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## SOME PRACTICAL USES IN DENTAL PRACTISE FOR TUNGSTEN AND MOLYBDENUM.

Being a Report of Further Studies from the Scientific Foundation  
and Research Commission of the National Dental Association.

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THIS report has to do with the adaptability of these metals for orthodontic appliances, bridge skeletons, or frames for casting or fusing upon, removable bridge wearing parts, connecting bars for saddles, crown posts and broaches for root canal work, and strengthening bars in cast compound inlays, etc.

Tungsten with its elastic content about twice that of steel, its melting point nearly twice that of platinum, its stiffness about six times that of 30% iridium in platinum, and with the remarkable property that it does not anneal or lose its stiffness and elasticity even when heated to the melting point of gold, makes it particularly adaptable for many parts of orthodontia appliances. We shall not presume to advise what principle of application of force shall be adopted or what particular design of appliance will best secure its application but will suggest how we may adapt ourselves to some of the properties of these new metals and, in part, to what extent we may adapt them to our needs. After testing tungsten in practical use in expansion arches for about a year, and after extreme laboratory tests, we believe it to be superior for various forms of expansion

arch to any metal that we have heretofore found for the following reasons. The required elasticity and rigidity can be secured with smaller sizes. Attachments of any kind may be made to it with pure gold or with any karat of gold solder, without changing its stiffness at the point of attachment, as in the retracting arch shown in Fig. 1 C. The entire appliance and its connecting parts can be of such noble metals that not only is there practically no discoloration or oxidation of the appliance, but also with very slight electrolytic potential difference between the various parts, thereby reducing the electrolysis. A tungsten bow arch of .030 inch diameter, or approximately 21 gauge, (See Fig. 1 B.) will have ample elasticity and rigidity for expansion arches for practically all children, with an efficiency equal to a gold clasp metal, iridio platinum or German silver bow arch of much larger size shown in A. When the threaded sections are used, they will be gold soldered to the bow or telescope, its squared ends as in the later forms of Angle appliance as shown in B.

This great elasticity of tungsten makes it particularly desirable and adaptable for the new type of adaptation ex-

pansion arches, which are bent to conform accurately to the irregularities of the teeth and to which are attached fingers or pins, which enter into tubes on the teeth and thereby move them at will. (See Fig. 1 D.) A much smaller size of tungsten can be used for this purpose than may be in the other metals and still have a large factor of stiffness for expanding the arch. The pins can be attached with any gold solder without danger of softening or annealing the arch and the bends can later be taken out cold, if not sharp and if sharp by heating to a dull red while bending. We believe that

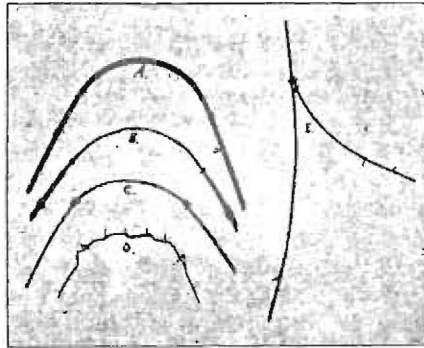


Fig. 1

with this metal, with its very high factor of strength and elasticity, the orthodontic appliances of the future will be modified to place more of the appliance out of sight, with slender arms attached, passing over the proximal contact points to their points of attachment, producing practically the same effect mechanically that is obtained at present, but with much more sightly appliances. Where the pins on the adaption arch require elasticity the small sizes of tungsten are particularly suitable.

The tungsten will prove particularly advantageous for anchorage retainers of all kinds, after orthodontic movement, for the following reasons. Its very large factor of strength makes it possible to

use smaller sizes and therewith secure even greater rigidity. It does not crystallize and break like gold clasp bar, and similar metals, under the strain of mastication, which force produces a slight spring or bend continually. All orthodontists are familiar with this embarrassment.

Fig. 1 E. shows two pieces of tungsten under strain, demonstrating that they do not bend where they were soldered with 22k gold solder.

Tungsten is also particularly well adapted for all sorts of auxiliaries such as fingers, springs, supports and alignment arms, all of which may be attached with any of the gold solders, and their factors of strength is so large that they withstand the strain much better than ordinary metals. The tungsten is particularly well adapted for certain parts of removable orthodontic appliances, in which case it has several distinctive advantages, among which are the following:

Relatively less bulk for the same strength.

High elasticity for clasping over teeth.

Great strength for clamping parts; soldering with pure gold or any gold solders.

Easily cleansed.

