A MARIGRAM SCANNER

by Robert H. PAYNE, Jr.
Physical Oceanographer, U.S. Coast & Geodetic Survey

ABSTRACT

The mounting volume of work connected with processing marigrams forced attention on the need for mechanization of the operation. In attacking the problem there were two courses open. One of these was to change the entire system from the tide gauges in the field to the paper work in the main office in Washington. The cost of making this conversion in one step would have been enormous, and it was impossible to plan the conversion and budget the money in a reasonable time. The alternative course of action which promised more immediate results from a much smaller investment of manpower and money was chosen. This alternative course was to mechanize certain selected steps in the present system. The first step selected was the slow manual work of scaling, writing and summing the hourly heights from the marigrams.

The Division of Tides and Currents and the Instrument Division of the Coast and Geodetic Survey worked together to design and build a machine which has proved to be helpful in reducing the handwork which was necessary. The machine does the printing and summing of the hourly heights while the operator guides a curve follower along the tide curve. The operator initiates the printing and summing operation by pressing a button as the curve follower reaches each hour mark.

The four major components of the machine are joined by an electrical circuit which makes them function as a unit. Those components are : (1) The curve follower. This device consists of the paper feed, datum setting and adjustment mechanisms, the pencil screw and hairline indicator, and the scale-selector gears. (2) The analog to digital converter. This device converts the position of its input shaft to digital form. The reading is done through its switch contacts. (3) and (4) The adding machine and typewriter. Both of these machines have solenoid-equipped keyboards for remote operation. The typewriter may be used for normal typing without any change. The adding machine could be converted for manual use by removing the block of keyboard solenoids and adding the standard keyboard and keys.

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Since its development many years ago the standard automatic tide gauge has been used by the Coast and Geodetic Survey to record the rise and fall of the tides. In this gauge the rise and fall of the tide operates a

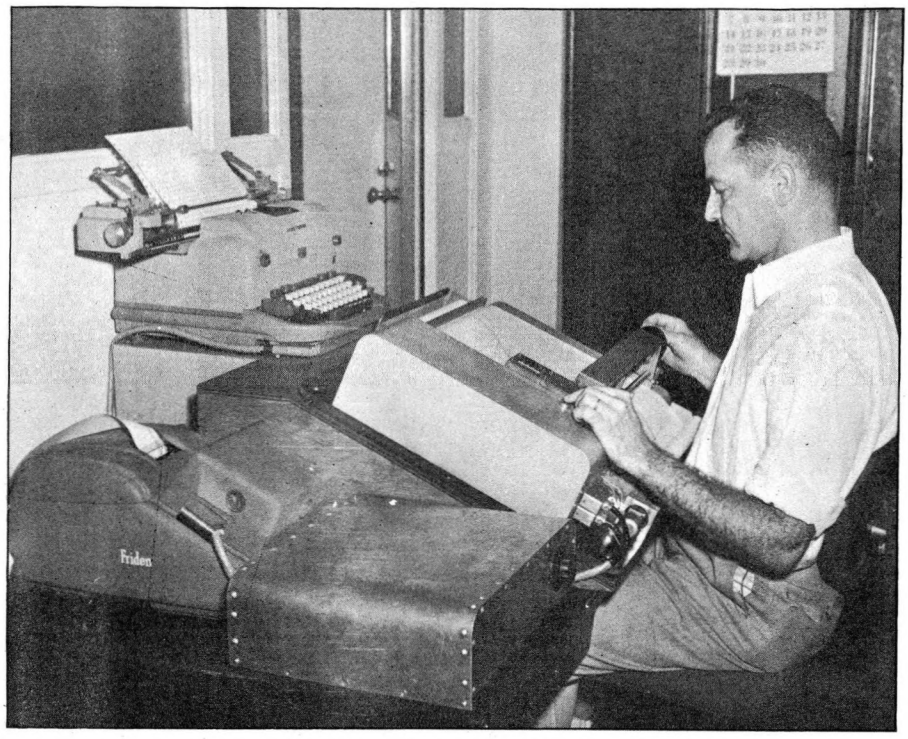

FIG. 1. — Marigram Scanner in Operation.

The operator is guiding the curve follower along the tide curve by turning the hand wheel with his right hand. His left hand is resting on the speed-control knob and the read-out button. The large knob on the front of the box in the front center of the picture is the hour-counter knob.

worm screw which moves a pencil to and fro across a wide strip of blank paper. At the same time this paper is being moved forward at a constant rate by clockwork. The combined motions of the pencil and paper give a continuous graph showing the rise and fall of the tide for periods of one month. After the tide curve has been traced upon the tide roll the record is called a marigram.

