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MODIFICATIONS OF A NILAB DILUTER-SAMPLER* USED IN THE DEVELOPMENT OF AN AUTOMATED GeMSAEC SAMPLE-REAGENT LOADER**

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AUGUST 1972

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* Nilab Automatic Diluter-Sampler, National Instrument Laboratories, Inc., Rockville, Md.

** Research supported by the National Institute of General Medical Sciences.

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MODIFICATIONS OF A NILAB DILUTER-SAMPLER USED IN THE DEVELOPMENT OF AN AUTOMATED GeMSAEC SAMPLE-REAGENT LOADER

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ABSTRACT

An automated sample-reagent loader for use with a GeMSAEC Fast Analyzer has been developed at the Oak Ridge National Laboratory. With it, the loading time is significantly decreased; for example, a 15-place GeMSAEC transfer disk can be automatically loaded with reagent and samples in 3.25 min, while manual methods require 15 min. In addition, the instrument is capable of providing precision and accuracy equal to, or better than, manual methods. The automated loader was developed from a commercially available Nilab Diluter-Sampler. The modifications that were required are described in this report.

1. INTRODUCTION

The GeMSAEC Fast Analyzer recently developed at the Oak Ridge National Laboratory[1-9] is potentially capable of increasing the rate at which many clinical and biochemical analyses may be performed as well as improving the precision and accuracy of these analyses. However, before these potential capabilities can be realized, a reasonable and economical sample analysis rate must be obtained.

The sample analysis rate can be increased by modifying the GeMSAEC analytical module per se (i.e., a previous paper[9] has reported an increase in the sample analysis rate of a GeMSAEC Fast Analyzer by increasing the number of cuvets per rotor). Alternatively, it can be

increased by automating one or more of the various steps necessary in the routine operation of a GeMSAEC Fast Analyzer. For example, the discrete loading of samples and reagents into their respective cavities in a transfer disk is a basic procedure in the operation of a GeMSAEC Fast Analyzer. Upon application of a centrifugal field, the samples and reagents are mixed and transferred into the proper cuvets, where their absorbances are monitored. Automation of this procedure, which heretofore has been performed manually with various micropipets, would prove advantageous in three respects: (1) the sample analysis rate of the GeMSAEC Fast Analyzers would be increased, (2) the technician would be relieved of the tedium of loading the transfer disks, and (3) the precision and accuracy of the system would be improved because manual pipetting (with its accompanying human error) is often associated with imprecision and inaccuracy.

Consequently, an automated sample-reagent loader for use with a GeMSAEC Fast Analyzer was developed at the Oak Ridge National Laboratory, utilizing commercially available components where possible. A previous report[10] describes this loader and presents evaluation and performance data. The loader is a modified version of the commercially available Nilab Diluter-Sampler. The modifications that were made are discussed in Sect. 3.

2. GENERAL DESCRIPTION OF THE GeMSAEC SAMPLE-REAGENT LOADER

The sample-reagent loader (SRL) designed to automatically load a GeMSAEC transfer disk is shown in Figs. 1 and 2. Basically, the system is a modified Nilab Automatic Diluter-Sampler (National Instrument

