Automatic Analysis of the Electrocardiogram

Electrocardiography has recently seen ~~man~~ ~~several~~ several the technical improvements

Electrocardiography has ~~long been~~ become one of the most valuable tools of ~~cardiology~~ medicine in spite of being limited to recording from pts. as completely, still ~~as~~ & relaxed as possible and for only a short periods of time; ~~because of~~ this was dictated by technical limitations of recorders. ~~There have been many efforts~~ ~~These limitations have long been seg~~ recognized. ~~Master's test~~ By means of simple radio telemetry and magnetic tape recording we are now able to obtain EKG records from individuals ~~undergoing~~ almost any activity short of swimming and for periods of many days. This has proven to be of great value in both clinical practice and research.

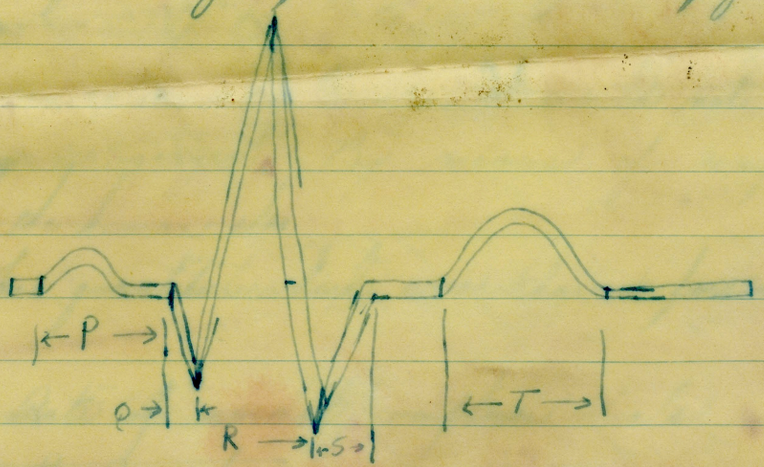
~~The nature of the EKG requires~~

~~Even~~ It was evident from the ~~start~~ beginning that some method of automatic data reduction would be required. ~~The typical record~~ The typical record

previously occupied only a relatively few seconds ~~and~~ whereas we were often faced ~~a~~ single records lasting 12 hrs. or more.

It may be worth the effort at this point to briefly describe some pertinent aspects of the EKG signal. The signal shown here is from the telemetry or 'T' lead used by us. (Illus. 7)

~~The signals with~~ ~~vary~~ of course ~~a~~ lead configuration ~~and~~



Appendix

The P wave represents the potential ~~wave~~ associated ~~a~~ the wave of biochemical activity which originates in the S.A. node, sweeps over the atria of the heart and causes the muscular contraction a ~~few~~ fraction of a ~~second~~ second later. After a delay

There have been a number of publications on the ~~analysis~~ automatic analysis of the EKG but they usually were methods of data translation and programming such that the analysis could be performed by large conventional digital units or else they were in terms not familar or accepted by the profession. It was desired to have a unit which was inexpensive, small, simple and would quantitate the desired features of the EKG in conventional terms. It would not attempt ~~to supplant the human~~ else

