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RESPIRABLE COAL MINE DUST SAMPLE PROCESSING

by

Lewis D. Raymond, Thomas F. Tomb and Paul S. Parobeck

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ABSTRACT

The Federal Coal Mine Health and Safety Act of 1969 established mandatory dust standards for coal mines. Regulatory requirements for complying with the provisions of the Act were prescribed in Title 30, Code of Federal Regulations, Parts 70 and 71, which were published in the Federal Register on April 3, 1970, and March 28, 1972, respectively. These standards and sampling requirements of coal mine operators, along with a description of the laboratory which was established to process respirable coal mine dust samples collected in accordance with these requirements, were published in MESA Informational Report 1045[4/] (MESA, the acronym for the Mining Enforcement and Safety Adminstration, was changed to MSHA, the acronym for the Mine Safety and Health Administration, in 1977). These standards and regulatory requirements continued under the Federal Mine Safety and Health Act of 1977 until November 1980, when major regulatory revisions were made in the operator's dust sampling program. This paper describes the changes in the respirable coal mine dust sampling program and the equipment and procedures used by MSHA to process respirable coal mine dust samples collected in accordance with regulatory requirements.

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3/ Chief, Instrumentation and Analytical Branch.
4/ Parobeck, Paul S. Respirable Mine Dust Sample Processing Laboratory. MESA IR 1045, 1976, 13 pp.

INTRODUCTION

Each operator of a coal mine is required to take accurate samples of the amount of respirable dust in the mine atmosphere as specified in Section 202(a) of Title II of the Federal Coal Mine Health and Safety Act of 1969[5/] (later amended to the Federal Mine Safety and Health Act of 1977). To enable the operator to fulfill his obligation, detailed instructions pertaining to dust sampling procedures are prescribed in three parts of Title 30 of the Code of Federal Regulations[6/]. Part 70 of these regulations gives Mandatory Health Standards for Underground Coal Mines, Part 71 gives Mandatory Health Standards for Surface Work Areas of Underground Coal Mines and Surface Coal Mines and Part 90 gives Mandatory Health Standards for Coal Miners who have evidence of the Development of Coal Workers Pneumoconiosis.

Section 202(b) of Title II of the Act establishes allowable limits for environmental dustiness. Dustiness is defined as the average concentration of respirable dust in the mine atmosphere during each shift to which each miner in the active workings of the mine is exposed. Effective December 30, 1972, the allowable limit became 2.0 milligrams of dust per cubic meter of air, except where an operator had obtained a permit for noncompliance. The limit of dustiness allowable under a noncompliance permit was not to exceed 3.0 milligrams of dust per cubic meter of air. Permits for noncompliance terminated December 30, 1975. To determine the level of dustiness, each operator was originally required to establish a basic sampling cycle on the "high risk" miner in each coal producing section. The "high risk" miner was defined as the worker exposed to the highest respirable dust concentration on that producing section. After establishing this basic sampling cycle, the operator was required to collect five valid samples every other month; provided compliance with the applicable standard was maintained. In addition, all underground miners regardless of where they worked, were required to be sampled periodically during the year. Workers employed "on section" had one sample collected every 120 days while nonsection workers were sampled every 180 days.

The amended respirable dust regulations became effective at all underground coal mines on November 1, 1980, and on February 1, 1981, for all surface coal mines and surface work areas of underground coal mines as well as for Part 90 miners. Promulgation of these regulations shifted the emphasis of personal sampling in the outby areas of underground coal mines to sampling of "designated" areas. This change in concept resulted in a 50 percent decrease

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5/ U. S. Congress. Federal Coal Mine Health and Safety Act of 1969. Public Law 91-173. December 30, 1969, 83 Stat. 742.

6/ U. S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter I--Mine Safety and Health Administration, Department of Labor.

in the number of samples previously required to be collected by Title 30 CFR. Under the amended (present) regulations mine operators are required to collect the following four different types of samples:

1. Designated Occupation samples (underground)
2. Designated Area samples (underground)
3. Designated Work Position samples (surface)
4. Part 90 Miner samples (underground or surface)

The Designated Occupation is the occupation on a mechanized mining unit (MMU) that has been determined, by results of respirable dust samples, to have the highest respirable dust exposure. On this occupation, five valid respirable dust samples are required to be collected each bimonthly period. The bimonthly periods in which these samples are required to be collected are:

January 1 - February 28 (29)
March 1 - April 30
May 1 - June 30
July 1 - August 31
September 1 - October 31
November 1 - December 31

By definition, a Designated Area is an area of a mine identified by the operator in the mine's Ventilation System and Methane and Dust Control Plan. This plan is subject to approval by MSHA's local District Manager. One sample is required to be collected from each of the identified areas in the plan on a bimonthly basis. The bimonthly periods during which Designated Area samples are collected are:

February 1 - March 31
April 1 - May 31
June 1 - July 31
August 1 - September 30
October 1 - November 30
December 1 - January 31

If a bimonthly Designated Area sample exceeds 2.0 milligrams per cubic meter of air, five additional samples are required to be collected. The average respirable dust concentration determined from these samples is used to determine compliance with the applicable standard.

Designated Work Position samples are those collected at surface mining operations and surface facilities of underground mining operations. The local District Manager is required to designate the work positions to be sampled by the operators. One valid respirable dust sample is required to be collected from each Designated Work Position. The bimonthly periods during which these

samples are collected are the same as for Designated Area samples. The criterion for obtaining additional samples whenever a sample exceeds 2.0 milligrams per cubic meter of air is also the same as that prescribed for samples collected at designated areas.

Part 90 Miner samples are those samples collected on individuals who have been given the option and have exercised the right to work in the area of a mine where the average exposure to respirable dust is at or below 1.0 milligram per cubic meter of air. This option is granted to miners by the Secretary of Health and Human Services and is based on evidence of the development of pneumoconiosis. Miners who exercise this option are required to be sampled (one sample) bimonthly. The bimonthly sampling cycle is also the same as for Designated Area sampling.

Mine operators are also required to collect samples at those designated entities (occupations, areas, surface work positions and Part 90 miners) that have been cited for violation of the respirable dust standard based on either operator bimonthly or MSHA sampling. In addition, nondesignated entities (occupations, areas and surface work positions) cited for noncompliance with existing dust standards, based on MSHA sampling, are also required to be sampled by mine operators. These samples are commonly referred to as either citation or abatement samples. When such sampling is required at designated or nondesignated entities, corrective action is first taken by the operator to lower the dust concentration and then samples are collected until five valid respirable dust samples are taken. Sampling is continued until the violation is abated and compliance is established. In accordance with the requirements of 30 CFR, Parts 70, 71 and 90, the mine operator, at the conclusion of each sampling shift, transmits the collected sample(s) along with a dust data card to a central processing laboratory located at the following address:

Respirable Dust Processing Laboratory
Pittsburgh Health Technology Center
4800 Forbes Avenue - Building D
Pittsburgh, Pennsylvania 15213

or to any other address designated by the District Manager.

