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Technical Memorandum

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77-53-52

AUTO-EDIT

(AUTOMatic Information EDITor)

G. R. Bussey

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ABSTRACT

A sampling theory is presented which provides for function representation by variable length linear segments. Equipment is described which furnishes sampling commands to an analog-to-digital data converter in accordance with the theory.

Non-linearity of the data to be sampled determines the sampling rate, which varies with the data and yields the desired information with a minimum number of samples. Used in conjunction with an analog-to-digital data converter, this technique materially reduces the necessary number of readings which must be taken, stored, processed, and ultimately plotted. (cont.)

Case No. 470.0

July 9, 1953

944 001

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1. Function

Auto-Edit is a sampling rate generator having an output rate that varies continuously in response to a changing analog input voltage. It is designed to automatically control an analog-to-digital data conversion system¹ in a way which yields desired information with a minimum number of digital conversions.

2. Background

Early in the study of the problem of digitizing telemetered information it was seen that a constant sampling rate of frequency high enough to delineate occasional rapid changes in data would lead to a burdensome and unnecessary number of samples during intervals of time when data was changing slowly. It was decided to investigate the possibility of using a sampling rate varying with the data in such a way that maximum information would be obtained with a minimum number of samples. This process has been called "auto-editing" and is analogous to the editing done by a skilled person reading points from an oscillograph record.

A study was made of typical oscillograph records that had been read by a skilled operator and the following facts were noted:

- (1) The ratio of maximum to minimum reading intervals was 50 to 1.
- (2) Readings were strategically placed, taking advantage of points of inflection, etc.
- (3) The number of readings taken was about one-fiftieth of the number that would have accrued had readings been taken constantly at minimum reading interval spacing.

These facts indicate that editing resulted in a 98 per cent reduction in the number of readings that would have been taken had these particular records been sampled continuously at the required maximum rate.

¹Digitel, a telemeter data digitizer.

3.

3. Basic Theory

In this particular application, the data to be sampled is a voltage amplitude varying with time:

$$A = f(t).$$

This function is continuous and bounded. It has an accuracy of 1 per cent of $A_{\max}$.

The approach taken is that of so spacing the samples on $f(t)$ that straight lines connecting adjacent samples deviate from the curve by some prescribed amount e . This is illustrated in Fig. 1.

Maximum deviation is arbitrarily shown to occur at the midpoint of the sampling intervals. This is not true for all functions but it is a good approximation for the functions of interest in this particular application. The geometrical situation is portrayed in detail in Fig. 2.

By inspection of Fig. 2 we may write:

$$e = f(t) - \frac{f\left(t + \frac{t_s}{2}\right) + f\left(t - \frac{t_s}{2}\right)}{2}$$

Expanding $f\left(t + \frac{t_s}{2}\right)$ and $f\left(t - \frac{t_s}{2}\right)$ as Taylor's series, we have

$$e = f(t) - \frac{1}{2} \left[f(t) + \left(\frac{t_s}{2}\right) f^I(t) + \left(\frac{t_s}{2}\right)^2 \frac{f^{II}(t)}{2!} + \dots \right. \\ \left. + f(t) - \left(\frac{t_s}{2}\right) f^I(t) + \left(\frac{t_s}{2}\right)^2 \frac{f^{II}(t)}{2!} + \dots \right]$$

This reduces to

$$2e = \left(\frac{t_s}{2}\right)^2 \frac{f^{II}(t)}{2!} + \left(\frac{t_s}{2}\right)^4 \frac{f^{IV}(t)}{4!} + \left(\frac{t_s}{2}\right)^6 \frac{f^{VI}(t)}{6!} + \dots \quad (1)$$

This equation must be solved for t_s , and the approach used is that of showing that the series converges rapidly for functions of interest so that, in practice, higher order terms may be neglected.