The quantities which were chosen for analysis were 1. Rate of normal complexes

~~2. R-R interval~~

2. Number of ventricular ectopic beats

3. S-T segment depression

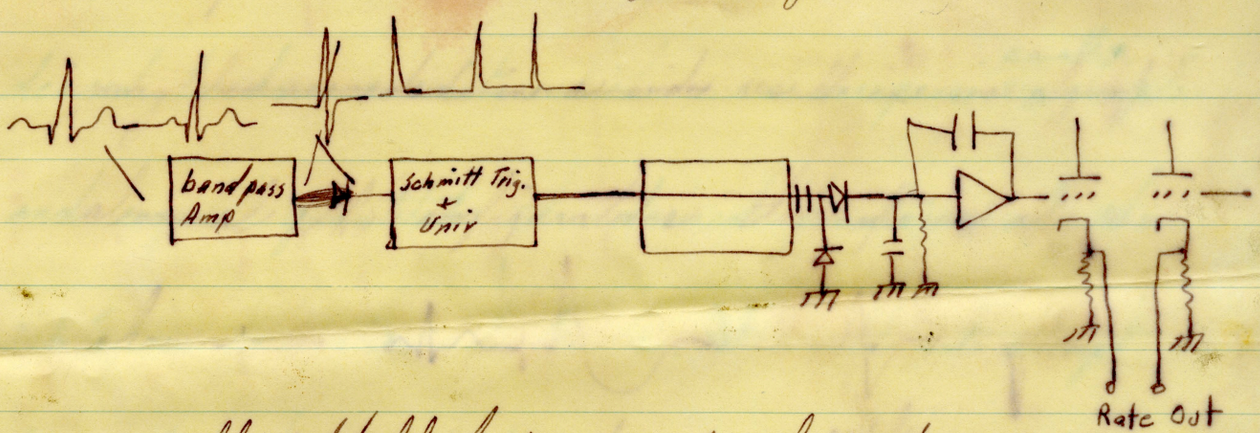
4. R-R interval

~~During normal activity~~

Rate: The ~~portion~~ QRS complex, particulary the 'R' wave provides the most reliable information pt. of and is the most constant feature of the record the record ~~in norms It is in normal activity~~ ~~or~~ from individual to individual especially in disease.

~~especially involving heavy muscular activity, a~~

Rate is ~~usually~~ normally taken as the number of beats for a given period of time, usually not less than 15 sec. ~~not~~ + expressed in terms of bts/min. The same thing was done here ~ the ↑ normal Q.R.S. complexes being counted and averaged over a 30 sec. epoch and expressed as bts/min in analog voltage -

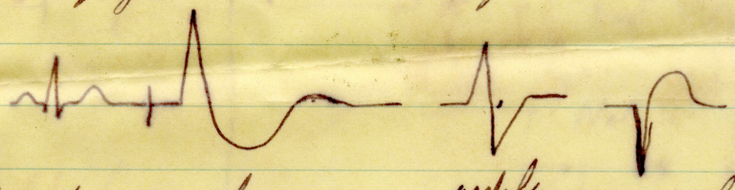


An abbreviated block diagram of the portion is shown and consists of a more or less conventional rate meter ~ a pulse averag circuit. ~~After careful empirical adjustment (i.e. a great deal of desk top after less than desirs~~

By proper selection of bandpass freqs - ~~and~~ the meter would count reliably in face of interference ~~that rendered~~ made visual recognition of the QRS complexes difficult.

