

APPLICATIONS OF THERMAL ENERGY STORAGE TO WASTE HEAT RECOVERY
IN THE FOOD PROCESSING INDUSTRY

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PROJECT OUTLINE

Project Title: TES for Food Processing Assessment

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Organization: Westinghouse Electric Corporation
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Project Goals: To assess the potential for waste heat recovery in the food processing industry and to evaluate prospective waste heat recovery systems and the benefits of thermal energy storage.

Analyze factory and food system operations of two manufacturing plants of Heinz USA Division of H. J. Heinz Company to determine waste heat availability applications

Perform a waste heat recovery system design

Assess potential energy savings in the food industry

Recommend a demonstration plan

Project Status: Waste heat is available in significant quantities which can be used for existing, on-site energy demands

Thermal energy storage/waste heat recovery (TES/WHR) systems can be effectively applied in these applications

Economics for waste heat recovery can be attractive for facilities with high energy demand levels

Return-On-Investment for recommended TES/WHR is estimated at 35-40%

Contract Number: EC-77-C-01-5002

Contract Period: August 1977 to October 30, 1978

Funding Level: \$96,195

Funding Source: U.S. Department of Energy
Division of Energy Storage Systems

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SUMMARY

The canning segment of the food processing industry is a major energy user within that industry. Most of its energy demand is met by hot water and steam and those fluids, in addition to product cooling water, eventually flow from the processes as warm waste water. To minimize the possibility of product contamination, a large percentage of that waste water is sent directly to factory drains and sewer systems without being recycled and in many cases the thermal energy contained by the waste streams also goes unreclaimed and is lost from further use. A study discussed herein indicates that the recovery of waste heat in canning facilities can be performed in significant quantities using systems involving thermal energy storage (TES) that are both practical and economical. A demonstration project has been proposed to determine actual waste heat recovery costs and benefits and to encourage system implementation by the food industry.

BACKGROUND

A study project* was conducted by Westinghouse and completed in October, 1978 to assess the potential for waste heat recovery in the food industry and to evaluate prospective waste heat recovery system concepts employing thermal energy storage. The project was performed with the cooperation of the H. J. Heinz Company (USA Division) and during the project, Heinz USA arranged access to two of their manufacturing plants and permitted Westinghouse personnel to analyze factory operations and food system performance at each site. The project's most productive work was accomplished at the company's Pittsburgh Factory. The Pittsburgh plant is engaged in the manufacture of baby foods and juices, canned soups and canned bean products. This product line places the factory in the Canned Specialties (SIC 2032) industry but the food processes and the associated hardware are also common to the Canned Fruits and Vegetables (SIC 2033) segment of the food industry. Therefore, the results of work at the factory would be applicable to SIC 2033 as well as to Canned Specialties and they did in fact prove to be particularly

*Contract EC-77-C-01-5002, 8/31/77 - 9/30/78, \$96,195.00.

interesting and attractive. They showed that a variety of waste heat sources and applications are available at a food canning facility and that those sources and applications could be coupled economically by systems containing a storage element.

The Pittsburgh Factory operates several common food processing systems (can/bottle washers, continuous coolers, stationary retorts and continuous pasteurizers) that produce heated waste water having temperatures in the 100 to 200°F range. The waste water streams are sent directly to the factory drain system as they emerge from the processes and waste heat recovery currently is not attempted. Flow rate and temperature data were taken from each system during the study and it was concluded that the temperatures were sufficiently high to permit accessing a portion of the available waste heat by conventional heat exchange. Three separate energy demands occur at the Pittsburgh Factory that could use this energy. They involve the heating of boiler make-up water, fresh water for the food processes and factory clean-up water. The make-up and food processing demands peak during the one or two production shifts of each day in unison with waste heat availability. Therefore, supplying waste heat to those demands will generally not involve significant storage. The hot water clean-up effort, however, is performed after-hours when the production systems are down and meeting a portion of that energy demand with waste heat from the production period would of course require a buffering storage device.

