TOUCHSTONE TESTING OF PRECIOUS METALS

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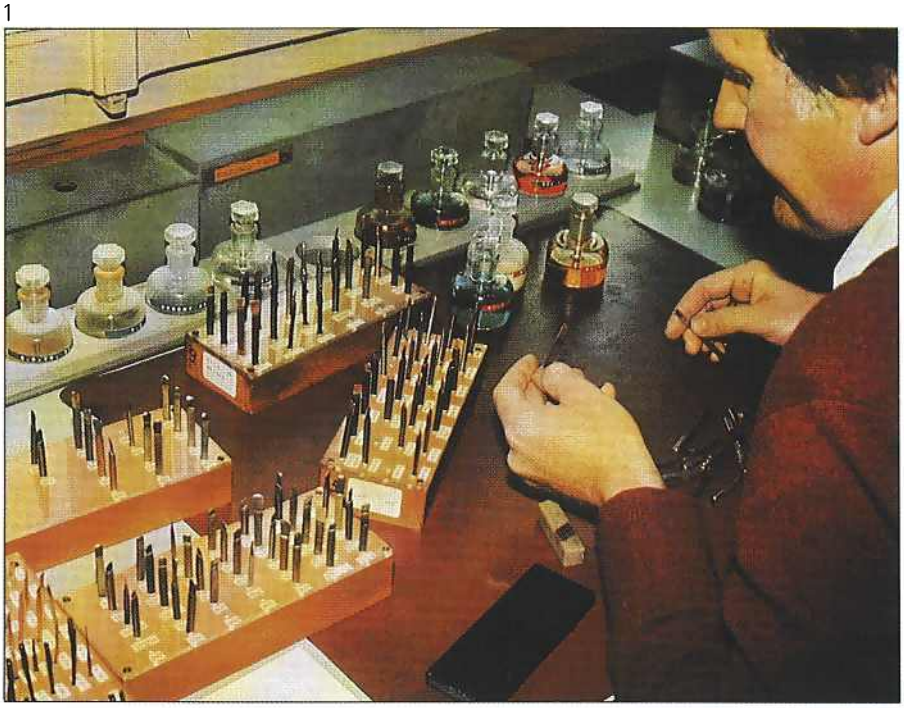

Owing to its simplicity, the touchstone method has found widespread application for testing gold and other noble metal articles of all types. In this article, the authors show in detail how to carry out the test and avoid erroneous results.

Figure 1 One of the authors (Mr Wälchli) testing an item of gold jewellery in his laboratory at Basle.

Introduction

Touchstone testing is among the oldest methods of assaying for gold and other noble metals. Often referred to simply as 'touching' in England, it is known to have been applied as early as 600 BC to the checking of gold coins by colour comparison. Today, it is mainly used in institutions and offices responsible for checking and hallmarking precious metal articles.

Every day, official assayers in many countries are required to carry out the delicate task of determining as accurately and non-destructively as possible the fineness of valuable jewellery articles. These are often in finished form, polished, set with stones or pearls and may even have undergone some treatment to improve the appearance or technical properties of their surfaces.

Swiss assayers have a long tradition of successfully testing finished jewellery articles and have acquired

by experience the ability to use the touchstone method at its maximum possible sensitivity. Thus, differences in precious metal contents as small as 10 to 20 parts per thousand can often be established with confidence by this test.

But the touchstone test is also an indispensable tool for jewellers, silversmiths and other professionals in the precious metals sector, who use it, for example:

- for sorting semi-finished products of different fineness and different metals
- for distinguishing between solid and plated articles
- for estimating the value of goods for insurance companies and private individuals (valuation)
- for making remelted alloys from old or scrap gold
- for buying and selling antique or second-hand jewellery.

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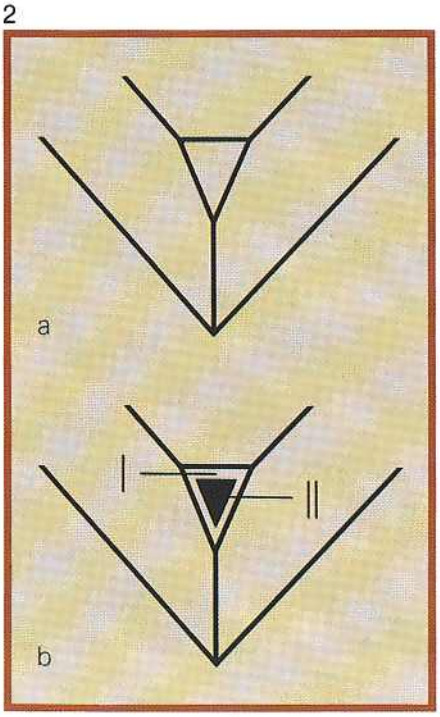

Figure 2 The appearance of a sharp corner on two articles after grinding with an emery stick:
a article in solid precious metal
b plated article
I plated layer
II substrate

Figures 3-5
3 Taking a rubbing from the article to be tested
4 Using an appropriate touch needle to produce a rubbing of a standard alloy for comparison
5 Left: rubbing from the test article
Right: rubbing from a touch needle

Experience has shown, however, that touchstone testing, although apparently very simple, is frequently not carried out correctly, thereby giving erroneous results. This article is intended to show how to carry out the test, and help to avoid as far as possible incorrect procedures and the associated errors of judgement.