Until recently all tidal data from the marigrams were scaled, written and summed by hand. The number of marigrams to be processed by the Coast and Geodetic Survey increased considerably as more and more tide gauges were installed to meet the needs for additional tidal data. The increasing work load demanded that some way to reduce the manual work be devised. A study of the problem led ultimately to the construction of an electro-mechanical device which enables an operator to scan a marigram and quickly tabulate and sum the hourly heights. This device, now known as the Marigram Scanner, is made up of a curve follower, an analog-to-digital converter, an electric typewriter, an electric adding machine and the electric circuit needed to make these components operate as a unit.

The Marigram Scanner has been in use for one year and the results of its use indicate that there is a worthwhile saving in man-hours while still maintaining the accuracy demanded in the work.

Before making the decision to build the machine at the Coast and

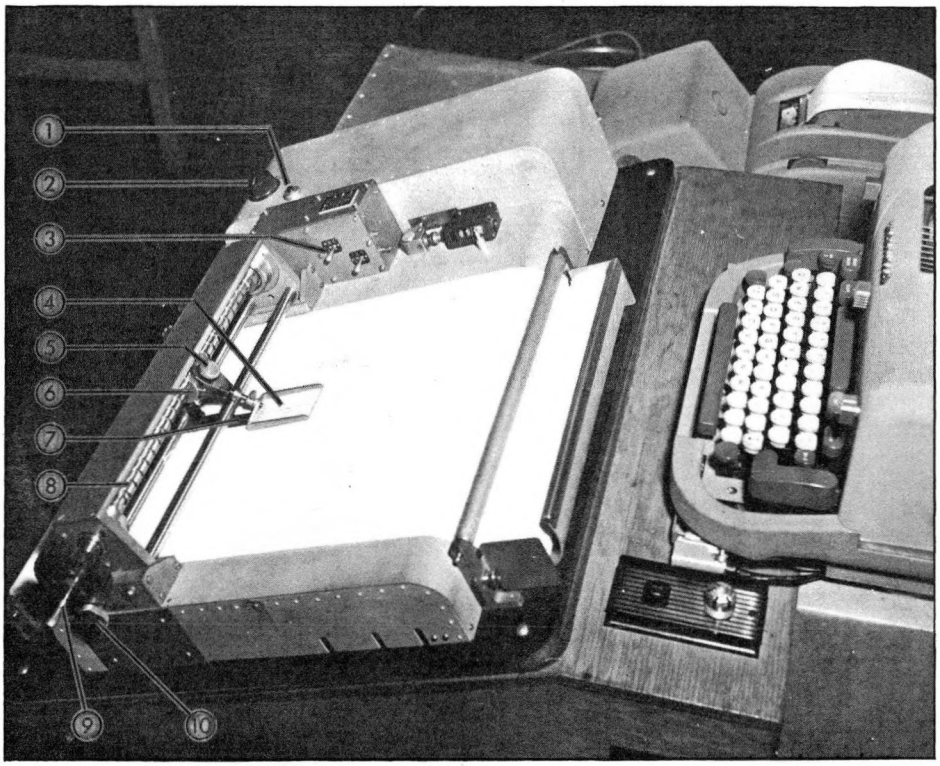

FIG. 2. — Locations of the Controls on the Marigram Scanner.

(1) Read-out button. (2) Paper-feed speed control knob. (3) Scale-selection levers. (4) Hairline curve follower. (5) Hairline-adjustment locking screw. (6) Hairline-adjusting wheel. (7) Datum-line follower. (8) Pencil screw. (9) Hand wheel. (10) Datum-follower adjusting screw.

Geodetic Survey facilities, we examined a number of instruments which were available on the market. The work of processing marigrams, however, has some peculiarities which would have made modification to those machines too costly.

Over a period of years the people engaged in the work had informally discussed and enumerated the features which were necessary for a machine to do the work. These features were used by the designers as a guide in translating the ideas into actuality. During the period that the design was taking shape, there was a tendency on the part of everyone concerned to add extra capabilities to the design. While these extra capabilities were considered desirable, we decided to base the design on necessities and leave the luxuries for subsequent models. Since freezing the design and building the machine, some ways to simplify the design have been noted and they too will be incorporated in later models when and if they are built. The useful life of the Marigram Scanner machine is not expected to be more than a few years, as the conversion to another system of recording will offer many advantages over the present procedure. Basically the machine is about as simple as it can be and still do the job. The operation follows closely the steps of the manual method and achieves a speedup through simultaneous performance of activities.

