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DEVELOPMENT AND EVALUATION OF AN AUTOMATIC FRAGMENT-WEIGHING AP--ETC(U)
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REPORT

MRL-R-803

DEVELOPMENT AND EVALUATION OF

AN AUTOMATIC FRAGMENT-WEIGHING APPARATUS

N.M. Burman

Approved for Public Release

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C O N T E N T S

* * *

DEVELOPMENT AND EVALUATION OF AN AUTOMATIC FRAGMENT-WEIGHING APPARATUS

1. INTRODUCTION

Readily-available access to computer facilities has markedly increased the ease of analysing explosively-produced fragmentation data [1-2]. However, the generation of these data by the manual weighing of large numbers of small fragments is not only tedious and time consuming, requiring extreme care and patience on the part of the operator, but is also very wasteful of manpower especially since this type of repetitive procedure readily lends itself to automation.

Although automatic and semi-automatic fragment weighing systems have been successfully built and operated overseas, specific constructional information was unobtainable and a system for MRL was consequently designed and built to incorporate existing weighing equipment. The need to use these existing facilities in the most economical manner has led to a reasonably simple automatic weighing facility which produces results which compare favourably with those obtained manually.

2. EXPERIMENTAL DESIGN AND OPERATION

Assessment of a material's fragmentation performance is evaluated at this laboratory by the computer analysis of the incremental cumulative weighing of fragments recovered after the firing of explosively-filled cylinders. The maximum cylinder size which can be tested in the available fragmentation facilities is dictated by a limit on explosive charge weight of 500 g. This limitation to the use of relatively small cylinder sizes, (i.e. compared to most full size shell), and the consequent detrimental effect on the assessment of fragmentation performance of even small losses of fragments, accentuates the need for both maximum fragment recovery and accurate weighing.

The development of an automated method of cumulative fragment weighing which produces results consistently as accurate and reproducible as those

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The development of an automated method of cumulative fragment weighing which produces results consistently as accurate and reproducible as those generated by the manual method, while apparently simple in concept, was beset by several practical constructional difficulties. These difficulties were mainly attributable to the large variation in size and geometry of the fragments and the need to separate and feed each of the fragments singly onto the balance for weighing.

The previously-used manual method of fragment weighing was based on a Mettler P1200 Electronic Balance interfaced to a Teletype printer, paper-tape punch/reader via a Mettler C10 Data Transfer Unit. In this mode, an operator used a push-button switch to provide the weight transfer command after placing each fragment on the balance pan. The printer-punch then recorded the new cumulative weight value as hard copy and punched paper tape, the latter providing the input for the computer sorting programs. In an automatic system, the fragments must be separated from each other, individually conveyed to the balance pan, and the new cumulative weight measured and recorded prior to the arrival of a new fragment. After evaluating several types of system, a combination of a sorter based on a Syntron vibrator and a long rotating tube was selected as the most effective technique for separating and feeding the fragments to the balance pan

Fragments introduced into the vibrating sorter are forced to travel slowly upwards along an ascending spiral path. Fragments are separated by using mechanical gates which return a proportion of the fragments to the start of the spiral. Fragment feed rate from the spiral can be further controlled by the amplitude of vibration of the spiral (speed of fragment ascent) as well as the variation of operating duty cycle, i.e. separately variable switch on and off periods. The circuit diagram for the variable duty cycle timer is shown in Figure 1.

On being ejected from the vibrating spiral, the fragments pass into a downward inclined variable-speed rotating tube which is intended to not only disentangle any fragments which may still be locked together after their passage through the vibrating spiral but also to align and separate the fragments along the length of the tube for individual presentation to the balance. Variable speed drive to the rotating tube is provided by a stepping motor and associated electronics (Figure 2).

During the initial trials of the automatic feeding system difficulties were experienced due to mechanical interlocking of and insufficient separation of the fragments, resulting in multiple weighings. These problems were minimized by the correct selection of feed rates and spiral sorter vibration amplitude, and by the inclusion of mechanical gates. However, the problems could not be completely eliminated, although repeated trial runs showed that the incidence of multiple fragments was normally less than 3 to 4% of the total number of fragments weighed.

The fragments pass through a light beam sensor onto the balance pan when they fall from the end of the rotating tube. The passage of a fragment activates the light beam sensor circuit and, after a finite delay to allow for balance stabilization, initiates the weighing and recording process. Additionally, activation of the light beam sensor circuit produces a signal which prevents the operation of the spiral vibrator and rotating tube, and consequently the feeding of any further fragments to the balance pan while a weighing and/or weight value transfer and recording is in progress. Figures 3 and 4 are diagrams for the light beam sensor and associated circuitry. A schematic diagram of the feed and weighing equipment and a photograph of the actual facility are shown in Figures 5 and 6 respectively.