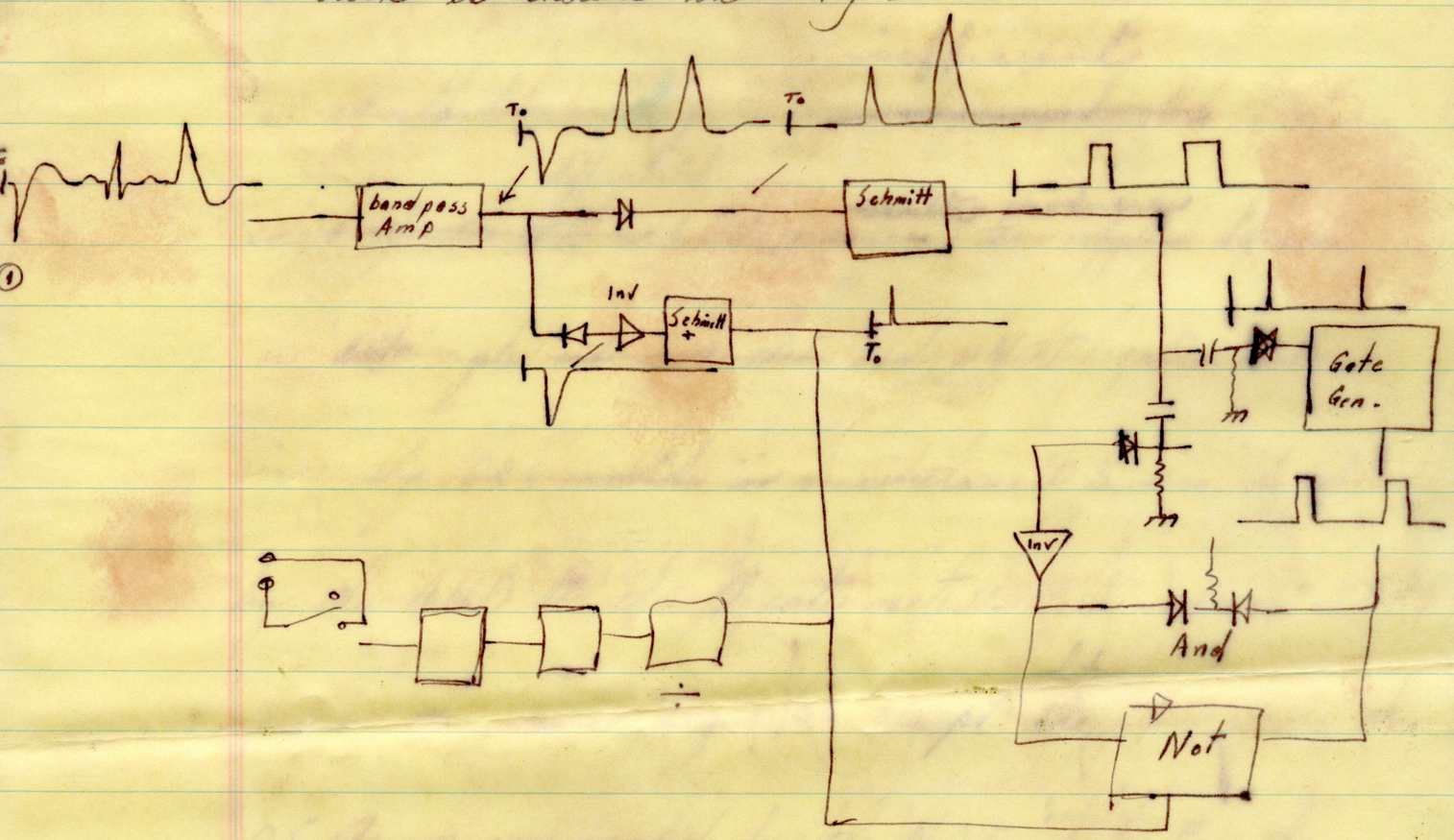
2. Ventricular Ectopic beats - These are ~~aberrant~~

abnormal contractions arising from ~~a hypersensitive~~ ~~areas~~ areas somewhere ~~foci~~ foci in the ventricles which produce ~~a~~ ~~trigger~~ foci of excitation which spreads over the heart causing ~~an poorly coordinated~~ inefficient beats. ~~Since these foci~~ This ~~results~~ produces ~~causes~~ ~~are entirely different~~ ~~and~~ unpredictable ~~to~~ vector loops ~~which~~ ~~is seen~~ may ~~be recorded in a wide~~ result in variety of abnormal QRS configurations three of which are shown —



~~A common feature~~ the common useful feature here is a widened QRS interval. ~~It was~~ This feature was chosen ~~as~~ to discriminate between these and normal complexes. Another difficulty however was that the ectopic complex was sometime negative going. However the lead configuration gave or could be adjusted to give normal ~~QRS~~ complexes a relatively low amplitude ~~QRS~~ negative going components. Two criteria are used to count V.E.B.'s, ① a QRS ~~amplitude~~

complex wider than .05 secs. at half amplitude or 2. a negative going QRS complex - The block is shown in Fig -



