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OPERATIONS CONTROL MANUAL
FOR STAR CIRCUITS INC.

BY

STEVEN WYNIA

A thesis submitted in partial fulfillment
of the requirements for the degree
Master of Science
Major in Industrial Management
South Dakota State University
1988

OPERATIONS CONTROL MANUAL

FOR STAR CIRCUITS INC.

The author wishes to express his sincere gratitude to
This thesis is approved as a creditable and
independent investigation by a candidate for the degree,
Master of Science in Industrial Management, and is
acceptable for meeting the thesis requirements for this
degree. Acceptance of this thesis does not imply that the
conclusions reached by the candidate are necessarily the
conclusions of the General Engineering Department.

Duane E. Sander
Thesis Adviser

Date

The author wishes to thank the staff, Secretary at Star
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paper needed in
finally the aut
The employees at Star C
velocity of the information needed for writing the Process
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Terry Forest
Acting Head, General Engineering

Date

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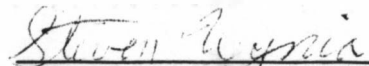

Steven Wynia

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CHAPTER 1

INTRODUCTION AND LITERATURE SURVEY

1.1 PURPOSE OF PRODUCTION CONTROL

Production of printed circuit boards in the United States amounted to more than \$3.7 billion in 1987. It is a highly fragmented business sector with more than 1000 printed circuit board producing sites. These sites are a combination of captive operations run by the companies consuming the boards, and producers that build printed circuit boards on a contract basis. (4)

Companies involved in highly technical manufacturing processes which involve the use of chemicals, electrical devices, and the handling of many different materials must train, monitor, and constantly check the product output quality of their employees. The quality of product, economical use of time and materials, and safety associated with each step of manufacturing are vital to insuring short and long term efficient operation of the company. As the processes are studied and improved in terms of each of the factors mentioned above, it is important to document the process steps. Documentation of all processes will provide a vital tool to be used for employee training purposes, customer quality assurance requirements, safety, and accurate product cost analysis.

1.2 INFORMATION SOURCES AND REFERENCES

1.2.1 QUALITY ASSURANCE

In the printed circuit board manufacturing, there is a tendency to confuse Quality Assurance with Inspection. Inspection is only one area of concern within a Quality Assurance Department. There are a number of other responsibilities that must be fulfilled by Quality Assurance in order for a printed circuit board shop to deal effectively with the tasks of manufacturing and meeting the customers' product requirements. Quality assurance functions must include the following items: (1)

1. Place inspection points at one or more junctures for work in progress. (1)
2. Establish written guidelines for purchasing critical materials, and inspection of these materials when they are delivered. (1)
3. Establish standards for work-in-progress and documentation of incoming orders and incoming materials. (1)
4. Coordinate with manufacturing and quality assurance personnel an ongoing training program. (1)
5. Work with manufacturing personal to anticipate manufacturing or quality problems before a customer order is released for manufacture. (1)
6. Resolve differing quality requirements for incoming customer documentation with respect to running quick turnaround/prototype jobs, versus major production runs. (1)

7. Have a written procedural framework for identifying, resolving, and preventing manufacturing errors and process problems from reoccurring. (1)
8. On a regular bases monitor critical manufacturing processes through operation of a chemical/metallurgical laboratory. (1)
9. Establish written procedures for tracking and using such information as: (1)
 - 9.1 Product yield. (1)
 - 9.2 Reasons for product defects that occur. (1)
 - 9.3 Customer return rate, and the reasons behind the returns. (1)
 - 9.4 A accurate dollar value of scrapped product. (1)
 - 9.5 Product turn-around time, and the percentage of jobs that are shipped complete. (1)
 - 9.6 Quality problems, and any recent industrial trends in quality. (1)
10. Distribution of all above data to all manufacturing and production personnel involved. (1)
11. Provide a means for immediate feedback to manufacturing personal when quality problems are encountered. (1)
12. Place the burden for quality on the shoulders of employees actually doing the work: the individual and his/her supervisor. (1)
13. Help bring a policy of uniformity and consistency to all manufacturing operations and ultimately to the quality of the manufactured product. (1)

14. Quality Assurance Managers must be able to deal effectively with in-house quality problems and with quality problems a customer claims to be having as a result of the printed circuit produced. (1)

Once the goals, policies, and procedures of the Quality Assurance department have been clearly established, the next goal is to carrying them out. The next area to address is establishing written and agreed upon procedures for each manufacturing operation. (1)

Reduction of costs can be accomplished by striving for reduced scrap, fewer rework labor hours, less material waste, higher quality finished product, and higher levels of productivity. These reductions are the result of the vigorous application of total quality control which can lead to a competitive advantage in the marketplace. (2)

Process control systems in circuit card assembly shops monitor quality at the source during the assembly process. When the above process control is tied in with single-card transfer manufacturing processes, basic problems can be discovered quickly and permanent solutions implemented with minimal rework. (3)

Circuit card assembly shops take the manufactured printed circuit boards one step further and install the electronic components on each board. Single-card transfer is a manufacturing process that allows inspection of each card at any point in the manufacturing sequence. (3)

By using these procedures, defects can be identified at the earliest possible stage in the manufacturing cycle which will result in reduced cost to the manufacturer which in turn can be passed on to the customer. These procedures also place the responsibility of quality on each person involved in the assembly process, since each defect can be traced to a particular step in the assembly process. (3)

1.2.2 MATERIAL CONTROL AND COST ACCOUNTING

All printed circuit board producers also share a common need for base substrate materials (laminates) and the chemistry and materials (process consumables) required to fabricate the finished product. Manufacturers must watch these materials costs, since they are reflected in end product price. Materials and chemistry used to build printed circuit boards equal roughly 33% of the finished value of the board. Suppliers of materials and chemistry are predicting a price increase of 5% for these materials. (4)

Considering the cost of materials involved and the competitive market, it is mandatory for every company involved in manufacturing printed circuit boards to have a accurate cost accounting of manufacturing and production cost. With the large number of companies already involved in manufacturing of printed circuit boards, and more entering the business all the time, the need for accurate price and cost predictions will be increased to the point where the companies without this knowledge will not be able to compete. (4)

1.3 SCOPE

The research described in this thesis involves the documentation and economic analysis of the manufacturing process for making printed circuit boards at Star Circuits Inc., located in Brookings SD. It consists of three parts, the first is a procedural manual, the second is a quality assurance manual and the third is an analysis of the manufacturing cost of printed circuit boards.

1.4 SCOPE AND PURPOSE OF PROCEDURAL MANUAL

The procedural manual will be used within Star Circuits Inc. to insure that uniform procedures are used in the manufacturing process. The procedural manual provides a standard by which to evaluate an employee's performance on the job. The procedural manual provides a clear picture of what is happening to each printed circuit board as it progresses through the manufacturing process. This is important from the customer's point of view to insure that quality is assured in each step of the manufacturing process.

The procedural manual also provides a section in each procedure on safety and precautions that must be observed during manufacturing. Safety must be monitored and carefully controlled for the following reasons. The first is, to insure employees a safe place to work, free from unknown hazards that can cause injury. The second is to make employees aware of safe practices involved in each process.

This in turn makes them aware of the proper procedure to follow at each step of manufacturing process. These concerns will also increase employee moral because they know the company is concerned about their safety and performance. The third is that as safety is emphasized and claims reduced a company will be rewarded by reduced insurance rates and therefore reduced overhead.

1.5 SCOPE AND PURPOSE OF QUALITY ASSURANCE MANUAL

Quality assurance manuals are vital to providing a standard by which to evaluate the manufacturing process, as well as locate and solve problems that may develop. This manual will be used to provide the customer with the assurance that every effort is being made to produce a printed circuit board that will meet and in most cases exceed expectations.

The quality assurance manual will also be used to train employees on what acceptable performance levels are in the manufacturing process. The manual explains correct standards and procedures for handling incoming work and work-in-process and the corrective action that will be taken if a problem is found. A section of the manual covers testing of the raw materials and storage controls used to ensure quality products are used to manufacture the printed circuit boards. Training of inspectors and the issuing of instructions to ensure product quality and an orderly flow of materials and products in the manufacturing process are

also covered. The scheduled calibration and testing of manufacturing equipment to ensure quality operation of each piece of equipment in the manufacturing process is discussed. A section on process conformance for each inspection and control point of the manufacturing process is covered. And finally a section on how the manual will be distributed and updated to ensure its continued accuracy and customer assurance that the required standards of quality are maintained.

1.6 SCOPE AND PURPOSE OF COST ANALYSIS

The cost analysis procedures developed will be used by management at Star Circuits Inc. to predict the cost of manufacturing each board. An accurate cost analysis is vital to the bidding process. Printed circuit manufacturing is a very competitive business that requires accurate cost and profit accounting to stay in business.

The cost analysis section consists of five sections which are arranged according to each of the six types of boards being produced at Star Circuits Inc. The first is an assembly flow diagram that shows each step of the assembly process. The flow diagram is followed by a description of the type of printed circuit board being produced. Next there is a breakdown of the process and time to perform each task of manufacturing each printed circuit board. Also included in the time per process section is percent of manufacturing complete on each board as it leaves each inspection station.

The time per process is followed by a summary of all the costs involved with the manufacturing process including material, chemicals, and labor. The last section is a procedure for using the cost summary to accurately calculate the cost of manufacturing a printed circuit board.

CHAPTER 2

OPERATING PROCEDURES MANUAL

The following procedural manual is intended for use as a training manual for the employees of Star Circuits Inc. This manual sets forth standard accepted procedures to perform each task in the manufacturing process. Although it is only a guide that is subject to change from time to time it does provide a standard from which to work and train employees in each manufacturing process.

The manual also provides customers with a means of looking at the manufacturing process in detail. Customer satisfaction in a very competitive business can mean the difference between returned business and dissatisfied customers. By showing customers that company manufacturing processes are open to inspection eases questions about quality, reliability, and abilities of the manufacturer to deliver an acceptable product on schedule.

Each step of the manufacturing process was written and documented while observing employees perform the process and explain what was taking place and why. To ensure accuracy of each input, after each step was written, it was followed up by consulting manuals on printed circuit manufacturing.

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STAR CIRCUITS, INC.
405 Railroad Street
Brookings, SD 57006

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SHEARING PROCEDURE

PURPOSE;

The sheering process is performed to cut the individual panels to be processed from the larger sheets of material stock.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. Wear gloves and safety glasses.
- b. The panels have sharp edges that can cause injury.
- c. Do not bend or drop panels.
- d. Make sure the right size stock is being used.
- e. Shear blades have sharp cutting edges that can amputate fingers of arms very easily. Use extreme caution and keep fingers and arms clear of cutting edge.
- f. Operator must be trained in the proper operation of the shear and safety before performing the procedure.

OPERATION PROCEDURE;

STEP 1

Examine traveler for the correct size panel stock to use.

STEP 2

Examine traveler for correct dimensions of panels.

STEP 3

Using the dimensions found in step 2, determine which direction of cut will yield the maximum number of panels per sheet of stock.

SHEARING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 4

Set the gage bar on the shear to the proper size for the first cut.

STEP 5

Lay a panel of stock in place and step on the shear foot control. Measure the width of the first piece sheared. If the sheared section is the proper width shear all the pieces of stock, backup material, and entry material needed for the run.

STEP 6

When shearing is complete for one direction reset the gage bar on shear for the other cut desired. Repeat step 5 for all the panel cuts in the run. Panels are now ready for drilling and pinning.

DRILLING and PINNING PROCEDURE**PURPOSE;**

Drilling and pinning is performed to secure two or three panels to the entry material and backup material for the numerical controlled drilling operation.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. Wear gloves and safety glasses when performing the operation.
- b. The panels have sharp edges that can cause injury.
- c. Do not drop or bend panels.

OPERATION PROCEDURE;**STEP 1**

Look at traveler for size of panel to be drilled and pinned.
Set gage bar on the machine to the proper width.

STEP 2

Stack 2-3 panels between a piece of entry material and backup material. Place the back up material toward the top of the stack. Insert stack into drill and pin machine with the Y axis flush against the gage bar on the back side.

STEP 3

Set the gage on the drill heads to the length of each panel. Insert a pin in each of the two pin presses.

DRILLING and PINNING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 4 Procedure insures that the drill will be warmed up and Place one hand on each of the two control buttons. Press both buttons at the same time. The machine will drill the holes and insert the pins automatically. Repeat step 2 through step 4 for all stacks of panels in the run. Below

- a. Moving mechanical parts. Always keep hands and fingers out of the way of moving mechanical parts. Be especially careful of the moving drill heads.
- b. Operator must be trained both in the operation of the drill and safety.
- c. Only one designated person will be operating the controls.
- d. Safety glasses and gloves must be worn at all times.
- e. Drill bits have sharp points that can cause injury.
- f. Drill bits can shatter and fly apart.
- g. Always monitor automatic bit exchanges.

OPERATION PROCEDURE:

STEP 1

START UP PROCEDURE:

- a. Plug in air in back of machine.
- b. Turn POWER switch ON.
- c. Turn SERVO switch ON.
- d. Turn MODE select switch to the MANUAL position.
- e. Push yellow switch (HOME BUTTON).

START UP AND WARM UP FOR DRILL PROCEDURE

PURPOSE;

The procedure insures that the drill will be warmed up and calibrated to ensure a quality drilling operation.

SAFETY and PRECAUTIONS;

The drill has several areas that will need to be monitored to insure safe efficient operation, they are listed below.

- a. Moving mechanical parts. Always keep hands and fingers out of the way of moving mechanical parts. Be especially careful of the moving drill heads.
- b. Operator must be trained both in the operation of the drill and safety.
- c. Only one designated person will be operating the controls.
- d. Safety glasses and gloves must be worn at all times.
- e. Drill bits have sharp points that can cause injury.
- f. Drill bits can shatter and fly apart.
- h. Always monitor automatic bit exchanges.

OPERATION PROCEDURE;

STEP 1

START UP PROCEDURE;

- a. Plug in air in back of machine.
- b. Turn POWER switch ON.
- c. Turn SERVO switch ON.
- d. Turn MODE select switch to the MANUAL position.
- e. Push yellow switch (HOME BUTTON).

START UP AND WARM UP DRILL PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 2

WARM UP PROCEDURE;

- a. Go to the control panel.
- b. Turn MODE select switch to SINGLE.
- c. On the keyboard enter; T,8.
- d. Press the key marked CR (carry return).
- e. Push the CYCLE START button until the table returns to the PARK position. Park position is all the way back and in the center of the table.
- f. Turn the following SPINDLE switches ON, 1,2,4,5.
- g. Set the spindle switch in the SPINDLE UP position.
- h. Set the spindle switch in the SPINDLE DOWN position.
- i. Turn the SERVO switch off.
- j. Let the machine warm up for 15 minutes.
- k. Set the spindle switch in the SPINDLE UP position.
- l. On the keyboard enter; T,0.
- m. Press the key marked CR (carry return).
- n. Press the CYCLE START button until table returns to the PARK position.

DRILLING PROCEDURE

PURPOSE; PROCEDURE: (CONTINUED)

The drilling procedure is used to drill the holes needed for screening, component connection, and hardware mounting.

SAFETY and PRECAUTIONS;

The drill has several areas that will need to be monitored to insure efficient operation, they are listed below.

- a. Keep hands and fingers out of the way of moving mechanical parts.
- b. Operator must be trained in both the operation of the drill and safety.
- c. Only one person will be operating the controls when drilling.
- d. Safety glasses and gloves will be worn at all times.
- e. Drill bits have sharp points that can cause injury.
- f. Drill bits can shatter and fly apart.
- g. Always monitor automatic bit exchanges.
- h. Bits will only be used for 1500 hits before resharpener and after 4500 hits must be discarded.

OPERATION PROCEDURE; order specifications.

The following items will be needed.

- a. Computer drill tape.
- b. Production film.
- c. Drill sheet.
- e. Micrometer.
- f. Dowel pins.
- g. Hammer.

DRILLING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

h. White gloves.

i. Hole gages. INSERT COMPUTER TAPE into the tape drive of the

j. Drill bit log.

DRILL INSPECTION;

During the drilling process the Drilling Supervisor will perform the following: the drill bits are found on the drill

a. Hole wall examination with a bore scope will be done each hour at the machine. Sample size will be two faults per hour and an A.Q.L. of 1.5% of the holes will be bits subject to inspection. the wire bits do not go over 1500

b. Hole sizes: Production will verify first piece quality assurance for each job. Hole sizes will be verified with pin hole gages before the lot may be processed. drilling

c. Template inspection: First piece drill patterns will be inspected for hole locations relative to the artwork. drill

d. Number of holes: First piece drill patterns will be they inspected to ensure that the number of holes correspond to the customer's order specifications.

The Drilling Supervisor will also inspect the lowest board in each stack of the production panels for (b. c. d.) above until all the panels in the run are complete. and secure

STEP 1 the drilling table by placing a dowel pin in each end

Make sure the drill has gone through the start up and warm up procedure found in the start-up and warm-up procedure.

DRILLING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 2

Load the DRILLING COMPUTER TAPE onto the tape drive of the control unit.

STEP 3

While the tape is loading get the drill bits ready. The required diameter of the drill bits are found on the drill sheet. Use the micrometer to measure the diameter of the bits. Also measure the length of the bits and set each one to a length of .8 inches from tip to the collar. Record bits in Drill Bit Log Book. Make sure bits do not go over 1500 hits before resharpener, 4500 hits total for bit life.

STEP 4

Set the bits in the Tool Pods in the front of the drilling table. Place the cutting portion of the bit down. The holes on the front of the table correspond to numbers on the drill sheet, starting on the left of each of the four drills they are T01 - T08.

STEP 5

Begin by using only one panel for a first drill run to make sure all the holes are aligned, in the right places, and the right size (See inspection above). Take a panel and secure it to the drilling table by placing a dowel pin in each end of the plate and driving them into the table holes.

PROCEDURE FOR DRILLING (CONTINUED)

OPERATION PROCEDURE; (Continued)

STEP 6

Adjust the pressure foot on the control head for the minimum clearance between the bit and the panels. The closer they are together the faster the drilling process will be performed.

STEP 7

Turn the selector switch to AUTOMATIC and begin the process.

NOTE; Always keep a close watch on the operation to insure that there are no mechanical problems. When the drill head picks up a bit or replaces one make sure that it completely performs the process or damage to the machine and bits will result.

STEP 8

Remove the panel when all of the passes have been completed. Use the inspection procedure guidelines found in the first part of the procedure to check the panel.

STEP 9

After it has been determined that everything is working properly begin using all of the drills that are needed for the run. Use the same procedure and precautions that were used when only one drill was used. Begin by taping the four corners of the boards together to make sure the surfaces do not pull apart.

PROCEDURE FOR DRILLING (CONTINUED)

OPERATION PROCEDURE; (Continued)

STEP 10

Place up to three stacks on the drill table and secure each stack under each respective drill head. When secure use the procedures in steps 6 and 7 to drill the boards.

STEP 11

When the drilling process is complete remove the stacks and check the bottom board in each stack against the production film, look for missing holes, extra holes, and wrong size holes, and misplaced holes. If the boards pass inspection sign them off. The panels are ready to be sanded and honed.

Place drilled panel into hane and close and lock door.

STEP 2

Turn on hane. Place hands in gloves on side of machine.

STEP 3

Place glass head nozzle in one hand and panel in the other hand. Run nozzle across panel two or three times.

STEP 4

Flip panel over and repeat step 3 for other side.

STEP 5

When complete shut off hane and remove panel. Visually inspect the drilled holes to ensure all foreign material has been removed.

STEP 6

Take panels to inspection station.

SANDING AND GLASS HONE PROCEDURE

PURPOSE;

This process will remove the burrs and filings from the holes drilled in the panels.

SAFETY and PRECAUTIONS;

Observe the following when performing the operation.

- a. Wear gloves and safety glasses.
- b. Do not bend, drop, or allow panels to come into contact with each other.
- c. Make sure hone door is closed before operating.

OPERATION PROCEDURE;

STEP 1

Place drilled panel into hone and close and lock door.

STEP 2

Turn on hone. Place hands in gloves on side of machine.

STEP 3

Place glass bead nozzle in one hand and panel in the other hand. Run nozzle across panel two or three times.

STEP 4

Flip panel over and repeat step 3 for other side.

STEP 5

When complete shut off hone and remove panel. Visually inspect the drilled holes to ensure all foreign material has been removed.

STEP 6

Take panels to inspection station.

PROOF BOARD DRILL INSPECTION PROCEDURE

PURPOSE;

This inspection of the proof board will help to insure the quality control of the drilling operation on all the panels in the run. It also serves to minimize cost if there is a problem in the drilling procedure.

SAMPLE RATE;

All first drill test panels will be inspected.

SAFETY AND PRECAUTIONS;

After drilling the holes will have sharp edges and burrs which can cause cuts to the skin. Wear gloves at all times when handling the panels to avoid cuts and getting finger prints on the panels.

OPERATION PROCEDURE;

The following items will be needed.

- a. traveler
- b. production film
- c. drill sheet
- d. blue print
- f. pin hole gauges
- g. magnifying eyepiece
- h. white gloves;

STEP 1

Check first drill size with drill sheet.

STEP 2

Remove the pin hole gauges needed from the storage box. The pin hole gauge sizes will need to be 1 size smaller than the

PROOF BOARD DRILL INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

size found on the traveler and drill sheet. Note; Using the same pin hole gauge size as is specified on the drill sheet will result in damage to the hole. Gauge the drill test hole(s) found on the side of the board. If any of the holes do not correspond to the gauge sizes report the finding to Quality Control and the Drilling Supervisor immediately.

STEP 3

If the drill test holes check out OK randomly select several holes in different locations on the board and gauge them. This will ensure uniformity of the holes sizes throughout the board. If holes are found that do not conform report the finding to Quality Control and the Drilling Supervisor immediately.

STEP 4

Place the board on the lighted test table. Lay the inspection copy of the production film on the board and line up all the holes. When all holes are lined up check for the following.

1. Missing or extra holes. Missing holes will show up as a black dot and extra holes will show up as light dot.
2. Misplaced special tooling holes.
3. Screening holes in correct location.
4. Holes which will cause a air gap problem because they are to close to traces or other circuits.

PROOF BOARD DRILL INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

5. Registration. insure uniform quality and also insures
6. Equal pad sizes. at the requirements set forth in the
7. Hole sizes. relating to drilled holes.
8. Misplaced circuit holes.
9. Partially drilled holes. drilling stack.

Check the panels against the blue print for any abnormalities. If any of the above items are found process a hold tag and report findings to Quality Control and the Drilling Supervisor. and figure prints on the panels.

STEP 5 ON PROCEDURE;

When doing double sided panels turn the panel over and repeat STEP 4 for the reverse side of the board.

STEP 6 reduction film

When inspection is complete report findings to the Drilling Supervisor and sign off in the correct columns.

e. magnifying eyepiece

f. blue print

g. white gloves

STEP 1

Take the bottom panel from each of the stacks of panels that have been drilled, the bottom panel will be marked with a (X). The bottom panel is all that will need to be inspected as it is a duplicate of the panels above it. It is also important that you keep the panels in order and know which stack they came out of so if there is a problem with the

PRODUCTION BOARD DRILL INSPECTION PROCEDURE

PURPOSE;

This procedure will insure uniform quality and also insures that all the panels meet the requirements set forth in the customers order relating to drilled holes.

SAMPLE RATE;

All the bottom panels in each drilling stack.

SAFETY and PRECAUTIONS;

These panel will have sharp edges and burrs which can cause cuts to the skin. Wear gloves at all times when handling the panels to avoid cuts and figure prints on the panels.

OPERATION PROCEDURE;

The following items will be needed.

- a. traveler
- b. production film
- c. drill sheet
- d. pin hole gauges
- e. magnifying eyepiece
- f. blue print
- g. white gloves

STEP 1

Take the bottom panel from each of the stacks of panels that have been drilled, the bottom panel will be marked with a (X). The bottom panel is all that will need to be inspected as it is a duplicate of the panels above it. It is also important that you keep the panels in order and know which stack they come out of so if there is a problem with the

PRODUCTION BOARD DRILL INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

bottom panel, the upper panels can be checked also. Now up as

STEP 2. Black dot and extra holes will show up as light

Check first drill size with drill sheet and blue print.

STEP 3. Displaced special tooling holes.

Remove the pin hole gauges needed from the storage box. The pin hole gauge sizes will need to be 1 size smaller than the size found on the traveler and drill sheet. Note; Using the same pin hole gauge sizes as is specified on the drill sheet will result in damage to the hole and ultimately the board.

Gauge the drill test hole(s) found on the side of the board.

If any of the holes do not correspond to the gauge sizes

report the finding to Quality Control and the Drilling Supervisor immediately.

STEP 4. Supervisor.

If the drill test holes check out OK randomly select several holes in different locations on the board and gauge them.

This will insure uniformity of the hole sizes throughout the board. If holes are found that do not conform, process a hold tag and report findings to Quality Control and the Drilling Supervisor immediately.

STEP 5

Place the panel on the lighted test table. Lay the inspection copy of the production film on the panel and line up all the holes. When all holes are lined up check for the following.

PRODUCTION BOARD DRILL INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

1. Missing or extra holes. Missing holes will show up as a black dot and extra holes will show up as light dots. send panels to be cleaned.
2. Misplaced special tooling holes.
3. Screening holes in the right place.
4. Holes which will cause a air gap problem because they are too close to traces or other circuits.
5. Registration.
6. Equal pad sizes.
7. Hole sizes.
8. Hole location relative to art work.

If any of the items listed above are found process a hold tag and report it immediately to Quality Control and the Drilling Supervisor.

STEP 6

Take the proof panel and lay it on top of the production panel and check for missing holes, extra holes, line up and size of holes. If any abnormalities are found process a hold tag and report it immediately to Quality Control and the Drilling Supervisor.

STEP 7

Repeat STEPS 5 and 6 for the other side of the panels.

STEP 8

Repeat STEPS 3 through 8 for all bottom panels in the run.

PRODUCTION BOARD DRILL INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 9 Cleaning process is used to remove all foreign material

When run is completely inspected sign-off in the correct columns and send panels to be cleaned.

manufacturing process.

SAFETY and PRECAUTIONS;

The following precaution must be observed when performing the operation.

- a. The scrubber (Cleaning Machine) uses a conveyor to move the boards through the machine, use extreme caution when placing hands near the input of the machine as it can result in severe injury to fingers and hands.
- b. Gloves must be worn at all times when handling the panels.
- c. Goggles will be worn for eye protection.
- d. Aprons must be worn in chemical bath area.
- e. Do not drop, bend or allow the panels to come into contact with other panels.

OPERATING PROCEDURE;

STEP 1

Turn the scrubber on by pushing the following green buttons, TOP BRUSH, BOTTOM BRUSH, BLOWER, and CONVEYOR.

STEP 2

When the machine is running place each panel flat on the conveyor from the control side of the machine.

CLEAN PANELS PROCEDURE

PURPOSE;

The cleaning process is used to remove all foreign material from the surfaces of the panels which may contaminate the surface. This process is used several times in the manufacturing process.

SAFETY and PRECAUTIONS;

The following precaution must be observed when performing the operation.

- a. The scrubber (Cleaning Machine) uses a conveyor to move the boards through the machine, use extreme caution when placing hands near the input of the machine as it can result in severe injury to fingers and hands.
- b. Gloves must be worn at all times when handling the panels.
- c. Goggles will be worn for eye protection.
- d. Aprons must be worn in chemical bath area.
- e. Do not drop, bend or allow the panels to come into contact with other panels.

OPERATING PROCEDURE;

STEP 1

Turn the scrubber on by pushing the following green buttons, TOP BRUSH, BOTTOM BRUSH, BLOWER, and CONVEYOR.

STEP 2

When the machine is running place each panel flat on the conveyor from the control side of the machine.

CLEAN PANELS PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 3

When a panel is done remove it from the far end of the machine and place it on a table rack.

STEP 4

Shut off the cleaning machine in the reverse order in which it was turned on.

OPERATOR PROCEDURE:

STEP 1

Place the rack of panels on the table and turn on the machine. Pick up the rack and place it on the table. The brush water tank will fill with water. When all the panels are rinsed.

STEP 2

Remove the first panel from the rack and place it on the table.

STEP 3

Remove the first panel from the rack and place it on the table.

STEP 4

Remove the rack from the machine and place it on the table.

RINSING PROCEDURE

PURPOSE;

The rinse procedure is used several times throughout the assembly process to remove excess chemicals and cleaners.

SAFETY and PRECAUTIONS;

Observe the following when performing the operation.

