems to be unsuited for our purposes. When combined with tin in about equal proportions, it forms an amalgam, but does not harden well, and it becomes softer if the proportion of tin is increased.§

Mr. Tomes‖ says: "Some of the experiments made with platinum and tin furnished beautifully smooth, white amalgams, which might, I think, prove useful as temporary fillings. They keep their color well, and become sufficiently hard, with the addition of a very small quantity of silver, to stand in any position where they are not much exposed to

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* T. O. S. G. B., vol. iv. p. 189.

† Tomes's System of Dental Surgery, 1873, p. 336.

‡ B. J. D. S., 1872, p. 254.

§ Fletcher, in Brit. J. D. S., 1872, p. 90. C. S. Tomes, T. O. S. G. B., vol. iv. p. 151. C. S. Tomes, etc., T. O. S. G. B., vol. iv. p. 151.

‖ C. S. Tomes, T. O. S. G. B., vol. iv. p. 155.

mastication; and the fact that they do not shrink much, and that they remain sufficiently soft to be readily removed with an excavator, would make them probably suitable for temporary fillings."

By the addition of gold and platinum to silver and tin alloys, we obtain one agent which controls to a great degree the shrinkage, and another which causes the amalgam to harden quickly. Mr. Fletcher, who, as far as I am aware, was the first to suggest the use of an alloy of this kind for amalgams, says that the amalgam called "platinum amalgam" is composed of the ordinary silver and tin alloy with 10 per cent. fine gold, to which sufficient platinum is added to cause it to set quickly.* When used with a small amount of mercury, it becomes so hard that often at the same sitting of the patient it can be finished with files and burnishers. It moreover keeps its color well.

Palladium is a metal which is found in platinum ore, and it strongly resembles platinum in color. In very fine powder, as a precipitate, it forms an amalgam, but the two metals require considerable stirring in the mortar to cause them to combine. When the combination has begun, the palladium will take up a very large amount of mercury, and unless there is a considerable quantity used, and the amalgam is made very soft, it will harden before it can be placed in the cavity of the tooth. In consequence of the extraordinary rapidity with which it hardens, a large amount of heat is evolved, which is sometimes so great that the mass explodes. This can be avoided, and the amalgam rendered much more manageable, by using mercury in which a per cent. of pure gold has first been dissolved.

It seems that palladium amalgam has been in use to a limited extent in Europe for many years, and those who have had the most experience with it speak highly of it. As before stated, however, it becomes quite black on the surface; though I am induced to think that, in those instances in which I have used gold with it, the discoloration has not been so great. As it shrinks so slightly, there is no discoloration of the tooth-structure. The plug made by it is extremely hard and brittle. It is a metal which is very difficult to obtain. I found it impossible to purchase more than a few dwts. in this country. By sending to Europe, it can be obtained either as precipitate or plate. The price is very high, costing somewhere in the vicinity of fifty dollars per ounce.

When added to a gold, silver, and tin amalgam, it hastens the setting about the same as platinum does.

Mr. Fletcher† speaks well of tellurium, which he thinks, either alone or in combination with other metals, would make a good amalgam. The price of this also is very high.

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* Fletcher, in B. J. D. S, 1862, p. 254.

† B. J. D. S., 1872, p. 90.

Of the manner of Using the Different Metals and Alloys.

The most diverse results may be obtained by the manner in which the various amalgams are prepared; even the best may be rendered worthless by improper manipulation.

In order to obtain the best results, the mercury used should be only sufficient to cause the mass to cohere.

A true amalgam should contain no free mercury, but as usually prepared, there is a very great excess. If only a small proportion be used, the amalgam hardens very much sooner. If the cavity to be filled will permit it, the amalgam should be used very dry, and even granular; and although it is worked with some difficulty, the result obtained is much more satisfactory. The use of heated instruments in condensing facilitates the operation by rendering the mass more plastic. If the cavity is a less favorable one, use the smallest possible amount of mercury, and depend upon heated instruments to aid you. Used in this manner, quick-setting amalgam will become hard in a short time, so that at the same sitting the filling may sometimes be polished with a file and burnisher. An amalgam hardens quicker when the filings or cuttings of the alloy are moderately coarse than when they are fine. When they are freshly made, or have been kept from the air, they also harden sooner, and moreover discolor less. A quick-setting amalgam, as a rule, is greatly to be preferred to those which harden less rapidly, because it is less likely to suffer from mechanical injury, by mastication and other causes, and is less likely to discolor from the smaller amount of mercury used. It can be polished sooner, and, most important of all, it can be condensed about the edges after it has partially hardened.

Amalgam fillings should always be carefully polished and burnished, if we wish to obtain the best results. Many fillings will retain a bright surface for years if polished, which otherwise would be quite dark.

By experiment, it is shown that if Fletcher's platinum and gold alloy be combined in the proportion of 10 grs. of alloy to 5 grs. of mercury, it will require about $1\frac{1}{2}$ hours for it to become sufficiently hard to file; whereas, if 10 grs. of alloy be combined with $2\frac{1}{2}$ grs. of mercury, the plug will be hard enough to take a fine finish in 15 to 20 minutes, and to file in about 35 minutes.*

The slight amount of contraction, or change to a spheroidal surface, which some of the best preparations are subject to, occurs just before hardening, and if the edges of the filling are carefully condensed with a plugger after the amalgam is nearly hard, this change of shape can be almost, if not entirely, compensated for. This is an important point, and should always be faithfully attended to.

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* Fletcher's Letter, December 10th, 1873.

When an excess of mercury is used in amalgam, it always comes to the surface, and an unequal plug is the result; moreover, the tendency to contract, or assume the spheroidal shape, is very largely increased. Mr. G. H. Makins, Lecturer on Metallurgy in the London School of Dental Surgery, well states the case as follows:*

"Amalgams, as a rule, are compounded of a metal with mercury, which compound is further dissolved in an excess of mercury; and although, when subjected to pressure, this excess is largely squeezed out, as in larger ore operations for gold or silver separating, yet it is very difficult to do this to such an extent that no free mercury is retained. And, indeed, by much the same action as when one squeezes a sponge containing a fluid, you get the mercury forced to the whole surface, and thus, in your operations, what is so forced between the sides of the cavity and the plug, by slow and gradual vapor exhalation, is liable to leave a minute interspace."

For when too much has once been added, any pressure to which we can subject it with the chamois-skin and plyers will fail to remove all the excess. The best results will only be obtained with a very much less amount than will remain after any attempt to remove the surplus by pressure.

The use of only a proper amount of mercury precludes the washing of the amalgam. With whom the idea of washing amalgams originated I am unable to say; but it seems to be practiced to a large extent. Many of the manufacturers recommend it. If they had taken the trouble to properly test plugs made of amalgam which had been washed, they would have been less ready to advise it.

If only the proper quantity of mercury is used in making the amalgam, there is but a very small amount of oxides present, and consequently less necessity exists for their removal. By an excess of mercury we get just what the washing is designed to remove.

Even if it were possible to remove all the excess of mercury after washing, the amalgam would still contain more or less water, which can only be removed after much trouble.

Tests made by Mr. Fletcher with amalgam plugs containing an excess of mercury, and with amalgam which had been washed, gave the following results, viz.:

"The plugs mixed with an excess of mercury are distinctly more imperfect, and have a decidedly greater shrinkage in every case. The proportion of mercury left in after thorough compression with powerful plyers is about double what is necessary to make a good amalgam,—and the excess of mercury cannot be squeezed out without making the amalgam so hard as to be unworkable; also, in packing, the mer-

* "On the Union of Metals by Welding," T. O. S. G. B., vol. iv. p. 197.

cury comes to the surface of the filling, making an unequal alloy. As regards washing, when once wet, I have *never* in any single case been able to get the amalgam properly dry without an amount of trouble such as would not be taken by ninety-nine operators out of a hundred, and the water works to the face in packing. Several plugs put in smooth parallel tubes, with an amalgam which had been washed, slipped out after hardening, on the slightest force being applied. With amalgams which had not been washed, this was most decidedly never the case under any possible circumstances with amalgams of moderate shrinkage."*

My own experiments, made under similar conditions, agree entirely with the results obtained by Mr. Fletcher.

I wish now to ask your attention to an examination of the results of those experiments which were made with American amalgams. I selected several kinds—those which seemed to be used most largely—and subjected them to the following tests, viz.:

I. For shrinkage.

II. For discoloration.

The shrinkage tests were of three kinds:

1st. Fillings were made in glass tubes of one-fourth of an inch bore. The alloy was carefully weighed in each instance, and the mercury added until sufficient was present to render the amalgam plastic. In most cases, I think the mass was finer and contained less mercury than is commonly used by those dentists who do not wash their amalgams. The proportion of mercury varied in nearly every case, some alloys requiring a much larger amount than others. The plugs were most thoroughly and carefully packed, special attention being paid to the edges, which always received the final condensation. I tried to make a perfect plug in each case. As soon as the plugs were finished, the tubes were partly filled with blue ink, and to prevent its evaporating a small cork was inserted in the upper end of the tube. After several days the corks were removed and the tubes emptied of the ink. Any shrinking of the filling of course allows the ink to penetrate between it and the tube. The point for examination, therefore, is the penetration of fluid past the top edge. If there has been no leakage, this edge should be sharp and well defined. The next experiments were made in the same manner, but with amalgam which had been washed and which contained a much larger proportion of mercury. In some cases the weight of the mercury was even equal to that of the alloy, and even then a few were rather hard to wash well. Most of the amalgams were washed with warm water and soap, and, after washing, as much of the surplus mercury as it was possible to remove was pressed out

* Letter of December 10th, 1873.

with chamois-skin and plyers. These plugs, as I have before stated, did not give nearly as good results as those which contained less mercury and were not washed. I therefore determined to try another series of tests with amalgam which should contain only a minimum of mercury, having the mass rather dry and perhaps somewhat granular. With a little care these packed well, no mercury coming to the surface except in one instance. For these tests I used tubes containing corners three or four sided; unfortunately these were rounding, and not sharp or acute as we find them in the cavities of the teeth, so that they do not illustrate the drawing away from the corners as well as I had hoped.