It should be borne in mind, however, that touchstone testing is much too complex to be described in terms of simple 'cookbook' instructions, and cannot be relied upon as a universal method for dealing with every case that may arise. It requires specialized knowledge and considerable experience that can only be acquired through practice. For this reason, only the simplest touchstone testing methods will be described here.

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Applicability and Accuracy of Touchstone Testing

Touchstone testing enables precious metal articles in any form – from raw materials to the finest

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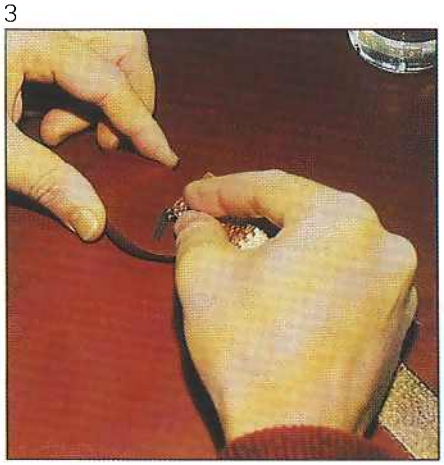

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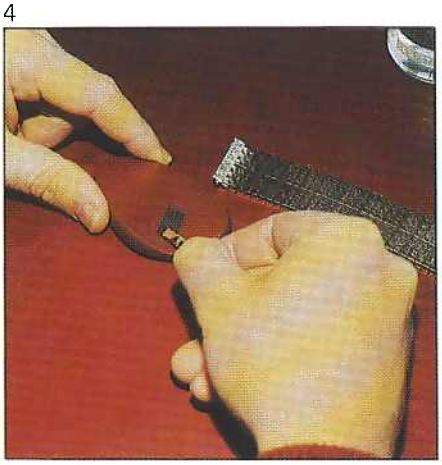

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gold jewellery – to be tested for alloy composition quickly, with the simplest of equipment, using only a minimum of metal and without causing significant damage.

In most cases, the method not only identifies qualitatively the constituents of a precious metal alloy, but also allows their quantitative determination. It is of particular interest when very little material is available for sampling and analysis – a typical test requires only about 0.5 mg (0.0005 g) of alloy. Moreover, it is well suited to the testing of inexpensive articles, when the cost of fire assay cannot be justified, or for very valuable pieces, for which sampling by scraping is unacceptable. In addition, it allows solid and plated objects to be distinguished.

Generally speaking, approximate results only can be expected from touchstone testing. Under optimum conditions, an experienced assayer can detect differences in fineness of 10 to 20 parts per thousand (more precise results – accurate to 1 part in ten thousand – may be obtained by analytical methods like the fire assay).

The accuracy of the touchstone test is essentially dependent on the following criteria:

- the experience, skill, and the metallurgical and other specialist knowledge of the person carrying out the test
- the type and composition of the alloy to be tested
- the quality of the touchstone
- the number and compositions of the available touch needles
- the strength of the acids used
- the lighting conditions under which the test is carried out.

Very soft materials, such as fine gold or alloys containing more than 920 parts per thousand of gold, often do not leave satisfactory rubbings on the touchstone, but 'smear'. Very hard alloys, such as some white golds, on the other hand, scratch the stone and are also unsuitable for touchstone testing.

Table 1

COMPOSITIONS OF SOME COMMONLY USED TOUCH ACIDS AND REAGENTS

a) Gold 650 to 800

Concentrated nitric acid (HNO_3)	40 ml
Concentrated hydrochloric acid (HCl)	1 ml
Distilled water (H_2O)	15 ml

b) Gold 500 to 650

Concentrated nitric acid (HNO_3)	30 ml
Concentrated hydrochloric acid (HCl)	0.5 ml
Distilled water (H_2O)	70 ml

or

Concentrated nitric acid (clearly attacks alloys of fineness less than 500 parts per thousand, alloys of greater fineness are slightly corroded)

c) Gold 350 to 500

Nitric acid (HNO_3) density 1.284 (32 ° Baumé)	5 ml
Solution of copper chloride ($CuCl_2$) (6 g $CuCl_2$ in 20 ml distilled water)	1 ml
Distilled water	20 ml

Aqua regia

Concentrated nitric acid (HNO_3)	10 ml
Concentrated hydrochloric acid (HCl)	30 ml

Acid for differentiation

Concentrated nitric acid (HNO_3)	30 ml
Concentrated hydrochloric acid (HCl)	30 ml
Distilled water	6 ml
Potassium iodide (KI)	3 g

Potassium dichromate solution

Distilled water (H_2O)	30 ml
Concentrated sulphuric acid (H_2SO_4)	3 ml
Potassium dichromate ($K_2Cr_2O_7$)	3 g

Stannous chloride solution

Dissolve approximately 25 g stannous chloride salt ($SnCl_2$) in 3 ml of concentrated hydrochloric acid and then add approximately 400 ml of distilled water.

