DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150599

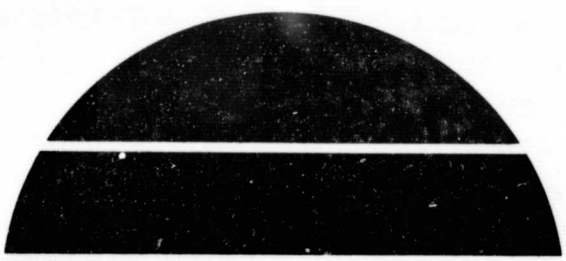
LIQUID FLAT PLATE COLLECTOR AND PUMP FOR SOLAR HEATING AND COOLING SYSTEMS (A Collection of Quarterly Reports)

Calmac Manufacturing Company
150 S. Van Brunt Street
Englewood, New Jersey 07631

Under Contract NAS8-32253 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



U.S. Department of Energy

Solar Energy

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This work was done under the technical management of Mr. John Caudle, George C. Marshall Space Flight Center, Alabama

16. ABSTRACT

This report is a collection of quarterly reports from Calmac Manufacturing Company covering the progress made during the period from October 15, 1976 to October 15, 1977. Calmac, under Contract NAS8-32253, for the development, fabrication, and delivery of solar subsystems consisting of a solar operated pump, and solar collectors which can be used in solar heating and cooling, or hot water, for single family, multi-family, or commercial applications.

These reports have been reformatted, retyped, the pages renumbered, and the cost information removed.

17. KEY WORDS	18. DISTRIBUTION STATEMENT Unclassified-Unlimited William A. Brooksbank, Jr. WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office

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QUARTERLY REPORT

October 15, 1976 through January 15, 1977

I. Solar Collector

1. Summary - Work is on schedule. No problems were encountered in the development.

2. Contract - No changes were requested during the quarter. No problems are being encountered in meeting requirements of the contract.

3. The development is proceeding on schedule--all milestones to date have been met. Master schedule is attached.

4. a. During the quarter all materials to be used in the collector were reviewed and some materials were replaced with new materials. The design of the collector was reviewed and slight changes in the structural design were made. Engineering testing was performed in order to establish the baseline performance requirements.

b. Future activity will include testing of materials and performance, followed by fabrication of the prototype and the deliverable articles. A review of materials will be continued--the current material are expected to meet all requirements but improvements are still possible.

c. No major problems have developed to date.

d. No data is being submitted with this report.

II. Pump

1. Summary - Milestones were met and work is on schedule subject to verification that a working model of the pump design meets requirements. Getting the proper design was more difficult than expected.

2. Contract - No changes were requested during the quarter. No problems have been encountered in meeting requirements of the contract.

3. All major milestones in the contract to date have been met. The master schedule is attached.

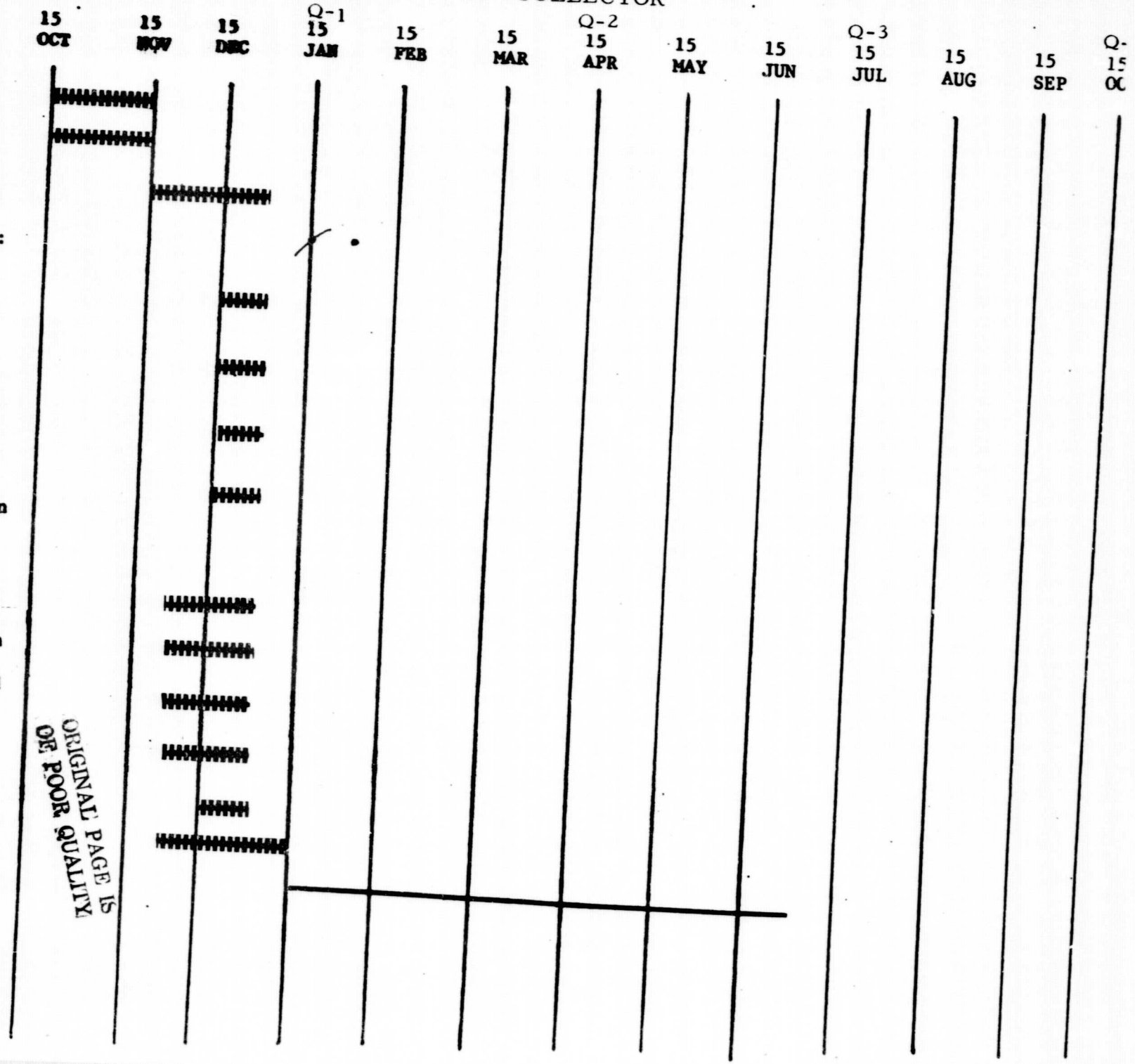
4. a. During the quarter materials to be used in the pump were researched and tested--suitable materials were identified without much difficulty. Most of the effort was devoted to analyzing and experimenting with the design of the pump. We have now worked out the design for the pump, but must still build an exact working model to verify its performance.

b. Future activity will include testing the working model for performance, then testing for certain critical elements of the IPC, followed by fabrication of the prototype and the deliverable articles.

c. The only major problem was the difficulty in perfecting the design to meet the pumping requirements at the required head. We believe we have these problems solved but must build an exact working model to verify this.

