AUTOMATED CONSTRUCTION OF LIGHTWEIGHT, SIMPLE, FIELD-ERECTED STRUCTURES

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Power plants requiring less labor per kilowatt to build will be cheaper, less affected by inflation, and not as constrained by labor shortages, Recent advances in such diverse fields as industrial automation and autonomous planetary rovers indicate that a synthesis of these advanced techniques could result in mobile construction robots. These robots would perform a limited number of very repetitive tasks at relatively benign construction sites.

The example demonstrating the feasibility of this proposal is the construction of a large photovoltaic power plant having a peak power output of 100 megawatts. This is similar to the support structures proposed for the Satellite Power System (SPS) rectenna. Preliminary cost estimates show that a limited labor force using construction robots could reduce direct labor costs between 23 to 79 percent.

The approach taken in this paper is: to present the reasons to automate the construction process; to define the conventional construction scenario as the reference for evaluation; to list the potential cost benefits by using robots; to demonstrate the technical feasibility of building several possible construction robots; and to show the application to build SPS ground stations. The conclusions in this paper would also apply to underground and surface mining operations, mechanized agriculture, and other industrial situations.

Reasons for Automation: Some of the major reasons for considering automating an assembly task are:

- shortage or unavailability of labor
- low skill level requirements
- increased productivity
- harsh environments
- simple, monotonous, and repetitive tasks
- cost savings

Recent trends in highway construction costs are shown in the attached figures along with a comparison of the cost of labor to the cost of a robot.

In addition, large power plant jobs often see a decline in productivity with respect to small jobs in the same area. This decline is due in part to the size of the job and to the narrow work assignments.

Application: The reason to consider using robots to build either photovoltaic power plants or the SPS rectennas is that these two applications involve all the reasons given above for considering automated assembly.

Either application involves the placement or assembly of a large number of identical structural elements in a very simple environment. A typical support design for each application is shown in the attached figures.

For a 100 megawatt electric photovoltaic power plant, over 250 thousand 4 ft. x 8 ft. panels of cells must be placed on beams. This assembly work will most likely be located in the open desert which provides a fairly simple environment. However, that location is hot, in a remote location, and the work can be considered monotonous.

Potential Savings: A summary of the direct costs (labor and equipment) is given in the attached table and reflects building a plant in a conventional way. This table also shows the potential savings that might be achieved by:

A. Keeping labor input constant and doubling equipment usage or productivity

B. Eliminating all direct construction labor and incurring charges for robot or automated assembly equipment equal to equipment rental charges that would be incurred by using present construction practices

C. Similar to case B but doubling the productivity by using the robots 16 hours per day

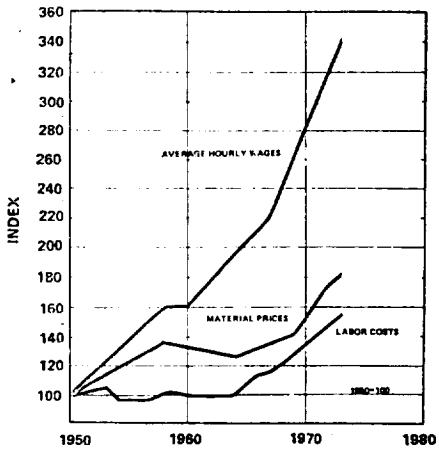
Status of Technologies Needed to Produce Construction Robots: To design and assemble a construction robot economically and with little effort various technologies must be sufficiently advanced to permit that effort to proceed without incurring a large development cost.

The technologies involved are:

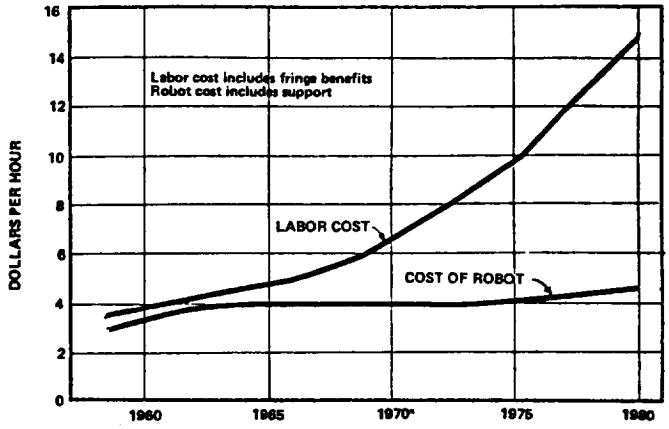
- Industrial automation
- Microprocessors
- Remotely piloted vehicle technology
- Autonomous planetary rovers

In all cases, the techniques needed to give a construction robot the necessary capabilities have been demonstrated either in actual working environments or field tests of prototype equipment. A fairly brief review of the literature in each of these fields will verify this statement.

