California AHMCT Program
University of California at Davis
California Department of Transportation

THE AUTOMATED LITTER BAG PICKUP MACHINE* (Phase II)

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16. Abstract

This report provides a description of the Automated Litter Bag Pickup machine. This machine was constructed at Lakeview Metal Construction (Nice, CA) and developed in conjunction with the Advanced Highway Maintenance and Construction Technology Center at the University of California at Davis. The system is designed to retrieve litter bags from the side of the highway with an emphasis on the increased safety of the workers. Overall system descriptions are given for the Automated Litter Bag Pickup machine. A detailed description is given for each of the major subsystems and the support equipment. The proposed system operation is also described.

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Abstract

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Table of Contents

List of Figures

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This work was supported by Federal Highway Administration Contract No. RTA-32J804 and by the California Department of Transportation (Caltrans) Advanced Highway Maintenance and Construction Technology Program and UC-Davis.

The name Pickall is a trademark of Pickall, Inc. (Nice, CA) The manipulator and its design are patent-pending.

1. Introduction

Currently the only practical method of removing litter from the highways and freeways is to use manual labor. For the California State Department of Transportation (Caltrans), roadside litter removal is accomplished using a combination of full time Caltrans maintenance crews, public volunteers, and prison labor. These workers search the roadway right-of-way for litter, where it is collected and placed in the standard Caltrans litter bag. Maintenance crews then manually retrieve the litter bags. This operation has no standard procedure. In some instances, it could be one maintenance worker driving a pickup truck, periodically stopping on the roadside, getting out of the truck, retrieving the bags, and placing them in the back of the truck. Other instances may call for larger crews, requiring a shadow truck with an attenuator to act as a physical barrier from traffic and a large garbage collection vehicle.

This current process presents two major problems: safety and cost. There have been numerous injuries and even some deaths resulting from retrieving roadside litter bags. Any procedure that requires a person to repetitiously stop a vehicle along a roadside and get out increases the probability for injury. Additionally, the repetitious nature of the procedure may sometimes cause the worker to have a lax attitude towards the hazard of the job, further increasing the chances for injury and/or death. In addition, manually retrieving litter has never been cost efficient. Caltrans expends over 1,600 person years removing 198,000 cubic meters [260,000 cubic yards] of litter from the roadway each year. Worker injuries also indirectly factor into the overall expense of keeping California's roadways clean.

1.1 History - The First Generation Machine

To address the two main issues of safety and cost, the Lakeview Metal Construction Company, in conjunction with the Advanced Highway Maintenance and Construction Technology Center (AHMCT) at UC-Davis, developed a first generation Automated Litter Bag Pickup machine. The main design goal of the machine was to keep personnel in the vehicle during hazardous situations while still performing their duties efficiently.

This first generation machine (Figure 1) enabled an operator to automatically pick up litter bags from the highway or shoulder area at approximately 8 kilometers/hour [5 miles/hour]. Each litter bag was picked up by a paddlewheel head, pushed to the rear by a conveyor and compacted into the vehicle's cargo area. The pickup head was shock mounted to accommodate any variations in litter bag density and weight. This machine was evaluated by Caltrans equipment and maintenance personnel during an extensive on-

road field testing phase. The results provided valuable information in determining the specifications required for the second generation design.

