W-616

TECHNICAL DEVELOPMENT REPORT NO. 387

AN EVALUATION OF TWO FORMATS FOR FLIGHT PLAN INPUT MESSAGES TO ATC COMPUTERS

FOR LIMITED DISTRIBUTION

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March 1959

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TECHNICAL DEVELOPMENT CENTER
INDIANAPOLIS, INDIANA

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SUMMARY

This evaluation project was undertaken to compare the use of a fixed-field-length format with that of a variable-field-length format in the preparation of flight plans for input to air traffic control computers. Three experienced typists were used to prepare the test flight plans on three different types of input machines: (1) the Remington Rand Synchro-Tape typewriter, (2) the Teletypewriter Model No. 19, and (3) the Friden Flexowriter Programatic typewriter.

The results of the evaluation were compiled from the performance figures of the three operators who processed 1,440 flight plans in 144 test runs. Flight plans utilized in the tests were representative of actual traffic in the Indianapolis ARTC Center control area. These results indicate that the operators required approximately 24 per cent more time to type flight plans when they used the fixed-field-length format than when they used the variable-field-length format. The number of errors was approximately the same in either case, being 0.48 per cent of the total characters with the fixed-field-length format and 0.49 per cent of the characters with the variable-field-length format. Under the test conditions described in the report, operators composed messages faster and made fewer errors with the Synchro-Tape typewriter than with the other two machines tested.

INTRODUCTION

In the proposed on-line system for use of computers in Air Route Traffic Control (ARTC) Centers, operators at field facilities would prepare flight plan messages for transmission over teletypewriter circuits to the computer. It is essential that these input messages be accurate; also, it is desirable that the messages be prepared in a minimum of time. Two different types of input format are possible, namely, fixed-field length and variable-field length.

For a fixed-field-length format, each item of information at the computer input is assigned a fixed number of spaces, corresponding to columns on a punched card, and if the significant characters of information in a particular flight plan do not require all of the spaces in the field, the operator must insert padding characters to complete the field before entering the next item of information in the following field. Figure 1 contains examples of fixed-field formats.

For a variable-field-length format, the significant characters of information are entered, followed by a space to indicate to the computer that a new item of information follows. Figure 2 shows flight plans with a variable-field format. Although it is shorter and somewhat easier for the operator

to type than the fixed-field format, it requires more processing time by the computer. For both formats, the items of information in the flight plans must follow in a specific sequence.

This report describes a series of tests made to compare the accuracy and speed of preparing flight plans for computer input using these two different input formats. The report does not cover a complete system evaluation, which would include such factors as error checking on transmission lines, error checking by logic tests in the computer program, and the processing times required by the computer.

EQUIPMENT AND SUBJECTS

Operators.

Three women operators prepared the test flight plans on three different types of electric typewriter/tape punch machines. These women operators were experienced typists, and prior to the start of the evaluation tests, each one had 12 to 15 hours practice on each of the machines.

Equipment.

The input devices were: (1) the Remington Rand Synchro-Tape typewriter, (2) the Teletype Corporation Model No. 19 teletypewriter, and (3) the Friden Flexowriter Programatic typewriter. The punched-tape output from all machines is in five-unit code.

The Synchro-Tape typewriter is a standard off-the-shelf machine with a few key modifications to adapt it for use in the ATC program for the UNIVAC File Computer. The Synchro-Tape typewriter has a four-row keyboard with separate keys for alphabetical and numerical characters. When a numerical key is depressed, the machine automatically punches a figure code in the output tape preceding the code of the figure character depressed. Similarly, when an alphabetical character key is depressed following a numerical character, the machine automatically punches a letter code in the output tape preceding the code of the alphabetical character which follows. The Synchro-Tape typewriter had a special program tape which permitted automatic insertion of end-of-message codes. Figure 3 is a view of the equipment.

The teletypewriter used was a standard Model No. 19 Teletype printer, with a visual format guide to aid the operator and a three-row keyboard. Each time it is desired to change from alphabetical characters to numerical characters, a letter or figure shift key must be depressed.

The teletypewriter does not have the automatic padding features of the Synchro-Tape typewriter; neither does it have a keyboard lock-out feature similar to the Flexowriter. Figure 4 is a view of the equipment and its keyboard configuration.

The Flexowriter Programatic typewriter is a standard off-the-shelf item with only a change in a few keys to fit the ATC program for the

UNIVAC File Computer. The Flexowriter has a special keyboard lock-out feature. When the letter shift key is depressed, all figure keys are locked out and cannot be depressed until the figure shift key is depressed. Also, when the figure shift key is depressed, all alphabetical keys are locked out and cannot be depressed until a letter shift key is depressed. The Flexowriter also has a programatic tape control which was set up to add end-of-message codes automatically. A picture of the equipment and its keyboard configuration is shown in Fig. 5.

