CONTROLLED FILTER AND SMOOTHING

D. BURD

Columbia University, Irvington-on-Hudson

N. WEBRE

Brookhaven National Laboratory, Upton L.I.

(presented by D. Burd)

CONTROLLED FILTER was designed to meet two basic problems which we encountered in the HAZE system. The first was to provide a bypass around FILTER II, which was producing neither the low rejection rate nor the high quality of data needed for production, without going so far as to write a third version of FILTER, which we estimated would take several months. The second problem was that no convenient means existed for studying the difficulties that FILTER was having.

The need for an editing feature such as the present smoothing program became apparent as soon as the first results were available from CONTROLLED FILTER. Small undetected errors, such as the usual one or two bad master points, could be corrected by fitting a smooth curve to the data and rejecting those points whose deviations were greater than some maximum amount. Large errors in filtering could be detected by the fact that the master points did not actually fit a smooth curve, or that a large section of the track had no master points.

1. CONTROLLED FILTER display

CONTROLLED FILTER displays the contents of each of the rejected roads on the CRT. This, of course, means that all the gated points for one event must be stored. The format of the display is as follows (see fig. 1) : event identification is at the bottom of the screen; the road stretches from left to right across the screen, its vertical extent being defined by the mid-road dots. The digitized points are plotted as dots and the master points are superimposed as X's. As filter can process two tracks, the master points of the auxiliary track (if one exists) are superimposed as + 's. The alphabetic codes in the upper right hand section have the meanings :

E - every point mode
R - rejected
A - abnormal mode

In the upper left are the three rough digitizer points inside of a chamber outline.

2. CONTROLLED FILTER Method

Let us suppose that a rejected road has been displayed on the CRT screen. At this point the operator may decide that the measurements are perfectly good, or at least that the imperfections are slight and probably cannot be eliminated. In this case he simply can override the rejection from the console and continue on to the next track. If there seems to be an error in the displayed road, he can proceed as follows : He chooses the track which he believes to be the correct one (this is usually obvious, but in any case can be decided from a sketch made at the scan table) and enters its CRT division at the beginning, middle and end of the road into the keys. Since the road covers 8 large divisions vertically, these can be entered as the numbers 0-7 and the divisions on the external display at Brookhaven are so labelled. The operator then pushes a button which interrupts the CRT display and returns control to the program. The information in the keys is now used to make a parabolic fit to the reduced track and the filtering process is repeated. This time, however, the look ahead region is determined only by the parabola. A byte will be filtered if it has one and only one pulse in the parabolic region. The refiltered track is then displayed once more and the operator is free to try again if he is still unsatisfied.

Figures 2 and 3 illustrate the use of CONTROLLED FILTER in a case where FILTER has strayed onto a crossing track and left the road.

Figures 4 and 5 illustrate a case where FILTER has initiated the wrong track and CONTROLLED FILTER sets it right.

3. Smoothing method

Bad points are rejected on the basis of a series of parabolic least squares fits to the master points. Each fit results in a single point rejection if the maximum deviation exceeds a calculated tolerance. The tolerance here depends on the turning angle of the measured portion of the track. If three or fewer point rejections are required, the track passes the smoothness test and the longitudinal distribution is checked. Here the master points are required to be separated by not more than a fixed fraction of the total road length. Likewise the end measurements are required to be reasonably close to the road ends. If either of these tests is not met, the entire track is rejected, hence displayed.

Figures 6 and 7 show a filtered road before and after smoothing.

4. Sequencing of smoothing and CONTROLLED FILTER

Immediately after the final call to GATING and FILTER II, smoothing is applied to all tracks which are not rejected by FILTER II. At this point, each track has skipped smoothing, been smoothed, or been rejected during the smoothing process. Control is then returned to DISPATCHER, which immediately calls CONTROLLED FILTER. Each of the rejected tracks is displayed. If a track is manually refiltered, the new master points are subjected to smoothing. This means that output from any point in the system will have been smoothed.

5. Production and rejection rates

The statistics from a batch of 100 events will give some idea of the present performance of CONTROLLED FILTER.