2d. Fillings in the V-shaped trough which I have before described. These all show contraction with the exception of one of precipitated silver, which shows expansion.

When the pieces are put in the trough now, they show contraction upon their sides, *i.e.* shrinkage away from the edges, so that they rest upon their lower corner and can readily be rocked back and forth.

3d. By weighing in water, as suggested by Mr. C. S. Tomes, a given amount of amalgam was used in each case, and its specific gravity obtained as soon after mixing as possible. After twenty-four hours the specific gravity was again taken. If the mass contracted, of course its specific gravity was greater, and *vice versa.*

II. *Color Tests.* This was by the method of Mr. Fletcher, before alluded to. Two glass tubes of each kind of amalgam—one washed, the other not—were selected, and the exposed surface of the plug nicely polished; they were then placed in a solution of sulphureted hydrogen for nine hours.

The foregoing tests are not so satisfactory as could be wished. The alloys of silver, tin, gold, and platinum, seem on the whole to give the best results. Now, if good results can be obtained with this alloy once, why can they not be had uniformly? Are not all the necessary conditions under control? and can we not make use of them? It seems to me we can with two exceptions, the more important of which lies with the manufacturer. The first is one of minor importance. I refer to discoloration of the fillings in some positions in some mouths. These positions are not the masticating surfaces of the teeth, but principally the proximal and buccal. And there are many mouths in which the discoloration even here is slight. None of us expect these fillings to remain bright in the majority of mouths. Even gold fillings sometimes change color, and how much more readily may we expect the same result with alloys composed principally of metals for which many of the chemical agents of the mouth possess strong affinity.

The second, as stated, has to do chiefly with the manufacturer. In

making the alloy, the metals used should be chemically pure,—fine tin and fine silver are seldom pure, and platinum often contains iridium and copper.* The mercury is also often impure. Examination of some which was sold with an amalgam as "distilled mercury, chemically pure," showed evident adulteration to the eye, clinging to the sides of the bottle as it was turned either way.

Some of the manufacturers state that each lot of amalgam should "be thoroughly tested by a competent dentist before offering it for sale."† Now, if this test has reference to fillings in the mouth, I take exception to it,—for the result of the test cannot be known often under several months. The testing should be done by the manufacturer, and not upon each lot, but upon each ingot, and the simple yet delicate means of testing which he may readily make use of should enable him to place upon the market an alloy which, when combined with a proper amount of mercury, will give uniform results. I stated above that the exact proportions of certain alloys were of little importance, and for this reason: It is impossible by any care or experience in making them to get precisely the same results. Mr. Fletcher‡ states that the addition of the proper amount of platinum to silver and tin is "troublesome to make, as the proportion of each metal requires to be very exact, a state of things seriously interfered with by the platinum unless very great care is taken, from its curious property of combining with tin at a red heat, with an evolution of heat so intense as to drive off a large portion of the tin instantly, and occasionally to project the whole mass out of the crucible with an explosion, or to split the crucible from sudden expansion."

A uniform amalgam can only be obtained by careful testing. Mr. Fletcher§ says, "the special point is not so much the composition of the alloy, as that it is tested for shrinkage, etc., in the ingot, inch by inch." By any process of melting, it is impossible to make an alloy which will give good results always. Each ingot should be tested at least at each end, and only those which prove satisfactory should be put upon the market; the remainder should undergo correction by the addition of platinum or gold, as the tests indicate. Sometimes some of the ingots will require melting and correcting six or seven times before they are satisfactory,—they will consequently contain a much greater proportion of gold or platinum than the ingots which came right at first and needed no correction. If the manufacturers wish to place a good article in the market, and will take the trouble to do so, they can. It should be the duty, however, of every dentist before using any of these alloys to test them himself. Mr. Fletcher‖ states the case well

* Fletcher's Letter, October 11th, 1873.
† Arrington's Circular.
‡ B. D. J. S., 1872, p. 90.
§ Letter of May 11th, 1872.
‖ B. J. D. S., 1872, p. 301.

when, after saying that the tests are so easy to apply, he remarks that "the amalgams used for the future must stand really upon their own merits, and not on the statements of the makers, which up to the present have been anything but a guide to their qualities."

Since this paper was commenced, I have received from Mr. Fletcher a sample of an alloy which, when combined with mercury, makes an amalgam which is very smooth and plastic. He states that when packed it will lie absolutely dead in place as packed, without the tendency to assume the spheroidal shape, or to draw away from the corners. He says there is a slight trace of expansion before hardening, which seems to wedge it firmly without danger to a fragile tooth. It does not, however, retain its color as well as could be desired, though this may perhaps be remedied by subsequent experiments. I wish to call your attention to some tests made with it, which seem to prove that there is no contraction. Besides the tube tests, there was one in which a piece of glass bottle with a cork filling the neck was filled with the amalgam, the inner end of the cork serving as a foundation for the plug, which fitted the remaining portion of the bottle. The whole was placed in blue ink for some days. Examination showed the ink to have penetrated entirely around the cork, but there was not the least leakage about the edges of the filling.

The results of these investigations I confess have somewhat modified my views in regard to dental amalgams. The fact also that experiment has proved that more care is needed in making fillings of adhesive gold, which shall be moisture-proof, than has generally been supposed, has decided me to use amalgam for filling some cavities which are very difficult of access. While I am willing to admit that a good amalgam is better than a poor gold filling, still I do not approve of its indiscriminate or general use. If an operator is unable to manipulate gold properly, he is unqualified to practice dentistry, and his first duty to himself and his patients is to become qualified. I did not at first propose, nor did I think it necessary, to allude to any special make of amalgam, but after I commenced the tests the results obtained were so positive that I was led more thoroughly into the subject, and I then became convinced that an investigation, to be of practical value, must include the consideration of all the amalgams in common use. If these investigations, commenced for my own satisfaction entirely, shall be of any help to my professional friends, or shall lead to the placing of a uniformly reliable article in the American market, I shall feel amply repaid for the time spent upon them.

The various papers to which I have referred and often quoted, are to be found as follows, viz. :

That by Mr. J. Tomes, Transactions Odontological Society of Great Britain, vol. iii., Nov. 1861.

Those by Mr. C. S. Tomes, Mr. Makins, Mr. Kirby, T. O. S. G. B., vol. iv., New Series, 1871–72.

Those by Mr. Fletcher, in the British Journal of Dental Science for 1872 and '73. I have also given a few extracts from his private letters to me. Although he is a manufacturer, his investigations and experiments have been so extensive that his testimony is too valuable not to be used. I have also to express my many thanks to my colleagues, Drs. Wood, Chandler, and Moffatt, for the valuable assistance they have rendered me in the study of this subject.

Tests.

The tube-test for these amalgams was suggested by Mr. Fletcher, of Warrington, England, and, as it seemed eminently fair and practical, having a great resemblance to their treatment in the teeth, it was adopted.

The results with some ten alloys are given, each tested in three different ways, with two tubes to each test, and, where directions for use accompanied the powder, one of the tests was made by rigidly following them. Much of the mercury, even the re-distilled, of the shops was found impure, being largely adulterated with lead in some cases, and one lot, which came with the alloy to be used with it, warranted pure, was the worst adulterated of all.

Besides the tube-test, a micrometer was devised to measure shrinkage or expansion: a V-shaped trough exactly one inch in length, open at the top, in which the amalgam was packed. Against the end of the plug the short arm of a lever was pressed by a spring, while the long arm travelled over a scale made to measure the $\frac{1}{1000}$ of an inch. Everything was done with the utmost fairness, the tests being made by numbers, so that no one had any advantage over another from any prejudice which might exist in the mind of the experimenter.

Through the kindness of Dr. E. S. Wood, Professor of Chemistry in the Harvard Medical and Dental Schools, quantitative analyses were made of these different alloys, the results of which will be given with the results of the tests.

Arrington's, marked I. Analysis: Silver, 40 per cent; Tin, 60 per cent.

Tube tests.—I. Mixed *very* dry; leaked badly around and *through* the filling. I.*a*. Both leaked badly, but not so much as I. I.*b*. Washed with water and squeezed out mercury; both leaked more than I., and one slipped in the tube. I.*c*. Both leaked about the same as I.*a*; mixed rather dry, and not washed. I.*d*. Washed and squeezed; both leaked more than I., and one slipped in tube.

Shrinkage test.—I. Mixed rather dry, but not granular; first half-

hour, shrank .004; after twenty-four hours, shrank .0045; edges of plug very sharp.