Filters used by mine operators to collect samples are preweighed by the manufacturer to 0.1 milligram (mg). The manufacturer of the filter also supplies a mine data card (Figure 1) with the filter. An identification number (cassette number) and the initial weight of the filter are marked on the card by the manufacturer. Information relative to the specific mining operation is inserted by a representative of the mining company who is responsible for the dust sampling.

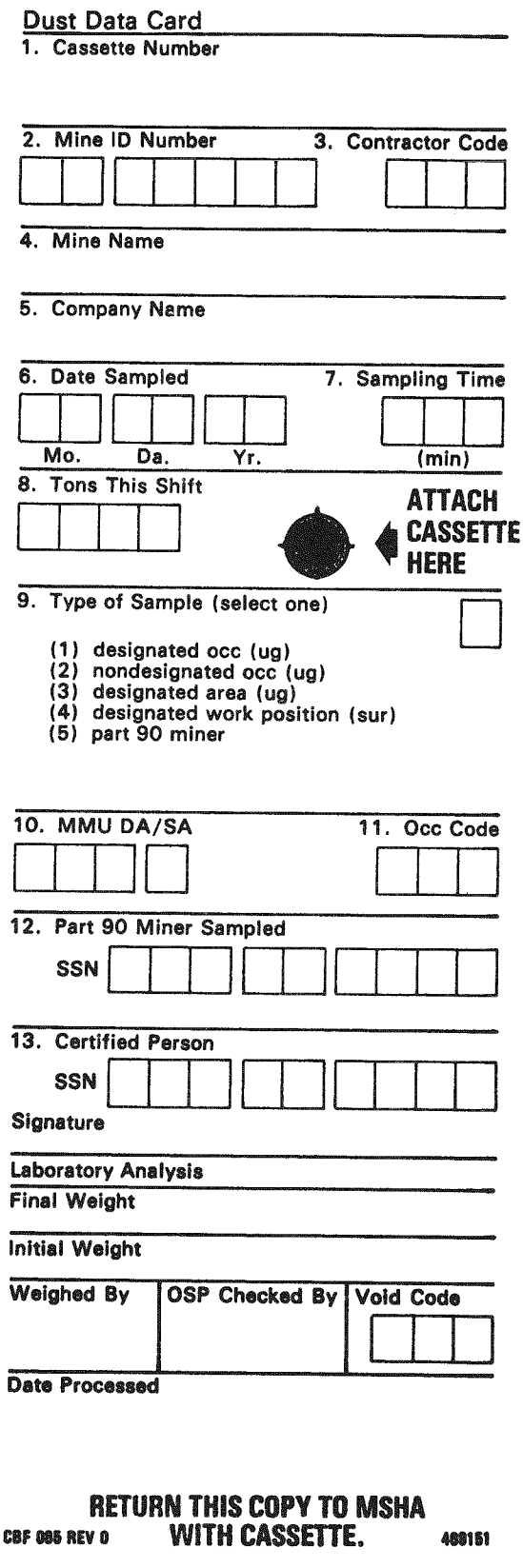

Figure 1. - Mine data card.

Upon receipt at the central processing laboratory, each sample is analyzed and the specific data on the data card are recorded. The data are then transmitted to an automatic data processing center in Denver, Colorado, and computed results are sent to the operator and the District/Subdistrict Office on a computerized "data mailer". The following sections of this paper describe the central laboratory facility and procedures used to process respirable dust samples and associated data.

LABORATORY FACILITY

All coal mine operator dust samples are processed in a "clean room" environment. The laboratory is a restricted area, off limits to other than authorized personnel working therein. The laboratory is divided into three main areas: a preparation area where packages are opened and samples are prepared for processing, an area where the filters are removed from the filter cassette housing and prepared for weighing and an area where the samples are weighed.

The laboratory is maintained at a slight positive pressure to limit the entry of extraneous dust from surrounding work areas. The environment in the room where samples are weighed is maintained at 74°$\pm$1°F and 50 percent $\pm$5 percent relative humidity. Ventilation in the room where samples are weighed is controlled to prevent air currents from passing over the balances, which could affect their operation. Under these conditions, optimum performance of the electronic weighing systems is achieved and maintained.

SAMPLE PROCESSING PROCEDURE

Upon receipt, the packaged samples are taken to the preparation area where the filter cassettes and data cards are removed from their mailers and placed together on flat trays (Figure 2). At this time the identification number on the data card is checked against that on the filter cassette to ensure that they match. If they do not match, the sample is not weighed; however, the card is marked with a void code indicating that a matched cassette was not received and the data on the card is processed in the same manner as all other data cards received.

After the samples and data cards are trayed, they are taken to the area where the cassettes are opened and the filter capsules are prepared for weighing. To prevent contamination, filter capsules are never touched with the hands. Once the cassette is opened, the capsules are only handled with forceps. After the capsule is removed from its cassette, it is placed on one of the two types of processing trays shown in Figure 3. Samples placed on the tray shown in Figure 3A which holds samples and associated data cards are manually weighed on an electronic balance. Those samples placed on the tray shown in Figure 3B, which holds 40 samples are weighed automatically using the

Figure 2. - Flat sample handling tray.