Preparation of recovered fragments for automatic weighing is performed in two stages. Because of the relatively small cylinder sizes used, the number of fragments heavier than 1 g is usually small and are firstly removed by sieving; they are then individually weighed manually. Fragments weighing less than 1 g are sieved to remove fines less than 0.05 g which are weighed en masse, the remainder being fed into the vibrating spiral sorter for automatic weighing. The limited fragment size range 0.05 - 1 g normally allows the use of a single light beam sensor although, if required, a range of larger bore size sensors is available.

2.1 Comparison of Automatic and Manual Weighing Trials

To test the accuracy and reproducibility of the automatic weighing equipment, the results of the automatic and manual weighing of fragments from three explosively tested cylinders were compared. Figures 7, 8 and 9 show the variation of fragment numbers with mass group for these trials. Although there are some differences in the numbers of fragments in any mass group, particularly in the low mass ranges, the overall comparison is in acceptable agreement. This agreement is further illustrated by the Modified Payman Parameters [3] derived from each of these data, as shown in Table 1. Under normal circumstances, deviations of ± 10-15% are expected in these parameters, for geometrically similar cylinders tested under identical conditions, and the above results fall well within this expected natural variation. The major cause of error in fragment numbers produced by the automatic method is the production of multiple fragment weighings, especially in the very fine fragment sizes. Further refinement of the equipment is continuing in an effort to solve this problem.

3. SUMMARY

An automatic fragment-weighing facility has been built and shown to perform its function to an acceptable level of accuracy. A drawback to the automatic weighing system is a threefold increase in throughput time as compared to the manual method, but this is heavily out-weighed by the ease of operation and the manpower savings.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

1. Krauklis, P. and Bedford, A.J. (1974). "Fragmentation Data Analysis I. Computer Program for Mass and Number Distributions and Effects of Errors on Mass Distributions".

2. Bedford, A.J. and Krauklis, P. (1976). "Fragmentation Data Analysis II. Computer Programs for Fragmentation Analysis and Effects of Errors on Mass and Number Distributions". MRL Report 666.

3. Bedford A.J. (1975). "Scaling of Fragmentation". MRL Report 624.

COMPONENTS OF MAJOR EQUIPMENT PARTS

SECTION NUMBERS 1-4 REFER TO COMPONENTS IN FIGURE 6

1. VIBRATOR SPIRAL FEED

   (a) Ascending circular spiral

   (b) Syntron M14 Vibrator

   (c) Electronic Timer

   CONTROLS

   (a) Mechanical gates on spiral

   (b) Variable amplitude on vibrator

   (c) (i) Continuous operation or

   (ii) variable on-time and variable period between switch on.

   (d) Both c (i) and (ii) operation can be controlled by TTY/balance delay/ready instruction.

2. SPIRAL TUBE FEED

   (a) Long tube

   (b) Motor drive

   CONTROLS

   (a) Tube speed

   (b) On/off operation can be controlled by TTY/balance delay/ready instruction.

3. FRAGMENT SENSOR

   (a) Sensor Tube (3 bore sizes)

   (b) Light beam/sensor array and associated electronics.

   CONTROLS

   (a) Variable delay between sensing fragment and balance weighing mode initiation.