In tasks involving uncertainty, one weak area is in the software routines involved in giving the robots limited decision making capabilities. Until more advanced software routines become available, construction robots may be limited to assembly and transportation tasks. Two conceptual designs are shown in the attached figures.



HIGHWAY CONSTRUCTION COSTS



COMPARISON OF HOURLY LABOR COST TO HOURLY CHARGES FOR A ROBOT

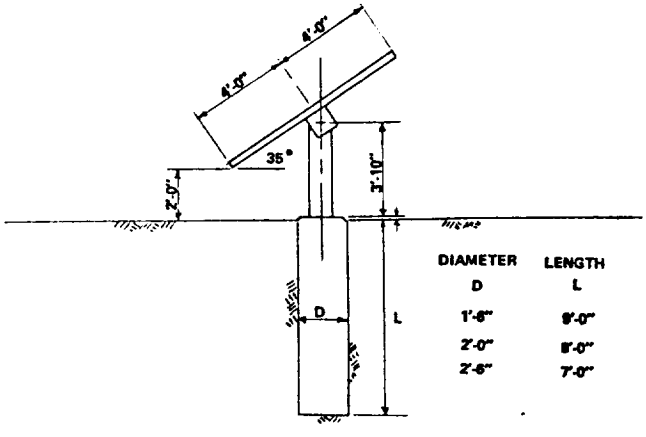
CONSTRUCTION COSTS PER 100 MEGAWATTS

	DIRECT COSTS 1978 DOLLARS (no overhead, or profit included)		
	Labor	Equipment	Total
PHOTOVOLTAIC PANEL INSTALLATION			
TOTALS	6,086,420	4,421,970	10,508,390

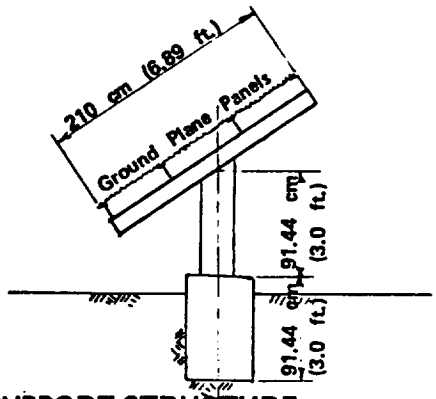
POTENTIAL COST SAVINGS 1978 DOLLARS

POTENTIAL SAVINGS FOR	same labor 16 hour equipment useage	no labor 8 hour equipment useage	no labor 16 hour equipment useage
100 MEGAWATTS INSTALLED	2,210,935	6,086,420	8,297,355
1,000 MEGAWATTS INSTALLED	22,109,350	60,864,200	82,973,550
10,000 MEGAWATTS INSTALLED	221,093,500	608,642,000	829,735,500

(no overhead, frings, or profit included)
(no credit taken for interest saved)