- a. Wear gloves and safety glasses.
- b. Do not bend or allow the panels to come into contact with other panels or the edges of tanks.
- c. When agitating the panels use a gentle rocking motion to avoid having the panels hit other panels or the sides of the tank.

OPERATION PROCEDURE;

STEP 1

Place the rack of panels in the first rinse tank. While holding the rack upright spray the panels thoroughly with the fresh water hose. Make sure that both sides of all the panels are rinsed.

STEP 2

Remove the rack from the first rinse tank and place it in the second rinse tank and gently rock it back and forth.

STEP 3

Remove the rack from the second rinse tank and place it in the third rinse tank and gently rock it back and forth.

Remove the rack, the panels are now ready for the next step of the operation.

ELECTROLESS COPPER PROCEDURE

PURPOSE;

Electroless copper is a process that adds copper to the holes that have been drilled and around the edges of the board to ensure a good conducting surface between the sides of the boards. Use the following steps to perform the task.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line or performing additions or changes to the baths. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the panels.

OPERATING PROCEDURE;

Look at the traveler of the job you wish to run.

- a. Are there any special instructions?
- b. Are the panels single sided or double sided?
- c. Does the traveler call for the panels to go through electroless copper?

STEP 1

Run the panels through the scrubber machine to clean and remove all foreign material.

ELECTROLESS COPPER PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 2

Place boards on dipping rod (rack). When using the spring racks examine the drawing and drill pattern on the panel to determine how to load the panels without destroying the copper surface where the circuit traces or contact figures are located.

- a. Place spring in table jig, stretch and secure.
- b. Place boards in spring. The number of boards will depend on the size of the boards being processed, usually from 15-30.

STEP 3

The boards are now ready to be dipped. Place the first rack of boards into the tank marked ALKALINE CLEANER by resting the steel rod on each side of the tank. Agitate the racks periodically to ensure uniform coverage on board. When agitating the rack gently rock them back and forth in the tank, never jerk the rack or hit the side of the tank or other boards as this will result in damage to the boards. Leave rack in tank for 6 minutes.

STEP 4

Remove rack from the ALKALINE CLEANER tank let panels drip thoroughly and rinse. Use the rinse procedure found in the procedure manual throughout the electroless copper process.

ELECTROLESS COPPER PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 5

After removing rack from second rinse tank place it in the tank marked MICROETCH for 1-2 minutes depending on the color of the boards, you want to have pinkish copper color. Note; if left in microetch to long it will remove all of the copper from the board. Remove rack let the panels drip and rinse.

STEP 6

After rinsing place rack in CATALYST PRE DIP for 1 minute then lift out and let panels drip.

STEP 7

After draining place rack in the CATALYST tank for 6 minutes and agitate occasionally. Remove from tank, let drip, and rinse.

STEP 8

After rinse place rack in ACCELERATOR for 4 minutes and agitate occasionally. Remove rack, let drip, and rinse.

STEP 9

After rinse place rack in ELECTROBRITE for 20 minutes agitate occasionally. Remove rack, let drip, and rinse.

STEP 10

After rinse place rack in 15% SULFURIC ACID for 1 minute. Remove rack, let drip, and rinse.

ELECTROLESS COPPER PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 11

After rinse place rack in small SULFURIC ACID tank which will complete the electroless process. Panels are now ready for the copper strike process.

COPPER STRIKE PROCESS

(flashing)

PURPOSE;

Copper strike (flashing) is the step after electroless copper which adds more copper to the surface of the panel. Use the following steps to perform the task.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line or performing additions or changes to the baths. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes. Room ventilation must be in operation when working in plating room.

Care must taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the boards.

OPERATION PROCEDURE;

STEP 1

Remove the rack from the SULFURIC ACID tank. Next remove panels from the spring holder and place them in the orange racks. The orange racks will hold from 2-4 panels depending on the size of each panel.

COPPER STRIKE PROCEDURE (Continued)

OPERATION PROCEDURE (Continued)

STEP 2

When each of the individual orange racks are full, place them in the SULFURIC ACID tank as quickly as possible to avoid oxidation of the surface of the boards. When all the boards have been placed on orange racks place them in the ACID COPPER tank. Tighten the wing nuts on the rack to the cross bars to insure a good electrical connection. The flash process will take 10 minutes.

STEP 3

Next calculate the ampere hours needed for the process.

a. first calculate the area of the plate by

$$\text{area} = (L \times W \times 2 \times \# \text{ of panels}) \text{ divided by } 144 \text{ (in)}^2$$

b. next find total amps.

$$\text{total amps} = \text{ASF} \times \text{area}$$

$$\text{ASF} = \text{constant}$$

c. next find ampere hours

$$\text{amp.hr} = (\text{total amps} \times \text{time in minutes}) \text{ divided by } 60$$

STEP 4

When flashing is complete remove racks and dip them in the 3% SULFURIC ACID and remove, let drip and place in the DEIONIZED WATER tank. There is no time limit in the deionized water solution.

This completes the flashing process, panels are now ready to be cleaned for lamination.

CLEANING FOR LAMINATION PROCESS

PURPOSE;

This process insures that the panel is free from contamination before it is laminated (dry-film resist). Optimum dry-film resist adhesion is accomplished only if the copper surface is properly cleaned.

SAFETY and PRECAUTIONS;

The following must be done to insure safe efficient operation when performing the process.

- a. Safety glasses, apron, and gloves must be worn at all times.
- b. Use caution when working around chemicals. If a chemical accident does occur notify someone immediately and go to first aid station located in the plating room.
- c. Use caution when feeding panels into cleaning machine. The cleaner uses a conveyor to move the panels, watch your hands and fingers.
- d. Do not bend, drop, or allow panels to come into contact with each other as this can cause damage to occur.
- e. Use lintless towels to dry panels.

OPERATION PROCEDURE;

STEP 1 visually inspect the panels for black spots. If any Use the rinse procedure described in the procedural manual to rinse the panels.

STEP 2 Place panels in 15% SULFURIC ACID solution for 1 minute. Remove panels and rinse as in step 1.

CLEANING FOR LAMINATION PROCESS (Continued)

OPERATION PROCEDURE; (Continued)

STEP 3

After rinse is complete place the panels into the CIR CLEAN solution for 2 minutes. Remove the panels and rinse as in step 1.

STEP 4

After rinse is complete dip the panels into the LOW SULFURIC ACID tank. Remove the panels and immediately dip them into the DEIONIZED water tank.

STEP 5

Remove the panels from the DEIONIZED water. Note: when removing the panels watch for breaks in the water run off. If breaks are noted look for contamination on the panel.

STEP 6

After the water has ran off place the panels into the CLEANING MACHINE. Set the cleaner machine feed rate at 30. Use the cleaning process described in the procedural manual.

STEP 7

Using white gloves to handle the panels remove them from the cleaning machine and dry them with lintless towels. While drying visually inspect the panels for black spots. If any black spots appear the whole cleaning process will need to be repeated. If panels pass inspection set them on a table rack and take them to be laminated.

LAMINATING PROCESS

PURPOSE;

This process is to apply the dry-film photo-resists to the panel which will have the circuit images exposed onto it.

SAFETY and PRECAUTIONS;

The following must be observed when performing the task.

- a. Safety goggles, glasses, and apron must be worn.
- b. The laminator uses a roller feed system. Use caution concerning fingers and hands.
- c. Knives are used to trim excess laminate. Use caution concerning fingers and hands.
- d. Do not bend, drop, or allow panels to come into contact with each other.

OPERATION PROCEDURE;

STEP 1

Turn the main power switch on. When the temperature reaches 103 degrees flip the lever on the side of the machine to place the rollers together. Turn on the AIR POWER and listen for a click sound.

STEP 2

Take hold of the laminate film on the output of the machine. Turn the DRIVE SWITCH on and run until all of the wrinkles are removed from the film. Trim off the excess film. The machine is now ready for a panel.

LAMINATING PROCESS (Continued)**OPERATION PROCEDURE; (Continued)****STEP 3**

Place a panel at the input to the laminator. As the panel appears at the output, trim off the excess film with a knife. When the board has cleared the machine the machine will make a hiss sound. If the sound is not heard consult the supervisor.

STEP 4

Place the boards on a table rack and wait 20 minutes before exposing. After 20 minutes the panels are ready to be exposed.

INSPECT INSPECTION BEFORE EXPOSURE PROCEDURE**PURPOSE;**

This process insures quality correct film is being used and avoids incorrect images being exposed.

SAMPLE RATE;

Repeat process every 25 panels.

SAFETY and PRECAUTIONS;

- a. Avoid skin contact with the film cleaner.
- b. Handle film by the outside edges to avoid damage to the film.

OPERATING PROCEDURE;

The following equipment will be needed.

- a. Production film.
- b. Lighted inspection table.
- c. Film cleaner.
- d. Magnifying eye piece.
- e. Fine point pen (0.1mm).
- f. Scalpel.

STEP 1

Place production film on lighted table.

STEP 2

Spray FILM CLEANER onto shiny side of production film.

Wipe off the film cleaner.

STEP 3

Turn on the white light.

Flip the production film over to the emulsion side.

INSPECTION BEFORE EXPOSURE PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 4

With a magnifying eyepiece begin in the upper right hand corner and inspect the film for the following;

- a. Film spots; If found scrape them off with a scalpel.
- b. Broken circuits; If found fill them in with the FINE POINT PEN.
- c. Light spots; If found fill them in with the FINE POINT PEN.

STEP 5

When inspection is complete film is ready to be exposed.

PROCEDURE FOR EXPOSING FILM

PURPOSE;

The exposing process forms a image on the dry film that corresponds to the artwork of circuitry patterns after it has been developed.

SAFETY and PRECAUTIONS;

Observe the following when performing the operation.

- a. Wear gloves and safety glasses.
- b. Use caution when pushing the developing table in to make sure your fingers are out of the way.
- c. Do not bend, drop, or allow panels to come into contact with each other.

OPERATION PROCEDURE;

STEP 1

Check the production film, make sure the sticky side of the red tape is on the dull side of the production film.

STEP 2

Go to the exposer machine, lift cover and clean all the surfaces with glass cleaner. Be thorough and make sure all surfaces are free of spots.

STEP 3

Gently push the glass surface all the way in to make sure there is a good seal.

STEP 4

Place the beaders (thin metal strips) along each side, position them according to the size of the panels.

minutes to develop

PROCEDURE FOR EXPOSING FILM (Continued)

OPERATION PROCEDURE; (Continued)

STEP 5

Lay the production film onto the unexposed film and inspect for the proper hole positions, check the smallest holes. When the holes on the film and panel are aligned tape the film into place. Repeat this process for the back side of the panel for double sided panels.

STEP 6

Place the unexposed panel on the glass surface of the exposor machine. Close the cover.

STEP 7

Turn the vacuum switch (toggle switch on the left) on and watch the vacuum gage. When the gage gets to 90 wait 20 seconds. While waiting set exposor time for 15 seconds, also check the screws around the edge of the frame and tighten if necessary.

STEP 8

After 20 seconds push the bed into exposor machine and wait for bed to come out (15 seconds). When the bed comes out it will only come part way you will need to lift it over the second latch.

STEP 9

Shut off the vacuum and lift the cover, remove panel and take off top layer of tape from each side of the panel. Place the panels into a table rack and wait a minimum of 20 minutes to develop.

PROCEDURE FOR DEVELOPING FILM

PURPOSE;

This process will develop the image of the circuit pattern that has been exposed onto the film.

SAFETY and PRECAUTIONS;

Observe the following when performing the operation.

- a. Wear gloves and safety glasses.
- b. Use caution when removing and replacing the rollers during cleaning.
- c. Use caution when handling the developing chemicals, avoid contact with skin.
- d. Do not bend, drop, or allow panels to come into contact with each other.
- e. Close monitoring of the developing chamber is necessary for quality development of panels.

OPERATION PROCEDURE;

CLEANING AND START UP;

STEP 1

Lift the large top off of the developer. Fill the reservoir with water up to the heat sensor (black peg on the side).

STEP 2

Get 5 gallons of hot water. To the hot water slowly add 4.5 cups of SODA ASH while stirring. Make sure all the soda ash is dissolved.

When level of PH is measured turn the POWER, PUMP, and CONVEYOR switches on, not the temperature switch.

The developer is now ready.

PROCEDURE FOR DEVELOPING FILM (Continued)

CLEANING AND START UP; (Continued)

STEP 3

Pour the 5 gallon bucket of hot water into the reservoir located on the back side of the developer. Add it slowly and make sure that all the soda ash has been dissolved.

STEP 4

To the same reservoir on the back side add .5 gallon of GLYCOL ETHER. Also add 2 ounces of 2341 ANTIFOAM (defoamer) to the same compartment.

STEP 5

Turn on the following switches POWER, PUMP, and TEMPERATURE. Allow the temperature to rise to 80 degrees. Turn off the TEMPERATURE, PUMP, and POWER switches in this order.

STEP 6

Get the PH METER and calibrate it 10. With the meter check the PH level in the reservoir. The ideal level will be 11.5. If the PH level is low add .5 cup of SODA ASH at a time to the reservoir. Each time the soda ash is added you will need to turn on the power, pump, and temperature switches on to ensure that the soda ash has mixed properly and shut them all off to test again.

STEP 7

When the proper level of PH is measured turn the POWER, PUMP, and CONVEYOR switches on, not the temperature switch. The developer is now ready.

PROCEDURE FOR DEVELOPING FILM (continued)

OPERATION PROCEDURE (Continued)

DEVELOPING PROCESS; (Continued)

STEP 1

Remove the mylar coating from the exposed panels and place them on the conveyor. For the initial run place only three panels on the conveyor.

STEP 2

When the first panel has reached the end of the first covered compartment shut off all the switches turned on in step 7. Lift the cover and inspect the panels. You are looking for the development process to be complete at the half way point in the first compartment. If the panels are being developed before they reach the half way point you will need to speed the conveyor up a little. If the panels are under developed you will need to slow the conveyor down.

STEP 3

After panels appear at the end of the machine visually inspect them for break out, pieces of mylar stuck to surface, and loose film strings.

NOTE 1; While the operation is taking place watch the reservoir under the end of the machine to make sure the pump is working.

NOTE 2; Monitor the temperature at all times to make sure it does not exceed 90 degrees. If it does, stop machine and remove the cover and add ice packs to bring temperature down to the 80-90 degree range before you continue developing.

PROCEDURE FOR DEVELOPING FILM (continued)

OPERATION PROCEDURE (Continued)

DEVELOPING PROCESS; (Continued) is to remove all excess

STEP 4 re from the surface and in the holes of each panel.

Place completed panels on a table rack, when rack is full take them to the rinse tank and thoroughly rinse each panel.

Inspect for any loose strings. when feeding the panels in.

STEP 5 r gloves, goggles, and apron when operating the

Let panels drip and take them to the COOL OVEN. Leave in cool until dry, 5 minutes at 150 degrees should do it. Make sure all the panels are separated before you place them in the oven. s can cause damage to the panels

STEP 6 LOW PROCEDURE:

Fill out the traveler for the run of panels and take them up to the inspection station. Make sure all boards are separated. TCH on the right ON.

STEP 2 Next set the FORWARD/REVERSE SWITCH in the forward position.

STEP 1 The feed rate will need to be adjusted for a speed that ensures proper drying of the surface. Try the panels first to find the proper speed. When the panels appear at the output of the dryer inspect them to make sure they are dry on the surface. Also check for any moisture in the holes. If this area is dry, moisture in the holes can cause problems in future steps.

DRYING PROCEDURE

PURPOSE;

The purpose of drying the panels is to remove all excess moisture from the surface and in the holes of each panel.

SAFETY and PRECAUTIONS;

- a. The input of the dryer has rollers that can catch fingers and hands so use caution when feeding the panels in.
- b. Wear gloves, goggles, and apron when operating the machine.
- c. Use caution when handling the boards. Do not bend, drop, or allow the panels to come into contact with each other as this can cause damage to the panels.

OPERATION PROCEDURE;

STEP 1

Turn the ON/OFF SWITCH on the left ON and then turn the ON/OFF SWITCH on the right ON.

STEP 2

Next set the FORWARD/REVERSE SWITCH in the forward position.

STEP 3

The feed rate will need to be adjusted for a speed that ensures proper drying of the surface. Try two panels first to find the proper speed. When the panels appear at the output of the dryer inspect them to make sure they are dry on the surface. Also check inside the holes to make sure this area is dry, moisture in the holes can cause problems in future steps.

TOUCH DRYING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 4 is a process of finding problem areas and
 Next feed the panels into the dryer from the control side
 and remove them from the opposite side. As the panels come
 out of the dryer place them in a table rack. When all the
 panels are dry they are ready for the next step indicated in
 the traveler.

panels in each rack. If the A.P.C. side found to
 be adequate it will be assumed that the other are adequate
 also. On the other hand if problems are found in the A.Q.C.
 sampled, all of the panels in the rack must be checked. When
 a repeated problem is encountered report it to Quality
 Control at once.

SAFETY and PRECAUTIONS:

- a. The edges of the panels are sharp so use caution when
 handling them.
- b. Gloves should be worn at all times when handling the
 panels to avoid contamination.

OPERATION PROCEDURE

The following items will be needed:

- a. production file
- b. traveler
- c. blue ink brush
- d. white gloves
- e. adequate light
- f. magnifying eyepiece

TOUCH UP AND IMAGE INSPECTION PROCEDURE

PURPOSE;

Touch up is a process of finding problem areas and correcting these problems that may have occurred in the imaging process.

SAMPLE RATE;

For touch up it will be adequate to use a A.Q.L. sample of 1.5% of the panels in each rack. If the A.Q.L are found to be adequate it will be assumed that the others are adequate also. On the other hand if problems are found in the A.Q.L. sampled, all of the panels in the rack must be checked. When a repeated problem is encountered report it to Quality Control at once.

SAFETY and PRECAUTIONS;

- a. The edges of the panels are sharp so use caution when handling them.
- b. Gloves should be worn at all times when handling the panels to avoid contaminating them.

OPERATION PROCEDURE

The following items will be needed.

- a. production film
- b. traveler
- c. blue ink brush
- d. white gloves
- e. adequate light
- f. magnifying eyepiece

consult Quality Control to be sure.

TOUCH UP AND IMAGE INSPECTION PROCEDURE (Continued)

STEP 1 INSPECTION PROCEDURE; (Continued)

Remove a panel from the table rack.

INSPECTION CRITERIA;

1. line width; Must be within 20% of the specified width.
2. broken traces; Any trace that does not provide a continued path for the circuit. Remove excess dry film from circuit.
3. raggedness; Traces that are uneven on the sides that affect the trace by more than 20% of the required width.
4. pinholes and pits; Small areas in the traces that could impair operation of the circuit, must be more than 20% of the trace width.
5. dents and scratches; Areas that have been damaged by some outside source that may cause the circuit to operate improperly.
6. pealed film; Image process not working properly.
7. spots of copper; Small areas of exposed copper that should not be there.

If any of the above occur correct it with the blue ink if possible. If you see a reoccurring problem report it to Quality Control immediately. If any of the above problems are questionable as to whether they can pass inspection consult Quality Control to be sure.

TOUCH UP AND IMAGE INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 2: plating is a procedure for plating the holes and
 When inspection of the A.Q.L. panels is complete sign the
 traveler and return the panels to the table rack and place
 the rack on the cart for the plating procedure.

when operating the line or performing additions or changes
 to the baths. The chemicals in this process can be very
 hazardous to health if they are not handled properly and if
 personal protective clothing is not used. If a chemical
 accident does occur notify someone immediately and go to
 the first aid center located in the plating room and flood
 the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to
 avoid contact with other panels and the sides of the tanks
 as this can cause irreversible damage to the boards.

OPERATING PROCEDURE:

Items to be understood before plating begins?

- a. What metals are to be plated?
- b. What thickness is required?
- c. What are the critical plating tolerances?
- d. What features of the pattern to be plated will need
 special attention?
- e. What current density range is likely to be required to
 successfully plate the job?
- f. Is the available plating set-up (tanks, bath, anodes,
 rectifier) adequate to do the job?

COPPER PATTERN PLATING PROCEDURE

PURPOSE;

Pattern plating is a procedure for plating the holes and circuitry with extra copper.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line or performing additions or changes to the baths. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not used. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the boards.

OPERATING PROCEDURE;

Items to be understood before plating begins?

- a. What metals are to be plated?
- b. What thickness is required?
- c. What are the critical plating tolerances?
- d. What features of the pattern to be plated will need special attention?
- e. What current density range is likely to be required to successfully plate the job?
- f. Is the available plating set-up (tanks, bath, anodes, rectifier) adequate to do the job?

COPPER PATTERN PLATING PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

The operator must be familiar with the following also.

- a. Daily operating routine.
- b. Maintenance procedures.
- c. Troubleshooting.
- d. Training.
- e. Understand how the processes work.
- f. Safety

STEP 1

Place panels on racks, examine the image on the panel to make sure no damage occurs to the circuit traces of contacts when the clamps are tightened. As each panel is placed on the rack examine it for any obvious contamination on the surface, scratches, or other obvious surface or imaging conditions which will result in scrap if the panels are plated. Note how much plating area is on each side of the panel, if one side is mostly land area, and the other side is circuitry, the panels should be flip-flopped in the rack to provide a more even current distribution through the anode bus bars.

STEP 2

Place rack into CLEANING TANK for 4 minutes, agitate occasionally.

STEP 3

Remove from CLEANING TANK and rinse. Use rinse procedure found in the procedure manual throughout this process.

COPPER PATTERN PLATING PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

STEP 4 the desired plating thickness has been attained.

Place rack in PATTERN PREP for 1-2 minutes and agitate.

STEP 5 Loosen wing bolts of the plating rack on the substrate.

Remove from pattern prep and rinse.

STEP 6 Remove panel racks from the plating tank. Let panels

Place rack in 15% SULFURIC ACID for 1-10 minutes. out.

STEP 7

Remove from 15% SULFURIC ACID and place rack in ACID COPPER TANKS. Use the following procedure.

- a. Load the racks into the copper plating tank.
- b. Tighten wing bolts on the plating rack, so as to attain an excellent electrical connection for plating.
- c. Care must be used to avoid striking the plating racks on either the anodes, or on other racks of panels.
- d. Raise rectifier amperage to approximate, predetermined value.
- e. Set timer.
- f. Log time into plating log.
- g. Check panels every 10-20 minutes.
 - I. Notice condition of plating.
 - II. Check hole sizes, in the panel center, and in the corners and edges. Use the holes with the tightest tolerances as the holes used to determine plating thickness.
 - III. Log plating amperage into plating log book.

COPPER PATTERN PLATING PROCEDURE (Continued)

OPERATING PROCEDURE; (Continued)

h. When the desired plating thickness has been attained.

I. Reduce amperage to a low value.

II. Loosen wing bolts of the plating racks on the cathode bus bar.

III. Remove panel racks from the plating tank. Let panels drain well, over the tank, to prevent dragout.

STEP 8

Panels are now ready for the tin lead plating process.

to the baths. Never mix two chemicals together unless authorized to do so as this can result in adverse reactions.

The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the boards.

OPERATION PROCEDURE:

STEP 1

Remove rack from ACID COPPER tank and rinse.

STEP 2

After rinsing place rack in DELONIZED WATER. NO TIME LIMITS

TIN LEAD PLATE (CONTINUED)

OPERATION PROCEDURE (not fused)

PURPOSE:

The process serves two purposes, one as a metal etch resist and the other as a solderable substrate for the subsequent soldering of components. This procedure will be for the panels that are not to be fused.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line or performing additions or changes to the baths. Never mix two chemicals together unless authorized to do so as this can result in adverse reactions. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks when time has elapsed remove panels from TIN LEAD PLATE tank as this can cause irreversible damage to the boards.

OPERATION PROCEDURE;

STEP 1

Remove rack from ACID COPPER tank and rinse.

STEP 2

After rinsing place rack in DEIONIZED WATER. No time limit.

TIN LEAD PLATE PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 3

Remove rack from DEIONIZED WATER and place it into the ACID SOLDER tank for 1-2 minutes. Remove and let it drip.

STEP 4

Place rack in TIN LEAD PLATE tank. Secure the racks for a good electrical connection.

STEP 5

Next you will need to calculate the amp. hours needed for the process. Use a time period of 7.5 minutes.

a. first find total amperes.

total amps = $\frac{ASF \times \text{area}}{2}$

area = L X W (in)

ASF = constant = 16

b. next find ampere hours

amp.hr = (total amps x time) divided by 60

STEP 6

Set power source for the calculated ampere hours.

STEP 7

When time has elapsed remove panels from TIN LEAD PLATE tank and rinse.

STEP 8

Panels are now ready to have dry film stripped.

STEP 9

After rinse place rack in PATTERNS WASH for 1 minute. Remove

rack and rinse.

TIN LEAD PLATE PROCEDURE

(fused)

PURPOSE;

The tin lead process serves two purposes, one as a metal etch resist and the other as a solder substrate for the subsequent soldering of components. This procedure will be for the panels that are to be fused.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line, performing additions, or changes to the bath. Never mix two chemicals together unless authorized to do so as this can result in adverse reactions. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the boards.

OPERATION PROCEDURE;

STEP 1

Remove rack from ACID COPPER tank and rinse.

STEP 2

After rinse place rack in PATTERN PREP for 1 minute. Remove rack and rinse.

TIN LEAD PLATE PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 3

After rinse place in DEIONIZED WATER.

STEP 4

Remove from deionized water and place rack in 15% ACID SOLDER tank for 1-2 minutes.

STEP 5

Remove from 15% ACID SOLDER tank and place in TIN LEAD PLATE tank.

STEP 6

Next calculate the ampere hours needed for the process.

Use a time of 7.5 minutes.

a. first find total amps.

$$\text{total amps} = \text{ASF} \times \text{area}$$

$$\text{ASF} = \text{constant} = 16$$

b. next find amp. hours

$$\text{amp hours} = (\text{total amps} \times \text{time}) \text{ divided by } 60$$

STEP 7

Set power source for the calculated ampere hours.

STEP 8

When time has elapsed remove rack from TIN LEAD PLATE tank and rinse. Place panels on table rack. Panels are now ready for the strip dry film procedure.

STRIP DRY FILM PROCEDURE

PURPOSE;

This process will remove the blue film from the surface of the panel.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line, performing additions, or changes to the bath. Never mix two chemicals together unless authorized to do so as this can result in adverse reactions. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of the tanks as this can cause irreversible damage to the boards.

OPERATION PROCEDURE;

STEP 1

Place panels on rack. The number of panels will depend on the size of the panels. Load rack until full or as many as you can carry safely, usually about 8-10 large panels, this number will increase as panel size decreases.

STRIP DRY FILM PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 2 Check the dry film stripper tank and the water tanks to make sure they are full. If they are low you will need to bring them up to the proper level.

STEP 3 Place rack in DRY FILM STRIPPER tank for 3-5 minutes until all the blue film is removed.

STEP 4 Remove rack from the DRY FILM STRIPPER tank and dip in the water tank next to it.

STEP 5 AND PRECAUTIONS;

Remove rack from the water tank and rinse with fresh water to remove any blue film that is left on the panel.

STEP 6 Run panels through dryer. Take panels to the inspection room.

The following items will be needed:

- a. Blue ink.
- b. Magnifying eyepiece.

STEP 1

Get a panel from the table rack. Inspect both sides of the panel for the following items:

TIN LEAD TOUCH UP INSPECTION PROCEDURE

PURPOSE; PROCEDURE; INFORMATION

The touch up tin lead inspection is needed to make sure that the plating processes have meet quality standards set by the company.

SAMPLE RATE; wrinkles then pull it off. If there is any

A 1.5% A.Q.L. lot sample from each rack will be used. If the A.Q.L. are acceptable it will be assumed that the other panels in the rack are acceptable. If one of the A.Q.L. sample has a problem, process a hold tag and all remaining panels in the rack must be inspected. When a repeated problem is encountered report it to Quality Control at once.

SAFETY AND PRECAUTIONS; cover it with blue ink, if copper is

- a. The edges of the boards are sharp so use caution when handling.
- b. Gloves are to be worn at all times when handling panels to avoid contaminating the panels.

OPERATION PROCEDURE; has been performed, place panel in oven

The following items will be needed.

- a. Blue ink.
- b. Magnifying eyepiece.

STEP 1 Ready for etching.

Get a panel from the table rack. Inspect both sides of the panel for the following items.