4. METTLER P1200 BALANCE

5. METTLER CT10 DATA TRANSFER UNIT

6. STC TELETYPE

TABLE I

MODIFIED PAYMAN PARAMETERS DERIVED FOR AUTOMATIC AND MANUAL WEIGHING OF FRAGMENTS FROM THREE CYLINDERS

CYLINDER	MANUAL	AUTOMATIC
55-3-D	550	560
55-6-D	345	320
55-7-D	145	140

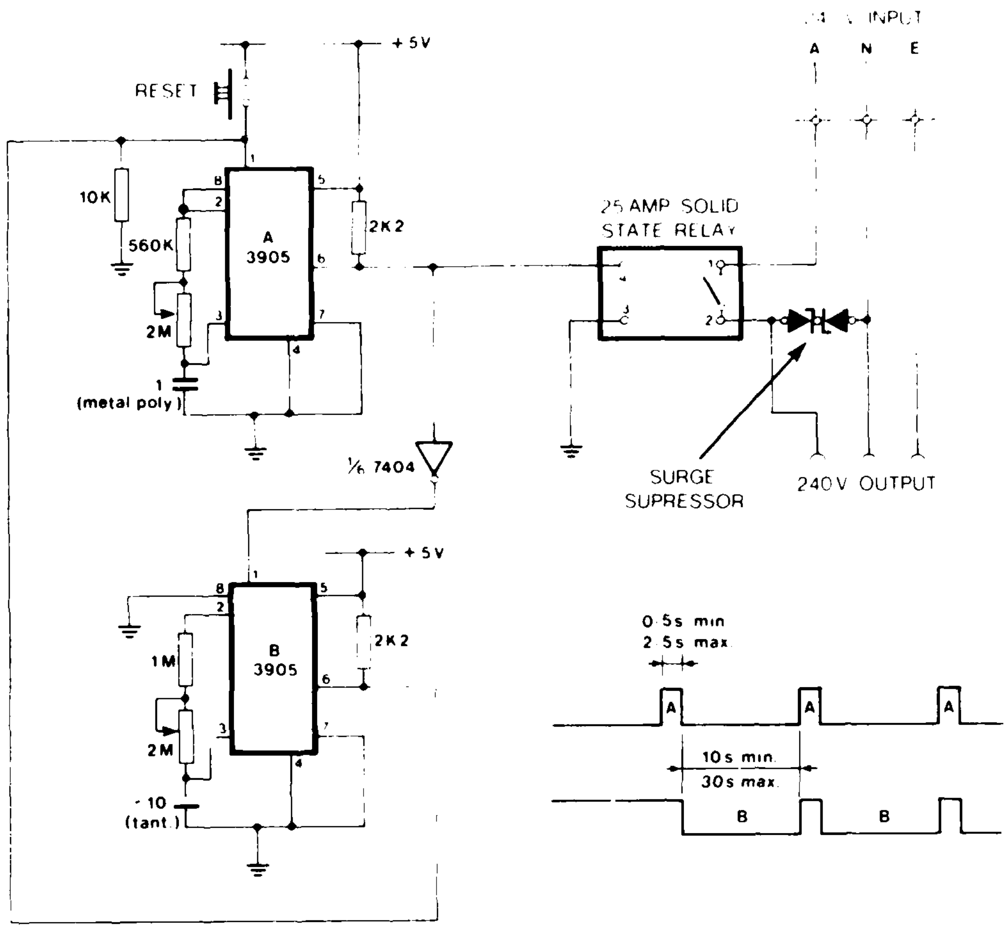


FIG. 1 - Circuit diagram of variable duty cycle timer for the
vibrating spiral sorter.