DIAMOND AMALGAM, MARKED II. ANALYSIS: SILVER, 31.76; TIN, 66.74; GOLD, 1.50; NO PLATINUM.

Tube tests.—II. Both mixed medium dry; not washed; both leaked badly. II.*a.* Dry, and packed well; leaked, but less than II. II.*b.* Rather dry, and washed and squeezed; leaked worse than II.

Shrinkage test.—II. Mixed medium dry, and not washed; in three-quarters of an hour shrank .003; in twelve hours shrank .005; in twenty hours, no change from .005; edges and corners sharp.

HOOD'S, MARKED III. ANALYSIS: SILVER, 34.64; TIN, 60.37; GOLD, 2.70; IRON, 2.29.

Tube tests.—III. Mixed medium dry, and not washed; leaked only at the edges, which in spots are not well defined. III.*a.* Mixed dry; leaked a little more than III. III.*b.* Washed and squeezed; leaked more than III.; edge not well defined.

Shrinkage test.—III. Mixed medium dry, packed well; in three hours shrank .001; in six hours, shrank .002; after twenty-four hours, remained the same; edge sharp.

JOHNSON & LUND'S, MARKED IV. ANALYSIS: SILVER, 38.27; TIN, 59.58; PLATINUM, 1.34; GOLD, .81.

Tube tests.—IV. Mixed medium dry, not washed; leaked but little, and only at the edge, which is sharp. IV.*a.* Mixed dry and packed well; leaked considerably. IV.*b.* Washed and squeezed; edge of one poor; other about the same as IV.

Shrinkage test.—IV. Mixed medium dry; in one-quarter of an hour, shrank .001; in eight hours, shrank .001+; in twenty-four hours, no change.

LAWRENCE'S, MARKED V. ANALYSIS: SILVER, 47.87; TIN, 33.68; COPPER, 14.91; GOLD, 3.54.

Tube tests.—V. Mixed medium dry; both leaked, one considerably, the other badly. V.*a.* Mixed dry and packed well; leaked at edge, but not so much as V. V.*b.* Washed and squeezed; both leaked badly; one dropped out of the tube, and the other slipped.

Shrinkage test.—V. Mixed medium dry; after two hours, shrank .001; after four and one-half hours, shrank .002; after thirteen and one-half hours, shrank .003; after twenty-four hours, no change.

MOFFITT'S, MARKED VI. ANALYSIS: SILVER, 35.17; TIN, 62.01; GOLD, 2.82.

Tube tests.—VI. Mixed dry; one leaked slightly, and only at a part of the edge; it seems as if it had expanded from lower edge of the tube;

one had no leak; the edge sharp and well defined; the mercury on both plugs seemed to flow freely to the lower surface, and on turning the tube flows back to part then lowest. VI.*a*. Mixed dry; plugs hard; edge sharp and clean, except at one point, which may be defect in packing. VI.*b*. Washed and squeezed; no leak; edges of both good, and well marked; same freedom of motion of mercury as in VI.; plugs not very hard.

Shrinkage test—VI. Mixed medium; after one-quarter of an hour, shrank .001; after twelve hours, shrank .002; after twenty-four hours, no change.

PRECIPITATED SILVER, MARKED VII.

Tube tests.—VII. Mixed dry; both leaked considerably. VII.*a*. Washed and squeezed; both leaked badly, and both projected from end of tube; fillings very soft.

Shrinkage test.—VII. Mixed medium; after fifteen hours, expanded .002; after twenty-four hours, expanded .003; after thirty-nine hours, expanded .004+; after fifty-seven hours, no further change.

TOWNSEND'S, MARKED VIII. ANALYSIS: SILVER, 40.21; TIN, 47.54; COPPER, 10.65; GOLD, 1.6.

Tube tests.—VIII. Mixed very dry; both leaked considerably. VIII.*a*. Mixed dry; both leaked considerably along the entire edge, and in some places through the whole thickness of the plug. VIII.*b*. Washed and squeezed; both leaked badly, and both slipped.

Shrinkage test.—VIII. Mixed medium; in five minutes, shrank .001; in forty minutes, shrank .002; in two hours, shrank .003; time not given, shrank .004; in twenty-six hours, shrank .005; in one month, shrank .006.

TOWNSEND'S IMPROVED, MARKED IX. ANALYSIS: SILVER, 39.00; TIN, 55.69; GOLD, 5.31.

Tube tests.—IX. Mixed dry, and granular; one leaked; edge poorly defined; other leaked considerably, and seems to have slipped in the tube. IX.*a*. Mixed dry; leaked at edge, which is poorly defined; about the same as IX. IX.*b*. Washed and squeezed; both leaked badly, and appear as if they had slipped.

Shrinkage test.—IX. Mixed medium; in one-quarter hour, shrank .018; after twelve hours, shrinkage had lessened to .014.

WALKER'S, MARKED X. ANALYSIS: SILVER, 34.89; TIN, 60.01; PLATINUM, 0.96; GOLD, 4.14.

Tube tests.—X. Mixed dry; both leaked at edges, which were poorly defined. X.*a*. Mixed dry; no leak, and sharp and well-defined edge. X.*b*. Washed and squeezed; both leaked at edges.

Shrinkage test.—X. Mixed medium; in one-half hour, shrank .001; in two and one-half hours, shrank .002; in twenty-four hours, no change.

All contained traces of iron.—E. S. WOOD.

Dr. E. A. Bogue read the following paper:

THE PHYSICAL PROPERTIES AND PHYSIOLOGICAL ACTION OF DENTAL AMALGAMS.

In my last communication before this Society on the subject of "Amalgams," I expressed the opinion "that much more should be known in regard to these compounds, before they are generally adopted or rejected by the profession."

Since that time I have prosecuted still further some experiments looking toward the settlement of some of the questions that arise in connection with the use of amalgam fillings in the teeth.

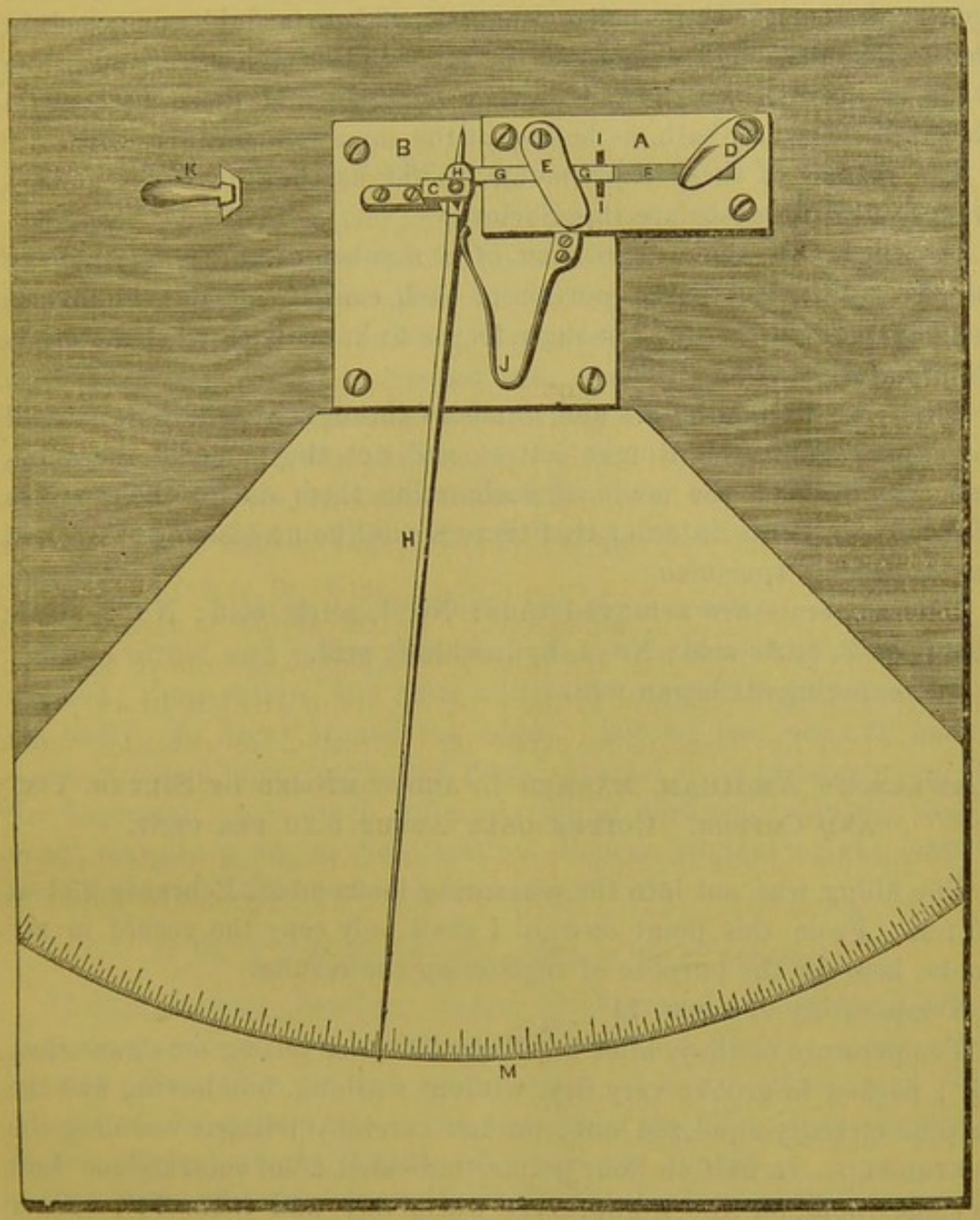
As there is a large number of different alloys in common use, I selected twelve of those which have come most prominently to notice, and subjected them first to tests for linear contraction or expansion, in an instrument designed for the purpose; but in view of the fact that the late Dr. Hitchcock was conducting a series of experiments on the physical properties of amalgams, my own researches in that direction have been only incidental, and must not be supposed to have been conducted with the same care as the experiments of Dr. Hitchcock.