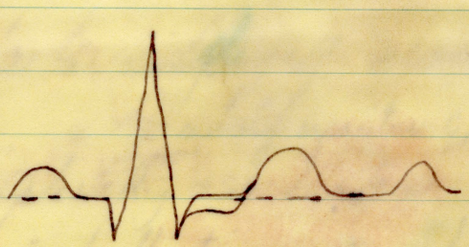
The three conditions which may exist are shown here - ① is a VEP & neg. going complex. This is passed ~~on to~~ by the diode D_2 but blocked by D_1. After passing D_2 it produces a ~~single~~ trigger and is counted by the binary chain. A normal complex is shown at ②. This is passed by D_1 and it ~~produces a trigger for the constant width gate generator which produces~~ triggers the schmitt which

produces a pulse equal to the ½ amplitude width of the QRS complex. ~~In addition the pulse~~ This pulse is differentiated and the leading edge triggers a constant width gate generator. The trailing edge of the ~~ECG~~ differentiated schmitt pulse is then applied to an 'AND' gate ~~and since the~~ and NOT gates and since the QRS width is less than .05 sec is passed by the 'AND' to the ∅ rate meter. The upright VEP's follow the same sequence except that they are wider than .05 sec. & are passed by the 'NOT' gate to the VEP binaries. These binaries, have neons on the front panel count up to 7 while the 8th pulse closes a relay to pass every 8th count to a recorder -

~~Most difficult~~

S. T. Segment depression - ~~This was the most difficult of measurements to make - First there is some disagreement as to definition~~ significance ~~& typical~~ Although there is

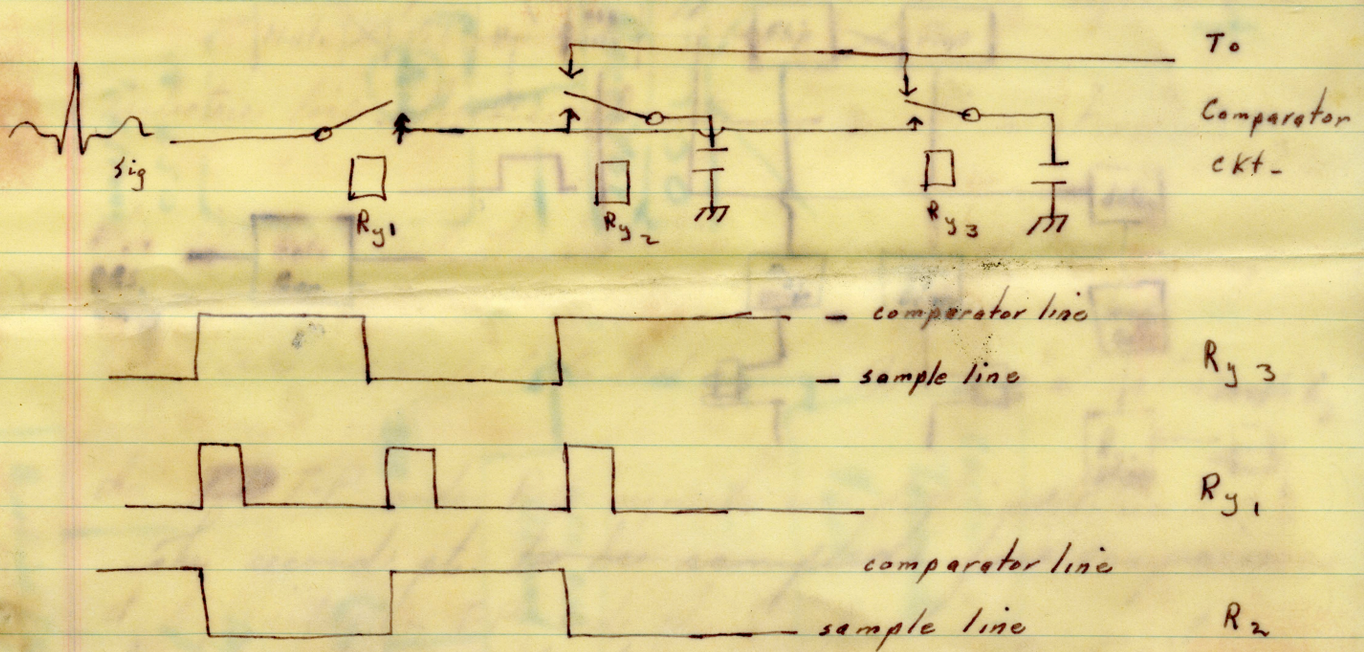
If the segment between the Q + T segments
below the isoelectric line
~~are~~ is depressed, it is an indication that the heart
(Infarction?)
is not receiving sufficient O2 oxygen. The problem