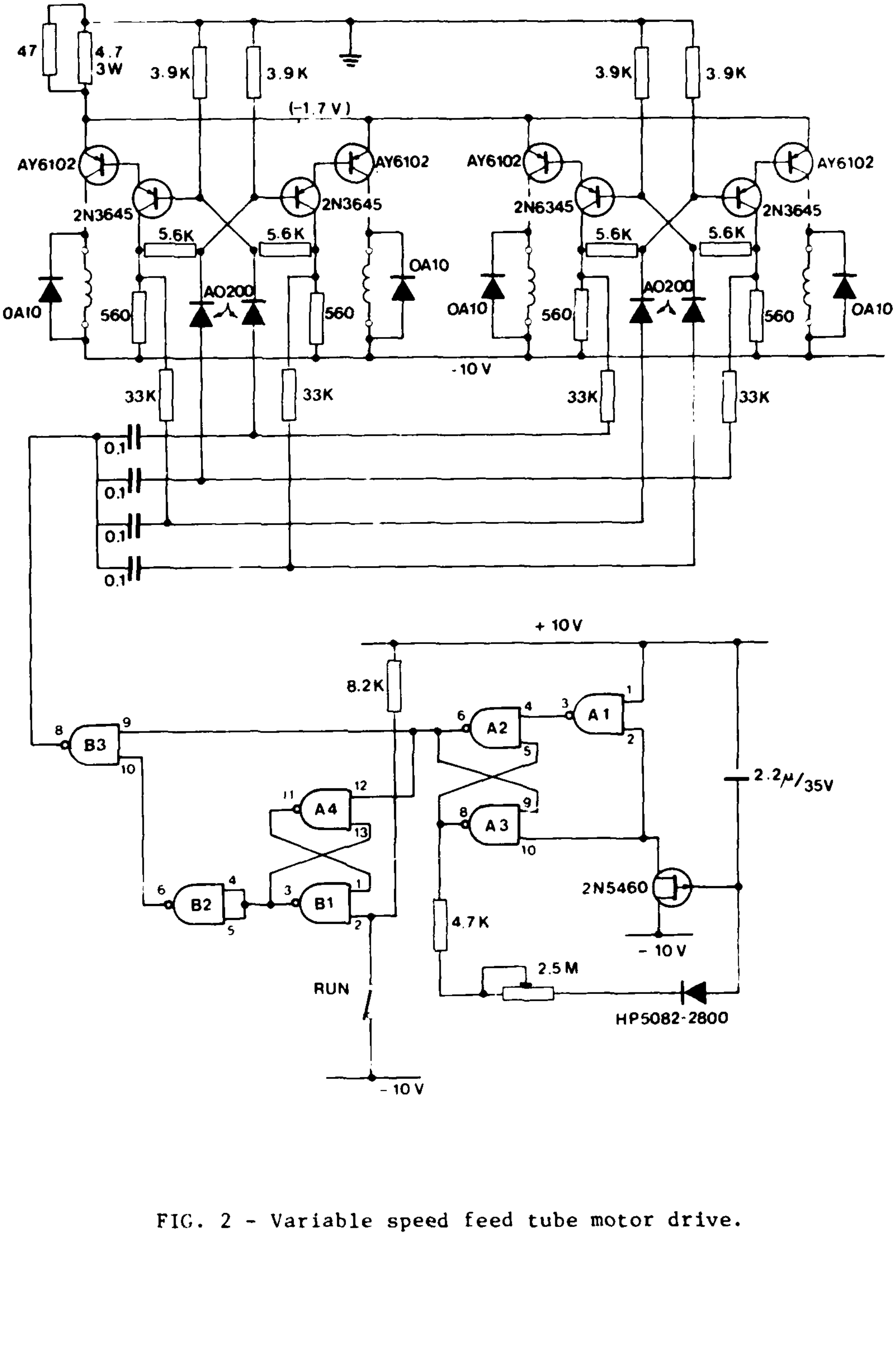


FIG. 2 - Variable speed feed tube motor drive.

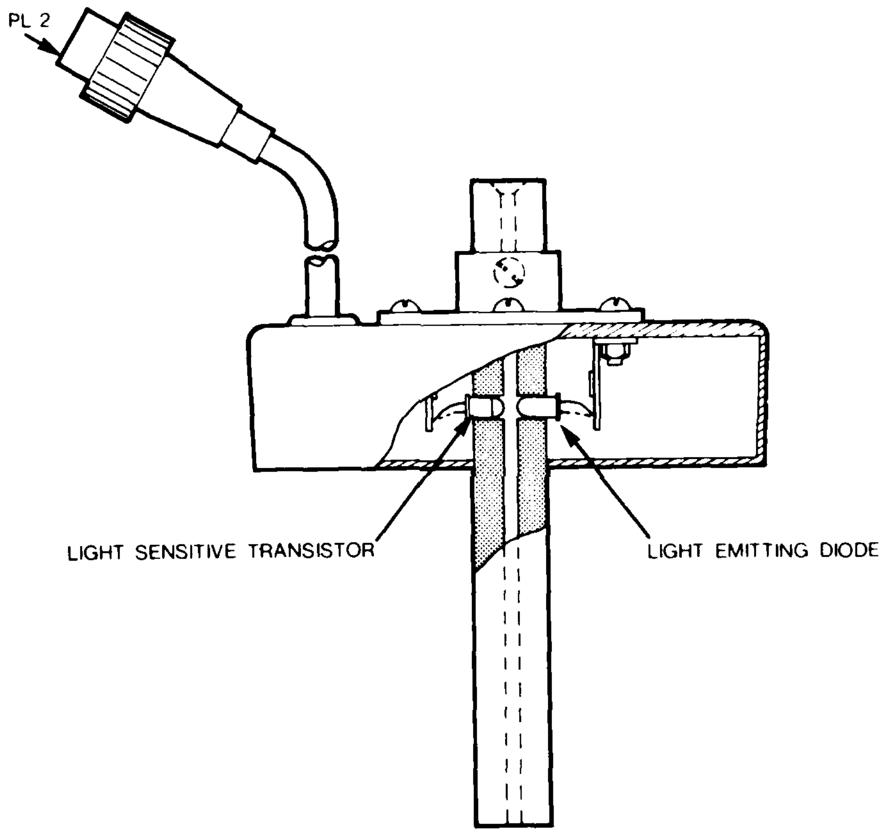


FIG. 3 - Light beam fragment sensor.