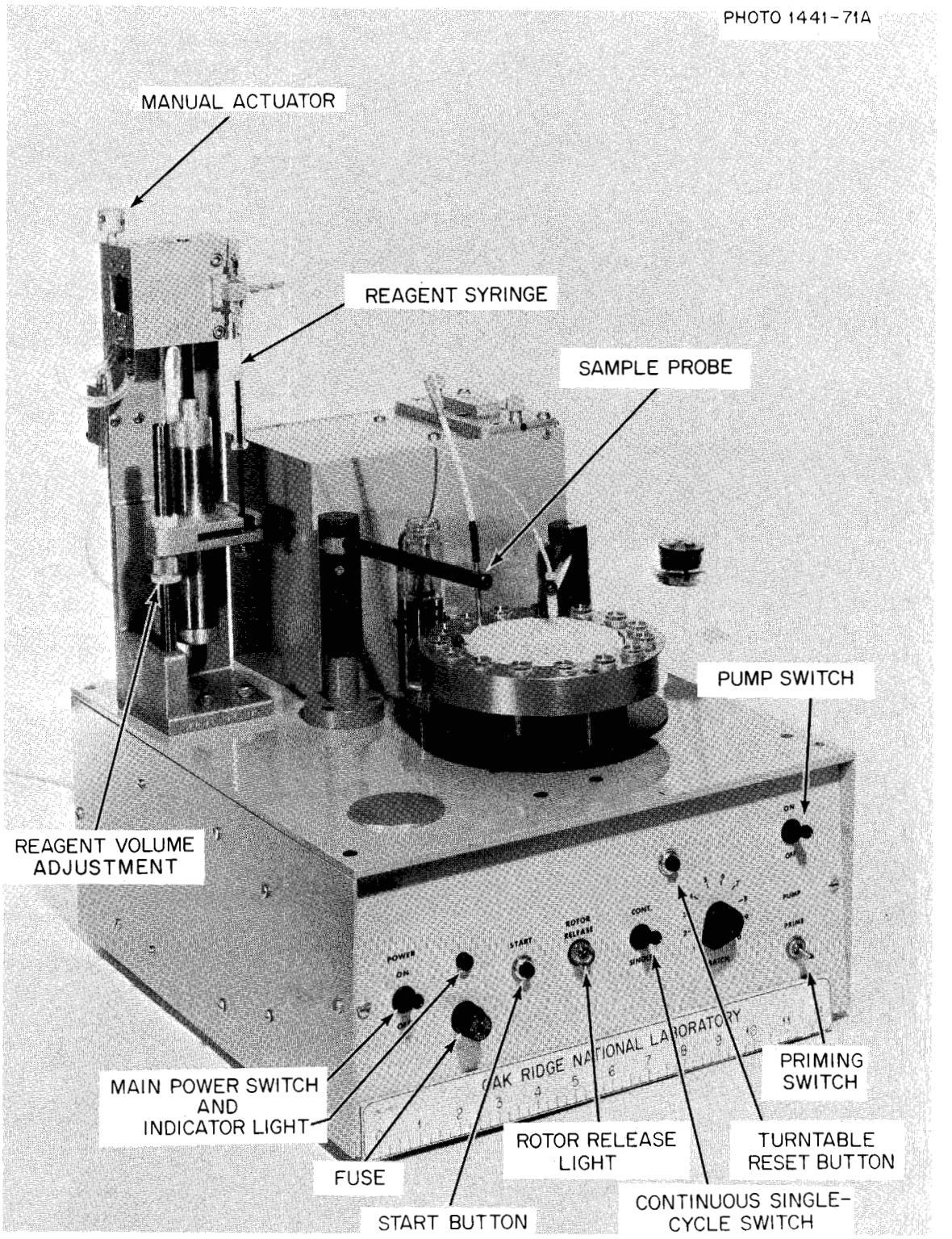

Fig. 1. Front view of GeMSAEC sample-reagent loader.