We believe this type of orthodontic appliance will greatly increase in favor because of the particularly adaptable qualities of the tungsten and molybdenum. Tungsten is also well adapted for retainers for various forms of orthodontic plates, as well as for retainers of all other kinds of plates. While tungsten has some very distinctively desirable qualities, it has some others to which we are compelled to adapt ourselves. Gold and gold solders do not readily flow on tungsten and molybdenum in an ordinary oxidizing atmosphere (See closing sentence), because while these metals resist oxidation at ordinary temperatures, they oxidize readily at high tem-

peratures, when exposed to oxygen or an oxidizing atmosphere. We expect to find a flux that will enable us to flow these metals directly onto tungsten and molybdenum. Accordingly, the material, as it will be provided for dental uses, will be already alloyed on its surface with gold or gold and palladium, which metals unite perfectly with it under a proper atmosphere, and all soldering that is done upon these metals later seems, as firmly attached, as if it were done on iridio platinum. The addition of seven per cent of palladium to gold raises its melting point in the neighborhood of 200 degrees C. which surface will receive solders made of gold and platinum or any gold solders or pure gold. These coatings of gold or gold and palladium have so nearly the electrolytic potential of 22K or high gold solders with which the parts would be attached that electrolysis is reduced to a minimum, and the entire completed appliance has the appearance of being constructed of gold or of gold and platinum, if the palladium covering is used. Both tungsten and molybdenum have very low co-efficients of expansion as compared with all the metals we have been using in dental practise. This point is of particular advantage in casting work, of which we shall speak later.

At this point we will review some of the characteristic features of both tungsten and molybdenum. Tungsten has a hardness so great (so we are informed by the General Electric Co.) that a specially prepared phonographic needle point made from it will out wear two hundred hardened steel points; will draw into a finer wire than any known metal, has a tensile strength thirty times that of gold and ten times that of iron; is not effected by ordinary acids or alkalies, except hydrogen dioxide in which it is soluble. Its melting point is over 3000° C. or

5400° F. It is from six to seven times as stiff as iridio platinum of 30% iridium.

Molybdenum has a melting point a little lower than tungsten, namely, 2500° C. (Note.—Gold is 1063° C. and platinum 1755° C.) and it has a tensile strength five and one-half times that of iron. Molybdenum has many properties similar to tungsten, its chief difference being its lack of elasticity, which makes it particularly desirable for those forms of orthodontic appliances where we require a very tough slightly elastic piece. When hard drawn it is not annealed at temperatures up to the melting point of gold and its elastic content is a little greater than annealed gold clasp metal. When once annealed at high temperatures it does not recover its elasticity originally put in by hard drawing but has enough elasticity for certain uses in orthodontia work, where this quality is wanted in low degrees. It has very great toughness and rigidity, making it particularly desirable for all those uses where the material requires to have great strength and rigidity with a small mass but capable of withstanding excessive bending.

This metal, like the tungsten, will be furnished with gold or gold and palladium coating, the latter having the color of platinum. The following table gives the sizes of tungsten and molybdenum that are at present being drawn. (Other sizes will be added as required). The approximate B. & S. gauges, weight per foot in grams and price per foot, etc. The cost of molybdenum is about two-thirds that of tungsten.

The present price for gold, or gold and palladium coated tungsten is about one-fifth that of platinum or one-sixth that of iridio platinum. The present price of molybdenum, gold or gold and palladium coated, is about one-eighth that of platinum or one-ninth that of iridio platinum. Since the strength of tungsten is approximately six to seven times that of iridio platinum, we can reduce the size to about

one-half by weight and still have a larger factor of safety. This reduces the relative cost of coated tungsten to about one-twelfth that of iridio platinum for a given case. There is the additional great advantage of conserving more of the root material with greatly added strength in proportion. This applies also to the porcelain. We fully expect that these prices will be greatly reduced in a short time, in fact a poorer quality can be purchased at present for about one-half the above prices. It is not possible as yet, however, to secure anywhere in the large sizes as choice a quality as we quite certainly will be able to get in the near future, for the

or small according to the standards of accuracy or ideals of the operator. While this can be corrected largely or partly by the treatment of the wax and investment, according to the skill of the operator, it is quite easily very largely controlled by casting the metal of the bridge over a frame of tungsten which is sufficiently strong to prevent the normal contraction of the gold by stretching it as it contracts. Figure No. 2 shows two bars representing two heavy bridges, each one inch long between abutments. Both are cast from wax patterns built over the abutments and are precisely the same in construction and treatment ex-

