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A REMOTELY CONTROLLED ROBOTIC VEHICLE FOR WORK WITHIN RADIOACTIVE ENVIRONMENTS

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ABSTRACT

A remotely controlled manipulator arm mounted on a miniature vehicle, originally designed for explosives ordinance disposal, has been modified for use in remote handling and inspection within the TRIUMF CP42/TR30 facility. Use of several cameras and accessories enables the detailed inspection of cyclotron and targetry systems at close range in high radiation environments. A modified manipulator enables the performance of simple tasks thereby saving personnel dose and (cooldown) time. The system is general enough for application in any cyclotron or radiation environment.

1. INTRODUCTION

1.1. Objectives

Radioisotope production facilities, such as the CP42 and TR30 cyclotrons at TRIUMF, use high intensity (several hundred μA) beams in the irradiation process. The resulting residual fields, particularly in target caves, can be quite high (~10 mSv/h) depending on the extent and nature of the irradiation. The drive to ever increasing currents and higher running efficiencies can be hindered or limited by several factors such as maintenance and repair requirements which increase with the load put on the system. To some extent this limits the efficiency of operation. Longer cooldown times are required for personnel access after particularly intense or long running periods. By prudent choices of materials and careful design the need for repairs and maintenance can be reduced.

The Isotope Production Group at TRIUMF is responsible for operation, maintenance, and improvements to the CP42 and TR30 systems. Experience has shown relatively simple tasks such as hot target retrieval and viewing target stations, beamlines, cyclotron systems etc., contribute several 10s of mSv to the overall group radiation dose each year. In addition, work is often hurried, shortcuts taken, etc. due to the awareness of the environment in which the person is working. This unfortunately can result in the need to redo the work or the problem reoccurring later thus compounding the radiation dose problem in the long run.

While the majority of work done in the radioactive environments is highly skilled and requires the versatility and adaptability that can only be provided by human workers there are some simple (yet potentially dose intensive) tasks, such as hot target retrieval and inspection work, that potentially could be undertaken by automated methods. We investigated various means of achieving this with the result that the most comprehensive solution was determined to be a system based on a remote controlled robotic vehicle.

1.2. Basic Robotic Vehicle

The prototype of a miniature remote vehicle (MRV) was purchased from Hovey Industries Ltd. This vehicle, shown in Fig. 1, was designed originally for explosives ordinance disposal (EOD). Basically, MRV contains three major sections : the drive, manipulator, and control systems.

The drive system is based on high efficiency permanent magnetic motors driving cleated tracks. The design gives high forward and reverse traction but low turning resistance. Full speed right angle and zero radius full circle turns are possible without losing the track. It can laterally traverse 30° slopes in addition to climbing stairs and slopes up to 45°.

The manipulator consists of an turret, boom, and arm systems on which a claw type hand is mounted. A particular feature of this vehicle system is its tremendous dexterity as demonstrated in Fig. 1. It has the ability to reach just about anything within a 2m radius of the boom base even within a confined area. It has the capability to lift objects up to 7 kg. A mount for a camera and other accessories was provided.

The control of the system is based on a microprocessor that processes audio, video, and data signals. Either a co-axial or radio link is available with a system incorporated to prevent cross talk from noisy environments. The control console is ergonomically designed to accentuate ease of operator control and monitoring. In particular,

