ELECTROPLATER

3rd Semester

TRADE THEORY

SECTOR: Power generation transmission,
Distribution & Electrical equipment

DIRECTORATE GENERAL OF TRAINING,
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP,
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL
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FOREWORD

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship has been developing, producing and disseminating Instructional Media Packages (IMPs) for various trades under the Craftsman Training Scheme, Apprenticeship Training Scheme, Center of Excellence (CoE) Scheme and Modular Employable skills (MES) under Skill Development Initiative (SDI) Scheme. These IMPs are extensively used in the Government and Private Industrial Training Institutes and other Vocational Training Institutes to impart both Theory and Practical training and develop work- skills for the trainees and trainers.

Providing the current industry relevant skill training to students requires regularly updated syllabus and trainers who are trained in the latest syllabus. Mentor Councils were constituted in January 2014 to revamp courses to be run in 25 sectors. The Mentor Councils have representatives from thought leaders among various stakeholders viz. one of the top ten industries in the sector, innovative entrepreneur who have proved to be game-changers, academic/ professional institutions, champion ITIs for each of the sectors and experts in delivering education and training through modern methods like through use of IT, distance education etc..

11 sectors were identified as priority sectors and internal core groups were created to tap the expertise of officers in the various institutions of Directorate General of Training (DGT). A review of curriculum, admission criteria, course duration etc. was done and a revised curriculum was recommended.

The Institute has now come up with instructional material to suit the revised curriculum under Semester pattern for **Electroplater Trade Theory 3rd Semester** in **Power Generation Transmission, Distribution, Wiring & Electrical Equipment sector** to enhance employability of ITI trainees across the country and also to meet the industry requirement.

I have no doubt that the trainers and trainees of ITIs, other vocational training institutes and industries will derive maximum benefits from this book and that NIMI's effort will go a long way in improving the quality of vocational training in the country by publishing the instructional materials for various courses and also assist in enhancing the employment opportunities of the trainees and other beneficiaries.

The Director and the staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

RAJESH AGRAWAL, I.A.S.,
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PREFACE

This National Instructional Media Institute (NIMI) an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship, Government of India was set up at Chennai in 1986 with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and disseminate uniform instructional materials for various trades as per the prescribed syllabi under the Craftsmen and Apprenticeship Training Schemes approved by NCVT.

The instructional materials are developed and produced in the form of Instructional Media Packages (IMPs). An IMP consists of Trade Practical book,Related Trade Theory book, Test and Assignment book, Workshop calculation & Science,Engineering Drawing, Instructor guide, Wall Charts and Transparencies.

Hon'ble **Prime Minister** of India during his speech on 15th August 2014 mentioned about developing **Skill India** and made the following announcement

"Skilling is building a better India. If we have to move India toward development then Skill Development should be our mission."

Providing the current industry relevant skill training to students requires regularly updated syllabus and trainers who are trained in the latest syllabus. Mentor Councils were constituted in January 2014 to revamp courses to be run in 25 sectors. The ultimate approach of NIMI is to prepare the validated IMPs based on the exercises to be done during the course of study. As the skill development is progressive the theoretical content on a particular topic is limited to the requirement in every stage. Hence, the reader will find a topic spread over a number of units. The test and assignment will enable the instructor to give assignments and evaluate the performance of a trainee. If a trainee possesses the same it helps the trainee to do assignment on his own and also to evaluate himself. The wall charts (NIMI Wall Chart are displayed in Premier Institutes like IIT-Madras etc.) and transparencies are unique, as they not only help the instructor to effectively present a topic but also helps the trainees to grasp the technical topic quickly. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirement ,

To fulfill the Prime Minister Vision of making **Digital India** NIMI has also taken the steps to diversify the Instructional Material in the form of **E- Book (Digitalized Content - www.nimilearningonline.in), E-Learning and Videos** for the IMP's developed. Thus the availability of a complete Instructional Media Package in an institute helps the trainer and management to impart an effective training. Hence, it is strongly recommended that the Training Institutes/Establishments should provide at least **one IMP** per unit. This will be small, one time investment but the benefits will be long lasting along with strengthening library facilities.

The **Electroplater Trade Theory 3rd semester in Power Generation Transmission, Distribution, Wiring & Electrical Equipment sector** is one of the book develop by the core group members of the Mentor Councils (MCs). The 3rd semester book includes **Module 1- Chromium plating, Module 2 - Cadmium plating, Module 3 - Silver plating, Module 4 - Gold plating, Module 5 - Brass plating, Module 6 - Zinc plating.**

The **Electroplater Trade Theory 3rd semester** is the outcome of the collective efforts of Members of Mentor Council which includes academic/professional institutions (IITs etc.), experts from field institutes of DGE&T, champion ITIs for each of the sectors, and also Media Development Committee (MDC) members and staff of NIMI.

NIMI wishes that the above material will fulfil to satisfy the long needs of the Trainees and Instructor and helps the trainees for their employability in vocational training for all Engineering and Non-Engineering disciplines.

NIMI would like to take this opportunity to convey sincere thanks to all the Mentor Council Core Group members and Media Development Committee (MDC) members.

A. MAHENDIRAN
Director, NIMI.

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Electroplater** under the **Power Generation Transmission, Distribution, Wiring & Electrical Equipment** Sector for Craftsman Training Scheme. This Book is prepared as per Revised Syllabus.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE THEORY

The manual of trade theory consists of theoretical information for the Third Semester course of the Electroplater Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theortical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self learning and should be considered as supplementary to class room instruction.

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the Third Semester course of the Electroplater trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered.

The manual is divided into six modules. The distribution of time for the practical in the six modules are given below.

Module 1	Chromium plating	13 Exercises
Module 2	Cadmium plating	08 Exercises
Module 3	Silver plating	11 Exercises
Module 4	Gold plating	10 Exercises
Module 5	Brass plating	08 Exercises
Module 6	Zinc plating	11 Exercises
	Total	61 Exercises

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instance where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there if a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

CONTENTS


Nimi

Basics of chromium plating and equipments

Objectives : At the end of this lesson you shall be able to

- **state the properties of chromium metal and its applications**
- **describe the equipments for bright chromium plating**
- **explain the anode maintenance and the chroffles.**

Chromium plating

The deposition of chromium is generally undertaken to provide a brilliant untarnishable finish, or to produce a hard abrasion resistant surface. Although the necessary equipment and the general principles are similar in both cases, the technique of hard chromium deposition defers from that for decorative plating, and the thickness of the metal applied is considerably greater.

Properties of chromium

Chromium is a chemical element with symbol Cr, atomic weight 52, valency 6 and atomic number 24. It is the first element in Group 6. It is a bluish white, lustrous, hard and brittle metal which takes a high polish, resists tarnishing, and has a high melting point. The name of the element is derived from the Greek word chroma, meaning colour. Chromium is remarkable for its magnetic properties. It has melting point of 1830°C, boiling point of 2,642°C and density of 7.1 g/cc.

Applications of bright chromium plating

Bright chromium plating is now applied to so many different types of articles that the brilliant bluish white appearance of the metal is familiar to everyone. The deposit does not tarnish and requires but occasional washing with soap and water, or wiping with a soft cloth, to remove any accumulation of dust and dirt from the surface.

The term bright chromium plating is used to describe a layer of nickel followed by a final deposit of bright chromium. Direct chromium deposits are not generally used for the decorative purposes. Experience over many years has confirmed that nickel is the most suitable undercoat for decorative deposits because of the ease with which bright chromium may be applied, the white colour and good corrosion resistance of the nickel deposit and relative simplicity of the nickel plating process. The nickel deposit gives protection to the basis metal, and is itself preserved from surface oxidation by the bright chromium deposit.

The usual thickness of bright chromium deposit is 0.25 to 0.8 microns.This thin deposit of chromium suffers from a random cracking and under corrosive conditions moisture containing atmospheric impurities provides an electrolyte and the chromium forms an electric couple with basis metal or undercoat. The chromium behaves as a noble metal, becoming cathodic whilst the basis metal becomes anodic and is gradually corroded. The electrochemical action between chromium and nickel is less than that between chromium and other common metals.

Equipments for bright chromium bath

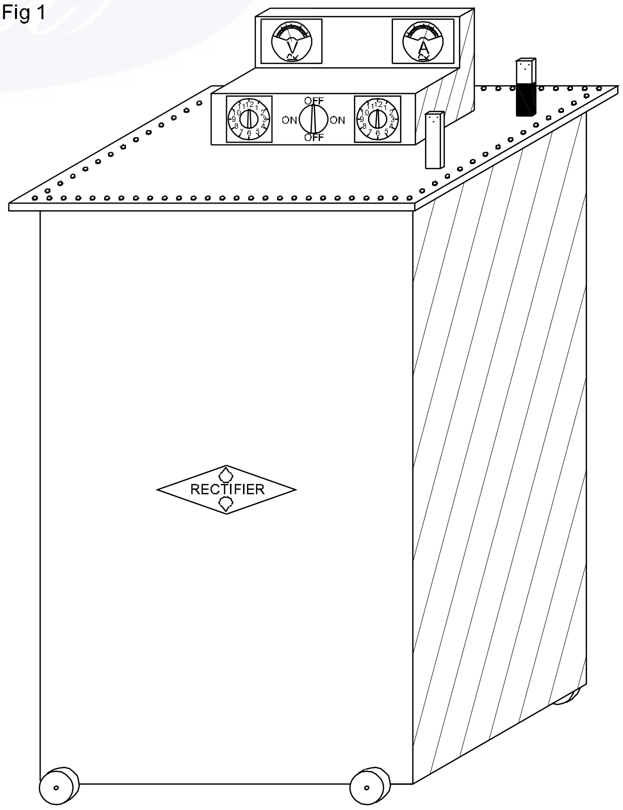
It is important that electroplater uses proper equipments for his work. The quality and efficiency of work will depend upon the use of proper equipment.

Listed below are the equipments are the most commonly used for bright chromium plating.

Rectifier

It is used to rectify the AC supply input to DC output required for electroplating. The output voltage is variable and the required current can be set. The polarity of the output is marked. The output capacity of the rectifier (Fig.1) should match the voltage and current requirements of the process for which it is to be used. Oil immersed metallic type rectifiers are best suited, although air cooled types may be used where the power demand is not high.

Fig 1

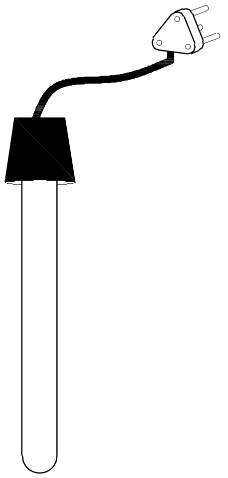


RECTIFIER

Immersion heater

Heating by electricity provides ease in control. Silica or lead lined electrical immersion heaters (Fig.2) are used for heating bright chromium solution.

Fig 2

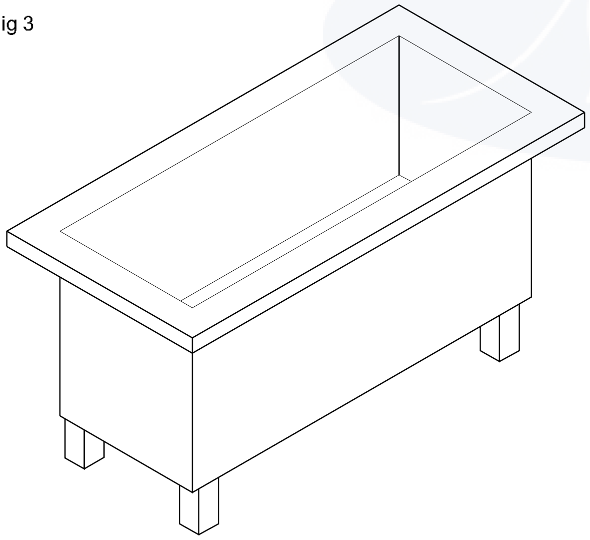


SILICA LINED HEATER

Plating tank

Lead lined tanks are used as container for the solutions of chromium plating. Stainless steel tanks are used for swilling, drag in and drag out operations. Now a days, polypropylene (PP) tanks are used for these purposes because of its resistance to chemicals.(Fig.3)

Fig 3



PLATING TANK

When starting up new lead lined tank, it is important that the temperature of chromium plating solution be brought up as rapidly as possible to above its normal operating value. In this way a protective film is formed on the surface of the lead.

Under no circumstances should cold chromium plating solution be left in contact with lead until the treatment above has been applied.

Busbars

Bus bar is a rigid conductor, made of copper, for carrying current to the anode and cathode rods from the rectifier. These should have enough capacity to carry the full load current.

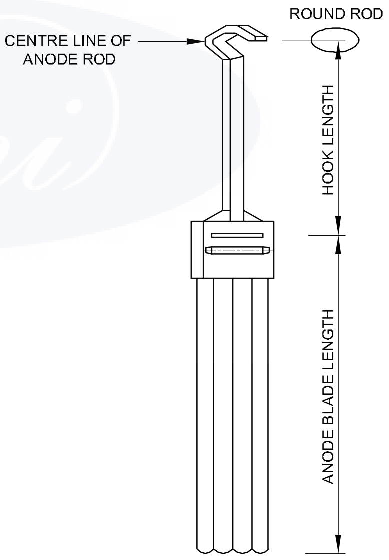
Anode rod and cathode rod

The anode and cathode rods are made of copper and should have enough capacity to carry the current from the bus bars. The two anode rods are placed above the plating tank to hook the anodes. The cathode rod is placed in between the two anode rods and suspends the job to be plated.

Anodes

Tin Antimony lead anodes of dog bone shape (Fig.4) are generally used for bright chromium plating. The Antimony lead anodes serve two purposes, they not only function as the positive electrode, but also help to maintain the solution in satisfactory balance by re-oxidizing the trivalent chromium to chromic acid. The anode area should be about 20% greater than the area of the plating load. Metallic chromium anodes are not practicable due to its difficult in preparation, high cost and also the chromium anodes are dissolved in chromium bath and getting coated powdery cathode. Anodes are usually hung at a distance of 125 to 150mm from the cathodes. Anodes should be slightly shorter than the articles to avoid building up deposits on the lower edges.

Fig 4



ANTIMONY LEAD ANODE

If the solution is idle for a period, as at weekends, the anode should be removed from the tank, and then swilled, brushed with a wirebrush, swilled again, and allowed to dry. This will preserve their surface so that they can be put into use again immediately plating is to be resumed.

Anode maintenance

When the current is passing through the chromium plating solution, gassing will occur at the anodes which are normally covered with a dark chocolate coloured film. It is recommended that new anodes be worked at 0.8 to 1 Ampere per centimeter length to ensure the formation of this anode film. The presence of a chocolate coloured film on the anode is necessary to ensure that the trivalent chromium produced by electrochemical reduction of the chromic acid at the cathode is re-oxidised. In this way, rapid buildup of trivalent chromium in the solution is avoided.

If the anode is allowed to idle owing to inefficient contact, the chocolate brown film will gradually be converted to yellow lead chromate. The presence of this yellow film on the anodes indicates unsatisfactory electrical connection.

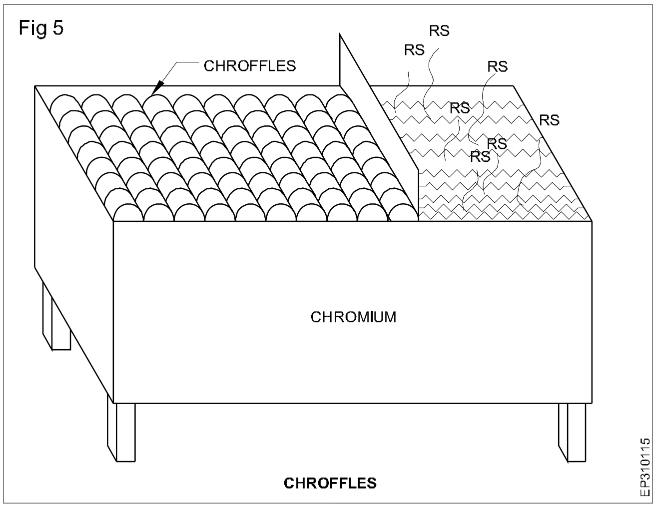
If an anode develops a yellow film or becomes covered with a thick hard scale, it should be cleaned then worked as for new anodes to ensure the reformation of the correct anode film. Oxide and chromate scale on all types of lead anodes used in chromium plating may be removed by wire brushing or by soaking in hydrochloric acid. After processing the anodes should be thoroughly washed in cold running water, then transferred to the plating tank and worked as for new anodes to establish the normal lead peroxide film.

Under no circumstances should an anode be put on the cathode rod, allowed to become coated with metallic chromium, then used again on the anode rod. This practice can lead to the production and accumulation of trivalent chromium in the solution.

Polypropylene chroffles

The polypropylene chroffles are used to reduce spray and the subsequent loss of solution. These are small moulded polypropylene balls which are used to form a layer on the solution surface. Chroffles are extremely effective for reducing heat and evaporation losses from the surface on the solution. (Fig 5)

Fig 5



CHROFFLES

Electrolytes for bright chromium plating and its maintenance

Objectives : At the end of this lesson you shall be able to

- **list the chemicals for various types of chromium plating solution**
- **describe the preparation of various types of chromium plating solutions**
- **explain the maintenance of various chromium plating solutions.**

Preparation of chromium plating solutions

Chromic acid containing solutions are very corrosive and powerful oxidizing agents.

Operators should wear proper safety equipments when making up or operating chromium plating solutions and if there is any danger of splashing, eye protection must be worn. Chromic acid containing salts and the solution should be kept out of contact with combustible materials and any spillage should be dealt with immediately.

Solution composition and preparation

The chromic acid and sulphuric acid used in chromium plating bath is in the ratio of 100:1.

The following figure shows the preparation of all types of solutions (Fig.1)

1. Regular or conventional chromium plating solution

Chromic acid- 280 to 320g/l

Sulphuric acid- 2.8 to 3.2g/l

The tank is half filled with clean warm water at a temperature of 40 to 50°C, firstly the chromic acid and then the sulphuric acid is added slowly and carefully with stirring. When they are completely dissolved, water is added to make up the solution to working level and to correct density. The solution should be thoroughly stirred to ensure that it is well mixed. On settling, there is usually slight sediment in the bottom of the tank. This can however, be ignored.

Solution maintenance

For the maintenance of a Regular or conventional chromium plating solution additions of high grade chromic acid are necessary to the extent of 70g/1000Ah.The usual practice is to make a regular addition of chromic acid at the end of each days operation. The level of the solution is restored to its original height by the addition of solution from an uncontaminated drag out tank or clean water, the bath well mixed by means of a plunger and the density checked. Additions of chromic acid should be made to restore the density to the recommended value.

Any deficiency in sulphate is made good by the addition of 10g/l of sulphuric acid for each g/l deficiency of sulphate. In the event of sulphates being in excess, an addition of barium hydroxide is recommended, 3.6g/l of barium hydroxide octahydrate being added for each g/l excess of sulphate. The barium hydroxide octahydrate should be dissolved in hot water and then added to the chromium solution, which must be well stirred for 10 minutes and then allowed to settle for at least an hour before recommencing the plating.

A rise in the trivalent content is usually due to the use of too small an effective anode area. Anode connection should be checked to ensure that all the anodes are operating and if necessary additional anodes provided. Normally sufficient anode area can be provided to keep the trivalent chromium content within reasonable limit. For some applications, such as the plating of internal surfaces where the anode area is of necessity less than that of the cathode, a rise in the trivalent chromium content is unavoidable.

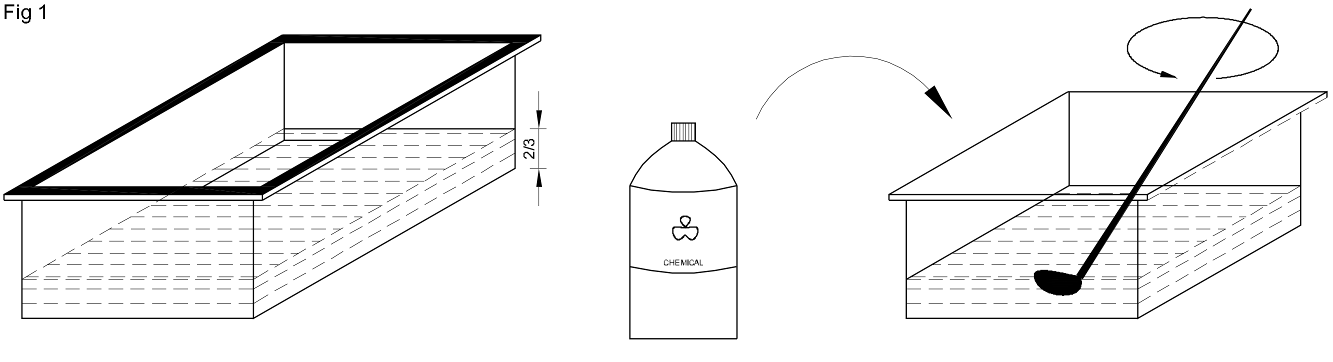
2. Self regulating chromium plating solution

Chromic acid- 225 to 275g/l

Sulphuric acid - 0.8-1.0 g/l

The tank is 3 quarter filled with plain water and then heated until a temperature of about 50°C is attained. Firstly the

Fig 1



PREPARATION OF SOLUTION

chromic acid and then the sulphuric acid is added slowly and carefully with stirring. When they are completely dissolved, heating should be continued until the temperature reaches 60 to 65°C.

The temperature should not be allowed to exceed 65°C

This temperature must be maintained for two hours, during which time the solution should be frequently agitated with a plunger to move this sediment from the bottom of the tank. Alternatively, low pressure compressed air may be used ,the air holes being directed towards the bottom of the tank. The slight sediment remaining at the bottom of the tank after this mixing may be ignored, but must be left in the tank. Finally the solution should be allowed to cool, then diluted with water until the density of the solution after mixing is correct. The solution should then be maintained at the operating temperature with frequent stirring for 8 hours before use.

While being brought up to temperature before beginning the day's work, the bath must be thoroughly and frequently stirred with a plunger. This is particularly important after a weekend or a long period of standing.

Solution maintenance

For the maintenance of a self regulating chromium plating solution, it is only necessary to maintain the solution at the specified temperature and density in order that it is kept in working balance. Nickel plated work should be rinsed in clean running water to prevent carryover of sulphate. The bath should be frequently stirred with a paddle or low pressure air, to keep the solution and active sediment in contact. The level of the solution is restored to its original height by the addition of solution from an uncontaminated drag out tank or clean water, the bath well mixed by means of a plunger and the density checked. Additions of chromic acid should be made to restore the density to the recommended value.

Additions of barium hydroxide octahydrate are the same as for conventional solutions but self regulating baths should be stirred for 30 minutes, kept at working temperature and allowed to settle for 2 hours before recommencing plating.

In order to prevent the oxide building up all work that falls off jigs or wires should be remove d at the end of the day and not left to dissolve.

Where chemical laboratory facilities are available, it is recommended that the chromium plating solutions should be regularly analysed and any necessary additions made to maintain the density and the sulphate content at their recommended values.

3. Black chromium plating solution

Chromic acid- 425 to 475g/l

Fill the tank to 2/3rd the working volume with clean cold water, then add the chemicals very slowly with continuous and rigorous stirring. Allow the solution to cool and then dilute with water to working level.

Heat and spray will be evolved on the solution of the chemicals, so fume extraction should be maintained.

Before use it is very important to work the solution on scrap plates until the equivalent of 22 to 33Ah/l has been passed through the solution. The bath temperature should not be allowed to exceed 50ºC during this operation, and the solution should be agitated periodically during the electrolysis.

Solution maintenance

Regular additions of chromic acid should be made in order to maintain the solution density. The solution must be sulphate free and care must be taken to avoid any carryover of sulphate into the solution from the nickel plating stage. The presence of trivalent chromium is necessary for the correct operation of the black chromium solution and this can be regulated by altering the anode to cathode ratio. The anodes should be added to lower the trivalent concentration and remove to raise the trivalent level.

Bright chromium plating process

Objectives : At the end of this lesson you shall be able to

- **explain the factors affecting cathode efficiency of chromium plating solutions**
- **state types of bright chromium plating**
- **state the chemical composition and operating conditions of bright chromium plating**
- **explain the defects and their remedies in bright chromium plating.**

Surface preparation

Chromium plays an important part in the protection provided by nickel chromium systems. It has been shown conclusively that heavier deposits of chromium have a much greater proportional effect on the corrosion resistance than increased thickness of nickel. Ordinary bright chromium deposits can only be applied to a limited thickness 0.25 to 0.5microns.

To ensure effective adherence of chromium deposits, it is essential that the surface to be electroplated are in clean condition, free from oils, greases, soils and oxides. This involves the use of a number of preparatory stages, we previously studied. After these preparatory stages, the articles enter the plating shop for final cleaning and electroplating.

Factors effecting cathode efficiency of chromium plating solutions

The cathode efficiency of chromium plating solutions is influenced by the following factors.

1. Concentration:

The cathode efficiency of a solution rises as the concentration of chromic acid raises until it reaches 250g/l, thereafter any increase in the concentration lowers the efficiency.

2. Current density:

The cathode efficiency varies with the current density. Higher the current density, greater the cathode efficiency. In practice, there is a specific current density range within which bright deposits are obtained.

3. Temperature:

The temperature is related to current density. The use of higher operating temperatures does permit the higher current densities and this may result in an increase in cathode efficiency.

4. Solution composition:

The cathode efficiency is also affected by the oxides. The trivalent chromium content, also contaminants such as iron and nickel build up in the solution, there is a fall in solution efficiency.

Types of bright chromium plating

Bright chromium plating on ferrous metals needs an undercoat of copper followed by bright nickel.

Refer the Fig.1 given below which is the connection diagram of three baths, from one rectifier, for chromium plating on ferrous metals.

Copper and its alloys can directly be bright chromium plated and hence it requires only one bath.

From the various types of bright chromium plating available, the following common methods are discussed. Refer the Fig.2 given below which is the common circuit diagram for all types of chromium plating.

1) Regular or conventional chromium plating.

2) Self regulating chromium plating.

3) Black chromium plating.

Delay between the bright nickel and chromium plating stages be reduced to a minimum and components are not allowed to dry out between stages.

'Shadowing' of the work must be avoided.

1. Regular or conventional chromium plating

For general purpose bright chromium plating and for applications which require a maximum resistance to corrosion, for example automobile fittings, the regular or conventional type of plating solution is employed. This solution is also employed where high efficiency bright chromium with a higher plating speed is required.

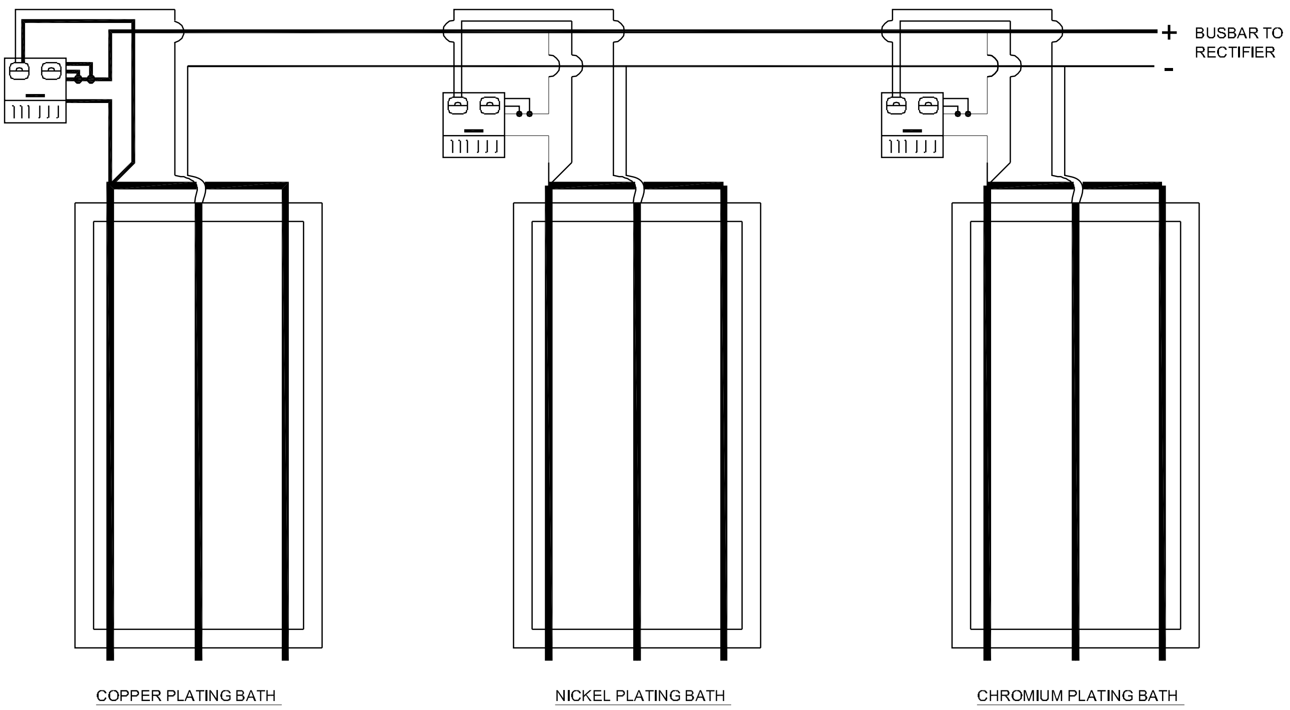
Solution composition and operating conditions

Chromic acid	- 280 to 320g/l
Sulphuric acid	- 2.8 to 3.2g/l
Current density	- 08 to 12A/dm^2
Voltage	- 5 to 8V
Temperature	- 35 to 40°C
Density	- 35° Be - 65° Tw

Rate of deposition at usual plating time

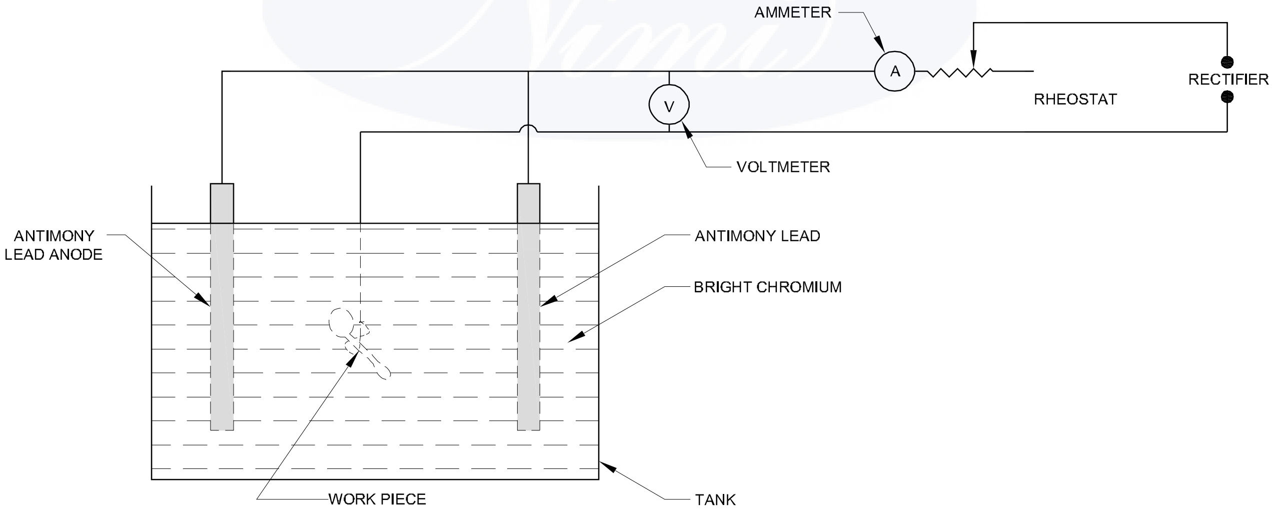
For decorative chromium deposits on nickel, a plating time of 5 to 10 minutes is generally employed. For a deposit of average thickness, 0.5 microns plating time of 8minutes should be allowed when operating at 10.8A/dm^2 . To allow for variations in current density over the surface of articles being plated, the minimum thickness of deposit depending upon the shape of the articles to be plated and the way they are mounted upon the jigs.

Fig 1



CONNECTION DIAGRAM FOR BRIGHT CHROMIUM BATH

Fig 2



PLATING PROCEDURE

The chromic acid and sulphuric acid used in chromium plating bath is in the ratio of 100:1.

2. Self regulating chromium plating

This solution has high cathode efficiency, a low solution concentration and in addition the solution has self regulating properties and so is simple to control and maintain while the low solution concentration reduces carryover of hexavalent chromium and hence effluent treatment problems, the oxides need to be controlled within reasonable limits.

Chromic acid	- 225 to 275 g/l
Sulphuric acid	- 0.8-1.0 g/l
Current density	- 11 to 16A/dm^2
Voltage	- 4 to 5V
Temperature	- 40 to 45°C
Density	- 20° Be - 32° Tw
Time	- 5 to 10 minutes.

Rate of deposition at usual plating time

For a deposit of average thickness, 0.5 microns, a plating time of 5 to 6minutes should be allowed when operating at 11A/dm^2 . To allow for variations in current density over the surface of articles being plated, the minimum thickness of deposit depending upon the shape of the articles to be plated and the way they are mounted upon the jigs.

3. Black chromium plating

Black chromium plating process enables black chromium deposits for decorative and functional purposes. It is to be applied directly to bright nickel and to most other metals excluding aluminium. The colour is retained in service and there s no need for any further protection. Black chromium is hard and resistant to wear, heat and corrosive environments.

Black chromium deposits are now being employed on an increasing commercial scale for the production of an unusual alternative to bright chromium on articles as varied as builders' hardware, door fittings, office furniture, plumbing fixtures and boat equipments. By using a combination of black and bright chromium plating very attractive effects can be produced to enhance the customer appeal of many products.

Black chromium has a number of properties which make it a useful functional finish. When applied to dull substrates there is reduction of reflectivity as compared with bright chromium deposits. This reduced reflectivity has made it useful as a non glare safety finish for automobile interior fittings, external components like wind screen wipers and also for optical equipments.

The deposit when plated onto satin nickel surface is selective absorber and is being considered as a suitable coating for solar energy collectors. The ideal selective absorber will have a high absorbing effect to incident solar radiation and a low emittance. This means that it will absorb solar radiation but simultaneously will emit little long wave thermal radiation. Black chromium comes close to this ideal and will retain more heat energy than other types of black coatings.

The coating has good thermal stabilities. At temperatures below 480°C there is no effect on the coating, at temperatures up to 590°C there is a slight greying on the deposit but the colour reverts to black on cooling. The use of black chromium is not recommended on components subjected to temperatures in excess of 700°C.

Black chromium deposits have a degree of micro porosity and this produces a corrosion resistance which is better than standard bright chromium. The same porosity gives it the ability to absorb and retain oil and paint films which make it useful for the machine tool and electronic industries.

Chromic acid - 425 to 475g/l

Current density - 10 to 50A/dm^2

Voltage - 5 to 10V

Temperature - 13 to 24°C

Density - 36.5 Be - 67°Tw

Time - 2 to 8 minutes.

Where possible articles should be loaded at 50A/dm^2 and after 30seconds the current density be lowered to the normal value.

Post treatment

1. Drag out and rinsing

After removing the articles from the bright chromium bath the parts are passed in to the drag out tank, where they receive most of the chrome solution. They are then rinsed thoroughly in clean cold water. The solution in the drag out tank should be utilised for maintaining the height of the solution in the chromium bath.

The drag out tank kept covered when not in use. The drag out solution may be returned to the main tank but if there is any possibility of contamination, this should not be done.

2. Neutralising dip

The neutralising dip is used to reduce the chromium solution carried over on plated components as they are transferred from the drag out tank after chromium plating. For this purpose 10% sodium bisulphite solution may be used in a plain steel tank. It not only neutralizes any free acid remaining upon the surface of the chromium plated articles, but also reduces the residual chromate to the green trivalent state. The use of neutralising dip can largely eliminate hexavalent chromium from the rinsing water and thus considerably simplify subsequent effluent disposal.

3. Final rinsing

The components are finally well rinsed in cold running water and then put through hot water to facilitate drying. Refer (Fig.3) for tank setup for rinsing.

Tank setup for rinsing

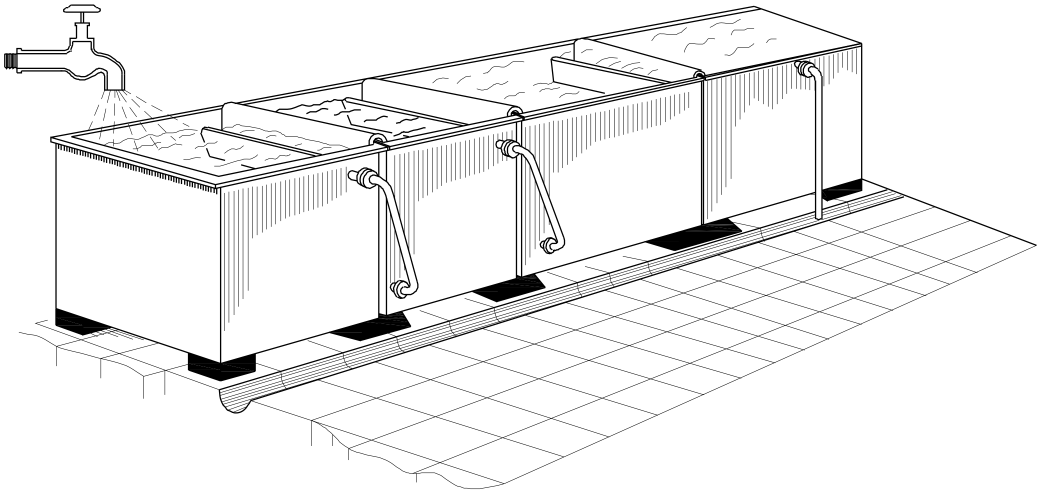
Barrel chromium plating

Where large quantities of small components, such as screws, nuts, bolts, rivets and similar articles are barrel chromium plated on a barrel nickel deposit. The general purpose plating barrels are not suitable for the production of barrel chromium plated deposits. For this application a modified plating barrel is required in which a high current density can be applied to the components and the possibility of intermittent electrical contact is reduced to a minimum.

Chromium plating procedure

Decorative chromium plating solutions operate at fairly high current density and have a relatively narrow operating range. It is therefore important that components are correctly positioned in the plating tank. Shadowing of the work must be avoided, i.e. every piece arranged so that it is in direct line with anodes.

Fig 3



TANK SETUP FOR RINSING

A considerable volume of hydrogen is liberated during the chromium plating process. If the articles to be processed contain open joints, holes or recesses, excessive gassing will occur. In these areas and the stream of gas passing upwards across the surface of the components may prevent the deposition of chromium. In these cases supporting the component so that the whole or recess directly faces the anode may be effective.

Suspension of articles

For the suspension of articles to be chromium plated, plating jigs or racks are used. It is essential that a firm contact be made between the jig contact points and the articles to be plated and that the jigs and contacts are of sufficient size to carry the heavy current employed. The contacts on plating dips on racks should be regularly stripped off to avoid excessive build up on the contact points and thus preventing the resultant poor contact.

Where the quantity, or the size and the shape of the articles to be plated does not justify the use of plating jigs, the articles may be wired with copper wire, using several strands if necessary either a single or numbers of articles.

Treatment of passive nickel deposit

It is advised that delay between the bright nickel and chromium plating stages be reduced to a minimum and that the components are not allowed to dry out between stages. Otherwise passivity of the nickel may develop and difficulty will then be encountered in obtaining a satisfactory bright chromium deposit. For the activation of bright nickel deposits, the following solutions operating at room temperature may be employed.

Pure concentrated sulphuric acid	- 20ml/l
Potassium iodide	- 2g/l
Iodine	- 0.0125 g/l

For this solution, a plastic container is used. The required volume of concentrated sulphuric acid is added slowly with stirring to cold water and then allowed to cool before any further addition is made. The potassium iodide is dissolved in a separate small volume of water and the solid iodine is added. When the iodine has dissolved the potassium iodide solution is added to the cold diluted sulphuric acid and the solution is stirred until thoroughly mixed. In use iodine should be added periodically to maintain a straw yellow colour.

The nickel plated components are immersed in the activating solution for a period from 10 to 30 seconds and then thoroughly rinsed through cold running water before chromium plating.

Precaution against solution contamination

Under no circumstances should any article accidently be dropped to the bottom of the tank or be allowed to remain there. The steel is slowly attacked and gives rise to gradual contamination, but brass and other non ferrous metals such as copper and zinc are rapidly corroded and cause deterioration of the chromium solution unless immediately removed. Neglect leading to an accumulation of articles will ultimately render the bath useless. The usual method of retrieving work is to comb the tank methodically with an iron rake, but small steel parts can often be recovered by means of magnet.

Defects and their remedies in bright chromium plating

Sl.No	Nature of defects	Possible causes	Remedies
1.	Deposit blistered or stripping from the basis metal	Poor adhesion of the underlying nickel deposit	Check the efficiency of cleaning prior to nickel plating
2.	Brown stains on deposit	Chromium solution out of balance or low in conductivity	Maintain the solution
		Jigs or wires too light to carry the necessary current	Use heavier jigs and contacts or more strands of wire
		Inefficient contact	Keep all hooks, rods and connections are cleaned. Strip chromium deposit from jig contacts after use
3.	Little if any, chromium deposit on the article	Passivity of nickel plated surface, due to the formation of a thin invisible film of oxide upon it, which renders chromium plating difficult	Reduce the delay between nickel and chromium plating. Not allowed to dry out between stages. Activate the passive nickel deposit.
4.	Dull, gray, rough deposit	Burnt deposit due to plating at too high current density	Reduce voltage. If plating small articles with sharp point, suspend the parts between large pieces of work and arrange that the sharp edges face upwards or away from the anodes
		Too low temperature	Stir the solution thoroughly and check its temperature with a thermometer. Heat the solution to its recommended value.
5.	Chrome deposit not continuous over the whole article, where nickel remains visible.	Temperature of plating solution too high	Run cold water in to outer jacket of chrome vat and leave bath until its temperature is adjusted to normal
		Dirty anode connections	Clean both hooks and rods
		Bad contact with jig and article or jig and cathode rod	Strip chrome deposit from jig and clean all the connections
		Shielding of the article by another	Avoid shielding by arranging the articles so that they are in direct line with the anodes.

