AC SPARK PLUG DIVISION
General Motors Corporation
Milwaukee, Wisconsin

16 PIP ELECTRONICS

XDE -34-A-513

ENGINEERING
DESIGN INFORMATION
EXHIBIT

By C. R. Ross   Date Nov. 14, 1962

Reference:

"Dynamics of the 16 PIP Accelerometer", J. Goclowski August, 1962,
XDE-34-A-501.

1. Basic Block Diagram

The amplitude modulated suppressed carrier output of the pickoff contains
two bits of information.

a. The signal phase indicates which side of null the pendulum is on.
b. The signal amplitude indicates pendulum angle.

The pickoff output is amplified and fed to the interrogator (Fig. #1).
When the pendulum angle exceeds a prescribed minimum, an interrogate pulse from
the computer samples the signal amplitude to see which side of null the pendulum
is on, and along with a precision switch pulse instructs the current switch to
supply current to the proper torquer coil. At a fixed time interval, dependent
upon mode, the interrogator receives a reset and switch pulse thereby instructing
the current switch to remove the applied current. The pendulum will have been
torqued into the threshold and if an acceleration is still present the pendulum
will again move out of the threshold and the above process will repeat.

2. Modes of Operation

There are three modes of operation which change the range and sensitivity
of the loop.

a. Sensitive Mode (Ternary)

Constant current pulses 100 ma. in amplitude and 78.125μ sec. in
width are applied to the torquer network at a rate that is a function
of the magnitude of the input acceleration. This mode has a velocity
resolution that is in the order of twelve times better than that of
emergency operation. Its maximum input acceleration capability is in
the order of one twelfth of that in emergency mode.

b. Normal Mode (Ternary)

Pulse amplitude is the same as the sensitive mode; however, the pulse
width has been increased to 312.5μ sec. This results in a velocity
resolution that is twice as good as emergency mode and a maximum input
acceleration capability of one half that of emergency.