SUPPORT STRUCTURE
FOR PHOTOVOLTAIC POWER PLANT



SUPPORT STRUCTURE
FOR SPS RECTENNA

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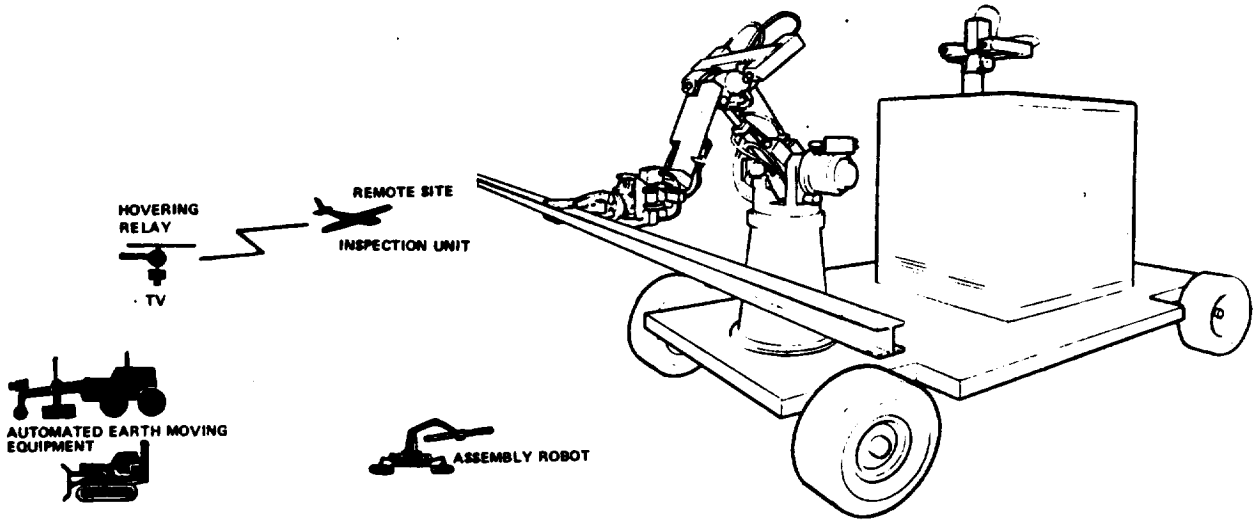
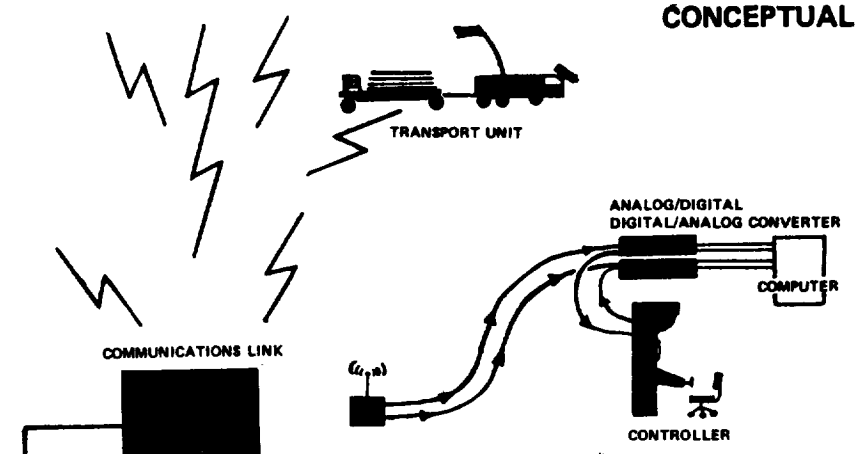
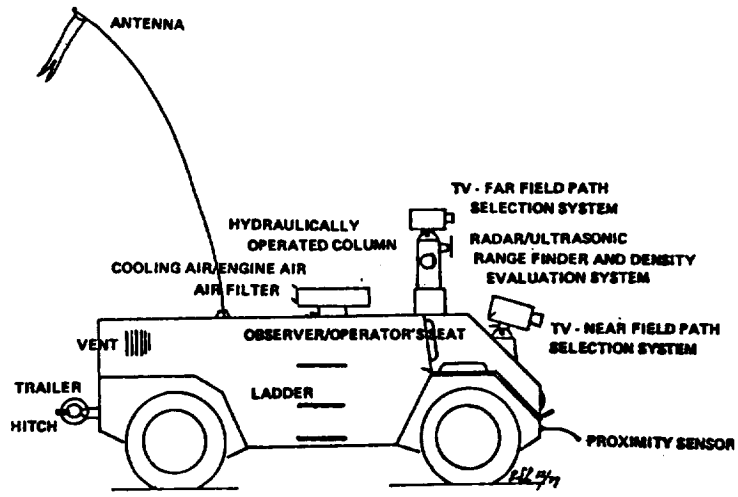
OF POOR QUALITY



CONCEPTUAL ASSEMBLY ROBOT





TRANSPORT UNIT WITHOUT MANIPULATOR