SECONDARY BEAM TARGETRY DEVELOPMENTS*

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Summary

Two recently developed target manipulators have increased the versatility of remote multitargeting in the production of secondary particles from within the Argonne Zero Gradient Synchrotron (ZGS). The Mark II manipulator is constructed in modular form to facilitate assembly in one of four arm-swing configurations. This allows new coverage patterns for the three to four manipulator combinations that can multitarget on a single synchrotron pulse. It also provides for quick, accurate target changes by replacement of a complete presurveyed arm and target assembly. A current pulsed coil, reacting with the guide field, thrusts the target of the Mark IV manipulator upwards from the bottom of the beam chamber. The Mark IV compact design permits close targeting positions between manipulators. The manipulator provides distinct target movements in each of the three coordinate axes (X, Y, and Z), as well as rotation in the XZ plane. This enhances automatic target positioning control. An exact replica of the 32-in x 70-in meson targeting area has been used for positional presurveys of meson targets and for the calibration of their positional readout systems. This use has greatly reduced radiation exposure to personnel and contributed substantially towards a 50% reduction in the ZGS maintenance time.

Introduction

Manipulators with greater versatility now thrust meson targets into the ZGS proton beam at Argonne. They facilitate further the production of various secondary particles for numerous high energy physics experiments on the same proton beam pulse. These devices provide new permissible geometric orientations of multitarget placements. One device with a beryllium lipped meson target provides beam for both secondary beam experiments and extracted proton beam experiments.[1] Use of a duplicate target chamber area enables the close survey of targets in a relatively unrestrictive environment.

Secondary Beam Targetry[2]

The operational target complex within the beam circulating ring of the ZGS consists essentially of two systems. One is the slow (Piccioni) and fast (beam bumper) system for extracting the circulating proton beam. The second system provides direct targeting into the circulating beam to produce secondary particle beams.

Three secondary particle beams are produced and channeled through separate tubes to their respective experiments.[3] The selection of these tubes, as well as the type and momentum of the secondary particles, is determined partially by the positions of the meson target immediately prior to collision by the circulating proton beam. A remote periscope-television complex verifies desired target positions. Each of the three targets is placed at a certain position and angle orientation within a few milliseconds timing pattern as referenced to the other targets and the proton beam. This produces three distinct secondary beams from a single burst of the RF-controlled proton beam. The targeting program is continually repeated with a period of approximately three seconds.

The added versatility of target placement by both the Mark II and Mark IV target manipulators, featuring new remote adjustment motions and readouts, allow operations to make new gross and fine experimental run changes without disturbing the machine operation or the other experimental runs. Their combined use also facilitates many coincidental experiments by experimental planning that were not previously possible.

Mark II Variable Meson Target Manipulator

Figure 1 is a top view of the Mark II target manipulator mounted in a track on the presurvey bench. The target is in the lower right hand corner nearest the viewer. It is 1/4-inch wide, three inches long, and only 0.025-inch high. The target is supported by two tubular posts of 0.004-inch wall thickness. The fragile target and supports are desirable for certain experiments such as K meson studies. The use of such a delicate target emphasizes the smooth actuation needed for arm-swings as fast as 0.1 to 0.2s over millions of continuous cycles. The target angle is remotely adjustable with readout for a 45° range.

The swing arm supporting the target is suspended from the manipulator body by a double-leaf