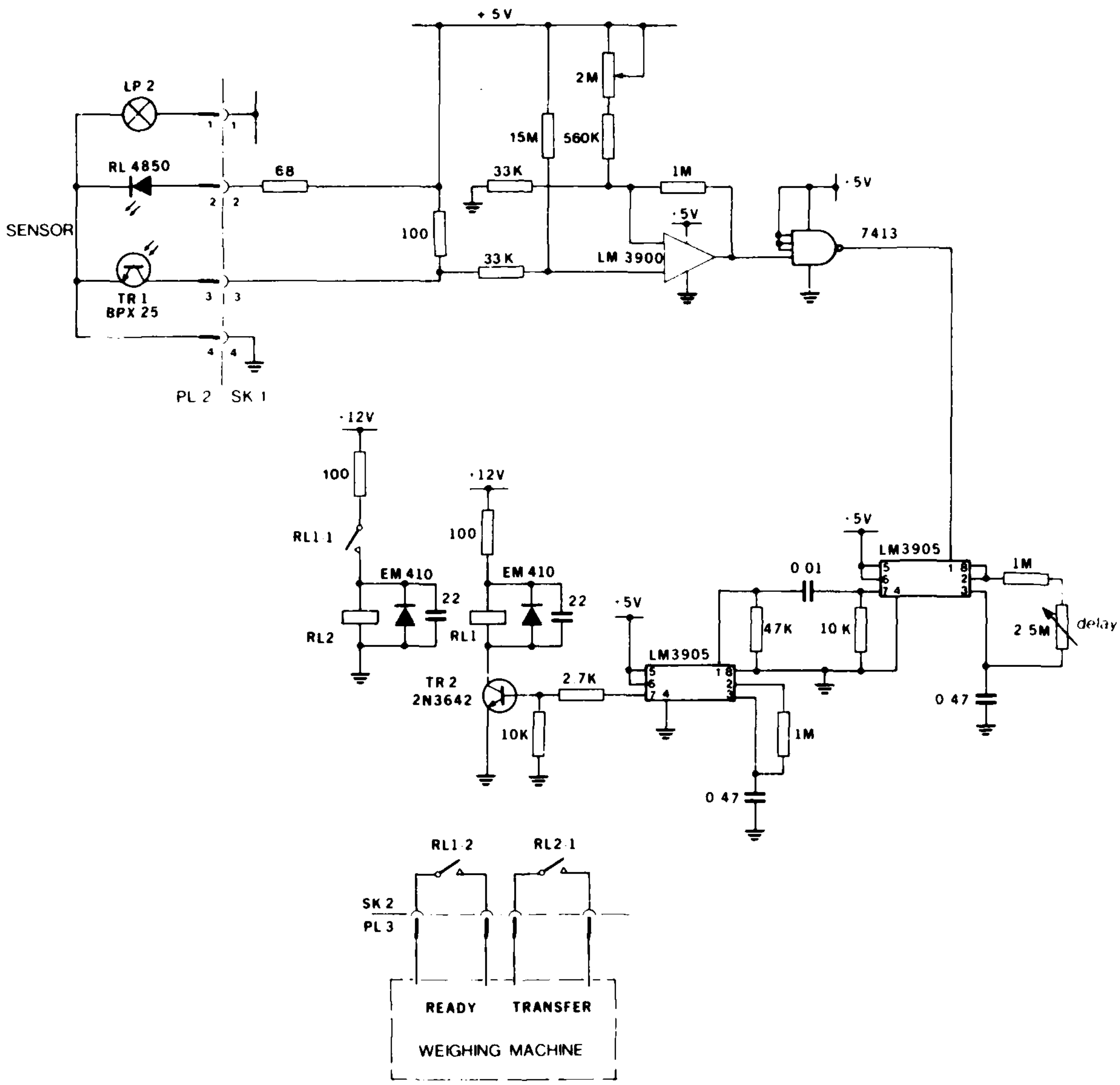


FIG. 4 - Fragment sensor and data transfer circuitry.