TIN LEAD TOUCH UP INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

1. Peeling; Check for peeling by laying a piece of masking tape from corner to corner of the panel, smooth it to make sure it has no wrinkles then pull it off. If there is any sign of peeling the panel will be scraped.
2. Bare copper; Look for areas of bare copper that may not have been adequately plated. Cover these areas with blue ink.
3. Scratched panels; This will depend on how deep the scratch is, if it is down to copper cover it with blue ink, if copper is deeply scratched or down to bare laminate the panel will need to be scraped.

STEP 2

If touch up with ink has been performed, place panel in oven and bake for 5 minutes at 150 degrees to set the ink.

STEP 3

Place the panels on table racks and back in the cart. Panels are now ready for etching.

STEP 4

Open the ETCHING chamber and remove all of the nozzled rollers from the chamber.

ETCHING PROCEDURE

PURPOSE;

Etching is a process used to remove the excess copper from the panel to yield the desired conductor pattern using a chemical process.

SAFETY and PRECAUTIONS;

Observe the following when performing the operation.

- a. The etching machine uses a conveyor to move the panels, use caution when working around or feeding panels into the machine.
- b. Gloves, goggles, and apron must be worn at all times when operating the etching machine.
- c. Use caution when cleaning the machine and adding chemicals to avoid injury to yourself and the equipment.
- d. Use caution when handling the panels, do not bend, drop, or allow the panels to come into contact with each other as this can cause damage to the panels.

START UP AND WARM UP PROCEDURE;

The following equipment will be needed.

- a. Hydrometer

STEP 1

Make sure machine is turned off before you begin.

STEP 2

Open the ETCHING chamber and remove all of the nozzled rollers from the chamber.

ETCHING PROCEDURE (Continued)

START UP AND WARM UP PROCEDURE; (Continued)

STEP 3

After removing all the rollers flush them thoroughly with fresh water. Place the water hose inside each roller and rinse until all foreign material is removed and water comes out clear.

STEP 4

Place all the rollers back in the ETCHING chamber.

STEP 5

The etching machine is now ready to be started, use the following sequence.

1. push the start button
2. turn on the pump
3. turn on the temperature switch
4. turn on the auxiliary switch
5. wait for the temperature to reach 118 degrees Fahrenheit

STEP 6

When a temperature of 118 degrees Fahrenheit is reached turn all the switches that were turned on in STEP 5 off. Turn them off in the reverse order of turn-on procedure.

STEP 7

When the ETCHING machine has stopped remove the round lid on side of the ETCHING chamber to measure the pH and specific gravity of the etching fluid.

following procedure.

ETCHING PROCEDURE (continued)

START UP AND WARM UP PROCEDURE; (Continued)

STEP 8

With the pH METER measure the level of pH. Acceptable levels are from 8.2 to 8.8.

STEP 9

With a HYDROMETER measure the specific gravity level.

Acceptable levels are from 1.207 to 1.227.

STEP 10

If the pH level is too high you will need to open the ETCHING chamber, this will ventilate the chamber and lower the pH level. Retest etching solution until the proper level is reached.

STEP 11

If the SPECIFIC GRAVITY is too high the following will have to be performed.

1. turn on main pump switch
2. turn on CHEMICAL PUMP, set for manual operation

This process will pump in new ETCHING Fluid. After 2 minutes turn the pumps off and test again. This process will need to be repeated until the proper levels are reached.

OPERATION PROCEDURE:

STEP 1

When the proper levels of pH and specific gravity are reached the machine is ready to be started. Follow the following procedure.

ETCHING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

1. turn on main pump .
2. turn on temperature switch
3. turn on auxiliary pump switch
4. turn on conveyor, Adjust conveyor speed for 300, the speed may have to be readjusted depending on the visual inspection at the end of the line.

STEP 2

Place panels flat on conveyor at control end of machine.

Panels can be fed into the machine end to end leaving a small space between each one.

STEP 3

After two panels have started into the machine turn the water on 1/8 turn for the rinse process.

STEP 4

Turn on the air for the drying process.

STEP 5

Turn on the pump to remove the water from the rinse chamber.

STEP 6

When panels begin arriving at the end of the machine

visually inspect them for.

- a. Copper remaining on board areas of panel. This may show up as a brown film on the laminate. The conveyor will need to be slowed down.

ETCHING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

- b. Overetched traces. Traces must not be ragged when an ungloved finger is run across the circuitry, the edges of the circuitry must be smooth. It will take experience to develop a feeling of what is "too sharp" and what is not. When overetch occurs the conveyor speed must be increased.
- c. Traces exhibiting apparent resist breakdown. If they do, the panel must be closely examined to verify that the breakdown is not in fact unetched copper due to poor stripping. If the unetched copper is due to poor stripping, the panels must be restripped in fresh stripping solution.

STEP 7

If panels are under etched they can be run through again at a increased conveyor speed of 700-800.

STEP 8

As finished panels arrive at the end of the etching machine keep visually inspecting them . If acceptable, place them onto table rack. The panels are now ready for inspection.

c. traveler

d. magnifying eyepiece

STEP 1

Get a panel from the rack and place it on the lighted table

ETCH AND STRIP INSPECTION PROCEDURE**PURPOSE;**

This inspection is performed to ensure that the etch and strip procedures are performed adequately.

SAMPLE RATE;

Use a 1.5% A.Q.L. lot sample rate for the panels. If the A.Q.L. is found to be acceptable it will be assumed that the others will be acceptable also. If any of the A.Q.L are found to have problems a hold tag will be issued and all the panels must be checked. When there is a repeated problem report it to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. The boards have sharp edges so handle them with caution to avoid injury.
- b. Wear white gloves at all times when handling the panels to avoid contaminating the surface.

OPERATION PROCEDURE;

The following items will be needed.

- a. Production film
- b. Radical
- c. traveler
- d. magnifying eyepiece

STEP 1

Get a panel from the rack and place it on the lighted table.

ETCH AND STRIP INSPECTION PROCEDURE (Continued)

INSPECTION CRITERIA; (CONTINUED)

1. Line width; Measure it with a radical.
ILW-insufficient, ELW-excessive,
ULW-uneven line width. The line width is
either over spec, (ELW). Under spec. (ILW)
or uneven line width (ULW). If line is
more then 20% under size the board will
need to be scraped.
2. Broken circuits; Any breaks found in the circuits
will make the board scrap.
3. Voids in holes; Look for areas were plating may not
have been adequate.
4. Pin holes in circuits; If they effect more then 20%
of the circuit scrap it.
5. Insufficient land area; The pad area as measured from
edge of the hole to the edge
of the pad.
6. Etch outs; Missing or voids in the circuitry and pad.
7. Spurious foil; Unwanted foil. Foil which has to be
removed. Under etched circuitry. A
sharp or pronounced projection on the
circuitry.
8. Over etch; Hold board at angle with light, look for
areas with a copper color.

ETCH AND STRIP INSPECTION PROCEDURE (Continued)

INSPECTION CRITERIA; (Continued)

9. Blemished circuitry; Nicks, scrapes, pits, dents, damaged, blisters, rough circuitry.
10. Spacing; The distance between circuit paths.
11. Incorrect finish; The top plating is incorrect, i.e. gold or nickel over tin lead or tin lead over gold tabs.
12. Warped; A bow or bend in the board.
13. Damaged boards; Cracked, chipped, measling, crazing, scraped, gouged, etc.
14. Improper dimensions; The outside dimensions are improper. Width, length, notches, angles, radiuses, etc.
15. Wrong type base material; Grain direction when applicable.
16. Dirty boards; Any foreign material that does not belong or will contaminate the board.
17. Copper showing; Copper that can be seen by looking straight down at the board, and can be repaired by tinning.;
18. Peeling; Gold, copper, tin lead or nickel is peeling back because of poor adhesion (tape test).
19. Nomenclature; Part number, assembly number, numbers, letters, logos.

ETCH AND STRIP INSPECTION PROCEDURE (Continued)

INSPECTION CRITERIA (Continued)

20. Solder test; Board to be taken from extra or scraped electrical contacts for solderability test.

All of the above attributes and variables will be cause for the rejection of the lot, per 1.5% A.Q.L. Report any defects to Quality Control immediately and process a hold tag. If the lot is accepted, sign off in the correct columns. Place panels on table rack, place rack on cart and send panels to next step of process as indicated on traveler.

personal protective clothing is not used. If a chemical accident does occur notify someone immediately and go to the nearest first aid center and flood the area with fresh water for 15 minutes.

OPERATION PROCEDURE:

STEP 1

After the panels have been taped place them in the FIRST SOLDER STRIP bath for 4 minutes. If the panels have contacts on both sides, flip the panel over and do the other side for 4 minutes. Remove the panel let it drip and rinse it thoroughly.

STEP 2

After rinse place the panel in the SECOND SOLDER STRIP bath for 30 seconds. Remove it and check for complete copper color on contacts. If tin lead still appears check the quality of the bath. Remove the panel let it drip and rinse thoroughly.

NICKEL AND GOLD PLATE PROCEDURE

PURPOSE;

Nickel and gold plating is a process used to coat the electrical contacts of the board for better electrical characteristics and less corrosion.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and apron when operating the line or performing additions or changes to the baths. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not used. If a chemical accident does occur notify someone immediately and go to the nearest first aid center and flood the area with fresh water for 15 minutes.

OPERATION PROCEDURE;

STEP 1

After the panels have been taped place them in the FIRST SOLDER STRIP bath for 4 minutes. If the panels have contacts on both sides, flip the panel over and do the other side for 4 minutes. Remove the panel let it drip and rinse it thoroughly.

STEP 2

After rinse place the panel in the SECOND SOLDER STRIP bath for 30 seconds. Remove it and check for complete copper color on contacts. If tin lead still appears check the quality of the bath. Remove the panel let it drip and rinse thoroughly.

NICKEL AND GOLD PLATE PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 3

After rinse dry the panel with lintless cloths. minutes. Hook

STEP 4 electrodes to the corner of the boards and set the

Place the panel in the COBER ETCH bath for 30 seconds to 1
minute until you see a good pink color on the contacts.

Remove from the bath and rinse.

STEP 5 the panels, rinse thoroughly and dry with lintless

After rinse place the panel in the 15% SULFURIC ACID
solution for 5 minutes. Remove and rinse.

STEP 6

Place the panel in deionized water for 15 seconds. Remove
the panel and place it in the NICKEL PLATE tank for 15
minutes.

STEP 7

Calculate the current for the live bath as follows.

$$\text{CURRENT} = \frac{\text{Area to be plated (sq.in)}}{144} \times 15 \times \text{number of panels}$$

Hook the electrodes to the corner of the panels and set the
current source the proper setting.

STEP 8

When time is up remove the panels from the nickel plate and
rinse. Dip the panels into the deionized water for 15
seconds.

NICKEL AND GOLD PLATE PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 9

Place the boards in the GOLD PLATE TANK for 13 minutes. Hook up the electrodes to the corner of the boards and set the current at 1/2 the setting that was required for the nickel plate bath.

STEP 10

Remove the panels, rinse thoroughly and dry with lintless cloth. The panels are ready for inspection.

Quality Control

SAFETY and PRECAUTIONS

Observe the following when performing the procedure:

- The edges of the panels are sharp and can cause injury to the person handling them.
- Do not grip, bend, or allow the panels to come into contact with each other.
- Wear gloves at all times when handling the panels.

OPERATION PROCEDURE

The following items will be needed:

- Magnifying eye glass.
- White gloves

STEP 1

Remove a panel from the tank. Observe all using the following procedure:

NICKEL AND GOLD PLATE INSPECTION PROCEDURE

PURPOSE;

This inspection is performed to ensure quality in the nickel and gold plating procedure.

SAMPLE RATE:

Every sixth panel will be tested. If the A.Q.L. sample is acceptable it will be assumed that the remaining panels are acceptable also. If problems are found in the sample you will need to process a hold tag and check all the remaining panels. If there is a reoccurring problem report it to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. The edges of the panels are sharp and can cause injury to the person handling them.
- b. Do not drop, bend, or allow the panels to come into contact with each other.
- c. Wear gloves at all times when handling the panels.

OPERATION PROCEDURE;

The following items will be needed.

- a. Magnifying eye piece.
- b. White gloves.

STEP 1

Remove a panel from the table rack. Inspect it using the following procedure.

NICKEL AND GOLD PLATE INSPECTION PROCEDURE (Continued)

STEP 2:

Place a piece of masking tape across the nickel and gold tabs. Smooth the tape with your fingers to remove any wrinkles and to insure tape is bonded to the surface of the tabs.

STEP 3

Hold the panel firmly in one hand and rapidly remove the tape with the other. Use a fast smooth pulling action.

STEP 4

Inspect the tabs for signs of peeling or cracking. If cracking or peeling occurs panel will be rejected. If no cracking or peeling occurs panels are ready for the next process indicated on the traveler.

area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of tanks as this can cause irreversible damage to the panels.

OPERATION PROCEDURE:

STEP 1

Place the individual panels in the FIRST STAGE SOLDER STRIPPER tub for 4 minutes.

STEP 2

Remove the panels from the FIRST STAGE SOLDER STRIPPER tub and rinse them thoroughly with fresh water hose.

TIN LEAD STRIP PROCEDURE

PURPOSE;

This process will remove the tin lead coating from the copper traces on the panels.

SAFETY and PRECAUTIONS;

Always wear safety glasses, rubber boots, gloves, and a apron when operating the line or performing additions or changes to the baths. Never mix two chemicals together unless authorized to do so as this can result in adverse reactions. The chemicals in this process can be very hazardous to health if they are not handled properly and if personal protective clothing is not worn. If a chemical accident does occur notify someone immediately and go to the first aid center located in the plating room and flood the area with fresh water for 15 minutes.

Care must be taken when handling and agitating the panels to avoid contact with other panels and the sides of tanks as this can cause irreversible damage to the panels.

OPERATION PROCEDURE;

STEP 1

Place the individual panels in the FIRST STAGE SOLDER STRIPPER tub for 4 minutes.

STEP 2

Remove the panels from the FIRST STAGE SOLDER STRIPPER tub and rinse them thoroughly with fresh water hose.

TIN LEAD STRIP PROCEDURE (Continued)

OPERATION PROCEDURE (Continued)

STEP 3 Inspection is performed to ensure quality of the tin

After rinsing place the panels in the SECOND STAGE SOLDER STRIPPER for 1-2 minutes until panel comes out a bright copper color.

STEP 4 It will be assumed that the inspection pass

Remove panels from SECOND STAGE SOLDER STRIPPER and rinse thoroughly with fresh water hose.

STEP 5 There is a commencing problem report to be

Place panels on a table rack. Take panels to inspection room for inspection.

Observe the following when performing the procedure:

- The edges of the panels are clean and the solder is applied to the pattern locations.
- Do not touch the panels or allow the panels to come into contact with each other.
- Wear gloves at all times when handling the panels.

OPERATION PROCEDURE:

The following items will be needed:

- Magnifying eye glass
- White gloves

STEP 1

Remove a panel from the table rack. Inspect it in the following areas:

TIN LEAD STRIP INSPECTION PROCEDURE

PURPOSE;

This inspection is performed to ensure quality in the tin lead stripping procedure.

SAMPLE RATE:

A 1.5% A.Q.L. sample rate will be used. If the A.Q.L. sample is acceptable it will be assumed that the remaining panels are acceptable also. If problems are found in the sample you will need to process a hold tag and check all the remaining panels. If there is a reoccurring problem report it to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. The edges of the panels are sharp and can cause injury to the person handling them.
- b. Do not drop, bend, or allow the panels to come into contact with each other.
- c. Wear gloves at all times when handling the panels.

OPERATION PROCEDURE;

The following items will be needed.

- a. Magnifying eye piece.
- b. White gloves.

STEP 1

Remove a panel from the table rack. Inspect it for the following items.

TIN LEAD STRIP INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

1. Check inside holes for tin lead; Any remaining deposits will show up as a dark black color or rainbow colors.
2. Bubbling or peeling copper; Scrap if found.
3. Deposits of tin lead on the circuits; If any deposits are found the boards will need to be redone, if it is questionable consult Quality Control.

STEP 2

Place panels on table rack and put rack back on cart.

When the A.Q.L. sample is complete the panels are ready for the next process stated in the traveler.

machine.

- a. Care must be taken when handling the panels to avoid damage to them by dropping. Do not stack the panels against each other.

OPERATION PROCEDURE:

STEP 1

First push the START BUTTON on the front panel. Then turn on the HEATER SWITCH. Wait for the heater to warm up.

STEP 2

Next turn the FLUX PUMP off. The pump is located on the floor on the left side of the machine. Turn the pump off and set it on the side of the machine. Then test the SPECIFIC GRAVITY of the flux.

FUSING PROCEDURE

PURPOSE;

Fusing, or reflow, is the process of melting codeposited tin and lead just long enough to form the alloy called solder.

It also improves the solderability of the board, extends the boards shelf life, and bonds the solder to the underlying copper.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. The fusing machine uses a conveyor to move the panels, use caution concerning your hands and fingers when feeding panels into the machine and when removing them.
- b. Wear gloves, apron, and goggles when operating the machine.
- c. Care must be taken when handling the panels to avoid damage to them by dropping, bending, or hitting them against each other.

OPERATION PROCEDURE;

STEP 1

First push the START BUTTON on the control panel then turn on the HEATER SWITCH. Wait 5-10 minutes for the machine to warm up.

STEP 2

Next turn the FLUX PUMP off. The pump is located on the floor on the left side of the control panel. Lift the lid and set it on the side of the can. Use the HYDROMETER to test the SPECIFIC GRAVITY of the flux. The specific gravity

FUSING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

should be 1.5. If the flux is too thin add flux, and retest, repeat this process until the desired value is obtained. If the flux is too thick add alcohol. Note; after you add either the flux or the alcohol replace the top of the pump and start it for 1-2 minutes before you retest to make sure it has blended properly.

STEP 3

After determining that you have the proper specific gravity level for flux replace the lid and start the pump. Visually inspect the plastic line from the pump to ensure that flux is flowing in the line. Also visually inspect the roller on the input of the machine to ensure uniform coverage of all points. The machine is now ready to have panels fed into it.

STEP 4

Begin by feeding one panel in from the left side of the control panel to make sure machine is operating properly. If the fuser is operating properly the panel will appear to have an alligator skin type texture when it appears at the other end of the machine. The conveyor speed may need to be adjusted if one of the two following conditions appear.

- a. Conveyor speed too fast; There will be the presence of unfused tin-lead (cold spots) on the panels.

FUSING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

b. Conveyor speed to slow; Three conditions may be present,

1. Darkened laminate.
2. Completely fused solder on the borders. It is good to have cold spots in the borders.
3. Measles in the laminate.

STEP 5

When it has been determined that the machine is operating properly begin placing the remaining panels flat on the conveyor leaving a small space between each panel.

STEP 6

When the panels appear at the other end of the machine remove them and visually inspect for the alligator skin type texture.

STEP 7

If the boards look acceptable place them in the water tub located next to the fuser.

STEP 8

Next scrub the surface of the panels lightly with a fiberglass brush to put a shiny finish on the surface.

STEP 9

After scrubbing rinse in fresh water and place in a table rack. Panels are now ready to be inspected.

FUSING PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 10

Shut fuser off by first turning the heater switch off then wait 5 minutes and push the stop button.

Use caution when applying pressure to the fuser assembly and gloves must be worn.

OPERATION PROCEDURE;

STEP 1

Place empty frame on work surface. Remove fuser from frame. Loosen all adjustment screws by turning counter clockwise with a screwdriver.

STEP 2

Select the proper screen mesh in accordance with the screen mesh for the frame size. Remove the screen mesh from around each side of frame.

STEP 3

Place the screen mesh on top of the frame and slide the four rods into place. Use the fabric pliers to stretch the mesh out of the screen.

STEP 4

Place the fuser in the frame and tighten the screws. Tightening the adjustment screws on the top of the frame. A maximum of 2 turns should be made on each adjustment screw. Work your way around the frame adjusting adjustment screws to make sure the mesh is stretched evenly across the frame.

PUTTING A SCREEN ON A FRAME PROCEDURE

PURPOSE;

Screens are put on frames for use in solder mask and silk screening of characters.

SAFETY and PRECAUTIONS;

Use caution when applying cleaners to the screen, Goggles and gloves must be worn.

OPERATION PROCEDURE;

STEP 1

Place empty frame on table. Remove slide lock rods from frame. Loosen all adjusting screws to their maximum point by turning counter clockwise with an Allen wrench.

STEP 2

Select the proper screen mesh to be used. Cut the screen mesh for the frame size being used, leave 3-4 inches extra around each side of frame.

STEP 3

Place the screen mesh on top of the frame and slide the lock rods into place. Use the fabric pliers to stretch the slack out of the screen.

STEP 4

Place the SERIMETER in the center of the screen. Start tightening the adjustment screws on the side of the frame. A maximum of 3 turns should be made on each adjustment screw. Work your way around the frame alternating adjustment screws to make sure too much tension is not applied to one area. For

PUTTING A SCREEN ON A FRAME PROCEDURE (Continued)

OPERATION PROCEDURE (Continued)

the initial tightening a meter reading of 15-20 is needed.

Move the meter to other areas of the screen to ensure uniform tension.

STEP 5 and PRECAUTIONS:

After the initial tightening is complete place the frame with screen in the storage rack. The tightening process will need to be repeated daily for 3-4 days. Each day the amount of tension will be increased by 5 from what it was the day before. At the end of the process there should be a uniform tension of 30-35 on the screen. The closer to 35 you get the better. Each of the 3-4 days use the same procedure of tightening where you work your way around the board and alternate adjustment screws.

STEP 6 Personal protective clothing.

After the screen has been tightened to desired tension apply ABRAD and DEGREASER CLEANER evenly over the surface of the screen using a scrubbrush. This will rough up the surface so the stencil will stick better.

STEP 7

Use the pressure sprayer to remove the ABRAD and degreaser cleaner from the surface. When thoroughly clean remove from pressure booth, let dry and store in rack.

removed. If either of the two remains it will affect the next print.

CLEANING AND PREPARING SCREEN FOR REUSE PROCEDURE

(Continued)

PURPOSE;

OPERATION PROCEDURE; (Continued)

This process will take a previously used screen and prepare

STEP 3

it to be used again for solder mask or silk screening

Shut off pressure sprayer and squirt STENCIL CLEANER on the characters.

screen to remove the remaining faint red tint. Use the brush

SAFETY and PRECAUTIONS;

to spread the stencil cleaner around on the screen. Let the

Observe the following when performing the task.

cleaner set for 2-3 minutes.

a. Use caution when working around cleaning tanks and

STEP 4

pressure spray booth.

Restart the pressure sprayer and spray the screen

b. Gloves, goggles, and a apron will be worn at all times.

thoroughly. Make sure all cleaner and foreign material are

c. The screens are fragile, use caution when handling.

completely removed.

OPERATION PROCEDURE;

STEP 5

The following will be needed.

Place screen in pressure booth and apply ABRASE and

a. Used screen.

DEGREASER CLEANER evenly over the surface using a

b. Stencil cleaner

scrubbrush. This will ruff up the surface so the stencil

c. Personal protective clothing.

will stick better.

STEP 1

STEP 6

Leave preused stretched screen on frame. Place preused

Remove the screen from the pressure booth, let it dry and

screen into SCREEN CLEANER TANK for 30 minutes. Remove and

reset the tension on the screen to 30-35 measured by the

let it drip.

SPRAYER. Store screen in rack until needed.

STEP 2

Next place screen into PRESSURE SPRAY BOOTH. Turn sprayer

on. Spray screen thoroughly on both sides. Make sure that

all of the previous stencil and cleaner (from step 1) is

removed. If either of the two remain it will effect the next

print.

**CLEANING AND PREPARING SCREEN FOR REUSE PROCEDURE
(Continued)**

PURPOSE:-

OPERATION PROCEDURE; (Continued)

This process will be used to put a image on the screen to be

STEP 3

used in solder masking and silk screening of characters.

Shut off pressure sprayer and squirt STENCIL CLEANER on the

SAFETY and PRECAUTIONS;

screen to remove the remaining faint red tint. Use the brush

Observe the following when performing the procedure.

to spread the stencil cleaner around on the screen. Let the

a. Use caution when using the developing fluids, use film

cleaner set for 2-3 minutes.

tongs to handle film when in solutions.

STEP 4

b. Keep hands and fingers out of the way when the exposing

Restart the pressure sprayer and spray the screen

machine is rotated.

thoroughly. Make sure all cleaner and foreign material are

c. Do not leave unexposed film in direct light for extended

completely removed.

periods of time.

STEP 5

d. Handle film by the edges as finger prints can cause

Place screen in pressure booth and apply ABRASE and

damage.

DEGREASER CLEANER evenly over the surface using a

OPERATION PROCEDURE;

scrubbrush. This will ruff up the surface so the stencil

STEP 1

will stick better.

Select NEGATIVE (production film) to be used. Apply a small

STEP 6

piece of tape to one corner of the top, this makes it easier

Remove the screen from the pressure booth, let it dry and

to identify the top in future steps.

reset the tension on the screen to 30-35 measured on the

STEP 2

SERIMETER. Store screen in rack until needed.

Align the negative to the board for which it is made.

Visually inspect to make sure all the holes and traces are

there and that there are no abnormalities to it.

STEP 3

Clean and dust stencil table. Bring negative to stencil

table. Remove film from round container. Note: Film should

be in light as short a time as possible.

PREPARING STENCIL PROCEDURE

PURPOSE;

This process will be used to put a image on the screen to be used in solder masking and silk screening of characters.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. Use caution when using the developing fluids, use film tongs to handle film when in solutions.
- b. Keep hands and fingers out of the way when the exposing machine is rotated.
- c. Do not leave unexposed film in direct light for extended periods of time.
- d. Handle film by the edges as finger prints can cause damage.

OPERATION PROCEDURE;

STEP 1

Select NEGATIVE (production film) to be used. Apply a small piece of tape to one corner of the top, this makes it easier to identify the top in future steps.

STEP 2

Align the negative to the board for which it is made. Visually inspect to make sure all the holes and traces are there and that there are no abnormalities to it.

STEP 3

Clean and dust stencil table. Bring negative to stencil table. Remove film from round container. Note; Film should be in light as short a time as possible.

PREPARING STENCIL PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

STEP 4

Lay negative on film and cut film to the correct size. The size should be 1-2 inches larger on each side than negative.

STEP 5

Go to Nu Arc Plate Maker (stencil maker). Unlatch and rotate the top 180 degrees until glass top appears. Open glass cover, clean and dust the glass surface and the plastic sheet on the bottom.

STEP 6

After cleaning surfaces, place the dull side of the piece of film just cut face down on the center of the plastic sheet. Lay the negative, tape side down in the center of the film. Close and latch the glass lid.

STEP 7

With lid closed turn on the master switch then turn on the vacuum pump. When the vacuum gage reads from 20-25 rotate the top 180 degrees. Set the timer for 3.5 minutes.

STEP 8

While waiting, get 3 pieces of paper, cut them larger than the film being used, for use in future steps.

STEP 9

When time is up shut all switches off. Rotate the top 180 degrees and remove the film.

PREPARING STENCIL PROCEDURE (continued)

OPERATION PROCEDURE; (Continued)

STEP 10

Place film immediately in the DEVELOPER TUB and wet the back side down. When the back side is wet immediately flip the film over and immerse it in DEVELOPING FLUID. Set the timer for 90 seconds. While waiting gently agitating the film.

STEP 11

When the time is up remove the stencil from the developer and gently spray it with 105 degree water. Look for removal of red coating from the surface, the stencil should take on the appearance of the original film. Spray until all the excess red is removed.

STEP 12

Switch from warm water to cold water and continue to flood for 2-3 minutes. The stencil should shrink slightly.

STEP 13

Remove the stencil and place it on a prepared screen with the slimy side toward the screen, it will stick to the screen so place it as smooth and straight as possible.

STEP 14

Take 1 sheet of the paper you got in the previous step and lay it on top of the stencil. With a rolling pin gently roll it across the surface of the stencil allowing the paper to soak up the excess moisture. Repeat this step for the other 2 sheets of paper.

PREPARING STENCIL PROCEDURE (continued)

OPERATION PROCEDURE; (Continued)

STEP 15 mask or screen printing is the art of forming ink

Remove the last sheet of paper and let the stencil dry thoroughly. rubber or plastic squeegee is used to push a small

STEP 16 of ink (plating resist; screen for stencil) area is

When the stencil is dry take your fingernail and scrape the edge of the stencil, there is a sheet of thin mylar that will peel off once it is started. When the sheet is removed inspect it for any red that might not have adhered to the screen. If you find places where the red did not stick you will have to start over. If you don't find any red the screen is ready for solder mask or silk screening of characters. panels with given

OPERATION SETUP PROCEDURES

The following items will be needed:

a. Screen printing station

b. Resist ink.

c. Squeegee.

d. Single sided and double sided tape

e. Prepared stencil on screen

f. Gloves.

g. Quick check plastic

h. Carlson pins.

