Transferable Gold Coatings

HISTORICAL AND TECHNICAL ASPECTS OF THEIR DEVELOPMENT

Barry J. Sitch

George M. Whiley Limited, Livingston, Scotland

For thousands of years gold was employed in the form of beaten gold leaf for purposes of decoration and embellishment. The fragility and the costs of production and application of the metal in this form were major obstacles to its more widespread use for much of this time. The development of transferable gold coatings produced by vacuum deposition revolutionised what was pre-eminently a hand craft.

Measured against the length of time for which gold has been employed for the ornamentation of books and manuscripts, the development of transferable gold coatings is a relatively recent innovation.

The significance of the introduction in the mid-1930's of a material in roll form capable of eliminating the piece by piece handling of small squares of beaten gold leaf will readily be appreciated by anyone who has actually handled the latter material — or has seen it being handled under workshop conditions. Indeed, it is difficult to believe that less than 50 years ago, all gold lettering and edge gilding of books was carried out by teams of operators cutting and applying this delicate material using age-old craft techniques.

The Craft Background

Transfer gold leaf — that is to say individual leaves of gold lightly adhered to individual pieces of tissue paper — has been in use for many years, meeting the requirements of craftsmen working in the open under conditions in which it would have been impossible to handle 'loose' gold leaf, and this same material continues to be widely used today under the same circumstances.

The first step in the development of truly transferable gold coatings came with the fashion, at the turn of the century, of applying gilded lines to the sides of railway carriages and other vehicles. To facilitate this practice the method was conceived by the gold leaf manufacturers of laying leaves of gold side by side upon a strip of waxed paper some 20 m in length, which was then coiled upon a wooden spool to be cut into whatever widths were required for the work to be undertaken. The line was painted with gold size onto the vehicle and the roll or ribbon of gold inserted into a hand tool which was run along

the sized section under light pressure, causing the gold to be transferred from the waxed paper to the sized area. A considerable saving in time and material resulted.

About 1914, a small amount of ribbon gold leaf found its way into the hands of the book-binding industry, where it was used to line book covers and in the context of this application it was a natural progression for the manufacturer to apply a size — in this case shellac — to the gold surface prior to winding the ribbon onto the spool. This resulted in a material (Figure 1) which could be transferred to any suitably receptive surface such as paper, leather or bookcloth

Fig. 1 Schematic section through a gold stamping foil. Glassine paper, viscose cellulose film and cellulose acetate film have each been used as carriers, but the material now in use is 12 μm thick polyester film. The release layer provides carefully controlled adhesion of the gold onto the carrier until transfer is activated by heat and pressure. The release agent (virtually a monomolecular layer) was originally wax. Nowadays, a variety of products is available to suit different applications. The gold layer first consisted of hand-beaten leaves, it was later deposited by sputtering and now layers typically 400 $\text{\AA}$ thick are deposited by vacuum evaporation onto the prepared substrate. Lastly, a heat and pressure sensitive coat of adhesive (1 μm thick) is applied on top of the gold layer

Fig. 2 In this illustration of traditional gold blocking with hand tools, the craftsman is seen applying the heated tool in register with the first 'blind' impression which is clearly visible through the gold leaf. Due to the high pressure required for the adhesion of the gold, small areas only can be gilded at a time and separate tools are required for application to different parts of the design. These tools can be seen kept hot in the background upon a gas heated stove

Photograph reproduced with the permission of Sangorski and Sutcliffe, London

by heat and pressure, whether applied by means of a heated hand tool or an engraved die mounted in a blocking press.

The Origin of Hot Stamping

This method of applying gold, referred to as gold blocking or more recently hot stamping, depended for hundreds of years upon the use of gold leaf. A 'blind' impression was made with the engraved tool or block into a substrate surface. 'Glair' — a heat sensitive adhesive consisting of strained egg white to which a small amount of vinegar has been added — was applied to the tooled area and allowed to dry. Vaseline was then thinly smeared over those parts of the surface to which gold was not required to adhere and a piece of gold leaf of a suitable size was applied over the whole area. The outline of the blind impression was clearly visible through the leaf, enabling a skilled craftsman to apply the heated tool for a second time in register with the first impression (Figure 2). This second application activated the adhesive properties of the glair, causing the gold to become firmly bonded to the substrate surface. The surplus gold in and around the impression area was then removed with a soft cloth. 'Hand tooling' was confined to one-off requirements where relatively small areas were involved. Larger designs, in excess of a few square centimetres, and larger quantities of the same design, were applied by means of an arming press, which in essence consisted of a supported pair of parallel metal plates, the top one latterly being provided with a method of heating, and a means whereby the two plates could be brought together under pressure (Figure 3). The engraved metal block would be