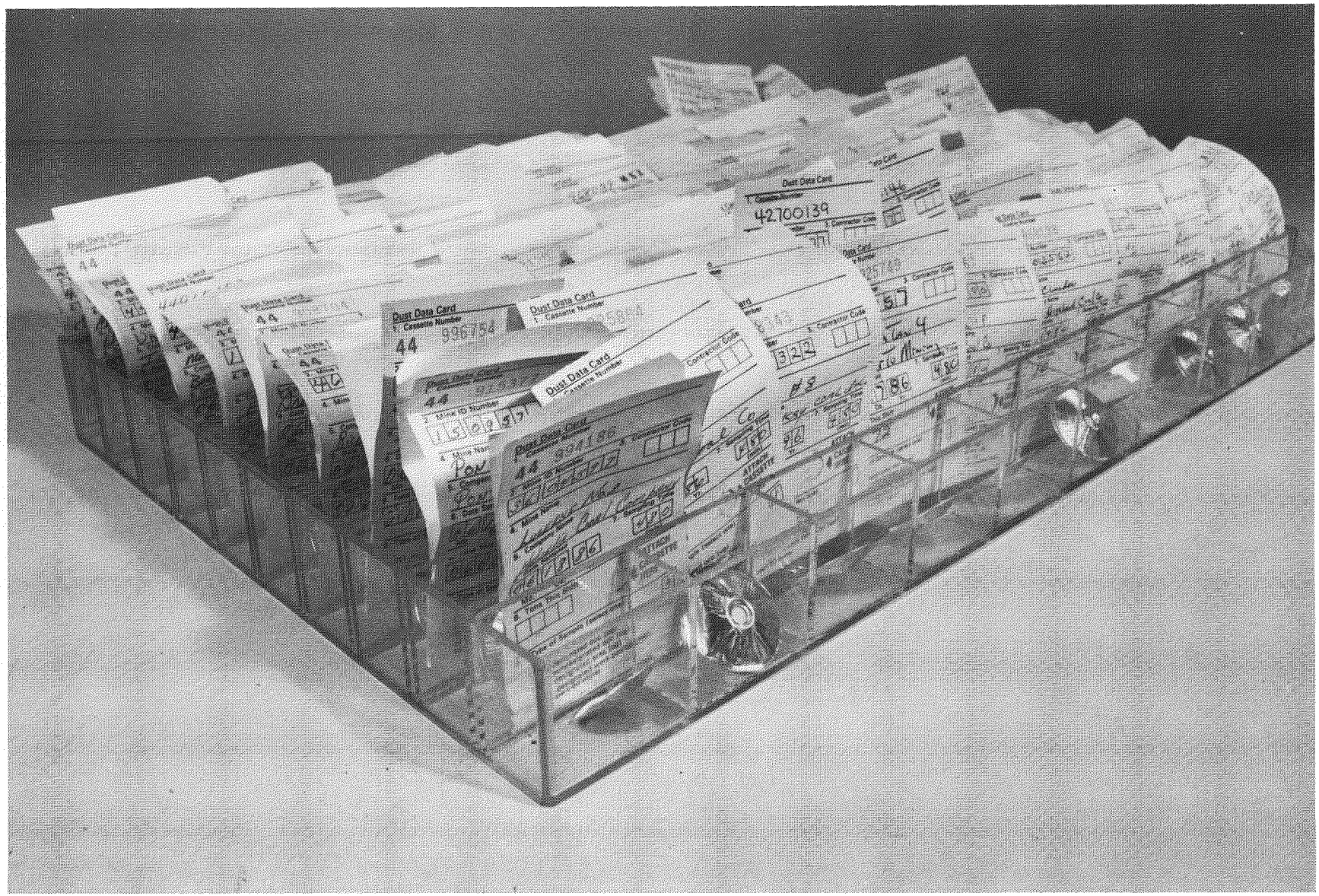

Figure 3A. - Sample holding tray used for manual weighing.

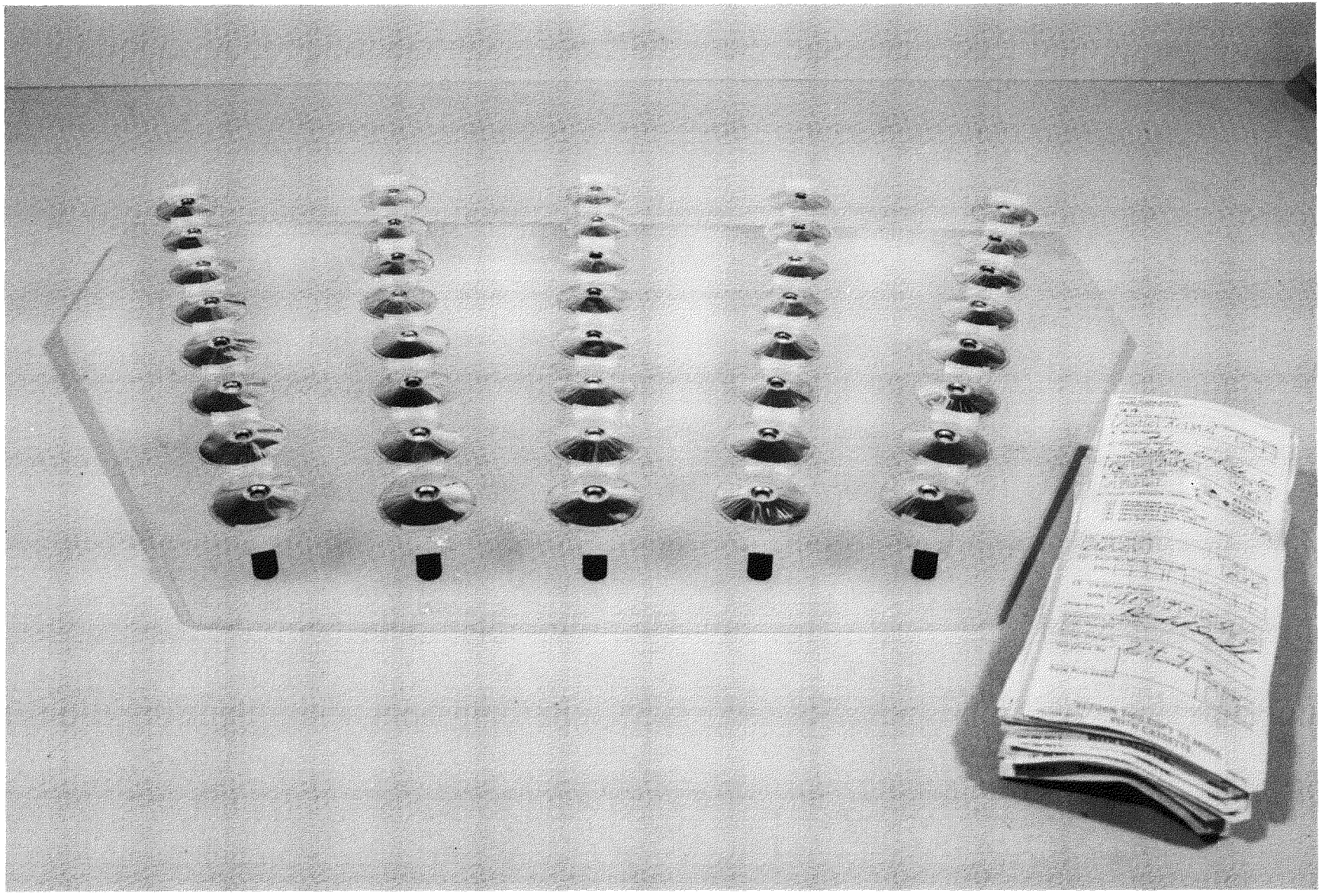

Figure 3B. - Sample holding tray used for robotic weighing.