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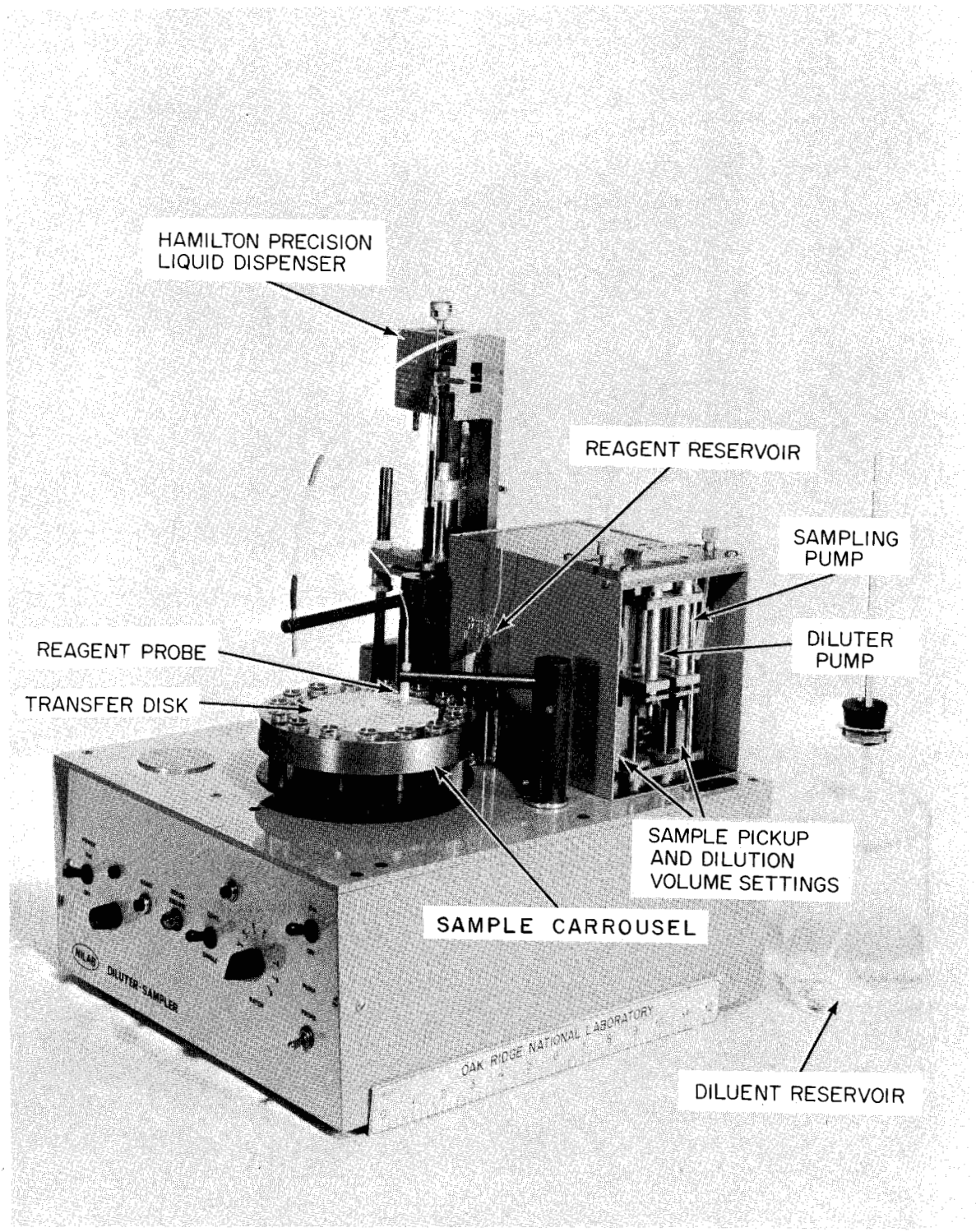