# of tracks	# of displays	# of rejections
935	242	84

This indicates that we had to look at about one track in four, which is misleadingly high. 51 of the tracks displayed were missing from the road completely. This is due to a bug in the system and is undoubtedly curable. 17 more were displayed because of an error in the program causing all tracks to be rejected when both secondaries were in the abnormal mode. If we subtract these out, we get the following set of numbers :

# of tracks	# of displays	# of rejections
935	174	16

This puts the number of displays at the 1 in 5 or 6 range. It is clear already that the tolerances we are using now in smoothing are much too conservative. Many of the displayed tracks seem perfectly good. Loosening these tolerances should significantly reduce the number of displays without affecting the quality of the data. We would like to, and think we soon can, reach the 1 in 10 region.

Our rate with this sample was about 50 events per hour or about 400 events/8 hour shift. If we reach the 1 in 10 region on displays and use 400 ft. rolls of film instead of the 100 ft. rolls used to get the above results, we believe we can reach 600 events/shift with no difficulty. Any substantial increase in this rate will probably require a basic revision of FILTER II.

Figure captions

Fig. 1 An example of the CONTROLLED FILTER display. The dots represent gated digitisations, the X's are the computed master points. In the upper left of the picture is shown the outline of the chamber and the positions of the three rough digitisings for the track which is displayed.

Figs. 2 and 3 These show a typical example where FILTER follows a crossing track (2) and is corrected by the use of CONTROLLED FILTER (3).

Figs. 4 and 5 Here FILTER fails due to starting on the wrong track (4) and is corrected (5).

Figs. 6 and 7 These show the effect of smoothing (7) on a track where some bad points are initially present (6).