FIG. 1
METHOD OF SAMPLING

5

AMPLITUDE

900 776

TIME

FIG. 2

GEOMETRICAL SITUATION

6

A convenient function, and one that has increasingly greater higher order derivatives, is the sine wave:

$$f(t) = \frac{1}{2} \sin \omega t$$

The amplitude is selected as one-half because it is desired to express e as a fraction of full channel or peak-to-peak amplitude, which is unity.

Now,

$$f^{II}(t) = -\frac{\omega^2}{2} \sin \omega t$$

$$f^{IV}(t) = \frac{\omega^4}{2} \sin \omega t$$

$$f^{VI}(t) = -\frac{\omega^6}{2} \sin \omega t$$

.....

Maximum non-linearity occurs when $\sin \omega t = 1$, and substituting in (1) we have the power series

$$2e = -\frac{\left(\frac{\omega t_s}{2}\right)^2}{2!} + \frac{\left(\frac{\omega t_s}{2}\right)^4}{4!} - \frac{\left(\frac{\omega t_s}{2}\right)^6}{6!} + \dots \quad (2)$$

or

$$1 + 2e = 1 - \frac{\left(\frac{\omega t_s}{2}\right)^2}{2!} + \frac{\left(\frac{\omega t_s}{2}\right)^4}{4!} - \frac{\left(\frac{\omega t_s}{2}\right)^6}{6!} + \dots \quad (3)$$

The right hand side of this expression is the series for the trigonometric function $\cos \left(\frac{\omega t_s}{2}\right)$.

Accordingly,

$$2e + 1 = \cos \left(\frac{\omega t_s}{2}\right)$$

or

$$|e| = \left| \frac{1 - \cos \left(\frac{\omega t_s}{2}\right)}{2} \right| \quad (4)$$

7

- 12 -

For $e = 1\%$ of full scale, we can solve (4) for $\frac{\omega t_s}{2}$.

$$.01 = \frac{1 - \cos\left(\frac{\omega t_s}{2}\right)}{2}$$

$$\cos\left(\frac{\omega t_s}{2}\right) = 1 - .02 = 0.98$$

$$\left(\frac{\omega t_s}{2}\right) = 0.20034 \text{ radians}$$

Substituting this value in (2) we obtain

$$|.02| = \left[-\frac{(0.20034)^2}{2!} + \frac{(0.20034)^4}{4!} - \frac{(0.20034)^6}{6!} + \dots \right]$$

Evaluating these terms:

$$\text{First term} = -0.02007$$

$$\text{Second term} = +0.00007$$

$$\text{Third term} = -0.00000$$

It is obvious that the series converges very rapidly. The first term alone is off by less than 0.4% of e or 0.004% of full channel. It is concluded for a value of e of .01 that

$$|e| = \frac{\left(\frac{t_s}{2}\right)^2 |f''(t)|}{2!}$$

or

$$|e| = \frac{(t_s)^2 |f''(t)|}{8}$$

and

$$t_s = \sqrt{\left| \frac{8e}{f''(t)} \right|}$$

944-8

The frequency of sampling f_s is the reciprocal of t_s , and

$$f_s = \sqrt{\left| \frac{f''(t)}{8e} \right|} \quad (5)$$

This is the basic auto-edit equation.

4. General Description

The equipment designed to mechanize equation (5) is illustrated by the block diagram, Fig. 3.

The analog input signal is passed through an isolating amplifier, filtered to eliminate noise components, and differentiated twice. Positive and negative parts of the second differentiator output are separated and the negative parts inverted and added to the positive parts to yield an absolute value of $f''(t)$. The square root of this is taken by a crystal diode device, the result scaled down, and the final output used to control an oscillator. The output of the controlled oscillator is mixed with the output of a fixed oscillator, then detected to produce a difference frequency which is then shaped and counted down to yield the final sampling rate output.

5. Theory of Operation

5.1 General

The equipment herewith described is an experimental model.