Attention has been more particularly directed towards the mooted question, as to whether any of the ordinary amalgam fillings have any physiological action upon the human system.

With this object in view, I had a water-bath prepared, inside of another water-bath, that a perfectly uniform temperature might be maintained. To the inner bath was attached a thermometer, and beneath the outer bath was placed a Bunsen gas-burner. Into this apparatus forty-eight bottles at a time were placed, each containing a quarter of an ounce of saliva, and seven drops of one of the following acids,—nitric, hydrochloric, citric, and acetic; the two former being taken because they readily act upon most of the metals to be tested, and because used in medical practice, especially hydrochloric acid. The two latter were chosen because they are in constant use as food, and because their effect upon the teeth is supposed to be most deleterious.

Each amalgam, therefore, of the twelve, was placed under the influence of all four of these acids in the following manner: A tooth was excavated, and carefully filled, the filling being finished in the usual way, after hardening. This filled tooth, together with a pellet of the same amalgam as that contained in the tooth, which had first been soaked in saliva, then washed in clear water, and then weighed carefully to the $\frac{1}{10000}$ part of a gramme, was placed in the bottle of saliva, acidulated as before described, and kept at blood heat, or about 100°, for a little over three months, when teeth and pellets were re-

moved from each bottle singly, washed in clear water, and once more carefully examined and weighed.



DESCRIPTION OF THE INSTRUMENT FOR MEASURING THE CONTRACTION OR EXPANSION OF DENTAL AMALGAMS.

A, a steel plate with a groove running from near *D*, at the right, to the end of the plate at the left, and being about one inch and three-quarters long. *I,I*, a slot exactly one inch from the right-hand end of the groove for the gate *K* to rest in while a filling, *F*, is being inserted. *GG*, a bar of polished steel sliding easily in the groove, one end of which rests against the filling *F*, and the other against the circular part of the pointer *H*. Beneath this steel plate is another, *B*, on which the pointer *H* is suspended at *C*, on two points like a compass-needle, that it may move freely. *J* is a light spring pressing the upper end of the pointer against the bar *G*, so that it will follow up the filling, *F*, in case of contraction. *E* and *D* are slides to hold the filling and bar down in their places, that no upward movement might be mistaken for a contraction. This apparatus is screwed to a mahogany board, and a paper scale arranged by means of microscope glasses, so that one degree of the scale at *M* equals one-thirty-six-hundreth of an inch at *F*.

Upon the completion of the first series of experiments, as the acetic and citric acid tests did not seem to be severe enough to destroy the

enamel of the teeth experimented upon, the fillings were filed down and burnished once more, and the little pellets were again weighed, and then each tooth with its pellet was dropped into a fluid, composed, in one bottle, of one-half saliva and the other half lemon juice, and in the other, of one-half saliva and one-half vinegar, and these were again placed in the water-bath, as before, at the same temperature, 100°.

The results of these experiments, so far as they have yet gone, I propose now to lay before this Society.

In doing this, the composition of a number of the alloys will be stated; not the relative proportion of each constituent, nor the precise mode of manufacture, but enough for us to know with what materials we are working.

The same Roman letters and numbers throughout will designate all the experiments; the Roman letters, and not the name of the amalgam, having been the mode of designating them during the progress of the experiments, in order that there should be no bias for or against any individual specimen.

The numerals are arranged thus: No. 1, nitric acid; No. 2, acetic acid; No 3, citric acid; No. 4, hydrochloric acid.

The experiments began with

Lawrence's Amalgam, marked I., and composed of Silver, Tin, and Copper. Copper only about 5.20 per cent.

The filling was put into the measuring instrument, February 23d, at 10 P.M. From this point onward I shall only copy the record in my books, kept for the purpose of registering the results.

Temperature of room, 74°.

Temperature of alloy, after handling, 77°; rise during amalgamation, $2\frac{1}{4}$°; packed in groove very dry, without washing, but having had the surplus mercury squeezed out; packed carefully without warming the instruments. In half an hour pointer indicated 2° of contraction. Left in same room for the night; very warm day, and room 74°. After washing with alcohol, put the rest into $\frac{1}{8}$-inch glass tube, held in the fingers, packing against wood plunger. Some squeezed by. Inverted it in a solution of indigo, in same room. After two days the pointer indicated 5° of contraction, which was not altered during a week.

Filling very brittle; broke into three pieces in removing from the measuring instrument.

Second trial. A little more mercury, other conditions being the same. Twenty-four hours gave $5\frac{1}{2}$° of contraction, ingot manifestly imperfect; filling in the tube admitted the indigo to about one-third its length. Filling quite hard and strong.

No. 1.—Nitric acid test, after three months' insertion.

Metal good color; tooth discolored around the edge of filling, but not badly; enamel not injured by the acid; cementum also uninjured, apparently; fluid quite offensive and turbid, of a brownish color. Pellet, original weight, 0.3157; after first test, 0.3198.

No. 2.—Acetic acid test, three months.

Fluid clear, offensive odor; enamel completely disintegrated, so as to be removed by the finger-nail for quite a depth; root soft and brown; color of the metal a little dark, but on the whole not bad; decay no worse at the margins of the filling than elsewhere; whole tooth covered with glistening crystals. Second test, one-half saliva, one-half vinegar, during ten days; enamel superficially disintegrated; roots much softened; filling slightly discolored, but not roughened; margins of filling good; no decay more than elsewhere over the entire tooth. Pellets, original weight, 0.3190; after first test, 0.3162; after second test, 0.3162.

No. 3.—Citric acid test, three months.

Fluid turbid and yellow, not very offensive; enamel not perceptibly affected; roots yellow, and quite a little softened; filling darkened, but not badly; no decay around the edges. Second test, one-half saliva, one-half lemon juice, during ten days; enamel so as to be removed by the finger-nail; root much softened; filling dark color, but not roughened; margins good; no discoloration. Pellets, original weight, 0.3257; after first test, 0.3257; after second test, 0.3257.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, very offensive; enamel disintegrated over all the surface; root clear, yellow, somewhat softened, but not deeply; a few small crystals discernible on the roots; color of metal good, very little blackened; decay no worse at the margins of the filling than elsewhere. Pellet, original weight, 0.3325; after first test, 0.3330.

The teeth were then dropped into indigo for forty-eight hours, after which they were sawed open through the filling, one-half of which was removed to note the condition of filling and tooth. The blue color had run completely around three of the fillings, which were all large, and did not show defective margins before the teeth were cut open.

The next alloy tested was,—

RUBENCAME & BARKER'S DIAMOND AMALGAM, MARKED II., AND COMPOSED OF SILVER, TIN, GOLD, AND PLATINUM.

Put in the measuring instrument under the same conditions as the preceding. In five minutes the pointer began to move; in fifteen minutes it indicated a little more than 2° of contraction; next morning it

showed a contraction of 5½°, which was not varied from at the end of twenty-four hours. A filling in a glass tube, containing a larger proportion of mercury, did not show contraction; but the tube was held in the hand during its insertion. Teeth filled with it, and soaked in indigo after the tests of acids, had the blue color run around two fillings badly, one a little, and one not any. Filling rather hard, and very strong when fully set.

No. 1.—Nitric acid test, three months.

Fluid clear, not offensive; enamel badly disintegrated; roots yellow, somewhat softened; metal quite dark; edges of filling good; scarcely any more decay there than elsewhere; crystals in small numbers on the roots; fingers whitened with disintegrated tooth from handling; magnifying-glass used in nearly all of the examinations of the margins of the fillings. Pellet, original weight, 0.2938; after first test, 0.2942.

No. 2.—Acetic acid test, three months.

Fluid clear, slightly yellow, very offensive; enamel not affected, roots very slightly; filling very dark, but seemingly sound at the margins; tooth very dense. Second test for ten days, one-half saliva, one-half vinegar; enamel not much disintegrated; root somewhat softened; filling slightly discolored, but smooth; margins excellent. Pellets, original weight, 0.3120; after first test, 0.3120; after second test, 0.3122.

No. 3.—Citric acid test, three months.

Fluid turbid and yellow, not very offensive; enamel not affected; roots somewhat softened, and quite yellow; filling very slightly darkened; no decay perceptible at its margins. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, so as to be removable with finger-nail; root much softened; filling smooth, slightly darkened; margins good. Pellet, original weight, 0.3020; after first test, 0.3007; after second test, 0.3003.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, slightly yellow, not very offensive; enamel entirely disintegrated over all its surface; roots yellow, much softened, and covered with crystals; filling very black, but seemingly perfect around the margins. Pellet, original weight, 0.2965; after first test, 0.2973.