Fig. 3 Arming press used in the eighteenth century for the embossing and later the gilding of large areas. The top plate consisted of an engraved block and was heated prior to being applied onto the item to be decorated which was covered with gold leaf after suitable preparation

mounted on the top plate and heated — originally by the insertion of hot metal bars into the top of the plate — to a temperature of approximately 100°C. The item to be stamped would be placed on the lower plate, having been prepared as described above, and the heated block then brought into contact with its gold covered surface. In this way the decoration of larger areas was feasible and the need for blind stamping was eliminated since guides could be fixed to the bottom plate to pre-determine the position of the stamped impression. With the introduction of gold leaf in a transferable form, a mechanism was developed to enable rolls to be mounted directly onto the press and the whole of the hand element of the operation, with the exception of subsequent cleaning, was eliminated. This material was the immediate forerunner of today's gold stamping foils and although it had many limitations — the impression produced from it requiring much cleaning and the maximum width of any roll at first not exceeding the width of the beaten leaf — between 75 and 100 mm — it proved to be an immediate commercial success.

No significant changes in materials or methods took place during the three decades following the introduction of ribbon gold leaf. Nevertheless, the more progressive gold beaters in Europe and the United States displayed increasing interest in the possibility of producing a continuous sheet or film of gold by means

other than beating since it was clear that any extension of the use of the gold blocking process — and thus of those materials upon which their livelihood depended — would continue to be restricted to luxury and semi-luxury items until a cheaper and more sophisticated medium became available. During the early 1930's, much experimental work took place in this connection.

Vacuum Deposition

In 1933 George M. Whiley Ltd., the largest gold beater in the United Kingdom, introduced their 'Spray Gold' which consisted of a layer of gold some 0.07 μm in thickness — rather thinner than most gold leaf — which had been deposited under vacuum onto a prepared glassine paper carrier. This 'foil', like the product it was to replace, incorporated a coating of heat sensitive adhesive applied to the gold surface. The new process, however, was capable of producing rolls 1 m wide and up to 90 m long at a significantly reduced cost due to the limited labour content. Additionally, it possessed superior handling properties and produced stamping results of a consistently higher quality, which required much less cleaning than those obtainable from the gold leaf-based product.

The deposition of the metal was achieved by sputtering. In the form in which the process was

Fig. 4 Although sputtering of gold was discovered by Sir William Grove in 1852 and was used by Edison about 50 years later to apply a conductive surface for subsequent electroplating upon his phonograph masters, other industrial applications were slow to develop. What was probably amongst the earliest of sputtering equipment developed for industrial purposes is illustrated here. It was used at George M. Whiley Ltd. from 1933 for applying a transferable layer of gold to various substrate films. Next to the vacuum chamber are the high accelerating voltage supply and the pumping equipment. The diagram illustrates the principle of the method which is detailed in the text

employed by Whiley, strips of gold approximately 3 mm thick and 450 mm long were suspended on frames and placed in a vacuum chamber adjacent to a large cooling plate. An unwinding and rewinding mechanism was installed above and below the plate, so positioned that a roll of prepared paper or carrier could be passed at a controlled rate between the cooling plate and the frame of electrodes (Figure 4). Preparation of the carrier involved the application of a thin even coating of wax which served the dual purpose of collecting the gold particles and ensuring the free release or transfer of the gold coating when in use. The vacuum chamber was pumped down to a pressure of approximately 1 kPa and an inert gas (nitrogen in this case) was bled into the chamber. A 2 000 V supply was connected to the electrodes (A.C. was found to be as effective as D.C. and much more convenient) and in the resultant ionized space, charged particles of gold passed at high velocity between the opposing rows of electrodes and the carrier film surface. While some would impinge upon the opposite electrodes, most would pass through the spaces and become embedded in the wax coating of the carrier film. In this way, a complete covering of metal was built up on the carrier and due to the method of deposition a matt finish which very closely resembled gold leaf in appearance was achieved. The electrodes would gradually disintegrate through loss of substance and required to be replaced every third run to maintain consistent results. Four rolls were coated from two electrode frames at a single loading and a run of some 90 m took approximately 30 hours.

This material rapidly replaced the use of beaten gold leaf products in all industrial blocking operations and within a very short length of time it was being sold throughout the world for use upon books, leather goods, shoes, pencils and a wide variety of other items. Impressions made from 'Spray Gold' proved to be at least as durable as those obtainable from gold leaf. In due course, the paper carrier was successively replaced by viscose, by acetate and finally by polyester film. No other significant change took place in the make-up of this product right up to the late 1960's, when it was finally rendered obsolete by an improved material which had been introduced by Whiley some years previously.