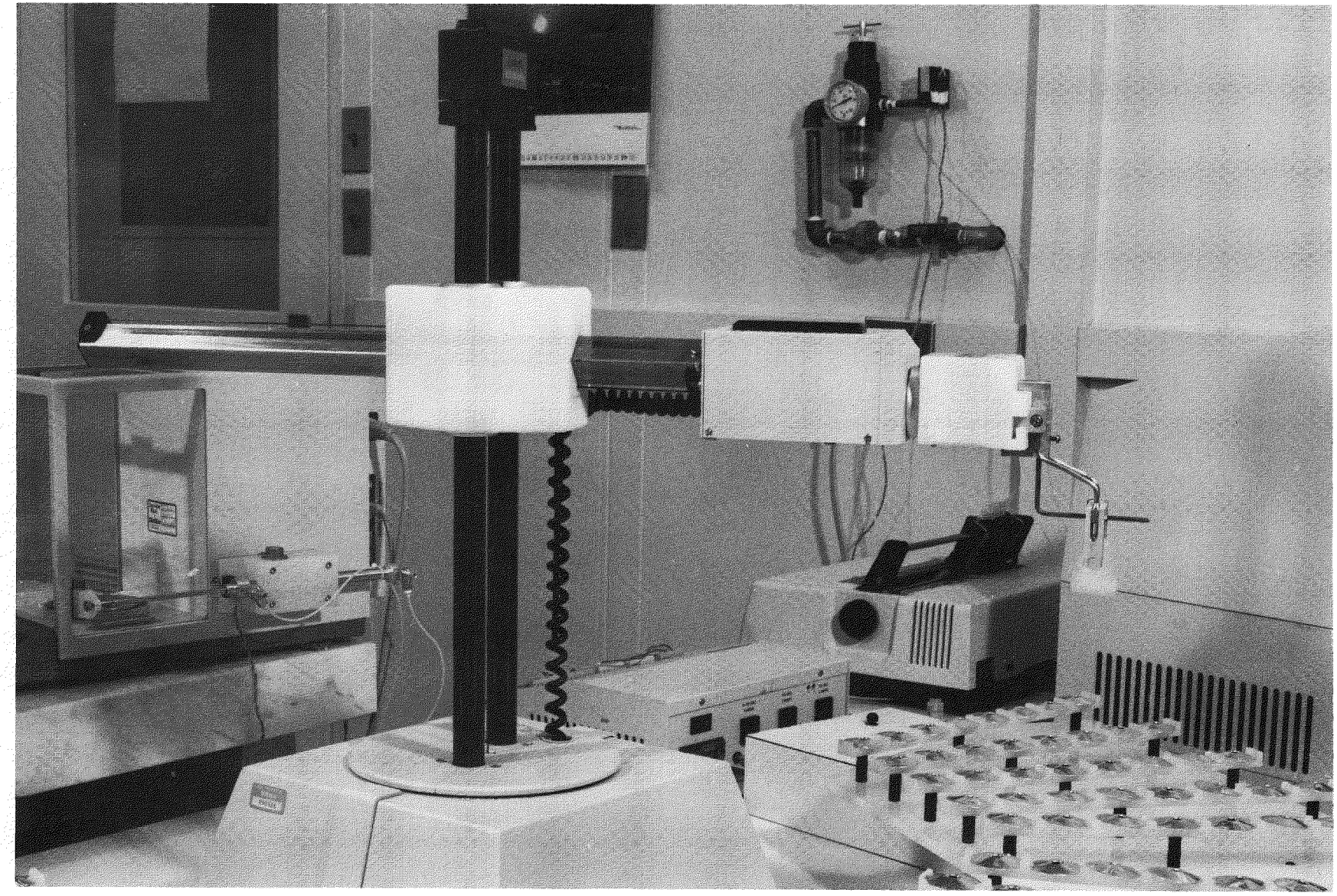

Figure 4. - Robotic arm.

robotic arm shown in Figure 4. All data cards are date stamped and sequentially numbered on the day of receipt using a Rapidprint[7/] Model ADN-E electronic stamping machine. Data cards with samples to be manually weighed are placed on the tray with the samples; while data cards with samples to be weighed automatically are sequentially assembled in the same order they are placed on the tray. Prior to weighing, samples are desiccated in a Webber Model F-3-AV vacuum chamber. The internal pressure of the chamber is reduced to 5mm Hg and held at that pressure for 15 minutes to remove moisture that may be present on the sample. After desiccation the samples are allowed to equilibrate in the weighing room for one hour before weighing.

In addition to verifying that the cassette number on the dust data card agrees with that printed on the cassette, samples and data cards are examined for irregularities. Questionable samples are normally voided. A list of reasons for voiding samples is shown in Table I. If the operator who submitted the samples suspects there may be a reason to void the sample, he may make written comments on the card. Cards with written comments and their respective samples are examined and voided, if appropriate.

WEIGHING OF SAMPLES

Since January 1985, approximately 70 percent of the respirable dust samples received from the coal mine operators' sampling program have been processed using an Automated Weighing System (AWS). The AWS, which is a robotic system consists of a Zymark Zymate Laboratory Automation System which has been designed for unattended weighing of filter capsules on a Mettler AE 163 analytical balance. The AWS is shown in Figure 5.

Movement of the central robotic arm is controlled by programs of recorded instructions. These programs consist primarily of instructions to move the robotic arm to exact locations on the laboratory bench. These locations are "learned" by manually moving the arm to the desired position, giving the location a unique name and storing the name in the computer-like controller. Programs are then written which can sequentially position the arm to a given series of preprogrammed locations simply by stating the location names. Programs are stored on magnetic disks which may be easily changed for different applications of the robotic system.

The robotic arm has the ability to rotate 360° around its central vertical axis. In addition, the arm may be made to move up and down the vertical axis as well as in and out from the horizontal axis. At one end of the robotic arm is a "hand" with a pair of gripping fingers which may be made to open and

7/ Reference to specific equipment, trade names or manufacturers does not imply endorsement by MSHA.

Table I. VOID CODES FOR RESPIRABLE DUST SAMPLES

ADB	Status is Abandoned
ANP	DA Not is Producing Status
BRK	Broken
CNR	Cassette Not Received
CON	Contaminated
CPN	Invalid Certification Number
DBN	Dated Before Citation
DIS	Discarded Sample (too old)
DNP	DWP Not is Producing Status
DNR	Dust Data Card Not Received
DTE	Invalid or Missing Data
EXC	Excess Sample
HLD	Hold
IMI	Invalid Part 90 Miner
INW	Invalid Initial Weight
IWS	Invalid Work Shift
MFP	Malfunctioning Pump
MIM	Cassette Did Not Match Card
MNP	Mine Not in Producing Status
NDO	Nondesignated Occupation
NON	Nonapproved Equipment
NSS	Part 90 Miner Not in Sampling Status
OCC	Invalid Occupation Code
OSP	Oversize Particles
OVE	Operator Void - Equipment
OVL	Operator Void - Location
OVP	Operator Void - Production
OVR	Operator Void - Rain
OVT	Operator Void - Time
OVM	Operator Void - Miscellaneous
PDT	Predated
PRO	Invalid Production
SAM	Invalid Sample Type
TME	Invalid or Missing Time
UNP	MMU Not in Producing Status
UWP	Unauthorized Work Position
WPE	Invalid Work Position