TEST PROCEDURES

The test series included the following variables:

1. Two formats (fixed- and variable-field length).

2. Three operators (or subjects).

3. Three machines.

4. Two modes of operation, that is, copying the flight plans from a sheet of paper visually, and copying the flight plans as received over an interphone circuit verbally.

Samples.

A test sample of 40 flight plans typical of those filed with the Indianapolis ARTC Center was made. The test sample was broken into four units of ten flight plans each.

In the visual copying test, the operator was given a sheet with ten typewritten flight plans. After completing the typing of these 10 plans on the input machines and permitting a minute or two break, the operators were given a sheet with the second group of 10 flight plans, until all 40 flight plans were reproduced.

For the aural copying tests, the operator wore a standard Bell System 52 B operator's headset, and another person read the flight plans over an interphone circuit to simulate the receiving flight plans in an ARTC Center. Again the 40 flight plans were read in groups of 10 with a minute or two interval between each group of 10 plans.

Each of the three operators started on a different machine to provide randomness with regard to learning effects and familiarity with the basic flight plans. The operators were instructed to make a perfect copy of the flight plans, and if they realized an error had been made, to start over again and retype the complete flight plan. They were not permitted to backspace and correct the tape in these tests because of the inability to back space the program tape simultaneously from the keyboard, and because the operators were not experienced in reading punched tape.

Test Measurements.

The two primary areas of investigation were. (1) the comparative speed of preparation of the flight plans, and (2) the comparative accuracy of the prepared data for the two different formats. An observer with a stop watch recorded the total length of time for reproducing ten flight plans in each test. This included time spent in restarts. To check the accuracy of the prepared data, the punched-tape output was converted into punched cards and the cards were compared with a master set having no errors. The errors made were divided into those recognized by the operator (restart required) and those not recognized by the operator.

TEST RESULTS

Time.

When using the fixed-field-length format, the average time of over-all preparation was 44.9 seconds per flight plan compared to 36.1 seconds per flight plan when the variable-field-length format was used. Thus, it required on an average about 24 per cent longer to prepare flight plans using the fixed- or rigid-field-length format.

Figures 6 and 7 show the average time per flight plan for each operator on each of the three machines and the average of all operators for each machine. It will be noted that the average time required for either format was least when using the Synchro-Tape typewriter.

Accuracy.

Figures 8 and 9 show that the average number of typing errors for both formats was approximately the same. When using the rigid-field-length format, an over-all average of 30.8 characters was typed in error out of a total of 6,398 characters required to complete the 80 flight plans (reproduced visually and aurally). For the variable-field-length format, an over-all average of 27.9 characters was typed in error for a total of 5,702 characters. The difference in total number of characters for the two formats is due to the necessary addition of padding characters in the rigid-field-length format. Comparatively, the errors in the rigid-field-length format were 0.48 per cent of the total characters and the errors for the variable-field-length format were 0.49 per cent of the total.

The above figures include those errors recognized and unrecognized by the operator. A breakdown of the errors made by individual operators on each machine and the average results are given in Table I, and graphically in Figs. 8 and 9. Again, it can be noted that the over-all averages indicate that fewer errors were made by these operators when using the Synchro-Tape typewriters. The fact that fewer errors were made using the Synchro-Tape machines probably accounts for the major portion of the differences in time of preparation, since the time figures shown include the time spent in making restarts after the operator recognized an error.

It is believed that the major reason for the improved performance of the operators when using the Synchro-Tape typewriter is due to the four-

row keyboard without any requirement for using a shift key when going from alphabetical to numerical characters, and vice versa.

Many of the errors made by the operators in composing these flight plans could be detected by the computer through suitable logic checks of data in the computer program routines. Some of the errors which would not be detected in this manner would be apparent to the controller on the flight progress boards once the data were posted; however, some errors might not be detected either by the computer or by the controller on the boards, since they might not be readily apparent. Fortunately, it appears that the number of errors undetected by either the composer of the flight plan, the computer program, or the controller would be quite small, and in most cases would be "fail safe" in character. Issuance of ATC clearances specifying altitude and route of flight and the reporting of takeoff times and positions over fixes would provide additional evidence to the controller of possible discrepancies in the posted data.

CONCLUSIONS

It is concluded that:

1. The use of a fixed-field-length format for encoding flight plan messages for computer input required on the average about 24 per cent more time than did the use of a variable-field-length format.

2. The number of typing errors on the part of the operator encoding flight plans for computer input was approximately the same for both types of format, being 0.48 per cent of the total characters for the fixed-length fields, and 0.49 per cent of the total for the variable-length fields.