*Work performed under the auspices of the U.S. Atomic Energy Commission

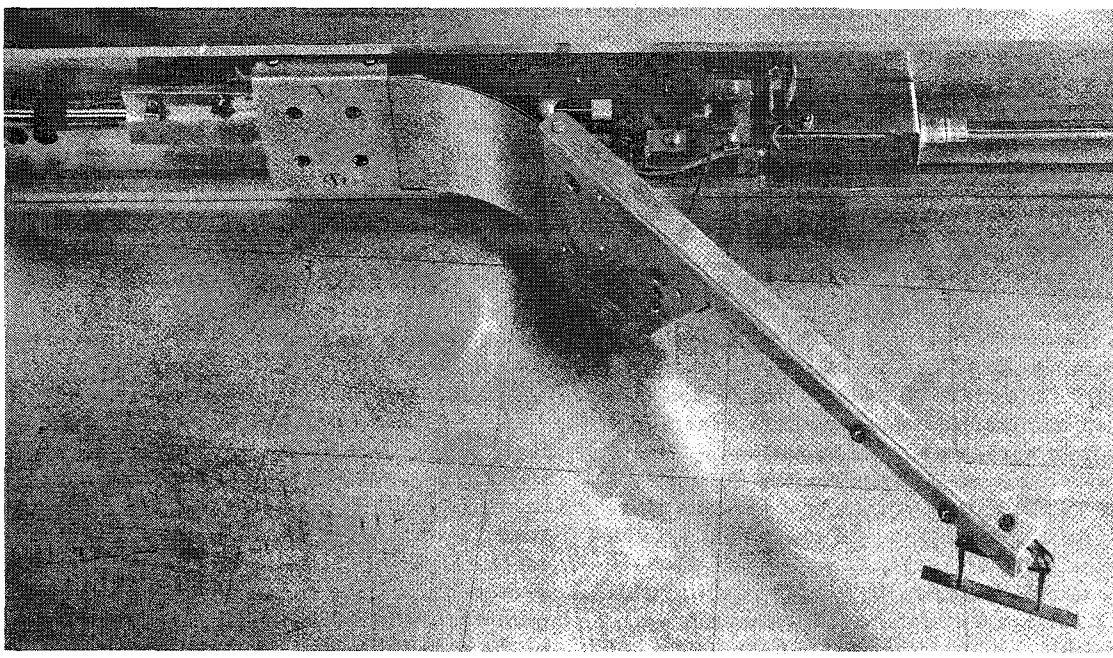

Figure 1 Top View of Mark II Target Manipulator

spring assembly as shown curved in Fig. 1 in the upper center of the photograph. A cable withdraws the arm. The cable also governs the smooth time-distance path of the target under the influence of the electro-hydraulic system which must draw in the arm or allow the springs to move the arm out. The target and spring arm are remotely adjustable in a vertical direction. The vertical drive motor (hidden by the springs) utilizes the beam guide magnet field as its field. The modular construction of this manipulator allows the arm assembly to be removed at its spring clamp base on the left of the body. It can be turned upside down and reattached on the right of the body. The target would then be supported from the bottom. Obviously, this convenient change adds new coverage patterns for the target, especially when used in combinations with other manipulators and targets. The same ease of arm removal facilitates relatively quick arm or target changes.

Figure 2 is a closer view of the Mark II from the right of Fig. 1. The motor drive for adjusting the angle of the target can be seen mounted within the arm channel above the target. The motor also utilizes the guide magnet field for rotating the target. The motor and its readout potentiometer ride with the target as it is whipped out to position and back again.

In addition to permitting a modular construction, the spring powers the arm outward, and so is, in itself, a limitation of the maximum force and speed with which the arm and target can be plunged. This limits possible damaging forces and speeds to the arm, angle drive, or target if component failure should occur in either the hydraulic or electronic portion of the system. Former manipulator models used thin cambered tapes to push as well as to pull the arm to position. Higher than normal control forces could cause the tape to fail by columnar compression. Since in the Mark II the cable is always in tension, such forces or vibrations can not harm it. These factors increase the general reliability of the Mark II.

A single Mark II manipulator has successfully double-targeted the same proton beam pulse, plunging the target first during the rising magnetic field and again during falling field. Thus one experimenter obtained information at a doubled rate while permitting other experimenters to utilize the high intensity beam during the field flattop.

Mark IV Variable Meson Target Manipulator

An earlier abbreviated form of meson targeting manipulator, the Mark III fixed point target mechanism,[2] has provided the basis for design of the new Mark IV variable meson target manipulator. The Mark III was remotely movable only in the direction of the circulating proton beam

