GALVANOPLASTIC PRECIPITATION OF COPPER ON ENGRAVED PLATES

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(*Translation from the Dutch Text.*)

Till recently modifications in the engraving on copper plates caused by new surveys, changes in fairways, shifting of buoys, *etc.*, were made at the Netherlands Hydrographic Office by totally erasing the obsolete engraving by means of the scraper and stone and by hammering the copper plate at the back until a new, even surface was obtained. Polishing with charcoal made this hammered-up surface perfectly smooth and ready for new engraving.

Both the scraping and the hammering, and the latter particularly, are objectionable from various points of view. Small corrections in the buoyage and the lighting occur continually in the same places, at which the copper has to be bulged out every time ; this obviously alters its tough structure and it becomes less resistant ; in one case the lines representing the parallels of latitude near such a spot suddenly developed a curve, the maximum deviation from the straight being no less two tenths of an inch.

This may be prevented by not erasing the engraving very locally but by grinding the copper off over a large area thus making hammering unnecessary or reducing it to a minimum, but this method of procedure entails, for a small correction, an incommensurate amount of new engraving.

In accordance with the Resolution passed at the International Hydrographic Conference, London 1919, it was decided to change the unit of depth used on the charts of the East Indian Archipelago from fathoms into meters and, in consequence of this decision, a very great number of small and some more important, corrections had to be made on 300 copper plates in the Netherlands Hydrographic Office. With a view to this extensive work and in order to avoid the disadvantages of the old proce-

dure mentioned above, it was decided to try to find a method of depositing new copper on the smaller erased parts by galvanoplastic precipitation.

The experiments made to ascertain the best way of doing this caused a great number of surprises and disappointments for, although the galvanoplastic process is generally applied in metal work, the requirements of the building up of superimposed copper on a copper plate are nowhere so arduous as in this case. The galvanoplastic process has been limited nearly always to spreading an even and general layer of metal on to some other metal surface which is not exposed to great pressure and for this reason not a single professional in this line was able to give definite advice as to the difficulties to be met with, the principal of which was found to be that the superimposed copper never thoroughly adhered to the plate and could be disengaged from it.

The advice received generally was that the grease on the plate was removed better by applying acid, but the exceedingly thin layer of oxides which is formed, and remains after the application of acid, continually prevented the adhesion of new copper which sticks firmly only to those places where the surface of the plate consists of absolutely clean copper. Eventually it was found that, on the spots on which it was intended that deposited copper should adhere thoroughly, the plate should be cleaned with the scraper.

The following description of the procedure which proved the most successful is an enumeration of apparently trifling operations which, however, are not devoid of interest as many investigations had to be made before it was evolved ; it is given here in order to save others the trouble and loss of time incurred in having to rediscover and overcome the difficulties met with.

Experiments were made on a copper plate of 4 square decimetres (62 sq. ins.) suspended in a glass container filled with a satured solution of copper sulphate, introduced into an electric circuit as the cathode (—) while, at a distance of about 8 cm. (3.2 ins.) a similar plate of electrolytic copper was suspended as the anode (+).

The current was generated by an accumulator and its initial strength was regulated at 0.25 amperes for every square decimetre on which it was intended to deposit copper. A voltmeter, an ammeter and a resistance were provided.

The whole cathode is covered on both sides with a layer of beeswax-melted in a double boiler and applied with a soft brush ; this layer should not be porous as copper is precipitated in every pore which causes, in addition to the trouble of removing it, an increase in the cost of the process.

The wax is then removed with a spatula of hard wood or vulcanised rubber at the spots which are intented to be filled up, these are thoroughly cleaned with turpentine and the scraper, after which the cathode is placed in the bath and the circuit closed.

Copper is superimposed on the scraped places and adheres thoroughly to them ; experiment showed that the slower the copper is deposited the finer is its structure. A current having a tension of 2 volts and a strength of 0.25 amperes per square decimetre of surface of the uncovered cathode, deposits about 1 mm. (0.04 in.) of copper in 12 hours. The cathode may be lifted out of the bath in order to inspect progress for this does not interfere with the process. The bath should be well stirred now and then and should be maintained at a constant temperature of about 20° centigrade (68° Fahr.) ; if it falls appreciably below this temperature the precipitation proceeds more slowly and crystals of copper sulphate are formed.

Copper is liable to be precipitated in the vicinity of the bare places where the layer of wax has been damaged by the spatula, however, this metal only adheres firmly in the middle, where the scraper has done its work. In order to prevent the deposit of copper round these spots, the wax layer might be restored by carefully encircling the engraving which it is intended to renew, but this requires much time.

Adhesion of copper in places where this is undesirable requires that, afterwards, the protruding parts be cut off with a chisel and the spot polished, whereas loosely deposited copper is lifted and torn off easily and no polishing is required. Therefore it is considered preferable to allow the copper to be precipitated loosely round those parts where it is required to adhere firmly.