3. The Remington Rand Synchro-Tape typewriter appeared to be the best of the three machines used in this test from the standpoint of minimum time of preparation and minimum errors.

RECOMMENDATIONS

Further study and evaluation should be made of the computer processing time required for handling both types of input format, and of the error-checking possibilities with both types of format before a final decision is made as to the type of format to be used for flight plan input messages.

TABLE I

BREAKDOWN OF TIME AND ERRORS
OF EACH OPERATOR USING VARIABLE- AND FIXED-FIELD-LENGTH
FORMATS WITH DIFFERENT MACHINES

Type of Machine	Operator	Average Time in Seconds	Number of Flight Plans	Number of Characters in Flight Plan	Total Number of Characters Typed Because of Errors (Restarts)	Total Number of Errors	Number of Errors Detected by Operator	Number of Errors Undetected by Operator
Variable-Field-Length Format								
Synchro-Tape Typewriter	Operator A	27 0	80	5702	445	10	10	0
	Operator B	33 3	80	5702	410	15	13	2
	Operator C	33 9	80	5702	176	13	8	5
Total	3 operators	30 6	240	17,106	1031	38	31	7
Teletypewriter	Operator A	31 5	80	5702	303	24	15	9
	Operator B	48 7	80	5702	663	53	33	20
	Operator C	44 2	80	5702	413	49	17	32
Total	3 operators	41 5	240	17,106	1379	126	65	61
Flexowriter	Operator A	30 5	80	5702	482	19	13	6
	Operator B	39 1	80	5702	204	7	4	3
	Operator C	38 9	80	5702	449	61	42	19
Total	3 operators	36 2	240	17,106	1135	87	59	28
Rigid-Field-Length Format								
Synchro-Tape Typewriter	Operator A	29 2	80	6398	246	13	8	5
	Operator B	40 7	80	6398	182	7	7	0
	Operator C	42 0	80	6398	184	44	42	2
Total	3 operators	37 3	240	19 194	612	64	57	7
Teletypewriter	Operator A	40 3	80	6398	674	45	39	6
	Operator B	56 3	80	6398	557	40	24	16
	Operator C	53 3	80	6398	470	21	20	1
Total	3 operators	50 0	240	19,194	1701	106	83	23
Flexowriter	Operator A	35 4	80	6398	358	17	10	7
	Operator B	45 7	80	6398	374	14	10	4
	Operator C	61 1	80	6398	1373	76	57	19
Total	3 operators	47 4	240	19,194	2055	107	77	30

	ADR	K	IDENTSS	D/DR	FIX	KTIME	ALT	TYPE	SPD	DPT FIX	AIRWY	FIX	AIRWY	FIX	AIRWY	FIX	AIRWY
1.	DCA	E	E402...	....	EKN	E1234	120	C...	189	DCA	V4...	CHW					
2.	CLE	E	A542...	....	FDY	A0402	080	M4..	205	CLE	V47..	CVG					
3.	CHI	P	NC275F.	....	FWA	D1313	040	TB..	135	FWA	V11..	[illegible]	V12..	HUF			

FIG. 1 FLIGHT PLANS WITH A FIXED-FIELD FORMAT

	ADR	K	IDENTSS	D-DR	FIX	KTIME	ALT	TYPE	SPD	FIX	AIRWY	FIX	AIRWY	FIX	AIRWY
1.	G	DCA	E	E402	EKN	E1234	120	C	189	DCA	V4	CHW	G		
2.	G	CLE	E	A542	FDY	A0402	080	M4	205	CLE	V47	CVG	G		
3.	G	CHI	P	NC275F	FWA	D1313	040	TB	135	FWA	V11	V12	HUF	G	