To assess the role of TES in canning industry waste heat recovery, a recovery system concept for application to the factory's Meat Products Building was devised and analyzed. Meat Products is the largest manufacturing unit at the factory and it houses several food processing operations and two waste heat applications that cause it to be similar in a variety of ways to manufacturing plants operated by other food processing companies throughout the industry. The waste water streams to be collected by the system (see fig. 1) would come from the stationary retorts, the can and bottle washers installed on several product filling lines and from the continuous pasteurizing system. The high temperature waste streams from these processes will flow by gravity to a collection tank and then by forced flow to a plate heat exchanger where heat will be transferred to circulating fresh water. The hot fresh water will then return to the food processes via the thermal energy storage tank and the existing water heater system (serving with the recovery system in a topping capacity) while the cooled waste water will flow directly to the existing drain system. The circulation flow rate, W_F , in the heat exchanger/TES loop will be controlled to satisfy the daytime production demand for hot fresh water, W_p , and also to accumulate during the production period a surplus volume of hot water which will be stored for later use during clean-up operations. The analysis of the system concept demonstrated a fundamental fact about waste heat recovery using thermal storage. Storage is beneficial in that it permits the recovery of an additional increment of waste heat over that which can be used immediately at the time of waste heat production. However, storage is also expensive and generally, at current fuel values, it will not support itself economically. Therefore, in a total recovery system involving storage, the storage portion must be "carried" by

a relatively low cost element that recycles waste heat immediately. By this approach, it is possible to design and optimize the total system for maximum heat recovery while still meeting the investment return hurdle rate.

The study predicted reductions in fossil fuel usage at the factory of nearly 3% through installation of the Meat Products waste heat recovery system. Projecting this to the canning segments (SIC 2032 and 2033) of the food industry results in an annual industry energy saving of approximately 0.002×10^{15} Btu having a fuel oil equivalent of 340,000 barrels. It should also be recognized that the same recovery system concept may be applicable to other segments of the food industry besides canning. A possible example is the frozen food industry where high temperature waste heat is now available in refrigerant vapor (as opposed to hot waste water). This energy could be used to preheat the large quantities of hot fresh water that are required in many frozen food plants during the production periods and during the after-hours clean-up. Alternate system applications in industry segments other than canning would lead to even larger reductions in fuel usage and they should be fully explored.

The predicted payback period for the Meat Products system is approximately three years. The Meat Products Building houses seven production floors and the recovery system piping, which accounts for nearly one-third of the operational system's cost, must traverse all seven floors. Still, the predicted payback would be acceptable to most companies and it quite possibly could be less than three years if the system were installed in a more compact factory. In view of this, the system commercialization prospects are attractive.

The best procedure for convincing industry that waste heat recovery by this method can be carried out economically and without adversely affecting product quality or plant operations is to install a demonstration system and then to carefully monitor its performance and report the findings. A project to do precisely that at the Pittsburgh Factory has been proposed by Heinz USA and the following section addresses the purpose, task and schedular features of that proposal.

DEMONSTRATION PROJECT

Purpose and Participants

The purpose of the demonstration project proposed by Heinz USA is four-fold:

1. To design, install and place in operation a system employing thermal energy storage that will recover heat from food system waste water.
2. To monitor the operation of the waste heat recovery system in a production setting over a period of one year, to assess its performance and to evaluate the benefits that accrue environmentally and in the form of dollar and fossil fuel savings.

3. To effectively inform the food industry, particularly the canning segment, concerning the actual costs and benefits of system operation and to encourage industry acceptance and implementation of the system concept.
4. To recommend a plan for system implementation in the food processing industry.

In particular, the demonstration system will be based upon the concept described above and it will be installed in the factory's Meat Products Building where it will service food processes that are housed in that building. The system design will conform to standard Heinz engineering practice and it will abide by all applicable food industry regulations as imposed by the regulating agencies - USDA, FDA, OSHA, etc. Actual costs incurred to design and place the system in operation will be carefully recorded, recognizing that a study of the system's economic performance will be of prime importance.