6.	Deposit gray and dull but smooth	Intermittent contact	Clean all the rods and connections and make certain of good contact.
		High temperature of articles at the time of loading	Articles that have become hot through polishing of the nickel deposit must be allowed to cool until their temperature is no higher than that of the plating solution.
7.	Deposit mainly bright but appearance spoiled but dull patches.	Presence of grease on underlying nickel deposits.	Strip the chromium plating from the article, swill, dry and activate the passive nickel deposit.
8.	Inability to maintain upon the anodes to the necessary film of lead peroxide.	Contamination of the plating bath with chlorides or hydrochloric acids. In such case the resulting chromium deposits may be burned or rough and grey in appearance owing to the unusually high current obtainable at normal voltage, due to the absence of a peroxide film on the anodes.	The presence of the chloride should be checked by analysis of the solution and the further contamination avoided by paying particular attention to the swilling of all hollow articles that have been put through hydrochloric acid for the purpose of stripping the chromium deposits. It is not easy to remove chloride from a chromium solution by chemical means. If the contamination is heavy, there is possibility that the anodes will be seriously corroded before impurity is all dissipated as chlorine.
9.	Contamination of the chromium solution with foreign metals, the presence of which has been revealed by analysis.	Derived from articles for slinging wires lying at the bottom of the tank.	Comb the tank with an iron rake and retrieve any lost articles.
10.	Sluggish working of the bath, due to deterioration of the chrome solution through reduction of chromic acid to trivalent chromium compounds.	Too small anode area or due to the anodes idling in the tank and becoming encrusted with lead chromate.	It is necessary to maintain an effective anode surface. The anodes must be in good electrical contact with the rods and a film of lead peroxide maintained upon them. See the Related theory for Exercise 3.1.01 for anode maintenance.

Basics of hard chromium plating and equipments

Objectives : At the end of this lesson you shall be able to

- **state the applications of hard chromium plating**
- **describe the equipments for hard chromium plating**
- **explain the anode maintenance and spray control.**

Chromium plating

Hard chromium deposits are widely used for the provision of hard, abrasion resistant wearing surfaces and for the building up of undersized and worn parts. The value of chromium for such purposes lies in its hardness, resistance to abrasion, passivity of surface and its anti seize properties when applied to rotating or reciprocating parts.

The techniques of heavy deposition defer from those involved in bright chromium plating for decorative effects. The deposits are thicker and are generally applied to the basis metal without any pre coating of nickel. The hard chromium layer must be at least 13 microns thick for adequate wear resistance and in many cases up to 50 microns are sufficient to give protection against seizing of moving parts.

Applications of hard chromium plating

Hard chromium deposits are widely used because of its low coefficient of friction, its high hardness, high resistance to corrosion, and ability to withstand high temperature. Due to the above properties the hard chromium is generally applied to rotating machined parts. Following are the main applications of hard chromium plating.

1) Gauges

Hard chromium is widely used for facing gauges and the deposit which normally has hardness between 800 and 900 HV. (Vickers hardness), has proved ideal for the purpose.

2) Cutting tools

As a rule, only thin deposits of chromium are applied to cutting tools, and the cutting edge itself is usually ground down to the steel after deposition. The thickness is generally from 5 to 12 microns and in the case of drills and reamers the chief function of hard chromium is to reduce friction.

Milling cutters and taps are similarly treated with a light coating of hard chromium, and their cutting faces are ground after deposition in the same manner as for drills and reamers.

Files deposited in the hard chromium last considerably longer than untreated files. The teeth do not become clogged and the file continuous cut much more readily. A thick should not be applied, however or the cutting edges of the teeth may be impaired.

3) Metal forming and drawing dies

Hard chromium deposition has proved to be especially valuable for facing many types of metal working die, as it results in a considerably extended life and minimises scoring and fouling of the tool by adhesion of the metal.

When the hard chromium plated surface has at last become worn, the deposit is stripped from the die and the latter is again faced with hard chromium. This also applies to the drawing plugs. Coining and pressing dies also have been successfully treated, but wire drawing dies present a problem, as it is difficult to obtain a uniform deposit in holes of very small diameter.

4) Machine parts

Components such as piston rings and cylinder loners, crank shafts for marine and aero engines, bearings, gears and other articles are deposited with a thickness of 0.12 mm.

5) Salvage of worn or faulty machined parts

A most important application of hard chromium is that of building up worn parts and salvaging of expensive components that would otherwise be rejected for defects in machining. Any deficiency in size may then be made good by the deposition of hard chromium. Such a treatment is very useful for engine parts and other valuable components.

6) Moulds

In the manufacture of plastics, it is advantageous to face the moulds with hard chromium. This coating affords protection against chemical attack, resists abrasion by the moulding powder and facilitates removal of the moulded article. A maximum thickness of 25 microns of hard chromium is all that is required.

7) Printing applications

Hard chromium facing is extensively applied for the facing of printing plates and cylinders. It provides a hard wearing, corrosion resistant surface, which not only enables much longer printing runs to be obtained but also permits the use of a wider range of printing inks.

8) Other specialised applications

Apart from the abrasion and anti seize properties of hard chromium deposits, it's untarnishable surface and passivity render it useful for other industrial purposes. For example in dip tinning and dip soldering, the tongs used for holding the articles may advantageously be coated with hard chromium to prevent adhesion of the molten tin or solder. hard chromium facing is particularly advantageous in colour printing and enables the length of the run to be increased by 8 to 10 times as compared with aa similar un plated copper plate or cylinder.

The thickness of hard chromium deposits necessary is dependant both upon the length of the printing run and the material to be printed. For the printing of smooth paper such as periodicals, a deposit of 5 microns is generally applied. For the printing of fabrics, board etc. where higher printing pressure are employed a deposit thickness of 12 micron is more usual.

Equipments for hard chromium bath

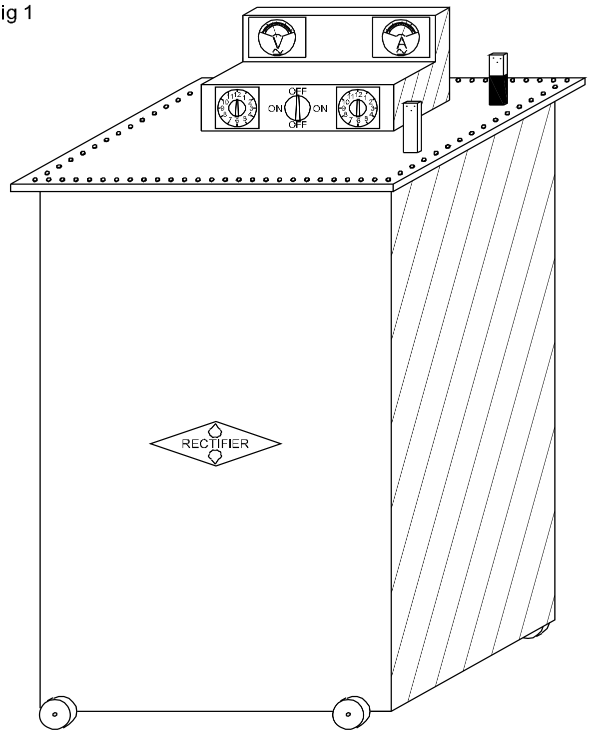
It is important that electroplater uses proper equipments for his work. The quality and efficiency of work will depend upon the use of proper equipment. The equipments necessary for the hard chromium deposition is similar to that used in bright chromium plating, except that a larger power unit and heavy duty bus bars are needed. The handling facilities required will depend upon the size and weight of the components to be processed. For large outputs, automatic or semi automatic equipments may be used.

Listed below are the equipments are the most commonly used for hard chromium plating.

Rectifier

It is used to rectify the AC supply input to DC output required for electroplating. The output voltage is variable and the required current can be set. The polarity of the output is marked. The output capacity of the rectifier (Fig.1) should match the voltage and current requirements of the process for which it is to be used. Oil immersed metallic type rectifiers are best suited, although air cooled types may be used where the power demand is not high.

Fig 1

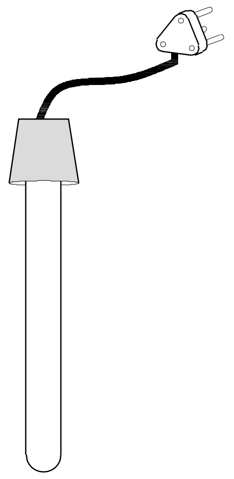


RECTIFIER

Immersion heater

Heating by electricity provides ease in control. Silica or lead lined electrical immersion heaters (Fig.2) are used for heating hard chromium solution.

Fig 2

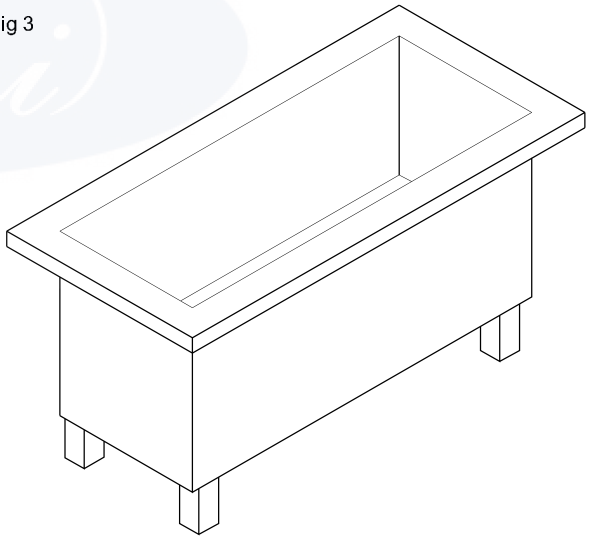


SILICA LINED HEATER

Plating tank

Lead lined tanks are used as container for the solutions of chromium plating. Stainless steel tanks are used for swilling, drag in and drag out operations. Nowadays, polypropylene (PP) tanks are used for these purposes because of its resistance to chemicals.(Fig.3)

Fig 3



PLATING TANK

When starting up new lead lined tank, it is important that the temperature of chromium plating solution be brought up as rapidly as possible to above its normal operating value. In this way a protective film is formed on the surface of the lead.

Under no circumstances should cold chromium plating solution be left in contact with lead until the treatment above has been applied.

Busbars

Bus bar is a rigid conductor, made of copper, for carrying current to the anode and cathode rods from the rectifier.

These should have enough capacity to carry the full load current.

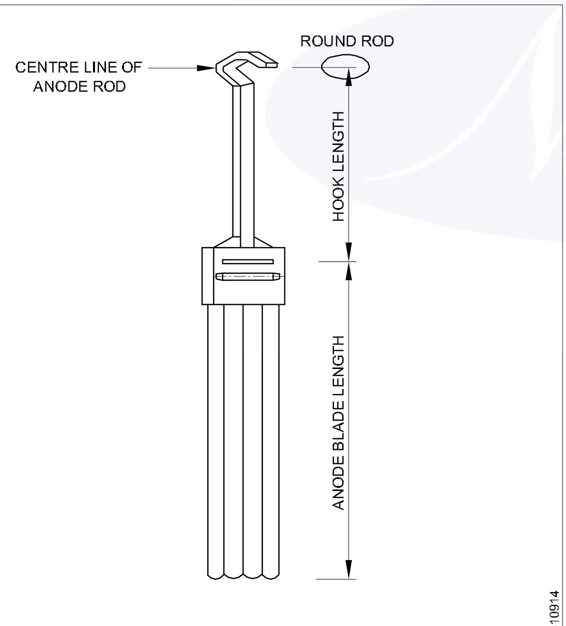
Anode rod and cathode rod

The anode and cathode rods are made of copper and should have enough capacity to carry the current from the bus bars. The two anode rods are placed above the plating tank to hook the anodes. The cathode rod is placed in between the two anode rods and suspends the job to be plated.

Anodes

Antimony lead anodes of dog bone shape (Fig.4) are generally used for hard chromium plating. The Antimony lead anodes serve two purposes, they not only function as the positive electrode, but also help to maintain the solution in satisfactory balance by re-oxidizing the trivalent chromium to chromic acid. The anode area should be about 20% greater than the area of the plating load. Metallic chromium anodes are not practicable due to its difficult in preparation, high cost and also the chromium anodes are dissolved in chromium bath and getting coated powdery cathode. Where possible the anode area should be greater than the cathode area. Anodes are usually hung at a distance of 125 to 150mm from the cathodes. Anodes should be slightly shorter than the articles to avoid building up deposits on the lower edges.

Fig 4



ANTIMONY LEAD ANODE

If the solution is idle for a period, as at weekends, the anode should be removed from the tank, and then swilled, brushed with a wirebrush, swilled again, and allowed to dry. This will preserve their surface so that they can be put into use again immediately plating is to be resumed.

Anode Maintenance

When the current is passing through the chromium plating solution, gassing will occur at the anodes which are normally covered with a dark chocolate coloured film. It is recommended that new anodes be worked at 0.8 to 1 Ampere per centimeter length to ensure the formation of this anode film. The presence of a chocolate coloured film on the anode is necessary to ensure that the trivalent chromium produced by electrochemical reduction of the chromic acid at the cathode is re-oxidised. In this way, rapid buildup of trivalent chromium in the solution is avoided.

If the anode is allowed to idle owing to inefficient contact, the chocolate brown film will gradually be converted to yellow lead chromate. The presence of this yellow film on the anodes indicates unsatisfactory electrical connection.

If an anode develops a yellow film or becomes covered with a thick hard scale, it should be cleaned then worked as for new anodes to ensure the reformation of the correct anode film. Oxide and chromate scale on all types of lead anodes used in chromium plating may be removed by wire brushing or by soaking in hydrochloric acid. After processing the anodes should be thoroughly washed in cold running water, then transferred to the plating tank and worked as for new anodes to establish the normal lead peroxide film.

Under no circumstances should an anode be put on the cathode rod, allowed to become coated with metallic chromium, then used again on the anode rod. This practice can lead to the production and accumulation of trivalent chromium in the solution.

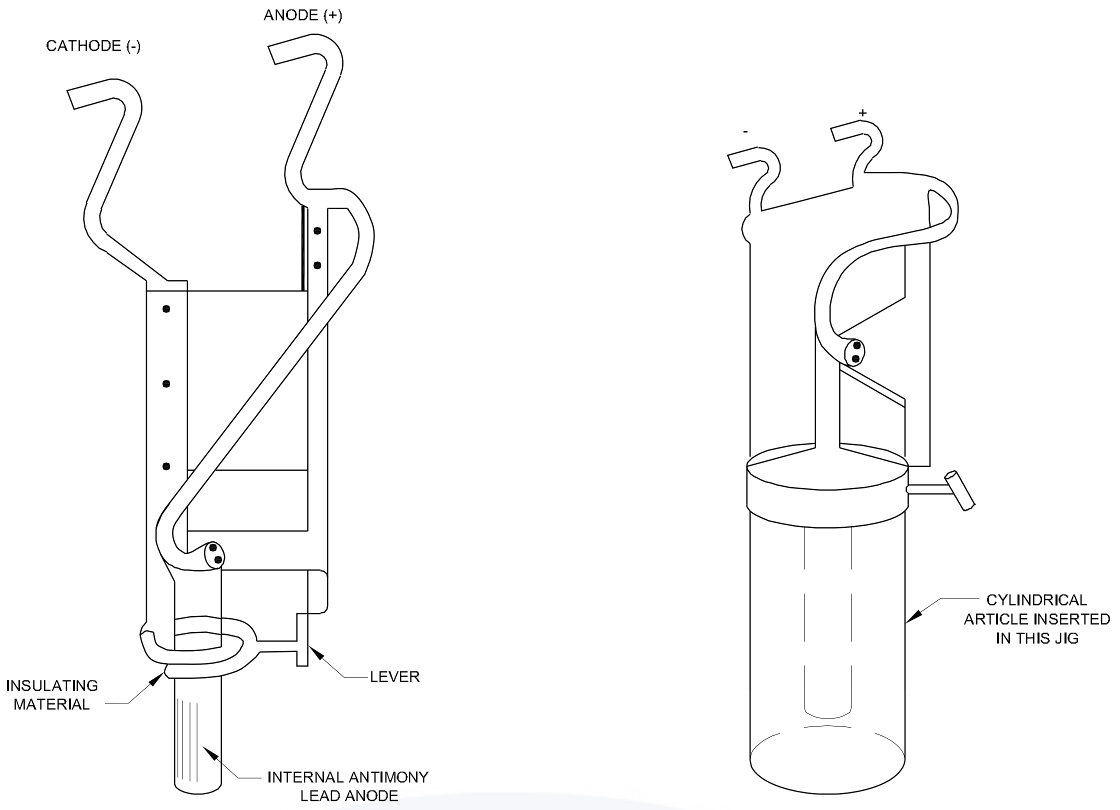
Auxiliary anodes

As the throwing power of a hard chromium solution is low in comparison with that of most other types of plating solution, it is often necessary to use auxiliary anodes to obtain a deposit in recessed parts. Such anodes are generally made of tin lead alloy and are shaped to the contours of the recesses. For deposition inside drawing dies, ring gauges and other hollow or cylindrical articles. Careful alignment is essential to ensure an eve distribution of the deposit.

When using internal anodes for deposition inside tubular parts of small bore, there is a tendency for local rapid exhaustion of the electrolyte and a polarization of the anode. This difficulty can often be overcome by circulating the solution through the tube. In the case of bigger articles, polarization may be avoided by using an electrode of large diameter as possible and by increasing the area of the anode. The internal anodes of this description are often tapered and should be a fraction of an inch shorter than the length of the cylinder. In view of the fact the surface area of the inside anodes is generally much less than that of the cathodes. It may be necessary to provide a number of auxiliary anodes.

With cylindrically shaped parts, however such as plug gauges, it is advantageous to suspend these individually in a special type of anodes with cathode jig (Fig 5). These circular anodes ensure maximum efficiency and uniformity of depositions.

Fig 5



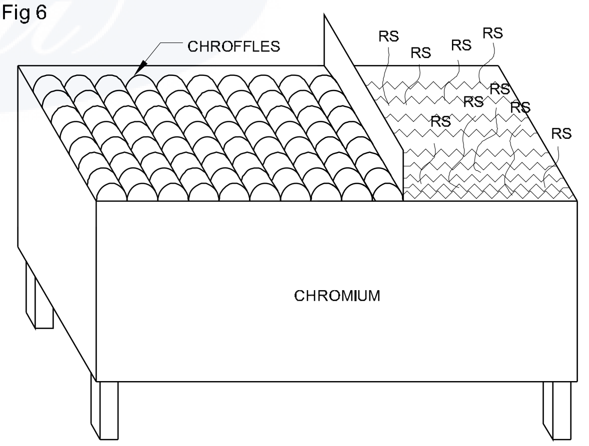
SPECIAL TYPE OF ANODE WITH CATHODE JIG FOR PLATING OF CYLINDRICAL SHAPED ARTICLES

Spray control

To control the emission of spray from hard chromium plating solution, an efficient mechanical fume extractor must be used or a suitable spray suppressant added to the solution.

The polypropylene chroffles (Fig.6) are used to reduce spray and the subsequent loss of solution. These are small moulded polypropylene balls which are used to form a layer on the solution surface. Chroffles are extremely effective for reducing heat and evaporation losses from the surface on the solution.

Fig 6



CHROFFLES

Electrolytes for hard chromium plating and its maintenance

Objectives : At the end of this lesson you shall be able to

- **list the chemicals for different types of chromium plating solutions**
- **describe different types of chromium plating solutions**
- **explain the maintenance of different types of chromium plating solutions.**

Preparation of chromium plating solutions

Chromic acid containing solutions are very corrosive and powerful oxidizing agents.

Operators should wear proper safety equipments when making up or operating chromium plating solutions and if there is any danger of splashing, eye protection must be worn. Chromic acid containing salts and the solution should be kept out of contact with combustible materials and any spillage should be dealt with immediately.

Solution composition and preparation

The chromic acid and sulphuric acid used in chromium plating bath is in the ratio of 100:1

For hard chromium deposition three types of solutions are generally used. The following figure shows the preparation of all types of solutions (Fig.1)

1. Regular hard chromium plating solution

Chromic acid- 225 to 250g/l

Sulphuric acid- 2.25 to 2.5g/l

The tank is half filled with clean warm water at a temperature of 40 to 50°C, firstly the chromic acid and then the sulphuric acid is added slowly and carefully with stirring. When they are completely dissolved, water is added to make up the solution to working level and to correct density. The solution should be thoroughly stirred to ensure that it is well mixed. On settling, there is usually slight sediment in the bottom of the tank. This can however, be ignored.

Solution maintenance

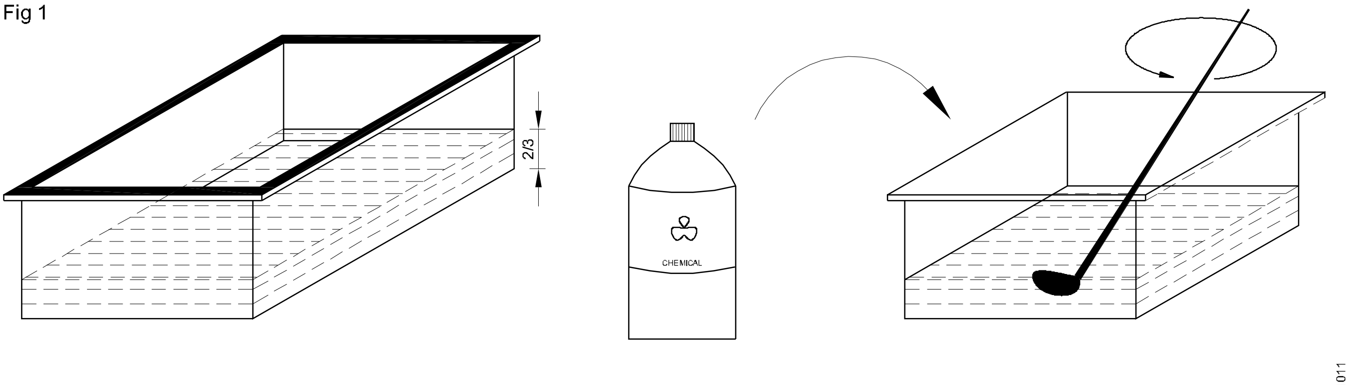
For the maintenance of hard chromium plating solution additions of high grade chromic acid are necessary to the extent of 100g/1000Ah.The usual practice is to make a regular addition of chromic acid at the end of each days operation. The level of the solution is restored to its original height by the addition of solution from an uncontaminated drag out tank or clean water, the bath well mixed by means of a plunger and the density checked. Additions of chromic acid should be made to restore the density to the recommended value.

Any deficiency in sulphate is made good by the addition of 10g/l of sulphuric acid for each g/l deficiency of sulphate. In the event of sulphates being in excess, an addition of barium hydroxide is recommended, 3.6g/l of barium hydroxide octahydrate being added for each g/l excess of sulphate. The barium hydroxide octahydrate should be dissolved in hot water and then added to the chromium solution, which must be well stirred for 10minutes and then allowed to settle for at least an hour before recommencing the plating.

For hard chromium deposition a more rigid control of the process is required than is generally necessary for bright chromium plating. A regular analysis and correction of the solution should be undertaken to ensure that which is in satisfactory balance. A close check should be kept on the trivalent chromium and iron content of the plating solution. The total oxides should not be allowed to rise above 1/20th of the total hexavalent concentration. If the oxide content rises above this value, the cathode efficiency of this solution will fall.

A rise in the trivalent content is usually due to the use of too small an effective anode area. Anode connection should be checked to ensure that all the anodes are operating and if necessary additional anodes provided. Normally sufficient anode area can be provided to keep the trivalent chromium content within reasonable limit. For some applications, such as the plating of internal surfaces where the anode area is of necessity less than that of the cathode, a rise in the trivalent chromium content is unavoidable.

Fig 1



PREPARATION OF SOLUTION

2. High speed hard chromium plating solution

Chromic acid- 250 to 300g/l

Sulphuric acid - 1.4-1.8 g/l

The tank is 3 quarter filled with plain water and then heated until a temperature of about 50°C is attained. Firstly the chromic acid and then the sulphuric acid are added slowly and carefully with stirring. When they are completely dissolved, heating should be continued until the temperature reaches 60 to 65°C.

The temperature should not be allowed to exceed 65°C.

This temperature must be maintained for two hours, during which time the solution should be frequently agitated with a plunger to move this sediment from the bottom of the tank. Alternatively, low pressure compressed air may be used ,the air holes being directed towards the bottom of the tank. The slight sediment remaining at the bottom of the tank after this mixing may be ignored, but must be left in the tank. Finally the solution should be allowed to cool, then diluted with water until the density of the solution after mixing is correct. The solution should then be maintained at the operating temperature with frequent stirring for 8 hours before use.

While being brought up to temperature before beginning the day's work, the bath must be thoroughly and frequently stirred with a plunger. This is particularly important after a weekend or a long period of standing

Solution maintenance

For the maintenance of hard chromium plating solution additions of high grade chromic acid are necessary to the extent of 140g/1000Ah.The usual practice is to make a regular addition of chromic acid at the end of each days operation. The level of the solution is restored to its original height by the addition of solution from an uncontaminated drag out tank or clean water, the bath well mixed by means of a plunger and the density checked. Additions of chromic acid should be made to restore the density to the recommended value.

Any deficiency in sulphate is made good by the addition of 10g/l of sulphuric acid for each g/l deficiency of sulphate. In the event of sulphates being in excess, an addition of barium hydroxide is recommended, 3.6g/l of barium hydroxide octahydrate being added for each g/l excess of sulphate. The barium hydroxide octahydrate should be dissolved in hot water and then added to the chromium solution, which must be well stirred for 10 minutes and then allowed to settle for at least an hour before recommencing the plating.

A monthly analysis should be carried out upon the high speed hard chromium plating solution and the total chromic acid, sulphates, oxides and iron content estimated. When sampling the solution particular care must be taken to ensure that the sample taken is truly representative of the plating solution. The sample for analysis should be taken when the plating solution is at the operating temperature after having been well stirred at intervals for an hour and then allowed to settle. Special plastic sample containers should be used, lead coated containers are not suitable.

Where chemical laboratory facilities are available, it is recommended that the chromium plating solutions should be regularly analysed and any necessary additions made to maintain the density and the sulphate content at their recommended values.

3. Self regulating hard chromium plating solution

Chromic acid- 175 to 225g/l

Sulphuric acid - 0.7-2.9 g/l

The tank is 3 quarter filled with plain water and then heated until a temperature of about 50?C is attained. Firstly the chromic acid and then the sulphuric acid is added slowly and carefully with stirring. When they are completely dissolved, heating should be continued until the temperature reaches 60 to 65°C.

The temperature should not be allowed to exceed 65°C.

This temperature must be maintained for two hours, during which time the solution should be frequently agitated with a plunger to move this sediment from the bottom of the tank. Alternatively, low pressure compressed air may be used, the air holes being directed towards the bottom of the tank. The slight sediment remaining at the bottom of the tank after this mixing may be ignored, but must be left in the tank. Finally the solution should be allowed to cool, then diluted with water until the density of the solution after mixing is correct. The solution should then be maintained at the operating temperature with frequent stirring for 8 hours before use.

While being brought up to temperature before beginning the day's work, the bath must be thoroughly and frequently stirred with a plunger. This is particularly important after a weekend or a long period of standing.

Solution maintenance

For the maintenance of a self regulating hard chromium plating solution has self regulating properties and it is only necessary to keep the solution at the specified temperature and density in order that it is kept in working balance. The level of the solution is restored to its original height by the addition of solution from an uncontaminated drag out tank or clean water, the bath well mixed by means of a plunger and the density checked. The Addition of 12g/l chromic acid will increase the solution density by 1ºBe and 7 g/l chromic acid to increase the density by 1ºTw.

Additions of barium hydroxide octahydrate are the same as for conventional solutions but self regulating baths should be stirred for 30 minutes, kept at working temperature and allowed to settle for 2 hours before recommencing plating.

In order to prevent the oxide building up all work that falls off jigs or wires should be remove d at the end of the day and not left to dissolve.

Where chemical laboratory facilities are available, it is recommended that the chromium plating solutions should be regularly analysed and any necessary additions made to maintain the density and the sulphate content at their recommended values.

Hard chromium plating process

Objectives : At the end of this lesson you shall be able to

- **explain the factors affecting cathode efficiency of hard chromium plating solutions**
- **state the types of hard chromium plating**
- **state the chemical composition and operating conditions of hard chromium plating**
- **explain the defects and their remedies in bright chromium plating.**

Hard chromium plating

Hard chromium deposits are widely used because of its low coefficient of friction, its high hardness, high resistance to corrosion, and ability to withstand high temperature. Due to the above properties the hard chromium is generally applied to rotating machine parts. The hard chromium deposits are thicker, and are generally applied directly to the basis metal without any precoating of nickel. The chromium layer must be at least 13 microns thick for adequate wear resistance. Hard chromium plating is generally used for gauges, cutting tools, metal forming and drawing dies, moulds, machine parts like piston rings, cylinder liners, crank shafts for marine and aero engines, bearings and salvage of worn and faulty machined parts.

Surface preparation

To ensure effective adherence of chromium deposits, it is essential that the surface to be electroplated are in clean condition, free from oils, greases, soils and oxides. This involves the use of a number of preparatory stages, we previously studied. After these preparatory stages, the articles enter the plating shop for final cleaning and electroplating.

Cathode efficiency of chromium plating solutions

The cathode efficiency of chromium plating solutions is influenced by the following factors.

1. Concentration:

The cathode efficiency of a solution rises as the concentration of chromic acid raises until it reaches 250 g/l, thereafter any increase in the concentration lowers the efficiency.

2. Current density:

The cathode efficiency varies with the current density. Higher the current density, greater the cathode efficiency. In practice, there is a specific current density range within which hard deposits are obtained.

3. Temperature:

The temperature is related to current density. The use of higher operating temperatures does permit the higher current densities and this may result in an increase in cathode efficiency.

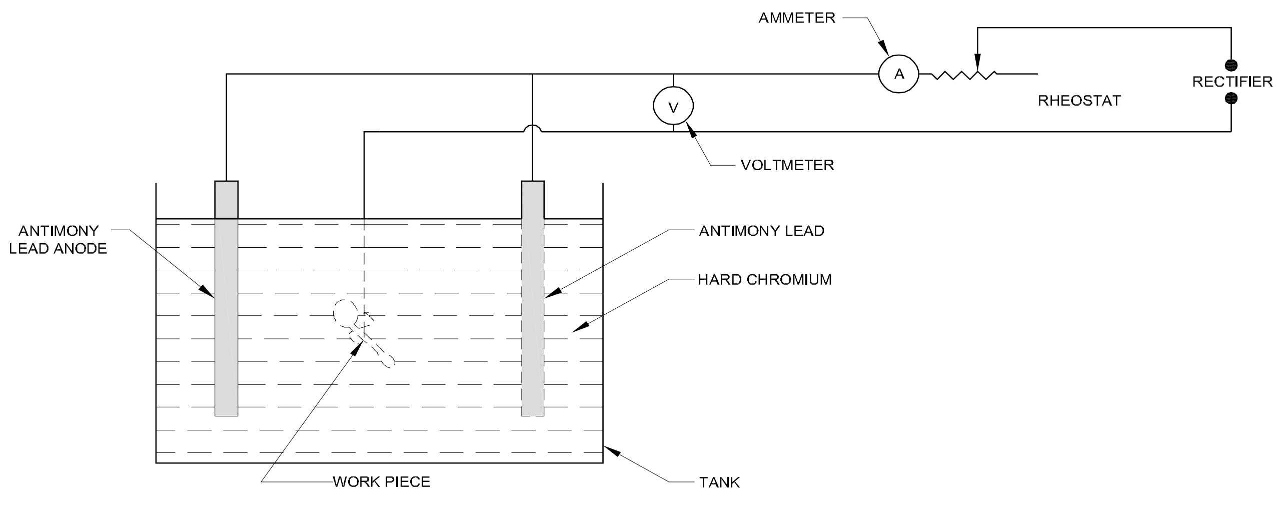
4. Solution composition:

The cathode efficiency is also affected by the oxides. The trivalent chromium content, also contaminants such as iron build up in the solution, there is a fall in solution efficiency.

Types of hard chromium plating

From the various types of hard chromium plating available, the following common methods are discussed. Following is the connection diagram for hard chromium plating bath (Fig.1).

Fig 1



CONNECTION DIAGRAM FOR HARD CHROMIUM PLATING BATH

1) Regular hard chromium plating

2) High speed hard chromium plating

3) Self regulating hard chromium plating

1. Regular hard chromium plating

For general purpose hard chromium plating and for applications which require a maximum resistance to corrosion the regular type of plating solution is employed.

Solution composition and operating conditions

Chromic acid - 225 to 250g/l

Sulphuric acid - 2.25 to 2.5g/l

Current density - 40A/dm^2

Voltage - 5.5 to 7V

Temperature - 50 to 60°C

Density - 19° Be - 30° Tw

Rate of deposition at usual plating time

The cathode efficiency of regular hard chromium solution is of the order of 12 - 13%, depending upon the operating conditions. An increase in the solution concentration will reduce the cathode efficiency. For the above operating conditions, 2.6 minutes is required for the deposition of the 1 micron thickness.

2. High speed hard chromium plating

The high speed hard chromium plating process is recommended for the high speed production of hard chromium deposit. It has cathode efficiency of the order of 20%, and its use enables plating times to be reduced by at least 1/3rd, the build of deposits on the edges and corners is reduced. The solution more corrosive than the regular hard chromium plating solution.

Chromic acid - 250 to 300g/l

Sulphuric acid - 1.4-1.8 g/l

Current density - 50A/dm^2

Voltage - 5.5 to 7V

Temperature - 55 to 57°C

Density - 22° Be - 36° Tw

Rate of deposition at usual plating time

The cathode efficiency of regular hard chromium solution is of the order of 22%, depending upon the operating conditions. An increase in the solution concentration will reduce the cathode efficiency. For the above operating conditions, 1.15 minutes is required for the deposition of the 1micron thickness.

3. Self regulating hard chromium plating

Chromic acid - 175 to 225 g/l

Sulphuric acid - 0.7-0.9 g/l

Current density - 40 A/dm^2

Voltage - 5.5 to 7V

Temperature - 52 to 63°C

Density - 17° Be - 27° Tw

Rate of deposition at usual plating time

The cathode efficiency of regular hard chromium solution is of the order of 23%, depending upon the operating conditions. An increase in the solution concentration will reduce the cathode efficiency. For the above operating conditions, 2 minutes is required for the deposition of the 1 micron thickness.

Post treatment

1. Drag out and rinsing

After removing the articles from the hard chromium bath the parts are passed in to the drag out tank, where they receive most of the chrome solution. They are then rinsed thoroughly in clean cold water. The solution in the drag out tank should be utilised for maintaining the height of the solution in the chromium bath.

> **The drag out tank kept covered when not in use. The drag out solution may be returned to the main tank but if there is any possibility of contamination, this should not be done.**

2. Neutralising dip

The neutralising dip is used to reduce the chromium solution carried over on plated components as they are transferred from the drag out tank after chromium plating. For this purpose 10% sodium bisulphite solution may be used in a plain steel tank. It not only neutralizes any free acid remaining upon the surface of the chromium plated articles, but also reduces the residual chromate to the green trivalent state. The use of neutralising dip can largely eliminate hexavalent chromium from the rinsing water and thus considerably simplify subsequent effluent disposal.

3. Final rinsing

The components are finally well rinsed in cold running water and then put through hot water to facilitate drying.

Heat treatment of steels after hard chromium plating

When a steel component is cleaned and hard chromium plated, hydrogen is produced which diffuses into the metal causing very high levels of surface stress and could cause fracture on subsequent grinding or other processes. This is called hydrogen embrittlement and must be removed by post plating heat treatment.

By heat treating, however, at 200ºC or above for an appropriate time, hydrogen readily diffuses out and the embrittlement is almost completely removed. This post plating heat treatment should be applied immediately after plating to minimize the risk of failure.

Heating at about 200ºC for the elimination of hydrogen embrittlement from high strength steel causes a reduction in fatigue strength but this can be subsequently restored by heating the plated part to 440 to 480 ºC and the air cooling. This however introduces compressive internal stress in the chromium deposit and the hardness falls.

Hard chromium plating procedure

Hard chromium plating solutions operate at fairly high current density and have a relatively narrow operating range. It is therefore important that components are correctly positioned in the plating tank. Shadowing of the work must be avoided, i.e. every piece arranged so that it is in direct line with anodes.

A considerable volume of hydrogen is liberated during the chromium plating process. If the articles to be processed contain open joints, holes or recesses, excessive gassing will occur. In these areas and the stream of gas passing upwards across the surface of the components may prevent the deposition of chromium. In these cases supporting the component so that the whole or recess directly faces the anode may be effective.

Suspension of articles

For the suspension of articles to be chromium plated, plating jigs or racks are used. It is essential that a firm contact be made between the jig contact points and the articles to be plated and that the jigs and contacts are of sufficient size to carry the heavy current employed. The contacts on plating dips on racks should be regularly stripped off to avoid excessive build up on the contact points and thus preventing the resultant poor contact.

Where the quantity, or the size and the shape of the articles to be plated does not justify the use of plating jigs, the articles may be wired with copper wire, using several strands if necessary either a single or numbers of articles.

Masking

The areas on which hard chromium is not required are masked with stopping off lacquer. The choice of masking material is dependent upon the shape of the components to be treated, and the processing conditions to which it is to be exposed. The exposed metal surfaces are then wiped with a cloth damped with a suitable solvent. Afterwards the metal surface is scoured with powdered pumice to remove all traces of the wax or any grease imparted by handling. After this treatment, the iron and steel parts must be electrolytically cleaned to ensure satisfactory adhesion of the hard chromium deposit.

Precaution against solution contamination

Under no circumstances should any article accidently be dropped to the bottom of the tank or be allowed to remain there. The steel is slowly attacked and gives rise to gradual contamination, but brass and other non ferrous metals such as copper and zinc are rapidly corroded and cause deterioration of the chromium solution unless immediately removed. Neglect leading to an accumulation of articles will ultimately render the bath useless. The usual method of retrieving work is to comb the tank methodically with an iron rake, but small steel parts can often be recovered by means of magnet.

Defects and their remedies in bright chromium plating

Sl.No	Nature of defects	Possible causes	Remedies
1.	Imperfect adhesion	Presence of grease	Review cleaning methods and check degreasing solutions to make sure that they are efficient
		Oxide scale on the article	Pickle in acid or remove mechanically
		Previous chrome deposit on the article	Strip thoroughly before re-plating
		Interrupted current supply	If break in current is prolonged, avoid laminated deposit by etching in chrome solution for 10 seconds before deposition is resumed.
2.	Roughness of deposit	Suspended solids in the solution	Allow suspended matters to settle. Transfer the solution to another tank and remove any sludge of lead chromate from the tank before replacing the solution.
		Burning due to excessive current density	Reduce current by lowering applied voltage until smooth deposition is obtained.
		Basis metal too rough	Mechanically polish the basis metal to a smoother surface.
3.	Soft deposit	Deposition at too low current density	Increase voltage to give maximum permissible current density without burning.
4.	Deposit having a milky appearance	Temperature too high.	Reduce temperature of the bath
		Solution out of balance	Submit a sample of the solution for chemical analysis.
5.	No deposition	Faulty electrical connections, such as poor contact, low current or reversed polarity	Test polarity, clean all contacts, check electric connections and correct.
6.	Dull deposit	Faulty relationship between temperature and current density, usually associated with burning of the deposit	Increased temperature of the solution if below normal, and reduce the current density if excessive. High current at low temperature results in rough deposit.

Stripping of chromium deposit

Objectives : At the end of this lesson you shall be able to
- **state the chemical composition and operating conditions of chromium stripping baths**
- **explain the process of removal of chromium plating.**

Chromium stripping is a process to remove chromium coating from the basis metal or undercoat without affecting the underlying metal. Two types of methods are used for the removal of electroplated coatings. They are electrolytic and immersion methods. The selection of stripping bath is depends upon the structure of basis metal or undercoat.

Electrolytic stripping process

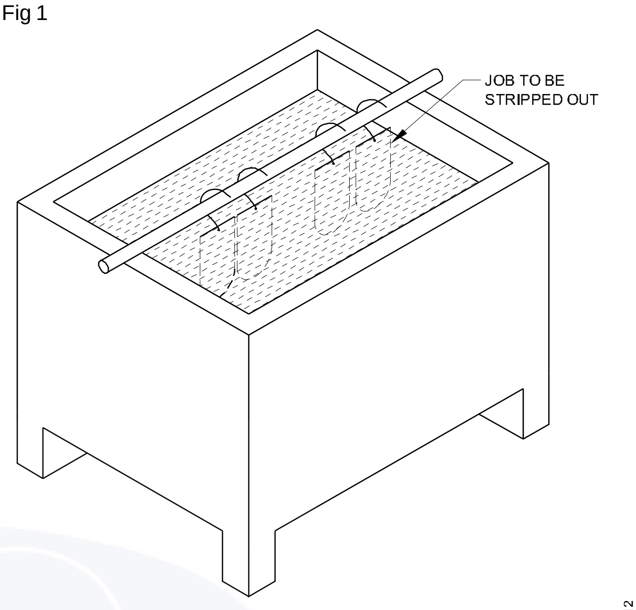
Stripping of chromium from ferrous articles is done electrolytically under the following conditions. Following is the connection diagram of electrolytic stripping for chromium deposit (Fig.1).

Sodium hydroxide	- 100g/l
Cathode	- Steel plates
Voltage	- 6V
Temperature	- Room

Immersion stripping process

Chromium may be removed from copper and its alloys without attack on the underlying metal by immersion in dilute hydrochloric acid. The usual concentration is one part of concentrated acid to two parts of water. Following is the connection diagram of immersion stripping for chromium deposit (Fig.2).