FIG. 2 FLIGHT PLANS WITH A VARIABLE-FIELD FORMAT

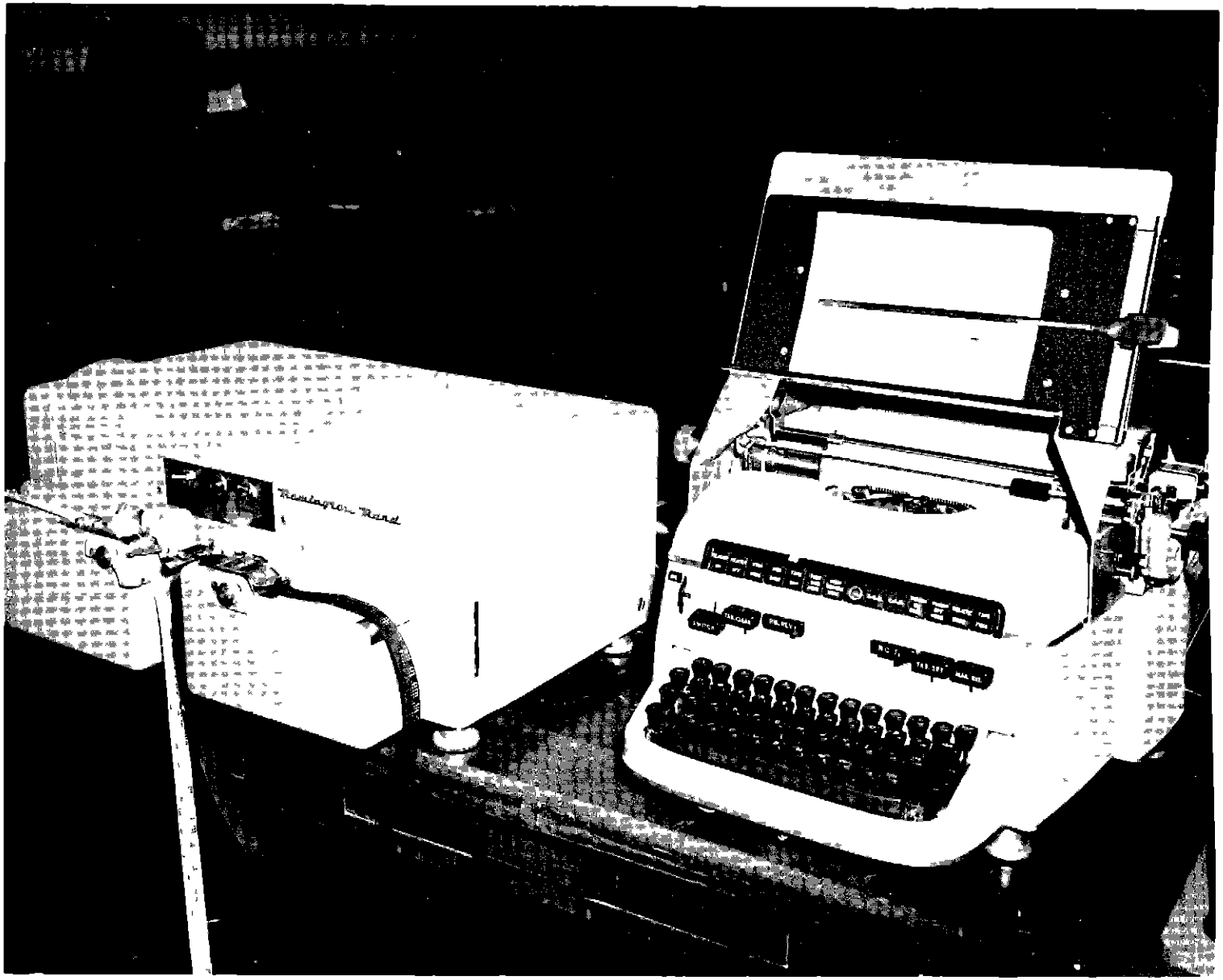

FIG. 3 SYNCHRO-TAPE TYPEWRITER