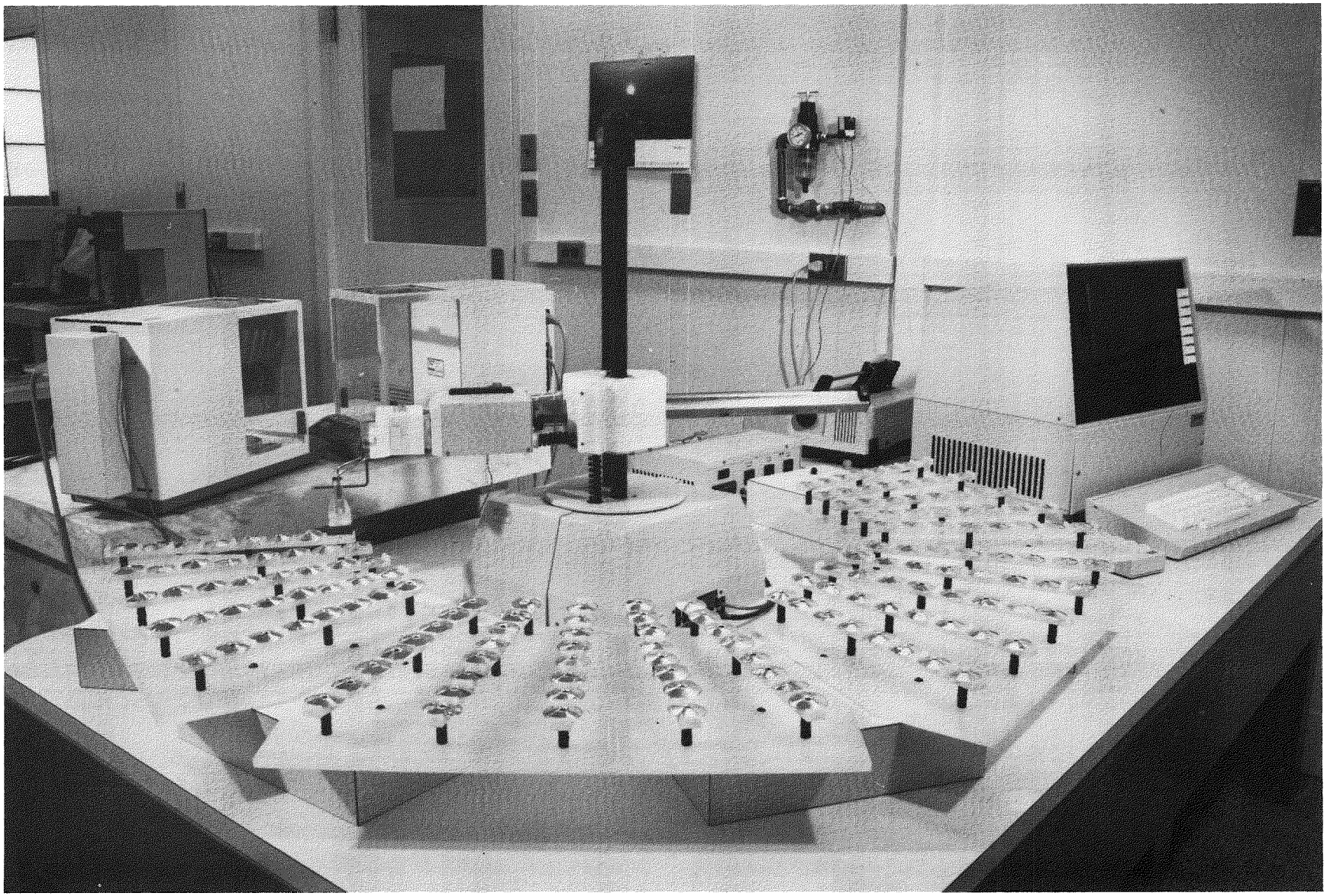

Figure 5. - Automated Weighing System.

close as well as rotate 180° in wrist-like movements around the arm's horizontal axis. The system is designed so that the robot can sequentially process up to 200 samples from five trays without manual intervention.

The computer-like controller is capable of being programmed to perform most mathematical functions (i.e., add, subtract, etc.) and to make logical decisions (i.e., test if quantities are equal, greater than, etc.). These functions allow the controller to perform calculations, perform tasks when required and branch to various parts of a program.

Tasks are performed by a power and event controller. In the AWS, the power and event controller is used to zero the balances before weighing each sample, switch a relay to select either of two balances, activate a solenoid to open and close a balance door and to sound an alarm buzzer when manual intervention with the AWS is required. Upon completion of a weighing, the computer controller activates a printer which prints the weight of each filter capsule and a sequence number on a 3/8" x 2" pressure sensitive label. The sequence number on the label is the same as the sequence number printed on each dust data card. The label is subsequently affixed to the data card.

One of two Mettler Model AE163 analytical balances which are used with the AWS is shown in Figure 6. This state-of-the-art analytical balance has a weighing precision of $\pm$0.02 mg. The balances are equipped with the optional Model 011 data output device which transfers the sample weighing result to the central AWS controller. Each balance is calibrated twice daily and checked with a Class M certified calibration weight. A radioactive deionizing unit is used to eliminate the presence of static charge on filter capsules. To isolate vibrations, the balances are positioned on a marble table weighing approximately 700 pounds.

The manual weighing system is the same as described in MESA IR 1045. Mettler HE20 balances, depicted in Figure 7, are used for weighing the filter capsules. These are semimicroelectronic analytical balances with electronic digital readout displays which provide a direct visual weight indication. The balances have a weighing precision of $\pm$0.05 mg. Balances are checked twice daily with Class M certified weights. To isolate the balances from vibrations, they also are positioned on marble tables weighing approximately 700 pounds.

A radioactive deionizing unit located in each balance chamber eliminates any static charges which might be present on a filter capsule. Balance zero is checked by the operator after five weighings, or less, to ensure the required precision in weighing is maintained. Mass determinations are made to a tenth of a milligram (0.1 mg). The weighing operation is shown on Figure 8. After recording the weight on the data card, the weigher initials the card.