REV.
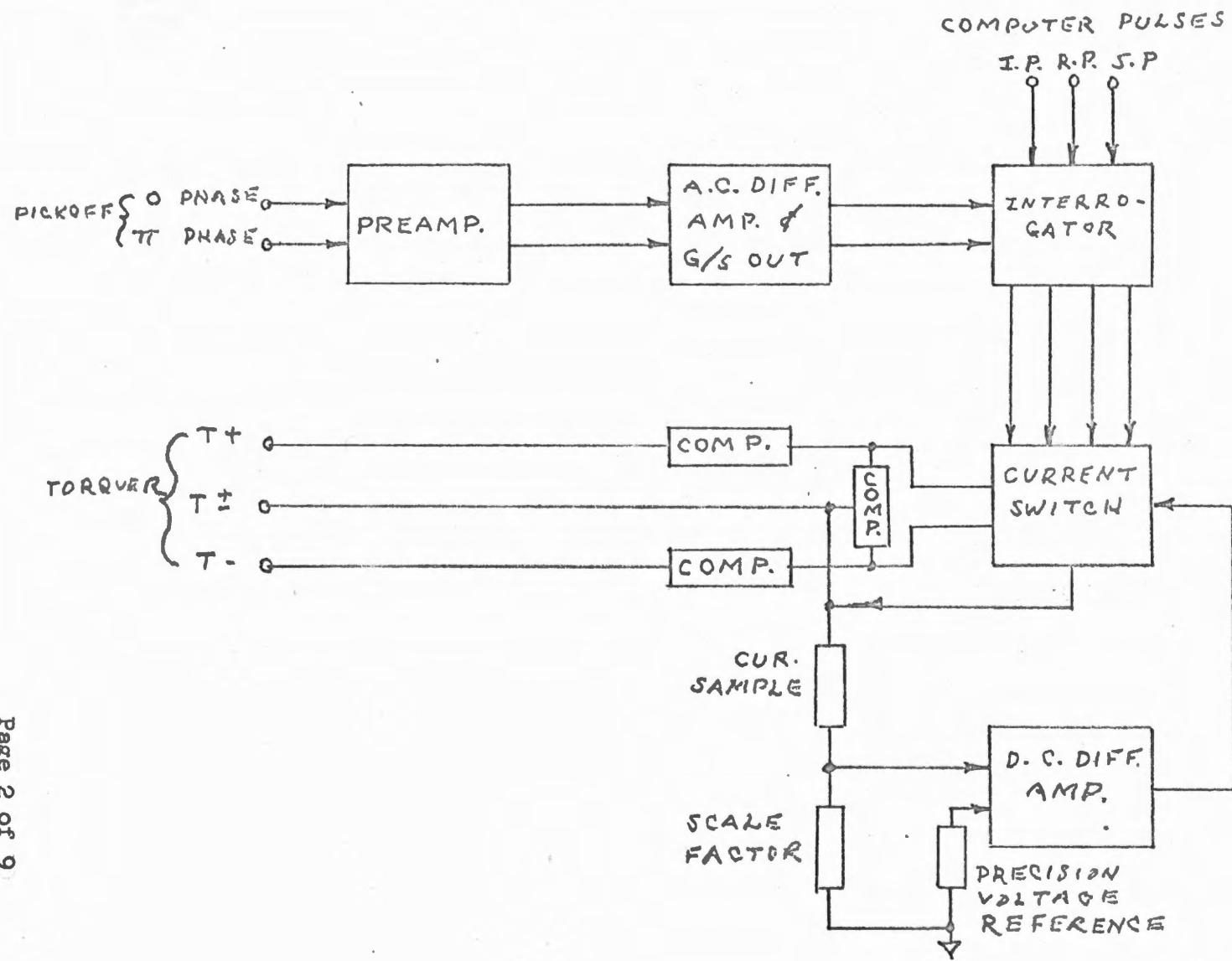
BASIC PIPA BLOCK DIAGRAM

FIG. #1

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c. Emergency (Binary)

In this mode the pendulum is kept continually in motion because current is fed alternately to each torquer. This mode has the poorest velocity resolution and the maximum input acceleration capability.

3. Interrogator & Current Switch Operation

For ease of explanation assume nearly +8G input acceleration and normal mode operation.

The zero and π phase outputs of the A.C. differential amplifier are fed to Schmitt triggers (Fig. #2). The bias level on these circuits determine the threshold (dead zone) of the loop. Once this bias is exceeded positive pulses appear on the output of Schmitt T+ (Fig. #3) and are in phase with the interrogate pulses. These pulses enable G I to supply negative triggers to 1-shot T+. The 1-shot stretches the G I pulse out to 10 μ sec. to insure coincidence with the switch pulses. With coincidence a negative pulse out of G3 sets F.F. T+ and also enables G6 to supply a reset pulse to F. F. T- (Fig. #4). F.F. T+ turns on the T+ switch to supply current to the T+ torquer. The pendulum will be torqued into the threshold but before it can exceed the opposite threshold the torque is removed. This is accomplished by suppling a reset pulse in conjunction with a switch pulse to G4 312.5 μ sec. after the interrogate pulse. The negative pulse out of G4 resets F.F. T+ and F.F. T- via G6 and G7. If the input acceleration is removed the pendulum will remain in the dead zone and no more current will be supplied to the torquer. However, if acceleration is maintained, constant current pulses will be fed to the torquer at a rate that is a function of the acceleration magnitude.

Since current through the torquer is maintained at a constant level by comparing the voltage across the scale factor resistors to a precision voltage reference (Fig. #1), current must be maintained in the scale factor resistors to prevent saturation of the D. C. differential amplifier. This is accomplished by feeding the reset sides of F. F. T+ and F.F. T- to an "and" gate. When there is no current in either torquer the F.F.'s will enable G8 (Fig. #4) to supply base current to the dummy switch, thereby maintaining current in the scale factor resistors.

G9 and G10 are $\triangle \vee$ computer output gates. The back swing of an amplified, differentiated interrogate pulse is gated with the set side of the F.F.'s to give a pulse out each time the torquer receives a current pulse.

REV.

SCHMITT TRIGGER T+

3.2 KC O PHASE

RESET PULSE

INTERROGATE PULSE

DIFF. & AMP.