Note: the stannous chloride solution will not keep indefinitely – it decomposes with time and becomes ineffective. The useful life of the reagent can be extended by the addition of a piece of tin.

Ammonia solution

A dilute solution of ammonia (NH_4OH) is used, (e.g. diluted with 40 % distilled water.

3
Testing Procedure

Preliminary test – differentiating between solid and plated articles

The touchstone method is suitable only for solid articles. If there is the slightest doubt that the article in question is not solid precious metal, but merely plated, a preliminary test should be carried out as follows:

At the least conspicuous place possible of the object – preferably on an edge or a corner – a small area is ground away using either the touchstone or an emery stick.

Observation of the ground area with a magnifying glass will suffice to detect a surface coating provided it is of a different colour from the substrate (e.g., steel plated with yellow gold, copper plated with silver, etc.). If this is not the case, the ground area is dabbed with an appropriate test acid. In the case of articles that are made of solid precious metal, the acid has the same effect over the whole test area. But with plated objects, the substrate and coating will react in different ways (Figure 2).

Thus, for example, yellow brass with a coloured gold coating is tested by means of a touch acid intended for gold of 350 to 500 parts per thousand fineness. The brass is rapidly oxidised and darkened, while the gold coating remains unaffected. However, other surface finishes may also resist acid attack – e.g. gold paint, yellow anodized aluminium and coloured intermetallic compounds. To determine whether the coating is of such resistant material or really contains gold, chemical assaying is necessary.

In the case of silver-plated articles, a solution of potassium dichromate is used for dabbing. The silver coating takes on a red colour whereas the substrate, if any, does not react with the solution.

With relatively thick coatings (e.g. silver-plated cutlery) there is a dilemma in that to be sure of reaching the base metal, grinding must be sufficiently deep and yet excessive damage to the object must be avoided.

The composition of the various reagents is given in Table 1.

Cautionary remarks

Once it has been ascertained that the object to be examined is of solid precious metal, the touchstone test may be carried out. However, attention must be given to the following points:

- The area chosen for the touchstone test must be such that damage to the object is minimized. But the test should never be made on regions that are soldered, since this will give erroneous results.
- In the case of silverware, any surface treatment that it may have undergone could well make touchstone testing impossible. Gold, nickel or chromium plating must first be removed by means of an emery stick or a fine needle-point file. Protective lacquer coatings can also interfere with the test: they must be filed or scraped off, or removed with acetone.
- The test is not affected by the following surface coatings since they are very thin: finish gold plating on coloured gold, thin gold plating on silverware and rhodium plating on white gold, silver or platinum.

Testing procedure

The touchstone test is essentially a comparative method which consists of the following operations:

The touchstone is first very lightly and uniformly oiled (the natural oils on the skin are ideal for this purpose). The object made of the alloy to be tested is then rubbed under firm and even pressure onto the touchstone until adjacent rubbings cover completely and uniformly an area 20 to 30 mm in length and 3 to 5 mm in width (Figure 3). Next to this, a similar film of metal is rubbed onto the stone from a needle (the 'touch needle') made of a standard alloy of known,

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Figure 6 Applying a drop of touch acid to the rubbings

and closely matching, fineness and colour (Figure 4). It is important that both the test and reference rubbings should be of similar sizes and intensities (Figure 5).

For assaying silver, the two rubbings produced in this way are simply compared visually – the lighter, or whiter, the colour, the higher is the fineness. For assaying gold, however, the procedure is as follows:

The rubbings are wetted with an appropriate test acid solution called a touch acid (Figure 6). The acid preferentially attacks the base metals in the alloy, as well as silver (Figure 7). When sufficient time has elapsed for the action of the acid on the rubbings, these are dried using filter or blotting paper (Figure 8).

It is now possible to make a visual estimate of the fineness of the sample (Figure 9). Usually, the degree of attack, and therefore the fineness, are revealed by the coloration of the area of the rubbing which has been in contact with the acid: the lighter this is, the higher the fineness, and vice-versa. This is because, as a rule, alloys of lower fineness are more readily and more completely dissolved than those which are rich in precious metals. Similar behaviour and appearance of the test and reference rubbings are indicative of identical fineness (Figures 10-12).

It is important to keep in mind that the acids used for this purpose always act over a limited range of fineness, but never at a single definite fineness. It is not possible to make up an acid in such a way that, for example, a gold alloy over 750 parts per thousand fineness would be completely unaffected while all golds of less than 750 would be clearly attacked.