The recovery system will be equipped with normal operational instrumentation. It will also be equipped with special demonstration instrumentation and an automatic data acquisition system (DAS). The demonstration instrumentation and the DAS would normally not be required in a production version of the waste heat recovery system. In this case, however, that equipment is essential to assess the system's thermal performance. All data collected by the DAS will be stored in a form compatible with a separate computer system which will be used to analyze the data during the performance evaluation phase.

Under the proposed management plan, Heinz USA will have overall project management responsibility and will execute the efforts of system definition review, system fabrication, installation, checkout, and operation. Other phases of the project will be subcontracted by Heinz USA. The demonstration system engineering and operational evaluation work is planned for subcontracting to the Advanced Energy Systems Division of the Westinghouse Electric Corporation. Westinghouse would then develop a detailed engineering design for the system which would include the preparation of engineering drawings, operation and maintenance procedures and manuals and predictions of system performance characteristics. In addition, Westinghouse would monitor and evaluate actual system performance, prepare performance analyses and carry out the program control and reporting functions.

It is planned that execution of the technology transfer task will be delegated to the National Food Processors Association (NFPA). As part of that effort, the NFPA would be responsible for an assessment of the system implementation potential within the food processing industry and for an analysis of benefits that would accrue if this implementation potential materialized. Further, the NFPA would plan and conduct on-site project reviews. The reviews would be attended by food industry personnel to report progress and to assess project results and findings. In addition, the NFPA would coordinate the development of a plan for implementing the demonstration system concept on an industry-wide basis.

Proposed Project Tasks

The proposed project would consist of five technical tasks geared to accomplishing the objectives identified above. The tasks are described below.

Task 1 - System Definition Review and Demonstration Plan Preparation

During this task, all previous work and the resulting system concept will be reviewed to verify the concept's acceptability. This effort is needed to provide the best system base for the demonstration project. The second Task 1 effort will address the preparation of a demonstration plan. This work will involve all project participants and will establish program details and a detailed schedule to meet the program goals.

Task 2 - System Design

In Task 2, the demonstration system design will be completed and all system hardware will be specified based upon the concept stemming from the completed Task 1. In addition, an operation and maintenance manual will be prepared and a major design review will be conducted. The design resulting from Task 2 will consider and include all operational hardware, instruments and controls and all hardware for the measurement and recording of special demonstration performance data.

Task 3 - System Fabrication, Installation and Checkout

Task 3 will include the procurement of all hardware for the demonstration system and its installation and checkout at the Heinz USA Pittsburgh Factory. The checkout phase will exercise all operational equipment, the special demonstration instruments and DAS and the data analysis computer program.

Task 4 - Performance Demonstration and Evaluation

The objective of this task is to assess the system's thermal performance, its operational performance and its practicality in a production setting. This work will be based largely upon data from the proposed demonstration instruments (see fig. 2) which will be used to determine heat recovery rates and to evaluate important operational concerns such as heat exchanger fouling rates and heat exchanger maintenance/cleaning requirements.

Task 5 - Technology Transfer

This task is of major importance and its purpose is three-fold.

- To communicate demonstration plans and results to the food processing industry and in particular to those industry segments involved in the preparation of canned food products.

- To assess the potential for implementing the demonstration system concept within the canning and food processing industries.
- To prepare a logical and efficient plan that will encourage system implementation within those industries.

The Task 5 work will be coordinated by the National Food Processors Association using established lines of communication between the association and its 850 member firms. The NFPA is a major canning industry trade association and its members are responsible for 90% of the canned goods packed in the United States for human consumption. This organization is therefore well suited and a logical choice to handle the technology transfer effort.

Demonstration Project Schedule

The proposed project schedule is shown in fig 3.

CONCLUSION

Heat recovery applying storage is relatively expensive and the completed study shows that to operate economically, a recovery system containing a storage feature will require an appropriate mix of immediate-need and storage-based waste heat applications. The survey work performed at the Heinz Pittsburgh Factory indicates that low grade waste heat (<200°F) is available in abundance in food canning facilities in the form of hot waste water streams and that a variety of suitable low temperature applications with the required mix will also exist. The study predicted attractive fuel savings and payback periods and therefore a demonstration effort to verify those predictions should be launched and has been proposed.