PROCEDURE FOR SOLDER MASK

PROCEDURE; SETUP PROCEDURE

Solder mask or screen printing is the art of forcing ink through a stencil which is mounted on a tightly stretched screen. A rubber or plastic squeegee is used to push a small puddle of ink (plating resist) across the stencil area on the screen, which forces the ink through open areas on the screen to print the circuit pattern or characters on the copper clad panel.

SAFETY and PRECAUTIONS; screening holes.

The following precautions will need to be observed.

- a. Do not get fingers in screen printing station hinged area.
- b. Handle panels with gloves.

OPERATION SETUP PROCEDURE; place shims that are equal

The following items will be needed.

- a. Screen printing station.
- b. Resist ink.
- c. Squeegee.
- d. Single sided and double sided tape.
- e. Prepared stencil on screen.
- f. Gloves.
- g. Quick check plastic.
- h. Carlson pins.

edge of the panel to ensure that the squeegee does not ride directly on the panel. There should be 1/8 to 1/5 inch of

PROCEDURE FOR SOLDER MASK (continued)

OPERATION SETUP PROCEDURE;

STEP 1

Lock prepared screen into screen printing station. On rectangular panels place long portion of board perpendicular to back side of station.

STEP 2

Raise front portion of screen and insert panel. Line up the panel with the image on the screen. When visually lined up insert carlson pins into screening holes.

STEP 3

Adjust the screen frame so that the screen has from 0.060-0.10 inches clearance between it and the panel underneath it. This is accomplished by placing shims around the edge of the frame. First place shims that are a equal thickness to the carlson pins and add 0.06-0.10 inches to each one. This will put the screen at approximately the right height.

STEP 4

Visually align the panel with the image on the screen again. Tape each of the carlson pins to the bottom surface to secure them in place.

STEP 5

Make a boarder frame of thin cardboard sheets around the edge of the panel to ensure that the squeegee does not ride directly on the panel. There should be 1/16 to 1/8 inch of

SOLDER MASK PROCEDURE (Continued)

OPERATION SETUP PROCEDURE; (Continue)

clearance between the top surface of the panel and the top of the border frame.

STEP 6

Remove the panel from the carlson pins. Tape the carlson pins securely to the lower surface.

STEP 7

Place double sided tape where the panel was, this area is called the nest. The tape is used to further secure the board from movement. Place the panel back into the carlson pins.

STEP 8

Place a sheet of QUICK CHECK PLASTIC, that is large enough to cover the entire panel, directly on top of the panel. Lower the hinged frame into place and check the alignment of the stencil and panel. If it needs to be realigned use the adjustments found on each side of the jig to move it into place. This alignment process must be precise with one exception, the stencil must be closer to the front of the jig than the panel to allow for the screen stretching as the squeegee is being pushed across the screen.

STEP 9

When alignment is complete tape from the carlson pins outward on the surface of the screen. Tape out 6 inches on the sides and go all the way to the edge on the top and bottom.

SOLDER MASK PROCEDURE (Continued)

OPERATION SETUP PROCEDURE; (Continue)

STEP 10

Choose a squeegee that is approximately 2 inches wider than the surface width of the panel. To aid in the cleanup process place a piece of tape on each side of the squeegee handle.

STEP 11

Apply a glob of ink to the top of the screen above the border of the image. Lift the hinged screen up. Using the squeegee pull the ink across the screen toward the front, this is called flooding the screen.

STEP 12

Lower the hinged screen. Hold the squeegee at a 30 degree angle with respect to the edges of the panel and at a 60 degree angle with respect to the surface. Using smooth even pressure and keeping a constant angle push the squeegee away from the front edge toward the back of the screen.

STEP 13

Lift hinged screen and examine the quick check plastic for proper alignment with panel. If alignment is not precise you will want to get a clean piece of quick check plastic and readjust the border adjustments again. Repeat steps 12 and 13 until the image is precisely aligned.

SOLDER MASK PROCEDURE (Continued)

OPERATION SETUP PROCEDURE; (Continue)

STEP 14

When alignment is complete lift hinged screen and remove the quick check sheet. Next clean the screen by placing a sheet of paper on the board and lowering the hinged screen on top of the paper. Using the squeegee push the excess ink to the back of the screen. The screen will need to be cleaned every 3-5 boards as needed during the process. When all the excess is pushed to the back lift hinged screen and remove the paper.

STEP 15

Using the procedure in step 11 flood the screen again. The solder mask procedure is now ready to begin.

OPERATION PROCEDURE;

STEP 1

Lower the hinged screen into place and repeat the process in step 12. Lift hinged screen and remove the panel. Place the panel in a table rack. Place another panel into place and repeat step 1 until 5 panels are complete.

STEP 2

After 5 panels are complete and while they are still wet take them to the inspection room. With a microscope inspect the panels for alignment, solder mask on pads and registration.

Steps 3 and 4 assume the panels passed inspection.

Steps 5, 6 and 7 assume the panels did not pass inspection.

SOLDER MASK PROCEDURE (Continued)

OPERATION PROCEDURE; (Continue)

STEP 3

If the panels are acceptable place them on the table rack in the HOT OVEN at 300 degrees for 20 minutes.

STEP 4

After 20 minutes remove the rack from the oven and let the panels cool. When cool the panels are ready to be cleaned and have the reverse side solder mask.

STEP 5

If panels did not pass inspection place them on a jig and submerge them in the cleaning solution tank for 10-15 minutes.

STEP 6

Remove panels from cleaning solution tank and place them in the pressure wash booth, turn the pressure washer on and wash the panels. Remove the panels from the pressure washer and dip them into the smaller tub of clean cleaning solution.

STEP 7

Remove panels from cleaning solution and rinse with hot water until they are clean. Dry the panels in the dryer or the oven. Realign screen and begin at step 1 and repeat procedure.

PROCEDURE FOR SOLDER MASK (continued)

OPERATION PROCEDURE; (Continued)

CLEANUP operation is performed by several methods usually

STEP 1 in the solder mask procedure.

After all the panels have been processed use the squeegee to scrape the remaining ink to the top of the screen. Scoop up and save all the excess ink.

STEP 2. If any of the A.G.I.s are found to have problems.

Remove all the tape from the screen, squeegee, surface, and carlson pins and discard. Clean, sharpen, and store squeegee.

Observe the following when performing the work:

- a. The panels have sharp edges that are easily broken.
- b. Do not bend, drop, or allow the panels to come into contact with each other.
- c. Use gloves when handling the panels.

OPERATION PROCEDURE:

The following equipment is required:

- a. Magnifying eyeglasses
- b. White gloves

STEP 1

Remove a panel from the rack with the following instructions:

following steps:

1. Hold the mask at the bottom edge and pull it up.
 2. Make sure corners are flat and solder mask is not broken.
 3. Do not touch the mask with your fingers.
- After the mask is removed, it should be stored in a clean, dry container.

SOLDER MASK INSPECTION PROCEDURE

PURPOSE;

This inspection is performed to ensure adequate quality control in the solder mask procedure.

SAMPLE RATE;

Use a A.Q.L. sample rate of 1.5% for this inspection. If the A.Q.L. sample is adequate there is no need to inspect the others. If any of the A.Q.L. are found to have problems process a hold tag and inspect all the panels. A reoccurring problem must be reported to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the task.

- a. The panels have sharp edges that can cause injury.
- b. Do not bend, drop, or allow the panels to come into contact with each other.
- c. Use gloves when handling to avoid damage to the panels.

OPERATION PROCEDURE;

The following equipment is required.

- a. Magnifying eyepiece.
- b. White gloves.

STEP 1

Remove a panel from the table rack and inspect it for the following items.

1. Solder mask should be around holes, and not on pads.
2. Make sure correct side and areas have solder mask.
3. Look for foreign material or abnormal material that may impair board performance.

SOLDER MASK INSPECTION PROCEDURE (Continued)

OPERATION PROCEDURE; (Continued)

4. Clearing around pads should not be so large that adjacent circuitry is exposed.

STEP 2

If all items are acceptable from the A.Q.L. sample place the panels into the table rack and put the rack on the cart. The panels are ready for the next procedure stated on the traveler.

SAFETY AND PRECAUTIONS:

Observe the following when performing the task:

- a. The panels have sharp edges which can cause injury if not handled properly.
- b. Do not touch any of the surfaces in the rack contact with skin.
- b. Use gloves when handling the panels.

OPERATION PROCEDURE:

The following steps will be used:

- a. Magnifying glass
- b. White gloves

STEP 1

Remove a panel from the rack and inspect it for the following items.

HOT AIR INSPECTION PROCEDURE

PURPOSE;

This inspection ensures quality control in the hot air process.

SAMPLE RATE;

For this inspection use a 1.5% A.Q.L. sample rate of panels out of each lot and use them for inspection. If the A.Q.L. is acceptable it will be assumed that all others are acceptable also. If anything is wrong with the sample, process a hold tag and all the remaining panels must be inspected. Report any problem to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the task.

- a. The panels have sharp edges which can result in injury if not handled properly.
- b. Do not bend, drop, or allow the boards to come into contact with each other.
- b. Use gloves when handling the panels.

OPERATION PROCEDURE;

The following items will be needed.

- a. Magnifying eyepiece.
- b. White gloves.

STEP 1

Remove a panel from the box and inspect it for the following items.

HOT AIR INSPECTION PROCEDURE (Continued)

INSPECTION CRITERIA;

1. Globbs or mounds; Any excessive amounts of solder left on the panels.
2. Over hang in holes; Any deposits that will effect the clear and unobstructed use of the holes.

STEP 2

When finished place panels in rack and sign traveler. Place rack on cart and move cart to routing.

- c. Only one person will be in charge of machine operation while machine is running.
- d. Safety glasses and gloves must be worn at all times.
- e. Router bits must be sharp.

OPERATION PROCEDURE:

- a. Make sure AIR COMPRESSION is turned on.
- b. Turn on the CONTROL switch.
- c. Turn on the MACHINE switch.
- d. Set the mode selector switch to MANUAL.
- e. Press the PROGRAM START button twice.
- f. Set the FEED RATE to 1.0.
- g. Set the selector switch on Z axis. Press the IN/OUT button until the table is in the center of the machine. Press the HOME button.
- h. Set the selector switch on X axis. Press the IN/OUT button until the table is in the center of the machine. Press the HOME button.

PROCEDURE FOR ROUTING MACHINE WARM-UP

PURPOSE;

Routing machine warm up is required to insure efficient quality operation of the routing machine.

SAFETY and PRECAUTIONS;

The following items will need to be observed when performing the procedure.

- a. Keep hands and fingers away from moving mechanical parts.
- b. Operator must be trained in both safety and operation of the machine.
- c. Only one person will be in charge of control operation while machine is running.
- d. Safety glasses and gloves must be worn at all times.
- e. Router bits must be sharp.

OPERATION PROCEDURE;

- a. Make sure AIR COMPRESSOR is turned on.
- b. Turn on the CONTROL switch.
- c. Turn on the MACHINE switch.
- d. Set the mode selector switch to MANUAL.
- e. Press the PROGRAM RESET button twice.
- f. Set the FEED RATE to 40%.
- g. Set the selector switch on Y axis. Press IN/OUT button until the table is in the center of the machine. Press the HOME button.
- h. Set the selector switch on X axis. Press the IN/OUT button until the table is in the center of the machine. Press the HOME button.

PROCEDURE FOR ROUTING MACHINE WARM UP (Continued)

OPERATION PROCEDURE; (Continued)

- i. Press the PROGRAM RESET button, look at the screen to make sure that (X,Y) are zero.
- j. Turn the MODE SELECTOR switch to MDI.
- k. On the keyboard enter, M,(CR) and G99 (CR).
- l. Turn the selector switch to AUTOMATIC, press CR on the keyboard.
- m. Press the start button.

Step (m) will start the warm-up cycle. When the warm-up cycle is complete the EMERGENCY LIGHT should be on. Also check the number of counts on the screen (TV), it should be 8 cycles, if not repeat steps (d-m) until the correct reading is achieved.

PROCEDURE FOR CHECKING A PROGRAM IN THE PARTS LIST

PURPOSE;

This procedure will allow you to check a program segment that is stored in the control unit.

- a. Turn the selector switch to MDI.
- b. Go to the keyboard and enter "P, CR" and "L, CR".

PROCEDURE FOR DELETING A PROGRAM IN MEMORY

PURPOSE;

This procedure will allow you to delete a program that is stored in the memory of the control unit.

- a. On the keyboard enter "P, CR"
- d. and "D (# of program)/ T or R, CR"

PROCEDURE FOR LOADING A PROGRAM TAPE

PURPOSE;

This process will be used when loading a numerical control tape into the control unit.

- a. Set the selector switch to MDI.
- b. On the keyboard enter "P, CR"
and "A (# of program) / T or R, CR"
- c. Check the screen (TV) for program part number, if number is correct, start if not repeat steps a and b.

HOW TO CALL A PROGRAM IN THE PARTS LIST

PURPOSE;

This process will allow you to call a particular segment of a program that is stored in memory.

- a. Set the selector switch to MDI.
- b. On the keyboard enter "P, CR"
and "# of program / T or R, CR"
- c. Check the screen (TV) for program part number, if number is correct, start if not repeat steps a and b.

PROCEDURE FOR MAKING A TOOLING HOLE

PURPOSE;

This process will be used to put tooling hole in a panel.

- a. Place the cutter in the spindle.
- b. Set depth by turning adjustment two turns to the right to lower router head.
- c. Next call PROGRAM IN PARTS LIST.
- d. Set selector switch to AUTOMATIC and press CR on the keyboard. This will start the process.

PROCEDURE FOR SETTING MACHINE TO ZERO

PURPOSE;

This process will be used set the router to the (0,0) coordinates to ensure uniformity between the programming stage and the routing procedure.

- a. Set the selector switch to MDI.
- b. Set the AXIS selector switch on Y and move the IN/OUT switch to center the machine. When centered press HOME button.
- c. Set the AXIS selector switch on X and move the IN/OUT switch to center the machine. When centered press the HOME button.
- d. Press the program reset button.
- e. Check the screen (TV) for (X,Y) to be (0,0). If not repeat steps b to d until it does.

OPERATION PROCEDURES

- a. Check the program for the kind of tools to be used.
- b. Load the router with the spindle.
- c. Set the depth of the router with a suitable dial.
- d. Set the spindle speed to the correct RPM.
- e. Set the program and start the machine.
- f. Set the spindle speed to the correct RPM.

PROCEDURE TO ROUT A BOARD

PURPOSE;

This process will be used to rout the board from a panel after the manufacturing process is complete.

SAFETY and PRECAUTIONS;

The router has several areas that will need to be monitored to ensure safe efficient operation.

- a. Keep hands and fingers out of the way of moving mechanical parts.
- b. Operator must be trained in the operation of the router and safety.
- c. Only one person will be in charge of operating the controls while routing.
- d. Safety glasses and gloves will be worn at all times.
- e. Router cutters must be sharp to operate correctly.
- f. Monitor all of the operation, never assume the automatic process will take care of itself.

OPERATION PROCEDURE;

- a. Check the program for the kind of tools to be used.
- b. Load the cutter onto the spindle.
- c. Set the depth of the router head by turning the adjustment two turns to the left. Note; this should only be done after making the tooling holes.
- d. Call the program that is being used.
- e. Set the selector switch to AUTOMATIC and press CR.

This will start the process.

FINAL INSPECTION PROCEDURE

PURPOSE;

This inspection will be the final inspection before shipment. It is important that all items on the board are gone over very carefully to ensure all operations throughout the process have been completed.

SAMPLE RATE;

A 1.5% A.Q.L. sample of boards will be used for this procedure. Report any problems to Quality Control at once.

SAFETY and PRECAUTIONS;

Observe the following when performing the procedure.

- a. The boards have sharp edges that can cause injury if not handled properly.
- b. Do not bend, drop, or allow the boards to come into contact with each other.
- c. Use gloves when handling boards.

OPERATION PROCEDURE;

The following items will be needed.

- a. Magnifying eye piece.
- b. White gloves.
- c. Blue prints.
- d. Drawings.

INSPECTION CRITERIA;

1. Review traveler and drawing for all manufacturing requirements.

FINAL INSPECTION PROCEDURE (Continued)

INSPECTION CRITERIA; (Continued)

2. A 100% check of all procedures performed on the board from start to finish. Look for any items missed or not found in the other inspections.
3. Inspect the finished hole sizes for correct gauge size.
4. Measure the board size, make sure it is within tolerance.
5. Verify and inspect solder mask requirements, touch up if necessary, after touch up bake at 300 degrees for 30 minutes.
6. Gauge all second drill holes sizes.
7. Check location and size of slots. If slotting was done between contact fingers, look for lifting of the electrical contacts.
8. Check all legends and screening characters. Make sure they are on the right side of board.
9. See that a solder test is completed and acceptable when required by customer specifications.
10. See that a micro-section is completed and accepted when required by customer specification.
11. Verify any hardware to be installed per print.
12. Verify that data code stamps, or logo stamps are placed where necessary.
13. Check if protective coating is required per print.

FINAL INSPECTION PROCEDURE (Continued)**INSPECTION CRITERIA; (Continued)****14. Visually inspect for:**

- a. Damage to board.
- b. Dirty boards.
- c. Spurious foil.
- d. Voids.

AFTER INSPECTION;

If a defect is found, process a hold tag per Q.C.I of the Q.A. manual. If the lot is accepted, sign off in the correct columns, and process a crib tag. Enter all Q.C. information in the shipping log. Make out a green acceptance tag. Send boards to the crib for packaging.

STAR CHAPTER 3 INC
QUALITY ASSURANCE MANUAL

The quality assurance manual will be used for the purpose of providing customers with the assurance of standard practices used at Star Circuits Inc. It provides standards taught to all employees at the company which are required to meet and ensure the production of high quality printed circuit boards by the company.

The quality assurance manual was rewritten and revised from an older version that was not suited and geared for the present manufacturing work being performed at Star Circuits Inc. The new revised version will provide a clear and accurate set of standards and guidelines to be used in the every day operation of the company. Having a clear set of guidelines to follow will also show the customer that the company is interested in providing a high quality printed circuit board that is produced on time and that every effort will be made to avoid delays.

QUALITY STAR CIRCUITS, INC

405 Railroad Street
Brookings, SD 57006
Phone 605-692-7557

RECEIVING CONTROL
IN-PROCESS CONTROL
DRAWING AND SPECIFICATION CONTROL
PRELIMINARY REVIEW
TO OUR CUSTOMERS:

This Quality Assurance Manual has been compiled for the purpose of establishing a uniform method of quality control.

TRAINING INSPECTORS
ISSUING INSTRUCTIONS
PURCHASE ORDERS
With these procedures, we can assure our customers of a product which will meet or exceed their requirements.

The Quality Control Department reports directly to the Operations Manager. The Department is responsible for establishing and maintaining a quality level acceptable to the customer's needs, as so stated in the purchase order, sales order, or contract.

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Operations Manager
Hal Halcomb

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all purchase orders, specifications and inspection requirements for the material.

PROCEDURE

The receiving department will receive all shipments of parts and/or materials to the inspection department along with a copy of the receiving notice. The receiving notice is matched with the inspection copy of the purchase order. This shipment is then inspected as per the inspection requirements of the applicable quality level. The inspection will be required by the Quality Assurance Manager. The inspection will be required if no direction is given by the customer or the Q.A. Manager.

CERTIFICATION: The inspection will be performed as per the

RECEIVING INSPECTION**PURPOSE:**

The Receiving Inspection Department verifies all incoming parts, assemblies and/or materials to the quality standards required by the purchase order.

RESPONSIBILITY:

The responsibility of the Quality Control Department is to conduct the necessary inspections and tests to assure that all purchase orders, specifications, and blueprint requirements have been met by the vendor.

PROCEDURE:

The Receiving Department will deliver each shipment of parts and/or assemblies to the Inspection Department along with a copy of the receiving notice. The receiving notice is matched with the inspection copy of the purchase order. This shipment is then inspected in accordance with Mil-STD-105D. Applicable quality level standards (AQLS) will be assigned by the Quality Assurance Manager. 100% inspection will be required if so directed per customer requirements or the Q.A. Manager.

Certification and test reports must be received from the

RECEIVING INSPECTION (Continued)

PROCEDURE: (Continued)

vendor when required. No product or material requiring certification will be released to production unless this data is on hand and filed with the receiving inspection report.

The results of visual, dimensional, and other tests are recorded on the Receiving Inspection Report Form GF No. 150. Disposition of material is also shown, along with the inspector's acceptance or rejection signature.

When material is rejected, the reason is recorded on a Hold Tag and Attached to the material. A Rejection Notice Form GF No. 151 is filled out and forwarded to Purchasing.

The inspection copy of the purchase order and the Receiving Inspection Form along with any certification papers will be kept on file by the Receiving Inspection Department.

The material will then be reviewed by quality and production department heads to determine disposition as to rework, hold for customer review, or scrap.

IN-PROCESS CONTROL**PURPOSE:**

To maintain sufficient inspection during manufacturing to assure our customer that quality products will meet end item requirements of contracts.

RESPONSIBILITY:

It will be the responsibility of the Quality Control Department to establish and maintain adequate inspection stations, as deemed necessary, to make certain all customer blueprints, specifications, and contract requirements are met.

PROCEDURE:

Our standard shop practice calls for inspection in-process to avoid costly errors.

All discrepant material found will be rejected and a hold tag filled out and attached.

The material will then be reviewed by quality and production department heads to determine disposition as to rework, hold for customer review, or scrap.

DRAWING AND SPECIFICATION CONTROL

PURPOSE:

To establish a method of control by which we can assure the customer that the latest applicable drawing will be issued to the Production and Inspection Departments.

RESPONSIBILITY:

It shall be the responsibility of the Quality Control Department to inspect all items and compare them to the latest engineering information.

It will also be the responsibility of the Sales Department to furnish as quickly as possible the necessary change and drawing information to all departments concerned.

PROCEDURE:

The latest applicable drawing, specifications, and engineering change orders are issued directly to the Quality Control Department by the Sales Department.

Any drawing that has been voided out by a revised drawing or change order will be immediately removed from inspection files and destroyed.

If the effective change point has not been met in Production, the superseded drawing will be retained until the effective point has been reached and then it will be destroyed by the Inspection Department.

PRELIMINARY REVIEW

PURPOSE:

To assure that parts or assemblies that vary from print or specifications are properly reviewed.

PROCEDURE:

1. Preliminary review will determine disposition as follows:

1.1 All defective material and parts shall be rejected.

A Hold Tag will be completed.

1.2 Only the Quality Control Department personnel are

authorized to remove Hold Tags.

1.3 Discrepancies will be reviewed by our Production,

Control Quality, and Engineering Departments to determine

disposition as to rework, scrap, or hold for customer

MRB action.

REWORK:

Parts or assemblies will be reworked if they can not meet blueprint and specification requirements. Rework will be reinspected, if accepted, hold tags will be removed and Q.C.

Data Report will reflect approval.

SCRAP: will eliminate repetition of defects.

Scrap parts or assemblies obviously unfit for use or repair are recorded on the Scrap Tag, and then routed to the scrap area.

Collected data will be studied for either recommended changes in manufacturing or information will be forwarded to the contractor for possible design change.

Requests for corrective action shall be issued on Form No.

147 and Form No. 148.

CORRECTIVE ACTION

PURPOSE:

To establish a method by which corrective action on repetitive discrepancies is obtained.

RESPONSIBILITY:

It will be the responsibility of the Quality Control Department to notify Production and/or Vendors by Corrective Action Requests, that future parts must conform to contractual, specification, and blueprint requirements.

PROCEDURE: raw materials are carefully inspected.

A "Corrective Action Request" will be issued by the Quality Control Department to Production or the Vendor when defects are repetitious. closely for purchase order requirements; also, screen certification test reports where applicable. These reports will list specific action taken and effective date. One copy of this report is retained in the Quality Control Departments follow-up file until Production or Vendor's copy is received, then processed together.

Corrective action taken will be analyzed to see if the action will eliminate repetition of defects.

Collected data will be studied for either recommended changes in manufacturing and/or information will be forwarded to the contractor for possible design change.

Requests for corrective action shall be issued on Form No. 147 and Form No. 148.

RAW MATERIAL AND STORAGE CONTROL**PURPOSE:**

The purpose of this procedure is to define a method of controlling, receiving and storage of raw material (wire and fiber board).

RESPONSIBILITY:

It is the responsibility of the Quality Control Department to conduct all necessary tests and inspections to assure that chemical and physical requirements have been met; also, Adequate training will be given by the Quality Control Foreman so the inspector will clearly understand what will be required to fulfill the assignment.

PROCEDURE:

Raw materials are received and inspected. The inspector will check materials closely for purchase order requirements; also, screen certification test reports to the applicable specifications.

TRAINING INSPECTORS**RESPONSIBILITY:**

It will be the responsibility of the Quality Control Manager to maintain a training program for inspectors.

PROCEDURE:

RESPONSIBILITY:
New inspectors will be trained and instructed in methods and procedures that are employed by the Quality Control Department to issue written inspection instructions, for general specifications and special inspection plans.

Adequate training will be given by the Quality Control

PROCEDURE:
Foreman so the inspector will clearly understand what will be required to fulfill the assignment.

Inspection instructions will be prepared and issued by inspectors when changes are made in the customers specifications that are not covered in our Q.C. manual.

Workmanship standards for various jobs will be prepared by the Q.C. Foreman in charge.

Contracts requiring a specification used in-process and final inspection, will be made up and issued to the assigned area inspector who must follow it.

Special instructions may be issued by the Quality Control Manager regarding, statistical Q.C. areas and the latest applications of good quality control practices.

ISSUING INSTRUCTIONS

PURPOSE:

The purpose of this procedure is to establish a method for issuing proper inspection instructions.

RESPONSIBILITY:

It will be the responsibility of the Quality Control Department to issue written inspection instructions to cover specifications and special inspection plans.

PROCEDURE:

Inspection instructions will be prepared and issued to inspectors when changes are made in the customers specifications that are not covered in our Q.C. manual.

Workmanship standards for various jobs will be prepared by the Q.C. Foreman in charge.

Contracts requiring a specification used in-process, and final inspection, will be made up and issued to the assigned area inspector who must follow it.

Special instructions may be issued by the Quality Control Manager regarding, statistical Q.C. terms, and the latest applications of good quality control practices.

PURCHASE ORDERS

RESPONSIBILITY:

The Purchasing Department shall be responsible in selecting vendors that can meet good quality standards.

RESPONSIBILITY:

PROCEDURE:

The Purchasing Department will select a vendor that is capable of meeting inspection requirements and quality standards prior to placing a purchase order.

The Quality Control Manager will be prepared to offer all assistance possible to the Purchasing Department in vendor selection regarding quality.

Vendor surveys will be conducted and vendor source inspection generated when deemed necessary by the Q.C. Manager.

following:

Survey reports will be on file in the Q.C. office and vendor evaluation results will be made available to the Purchasing Department.

1.2. Daily calibration of special purpose test equipment will be accomplished by the Test Technician in charge.

1.3. Electrical - All complex equipment shall be calibrated by an approved outside source.

2. Control of precision gages.

TEST EQUIPMENT AND GAGES

PURPOSE: (Continued)

This procedure is to establish a method of control for calibration of test and precision measuring equipment.

RESPONSIBILITY:

It shall be the responsibility of the Quality Control Department to assure that all gages and test equipment in use are within the correct limits as outlined in this procedure.

It will be the responsibility of the Test Department to assure that all test equipment is properly calibrated.

PROCEDURE:

Evidence of inspections are to be recorded in a manner to show dates of calibration.

1. Control of all test equipment will involve the following:
 - 1.1. Identify the equipment with a serial number and record in the equipment and gage calibration log.
 - 1.2. Daily calibration of special purpose test equipment will be accomplished by the Test Technician in charge.
 - 1.3. Electrical - All complex equipment shall be calibrated by an approved outside source.
2. Control of precision gages.