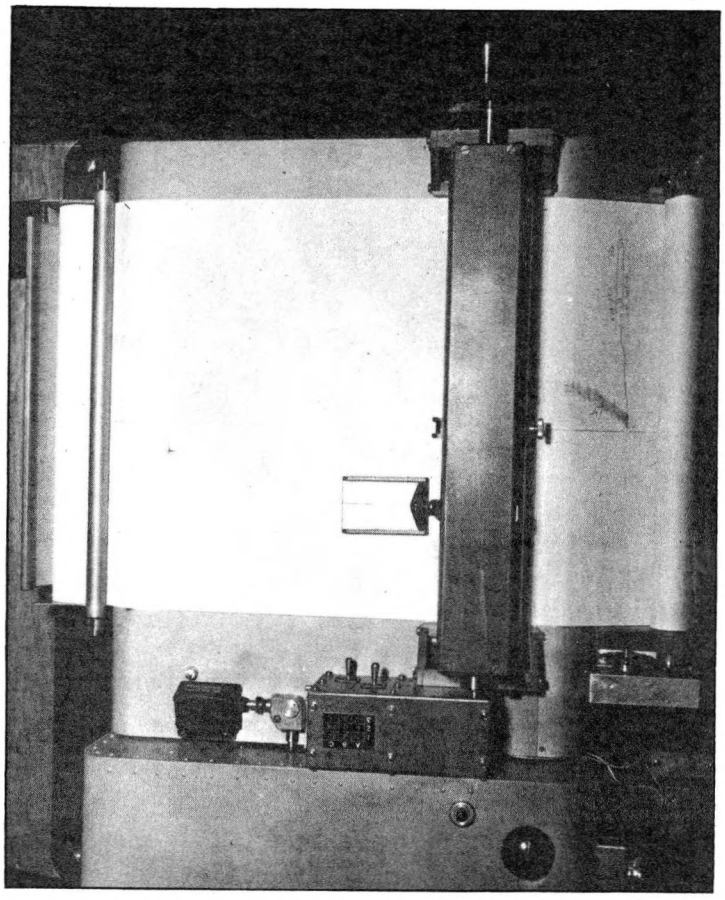

FIG. 3. — View on the Marigram Scanner from the Operator's Position.
The speed-control knob and read-out button are at the left. The curve-follower hairline is positioned over the tide curve and the datum-line follower is aligned with the datum line.

One of the major components of the Marigram Scanner is the curve follower. The heart of the curve follower is a pencil screw from a standard tide gauge. Turning a small hand wheel on the pencil screw moves a hairline pointer in a motion similar to that of the pencil on a standard tide gauge. The amount of rotation of the pencil screw which is necessary to position the hairline on the hour mark is interpreted by the digital converter as a three-digit number.

Between the pencil screw and the digital converter is a gearbox which permits selection of any of the scales normally used in recording marigrams.

An adjusting screw was incorporated which can move the pencil screw back and forth along its longitudinal axis. The datum-line follower moves with the pencil screw and allows the operator to compensate for any wandering of the datum line. This was necessary because the datum line is the base for the measurement of each of the hourly heights and it tends to wander a small but still significant distance from its original position.

The marigram is pulled across the working area and onto a takeup

spool by an electric motor. The speed of this motor and, therefore, the speed of the paper travel is controlled by the operator. The paper speeds which are available run from zero to about two inches a second.

At the start of each marigram the machine must be set to read the correct value of the datum line when both the hairline and the datum-line follower are positioned on the datum line. This setting is accomplished by rotating the hand wheel to achieve the correct reading at the digital converter then adjusting the hairline to coincide with the datum line.

The input shaft of the digital converter is turned by the shaft from the scale-selector gearbox. The rotation of the input shaft of the digital converter turns its coding drums. When the read-out solenoid is energized the sensing blocks containing the sensing pins and contacts are pulled down against the coding drums. The sensing pins *feel* the *hills, plateaus* and *valleys* on the coding drums and make circuits through the contacts to read out the correct value of the tide height. The contacts are grouped in sets of ten with each set representing the ten possible digits for one column or place in the read-out. Each contact is wired directly to the actuating coil of one individual relay which will set up the circuit to the adding-machine and typewriter-keyboard solenoids.