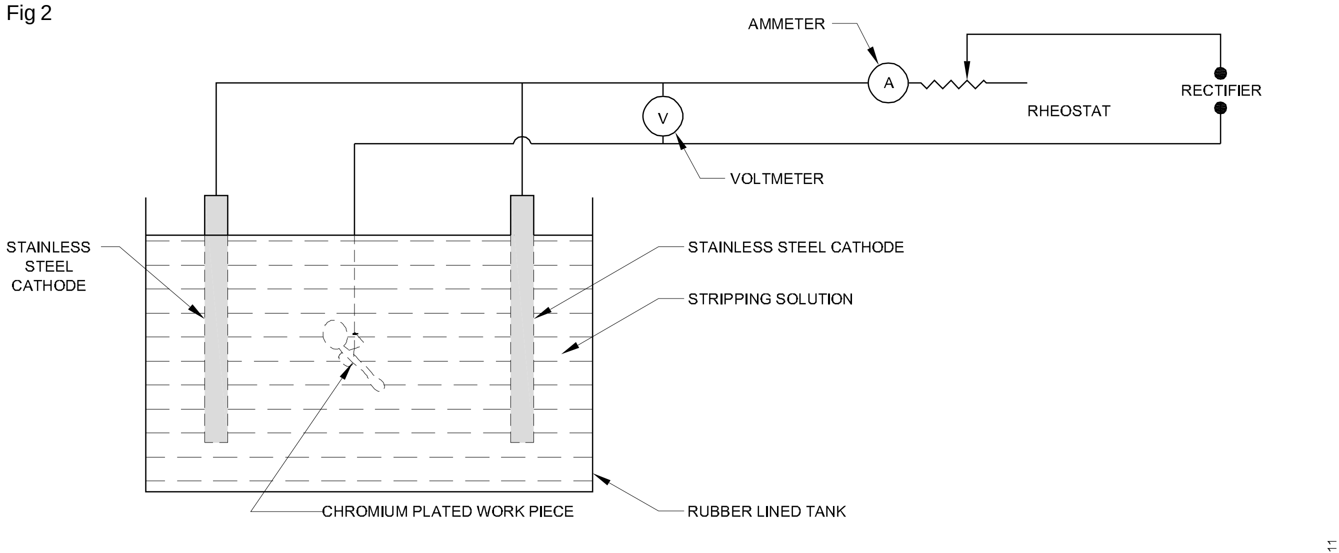
Fig 1



IMMERSION STRIPPING

The dry articles are immersed in the solution for stripping. The articles are withdrawn as soon as the chromium has been removed. After chromium stripping the articles should be thoroughly rinsed in cold water. Care should be taken when rinsing to avoid splashing.

Fig 2



CONNECTION DIAGRAM FOR ELECTROLYTIC STRIPPING FOR CHROMIUM DEPOSIT

Basics of cadmium plating and equipments

Objectives : At the end of this lesson you shall be able to
- **state the properties of cadmium metal**
- **describe the equipments for bright chromium plating**
- **explain the anode maintenance and the chroffles.**

Cadmium plating

Electroplated cadmium affords excellent protection to iron and steel as, under corrosive conditions, the coating is electrolytically sacrificed to protect the underlying ferrous metal. In many applications, however, cadmium is now being replaced by zinc because electroplated zinc has a much lower basic cost than that of cadmium. The standards of finish and corrosion resistance of zinc are now equal to, if not better than, those obtainable with cadmium plating.

Properties of chromium

Cadmium is a chemical element with symbol Cd, atomic weight 112.4, valency 2 and atomic number 48. It is chemically similar to the two other stable metals in group 12, zinc and mercury. It has melting point of 321°C, boiling point of 766.8°C and density of 8.7 g/cc. Cadmium is a silver white metal with excellent corrosion resistance in marine conditions. The metal is harder than tin but may be cut with a knife. It is very ductile and can be easily rolled into a foil or drawn into a wire. Cadmium in its melting temperature gives off highly toxic fumes of cadmium metal vapour and cadmium oxide. Cadmium salts are also poisonous.

Applications of cadmium plating

Cadmium is unaffected by alkalies and can be used in situations where which come into contact with soaps, washing powders and industrial and domestic cleaners. Electroplated cadmium is used in the electrical and air craft industries. Cadmium is widely used as a corrosion resistant finish for sea going equipments.

Cadmium cannot be electroplated on the articles which come into contact with food stuffs or drinking water because of its toxic nature. For this reason also, it should not be applied to articles which may be subjected to temperatures in excess of 250°C.

Equipments for cadmium bath

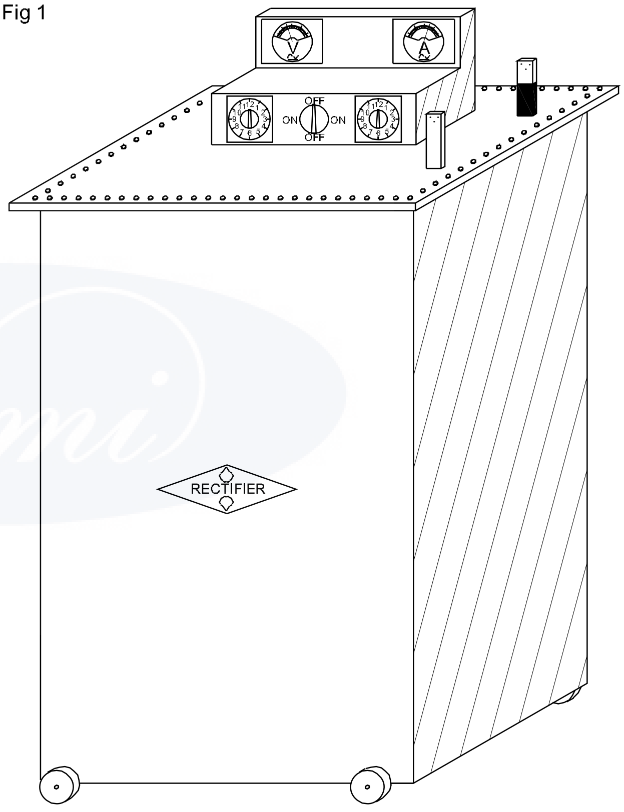
It is important that electroplater uses proper equipments for his work. The quality and efficiency of work will depend upon the use of proper equipment.

Listed below are the equipments are the most commonly used for cadmium plating.

Rectifier

It is used to rectify the AC supply input to DC output required for electroplating. The output voltage is variable and the required current can be set. The polarity of the output is marked. The output capacity of the rectifier (Fig.1) should match the voltage and current requirements of the process for which it is to be used. Oil immersed metallic type rectifiers are best suited, although air cooled types may be used where the power demand is not high.

Fig 1



RECTIFIER

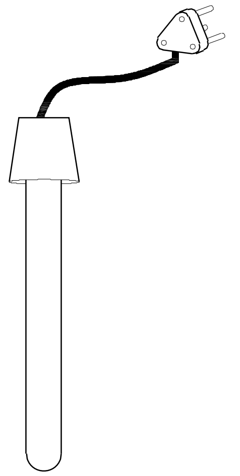
Immersion heater

While heating is necessary, mild steel electrical immersion heaters (Fig.2) are used.

Plating tank

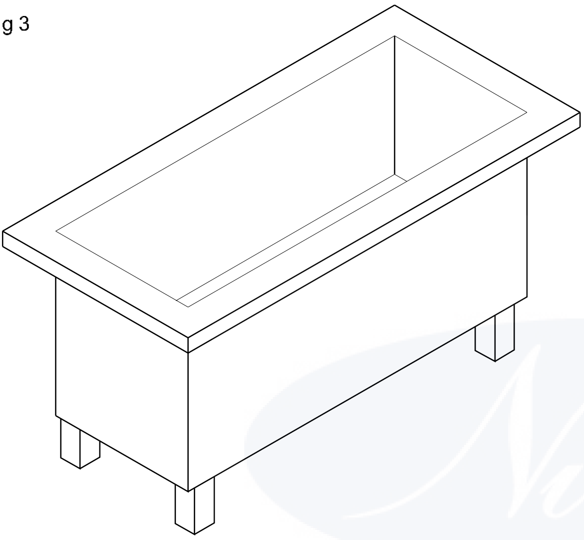
Plain welded steel tanks are used as container for the solutions of cadmium plating. Alternatively rubber or plastic lined tanks also be used. Stainless steel tanks are used for swilling, drag in and drag out operations. Now a days, polypropylene (PP) tanks are used for these purposes because of its resistance to chemicals.(Fig 3)

Fig 2



MILD STEEL ELECTRICAL IMMERSION HEATERS

Fig 3



PLATING TANK

Plating barrel

For barrel plating the use of horizontal immersed barrel is recommended. The use of small self contained barrels is not advised

Bus bars

Bus bar is a rigid conductor, made of copper, for carrying current to the anode and cathode rods from the rectifier. These should have enough capacity to carry the full load current.

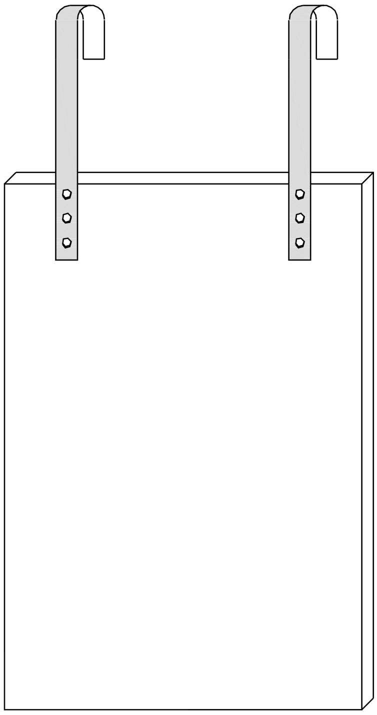
Anode rod and cathode rod

The anode and cathode rods are made of copper and should have enough capacity to carry the current from the bus bars. The two anode rods are placed above the plating tank to hook the anodes. The cathode rod is placed in between the two anode rods and suspends the job to be plated.

Anodes

Either flat type anodes Fig (4) or ball type pure cadmium metal supported on steel hooks is used as anodes for cadmium plating. Sufficient anodes should be provided to give an anode area equivalent to that of the cathode area. it is essential that the purity of the anodes be 99.95% cadmium in order to ensure the high quality of the deposit.

Fig 4

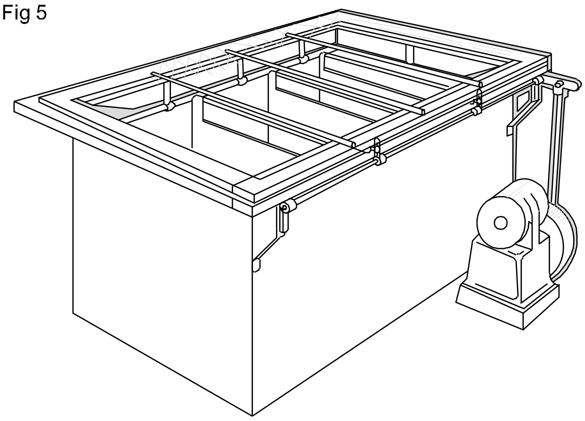


CADMIUM ANODE

Agitation

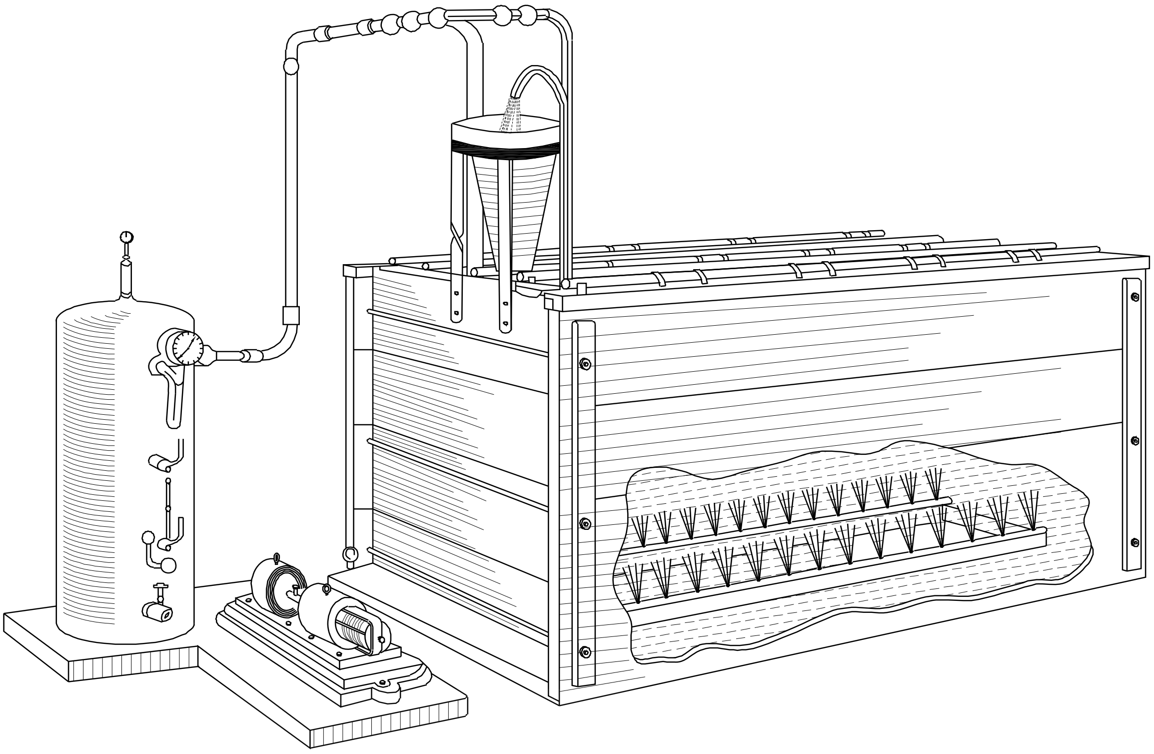
Cathode rod movement Fig(5) is advantageous for certain cadmium plating solutions or as an alternative mild air agitation Fig(6). Where such movement is employed, it is generally advisable to filter the solution continuously. Plain steel filters or filter units Fig.(7)lined with special quality rubber may be used. All pipe work should be of mild steel with welded joints. Rubber or plastic pipe work may be employed on small scale plants providing it are of an approved grade.

Fig 5



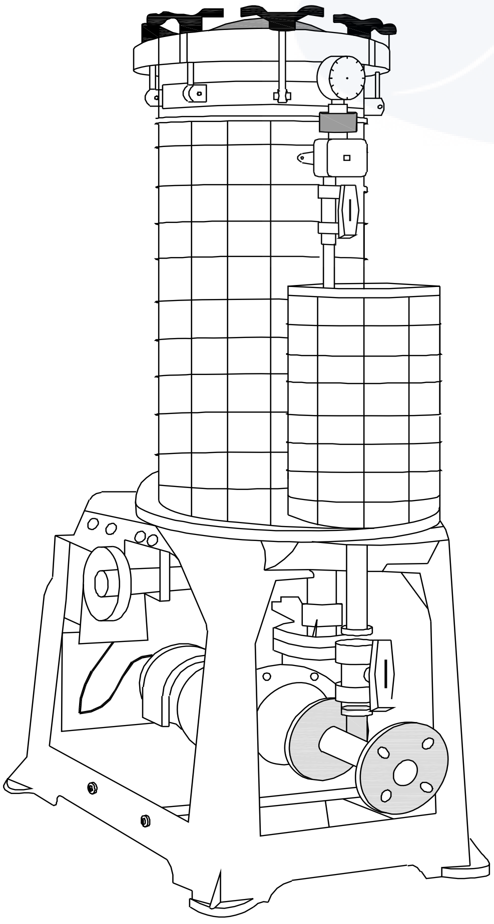
CATHODE ROD MOVEMENT

Fig 6



AIR AGITATION

Fig 7



CARTRIDGE TYPE FILTER UNIT

Electrolytes for cadmium plating and its maintenance

Objectives : At the end of this lesson you shall be able to
- **list the chemicals for various types cadmium plating solutions**
- **describe the preparation of different types of cadmium plating solutions**
- **explain the maintenance of different types of cadmium plating solutions.**

Preparation of cadmium plating solutions

Cadmium is usually deposited in the mat condition when intended purely for protection but can be electroplated fully bright where an attractive appearance and corrosion resistance is required. Where the metal is to be passiveted after plating, the bright finish id often preferred. The deposit may be polished or scratch brushed providing that precautions are taken to avoid over heating the metal.

The following figure shows the preparation of all types of solutions (Fig.1)

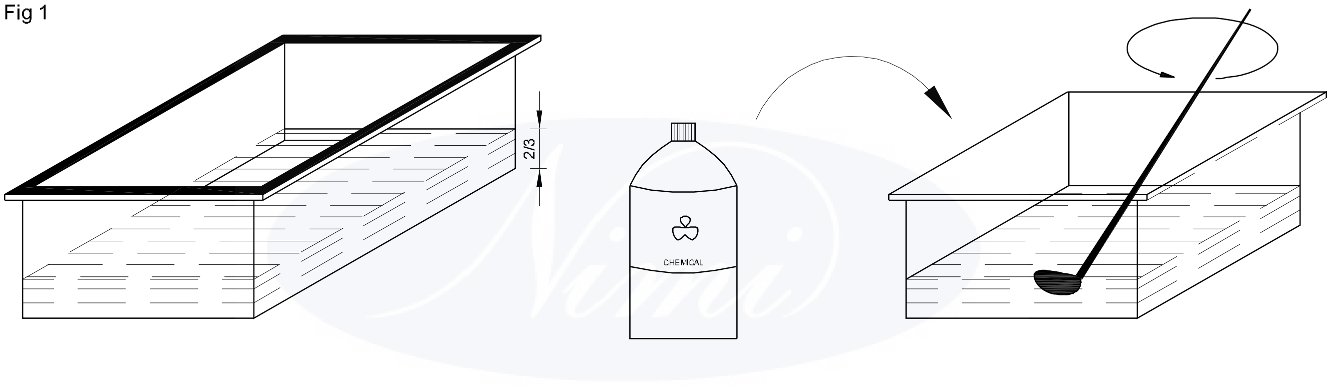
Chemicals for solution maintenance

Where any cadmium solution is deficient in all constituents it is maintained by additions of its particular chemical.

Cadmium oxide

This chemical is used to raise the cadmium and sodium hydroxide content of the solution without affecting the total cyanide content.

Fig 1



PREPARATION OF PLATING SOLUTIONS

TABLE 1

Name of chemical	Rate of adhesion (g/l)	Increase in concentration		
		Cadmium (g/l)	Total sodium cyanide(g/l)	Sodium hydroxide(g/l)
Cadmium oxide	1.2	1.0	---	0.75
Cadmium carbonate	1.6	1.0	---	---
Cadmium cyanide	1.6	1.0	0.82	---

Cadmium carbonate

This chemical is used for raising the cadmium content without increasing the sodium hydroxide content. It does, however results in an increase in the sodium carbonate content which may be disadvantageous.

Cadmium cyanide

This chemical may be used with an advantage in solutions which are adequate in sodium hydroxide and in which an increase in the carbonate content is undesirable.

These chemicals should not be added directly to the plating bath, but should first be dissolved in a portion of the plating solution that has been transferred to a plain steel tank and heated to a temperature of 55 to 65°C.

1. Matt cadmium plating solution

Cadmium oxide - 12-20 g/l

Sodium cyanide - 38-50 g/l

The tank is half filled with clean warm water at a temperature of 40 to 500C, firstly the sodium cyanide and then the cadmium oxide added slowly and carefully with stirring. When they are completely dissolved, water is added to make up the solution to working level and to correct density. The solution should be thoroughly stirred to ensure that it is well mixed. On settling, there is usually sediment in the bottom of the tank. This can be removed by filtering.

Solution maintenance

Regular additions of sodium cyanide are necessary to maintain the sodium cyanide content of the solution. These additions are usually are the order of 1.5g/l every 2 or 3 weeks. If the cadmium content tends to rise, then a proportion of cadmium anodes may be replaced by stainless steel plates. If the solution is deficient in cadmium, then cadmium oxide, carbonate or cyanide may be used for the correction of the solution a shown in the above Table (1).

2. Bright cadmium plating solution

Cadmium oxide - 22 g/l

Sodium cyanide - 125 g/l

Sodium hydroxide - 35 g/l

The tank is half filled with clean warm water at a temperature of 40 to 500C, firstly the Sodium hydroxide and then the sodium cyanide and cadmium oxide added slowly and carefully with stirring. When they are completely dissolved, water is added to make up the solution to working level and to correct density. The solution should be thoroughly stirred to ensure that it is well mixed. On settling, there is usually sediment in the bottom of the tank. This can be removed by filtering.

Solution maintenance

Regular additions of sodium cyanide are necessary to maintain the sodium cyanide content of the solution. These additions are usually are the order of 1.5g/l every 2 or 3 weeks. If the cadmium content tends to rise, then a proportion of cadmium anodes may be replaced by stainless steel plates. If the solution is deficient in cadmium, then cadmium oxide, carbonate or cyanide may be used for the correction of the solution a shown in the above TABLE 1.

Where chemical laboratory facilities are available, it is recommended that the cadmium plating solutions should be regularly analysed and any necessary additions made to maintain the density and the cyanide content at their recommended values.

Cadmium plating process

Objectives : At the end of this lesson you shall be able to

- **describe the chemical composition and operating conditions of cadmium plating**
- **explain the measurement of local thickness and the porosity test of cadmium deposit**
- **describe the passivation process for cadmium deposit**
- **explain the defects and their remedies in cadmium plating.**

Cadmium plating operating condition

Cadmium is usually deposited from an alkaline cyanide solution. Where high tensile steels are to be plated and hydrogen embrittlement is a serious problem, an acid based cadmium fluoborate solution may be used in place of a cyanide type solution.

Surface preparation

To ensure effective adherence of cadmium deposits, it is essential that the surface to be electroplated are in clean condition, free from oils, greases, soils and oxides. This involves the use of a number of preparatory stages, we previously studied. After these preparatory stages, the articles enter the plating shop for final cleaning and electroplating.

Types of cadmium plating

From the various types of cadmium plating available, the following common methods are discussed. Following is the common connection diagram for cadmium plating (Fig.1)

1) Matt cadmium plating

2) Bright cadmium plating

1. Matt cadmium plating

This solution is employed for general purpose and where a matt finish is required. The chemicals are carefully balanced combination of cyanide and the metal for ease of operation, and the production of an adherent smooth white deposit. This solution has good throwing power and is perhaps the simplest of all electroplating solution to operate and maintain.

Solution composition and operating conditions

Cadmium oxide	- 12-20 g/l
Sodium cyanide	- 38-50 g/l
Current density	- 1.0 to 1.5 A/dm^2
Voltage	- 2.0 to 2.5V
Temperature	- Room temperature but not below 15ºC.

2. Bright cadmium plating

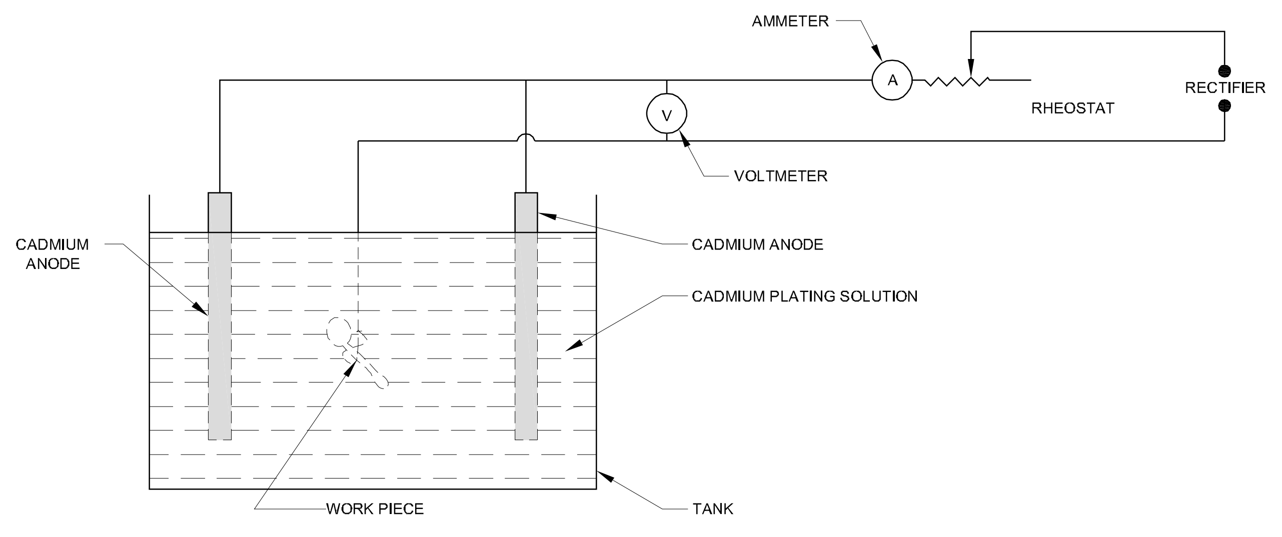
The solution is suitable for the rack and barrel plating and provides a fully bright cadmium plated deposit.

Cadmium oxide	- 22 g/l
Sodium cyanide	- 125 g/l
Sodium hydroxide	- 35g/l

For rack plating

Current density	- 1.0 to 3.0A/dm^2

Fig 1



Connection diagram of cadmium plating

Voltage - 1.5 to 2.5V

Temperature - Room temperature but not below 15ºC

Agitation - for high current density operation cathode movement is advised.

For barrel plating

Current density - 0.5 A/dm^2

Voltage - 8.0 to 16.0V dependent on the type of barrel and size of component plated.

Temperature - 20 to 40ºC It is important that the upper limit is not exceeded.

Rate of deposition at usual plating time

The cathode efficiency of a cyanide cadmium plating solution can vary both with the current density employed and with the cyanide content of the solution in relation to the cadmium content.

At current densities below 1.5A/dm^2, the cathode efficiency will gradually be about 95%. With solutions operated at higher current densities, the efficiency may be between 85 - 95% at 2 to 3 A/dm^2 and falling to 80% or less at higher current densities.

Increasing the free cyanide content in relation to the metal content will lower the cathode efficiency but improve the throwing power.

Strip and reweigh method for average thickness of cadmium deposit.

Cadmium plated steel test piece, a few square inches in surface area, in the form of a small strip, disc or other simple shape, not more than about 50g in weight, is degreased, dried and carefully weighed.

It is then immersed in the ammonium nitrate stripping solution, 30g/100ml and allowed to remain until the cadmium coating has been completely dissolved. This usually takes about 10 minutes. The solution should be stirred occasionally to make sure that it has access to all parts of the metal surface.

The test piece is then removed, rinsed thoroughly in water, dried, cooled to room temperature, and carefully reweighed.

The thickness of the plating is calculated by the weight of the deposit in milligrams (i.e., the difference in weight of the test piece before and after the stripping) by the surface area of the plating in square centimeters x 0.864

$$T = \frac{\text{Weight of cadmium deposit (mg)}}{\text{Area (cm}^2\text{) x 0.864}}$$

For example;

Weight of the cadmium plated test piece = 28.891 g

Weight of test piece after stripping = 28.758 g

Weight of the cadmium deposit = 133 mg

Thus if the surface area of the test piece is 16 cm^2, then the thickness of the cadmium deposit is :

$$\frac{133}{16\text{x } 0.864} = 9.62 \text{ microns}$$

Test for porosity of deposit

Cadmium coatings may be readily tested for porosity by immersing the plated articles in a 1per cent by the volume solution of hydrochloric acid at room temperature.

The article if taken straight from the plating solution, is well swilled in cold water or if taken from stock must be degreased by a suitable solvent or an alkaline cleaning solution and well swilled, before being immersed in the dilute acid.

Porosity is indicated by the formation of hydrogen bubbles. In the case of doubt as to whether a bubble is merely entrapped air or actually a hydrogen bubble covering a pore in the surface; it may be brushed off, when a new bubble will soon form if there is porosity.

If the pores are very numerous, a large number of small hydrogen bubbles will appear within a few seconds of immersion, absence of bubbles over a period of 5 minutes indicate a non-porous deposit.

The treatment does not injure the cadmium plating, but the article having satisfactorily passed the test must be thoroughly swilled in water and dried before it is put into store.

Removal of embrittlement

Hardened steels, high tensile steels and springs may become brittle due to the absorption of hydrogen during the pre-treatment and plating stages.

For the removal of embrittlement the following heat treatments used;

Springs

Immersion in boiling water for not less than two hours.

High tensile steels

Steels over 1000 N/mm^2 tensile strength should be baked at 200ºC from two to twenty four hours, depending upon the specification requirements.

Carburised surface steels

These should be baked at 130ºC from two to six hours, depending upon the specification requirements.

In order to prevent surface discoloration and to improve the corrosion resistance, a range of passivations process is available.

Post plating treatment

The post plating treatments listed below generally prove effective in preventing discolouration of the cadmium deposit occurring in storage or in use. The dark staining which develops under certain atmospheric conditions is due to retention of alkali in the deposit and is highlighted by the roughness or porosity in the steel base and also by inadequate swilling of the plated articles.

Chromic acid dip

A post plating dip in chromic acid will usually prove effective in preventing the discolouration of cadmium deposits occurring in storage or in use. This dark staining which develop under certain atmospheric conditions is due to the retention of alkali in the deposit and is highlighted by roughness or porosity in the steel base and also by inadequate swilling of the plated articles. This defect can occur on both bright and dull cadmium deposits.

The chromic acid treatment neutralizes any alkali present on the plated surface and leaves a light chromate film which does not affect the colour or the cadmium plate.

Solution composition and operating condition

Chromic acid	- 50 g/l
Tank	- Lead lined or PP
Temperature	- room
Time	- 15 to 30 seconds

Passivations process

Passivation is a dipping process to form a thin protective surface film on the zinc or cadmium plated surface to prevent surface discolouration. In conditions of high humidity, the zinc and cadmium form a white corrosion product on their surfaces called white rust. Where plated components are packed in closed spaces, emission of small quantities of vapours from the packing material can also cause white rust corrosion and in certain cases this can be so severe that it leads to complete failure of coating, permitting heavy rusting of steel basis metal.

The passivated coatings increase the resistance of zinc and cadmium against this type of corrosion and thus extend considerably the life of the basis metal. Passivated coatings also form a perfect bonding layer for subsequently applied paint schemes.

Yellow and blue passivation

The zinc and cadmium coating is given a bright yellow or blue shine on dipping few seconds in the solution at room temperature. This treatment may be applied to either matt or bright cadmium and zinc deposits.

Solution composition for yellow passivation

Chromic acid	- 250g/l
Aluminium sulphate	- 20g/l
Chrome alum	- 20g/l
Sodium fluoride	- 8gm/l
Nitric acid	- 1oml/l
Sulphuric acid	- 7ml/l

Solution composition for blue passivation

Sodium di chromate	- 200g/l
Sulphuric acid	- 10ml/l

When freshly produced passivated film is soft and should not be touched before drying. It is generally dip in a colourless lacquer to prevent finger marking.

Cadmium plating troubles

Sl.No	Nature of defects	Possible causes	Remedies
1.	Imperfect adhesion	Presents of acid on basis metal before plating	Pass the article through cyanide dip and water swills before cadmium plating
		Lack of cyanide as indicated by very little gassing of the solution and the presence of a black cream on the anodes.	Check the cyanide content and the required amount of sodium cyanide. Failing analysis, add 6g/l followed by a little more if necessary, until the anodes become clear.
		Presence of grease, oxide, or stains on the metal before plating	Review cleaning processes and check cleaning solutions.

2.	Rough and dark deposit	Excessive current density resulting in a burned deposit. Tendency aggravated by lack of free cyanide in the bath	Check the cyanide content of the solution and make good any deficiency by adding high grade sodium cyanide. Reduce voltage and plate at a lower current density. Do not use too large anode surface when plating small parts, if possible hang such articles between larger pieces in the tank or place them where they are not opposite to an anode.
3.	Anodes covered with black film	Lack of cyanide content	Check the cyanide content and add required amount
4.	Poor coverage	Low current density	Increase current density
		Low metal content	Add cadmium salt or increase anode area
		Faulty electrical contact	Check and rectify
5.	Deposit dark	Contamination of the solution with lead.	Trace origin of contamination, prevent recurrence, and eliminate the impurity by plating on to scrap, for several hours at low current density.
6.	Deposit of good colour and appearance but rough	Presence of suspended matter in solution	Either filter solution or allow the bath to stand overnight until the suspended matter settles as sediment, and then transfer the bulk of the clean solution into a clean steel tank. Dispose of the last few inches containing the sludge, then clean out the plating tank before replacing the clear solution.
7.	Poor throw of deposit. Excessive gassing of the solution at cathode face.	Excess of cyanide in solution. Cyanide content too high in relation to the metal content.	Determine the amount of metal content, cyanide and sodium hydroxide. Rectify the solution by adding cadmium cyanide, oxide or carbonate.

8.	Anodes abnormally bright and crystalline in appearance	Excess of cyanide in solution.	Neutralise the excess of sodium cyanide by adding cadmium cyanide, oxide or carbonate.
9.	Low current density at normal plating voltage	Poor conductivity of the solution due to either low temperature or lack of sodium hydroxide.	Raise the temperature of the solution. Analyse the sodium hydroxide content and make good any deficiency by adding sodium hydroxide. If no analytical facilities are available add 6 g/l
10.	Solution vey dense, crystallizing out all anodes and sides of tank when cold.	Accumulation of carbonates over a long period of use, due to gradual but continuous decomposition of cyanide.	Remove any carbonate crystal that form during cold weather when the bath is not in use. Use an iron shovel for the purpose and subsequently restore the level of the solution with water.
11.	Embrittlement of hardened steel articles by plating	Absorption of hydrogen by the basis metal	Do not cathodically clean high tensile steel, springs, or other hardened steel parts. Remove any brittleness introduced during plating by treatment as described above.

Stripping of cadmium deposit

Objectives : At the end of this lesson you shall be able to

- **state the chemical composition and operating conditions of cadmium stripping baths**
- **explain the process of removal of cadmium plating.**

Cadmium stripping is a process to remove cadmium coating from the basis metal without affecting the underlying metal. Two types of methods are used for the removal of electroplated coatings. They are electrolytic and immersion methods. The selection of stripping bath is depends upon the structure of basis metal.

Electrolytic stripping process

Following is the connection diagram for electrolytic stripping process (Fig.1). Stripping of cadmium from ferrous articles is done electrolytically under the following conditions.

Sodium hydroxide	- 100 g
Cathode	- Steel plates
Voltage	- 6V
Temperature	- Room

Immersion stripping process

Following is the figure for immersion stripping process (Fig.2).

Using ammonium nitrate solution

Deposits may be quickly and cleanly stripped by immersing the work in a cold 10 percent solution of ammonium nitrate in water contained in a welded steel tank or a plastic or rubber lined container.

Using ammonical persulphate solution

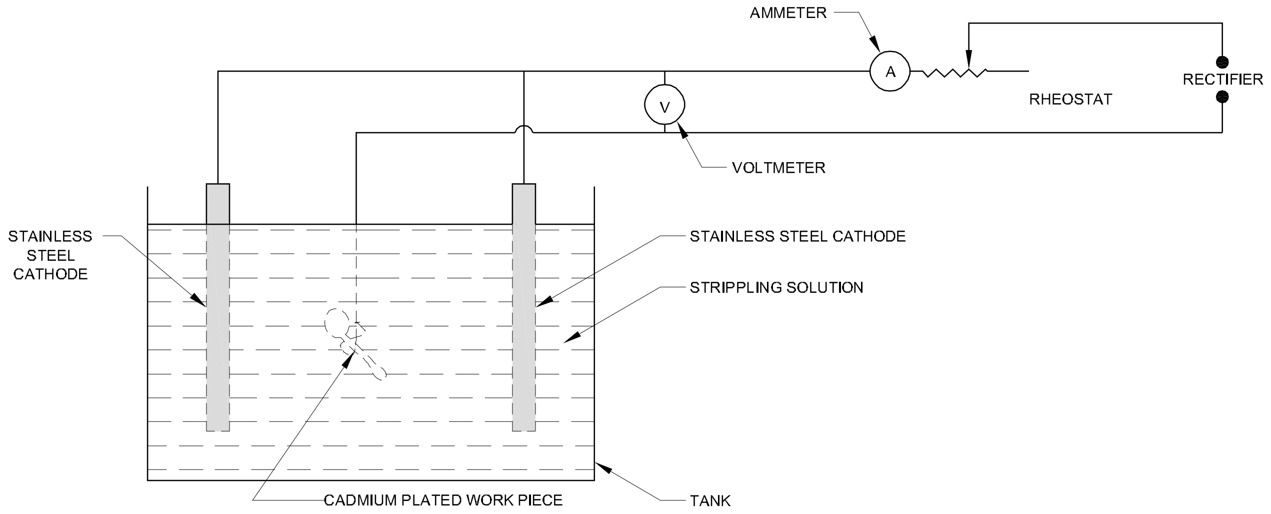
Cadmium may also be removed from steel, with a negligible attack on the basis metal, by immersing the articles for a few minutes in a solution of ammonium per-sulphate and ammonia. This stripping solution, which is used cold and contained in a plastic container, is prepared by dissolving 50 g of ammonium per sulphate in 1 litre of water and then adding 25ml of ammonia liquor, sp. Gr. 0.880

Using hydrochloric aid

As an alternative to the above methods, dilute hydrochloric acid may be used, but the operation must be watched and the articles removed when stripped, otherwise the steel become etched. The solution is also used cold, and should be contained in a rubber lined tank or a plastic container. The usual concentration is 1 part of concentrated hydrochloric acid to 3 parts of water.

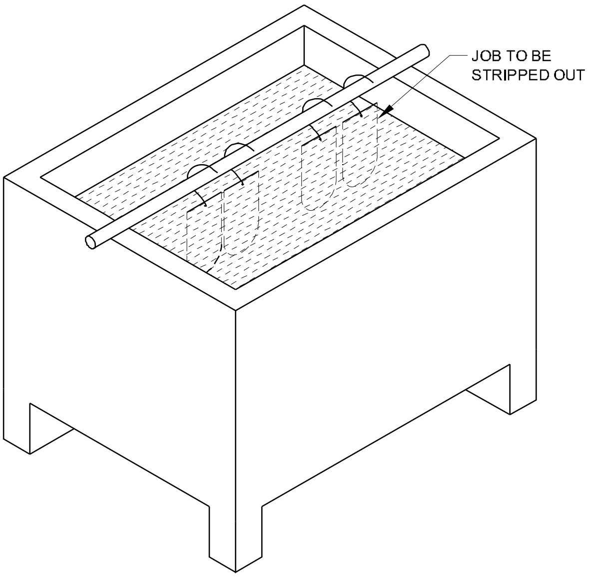
The dry articles are immersed in the solution for stripping. The articles are withdrawn as soon as the cadmium has been removed. After cadmium stripping the articles should be thoroughly rinsed in cold water. Care should be taken when rinsing to avoid splashing.

Fig 1



ELECTROLYTIC STRIPPING PROCESS FOR CADMIUM DEPOSIT

Fig 2



IMMERSION STRIPPING PROCESS FOR CADMIUM

Basics of silver plating

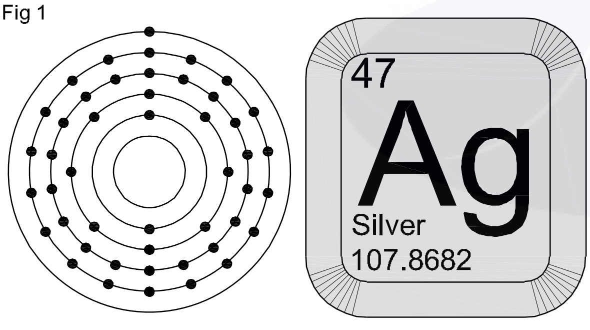
Objectives : At the end of this lesson you shall be able to
- **state and list out the properties of silver metal**
- **state the applications of silver**
- **list the equipments required for silver plating**
- **specify and explain the use of each equipment.**

Silver plating

Silver in its pure form is a soft, white, lustrous metal which is extremely malleable and ductile and is capable of taking a high polish. It is resistant to most common acids except nitric acid, in which it dissolves readily, and chromic acid with which it forms a dark red deposit of silver chomate; this reaction serving as a useful 'spot' test for identifying the metal. Silver has the highest thermal conductivity and the lowest electrical resistivity of any metal a normal temperatures. On heating in clean air, the pure metal does not oxide but because it has an affininty for sulphur, traces of sulphur compounds present in both industrial and air cause tarnishing.

Properties of silver:

Fig 1



PROPERTIES OF SILVER

Symbol : Ag

Color : Metallic, white

Atomic number : 47

Atomic weight : 107.86

Element category : Transition metal

Melting point : 961.78°C

Boiling point : 2162°C

Density : 10.49 g/cm^3

Silver plating can be applied utilizing either rack fixture or barrel plating technology. Typically a silver - plating specification will specify a matte, semi- bright or bright finish with or without chromate post treatment to improve tarnish resistance.

Silver plating has the following properties

- White matt to very bright finish
- Good corrosion resistance (depending on base metal)
- Will tarnish easily
- Hardness varies from 0 to 135 brinnel
- Excellent solderability (decreases with time)
- Good lubricity and smear characteristics
- Used as anti - galling on static seals, bushing etc

Excellent electrical conductor

Plating specifications also designate the base coating to be applied under the silver plate. The thickness of coating can range from 1 micron for short - term shelf life and solderability to 10 microns for thermo - compression bonding and die attachment and upto 40 microns for severe wear resistance applications. In general silver serves as a more cost - effective plating solution because it is cheaper than gold and silver is plated on aluminium, brass castings, copper, invar, steel and titanium items.

Silver strike solution

A silver strike solution is always recommended prior to silver deposition to promote excellent adhesion and prolong the life of the main plating solution.

In silver plating, the object to be plated in made from the cathode. The anode is a bar of pure silver metal and the electrolyte is a solution of silver cyanide AgCN, in water. When a direct current is passed, positive silver ions (Ag+) from the silver cyanide migrate to the negative anode where they are neutralized by electrons and stick to the article as silver metal. The silver anode gives up electrons to become silver ions.

Thus the anode bar gradually dissolves to replenish the silver ions in the solution. Thus silver metal has been transferred from the anode to the cathode. The process continues until the desired coating thickness is built up on.

Anode and cathode reactions

Electro deposition of silver involves the reduction of silver metal ions from the electrolyte. At the cathode electrons are supplied to cations, which migrate to the anode. The reaction at the cathode is.

$Ag^{n+} + ne^{-} \rightarrow Ag$ ....(1)

At the anode electrons are supplied to the anions which migrate to the anode.

$Ag(CN) \rightarrow Ag^{+} + CN^{-}$ ....(1)

Applications of silver plating

Silver plating is an electro deposit process for electrical engineering, electronic and decorative applications. Due to its property of high electrical conductivity it is used in electronics and semi conductor industries. It finds usage in bearing surfaces and anti - galling applications. Being ductile it is be preferred by jewellery and flatware industries for its decorative appeal. Due to its antibacterial quality silver plating is done on jewellery, food packages, washing machines, clothing and personal hygiene products.

Equipments required for silver plating process

The general basic requirements of a electroplating plant after suitable cleaning and pretreatment process are as follows

1. D.C. electrical supply
2. Electroplating tank equipped with adequate circulation and pumping arrangements, filter and heat exchanger.
3. Suitable workpiece carrier.
4. Rinsing arrangements and effluent disposal system.
5. Heating accessories.
6. Facilities for cleaning hooks, jigs and rejects.
7. Adequate supply of deionised or equally pure water.