FIG. 4 MODEL NO. 19 TELETYPEWRITER

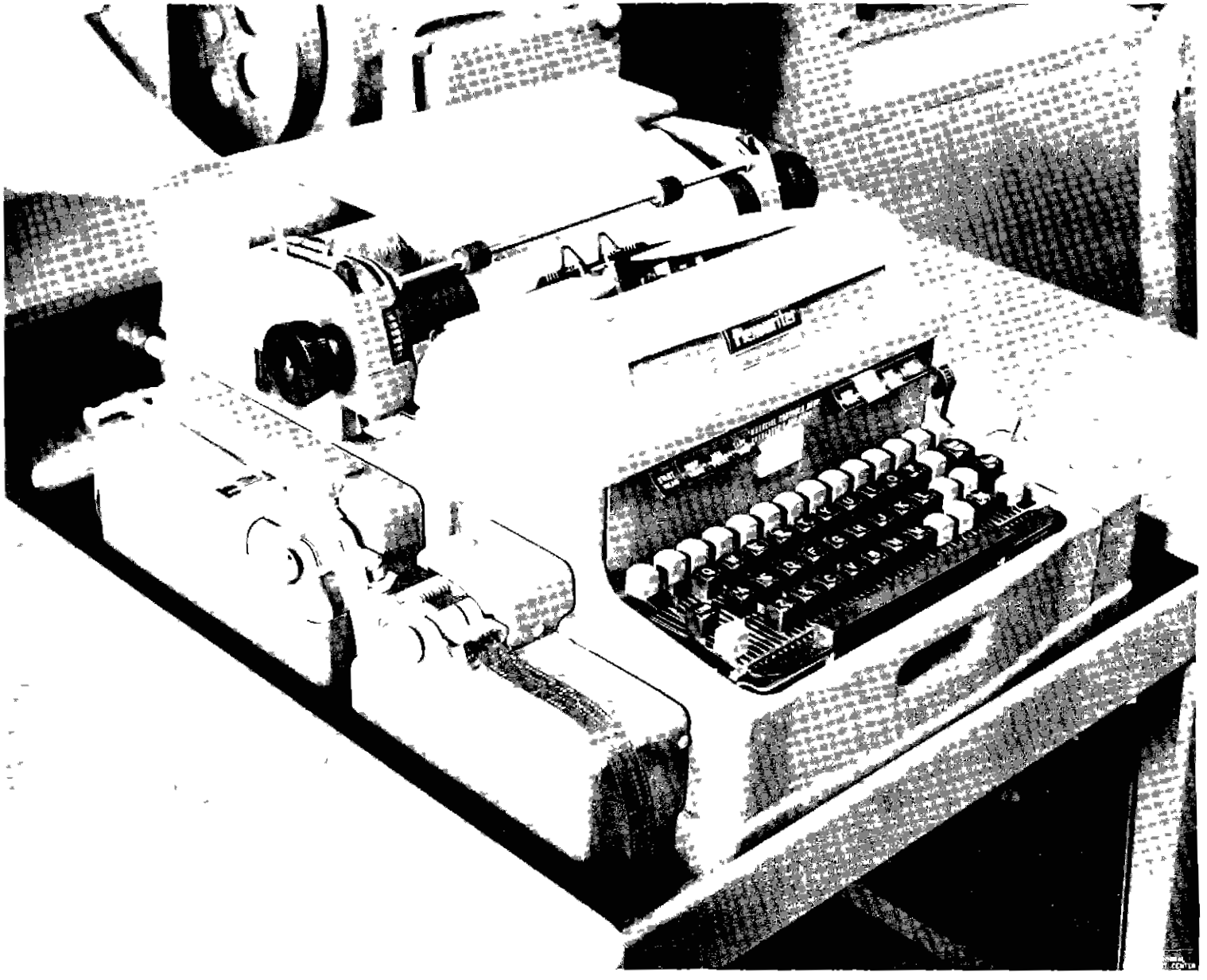

FIG. 5 FLEXOWRITER PROGRAMATIC TYPEWRITER

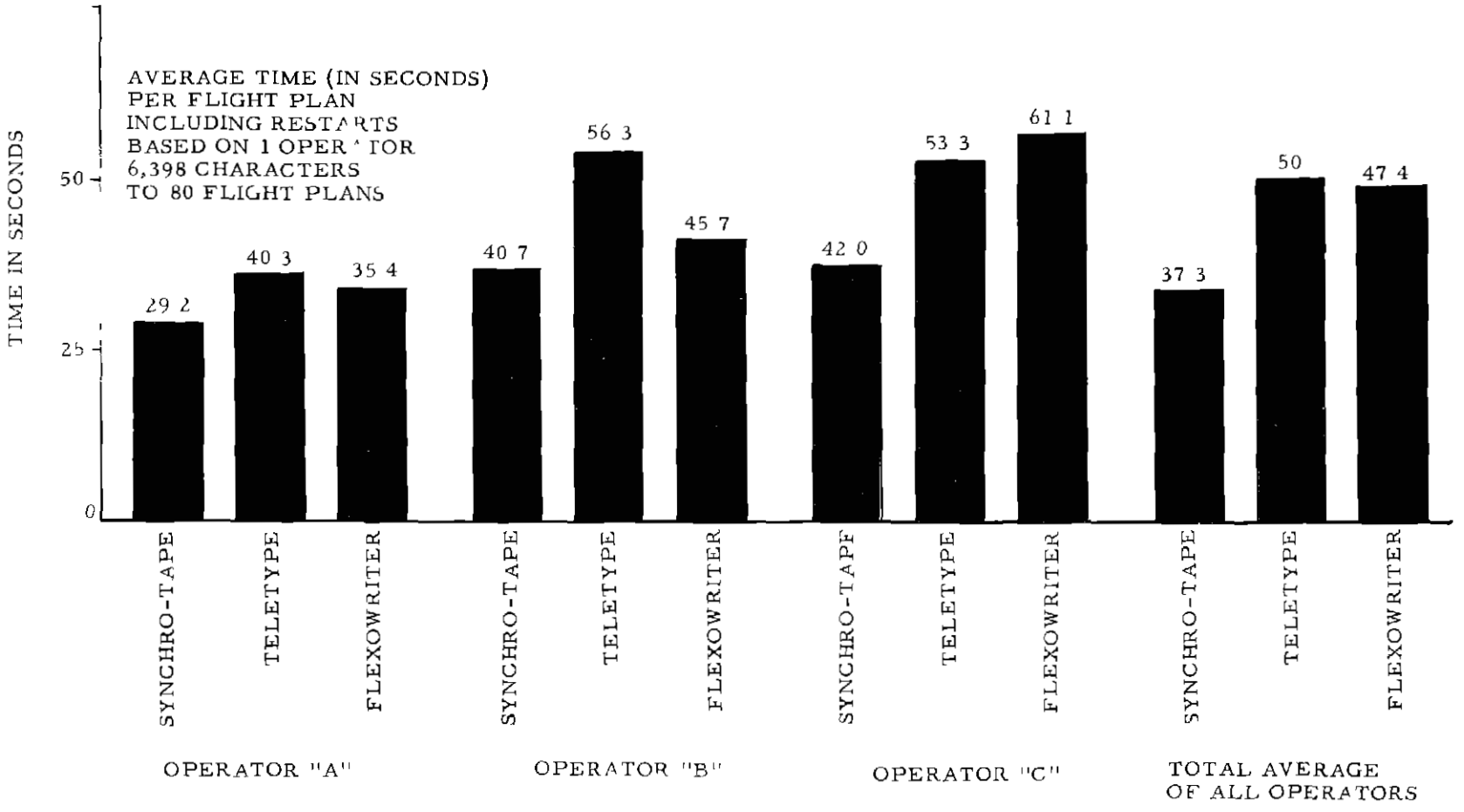