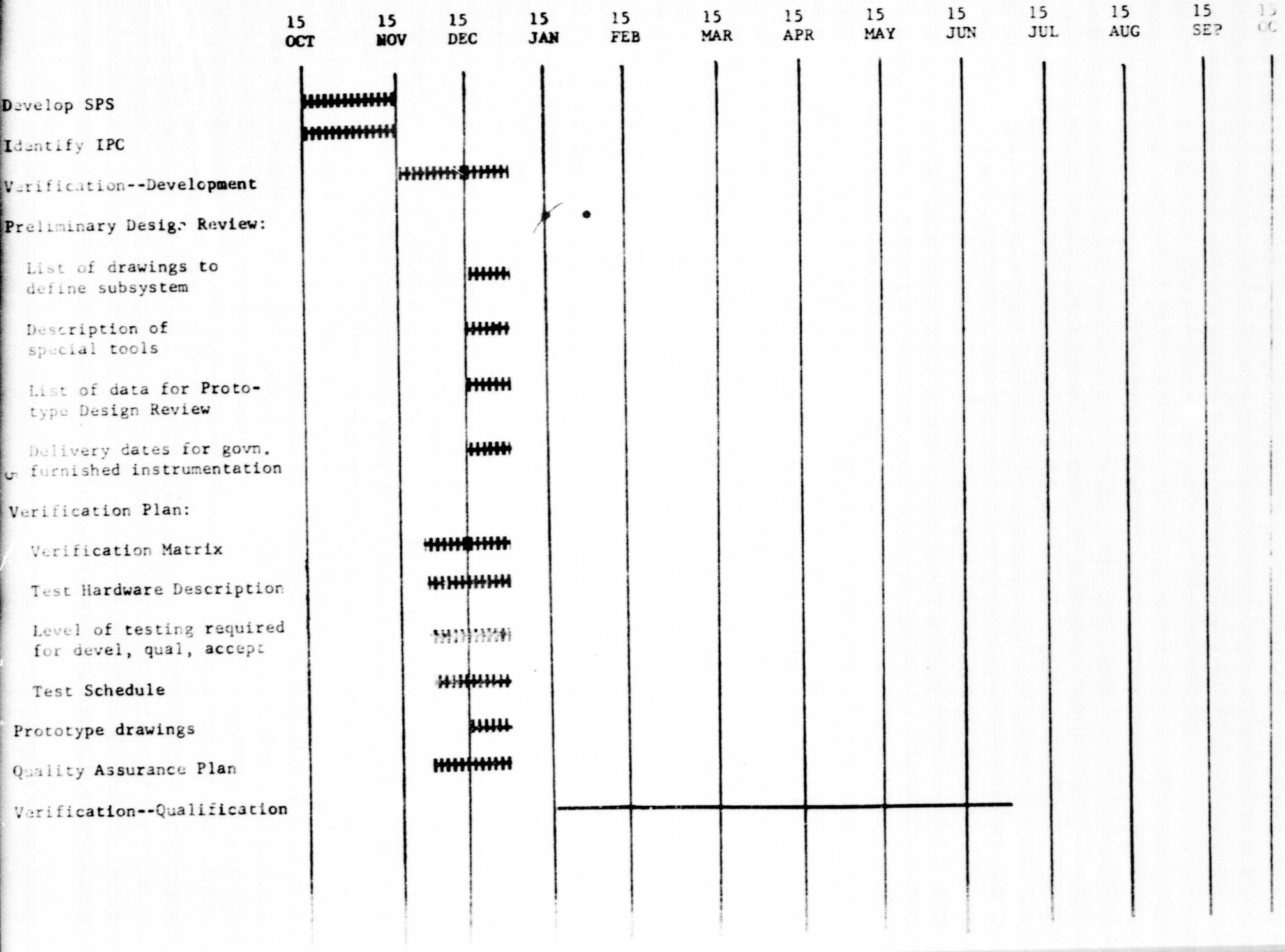
d. No data is being submitted with this report.

MASTER SCHEDULE - COLLECTOR



- Develop SPS
- Identify IPC
- Verification--Development
- Preliminary Design Review:
  - List of drawings to define subsystem
  - Description of special tools
  - List of data for Prototype Design Review
  - Delivery dates for govn. furnished instrumentation
- Verification Plan:
  - Verification Matrix
  - Test Hardware Description
  - Level of testing required for devel, qual, accept
  - Test Schedule
- Prototype drawings
- Quality Assurance Plan
- Verification--Qualification

MASTER SCHEDULE - PUMP



QUARTERLY REPORT

January 15, 1977 through April 15, 1977

I. Solar Collector

1. Summary - We are somewhat behind in our schedule because of the delay in getting material. Delays in getting material and the failure of certain materials to perform properly were the major problems encountered. Material performance problems seem to have been solved, but delays are still a problem.

2. Contract - Changes to the list of applicable Interim Performance Criteria incorporated in the Subsystem Performance Specifications were submitted and approved. The changes resulted from a more careful analysis of which IPC were relevant to the collector subsystem. No problems were encountered in meeting the administrative or technical requirements of the contract.

3. Schedule - All milestones to date have been met. However, at this point we are somewhat behind schedule because of the delays in getting the EPDM SUNMAT tubing. We have also been delayed in doing a test for potability of water circulated through the system because of a lack of cooperation from the U.S. Environmental Protection Agency. Our master schedule is attached.

4. Technical

   a. During the quarter engineering testing led to changes in both materials and design configuration. Corbin clamps were replaced with Stimpson clamps. The silica gel-in-copper tube dryer was replaced with a silica gel-in-wire mesh dryer. The adhesive used to bond the SUNMAT tubing was changed several times. The unfaced insulation board was replaced with foil-faced board. The number of tubes in the mat was reduced from 32 to 31. The use of double-faced tape as an aid in the construction process was adopted. A number of 4' x 10' collectors were built during the quarter to identify problem areas and test these design changes.

   b. The two activities remaining are the accomplishment of rigorous testing to verify the performance of the final design, and the documentation of the design, including the installation, operation and maintenance manuals.

c. Most of the changes made during the quarter, while significant, were essentially refinements and improvements on the basic initial design. The most significant problem was the failure of adhesives to perform in accordance with the specifications of the supplier/ manufacturer - we relied on data given to us to select cements and then later found the actual performance did not match the data. We feel now that we have identified all the proper materials and that these problems are solved.

d. No data is being submitted with this quarterly report.

II. Pump

1. Summary - Further design modifications required additional engineering time and material. This additional design work has put us behind in our schedule, and further design modifications to get the required efficiencies may still be required.

2. Contract - There were no changes to the contract during the quarter. No problems were encountered in meeting management and administrative requirements of the contract - all problems were of a technical nature.

3. Schedule - All milestones to date have been met. However, at this point we are still doing design modification and testing to get the 50% efficiency called for in the specifications. If the results in the next two weeks are successful, we can meet the original schedule. If not, we will propose a change in the efficiency called for in the specifications, and plan to deliver on schedule a pump that will meet the revised specifications.