Electrical requirements

The first requirement is for an adequate source of d.c. current at voltages determined. The direct current required can be supplied by means of a 3 - phase transformer rectifier which may be of the air- cooled silicon, water - cooled germanium or oil - immersed selenium type.

The current is applied as the article is slowly immersed into the tank. If the article is wet, as it probably would be after the final rinse and if the current is then applied during immersion, water marks may be formed due to local dilution at the wet areas.

This problem can be overcome and the initial current surge is avoided if the current is applied after the article has been submerged in the bath for about 10 seconds. This will be at low voltage for about 15 seconds before going to the required voltage. The voltage control is simply obtained by splitting the bus bar from which the current is picked up and connecting the sections of the bus bars.

With standard silver solutions the current densities are of 1.6 to 2 amp/dm^2 (15 to 20 Amp/ft^2) are employed. With the half strength silver solutions current densities up to 0.8 or 1 amp/dm^2 (8 amp/ft^2) are used. The voltage between anode and cathode rods is approximately 2.

Current transference

The article being plated usually acts as the cathode and separate anode incorporated with a insulated membrane is inserted in the tank.

The current is transferred from the bus bar to the article by means of jigs for holding work.

Auxillary equipment

1. Plating tank

This is the centre piece of the plant around which the remainder of the equipment should be designed. Careful consideration should be given regarding the requirements of the process. The immersion time required, will be fixed by the type of article thickness required, operational voltage will be determined accordingly.

A rubber lined steel tank or a lead lined tank with loose inner linings of reinforced glass is used. As an alternative cement - lined stoneware or enameled tank is preferred. A treatment tank is required so that the solution may be transferred for storage or treatment at any time, such as when the platings tank springs a leak. The tank used for plating should be set on an insulted brick piers. If a plain steel is used, it must be properly insulted against bipolar and stray currents, or else a considerable amount of silver may plate out on the tank sides. Silver tanks are normally ventilated.

For silver - strike solutions, steel tanks usually lined with polyvinyl chloride or rubber is employed.

2. It is not necessary to agitate either, but if agitation is required, it should be of the solution agitation or cathode rod type, since air agitation leads to carbonate build - up. The plating tank should be equipped with a 5 - v drop rheostat.

3. The tank should be fitted with anode and cathode rods and also if required cathode moving gear. The pumps and piping between the heat exchanger and the plating tank suffice for solution agitation.

4. To ensure that the electroplated surface is of maximum cleanliness it is essential to have satisfactory filters in the line with a fineness of 50 - 80 microns. The filter should preferably be made of stainless steel and equipped with stainless steel pumps and valves. The capacity of the filter should be sufficient to provide for a complete turnover of solution once every ½ hour.

5. Anodes

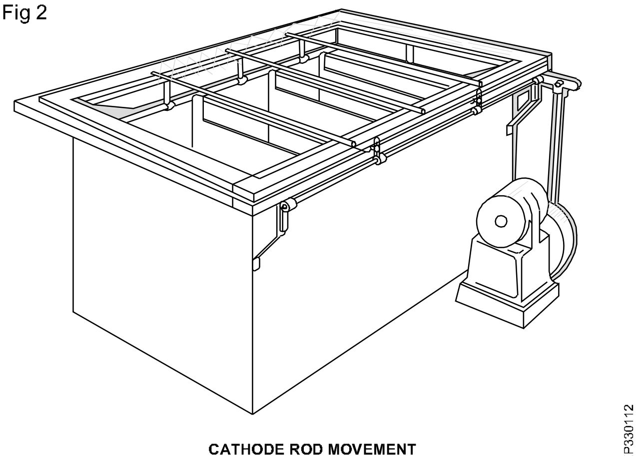
High purify of 99.97 percent purify rolled silver anodes are recommended although annealed cast silver anode have occasionally been used. For most applications it is advisable to bag the anodes in cotton bags, nylon stitched in this bath. The anode surface should be arranged so that the anode current density does not exceed 10 asf. It is suggested that the anode and cathode rods be nickel - plated in both silver - strike and silver plating tanks. The anodes should dissolve in the solution without any formation of black oxide upon them, and be of sufficient number or size to afford a good surface area.

6. Heating medium

Heating may also be accomplished by means of steam coils in the tank or by immersing an immersion heater. Excessive solution temperature may result in loss of brightness.

Cathode movement (Fig 2)

Fig 2



CATHODE ROD MOVEMENT

In silver plating it is important that each article in a load shall receive the same thickness of deposit, hence the work must be at a uniform distance from the anodes and evenly spaced in the vat. Some form of cathode movement should also be provided to prevent stratification of the solution. During heavy deposition in a still vat involving a long period of immersion, there is a tendency for the solution to become impoverished in metal and rich in free cyanide at the cathode face, with a corresponding concentration of silver ions at the anode. Hence it is customary to provide cathode moving gear or to fit the cathode bars on to a movable frame as shown in the illustration, instead of their being fixed in position on the tank itself.

With the cathode moving gear as illustrated opposite movement is applied to the individual cathode rods, for silver plating the normal speed is 10 r.p.m. and the stroke is variable from 50 to 150 mm (2 to 6 in).

The movable frame system is used mainly for the plating of tableware and decorative articles and has now, to a large extent, been superseded by the normal cathode moving gear.

The frame is automatically moved backwards and forwards for a distance of about 40 to 50 mm (1 ½ to 2 in) across the top of the vat, approximately 15 to 23 strokes per minute by means of belt or motor - driven gear, thus giving sufficient movement to the articles to prevent stratification troubles and yet leave undisturbed any sediment that may be at the bottom of the vat. For dull silver plating, the lower speed and length of stroke giving a linear movement of about 1 m/min (3ft/min) is adequate. For bright and high - speed silver plating a more vigorous cathode movement of about 2 m/min (6 to 7 ft.min) is usual; where a 50 mm (2 in) stroke is employed this involves a speed of 18 to 22 strokes per minute. For the plating of hollow work and other large articles the lower speed, i.e. 18 strokes per minute, is preferred. For spoons and forks the higher speed is recommended. Cathode movement is particularly useful when plating hollow work such as entrée dishes and bowls, as it ensures a better distribution of the deposit and freedom from "current" marks.

Electrolytes of silver plating

Objectives : At the end of this lesson you shall be able to
- **state the types of silver plating baths**
- **explain the types of silver plating baths**
- **explain the importance of silver strike solution**
- **explain the process of silver strike solution.**

Types of the silver plating baths:

The basis for a silver plating bath contains silver in the form of potassium silver cyanides and free potassium cyanide. Platers also can use sodium cyanide, but they generally prefer the potassium form.

The amount of free cyanide in silver solutions is extraordinary high..For example, a common copper-cyanide bath has 2 to 4 ounces of free cyanide per gallon while the amount of free cyanide in silver solutions commonly is 16 to 22 ounces. Large quantities of cyanide are required to increase the throwing power of the solution. Usually, a small amount of additives are also added to the bath.

The silver plating baths are the following types:

1. Conventional silver baths which are used for producing matt silver deposits.
2. Bright silver baths is recommended for bright electrodepositions and as a decorative finish.
3. High speed silver baths is used for the high speed production of heavy silver coatings.

These solutions may be used for normal plating with the articles on jigs or wires and also for barrel plating.

Silver strike solution: It is necessary to strike most metals to prevent immersion deposits of silver from the regular silver plating bath. In the past, either a nickel strike or a mercury dip was used. The mercury dip has been largely discontinued, in favor of present day silver strike solutions.

Basically the principle involved is the use of a low silver content and a high free cyanide, in order to reduce the silver ion concentration, thereby immersion deposits.

The use of a silver strike solution having a high free cyanide content and a low silver content enables an adherent initial deposit of electro-deposited silver to be applied.

If a copper or copper alloy article were to be immersed directly in a normal silver plating solution, silver may be deposited by displacement. Such a silver deposit would only be poorly adherent but would not dorm a satisfactory base for a silver coating.

Solution Composition:

Silver cyanide	5g
Potassium cyanide	60g
Water	to 1 litre

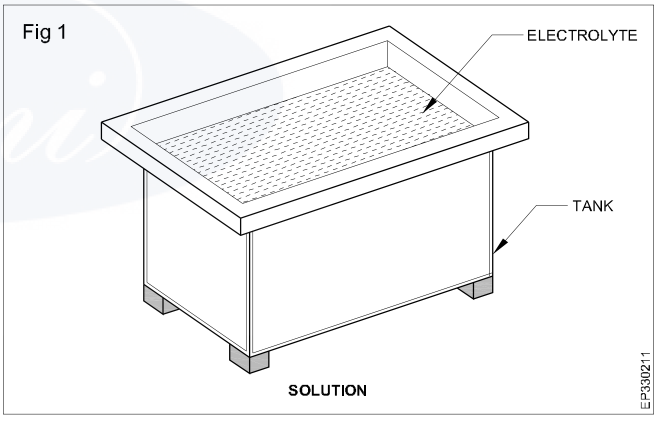
In silver plating directly on steel, it is advisable to use either a copper strike first or else the special silver strike listed above. Articles of stainless steel, nickel, nickel alloys or other materials that passivate readily should first be activated and nickel-struck prior to silver plating is recommended when plating over zinc or lead alloy.

Anodes: Anodes for silver strike should be of fine silver anodes or steel anodes

Preparation of the silver strike solution:

Fill the treatment tank with two thirds of the desired volume of water. Add Potassium cyanide in the tank and dissolve. Then add the required amount of silver cyanide till complete dissolution. The solution should then be brought to proper working level in the tank.

Fig 1



Operating Conditions:

A current of 5 to 6 v is required to carry out silver striking at room temperature with a current density 0f 1.5 to 2 amps/dm^2.

Filtration is a continuous process in plating wherever necessary. Heating is by means of steam coils in the tank or immersion lead heaters.

Maintenance of the bath

The solution is used at room temperature and for silver striking a voltage of 2 to 4 volts should be applied. It is essential that the voltage be applied to the tank before the work is introduced, the purpose of the "striking" operation being to secure an electro deposit before the article becomes silvered "by immersion" i.e., by chemical displacement.

Free cyanide

The concentration of free cyanide in a silver strike is extremely important. If the value falls too low, immersion plating of silver may take place, and the purpose of using a strike is thereby negated. In general, the free KCN content is kept at 12 oz/gal, and should never be allowed to fall below 10 oz/gal.

Scratch brushing

It is no longer usual to scratch brush between the silver strike and silver plating stages unless the silver deposit is patchy. Scratch brushing may however, be used after the hot cleaning stage particularly with work having soldered joints.

Procedure

The articles are cleaned and degreased in the usual manner, then put through a dilute sulphuric acid dip, rinsed in water and nickel plated. On removal from the nickel plating solution they are well rinsed again in cold running water and transferred immediately to a silver strike solution.

The articles are left in the silver strike for 15 seconds or until a complete covering of silver is obtained and then transferred to the normal silver plating tank with, preferably, an intermediate water rinse.

Amalgamating or "Quicking"

This operation involves immersing the cleaned articles in a dilute solution of mercuric salts, and results in the formation of a very thin film of mercury on the surface of the metal. The purpose of amalgamating or "quicking" in this manner is to prevent the work from being silvered by "immersion". i.e. by simple chemical displacement when placed in the plating solution, instead of its receiving an adherent electro - deposited coating of silver.

1. Ammonium chloride	1g
2. Mercuric chloride	1.5 g
3. Water	to 1 litre

Operating conditions

The solution is worked at room temperature and at a voltage of 1.5 to 2 volts.

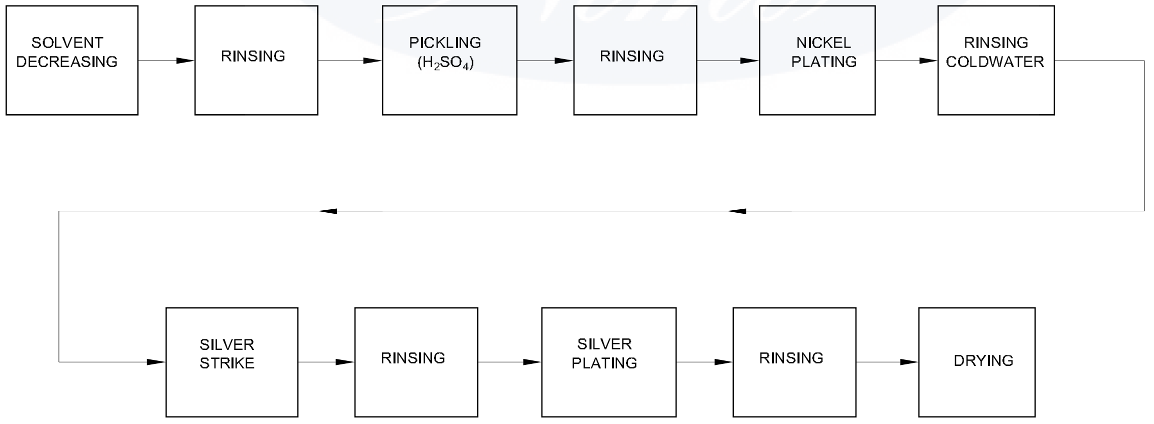
Procedure

The articles are immersed in the cold amalgamating solution for two or three seconds, until they have a faint whitish appearance. Should they appear "smoky" it is an indication that the solution is too strong and requires diluting with water. The "smokiness" may be cleared by passing the work through the cleaning bath.

"Quicking" is not applicable to ferrous metals, or to tin and lead alloys such as Britannia metal, zinc or zinc base alloys, aluminium or aluminium alloys, components for any aircraft airborne equipment or ground equipment associated with aircraft.

Fig 2 shows the block schematic diagram of silver plating process.

Fig 2



SILVER PLATING

Bright silver plating

Objectives : At the end of this lesson you shall be able to
- **explain the chemical composition of bright silver plating solution**
- **explain the operating conditions of bright silver plating**
- **explain the preparation and process of bright silver plating**
- **explain the maintenance of bright silver plating solution.**

Bright silver plating

The solution is recommended for production of decorative finishes and also for technical application. This solution gives better control of brightness and smooth deposit properties. The solution has an excellent throwing power and is easily maintained.

This silver plating solution is suitable for plating electrical contacts and other wearing surfaces. In addition to the bright deposit is resistant to finger marking, a feature which greatly simplifies the subsequent assembling of the plated components.

Solution composition

Silver cyanide	225 g
Potassium cyanide	25 g
Water	1 litre

Operating conditions

A current density of 1.5 to 2 amps/dm^2 may be applied. Where a lower concentration solution is required then the silver solution may be used at half strength. With the half strength solution, the maximum current density is 0.8 to 1 amp/dm^2.

The bright silver solution is used within the temperature range 15 to 25°C (60 to 75°F). Solution heating or cooling is not normally required, but the use of excessive solution temperature may result in loss of brightness.

The voltage between the anode and cathode rods is approximately 2.

Rate of deposition

The capital deficiency of a bright silver solution is high (99 to 100 percent). An average thickness of 20 microns is plated at a current density of 1.5 to 2 amps/dm^2.

Anodes

Anodes for this solution should be of fine silver 99.97 percent well annealed and closed in cotton anode bags (nylon stitched).

Preparation of the solution

The solution is prepared by dissolving the bright silver cyanide salts, together with any potassium cyanide, in approximately half the final required volume of warm water, at a temperature not exceeding 40°C (100°F). When the salts have completely dissolved a requisite quantity of brightener can be then added. The solution is finally diluted to working level and well mixed.

Bright silver

Fig 1 shows the flow diagram of silver plating procedure.

1. Hot alkaline clean.
2. Water swill
3. Cathodic clean
4. Water swill
5. Silver strike
6. Water swill
7. Bright silver plate
8. Water swill
9. Centrifugal drying
10. Packing

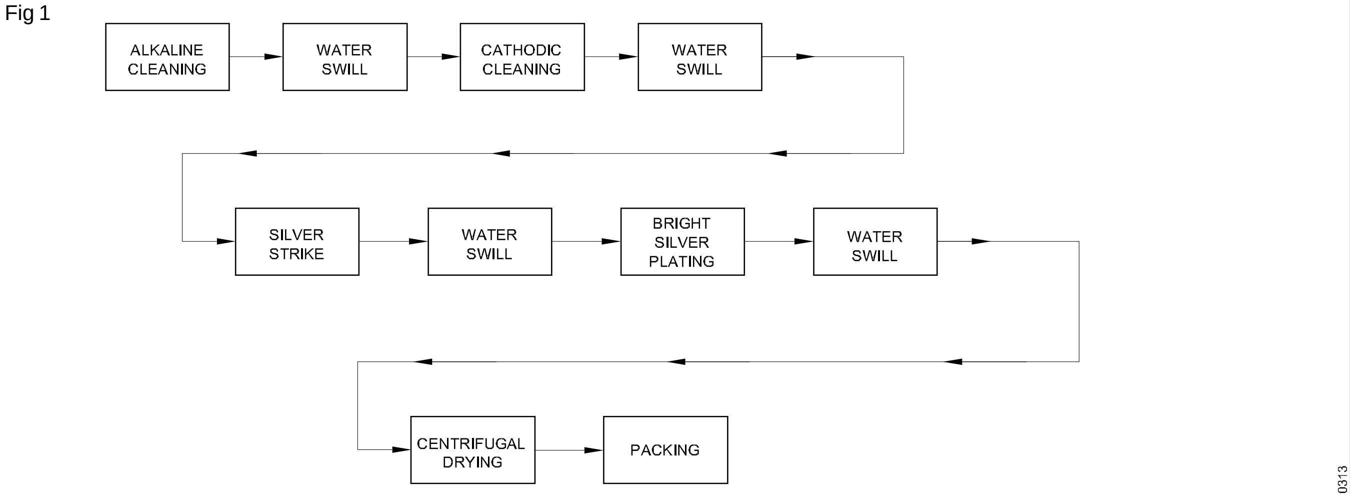
As an alternative to copper an initial deposit of nickel may be applied. Aluminium articles should be pretreated by the following process.(Fig 2)

1. Degrease in trichloroethylene liquor/vapour degreaser
2. Cathodic clean at room temperature
3. Water swill(Rinsing)
4. Nitric acid dip
5. Water swill(Rinsing)
6. Nickel plate
7. Water swill(Rinsing)
8. Silver strike
9. Water swill(Rinsing)
10. Bright silver plate
11. Rinsing
12. Drying

Maintenance of the bath

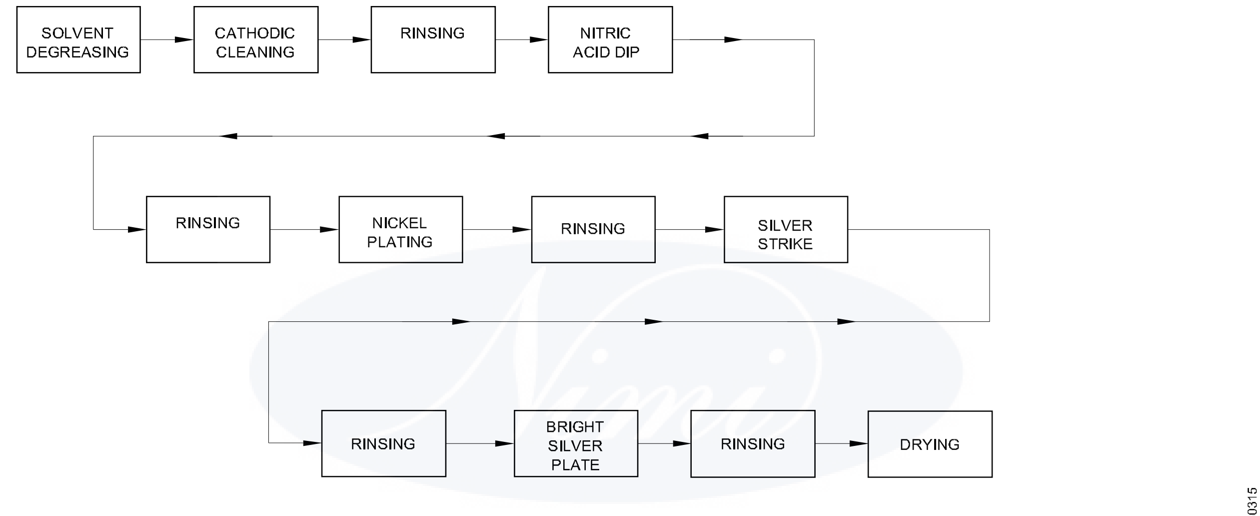
The free cyanide content should be determined at least once a week and any deficiency made good by the addition of high grade potassium cyanide. The silver and carbonate contents should also be determined from time to time. Plating efficiency is controlled by silver cyanide content (i.e the higher the silver metal content, the higher

Fig 1



BRIGHT SILVER PLATING PROCEDURE

Fig 2



SILVER PLATING ON ALUMINIUM

the efficiency). Temperature also place key role in the efficiency of the bath solutions.

The potassium carbonate content will rise as the solution ages; providing however it does not exceed 60 to 75 g/l, the operation of the silver solution will not be greatly affected.

If the carbonate content does become excessive the solution should be decarbonated. Addition of silver cyanide is necessary for the correction of silver content of the plating solution. Regular small additions of brightener are necessary to maintain the brightness of the silver deposit.

Silver plating of brass reflectors

Brass reflectors are generally nickel plated for five minutes and subsequently silvered for approximately one minute.

The silver deposit is then carefully finished with rouge powder moistened with seal oil or methylated spirit and applied to a soft mop, after which the polished surface is protected with a thin film of transparent lacquer.

Many reflectors are now lacquered and then aluminised.

Silver plating of knife handles

For silver plating, the knife handles are immersed in the plating solution, as illustrated, without the stainless steel blades being "stopped off". During the plating operation some silver is deposited on to the blade. This is subsequently removed by buffing through the deposit at the point on the bolster, indicated in the second illustration, the silver, which is not adherent to the stainless steel, can then the easily peeled from the blade, accumulated, and sold as scrap silver.

The normal practice is to silver plate the handles while the blades are in the fine glazed state, the blade handles being protected during the final finishing operation on the blade. Where the blades have been polished prior to plating the removal of the excess silver has to be undertaken with considerable care; the blades should then be given a final finish on a mop using green composition to remove any marking or discoloration.

Stopping - off

In the process, where at certain area of the article plating is not required; it necessitates stopping - off or insulating those portions of the surface that or to remain unplated.

The simplest method of effecting this is to apply a coating of lacomit stopping - off lacquer by means of a soft hair brush to the areas where silver is not required, allowing the coating to dry thoroughly before the article is immersed in the plating bath.

Polishing of silver deposits

With filigree or embossed articles that have not been plated in a bright solution it is customary to wet scratchbrush the deposit before the work is dried and mopped. The usual process for silver finishing is to buff the articles with a soft brown mop and white finishing composition such as peerless polish, then finally "colour" with a swansdown or reflex mop used with rough composition or with rough powder moistened with methylated spirit.

High speed silver plating solution

Objectives : At the end of this lesson you shall be able to
- **explain the chemical composition of high speed silver plating solution**
- **explain the operating conditions of high speed silver plating**
- **explain the preparation and process of high speed silver plating**
- **explain the maintenance of high speed silver plating solution.**

High speed silver plating

High speed silver plating is employed for high speed production of heavy silver deposits. It finds its applications in the plating of bearings and electrical components.

Solution composition

Silver salts	210 g
Potassium cyanide	20 g
Water	1 litre

Operating conditions

The high speed silver solution is operated at a temperature of 30°C (90°F) and a wide range of current densities may be employed. The recommended current density for normal production is 2 amp/dm^2 (20 amp/ft^2). At this current density, a potential of 1 to 2 volts between the anode and cathode connections is required. Where higher current densities are used it is necessary to increase the speed of cathode movement.

Controlling of the weight of silver deposited

It is important that the amount of silver deposited upon a load of articles shall be closely controlled, and that plating shall cease as soon as the predetermined weight or thickness has been applied; hence the operator must determine the number of ampere minutes or ampere hours necessary to deposit the amount of metal required for a particular load, and must promptly remove the work at the end of the calculated period. As a check, the articles should be carefully weighted before and after plating. An alternative method which saves calculation and prevents waste of metal by over - plating is the use of a pre - setting ampere - hour meter on each plating tank.

Preparation of the solution

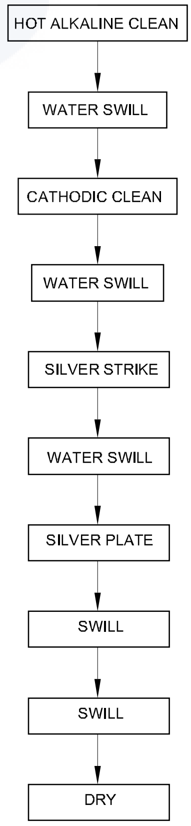
The solution is prepared by dissolving the high speed silver solution in approximately half the final required volume of warm water at a temperature not exceeding 40°C (100°F). The solution is finally diluted to working level and well mixed.

The density will gradually increase as the solution ages, and in time will, therefore, give no indication of the silver content and balance of the solution.

The barrel plating solution is prepared by dissolving the potassium cyanide and then the high speed silver solution in one - third to one - half the final required volume of warm water. When the salts have dissolved the solution is diluted to working level.

Plating procedure (Fig 3)

Fig 3



SILVER PROCESS

1. Hot alkaline clean
2. Water swill
3. Cathodic clean
4. Water swill
5. Silver strike
6. Water swill
7. Silver plate
8. Water swill
9. Water swill
10. Dry

Barrel plating

The high speed silver solution is used warm at a temperature of 25 to 30°C and at a voltage of 4 to 6 in immersed barrels(Fig 4). Current density of 0.3 amps/dm^2 of cathodic area is recommended.

Maintenance of the solution

The following table shows the maintenance of silver salts

	Standard solution for rack plating	**Barrel plating solution**
Free potassium cyanide	50 to 55 g/l	75 g/l
Silver (as metal)	40 g/l	40 g/l
Potassium hydroxide	10 g/l	10 g/l

Regular additions of high grade potassium cyanide and pure flake potassium hydroxide are required to maintain the free potassium cyanide and potassium hydroxide contents of the solution.

Silvering by immersion

Small brass and copper articles that are perfectly clean and bright, or steel articles such as hooks and eyes and buttons that have been coppered or electro - brassed, can be silvered without applied current, simply by dipping them in a solution composed of.

Single silver cyanide (80.5%)	3 g
Potassium cyanide	3 g
Water	1 litre

The solution is contained in either a plain steel, enamelled or plastic vessel, and is used at a temperature of 40° to 50°C (100° to 120°F).

The articles, after having been bright dipped, barrel plating or burnished, according to the nature of the metal, are placed in a stainless steel dipping basket, immersed in the warm silver solution and shaken until they are coated. They are then removed and swilled first in cold, then in hot water, and finally dried by means of warm boxwood sawdust or a centrifugal dryer.

It is necessary to replenish the bath with potassium cyanide and silver cyanide from time to time, whenever the need is indicated by slow deposition.

Alternative method

Another formula for silvering by immersion that gives a duller but some what thicker coating than the former is.

Zonax silver salts (30%)	12 g
Potassium cyanide	25 g
Water	1 litre

The solution is used at a temperature of 40° C (100°F) in exactly the same manner as the bright immersion solution, except that the articles are allowed to remain in it for several minutes if a comparatively thick film of silver is required upon them. It is not practicable, however, to apply a thickness of 2 to 3 microns (0.0001 in) by immersion methods, hence electro deposition must be employed when substantial coatings are necessary.

Doctoring silver plate (Fig 5)

Electro - plated articles occasionally show slight defects after finishing as, for instance, a small bare patch on an edge where the deposit has been cut through in mopping. Such defects can often be made good in the following manner, without having to replate the whole article.

A suitable anode is first prepared by placing a piece of silver sheet, a few inches long and an inch or so wide, between two thin strips of wood long enough to handle conveniently.

Electrical connection is made by means of a length of copper wire, and several thickness of swansdown cloth then wrapped round the end of the rod containing the silver, and tied securely.

The defective article is cleaned free from grease, as in the normal way of plating, and the fully portion lightly amalgamated by wiping with a rag that has been dipped in "quicking" solution. The article is then connected with a flexible wire to the end of the cathode rod, and the small anode to the positive rod of a vat, a voltage of 4 to 6 being applied at the terminals.

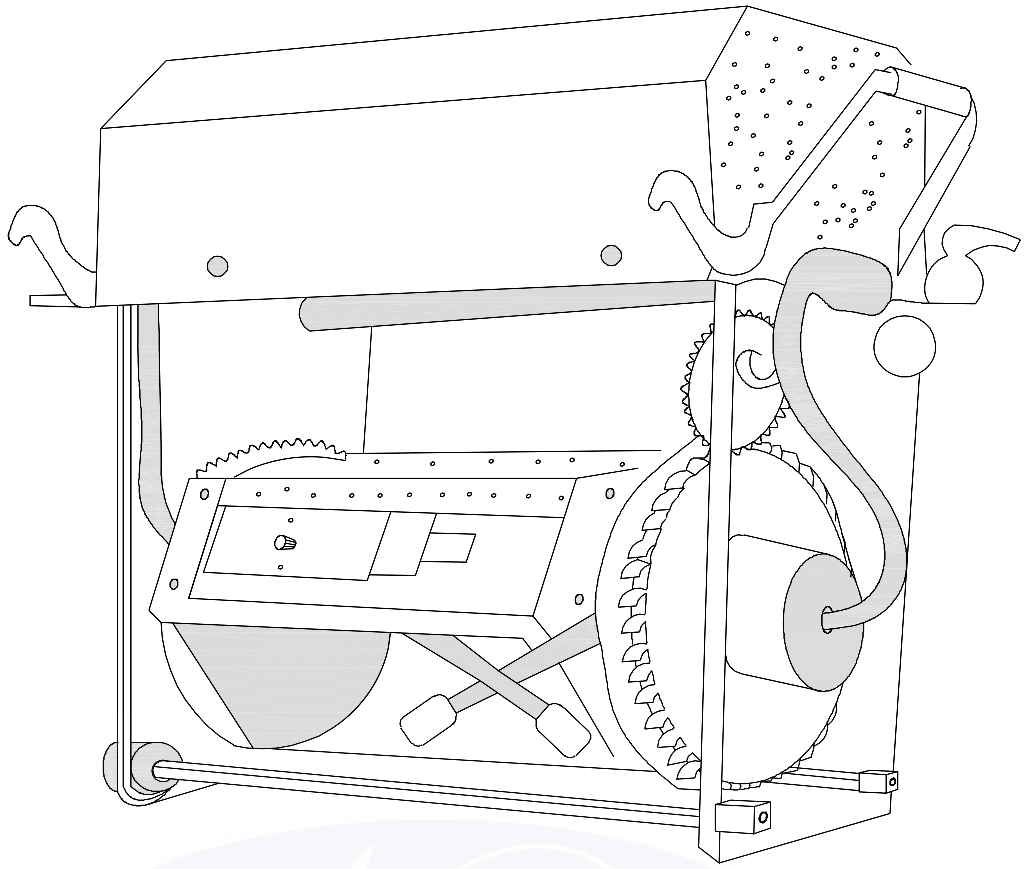
The wrapped end of the anode is immersed in silver solution to saturate the swansdown cloth, then applied to the defective place and moved gently to and fro over this area for a few minutes until an appreciable thickness of metal has been deposited. The anode assembly must be dipped frequently in the silver solution to keep the swansdown saturated.

Finally, after the "doctored" article has been swilled and dried, the surface may be lightly buffed with rouge on a soft mop, or else burnished. After this treatment there should not be any discernible blemish.

Deposition of silver on glass and china

The design is painted on the glass or china by the artist, using a mixture of very finely powdered soft lead glass and precipitated silver, made into a thin paste of suitable consistency with artists oil of lavender.

Fig 4



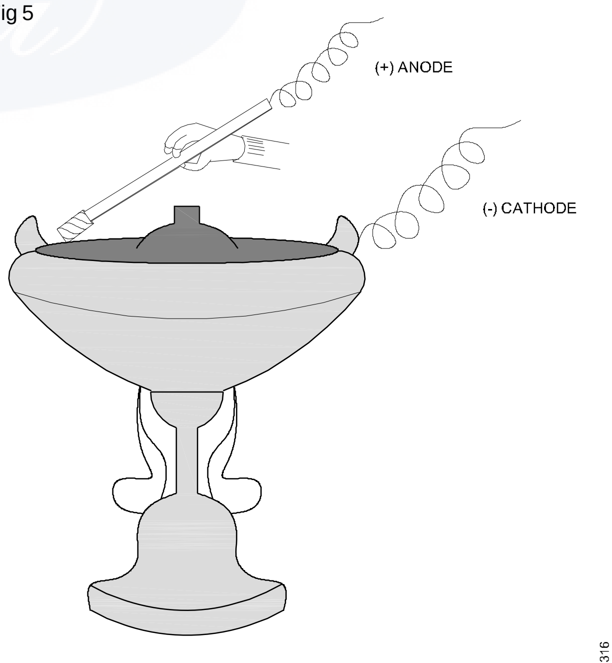
BARREL SILVER PLATING

After application the articles are set aside for a few hours, and are then fixed in a muffle at a temperature just sufficient to fuse the glass and silver mixture on to the surface of the work, and thus permanently fix the design.

The silver coating so produced is conductive and may be built up by electro - deposition, applying a thickness of 50 to 75 microns (0.0020 to 0.0030 in) of silver, or other metal if required. Considerable care and experience in the firing process are necessary to produce good results, and a pyrometer is essential to enable the operator to control the temperature of the muffle within fine limits.

To great a heat can cause sagging of delicate glassware, and too rapid cooling is liable to craze the glaze surface of china articles, rendering them pervious to the plating solution and thus unfit for use.

Fig 5



SILVER PLATING A SMALL AREA (DOCTORING)

Fault finding, causes and remedies in silver plating

Objectives : At the end of this lesson you shall be able to
- **explain the faults and causes in silver plating**
- **explain the correction of fault finding in silver plating.**

Nature of defect	Possible cause	Method of correction
(1) Imperfect adhesion of deposit as indicated by the presence of blisters, or by actual stripping when the articles are scratch brushed or polished.	(a) Grease on the surface of the article before plating. (b) Faulty, amalgamation. (c) Unsuitable method of pre – treatment for the type of metal	(a) Replenish or renew, if necessary, the cleaning solution, and examine the surface of all swills, dips and the plating bath itself for signs of oil or grease. If the work is scratch brushed after cleaning, make sure that the scratch brush is not greasy; if in doubt, rinse the articles through the cleaner again and swill before placing in the silver vat. (b) Test the mercuric "quicking" solution to see if it is working correctly. Maintain the strength of this dip, but avoid over amalgamating the articles. (c) Do not attempt to amalgamate iron and steel, or pewter, Britannia metal, and other tin or lead alloys for specific recommendations.
(2) Porous deposits, Spongy in texture, dark in colour	Excessive current density	Reduce the voltage, remove the articles, rinse them, wet scratch brush the "burnt" parts, again rinse in water and return them to the silver bath.
(3) Rough deposits of normal colour and appearance. Roughness most pronounced on surfaces that have been uppermost in the vat	Presence of suspended solids in the plating solution	Allow the bath to stand overnight or until the suspended matter settles as a sediment. Do not disturb this sediment when plating – or, preferably, remove it altogether by filtering the solution. Time may be saved by decanting or syphoning off the bulk of the clear solution and filtering only the last few gallons that are turbid. Failing a spare tank, the clear solution may be stored in a welded steel tank or glass carboys pending its return.
(4) Abnormally hard dull silver deposits, fine grained and difficult to finish.	Too low a current density.	Do not work at current densities lower than 0.2 amp/dm^2 (2 amp/ft^2)

(5) Meagre bluish - white or bright deposits, slow rate of deposition from zonax silver.	(a) If anodes are in normal condition, is probably due to low temperature or lack of silver in solution. (b) If anodes encrusted, is due to insufficient free cyanide.	Do not allow the temperature of the bath to fall below 15°C (60°F). Check metal content by analysis and, if low, replenish solution with zonax silver salts or silver cyanide as directed.
(6) Anodes discoloured or encrusted with loose white deposit.	Deficiency of free potassium cyanide in solution.	Check the free cyanide content of the solution by titration and add the requisite amount of potassium cyanide. Failing the use of a test set, add 2 g/l (1/3 oz/gal) at a time, until the anodes become clean but not bright.
(7) Anodes bright and crystalline in appearance. High current density at normal voltage.	Excess of free potassium cyanide.	Ascertain free cyanide content and if excessive, reduce to normal by adding single silver cyanide (80.5%) and diluting the bath, as advised.
(8) Low current density at normal voltage.	(a) Low temperature. (b) Solution impoverished. (c) Deficiency of free cyanide. (d) Dirty hooks and connections. (e) High internal resistance of solution due to accumulation of carbonates.	(a) Do not work bath at temperatures below 15°C (160°F). (b) Replenish with silver salts. (c) See section 6 above. (d) Maintain all hooks, rods and connections in clean condition to ensure good electrical contact. (e) Determine carbonate content by analysis and remove any large excess with decarbonator salts as suggested.

(9) Localised brown stains or spots on the finished article.	(a) This defect is generally due to the "spotting out" of traces of silver solution entrapped in "spills" or surface flaws of the basis metal. (b) Over – amalgamation of the article before plating.	(a) Rinse the plated articles alternately in cold and boiling water several times before drying them, or soak for an hour or so in cream of tartar solution 6 g/l. (1 oz/gal) to neutralise the entrapped cyanide before rinsing and finally drying.
(10)Thin patchy deposits, bright in parts. Solution tends to froth if agitated, and has a resinous or "woody" odour if warmed.	Contamination with resin, derived from: (a) Resin – loaded hollow articles (such as ornamental candlesticks) during plating. (b) Resinous pine or other soft wood vat lining.	a) Can be removed by treatment of the solution with activated Do not attempt to plate work of this description unless the resin filling can be removed. b)Use reinforced glass sheet in preference to wood match boarding inside a lead - lined vat. c)If the silver solution is badly contaminated, dispose of it to a refiner for the value of the metal present. Rectification is not easy, but some improvement can be effected by gently boiling the solution for several hours, and removing any co – agulated resinous matter that separates. Wood lining must be stripped from the vat before attempting this operation. Mild contamination carbon.
(11)Deposit yellowish or faint pink in colour.	Heavy contamination with copper and low silver content of the solution.	Silver is deposited preferentially to copper, hence this defect does not arise unless the solution is in very poor condition, with copper present in excess of silver. Avoid contamination by removing immediately any articles or slinging wires that fall into the tank. Use separate striking solution in preference to striking in the plating bath. If solution is old and heavy in carbonates, dispose of it; if not, correct by replenishing with silver salts or silver cyanide.

(12)Non - deposition of silver on nickel	Any failure to deposit silver on a nickel plated surface is generally due to passivity of the latter.	To avoid passively, swill and transfer nickel plated articles without delay to the special silver tank. If the nickel plated work has dried and become oxidised, over come the passivity of surface by treating for one minute cathodically in either kleenax or klenewell solution. Alternatively, anodically acid clean and re – nickel plate steel articles.
(13)Silvax bright silver. Lack of brightness.		For methods of correction.

Stripping of silver plated deposit

Objectives : At the end of this lesson you shall be able to
- **explain the stripping process of silver deposit by immersion method**
- **explain the stripping process of silver deposit by electrolytic method.**

Stripping of silver deposits

Immersion process

For the removal of silver deposit from articles of brass, copper or nickel silver, a hot solution of sulphuric acid and nitric acid as described below may be used.

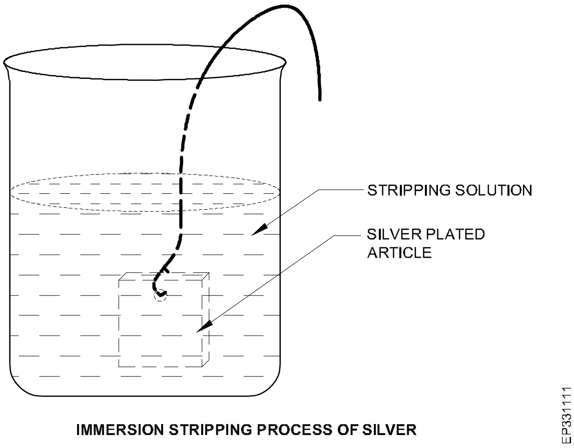
Care must be taken when treating hollow or tubular articles, which may retain solution, to avoid carry - over of quantities of hot acid into the water rinse or of water into the acid.

Equipment

For this solution either a stainless steel or plastic container may be used, this being provided with a silica - cased immersion heater or a hot water jacket for solution heating. The stainless steel or plastic must be of a suitable quality for the acid employed.

The tank should be fitted with fume extraction and preferably covered when not in use to prevent absorption of moisture from the atmosphere.(Fig 1)

Fig 1



IMMERSION STRIPPING PROCESS OF SILVER

Solution composition

Sulphuric acid concentrated sp.gr 1.84	19 parts by volume
Nitric acid concentrated sp.gr 1.4	1 part by volume

An alternative solution composition with a lower nitrate content is:

Sulphuric acid concentrated sp.gr 1.84	1 litre 1 gal
Potassium nitrate	10 g 1 ½ oz

Operating conditions

The mixed acid is used at a temperature of 50° to 60° C (120° to 140°F) The dry articles are immersed in the acid solution. The articles should be kept moving whilst immersed and withdrawn as soon as the silver has been removed.

After silver stripping the articles should be thoroughly rinsed in cold water. Great care must be taken when rinsing to avoid splashing. Hollow and tubular articles should be drained free of acid before being transferred to the water swill.

After rinsing the articles should be wet scratch brushed to remove any film of loosely adherent silver.

Maintenance of the solution

If when silver plated articles are immersed in the acid solution there is a vigorous reaction with the evolution of brown nitrous oxide fumes, this is an indication that either the solution has become diluted with water or that an excess of nitric acid is present.

In the action ceases or becomes slow, small quantities of concentrated nitric acid (about 10 cc/1 - 2 fl oz/gal) or potassium nitrate should be added, but excessive amounts must be avoided, particularly when the silver deposit is partially stripped, otherwise the basis metal may become deeply etched. The necessity for further additions of nitric acid or potassium nitrate is indicated by a change in the colour of the solution from lime - green to purple.

When eventually the acid has become spent, the solution may be sold to a refiner or alternatively treated to recover the dissolved silver.