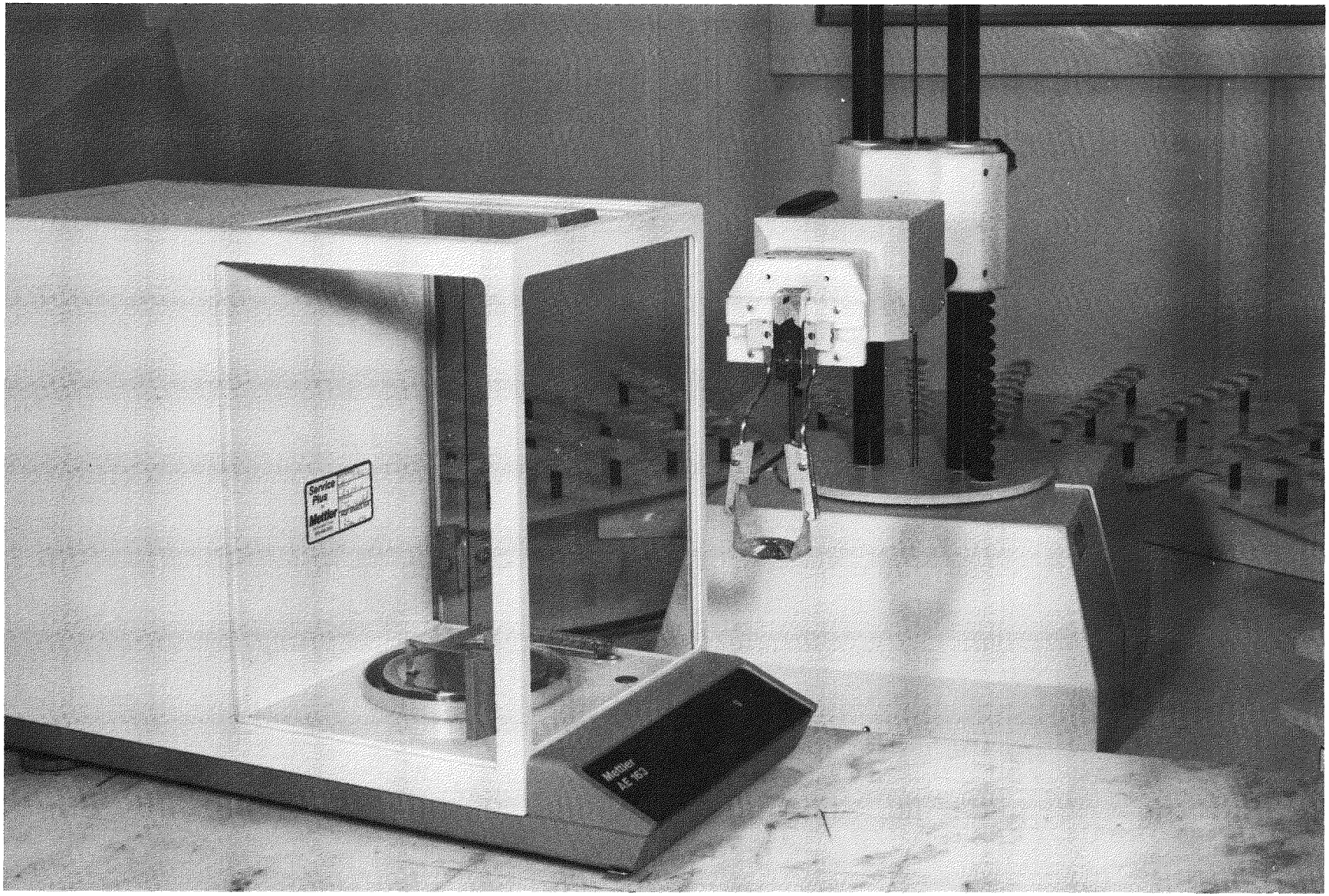

Figure 6. - Analytical balance used in Automated Weighing System.

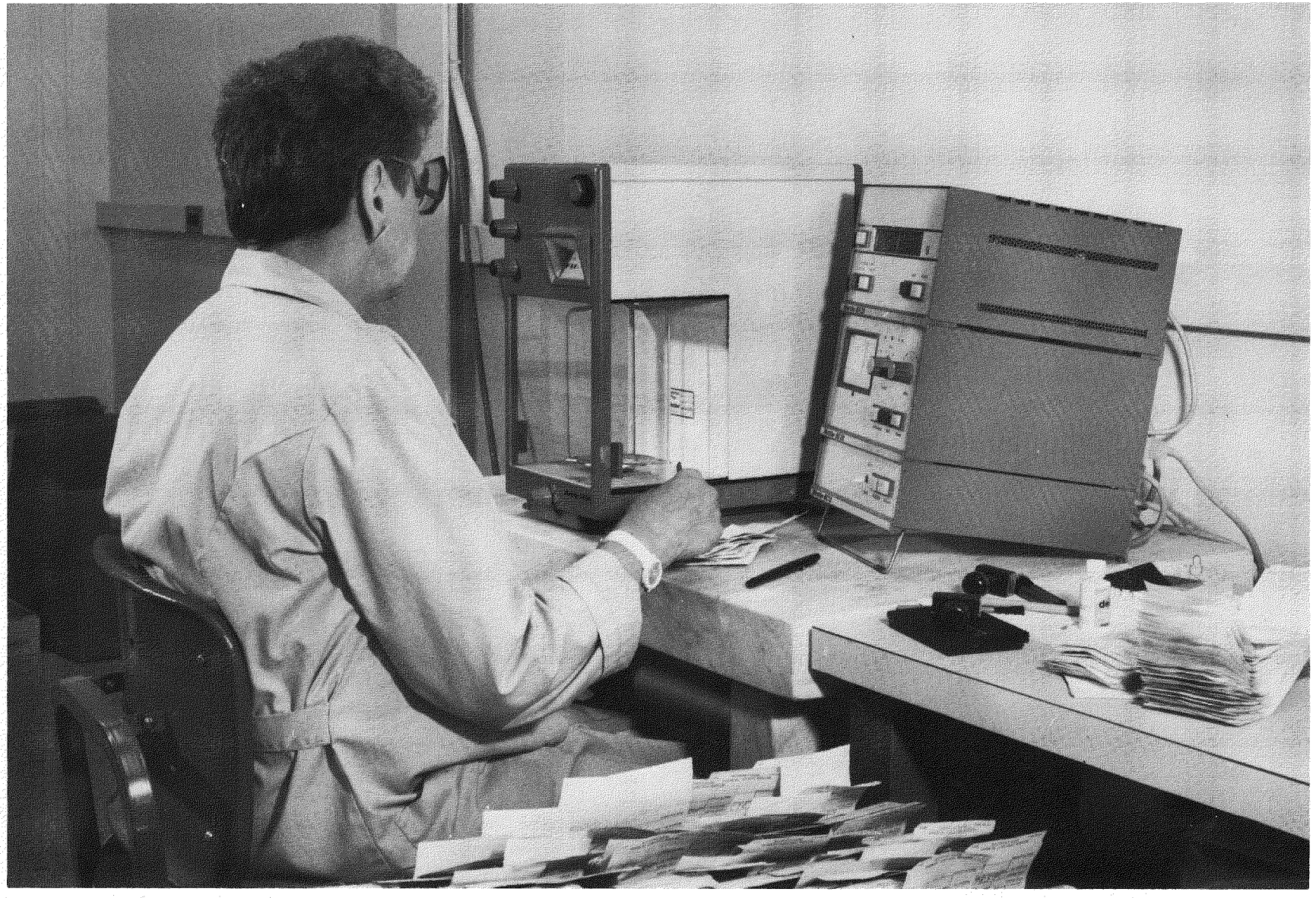

Figure 7. - Analytical balance used in manual weighing operation.