4. Technical

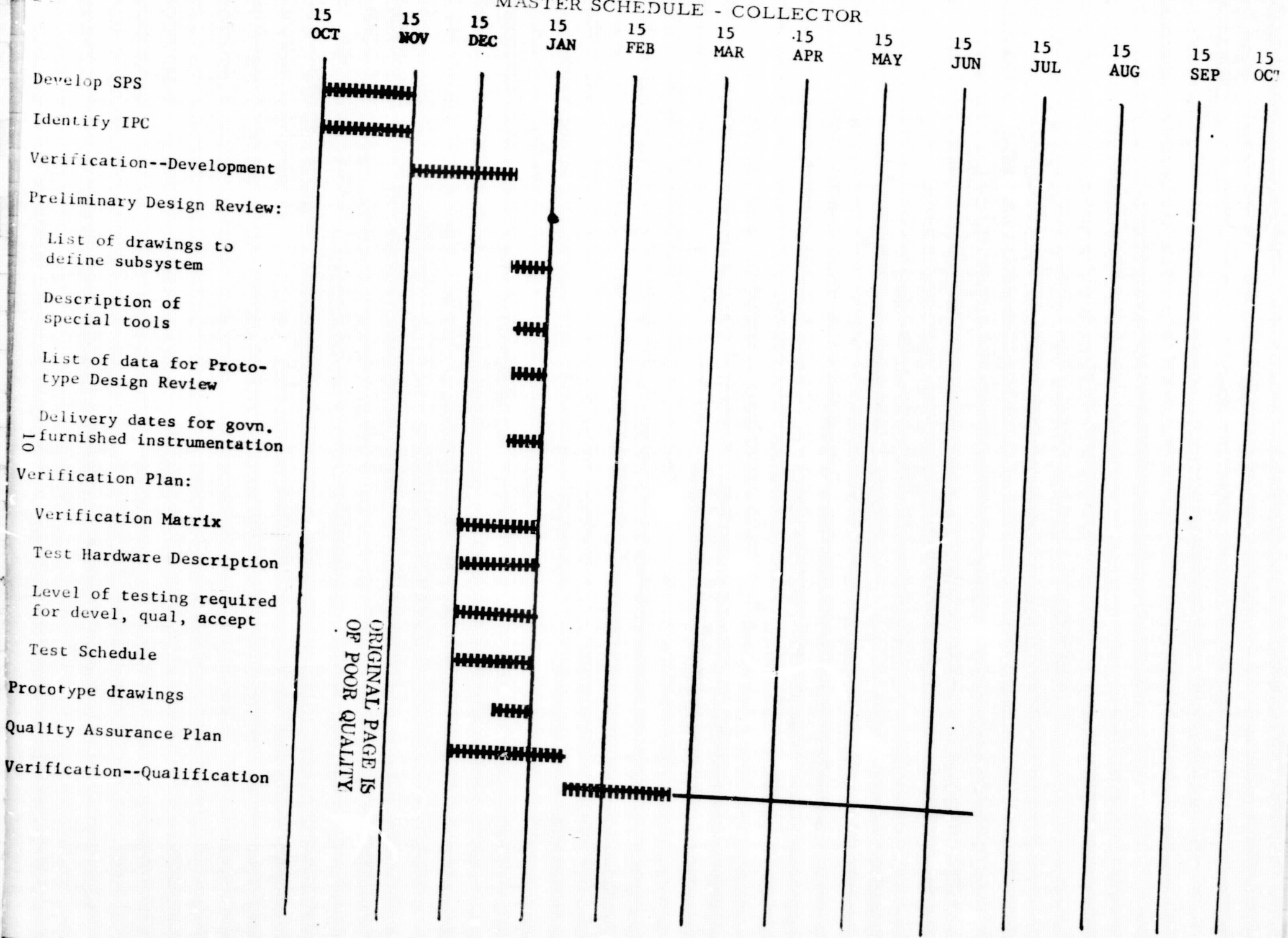
a. During the quarter we designed and tested a valve at the steam inlet that improves the cycling of the pump and its performance on the suction stroke. The rest of the work was devoted to identifying and eliminating the source of heat losses causing unexpected inefficiencies. Engineering analysis led to the conclusions that heat from the steam was being absorbed by or through the cylinder wall, so we searched for and tested different materials to reduce these losses. Improvements were made, but the work continues.

b. In the next two weeks we plan to test a teflon-lined cylinder made of Foam Glass which should allow rapid runoff of water from the sides and good insulation. Following this test, we will run a 500-hour test, operate the pump with the concentrating collectors, measure efficiencies and performance in a more rigorous way, and complete the necessary manuals.

c. The problem throughout the quarter has been the difficulty in getting the pump to operate with adequate thermal efficiencies. Underlying this problem is the difficulty we have had in analyzing this heat loss problem with conventional engineering techniques. Our analyses suggest the pump should be more efficient, and have not helped us pinpoint the problem, so we have had to supplement the analysis with intuition and trial and error experimentation.

d. No data is being submitted with this quarterly report.