The basic building blocks are direct current plug-in amplifiers manufactured by George A. Philbrick Researches, Inc. (Fig. 4).

5.2 Input Amplifier

The input amplifier is a DC amplifier with unity gain and low impedance output.

Ordinarily, the input to this amplifier is a voltage to ground, but for typical telemeter discriminator outputs the amplifier may be arranged as a difference amplifier.

5.3 Low Pass Filter

This is a replaceable unit, the expectation being that optimum filtering will have to be empirically determined by the particular application

9

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		ORIGINAL ISSUE		CHK ENG

15 & 16

MATERIAL		APPO	UNLESS OTHERWISE SPECIFIED	DRAWN	4/2/53	TITLE	BLOCK DIAGRAM
ADDITIVE FINISH		APPO	DIMENSIONS ARE IN INCHES. LIMITS APPLY OVER FINISH. SURFACE ROUGHNESS EXPRESSED AS RMS MICROINCHES.	CHECKED	7/2/53	DIGITAL	
NEXT ASST				APPO		AUTO-EDIT UNIT	
APPLICATION				APPO		UNCLASSIFIED	
				CONTRACTOR APPROVAL		CLASSIFICATION	
				DRAWN		SCALE	
				CHECKED		RAW STK	
				APPO ENGR		WT LBS	
						UNIT WT	
						LBS	
						SHEET	
						OF	

010 888 776

MODEL K2-W

- 17 & 18 -

DIRECT CURRENT PLUG-IN AMPLIFIER DESIGNED FOR FEEDBACK COMPUTING IN ELECTRONIC ANALOG SYSTEMS FAST & SLOW

SUGGESTED ZEROING METHODS:

FOR NEG. GAIN ONLY

UNIVERSAL

INPUTS: DIFFERENTIAL PAIR, POS. & NEG.
IMPEDANCE OVER 10 MEGOHMS
WITHIN OPERATING RANGES.

OUTPUT: RANGE MINUS TO PLUS 50 VOLTS
UNDER LOADS TO 50K OR 1 MA.
IMPEDANCE 300Ω WITHIN RANGE.

GAIN: PLUS AND MINUS 15,000, APPROX.

RESPONSE: FEEDBACK FOR UNITY GAIN;
BANDWIDTH WELL OVER 100 KC.
RISE TIME APPROX. 2 μSEC.

POWER: REGULATE VOLTAGES FOR MAX. STABILITY.
6.3 VAC OR VDC AT 0.6 AMPERES
+ AND -300 VDC AT 5 MILLIAMPS.

BASE: OCTAL PLUG, WITH KEY ON
LINE OF TUBE CENTERS.

WEIGHT: 2.8 OZ. **LENGTH:** 4.5 INS. OVERALL.

SCHEMATIC DIAGRAM AMPLIFIER SYMBOL

ALL VOLTAGES ARE
WITH RESPECT TO
AN IMPLIED GROUND.

JUNCTION
SYMBOL

CROSS-OVER
SYMBOL

FIG. 4

ELECTRICAL NOTES

TUBES:

2 12AX7

CAPACITORS

INTEGERS — mF
DECIMALS — μF

RESISTORS:

K — kilohms, others mega
1/2 W. — 10 W.

MECHANICAL NOTES

MATERIAL

CASE: MOLDED
TENITE 2, SEALED,
WITH FINGER
GRIP.

TOLERANCES:

FRACTIONS: 1/4
DECIMALS: 0.005
ANGLES: —

GEORGE A. PHILBRICK RESEARCHES, INC.,
230 CONGRESS ST., BOSTON 10, MASS.
Analog Computers for RESEARCH & DESIGN

OPERATIONAL AMPLIFIER

DR.

SCALE

CH.

DRAWING NO.