Figure 8. - Manual weighing operation.

All samples containing 6 milligrams or more of dust and any questionable samples are set aside. These samples are transported to a location in the laboratory where they are opened for examination in accordance with the procedure given in Standard Method A4, Weighing Branch, Pittsburgh Health Technology Center.

Basically a sample is considered contaminated when the filter's collection surface contains deposits of dust particles of nonrespirable size. This may be produced in the mine operator's sampling program by the dumping of the cyclone grit pot, faulty sampler operation or deliberate contamination. The following briefly describes the procedure used to examine samples for oversize particles:

1. Open capsule to expose dust-laden filter surface.

2. Observe filter surface under illumination with the light source at an angle of 45° to the specimen; large dust particles will generally show shiny surfaces. If large particles are present, the data card is marked with an appropriate void code.

3. If visual inspection is not conclusive, the sample is examined with a stereomicroscope at a magnification of 100X. The microscope eyepiece contains a Whipple disk which has been calibrated with a stage micrometer. After focusing on the dust, the filter is traversed and observed for particles having sizes greater than 10 micrometers. If 30 or more oversized particles are evident in 10 fields of 0.25 mm^2 each, the sample is invalid and the data card is marked with the appropriate void code.

QUALITY CONTROL PROGRAMS

The AWS has been programmed to systematically weigh a sample twice on two different Mettler AE163 balances. One filter capsule in each row of eight is reweighed on the second balance. If the weight difference obtained between the two balances is within $\pm$0.1 mg, the weighings are considered to be within tolerance and weighings are continued. Labels with both readings are affixed to the data card and the data card is stamped "checked". If the weights are out of tolerance, an alarm sounds and both balances are recalibrated. The system then reweighs the last seven filters, performs another quality control check weighing and continues processing additional samples, if the check weights are within the preestablished tolerance.

Samples weighed manually are trayed 100 to a tray. After the samples on a tray are weighed, eight of the samples are randomly selected and reweighed by a different person on another HE20 balance which is connected to a printer. Upon completion of the reweighing, the check weight is automatically printed on the back of the data card. If the check weight of any of the eight samples deviates by more than $\pm$0.1 mg from the handwritten weight on the front of

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Figure 10. - Data processing station.

DATA PROCESSING

As previously discussed, each respirable dust sample is accompanied by a mine data card (Figure 1). The data on each card in manually transcribed, in numeric notation, onto magnetic discs using IBM 3742 data entry stations. Each card contains 62 keystrokes or digits. Data transcription is verified using a double entry system. Data retranscribed by a second operator is compared to the originally transcribed data by the IBM 3742. The verifying operator is alerted to resolve errors or mismatched data. All disks generated during the day are then machine edited for completeness and accuracy using an IBM 3741 data station (Figure 10). The IBM 3741 is an "intelligent" unit that has limited programming capability. After editing, all data is accumulated onto one diskette and telecommunicated to MSHA's Information Systems Center in Denver, Colorado. The source data cards are then mailed to Denver, where they are stored for possible use in legal proceedings.

The information telecommunicated to the Information Systems Center in Denver, Colorado, is put on a Honeywell 66/80 Computer. After the close of business each day, a computer run updates the files and produces several output messages. These computer messages are generated and stored on disk files in Denver for retrieval the next morning at appropriate CMS&H offices. These messages are retrieved at the offices over Honeywell VIP terminals and are also mailed directly to the mine operators. A Honeywell VIP 7705R Keyboard Display Terminal is also available in the data processing section for on-line interactive entry of all dust data file information. The terminal is used for inquiries about data specific to respirable dust samples and for making corrections or updates based on data validity checks made at the Information Systems Center.

the card, then the balance originally used to weigh the tray is recalibrated and the entire tray of 100 capsules is reweighed. The cards of all eight samples which were checked are initialed and the bottom front area of the card is stamped "checked".

In order to assure that the weighing process continues to produce reliable measurements with the passage of time, a program is maintained to provide information about the quality of the weighing operation on a continuing basis. This program as developed jointly by MSHA and the National Bureau of Standards is described in detail elsewhere[8/]. In brief, the program consists of weekly weighing 10 samples on two different days, by two different people, on different balances. The statistical evaluation consists of subtracting the 10 weight pairs and calculating an average weight difference, "d", and a process standard deviation, "s". These data are updated quarterly and boundry limits for "d" and "s" are established. The results of the comparative weekly weighings are maintained in graph form in order to permit timely monitoring of the weighing process (Figure 9). If either of the "d" or "s" values fail to fall within the acceptable limits established for the weighing process, the entire weighing process is examined and results are not accepted until any problems are corrected and comparative weighings meet established quality control criteria.

Quality Control of Newly Manufactured Dust Cassettes

Federal Regulations (Title 30, Code of Federal Regulations, Part 74.3 (b)(2)(ii)) require that newly produced filter capsules be preweighed by the manufacturer to a precision of ±0.1 milligram. To ensure maintenance of this precision in weighing, MSHA requires that the manufacturer randomly select 10 filter capsules from each shift of production and submit them to MSHA for check weighing. Prior to check weighing, the capsules are heated at an elevated temperature of 120°F for 16 hours. Following this heat treatment, the capsules are allowed to stabilize in the weighing room's controlled environment for four hours before weighing. If the weight of any one unit falls outside the specified limits (greater than ±0.1 mg), the maufacturer is notified to reweigh all filter capsules produced during that production shift and submit 10 additional randomly chosen filter capsules for reevaluation. A shift production is not approved for distribution to the mining industry until all 10 of the check weighed filter capsules meet the specified requirement.

8/ P. Parobeck, T. Tomb, H. Ku and J. Cameron. Measurement Assurance Program for Weighings of Respirable Coal Mine Dust Samples. Journal of Quality Technology, V. 13, No. 3, July 1981, pp. 157-165.