MASTER SCHEDULE - COLLECTOR



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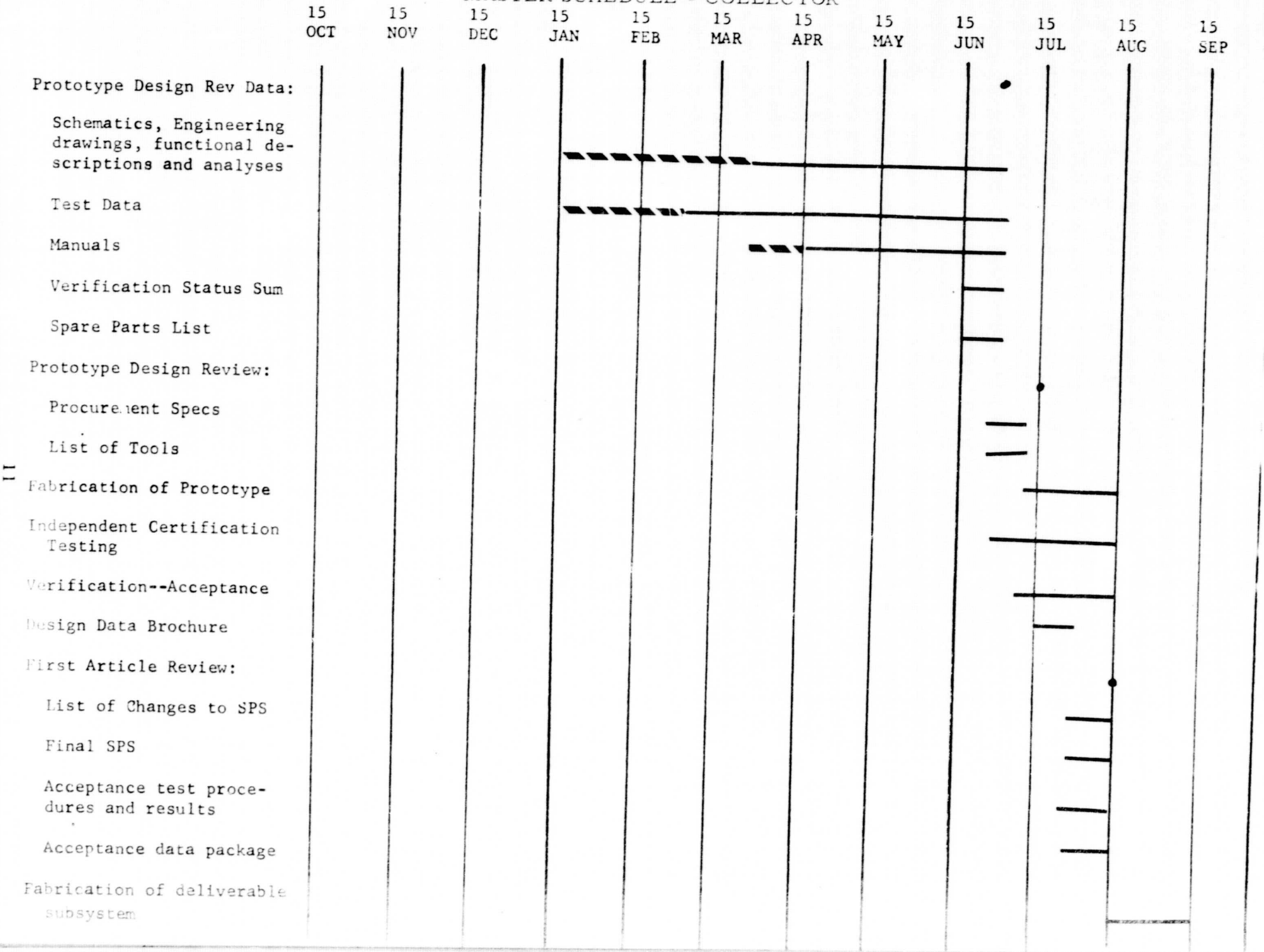
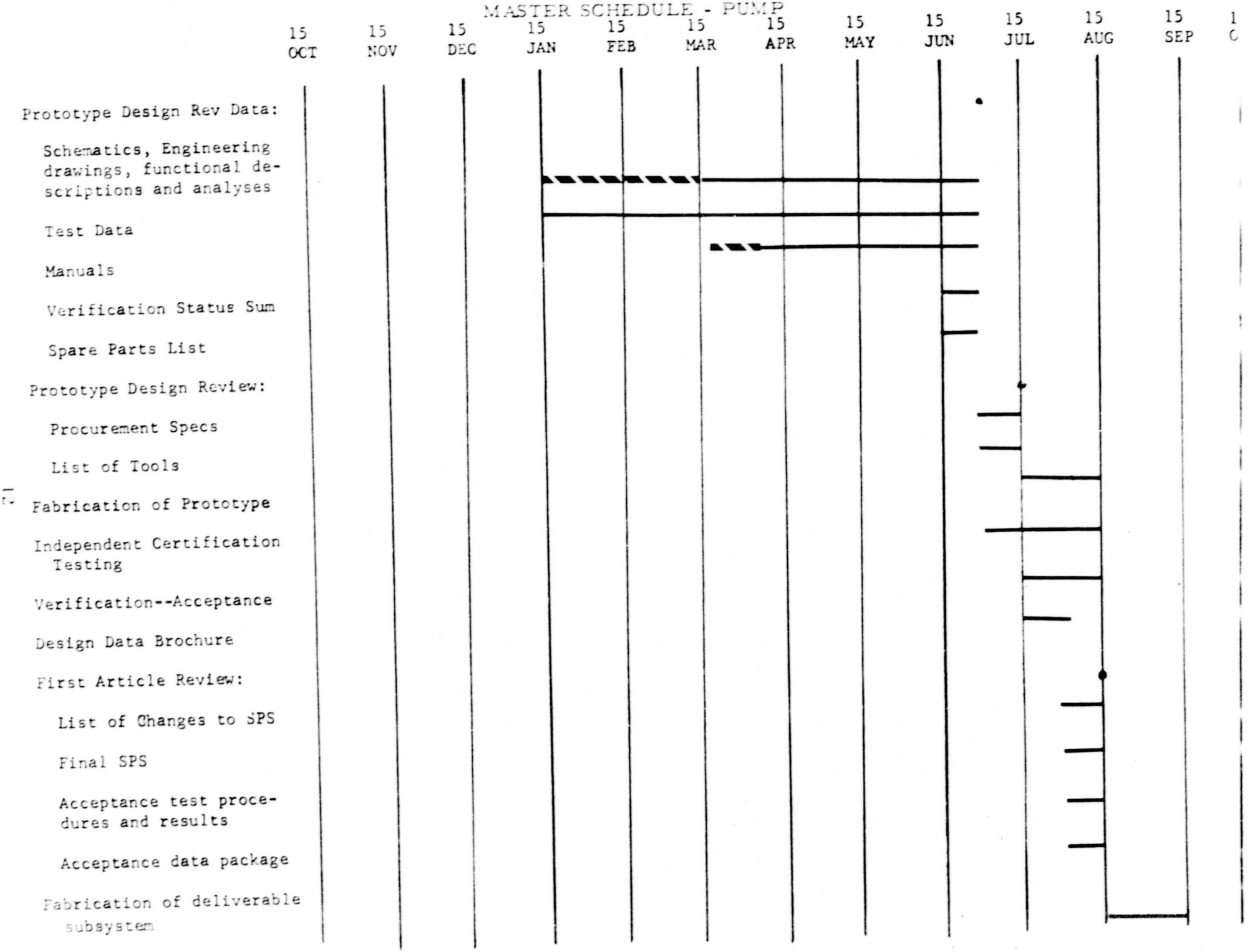
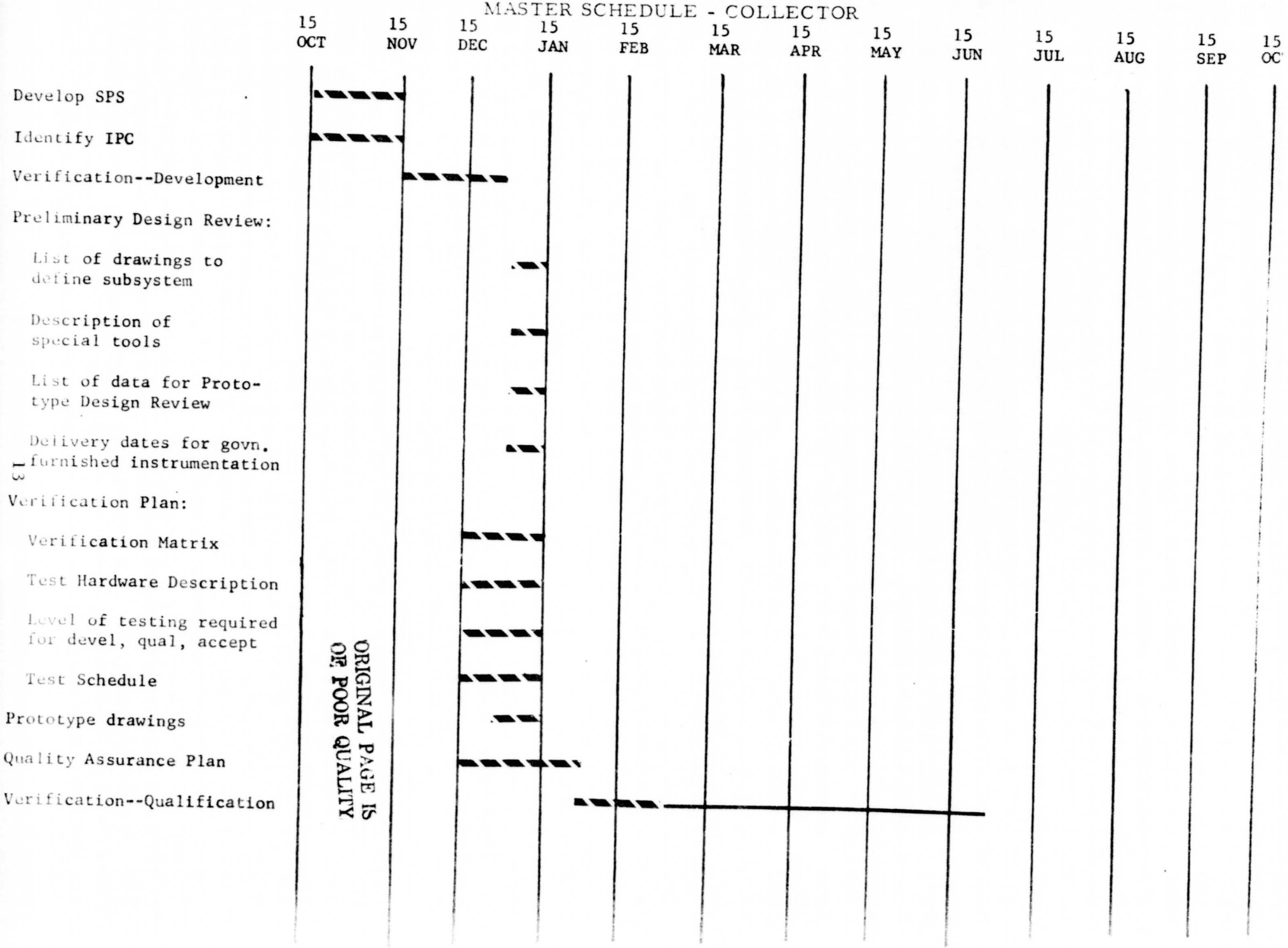


MASTER SCHEDULE - PUMP



MASTER SCHEDULE - COLLECTOR



QUARTERLY REPORT

April 15, 1977 through July 15, 1977

I. Solar Collector

1. Summary - A change was made in the statement of work to incorporate a plastic frame, and a two-month extension was arranged to allow for this new work. We are behind the original schedule, but will finish ahead of the new schedule. Testing during the quarter was generally successful, except for unexpected outgassing of insulation. This represents the only major problem to be solved.