Fig. 2. Side view of GeMSAEC sample-reagent loader.

Laboratories, Incorporated, Rockville, Maryland) to which a Hamilton Precision Liquid Dispenser (Hamilton Company, Whittier, California) has been added for automatic reagent dispensing. The integrated instrument utilizes the Nilab module to obtain a discrete volume of sample, transport this sample to a GeMSAEC transfer disk, and then transfer the sample into its respective sample cavity in the disk by expelling it with a preset volume of wash diluent. Discrete volumes of reagent are loaded into the reagent cavities by means of the Hamilton Precision Liquid Dispenser. The time required to automatically load a 15-place transfer disk with samples and reagent is 3.25 min.

3. MODIFICATIONS

Sample Rate. - The sampling rate of the Nilab unit was increased by a factor of 3 by replacing the original drive and motor gears with Boston gears (Boston Gear Works, Quincy, Massachusetts) Nos. G261 and G265, respectively. The locations of these gears are shown in Fig. 3.

Turntable. - The original turntable was replaced with a bilevel unit that contains a central peg and indexing pin on its upper deck. The modified turntable is shown in detail in Fig. 4 and in place in Fig. 5.

A GeMSAEC transfer disk can be placed onto the upper deck of this turntable and properly positioned by matching the holes found in the bottom of the disk with the central peg and indexing pin of the turntable. A sample carrousel containing compartments for 15 sample cups (Fig. 6) is positioned concentrically around the transfer disk. Proper indexing of the sample carrousel and the transfer disk is accomplished

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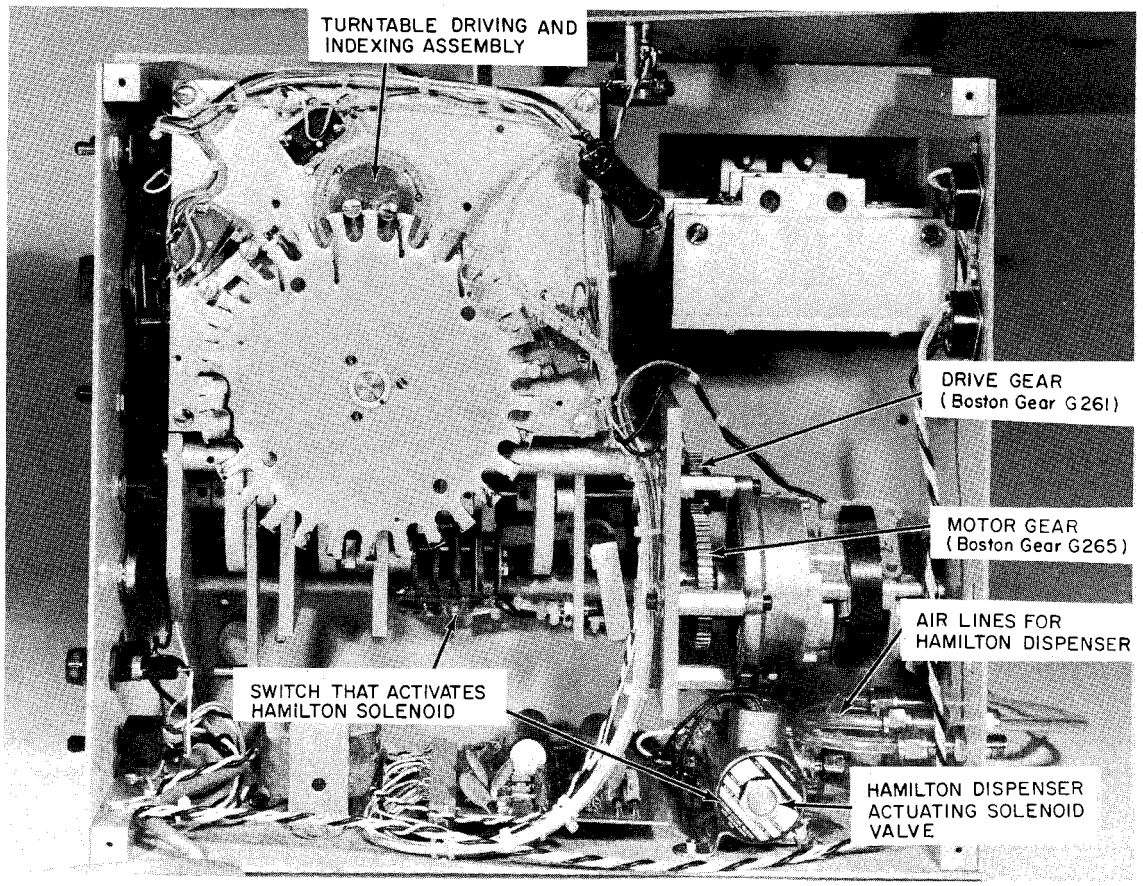