Electrolyte process

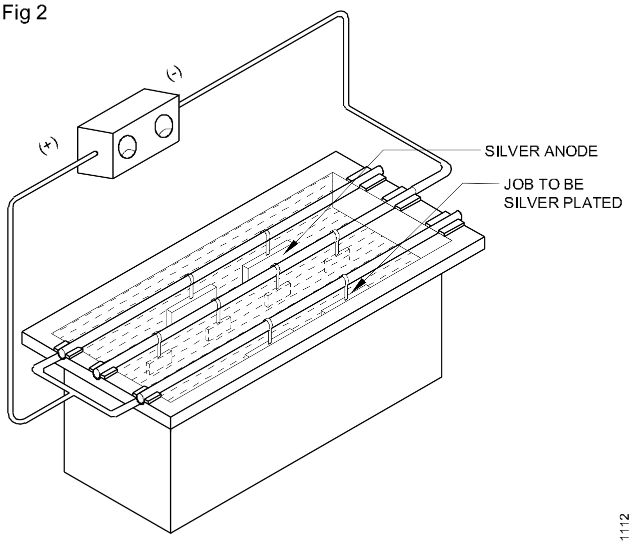
Silver deposits may also be stripped electrolytically in a cyanide solution, making the work the anode in the circuit. The bath is prepared from.

Sodium (or potassium) cyanide	100 g	16 oz
Caustic soda (Sodium hydroxide)	50 g	8 oz
Water	1 litre	1 gal

This is contained in a stoneware or welded steel tank, and is used at room temperature at a pressure of 6 volts, with mild steel sheets as cathodes.(Fig 2)

Little care is required when removing deposits from iron or steel articles, but very careful attention should be paid to non - ferrous metals, as most of these are liable to attack by the solution.

Fig 2



ELECTROLYTIC STRIPPING PROCESS OF SILVER

Universal stripping salts for steel

The solution of universal stripping salts for steel may also be used for the electrolytic stripping of silver deposits from a steel base.

After stripping articles should be well rinsed and care taken to avoid contamination of silver plating solutions with stripping solution.

Electrolytic process for removal of "fire" discoloration from silver

When silversmiths make articles in solid sterling silver the metal has periodically to be annealed during make - up. The relatively high temperature used creates on the surface of the silver an oxide layer of silver and copper called "Fire".

For the removal of "fire" discoloration from annealed sterling silver, the following process will be found more satisfactory and economical than polishing.

The solution, which may be contained in a plain welded steel, enamelled iron, stoneware or lead - lined tank, is prepared from

Silver fire stripping salts	150g	24 oz
Water	1 litre	1 gal

The tank is generally fitted with three rods, the middle one from which the articles are suspended being connected to the positive cable, and the outer rods, which carry sheet lead cathodes, connected to the negative.

To control the low voltage D.C. supply, a resistance board should be provided unless the tank is operated from an individual rectifier with on - load control.

The solution is used at room temperature and the voltage required is from 3 to 8 depending upon the surface area of the load. At the correct current density the silver surface from which the "fire" has been removed will be semi - bright in appearance. If the silver surface is dark, the voltage is too high, whilst if the surface is dull, possibly with etching occurring, the voltage is too low.

The normal current density on the surface of the article varies from 7.5 amp/dm^2 (70 amp/ft^2) where vigorous agitation is employed down to 4 amp/dm^2 (40 amp/ft^2) in the absence of agitation. As indicted in subsequent paragraphs, work or solution movement should be used to assist in the removal of the fire.

The articles are suspended from iron wires and, if greasy from handling, are first cleaned in hot zonax metal cleaner solution and willed before being placed in the "fire" stripping vat. After the current has been switched on, the articles must be kept moving in the bath throughout the operation, in order to assist the removal of the black copper oxide film that constitutes the "fire" discoloration. The necessary motion may be effected by mechanical movement of the anode rod or by stirring the solution; alternatively the bath may be agitated by means of compressed air.

The work is removed from the tank as soon as the surface is clean and white, the time required for stripping usually being from ten to thirty minutes according to the depth of the oxide coating. The silver that is dissolved during the process is deposited upon the cathodes in the form of a loosely adherent metallic powder, which falls off and can be recovered periodically from the bottom of the tank.

Basics of gold plating and equipments

Objectives : At the end of this lesson you shall be able to
- **state the properties of gold**
- **explain the applications of gold plating**
- **describe the equipments for gold plating.**

Gold plating

Gold is a relatively scarce yellow metal, often found in the 'native' state, which is the most malleable of all metals. Pure gold can be rolled and beaten into extremely thin, ductile sheets about 100 nm thick (less than the wave length of the visible light.

Properties of gold

Gold is extremely corrosion resistant but it may be dissolved by aqua regia, a mixture of concentrated nitric and hydrochloric acid. Gold is also Soluble in potassium cyanide solution and in aqueous solutions of the halogens, bromine and iodine. The metal does not form a coherent oxide film on its surface even at very high temperatures and therefore it has a very low contact resistance. Gold readily forms alloys with other noble and base metals by fusion, Diffusion or by electroplating. The metal can be electroplated from acid, alkaline and neutral solutions as a hard or soft, dull or bright deposit depending on the uses to which it is to be put. Gold can be burnished and polished to an extremely smooth finish which has the highest infra-red reflectivity of any metal.

Applications of gold plating

- Gold plating is a method of depositing a thin layer of gold onto the surface of copper or silver (to make silver-gilt), by electrochemical plating.
- It gives a tarnish resistant coating on fancy goods. Thin deposits of pure gold may be applied over bright nickel and this can be more economic than brass plating.
- The thicker deposits of harder gold are employed for the plating of watch cases, pen cases, plumbing fixtures, window catches etc. In all those decorative uses the colour of the gold is very important ranging from white gold through many shades of yellow to rose, red, green etc.
- The electronic equipments such as pocket calculators, transistors and diodes particularly those which are exposed to severe environments are completely gold plated. Springs, wires, connectors, switches and contacts are barrel gold plated in large numbers. Because of its unique properties it has become an extremely valuable element in the plating of microelectronic devices. Printed circuits often use gold to form or protect the tracks and to improve the solderability of the copper. Electroplated gold is used in many other engineering, aerospace and scientific applications.
- Gold plating of silver is used in the manufacture of jewellery.
- Bright hard gold on printed circuit board tabs is deposited using lower concentration of gold in the baths.
- Soft, pure gold is deposited from special electrolytes. Entire printed circuit boards can be plated. This technology can be used for depositing layers suitable for wire bonding.

Equipments for gold plating

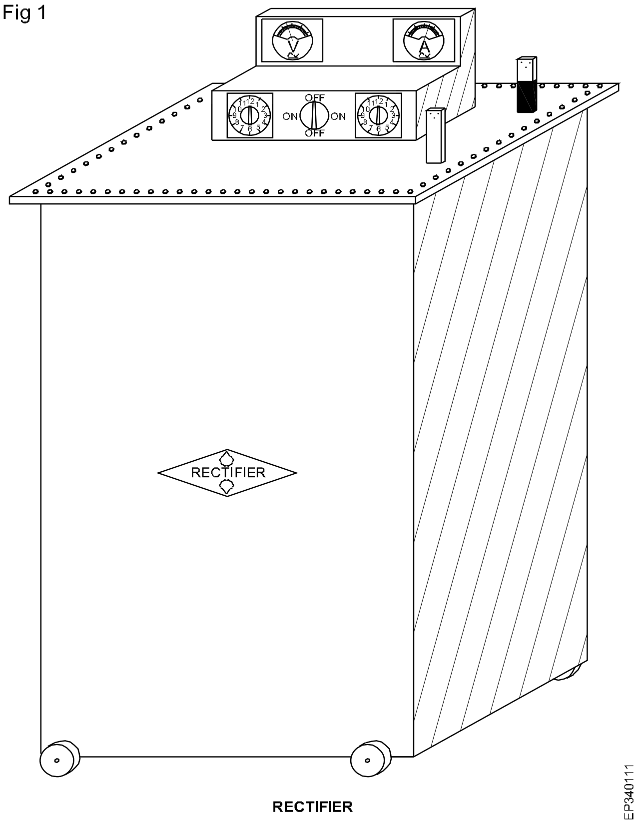
It is important that electroplater uses proper equipments for his work. The quality and efficiency of work will depend upon the use of proper equipment.

Listed below are the equipments are the most commonly used for gold plating.

Rectifier

It is used to rectify the AC supply input to DC output required for electroplating. The output voltage is variable and the required current can be set. The polarity of the output is marked. The output capacity of the rectifier (Fig.1) should

Fig 1



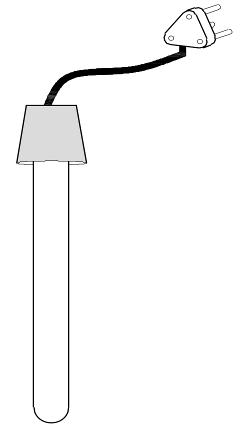
RECTIFIER

match the voltage and current requirements of the process for which it is to be used. Oil immersed metallic type rectifiers are best suited, although air cooled types may be used where the power demand is not high.

Immersion heater

For solution heating silica cased electric immersion heaters (Fig.2) are used. Thermostats are essential for accurate temperature control.

Fig 2

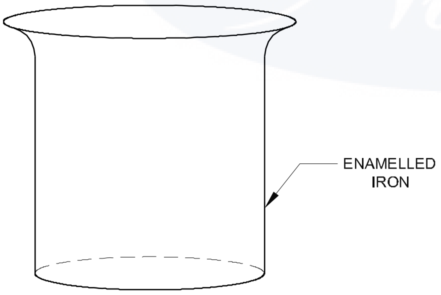


SILICA LINED HEATER

Plating tank

For gold plating solutions, stainless steel or polypropylene tanks are used. Nowadays, polypropylene (PP) tanks are used for these purposes because of its resistance to chemicals.(Fig.3)

Fig 3



ENAMELLED IRON TANK FOR GOLD PLATING

Fully immersed polypropylene barrels are used for barrel gold plating. Covers should always be used over gold tanks when not in use.

Busbars

Bus bar is a rigid conductor, made of copper, for carrying current to the anode and cathode rods from the rectifier. These should have enough capacity to carry the full load current.

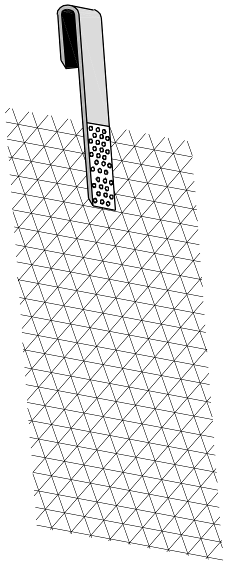
Anode rod and cathode rod

The anode and cathode rods are made of copper and should have enough capacity to carry the current from the bus bars. The two anode rods are placed above the plating tank to hook the anodes. The cathode rod is placed in between the two anode rods and suspends the job to be plated.

Anodes

For gold plating pure gold or platinum coated titanium anodes (Fig.4) may be used. Some solutions, particularly with large quantities of metallic impurities, may be used with stainless steel anodes.

Fig 4

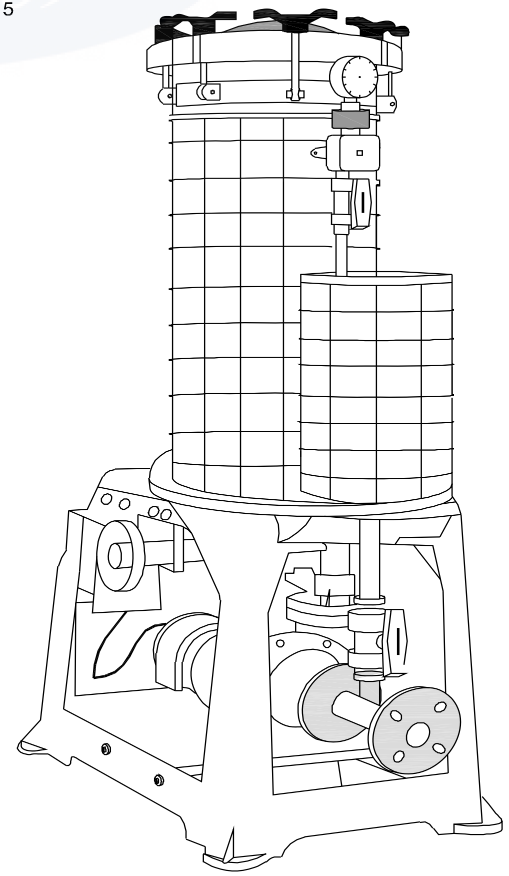


PLATINUM COATED TITANIUM ANODE

Filter unit

Cartridge type filter pumps and units (Fig. 5) are of plastic or polypropylene should be used for filtering. Gold solutions should not be air agitated but mechanical agitation should be provided.

Fig 5



CARTRIDGE TYPE FILTER UNIT

Electrolytes for gold plating and equipments

Objectives : At the end of this lesson you shall be able to
- **list the chemicals for gold plating**
- **explain the preparation of gold plating solution**
- **explain the maintenance of gold plating solution.**

Chemicals for gold plating

Potassium cyanide - 12.5 g/l

Potassium gold cyanide - 19.5 g/l

Caustic potash - 12.5 g/l

Potassium sulphite - 6 g/l

Preparation of gold plating solution

The tank is half filled with clean warm water at a temperature of 40 to 50°C, firstly the Potassium cyanide and then the Potassium gold cyanide, Caustic potash and Potassium sulphite are added slowly and carefully with stirring. When they are completely dissolved, water is added to make up the solution to working level and to correct density. The solution should be thoroughly stirred to ensure that it is well mixed. On settling, there is usually slight sediment in the bottom of the tank. This can however, be ignored.

The following figure shows the preparation of all types of solutions (Fig.1)

Where chemical laboratory facilities are available, it is recommended that the gold plating solutions should be regularly analysed and any necessary additions made to maintain the density and the cyanide content at their recommended values.

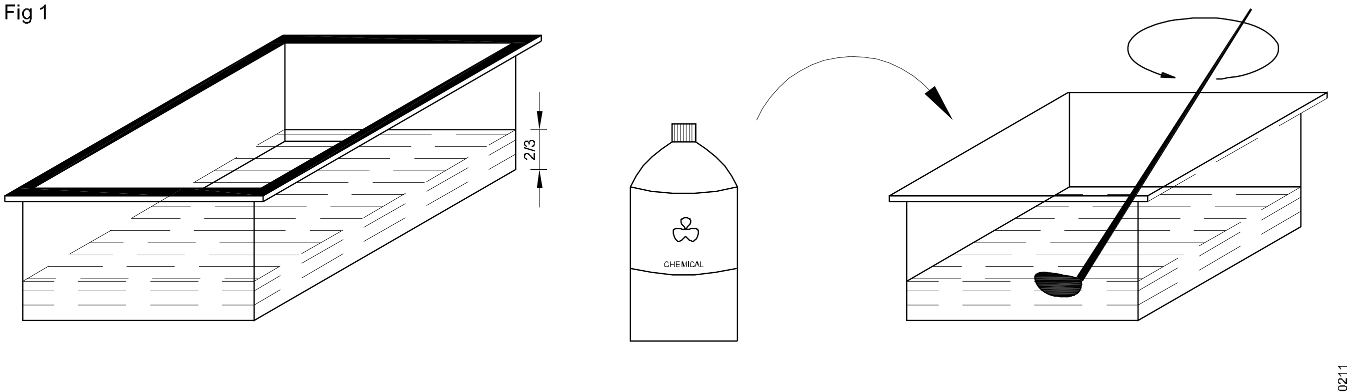
Solution maintenance

Regular additions of potassium cyanide are necessary to maintain the free cyanide content of the solution provided the anode area is equal to or slightly less than the cathode area, the gold content of the solution will remain stable over a long period. The potassium sulphite content of the solution should be kept 6g/l in order to ensure maximum brightness of the deposit.

The pH value of the solution should be maintained between 6 and 7 if the pH value rises above this range, it should be corrected by the addition of 10% dilute phosphoric acid. If the pH value falls below 6, it should be adjusted by the addition of 10% potassium cyanide solution.

The recommended gold content of the solution is 7.5g/l. To maintain the gold content of the solution, potassium gold cyanide is added on an Ampere Hour basis. When the bath has become old and no longer gives a bright deposit, it should be evaporated to dryness and the residue dissolved in water. The resulting solution, when filtered and made up to half of the volume of the original bath, will usually produce excellent results after the addition 6g/l of potassium cyanide.

Fig 1



PREPARATION OF GOLD PLATING SOLUTIONS

Gold plating process on alloys

Objectives : At the end of this lesson you shall be able to
- **describe the gold deposits and solutions**
- **state the chemical composition and operating conditions of gold plating**
- **explain methods of gold plating process**
- **explain the gilding or traditional gold plating**
- **list out the defects, causes and remedies in gold plating.**

Anodes

For small volumes of solution and for flash gilding pure gold or platinum coated titanium anode may be used.

Some solutions with large quantities of metallic impurities may be used with stainless steel anodes.

Hard graphite anodes may also be used where they are not contaminating and relatively cheap, but have to be used with polypropylene anode bags as over a period of time.

Gold deposits and solutions

There is a great variety of gold solutions used for different applications. Articles are usually given an initial deposit of copper-nickel or silver as basis for subsequent gold plating. Gold plating is costly, there for all pre treatments, processing and operating procedure should be carried out with great care to ensure minimum of solution loss and component rejection.

Ultra pure gold deposits

Ultra pure gold deposits of at least 99.99% purity are primarily used in the electronics industry where the electrical and physical property of the pure metal is necessary. For corrosion and tarnish resistance at high temperatures, for all alloying and diffusing properties, for freedom from porosity, for the correct hardness range, for the best thermal and optical properties and for the maximum solderability, it is important that the gold deposit is as pure as possible.

Pure gold when deposited 2.25 micron thick on to a carefully prepared sulphate should be pore free and able to resist 500ºC for 10 minutes or 300ºC for 96 hours without any visual discolouration. Electrolytic or chemical polishing should be used to smooth the basis metal. These solutions have cathode efficiency of about 100% and it can be used at very high current density.

Low alloy gold deposit

Low alloyed gold are classed as pure gold deposits but they actually contain small but significant amount of other metals. Nickel and cobalt are mainly used but occasionally other elements such as indium are used for alloying. The presence of these alloying metals alters the physical properties of gold, imparting hardness; wear resistance, and an improved grain structure while retaining a low resistivity and a good tarnish resistance. The depositions are normally brighter than ultra pure gold.

For the above reason, low alloy golds are chosen for sliding or wiping contacts of all varieties and for general printed circuit boards. This type of deposit also finds use in the high speed electroplating of strip and wire where there is increased need for wear resistance.

To reduce porosity the substrate should be prepared with care and for this reason gold is often applied over a bright levelled copper, nickel or silver deposit. The low alloyed gold must also be plated to a greater thickness than ultrapure gold in order to achieve the same degree of pore freedom.

The use of nickel in the gold solution deposits a pale yellow gold and gives a plate with a high hardness but this deposit has much poorer electrical properties than the gold cobalt alloy. Cobalt in the solution deposits a more golden gold and this has a hardness considerably less than the gold nickel alloy, the resistivity is almost as good as pure gold.

The colour of both the deposits is not wholly dependent on the operating conditions of the solution such as temperature, the pH and the current density employed and therefore acquired wide variations can be tolerated without a change of colour. The low alloy gold deposits are generally electroplated from a wide range of neutral to strong cyanide solutions. These operate over a range of temperatures from 20 to 60ºC. But generally speaking the brighter deposits came from lower temperature solutions. Most have a good tolerance to metallic impurities, particularly lead, copper and zinc, thus making them ideal for edge connectors on printed circuit boards.

High alloy decorative gold deposit

The main objective of decorative gold deposits particularly for the mass production of goods, is to produce a gold finish with a bright yellow colour and a good tarnish resistance. The high alloy gold deposits are unsuitable for use in a functional role. The deposits have inferior electrical, thermal and physical properties. Many are so hard and brittle that only limited thickness can be plated whereas others can be plated to almost any thickness. The high alloy deposits are sufficiently resistant for its use for the plating of Giftware, tableware and costume jewellery.

These decorative gold deposits can be plated from acid, neutral and alkaline cyanide and from alkaline non cyanide solutions. Nickel, cobalt, silver, copper cadmium, antimony and other elements are used as alloying materials, each with its particular effect on the gold. All the solutions tend to have lower cathode efficiency than pure gold deposits. The alloys with nickel, cobalt and silver alone, produce economical yellow gold finishes of various shades with a reasonable tarnish resistance. The more different metal required in the deposit, the more complex and difficult is the control of the electroplating solution.

Variations in colour of gold deposits

The colour of gold deposit may be varied by adding small quantity of various metal cyanides to the solution. These metal cyanides should be first dissolved in potassium cyanide and then added a few drops at a time, the required amount being estimated from the colour of the deposit. These coloured deposits are usually applied as flash of 1 micron or less on to the substrate.

Silver gives a greenish yellow shade and these can be used as a harder substitute for pure silver or as a tarnish resistant flash over pure silver. The colour may be varied by changing the amount of the silver in the deposit and can be widely used on watch cases and straps because of the hardness of the deposit combined with a good colour and ease of solution control.

Copper gives reddish colour called pink gold, rose gold or red gold depending on the shade. The colour may be varied by changing the amount of the copper in the deposit.

Additions of nickel cyanide are also sometimes made to produce a white gold somewhat similar in appearance to platinum. It is more corrosion resistant than the silver alloy and may be used as a substitute for rhodium over bright nickel in high temperature functions

Cadmium gives deposits with a green colour called green gold. These are used in plating of the items such as buckles, buttons etc.

General decorative gold plating solution

Gold plating is costly; therefore all pre treatment processing and operating procedures should be carried out with great care to ensure the minimum of solution loss and component rejection.

For general decorative gold plating some of the following points are not so important, but for any functional or high quality decorative plating they should strictly implemented.

The base metal, of whatever type, should be free from defects such as scratches, burrs from drilling or punching, tool marks and pitting in castings. All these defects, while they may be visually small, can have a serious effect on the performance of components by causing roughness, porosity, poor adhesion and failure in a corrosive environment.

Following is the connection diagram for gold plating (Fig.1).

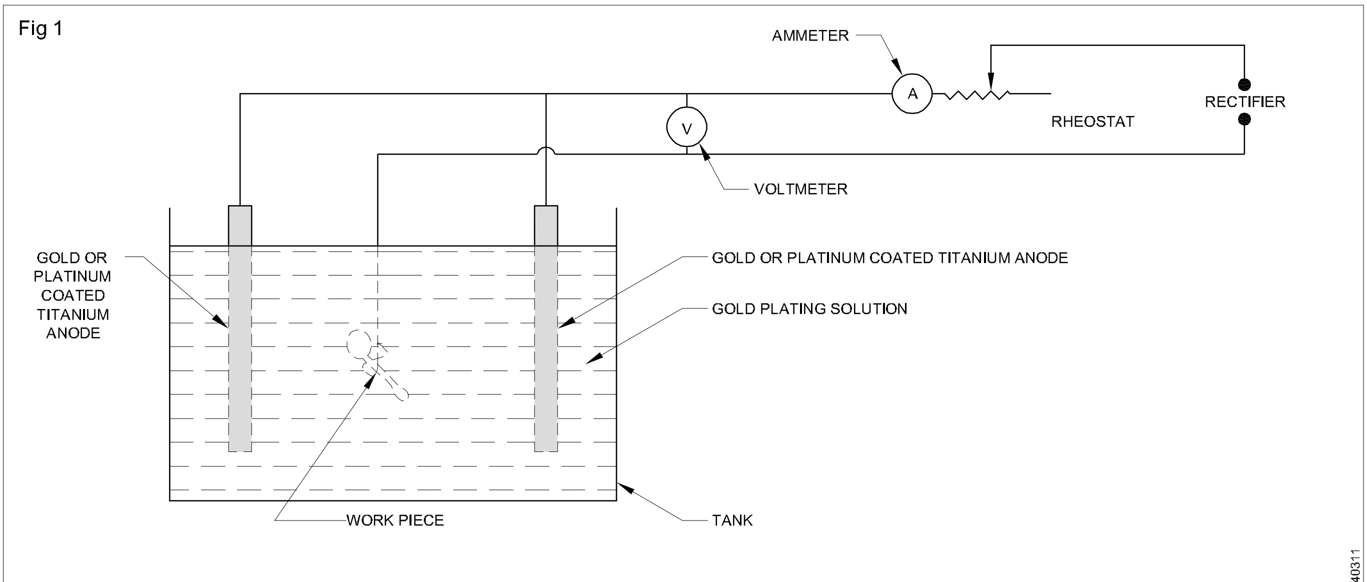
Chemical composition and operating conditions

Potassium cyanide	- 12.5 g/l
Potassium gold cyanide	- 19.5 g/l
Caustic potash	- 12.5 g/l
Potassium sulphite	- 6 g/l
Current density	- 02 to 06 A/dm^2
Voltage	- 1.5 to 2V
Temperature	- 120 to 180°C

Undercoats for gold plating

Articles that are to be plated are usually given an initial deposit of copper, bright nickel or silver as basis for subsequent decorative gold plating. It is very important, where they are undercoated, that they should enter the gold plating solution within a few seconds after cleaning, already connected to the cathode.

Fig 1



CONNECTION DIAGRAM OF GOLD PLATING BATH

Gold Strike solution

Gold strike is the production of a thin film of gold metal which improves the deposition of subsequent gold coating. These are different from undercoat layers in that they are applied as extremely thin flash deposits. Whose primary aim is to prevent the gold electrolyte from attacking reactive basis metals or electroplated undercoat. If this happens either an immersion deposit of gold is formed, causing bad adhesion, or the gold solution is contaminated with basis metal. By using a gold strike solution this contamination is restricted to this strike bath.

Many proprietary gold solutions have their own strike system, which is generally a solution based on the same chemical compounds as the main bath. The advantage of this is that parts can be transferred directly from one to the other. These contain a very low metal concentration. On removing from the strike solution after 20 to 30 seconds, the articles should be connected to the cathode rod before immersion in the main gold solution. Barrel loads of small parts should be plated in the gold strike solution for at least 10 minutes before transfer to the main gold solution.

Gilding or traditional gold plating

Gilding is a traditional term for flash gold plating. It is used at cheaper on the market for fancy goods, gift ware etc. Base metal such as zinc and brass are usually given a deposit of bright nickel before being finished in a colour gold or a bright 24 carat gold for about 5 to 10 seconds. Some low carat gold articles such as cheap rings are directly gilded.

For flash gilding on a small scale, the anode connected by means of a flexible wire to the positive terminal is generally held in the right hand and is used to agitate to the solution slightly. For ordinary gilding 5 to 15 seconds immersion time is sufficient. The solution is normally worked in an enamelled iron vessel heated to the recommended temperature. If the gold anodes are used they should be withdrawn when the solution is not in use.

In gilding, the colour of the gold deposited is of great importance. For this purpose it is necessary to use a freshly made gold solution, because after working for some time the gold darkness in appearance and becomes more the colour of old gold. For this reason it is found better to use an insoluble anode and to work the solution until the gold is exhausted and then reclaim the gold from the residue.

Gold solution which has become exhausted may be recovered by treating with hydrochloric acid to decompose the cyanide and then adding ferrous sulphate. This in the course of few hours deposits the gold as brown powder. This can be made up to the fresh gold plating salt.

Articles that require bright gilding inside such as sugar basins, jugs, presentation cups etc are first polished, then cleaned and filled with gold solution. Then it is connected to the cathode terminal by a length of wire and a small gold anode suspended inside the article for a few seconds. A potential difference of 4 to 6V is necessary for uniformly gilding inside.

Post plating treatment

After gold plating it is important to be swilled and dried to leave a stain free surface. Most stains are the result of a slight residue of salts left over after hard or contaminated swill water has evaporated. To prevent this, first swill through cold and then hot de-ionized or distilled water, followed by rapid drying in a centrifugal dryer or hot air oven.

Large decorative items such as cups, vases and cutlery plated with a relatively thick deposit, can be finally buffed.

Defects and their remedies in Gold plating

Sl.No	Nature of defects	Possible causes	Remedies
1.	Pale deposit	Excess of potassium cyanide	Destroy excess by boiling the solution for an hour or so, and then restore to original volume with water.
		Low temperature of the solution	Raise temperature of the bath
		Current density too low	Increase the current density
2.	Deposit too rich in colour, reddish brown colour in extreme cases	Too high temperature	Cool the solution
		Excessive current density	Reduce the current. See also variations in colour of gold deposit in this lesson.
3.	Slow deposition	Low temperature	Increase to correct value
4.	Slow deposition and anode slimy or discoloured	Lack of free cyanide	Check and make good any deficiency by the addition of potassium cyanide
5.	Slow deposition and coppery shaded deposit	Low gold content in the solution	Analyse and add required amount of Potassium gold cyanide or use pure gold anode
6.	Non deposition	Electrical faults	Track the fault by examining connections. Make sure that there is no short circuit across the gilding vessel
		Excess of free cyanide	Destroy excess by boiling the solution for an hour or so, and then restore to original volume with water

Stripping of gold deposit

Objectives : At the end of this lesson you shall be able to
- **state the stripping process of gold deposit**
- **explain the methods of stripping process of gold deposit.**

Gold stripping is a process to remove gold coating from the basis metal or undercoat without affecting the underlying metal. Very thin coatings of gold as applied in gilding readily be removed by polishing the article, as the normal practice when re-plating. Two types of methods are used for the removal of electroplated coatings. They are electrolytic and immersion methods. The selection of stripping bath is depends upon the structure of basis metal or undercoat.

Electrolytic stripping process

Thicker coating can, if required, be stripped electrolytically under the following conditions. But considerable care must be taken in order to avoid spoiling the surface of the underlying metal. Following are the solution composition and connection diagram of electrolytic stripping for gold deposit (Fig.1).

Sodium hydroxide	- 100g/l
Cathode	- Steel plates
Voltage	- 6V
Temperature	- Room

Immersion stripping process

Gold may be removed without attack on the underlying metal by immersion in the following solution and operating conditions.

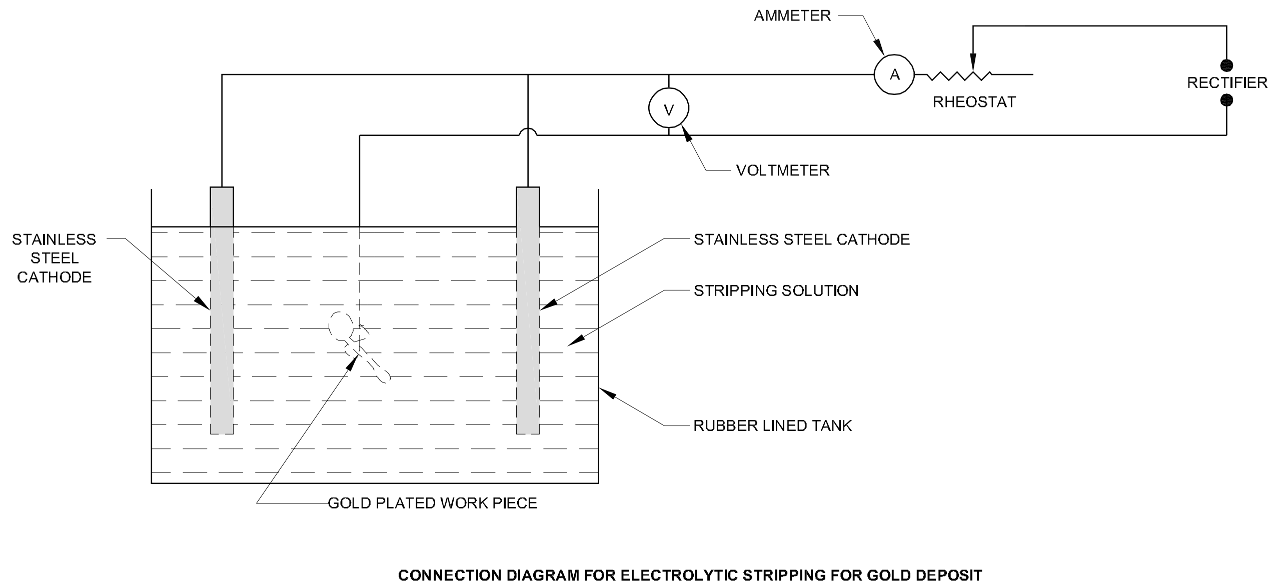
Sodium cyanide	- 100 g/l
Hydrogen peroxide	- 20ml/l

The solution should be contained in a plain steel or enamelled iron vessel. Not more than one or two pieces of work should be stripped at a time, because heat is developed during stripping. Further small additions of hydrogen peroxide may be made whenever the bath becomes sluggish in action.

Following is the figure for immersion stripping of gold deposit (Fig.2).

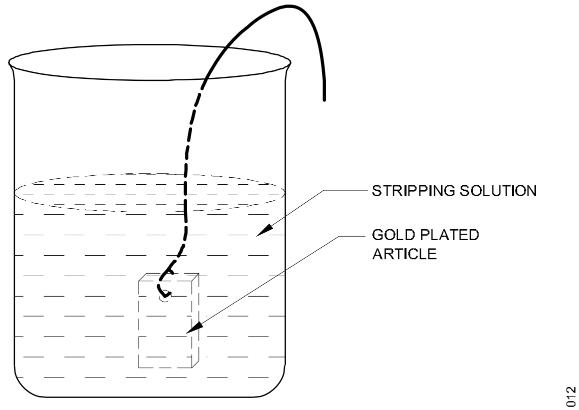
The dry articles are immersed in the solution for stripping. The articles are withdrawn as soon as the gold has been removed. After gold stripping the articles should be thoroughly rinsed in cold water. Care should be taken when rinsing to avoid splashing.

Fig 1



CONNECTION DIAGRAM FOR ELECTROLYTIC STRIPPING FOR GOLD DEPOSIT

Fig 2



IMMERSION STRIPPING FOR GOLD DEPOSIT

Basics of brass plating and equipments

Objectives : At the end of this lesson you shall be able to

- **listout properties and applications of brass plating**
- **list the equipments for brass plating**
- **state the use of each equipment and auxiliary materials.**

Brass plating

Brass is alloy of copper and zinc that has been produced for its workability, hardness, corrosion resistance and attractive appearance.

Brass plating is one of the most common alloy plating processes in use today. Brass can be plated in many applications and in varying thicknesses. Another property of brass plating is its ability to provide good adhesion to steel and rubber. Brass is, therefore, commonly used in the manufacture of steel wire cord for use in tires. Other applications of brass plating include a variety of decorative and engineering finishes.

Brass plate comes in variety of colors from yellow to various shades of bronze and brown. In some cases, platers use brass as a very thin plate over other bright plates. Nickel often is used under a brass plate to level the surface. A brass plate then is applied over the nickel to provide a bright brass surface. Yellow brass is the most common material used in brass plating. Gold - colored brass often is used as a decorative plate. The main problem in applying a brass finish is rapid tarnishing. The conventional solution to this problem is to apply a protective layer of clear transparent powder coat or lacquer.

Properties

- Type : Alloy
- Content : Copper & Zinc
- Density : 8.3 - 8.7 g/cm^3
- Melting point: 930^0 C
- Colour : Yellow

Applications of brass plating

The principal applications of brass plating are the production of decorative coating iron and steel (Anti corrosion and batteries) brass plating on plastics increasingly used for furnitures bathroom fittings on aluminium, zinc die casting and steel tubing, lamps, caskets, hardware, and novelties. Another important industrial use is the brass plating of steel to which rubber is to be bonded; such plating results in better adherence of the rubber.

Brass plating is usually done on cast-iron articles, steel stampings, zinc-base die castings, and lead slush castings. The resistance of a decorative brass deposit to corrosion is largely dependent on the quality of the clear lacquer which is normally sprayed on the deposit. In addition to lacquering, oxidized finishes (see coloring) are commonly applied to brass-plated articles. Parts finished in this manner are subsequently relieved or highlighed, and then lacquered. White brass deposits are used on gas stove parts, tublar furniture, and tools.

The deposition of alloy deposits requires more care than the deposition of single metal and it is necessary to use a solution with a carefully balanced composition. For decorative brass plating the alloy employed is generally 60% copper and 40% zinc.

Listed below are the equipments are the most commonly used for brass plating

Brass plating solution should be contained in plain, welded steel tank. Rubber or plastic lined or polypropylene tanks also be used. Where heating is necessary, plain steel coils or mild steel electric immersion heaters may be used. To maintain constant brass plating it is important to control temperature and current accurately. The rectifier and all the electrical connections should be clean and well maintained. The meters for measuring voltage and current should be accurate and regularly checked for error. If heating is used, the vats should be provided with an accurate and sensitive thermostat. For decorative plating, high purity lead free brass anodes of a composition of 60% and 40% zinc are advised.

1) Rectifier
2) Tublar immersion heater
3) Hooks
4) Brass anodes
5) Tank (Welded steel tank)
6) Electrolytes
7) Electrodes
8) Bus bar.
9) Brass wire brush
10) Emery paper
11) Heater mild steel

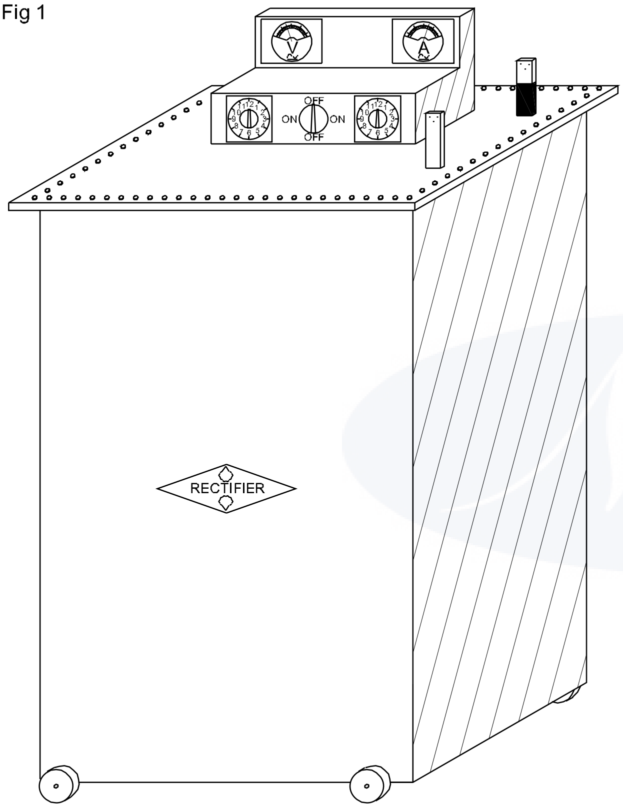
It is important that elelctroplater uses proper equipments for this work. The quality and efficiency of work will depend upon the use of proper equipment.

Rectifier (Fig 1)

It is used to rectify the AC supply input to DC output required for electroplating. The output voltage is variable and the required current can be set. The polarity of the output is marked. The output capacity of the rectifier (Fig 1) should match the voltage and current requirements of the process for which it is to be used. Oil immersed metallic type rectifiers are best suited. Input AC 3 phase 400 volt 50 cycle. Output DC 16-20 volt 500 Amp. Air cooled types may be used where the power demand is not high.

The rectifier elements (which provide an extremely high resistance to the passage of electric current in one direction and neglible resistance in the other) convert this low voltage AC to low voltage D.

Fig 1



RECTIFIER

Tubular immersion heater

Heating by electrically provides easy in control. Tublar immersion mild steel (1 KW) are used for this purpose. Immersion heater must be use for brass plating. (Fig 2)

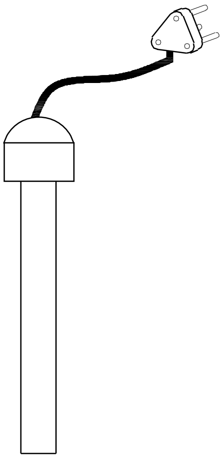
These are bobbin type having replaceable element heaters. Vertical mounting meant for all electroplating processes. The standard size ranges from 300 to 1200 mm length, 0.5 to 1 KW capacity and in 1.0 & 2.0 inches outer sheathings of.

Check that heaters are in good condition. Clean and dipped int he solution and only 6 inches or less heater surface is visible above the solution.

For cold solution room temperature, not below 15^0C (60^0 F) warm solution should be at 50^0C(120^0F)

The surface of the heaters be kept clean and free from any surface scale or film which might result in local overheating.

Fig 2



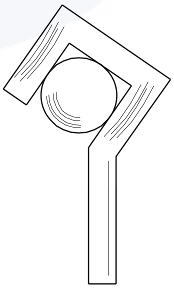
TUBULAR IMMERSION MILD STEEL HEATER

Hooks

Anode hooks, or cathode hooks

Hooks for load and current carrying capacity. Sizes varying from 4.5” to 12” width 1” x 2” thickness and 6” x 48” height (Titanium baskets). Hook shapes like horizontal, round, bend, hooks usually contact with the electrode’s shaped. Regularly made for the hooks in copper, or brass or nickel. (Fig 3)

Fig 3

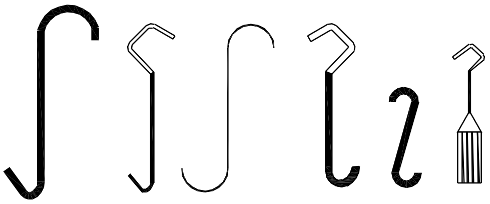


HOOK

Hooks contact surface are is usually bend, half circle, the function of anode hook in any plating solution attach with anode.

Titanium copper & SS hooks for both plate and oval type anodes. (Fig 4)

Fig 4

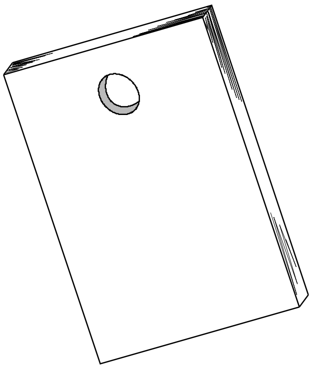


ANODE HOOKS OR CATHODE HOOKS

Anodes

For decorative plating, brass anodes of a composition of 60 percent copper 40 percent zinc are advised. (Fig 5)

Fig 5



BRASS ANODE

It is important that high purity lead-free brass anodes be employed; those of oval section being recommended. The anode area should be as large as possible to minimize the formation of slimes and prevent polaraisation.

Where a richer brass is required than 70/30 percent brass anodes may be used or alternatively a proportion of pure copper anodes employed.

The functions of anodes in any plating solution is to provide the bath for the current out of the solution and to replenish the metal ions.