2. Contract - A change to the Statement of Work was proposed and approved. In place of a double-glazed collector we will be designing an extruded plastic frame which will allow manufacturing of conventional panels with good appearance and easy access to the absorber plate. To allow time for this work a two-month no cost extension was approved.

3. Schedule - Delays in getting EPDM tubing up to specification continued well into the quarter, but towards the end of the quarter progress was made in catching up on the schedule. With the two-month extension we anticipate no problems in meeting the schedule for delivery of equipment. A copy of the master schedule is attached.

4. Technical

a. Most of the work during the period focussed on testing of various kinds. A wind tunnel was constructed and the collector exposed to a 75 mph wind. The collector was cycled 1000 times with a 12.5 PSF pull from the glazing. The tubing was held pressurized at 40 PSI and 240°F for 500 hours. Stagnation tests of collectors were run during which collector temperatures approached 300°F. As a result of these tests, several problems were noted. The header nipples and U-bends had to be redesigned with a deeper groove and the use of an epoxy cement was incorporated to insure against leaks. The fiberglass insulation outgassed during stagnation--this is a problem we are still considering. In addition during the quarter the plastic frame was designed, the die was made, and the frame extruded. Initial examination indicates the frame will work very well. Also, the installation, operation and maintenance manuals were prepared, and engineering drawings prepared.

b. Activities remaining include settling on a solution to the outgassing problem, further testing of the extruded frame and developments of ways to cover it and seal in the glazing, and efficiency and operational testing of completed collectors.

c. The most significant remaining problem is the outgassing of the insulation. We did not think the collector would get up to 300°F during stagnation, and we thought the insulation would stand up to 350°F. One solution is to outgas the insulation in the factory before fabrication. We are also looking at alternative insulations.

d. No data is being submitted with this report.

II. Pump

1. Summary - The pump was completed; the concentrating collector was assembled; the whole system was operated successfully. Pump efficiency is still below desired levels. Testing is underway to measure actual efficiency.

2. Contract - There were no changes to the contract during the quarter. No problems were encountered in meeting management and administrative requirements of the contract. All problems continued to be of a technical nature.

3. Schedule - We were put behind schedule during the quarter because of problems with the concentrating collector. Delivery of the collector was on time, but a number of components were missing or faulty, and there were considerable delays in getting the necessary components. Work has progressed rapidly since then and we are close to being back on schedule. Because of the two-month extension of the collector program and the administrative inconvenience of not running both programs on the same track we will be delaying various milestones so that they coincide with the collector timetable.

4. Technical

a. During the quarter we completed design of the pump, and after trying a variety of approaches ended up waterproofing the inner cylinder cork with a sealant. The pump still does not approach the

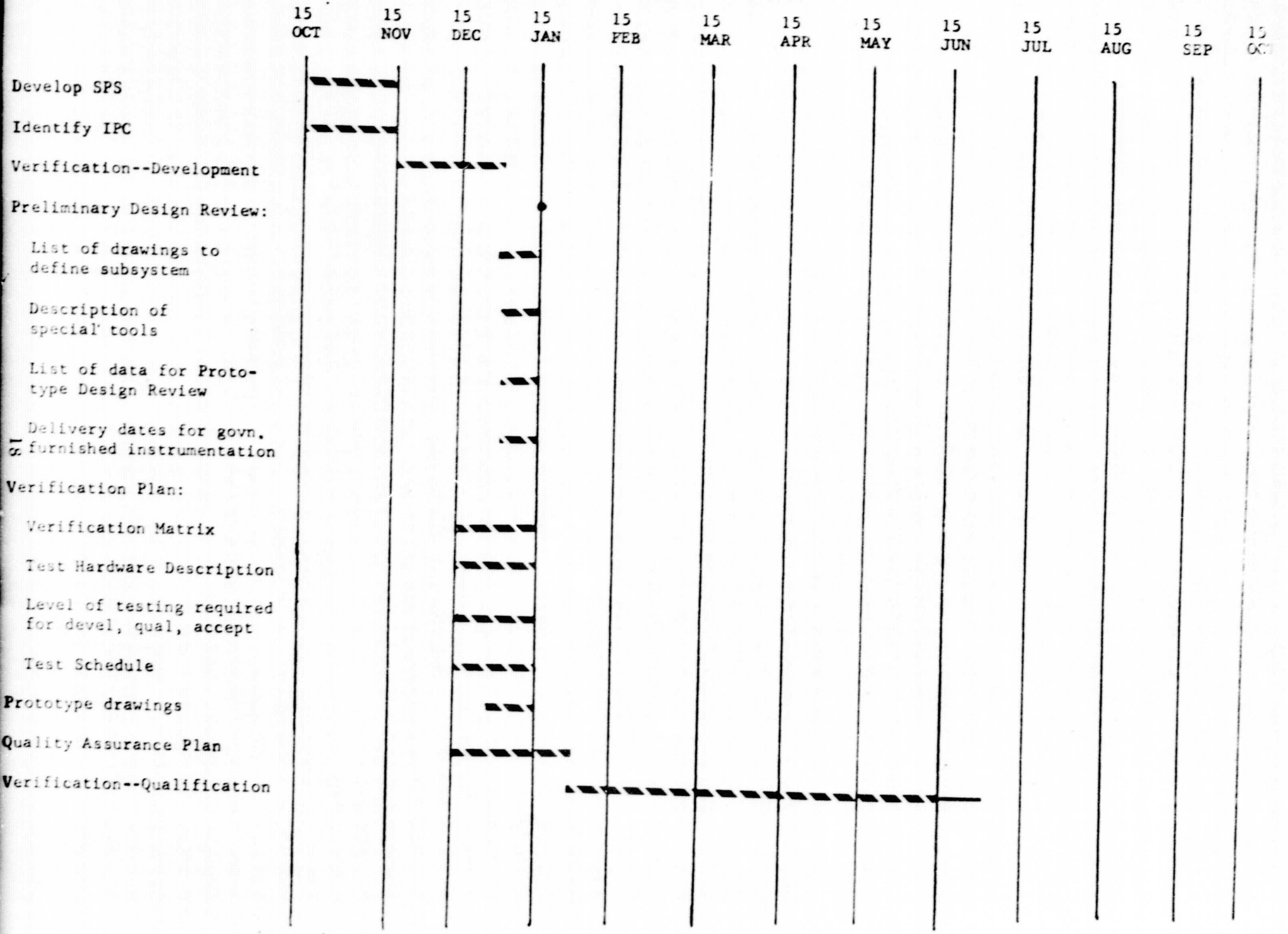
expected 50% efficiency. Testing indicates it is closer to 20 to 25% efficient. The collector was assembled during the quarter, and the entire system set up and operated successfully. A manual was also prepared, and engineering drawings completed.