When the sensing blocks approach the drum they may find the drums in such a position that they will be between two digits. In this case, a detent pin mounted on the units digit-sensing block will force the drums to rotate a small amount to the nearer of the two digits.

After the read-out is completed the read-out solenoid returns to its relaxed position, the sensing blocks move away from the drums and the drums are free to turn to the position of the next reading. The input shaft of the digital converter has a lost-motion coupler which permits the drums to be locked for the read-out while the shaft is being turned to the next position. Upon being freed at the end of the read-out the drums quickly catch up to the advanced position of the shaft. This permits the operator to move towards the next height during the fraction of a second that it takes for the machine to read, print and sum the height.

The adding machine is very similar in appearance to the familiar ten-key serial-entry electric models in use in nearly all offices. This particular model has a block of solenoids mounted over the keyboard for remote operation.

The adding-machine and typewriter-keyboard solenoids are wired in parallel. A pulse which energizes the number-2-key solenoid on the typewriter will also energize the number-2-key solenoid on the adding machine. This is true for all ten digits. When the three digits of a height have been read out there is a pulse to the typewriter space-key solenoid which positions the carriage for the next height. This pulse also goes to the adding-machine motor-bar solenoid which adds the height value and clears the keyboard for the next reading. At the end of each day of twenty-four hourly heights, the carriage-return solenoid on the typewriter and the total-bar solenoid on the adding machine are activated. This prepares the typewriter for the next line and the adding machine for a new column.

The typewriter is an electrically operated model with a solenoid-equipped keyboard for remote operation. These solenoids do not interfere with the normal use of the keyboard and the station name, dates, etc., are

typed in manually. The stock platen was replaced with a pin-feed platen which makes it easy to re-insert a form in alignment and continue the recording of hourly heights after an interruption.

The electrical circuit is built around a circuit selector which energizes various circuits at the proper time and for the correct duration. When the operator aligns the hairline on the hour mark and presses the read-out button he starts a self-sustained rotation by the Ledex rotary circuit selector. This circuit selector is actually a twenty-four position switch with the wafer contacts and the rotors spaced and cut to give the correct timing for this application. The twenty-four positions are convenient points to use in indicating the timing and sequence of the steps. The number of steps are constant while the total time for one cycle may be changed by changing the resistance in series with the Ledex « A » solenoid. The « ON » times for the various circuits are indicated by the black bars on the graph. The total time for one cycle is approximately three quarters of a second.

When the operator is ready to process a marigram he places it in the trough at the top of the working area. He then pulls the leading edge under the hairline and datum follower and on to the take-up spool. The paper-feed motor is then used to move the marigram until the beginning of the tide curve is in position to be read. The scale-selection levers should be set to agree with the scale of the marigram. The datum-line follower is set on the datum line and locked in position. The hand wheel is turned to get a reading on the Veeder-Root counter which is the same as the computed value of the datum line. The hand wheel is held still while the hairline curve follower is set and locked on the datum line. The hourly-height form is inserted in the typewriter at the proper space. The adding machine is cleared. The hour counter is set to agree with the first hour of the marigram. The paper-feed motor is started and as each hour mark comes into the area covered by the hairline the operator turns the hand wheel to position the hairline directly over the hour mark then pushes the read-out button. This is repeated as each hour mark in turn passes. At the end of each day of recording the typewriter carriage will return and the adding machine will take a total.

Each form covers a period of one month and at the end of the month's recording a fresh form must be inserted in the typewriter. When the marigram is completely scanned this partially completed form is removed and filed until the next marigram from that station comes in for processing.

With a little experience a person can scan a marigram in less than half an hour. This means that he will have the month's hourly heights tabulated and summed in days and a few minutes of additional time is all that is needed to arrive at the month's sea level.

This reduction in time is not only an economic advantage but, since it permits the worker to finish quickly the monotonous portion of the work, it secured immediate popularity for the scanner.