Diameter in thousandths of an inch.	Approximate Gauge B. & S.	Weight per ft. in grams.	PRICE PER FOOT					
			Bare Wire		Gold Coated.		Gold and Palladium Coated.	
			Mo.	W.	Mo.	W.	Mo.	W.
.010	31	.30	\$.21	\$.31	\$.40	\$.50	\$.41	\$.51
.015	27	.8	.27	.48	.50	.70	.52	.72
.017	26		.36	.60	.60	.83	.62	.85
.020	25	1.2	.45	.77	.70	1.02	.72	1.04
.022	24		.53	.93	.78	1.18	.80	1.20
.025	23	2.0	.64	1.14	.90	1.40	.93	1.43
.027	22		.71	1.29	.97	1.55	1.00	1.58
.030	21	2.8	.83	1.48	1.10	1.75	1.13	1.78
.035	20		1.04	1.89	1.30	2.15	1.34	2.19
.040	18	4.8	1.22	2.22	1.50	2.50	1.54	2.54
.045	16		1.42	2.58	1.70	2.86	1.74	2.90
.050	17	7.6	1.60	2.85	1.90	3.15	1.95	3.20

expense for large diamond dies and the skill required for drawing constitute the chief expense for the material, as well as the chief drawback to producing soon the quality in the large sizes that is now available in the smaller sizes. The quality of the small sizes will also improve. An established demand will also rapidly reduce the price.

The normal contraction of gold and of its alloys which we use is over two percent of the linear dimension between the melting and normal temperatures. This large change prevents our casting long bridges with the foundations and inlay or crown abutments attached without quite large error or change, which amount may be considered to be large

cept that in the one marked A there is a cross bar of tungsten butted between the abutments and gold soldered as shown in C. This bar not only supported the wax and prevented its distortion and contraction before investment but has also prevented the distortion of the bridge by preventing the normal shortening due to the contraction of the gold. The difference in distance between the two abutments of the two bridges, A and B, both of which were invested together and cast together, as shown on the same sprue, is over forty thousandths of an inch. Of this twenty-two thousandths was caused by the unprevented or normal contraction of the gold and the balance was the change in the wax after it was removed

from the form and before investing. The dark pieces between the abutments are one inch rulers to show the distance between them. In these pieces the abutments of A and C are the same distance apart, but those of B have been drawn towards each other as shown by the offset between B and C.

On account of its great hardness and strength, tungsten is destined to be of

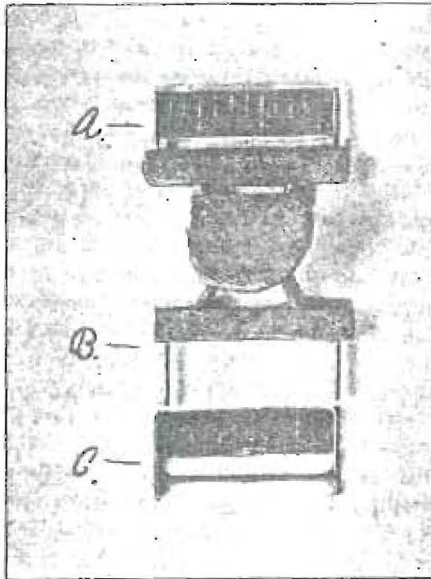


FIG. 2

very great use in dental practise for the wearing parts of removable bridge work. When we realize that it is almost impossible to get a file hard enough to cut it without ruining the file, and also that when a tungsten phonographic needle point will outwear two hundred hardened steel points, we get a conception of its great superiority over the soft gold and platinum alloys, that we are using at present for wearing parts. We have used it for about a year in such places as the bar for Gillmore attachments and the wear has scarcely polished it. In fact,

we cannot detect the slightest wear at this time, in such situations as we have formerly used gold and platinum alloys, which show the excessive wear in a few months and many bars have had to be replaced on account of this wear. It is as easily adapted as are the ordinary metals. On account of its superior strength, it will be possible to make removable attachments of much less bulk than have been necessary with gold and platinum compounds. The neck and ball for a Roach attachment, for example, may be very much smaller and have the same or a larger factor of safety of strength, besides the great superiority in wearing quality. The tungsten round wire can be ground to one-half its thickness and two pieces placed together for a split pin attachment, with the corresponding great advantages of strength and wear. The superior strength is of great value in making anchorages to vital teeth, for small posts can be put in laterally to the pulp and still have sufficient strength to carry their load.

The tungsten is also very valuable and advantageous for the connecting bars between saddles, used as removable bridges and plates. For irregular shapes several small pieces of coated tungsten may be laid together in a bundle or side and side and any karat of gold solder flowed over them, producing a rigidity many fold that we have been able to procure with any ordinary gold and platinum compounds. It is particularly advantageous for the lingual bar of lower bar plates, which may be relatively much smaller and have a still larger factor of strength.