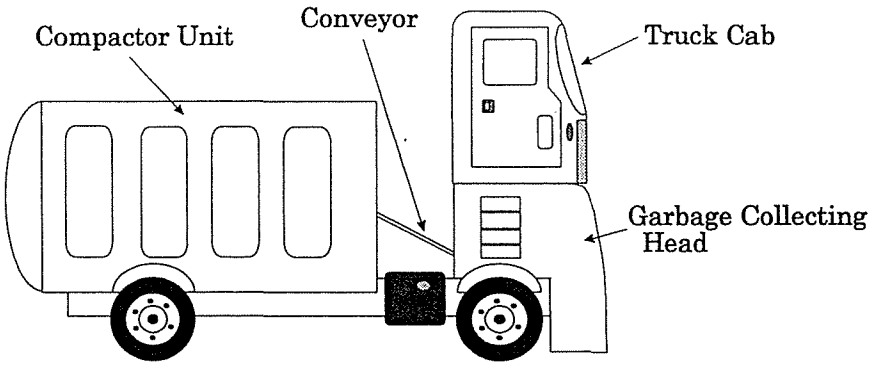

Figure 1: First Generation Machine

1.2 The Second Generation Machine

The main goal of the second generation machine (Figure 2) was to develop a machine using the "lessons-learned" from the first generation machine. This second generation machine is based on the Pickall^{tm} (patent-pending) manipulator. In the first generation machine, the litter bags could only be retrieved from the road from the front of the machine. This second generation machine, however, was designed to include a multi-terrain 180 degree pickup ability (90 degrees per side). Additionally, the machine was to be capable of picking up other large debris besides litter bags. Other improvements included reduced machine housing size and reduced vehicle weight.

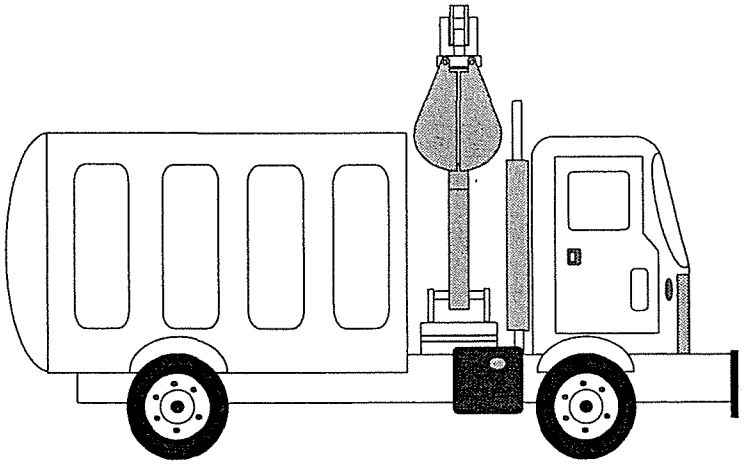

Figure 2: Second Generation Machine

2. System Description

2.1 The Pickall Manipulator

The second generation machine consists of the hydraulically actuated Pickall (Figure 3) manipulator mounted between the cab and the compactor of a truck. The locations of all the actuators are shown in Figure 4. The possible joint motions are shown in Figure 5. At the end of the manipulator is a "pinch bucket" (Figure 6) that can grab a litter bag by enclosing it within the bucket. Additionally, the pinch bucket can also grip onto objects such as tires, mufflers, lumber and the like. The maximum payload of the bucket is approximately 45.4 kilograms [100 pounds]. Once the operator has grabbed the desired object, the Pickall manipulator will "retract" to a position above the opening of the trash compactor (Figure 7). The compactor lid is then opened and the pinch bucket releases its load into the trash compactor. The Pickall machine can pick up debris that has a minimum height of 5 centimeters [2 inches], a maximum width of 0.61 meters [2 feet], and a maximum length of 0.61 meters [2 feet]. The maximum extension of the manipulator is approximately 4.56 meters [15 feet] from the centerline of the truck. All of the operations of the machine are controlled from the control panel (Section 2.4).