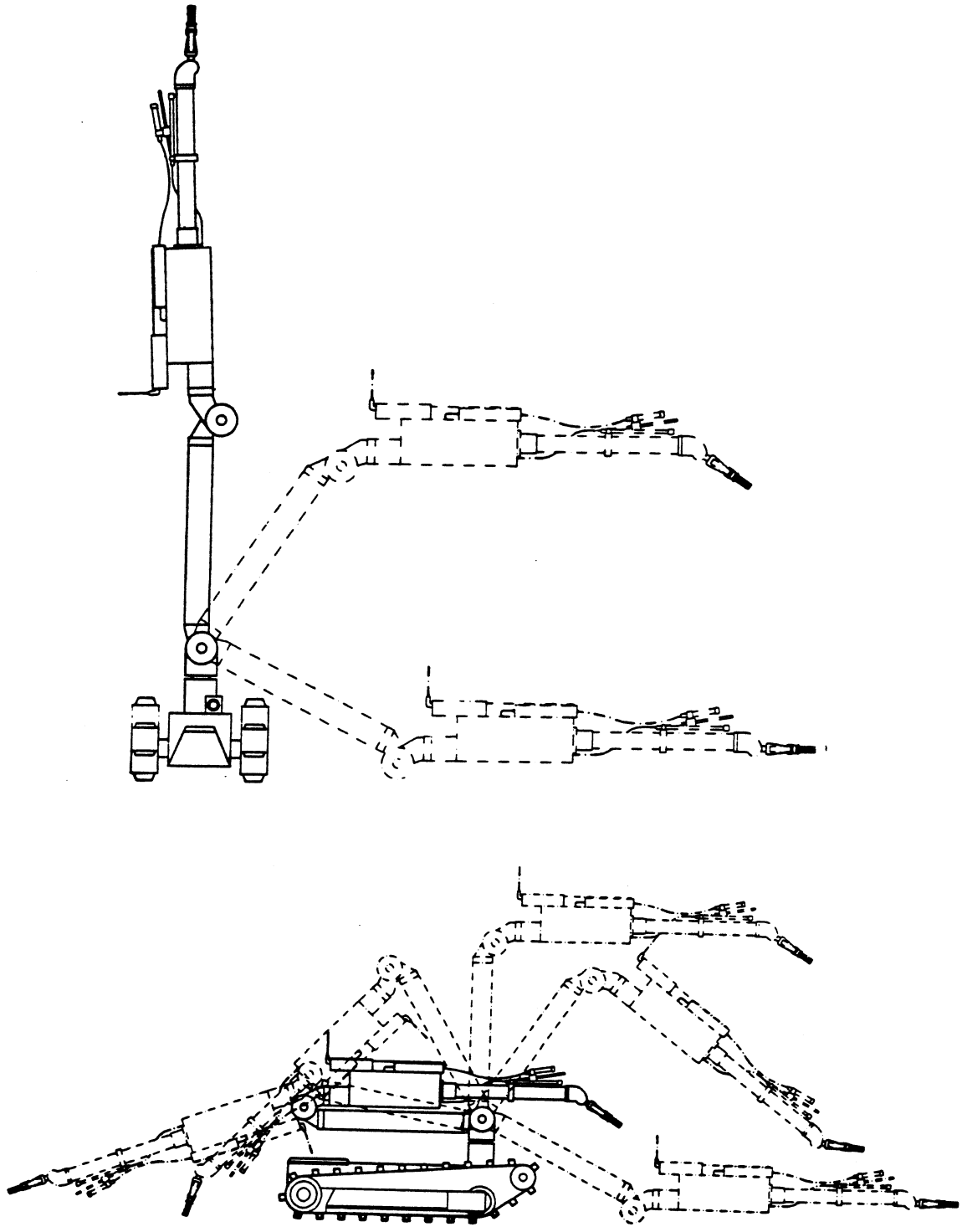

Fig. 1. The basic MRV model demonstrating its dexterity and reach capabilities.