There are few places that tungsten will be appreciated more often than for posts for crowns, where we need a very large factor of strength with a small cross section, it being six to seven times stiffer than iridio platinum. The tungsten may be used in much smaller diameters and still have a much larger factor

of safety. This not only permits us to preserve the tooth structure for its much needed strength, but also permits of a much smaller hole in the porcelain crown, which would be appreciated by our practising dentists, since we have been required to use crowns for small teeth, which had the strength greatly reduced because of the needed large hole for the ordinary large size post material. The gold base for a porcelain crown will be made by building the wax pattern base about the post, underneath the porcelain crown and proceeding in the usual way to cast directly on to the post. The hot gold compounds unite with the alloyed surfaces of the tungsten, making a perfect union between that is very strong. While the coefficient of expansion and contraction of tungsten and molybdenum are much lower than that of porcelain, making it unadvisable to fuse porcelain directly around them, as is done over platinum, these metals probably will have an important place for pins for porcelain teeth, because of their much greater strength. This may be done by putting a metal over the outside of the tungsten or molybdenum, which has a relatively high coefficient of expansion and will, thereby, correct for the too low coefficient of these metals alone. This is done in part at present, by putting a platinum coating over an iron and nickel compound, also by soldering a non-platinum pin into a platinum tube, which has been baked into the porcelain. On account of their much greater tensile strength, not only may you use smaller sizes of pins, but it is not improbable that a removable pin bridge tooth will be constructed, using these metals.

Both tungsten and molybdenum are of great advantage to prevent the distortion of M. O. D. of horse shoe shaped inlays. The method of using, is to either bend suitably a piece of tungsten or molybdenum or use a straight piece and imbed it into the wax pattern in the cavity.

The wax pattern is thereby prevented from warping or shortening across the occlusal dimensions by the rigidity of the tungsten or molybdenum. The pattern is invested in the usual way as though the metal support was not within the wax. It cannot get far out of position, when the wax melts from around it and the gold is cast about it without a special consideration for the metal bar. As the gold contracts about it, it is prevented from behaving according to its normal law of contraction, and it does not shorten across the occlusal as it otherwise would. The coefficient of contraction and expansion of these metals is so much lower than that of gold, which latter increases its rate as it approaches its melting point, that the total dimension change of tungsten between room temperature and the temperature of molten gold is about  $\frac{1}{4}$  that of gold and its ordinary alloy compounds, for that same range, while the change with molybdenum for that temperature range is only about 1-6 that of gold and its compounds. The judicious use of these metals under these conditions make it possible to make difficult cast restorations which will go into place with much greater freedom and accuracy than when they are not used, unless a very careful technic is used to introduce an error in the dimensions of the wax after releasing its elasticity sufficient to compensate for the contracting gold.

Another important use for these two metals is for special broaches for treating root canals, particularly for the sulphuric acid treatment. Molybdenum, on account of its being softer follows the canals more readily than tungsten, and being exceptionally tough, is in little danger of being broken. Neither are affected by the acids that would be used in the tooth. On account of its being brittle, however, tungsten requires to be used with greater care and judgment than molybdenum when used for broach-

es. It is difficult to cut barbs on the tungsten, though they can be cut readily in the molybdenum.

Tungsten is particularly well adapted for instruments for mixing and handling cements, because of its resisting action to practically all acids.

Tungsten has relatively very high thermo conductivity. This fact, together with that of its non-oxidizing qualities at ordinary temperatures, makes it superior to platinum and platinum iridium for all forms of make and brake contacts for electrical appliances, in fact it has already largely supplanted platinum for this purpose.

We shall expect to discuss some practical uses for palladium and its compounds in a later issue.

Palladium may be purchased by anyone directly or thru his dealer from the American Platinum Works, Newark, New Jersey, or from any other dealer in noble metals. The cost at the above named place will be approximately \$48.00 per

ounce for  $\frac{1}{2}$  ounce or less, or \$46.00 an ounce for larger quantities. Please note this is equivalent to buying platinum at about \$26.00 an ounce since the bulk of palladium is nearly double that of platinum per ounce.

The metallurgical research department will not supply metals for commercial purposes. They will, however, supply limited quantities of coated or bare tungsten and molybdenum for dental experimental purposes and at the cost to us plus postage. The money must accompany the order as we cannot open accounts. Special forms are provided both for ordering and for reporting the results of the experiments to this department. For these you will address Weston A. Price, Chairman, 10406 Euclid Ave., Cleveland, Ohio.

As this goes to press we are greatly encouraged that a satisfactory flux will be developed for tungsten and molybdenum. We can now gold solder tungsten with the aid of a special flux. It is not entirely satisfactory as yet, however.