then is to compare the amplitude of the ST segment & the isolectric line. Because ~~of extremely~~ small variations are of importance and the base line may vary it is necessary to do this on a beat to beat basis - At normal rates the ~~[illegible]~~ T-P and P-Q segments are both isollectric but at high rates O< T-P and the complexes merge so it was necessary to use the P-Q segment - As previously stated the only reliable timing point source is the QRS complex but this followed the desired sample point (P-Q). ~~After studying~~ Analysis of a large sample of EKG is showed that the interval did not end less than .035 sec ~~before~~ before the 1/2 amplitude point of the positive going

portion of the R nor did it begin less than .09 sec. earlier. Since the segment is flat a point chosen at random between .04 and .08 sec. ahead of the R could give a sample of the isoelectric amplitude.

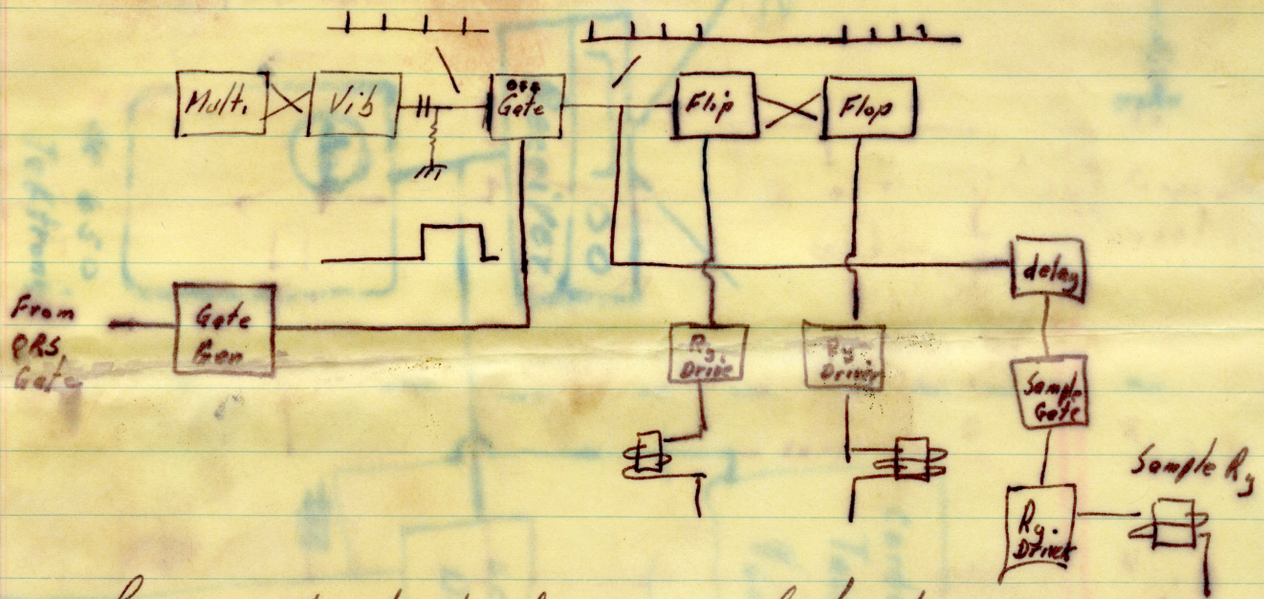
A sample Ry and memory capacitors $C_1 + C_2$ two transfer relays were arranged as shown with dwell times as shown.