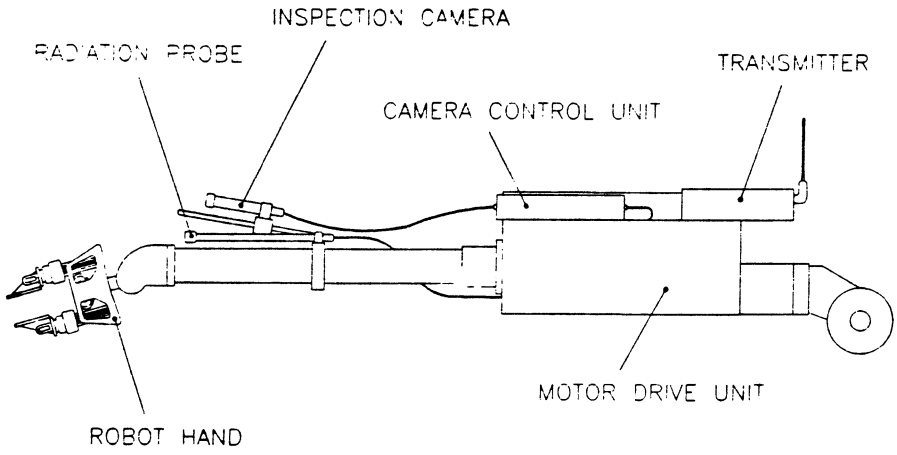

Fig. 2. The new manipulator arm designed to pick up hot targets and other small objects.

multi-function joy sticks give proportional control over drive and manipulator functions.

2. IMPROVEMENTS AND ADAPTATIONS

2.1. Manipulator Arm

Tasks that could be undertaken by the MRV are numerous. While hot target retrieval is no longer undertaken frequently it is a good example of a high dose simple task that should be possible with the MRV. Therefore, one of our primary goals was to design a suitable manipulator hand that could be attached to the present arm replacing the claw mechanism that was designed for EOD work. A schematic of the prototype hand is shown in Fig. 2. This hand is a modification of the present manipulator system currently being used in the hot cells for processing radioisotopes, handling targets, chemicals etc. Since the system works well in the hot cells for preparing targets it is also well suited for the task of hot target retrieval.

2.2. Vision and Monitoring System

Areas in which cyclotrons and target stations are situated are often confined and contain delicate equipment. To negotiate a path through this maze and perform the task under consideration requires an operator who is skilled at controlling the MRV. Obviously, the operators requires sufficiently good visual information to perform this correctly. Some areas may have wide angle or panning camera systems that can be of great assistance. In general, though, the best solution lies in on-board cameras.

The MRV came with the provision for two cameras. A navigation camera is mounted on the chassis. The second camera, which was mounted on the back of the manipulator arm, has been replaced with a miniature camera on the wrist of the new manipulator hand for close-up viewing of local objects.

Radiation monitoring is performed by using a monitor attachment near the manipulator hand with information being fed to an LED display in the direct view of the navigation camera.

3. FUTURE PLANS

Future plans for this device include the following :

- Improve the precision of motion through the use of anti-backlash gears on the arm, boom, and turret.
- Drive train operation will be smoothed out by improvements to the track slides and idlers.
- A wheeled version of the drive system may work better on certain surfaces.
- The communications will be upgraded to use commercially available components (e.g., PLCs) and include such things as control feedback for positional information and allow proximity, radiation, and temperature information to be read at the control console.
- The versatility of the navigation camera would be increased if it were mounted on a separate boom with zoom, pan, and tilt capabilities.
- The arm motor drive has the provision to allow for rotational motion. Having a selection of different end-effectors (i.e., the manipulator hand, claw, grappling hook etc.) would accentuate this degree of freedom for certain types of work.

4. CONCLUSION

A remotely controlled robotic vehicle with a mounted manipulator hand has been adapted for viewing and performing simple tasks in the CP42 and TR30 radioisotope production facilities at TRIUMF. Changes to the manipulator hand and the vision/monitoring systems enable it to do hot target and similar basic tasks in addition to inspecting target stations at very close

range. Little or no cooldown is required thereby saving production time and also personnel dose. The system is robust and resilient enough to be used in other radioactive environments (e.g., other cyclotrons, irradiators, nuclear reactors etc.). Other potential uses include waste management in chemically hazardous/toxic environments and explosives ordinance disposal (its original purpose).