TEST EQUIPMENT AND GAGES (Continued)

PROCEDURE: (Continued)

2.1. Inspection of precision tools immediately upon receipt.

2.2. Record each item in our gage log with serial number and date of receipt.

2.3. Provide regular reinspection of all items to assure that wear or damage has not rendered them inaccurate.

3. All gages and inspection equipment that are sent out for frequency calibrations, or inspected in our plant, must have a written certification report on its findings. The standards used must be traceable to the National Bureau of Standards. The frequency of inspection of gages and test equipment will be controlled as follows:

- | | |
|-----------------------------|---------------------|
| 3.1. Gage blocks | each year |
| 3.2. Micrometers | 30 days |
| 3.3. Vernier calipers | every 30 days |
| 3.4. Cylindrical plug gages | every 30 days |
| 3.5. Straight edges | every 30 days |
| 3.6. Jigs and fixtures | first piece article |
| 3.7. Oscilloscopes | each 6 months |
| 3.8. Meter volt-ohm | each 6 months |
| 3.9. Dual trace amplifiers | each 6 months |
| 3.10. D.C. power supplies | each year |

SPECIAL PROCESSES

PURPOSE:

To provide a method of inspection of the plating and etch processes.

RESPONSIBILITY:

It shall be the responsibility of the Production Department to control the processes. The Quality Control Department will provide a monitoring and a recording inspection program to assure the processes are correct.

PROCEDURE:

All tank analysis will be completed daily and all data logged by production.

Micro-sectioning shall be done by Q.C.

Calibration of instruments shall be the responsibility of the Quality Control group.

The following controls are completed daily:

Chemical Analysis

1. Copper tanks
 - 1.1. Cu as metal
 - 1.2. Ammonium
 - 1.3. P.H.
 - 1.4. Ratio
 - 1.5. Temperature
2. Nickel tanks
 - 2.1. Nickel as metal

SPECIAL PROCESSES (Continued)

PROCEDURE: (Continued)

- 2.2. P.H.
- 2.3. Nickel chloride
- 2.4. Boric acid
- 2.5. Temperature
3. Solder tank
 - 3.1 Stannous tin
 - 3.2 Lead (Bath)
 - 3.3 Fluoboric acid
 - 3.4 % of tin (deposit)
4. Gold tank
 - 4.1 Gold as metal
 - 4.2 Temperature
 - 4.3 P.H.
5. Electroless Copper tank
 - 5.1 % of copper
 - 5.2 P.H.
6. Accelerator
 - % of concentration
7. 9250 Cleaner tank
 - % concentration
8. Activator tank
 - % of concentration
9. Soft water
 - Grain hardness

SPECIAL PROCESSES (Continued)

PROCEDURE: (Continued)

10. D.I. Water

Purity

11. Waste Water

Heavy Metals

The following process requirements have been established for each of these processes, as a result of our quality level will reflect these standards.

PROCESS CONFORMANCE PROCEDURES

The purpose of the quality plan designed for our printed circuit manufacturing is to maintain a positive quality product. This type of product will then be passed on to our customers and in turn gain for Star Circuits a positive quality reputation. Furthermore, the Quality Assurance (Q.A.) plan, when properly carried out, will aid in the reduction of scrap cost and rework.

The following "Process Conformance Procedures" will establish the methods to help production control their processes. as a resultant, our outgoing product quality level will reflect these controls.

PROCESS CONFORMANCE PROCEDURES

1. QUALITY ASSURANCE ENGINEERING:

The Q.A. Manager will be responsible for vendor surveys, inspection planning, customer liaison, documentation control, purchase order review, print and specification review, Q.A. Manual up dating, process conformance procedures, Acceptable Quality Level (A.Q.L.) assignments, material review, and general supervision of all Quality Control (Q.C.) personnel.

2. QUALITY CONTROL:

The Q.C. Supervisors and Q.C. Foreman will be responsible for directing the inspectors. Their task is to maintain the outgoing quality level by enforcing the "Process Conformance Procedures". Supervision and training of inspection personnel are their responsibility.

PROCESS CONFORMANCE PROCEDURE

3. ARTWORK INSPECTION:

- 3.1 All artwork as received must be subjected to the following inspections:
 - 3.1.1. Set up on grid light table.
 - 3.1.2. Verification of grid center line to holes per customer specifications.
 - 3.1.3. Overall dimensions.
 - 3.1.4. Proper revision levels to purchase order or prints.
 - 3.1.5. Nomenclature present.
 - 3.1.6. Apparent damages such as scratches, line breaks, spurious emulsions, voids, and general workmanship layout.
 - 3.1.7. Front to back registration per customer requirements.
- 3.2 If any of the above characteristics are found to be defective, process a hold tag and the customer must be contacted for disposition.

PROCESS CONFORMANCE PROCEDURE

4. TOOL INSPECTION:

- 4.1 All tooling for printed circuit manufacture must be accepted by Quality Control.
- 4.2 Router guides will be set up on surface plate equipment and inspected.
- 4.3 Accepted tools will be metal stamped with the date of acceptance by Q.C.
- 4.4 Stowage and issuance will be maintained by tool inspection.
- 4.5 Blank dies and drill jigs will be required to have first piece acceptance of the tool prior to running.
- 4.6 Tooling inspection records will be kept on file for review.

PROCESS CONFORMANCE PROCEDURE

5. RECEIVING INSPECTION:

- 5.1 The Q.A. manual Quality Control Inspection (Q.C.I.) will govern the procedure of acceptance or rejection of materials received.
- 5.2 The following inspections relating to raw material will be done.
 - 5.2.1 Base board material will be verified to the specifications on the purchase order such as:
 - A. Certification to MIL-P-13949E.
 - B. Certification to customer specification.
 - C. U/L approved supplier.
 - 5.2.2 Inspection will consist of:
 - A. Attach inserts to receiving inspection report.
 - B. Use the deep throated dial indicator to verify thickness of sheets at a 1.5% AQL.
 - C. Use a 1" micrometer to verify foil thickness. Destructive test a 1" strip 6" long per lot.
 - D. Visual inspect all sheets for any nicks, dents, scratches, or delamination.

PROCESS CONFORMANCE PROCEDURE (Continued)

5. RECEIVING INSPECTION: (Continued)

4.1.1. E. Flame test a 1" strip 6" long per the MIL-P-13949E per lot.

4.1.2. F. Pull test one coupon per lot per MIL-P-13949E.

4.2. G. Delineation glass, one coupon per lot per MIL-P-13949E.

4.3. H. Chemicals will be verified as received for cure dates and crib stock checked once each month.

4.4. Products in any lot shall be checked at 100%

PROCESS CONFORMANCE PROCEDURES

6. MATERIAL INSPECTION:

At the start of each job, the inspector will verify the following:

- 6.1. Base board material is the correct size and type.
(Verify material labels).
- 6.2. Documentation is complete and in the job jacket.
- 6.3. Should a defect be found, a hold tag will be made out per Q.C.I. on the Q.A. manual.
- 6.4. If accepted, sign off the job jacket in the correct columns.
- 6.5. Production may then begin process of the job.

PROCESS CONFORMANCE PROCEDURES

7. DRILL INSPECTION:

The inspector will look for the following characteristics:

7.1. Hole wall examination with the bore scope will be done each hour at the machine. Sample size will be two faults per hour and an A.Q.L. of 1.5% of the holes will be subjected to inspection.

The prime purpose will be to help production control hold wall smoothness. When the walls begin to tear and fill up with residue, the inspector will notify the production foreman at once. Sample boards of acceptability will be at the inspection station for comparison.

7.2. Hole Sizes: Production will submit a first piece sample off the drills for each job. Hole sizes will be verified with pin gages, before the lot may be processed. If a defect is found, a hold tag will be made out per Q.C.I. of the Q.A. manual. If the first piece is accepted, sign off the job jacket in the correct columns. Production may then complete the drilling process.

7.3. Template Inspection: First piece drill patterns will be inspected for hole locations relative to the artwork. The registration of the sample to the artwork shall be as close to center as possible and must meet customer requirements.

PROCESS CONFORMANCE PROCEDURES (Continued)

7. DRILL INSPECTION: (Continued)

The number of holes and hole sizes will also be inspected. If a defect is found, a hold tag will be made out per Q.C.I. of the Q.A. manual. If the template is accepted, sign off in the correct columns and also on the template.

PROCESS CONFORMANCE PROCEDURES

8. SAND INSPECTION:

Inspection of drilled holes after sanding will be as follows:

Sample the lot using and A.Q.L. of 1.5% with a microscope, visual inspect 1.5% of the holes per board. Allow no burrs or material in holes such as fibers, dirt, or copper. Inspect for scratches or nicks in the clad, and look for excessive sanding which can result in an etchout around holes.

If a defect is found, a hold tag will be made out per Q.C.I. of the Q.A. manual.

If the lot is accepted, sign off the job jacket in the correct columns. Production may then continue process.

PROCESS CONFORMANCE PROCEDURES

9. FIRST TOUCH UP:

Inspection will use a 1.5% A.Q.L. per sample. Touch up areas that are missed, or areas that are over painted onto circuits are cause for rejection. The use of blacklight and a 10 power glass will be inspection aids. Registration of hole center lines will be inspected per customer specifications. Film not developed off of circuits will be a reject.

If defects are found, a hold tag will be made out per Q.C.I. of the Q.A. manual.

If a lot is accepted, sign off in the correct columns and production may then continue the process.

10. SECOND TOUCH UP:

Inspection will use a 1.5% A.Q.L. per lot sample, Touch up areas that are missed will cause an etch out!

Therefore, allow no defects. If a defect is found, a hold tag will be made out per Q.C.I. of the Q.A. Manual.

If the lot is accepted, sign off in correct columns and production may then continue the process. The same inspection aids as first touch up will be used.

PROCESS CONFORMANCE PROCEDURES

11. ETCH INSPECTION: (cont.)

A 1.5% A.Q.L. will be used as a lot sample. Because of the numerous characteristics required to be inspected at this station, a code of defects will apply. They are as follows:

11.1. Wrong size hole:

The hole diameter does not meet requirements.

11.2. Extra hole:

A hole drilled which was not called for.

11.3. Undrilled hole:

A required hole which was not drilled.

11.4. Hole form:

Burrs, double drill, out of round, not drilled all the way, foreign matter in hole, nodules in hole. Anything which causes the form or shape of the hole in such a manner as not to allow the hole to be used.

11.5. Void in Plated Through Hole (P.T.H.):

An etch out of void in a P.T.H.. A P.T.H. not plated.

11.6. Insufficient land area:

The pad area as measured from edge of the hole to the edge of the pad; i.e., missdrilled, break outs, drill pattern, etc.

PROCESS CONFORMANCE PROCEDURES

11. ETCH INSPECTION: (continued)

11.7. Etch outs:

Missing or voids in the circuitry and pad. This also includes the pad area. A sharp or pronounced void.

11.8. Spurious foil:

Unwanted foil. Foil which has to be removed.

Under etched circuitry. A sharp or pronounced projection on the circuitry.

11.9. Line width, ILW-insufficient, ELW-excessive:

The line width is either over spec, (ELW). under spec. (ILW) or uneven line width (ULW).

11.10. Blemished circuitry:

Nicks, scrapes, pits, dents, damaged, blisters, rough circuitry.

11.11. Spacing:

The distance between circuit paths.

11.12. Incorrect finish:

The top plating is incorrect, i.e., gold or nickel over tin lead or tin lead over gold tabs.

11.13. Warped:

A bow or bend in the board.

11.14. Damaged boards:

Cracked, chipped, measling, crazing, scraped, gouged, etc.

PROCESS CONFORMANCE PROCEDURES

11. ETCH INSPECTION: (continued)

11.15. Improper dimensions:

The outside dimensions are improper. Width, length, notches, angles, radiuses, etc., due to mishearing, routing, punching, stamping, etc.

11.16. Wrong type base material:

Grain direction when applicable.

11.17. Dirty boards:

11.18. Copper showing:

Copper that can be seen by looking straight down at the board, and can be repaired by tinning.

11.19. Peeling:

Gold, copper, ton-lead or nickel is peeling back because of poor adhesion (tape test) L-T-90.

11.20. Nomenclature:

Part number, assembly number, numbers, letters, logos.

11.21. Hardware:

Hardware mounted incorrectly, not secure, wrong location, damaged.

11.22. Solder test:

Board taken from extra or scraped to be used for solderability test (see solder test procedure).

All of the above attributes and variables will be cause for a rejection of the lot, per 1.5% A.Q.L. Corrective action will be required on all defects found and

PROCESS CONFORMANCE PROCEDURES

11. ETCH INSPECTION: (continued)

production will sort their defects and the process corrected as soon as possible. Inspection will aid in sort operations when there is a definite need or the work load so defines. If defects are found a hold tag will be made out per Q.C.I. of the Q.A. manual. If a lot is accepted, sign off in the correct columns and production may then continue the process.

PROCESS CONFORMANCE PROCEDURES

12. FIRST PIECE TO SIZE:

All printed circuit boards will have first piece to print and/or specifications. Production will set up on tooling and submit the first piece for review.

Inspection will use micrometers, vernier calipers, and surface plate equipment when necessary to inspect.

Radius gages, cylindrical plugs and depth micrometers will be utilized.

If a defect is found, the inspector will inform the production set-up personnel of their findings. A new first piece will be required until set-up is correct.

When the first piece is accepted, sign off in the correct columns and then production may continue the finishing to size. Periodic inspection for blanking or routing may be required when necessary.

PROCESS CONFORMANCE PROCEDURES

13. FINAL INSPECTION:

The prime purpose of final inspection is to assure that all operations throughout the process have been completed. This will be accomplished by using the following inspection criteria:

13.1. See that a solder test is completed and accepted when required by customer specification.

13.2. See that a micro-section is completed and accepted when required by customer spec.

13.3. Verify any hardware to be installed per print.

13.4. Verify any silk screening requirements.

13.5. Data code stamps, or logo stamps where necessary.

13.6. Is protective coating required per print?

13.7. Sample, using a 1.5% A.Q.L., for profile dimensions to print.

13.8. With the same sample as above, visual inspect for:

13.8.1. Damage

13.8.2. Dirty boards

13.8.3. Spurious foil

13.8.4. Voids

13.9. If a defect is found, process a hold tag per Q.C.I. of the Q.A. manual. If the lot is accepted, sign off in the correct columns, and

PROCESS CONFORMANCE PROCEDURES

13. FINAL INSPECTION: (Continued)

process a crib tag. Enter all Q.C. information in the shipping log. Make out a green acceptance tag. Send parts to the crib for packaging.

PROCESS CONFORMANCE PROCEDURES

14. SPECIAL TESTING:

Certain tests are required to control processes where necessary. Q.C. will do this testing or monitor these tests as follows:

14.1. Copper Test: Production will supply Q.C. a copper test flat from the plating tanks, at least one sample per shift per tank. This sample will be on stainless steel and will accompany boards being plated. Inspection will complete a 180 degree bend test and will allow no cracking or indication of a brittle copper condition. Should a bad sample be found, the production department will be notified at once for immediate tank control to begin. No boards may be plated in any tank showing a defective coupon, until a good sample is submitted.

14.2. Solderability Test: When a customer requires solder testing the Q.C. department will perform a float test as follows:

14.2.1. Solder pot temperature will be 450 degrees F + 10 degrees.

14.2.2. Flux sample board with Kester Flux No. 145.

14.2.3. Skim dross off surface of solder pot just before floating sample.

PROCESS CONFORMANCE PROCEDURES

14.3 SPECIAL TESTING: (Continued)

14.2.4. With a pair of tongs hold board and float
 performed. with gentle pressure on solder for five
 retained for seconds.

14.2.5. Remove board gently.

14.2.6. Allow no more than 5% blow holes. If in
 excess of this amount, rejection of the
 lot will be required.

14.3.3. Tin lead

14.3.4. Nickel gold

14.3.5. Void

14.3.6. Cracks

14.4. In-Process Control: Production will control their own
 processes. Quality will audit these controls at
 least once each week, and when required Q.C. will
 take test as requested. Verification testing by an
 outside source must be utilized as a double reference.
 Calibration of instruments and power supplies will be
 handled by Q.C.

PROCESS CONFORMANCE PROCEDURES

- 14.3. Micro-section Testing: As per customer requirements and in-house control, micro testing will be performed. Test boards, coupons, and residue will be retained for review. Production shall be notified at once when a defect is found. Microsection shall evaluate the following:
- 14.3.1. Hole wall contour
 - 14.3.2. Copper thickness
 - 14.3.3. Tin lead thickness
 - 14.3.4. Nickel, gold thickness
 - 14.3.5. Voids
 - 14.3.6. Cracks
- 14.4. Tank Control: Production will control their own processes. Quality will audit these controls at least once each week, and when required Q.C. will make test as requested. Verification testing by an outside source must be utilized as a cross reference. Calibration of rectifiers and power supplies will be handled by Q.C..

PROCESS CONFORMANCE PROCEDURES

15. SHIPPING AND PACKAGING:

Each customer's printed circuit boards will be packaged per their specification. If no specification is required, we will use our in-house method of plastic heat sealed bags, with good cushioning material.

Inspection will randomly verify packing. When a special specification for packing is required, shipping will be notified by a written memo and follow-up by inspection will be mandatory.

MANUAL MAINTENANCE AND DISTRIBUTION

PURPOSE:

The purpose of this procedure is to establish a method for reviewing, revising, and distributing the manual.

RESPONSIBILITY:

It shall be the responsibility of the Quality Control Manager to keep the manual up to date in conformance with customer requirements.

PROCEDURE:

The Quality Control instructions will be written by the Quality Control Manager and approved by Management.

Procedures are presented to Management for approval. It is then typed and distributed to the recorded manual holders.

The manual shall be reviewed every six (6) months and revised, if necessary.

The index and manual proper will be kept current at all times to assure that all objectives of the general requirements are being met.

A record sheet listing the Quality Control manual number, to whom it was issued and date issued, shall be on file in the Quality Control office subject to examination by authorized personnel concerned.

CHAPTER 4

COST ANALYSIS

Cost analysis is used as a tool for bidding new contracts and predicting profit and loss for the company. This analysis will consist of three main summary sections for each of the six types of printed circuit boards built. It will begin with a flow diagram of the manufacturing process involved followed by a description of the type of board being built. Next there is a break down of the labor for each step and a percent complete with respect to the labor for each panel being processed. The next section analyzes the labor and cost involved for setup and other cost that can be attributed to all the boards in the customer's order. The next section is a summary of all the costs including labor and material. The final section is a formula for calculating labor and material cost per board.

A flow diagram is used in each process for a visual overview of the entire manufacturing process. It provides a clear picture of when each step is performed in the manufacturing sequence. With the aid of the percent complete table for each process an accurate prediction of the amount complete of a customer's product can be obtained.

When a printed circuit board is bid, one of the main cost factors involved is labor. Costs based on time and labor are variables that must be closely monitored to insure that overhead for each printed circuit board is

held to a minimum. Keeping overhead to a minimum will allow the company to be competitive in bidding of future jobs.

Labor costs for the analysis were obtained by timing each of the processes and recording the time. In most of the processes average time to do groups of panels is used. A complete labor cost breakdown is provided in Appendix B

The next section is a summary of the total cost involved including material and labor. The material and chemical consumption is based on what it would cost to process one square foot of panel on one side only, except where otherwise noted. Material and chemical costs are based on the actual cost to acquire the product. This section can be used to determine the actual cost from start to finish of the board. The information that will be needed is the area of each board, number of holes, type of board being processed, the percent of circuit verses bare panel for each side of the board, and how many boards there will be in the order. The last part is a explanation of how to use the information above to accurately predict the cost of manufacturing a printed circuit board.

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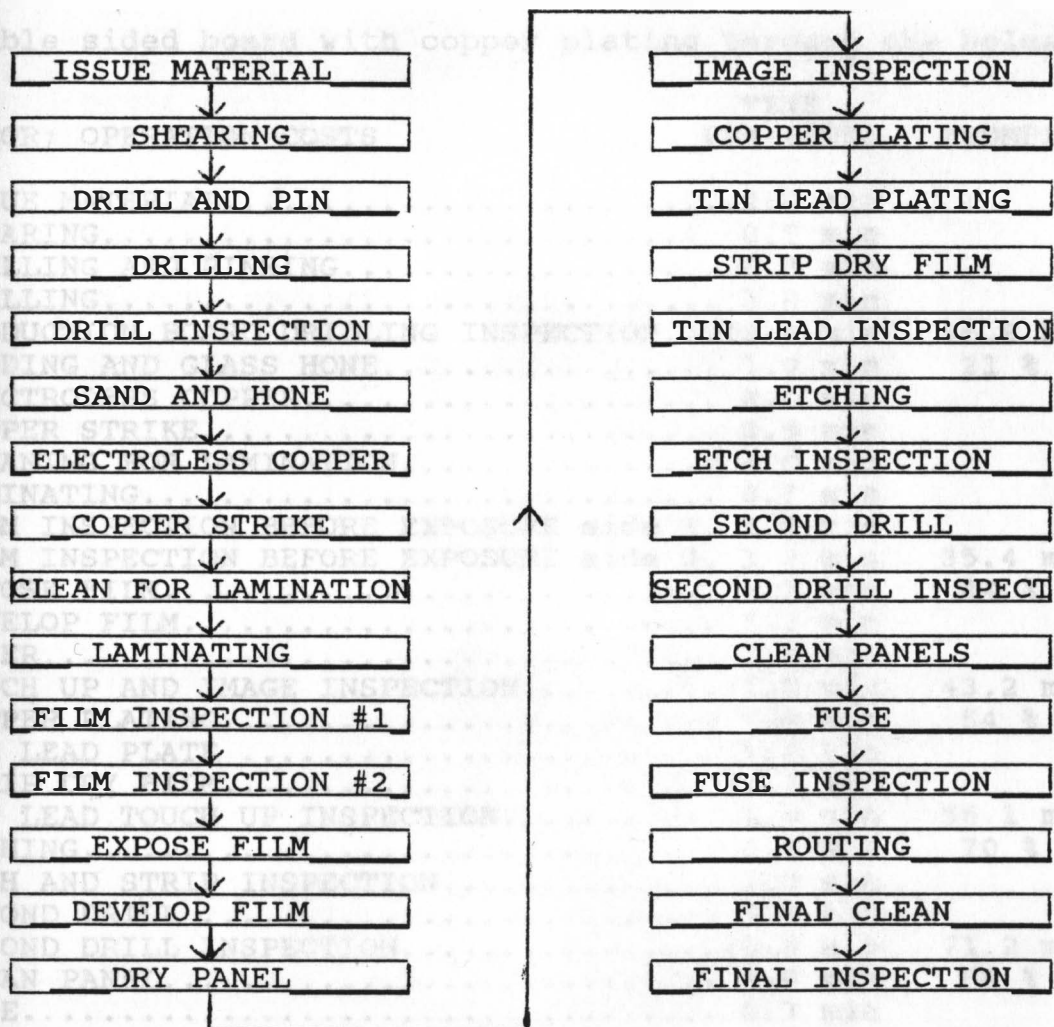
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ASSEMBLY FLOW DIAGRAM

PROCESS A



PROCESS A OPERATION, TIME, AND PERCENT COMPLETE

LABOR; SETUP COSTS

PROCESS A

Double sided board with copper plating through the holes.

LABOR; OPERATION COSTS	TIME PER PANEL	%COMPLETE
ISSUE MATERIAL.....	2.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	16.8 min
SANDING AND GLASS HONE.....	1.0 min	21 %
ELECTROLESS COPPER.....	8.0 min	
COPPER STRIKE.....	2.5 min	
CLEANING FOR LAMINATION.....	4.0 min	
LAMINATING.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	35.4 min
EXPOSE FILM.....	2.5 min	44 %
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	43.2 min
COPPER PLATING.....	7.0 min	54 %
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	56.1 min
ETCHING.....	0.3 min	70 %
ETCH AND STRIP INSPECTION.....	1.0 min	
SECOND DRILL	3.8 min	
SECOND DRILL INSPECTION.....	10.0 min	71.2 min
CLEAN PANEL.....	3.0 min	88 %
FUSE.....	0.3 min	
FUSE INSPECTION.....	1.0 min	75.5 min
ROUT A BOARD.....	1.0 min	94 %
FINAL CLEAN BOARD.....	3.0 min	
FINAL INSPECTION.....	1.0 min	100%
	80.5 min	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total labor cost per panel	\$5.394	
Total labor cost per panel \$5.00/hr	\$6.71	
Total labor cost per panel \$6.00/hr	\$8.05	

PROCESS A (Continued)

LABOR; SETUP COST

START UP AND WARM UP FOR DRILL.....15.0 min
 DRILLING PROOF BOARD INSPECTION..30.0 min
 SECOND DRILL SETUP.....15.0 min
ROUTING MACHINE WARM UP.....15.0 min

MATERIAL; 75.0 minutes

Cost per minute at \$4.00 \$0.067

Total labor setup cost \$5.03

Total labor setup cost \$5.00/hr \$6.25

Total labor setup cost \$6.00/hr \$7.50

ELECTROLESS COPPER.....

COPPER STRIKE.....

LAMINATING.....

DEVELOP FILM.....

COPPER PATTERN PLATING.....

PLI-BOARD PLATE.....

STRIP DRY FILM.....

TOTAL \$ 9.340

ETCHING.....

FUSING.....

DRILLING COST PER BIT.....

LABOR; OPERATION COST.....

LABOR; SETUP COST.....

COST SUMMARY

PROCESS A

STEP 1
OPERATION CHEMICAL COST AND
MATERIAL COST
PER SQUARE FOOT

MATERIAL;

ENTRY AND BACKUP MATERIAL..... \$0.565

PANEL STOCK..... 1.325

CHEMICAL AND MATERIAL PROCESSES;

ELECTROLESS COPPER..... 0.128

COPPER STRIKE..... 0.124

LAMINATING..... 0.37

DEVELOP FILM..... 0.033

COPPER PATTERN PLATING..... 0.124

TIN LEAD PLATE 0.114

STRIP DRY FILM..... 0.022

Total \$ 2.240

ETCHING..... 0.420

FUSING..... 0.364

DRILLING COST PER HIT..... 0.00051

STEP 5
LABOR; OPERATION COST.....\$ 5.40/ 6.75/ 8.05

LABOR; SETUP COST.....\$ 5.03/ 6.25/ 7.50

STEP 6

Take the total number of drill hits that must be completed

for both the first and second drill and multiply it times

the cost per hit. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS A

STEP 1

Take the area of one side of the board in square feet and multiply it times the cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply the panel stock cost per square foot times the area of one side of a board. Save the result.

STEP 3

Take the cost of chemicals consumed per square feet and multiply it times the surface area of both sides of the board in square feet. Save the result.

STEP 4

Take the area of copper that must be etched from both sides of the board in square feet and multiply it times the cost per square foot for etching. Save the result.

STEP 5

Multiply the area of circuitry to be fused on both sides of the board times the price to fuse one square foot of panel. Save the result.

STEP 6

Take the total number of drill hits that must be completed for both the first and second drill and multiply it times the cost per hit. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS A (Continued)

STEP 7

Take the labor cost per panel and divide it by the number of boards being processed on each panel. Save the results.

STEP 8

Take the labor setup costs per run and divide it by the number of boards in the entire run. Save the results.

Add the results of step 1 through step 8 for the total material and labor costs to produce one board.