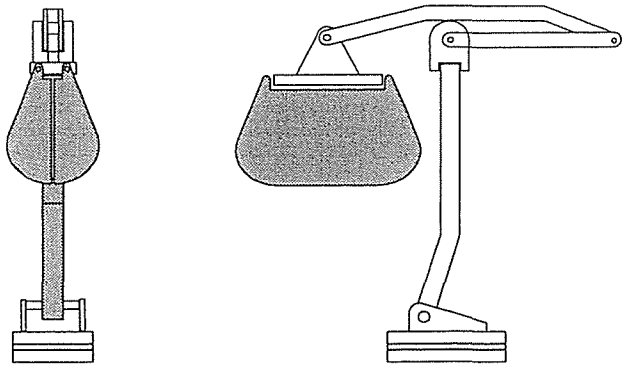

Figure 3: Pickall Manipulator

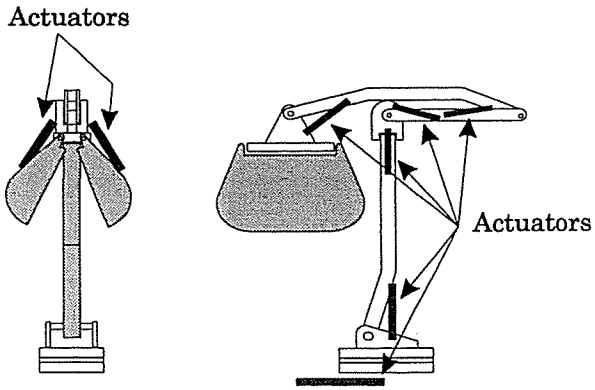

Figure 4: Actuator Locations

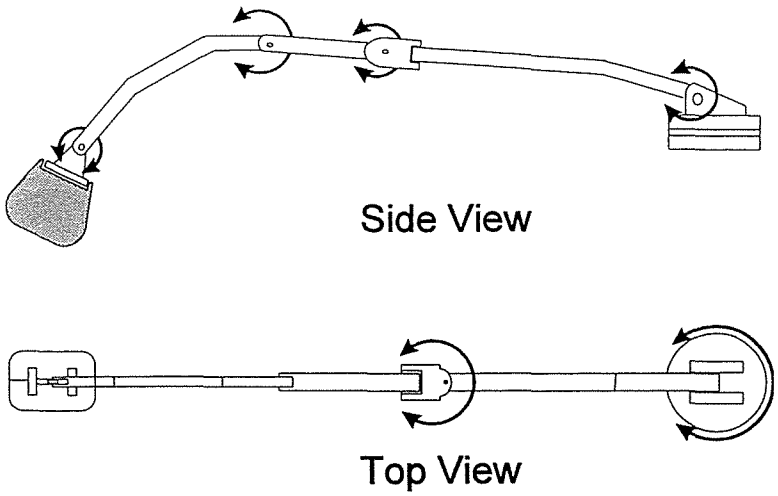

Figure 5: Joint Motion

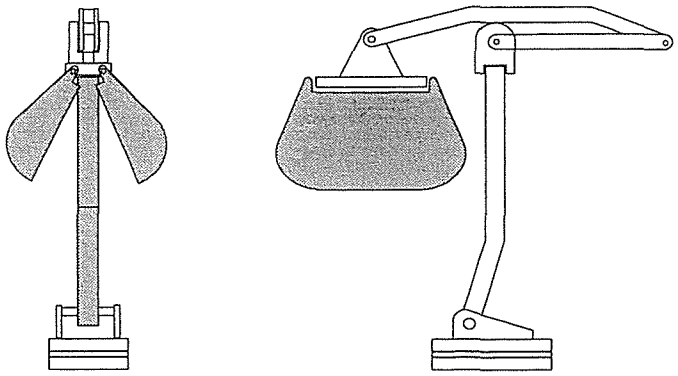

Figure 6: Bucket in Open Position

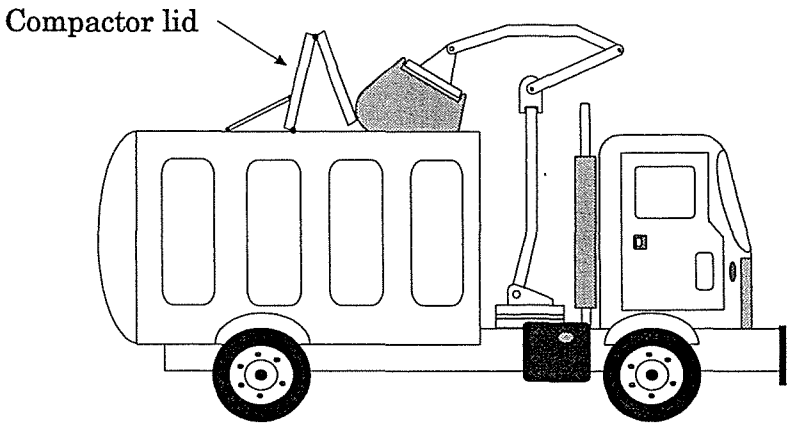

Figure 7: Manipulator in Dumping Position

2.2 The Truck

The truck (Figure 8) is a standard 7.6 cubic meter [10 cubic yard] compacting conventional cab truck. The compactor portion of the truck has been modified by the contractor. The modifications include moving the compactor aft approximately 0.61 meters [2 feet] to allow the mounting of the Pickall between the cab and the compactor. Additionally, the top of the compactor was modified to included a hydraulically actuated self-opening lid that works in conjunction with the manipulator controller during the dumping cycle.