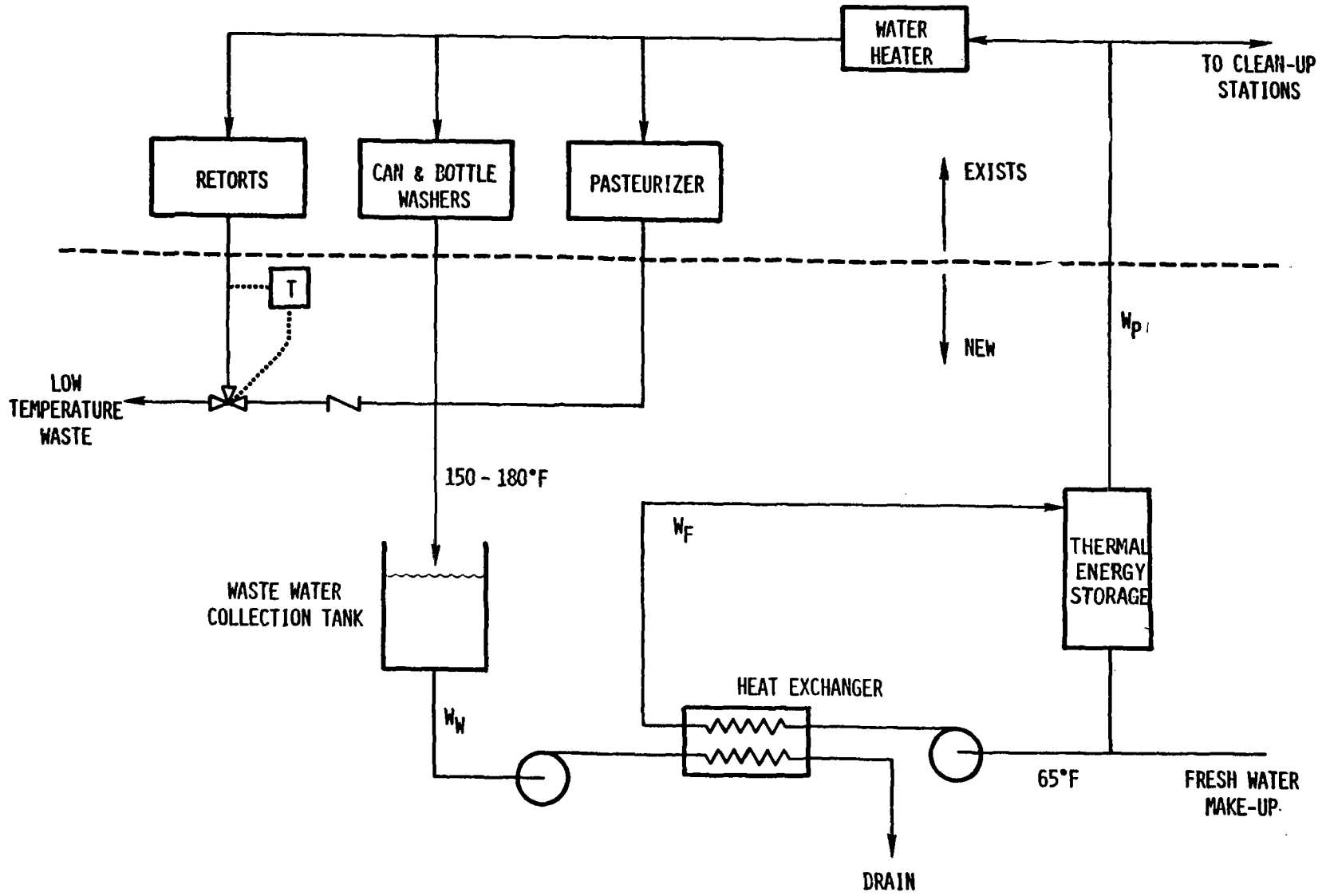


Fig. 1 - Waste Heat Recovery System Schematic