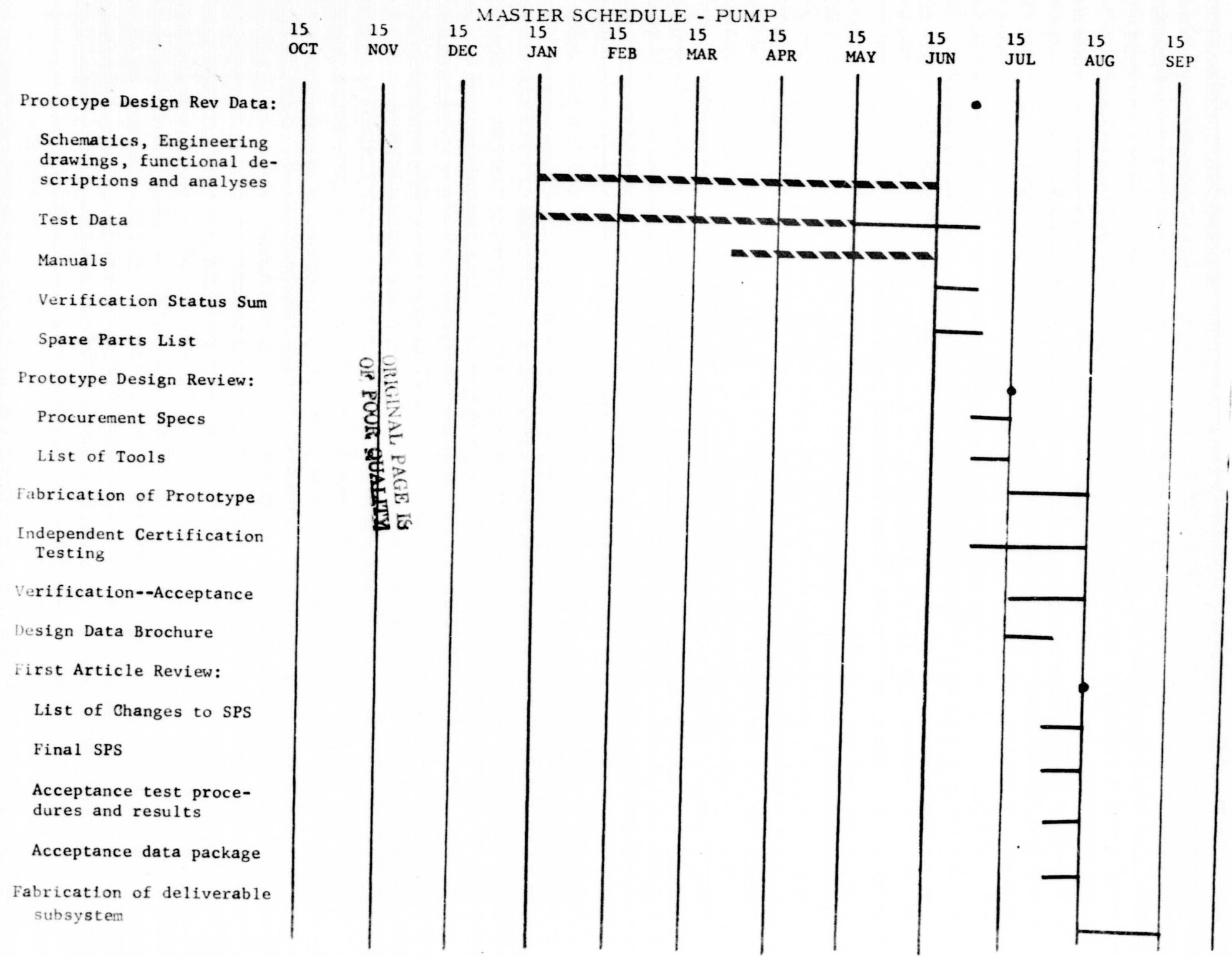
b. We plan to focus on measuring the efficiency of the pump as accurately as possible. We plan to do this by using both the steam generator and the collector, and comparing estimated outputs from both with the mechanical pumping output from the pump.

c. The problem throughout the development has been identifying sources of inefficiency and correcting them. In spite of much analysis and intuitive tinkering we have not been able to achieve efficiencies close to those we calculated we could get and those we had on smaller versions. In short, we are stumped and after measuring actual efficiencies more closely will be proposing a modification to the specs.

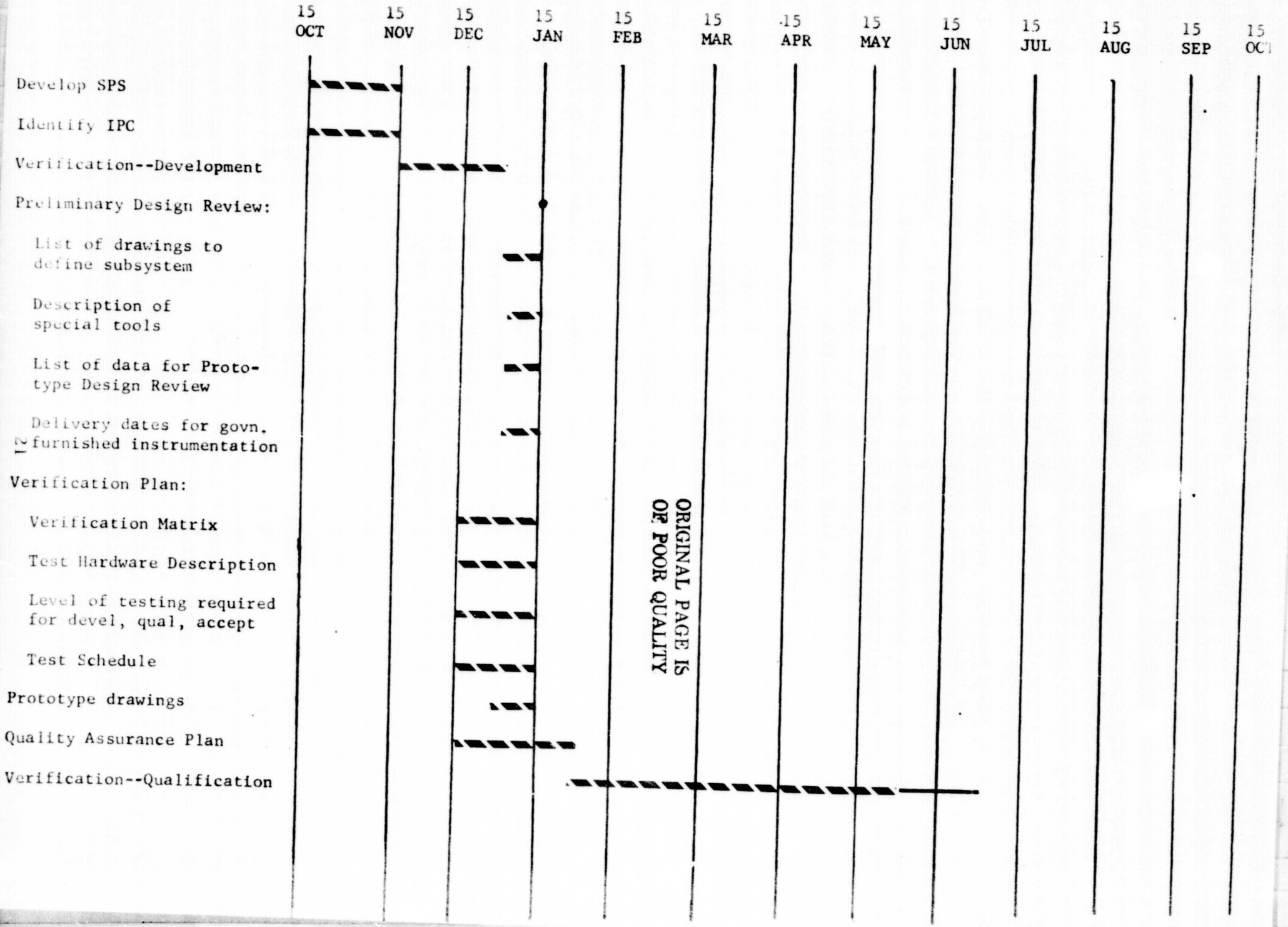
d. No data is being submitted with this report.