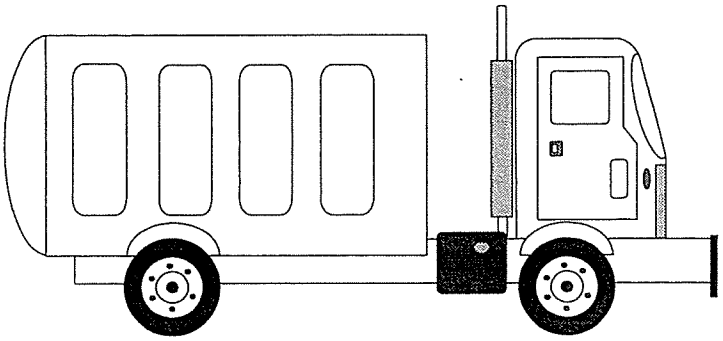

Figure 8: Truck

2.3 Actuation

The Pickall manipulator is actuated by a 10,341-13,789 kilopascal [1,500-2,000 PSI (pounds/inch^2)] open loop hydraulic system (Figure 9). The main motive force is derived from an engine mounted power-take-off hydraulic pump (Figure 10). The pump is a variable displacement type pump. A heavy duty air/oil heat exchanged is mounted in front of the vehicle's radiator to cool the hydraulic oil (Figure 10). Hydraulic oil is stored in a 227 liter [60 gallon] hydraulic tank mounted on the underside of the truck, near the main diesel tank (Figure 10).

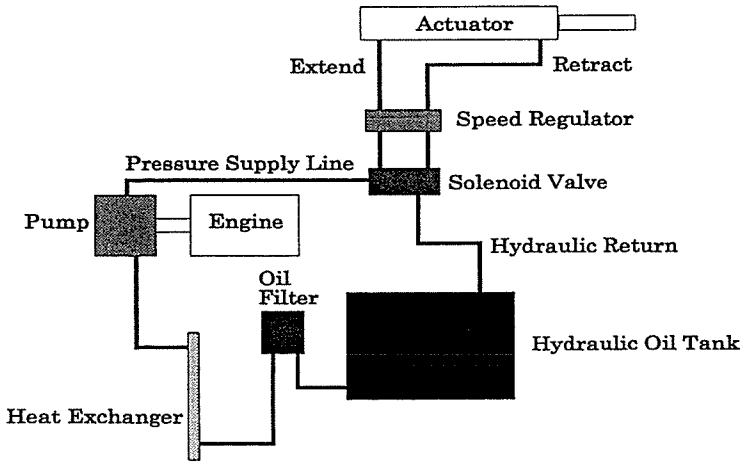

Figure 9: Hydraulic Loop (One actuator shown)

After the hydraulic oil has passed through the pump, it then is filtered. The oil enters a manifold that distributes the oil to the solenoid valves that control each linear actuator (Figure 9). Each solenoid valve is actuated by the main system controller (see Section 2.4, below). From each solenoid valve, the oil flows to each respective actuator. The speed of the actuator is controlled by throttling speed regulators mounted on the oil output side of the actuator. The speed can be adjusted by turning the control knob on each throttling speed regulator. From the speed regulator, the oil is then collected and returned to the hydraulic oil tank.