MODEL K2-W

FIG. 5
COMPENSATORY DELAY

K2-W CIRCUITS

EFFECTS OF EXTERNAL COMPUTING IMPEDANCES
ASSUMING ZERO GRID CURRENTS,

$$\frac{e - e_g}{Z} = \frac{e_g - e_0}{Z_0}, \text{ AND } \frac{e' - e_g'}{Z'} = \frac{e_g'}{Z_0}$$

WITH μ LARGE, $e_g = e_g'$, SO THAT

$$e_0 = -\frac{Z_0}{Z} e + \frac{1 + \frac{Z_0}{Z}}{1 + \frac{Z_0}{Z'}} e'$$

EACH INPUT MAY BE MADE MULTIPLE. FOR EXAMPLE INSTEAD OF C AND Z ONE MAY USE:

THIS REQUIRES ONLY REPLACEMENT OF $\frac{1}{Z}$ BY $\sum_{i=1}^3 \frac{1}{Z_i}$, AND OF e BY $\sum_{i=1}^3 \frac{e_i}{Z_i}$. (SIMILARLY FOR e' AND Z' .)

EACH IMPEDANCE ELEMENT MAY BE REPLACED BY A 3-TERMINAL NETWORK:

II SUGGESTED INDIVIDUAL APPLICATIONS

VOLTAGE FOLLOWER

SIMPLE INVERTER

TIME INTEGRATOR

INVERTING ADDER

DIRECT ADDER

AMPLIFIER WITH LINEAR GAIN ADJUSTMENT

AMPLIFIER WITH WIDE-RANGE GAIN ADJUSTMENT

TIME DIFFERENTIATOR

SUBTRACTOR

NONLINEAR VOLTAGE TRANSF.

"CONTROLLER MECHANISM"

e : FROM MEAS. VARIABLE
 e^* : DESIRED VALUE OF e
 e_0 : TO MANIP. VARIABLE
 S : SET SENSITIVITY
 R : SET RESET RATE
 D : SET DERIV. EFFECT

REFERENCES:

1. J. R. RAGAZZINI et al, ANAL. OF PROBS. IN DYNAMICS BY ELEC. CIR., PROC. IRE, May 1947
2. G. A. KORN, ELEMENTS OF DC ANALOG COMPUTERS, ELECTRONICS, April 1948
3. RECENTLY OF INTEREST IN ELECTRONICS: Oct. 1951, p. 128; April 1952, p. 147, Aug. 1954, p. 144
4. CATALOG & MANUAL ON HIGH-SPEED ALL-ELECTRONIC ANALOG COMPUTERS...

JUNCTION
SYMBOL

CROSS-OVER
SYMBOL

FIG. 6

ELECTRICAL NOTES		MECHANICAL NOTES		GEORGE A. PHILBRICK RESEARCHES, INC., 230 CONGRESS ST., BOSTON 10, MASS. Analog Computers for RESEARCH & DESIGN	
UNLESS OTHERWISE SPECIFIED)		MATERIAL		COMPUTING CIRCUITS FOR K2-W	
TUBES: *SEE SUGGESTIONS FOR BIASING ON GAP/R MODEL K2-W DATA SHEET, BUT NOTE		50KΩ ≤ R ≤ 10M 0.0001 mfd ≤ C ≤ 10mfd FOR MANY USEFUL PURPOSES, BIAS MAY BE OMITTED IN THE ABOVE.		DR _____	
CAPACITORS: — mfd RESISTORS: — m, — 10K		TOLERANCES: FRACTIONS: 1/64 DECIMALS: 0.005 ANGLES: —		SCALE _____	
DRAWING NO. K2-W CIRCUITS		APP. _____		DRAWING NO. _____	

13

23 & 24

OBJECTIVE ONE UNIT

NOTES:
 1. ALL RESISTORS 1/4WATT, 5% TOL UNLESS OTHERWISE SPECIFIED.
 2. ALL CAPS 400V DC AND 50V AC UNLESS OTHERWISE SPECIFIED.
 3. 12-W UNITS REFER TO VOLKREIT PLUS ASSEMBLIES.
 4. 12-W UNITS ARE 12-W OPERATIONAL AMPLIFIERS MANUFACTURED BY GEORGE A. PHILBRON RESEARCHES, INC.
 5. 12-W AND 12-W SUPPLY REGULATED TO WITHIN 2.00%
 6. 12-W FILAMENT SUPPLY E-3, REGULATED TO 1% FOR LIVE VIBRATIONS FROM 50-120 HZ.