Fig. 3. Bottom internal view of GeMSAEC sample-reagent loader.

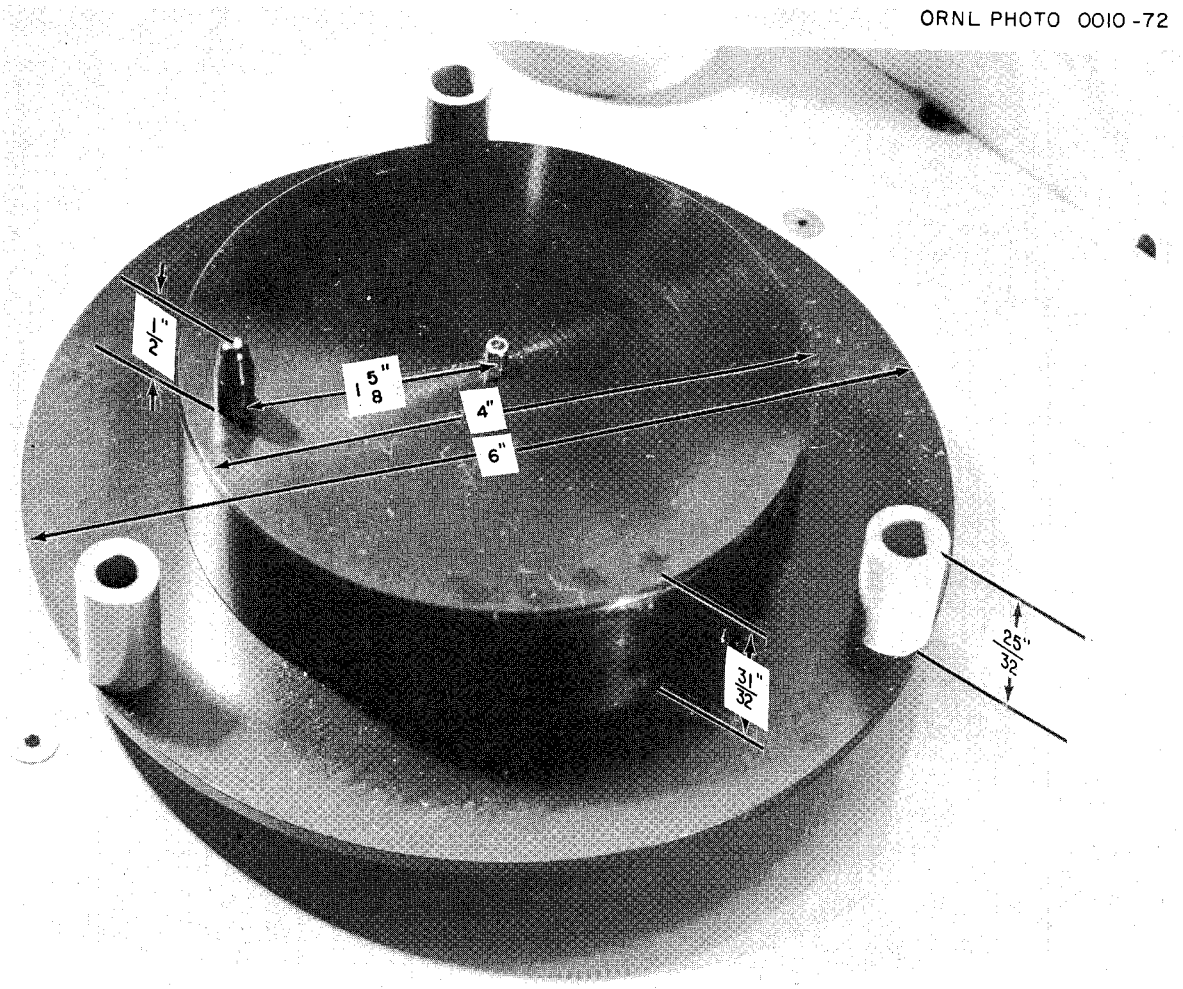

Fig. 4. Close-up of bilevel turntable used in the GeMSAEC sample-reagent loader.

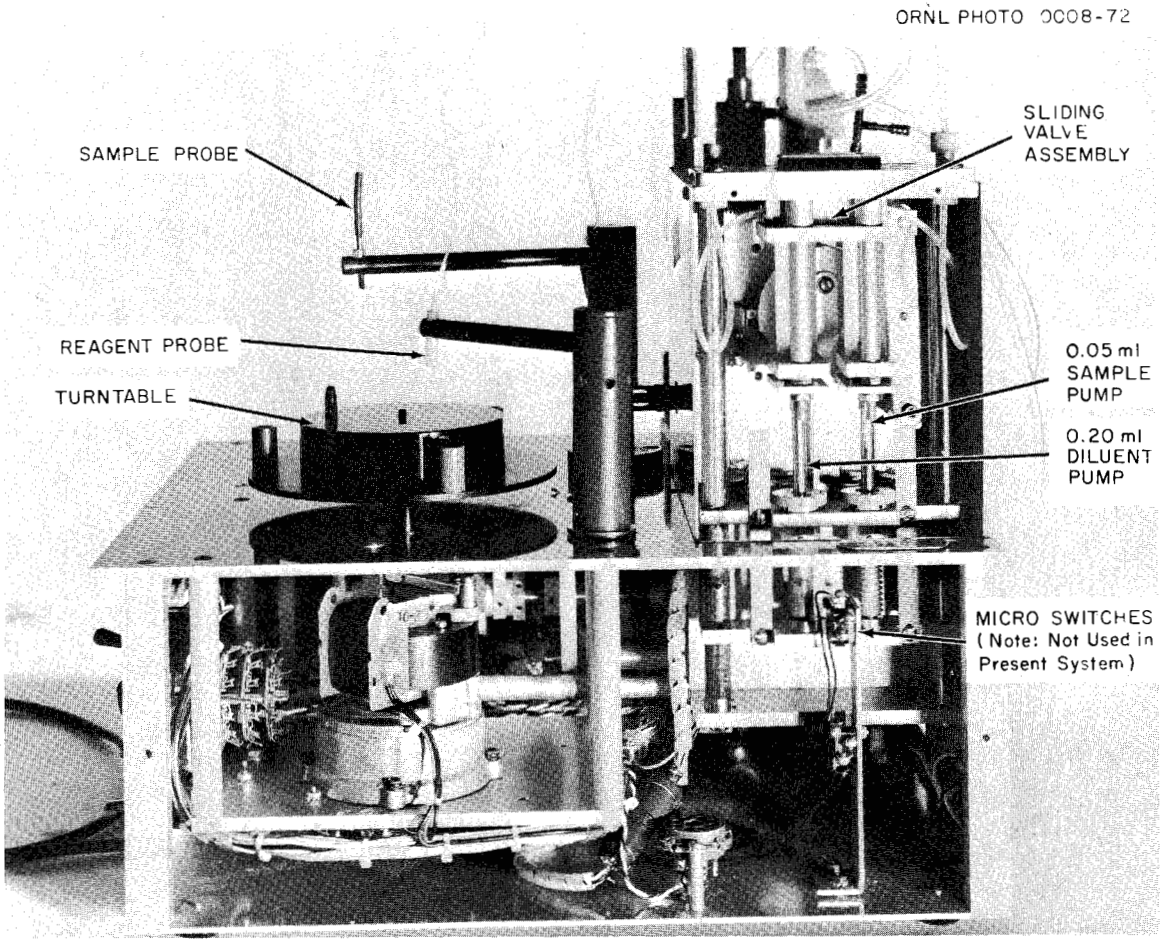

Fig. 5. Side internal view of GeMSAEC sample-reagent loader.