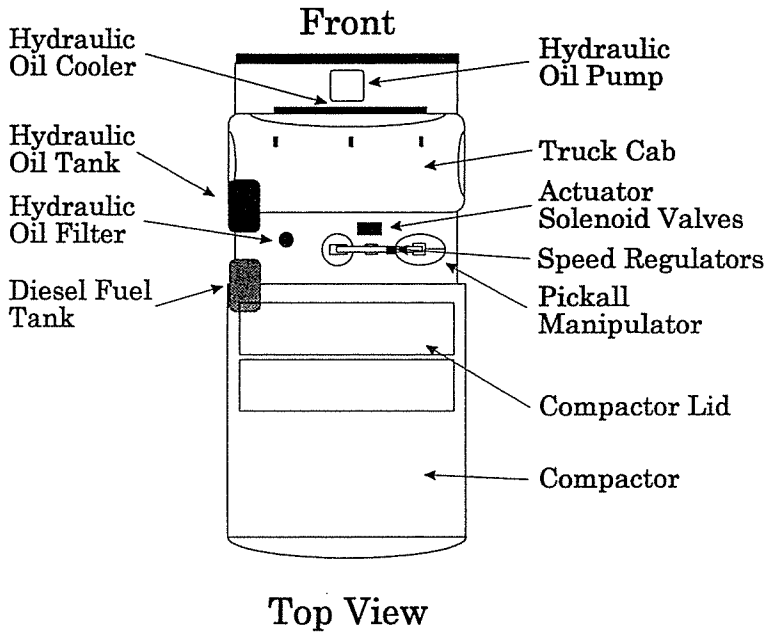

Figure 10: System Component Location

2.4 The Controller

The main system controller is a custom manufactured analog controller. Manipulator position sensing is provided by potentiometers mounted on four of the manipulator joints. The locations are shown in Figure 11. Position preset information is stored on four potentiometers. There are seven "memory boards" which correspond to the seven default preset positions provided on the control panel. Each of the preset "memory" potentiometers corresponds directly to the position potentiometer on the manipulator joint.

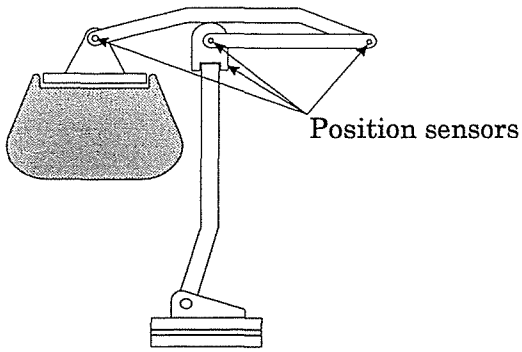

Figure 11: Position Sensors

When the operator selects a preset position, the analog controller compares the voltage signal from the position potentiometer on the manipulator with the voltage signal from the preset potentiometer on the memory board. If the voltage difference is greater than a threshold of +/- 0.5 volts, the analog controller actuates the desired solenoid valve to the full open position. When the voltage difference between the two potentiometers drops below the threshold of +/-0.050 volts (indicating that the actuator is nearing the desired position), the analog controller then resorts to "pulse-mode" operation. In pulse-mode operation, the analog controller pulses the solenoid valve to the on position for a brief period of time. The actuator then "steps" in small increments to the desired position. Once the desired position is obtained, the operator can then use the directional buttons on the control panel to make final position adjustments. The directional buttons command movement of the manipulator by directly actuating the hydraulic solenoid valves on the manipulator. The entire sequence of joint movements is sequenced by the controller during the preset movements to prevent joint collisions and other undesired effects.

The analog controller also implements the automatic return of the manipulator to the dumping position. During the return sequence, the compactor lid is automatically opened. Every fourth dumping cycle, the compactor is automatically run to ensure that the refuse does not overflow the compactor.

3.0 System Operation

System operation is very simple and intuitive. When the operator spots an object to be picked up, the operator selects the preset position on the control panel that will place the manipulator bucket nearest to the object. The manipulator will then move to the desired position. An example of the extension sequence is shown in Figure 12. For clarity, the truck is not shown. As the manipulator is moving, the controller automatically opens the

collection basket slightly. If desired, the operator can open the collection basket even wider by pressing a button on the control panel. When the manipulator arrives at the preset position, the operator can then make fine position adjustments by maneuvering the manipulator by using the directional buttons on the control panel. Once the object is within the basket, pressing another button on the control panel grabs the object. Then pressing another button automatically retracts the manipulator to the dump position. During this retraction movement (reverse sequence of Figure 12), the compactor lid is opened (Figure 6). Once the manipulator has reached the compactor opening, the bucket is opened and the refuse dumped. Every four dumping cycles, the trash compactor is cycled automatically.