Vaporising

This new foil was also produced by vacuum deposition but the vaporising rather than the sputtering process was employed. Continuous evaporation of aluminium onto a paper carrier had been pioneered by Whiley during the second World War and the experience thus gained was applied to gold in the early 1950's. However, a totally different metallising technique had to be developed, bearing in mind the

Fig. 5 The current method of gold deposition for the manufacture of transferable coatings is vacuum evaporation. The substrate, already coated with the release layer, moves under vacuum past a source of vaporized gold, some of which condenses onto the film. The gold vapor is supplied by continuously feeding gold or gold alloy wires onto a heat source:

high value of the raw material and the importance of recovering readily and without loss that portion of it which was deposited within the chamber. Those were of course the early days of industrial vacuum technology and Whiley had only their own resources to draw upon in regard to both the design and the construction of the necessary coating equipment. It was found that small variations in the coating uniformity of the gold had a much greater effect upon the visual appearance of the product than was the case with aluminium and this factor had to be taken into account. Initially, acetate film was employed as the carrier and this required pre-treatment to remove excess plasticiser and reduce outgassing to acceptable limits when under vacuum. The introduction of polyester film by ICI played an important part in the further development and application of the process and provided for the first time a truly stable base for the coating process while enhancing the overall performance of the product.

The vacuum chamber developed for the new process was equipped with a bank of resistance heaters on to which gold wire was fed at a pre-determined rate. The carrier film was first coated with a release layer and passed over the vaporising sources, a system of braked and driven rollers controlling the speed and path of the film (Figure 5). The thickness of the metal deposited was determined by the rate at which gold wire was fed onto the heaters and by the running speed of the film. It was found that to ensure freedom from discolouration after application, alloys of low caratage had to be avoided in the production of transfer products of this type — the material referred to above, for example, being manufactured from 23 carat gold wire. The surface finish of any transferable metal coating produced by this means is greatly in-

Fig. 6 Most of the transferable gold coatings produced today are used on hot blocking machines similar to that illustrated here. The principle remains the same as that of the press in Figure 3 with two important exceptions: the substrate does not require any preparation as the foil is pre-coated with a heat and pressure sensitive adhesive and the continuous feeding of the foil enables fast operation

fluenced by the texture of the surface upon which the metal is deposited in the first instance. One great advantage of the vaporising process as compared with the earlier sputtering process was that it was possible to produce a really brilliant metallic finish, or, by suitable pre-treatment of the carrier film, more subdued effects. The new process also permitted the production of foils capable of producing cleaner, sharper impressions at considerably higher running speeds, which resulted in significant cost reductions for the user. The same length of material that had taken 12 to 14 hours to metallise by the old process could now be coated in less than 10 minutes.

Applications

The usage of transferable gold coatings has, over the years, been subject to almost as much change as have the means by which they have been produced. The very early products, which were based upon gold leaf, were employed mainly for the titling and decoration of book covers (Figure 6) — that is to say they did little more than displace 'loose' gold leaf from its traditional role. However, with the development of the continuous metallising processes and of adhesives of greater versatility than shellac, many other uses began to emerge and by the end of the 1930's gold

stamping foils were being applied to items as diverse as leather skins (to be made into ladies' evening shoes and handbags), pencils, hat bands, cricket balls, leather goods of all types, clock faces, picture frames and even scent bottle labels. With the introduction of vaporised gold, the field of use extended even further, taking advantage of the superior working properties of this material and its inherently brighter finish. Advances in adhesive technology also played a role in achieving compatibility with the many new plastic substrates that were appearing on the market.

Current Trends

During the 1960's, simulated gold foils based upon vaporised aluminium and transparent lacquers were developed and introduced and these have in turn gradually replaced the use of the more expensive genuine gold product in many applications. The wheel has now almost turned full circle, in that today real gold is again seldom encountered outside the bookbinding industry where its use originated. However, it is largely restricted to edge gilding where automated application is now possible, as a result of the availability of transfer coatings of consistent quality in long rolls (Figure 7), and to the titling and embellishment of high value publications.

Fig. 7 One consequence of the availability of transferable gold coatings in long coils has been the mechanisation of traditionally labour intensive applications. The machine shown here performs the continuous edge gilding of books. In one single pass, one edge of the book is sanded and coated with adhesive after which the gold foil is applied

Photograph by courtesy of Ochsner & Co., Schmerikon, Switzerland

It is no exaggeration to state that a whole industry and a new means of decoration have been built on the foundation of gold transfer products.

There would appear to be little doubt that the future of genuine gold in this form and of the technique by which it is produced now lie in technical

rather than decorative applications and possibilities and opportunities in space technology, and in the electronics and other industries are under constant investigation. In these applications, the intrinsic qualities of gold are as important to today's scientists as they were to artists and craftsmen of days gone by.