Necessary anodes are highest purity, high conductivity and polarise and passive.

The cast brass anodes ordinarily used in brass plating should consist of electrolytic copper and horsehead zinc. The proportion of the constituents is 70/30 or 80/20 copper/zinc, depending on the color of deposit that is desired. It is important that the supplier cast only brass anodes in a given crucible; otherwise deleterious impurities such as cadmium, nickel, arsenic, antimony, lead or tin may appear in the anodes.

Brass anodes are either elliptical or ball-shaped. One of the advantages of the latter shape is the resulting absence of scrap anode butts.

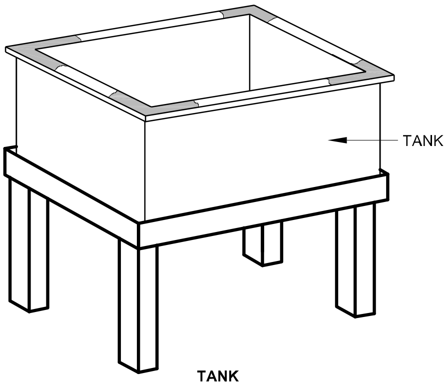
Tank : In brass plating steel tanks are sometimes used, a rubber-lined tank is preferable, since a rubber lining prevents formation of ferrocyanide and minimizes bipolar current effects. If an unlined steel tank is used, the bottom should be covered with a glass plate. Whether the tank is rubber-lined or not, it should be set on glass bricks to insultate it from stray currents. (Fig 6)

The tops of tanks be of a safe height above the floor or adjacent walkway. If not otherwise walkway. If not otherwise protected to prevent anyone from failing in.

Factories act, a height of 36 inches is specified.

Plain double welded tailor made tanks of plain double welded tailor made tanks of any dimensions and volume from 30 litres to 10000 litres or in any desired capacity and can be adopted for storage. Fabricated from M.S.Rigid, PVC, Perspex, Polypropylene(PP) polyglass, SS, Lead, etc. supplied reinforcement and legs, all the tanks painted outside with acid and alkali resistant epoxy paint or FRP coated.

Fig 6



TANK

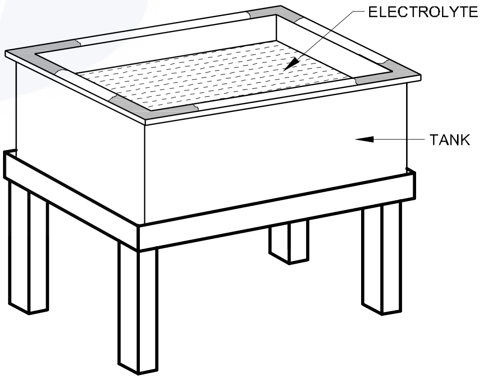
Polypropylene(PP) tanks are used for electroplating. Because of its resistance to chemicals.

Electrolytes

The electrolyte is the medium that carries the current by means of ions. Which carries negatively and positively charge that enables electroplating possible.

This electrolyte is cyanide type are usually good throwers. Warm or cold, but speedier depositions and brighter results are with warm solutions. (Fig 7)

Fig 7



ELECTROLYTE

Electrolytes allow the electric current to pass through themselves either in solution or in molten state and undergo decomposition.

Current passes through some liquides while it can not alcohol are insulators of electric current. While dilute acid, alkali, salt solution are conductors. These conductors of called electrolytes.

Effect of current in electrolytes

We can increase current by increasing the voltage, reduce the distance in anode and cathode.

Electrodes

Most electrodes, commonly brass or copper rod, or pipe and flat shape only.

Electrode position is equal distance to anode and cathode.

Electrodes are connected to the two terminals anode and cathode of a rectifier with conducting copper wires or bus bars.

Two positive connections are connected with two positive electrodes or anodes consists of brass sheets or brass bars of the metal that is to be dissolved.

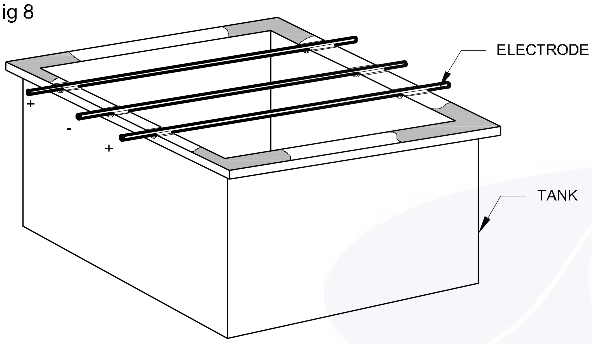
The anode and cathod electrodes are made of copper, or brass should have enough capacity to carry the current from the bus bars.

The two anode rods are placed above the plating tank to hook the anodes.

The cathode electode(-) is placed in between the two anode electrodes suspends the job to be deposited.

Middle of the electrodes is connected with cathode connections(-) that is called to cathode electrode (or) negative electrode. (Fig 8)

Fig 8



TANK AND ELECTRODE

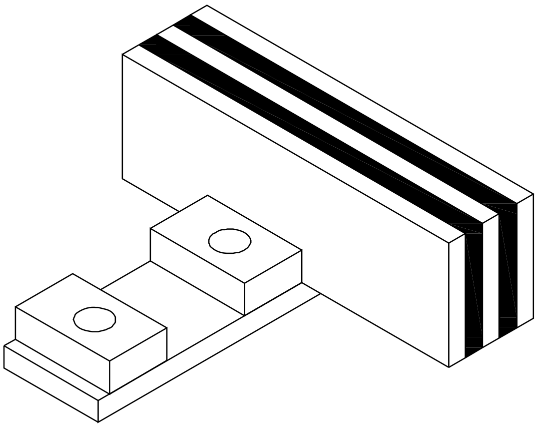
The polarity of the centre electrode is should be negative electrode.

Busbar supports

Flat busbars may be supported on edgewise on insulated busbar supports and when assembled with the plastic clamp blocks equal to the thickness of the bars used.

Brackets for positioning the runs of busbar in the plating shop. (Fig 9)

Fig 9

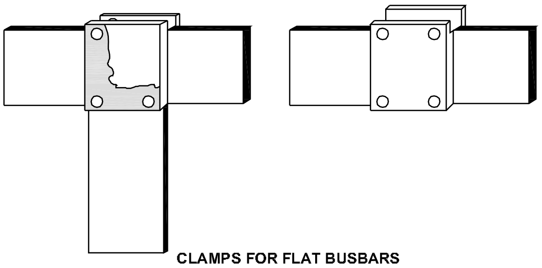


INSULATED BUSBAR SUPPORTS

Jointing with flat busbars

Wherever joints are to be made. Surface correct electrical jointing compound or petroleum jelly, and the busbars with flat rectangular sections and clamped together between steel plates and bolts, as illustrated. This arrangement is preferable to drilling and bolting. (Fig 10)

Fig 10



CLAMPS FOR FLAT BUSBARS

Made of copper or aluminium carrying current to the anode and cathode electrodes from the rectifier.

Bus bars are used to carry the current from the rectifier or motor generator set to the plating tank. Bus bars are usually made of copper but sometimes of aluminium for purpose of economy. When aluminium is used, it is recommended that the connection points be silver-plated. Bus bars usually come in the following sizes: 1/4 x 1 in., 1/4 x 2 in., 1/4 x 4 in., and in aluminium, 1/4 x 6 in when using aluminium for bus bars, multiply the area indicated by 11/2 to get the equivalent conductivity.

Brass wire brush

Rotary wire brushes have a number of differing applications. Which may be classified

- Stratch brushing
- Satin finishing
- Mechanical cleaning and deburring

Brass wire brush hand scratch brushing

Scratch brushing is used for the final cleaning of articles prior to plating. Particularly where gold or silver is to be deposited and for the production of satin finishes upon components which have been electroplated with one of the softer metals. eg., silver, gold, brass, copper, cadmium, tin or zinc. where heavy deposits of soft dectile metals, such as silver, are applied, it is quite used for articles to be taken out of the plating tank at intervals and scratch brush to remove the roughness. (Fig 11)

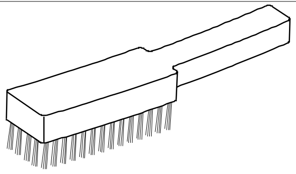
Satin finish is applied to brass, copper, stainless steel and aluminium sheets or fabrications.

Simple hand scouring with wet pumice is still a very effective method of cleaning.

A hand brush with stout stiff fibre or bristles is used for iron and steel, and a similar wire brush, with soft bristles for brass and other non-ferrous metals.

Wet brush the item by using soap nut water to remove oxide scales and casting sand etc.

Fig 11



HAND SCRATCH BRUSH

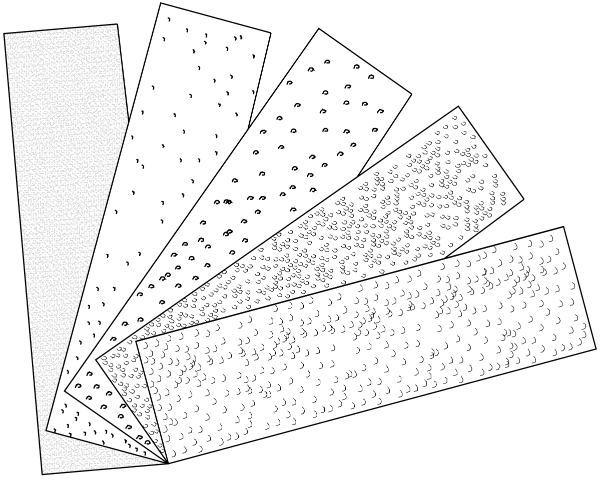
EP35011B

Cleaning of the articles is scoured with brass bristles wire brush and pumice powder.

Emery paper or ‘O’ grade paper (Fig 12)

Emery paper or ‘O’ grade paper are generic names used for a type of coated abrasive that consists of a heavy paper with abrasive material attached to its surface (such as old plating) or sometimes to make the surface rougher (for example, as a preparation for cleaning.

Fig 12



SHEETS OF EMERY PAPER WITH DIFFERENT GRITS 40, 80, 150, 240, 600)

EMERY PAPER

EP35011C

Electrolytes for brass plating

Objectives : At the end of this lesson you shall be able to

- **explain auxilary equipments for brass plating**
- **list the chemicals for brass plating**
- **explain the method of chemical preparation**
- **explain the purpose of the chemicals**
- **explain the safety measures for preparing brass plating solutions.**

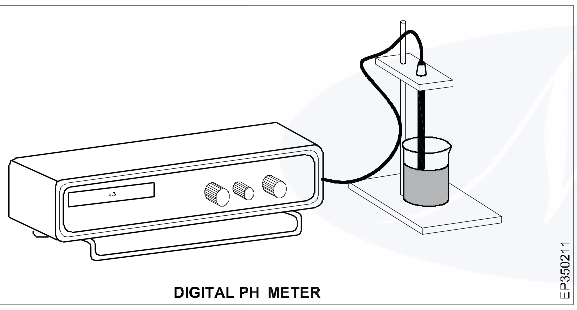
Auxilary equipments for brass plating digital pH meter

The pH meter is valuable for the direct determination of pH and as a means of recognizing the end point where a titration is made to a definite pH.

Electronic pH meter suitable for laboratory use. This type of instrument is completely portable and used in the plating shop.

Fully automatic pH control of plating processes. The pH is automatically determined and any necessary addition made to restore it to its normal value. It is used for solution control.

Fig 1



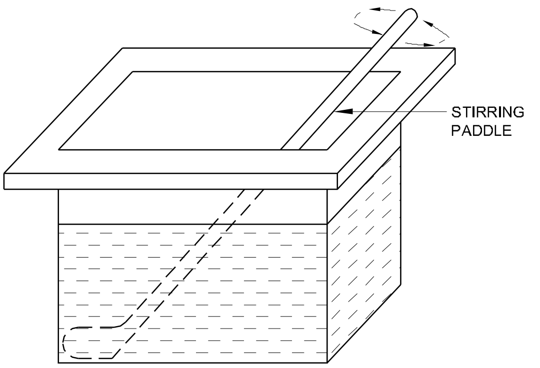
DIGITAL PH METER

Stirring paddle

When you added the acid in to the water slowly and cautiously poured with constant stirring with stirring paddle.

Where you are preparing solution acid or alkali undissolved the chemicals you should be use one of stirring paddle, and stir in the solution gently. (Fig 2)

Fig 2



STIRRING PADDLE

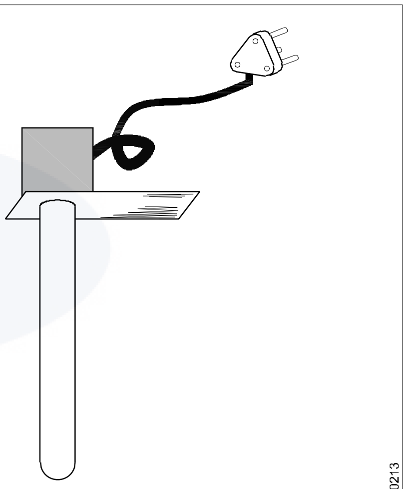
Mixing chemicals is important using stirring paddle, stirred until the salts have dissolved.

Immersion heater (1 kW)

Heaters are used in the electroplating bath for maintaining the required temperature of the bath for a good quality plating.

Various types of heaters are mild steel. Stainless steel, lead over M.S.Tubing, Titanium. Glass quartz. (Fig 3)

Fig 3



SILICA HEATER

The tube or casing must be made from or covered with a metal which is resistant to the solution in which it is to be used.

Immersion heaters fitted with earth trips set at 30 milliamps. Check that heaters are in good condition.

Where the electric immersion heaters are used it is essential they be effectively earthed to ensure safety.

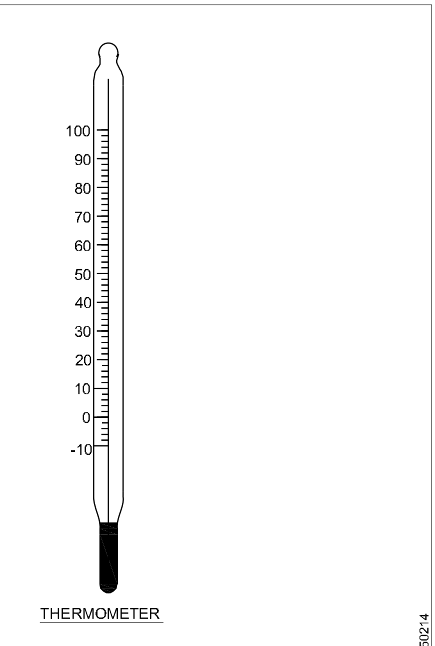
Thermometer

Glass thermometer pocket type 150 mm/needle type 300 mm in mercury or red toluene filled up 0-100^0c range for instant meausring liquid temperature. (Fig 4)

1. Lower fixed point 32^0F
2. Higher fixed point 212^0F
3. To convert - Fahrenheit to centigrade

$$C=(F-32) \times 5/9$$

Fig 4



MEASURING EQUIPMENTS

4. To convert - centigrade to Fahrenheit

   F = (9/5 x C) + 32 ; C=5/9 (F-32)

5. Temperature (Kelvin) absolute

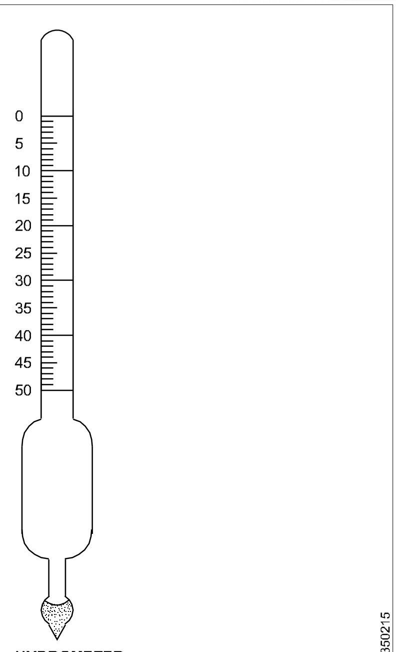
   K = C+ 273

6. Two fixed point is divided into 180 equal parts each part is called a degree fahrenheit.(^{o}F)

Hydrometer

Hydrometer of 300 mm having combined range of sp. gr 1-2 and baume 0-70^{0}C for determining the strength of any electrolyte. (Fig 5)

Fig 5



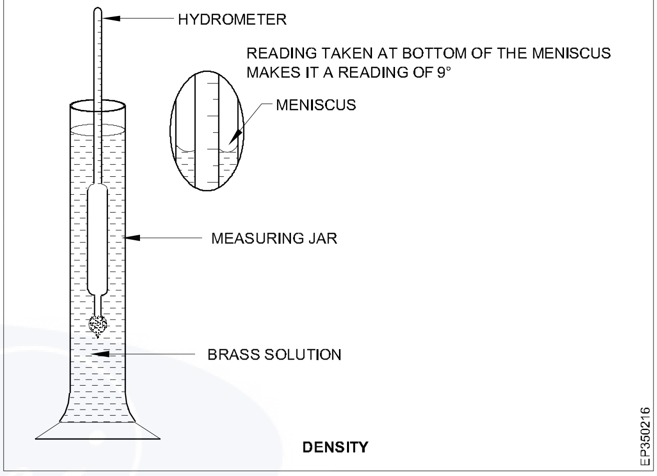
HYDROMETER

Hydrometer is used to check the density. The unit of density is called baume. (^{o}Be)

Auxiliary equipment

The tank should be equipped with seamless steel coils for heating. The coils should have electrically insulated hose-type connections at the live and return ends of the coil. An indicating type of temperature controller should be provided. In still plating, cathode-rod agitation is beneficial for many types of work and can be supplied by a small motor with a gear reducer operating a cam attached to the cathode rod. The cam should result in a cathode movement of 4 to 6 in. When several plating tanks derive power from a single 6-v source, a 3-v drop rheostat is required. When a tank has an individual power source, the rheostat is not needed. (Fig 6)

Fig 6

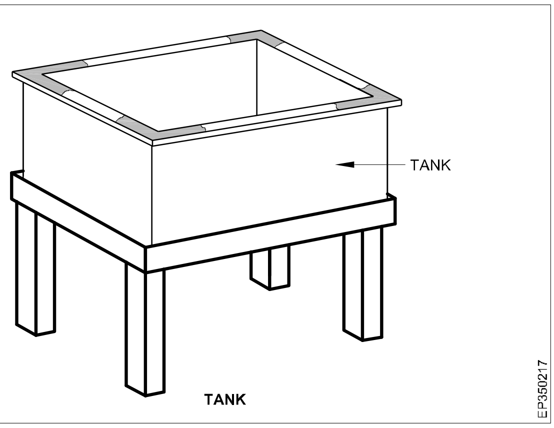


DENSITY

Plain welded steel tank

For the brass solution a welded steel tank is normally employed alternatively a plastic tank may be used. The steel tank in its usual form consists of an open rectangular box with welded joints and an angle stiffener on the top edge. For cleaning and rinse tanks the outlet can be fitted to the bottom of the tank. For plating tanks it is usual to fit the outlets to the end of the tank. (Fig 7)

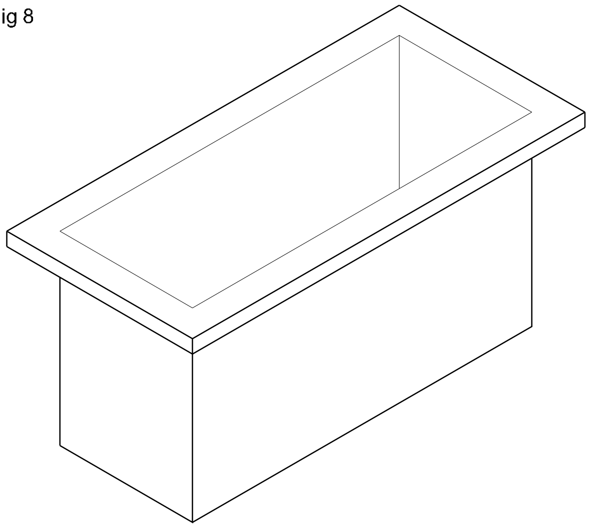
Fig 7



TANK

Steel tanks are also available provided with a sloping bottom. This form of construction greatly simplifies emptying and cleaning out. Unlined steel tanks preferably double welded are employed as containers solutions, also cyanide dips and sulphide brass baths. (Fig 8)

Fig 8



TANK

EP350218

Plastic tanks

Rubber lined or plastic tanks are used as container for the solutions of brass plating decreasing and acid dipping to prevent the possibility of metallic contamination of the solution stainless steel tanks are used for swilling drag in and drag out operations. Now-a-days polypropylene (PP) tanks are used for these purposes. Because of its resistance to chemicals. (Fig 9)

List the chemicals for bright brass plating

The chemicals composition of brass plating solution but speedier deposition and brighter results with the warm solution.

Copper cyanide	- 26 g/l
Zinc cyanide	- 11 g/l
Sodium cyanide	- 45 g/l
Free cyanide	- 7.5 g/l
Sodium carbonate	- 0.30 g/l
Ammonium hydroxide	- 3 g/l
Distilled water	- 1 litre
Temperature	- 27-56^{0}c (80^0-95^{0}F)
pH	- 10 - 11
Current density	- 9 amps/dm^2
Voltage	- 2-3 volt
Density	- 6.5^0 baume
(9-10^0 twaddell at the lower concentration)	
	- 9^0 Be
(13-14^0 twaddell at the higher concentration)	
Cathode efficiency	- 75%

The equipment necessary for the operation of the solution.

Preparation of brass plating solutions

Pickled the plain welded tank and cleaned it and if it is not to be used immediately.

It should be filled with 1 percent sodium hydroxide or trisodium phosphate solution to prevent excessive rusting.

Now the tank throughly cleaned out should be filled the distilled water. Two third of its capacity of the tank.

The temperature of the tank is 70^{0}C and required the chemicals should be slowly added, the mixture being agitated and well stirred by stirring paddle.

The order of mixing chemicals is important. (Fig 9)

The solution being heated to 70^{0}C and stirred until the salts have dissolved.

Use safety equipments while handling chemicals.

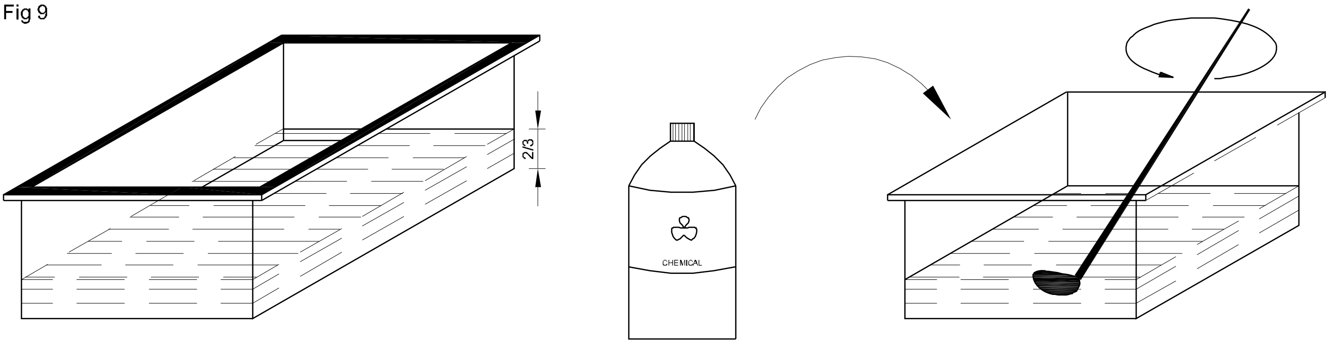
If a cyanide brass bath is to be made up the alkali cyanide must be added, before the copper cyanide and zinc cyanide is insoluable in water.

Add addition of the carbonate and hydroxide salt is relatively unimportant.

Dissolve copper cyanide, zinc cyanide slowly stirring with paddle gently.

After completely dissolving the chemicals bring up the working level of the solution by adding extra water.

Fig 9



PREPARATION OF BRASS PLATING SOLUTIONS

EP350219

While stir the solution should not be splash out.

Purpose of the chemicals

Copper cyanide

Copper cyanide supplies the copper ions; these ions together with sodium cyanide form the sodium copper cyanide complex.

Zinc cyanide

Zinc cyanide supplies the zinc ions; these ions together with sodium cyanide form the sodium-zinc cyanide complex. Hydroxide ions also contribute to the formation of a zinc-ion complex; in fact, most of the zinc plating takes place from this complex.

Sodium cyanide

Sodium cyanide is used to form the copper and zinc cyanide complex salts, whose action permits copper and zinc to be soluble in an alkaline bath, and prevents immersion deposits of copper on the work. Free cyanide, that is, the sodium cyanide that does not combine with the copper and zinc cyanides, influences efficiency, throwing power, and other operating conditions of the bath. Its presence is required for anode corrosion.

Sodium carbonate

Sodium carbonate is used to minimize the formation of sodium ferrocyanide. Although carbonate increases the conductivity of the bath, a concentration above 7 oz/gal seriously reduces the cathode efficiency of the bath.

Ammonium hydroxide

Ammonium hydroxide has been used by platers for a long time as a cure-all for their troubles in handling brass-plating baths. Its action is related to the fact that it complexes the copper ion, but has a less pronounced effect on the zinc ion. The addition of 1 to 2 pints of ammonia(30%) per 100 gal of solution will frequently help correct the color of the deposit. In very high-pH baths, ammonia may be used to lower and control pH.

Free cyanide

Between 7.5 g of free cyanide should be present. However, no exact rule can be applied to all brass plating baths; some operate with more than 10 g/l and others with less than 7.5 g/l. An increase in the free cyanide tends to reduce the copper content of the deposit.

Safety measures for preparing brass plating solution

Use safety equipments while handling chemicals.

The solution contain cyanide, therefore the operator must wear suitabe eye protection, a face mask, to prevent contact with the salts or solution.

While stir the solution should not splash out.

Wear gloves, aprons, boots and googles while preparing solution.

Any corrosive solution splashed on top the skin should be immediately washed off with plenty of water.

- Rubber or plastic lined tankds require no further cleaning.
- Wooden tanks may require painting of lining with pitch.

Warning :

When copper cyanide and zinc cyanide are being dissolved in their respective tanks, the operator should either wear a respirator or completely cover his nose and mouth in order to protect himself from the poisonous zinc and/or copper cyanides, both of which are fine powders and easily inhalable.

The sodium cyanide solution should be stirred while each small portion of zinc cyanide or copper cyanide is being added, and wait until that portion is wholly dissolved before the next addition is made. After both copper and zinc cyanides have been dissolved in their respective tanks, the solution containing the copper and sodium cyanides should be transferred from the first tank to the plating tank through a fiter which has had a precoat of filterbestos and activated carbon. About three fourths of the zinc cyanide solution should then be transferred to the plating tank from the second tank, and then through the filter. The required amount of sodium carbonate should then be added and the pH adjusted. A few test pieces should be plated at the proper temperature, current density, and pH in order to ascertain the color of the deposit. If the deposit is too much like bronze in color, or too red, a sufficient quantity of the remaining zinc cyanide solution should be transferred from the second tank in a porcelain or hard-rubber bucket (rather than through the filter) to the plating bath in order to produce a less red color. However, in most cases, three fourths of the zinc cyanide solution will prove to be ample.

Maintenance of brass plating solutions

Objectives : At the end of this lesson you shall be able to

- **explain testing and maintenance of the pH value of brass plating solutions**
- **explain testing and maintenance of the temperature of brass plating solutions**
- **explain testing and maintenance of the density of brass plating solutions**
- **explain the brass plating for rubber adhesion.**

Maintenance of the pH value of the solution.

This should be checked daily during operation as it tends to slowly increases. The free cyanide content of the brass solution should be determined regularly and any necessary addition of the sodium cyanide made. The metallic concentration is normally maintained by dissolution of the anode and should remain fairly constant for long periods.

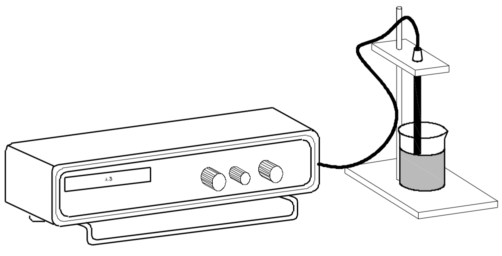
Sl. No.	Type of solution	Recommended pH value
1.	Warm solution	10 - 11
2.	Cold solution	10.2 - 11

The lower pH value of a brass plating solution, small additions of dilute acetic acid are necessary. At values outside these ranges. The bath is unstable and difficult to control.

The raise pH value of small additions of caustic soda(Sodium hydroxide) solution and lowered by the addition of ammonium sulphate. If the pH of the bath between 11 to 12, ammonium hydroxide will lower pH, to a point below 11. Sodium bi carbonate has been used in the past to lower pH; this increases the carbonate content of the bath, however, and for this reason ammonium sulphate, which does not increase the carbonate content is preferred. All pH values are determined colorimetrically.

After each addition of acid or alkali, the plating solutions should be well stirred and the pH value rechecked. (Fig 1)

Fig 1

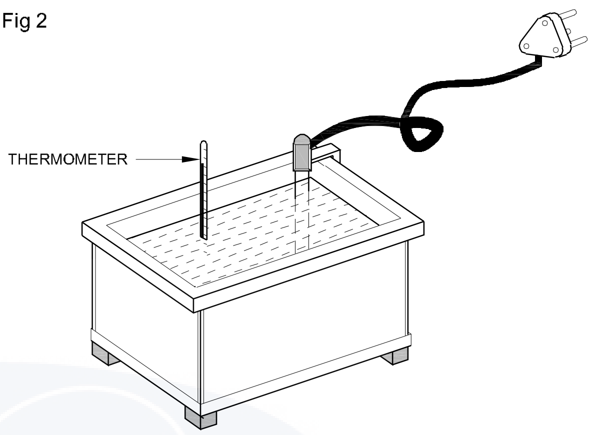


DIGITAL PH METER

Maintenance of the temperature

Temperature - The temperature of the bath has a decided effected on the color of the deposit. Increasing temperature increases the copper content, and hence the redness, of the deposit. At low temperatures, the copper content decreases, and the color of the deposit is a lighter brass. For color control, the temperature should not vary more than ± 5^0 F. (Fig 2)

Fig 2



CHECKING OF TEMPERATURE

Temperature	For the cold solution, room temperature but not below 15^0 C. The warm solution should be at 50^0C. Variation in temperature causes color variations int he brass deposit.
pH	10-11
Voltage	For the cold solution 3 - 4 volts For the warm solution 2 - 3 volts.

Color consistency and control

The brass deposit is normally a rich golden color, but any shade from a pale yellow to a reddish gold may be obtained from the same soltion by varying the temperature and current density.

An increase in the temperature of the bath will increase the copper content of the deposit, and may therefore, result in plating of a coppery color. Conversely, a decrease in temperature will result in higher zinc content, and hence give a paler deposit. To ensure good result, efficient temperature and voltage control and accurate instruments for measuring the temperature, current and voltage should be rigidly maintained.

If the operating conditions are correct and the color of the deposit is wrong then the fault will be in the chemical composition of the solution. If too red deposit be obtained at correct operating conditions, the addition of small amount of ammonium chloride will usually rectify the trouble. If this fails, the fault is due to a deficiency of zinc in solution and may be corrected by additing zinc cyanide at the rate of 0.6 g/l.

If a pale deposit be obtained at correct operating conditions, denotes that the solution is deficient in copper, in which case a small quantity of copper cyanide, approximately 5g/l of solution should be added.

The chemicals should be dissolved in a small quantity of solution containing 0.6 g/l sodium cyanide, in a separate vessel and the bath should be well stirred after this addition. The operation may be repeated, if necessary, until the required color is obtained.

Coppery deposits - Should too red a brass deposit be obtained, even at fairly high current densities, the addition of a small amount of ammonium chloride will usually rectify the trouble. If this fails, the fault is probably due to a deficiency of zinc in solution and may be corrected by adding zonax zinc salts at the rate of 3 g/l (1/2 oz/gal). The salts should be dissolved in a small quanitity of a plating solution in a separate vessel and the bath be well stirred after the addition. The operation may be repeated, if necessary until the required color is obtained.

N.B - Zinc salts are intended solely for the correction of a brass solution as advised above - they should not be used for the preparation of a zinc plating solution.

Deposit too pale - A pale deposit, even at a low current, denotes that the solution is deficient in copper, in which case a small quantity of zonax copper salts, approxiately 5 g/l (0.8 oz/gal) of solution, should be added in the manner advised in the previous paragraph, repeating the operation of necessary.

Brass plating upon cast iron and lead

For the plating of cast iron and lead a minimum of free cyanide is necessary owing to the low hydrogen overvoltage of these metals, which favours the evolution of hydrogen in preference to the deposition of brass at normal potentials. Hence, when preparing a new solution for plating this class of work, or adapting an existing brass plating solution for the purpose, it is usually necessary to reduce the free cyanide by the addition of single copper and zinc cyanide, as described on (3.5.02) under “Excess of free cyanide”

Visual control of the solution

In the absence of laboratory facilities the brass solution maybe controlled from the appearance of the anodes and the colour of the brass deposit.

Lack of free cyanide is usually denoted by the formation of a greenish white slime or encrustation on the anodes, and by the pale colour of the brass deposit. The deficiency should be made good with high grade sodium cyanide. Failing a test set the best alternative is to add 3 g/l sodium cyanide, followed by more, if necessary, until the anodes become clean and no longer polarise when the vat is worked.

Excess of free cyanide is denoted by copious gassing at the electrodes, especially if the metal content of the solution is low, and may result in a coppery deposit or prevent deposition altogether is some cases.

To reduce the free cyanide content, an addition of zinc cyanide and copper cyanide c should be made in the proportion of 2 g/l of zinc cyanide and 4 g/l of single copper cyanide for each 6 g/l of free sodium cyanide in excess. The chemicals are added to a portion of the plating solution contained in a small steel tank. The solution being heated to approximately 70°C and stirred until the salts have dissolved.

Metallic content :

If the solution works slowly although the free cyanide concentration is correct, then the solution may be low in metal.

The free cyanide content of the brass solution should be determined regularly and necessary addition of sodium cyanide made. The metallic concentration is normally maintained by dissolution of the anodes and should remain fairly constant for long periods.

If the solution works slowly then there may be a deficiency in the metal content.

An addition of 6g/l sodium cyanide, 2 g/l zinc cyanide and 4 g/l copper cyanide should be made, these being dissolved in a portion of the solution, as described in the previous paragraph.

Deposit Bronze in colour :

A bronze colour may arise from too high a zinc /copper ratio as indicated earlier in this chapter, under "Operating Conditions - Temperature". This can be mistaken for a deficiency of zinc and an addition of zinc. Salts will aggravate the position. If under normal working conditions the deposit is not the correct colour, an addition of 1.5 to 3 g/l (1/4 to 1/2 oz/gal) of single copper cyanide (dissolved in a portion of the plating solution) should be made at intervals until the required colour of deposit is obtained.

Maintenance of density

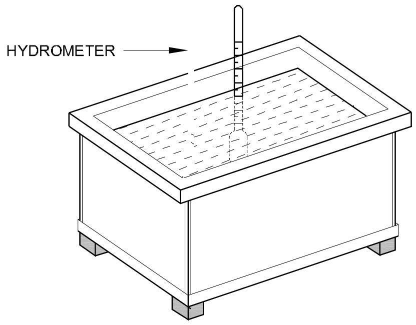
Density

The density of new solution taken at room temperature, should be 6.5° Baume (9 to 10° Twaddell) at the lower concentration, and 9° Baume (13 to 14° Twaddell) at the higher. (Fig 3)

N.B - Although the density is a good indication of the strength of a freshly prepared solution, it is not a reliable guide to the metal content of a bath that has been in use of any appreciable time.

If the operating conditions are correct and the colour of the deposit is wrong then the fault will be in the chemical composition of the solution should too red a brass deposit be obtained, even at fairly high current densities, the addition of a small amount of ammonium chloride will usually rectify the trouble. If this fails, the fault is probably due to a deficiency of zinc in solution and may be corrected by adding zinc cyanide at the rate of 0.6 g/l. The salts should be dissolved in a small quantity of

Fig 3



CHECKING OF DENSITY

solution containing 0.6 g/l sodium cyanide, in a separate vessel and the bath should be well stirred after this addition. The option may be repeated, if necessary, until the required colour is obtained.

A pale deposit, even at a low current, denotes that the solution is deficient in copper, in which case a small quantity of copper salts, approximately 5 g/l of solution, should be added in the manner advised.

Decorative brass plating

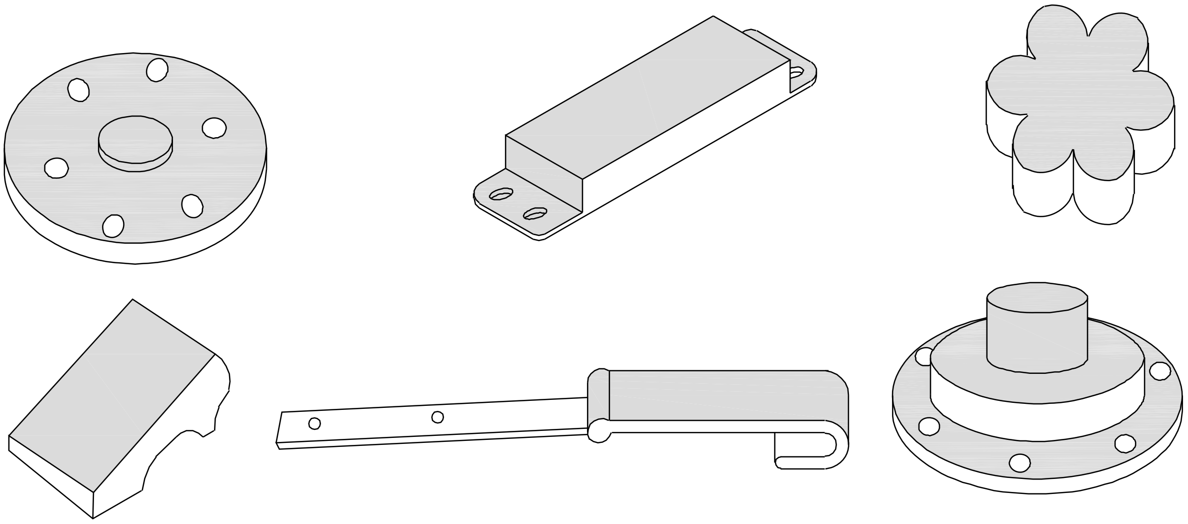
	Warm Solution	Cold solution
Free Sodium Cyanide	6 g/l	8 g/l
Copper as Cu	6 g/l	9 g/l
Zinc as Zn	2 g/l	3 g/l
Ammonium chloride	3 g/l	3 g/l
Voltage	2.5 - 3 V	3 - 4 V
Density of a new solution at 15°C (60°F)	1.048 sp.gr. 6.5° Be (9 to 10° Tw)°	1.067 sp.gr. 9° Be (13 to 14° (Tw)
Cathode current density	0.5 - 0.6 Amp/dm^2	0.3 to 0.4 amp/dm^2
Current density pH	9.8 - 10.8	9.8 - 10.8
Temperature	50°C	Above 15°C

Brass plating for rubber adhesion (Fig 4)

In the bonding of rubber to steel, an electro - deposit of brass provides an effective medium for ensuring adhesion of the rubber to the ferrous metal. The process is used extensively in the manufacture of engine mountings, shock absorbers and similar components which are designed to eliminate the transmission vibration.

The composition of the brass deposit must be carefully controlled and should be 70 per cent copper, 30 per cent zinc, with a tolerance of 2 per cent either way.

Fig 4



COMPONENTS BRASS PLATED AND THEN RUBBER BONDED

Brass solution

For the plating of steel components prior to rubber coating, the brass solution is used as described in the following paragraphs.

Equipment

For the brass solution is welded steel tank is employed fitted with the necessary anode and cathode rods together with means of heating.

Anodes

Where the brass solution is used for brass plating prior to rubber bonding, anodes of pure alpha brass 70 percent copper 30 percent zinc are employed.

Density

The density of a newly prepared solution is 13° Baume (20° Twaddell) at 15°C (60°F) corresponding to 12° Baume (18.5° Twaddell) at 40°C (100°F)

Operating conditions

Temperature

The temperature of the solution is usually maintained at 40°C (100°F) but may be varied in conjunction with other operating conditions to control the composition of the deposit. A higher temperature will increase, and lower temperature decrease, the proportion of copper in the brass deposit .

Voltage and current density

The bath is operated at a current density of 1 to 1.2 amp/dm^2 (10 to 11 amp/ft^2) with a pressure of to 3 volts across the terminals.

If worked at a current density higher than that specified the solution will tend to give deposits rich in copper, and at a lower current will yield deposit rich in zinc, the effect being contrary to the usually obtained with the less conductive baths employed for decorative plating.

Plating procedure

After hot alkaline cleaning the components should be anodically clean or acid etched in order to ensure effective adhesion to the steel of the brass deposit and the subsequently applied rubber.

Where the articles have been treated in an acidic solution, it is usual include a cyanide dip prior to the brass plating stage.

Cast iron components are usually copper plated prior to brass plating. The articles are electro - plated for 20 to 30 minutes, after with they are swilled thoroughly in cold water, rinsed in boiling water, and then allow to dry spontaneously in air.

The work must not be dried in sawdust nor be handed, and unless bonding be carried out immediately, the brass deposit should be prevented from fainting by dipping the article sin a thin rubber solution or in a suitable temporary lacquer.

Maintenance of the solution

This solution is maintained in a similar manner to a decorative brass solution, but control is governed by the actual composition rather than the appearance of the plating. Colour is not a reliable guide and is apt to be mis-leading, as a deposit of high zinc content of ten has a reddish - bronze appearance, whereas 70/30 deposit, although richer in copper, is relatively pale and of a clear yellow colour. Hence analytical control is necessary to maintain the composition of the solution and to assist the operator in adjusting the plating conditions, i.e temperature and current density, so as to obtain consistently a deposit of the correct composition for bonding.

pH value

The pH value of the heavy brass solution should be maintained between 10.2 and 11.0.