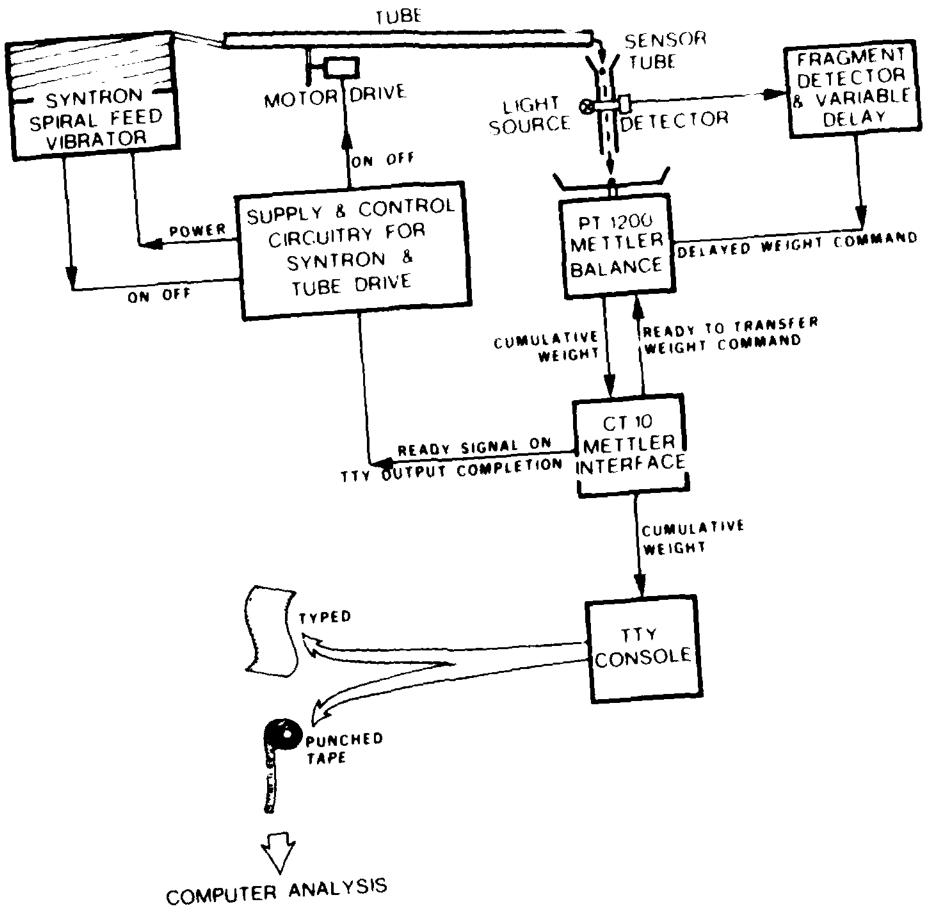
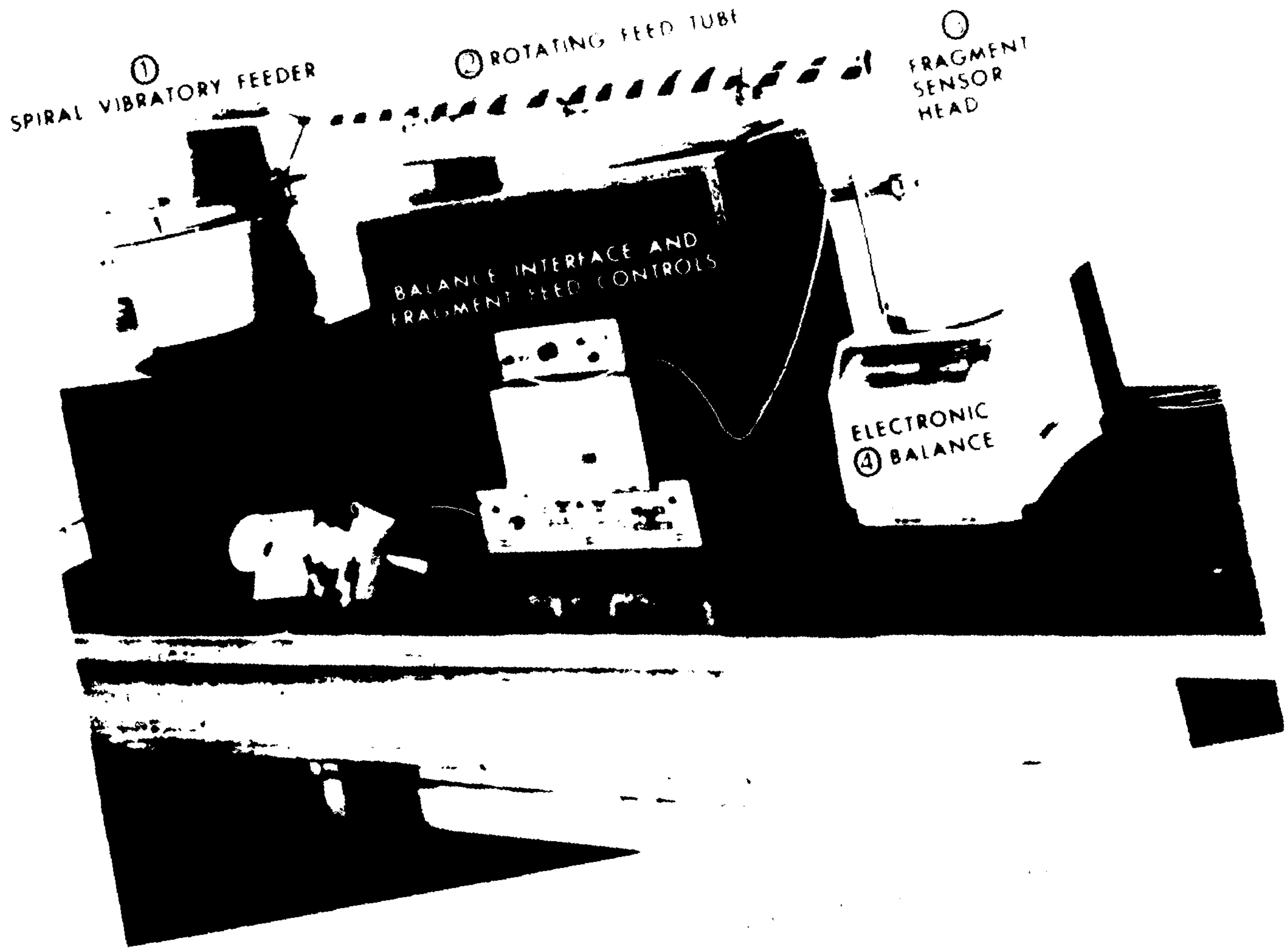


FIG. 5 - Schematic diagram of automatic fragment weighing machine.