SWITCH PULSE

SCHMITT TRIGGER T-

3.2 KC T PHASE

G1

G2

1-SHOT T+

1-SHOT T-

G3

G4

G5

G6

G7

T+ O SET

O T- RESET

DATA O PULSE

T+ O RESET

O T- SET
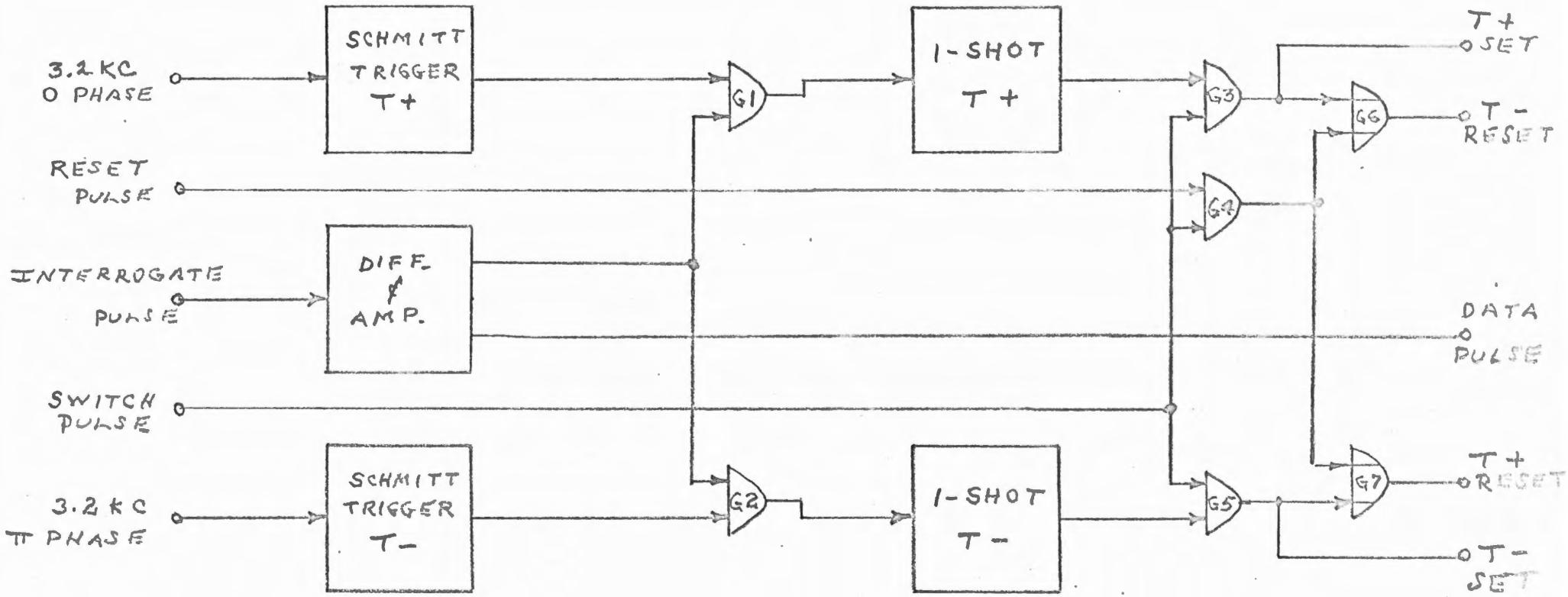
INTERROGATOR

FIG. # 2

FIG. #3
NORMAL MODE

Signal labels (left side, top to bottom):
- 3.2 KC O PHASE
- SCHMITT T+
- 3.2 KC π PHASE
- SCHMITT T−
- 6 KC I.P.
- G 1 OUTPUT
- T + 1-SHOT
- 2.8 KC S.P.
- G 3 OUTPUT
- 1.6 KC R.P.
- G 4 OUTPUT
- G 8 OUTPUT
- DUMMY CUR.
- T + CUR.
- T − CUR.