FIG 6 FLIGHT PLANS OF A RIGID-FIELD LENGTH FORMAT

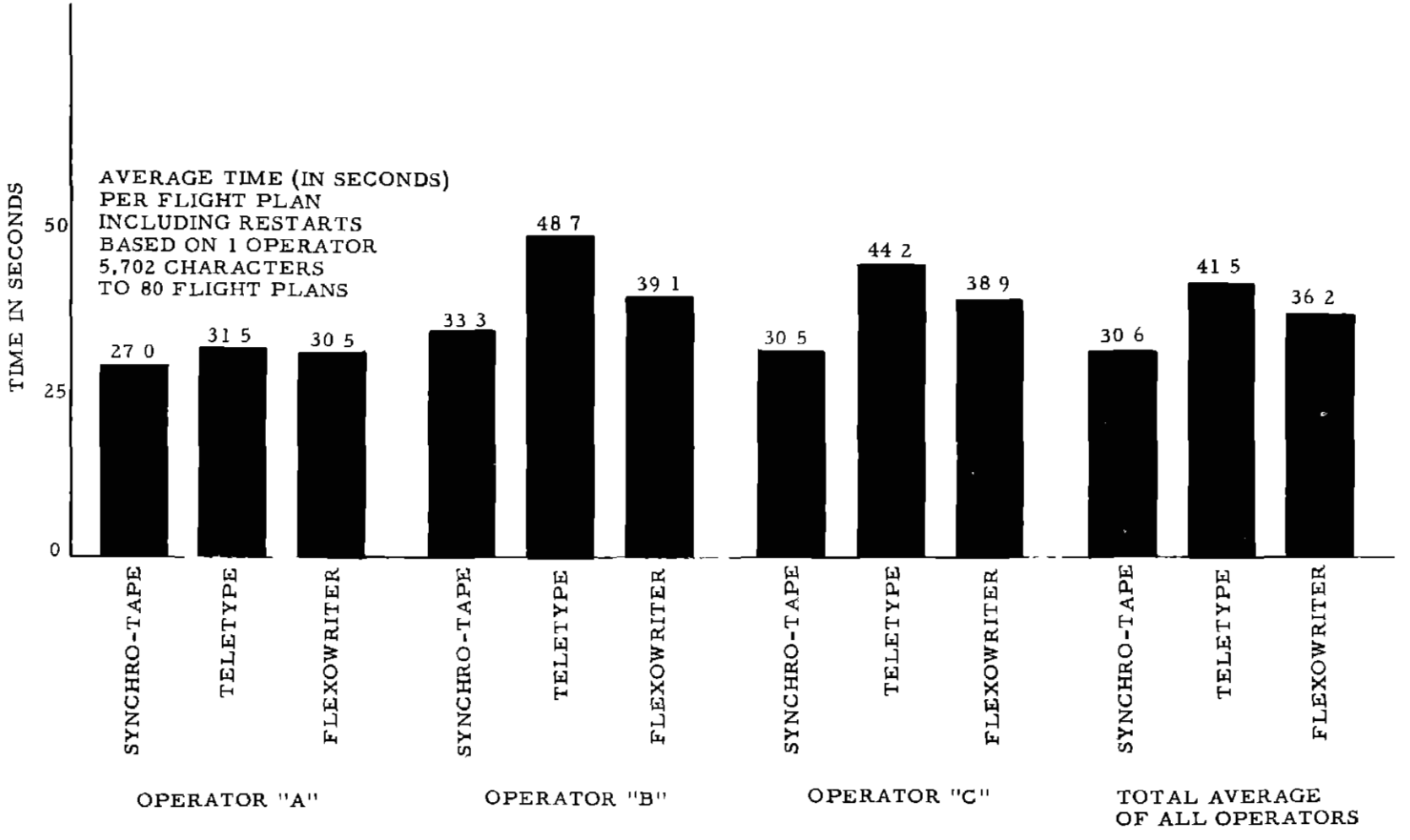

FIG. 7 FLIGHT PLANS OF A