Figures 7-12

7 The attack of the touch acid varies with the fineness of the metal film

8 Soaking up the acid with filter paper after sufficient time has elapsed

9 Visual observation shows that the touch acid has attacked the rubbing taken from the test article (left) much more than that from the touch needle

10 Left: rubbing from a 14 carat (585) gold alloy
Right: rubbing from an 18 carat (750) gold alloy

11 Left: rubbing from a gold alloy of 700 parts per thousand fineness
Middle: 720 gold
Right: 750 gold

12 These three rubbings, with the unknown alloy in the middle surrounded by rubbings from a 750 touch needle, are identical in colour and in their reaction with the touch acid. Therefore, the unknown alloy is assumed to contain 750 parts per thousand of gold

Figure 13 Equipment and supplies for touchstone testing: touchstones, touch needles, touch acids and filter paper

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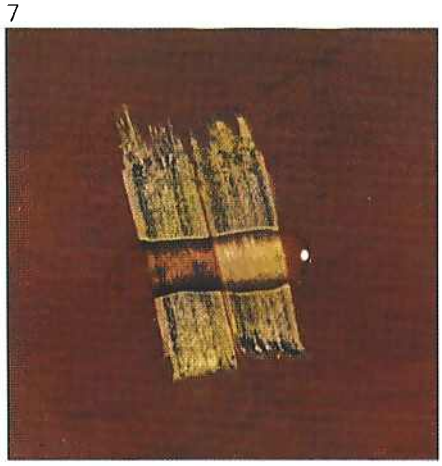

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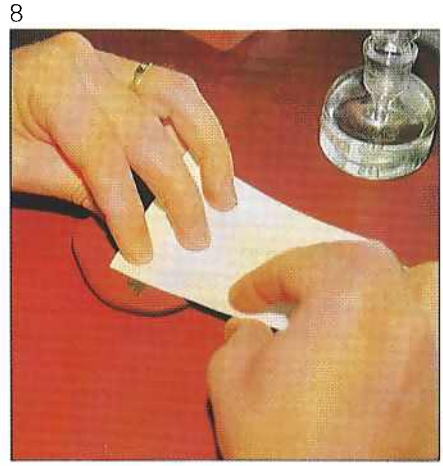

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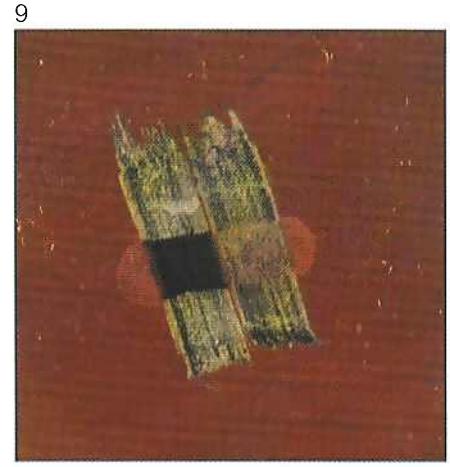

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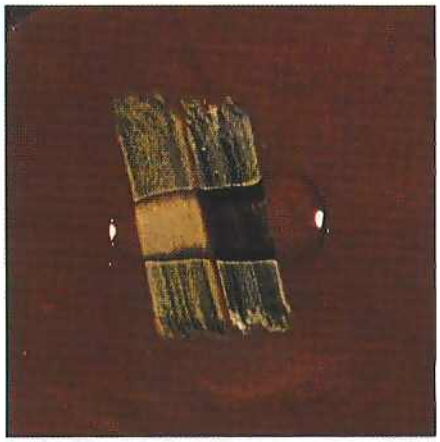

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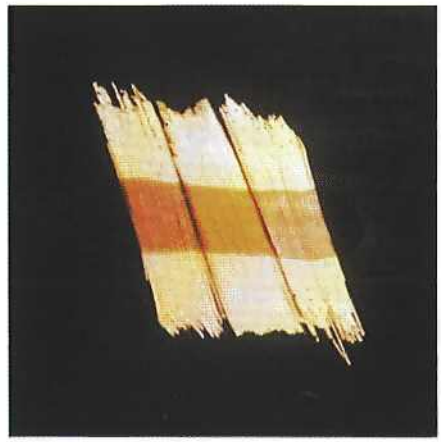

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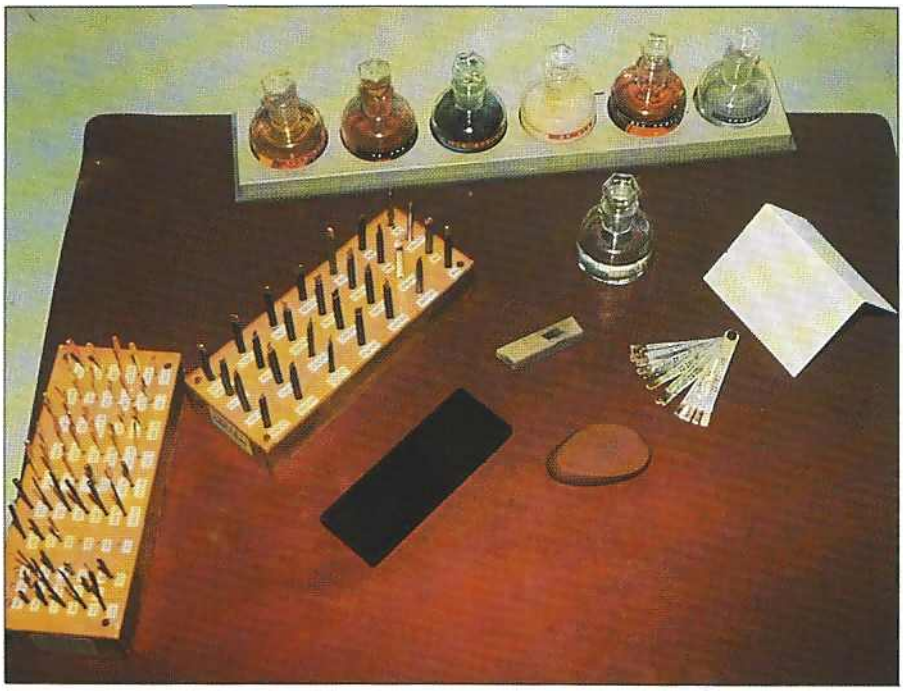