MASTER SCHEDULE - PUMP





MASTER SCHEDULE - COLLECTOR



QUARTERLY REPORT

July 15, 1977 through October 15, 1977

I. Collector

1. Summary - A number of design and material changes were successfully made during the quarter, and collectors of the final design were manufactured and tested. One was sent to DSET in Arizona for testing there. A one-month extension of the contract was requested to allow time for manufacturing the collectors after the completion of certification.

2. Contract - A one-month no-cost extension of the term of the contract was requested to allow adequate time for manufacturing deliverable items after the completion of certification.

3. Technical

a. Design and material changes made successfully during the quarter include the following:

1) Insulation board outgassed in an oven at 350°F for an hour is being used to avoid outgassing from stagnation.

2) Several new adhesives were used successfully--Polyshim adhesive and elastic tape and Stic-Safe insulation adhesive.

3) Gusset plates and angle irons were added to improve structural strength.

Six 25-foot long collectors were manufactured and installed on a building on Long Island. Other collectors were manufactured for testing and demonstration purposes. Our early experience has confirmed that we can make large, custom-sized panels and that this approach reduces installation costs and makes integration into a roof structure easier.

Rigorous testing in accordance with ASHRAE 93-77 indicated the slope of the efficiency line was steeper than earlier tests showed. The results show the efficiency is in line with other non-selective, single-glazed metal collectors.

b. In the remaining part of the contract we will have the certification completed and manufacture the collectors for delivery to NASA.

c. No major technical problems were encountered.

d. No data is being submitted with this report.

II. Pump

1. Summary - Final design of the pump was completed. The use of a silicone sealant was the most significant technical development. A tradeoff between efficiency and pumping capacity became evident during the quarter, and the efficiency specification was lowered accordingly. The pump functioned well during testing.

2. Contract - A change to the specifications for the unit's pumping efficiency was submitted. There were no other changes or problems in contract administration.

3. Technical

a. During the quarter design of the pump was completed and performance tests conducted. A key design development during the quarter was the use of a silicone material to seal the inner cork cylinder. This material effectively waterproofs the system and allows extended operation at constant efficiencies.

Testing and further analysis during the quarter showed that we would not get improved efficiencies without sacrificing pumping capacity. Adding insulation takes up volume in the pump and therefore lowers the pumping output per stroke. Given these limits, the pump performed well during testing using both the steam generator and the concentrating collectors.

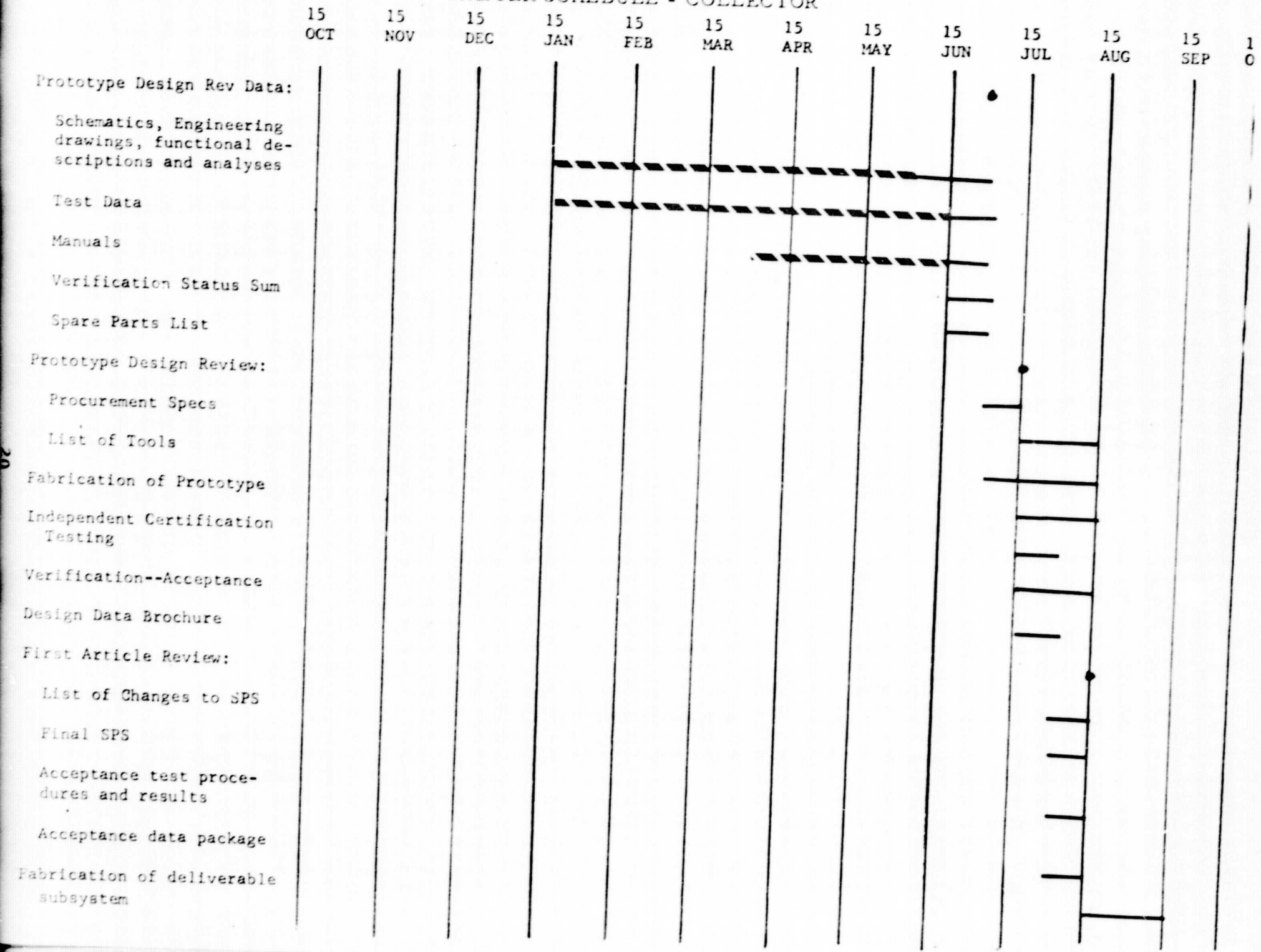
Although no marketing plans for the pump have been formulated, it does find potential application in irrigation or in pumping water for domestic use in underdeveloped areas. The key lies in the development of a reliable, reasonably priced concentrating collector.

b. In the remaining part of the contract we will accomplish final testing for certification.

c. No major technical problems were encountered.

d. No data is being submitted with this report.