VARIABLE-FIELD LENGTH FORMAT

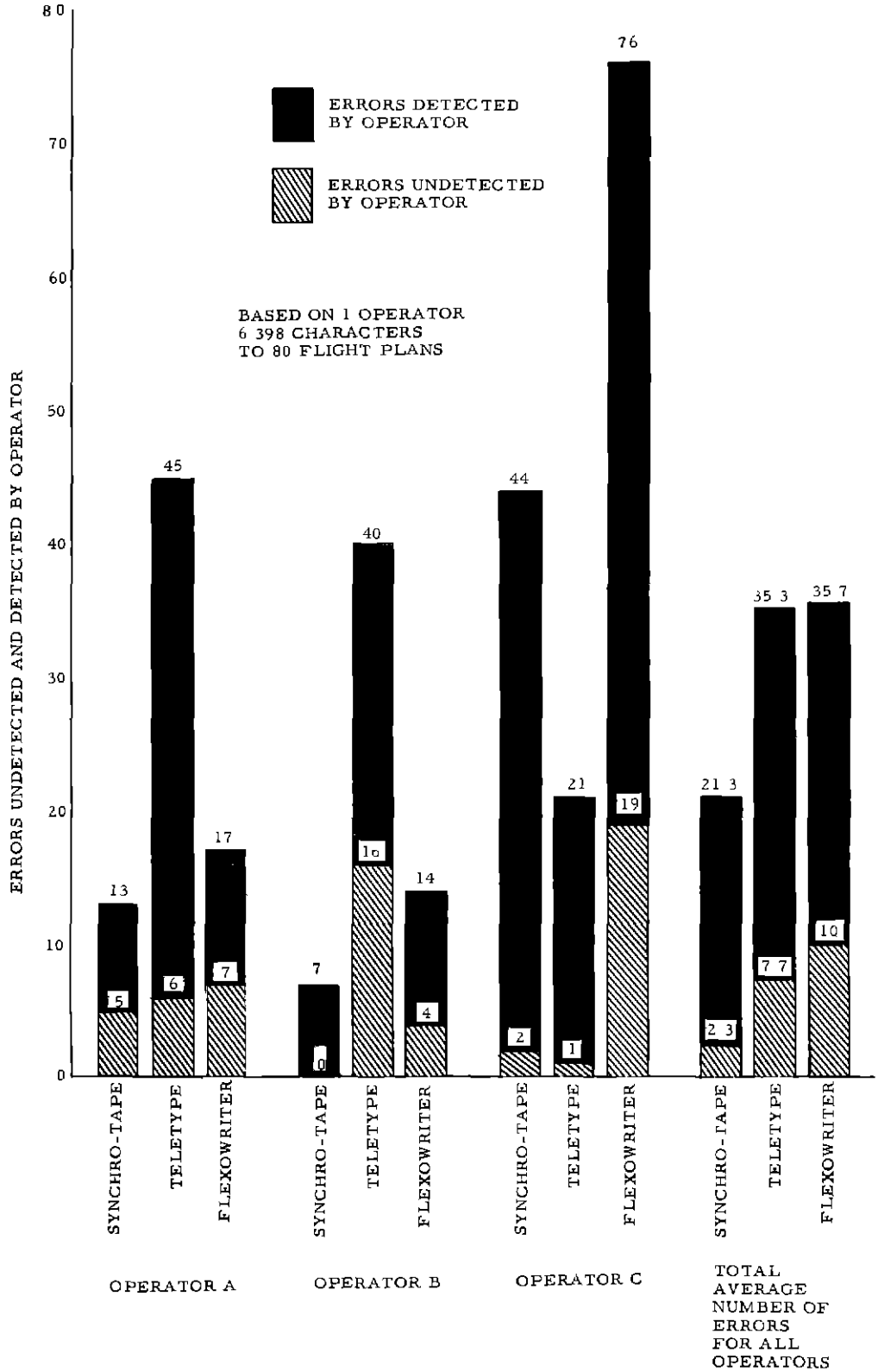

FIG 8 TOTAL NUMBER OF ERRORS FOR FLIGHT PLANS OF A RIGID-FIELD-LENGTH FORMAT