JOHNSON & LUND'S EXTRA AMALGAM, MARKED III., AND COMPOSED OF SILVER, TIN, GOLD, PLATINUM, AND A TRACE OF CADMIUM.

Temperature of room when measurement was taken, 70°; no rise during amalgamation; pointer indicated 4½° of shrinkage in fifteen minutes; twenty-four hours later, pointer indicated 5°, after which no further change for some days; after a week or more, the pointer indi-

cated 16° of shrinkage; filling pretty hard, and very strong when fully set; when soaked in indigo the blueing scarcely penetrated the edge of one filling, the others not at all; fillings pretty large.

No. 1.—Nitric acid test, three months.

Fluid clear, not offensive, strong of the acid; enamel much disintegrated; roots slightly so; filling a dirty brown, but clear underneath that surface; no more decay visible at the margins than elsewhere; filling quite soft, and evidently disintegrated on the surface. Pellet, original weight, 0.2922; after first test, 0.2920.

No. 2.—Acetic acid test, three months.

Fluid all evaporated; tooth somewhat disintegrated on one side; that same half of filling also roughened, and dull in color; no decay around the margins. Second test, ten days; one-half saliva, one-half vinegar; enamel not disintegrated; root much softened; filling bright and smooth; margins good. Pellet, original weight, 0.2607; after first test, 0.2613; after second test, 0.2610.

No. 3.—Citric acid test, three months.

Fluid all evaporated; tooth quite yellow; roots slightly softened; enamel bright and not affected; filling dark and rough, but bright beneath that surface; apparently not decayed around the margins. Second test, ten days; one-half saliva, one-half lemon juice; enamel disintegrated, superficially removable with finger-nail; root much softened; filling quite dark, but smooth; margins good. Pellet, original weight, 0.2678; after first test, 0.2685; after second test, 0.2680.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, quite offensive; enamel a good deal disintegrated; roots slightly so; filling very dark brown, but clear beneath that surface; edges discolored; filling evidently disintegrated on surface, and quite soft. Pellet, original weight, 0.2752; after first test, 0.2752.

Walker's Excelsior Amalgam, marked IV., and composed of Silver, Tin, Gold, and Platinum.

Measurement test, first trial, shrank in all 8°; second trial, packed dry without washing; amalgamated with great difficulty; packs badly; granular; temperature of room, 72°; amalgam shrank in fifteen minutes 3°; no further shrinkage perceptible for twenty-four hours, which ended the second test; filling not very hard, and quite brittle; when soaked in indigo the color scarcely penetrated at all around any of the plugs.

No. 1.—Nitric acid test, three months.

Fluid clear, not offensive; filling covered with crystals, few on roots; enamel much disintegrated, can be removed with the finger-nail; roots

yellow, somewhat softened, not much; filling dark-brown on surface; bright immediately beneath; margins of filling, partly on enamel, partly on dentine, not more imperfect than the tooth elsewhere; filling soft, easily cut, much corroded on surface, and overlaid with a brown deposit. Pellet, original weight, 0.2813; after first test, 0.2827.

No. 2.—Acetic acid test, three months.

Fluid clear and bright; enamel apparently perfect; roots slightly softened; filling dark-brown on the surface, bright immediately underneath; darkened all around the filling, as we often see in the mouth. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root softened; filling very slightly discolored, but smooth; margins good. Pellet, original weight, 0.3023; after first test, 0.3023; after second test, 0.3023.

No. 3.—Citric acid test, three months.

Fluid little yellow, rather offensive; enamel perfect; root but very slightly softened; filling very dark on the surface, bright immediately below; margins good; no decay or discoloration around them. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can remove it with the finger-nail; root much softened; filling dark, and slightly roughened; margins fair. Pellet, original weight, 0.2877; after first test, 0.2875; after second test, 0.2870.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, offensive odor; enamel quite decomposed superficially; roots softened somewhat, and apicial foramen much enlarged by solution; filling dark-brown on surface, bright underneath; perfect at margins, and not discolored beyond; surface of filling considerably corroded. Pellets, original weight, 0.3035; after first test, 0.3038.

Holmes's Star Amalgam, marked V., composed of Silver, Tin, and Gold.

In putting it into the measuring instrument, it was put in dry, without washing, and with as little mercury as would allow working; temperature of room, 70°; in fifteen minutes it shrank 3°; next morning it had shrunk to 5°; after that, for several days, no further shrinkage; works freely; takes up considerable mercury; filling quite hard, and rather strong; when soaked in indigo, the color penetrated only just below the margin of any of the plugs.

No. 1.—Nitric acid test, three months.

Fluid clear, not offensive; enamel much disintegrated; roots somewhat so; crystals on roots; filling dark, but clear; margins good; though the tooth itself is very defective, it showed no more decay around the

filling than elsewhere; filling not corroded; still burnished, though dark. Pellet, original weight, 0.2962; after first test, 0.2978.

No. 2.—Acetic acid test, three months.

Fluid turbid, very offensive; enamel not affected; roots very little; filling very dark, bright just below the surface; margin good; no decay or discoloration. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root much softened; filling bright and smooth; margins excellent. Pellet, original weight, 0.2788; after first test, 0.2792; after second test, 0.2795.

No. 3.—Citric acid test, three months.

Fluid quite offensive, slightly turbid, yellow in color; enamel unaffected; roots slightly softened; filling rather dark, but powder and stick makes it bright and clear again; margins of filling good; no decay or discoloration visible. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, and slightly soft under the finger-nail; roots much softened; filling slightly discolored, but smooth; margins excellent. Pellet, original weight, 0.2753; after first test, 0.2753; after second test, 0.2747.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, offensive; enamel quite disintegrated; roots much softened; filling very black, bright just beneath the surface; margins all right; next the enamel seems a little decayed on the side toward the root; surface of filling quite rough, and superficially corroded. Pellets, original weight, 0.2973; after first test, 0.2980.

ARRINGTON'S NEW AMALGAM, MARKED VI., AND COMPOSED OF SILVER AND TIN.

Put into the measuring instrument with the temperature of room 74°; mixes easily; inserts with facility; pointer indicated 3° of contraction in six minutes; filling inserted rather soft; twenty-four hours later, pointer showed 4½° of contraction, after which no further time was allowed. This amalgam is not hard, and is quite brittle when first put in; strong after fully set; when soaked in indigo, the color went all around one plug, around the margins only of two; one was not removed, but it seems colored.

No. 1.—Nitric acid test, three months.

Fluid somewhat turbid, not very offensive; enamel superficially disintegrated; roots yellow, softened, and the apex dissolved away; filling purple, color of dark watch-spring, but still polished bright beneath the surface; margins good, not decayed more than the rest of the tooth. Pellet, original weight, 0.3057; after first test, 0.3065.

No. 2.—Acetic acid test, three months.

Fluid clear, not very offensive; tooth untouched by the acid; filling as bright as when put in acid; margins perfect. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root softened; filling bright and smooth; margins excellent. Pellet, original weight, 0.2965; after first test, 0.2965; after second test, 0.2965.

No. 3.—Citric acid test, three months.

Fluid clear, but yellow, rather offensive; enamel scarcely affected; roots slightly so; apex dissolved off; filling very black; margins perfect; no decay or discoloration of the tooth at margins. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated so as to be removable with the finger-nail; root much softened; filling dark but smooth; margins fair. Pellets, original weight, 0.2952; after first test, 0.2952; after second test, 0.2940.

No. 4.—Hydrochloric acid, three months.

Fluid clear, quite yellow, quite offensive; enamel much disintegrated; roots somewhat softened; filling lead color, smooth; margins good; filling seems to stand out at margins as though expanded. Pellets, original weight, 0.2637; after first test, 0.2653.

TOWNSEND'S AMALGAM, MARKED VII., AND COMPOSED OF SILVER AND TIN.

Filling put in the measuring instrument while the temperature of room was 72°; alloy mixes less easily with mercury than some others; forms a granular mass, unless very thoroughly mixed; put in quite stiff; packed well; pointer indicated 3° of contraction within ten minutes. Filled Dr. Hitchcock's machine at the same time, second mixing; after twenty-four hours pointer indicated $8\frac{1}{2}$° of contraction. In Dr. Hitchcock's measurer the contraction was 3°; filling pretty hard, and quite strong when fully set; when soaked in indigo, the color went all around one plug, and around the margins only of three.

No. 1.—Nitric acid test, three months.

Fluid slightly yellow, not offensive, clear; enamel much disintegrated; roots somewhat softened; filling black, covered with crystals; blackness extends to quite a depth below the surface; margins apparently good. Pellets, original weight, 0.2665; after first test, 0.2678.

No. 2.—Acetic acid test, three months.

Fluid brownish-yellow, offensive; enamel not affected; roots slightly softened; filling copper color in the middle, mottled with black; tooth slightly discolored around the filling; very slightly discolored on the surface of filling; not very deep. Second test, ten days, one-half

saliva, one-half vinegar; enamel not disintegrated; roots softened; filling bright and smooth; margins good. Pellets, original weight, 0.2747; after first test, 0.2752; after second test, 0.2752.

No. 3.—Citric acid test, three months.