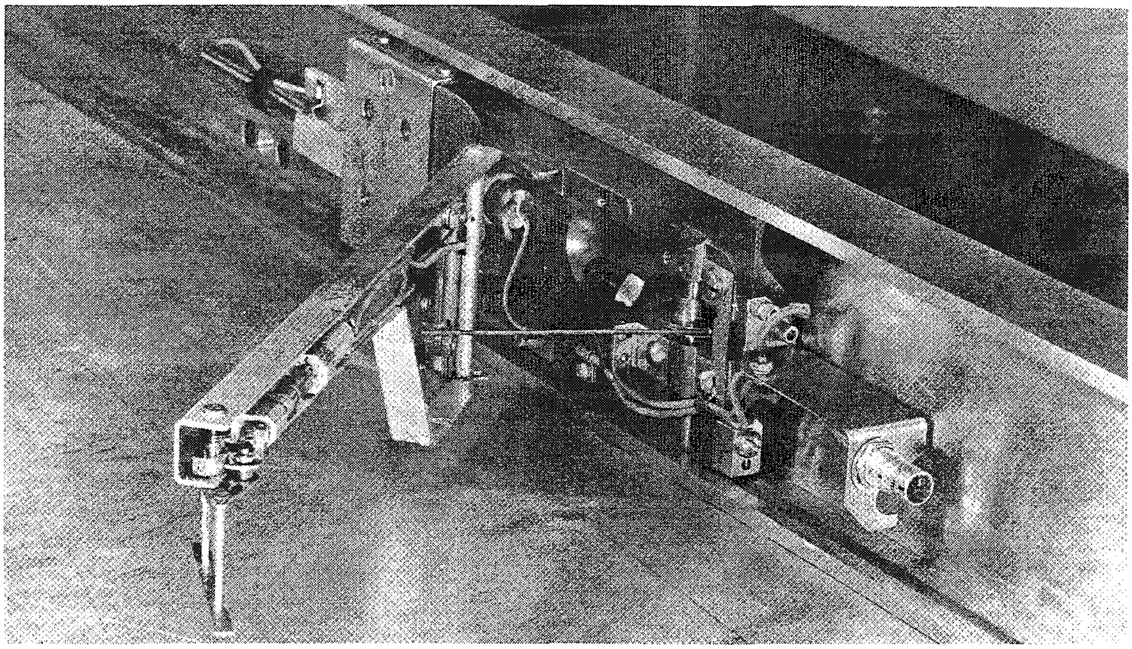

Figure 2 End View of Mark II Target Manipulator

(Z direction). This was satisfactory for a single specific long-term experiment which used only one precise target location point and orientation previously identified. In the Mark III, the target was mounted at the end of an outrigger positioned along the chamber floor away from the chamber wall track. The target was elevated from the chamber floor by a reaction coil supported near the track. The Mark III proved to be highly reliable, principally because of simplicity in construction and relatively short, fast upward stroke.

The Mark IV now utilizes the simplicity of coil-field reaction and short stroke which the older Mark III obtained. The Mark IV also combines these features with variable remote target positioning radially (X direction) with readout, target angular orientation with readout, and target elevation adjustment (Y direction). (The Y-elevation movement is observed directly by the television-periscope system). Thus, the Mark IV is a completely variable target manipulator with great reliability. It has demonstrated this reliability for approximately 1.5 million continuous cycles on several occasions with consistent repetition of target accuracy.

Figure 3 shows the Mark IV target manipulator. The drive package that mounts inside the track against the chamber wall is on the left. On the right is the target and mount as supported and positioned from the drive package by the outrigger assembly. Drive screws within two of the outrigger tubes telescope to move the target and mount relative to the drive assembly (X direction). A third screw and telescoping tube (the tube shown closest to the scale) drives the target in horizontal angular adjustment (X-Z plane). The target in Fig. 3 is quickly raised (Y direction) to the centerline of the circulating beam by a parallelogram linkage as shown. The link raising the target is driven through a flexible coupling and telescoping shaft from the fast drive coil in the drive unit on the left. A spring at the target mount pulls down the other link to return the target to the floor of the chamber. Cams, also on the target mount and driven from the motor package,finely adjust the target elevation.

Figure 4 is a close-up view of the rear of the drive unit that accomplished all motions. It is closely packaged to conserve space for the injected beam. The fast-target actuating coil is in the center of the drive complex shown with a copper damping flag attached. The slow X, Y, and angle drives are powered by special 1/2-inch diameter fieldless motors through miniature planetary gear trains. These are shown mounted horizontally at the bottom of the drive unit.