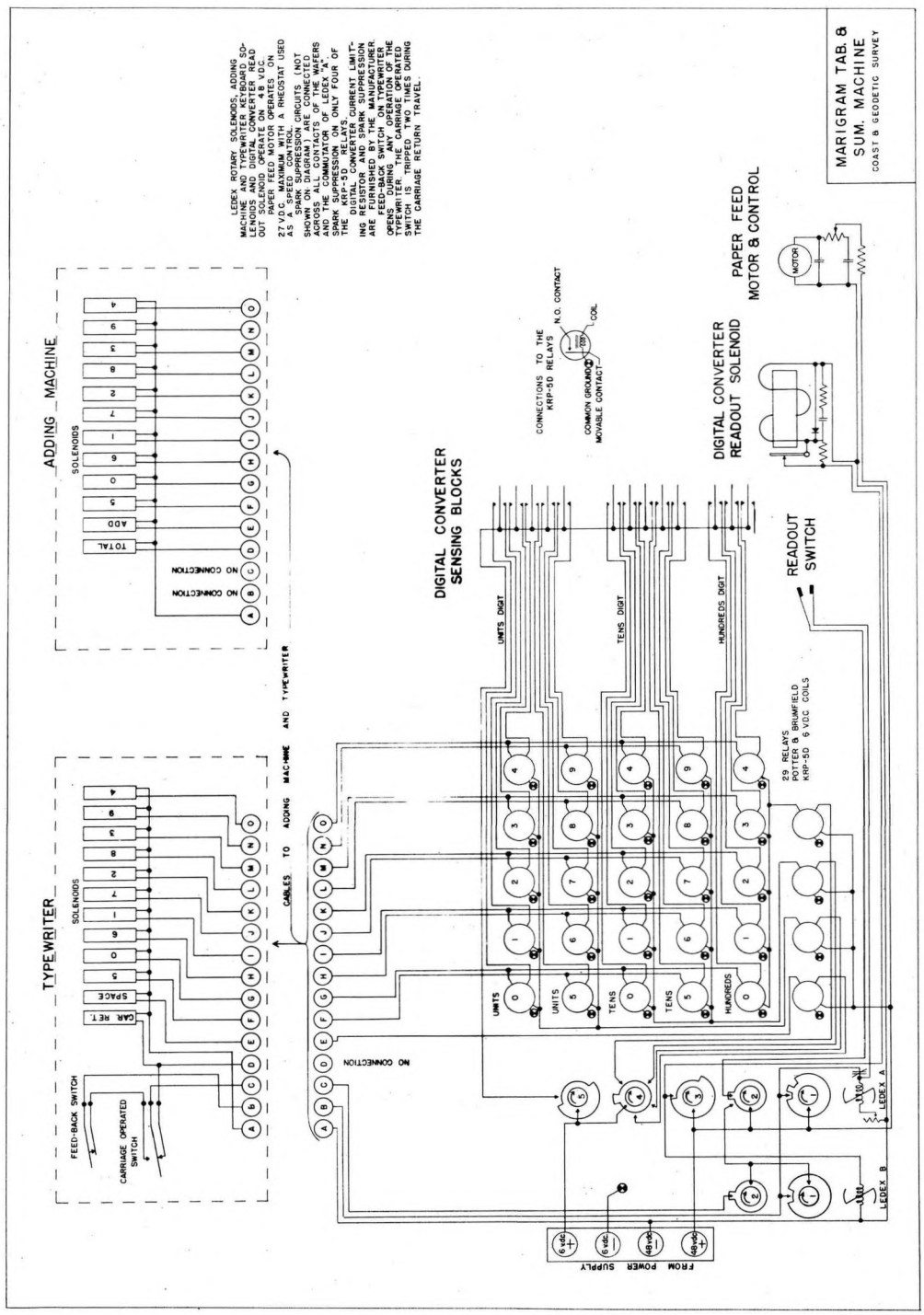
MARIGRAM TAB. & SUM. MACHINE
COAST & GEODETIC SURVEY
TYPEWRITER
ADDING MACHINE
SOLENOIDS
FEED-BACK SWITCH
CARRIAGE OPERATED SWITCH
CAR RET
SPACE
TOTAL
ADD
NO CONNECTION
CABLES TO ADDING MACHINE AND TYPEWRITER
DIGITAL CONVERTER SENSING BLOCKS
UNITS DIGIT
TENS DIGIT
HUNDREDS DIGIT
UNITS
TENS
HUNDREDS
29 RELAYS POTTER & BRUMFIELD KRP-50 6 VDC COILS
CONNECTIONS TO THE KRP-50 RELAYS
N.O. CONTACT
COIL
COMMON GROUND
MOVABLE CONTACT
DIGITAL CONVERTER READOUT SOLENOID
PAPER FEED MOTOR & CONTROL
MOTOR
READOUT SWITCH
FROM POWER SUPPLY
6 VDC
LEDEX A
LEDEX B
LEDEX ROTARY SOLENOIDS ADDING MACHINE AND TYPEWRITER KEYBOARD SOLENOIDS AND DIGITAL CONVERTER READOUT SOLENOID OPERATE ON 4 VDC. THEY ARE RATED FOR DUTY CYCLES ON 27 VDC MAXIMUM WITH A RHEOSTAT USED AS A SPEED CONTROL.
DIODE SUPPRESSION CIRCUITS (NOT SHOWN ON DIAGRAM) ARE CONNECTED ACROSS ALL CONTACTS OF THE WAFERS AND THE COMMUTATOR OF LEDEX A OF SPARK SUPPRESSION ON ONLY FOUR OF THE KRP-50 RELAYS.
DIGITAL CONVERTER CURRENT LIMITING RESISTORS AND SPARK SUPPRESSION ARE FURNISHED BY THE MANUFACTURER.
FEED-BACK SWITCH ON TYPEWRITER OPERATES DURING ANY CARRIAGE OPERATED TYPEWRITER RETURN. THE CARRIAGE OPERATED SWITCH IS TRIPPED TWO TIMES DURING THE CARRIAGE RETURN TRAVEL.