① SPIRAL VIBRATORY FEEDER
② ROTATING FEED TUBE
FRAGMENT
SENSOR
HEAD
BALANCE INTERFACE AND
FRAGMENT FEED CONTROLS
ELECTRONIC
④ BALANCE

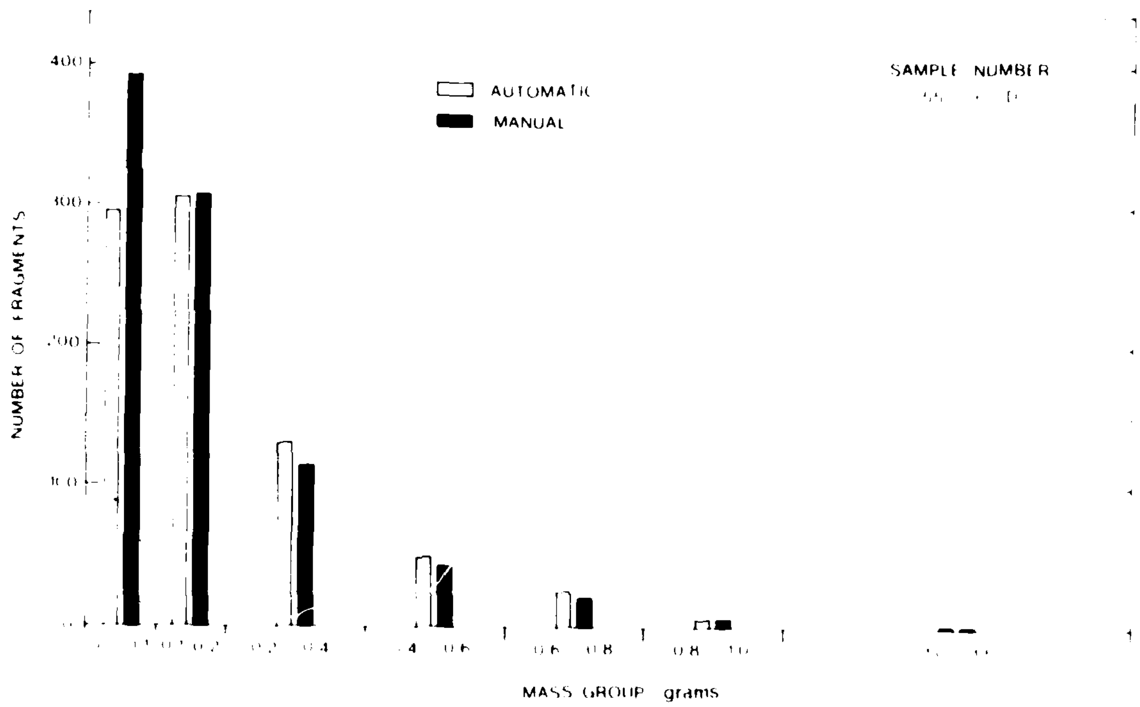


FIG. 7 - Comparison of manual and automatic fragment counts in individual mass groups for cylinder 55-3-D.