Suitable analytical standards for the maintenance of the heavy brass solution are

Free sodium cyanide - - - - 12 g/l

Copper cyanide - - - - - - 12 g/l

Zinc cyanide - - - - - - - 4 g/l

Ammonium chloride - - - - - 5 g/l

Cathode current density - - - - 1 to 1.2 amp/dm^2

Voltage - - - - - - - - - - 2.5 to 3 volts

pH - - - - - - - - - - 10.2 to 11

Temperature - - - - - - - 40° (100°F)

Correction of faults in brass plating

Sl.No	Nature of defect	Possible causes	Method of corrections
1	Imperfect adhesion of the deposit as indicated by the presence of blisters	a) Excess of free cyanide, usually indicated by copious gassing at the cathode	a) Check the free cyanide content of the solution and correct
		b) Insufficient free cyanide, denoted by the presence of a greenish film on the anode	b) Determine the free cyanide content and add the required amount of high grade sodium cyanide to correct the solution
		c) Presence of grease, oxide or tarnish on the metal before plating	c) Review cleaning processes and check degreasing solution to make sure that they are efficient.
2	High copper content, denoted by coppery red colour of the deposit	a) Too high temperature	a) Reduce to 50°C or lower
		b) Lack of ammonium chloride	b) Add 1.5 to 3 g/L of ammonium chloride
		c) Deficiency of copper in solution	c) Correct the balance by adding zinc cyanide at the rate of 0.6 g/l
3	High zinc content, denoted by pale colour of the deposit	a) Too low temperature	a) Warm the solution in between 40 to 50°C
		b) Deficiency of copper in solution	b) Add copper cyanide at the rate of 5 g/l
		c) Too high current density	c) Reduce the voltage and current
4	Rapid tarnishing of the plated article	Failure to remove last races of plating, solution from surface	Rinse the work thoroughly after plating, change the swilling water regularly.
5	Anode covered with a white film	Lack of ammonium chloride	Add 1.5 to 3 g/l of ammonium chloride

Brass plating process

Objectives : At the end of this exercise you shall be able to

- **list out various types of the brass plating solution**
- **state the chemical composition and operating conditions of brass plating**
- **explain the brass plating on small articles by barrel method**
- **explain the correction of defects in brass plating.**

Various types of brass plating solutions and operating conditions are given in TABLE 1.

TABLE 1

No.	Constituent	Symbol	g/l
1.	Copper (Cuprous) cyanide	$CU_2(CN)_2$	40
Dull brass	Zinc cyanide	$Zn(CN)_2$	15
plating	Sodium cyanide (total)	NaCN	60
	Sodium carbonate	Na_2CO_3	15
	Sodium bicarbonate	$NaHCO_3$	15
	Ammonium hydroxide	NH_4OH	25
	Temperature		95-105^{0}F
	pH		10-11
	Current density		9 A/dm^2
	Voltage		3 volt
2.	Copper (cuprous) cyanide	$Cu_2(CN)_2$	40 g
Matt brass	Zinc cyanide	$Zn(CN)_2$	15 g
plating	Sodium cyanide(total)	NaCN	60 g
	Sodium cyanide(free)		10 g
	Ammonium hydroxide(30%)	NH_4OH	5
	Temperature		90-110^{0}F
	pH		10.5-11.5
	Current density		5 A/dm^2
	Voltage		1 - 2
3.	Copper(cuprous)cyanide	$Cu_2(CN)_2$	75 g
Alloy plating	Zinc cyanide	$Zn(CN)_2$	35 g
process	Sodium cyanide(total)	NaCN	150 g
	Sodium cyanide(free)		40 g
	Sodium carbonate	Na_2CO_3	45
	Temperature		100-110^{0}F
	pH		9.2-9.6
	Current density 5-40		10 A/dm^2
Adjust with NaOH if too low; adjust with $(NH_4)_2SO_4$ if too high.			

Brass plating solution composition for zinc-base diecastings and undercoat for nickel on aluminium:

	g/l
Sodium cyanide (NaCN)	60
Copper cyanide (CuCN)	30
Zinc oxide (ZnO)	8
Sodium bicarbonate ($NaHCO_3$)	11
Ammonia (0.880 NH_4OH)	3 ml

Operating conditions

Temperature	95-104^{0}F		35-40^{0}C
Current density	Cathode	10 A/ft^2	1 A/dm^2
	Anode	5 A/ft^2 max	0.5 A/dm^2
Cathode efficiency	60-70%		
Volts	3.5		
pH	10.5 - 11.5		
Anodes	70-30 brass cast or rolled.		
Vat	Steel or rubber lined steel		
Brightener	2 lb. of caustic soda dissolved in 1/2 gal. water to which 1 lb. of white arsenic is added. Use 2-4 fl. oz/100 gal. solution. (15-30 ml. per 100 litres)		
Free cyanide	1 oz/gal (6¼ g/l)		

Solution maintenance

Brass can be deposited quite easily from the mixed cyanide solution. The alloy will vary somewhat according to conditions of deposition but a 70/30 copper-zinc alloy is the most generally used. The deposit is used as a finish on steel and also as an undercoat for nickel on aluminium and zinc-base diecastings, and for bonding rubber.

The content of ammonia is important, the addition of ammonia usually furthering the deposition of zinc. The deposition of zinc is also helped by increase of free cyanide or current density. Higher temperatures further the copper deposition.

When the arsenic brightener is used, care must be taken to avoid excess, otherwise the anodes will blacken, and the solution become unworkable.

Brass plating solution

Rack and barrel brass plating solution

Copper cyanide	-	26 - 52 g/l
Zinc cyanide	-	11 - 30 g/l
Sodium cyanide	-	45 - 90 g/l
Free cyanide	-	7.5 g/l
Sodium carbonate	-	0.30 g/l
Ammonium hydroxide	-	5.3 - 13 g/l
Temperature	-	50°C - 120°F
Distilled water	-	1 litre
Current density	-	9 amp/Dm^2
pH	-	10 - 11
Density	-	6.5° Be (9-10° Twaddell) at the lower concentration
	-	9° Baume (13 to 14° twaddell) at that higher concentration
Cathode	-	75%
Voltage	-	2 - 3 volts

Solution composition and operating conditions

Brass is usually deposited from an alkaline cyanide solution. The solution is suitable for both rack and barrel plating. On steel it is usual to apply an initial deposit of bright nickel or bright copper.

Solution preparation

The plating tank should be filled to one third its capacity with clean cold water and the chemicals should be added one by one slowly with stirring. After which the ammonium chloride is added and allowed to dissolve. When all the salts have been completely dissolved the solution should be diluted with cold water to working level and well stirred. The solution contains cyanide, therefore the operator must wear suitable eye protection, a face mask and other appropriate safety equipments to prevent contact with the salts or solution.

Mechanical cleaning

Mechanical scouring is employed as aid to both chemical and electro - chemical cleaning. The articles are firs washed with caustic potash to remove grease and then it is immersed in acid dip. After remaining in this for a while, the article is removed and rinsed. The article is now brushed with a bristle brush that has been rubbed is powdered pumice so as to remove all deleterious materials from the surface.

- Small objects, such as casting, stampings etc, are best cleaned by tumbling or rattling.
- By the help of these barrels large quantities of work are thus easily and cheaply without much manual labour.

Polishing :

Polish the item to make it finish and glazy by following process.

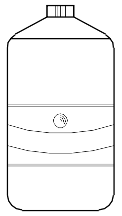
a. **Emery :** Remove roughness and deep scratch of the job surface on emery wheel (120 emery) wheel

b. **Brushing :** Remove emery scratches by applying luster composition (powder) on brush glazy and finish.

Solvent cleaning :

After polishing clean the job petrol to remove polishing composition. (Fig 1)

Fig 1



SOLVENT

Anodic or cathodic cleaning :

Dip the job in anodic or cathodic solution to remove stain, finger prints and oxide scales etc.

For ferrous item mostly used anodic process.

For non ferrous item used cathodic process.

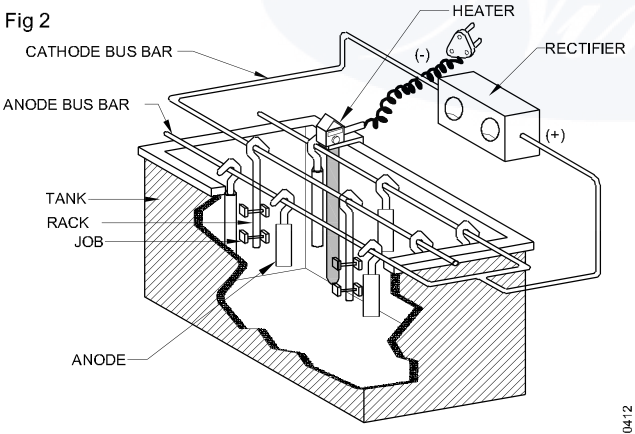
Solution for cyanide dip

Sodium cyanide	- 50 g/l
Time	- 04 to 05 seconds

Swill and hang the job for cyanide brass plating solution for brass plating.

Now the articles are dip in the brass plating solution as required time. (Fig 2)

Fig 2

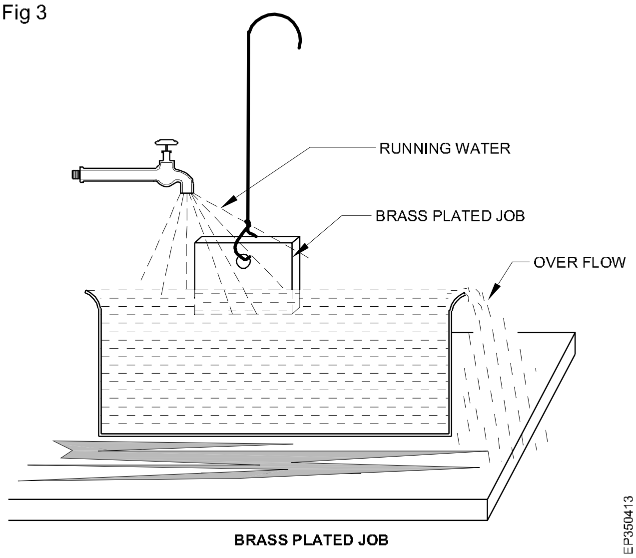


BRASS PLATING BATH

Post treatment

After removing the articles from the brass plating bath the parts are passed in to the drag out tank. There are then rinsed thoroughly in clean cold water. To prevent the brass from tarnishing, it is usuall to lacquer or alternatively passivate by the use of sodium dichromate solution (25 g/l). The parts are again rinsed, then dipped in hot water and finally dried. The solution in the drag out tank should be utilized for maintaining the height of the solution in the brass bath. (Fig 3)

Fig 3



BRASS PLATED JOB

Alternative bath solutions for brass plating

Various non - cyanide brass solutions have been developed in the past, however, cyanide brass solutions are still the most prevalent used by metal finishers today. Some of the original non - cyanide solutions had some problems including insufficient color in the deposit, poor appearance, narrow operating ranges, or bath instability. One of the most critical disadvantages is the lack of uniformity of color or appearance of the non - cyanide brass deposit. Currently, not much literature is available for alternatives to brass cyanide baths.

Brass pyrophosphate

Among the non - cyanide brass plating baths, pyrophosphate appears to be one of the most promising. However, field reports have stated that additives are necessary to operate this application properly. Otherwise, problems develop with unalloyed zinc getting contained in the deposit. Metal finishers have used the additive histidine in a pyrophosphate solution successfully. The deposits have shown similar qualities to the traditional copper zinc alloy deposits.

Brass pyrophosphate - Tartare

Tests have been completed on an alkaline pyrophosphate - tartare bath containing his diness as an alternative to brass cyanide solutions. Tests on these solutions have found that their alloy composition was almost constant over a wide range of current densities. Moreover, bright brass deposits having a uniform composition and color were obtained over almost the entire cathode area. The tests were performed on a bath solution that had a pH of 12.0 and a constant temperature of 30°C.

Some non cyanide processes do not satisfactory adhere to all surfaces and tend to become brittle at high temperatures.

Brass plating upon mild steel, copper and aluminum article.

After chemical cleaning mild steel should be suspended in the bras plating solution.

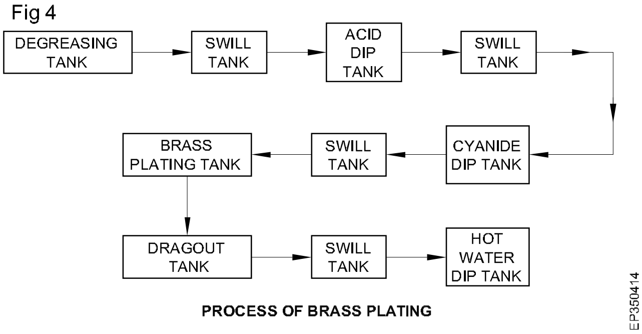
The procedure for preparing articles for brass plating is similar to that described for copper plating. The operating condition must be closely controlled in order to ensure uniformity of deposit colour.

Plating procedure

After hot alkaline cleaning the components should be anodically cleaned or acid etched in order to ensure effective adhesion to the steel of the brass deposit and the subsequently applied rubber.

Where the articles have been treated in an acidic solution, it is usual to include a cyanide dip prior to the brass plating stage. (Fig 4)

Fig 4



PROCESS OF BRASS PLATING

Cast iron components are usually copper plated prior to brass plating . The articles are electro - plated for 20 to 30 minutes, after which they are swilled thoroughly in cold water, rinsed in boiling water, and then allowed to dry spontaneously in air. (Fig 5)

The work must not be dried in sawdust nor be handled, and unless bonding can be carried out immediately, the brass deposit should be prevented from staining by dipping the article sin a thin rubber solution or in a suitable temporary lacquer.

Brass plating on small articles

Barreling is particularly suitable for finishing small articles. It is quite impossible, to polish articles, the corners or edges of which have to be kept sharp. Nor is possible to avoid polishing some surface on the article which is not desired to touch. Barreling is an extremely cheap and convenient way of polishing a number of small articles of commerce on which a very high finish is not essential. (Fig 6)

Abrasives

A number of abrasives are used for barreling, varying from lumps of bricks and coke to finely graded powders. An abrasive may be powder or in the form of pebbles or blocks. It is usual to add a small quanity for alkali, sodium carbonate or tri - basic sodium phosphate being suitable. An addition of 150 gramms per gallon is usually sufficient. This alkali will prevent rusting of the steel balls or of steel pars being burnished, and will also assist in maintaining a suitable slurry. A little soap or wetting agent is beneficial for many purposes.

Leather cuttings

Small pieces of leather cuttings are some time used in barrels for additional polishing action.

Burnishing with steel balls

For burnishing brass, etc, hardened steel balls are used. The balls themselves should first be barreled for sometime in a solution of soap. After this operation the soap solution should be poured off, and the balls very thoroughly washed out and then placed in the barrel with a clean soap solution. It is important that the soap should be of good quality and that a good lather should be obtained. The articles to be burnished are then placed in the barrel and the barreling operation started.

Fig 5

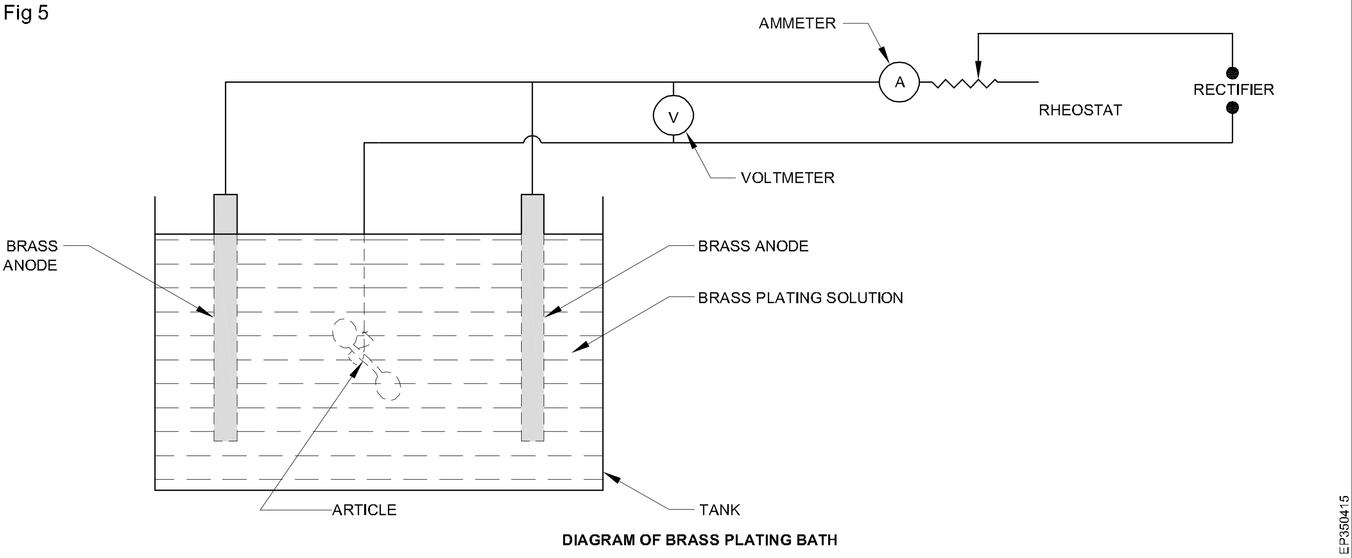
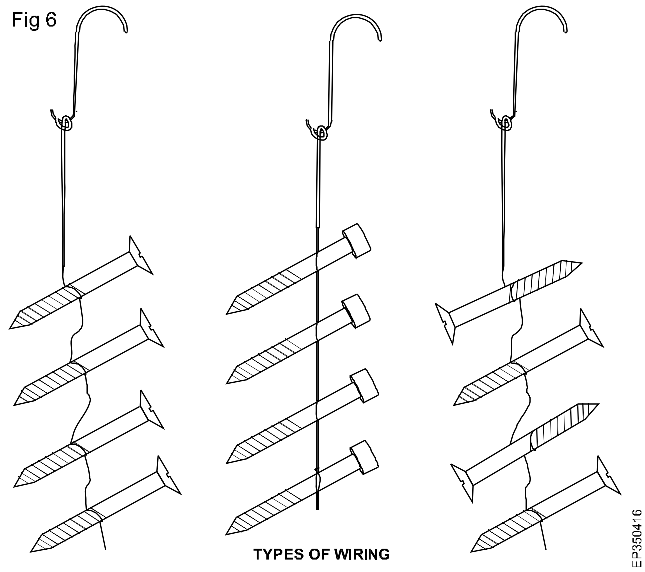


DIAGRAM OF BRASS PLATING BATH

Fig 6



TYPES OF WIRING

Polishing procedure

The barrel is opened and located with the required quantity of abrasive pebbles. The work is then loaded into the barrel and the barrel closed. The tank is filled with fresh soap solution, warmed to the required temperature, and the barrel rotated. The speed of the barrel should not be excessive, but for certain work it may be rotated upto about 30 r.p.m

The time of the operation will depend a very large extent on the nature of the work itself but excessive time will tend to round the corners of the objects. It will therefore be necessary to judge the optimum time required for each type of article by withdrawing samples from the barrel from time to time until the desired finish has been attained.

When the desired finish has been obtained, the barrel is stopped, opened and rotated so that the work falls on to the slopping bottom of the tank. The tank is empted and the water tight door opened so that the work can be withdrawn. The articles can be separated from the pebbles by means of a suitable screen.

To prevent tarnishing of brass components which are subsequently plated it is advisable that these be dipped through a solution of potassium or sodium bichromate (25 gms / litre) again well rinsed and then dried out.

Barrel brass plating

For the successful barrel deposition of brass, a well - balanced solution with a considerable reserve of metal is necessary to ensure consistent results over a long period of operation.

For this purpose the brass solution is employed under the following conditions. (Fig 7)

Equipments

For electroplating on small articles like, clips, buttons etc., Barrels are thought to be the most convenient type.

Equipment for barrel plating is open - ended barrels, cast brass anodes are used, whilst for immersed barrels oval brass anodes are employed. (Fig 7)

The solution may be contained in a plastic vessel in a rubber lined or welded steel tank. The method of preparation is as described previously.

Operating conditions

The solution is used warm at a temperature of 20° (70°F)

For open ended barrels (Typhon) The normal plating voltage is 6 to 7. Whilst for partially and fully immersed barrels (e.g Midget)

The voltage is usually between 6 and 10. The current required will depend from the type of barrel employed, the type and quantity of articles to be plated the voltage applied and the condition of the plating solution.

Maintenance of the solution

The density of the solution when new will be approximately 13° Baume (20° Twaddell) at room temperature, but will tend to rise as the carbonate content increases with age. Too high a density must be avoided however, and the volume of the solution should be maintained by the addition of water from time to time.

The free sodium cyanide content should be kept at approximately 12 g/l by adding high grade sodium cyanide whenever necessary.

Suitable analytical methods for the zonax brass solution when used for barrel plating are.

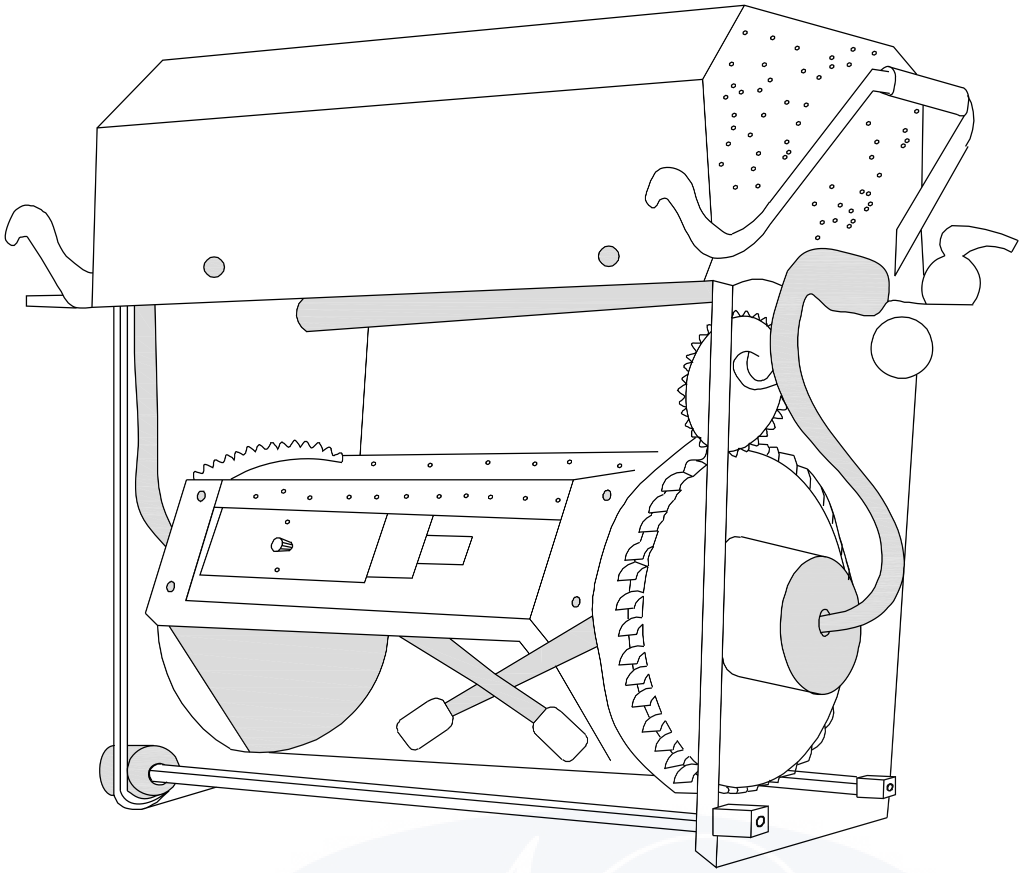
Free sodium cyanide - - -	12 g/l
Copper cyanide - - - - -	12 g/l
Zinc cyanide - - - - - -	4 g/l
Ammonium chloride - - - -	6 g/l
Density (20° C) - - - - -	13 Be(1100 sp.gr)
Temperature - - - - - -	20° C (70° F)
pH - - - - - - -	10.2 to 11
Voltage - - - - - - - - -	6 to 7 (Open ended barrel) - 6 to 10 (Fully immersed barrel)

Methods for the analysis of brass plating solution.

The electric current does not flow due to high density, which effects the process of electroplating.

- The temperature at 20°C (70°F).
- The density should be maintained at 20°C - 13° BC.
- The water be added at intervals.

Fig 7



PLATING BARREL FOR BRASS PLATING

Correction of defects in brass plating solutions

Nature of defect	Possible cause	Method of corrections
1) Imperfect adhesion of deposit, as indicated by the presence of blisters, or actual stripping. Defect may be visible on removal of the articles from the plating bath, or become apparent later if the metal is bent , scratch brushed or polished	a) Excess of free cyanide, usually indicated by copious gassing at the cathode, and by the bright crystalline appearance of the anodes.	a) Check the free cyanide content of the solution .
	b)Insufficient free cyanide, denoted by the presence of a greenish – white slime or encrustation on the anodes and resultant polarisation.	b) Determine the free sodium cyanide content and add the required amount of high grade sodium cyanide to correct the solution
	c) Presence of grease, oxide or tarnish on the metal before plating	c) Review cleaning processes and check degreasing solutions is to make sure that they are efficient. Examine surface of the brass solution and swills for signs of oil or grease which may have come from. 1. Alkaline cleaner with in soluble oil film on its surface. 2.Crevices or tapped holes in the article,, or 3. External sources, e.g over head machinery. Scale or oxides should be removed by sandblasting pickling or acid dipping
	d) Surface in acidic condition when placed in plating solution	d) Improve water swilling and introduce cyanide dip before plating stage.
2) High copper content of deposit, denoted by coppered – red colour or as ascertained by analysis if plating for rubber bonding N.B . Some zinc rich deposits are of deceptive appearance and have a reddish bronze colour, similar to that of a high copper alloy.	a)Too high a temperature	a) Reduce to 50°C (120°F) or lower.
	b)Lack of ammonia or ammonium chloride	b) Add 1.5 to 3 g/L of ammonium chloride
	c) Deficiency of zinc in solution	c) Correct the balance by adding zinc salts to the exceed of 3 g/l.
	d)Unsuitable free cyanide content	d) Check by titration, and a excessive, correct as described
	e) Unsuitable current density usually too low.	e) The effect of variation in voltage and current density is often considerable, but differs with the working condition and type of solution.
3) High zinc content of by the pale colour or as ascertained by analysis N.B : - Some zinc rich deposits have a bronze colour and should not be confused with (2) high copper content.	a) Too low a temperature	a) Warm the solutions, Baths for use at room temperature should never be worked below 15° C (60°F) . Heated solution are usually operated at 40° to 50°C (100° to 120° F) but may be used warmer
	b) Deficiency of copper in solution	b) Add copper salts at the rate of 5 g/l.
	c) Lack of free cyanide	c) Check the titration, and add the required amount of high grade sodium cyanide.

Nature of defect	Possible cause	Method of corrections
	d) Unsuitable current density usually too high	d) A reduction in voltage and current density will generally increase the copper content of the deposit in decorative brass plating, but have the reverse effect with more conductive solution as used for rubber bonding.
4) Deposit rough – more particularly on surfaces that have been uppermost in the vat	Presence of suspended solids in the plating solution	Filter the solution or alternatively, allow the bath to stand over night, then decant or syphon off the bulk of the clear solution into an iron tank. Dispose of the last few inches containing any sediment, and clean out the plating tank before replacing the clear solution
5) Rapid tarnishing of the plated articels	a) Failure to remove last trace of plating solution from surface, due to insufficient swilling or use of contaminated water b) Use of resinous or contaminated sawdust for drying the work. c) Spongy texture of deposit, and retention of electrolyte	a) Rinse the work thoroughly after plating. Test reaction of final swill water frequently with litmus paper and change the water before it becomes alkaline. b) Use box or other hard wood (not resinous pine) sawdust. Swill the articles thoroughly to prevent contamination of the sawdust with plating solution. N.B. Work intended for rubber bonding should be dried in air, or by means of the centrifugal dryer. c) Check free cyanide content of the solution and, if low, make good the deficiency with high grade sodium cyanide. In the absence of a test set add from 1.5 to 3 g/l of cyanide.
6) Localised staining or "spotting out" of the brass deposit	This defect is due to the ozzing out of plating solution that has been entrapped in pores of the metal, and is generally confined to castings	In severe cases where the metal is extremely porous the trouble is difficult to avoid, but may be minimised by swilling the plated articles several times in cold and boiling water alternatively before they are finally dried. An alternative method is to soak the work, after swilling in a solution of 5 g/l potassium hydrogen tartrate in water and again swill before drying.
7) Scanty deposit and excessive gassing at cathode face	Excess of free cyanide or lack of metal in solution	Determine the free sodium cyanide content by titration and correct if excessive. If cyanide content is not high and fault is due to lack of metal brass salts may be added, in the proportion of 25 g/l to make good the deficiency.

Nature of defect	Possible cause	Method of corrections
8) Non deposition	a) Faulty contacts or reversed polarity of current b) Passivity of cathode c) Excess of free cyanide, which favours the evolution of hydrogen in preference to deposition of brass on metals such as cast iron and lead	a) See that electrical condition are correct. b) Remove passive surface by polishing, scratch brushing or etching the articles. c) Add copper and zinc cyanide as described "solution maintenance".
9) Anodes bright and crystalline in appearance	Usually an indication of excess of cyanide	Check the free sodium cyanide content, and if much above normal, neutralise the excess as above.
10) Anodes coated with greenish white slime or encrustation	Lack of free cyanide	Add high – grade sodium cyanide
11) Anodes covered with a white encrustation	Lack of ammonium chloride	Add. 1.5 to 3 g/l ammonium chloride N.B. This may increase the zinc content of the brass deposit and alter its colour, but this effect may be counteracted by regulating the temperature and current density.
12) Anodes coated with a black deposit, not to be confused with a brown coloration, which is normal	Contamination of the solution with lead, resulting in a deposit of lead peroxide on the anodes	Do not employ a lead – lined tank for the solution, or use commercial brass anodes which may contain lead as an impurity. Remove source of contamination and eliminate the lead from the solution by removing and souring the anodes at frequent intervals, whenever they become heavily coated.
13) Solution very dense, crystallizing out on anodes and sides of tank when cold	Accumulation of carbonates due to continuous decomposition of cyanide over a long period of use.	If solution is old and analysis indicates that its is nearly exhausted of metal, throw away and make up afresh. See deposal of concentrated solutions. Should it still contain plenty of metal, its life may be extended by chilling the bath during cold weather, and then removing any crystals that form. A plain steel shovel or scraper may be used, and the solution should subsequently be brought up to working level again by dilution with water.

Stripping of brass deposit

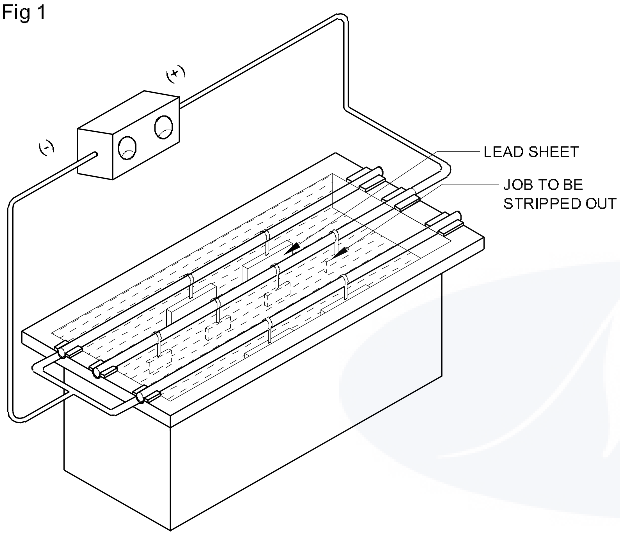
Objectives : At the end of this lesson you shall be able to

- **explain the electrolytic process for stripping brass deposit**
- **describe about immersion stripping.**

Brass stripping is a process to remove brass coating from the basis metal or without affecting the underlying metal. Two types of methods are used for removal of electroplated coatings . They are electrolytic and immersion methods. The selection of stripping bath (fig 1) is depending upon the structure of base metal.

Electrolytic process (Fig 1)

Fig 1



ELECTROLYTIC BRASS STRIPPING

Brass deposits may also be stripped electrolytically in a cyanide solution, making the work the anode in the circuit. The bath is prepared from,

Sodium cyanide	- 100 gr
Caustic soda	- 50 gr
Water	- 1 lit

This contained in a welded steel tank and is used at room temperature at a pressure of 4 to 6 volt with lead sheet or steel sheets as cathode

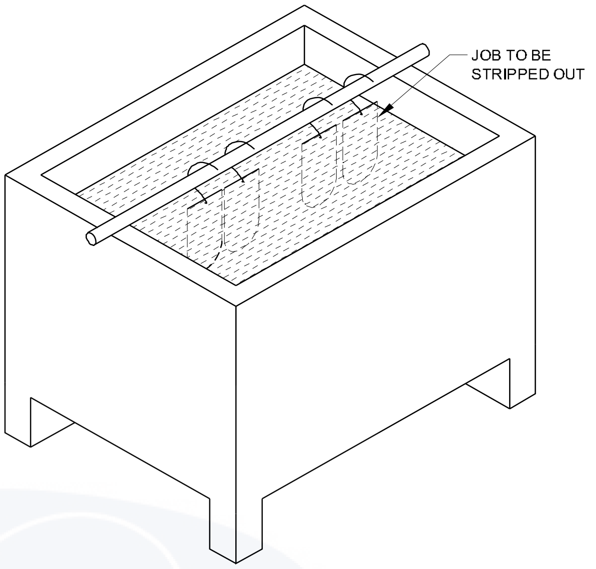
After completely removing of the deposition unload the job from the tank and swill well in fresh running water to remove prior solution and thoroughly cleaned swill and dried out.

Check the job frequently should not give current and time more than required.

2) Immersion stripping process (Fig 2)

The following solution may be used for the immersion stripping of brass from ferrous and non ferrous alloys.

Fig 2



IMMERSION STRIPPING OF BRASS

The preparation of acid solution is the sulphuric acid is added carefully to the water with stirring followed by safety. For this solution in a rubber lined or plastic container should be used (Fig 2)

Sulphuric acid	-	50 ml
Nitric acid	-	25 ml
Temperature	-	Room

After all the brass has been removed where an immersion copper deposit is formed on the surface this may be easily removed by a short immersion in an aqua fort is bright dipping solutions.

Aqua fort is trade term for a mixture of (HNO_3 and H_2SO_4) nitric acid and sulphuric acid in its proportion.

Sulphuric acid (1.84 sp.g)	- 500 CC
Nitric acid (1.38 sp.g)	- 185 cc
Sodium chloride (common salt)	- 1 gram

To prepare the solution sulphuric acid is added to the cold water slowly and with stirring care being taken to avoid excessive over, then Nitric acid can then be added, they by addition of common salt.

Acids must be handled with great care.

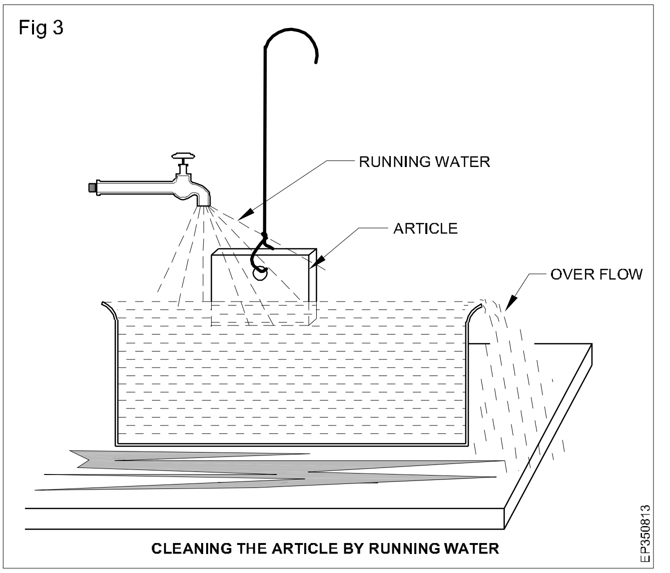
Immerse the brass plated article above the solution for a few minutes without spoil of the base metal.

Rinse thoroughly with cold running water (Fig 3) and allow to dry sunlight (or) oven (or) hot air.

The solution is stored with completely covered.

- When the action of the stripping solution becomes slow, add addition of the acid.
- The solution is stored with completely covered.

Fig 3



CLEANING THE ARTICLE BY RUNNING WATER

Basics of zinc plating

Objectives : At the end of this lesson you shall be able to
- **state the properties of zinc and zinc plating process**
- **state the applications of zinc plating**
- **state the list of equipments for zinc plating.**

Properties of zinc

Zinc is a bluish- white , lustrous, diamagnetic metal (Fig 1). It is less dense than iron and has a hexagonal crystal structure with a distorted form of hexagonal close packing. The metal is hard and brittle at most temperatures but becomes malleable between 100 and 150°C. Above 210°C, the metal becomes brittle again and can be pulverized by heating. Zinc is a fair conductor of electricity. It has relatively low melting 420°C and boiling point 907°C. Its melting point is the lowest of all the transition metals aside from mercury and cadmium.

Fig 1

Zinc is a member of the group 12 of the periodic table. It is a moderately reactive metal and strong reducing agent. The surface of the pure metal tarnishes quickly, eventually forming a protective passivating layer of the basic zinc carbonate, this layer helps prevent further reaction with air and water.

Zinc burns in air with a bright bluish-green flame, giving off fumes of zinc oxide. Zinc reacts readily with acids, alkalis and other non-metals. Strong acids such as hydrochloric or sulfuric acid can remove the passivating layer and subsequent reaction with water releases hydrogen gas.

Brass is a zinc and copper alloy that has been used by humans since ancient times. An important quality of zinc is its ability to resist corrosion and therefore protect other metals. Half of all zinc produced today is used to galvanize steel to prevent against corrosion. It is used to protect buildings, cars, nails, wire, pipes and more.

Zinc compounds such as zinc oxide are found in many common commercial products, including batteries, paint, plastics, rubber product, pharmaceuticals, floor covering, inks, cosmetics, soap and textiles. Zinc is also a natural insect repellent and sun screen, helping to protect our skin.

Zinc plating process:

Zinc Electroplating is one of the most common forms of electroplating and popular because of its relatively low cost, protective nature and attractive appearance. The coating done through this process gives corrosion protection to ferrous components and it can give color like gold, black or olive drab finish, by post treatment.

The zinc electroplating process can be used to coat nuts, bolts, washers and automotive parts, such as interior components and gas filters. It also provides an effective undercoat for paints, when high corrosion performance is required.

Any metal can be plated through the zinc electroplating process, but the most common are steel and iron on which the process offers sacrificial protection. Zinc plating is identical to electro-galvanizing in principle because both are electro-deposition processes. However, zinc plating is used on small parts such as fasteners, crank handles, springs and other hardware items rather than sheet metal. The zinc is applied as an expandable electrode in a cyanide, alkaline non-cyanide or acid chloride salt solution.

Zinc plating is typically used for screws and other small fasteners, light switch plates, and various small parts that will be exposed in interior or mildly corrosive conditions. For use in moderate or severe environments, the materials be chromate- conversion coated for additional corrosion protection.

The advantages of zinc plating are as follows:

1.Ease of deposition

2.Operation at room temperature

3.Common chemicals

4. Least ventilation as compared to chromium plating

5.Wide operating range

Coating characteristics:

Zinc metal has a number of characteristics that make it a well-suited corrosion protective coating for iron and steel products. Zinc's excellent corrosion resistance in most environments accounts for its successful use as a protective coating on a variety of products and in many exposure conditions.

The normal zinc-plated coating is dull gray in color with a matte finish, although whiter, more lustrous coatings can be produced, depending on the process or agents added to the plating bath or through post-treatments. The coating is thin, ranging upto 25 microns.

Application:

Major application of zinc include:

1.Galvanizing

Galvanization is the coating of iron or steel to protect the metals against corrosion by completely immersing the steel product in a bath of zinc electrolyte.

Hot dip galvanized coatings are used on electric utility to artistic sculptures. In hot galvanizing prior to immersing in the zinc bath the iron and steel is chemically cleaned and passed through a bath of motlen zinc. A substantial coated is thus applied. The deposit is sometimes uneven and in some parts deposits lump.

Electrogalvanising or cold galvanizing is the electrodeposition of zinc which is carried out in ordinary temperature for a more uniform coating.

2. Alloys

A widely used alloy that contains zinc is brass, in which copper is alloyed with anywhere from 3% to 45% sinc, depending upon the type of brss. Brass is more ductile and stronger than copper and has superior corrosion resistance. These properties make it useful in communication equipment, hardware, musical instruments, and water valves. Other used alloys that contain zinc include nickel silver, typewriter metal, soft and aluminium solder and commercial bronze.

Equipments:

The following are the equipments required for zinc plate are:

1.Rectifier - The direct current required can be supplied by means of a 3-phase transformer rectifier which may be of the air-cooled silicon, water-cooled germanium or oil-immersed selenium type. The supply of current through rectifier has limited advantages as for power outputs upto 100 KW construction will be cheap. The degree of efficiency is about 88% and residual ripple about 5%.

2.Polishing and buffing machine

3.Treatment tanks (Pre-treatment & Post treatment)

4.Plating Vats - For solution, either a rubber-lined or plastic tank, or a lead - lined fitted with an inner lining of loose glass sheets, may be used. Plastic containers are also satisfactory.

5.Agitation units

6.Filtration

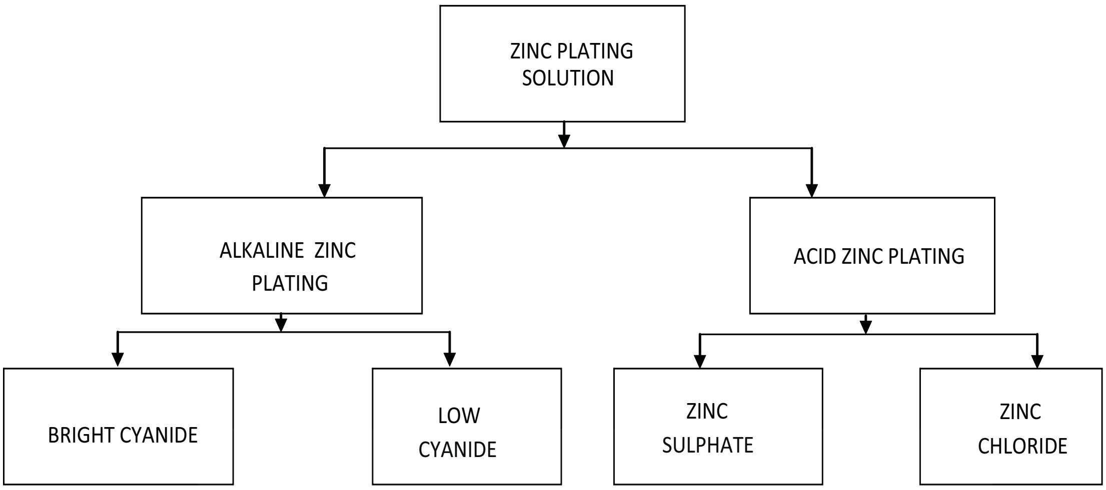
7.Immersion heater - Silica based immersion heaters or hot water jacket is used for heating the solution.