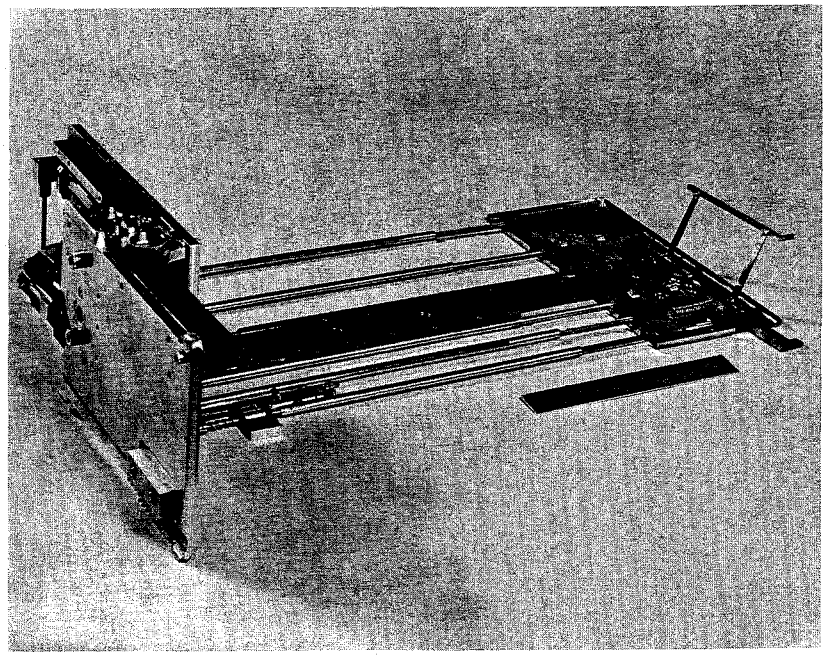

Figure 3 Mark IV Target Manipulator

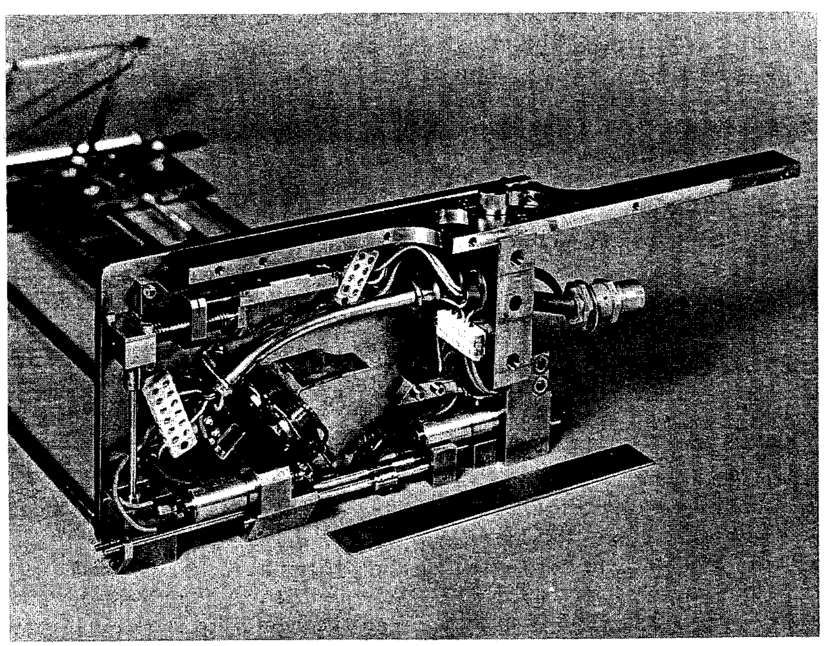

Figure 4 Drive Unit of Mark IV Target Manipulator

The directions of the slow placement motions of the Mark IV manipulator are duplicate of the target locating coordinate axes. They are singular and only one drive affects each axis. This enhances the adaptability of the Mark IV type manipulator to a future automatic positioning control system. The relatively narrow width of the Mark IV allows adjacent targets to be placed as close as 13 inches apart in the Z or beam direction.

Normally, two Mark IV manipulators are supported from the inner radius track and two Mark II manipulators are supported from the outer radius track for targeting in their respective areas. Occasionally as many as three targeting positions close to the outer radius have been desired for producing secondary beams from a single circulating proton beam pulse. For this purpose, special Mark IV manipulators with extra long outriggers have been extended across the chamber floor to reach the third of these target locations. On occasion, while introducing new experimental runs during a continuous operating period, the availability of the third target in such an extended location has eliminated the need for machine shutdowns to make otherwise needed target changes on the Mark II manipulators.

Chamber Replica for Target Presurvey

Utilization of a full-scale replica of the actual target chamber area enables precise optical survey of target orientations correlated to their readout systems with a minimum of radiation hazards. Figure 1 shows a manipulator mounted on the replica presurvey bench. On the replica, a 1-inch thick aluminum surface plate "floor" duplicates the thinner chamber floor and is accurately ruled in 5-inch X-Z coordinate squares. Thick manipulator tracks are mounted and adjusted on the surface plate to reproduce the slight deflections of the thinner tracks mounted in the actual chamber.

While the radiation levels have been building up in the target area over the past 18 months, many correlation checks have been made between the area and the presurvey bench. This data has demonstrated that target placements can be repeated well within experimental needs through use of the replica. Spot optical checks in the target area are still made. The periscope-television complex continues as a remote check of target positions during operation runs. The ease of performing survey work under these conditions and while the accelerator is operating has greatly contributed to reducing the duration and frequency of accelerator maintenance periods.

Future Development

It is now apparent that future ZGS target manipulator development should follow the basic concepts, as exemplified by the Mark IV target manipulator. In addition to the obvious one of cost advantage, there are the following performance reasons. The short target movement up from the floor of the chamber can become a servo-controlled motion that would make possible increased speeds of target placement to 40 ms or less. Positional sensing would, of course, be close to the target. This speed would further increase the versatility of targeting by a noticeable degree. It also appears that an actuator coil for this fast target upward motion can be close to the target itself. The magnetic field perturbations from the coil on the final formed beam would be negligible. This would simplify the fast motion mechanism which, in turn, would increase overall reliability. One model now under test has only one pair of bearings. The separation of the motions coinciding with the directions of the coordinate axes will facilitate rapidly programmed target positions. The unitized packaging of all fast and slow positional drives within the manipulator makes feasible remote withdrawal and remote interchange of manipulators and targets.

Acknowledgments

The development of these devices was accomplished only with the creative cooperation of the ZGS targetry staff and technicians and the Central Shop's personnel.

References

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