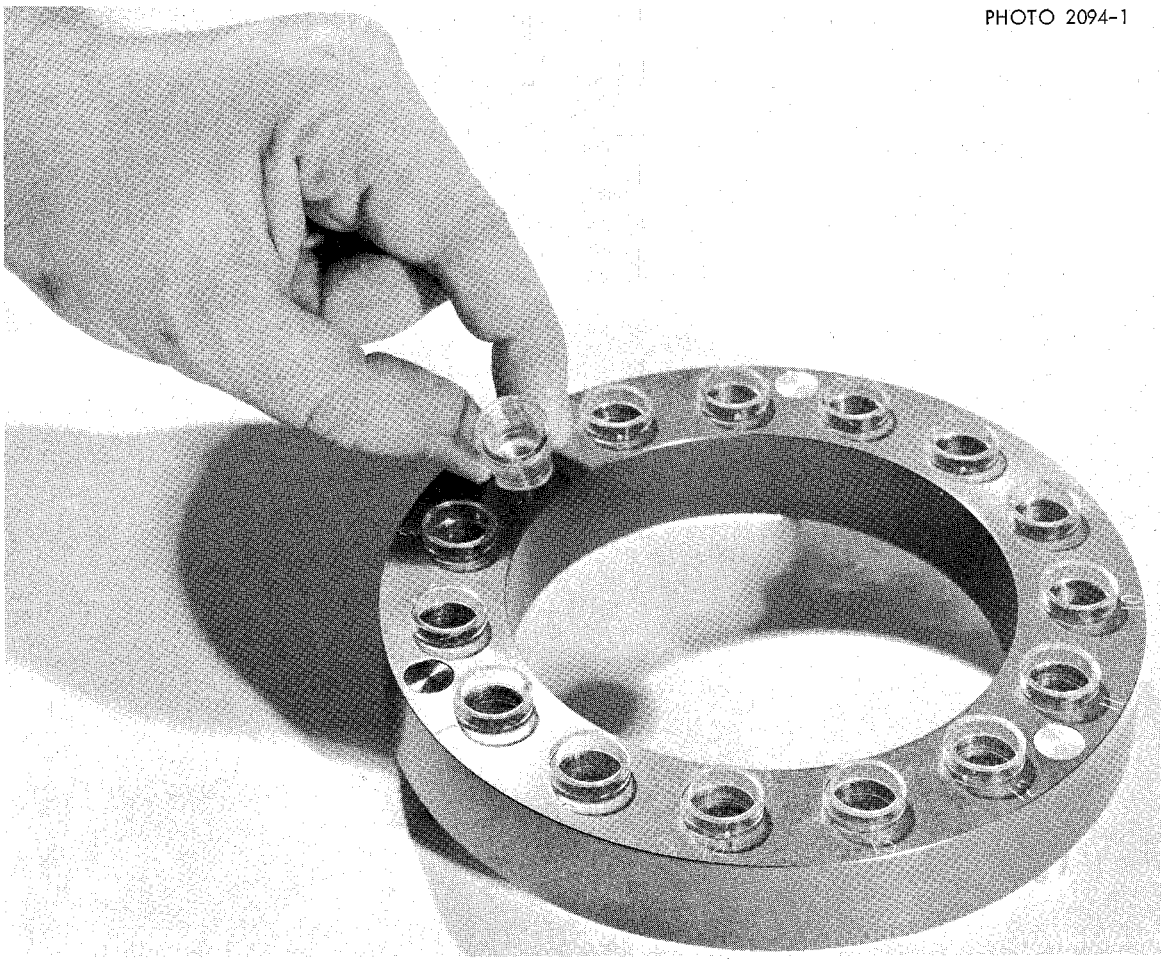

Fig. 6. Sample carrousel containing 15-sample cups.

by fitting the three offset legs of the sample carrousel into three matching supports mounted on the lower deck of the turntable. This ensures a single orientation of the carrousel and the transfer disk.

Turntable Indexing. - As delivered, the Nilab unit had provisions for 30 sample compartments in its sample carrousel; however, the number of compartments was decreased to 15 in order to make the unit compatible with a 15-place GeMSAEC Fast Analyzer. This change, in turn, necessitated replacing the turntable drive assembly with the new dual-pin unit shown in Fig. 7; in addition, the original motor timing switch was moved to accommodate the new assembly. These modifications, along with the air lines, solenoid valve, and actuator switch for the Hamilton Dispenser, are shown in Fig. 3.