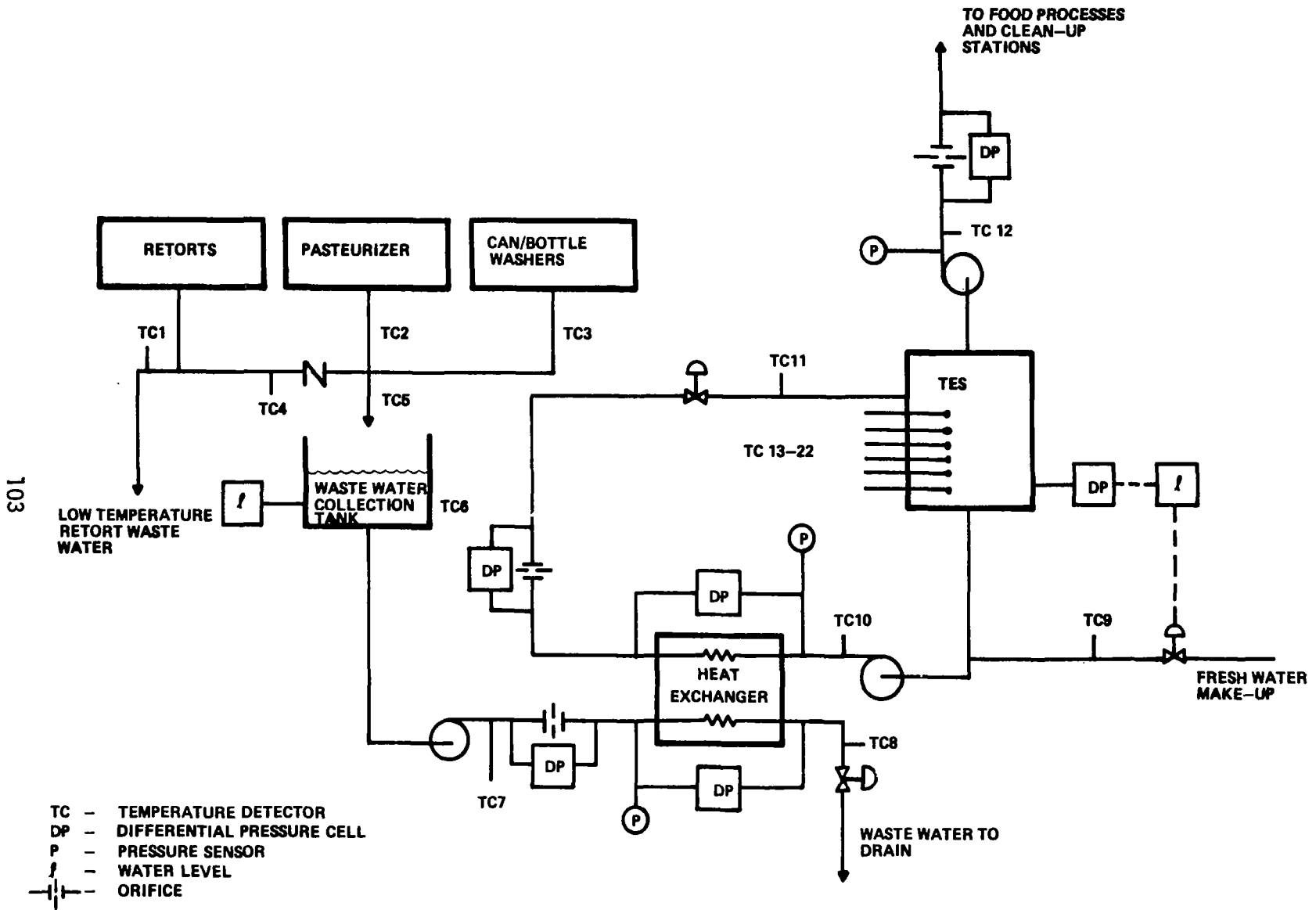


Fig. 2 - Demonstration System Instrumentation