+ (cost to drill one board)

+ $\frac{\text{labor operation cost per panel}}{\text{number of boards per panel}}$

+ $\frac{\text{labor setup cost per run}}{\text{number of boards in run}}$

Total cost per board

FORMULA FOR CALCULATING COST

PROCESS A

$\frac{(\$ \text{ entry material} + \$ \text{ backup material/sq ft}) \times \text{area in sq ft}}{\text{Number of panels in stack}}$

+ (cost of panel stock/ sq ft) X area in sq ft

+ (cost of chemicals and materials/ sq ft) X area in sq ft

+ (cost of etching/ sq ft) X area etched in sq ft

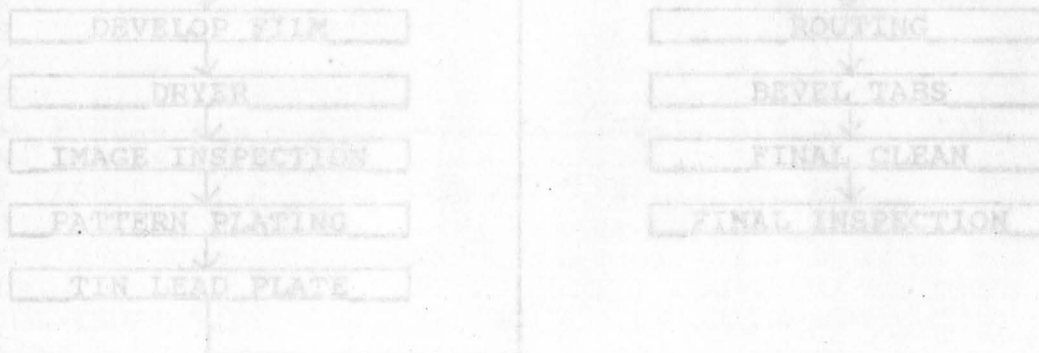
+ (cost of fusing/ sq ft) X area fused in sq ft

+ (cost to drill one hole) X number of holes

+ $\frac{\text{labor operation cost/ panel}}{\text{number of boards/ panel}}$

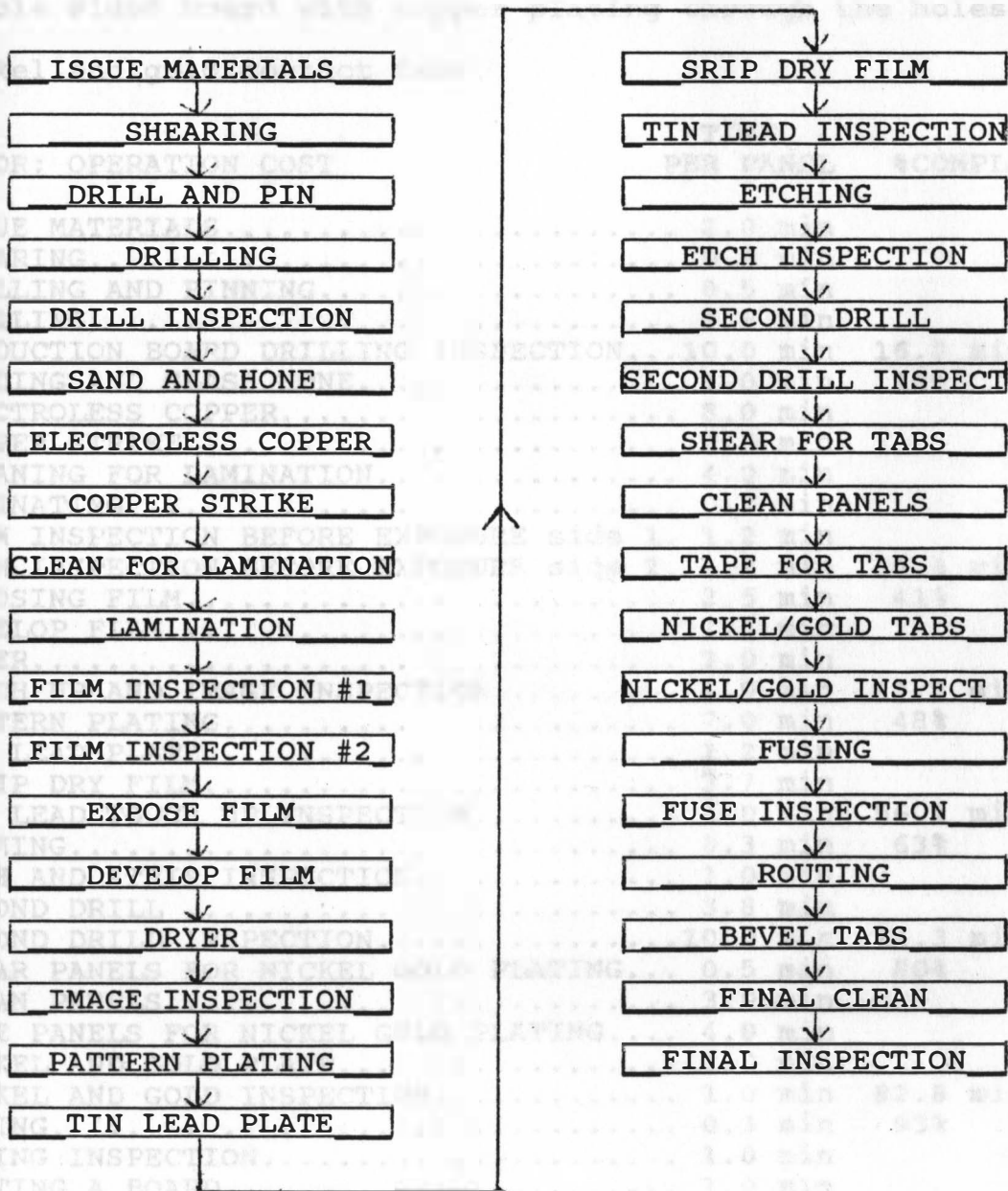
+ $\frac{\text{labor setup cost/ run}}{\text{number of boards in run}}$

Total cost per board equals the sum of above.



MANUFACTURING FLOW CHART

PROCESS B



OPERATION, TIME, AND PERCENT COMPLETE

PROCESS B

Double sided board with copper plating through the holes and nickel and gold contact tabs.

LABOR; OPERATION COST	TIME PER PANEL	%COMPLETE
ISSUE MATERIALS.....	2.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	16.8 min
SANDING AND GLASS HONE.....	1.0 min	19%
ELECTROLESS COPPER.....	8.0 min	
COPPER STRIKE.....	2.5 min	
CLEANING FOR LAMINATION.....	4.0 min	
LAMINATING.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	36.4 min
EXPOSING FILM.....	2.5 min	41%
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	43.3 min
PATTERN PLATING.....	7.0 min	48%
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	56.2 min
ETCHING.....	0.3 min	63%
ETCH AND STRIP INSPECTION.....	1.0 min	
SECOND DRILL	3.8 min	
SECOND DRILL INSPECTION.....	10.0 min	71.3 min
SHEAR PANELS FOR NICKEL GOLD PLATING...	0.5 min	80%
CLEAN PANELS.....	3.0 min	
TAPE PANELS FOR NICKEL GOLD PLATING....	4.0 min	
NICKEL AND GOLD PLATE.....	3.0 min	
NICKEL AND GOLD INSPECTION.....	1.0 min	82.8 min
FUSING.....	0.3 min	93%
FUSING INSPECTION.....	1.0 min	
ROUTING A BOARD.....	1.0 min	
BEVEL TABS.....	0.25 min	
FINAL CLEANING.....	3.0 min	
FINAL INSPECTION.....	1.0 min	100%
Total time	89.35 min	
Cost per minute at \$4.00	\$0.067	
Total labor cost per panel	\$5.99	
Total labor cost per panel \$5.00	\$7.45	
Total labor cost per panel \$6.00	\$8.94	

OPERATION, TIME, AND PERCENT COMPLETE

PROCESS B (Continued)

LABOR; SETUP COSTS

OPERATION		CHEMICAL COST AND MATERIAL COST
START UP AND WARM UP FOR DRILL.#1.....	15.0 min	
SECOND DRILL SET-UP	15.0 min	
DRILLING PROOF BOARD INSPECTION..	30.0 min	
<u>ROUTING MACHINE WARM UP.....</u>	<u>15.0 min</u>	
	75.0 minutes	
<u>Cost per minute at \$4.00</u>		<u>\$0.067</u>
Total labor setup cost		\$5.00
Total labor setup cost \$5.00/hr		\$6.25
Total labor setup cost \$6.00/hr		\$7.50

COPPER PRINTING		
LAMINATING		
DEVELOP FILM		
COPPER PATTERN PLATING		
TIN LEAD PLATE		
<u>STRIP OFF FILM</u>		
Total		

ETCHING		
FUSING		
DRILLING COST PER HOLE		
NICKEL AND GOLD TAMP		
COST PER SQUARE INCH		
LABOR - OPERATION COST		
LABOR - SETUP COST		

COST SUMMARY

PROCESS B

OPERATION	CHEMICAL COST AND MATERIAL COST PER SQUARE FOOT
MATERIAL;	
ENTRY AND BACKUP MATERIAL.....	\$0.565
PANEL STOCK.....	1.325
CHEMICAL AND MATERIAL PROCESSES;	
ELECTROLESS COPPER.....	0.128
COPPER STRIKE.....	0.124
LAMINATING.....	0.37
DEVELOP FILM.....	0.033
COPPER PATTERN PLATING.....	0.124
TIN LEAD PLATE	0.114
<u>STRIP DRY FILM.....</u>	<u>0.022</u>
Total	\$ 2.240
ETCHING.....	0.420
FUSING.....	0.364
DRILLING COST PER HIT.....	0.00051
NICKEL AND GOLD TABS cost per square inch.....	0.016
LABOR; OPERATION COST.....	\$ 5.99/ 7.45/ 8.94
LABOR; SETUP COST.....	\$ 5.00/ 6.25/ 7.50

Take the surface area of the tabs in square inches and multiply it times the cost per square inch for nickel and gold plate. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS B

STEP 1

Take the surface area of one side of the board in square feet and multiply it times the cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply the panel stock cost per square foot times the surface area of one side of a board. Save the result.

STEP 3

Take the cost of chemicals consumed per square feet and multiply it times the surface area of both sides of the board in square feet. Save the result.

STEP 4

Take the area of copper that must be etched from both sides of the board in square feet and multiply it times the cost per square foot of etching. Save the result.

STEP 5

Multiply the area of circuitry on both sides of the board times the price to fuse one square foot of panel. Save the result.

STEP 6

Take the surface area of the tabs in square inches and multiply it times the cost per square inch for nickel and gold plate. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS B (Continued)

STEP 7

Take the total number of drill hits that must be completed for both the first and second drill and multiply it times the cost per hit. Save the result.

STEP 8

Take the labor cost per panel and divide it by the number of boards being processed on each panel. Save the results.

STEP 9

Take the labor setup cost per run and divide it by the number of boards in the entire run. Save the results.

Add the results of step 1 through step 9 for the total material and labor costs to produce one board.

$$+ \frac{\text{labor overhead cost per panel}}{\text{number of boards per panel}}$$

$$+ \frac{\text{labor setup cost per run}}{\text{number of boards in run}}$$

Total cost per board equals sum of the above.

FORMULA FOR CALCULATING COST

PROCESS B

$$\frac{(\$ \text{ entry material} + \$ \text{ backup material/sq ft}) \times \text{area in sq ft}}{\text{Number of panels in stack}}$$

+ (cost of panel stock/ sq ft) X area in sq ft

+ (cost of chemicals and materials/ sq ft) X area in sq ft

+ (cost of etching/ sq ft) X area etched in sq ft

+ (cost of fusing/ sq ft) X area fused in sq ft

+ (cost of nickel gold tabs/ sq inch) X area of tabs
in sq inches

+ (cost to drill one hole) X number of holes

+ $\frac{\text{labor operation cost/ panel}}{\text{number of boards/ panel}}$

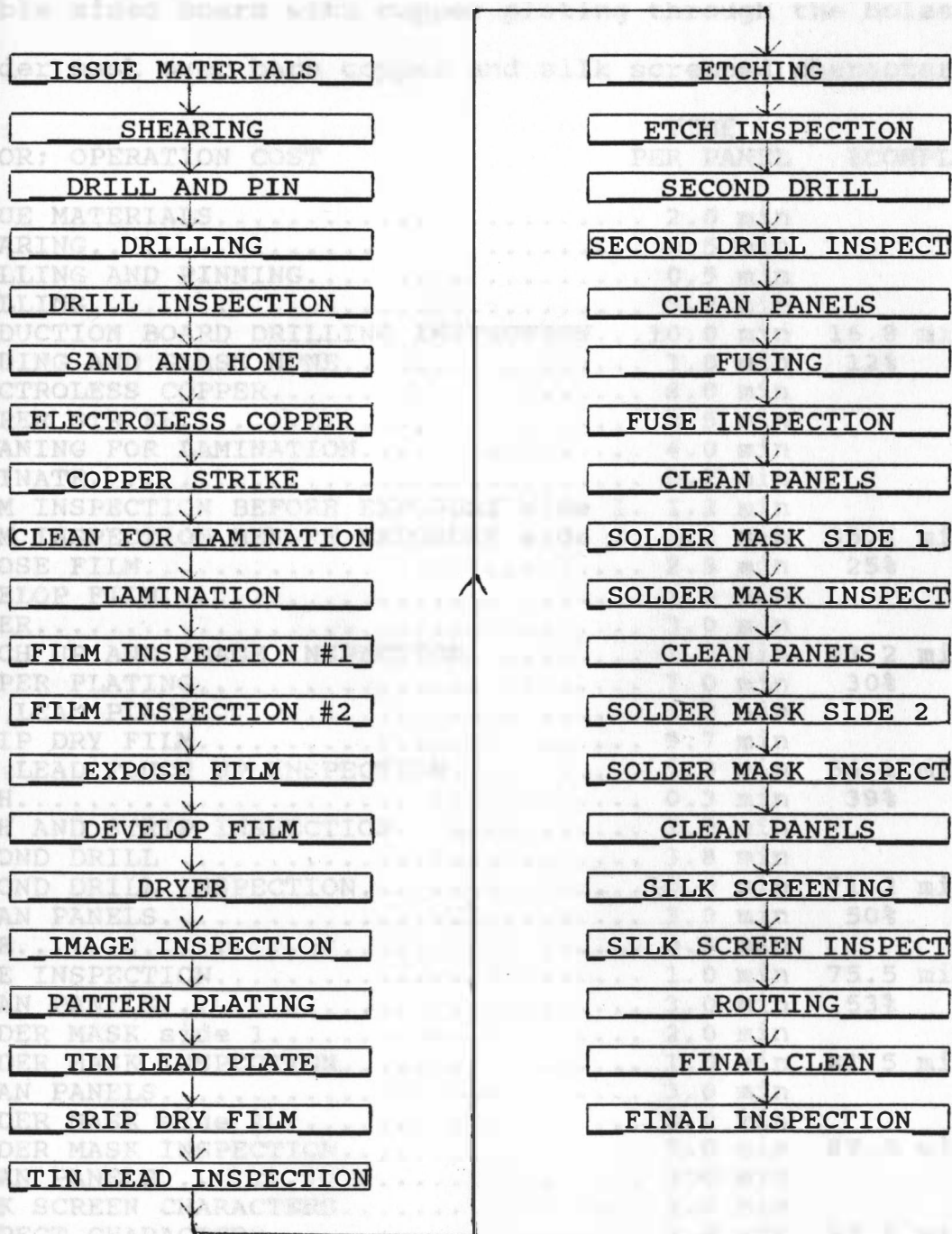
+ $\frac{\text{labor setup cost/ run}}{\text{number of boards in run}}$

Total cost per board equals the sum of the above.



MANUFACTURING FLOW CHART

PROCESS C



OPERATION, TIME, AND PERCENT COMPLETE

PROCESS C

Double sided board with copper plating through the holes,
solder mask over bare copper and silk screened characters.

LABOR; OPERATION COST	TIME PER PANEL	%COMPLETE
ISSUE MATERIALS.....	2.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	16.8 min
SANDING AND GLASS HONE.....	1.0 min	12%
ELECTROLESS COPPER.....	8.0 min	
COPPER STRIKE.....	2.5 min	
CLEANING FOR LAMINATION.....	4.0 min	
LAMINATE.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	35.4 min
EXPOSE FILM.....	2.5 min	25%
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	43.2 min
COPPER PLATING.....	7.0 min	30%
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	56.1 min
ETCH.....	0.3 min	39%
ETCH AND STRIP INSPECTION.....	1.0 min	
SECOND DRILL	3.8 min	
SECOND DRILL INSPECTION.....	10.0 min	71.2 min
CLEAN PANELS.....	3.0 min	50%
FUSE.....	0.3 min	
FUSE INSPECTION.....	1.0 min	75.5 min
CLEAN PANELS.....	3.0 min	53%
SOLDER MASK side 1.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	81.5 min
CLEAN PANELS.....	3.0 min	
SOLDER MASK side 2.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	87.5 min
CLEAN PANELS.....	3.0 min	
SILK SCREEN CHARACTERS.....	2.0 min	
INSPECT CHARACTERS.....	1.0 min	93.5 min
ROUTING A BOARD.....	1.0 min	
FINAL CLEANING.....	3.0 min	
<u>FINAL INSPECTION.....</u>	<u>1.0 min</u>	<u>100%</u>
Total time	98.5 min	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total labor cost per panel	\$6.60	

OPERATION, TIME, AND PERCENT COMPLETE

PROCESS C (Continued)

LABOR; OPERATION COST (Continued)

Total labor cost per panel	\$5.00	\$8.21
Total labor cost per panel	\$6.00	\$9.85

LABOR; SETUP COST

START UP AND WARM UP FOR DRILL.....	15.0 min	
DRILLING PROOF BOARD INSPECTION..	30.0 min	
SECOND DRILL SETUP.....	15.0 min	
PREPARING STENCIL.....	30.0 min	
SILK SCREEN SET-UP.....	35.6 min	
CLEAN UP.....	7.0 min	
PREPARING STENCIL.....	30.0 min	
SILK SCREEN SET-UP.....	35.6 min	
CLEAN UP.....	7.0 min	
PREPARING STENCIL.....	30.0 min	
SILK SCREEN SET-UP.....	35.6 min	
CLEAN UP.....	7.0 min	
<u>ROUTING MACHINE WARM UP.....</u>	<u>15.0 min</u>	
	292.8 minutes	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total labor setup cost		\$19.62
Total labor setup cost	\$5.00/hr	\$24.40
Total labor setup cost	\$6.00/hr	\$29.28

PROCESSING COST SUMMARY COST PER BOARD

PROCESS C

STEP 1 OPERATION	CHEMICAL COST AND MATERIAL COST PER SQUARE FOOT
<u>MATERIAL;</u>	
ENTRY AND BACKUP MATERIAL.....	\$0.565
PANEL STOCK.....	1.325
<u>CHEMICAL AND MATERIAL PROCESSES;</u>	
ELECTROLESS COPPER.....	0.128
COPPER STRIKE.....	0.124
LAMINATING.....	0.37
DEVELOP FILM.....	0.033
COPPER PATTERN PLATING.....	0.124
TIN LEAD PLATE	0.114
<u>STRIP DRY FILM.....</u>	<u>0.022</u>
Total	\$ 2.240
<u>ETCHING.....</u>	
FUSING.....	0.364
DRILLING COST PER HIT.....	0.00051
SOLDER MASK.....	0.144
SILK SCREEN CHARACTERS.....	0.144
LABOR AT \$4.00/5.00/6.00/hr	
STEP 6 LABOR OPERATION COST.....	\$ 6.60/ 8.21/ 9.85
LABOR SETUP COST.....	\$ 19.62/ 24.40/ 29.28

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS C

STEP 1

Take the surface area of one side of the board in square feet and multiply it times the cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply panel stock cost per square foot times the surface area of one side of a board. Save the result.

STEP 3

Take cost of chemicals consumed per square feet and multiply it times the area of both sides of the board in square feet. Save the result.

STEP 4

Take the area of copper that must be etched from both sides of board in square feet and multiply it times the cost per square foot of etching. Save the result.

STEP 5

Multiply the area of circuitry to be fused on both sides of the board times the price to fuse one square foot of panel. Save the result.

STEP 6

Take the area of board to be covered with ink for solder mask and multiply it times the cost of solder mask per square foot. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS C (Continued)

STEP 7

Take the area of the board to be covered with ink for silk screening and multiply it times the cost of silk screening per square foot. Save the result.

STEP 8

Take the total number of drill hits that must be completed for both first and second drill and multiply it times the cost per hit. Save the result.

STEP 9

Take labor cost per panel and divide it by the number of boards being processed on each panel. Save the result.

STEP 10

Take labor setup costs per run and divide it by the number of boards in the entire run. Save the result.

Add results of step 1 through step 10 for the total material and labor costs to produce one board.

FORMULA FOR CALCULATING COST

PROCESS C

(\$ entry material + \$ backup material/sq ft) X area in sq ft
Number of panels in stack

+ (cost of panel stock/ sq ft) X area in sq ft

+ (cost of chemicals and materials/ sq ft) X area in sq ft

+ (cost of etching/ sq ft) X area etched in sq ft

+ (cost of fusing/ sq ft) X area fused in sq ft

+ (cost to solder mask/sq ft) X area solder mask in sq ft

+ (cost to silk screen/sq ft) X area silk screened in sq ft

+ (cost to drill one hole) X number of holes

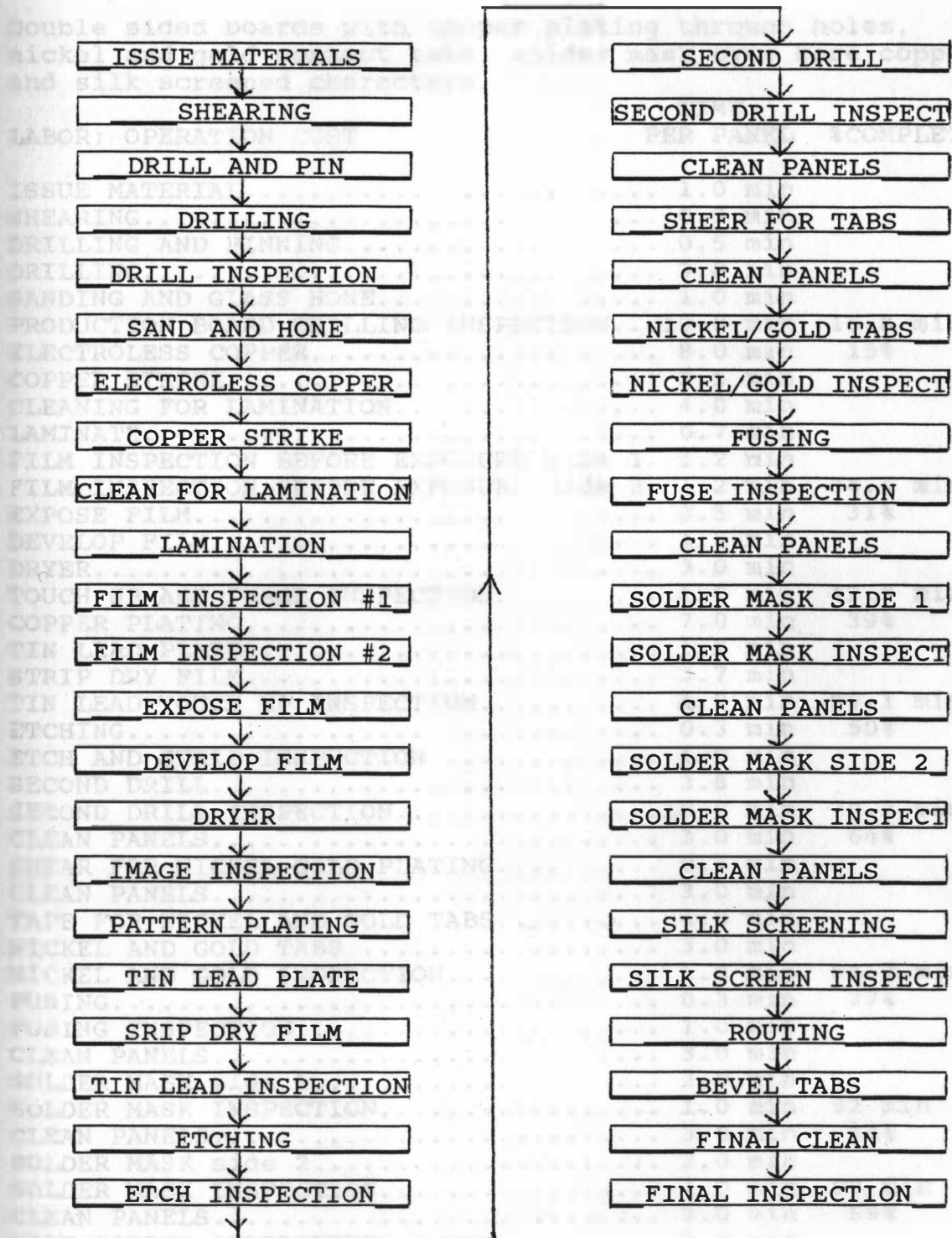
+ labor operation cost/ panel
number of boards/ panel

+ labor setup cost/ run
number of boards in run

Total cost per board equals the sum of the above.

MANUFACTURING FLOW CHART

PROCESS D



OPERATION, TIME, AND PERCENT COMPLETE

PROCESS D

Double sided boards with copper plating through holes, nickel and gold contact tabs, solder mask over bare copper, and silk screened characters.

LABOR; OPERATION COST	TIME PER PANEL	%COMPLETE
ISSUE MATERIAL.....	1.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
SANDING AND GLASS HONE.....	1.0 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	16.8 min
ELECTROLESS COPPER.....	8.0 min	15%
COPPER STRIKE.....	2.5 min	
CLEANING FOR LAMINATION.....	4.0 min	
LAMINATE.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	34.4 min
EXPOSE FILM.....	2.5 min	31%
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	42.2 min
COPPER PLATING.....	7.0 min	39%
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	55.1 min
ETCHING.....	0.3 min	50%
ETCH AND STRIP INSPECTION.....	1.0 min	
SECOND DRILL.....	3.8 min	
SECOND DRILL INSPECTION.....	10.0 min	70.2 min
CLEAN PANELS.....	3.0 min	64%
SHEAR FOR NICKEL GOLD PLATING.....	0.5 min	
CLEAN PANELS.....	3.0 min	
TAPE FOR NICKEL AND GOLD TABS.....	4.0 min	
NICKEL AND GOLD TABS.....	3.0 min	
NICKEL AND GOLD INSPECTION.....	1.0 min	84.7 min
FUSING.....	0.3 min	77%
FUSING INSPECTION.....	1.0 min	
CLEAN PANELS.....	3.0 min	
SOLDER MASK side 1.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	92 min
CLEAN PANELS.....	3.0 min	84%
SOLDER MASK side 2.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	98 min
CLEAN PANELS.....	3.0 min	89%
SILK SCREEN CHARACTERS.....	2.0 min	
SILK SCREEN INSPECTION.....	1.0 min	104 min

OPERATION, TIME, AND PERCENT COMPLETE

PROCESS D (Continued)

LABOR; OPERATION COST (Continued)

ROUTING A BOARD.....	1.0 min	95%
BEVEL TABS.....	0.5 min	
FINAL CLEAN.....	3.0 min	
FINAL INSPECTION.....	1.0 min	100%
	109.5 min	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total labor cost per panel	\$7.34	
Total labor cost per panel \$5.00	\$9.125	
Total labor cost per panel \$6.00	\$10.95	

LABOR; SETUP COST

START UP AND WARM UP FOR DRILL.....	15.0 min
PROOF BOARD DRILLING INSPECTION.....	30.0 min
SECOND DRILL SET-UP.....	15.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
ROUTING MACHINE WARM UP.....	15.0 min
	292.8
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>
Total labor setup cost	\$19.62
Total labor setup cost \$5.00	\$24.40
Total labor setup cost \$6.00	\$29.28

COST SUMMARY

PROCESS D

STEP 1 OPERATION	CHEMICAL COST AND MATERIAL COST PER SQUARE FOOT
MATERIAL;	
ENTRY AND BACKUP MATERIAL.....	\$0.565
PANEL STOCK.....	1.325
CHEMICAL AND MATERIAL PROCESSES;	
ELECTROLESS COPPER.....	0.128
COPPER STRIKE.....	0.124
LAMINATING.....	0.37
DEVELOP FILM.....	0.033
COPPER PATTERN PLATING.....	0.124
TIN LEAD PLATE	0.114
<u>STRIP DRY FILM.....</u>	<u>0.022</u>
Total	\$ 2.240
NICKEL AND GOLD TABS	
cost per square inch.....	0.016
ETCHING.....	0.420
STEP 5	
FUSING.....	0.364
SOLDER MASK.....	0.144
SILK SCREEN CHARACTERS.....	0.144
DRILLING COST PER HIT.....	0.00051
STEP 6	
LABOR COST AT \$4.00/5.00/6.00	
LABOR OPERATION COST.....	\$ 7.34/ 9.125/ 10.95
LABOR SETUP COST.....	\$ 19.62/ 24.40/ 29.28

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS D

STEP 1

Take the surface area of one side of the board in square feet and multiply it times cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply panel stock cost per square foot times the surface area of one side of a board. Save the result.

STEP 3

Take cost of chemicals consumed per square feet and multiply it times the surface area of both sides of board in square feet. Save the result.

STEP 4

Take surface area of the tabs in square inches and multiply it times the cost per square inch for nickel and gold plating. Save the result.

STEP 5

Take area of copper that must be etched from both sides of board in square feet and multiply it times cost per square foot of etching. Save the result.

STEP 6

Multiply area of circuitry on both sides of the board times the price to fuse one square foot of panel. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS D (Continued)

STEP 7

Take area of board to be covered with ink for solder mask and multiply it times the cost of solder mask per square foot. Save the result.

STEP 8

Take area of board to be covered with ink for silk screening and multiply it times the cost of silk screening per square foot. Save the result.

STEP 9

Take total number of drill hits that must be completed for both first and second drill and multiply it times cost per hit. Save the result.

STEP 10

Take labor cost per panel and divide it by the number of boards being processed on each panel. Save the result.

STEP 11

Take labor setup costs per run and divide it by the number of boards in entire run. Save the result.