Fluid turbid, light yellow; odor bad; enamel unaffected; roots slightly softened; filling black; copper-colored spots under the glass, bright a little distance beneath the surface; margins seem pretty good, though not perfect. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can remove it with the finger-nail; root softened; filling slightly discolored; margins poor. Pellets, original weight, 0.2955; after first test, 0.2958; after second test, 0.2960.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, slightly yellow, not very offensive; enamel softened all over; roots very slightly; filling lead color, bright beneath the surface; margins good; superficial oxidation, with slight roughening. Pellets, original weight, 0.2835; after first test, 0.2840.

Fletcher's Platinum and Gold Alloy, marked VIII., and yielding upon Assay these two different Results: Gold, 3.60; Platinum, 3.30; Silver, 37.63; Tin, 55.47. Gold, 5.10; Silver, 39.50; Tin, 55.40; Platinum, none.

When measured, the temperature of the room was 72°; alloy amalgamates easily; packs well; requires but a small amount of mercury to get a plastic mass; mercury packs freely to the surface if in excess; the pointer, in fifteen minutes, indicated 2° of contraction in my instrument, and one-half of 1° in Dr. Hitchcock's; packed glass tube at same time, and dropped it into the colored solution at 100° F.; in twenty-four hours pointer showed no change in either instrument, having both been in the same room at about the same temperature, steadily day and night; filling quite hard and rather brittle; indigo did not penetrate around the margins of any of the plugs.

No. 1.—Nitric acid test, three months.

Fluid clear, not offensive; enamel much disintegrated, though superficially; root considerably softened; filling covered with crystals, quite black and rough; after scraping, was found bright and perfect at margins; no decay or discoloration of the tooth; filling considerably oxidized, but not deeply. Pellet, original weight, 0.2865; after first test, 0.2877.

No. 2.—Acetic acid test, three months.

Fluid turbid, quite offensive; enamel not affected; roots slightly discolored only; filling black; perfect around the margins; tooth not discolored. Second test, ten days, one-half saliva, one-half vinegar;

enamel not disintegrated; root softened; filling black, but smooth; margins good. Pellet, original weight, 0.2480; after first test, 0.2480; after second test, 0.2488.

No. 3.—Citric acid test, three months.

Fluid slightly yellow, and offensive; enamel not affected; roots slightly softened; filling lead color, bright just beneath the surface; margins perfect. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can be removed by finger-nail; root softened; filling black, but smooth; margins good. Pellets, original weight, 0.2872; after first test, 0.2872; after second test, 0.2867.

No. 4.—Hydrochloric acid test, three months.

Fluid clear, not offensive, nearly evaporated; filling lay upward; enamel entirely soft on under side of tooth; root much softened; filling good and bright; margins perfect. Pellet, original weight, 0.2955; after first test, 0.2935.

Hood & Reynolds's Amalgam, marked IX., and composed of Silver, Tin, and Gold.

When put in the measuring instrument the temperature of the room was 74°; it amalgamates easily and smoothly with a moderate amount of mercury; packs easily; pointer indicated 2° of contraction in ten minutes after insertion; packed also a glass tube, which was dropped into the colored fluid in the water-bath at 100°; in twenty-four hours pointer showed 3° of shrinkage in my instrument, 1° in Dr. Hitchcock's; filling not hard, and rather brittle; indigo penetrated only just below the margins of the fillings.

No. 1.—Nitric acid test, three months.

Fluid turbid, yellow, offensive; enamel disintegrated all over; root softened; filling lead color, bright when burnished; margins good, without discoloration; filling pretty hard, but brittle. Pellet, original weight, 0.2838; after first test, 0.2850.

No. 2.—Acetic acid test, three months.

Fluid yellow, offensive; enamel not affected; roots scarcely; filling bright; margins good; tooth somewhat discolored around. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root softened; filling slightly discolored, but smooth; margins perfect. Pellet, original weight, 0.3030; after first test, 0.3030; after second test, 0.3030.

No. 3.—Citric acid test, three months.

Fluid turbid, light yellow, odor sour; enamel not affected; roots softened and yellow; filling lead color, but smooth; margins perfect.

Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can be removed with the finger-nail; root softened; filling dark, but smooth; margins good. Pellet, original weight, 0.2935; after first test, 0.2905; after second test, 0.2902.

No. 4.—Hydrochloric acid test, three months.

Fluid turbid and brown, offensive; enamel disintegrated all over; roots yellow and softened; filling black, but smooth; margins good, but filling seems started out from the cavity, as though expanded; filling hard and strong. Pellet, original weight, 0.3355; after first test, 0.3355.

COPPER AMALGAM, MARKED X., AND COMPOSED OF COPPER PRECIPITATED UPON MERCURY.

When put into the measurer, the temperature of room was 74°; it requires heating until the mercury is developed, then rubbing and packing; it packs easily, and becomes very hard, but black; the pointer stood, after six hours, in the same position it was placed in when the filling was put in; twenty-four hours later the pointer was in the same position, the filling having neither contracted nor expanded; indigo did not penetrate between filling and tooth in one case; the other was not removed.

No. 1.—Nitric acid test, three months.

Fluid green, nearly evaporated; enamel badly disintegrated; roots quite softened; filling green, black beneath that, bright still farther down; margin good; filling hard. Pellet, original weight, 0.2862; after first test, 0.2780.

No. 2.—Acetic acid test, three months.

Fluid green, not offensive, nearly evaporated; enamel not affected; root slightly so; filling black; margins green all around; seems close, however, even to the glass. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root soft on surface; filling very dark; margins smooth. Pellet, original weight, 0.3197; after first test, 0.3190; after second test, 0.3137.

No. 3.—Citric acid test, three months.

Fluid clear, light green, odor sour, slightly; enamel not affected; root jet black, slightly softened; filling light lead color; margins good. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can be removed by the finger-nail; root softened; filling dark, green on edge; margins good; no more decay than elsewhere.

No. 4.—Hydrochloric acid test, three months.

Fluid nearly evaporated, green, rather offensive; enamel disintegrated, and very green; roots very dark; green deposit on them; filling

covered with brown crystals; below that, filling dissolved out, leaving a glistening surface; margins seem good.

PRECIPITATED PALLADIUM, MARKED XI.

Inserted in the measuring instrument with the temperature of room at 70°; amalgam sets so rapidly that no variations were noted; pointer did not move for fifteen minutes after filling was inserted; next morning it was found indicating 9° of expansion, and did not vary from that point for twenty-four hours; repeated the experiment with Dr. Hitchcock's machine; in removing the ingot from my measurer, I broke the filling into three or four pieces; it seemed to have really expanded; put a large amount into Dr. Hitchcock's measurer, and in twenty-four hours the pointer indicated 15° of expansion by his scale; filling very hard and brittle, like glass; little elasticity about it; indigo did not go around one plug, the other was in a dry tooth which soaked.

No. 1.—*Nitric acid test, three months.*

Fluid clear, slightly yellow, slightly offensive; enamel much disintegrated; root yellow and softened; filling lead color. Pellet, original weight, 0.3622; after first test, 0.3617.

No. 2.—*Acetic acid test, three months.*

Fluid yellow, disagreeable; tooth not acted on; filling dark lead color; hard and bright just below the surface. Second test, ten days, one-half saliva, one-half vinegar; enamel slightly soft; can be removed with an excavator; root softened; filling dark; margins perfect. Pellet, original weight, 0.3562; after first test, 0.3563; after second test, 0.3562.

No. 3.—*Citric acid test, three months.*

Fluid clear yellow, brown sediment; enamel not affected; root dark brown; filling nearly lead color, but hard and clear just below the surface. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can be removed with the finger-nail; root softened; filling very dark; margins good. Pellet, original weight, 0.2572; after first test, 0.2267; after second test, 0.2267.

No. 4.—*Hydrochloric acid test, three months.*

Fluid yellowish brown, not very offensive; enamel somewhat softened; roots dark brown, slightly soft; filling dark lead color, hard and bright beneath the surface. Pellet, original weight, 0.3343; after first test, 0.3318.

PRECIPITATED SILVER, MARKED XII.

Put in measurer with temperature of room at 74°; precipitate does not amalgamate easily, and takes up a large comparative amount of

mercury; packs with difficulty, and shows a tendency to rise or move from the sides of the trough; after five hours, showed one-half of 1° of shrinkage in Dr. Hitchcock's instrument; makes a very hard and strong filling when set; next morning, showed 8° of expansion; after twenty-four hours, showed 20° of expansion; indigo barely penetrated around the margins of the fillings.

No. 1.—*Nitric acid test, three months.*

Fluid turbid, yellowish, offensive; enamel superficially disintegrated; roots slightly softened; filling bright and hard; margins perfect; no discoloration. Pellet, original weight, 0.3050; after first test, 0.3052.

No. 2.—*Acetic acid test, three months.*

Fluid yellowish, offensive; enamel not affected; root blackened; filling fairly bright; margins good; tooth not discolored at margins. Second test, ten days, one-half saliva, one-half vinegar; enamel not disintegrated; root very soft; filling very bright; margins good. Pellet, original weight, 0.2840; after first test, 0.2838; after second test, 0.2838.

No. 3.—*Citric acid test, three months.*

Fluid clear, very offensive; enamel not affected; roots quite brown; apex dissolved off and somewhat soft; filling bright, hard, clear, and perfect at margins. Second test, ten days, one-half saliva, one-half lemon juice; enamel disintegrated, can be removed by the finger-nail; root soft; filling very bright; margins good. Pellet, original weight, 0.3535; after first test, 0.3535; after second test, 0.3535.