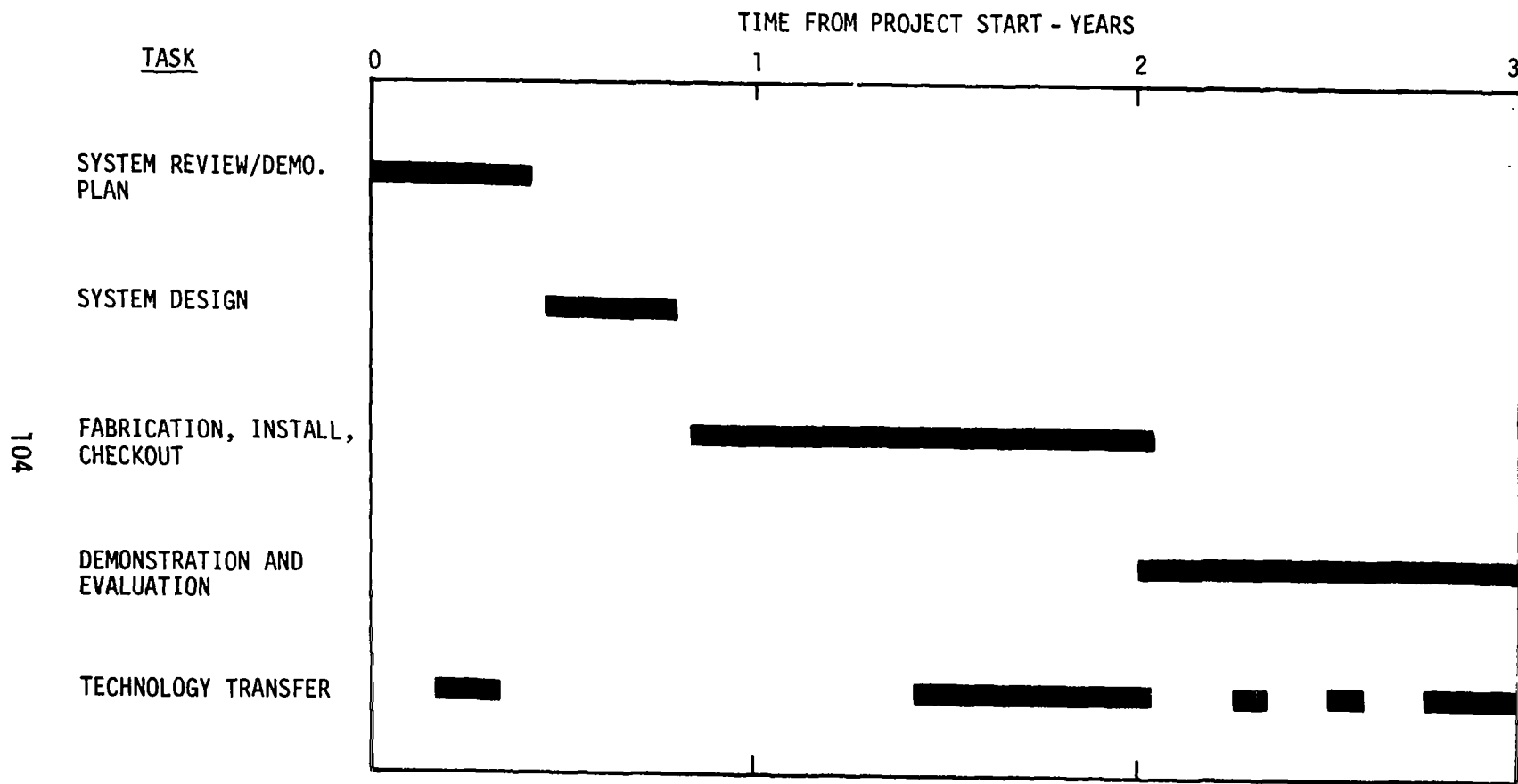


Fig. 3 - Demonstration Project Schedule