Annotations:
- THRESHOLD
- 3 μsec. P.W.
- 10 μsec.
- 1 μsec.
- 3 μsec.
- 312.5 μsec −100 ma.
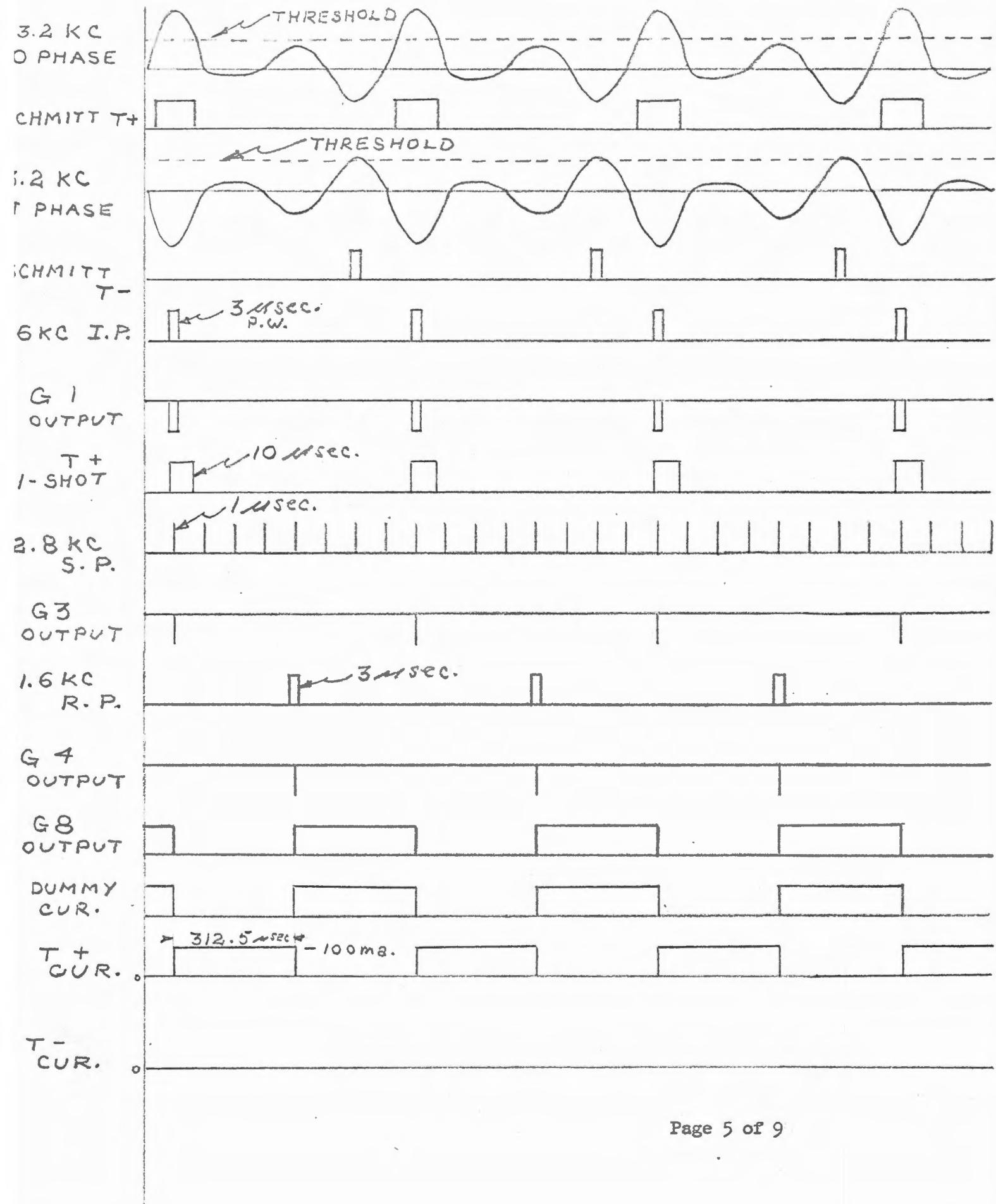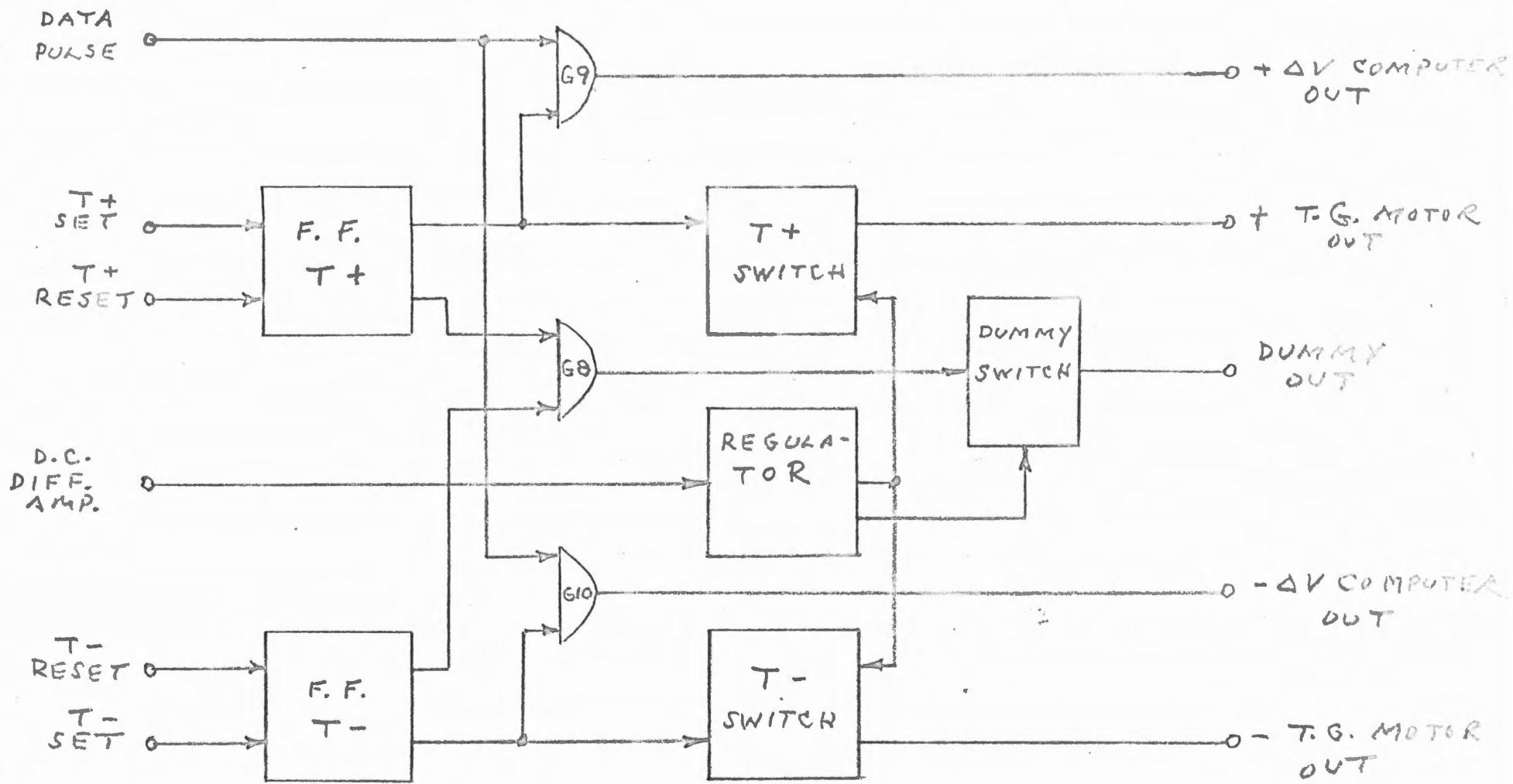
CURRENT SWITCH