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Equipment and Reagents Used in Touchstone Testing

It is apparent from the above that a touchstone, touch needles, filter (blotting) paper and touch acids are all the equipment that is required for normal touchstone testing (see Figure 13 and Table 2).

Touchstones

In the past, obtaining good quality touchstones was a major problem. The most suitable natural stones, whether black flinty slate ('lydite') or red-brown radiolarite, were not commercially available, and the ceramic or glass plates, the only available alternative until recently, are a very poor substitute.

Fortunately, however, satisfactory touchstones are now on the market, e.g., those of black agate, whose properties closely approach those of natural stones.

Good touchstones are coloured a uniform jet black or dark red, have no veins or blemishes, are fine-grained, acid resistant and sufficiently hard. The surface should be ground matt, not polished, since otherwise the rubbings do not adhere to the stone.

Before use, the touchstone must be lightly oiled. As already mentioned, the best way of doing this is by using the oils in one's own skin, for example by rubbing the stone on the forehead. If the stone were not oiled, it would abrade too much material too unevenly.

Touchstones are easily cleaned by carefully rubbing with a cork and a fine non-abrasive scouring powder and water. Acids should not be used to remove old touch marks, but it is advisable from time to time to leave the cleaned stone overnight in a dilute solution of ammonia in order to remove excessive oil.

Touch needles

The alloys of known compositions, which are required for reference, are commercially available as touch needles or stars. The higher the accuracy demanded of the touchstone test, the greater the number of comparison needles of different fineness that must be available. When assaying gold alloys, it is not sufficient to have needles covering the range of fineness alone – for a given fineness, alloys of different colours must also be available (Figure 14).

Figure 14 A set of touch needles for 750 gold, each of a slightly different colour

Touch acids and reagents

The touch acids used for touchstone testing of gold should under no circumstances attack the rubbings too violently or the detection of small differences in fineness will be rendered impossible. These acids are essentially composed of nitric acid of different strengths, with or without the addition of copper or sodium chloride, or hydrochloric acid (see Table 1).

They may be kept for long periods since they do not deteriorate during storage. Indeed, their activity tends to increase with time since their water content is reduced by evaporation. Consequently, from time to time, distilled water must be added drop by drop to bring them back to their original strength.

The determination of the fineness of silver alloys is generally by comparison of the colours of the streaks. Test acids are rarely used and then only in special cases. For the identification of silver, it is possible to use a red test acid composed of potassium dichromate solution and sulphuric acid, or a gold touch acid which contains hydrochloric acid.

To differentiate between platinum, white gold, palladium and steel, an acid containing potassium iodide is used.

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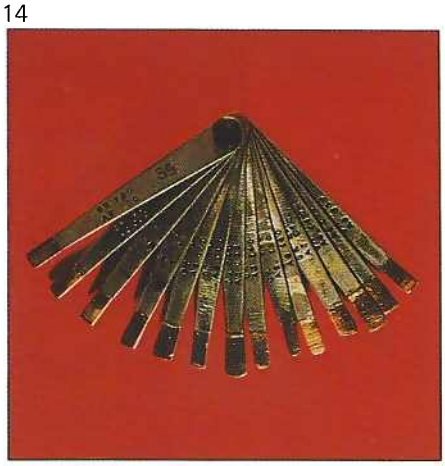

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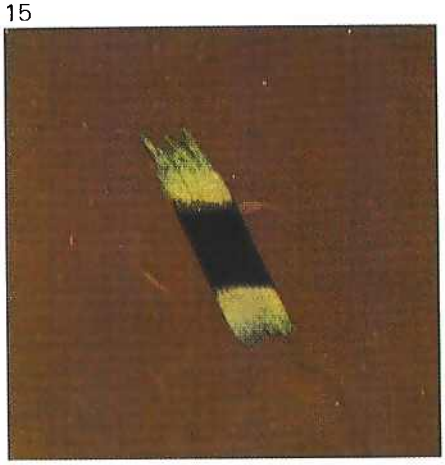