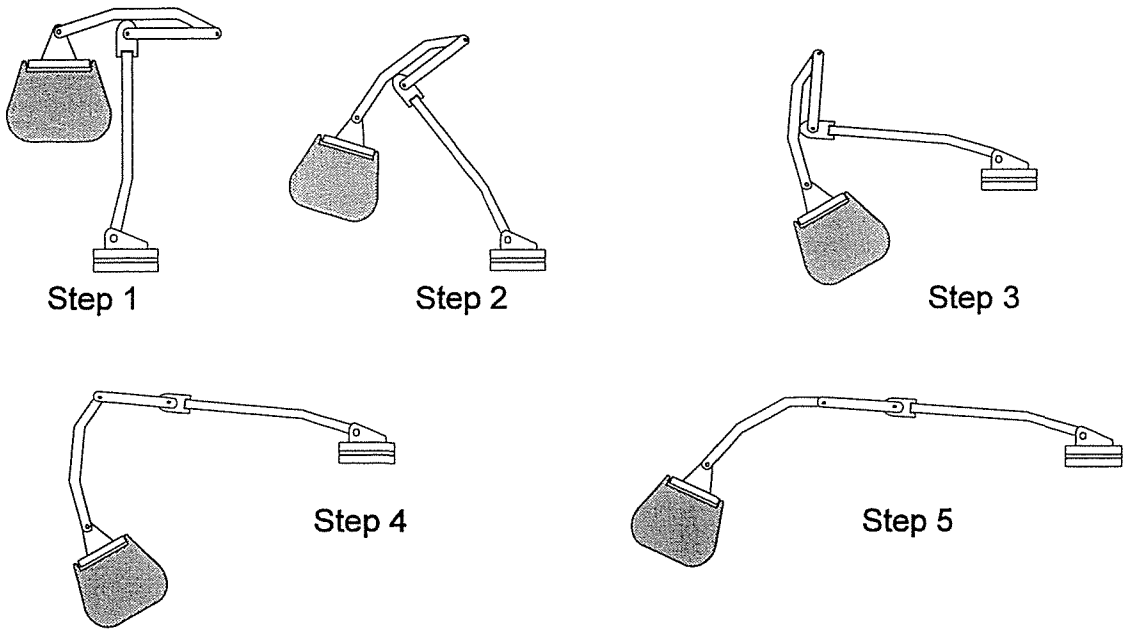

Figure 12: Extension and Retraction Sequence

4.0 Conclusions

As of the date of this writing, little field testing using the automatic controller has been accomplished. However, extensive testing of the manipulator using manual controls has shown that the manipulator has accomplished the reachability goals and payload capacity for the manipulator. Based on previous experience with products from Lakeview Metal Construction, it is expected that when final testing is complete on the Pickall manipulator it will be declared a good and reliable product.