FIG. #4

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Operation in the sensitive mode is the same as above except that the reset pulse occurs sooner, 78.125 μ sec. after the interrogate pulse (Fig. #5). This results in a reduction of maximum input acceleration capability and an increase in velocity resolution.

Disabling the reset pulse results in emergency mode operation. Once the pendulum angle exceeds the threshold the gating of switch and interrogate pulses ultimately turn on the proper current switch to torque the pendulum back into the threshold (Fig. #4 and #6). Since there is no reset pulse the torque will be sustained until the pendulum emerges from the opposite threshold. When this happens proper gating of interrogate and switch pulses will simultaneously supply a reset pulse to turn off the on switch and a set pulse to turn on the off switch. The direction of torque reverses and the pendulum is torqued back to the threshold. Hence the absence of a reset pulse results in current being supplied alternately to each torquer coil causing the pendulum to oscillate around the threshold.

REV.

FIG. 5
SENSITIVE MODE
NEARLY 2 G INPUT

3.2 KC O PHASE — THRESHOLD

SCHMITT T+

3.2 KC π PHASE — THRESHOLD

SCHMITT T-

1.6 KC I.P. — 3 μsec. P.W.

G1 OUTPUT

T+ 1-SHOT — 10 μsec.

12.8 KC S.P. — 1 μsec.

G3 OUTPUT

1.6 KC R.P. — 3 μsec.

G4 OUTPUT

G8 OUTPUT

DUMMY CUR.

T+ CUR. — 78.125 μsec.