MASTER SCHEDULE - COLLECTOR



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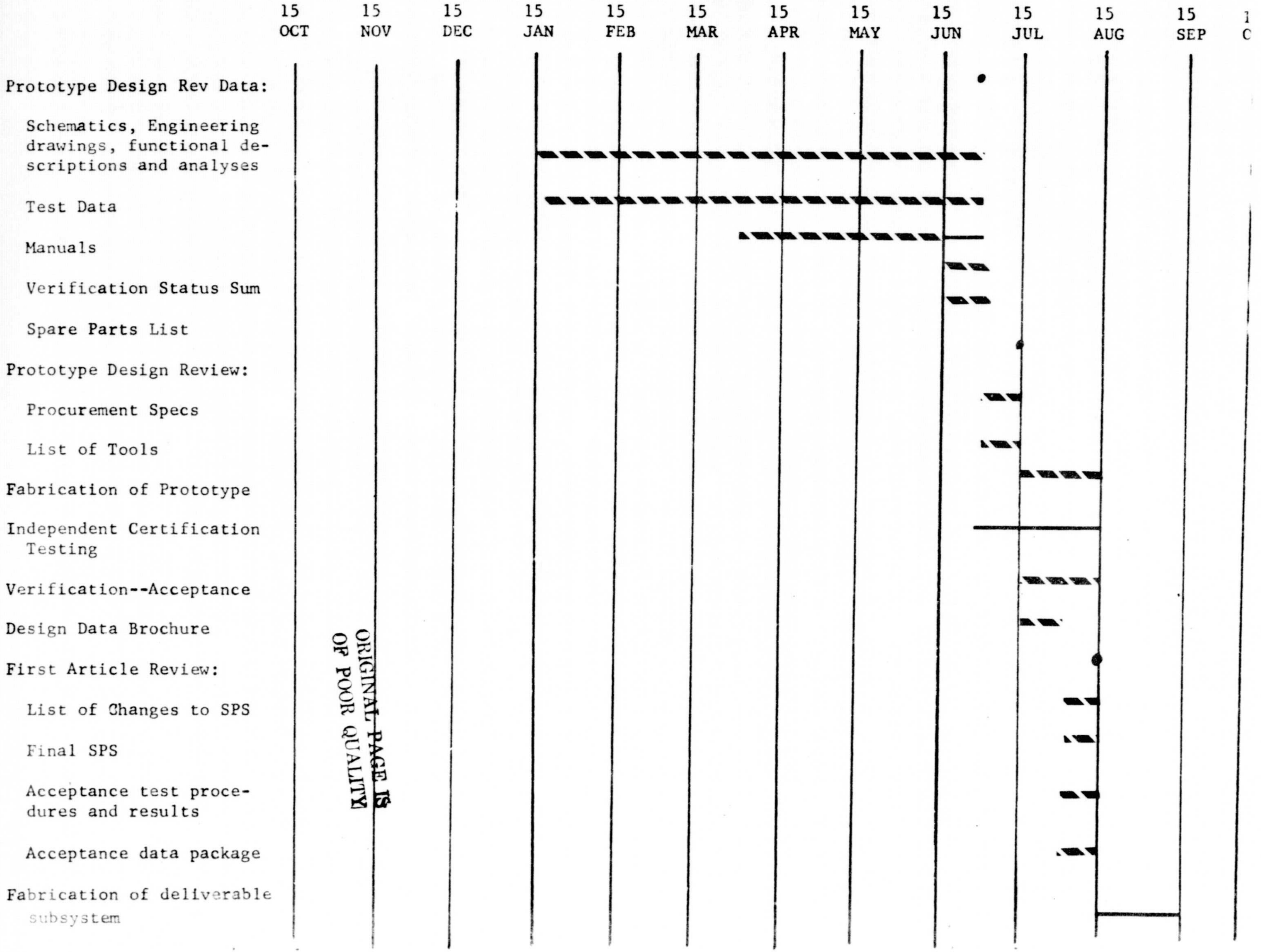

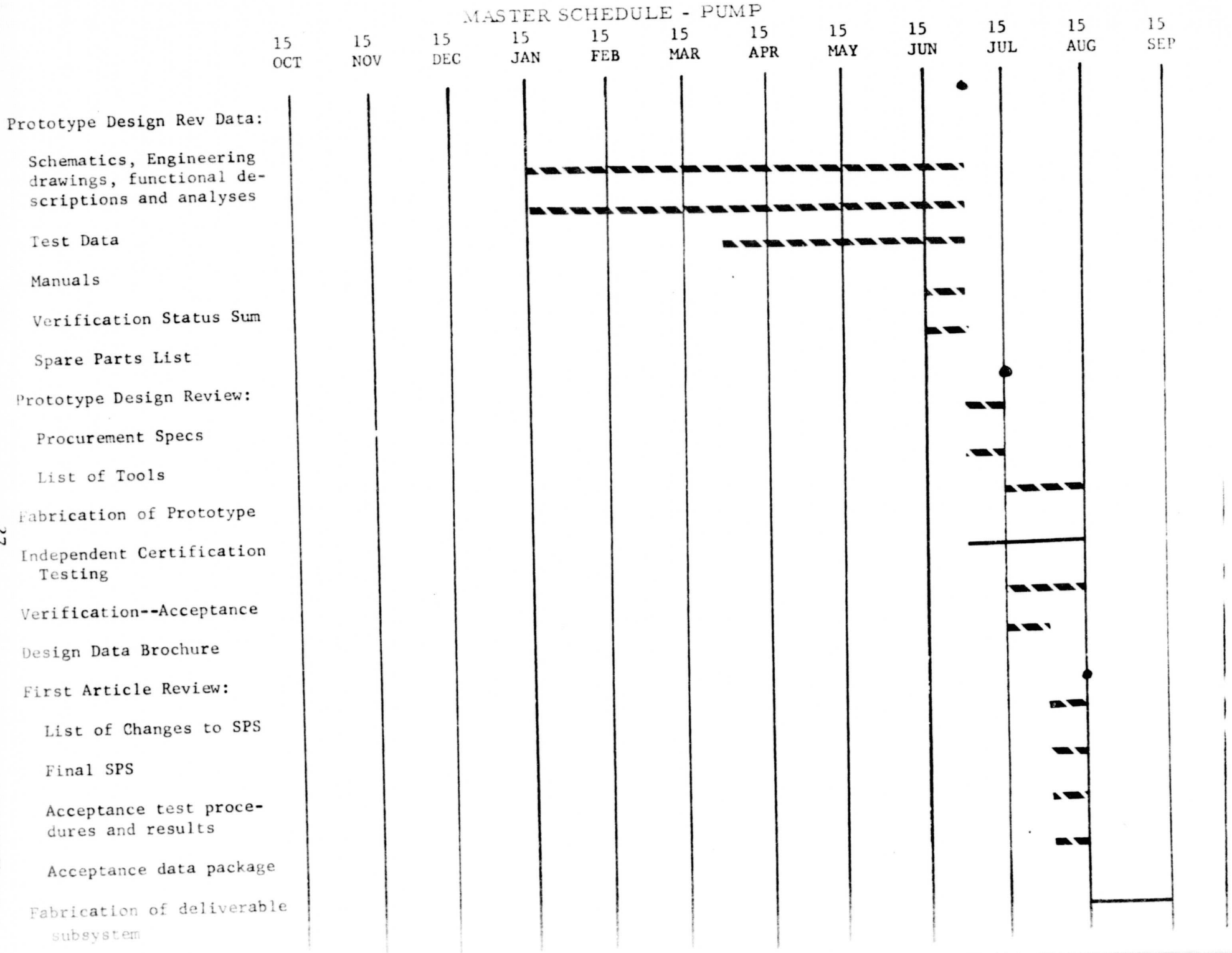

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