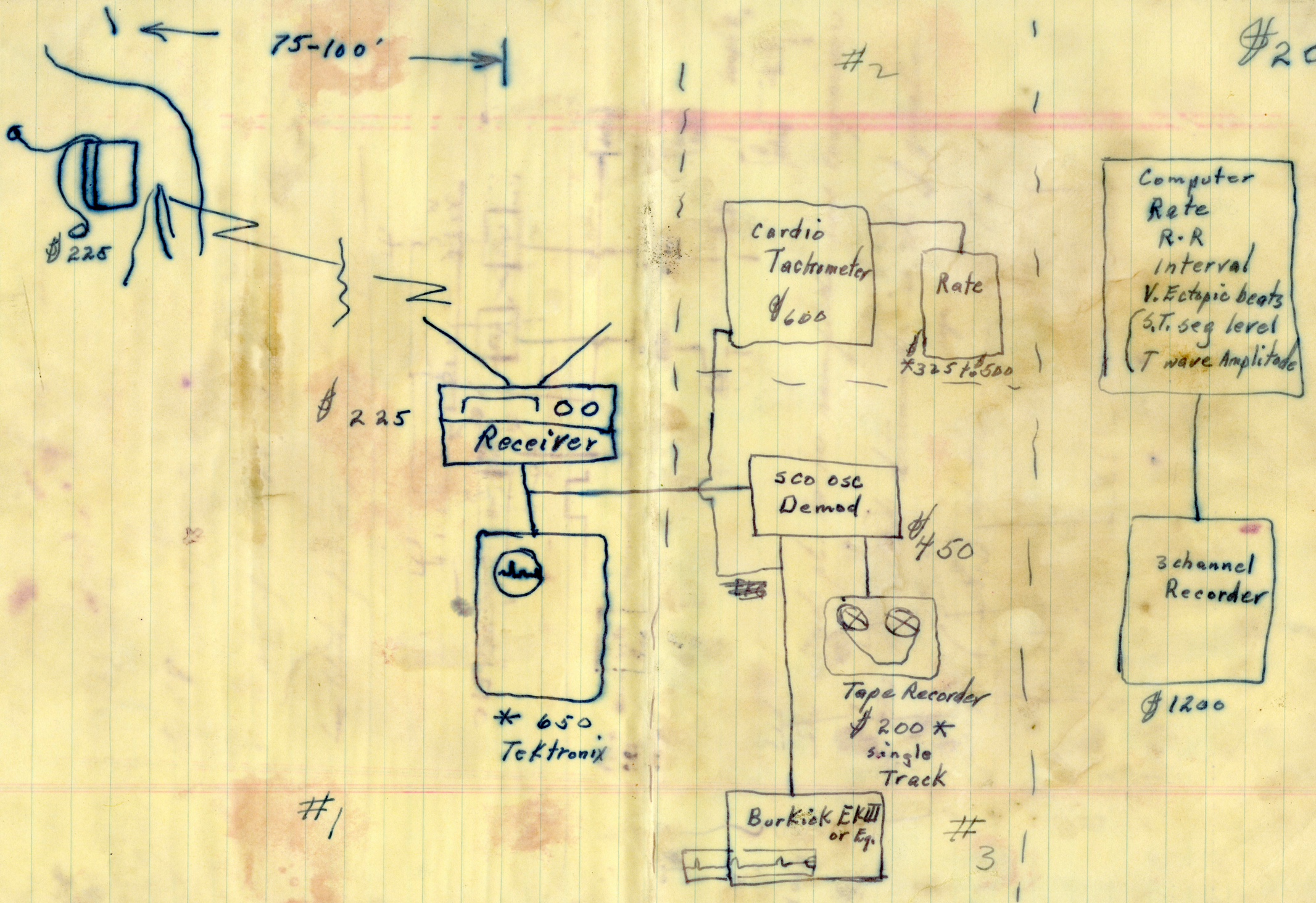
It can be seen that in this arrangement a sample cannot be made available less than 35 msec after the sample point nor be kept available more than 75 msec after this point.