Appendix A

Detailed Drawings

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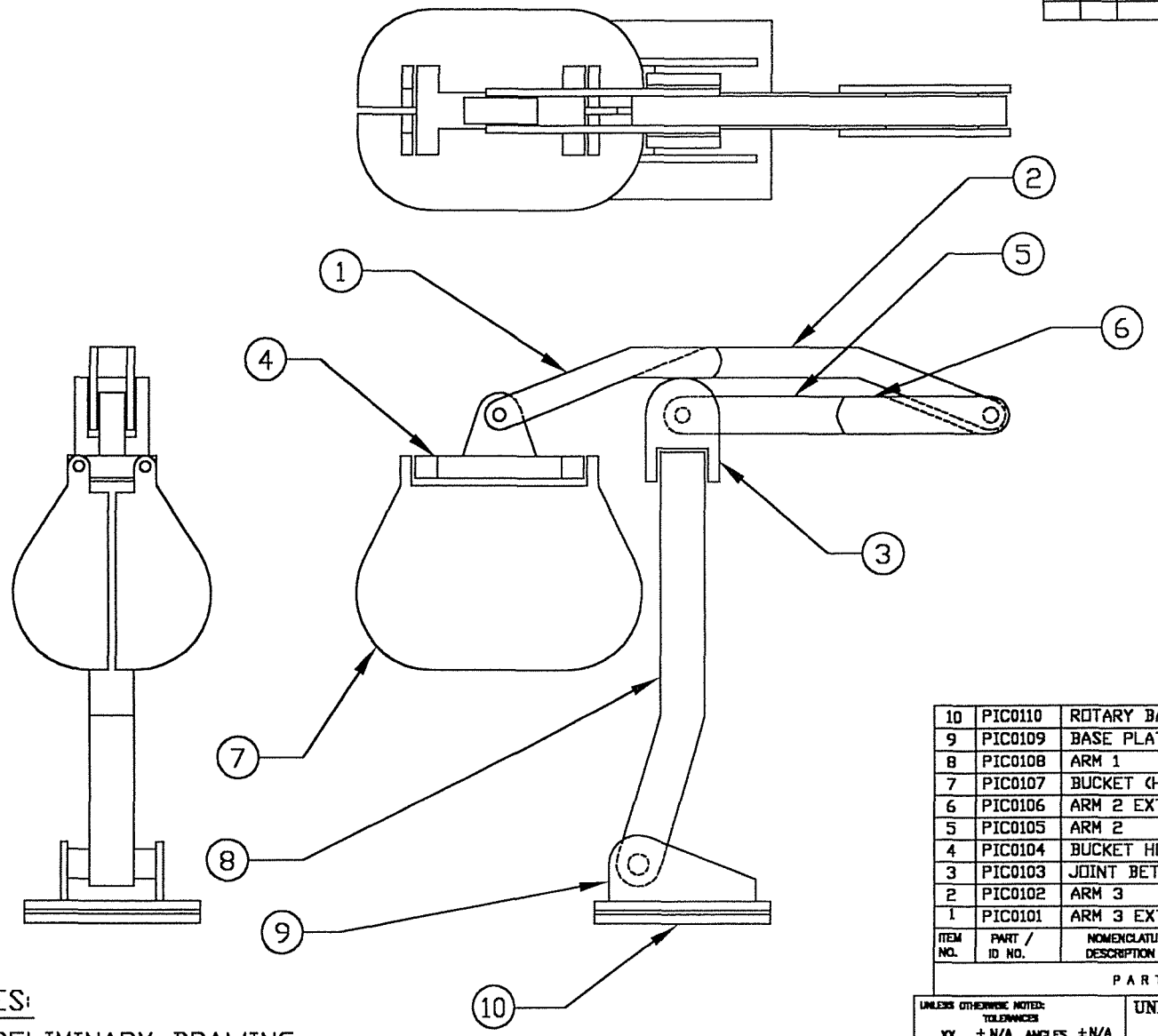

ITEM NO.	PART / ID NO.	NOMENCLATURE / DESCRIPTION	MATERIAL / SPECIFICATION	QTY REQD
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9	PIC0109	BASE PLATE	STEEL	2
8	PIC0108	ARM 1	STEEL	1
7	PIC0107	BUCKET (HALF)	STEEL	2
6	PIC0106	ARM 2 EXTENSION	STEEL	2
5	PIC0105	ARM 2	STEEL	1
4	PIC0104	BUCKET HOLDER	STEEL	1
3	PIC0103	JOINT BETWEEN 1 & 2	STEEL	1
2	PIC0102	ARM 3	STEEL	1
1	PIC0101	ARM 3 EXTENSION	STEEL	2

PART LIST

NOTES:
1. PRELIMINARY DRAWING
2. DRAWING IS NOT TO SCALE
3. ACTUATORS ARE NOT SHOWN

UNLESS OTHERWISE NOTED: TOLERANCES
XX ± N/A ANGLES ± N/A
XXX ± N/A N/A

UNIVERSITY OF CALIFORNIA, DAVIS
MECHANICAL ENGINEERING DEPARTMENT

TITLE: ASSEMBLY DWG FOR PICK ALL

DESIGN	J.K.	DATE	9/26/94
DRAWN	J.K./WN	QTY	N/A
APPRV	J.K.	SCALE	N/A
RELEASE		SIZE	C
		SHT	

DRAWING NO. PICKALL-100
PROJECT AHMCT/J.K.