DATE	10/10/64
BY	SK
UNCLASSIFIED	SK(5226)24602

944 0144

14

circumstances and that a universal filter cannot be realized.

From theoretical considerations, however, several requirements can be specified. The first is that the filter must have at least two half-sections to be effective, inasmuch as the double differentiation following the filter in effect neutralizes one half-section.

A second specification is that the filter pass the highest frequency that can be accommodated by the auto-edit equipment for a particular value of e . In any case, however, the filter need not pass any higher frequency than can be transmitted by the telemetering channel.

If occasional step functions in otherwise slowly changing data must be efficiently detected, it is desirable to have the filter pass a frequency approximately one-fourth as great as the maximum sampling rate. This will insure that a sample will be taken within $\frac{1}{(f_s)_{\max}}$ of the occurrence of such a step function. Use of a filter is necessary to prevent noise and intermodulation components from seizing control of the auto-edit unit, but at the same time a time delay is introduced which delays auto-edit response. This delay may or may not be objectionable in practice. If it is, it will be necessary to insert a compensatory delay in the analog signal to be sampled, as shown in Fig. 5. There are other time delays in the auto-edit unit, but these are generally small compared with that introduced by the filter.

5.4 Differentiators

The differentiators used are shown in Fig. 6. It is convenient to choose the product RC so that a part of the constant $8e$ in equation (5) is inserted at this point to maintain signal levels within ranges easily handled by the DC amplifiers and yet optimize signal-to-noise ratio and time constant. The signal-to-noise ratio here mentioned refers to local noise pickup, mostly of 60 cycle origin, not kept out by careful shielding. The time constant referred to is both a delay and a stretch, resulting, for example, in a step function at the input giving rise to several output cycles where theoretically only one or two should occur.

5.5 Sorter

The sorter is merely a diode pair, as shown in Fig. 7.

5.6 Inverter

The inverter is shown in Fig. 7. It has unity gain.

5.7 Adder

The adder used is shown in Fig. 7. The gain provided is for the purpose of boosting the signal before extracting the square root, as explained below.

5.8 Square Root Extractor

The requirements for this circuit were those of good accuracy and rapid response. No suitable circuits were known, but it was possible to achieve a rather simple one by utilizing certain characteristics of germanium crystal diodes. The characteristic curve of such diodes is approximately square law for values of control voltage close to zero. It was reasoned that the use of a number of such diodes in series would divide the impressed voltage so that each diode and thus the chain as a whole would operate as an approximate square law attenuator. (See Fig. 8).

The voltage equation for the circuit in Fig. 8 is

$$E = e_o + iR \quad (6)$$

The current through an individual diode is

$$i = A e^{\frac{ae_o}{n}} - 1 \quad (7)$$

where A and a are constants associated with the crystal and n is the number of diodes in series. Now

$$e^{\frac{ae_o}{n}} = 1 + \left(\frac{a}{n}\right) e_o + \left(\frac{a}{n}\right)^2 \frac{e_o^2}{2!} + \left(\frac{a}{n}\right)^3 \frac{e_o^3}{3!} + \dots \quad (8)$$

and since $\frac{a}{n}$ is generally small we neglect all terms beyond the third.