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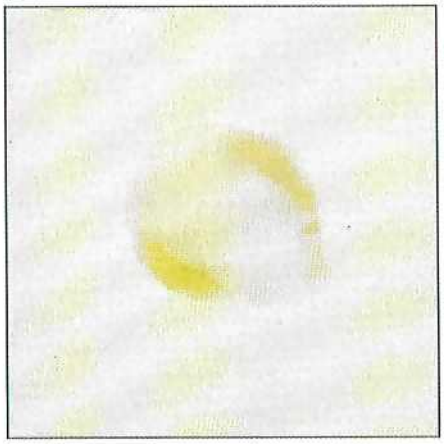

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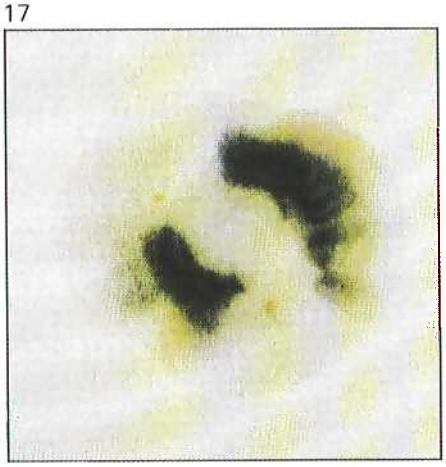

Filter paper
Thick filter paper (or blotting paper) is used to soak up excess acid from the touchstone. The used portions of the paper, impregnated with acid, are cut off or the whole filter paper is discarded.

5
Remarks on the Touchstone Testing of Gold Alloys

If the person carrying out the test is not very experienced, touchstone testing should be restricted to gold alloys of fineness between 375 and 750 parts per thousand. The best results are obtained with 750 golds; accuracy falls off with increasing or decreasing fineness.

For alloys of low fineness – about 375 and below – it may even be difficult to determine whether the alloy is really a gold alloy and not merely a base metal alloy. In such cases, the only sure way of establishing the presence of gold is by a chemical method.

Identification of gold
The reagent used for establishing the presence of gold is a solution of stannous chloride ($SnCl_2$). The rubbing on the touchstone is first dabbed with aqua regia. After the metal film has been completely dissolved, the acid is blotted with filter paper and to the damp spot on the paper is added a drop of stannous chloride solution. The presence of gold will be indicated by the formation of a red to violet jagged, crown-like ring of colloidal gold, known as Purple of Cassius (Figures 15-17).

Touchstone testing of coloured gold alloys (red, yellow or green gold)

1. It is very difficult for an inexperienced person to choose the right moment for using the filter paper to soak up the acid:

Waiting too long results in an excessively strong attack – the areas treated become too dark and during the action of the acid differences in fineness are no longer visible because of the heavily oxidized surface.

On the other hand, not waiting long enough gives rise to errors, especially in the case of alloys of 585 parts per thousand and lower. At such levels of fineness, applica-

Figures 15-17
Establishing the presence of gold
15 The dark brown residue characteristic of fine gold is here clearly visible after the application of diluted aqua regia to the test rubbing
16 The gold residue is now dissolved in concentrated aqua regia which is absorbed onto filter paper
17 The Purple of Cassius formed after the addition of a drop of stannous chloride solution to the wet spot is confirmation of the presence of gold

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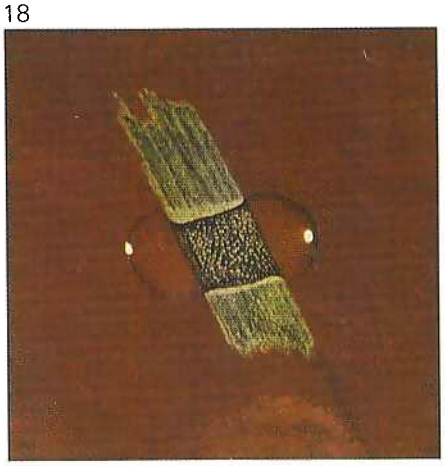

Figure 18 Attack on red gold rubbings is characterized by the evolution of gas as small bubbles

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Figure 19 Silver chloride has formed on the left hand rubbing after the application of touch acid for 750 gold, preventing accurate observation. It is easily removed by applying a drop of ammonia (right)

Table 2

EQUIPMENT AND SUPPLIES REQUIRED FOR NORMAL TOUCHSTONE TESTING

I Touchstone

II Set of touch needles (appropriate to the usual standards of fineness in the country concerned and to the most frequently encountered standards of fineness), e.g.

- 1 touch needle, silver 925
- 1 touch needle, silver 835
- 1 touch needle, silver 800
- 1 touch needle, red gold 750
- 1 touch needle, yellow gold 750
- 1 touch needle, white gold 750 (nickel-zinc white gold)
- 1 touch needle, white gold 750 (palladium white gold)
- 1 touch needle, red gold 585
- 1 touch needle, yellow gold 585
- 1 touch needle, white gold 585 (nickel-zinc white gold)
- 1 touch needle, red gold 375
- 1 touch needle, yellow gold 375

III Touch acids and reagents

- acid for gold 650 - 800
- acid for gold 500 - 650
- acid for gold 350 - 500
- aqua regia
- acid for differentiation – platinum/white gold/palladium/steel
- potassium dichromate solution
- stannous chloride solution
- dilute solution of ammonia

IV In addition, for testing for the presence of surface coatings: 1 emery stick.

tion of acid to the test rubbings often leads to the evolution of gas bubbles. The action of the acid is not completed until gas evolution ceases, and it is therefore necessary to wait until this moment before removing the acid (Figure 18).