Add results of step 1 through step 11 for total material and labor costs to produce one board.

FORMULA FOR CALCULATING COST

PROCESS D

$\frac{(\$ \text{ entry material} + \$ \text{ backup material/sq ft}) \times \text{area in sq ft}}{\text{Number of panels in stack}}$

+ (cost of panel stock/ sq ft) X area in sq ft

+ (cost of chemicals and materials/ sq ft) X area in sq ft

+ (cost of nickel gold tabs/ sq inch) X area of tabs in
square inches

+ (cost of etching/ sq ft) X area etched in sq ft

+ (cost of fusing/ sq ft) X area fused in sq ft

+ (cost to solder mask/sq ft) X area solder masked in sq ft

+ (cost to silk screen/sq ft) X area silk screened in sq ft

+ (cost to drill one hole) X number of holes

+ $\frac{\text{labor operation cost/ panel}}{\text{number of boards/ panel}}$

+ $\frac{\text{labor setup cost/ run}}{\text{number of boards in run}}$

Total cost per board equals the sum of above.

OPERATION, TIME, AND PERCENT COMPLETE

PROCESS S

Double sided board with copper plating through holes, solder mask over bare copper, silk screened characters, and hot air leveling.

LABOR; OPERATION COST	TIME PER PANEL	%COMPLETE
ISSUE MATERIAL.....	1.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
SANDING AND GLASS HONE.....	1.0 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	16.8 min
ELECTROLESS COPPER.....	8.0 min	16%
COPPER STRIKE.....	2.5 min	
CLEANING FOR LAMINATION.....	4.0 min	
LAMINATE.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	34.4 min
EXPOSE FILM.....	2.5 min	34%
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	42.2 min
COPPER PLATING.....	7.0 min	41%
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	55.1 min
ETCH.....	0.3 min	54%
ETCH AND STRIP INSPECTION.....	1.0 min	
SECOND DRILL.....	3.8 min	
SECOND DRILL INSPECTION.....	10.0 min	70.2 min
CLEAN PANELS.....	3.0 min	70%
TIN LEAD STRIPPER.....	1.0 min	
STRIP TIN LEAD INSPECTION.....	1.0 min	75.2
CLEAN PANELS.....	3.0 min	74%
SOLDER MASK side 1.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	81.2 min
CLEAN PANELS.....	3.0 min	80%
SOLDER MASK side 2.....	2.0 min	
SOLDER MASK INSPECTION.....	1.0 min	87.2 min
CLEAN PANELS.....	3.0 min	85%
SILK SCREEN CHARACTERS.....	2.0 min	
SILK SCREEN INSPECTION.....	1.0 min	93.2 min
CLEAN PANELS.....	3.0 min	91%
HOT AIR INSPECTION.....	1.0 min	
ROUTING A BOARD.....	1.0 min	
FINAL CLEAN	3.0 min	
FINAL INSPECTION.....	1.0 min	100%
	102.2 min	

OPERATION, TIME, AND PERCENT COMPLETE

PROCESS S (Continued)

LABOR; OPERATION COST (Continued)

<u>Cost per minute at \$4.00</u>		<u>\$0.067</u>
Total labor cost per panel		\$6.85
Total labor cost per panel	\$5.00	\$8.52
Total labor cost per panel	\$6.00	\$10.22

LABOR; SETUP COST

START UP AND WARM UP FOR DRILL.....	15.0 min
DRILLING PROOF BOARD INSPECTION..	30.0 min
SECOND DRILL SET-UP.....	15.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
PREPARING STENCIL.....	30.0 min
SILK SCREEN SET-UP.....	35.6 min
CLEAN UP.....	7.0 min
<u>ROUTING MACHINE WARM UP.....</u>	<u>15.0 min</u>
	292.8
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>
Total setup cost	\$19.62
Total setup cost	\$5.00/hr \$24.38
Total setup cost	\$6.00/hr \$29.28

PROCESSING COST SUMMARY

PROCESS S

OPERATION	CHEMICAL COST AND MATERIAL COST PER SQUARE FOOT
MATERIAL;	
ENTRY AND BACKUP MATERIAL.....	\$0.565
PANEL STOCK.....	1.325
CHEMICAL AND MATERIAL PROCESSES;	
ELECTROLESS COPPER.....	0.128
COPPER STRIKE.....	0.124
LAMINATING.....	0.37
DEVELOP FILM.....	0.033
COPPER PATTERN PLATING.....	0.124
TIN LEAD PLATE	0.114
<u>STRIP DRY FILM.....</u>	<u>0.022</u>
Total	\$ 2.240
ETCHING.....	0.420
STRIP TIN LEAD.....	0.179
SOLDER MASK.....	0.144
SILK SCREEN CHARACTERS.....	0.144
DRILLING COST PER HIT.....	0.00051
HOT AIR LEVEL.....	
LABOR AT \$4.00/5.00/6.00/hr	
LABOR OPERATION COST.....	\$ 6.85/ 8.52/ 10.22
LABOR SETUP COST.....	\$ 19.62/ 24.38/ 29.28

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS S

STEP 1

Take surface area of one side of board in square feet and multiply it times the cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply panel stock cost per square foot times surface area of one side of board. Save the result.

STEP 3

Take cost of chemicals consumed per square feet and multiply it times the surface area of both sides of the board in square feet. Save the result.

STEP 4

Take the area of copper that must be etched from both sides of the board in square feet and multiply it times the cost per square foot of etching. Save the result.

STEP 5

Take area of circuitry to be stripped on both sides of board times the price to strip one square foot of tin lead. Save the result.

STEP 7

Take area of board to be covered with ink for solder mask and multiply it times the cost of solder mask per square foot. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS S (Continued)

STEP 8

Take area of board to be covered with ink for silk screening and multiply it times the cost of silk screening per square foot. Save the result.

STEP 9

Take cost to hot air level one square foot of panel and multiply it times the area to be hot air leveled. Save the result.

STEP 10

Take total number of drill hits that must be completed for both first and second drill and multiply it times the cost per hit. Save the result.

STEP 11

Take labor cost per panel and divide it by the number of boards that are being processed on each panel. Save the result.

STEP 12

Take labor setup cost per run and divide it by the number of boards in the entire run. Save the result.

Add results of step 1 through step 12 for total material and labor costs to produce one board.

FORMULA FOR CALCULATING COST

PROCESS S

$\frac{(\$ \text{ entry material} + \$ \text{ backup material/sq ft}) \times \text{area in sq ft}}{\text{Number of panels in stack}}$

+ (cost of panel stock/ sq ft) X area in sq ft

+ (cost of chemicals and materials/ sq ft) X area in sq ft

+ (cost of etching/ sq ft) X area etched in sq ft

+ (cost to strip/ sq ft) X area stripped in sq ft

+ (cost to solder mask/sq ft) X area solder masked in
square feet

+ (cost to silk screen/sq ft) X area silk screened in sq ft

+ (cost of hot air level/ sq ft) X area leveled in sq ft

+ (cost to drill one hole) X number of holes

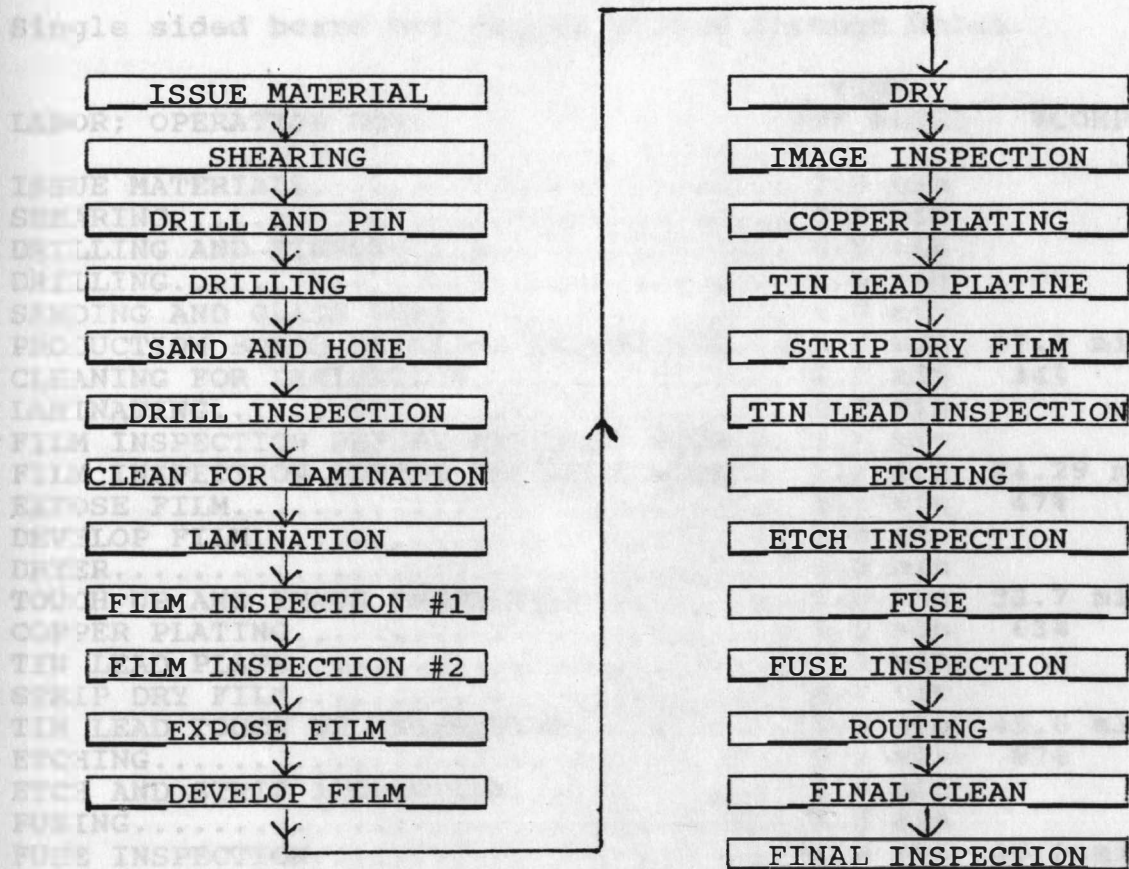
+ $\frac{\text{labor operation cost/ panel}}{\text{number of boards/ panel}}$

+ $\frac{\text{labor setup cost/ run}}{\text{number of boards in run}}$

Total cost per board equals sum of above.

MANUFACTURING FLOW CHART

PROCESS T



OPERATION, TIME, AND PERCENT COMPLETE

PROCESS T

Single sided board not copper plated through holes.

OPERATION	TIME PER PANEL	%COMPLETE
LABOR; OPERATION COST		
ISSUE MATERIALS.....	2.0 min	
SHEARING.....	0.5 min	
DRILLING AND PINNING.....	0.5 min	
DRILLING.....	3.8 min	
SANDING AND GLASS HONE.....	1.0 min	
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	17.8 min
CLEANING FOR LAMINATION.....	4.0 min	34%
LAMINATING.....	0.7 min	
FILM INSPECTION BEFORE EXPOSURE side 1.	1.2 min	
FILM INSPECTION BEFORE EXPOSURE side 2.	1.2 min	24.29 min
EXPOSE FILM.....	2.5 min	47%
DEVELOP FILM.....	1.3 min	
DRYER.....	3.0 min	
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	32.7 min
COPPER PLATING.....	7.0 min	63%
TIN LEAD PLATE	1.2 min	
STRIP DRY FILM.....	3.7 min	
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	45.6 min
ETCHING.....	0.3 min	87%
ETCH AND STRIP INSPECTION.....	1.0 min	
FUSING.....	0.3 min	
FUSE INSPECTION.....	1.0 min	48.2 min
ROUTING A BOARD.....	1.0 min	92%
FINAL CLEAN	3.0 min	
FINAL INSPECTION.....	1.0 min	100%
	52.2 min	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total labor cost per panel	\$3.50	
Total labor cost per panel \$5.00	\$4.35	
Total labor cost per panel \$6.00	\$5.22	
SETUP LABOR COST		
START UP AND WARM UP FOR DRILL.....	15.0 min	
DRILLING PROOF BOARD INSPECTION..	30.0 min	
ROUTING MACHINE WARM UP.....	15.0 min	
	60.0 min	
<u>Cost per minute at \$4.00</u>	<u>\$0.067</u>	
Total setup cost	\$4.00	
Total setup cost per run \$5.00	\$5.00	
Total setup cost per run \$6.00	\$6.00	

PROCEDURE FOR COST SUMMARY COST PER BOARD

PROCESS T

STEP 1 OPERATION	CHEMICAL COST AND MATERIAL COST PER SQUARE FOOT
<i>Multiply it times the cost of every material plus backup</i>	
MATERIAL;	
ENTRY AND BACKUP MATERIAL.....	\$0.565
PANEL STOCK.....	1.325
CHEMICAL AND MATERIAL PROCESSES;	
<i>Multiply panel stock cost per square foot times the area of</i>	
LAMINATING.....	0.37
<i>one side of board. Save the result.</i>	
DEVELOP FILM.....	0.033
<i>STEP 2</i>	
COPPER PATTERN PLATING.....	0.124
<i>Take cost of chemicals consumed per square foot and multiply</i>	
FUSING.....	0.364
<i>it times the area of both sides of board in square feet.</i>	
STRIP DRY FILM.....	0.022
Total	\$ 0.913
<i>STEP 3</i>	
ETCHING.....	0.420
<i>Take area of copper that must be etched from both sides of</i>	
FUSING.....	0.364
<i>board in square feet and multiply it times the cost per</i>	
DRILLING COST PER HIT.....	0.00051
<i>square feet of etching. Save the result.</i>	
LABOR COST AT \$4.00/ 5.00/ 6.00	
<i>Multiply area of circuitry to be fused on circuit side of</i>	
LABOR OPERATION COST.....	\$ 3.50/ 4.35/ 5.22
<i>board times the price to fuse one square foot of panel. Save</i>	
LABOR SETUP COST.....	\$ 4.00/ 5.00/ 6.00
<i>the result.</i>	
<i>STEP 4</i>	
<i>Take total number of drill hits that may be computed for</i>	
<i>both first and second drill and multiply it times the cost</i>	
<i>per hit. Save the result.</i>	

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS T

STEP 1

Take area of one side of the board in square feet and multiply it times the cost of entry material plus backup material. Divide this value by the number of panels in each drill stack. Save the result.

STEP 2

Multiply panel stock cost per square foot times the area of one side of board. Save the result.

STEP 3

Take cost of chemicals consumed per square feet and multiply it times the area of both sides of board in square feet. Save the result.

STEP 4

Take area of copper that must be etched from both sides of board in square feet and multiply it times the cost per square foot of etching. Save the result.

STEP 5

Multiply area of circuitry to be fused on circuit side of board times the price to fuse one square foot of panel. Save the result.

STEP 6

Take total number of drill hits that must be completed for both first and second drill and multiply it times the cost per hit. Save the result.

PROCEDURE FOR CALCULATING COST PER BOARD

PROCESS T (Continued)

STEP 7

Take labor cost per panel and divide it by the number of boards being processed on each panel. Save the result.

STEP 8

Take labor setup costs per run and divide it by the number of boards in the entire run. Save the result.

Add results of step 1 through step 8 for total material and labor costs to produce one board.

+ (cost to drill one hole) x number of holes

+ $\frac{\text{labor cost per panel}}{\text{number of boards per panel}}$

+ $\frac{\text{labor setup costs per run}}{\text{number of boards in run}}$

Total cost per board equals sum of above.

SAMPLE PROBLEM CALCULATION

A customer sends the following specifications.

Double sided board with copper plating through holes, nickel and gold contact tabs, solder mask over bare copper, and silk screened characters.

1000 boards

Size= 6 inches X 8 inches

Number of holes = 75 All holes will receive a first and second drill.

1.5 square inches of nickel and gold contacts.

15% circuit 85% bare panel on solder side.

60% circuit 40% bare panel on component side.

It is estimated that 10% of surface area on component side will be silk screened characters.

It is also determined that 4 boards can be produced on each panel.

CALCULATION PROCEDURE;

Find area of board, circuitry, bare board, and silk screen in square feet.

1. Board area in square feet.

$$\begin{aligned} \text{area in square inches} &= 6 \text{ inches} \times 8 \text{ inches} \\ &= 48 \text{ square inches} \end{aligned}$$

$$\begin{aligned} \text{area in square feet} &= 48 \text{ sq in} \times (1 \text{ sq ft}/144 \text{ sq in}) \\ &= 0.34 \text{ square feet} \end{aligned}$$

2. Area of circuitry

$$\begin{aligned} \text{solder side (SS)} &= \text{board area} \times \text{percent circuitry (SS)} \\ &= 0.34 \text{ sq ft} \times 15\% \\ &= 0.051 \text{ square feet} \end{aligned}$$

$$\begin{aligned} \text{component side (CS)} &= \text{board area} \times \text{percent circuitry (CS)} \\ &= 0.34 \text{ sq ft} \times 60\% \\ &= 0.204 \text{ square feet} \end{aligned}$$

SAMPLE PROBLEM CALCULATION

CALCULATION PROCEDURE; (Continued)

3. Area of bare board.

$$\begin{aligned} \text{solder side} &= \text{board area} \times \text{percent bare (SS)} \\ &= .34 \text{ sq ft} \times 85\% \\ &= 0.289 \text{ square feet} \end{aligned}$$

$$\begin{aligned} \text{component side} &= \text{board area} \times \text{percent bare (CS)} \\ &= .34 \times 40\% \\ &= .136 \text{ square feet} \end{aligned}$$

4. Area of silk screened characters

$$\begin{aligned} \text{component side} &= \text{board area} \times \text{percent silk screened (CS)} \\ &= .34 \text{ sq ft} \times 10\% \\ &= .034 \text{ square feet} \end{aligned}$$

With the above information use steps 1-11 for process D.

STEP 1

$$\frac{[(\$ \text{ entry} + \$ \text{ backup}) \text{ material/sq ft}] \times \text{area in sq ft}}{\text{Number of panels in stack}}$$

$$= \frac{\$0.565/\text{sq ft} \times 0.34 \text{ sq ft}}{3}$$

$$= \$0.064$$

STEP 2

$$+ (\text{cost of panel stock/ sq ft}) \times \text{area in sq ft}$$

$$= \$1.325/\text{sq ft} \times 0.34 \text{ sq ft}$$

$$= \$0.451$$

STEP 3

$$+ (\text{cost of chemicals and materials/sq ft}) \times \text{area in sq ft}$$

$$= \$2.24/\text{sq ft} \times 0.68 \text{ sq ft}$$

$$= \$1.52$$

STEP 4

$$+ (\text{cost of nickel gold tabs/ sq inch}) \times \text{area of tabs in square inches}$$

$$= \$0.016/\text{sq in} \times 1.5 \text{ sq in}$$

$$= \$0.024$$

SAMPLE PROBLEM CALCULATION

CALCULATION PROCEDURE; (Continued)

STEP 5

$$\begin{aligned}
 &+ (\text{cost of etching/ sq ft}) \times \text{area etched in sq ft} \\
 &= \$0.42/ \text{ sq ft} \times 0.425 \text{ sq ft} \\
 &= \$0.179
 \end{aligned}$$

STEP 6

$$+ (\text{cost of fusing/ sq ft}) \times \text{area fused in sq ft}$$

$$\text{Total} = \$0.364/ \text{ sq ft} \times 0.255 \text{ sq ft}$$

$$\text{Sum} = \$0.093$$

STEP 7

$$+ (\text{cost to solder mask/sq ft}) \times \text{area solder masked in square feet}$$

$$\text{Cost} = \$0.144/ \text{ sq ft} \times 0.425 \text{ sq ft}$$

$$\text{Nickel} = \$0.061$$

STEP 8

$$+ (\text{cost to silk screen/sq ft}) \times \text{area silk screened in square feet}$$

$$= \$0.144/ \text{ sq ft} \times 0.034 \text{ sq ft}$$

$$= \$0.005$$

STEP 9

$$+ (\text{cost to drill one hole}) \times \text{number of holes}$$

$$\text{Labor} = \$0.00051/ \text{ hole} \times (75 + 75)$$

$$\text{Labor} = \$0.077$$

STEP 10

$$+ \frac{\text{labor operation cost/ panel}}{\text{number of boards/ panel}}$$

$$= \frac{\$9.13/ \text{ panel}}{4 \text{ boards/ panel}}$$

$$= \$2.28/ \text{ board}$$

SAMPLE PROBLEM CALCULATION

CALCULATION PROCEDURE; (Continued)

STEP 11

+ labor setup cost/ run
 number of boards in run

= \$24.40/ run
 1000 boards/ run

= \$0.024/ board

Total cost per board equals the sum of step 1-11.

Summary;

Entry and backup material.....	\$0.064
Panel stock.....	0.451
Chemicals and materials.....	1.52
Nickel and gold tabs.....	0.024
Etch.....	0.179
Fuse.....	0.093
Solder mask.....	0.061
Silk screen.....	0.005
Drilling.....	0.077
Labor operation cost.....	2.28
<u>Labor setup cost.....</u>	<u>0.024</u>
Total cost per board	\$4.78

APPENDIX A
ITEMIZED MATERIAL AND CHEMICAL COSTS

ISSUE MATERIALS;

Based on cost per square foot.

A. ENTRY MATERIAL;

12 square foot panels, total cost = \$3.54

cost per square foot = \$0.295

TOTAL COST = (\$ sq ft) X (sq ft used) / (# panels in stack)

of panels will be 1, 2, or 3

B. BACK UP MATERIAL;

12 square foot panels total cost = \$3.24

cost per square foot = \$0.27

TOTAL COST = (\$ sq ft) X (Sq ft used) / (# of panels in stack)

of panels will be 1, 2, or 3

C. PANEL STOCK;

1. 0.059 1/2 1/2 FR4 costs \$2.65 per square foot

2. 0.059 1/0 FR4 costs \$2.65 per square foot

3. 0.093 1/2 1/2 FR4 costs \$4.54 per square foot

4. 0.059 1/1 FR4 costs \$2.65 per square foot

TOTAL COST = (\$ sq ft) X (amount of square foot)

DRILLING:

Drill bit cost will be based on using new bits that can be resharpened two times. Total number of hits will be 1500 per sharpening.

Cost of small bits, up to 1/16 inch = \$1.80 per bit

Cost of large bits, greater than 1/16 inch = \$2.20 per bit

Cost to resharpen average bit = \$0.25 per bit

Total cost on small bit = new cost + 2(resharpen cost)
= \$1.80 + 2(\$0.25)
= \$2.30 per bit

REWORKING COSTS

Total cost of large bits = new cost + 2(resharpen cost)
 This analysis will assume = \$2.20 + 2(\$0.25)
 products throughout = \$2.70 per bit

Cost per hit based on 4500 total hits;

\$ per hit small bit = $\frac{\$2.30}{4500 \text{ hits}}$
 = \$0.00051 per hit

\$ per hit large bits = $\frac{\$2.70}{4500 \text{ hits}}$

Replacement rate = \$0.0006 per hit 1000 square feet
 of surface area.

Cost to replace = .25 x cost of \$2.70
 = .25 x \$2.70
 = \$0.675

The entire bath will need to be replaced after 100,000
 square feet of surface area has been processed.
 Total cost per square foot:

Make-up cost = \$10.00

Enginishment

cost per

1000 square feet = \$117.50

Total cost per = \$127.50

100,000 sq. ft.

2/square foot = \$1.275

= \$1.275 per square foot

ELECTROLESS COPPER (CONTINUED)

This analysis will assume the use of CIRCUIT CHEMISTRY products throughout.

Alkaline Cleaner Conditioner (ML-471-P)

Make-Up cost based on 100 gallon tank.
It will take 5 gallons of ML-471-P for bath.

Make-Up Cost = 5 gallons X cost of ML-471-P
= 5 X \$18.00
= \$90.00

Replenishment rate is .25 gallons per 4000 square feet of surface area.

Cost to replenish = .25 X cost of ML-471-P
= .25 X \$18.00
= \$4.50

The entire bath will need to be renewed after 100,000 square feet of surface area has been processed.
Total cost per square foot.

Make-Up cost = \$90.00

Replenishment
cost per
100K square feet = \$112.50

Total cost per = \$202.50
100,000 sq. ft.

$\frac{\$202.50}{100,000 \text{ square feet}} = \$0.002 \text{ per square foot}$

ELECTROLESS COPPER (Continued)

Micro-Etch CO-ETCH

Make-up cost based on a 100 gallon tank.

CHEMICAL	MAKE-UP AMOUNT	PRICE/ UNIT	TOTAL PRICE
CO-BRA ETCH Inhibitor (make-up only)	7 gallons	X \$4.54 =	\$31.78
CO-BRA ETCH	2 gallons	X \$21.20 =	\$42.40
Sulfuric Acid	20 gallons	X \$1.87 =	\$37.40
Total price for make up			\$111.58

Consumption Cost based on etching 50 microinches from 1 square foot of panel.

CHEMICAL	Amount consumed for 50 microinches per sq.ft.	PRICE/ UNIT	TOTAL PRICE
CO-BRA ETCH	0.0040 lbs. X	\$2.12 =	\$0.0085
Sulfuric Acid	0.0037 lbs X	\$0.15 =	\$0.0005
Total to etch 50 micro inches per sq. ft.			\$0.0090

ELECTROLESS COPPER (Continued)

PRE-DIP (PD-472)

Based on a tank size of 100 gallons. The entire bath it to be renewed when copper content reaches 1000 ppm.

Make-up cost

CHEMICAL	AMOUNT		PRICE/ UNIT		TOTAL PRICE
PD-472	200 lbs.	X	\$0.97	=	\$194.00

Replenishment Cost per 1000 square feet

PD-472	4.0 lbs.	X	\$0.97	=	\$3.88
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Replenishment cost per square foot

$$\begin{aligned} & \frac{\$3.88}{1000 \text{ square foot}} \\ & = \$0.004 \text{ per square foot} \end{aligned}$$

ELECTROLESS COPPER (Continued)

CATALYST (C-473)

Make-up cost based on a 100 gallon tank.

Make-up cost

CHEMICAL	AMOUNT	PRICE/ UNIT	TOTAL/ PRICE
CATALYST C-473	3 gallons	X \$350.00	= \$1050.00
PRE-DIP PD-472	200 lbs.	X \$0.97	= \$194.00
Total cost of make-up			\$1244.00

Replenishment cost excluding make-up cost per 1000 square foot of processed material.

C-473	0.063 gallons	X \$350.00	= \$22.05 per 1000 sq ft
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Cost per square foot = $\frac{\$22.05}{1000 \text{ sq ft}}$

Total cost per square foot = \$0.022 per square foot

ELECTROLESS COPPER (Continued)

ACCELERATOR (A-474)

Based on a 100 gallon tank.

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
ACCELERATOR			
A-474	7 gallons X	\$19.85 =	\$138.95

Replenishment cost per 4000 square foot of surface area.

ACCELERATOR			
A-474	0.6 gallons X	\$19.85 =	\$11.91

Renew entire solution when approximately 40,000 square feet of surface have been processed.

ACCELERATOR	6 gallons X	\$19.85 =	\$119.10
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Total cost for 40,000 square feet = make-up + replenish
 = \$138.95 + \$119.10
 = \$258.05

Total cost per square foot = $\frac{\$258.05}{40,000 \text{ square foot}}$
 = \$0.006 per square foot

ELECTROLESS COPPER 2000

Cost based on 100 gallon tank.

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-brite 2000-A	2.25 gallons	X \$23.04	= \$51.84
Electro-brite 2000-B	15.0 gallons	X \$13.22	= \$198.30
Electro-brite 2000-C	1.75 gallons	X \$10.20	= \$17.85
<u>Total make-up cost</u>			<u>\$267.99</u>

Replenishment cost per 1 square foot of surface area used to plate 50 microinches.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite 2000-A/B Mix	0.0026 gallons	X \$21.25	= \$0.0553
Electro-Brite 2000-C	0.0020 gallons	X \$10.20	= \$0.0204
<u>Total to plate 50 microinches</u>			<u>\$0.0757</u>

1. Cleaner
2. Micro-Trace
3. Pre-Dip
4. Catalyst
5. Accelerator
6. Electroless Copper
7. Inhibitor

ELECTROLESS COPPER (Continued)

COPPER INHIBITOR LD

Cost based on 100 gallon tank.

Copper Inhibitor

LD 2 gallons X \$30.93 = \$61.86

Replenishment rate is 1 gallon per 4000 square feet.
Bath will be completely renewed when approximately
50,000 square feet have been processed.

Copper Inhibitor

LD 12.5 gallons X \$30.93 = \$386.62

Total cost per 50,000 square feet.