No. 4.—*Hydrochloric acid test, three months.*

Fluid dark brown, very offensive; enamel all soft; root dirty brown, and quite soft; worst looking tooth, save one, in the whole lot; filling bright and clear; margins raised, as though expansion had taken place; decay same as elsewhere. Pellet, original weight, 0.3383; after first test, 0.3388.

Fletcher's Expanding Amalgam works soft and amalgamates easily; takes up a large proportion of mercury; works as though it contained palladium; temperature of room 73°; pointer showed $2\frac{1}{2}$° of shrinkage in one-quarter hour; in twenty-four hours, $7\frac{1}{2}$° of shrinkage.

Hood's cheap Amalgam works easily and packs well, and showed in Dr. Hitchcock's instrument $1\frac{1}{2}$° of shrinkage in fifteen minutes, and in twenty-four hours 1° of shrinkage; in three days, 18° of shrinkage. No further experiment made with it.

What, now, is the practical value of this mass of experiments, with all these carefully kept records; and is the knowledge worth the expenditure of one-hundredth part of the time and labor it has cost? In the

Chicago Medical Journal for July, 1873, is an article by Dr. Payne, in which he gravely speaks of the "poisoning of thousands of people all over the world from corrosive sublimate generated in the mouth from amalgam plugs in the teeth." And he says that "neither Asiatic cholera, nor smallpox, nor any malarious disease, is doing half the mischief in the world that is done by this poisoning." Is there any ground for this statement?

Dr. Cutler says "that protoxide of mercury is the only deleterious oxide of consequence, and that in order to get it, mercury must be heated up to 600°, with free access of air; then red precipitate is formed, which is the protoxide, and on raising the heat higher, this oxide is again decomposed into the simple elements.

"To form calomel, which is a subchloride, subnitrate of mercury is precipitated by common salt; it is also formed by other processes. Protochloride of mercury, or corrosive sublimate, may be made in several ways. When metallic mercury is heated in chlorine gas, it takes fire and burns, producing this salt.

"From the above formulæ it will be seen that mercury is not readily acted upon by any fluids that may exist in the mouth, as these fluids always contain at least from eight hundred to nine hundred parts of water in one thousand parts, so that any acid, or any other agent contained in this fluid, could absolutely have no action of any moment; so that all the apprehension that we need have in connection with amalgam fillings, is from the vaporization of the mercury during the process of hardening."

I think I may venture to add to Dr. Cutler's remarks, that any mercury that vaporizes in the temperature of the mouth would remain vaporized, and pass out by the expiration as it went in, "a vapor."

But discussion does not establish a truth; only demonstration can do that. These tests, therefore, were needed to enable us as a profession to say positively whether or not the mercury in an amalgam filling, or any number of amalgam fillings, properly inserted, could, by any possibility, cause mercurial symptoms, or cause mercurial poisoning with unrecognizable symptoms. And, as has been shown, three months and over of chemical action so severe as to almost completely disintegrate or dissolve the enamel of most of the teeth subjected to the tests, has failed to diminish the aggregate weight of the amalgam pellets, that were subjected to the same tests as the teeth with their fillings, more than about 3 grs., in nearly 11½ dwts. That is to say, the gain from the addition of oxygen by the oxidation of the surface of certain pellets has nearly balanced the loss of weight of certain other pellets, so that the pellets now weigh in the aggregate only about 3 grs. less than at the beginning of the experiments, the copper being the greatest loser; and copper amalgam is not used in this country, though it is in Germany.

To complete the statement, the fluids in which these teeth and amalgams have been lying in corruption together have been carefully tested for mercury, not only by myself, but in the chemical laboratory of Columbia College School of Mines, under the supervision of Prof. Chandler, and his report and certificate is appended hereto.

"NEW YORK, DEC. 12th, 1874.
"*Laboratory of the School of Mines, Columbia College, cor. 49th St. and 4th Ave.*

"*Certificate of Analysis.*

"SIR,—The samples of saliva in which various alloys had been digested, submitted to me for examination, contain no mercury in solution.

"Respectfully, your obedient servant,
"C. F. CHANDLER, PH.D.,
"*Professor of Analytical and Applied Chemistry.*

"To DR. E. A. BOGUE,
"29 East 20th St., City."

So much for the effects of amalgam fillings upon the human system.

Now for a few observations upon the mechanical or physical properties of these various alloys.

We notice, in the first place, that there is but little variation in the shrinkage of those that shrink, the largest amount being $8\frac{1}{2}°$,—about $\frac{1}{424}$th of an inch; and the smallest amount being 2°,—about $\frac{1}{1300}$th of an inch; provided our instruments are correctly made; while the two that expand permanently, expand, the one, palladium, 9°, and the other, pure silver, 20°.

We have here a clue to the bulging out often apparent after the filling was finished, of the old amalgams made of coin filings.

A noticeable thing in the experiments with the acids, was the apparently good margins of nearly all the fillings.

To carry still further positive knowledge on that point, I dropped all these teeth, wet with saliva as they had been for months, into a solution of indigo, which was placed in the water-bath at 100°. After lying for two days in that blue fluid, I took them out, cut them open through the filling, and have attached to each a label showing which amalgam was used, and what action it had been subjected to. These teeth can be examined by the gentlemen present.

It will be seen that, if almost any amalgam is used intelligently, teeth can be filled so as not only to preserve them, but to do so without danger to the general health from any element of the filling, unless it be copper. Of that I am not sure.

Discussion.

Dr. Thomas H. Chandler, of Boston. It seems to me that the labor that has been expended on these papers is worthy of something more than passing by in simple silence. For myself, I feel deeply grateful to these gentlemen for having submitted to us the valuable results of their research.

With regard to amalgam, viewed in the light of these researches, I have almost come to the conclusion that wherever we can make a *perfect* amalgam filling we can make a perfect gold filling. There are a thousand little things that defeat us in the operation; mercury working to the surface, not only the outer surface under our pluggers, but the surface between the filling and the tooth. Mercury going there leaves a film, which, being afterwards reabsorbed into the filling, leaves a space or crevice.

Again, in reference to washing or wetting; it is next to impossible to get water out, if it once gets into amalgam.

We think, perhaps, we can hurry up matters, and if there is a little moisture round the edge of a filling, it is no great matter, we can pack until we squeeze it out; but we cannot do it.

There are many difficult places about the mouth where we cannot use amalgam and be sure of the best results, simply because it is impossible to keep the tooth dry. In these cases we cannot make perfect amalgam fillings, no matter how good the amalgam may be. Hence, if a moisture-tight plug be essential to the preservation of the tooth, we may about as well attempt to use gold as amalgam.

Dr. N. W. Kingsley. I would offer a resolution of thanks to Drs. Cutler and Bogue for the able papers we have listened to, and for thus placing before us the very valuable results of their thought and investigation in this direction; and I desire also that the resolution shall show respect to the memory of him who is dead, and whose paper we have heard read, by way of acknowledging the indebtedness under which he has left us, as a profession, for various and valuable contributions to dental science. All these papers bear the impress of patient and persevering research, and for the results of their experiments the dental profession will give these gentlemen their hearty thanks.

The motion was carried.

Dr. James Truman, of Philadelphia. I feel that this vote should not be wholly passed by without further remarks. It seems to me that these papers are worthy something more than a mere vote of thanks.

As I sat here listening to the reading, a new era seemed dawning upon our profession,—one that was to be characterized by individual work and laborious investigation. I must confess that I have been very much enlightened by the reading of these papers, and acknowledge to the removal of some prejudices that have been engendered during years

of practice. I have always ranked myself among those who have opposed the excessive use of this material; but if the conclusions drawn from these investigations be correct, the opinions heretofore entertained must undergo modification. It would seem impossible to answer some of the arguments brought forward.

I regret, with others, the untimely death of Prof. Hitchcock. It has deprived the profession of one of its most useful and honorable members, and one who was doing much good in the direction of original investigation. His ardent temperament may have led to excess of labor, but while we sadly feel that he fell a sacrifice to his love of scientific truth, it is, nevertheless, true that the work he performed so well is what we most need at the present time. It is certainly a most promising indication of a higher professional standard that an increasing number are engaged in original investigations, in a generous rivalry to enlighten each other.

Dr. E. A. Bogue. Dr. Chandler says that he has almost come to the conclusion that wherever a good amalgam filling can be put in, a good gold one can be likewise.

I will state an incident in my own experience that illustrates to some extent the different saving properties of gold and amalgam fillings in certain cases of difficulty. In 1865 a patient with strong, firm teeth was in my hands for treatment; I felt much solicitude about one of the teeth, and called in Dr. Bronson, to consult him in regard to what was best to be done; he was also called in when the work was finished, and I was much pleased to have had his approval in the case.

The right and left lower molars were both filled with gold. The right upper molar was filled with Morgan's plastic gold, with which I was experimenting at the time, and, I may say, somewhat in the dark.

The left upper bicuspid was so broken away that I did not feel that it was expedient to fill it with gold, and I knew of no other substance which seemed so well adapted to the case as amalgam. I did not know anything about the use of it, not even how to put it in properly. However, I filled it with that material as best I could, supposing that the tooth would break off before long.