Substituting in (7) we have

$$i = A \left[\frac{a}{n} e_o + \left(\frac{a}{n}\right)^2 \frac{e_o^2}{2} \right] \quad (9)$$

Substituting (9) in (6), we obtain

$$E = \left(1 + \frac{RAa}{n} \right) e_o + \left(\frac{RAa^2}{2n^2} \right) e_o^2 \quad (10)$$

FIG. 8
SQUARE ROOTER CIRCUIT

944 017

We choose $\underline{R}$ and $\underline{n}$ so that

$$\frac{RAa^2}{2n^2} = 1$$

and

$$1 + \frac{RAa}{n} = 0$$

(The constant a is always negative).

Then (10) reduces to

$$E = e_o^2$$

or

$$e_o = \sqrt{E} \quad (11)$$

Experimental curves are shown in Fig. 9. The irregular spacing between curves is due to the differing characteristics of individual diodes. By adjusting R so that a curve crosses zero at some intermediate point in the range of interest, it is possible to reduce the error to about $\pm 2\%$ throughout the range except in the region of low input voltages. In auto-edit, the voltage fed into the square root extractor is k^2 times the value desired for controlling the voltage-controlled oscillator. Proper voltage range is obtained, therefore, by dividing the output by k . This throws the low voltage region of poor accuracy into a range very close to zero and below the level selected for minimum f_s (2 samples per second).

5.9 Sampling Rate Generator (Fig. 7).

The output of the square root extractor is controlled by a potentiometer that sets in the value of $\underline{e}$ determining the precision of sampling. The resultant voltage controls a voltage-controlled multivibrator operating at approximately 1 kc.

The control voltage is amplified and applied to the multivibrator. The control voltage vs. frequency curve of the controlled multivibrator is shown in Fig. 10. Linearity is within 1%.

An identical control-tube and multivibrator combination is set at fixed frequency and adjusted so that, at zero square-root-extractor output, the frequency difference between the two oscillators is 8 cps which is counted down to produce the minimum sampling rate of two samples per second. Introduction of this shift in zero point adds two samples

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FIG. 10
OSCILLATOR VOLTAGE
VS.
BEAT FREQUENCY CHARACTERISTIC

944-~~111~~
020

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per second to the sampling rate output at all output frequencies, which insures that the sampling rate output is slightly on the fast side of theoretical despite inaccuracies in the system. This results in slightly reduced sampling efficiency but is not a factor of real importance.

Special construction techniques were used to keep the conditions affecting the two oscillators identical, so that not only are their individual frequency drifts low but largely compensatory. As a result, difference frequencies vary on the average across the band less than 2 cycles per second over long periods of time.

Shielding around the oscillators was necessary to keep them from "locking-in" with each other at low difference frequencies.

The difference frequency is detected and filtered out to produce a rectified sine wave varying between 8 and 200 cps. This is amplified by a DC amplifier, squared by a Schmitt trigger tube, and divided by four in a pair of flip-flop stages.

The output, then, is a square wave varying between 2 and 52 cps.

5.10 Power Requirements

It is necessary that the 6.3 VAC filament supply for the oscillators and oscillator control tube be regulated in order to minimize drift. Excellent stability is required for the ± 300 volt supply to maintain zero adjustment of the DC amplifiers.

6. Performance

6.1 General

Figures 11-14 are Miller oscillograph records of typical auto-edit inputs and outputs. Portions of these records were analyzed to evaluate sampling effectiveness.

6.2 Sampling Efficiency

Sampling efficiency is defined as follows:

$$\text{Sampling Efficiency} = 100 \left(1 - \frac{N}{N_{\max}} \right)$$

Where N is the number of samples taken and $N_{\max}$ is the maximum number of samples which would have been taken if the data had been sampled repetitively at the maximum rate.

944-~~021~~
021

Sampling efficiency is of course a function of the nature of the data being sampled. For smooth data with only occasional irregularities it will approach 100%, while for very irregular data it may be quite low. It is useful, however, as a relative measure.