Make-Up = \$61.86

Replenish = \$386.62

\$448.48

\$448.48

Total cost per square foot = 50,000 square feet

= \$0.009 per square foot

SUMMARY OF ELECTROLESS COPPER COSTS

All based on 1 square foot of surface area.

1. Cleaner conditioner	=	\$0.002
2. Micro-Etch CO-BRA	=	\$0.009
3. Pre-Dip PD-472	=	\$0.004
4. Catalyst C-473	=	\$0.022
5. Accelerator A474	=	\$0.006
6. Electroless copper		
2000	=	\$0.076
7. Inhibitor	=	\$0.009
<u>Total</u>		<u>\$0.128 per square foot</u>

LAMINATE DRY FILM:

Cost is based on a per foot length basis for three different width of dry-film.

1. 12 or 14 inch dry film by 400 foot length.

Cost is \$0.37 per square foot.

double side X 2

Total cost \$0.74 per 2 square foot of panel.

DEVELOP FILM:

1. Soda Ash; 100 pounds is used to develop 1449 square feet of panel area.

$$\begin{aligned} \text{pounds per square foot} &= \frac{100 \text{ pounds}}{1449 \text{ square feet}} \\ &= 0.069 \text{ lb. / sq. ft.} \end{aligned}$$

$$\begin{aligned} \text{Price per 100 pounds} &= \$33.00 \\ \text{or price per pound} &= \$0.33 \end{aligned}$$

$$\begin{aligned} \text{Price per square foot} &= \text{Price / lb X lb / sq ft} \\ &= \$0.33 \text{ X } 0.069 \\ &= \$0.023 \text{ per square foot, 1 side} \\ &= \$0.046 \text{ per 2 square foot} \\ &= 2 \text{ sides} \end{aligned}$$

2. Defoamer; 2 ounces are required to do 290 square feet of surface area.

$$\begin{aligned} \text{ounces per sq ft} &= \frac{\text{total ounces}}{\text{total square feet}} \\ &= \frac{2 \text{ ounces}}{290 \text{ square feet}} \\ &= 0.007 \text{ ounces / sq ft} \end{aligned}$$

$$\begin{aligned} \text{Cost per gallon} &= \$18.50 \\ \text{Ounces per gallon} &= 128 \text{ oz/gal} \end{aligned}$$

$$\begin{aligned} \text{Cost per ounce} &= \frac{\text{Cost per gallon}}{\text{Ounces per gallon}} \\ &= \frac{\$18.50 \text{ per gallon}}{128 \text{ ounces per gallon}} \\ &= \$0.145 \text{ per ounce} \end{aligned}$$

$$\begin{aligned} \text{Cost per sq ft} &= \text{cost/ounce X ounces/ sq ft} \\ &= \$0.145/\text{oz X } 0.007 \text{ oz/sq ft} \\ &= \$0.001 \text{ per square foot} \end{aligned}$$

DEVELOP FILM: (Continued)

Developer; 64 ounces are used to develop 290 square foot of panel surface area.

$$\begin{aligned} \text{Ounces per square foot} &= \frac{\text{Total ounces}}{\text{Total square feet}} \\ &= \frac{64 \text{ ounces}}{290 \text{ square feet}} \\ &= 0.221 \text{ oz / sq ft} \end{aligned}$$

$$\begin{aligned} \text{Cost per gallon} &= \$5.21 \\ \text{Ounces per gallon} &= 128 \text{ oz/gal} \end{aligned}$$

$$\begin{aligned} \text{Cost per ounce} &= \frac{\text{cost/gallon}}{\text{ounces/ gallon}} \\ &= \frac{\$5.21/\text{gal}}{128 \text{ oz/gal}} \\ &= \$0.04/\text{ounce} \end{aligned}$$

$$\begin{aligned} \text{Cost per square foot} &= \$/\text{oz} \times \text{oz/sq ft} \\ &= \$0.04/\text{oz} \times 0.221\text{oz/sq ft} \\ &= \$0.009 \text{ per square foot} \end{aligned}$$

COPPER PATTERN PLATE:

Based on a 100 gallon tank.

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Copper Sulfate	62.5 lbs.	X \$0.69	= \$43.12
Sulfuric Acid	10 gallons	X \$1.89	= \$18.70
Hydrochloric Acid	50 cc's		
Acid Copper PC-667	0.5 gallons	X \$20.15	= \$10.07
<u>Total for make-up</u>			<u>\$71.89</u>

Consumption cost per 1 square foot used to plate 1 mil
(0.001 inches) thick of copper.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Acid Copper PC-667	0.001 gallon	X \$20.15	= \$0.020
Copper Anode	0.050 lbs	X \$2.09	= \$0.104
<u>Total consumption cost</u>			<u>\$0.124</u>

total cost to plate

one side of panel = % of surface plated X consumption cost

= % of surface plated X \$0.124

total cost to plate

two sides of panel = total cost for one side X 2

TIN LEAD PLATING:

Based on a 100 gallon tank.

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Boric Acid	10 lbs X	\$0.59	= \$5.90
Fluoboric Acid (48%)	25 gallons X	\$11.25	= \$281.25
Lead Fluoborate (53%)	2.6 gallons X	\$13.05	= \$33.93
Tin Fluoborate (50%)	5.8 gallons X	\$47.44	= \$275.15
Electro-Brite #848	2 gallons X	\$21.63	= \$43.26
Deionized Water for balance	Balance X		= \$0.000
total for make-up			\$639.49

Consumption cost per 1 square foot used to plate .5 mil
(0.0005 inches) thick of tin lead.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite #848	0.00014 gallons X	\$21.63	= \$0.003
Tin Lead Anode	0.023 lbs X	\$4.83	= \$0.111
Total consumption cost			= \$0.114

Total cost to plate

one side of panel = % of surface plated X consumption cost

= % of surface plated X \$0.114

Total cost to plate

two sides of panel = total cost for one side X 2

STRIP DRY FILM

Based on a 100 gallon tank.
Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite Resist			
Stripper RS-8000	10 gallons	X \$11.32	= \$113.20
Total make-up cost			\$113.20

Consumption based on stripping 1.5 mil thick resist on
1000 square feet.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite Resist			
Stripper RS-8000	2 gallons	X \$11.32	= \$22.64
Total for 1000 square feet			\$22.64

Total consumption per square foot = $\frac{\$22.64}{1000 \text{ square foot}}$

= \$0.022 per square foot

Total consumption required = \$per sq ft X % of surface strip

= \$.022 X % of surface to strip

Total consumption required

double sided panel = \$.022 X % of surface X 2

ETCHING

Cost will assume etching 1 ounce of copper per side of a 1 square foot panel.

Cost of Etchant

Etchant	\$114.00 for 8 gallon drum	\$2.07/gallon
Freight in		\$0.96/gallon
<u>Freight out for recycled</u>		<u>\$0.96/gallon</u>
Total cost of etchant per gallon		\$3.99

1 square foot of double sided panel = 2 ounces of copper
 1 gallon of Etchant spent holds = 19 ounces of metal

Amount consumed to $\frac{2 \text{ oz}}{19 \text{ oz/gallon}}$
 etch 2 ounces of copper = 19 oz/gallon

= 0.1053 gallons

Cost to etch 2 ounces = 0.1053 X \$3.99

= \$0.42 per square foot

Total cost including
 etch factor for

double sided panel = % Etch factor X \$0.42 /sq ft

STRIP TIN LEAD

Based on a 100 gallon tank.

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Solder Stripper			
808-A	100 gallons	X \$6.90 =	\$690.00
Solder Stripper			
808-B	100 gallons	X \$6.90 =	\$690.00
Total for make up			\$1380.00

Consumption based on 1 square foot of panel stripping off
0.5 mil thick tin lead deposits.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Solder Stripper			
808-A	0.016 gallon	X \$6.90 =	\$0.110
Solder Stripper			
808-B	0.010 gallon	X \$6.90 =	\$0.069
Total consumption per sq ft			\$0.179

FUSING

Make-up cost

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite Solder Cleaner			
801 concentrate	10 gallons	X \$16.73	= \$167.30
<u>Total make up costs</u>			<u>\$167.30</u>

Consumption based on processing 1 square foot of panel.

<u>CHEMICAL</u>	<u>AMOUNT</u>	<u>PRICE/ UNIT</u>	<u>TOTAL/ PRICE</u>
Electro-Brite Solder Cleaner			
801 Concentrate	0.001 gallon	X \$16.73	= \$0.017
<u>Fusing Fluid</u>	<u>0.0304 gallon</u>	<u>X \$11.40</u>	<u>= \$0.346</u>
<u>Total consumption cost per sq ft</u>			<u>\$0.364</u>

SOLDER MASK;

Solder mask; 497 square feet of panel surface area will use a average of 1 gallon of solder mask.

Amount used / sq ft = $\frac{1 \text{ gallon}}{\text{total square foot}}$
 = $\frac{1 \text{ gallon}}{497 \text{ sq ft}}$
 = 0.002 gal/ sq ft

Cost per gallon = \$71.40

Cost/ sq ft = cost/ gal X gal/ sq ft

= \$71.40/ gal X 0.002 gal/sq ft

= \$0.144 per square foot, 1 side

\$0.288 per 2 sq ft, 2 sides

DESCRIPTION	AMOUNT	PRICE/ UNIT	TOTAL/ PRICE
Nickel plate	2.00 ounces	\$5.00	\$10.00
Gold	10 wires in case	\$1.00	\$10.00
Process	2.2 micro mil	\$4.50	\$9.90
TOTAL			\$29.90

NICKEL AND GOLD PLATE

Based on a 100 gallon tank.
Make-up cost

CHEMICAL	AMOUNT		PRICE/ UNIT	=	TOTAL/ PRICE
Nickel Sulfate	250 lbs	X	\$1.39	=	\$347.50
Nickel Chloride	50 lbs	X	\$1.79	=	\$89.50
Boric Acid	40 lbs	X	\$0.59	=	\$23.60
Gold	1 ounce	X	\$460.00	=	\$460.00
Electro-Brite P-730 Nickel Plating process	1 gallon	X	\$20.24	=	\$20.24
Total make-up cost					\$940.84

Consumption cost per square inch at 0.2 mil thickness for
nickel and 50 micro inches thick for the gold.

CHEMICAL	AMOUNT		PRICE/ UNIT	=	TOTAL/ PRICE
Nickel anode	0.0011 ounces	X	\$0.186	=	\$0.0002
Gold	50 micro in cubed	X	\$320.51	=	\$0.016
Electro-Brite P-730 Nickel Plating Process	2.7 micro gal	X	\$20.24	=	\$0.0001
Total to plate 1 square inch					\$0.0163

APPENDIX B

ITEMIZED TIME AND LABOR COST

OPERATION	TIME PER PANEL	COST at \$4.00 hr.
SHEARING.....	0.5 min	0.033
DRILLING AND PINNING.....	0.5 min	0.033
START UP AND WARM UP FOR DRILL.....	15.0 min	1.000
DRILLING.....	3.8 min	0.253
SANDING AND GLASS HONE.....	1.0 min	0.067
DRILLING PROOF BOARD INSPECTION..	30.0 min	2.000
PRODUCTION BOARD DRILLING INSPECTION..	10.0 min	0.667
ELECTROLESS COPPER.....	8.0 min	0.533
COPPER STRIKE.....	2.5 min	0.167
CLEANING BOARDS.....	3.0 min	0.200
CLEANING FOR LAMINATION.....	4.0 min	0.267
LAMINATING.....	0.7 min	0.047
INSPECTION BEFORE EXPOSURE.....	30.0 min	2.000
EXPOSING FILM.....	2.5 min	0.167
DEVELOPING FILM.....	1.3 min	0.087
DRYER.....	3.0 min	0.200
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	0.067
PATTERN PLATING.....	7.0 min	0.467
TIN LEAD PLATE (NOT FUSED).....	1.2 min	0.080
TIN LEAD PLATE (FUSED).....	1.2 min	0.080
STRIP DRY FILM.....	0.5 min	0.033
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	0.067
ETCHING.....	0.3 min	0.020
ETCH AND STRIP INSPECTION.....	1.0 min	0.067
NICKEL AND GOLD PLATE.....	3.0 min	0.200
TIN LEAD STRIPPER.....	1.0 min	0.067
STRIP TIN LEAD INSPECTION.....	1.0 min	0.067
FUSING.....	0.3 min	0.020
PUTTING SCREEN ON FRAME.....	42.0 min	2.800
CLEANING AND PREPARING SCREEN FOR REUSE.....	15.0 min	1.000
PREPARING STENCIL.....	30.0 min	2.000
SOLDER MASK.....	55.0 min	3.667
CLEAN UP.....	7.0 min	0.467
SOLDER MASK INSPECTION.....	1.0 min	0.067
HOT AIR INSPECTION.....	1.0 min	0.067
ROUTING MACHINE WARM UP.....	15.0 min	1.000
CHECKING A PROGRAM IN PARTS LIST.....	0.5 min	0.033
DELETING A PROGRAM IN MEMORY.....	0.5 min	0.033
LOADING A PROGRAM TAPE.....	0.5 min	0.033
CALL A PROGRAM IN THE PARTS LIST.....	0.5 min	0.033
MAKING A TOOLING HOLE.....	15.0 min	1.000
ROUTING A BOARD.....	1.0 min	0.033
SETTING ROUTER TO ZERO.....	1.0 min	0.033
FINAL INSPECTION.....	1.0 min	0.033

OPERATION	TIME PER PANEL	COST at \$5.00 hr.
SHEARING.....	0.5 min	0.042
DRILLING AND PINNING.....	0.5 min	0.042
START UP AND WARM UP FOR DRILL.....	15.0 min	1.250
DRILLING.....	3.8 min	0.317
SANDING AND GLASS HONE.....	1.0 min	0.084
DRILLING PROOF BOARD INSPECTION..	30.0 min	2.500
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	0.833
ELECTROLESS COPPER.....	8.0 min	0.667
COPPER STRIKE.....	2.5 min	0.208
CLEANING BOARDS.....	3.0 min	0.250
CLEANING FOR LAMINATION.....	4.0 min	0.333
LAMINATING.....	0.7 min	0.058
INSPECTION BEFORE EXPOSURE.....	30.0 min	2.500
EXPOSING FILM.....	2.5 min	0.208
DEVELOPING FILM.....	1.3 min	0.108
DRYER.....	3.0 min	0.250
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	0.084
PATTERN PLATING.....	7.0 min	0.583
TIN LEAD PLATE (NOT FUSED).....	1.2 min	0.100
TIN LEAD PLATE (FUSED).....	1.2 min	0.100
STRIP DRY FILM.....	0.5 min	0.042
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	0.100
ETCHING.....	0.3 min	0.025
ETCH AND STRIP INSPECTION.....	1.0 min	0.084
NICKEL AND GOLD PLATE.....	3.0 min	0.250
TIN LEAD STRIPPER.....	1.0 min	0.084
STRIP TIN LEAD INSPECTION.....	1.0 min	0.084
FUSING.....	0.3 min	0.025
PUTTING SCREEN ON FRAME.....	42.0 min	3.500
CLEANING AND PREPARING SCREEN FOR REUSE.....	15.0 min	1.250
PREPARING STENCIL.....	30.0 min	2.500
SOLDER MASK.....	55.0 min	4.583
CLEAN UP.....	7.0 min	0.583
SOLDER MASK INSPECTION.....	1.0 min	0.084
HOT AIR INSPECTION.....	1.0 min	0.084
ROUTING MACHINE WARM UP.....	15.0 min	1.250
CHECKING A PROGRAM IN PARTS LIST.....	0.5 min	0.042
DELETING A PROGRAM IN MEMORY.....	0.5 min	0.042
LOADING A PROGRAM TAPE.....	0.5 min	0.042
CALL A PROGRAM IN THE PARTS LIST.....	0.5 min	0.042
MAKING A TOOLING HOLE.....	15.0 min	1.250
ROUTING A BOARD.....	1.0 min	0.042
SETTING ROUTER TO ZERO.....	1.0 min	0.042
FINAL INSPECTION.....	1.0 min	0.042

OPERATION	TIME PER PANEL	COST at \$6.00 hr.
SHEARING.....	0.5 min	0.050
DRILLING AND PINNING.....	0.5 min	0.050
START UP AND WARM UP FOR DRILL.....	15.0 min	1.500
DRILLING.....	3.8 min	0.380
SANDING AND GLASS HONE.....	1.0 min	0.100
DRILLING PROOF BOARD INSPECTION..	30.0 min	3.000
PRODUCTION BOARD DRILLING INSPECTION...	10.0 min	1.000
ELECTROLESS COPPER.....	8.0 min	0.800
COPPER STRIKE.....	2.5 min	0.250
CLEANING BOARDS.....	3.0 min	0.300
CLEANING FOR LAMINATION.....	4.0 min	0.400
LAMINATING.....	0.7 min	0.070
INSPECTION BEFORE EXPOSURE.....	30.0 min	3.000
EXPOSING FILM.....	2.5 min	0.250
DEVELOPING FILM.....	1.3 min	0.130
DRYER.....	3.0 min	0.300
TOUCH UP AND IMAGE INSPECTION.....	1.0 min	0.100
PATTERN PLATING.....	7.0 min	0.700
TIN LEAD PLATE (NOT FUSED).....	1.2 min	0.120
TIN LEAD PLATE (FUSED).....	1.2 min	0.120
STRIP DRY FILM.....	0.5 min	0.050
TIN LEAD TOUCH UP INSPECTION.....	1.0 min	0.100
ETCHING.....	0.3 min	0.030
ETCH AND STRIP INSPECTION.....	1.0 min	0.100
NICKEL AND GOLD PLATE.....	3.0 min	0.300
TIN LEAD STRIPPER.....	1.0 min	0.100
STRIP TIN LEAD INSPECTION.....	1.0 min	0.100
FUSING.....	0.3 min	0.030
PUTTING SCREEN ON FRAME.....	42.0 min	4.200
CLEANING AND PREPARING SCREEN FOR REUSE.....	15.0 min	1.500
PREPARING STENCIL.....	30.0 min	3.000
SOLDER MASK.....	55.0 min	5.500
CLEAN UP.....	7.0 min	0.700
SOLDER MASK INSPECTION.....	1.0 min	0.100
HOT AIR INSPECTION.....	1.0 min	0.100
ROUTING MACHINE WARM UP.....	15.0 min	1.500
CHECKING A PROGRAM IN PARTS LIST.....	0.5 min	0.050
DELETING A PROGRAM IN MEMORY.....	0.5 min	0.050
LOADING A PROGRAM TAPE.....	0.5 min	0.050
CALL A PROGRAM IN THE PARTS LIST.....	0.5 min	0.050
MAKING A TOOLING HOLE.....	15.0 min	1.500
ROUTING A BOARD.....	1.0 min	0.050
SETTING ROUTER TO ZERO.....	1.0 min	0.050
FINAL INSPECTION.....	1.0 min	0.050

APPENDIX C
DEFINITIONS

ACCELERATOR: A chemical that is used to speed up a reaction or cure, as cobalt naphthenate is used to accelerate the reaction of certain polyester resins. It is often used along with a catalyst, hardener, or curing agent.

ADDITION AGENT: (ADDITIVES). A material added to a plating bath for the purpose of modifying the character of the deposit.

ADDITIVE PROCESS: A process for obtaining conductive patterns by the selective deposition of conductive material on an unclad base material.

ADHESIVE: Broadly, any substance used in promoting and maintaining a bond between two materials.

ALLOY PLATE: An electrodeposit containing two or more metals so combined as to be indistinguishable with an unaided eye.

AMP-HOUR: An amount of electricity defined as one amp supplied for one hour.

ANNULAR RING: The pad of circuit metal surrounding a hole.

ANODE: The electrode in a plating tank which has a positive charge placed on it.

ARTWORK: The design which is photographed to produce the master circuit pattern.

BASE MATERIAL: (1) The insulating material upon which the printed wiring pattern may be formed. (2) The film support for photographic emulsions.

DEFINITIONS (Continued)

BASE MATERIAL THICKNESS: The thickness of the base material excluding metal foil cladding or material deposited on the surface.

BATH VOLTAGE: The total voltage between the anode and cathode of the plating bath.

BLISTERING: Swilling or separation between resist and the surface to which it is applied.

BOARD: (1) Printed circuit board. (2) The foil and base from which a printed circuit is fabricated.

BRIGHTENER: An addition agent which caused the formation of a bright plate, or which improves the brightness of the deposit.

BUILD-UP: Undesirable overplating which occurs on corners and edges of the base metal during plating.

BURNT DEPOSIT: A rough, nonadherent, or otherwise unsatisfactory electrodeposit produced by the application of excessive current density.

BUS BAR: The long copper bars which run the length of the plating tank, and from which the anodes and printed circuit panels (cathodes) are suspended.

CATALYST: A chemical that causes or speeds up the cure of a resin but does not become a chemical part of the final product.

CIRCUIT: The interconnection of a number of electrical devices in one or more closed paths to perform a desired electrical or electronic function.

DEFINITIONS (Continued)

CLAD: A thin layer of metal foil bonded to a substrate.

CLEANING: The removal of grease, oxides and other foreign material from a surface.

COAT: To cover with a finishing, protecting, or enclosing layer of any compound.

COMPONENT: Commonly used to describe resistors, capacitors, transistors, etc.

COMPONENT HOLE: A hole used for the attachment and electrical connection of a component termination, including pin or wire, to the printed board.

CONDUCTIVE FOIL: The conductive material that covers one side or both sides of the base material and is intended for forming the conductive pattern.

CONDUCTIVE PATTERN: The configuration or design of the electrically conductive material on the base material.

CONDUCTOR SPACING: The distance between adjacent edges (not center to centerline) of conductors on a single layer of printed board.

CONDUCTOR THICKNESS: The thickness of the copper conductor exclusive of coatings or other metals.

CONDUCTOR WIDTH: The width of the conductor viewed from vertically above.

CONNECTOR AREA: The portion of the printed board that is used for providing external electrical connections.

DEFINITIONS (Continued)

CORNER MARKS: The marks at the corners of printed board artwork, the inside edges of which usually locate the borders and establish the contour of the board.

CORROSION: Gradual destruction of a material usually attributable to a chemical process.

CURRENT DENSITY: Total amps per square foot of plating area.

DEBURRING: Removal of burrs, sharp edges from work.

DEFINITION: Fidelity of reproduction of the printed board conductive pattern relative to the production master.

DEIONIZED WATER: Chemically pure water which is equivalent to distilled water.

DELAMINATION: Separation of resist from the metal substrate.

DENSITY: Concentration of matter; mass per unit volume.

DIELECTRIC: The insulating support for circuits.

DRAG-IN: The quality of water or solution that adheres to the material introduced into a bath.

DRAWING, or PRINT: The blueprint of the printed circuit board.

ELECTRODE: The metal conductor through which current enters or leaves an electrolytic cell.

ELECTROFORMING: The production or reproduction of articles by electrodeposition.

ELECTROLESS COPPER: This is copper which is chemically deposited inside the holes which have been drilled in printed circuit panels.

DEFINITIONS (Continued)

ELECTROLESS PLATING: A type of immersion plating in which a chemical reducing agent is employed to reduce metal ions to metal on the surface of the work.

ELECTROPLATING: This is the type of plating which results from using electricity to supply the energy for metal deposition.

EMULSION: The light sensitive silver halide coating of photographic films which produces an image after exposure and development. The side with the image present.

ETCH FACTOR: Ratio of depth of etch to undercut lateral etch.

ETCHANT: A solution which removes unwanted metallic portions of a printed board by chemical action.

ETCHED PRINTED CIRCUIT: A printed circuit formed by etching.

ETCHING: This is the removal of metal by chemical methods.

EXPOSURE: Subjecting photoresist to UV light to cause polymerization.

EYEBALLING: A registration technique where the phototool is aligned visually with drilled holes.

FINGER: That part of a circuit board used to provide electrical connection by pressure contacts.

FLASH PLATING: A very thin deposit of metal.

FLIP FLOP: This refers to running multiple circuits on a panel. When run flip flop, panes are processed with from the circuits oriented from the circuit side, and half from the component side.

DEFINITIONS (Continued)

FOIL: A very thin sheet of metal.

HALOING: Change of resist color along image edges.

HOLE SIZE: The diameter of a hole.

IMAGE: A likeness of an object produced on a light sensitive material.

IMMERSION PLATING: Deposit by simple immersion without any outside source of current.

INCLUSION: Foreign particles which may be included in metal.

LAMINATE: A product of two or more layers of material bonded together.

LAMINATION: The process of applying photoresist to a surface, while removing the coversheet.

LATENT IMAGE: The stored up affect of light on a photosensitive material, when it is developed the true image appears where the latent image was.

LEGEND: A format of lettering or symbols on the printed board, e.g., part number, component locations, or patterns.

LINE: A single conductor on a printed circuit board.

LINE WIDTH: The width of a conductor on a printed circuit board.

MASK: A covering to protect the circuitry pattern, or background during board manufacturing.

MEASLING: Discrete white spots or crosses below the surface of the base laminate that reflect a separation of fibers in the glass cloth at the weave intersection.

Mil. One-thousands of an inch (.001 inch).

DEFINITIONS (Continued)

OUNCES OF COPPER: This refers to the thickness of copper foil on the surface of the laminate. Refers to weight per square foot.

OVERHANG: The increase in conductor width caused by plating buildup.

OVERLAY: A transparent film which includes the master pattern.

PAD: Area of a printed circuit used for making connections to the pattern; also, the area around a drilled or plated-through hole.

PANEL PLATING: Plating which is performed to an unimaged panel, bare copper.

PATTERN PLATING: Plating which is done to panels which have a circuit image applied with plating resist.

PEELING: Detachment of a plated metal coating from the basis metal.

pH; Measure of acidity or alkalinity.

PHOTOGRAPHIC SPREAD or CHOKe: The increasing (spread) or decreasing (choke) of circuitry line width.

PHOTORESIST: A photosensitive, chemically resistant material used to mask areas of printed circuit board blanks

PHOTOTOOL: Photomask, photographic master, etc.

PINHOLE: Small hole or imperfection; minute void.

PIT: Depression produced in a metal surface by nonuniform electrodeposition, corrosion, or contamination.



DEFINITIONS (Continued)

PLATED-THROUGH HOLE: Connections between insulated layers of circuit foil formed by holes. Hole walls are chemically metallized then electroplated to the desired thickness.

PLATING: Chemical, galvanic, or electrochemical deposition of metal.

PLATING AREA: This is the portion of an imaged or unimaged panel which is copper; it is the area which will be plated.

PLATING BATH: The electroplating solution or electrolyte.

PLATING RESIST: This is the resist used to image a printed circuit panel for plating, or for etching.

PLATING VOID: The area of absence of a specific metal from a specific cross-sectional area.

PORES: Discontinuities in a metal coating which extend through it.

POSITIVE: Clear and opaque areas in the same order as the original.

PRINTING: Reproducing a pattern on a surface; exposing photoresist through a phototool, or silk screening.

PRODUCTION TEST BOARD: A test board the purpose of which is to determine whether, prior to the production of finished boards, the contractor has the capability of producing a board satisfactorily.

RACK: Frame used to suspend and conduct current to boards (cathodes) during electrodeposition. Frame used to hold panels upright while storing.

DEFINITIONS (Continued)

REGISTRATION: The ability to reproduce artwork of various size lines and spaces. The relative position of one or more printed wiring patterns, or portions thereof, with respect to desired locations on a printed wiring base or to another pattern on the opposite side of the board.

RESIST: A material (ink, paint, metallic plating, etc.) used to protect portions of a printed circuit from the etchant.

RESOLUTION: The ability to reproduce artwork of various size lines and spaces.

SCREEN PRINTING: Putting an image onto base material by forcing ink through a stencil screen with a squeegee.

SCUM: Areas in which the resist has not been completely removed or in which dissolved resist has been redeposited after development.

SOLDERABILITY: Surface sustains an unbroken molten solder film, all holes fill during wave solder.

SPECIFIC GRAVITY: The density of a substance relative to water.

STRIP: Removal of the photoresist film from the etched or plated circuit board.

STRIPPER: Organic solvent to remove photoresist from etched or plated circuit boards.

TOOLING HOLES: Holes placed in the PC base to accurately position the boards for drilling or exposure.

DEFINITIONS (Continued)

TRAVELER: Set of instructions which the planning engineer writes for manufacturing the printed circuit.

ULTRAVIOLET: That portion of the light spectrum with wavelengths shorter than visible light and longer than X-rays.

VISCOSITY: The resistance to flow of liquids.

All definitions are quoted, copied and credit given to references (1) and (5).

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