Diluent Pump Capacity. - The requirement that the combined volume and diluent in an individual cavity of GeMSAEC transfer disk cannot exceed 0.3 ml necessitated a change in the diluent pump (Fig. 2) of the Nilab module since, as delivered, the Nilab Diluter-Sampler allowed sample pickup and diluent volume selections of 0 to 0.05 and 0 to 5.0 ml respectively. The 0- to 0.05-ml range of the sample pump is ideal for GeMSAEC applications,[9] but the volume restrictions of the transfer disk would dictate a diluent volume range of 0 to 0.25 ml. This would require that the 5.0-ml diluent pump be operated at less than 10% of its capacity, with a resulting loss in precision and accuracy. For this reason, the 5.0-ml diluent pump was replaced with a 0- to 0.05-ml pump. Consequently, in order to obtain a diluent/sample ratio of at least 4/1, a new piston was fabricated for this pump from conveniently available 1/8-in. stainless steel rod stock. Calibration of this pump indicated a volumetric

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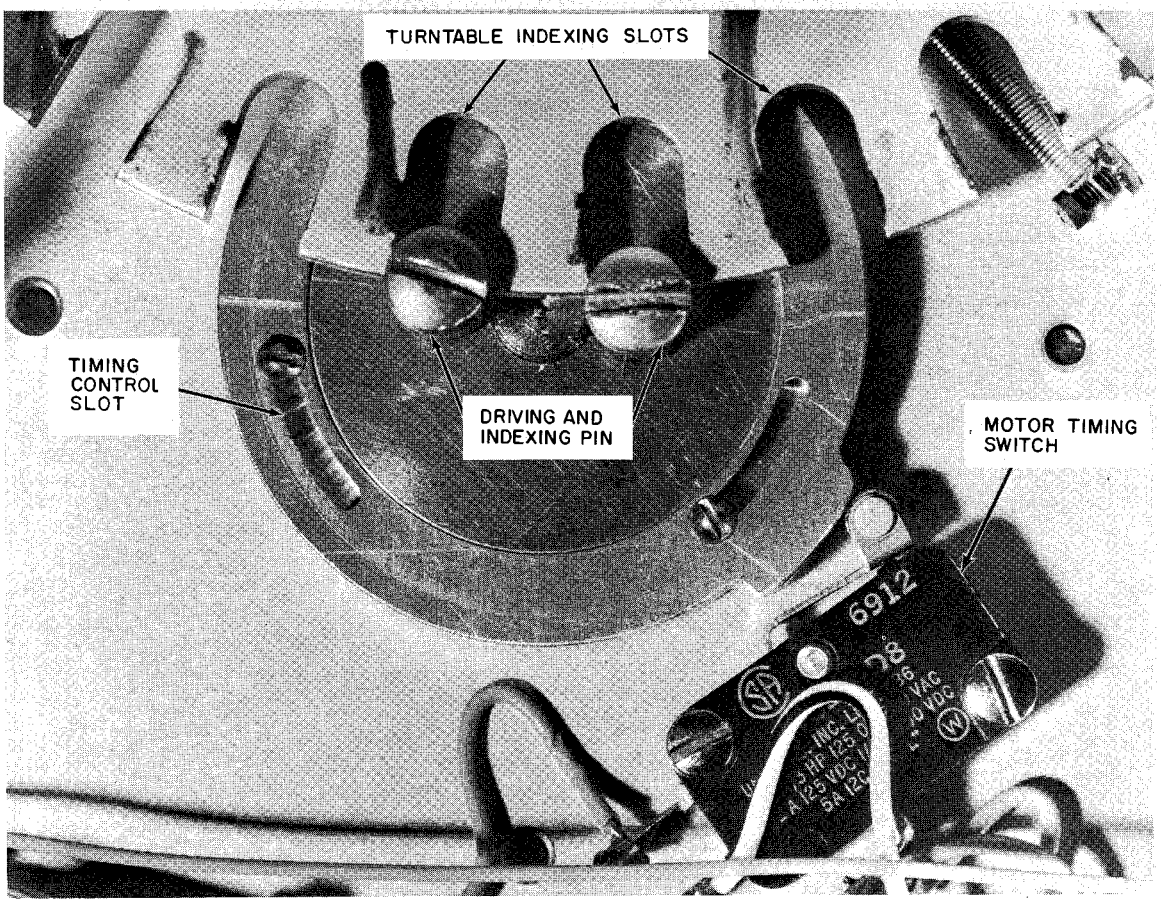

Fig. 7. Turntable drive and indexing assembly used in GeMSAEC sample-reagent loader.

range of 0 to 0.2 ml with the same degree of precision and accuracy as had been obtained with the 5.0-ml pump.

Sample and Reagent Probe. - As delivered, the Nilab unit contained two probes attached to their respective support arms and cylinders. These have been utilized as sample and reagent probes in the modified unit (see Figs. 1 and 2). The reagent probe is stationary, while the sample probe is movable in order that it may obtain, transport, and dispense an aliquot of sample.

The original sample probe on the Nilab unit was also replaced with a section of 0.027-in.-ID Teflon tubing, as shown in Fig. 1. This reduction in the cross-sectional area of the probe caused an increase in the delivery pressure encountered by the sliding valve assembly (see Fig. 5). To prevent leakage, the valve assembly was modified as shown in Fig. 8.