6.3 The Dispersion of $\underline{e}$.

There are a number of reasons why $\underline{e}$ should be expected to vary around a norm and not be constant as indicated by the mathematical basis of auto-edit. Analysis of oscillograph records indicates that certain anticipated sampling deficiencies which give rise to variations in $\underline{e}$ do in fact occur.

A common type is that occasioned by the fact that, without compensatory delay, the auto-edit unit is inherently always behind; it has no ability to look at $f(t)$ now and place a sample in the past, although it can place a future sample with limited precision. This is illustrated in Fig. 15.

The sample last taken preceding the break might have occurred at any time within the period of sampling, as illustrated. This uncertainty obviously gives rise to variations in $\underline{e}$.

Lesser variations in $\underline{e}$ arise because there is no certainty in the exact placement of the first sample following a command to increase sampling rate. Precisely when a sample will occur depends on the point at which the oscillator is caught in its cycle and the status of the two dividing flip-flop stages.

These effects are accentuated by time delays in the system such as those introduced by the filters and differentiators, the effect of which in Fig. 15 is to displace the first sample following the break to a point later in time and thus increase $\underline{e}$ for all cases.

The values of $\underline{e}$ for Figs. 11-14 were scaled off and plotted to illustrate the frequency distribution, a typical one of which (for Fig. 13) is shown in Fig. 16. At present the inconstancy in $\underline{e}$ is not considered sufficient to warrant corrective measures, inasmuch as the purpose of auto-edit is more qualitative than quantitative.

6.4 Summary

While auto-edit does not function perfectly it does permit effective variable sampling with considerable reduction in the number of samples otherwise necessary. Used in conjunction with an analog-to-digital data

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FIG. 11
 $f(t)$ vs. f_s , $e = 8\%$, 55% efficiency

944 - 023

23

FIG. 12

$f(t)$ vs. f_s , $e = 1.5\%$, 68% efficiency

944 24

FIG. 13
 $f(t)$ vs. f_s , $e = 0.75\%$, 74% efficiency

FIG. 14
 $f(t)$ vs. f_s , $e = 0.5\%$, 84% efficiency

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FIG. 15
ILLUSTRATION OF VARIATIONS IN $\underline{e}$

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FIG. 16
TYPICAL DISPERSION OF $\underline{e}$

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FIG. 17
AUTO-EDIT UNIT, FRONT VIEW

944-029

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FIG. 18
AUTO-EDIT UNIT, REAR VIEW

POWER REQUIREMENTS: 250V 4MA
6.3V 0.3AMP

COLOR: RED

BASE: 11PIN WILL FIT AMPHENOL 77-MIR-11 SOCKET

INPUT: 75V NEG PULSES $2 \mu \text{ SEC} < \text{FALL TIME} < 10 \mu \text{ SEC.}$

OUTPUT: 80V PEAK TO PEAK

PLATE TO GND VOLTAGE 55V WITH TRIODE CONDUCTING
135V WITH TRIODE NONCONDUCTING

FIG. 19.

BINARY COUNTER

944 024
WALKIRT M-1253

DR.		CHK <i>22B</i>	ENG
APP		APP	APP
5Y	A	SK(5226)24606	
SHEET		OF	SHEETS

744-31

POWER REQUIREMENTS: 250V 19MA
6.3V 0.3AMP

COLOR: SILVER

BASE: 11 PIN, WILL FIT AMPHENOL 77-MIP-11 SOCKET

OUTPUT: 150V PEAK TO PEAK

FIG. 20

SCHMITT TRIGGER

WALKIRT M-1563

DR.	CHK <i>DRB</i>	ENG
APP	APP	APP
5Y	A	SK(5221)24607
SHEET	OF	SHEETS

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conversion system, it materially reduces the number of readings which must be taken, stored, processed, and ultimately plotted. As a result, substantial savings in data handling time are anticipated with its use in the Digitel system.

G. R. BUSSEY - 5226

Case No. 470.0
July 9, 1953

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