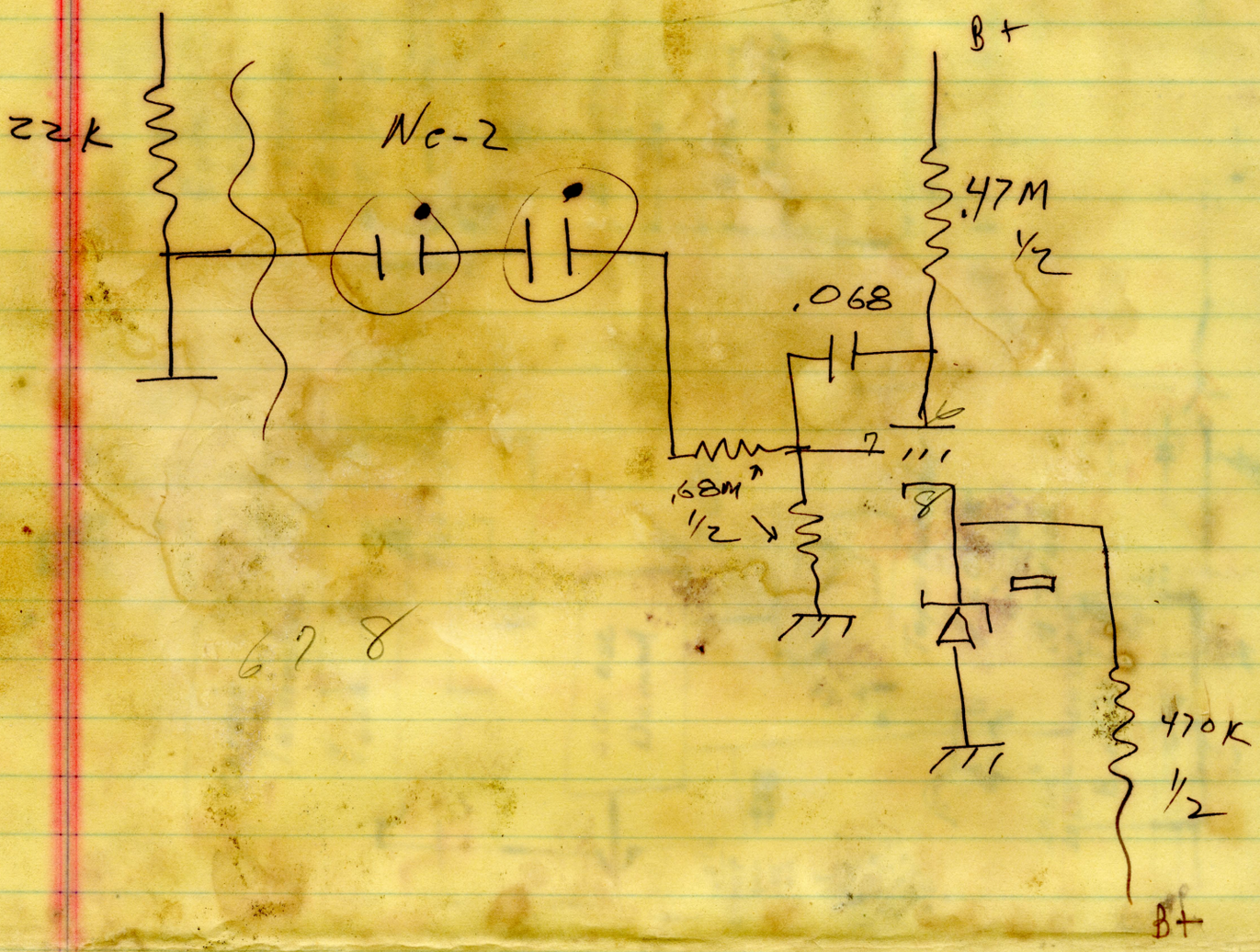
The relays run at the rate shown sampling at random with respect to the complexes. They are stopped on by the R wave and held in this