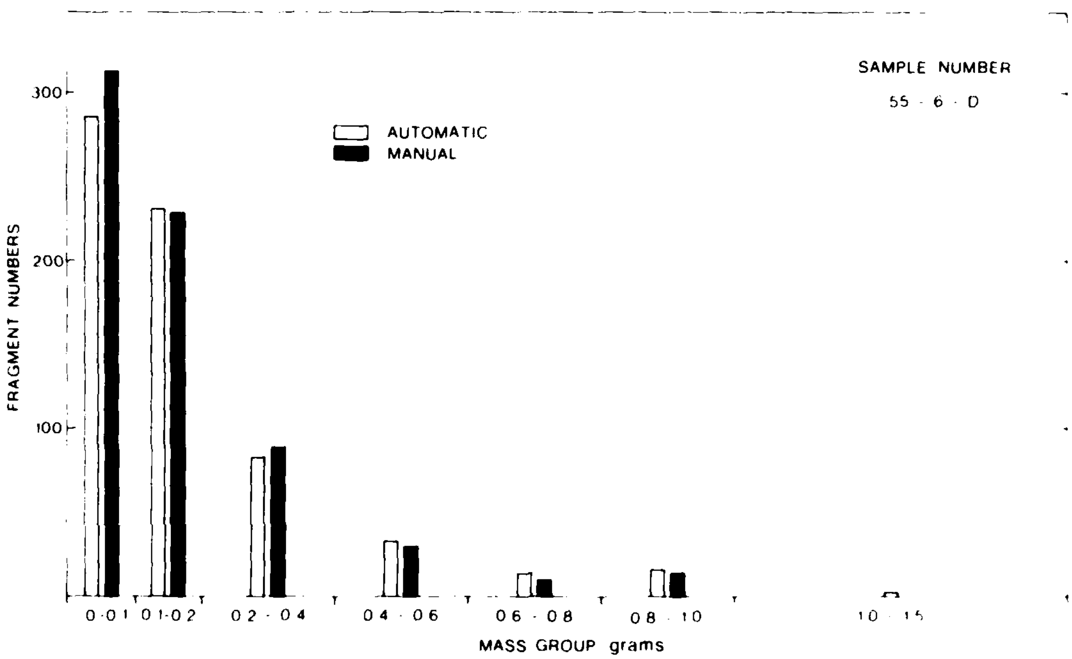


FIG. 8 - Comparison of manual and automatic fragment counts in individual mass groups for cylinder 55-6-D.

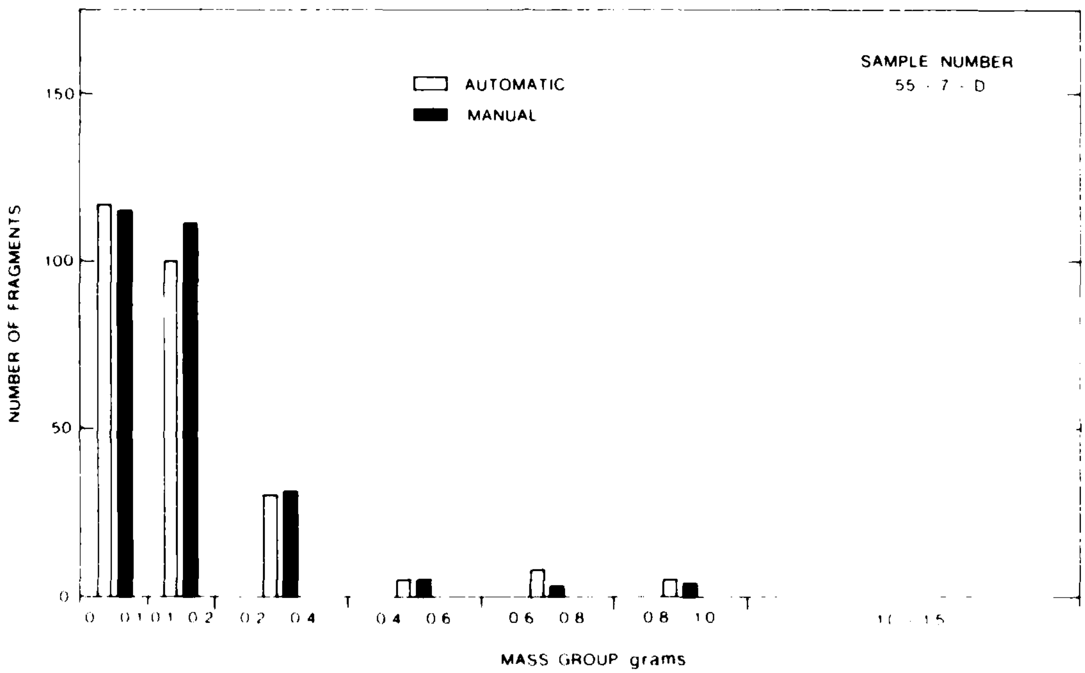


FIG. 9 - Comparison of manual and automatic fragment counts in individual mass groups for cylinder 55-7-D.

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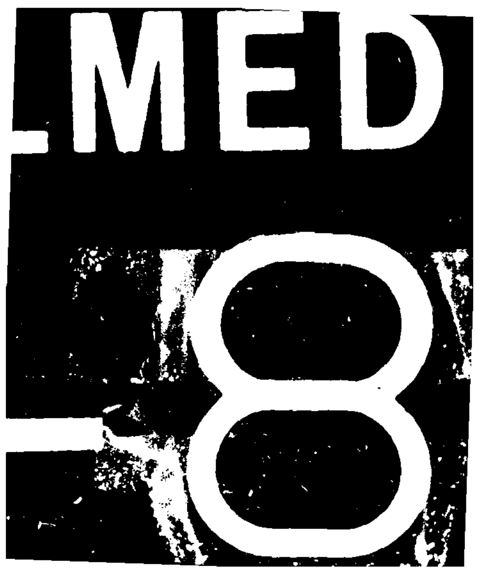
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