2. The silver contained in most gold alloys forms, with the chlorides present in many test acids, a milky white precipitate of silver chloride, which rapidly takes on a blue colour and considerably reduces the ease with which the touchstone test can be interpreted. However, silver chloride is soluble in ammonia. Therefore, it is advisable – after first blotting up the test acid – to clean the rubbings with a solution of ammonia, and then to apply the test acid again for a short time and again remove it with filter paper. This procedure renders small differences in fineness more clearly visible (Figure 19).

3. The majority of gold alloys used in dentistry contain platinum as an alloying element. Even a very low platinum content makes the fineness of gold alloys appear higher than it really is.

Touchstone assaying of white gold alloys

In general, the gold content of white gold alloys cannot be determined as precisely as that of coloured gold alloys. This is essentially because white golds, for all standards of fineness between 333 and 916 parts per thousand, despite their very different compositions, are of a greyish white colour that varies only very slightly from one alloy to another (Figures 20-21). The choice of the corresponding touch needle is accordingly difficult, since the colour of the alloy provides practically no indication of its composition.

White golds containing platinum are attacked to a lesser degree and appreciably less rapidly than white gold alloys of the nickel-zinc type. The presence of palladium, an alloying element of many white golds, can be detected, provided the content is sufficiently high, by the brown colour it gives to the acid.

6

Remarks on Touchstone Testing of Silver Alloys

As already mentioned, touch acids are used only very rarely and only in special cases for determining the fineness of silver alloys. The potassium dichromate solution is not used for the determination of the silver content but only as a means of identifying the metal. Moreover, for alloys of fineness below 500 parts per thousand, it no longer gives a conclusive indication.

Silver alloys are frequently plated with gold, nickel or chromium, or coated with a colourless lacquer. Such coatings must first be removed since otherwise they will make touchstone testing erroneous or even impossible.

Identification of silver

To identify silver, the potassium dichromate solution is applied to the test rubbing. Deep red to light red silver chromate forms on the wetted surface if silver is present.

Silver can also be detected by means of the touch acid for 650 to 800 gold. It reacts with the chloride in the acid to form a milky white precipitate that rapidly turns blue when exposed to light. It is also soluble in ammonia (Figure 22).

Determination of fineness

The determination of the fineness of silver is by comparison of the colour of the test rubbing on the touchstone with that of adjacent rubbings produced by means of touch needles.

The silver content of binary silver-copper alloys is the most readily determined because of the different colours they exhibit, ranging from red to pink to yellowish to white as the silver content increases (Figure 23).

Figures 20-21
Testing white golds

20 These rubbings taken from several white gold alloys are identical in colour

21 After the application of touch acid, it is clear that the alloys differ widely in fineness (in this example the rubbings were taken from 8, 9, 14 and 18 carat white golds)

Silver is often alloyed with other metals as well, and this means that touchstone testing of silver is always associated with a degree of uncertainty and inaccuracy, since the presence of such alloying additions is not evident even though they may have a considerable effect on the colour of the rubbings. Thus, platinum, palladium, zinc and cadmium affect the colour of the rubbings produced by silver alloys so that a higher standard of fineness will be deduced than is really the case.

7

Differentiation between Platinum, White Gold, Palladium and Steel

Although it is possible to determine the fineness of platinum alloys by the touchstone test, this will not be described here since the method employs highly concentrated hot aqua regia (a mixture of nitric and hydrochloric acids) and therefore requires special equipment.

There is also a potassium-nitrate-based touch acid for platinum

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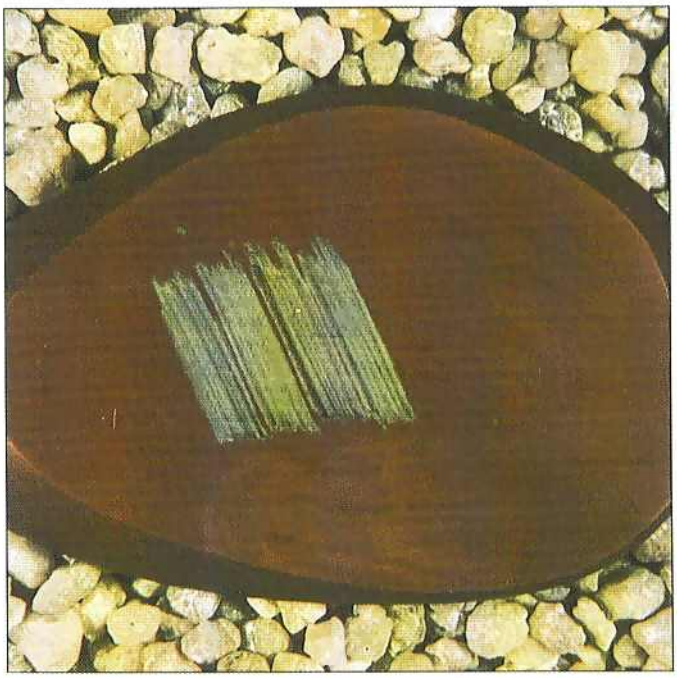