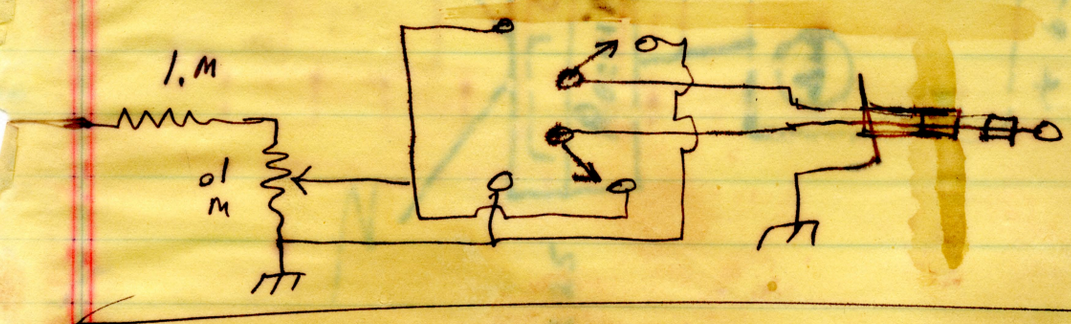
this position ~~c~~ one of the ~~other~~ ~~to~~ memory condensers available. This capacitor contains a sample made .035 to .085 secs. prior to the R wave or in other words a sample of the P-R interval which is isoelectric. ~~Two~~ Blocks for this are shown below -

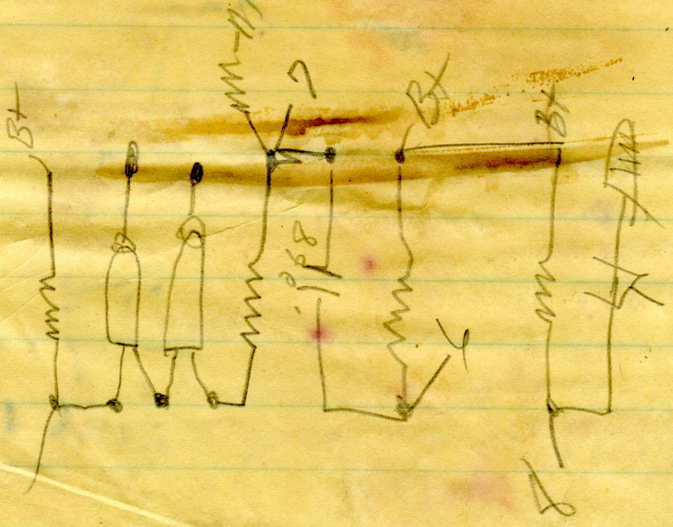


The second pt. ~~to be sampled for comparison~~ ~~is the~~ determined ~~determined~~ is the J junction point (j pt.) of the S ~~o~~ seg. the T.


1
75-100'
#2
$2000
$225
$225
Receiver
Cardio Tachometer
$600
Rate
$325 to $500
Computer
Rate
R-R Interval
V. Ectopic beats
S.T. seg level
T wave Amplitude
SCO osc Demod
$450
3 channel Recorder
$1200
Tape Recorder
$200 *
single Track
* 650
Tektronix
Bur Kick EKIII or Eq.
#1
#3


22K
Nc-2
B+
.47M
1/2
.068
.68M
1/2
470K
1/2
B+


1.M
.01
M


B+
B+
B+