Within the past six weeks that patient has been in my hands again, for the first time since 1865, and nothing has been done upon his teeth meanwhile. Those two lower molars filled with gold broke away two or three years ago. There was very little left of one tooth,—only the anterior portion of the buccal cusp; of the other tooth, nothing above the roots. The right upper molar, in which was a large cavity filled with crystal gold, I found still perfect. The left upper bicuspid, which I filled with amalgam, was discolored around the filling, but there was nothing broken, and the tooth was in good condition, excepting that it was dark-colored. I took that filling out and found what seemed to be

an oxyd of the metal under and around the filling, but I did not find any further decay in the tooth. I don't know what amalgam I used; I don't know that my book shows. It is perhaps needless to say that I filled all these teeth with amalgam this time.

I am greatly indebted to Dr. Jack for the manner in which I was able to fill them, and I wish he would explain to the other gentlemen present what he was kind enough to explain to me long ago,—his mode of matrix filling. I built on with gutta-percha to the tooth I wished to fill, the shape I wanted my future filling should be; of that tooth and the adjoining two teeth I then took an impression, and made a hard rubber matrix, which surrounded the two teeth adjoining front and rear and left a complete ring around the tooth I wished to fill. This matrix was adapted to the mouth, and so fixed that the patient could shut the teeth; thus I had a well in which to pack my amalgam as hard as I pleased. The filling was then inserted and the patient went home, retaining the matrix until the next day, when it was removed, and the filling was polished down and burnished.

The next case is that of a young lady, weak and frail, and much of the time an invalid, and who would not endure the mallet. She first went, I believe, to Dr. Kingsley, who became disgusted with the case, not knowing what to do for such frail teeth. She finally fell into my hands, and I became equally disgusted. Her teeth were like chalk and extremely sensitive, and it did not seem as if anything could be permanently done. Into that mouth I put my first amalgam filling, in a badly decayed molar with two walls. The date I don't precisely know. Of course it was anterior to the last mentioned.

That filling I saw two months ago, and it is still in just as good order as when it was put in, excepting a slight discoloration around the edges, not deep.

Now, considering my inexperience in the use of amalgam, and the fact that I was obliged to go to my neighbor to ask him how to put in that filling, I think that is a noticeable case. It does not show a great deal, but it shows something. It is cumulative evidence in favor of amalgam fillings, where gold seems inexpedient from any reason; and now that we may be certain that the health can in no way be affected by such material properly inserted, we have but to make a good selection, and use care in its insertion, to feel very certain of good results from its use.

Dr. John B. Rich. Of late years I have had very little knowledge of amalgam. But nearly thirty years ago I had some experiences in connection with it, which resulted in a great degree of mortification to me. About that time a bitter controversy arose among the dentists of this country on the subject of amalgam. With very few exceptions, the most eminent men in the profession throughout the United States denounced the use of it in unmeasured terms. They stated that it was a

dangerous and poisonous substance, and in all respects an unfit material for filling cavities in the teeth. And they further characterized the use of it, for such purpose, as a dishonest practice, and the very worst kind of charlatanry.

Foremost among those who denounced its use was Dr. Eleazar Parmly of this city, who, at that time, stood, by common consent, at the head of the dental profession in this country. I had always regarded him as a reliable mentor to guide me in the adoption of the proper principles to govern me in the practice of my profession. He had been most kind to me in the early part of my professional life, and I had always found him to be an eminently practical man, whose opinions were based upon close observation and experience. We had often conversed together upon the subject of amalgam; and some years before the breaking out of the controversy on that subject, we had both taken an active part in exposing the impositions of a person who called himself Monsieur Mallan, who used nothing but amalgam for filling cavities in all parts of the mouth.

The action in relation to amalgam, so far as the American Society of Dental Surgeons was concerned, commenced in 1841, and reached its height in 1847, when several of its members were expelled because they would not sign a pledge not to use it in their practice. Dr. Parmly was, at that time, the president of that Society, and a large majority of its members took sides with him against its use; and the subject occupied the time and attention of that body, almost to the exclusion of any other business, for several years. The debates in relation to it were at length carried on with a great degree of feeling. Those opposed to it being in the majority, were determined that the Society should be purged of those members who would not take sides with them against it, and many members resigned rather than be subjected to such discipline; while others stood up and fought against such action on principle, although they did not want to use it, and were eventually expelled from membership.

The result of this action on the part of the majority was most unfortunate. Men who had been friends for years became bitter enemies, and the usefulness of the Society was at an end. And yet I believe now, from what I have known of those who so arrayed themselves against the use of amalgam, that they were entirely honest in what they said and did in this matter, and that they truly believed their action was for the best interest of their profession.

I believed that my action was right, and no one took a more active part in that Society against its use than myself, and both in the Society and out of it, whenever I could get a chance to talk about it, I denounced it as strongly as anybody. I had formed my opinion in relation to it from what I then believed to be the practical experience of

Dr. Eleazar Parmly, and I believed in him. But some time in 1848, while I was still full of enthusiasm and activity in this matter, a circumstance occurred which changed my enthusiasm into distrust of the course I had been pursuing, and led me to make investigations into the properties of amalgam, which proved that its opponents were wrong.

This circumstance I will briefly state. One of my patients introduced a lady to me, upwards of thirty years of age, who had just arrived from England, and had suffered much from her teeth during the voyage here. She requested me to use my best skill to save what teeth she had left. Upon examination I found but two teeth had fillings in them, and these were the two upper cuspids, that were filled at the point where those teeth join the bicuspids. They were quite large fillings, and composed of amalgam. They looked bright and fresh, and from that circumstance, I supposed, they had been put in just before she left England.

After I had treated several of her teeth, and had gained her confidence in my professional skill, I spoke about the two fillings, and told her they ought to be taken out and the cavities filled with gold, as the amalgam would not preserve the teeth. She at once assented to that proposition, and I removed the amalgam.

There was no vestige of decay. The cavities had been well prepared, and looked as fresh and clean as if they had just been excavated, and the teeth were perfectly preserved.

As I removed the last portion of the amalgam, I casually asked how long they had been filled. To my great astonishment and confusion she told me they had been put in when she was at school, and about sixteen years of age, and that she had not been to any dentist since that time,—and stated some incidents that had fixed the time in her memory.

This was a new revelation to me, this result of filling with that substance.

I did nothing more to the cavities that day but to fill them with wax, as I was anxious that Dr. Parmly should see them in the condition they were in when I removed the amalgam; and as soon as the lady departed, I went immediately to him, and told him what I had seen, and the statement of the lady; and, as he lived but two blocks from my house, I asked him if he would not call at my office in the morning and examine this, to me, most extraordinary case. He said that he would like very much to see the patient, if I would bring her to his office. Upon telling him that I would not like to take that liberty with her, he said he would be busy next day, and could not possibly call at my house to see her. I left him, very much mortified at the manner in which he treated my request and information; but, upon reflection, the idea occurred to me that perhaps I had not stated the case clearly

to him, and I resolved to go to him again that evening. I acted upon this thought, called again in the evening, told him how much this case had interested me, and asked him if he had had any such experience in the use of amalgam.

He surprised me very much by saying that he had never used it, or experimented with it in any manner.

I then said to him, "Do you really say that you have denounced this substance, and the use of it, in the terms you have without ever having investigated its merits at all?" His reply was, "I do say that I have neither used nor experimented with it in any way. *I would not touch the nasty stuff!*"

I can scarcely tell you, gentlemen, what a blow this was to me; and I told him so; and also that I had taken the side that I had in the "Amalgam Controversy" mainly from what he had said to me about it, and that I was deeply mortified to know that he, in whom I had so believed, knew nothing about the substance he had said and done so much against.

This interview ended our professional intercourse; for I felt that he had led me into an error which might be a subject of regret to me my whole life. And so it has proved. I immediately instituted a series of experiments to ascertain the properties of this substance. I had a water-bath prepared, and arranged so that it could be kept at a temperature of one hundred degrees of Fahrenheit. I prepared three kinds of amalgam, of different proportions of mercury and Spanish coin silver: these were placed in small vials, along with fragments of tooth-bone, and immersed in every condition of saliva that I could procure.

The vials were placed in the bath, and kept there nearly a year, when the fluid in which they were immersed was carefully analyzed; and I need scarcely say that nothing poisonous or injurious to the system was found; thus proving, beyond a doubt, that the main charge brought against amalgam, as being a poisonous substance, was utterly false and without foundation.

In conducting these experiments I had the assistance of my friends Dr. John Torrey and James R. Chilton, both eminent chemists.

At the next meeting of the American Society of Dental Surgeons, I stated in detail the experiments I had made, and their results, using my best endeavors to have the Society rescind the "Amalgam Resolutions," and, as an act of justice, restore to membership those who had been forced to resign on account of their action, or had been expelled for refusing to comply with the mandates of the Society in relation to them; or, if they were not prepared to act upon the information I had presented, to appoint a committee to make similar experiments to those I had made, and report at the next meeting.

All of these propositions the Society refused to entertain, and would

not examine the subject at all. Under these circumstances I could not remain in fellowship with them, and resigned my membership.

Since that time I have used amalgam in rare cases, where filling with gold was impossible; but they could not be considered as fair tests. I think that I cannot do as well with it as with gold, where gold can be used.