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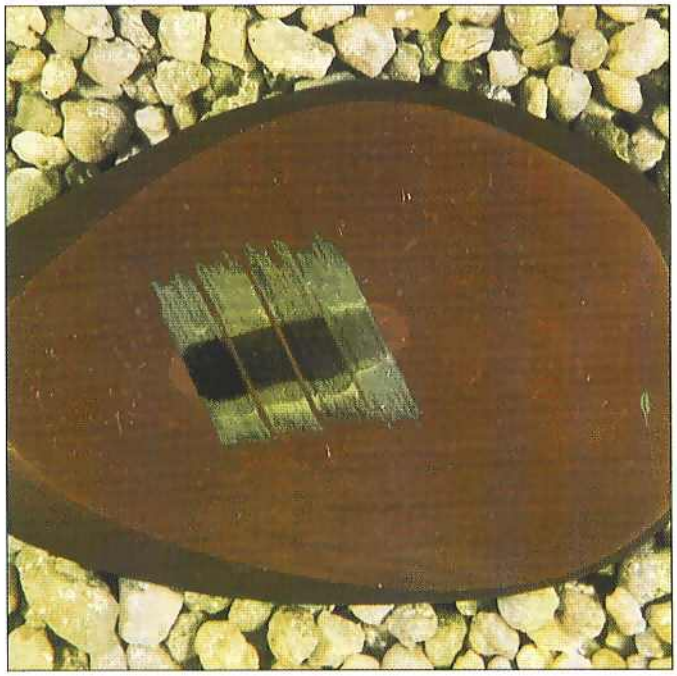

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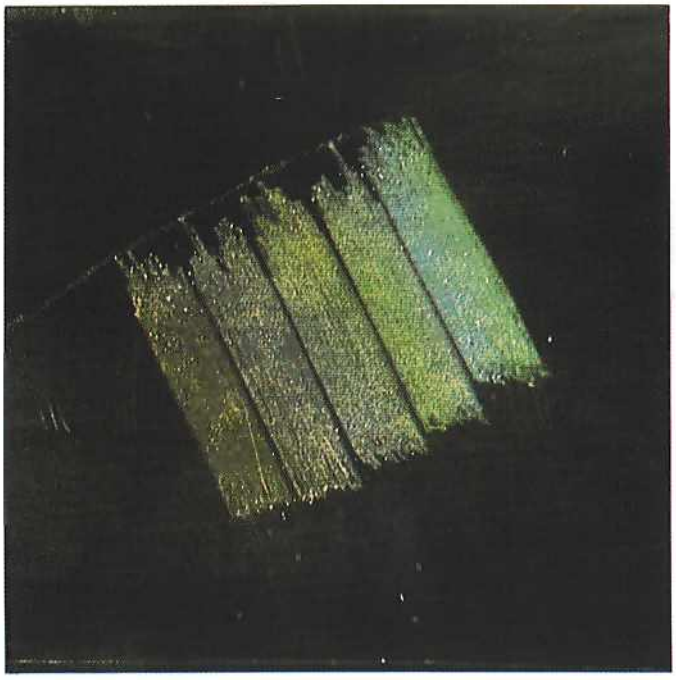

Figures 22-23
Testing silver alloys

22 The left hand rubbing taken from a silver alloy has been treated with potassium dichromate solution. The dark-red residue is silver chromate and confirms the presence of silver. The rubbing on the right was treated with a 750 gold touch acid containing chlorides, and is covered with a layer of white silver chloride.

23 These four rubbings were taken from silver-copper alloys ranging in fineness from 200 to 800 parts per thousand from left to right: 200, 400, 600 and 800)

which is used cold. However, the reaction is very slow and the acid rapidly loses its effect.

In order to distinguish platinum from either white gold alloys, palladium or stainless steel when the rubbings resist the touch acid for 650 to 800 gold, the rubbing is dabbed with the special acid called a differentiation acid. Platinum remains unaffected, even after exposure to the acid for a long time, whereas white gold and most palladium alloys react to give a dark red colour, and steel is generally completely dissolved. However, a few other base metals, such as tantalum, are also unaffected by this acid and only qualitative chemical analysis of the metal will remove all uncertainty.

Sometimes, the effect of the differentiation acid is clearer if a drop of the acid is applied directly to the article being examined.

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Concluding Remarks

This article has attempted to give the reader an insight into an important method, little known outside the jewellery industry, of analysing for gold, silver and platinum (and sometimes other constituents) in alloys. The technique of touchstone testing has acceptable accuracy in most cases. Moreover, it is rapid and has the advantage of requiring only a very small amount of test material. It will undoubtedly retain its value as a method for the testing of precious metals and, in particular, gold alloys.

The authors are both sworn-in assayers with the Swiss Federal Bureau for the Control of Precious Metals and may be contacted directly for any additional information.

Photographs by Urs Bangerter