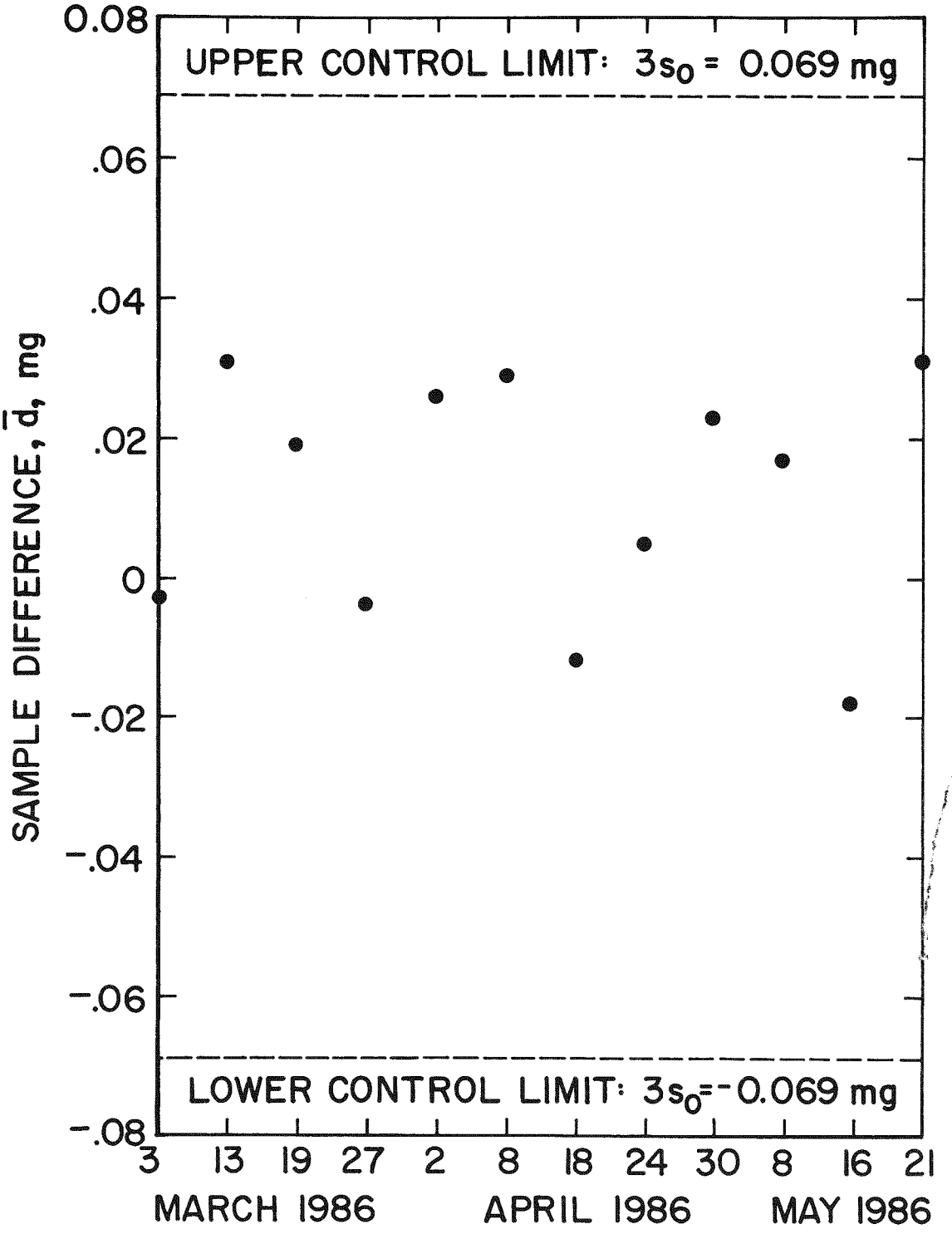

Figure 9B. - Quality control chart of sample difference.

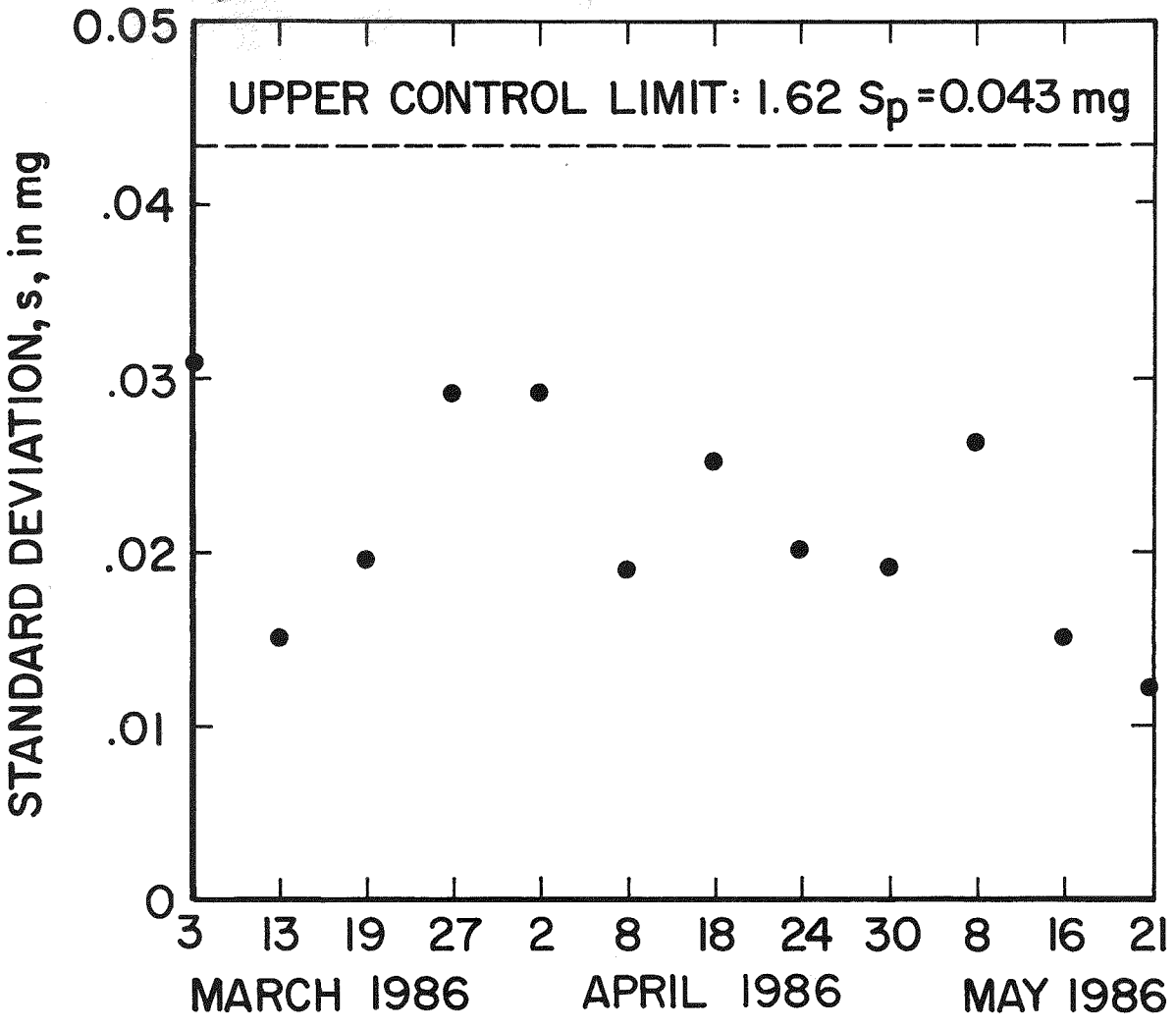

Figure 9A. - Quality control chart of standard deviation.