This object is obtained by brushing the places where the wax is removed with a solution of cyanide of silver which covers the copper with an exceedingly thin coating of silver. But the cyanide must be neutralized by a second cleaning with whiting, and by flushing off and drying with unsized paper, in order to prevent the plate from being impaired and the deposit of copper from being delayed.

The copper precipitated adheres but loosely to the silver and this latter is removed with the polishing mop after the loose deposit has been torn off.

This process of silvering requires very little time ; when it is finished the plate shows a thick layer of beeswax interrupted by small silver squares and, in the middle of each square the engraving which is to be renewed.

This engraving is now cut out completely with a rotary cutter driven by electricity such as is used by dentists, which process is preferable to hand scraping because it requires less time, is easier and the edges of the

depression can be bevelled off more smoothly and small cracks and holes, which usually are made by scraping (and gave a great deal of trouble) are avoided. Clean copper is liable to oxidize when it is exposed for some time to the air, to the breath of the engraver or to contact with his moist hands therefore, when cutting out the old engraving, the mouth of the engraver should be covered and he should wear rubber gloves.

If the cutting out is a lengthy operation, it is advisable to cover the rest of the cathode with paper.

The next step is the galvanic process which should not last longer than is absolutely necessary.

The container for the copper plate is an iron tank of 120 × 90 × 35 cms (47 1/4 × 35 1/2 × 13 3/4 ins.) lined with lead and having copper cross bars at the top from which to hang the plate and the anode ; gas heating at the bottom enables the bath to be kept at a constant temperature.

When the plate is taken out of the bath, the wax is removed and the loosely deposited copper round the erased engraving is torn off after which the plate shows only small protuberances over the places filled up. These are levelled off with a chisel and hammer and should be as small as possible to prevent small cracks being caused by the chiselling.

As a rule copper plates contain other metals whereas the superimposed electrolytic copper is pure, however in practice this is no impediment and engraving on the new part never gave any trouble. Even if an old plate were used as the anode, the deposited copper would be purely electrolytic, but if this device be used, the bath becomes polluted.

The following is a summary of the various manipulations : —

cover the whole plate on both sides with a layer of beeswax,

remove the wax from the parts on which deposit is required,

clean the plate with whiting and flush off,

apply cyanide of silver on parts where the wax is removed,

clean again with whiting, flush off and dry,

erase old engraving completely, and,

deposit copper galvanically.

After sufficient copper has been superimposed : —

flush off the plate,

remove the wax by melting and turpentine,

remove the loosely deposited copper round the convex, protruding parts of the superimposed copper,

cut these parts off with a chisel, and polish with charcoal.

There is a fairly considerable amount of polishing to be done but this is by far outweighed by the advantages that :

(1) the plate is in no way damaged, and

(2) the surrounding engraving remains intact.

As a generator of current an accumulator of one cell (or two coupled) is ideal on account of its production of a constant current in one direction, but it is troublesome and expensive on account of the necessity of recharging every three weeks. Therefore the lighting current of the municipal plant was adopted later on and this alternating current was transformed into continuous current by a transformer, at the same time it was reduced to 4 volts. However, the transformer never works as well and as steadily as an accumulator, and this is clearly indicated by the oscillations of the index of the ammeter.

The method gives full satisfaction.

Some engravers use another method to clean thoroughly the parts of the plate on which the copper should be superimposed, and they do not erase the parts on which it is intended to deposit.

After having cleaned the plate chemically by boiling it in a potash bath, in order to remove the ink, and applying weak nitric acid solution, to get rid of the grease, it is hung in the bath and the current is reversed ; then the plate works as an anode and in a few minutes repels every impurity which may still be adhering to it. The plate is taken out of the bath, flushed with a strong jet of water, and covered with beeswax except in the places where the precipitated copper is to fill up the old engraving ; the current is then reversed to normal, the plate hung in the bath and precipitation on the bare parts begins.

The application of this method in practice (this Office had been acquainted with the theory thereof for some time) was found out by minute inspection of plates corrected by an engraver abroad. The slight difference of colour between the superimposed copper and the copper of the old plate, which always shows when the latter is not yet highly polished, permitted the detection of the form of the original soundings and contours of depths which proved that they had not been cut out of the plate.

At present, when carrying out a large correction, a combined method is followed, *viz* : an extensive surface is ground down with the stone to a small depth at places where the old engraving need not be saved and the galvanic method of filling up is applied in places between the parts of the engraving which should be preserved. This turned out to be the most economical system with regard to time required for both cutting out and engraving, while it does not affect the plate materially.

After some practice and experience, the work may be done by any engraver ; however, the trials required a cautious, considerate and inventive engraver and, fortunately, he was available.