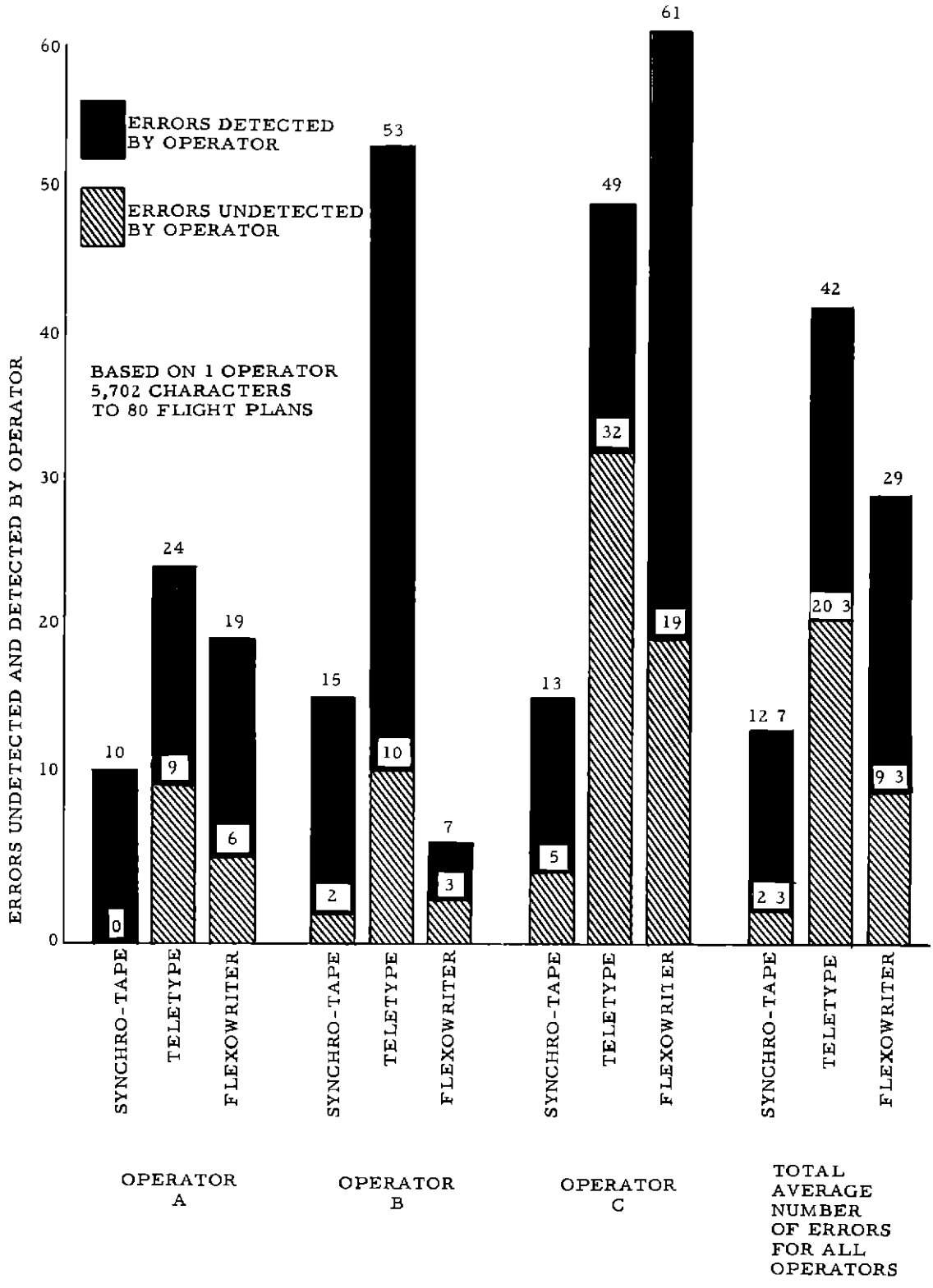

FIG 9 TOTAL NUMBER OF ERRORS FOR FLIGHT PLANS OF A VARIABLE-FIELD-LENGTH FORMAT