8.Centrifugal drier

9.Hooks and dipping jackets - High purity copper hooks and dipping baskets are suitable for use in acids baths.

Electrolytes for zinc plating

Objectives : At the end of this lesson you shall be able to
- **state the types of zinc plating solutions**
- **explain the different zinc plating solutions.**



For the electro-deposition of zinc, various solutions are available, these differ considerably both in compostion and in characteristics, but may generally be deposited electrolytically from alkaline or acid type solutions.

Alkaline baths are usually based on the double cyanide of the metal, viz. sodium zinc cyanide, and contain zincates according to the degree of causticity maintained.

The acid baths are based upon zinc sulphate or chloride, often both and contain a proportion of other salts and colloids necessary for the production of smooth fine-grained electro-deposits.

The choice of solution is influenced by the nature of the basis metal, whether cast iron or steel , its form whether flat strip or complex pressing and the type of deposit required i.e. matt or bright.

For cast iron and malleable irons, an acid type solution is employed, this type of solution is also used for the plating of steel strip.

For steel pressings, it is usual to employ a cyanide type solution to give a matt or bright deposit.

There are numerous formulations. Acid plating is essentially for strip and wire. For commercially fabricated parts, standard cyanide, medium cyanide, low cyanide, alkaline non cyanide, bright acid sulphate, bright acid chloride, bright neutral chloride and several others including pyrophosphate and fluoborate are available. Greatest bulk of plating is from cyanide bath, which is on the decrease due to ecological and waste disposal problems.

Cyanide zinc plating solutions

Bright cyanide zinc bath:

This is an alkaline-cyanide type solution for bright zinc plating which is suitable for use in automatic, manual and barrel installations. It produces a bright deposit over a wide temperature and current density operating range, is economical to operate and with a liquid brightener is simple to maintain. These have come to stay because of the availability of obtaining low cost protective and decorative finishes, good throwing and covering power. The disadvantages are the texicity of the bath, poor bath conductivity, low efficiency, the efficiency being 50% in rack plating and higher in barrel plating.

Low cyanide zinc plating solutions:

With low cyanide bright zinc plating solutions, the zinc and cyanide contents are much lower than in the standard formulations; this can be of considerable advantage where the treatment and disposal of cyanide containing effluents present problems.

For Matt deposits:

This is a cyanide type zinc plating solution which can be operated at current densities between 1.6 and 6.5 amps/dm^2 (15 and 60 amp/ft^2) and is therefore suitable for use where the high speed production of dull zinc deposits is required.

Ductile Zinc bath is used for producing ductile deposits on electrical fitting which are subjected to extreme deformation after plating.

$Zn(CN)_2$	50 g/l
NaCN	110g/l
NaOH	120g/l

Temperature and other parameters are like that of standard cyanide bath.

Acid zinc plating solutions:

Sulphate type acid bath:

This Plating is recommended for cast iron, malleable castings, wrought and forged iron and steel. The bath is cheaper to run and very easy to maintain. The deposit is smooth, grayish-white in colour and has a slight sheen upon it, it is close-grained and non-porous, but sufficiently malleable to withstand bending or spinning without sign of fracture.

Chloride type acid bath:

For the plating of steel strip and where a highly conductive solution is required for fast deposition the chloride zinc solution is suitable. With a moving cathode, high current densities of 10 amp/dm^2(100 amp/ft^2) and over can be obtained. The deposit is matt and bluish-white in appearance.

Acid fluborate bath:

Fluoborate baths permit use of high current density with high efficiency and give rise to excellent fine grained deposit of acceptable color. The baths are highly suitable for high speed plating of wire and strip where high throwing power is not required. Improved covering power and smooth fine grained deposits are their special feature.

Acid zinc plating process

Objectives : At the end of this lesson you shall be able to
- **state the chemical composition of acid zinc plating**
- **explain the process of acid zinc plating**
- **explain about the passivation process in zinc plating**
- **explain the maintenance of the sulphate zinc bath.**

Acid zinc plating

Zinc sulphate plating solution

Zinc sulphate type plating solution and is especially suitable for the plating of cast iron, malleable castings, wrought and forged iron and steel components. Zinc sulphate is the main constituent and the deposit from sulphate is brighter.

Solution composition:

Zinc sulphate	300 g
Sodium Chloride	13 g
Boric acid	20 g
Aluminium sulphate	26 g
Dextrine	13 g
Water	to 1 litre

Each constituent has its particular function. Zinc compound supplies metal to be deposited. Common salt(Sodium Chloride) contributes to conductance. Boric acid controls acidity, while aluminium sulphate and dextrine function as addition agents improving the physical character of the deposit.

Anodes

Cast, rolled, or oval section anodes of highest purity zinc are used, the oval type being the most economical for general purposes.

Their surface area should be equal to the cathode area and whichever type is employed the anodes must be removed from the bath at the close of each day's work or whenever the vat is to remain idle for a long period.

Before being replaced, the anodes should be rinsed in water and well scoured to remove any loose encrustation from the surface.

Preparation of the solution:

The solution is prepared by dissolving the salts in hot water at the rate of 200 to 300 g/l in an enameled iron container.

The plating tank is half filled with clean cold water, the concentrated zinc solution added, and the mixture well stirred. The first part of the process is then repeated, if necessary, until the requisite amount of salts has been dissolved, when the bath is diluted with cold water to working level and again stirred thoroughly.

Any "Scum" that appears on the surface must not be removed but should be stirred in until dissolved.

Operating conditions

The solution is operated at room temperature (not less than 15°C; 60°F) with a current density of 1.0 amp/dm^2 (10 amp/ft^2) at a potential of 2 to 2 ½ volts.

A small voltage should be applied to the tank before loading, and the articles, when plated, must not be left in the solution after the current has been switched off.

Rate of deposition:

Zinc solution has a high cathode efficiency, normal conditions a current density of 1.0 amp/dm^2 (10 amp/ft^2) will deposit a thickness of 18 microns (0.0007 in) of zinc is one hour.

Maintenance of solution

pH value

The pH value of the solution should be maintained between 4 to 4.5. For the determination of the pH value, yellow label comparator papers may be used.

The original acidity of the bath must be maintained with pure sulphuric acid, adding 0.1 cc/1 (1.5 fl oz/100 gal), whenever necessary. After the addition, the bath should be thoroughly stirred and the pH value checked, when if this is still high the operation should be repeated, using a further small quantity of acid. Should an excess of acid be added in error, the fault can be rectified by leaving the anodes in the solution for an hour or so without current when the tank is not in use.

Metal content and salts concentration

Density of the solution is maintained at between 18° to 19° Baume (29° and 30° Twaddell) by the addition of zinc salts, the salts being dissolved in a quantity of solution taken from the tank and then added to the remainder of the solution and well mixed.

Passivation process for zinc

This treatment may be applied to zinc deposit for the purpose of preventing the formation of white corrosion products, commonly seen on the surface of the articles subjected to humid conditions, particularly where condensation occurs and is known as "white rust".

Passivation imparts an iridescent luster to zinc surface. It preserves the plating from atmospheric corrosion, thus prolonging its life and increasing the measure of protection of afforded to the basis metal or the article. Further, the passivating film provides an ideal surface for painting and lacquering.

Blue passivating salts for zinc:

This provide a low concentration, low cost, chemical bright dip for zinc plated components, and produce an attractive bright, light blue, iridescent-free, passivated film of medium corroision resistance.

Equipment required for passivation

For this solution a plastic or plastic lined container or alternatively stainless steel or stoneware vessel may be used. For solution heating immersion heater or stainless steel coil may be used.

Solution composition

Sodium dichromate	180 g/l
Sulphuric acid	12 g/l
Water	1 litre

Passivation procedure:

Immerse the zinc plated articles completely free from grease in the passivating solution for 5 to 15 seconds, at room temperature, then swilled in cold water and dried in hot air. The process should produce an iridescent greenish Film.

Maintenance of the solution:

If the solution is worked continuously, an occasional addition of 3cc/l of conc,nitric acid and 0.5g/l blue passivating salt is added. Optimum pH range 0.6 to 1.2.

Zinc chromate passivation :

With this process an attractive chrome like colour can obtained on bright zinc plated components. The finish is obtained in a single operation and it is not necessary to bright dip the article between the zinc plating and passivation stages or to bleach the passivation film in order to obtain the required color. The finish produced is colourless to a very light blue and having passivating properties, minimizes finger marking and corrosion.

Equipment required for zinc chromate passivation:

For this solution a tank lined with semi-hard rubber, P.V.C lined polythene container may be used. A provision of air or mechanical agitation is advantageous.

Solution composition:

Zinc chromating salt	3g/l
Nitric acid	12.56cc
Water	1 litre

Zinc chromate passivation procedure:

The required weight of zinc chromating salts is dissolved in a clean cold water and then the necessary volume of concentrated nitric acid is added carefully. The solution is finally stirred until thoroughly mixed.

Operating condition:

The solution is used at room temperature. It is however effective upto 40° C. The immersion time is 15 to 40 seconds.

The process sequence is as follows:

- Chloride zinc plate
- Swill thoroughly in cold running water
- Dilute Sulphuric acid Dip
- Water Swill
- Passivate
- Water Swill thoroughly
- Dry out.

Maintenance of the solution:

In view of the low concentration of the solution, it is usual to prepare a fresh solution everyday.

Coloured finishes on zinc:

For identification purpose bright zinc components can be finished in a variety of colours by dyeing the zinc surface after blue passivation. The bright passivated zinc articles are well rinsed and then dyed with a suitable dyestuff, again well rinsed then finally dried. The dyes are usually made up at 1 percent concentration in water and operating temperature is generally between 15 to 25°C. The dyeing time depends upon the intensity of the colour required, but is usually of the order of ½ to 1 minute.

Chloride zinc plating

Objectives : At the end of this lesson you shall be able to

- **state the chemical composition of acid chloride zinc plating**
- **explain the process of acid chloride zinc plating**
- **explain about the passivation process in chloride zinc plating**
- **explain the maintenance of the sulphate chloride zinc bath.**

Chloride zinc plating solution:

This type of solution is used chiefly for the rapid deposition of zinc on to steel strip and wire and also for barrel plating where an acid zinc solution is required.

Solution composition:

Zinc Chloride	150 grams
Sodium Chloride	250 grams
Aluminium Chloride	25 grams
Water	to 1 litre

The aluminium chloride serves the purpose of an additional agent giving whiter and smoother deposit without the deposition of any aluminium.

Anodes:

High purity zinc anodes are used; these should have a surface area at least equal to that of the cathodes. The anodes must be removed from the bath when it is not in use, and before being replaced should be rinsed in water and well scoured to remove any loose encrustation from their surface.

The aluminium chloride serves the purpose of an additional agent giving whiter and smoother deposit without the deposition of any aluminium.

Preparation of the solution:

The zinc chloride is added in the proportion of 150 g/1 to cold water in an enameled iron vessel. The mixture will not require heating, but will become hot through dissolution of the chloride; it should be well stirred until the whole of the material has been taken up, when the solution should be allowed to cool and afterwards filtered through a cotton filter bag into the plating tank. This operation is repeated until the total amount of zinc chloride for the vat has been dissolved.

The chloride conducting salts are then dissolved in similar manner in water contained in an enameled iron vessel, but the water should be hot at a temperature of about 70°C (160°F) and the salts added in the proportion of 275 g/1 (2 ¾ 1b/gal).

The solution must not be boiled, but should be well stirred until the salts and any "scum" that rises to the surface have been completely dissolved. The resulting solution is then filtered into the tank containing the zinc chloride solution, and the two thoroughly mixed by stirring.

Finally the bath is diluted with cold water until it is brought up to working level and its density adjusted to 30° to 32° Baume (52° to 57° Twaddell).

To obtain satisfactory deposits it may be necessary to electrolyse a new solution by operating upon scrap work or steel sheets for a period. During this treatment the pH value of the solution will rise from approximately 1.5 to the normal value of 3.5 to 4.0.

Operating conditions:

For rack plating

The solution may be operated at room temperature (but not below 15°C, 60° F) and at a current density of 1.6 to 2.0 amp/dm2 (15 to 20 amp/ft^2)

The voltage required is usually between 2 and 3 volts.

For high speed operation the solution should be used at a temperature of 12 to 40° C (90 to 100°F) and at current densities up to 4 amp/dm^2 (40 amp/ft^2). With the warm solution a potential of 2 volts between the anode and cathode is usually sufficient.

For continuous strip and wire plating a higher temperature (up to 55° C, 130°F) and a current density of the order of 10.8 amp/dm^2 (100 amp/ft^2) may be employed.

Rate of deposition

A chloride zinc solution has a high cathode efficiency, very little short of the theoretical maximum.

For barrel plating

For barrel plating the solution is used at room temperature and a minimum voltage of 8 volts is required. A large anode area should be provided and it is advisable to remove the anodes from the solution when the barrel is not is use. Before being replaced the anodes should be well scoured in order to remove any loose ercrustation from the surface.

Plating procedure

With the chloride zinc solution the articles are thoroughly cleaned to remove all oils, greases and soils. The pre - treatment procedure is generally similar to that required before nickel plating. A higher standard of cleaning is necessary than with cyanide zinc plating.

Where the articles are treated in an alkaline or cyanide second stage cleaner, then it is necessary to rinse well, activate in dilute sulphuric acid, and again rinse well before immersing the articles in the Chloride zinc solution.

Cast iron should be de - scaled by sand - or shot - blasting in preference to acid pickling, and if not handled subsequently or left to rust it may be placed directly in zinc solution.

The process sequence is as follows:

Chloride zinc plate

Swill thoroughly in cold running water

Dilute Sulphuric acid Dip

Water Swill

Passivate

Water Swill thoroughly

Dry out.

Maintenance of the solution

1. pH value

The pH value of the solution should be maintained at 3.5 to 4.0. If the pH value is above 4.0 small additions of hydrochloric acid or sulphuric acid should be made. If the pH value is below 3.5 the solution should be worked on steel sheets or scrap for a period.

2. Metal content and solution concentration

A hydrometer reading, which is a measure of the general concentration of the solution, is also a fairly good indication of the metal content; this can be assumed to be correct so long as the density is between 30 and 32° Baume (52 and 57° Twaddell). Any increase above 32° Baume (57° Twaddell) should be rectified by diluting the bath with water, and any deficiency below 30° Baume (52°Twaddell) made good by adding pure zinc chloride (98 percent.).

3. Conductivity

Should the bath appear to be sluggish in deposition, even though its density and temperature are both correct, an addition of 12 to 25 g/1 (2 to 4 oz/gal) of chloride conducting salts should be made to correct the fault. The need for these conducting salts is also indicated when there is a tendency for the zinc deposit to be rough and course in texture, and the roughness is not due to the presence of suspended matter in the solution or the use of too high a current density. Methods for the analytical control of the chloride conducting salts concentration are available upon request.

To keep the composition of the solution uniform the chloride zinc solution should be well stirred at the end of each day's work.

Zinc chromate passivation procession:

- The process sequence is as follows:
- Chloride zinc plate
- Swill thoroughly in cold running water
- Dilute sulphuric acid dip
- Water swill
- Passivate
- Water swill thoroughly
- Dry out.

Alkaline zinc plating

Objectives : At the end of this lesson you shall be able to
- **state the chemical composition of acid alkaline zinc plating**
- **explain the process of alkaline zinc plating and passivation**
- **explain the process parameters of alkaline plating**
- **explain the maintenance of the bath.**

Alkaline zinc plating solution:

Bright zinc solution gives bright zinc deposits over a wide current density and temperature ranges, is suitable for both rack and barrel deposition and extremely economical in operation. This plating solution has higher throwing power.

Chemistry of the process:

The bath is a mixture of sodium zincate and zinc cyanide. The bath is made from zinc cyanide $Zn(CN)_2$, NaOH and NaCN. ZnO can be used instead of $Zn(CN)_2$.

The reactions are:

$$Zn(CN)_2 + NaCN \rightarrow Na_2Zn(CN)_4$$

$$Zn(CN)_2 + 4NaOH \rightarrow Na_2Zn(OH)_4 + 2NaCN$$

These are in equilibrium.

$$Na_2Zn(CN)_4 \rightarrow 2Na+ + Zn(CN)_4 \rightarrow Zn++ + 4CN-$$

$$Na_2Zn(OH)_4 \rightarrow 2Na+ + Zn(OH)_4 \rightarrow Zn++ + 4OH-$$

Air agitation of the bath is not recommended.

Solution composition:

Zinc cyanide	50-60g/l
Sodium cyanide	50-55g/l
Sodium hydroxide	40-50g/l
Sodium carbonate	9- 10g/l
Aluminium sulphate	4-5g/l
Water	1 litre

Anodes:

High purity zinc anodes (99.99 per cent lead-free) must be used to maintain the purity of the solution and ensure the maximum brilliancy and whiteness of the deposit. Cast, rolled and oval section anodes are available, and whichever type is employed, they should be removed from the bath at the close of each day's work, as they tend to dissolve by chemical action when the vat is idle and may cause the solution to become too rich in metal.

Preparation of the solution:

To prepare the solution the tank is filled to not more than one third its capacity with clean water. The salts are then added slowly with care while the solution, be heated to a temperature of 60^o to 70^oC(140^o to 160^oF), stirring being continued until the salts have been completely dissolved.

The solution is then diluted with water until the tank is two thirds full and brightener is added with vigorous stirring. The Brightener should be diluted with water in the proportion of one volume brightener to three volumes of water before addition to the plating tank. The solution is finally diluted to working level and well stirred.

Sodium carbonate of about 25-30g/l is added to age the solution and sodium polysulphide of 0.5-1.0g/l to precipitate heavy metals, Pb and Cd. Lead and Cadium are undiserable impurities in the bath.

Operating conditions:

Temperature:

The recommended temperature range is 25-40^oC(80 to 100^oF). The optimum temperature is 27^oC(85^oF).

Current density:

Anode current density is 1-2 amps/dm^2(10-20 amps/ft^2) is recommended.The cathode current density for rack plating is between 1-10 amps/dm^2.

The cathode current efficiency varies on the cathode current density, the cyanide content and temperature.

Low cyanide zinc plating solutions

With the increasing problems arising from the treatment and disposal of effluents for plating processes, there is a demand for zinc plating solutions having a lower cyanide and metal content.

The use of low and medium cyanide content solutions can result in considerable reduction in the cyanide and zinc carryingover into the rinse waters

Solution composition

A. Solution for rack and barrel plating:

1.	Sodium hydroxide	50g/l
2.	Sodium cyanide	25g/l
3.	Zinc oxide	20g/l
4.	Water	1 litre

B. Solution for barrel plating:

1.	Sodium hydroxide	65g/l
2.	Sodium cyanide	8g/l
3.	Zinc oxide	10g/l
4.	Water	1 litre

Preparation of the solution

Fill the container with 1/2 to 1/3 the final required volume of cold or warm water then add the sodium hydroxide followed by sodium cyanide slowly with stirring. Care must be taken to avoid splashing or overheating. Overheating or even boiling of the solution may occur if the initial temperature of the water is too high or if the sodium hydroxide is added to rapidly.

When the caustic soda and cyanide have been dissolved the zinc oxide should be added with stirring. If necessary the solution may be heated to accelerate the dissolution of the zinc oxide. After the zinc oxide has completely dissolved the solution is then diluted to above 3/4th the final volume.

Operating conditions

Temperature: The solution temperature should should preferably kept within the range of 20-35^oC if maximum deposit brightness is required.

Current Density: With immersed horizontal barrels current density upto 0.8 amp/dm^2 may be used. The voltage required is from 12 to 16 depending the barrel type, size and current loading.

Rack plating: For rack plating a current density upto 4 amps/dm^2 of work area may be employed.

Cyanide zinc plating procedure

Cleaning and preparation of work:

All articles must first be cleaned free from grease and any scale or oxide removed from the surface by pickling or sand blasting. Acid pickling is suitable for mild steel but satisfactory for high tensile steel, hence these metals should be shot blasted. If shot blasting is employed the steel grit must be clean angular and sharp, to ensure the effective removal of the scale, which if hammered into the surface of the work may cause "passivity" and thus may prevent ready deposition of zinc.

A. Suitable sequence for zinc plating is as follows:

1. Pre clean (Soak clean if necessary)

2. Water swill

4. Dilute hydrochloric dip (Pickling)

5. Water swill

6. Cyanide dip

7. Zinc Plate

Treatment after zinc plating

The following general post-plating treatment are as follows:

1. Bright zinc plate

2. Water swill

3. Water swill

4. Dilute nitric acid bright dip

5. Bright blue passivation

6. Water swill

7. Water swill

8. Passivate if required
9. Water swill and dry

Dilute nitric acid bright dip

The dilute nitric acid dip stage (4) serves to remove any coloured surface film from the bright zinc deposit and thus give improved brightness. It also neutralizes any alkalinity present.

Matt zinc plating

After plating the articles should be well rinsed in running water, and then if required passivated, using blue passivation.

Where articles are not passivated, the following treatment is advised to prevent subsequent staining occurring due to the retention of traces of cyanide in pores in the deposit.

1. Zinc plate
2. Water swill
3. Chromic acid dip 50 g/l for 15 to 20 seconds at room temperature
4. Water swill and dry.

Zinc content

Zinc from anode dissolves chemically and electro chemically and there will be a build up in the bath because the cathode efficiency is less than 100%. One way to overcome this is to use alloy zinc anodes containing 0.1 - 0.2% Al or mg. During shut downs for more than say 24 hours the anodes should be removed from solutions, since the galvanic action between zinc and iron basket will result in zinc going into solution.

Cathode current density:

Bright cyanide solutions will operate at wide cathode current densities. 0.002 amps/dm^2 to 25 amps/dm^2 without burning of the deposit. Useable current densities will depend on composition, temperature, cathode film movement and addition agents used. The usual figures are 0.6 amp/dm^2 for barrel plating and 2 to 5 amps/dm^2 for rack plating. In rack plating with proper control if 4 microns are required on the average the plating can be maintained between 2.5 microns and 8 microns.

Current efficiency:

Cathode current efficiencies in barrel cyanide zinc plating are high (92 - 98%). In rack or still plating there might be a wide variation composition used.

g/L	Std	Mid	Low
Zn	34	18	7.5
NaCN	94	45	15
NaOH	79	79	79
Na_2CO_3	15	15	15
Ratio	2.75	2.5	2.0

Caustic soda content

Generally both regular and mid cyanide baths operate with a NaOH content of 80 gms in the range 67 - 90 g/L. Raising NaOH content has adverse effect on throwing power and brightener consumption and several other adverse effect.

Addition agents

The effect has been to change the deposit from a dull stained deposit to brilliant, blue - bright deposit.

Zinc plating on aluminium articles

Objectives : At the end of this lesson you shall be able to

- **state the bath composition of zinc plating**
- **explain the process of zinc plating and passivation**
- **explain the process parameters of maintenance of zinc plating**
- **explain the deposition of zinc on aluminium articles**
- **explain the maintenance of the bath.**

Ductile zinc is used for producing ductile deposits on electrical fitting which are subjected to extreme deformation after plating.

This solution is also recommended for the plating of steel pressings and other sheet metal components where a ductile white deposit is required. The process is simple to maintain and has an excellent throwing power; it is not, however, suitable for plating cast iron.

Anodes

To ensure the maximum whiteness of deposit it is essential that only high purity zinc anodes (99.99 percent., lead - free) be used. Cast, rolled and oval section anodes of this purity are available, and whichever type be employed, they should be removed from the bath whenever it is not in use.

Solution composition

$Zn(CN)_2$	50 g/l
NaCN	110g/l
NaOH	120g/l
Water	to 1 litre

Preparation of the solution:

The usual procedure is to half fill the tank with warm water at a temperature not exceeding 40°C (100°F), add the zinc salts and stir until dissolved. Cold water is then added to bring the level of the solution to within a few inches of working height, after which the bath is well stirred and further diluted with small quantities of water until after well mixing a density of 12° Baume (18° to 19° Twaddell) is attained. It should be noted that although the density is a measure of the concentration of a new solution, it is not a reliable guide to the metal content of a bath that has been in use for any considerable time, since the density tends to rise as the carbonate content increases with age.

Operating conditions

The solution is operated at a temperature of 30° to 35°C (85° to 95°F.), and current densities between 1.6 and 6.5 amp/dm2 (15 and 60 amp/ft^2) may be used.

Plating process:

A Suitable sequence for zinc plating is as follows:

1.Pre clean (Soak clean if necessary)

2.Water swill

4.Dilute hydrochloric dip (Pickling)

5.Water swill

6.Cyanide dip

7.Zinc Plate

Treatment after zinc plating:

The following general post-plating treatment are as follows:

1. Bright zinc plate
2. Water swill
3. Water swill
4. Dilute nitric acid bright dip
5. Bright blue passivation
6. Water swill
7. Water swill
8. Passivate if required
9. Water swill and dry

Maintenance of the solution

Suitable standards for analytical control of Ductile zinc solution are:

Zinc	48 g/1	7.5 oz/gal
Total sodium cyanide	100 g/1	16 oz/gal
Caustic soda (Sodium hydroxide)	75 g/1	12 oz/gal

To maintain the whiteness of the deposit, a weekly addition of to the extent of Galvanite 0.6 g/1 (0.1 oz/gal) is made.

The solution should be analysed from time to time for the above constituents and any necessary additions of sodium cyanide, caustic soda or high speed zinc salts made.

Methods for the analysis of zinc plating solutions are given in chapter 29.

If the solution is low in all its constituents salts should be added, the addition of 1 g/1 of salts is equivalent to 0.2 g/1 of zinc, 0.5 g/1 of total sodium cyanide and 0.15 g/1 of caustic soda.

(1 oz/gal of these salts will increase the zinc concentration by 0.2 oz, the total sodium cyanide by 0.5 oz, and the caustic soda by 0.15 oz per gal).

If the zinc content is proportionally lower than either the cyanide or caustic soda contents, then it may be necessary to add either zinc cyanide or zinc oxide.

Zinc oxide

Addition of zinc oxide are necessary where the solution is low in zinc and in caustic soda (sodium hydroxide), but adequate in cyanide.

Zinc cyanide

Zinc cyanide is employed for the correction of the zinc content of solutions which are high in caustic soda, but low in total cyanide.

These materials are not added directly to the zinc plating solution but dissolved in a portion of the plating solution which has been transferred to a plain steel or enameled container and heated to a temperature of 55 to 65°C (130 to 150°F).

Deposition of zinc on aluminium:

As a means of protection from corroision aluminium is coated with zinc oxide. The best preliminary treatment of the aluminium, or the alloy of this metal, with constituents which impart the desirable mechanical properties is as follows:

1. The Article is first vapor degreased
2. Alkaline cleaning
3. Chrome pickling
4. HF-HNO$_3$ pickling(1part HF and 3 parts HNO$_3$ for 10 seconds)
5. Zinc coating by immersion method with the following solution for 5 to 10 seconds:

Caustic soda	275-325g/l
Zinc oxide	70-80 g/l
Sodium cyanide	3-5 g/l
Water	to 1 litre
Temperature	30°C.

The current density is started at a low level and increased gradually to 1 amp/dm^2 and plated until required thickness.

Barrel zinc plating

Objectives : At the end of this lesson you shall be able to
- **state the chemical composition of alkaline barrel plating**
- **explain the process of barrel alkaline zinc plating and passivation**
- **explain the process parameters of barrel zinc plating**
- **explain the maintenance of barrel zinc plating.**

Bright zinc solution for barrel plating

These barrel plating is employed for plating of small components used in electronic and electrical industry.

Where the solution is for use under temperate climate conditions, the use of gel is advised, whilst for tropical and semi - tropical conditions, the use of (Liquid) brightener is generally preferred. Under high temperature conditions for transmit and storage, there is a possibility that gel type formulations may melt.

Equipment

The Suitable equipment for this type of barrel plating is Horizontal barrel..The barrel is a plating tank, approximately one foot (300mm) cube in size. To simplify loading and unloading the barrel is mounted on a pivoted carrier. This enables the barrel to be lifted out of the solution without the need of an overhead hoist.

Anodes:

High purity zinc anodes (99.99 percent., lead - free) be used. Cast, rolled and oval section anodes of this purity are available. It is usually required a big surface area to maintain the metal content and general of the solution. It is necessary to examine the anodes regularly and replace the anode whenever it becomes thin and much reduced in area. They should be removed from the bath whenever it is not in use

Operating conditions

Temperature

The solution temperature should preferably be kept within the range of 25 to 40°C (80 to 105°F) if maximum deposit brightness is required.

Current density

With immersed horizontal barrels current densities up to 0.5 or even 1 amp/dm^2 (5 or 10 amp /ft^2) of work area may be used.

The voltage required is from 12 to 16 or in special cases 20 depending upon the barrel type, size and the current loading employed.

Speed of barrels

For bright zinc plating a speed of 5 to 6 r.p.m is recommended.

Barrel pickling

The descaling of small iron and steel parts is often more effective and rapid if they are treated in a revolving barrel, instead of in baskets immersed in a still vat. Dilute hydrochloric or sulphuric acid may be used, but scalene is to be preferred for this purpose. Hardwood barrels having copper bands are generally employed, but rubber lined barrels, as used for the Typhon type of plating apparatus, but without contacts, are also satisfactory. The acid should be cold and the time necessary depends on the thickness and tenacity of the scale, but it is generally a matter of from 10 to 30 minutes. When treating small cup - shaped or welded articles an addition of washed granite chippings is useful, as the scouring action removes the oxide when it has been loosened by the pickle.

Process for barrel plating:

The sequence of operations for zinc barrel plating is as follows:

1. Pre cleaning(soak Cleaning)
2. Anodic cleaning
3. Water swill
4. Hydrochloric acid dip
5. Water swill
6. Water swill
7. Zinc barrel plate
8. Water swill
9. Nitric acid dip
10. Water swill
11. Passivation
12. Water swill
13. Drying

Maintenance of the solutions

Gel is recommended for use in bright barrel zinc plating solutions. It can provide deposits which are bright as from barrel and the use of subsequent bright dip is not necessary, subsequent bright passivation treatment is however in order to prevent superficial corrosion or "white rusting" of the zinc deposit.

Gel is stable to the high solution temperature conditions encountered where high current loadings are employed.

However where solution temperatures rise above 43°C (110°F), Brightener is recommended since this is even more temperature resistant. With brightener, however, it is necessary to bright dip or use a bright passivation treatment.

The Gel dissolves readily in warm water, addition of brightener to the plating solution is thus facilitated. It is recommended that 1 litre of hot water (70°C) be used for each 100 g of gel to be added (1 gal of water at 160°F per 1lb.of gel).

For maintenance of the brightness of the deposit gel should be used at the rate of 50 to 120 g (2 to 4 oz) per 1,000 ampere hours. The higher figure is recommended where bright deposits direct from the barrel are required.

Brightener

Where it is necessary to operate the solution at temperatures in excess of 43° C (110°F) the addition of 80 to 140 cc (3 to 5 fl oz) of brightener per 1,000 ampere hours of operation, in place of hylite gel, is advised.

For barrel plating (where there is plenty of solution movement) the hylite brightener may be added directly to the solution.

Where brightener is used then it is also necessary to make regular additions of gelatin.

Analytical standards

For the most effective bright barrel plating resulting, it is recommended that the composition of the bright zinc solution be maintained as follows:

Zinc - - - - - - - - - - - - - - - - ---- 34 to 38 g/1

Total - - - - - - - - - - - - - - - - --- 80 to 90 g/1

Sodium hydroxide - - - - - - - --- 80 to 94 g/1

Defects, causes and remedies in cyanide and acid zinc plating

Objectives : At the end of this lesson you shall be able to
- **explain the faults, causes and remedies in cyanide zinc plating**
- **explain the faults, causes and remedies in acid zinc plating.**

The following are the faults, causes and correction of faults in zinc plating.

Correction of faults in cyanide zinc plating solutions

Nature of defect	Possible cause	Method of correction
(1) Imperfect adhesion of deposit, as indicated by the presence of blisters, or actual stripping from the basis metal.	Solution out of balance. (a) This can be due to failure to dissolve the salts completely when marking up a new solution. (b) Absorption of hydrogen by the basis metal during cleaning operations. Presence of grease, oxide, or stains on the metal before it is plated. Oxidising matter in solution.	Check the metal, total cyanide content and causticity, and correct if necessary. Hardened steel must not be cleaned cathodically, but should be anodically cleaned in klenewell or anodically acid etched. Review cleaning processes and check cleaning solutions. Examine surface of the plating solution and swills for signs of grease which may have come from (1) Cleaning bath with insoluble oil film on its surface. (2) Crevices or holes in the article. (3) External sources, e.g. overhead machinery. (d) If all conditions are correct and blistering persists, add 0.6 g/1 (0.1 0z/gal) zinc dust, stir well at intervals for several hours and allow to settle before plating.
(2) Deposit rough, dark and granular.	Excessive current, resulting in a “burnt” deposit. Tendency aggravated by lack of cyanide and caustic soda in the bath	Check composition of solution by means of test set and make good any deficiency of cyanide or caustic soda. Reduce voltage and plate at lower current density. Do not use too large an anode surface when plating small articles; these should be hung (if possible) between larger articles and not placed immediately opposite an anode.

(3) Deposit dark or leaden in colour, but not necessary rough.	(a) Solution out of balance. (b) Contamination of the solution with foreign metals, e.g. by use of unsuitable vessels, or from non - ferrous articles that have fallen into the vat. (c) In a Galvanax solution, may be due to lack of Galvanite.	(a) See (1) (a) overleaf. (b) Trace source of contamination and prevent recurrence of the trouble. Deposit on the steel plates or scrap articles for a time until impurities are eliminated and colour of the deposit is improved. (c) Alternative methods of treatment are with sodium sulphide (0.6 g/1 - 0.1 oz//gal) or with zinc dust as (1) (d).
(4) Bright zinc deposits stained or lacking in brilliancy.	(a) Solution out of balance. (b) Insufficient swilling of the plated article, or use of dirty swill water. (c) Plating solution deficient in brightener. (d) Contamination of the plating solution with foreign metals.	(a) Rinse very thoroughly in clean cold water both before and after dipping the articles in the dilute acid, using two separate swills. (b) To hylite add 1.5 g/1 (1 f oz/gal) of hylite brightener. (c) See “Anodes”, regarding prevention of contamination. Do not fall to make a daily addition of Doctor solution as indicated. If deposit still lacks brightener, add Doctor solution until the correct quantity is prevent. Alternatively, plate on to steel plates until impurities are eliminated.
(5) Deposit of good colour and appearance, but rough on surfaces that have been uppermost in the vat.	Presence of suspended matter in the plating solution.	Remove suspended matter by filtering the solution through nylon or by allowing the bath to stand overnight and then throwing away any sediment after carefully decanting or syphoning off the clear liquid into a temporary container. Disposal of concentrated solutions.
(6) Thin meager deposit slow rate of deposition.	(a) Low conductivity of solution due to its being out of balance, or at too low a temperature.	(a) Raise temperature if low, and check chemical composition of the solution. (b) Add the appropriate zinc salts. Sufficient to make good the deficiency.

(7) Poor throw of deposit. Excessive gassing of solution at cathode face.	Large excess of cyanide or caustic soda in the solution. Proportion too high in relation to the metal content.	Determine the amount of metal, caustic soda and total cyanide present, and then rectify the balance of the solution, leaving the anodes in the vat overnight if necessary to effect this.
(8) Anodes covered with white encrustation. Amperage falls and voltage rises when bath is worked.	Anode polarization due to lack of cyanide or caustic soda in solution.	Check causticity and total cyanide content of the solution and make good any deficiency by adding caustic soda and sodium cyanide.
(9) Metal content of solution high and tending to increase. (Condition revealed by analysis).	Too large a zinc anode surface.	Reduce the surface area by removing some of the zinc anodes, or replace a proportion of them (25 to 30 percent of total) with bright mild steel sheets.
(10) Solution very dense, crystallizing out on anodes and sides of tank when cold.	Accumulation of carbonates over a long period of use, due to gradual but continuous destruction of caustic soda and cyanide and by absorption of carbon dioxide from the atmosphere.	Remove any carbonate crystals that from during cold weather; they are valueless and their removal will improve the solution. Use an iron shovel or scraper for the purpose, and subsequently restore the level of the solution with water.
(11) Embrittlement of hardened steel articles in plating or during the preliminary cleaning processes.	Absorption of hydrogen by the basis metal.	Do not catholically clean high tensile steel, springs or other hardened steel parts. Remove any brittleness arising from plating by treatment as described.
(12) Staining or discoloration of the plated articles in store.	General staining or darkening of the surface due to insufficient swilling after plating. Localized staining or “spotting out” due to retention of cyanide plating solution in pores of the base metal.	(a) Make certain that the final swill water is clean and not alkaline with plating solution carried over by the articles. Follow post - plating sequences. (b) If the basis metal is porous, immerse the plated articles in boiling water for 20 to 30 minutes before drying them. Spotting out is minimized, if not obviated entirely by “passivating” or treatment in chromic acid solution as described.

Correction of faults in acid zinc plating solutions

Nature of defect	Possible cause	Method of correction
Deposit hard, rough, dark and granular.	Too high a current density, resulting in a “burnt” deposit.	Reduce voltage and plate at a lower current density. Do not use too large and anodes surface when plating small articles.
Deposit dark and spongy. Poor throw into recesses.	Solution deficient in acid.	Reduce the pH value of the solution to 4.0 - 4.5 (3.5 to 4.0 for chloride zinc) by the addition of pure sulphuric acid or hydrochloric acid – checking after each addition with comparator paper (yellow label)
Deposit of good colour and appearance, but rough on surfaces that have been uppermost in the vat.	Presence of suspended mater in the solution.	Filter the solution, or allow it to stand overnight until the suspended matter settles, then clean out the vat and throw away any sediment after carefully decanting or siphoning off the clear liquid into a spare vat or other temporary container.
Thin meager deposit slow rate of deposition.	Solution very cold, deficient in metal, or generally lacking in conductivity.	Do not work at temperatures below 15°C (160°F). Small baths can often be warmed sufficiently by withdrawing a few gallows of the solution and heating this nearly to boiling point in enameled iron buckets, then returning the hot solution to the vat and well mixing with the bulk. Check density of the solution with a hydrometer, if low, add the appropriate salts.

Uneven deposition bare patches.	Presence of grease, or passivity of the metal surface due to scale, sand, etc.	Check all cleaning processes to make sure that they are efficient. Pickle sand castings in a mixture of hydrofluoric and sulphuric acids then swill and scour thoroughly to remove any smut from their surface before placing them in the zinc solution. Alternatively, remove scale by shotblasting with sharp angular grit.
Staining or localized discoloration of the plated articles in store.	General staining due to traces of plating solution retained by a spongy zinc deposit. Localised “spotting out” caused by of entrapped solution from pores in the basis metal.	Ensure a smooth close - grained deposit by working at the correct density, keeping the solution clean, and maintaining its pH value withing the range 4.0 to 4.5 (3.5 to 4.0 for chloride zinc solution.) If the basis metal is very porous, spotting - out is difficult to avoid entirely. To minimize it, immerse the plated articles in boiling water for 20 to 30 minutes before drying them. Spotting out is often prevented by the “passivating” or chromic acid treatments.

Stripping and correct of faults in zinc plating

Objectives : At the end of this lesson you shall be able to

- **explain the stripping process by immersion process**
- **explain the stripping process by electrolytic process.**

Stripping zinc deposits

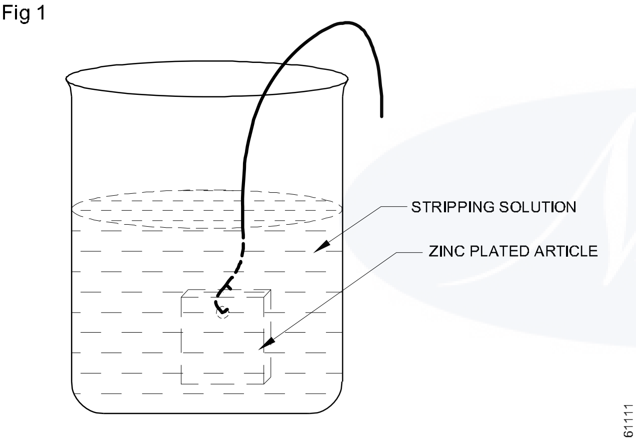
The simplest method is strip zinc plated articles is by two methods

Immersion process

Immersion the plated article for a minute or so, in cold dilute hydrochloric acid with one part by volume of acid to three parts of water in a stoneware vessel or rubber - lined tank.

Careful attention should be given while stripping and the articles are removed immediately in order to prevent etching of the basis metal.

Fig 1



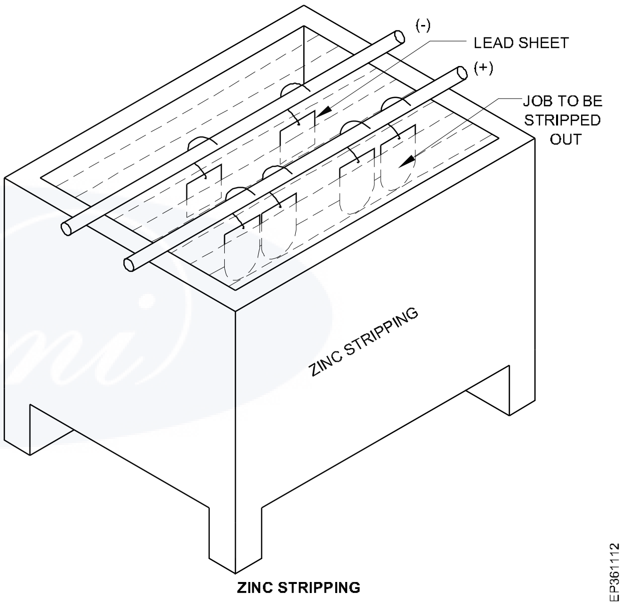
IMMERSION PROCESS OF ZINC

Electrolytic process

Zinc deposits may also be removed from iron and steel, without damage to the article, by making the plated material the anode in a cold 10 percent solution of caustic soda (sodium hydroxide) 100 g/1 (16 oz/gal).

For this solution a welded steel tank is normally employed and either the tank itself of separate steel sheets used as the cathode. The voltage employed is approximately 6.

Fig 2



ZINC STRIPPING


Nimi