T- CUR.
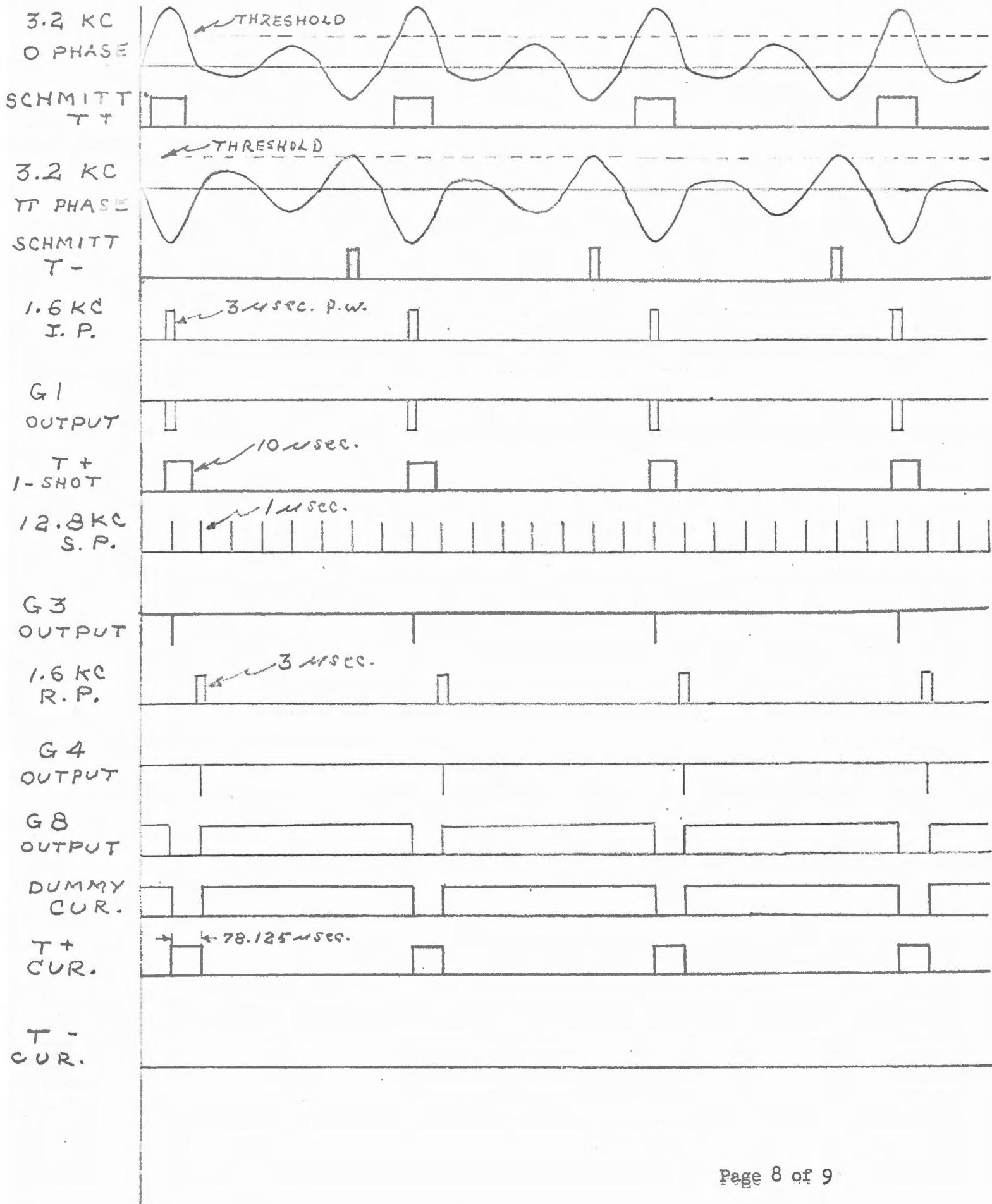
FIG. #6.

EMERGENCY MODE

HIGH G INPUT

1.2 KC 0 PHASE	THRESHOLD
SCHMITT T+	
1.2 KC " PHASE	THRESHOLD
SCHMITT T-	
1.6 KC I. P.	3 μSEC. P.W.
G 1 OUTPUT	
G 2 OUTPUT	
T+ 1-SHOT	10 μSEC.
T- 1-SHOT	10 μSEC.
12.8 KC S.P.	1 μSEC.
G 3 OUTPUT	
G 5 OUTPUT	
G 6 OUTPUT	
G 7 OUTPUT	
T+ CUR.	
T- CUR.	