REVISION					
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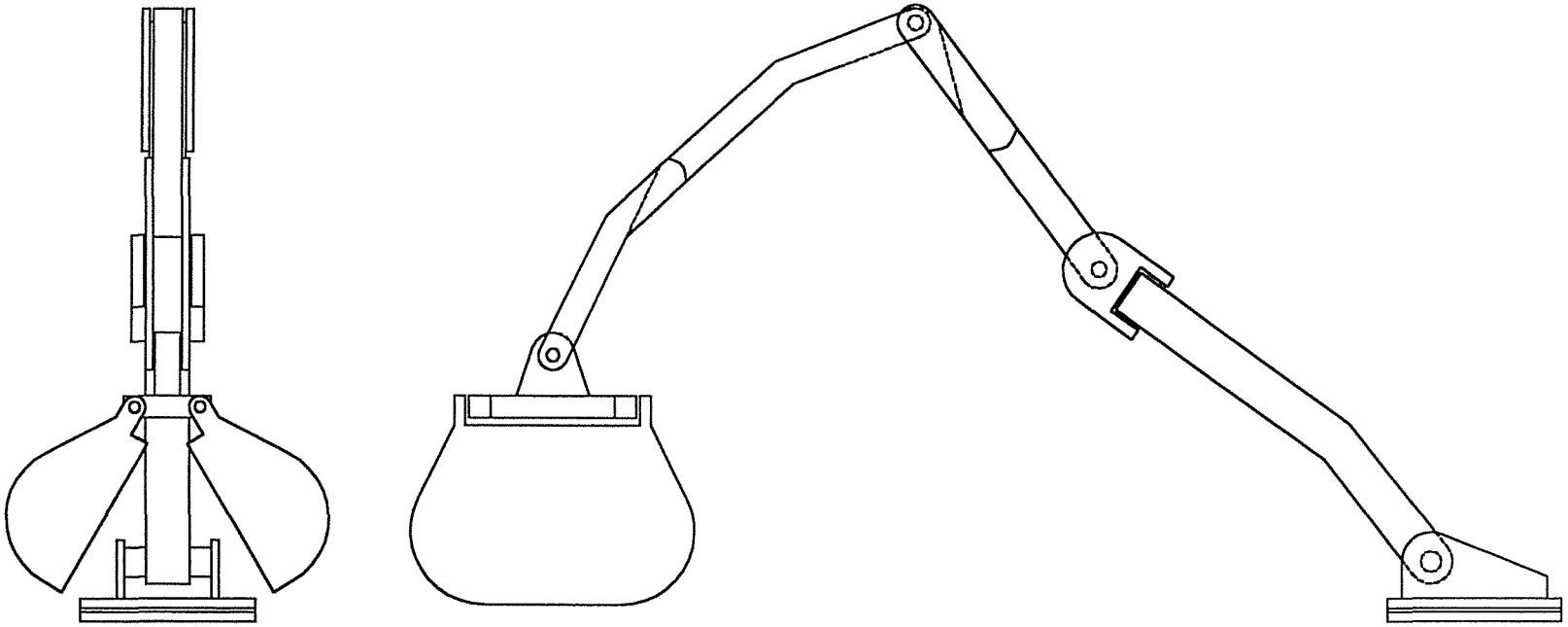

NOTES:

1. PRELIMINARY DRAWING
2. DRAWING IS NOT TO SCALE
3. ACTUATORS ARE NOT SHOWN

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PART LIST

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MECHANICAL ENGINEERING DEPARTMENT

TITLE: DRAWING OF PICK ALL EXTENDED POSITIONS

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DRAWN	J.K./VVN
APPV	J.K.
RELEASE	
DATE	9/26/94
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SCALE	N/A
SIZE	C
SHT	
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PROJECT	AHMCT/J.K.