General. - The original prime push button was replaced with a toggle switch to facilitate the priming operation. As shown in Fig. 3, the cam-operated switch supplied with the unit was utilized to operate the Hamilton Dispenser. Minor adjustments were also made to the relative positions of the remaining cam-operated switches in order to optimally operate the loader. Except for the timing changes mentioned earlier, the electrical portion of the system was altered only slightly.

4. EVALUATION

A detailed description and an evaluation of the integrated sample-reagent loader have been presented previously.[10] To summarize, the instrument is capable of providing precision and accuracy equal to, or

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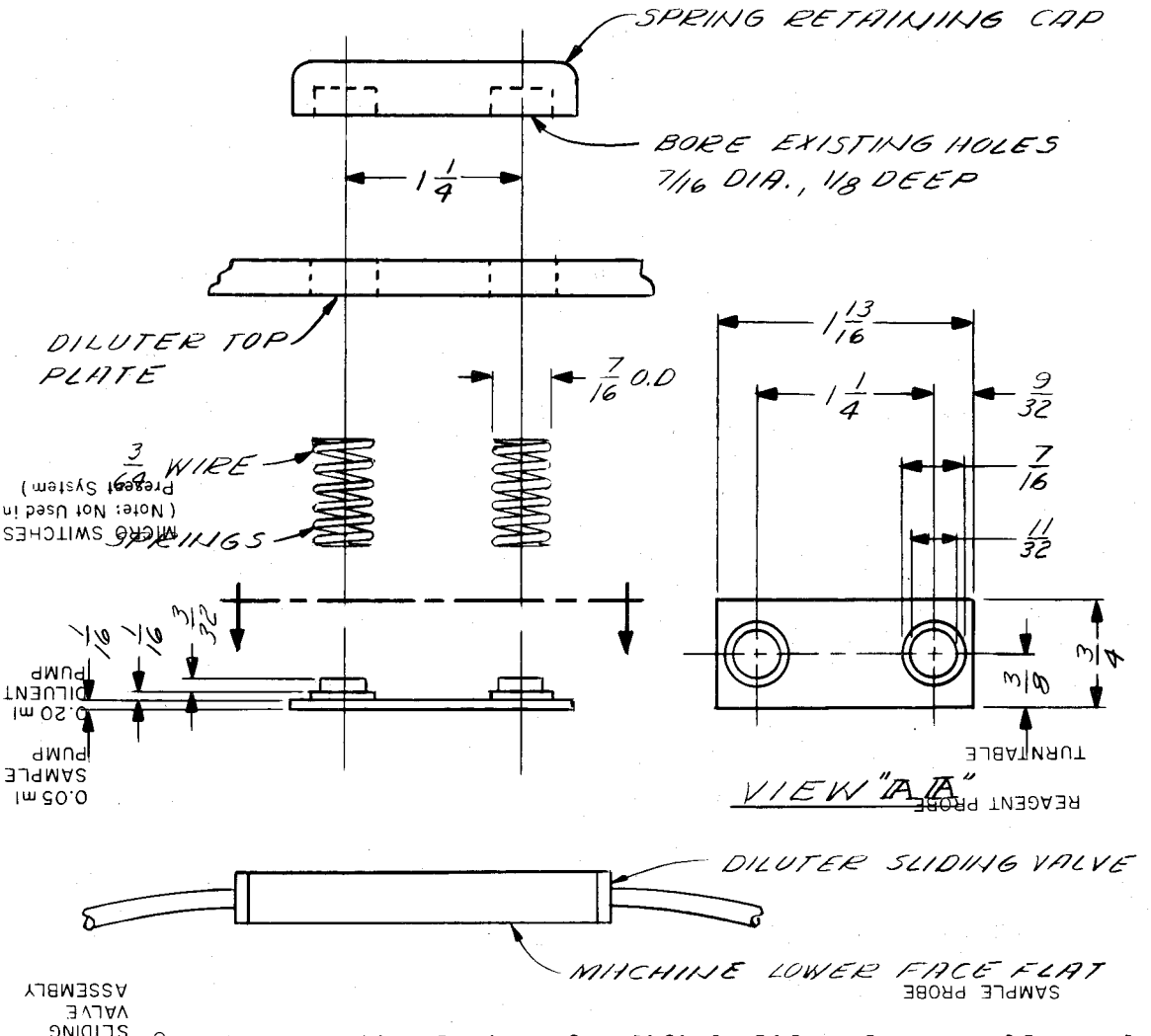

Fig. 8. Cross-sectional view of modified slide valve assembly used in GeMSAEC sample-reagent loader.

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better than, manual methods of loading. Sample carryover of the system was found to be approximately 1%.

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