FIG. 4

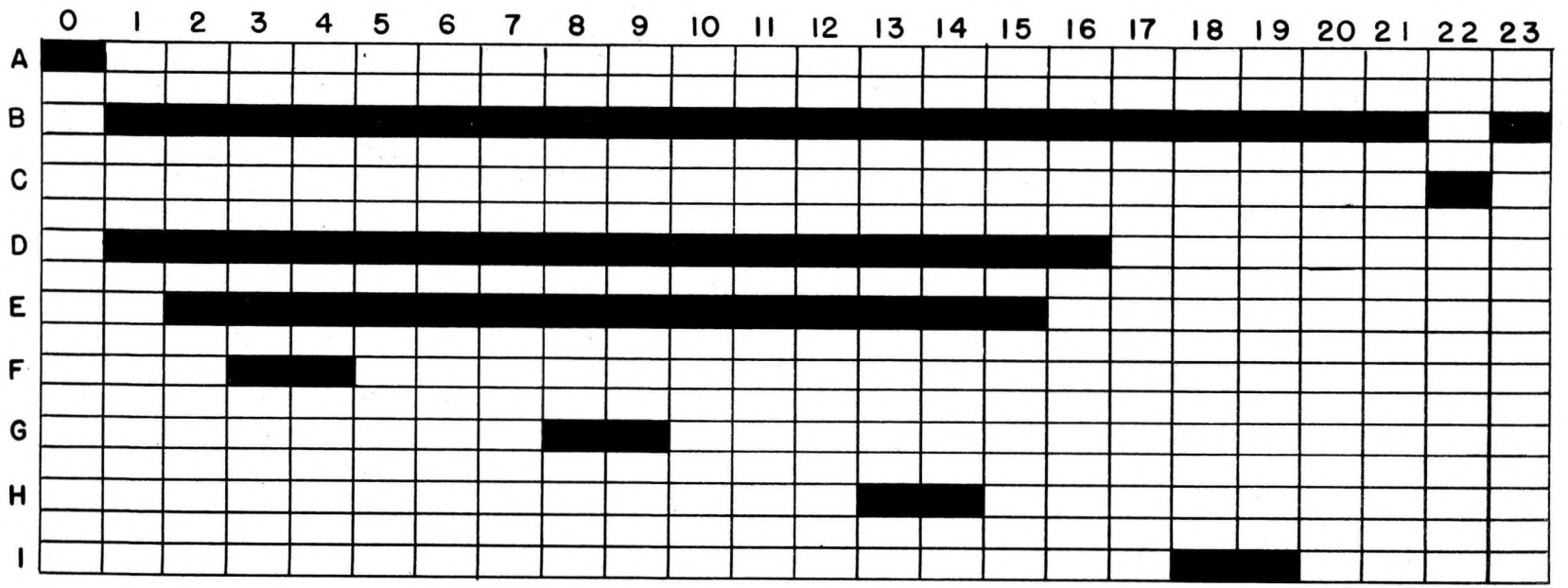

FIG. 5

A Energizes the read-out button.
B Energizes the self-pulsing circuit.
C Energizes circuit to the contacts of the counting solenoid which will either return it to the self-pulsing circuit or, if at the end of a day, send it on to the carriage-return solenoid of the typewriter.
D Energizes the digital-converter read-out solenoid and the counting solenoid (Ledex B).
E Energizes the three relays determined by the digital-converter position.
F Energizes hundreds-digit pulse relay.
G Energizes tens-digit pulse relay.
H Energizes units-digit pulse relay.
I Energizes *space-add* pulse relay.