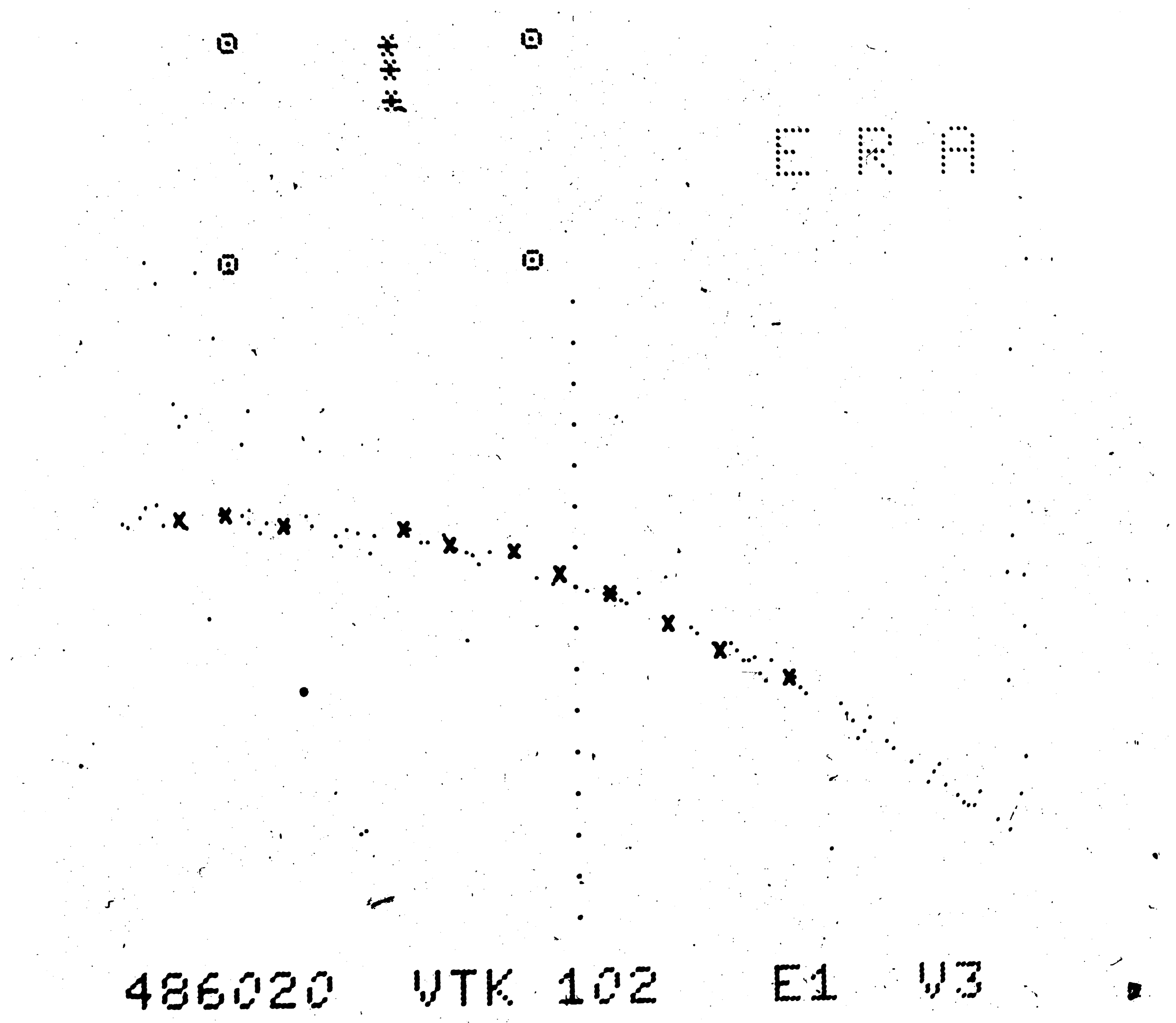

Figure 1

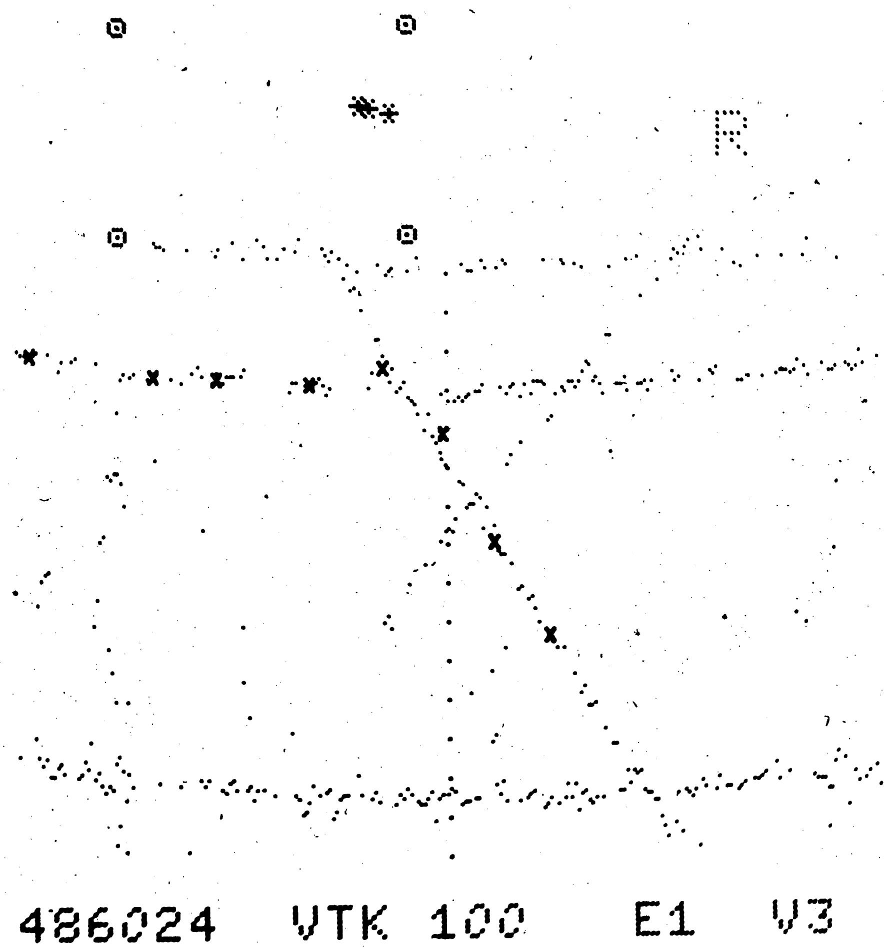

Figure 2

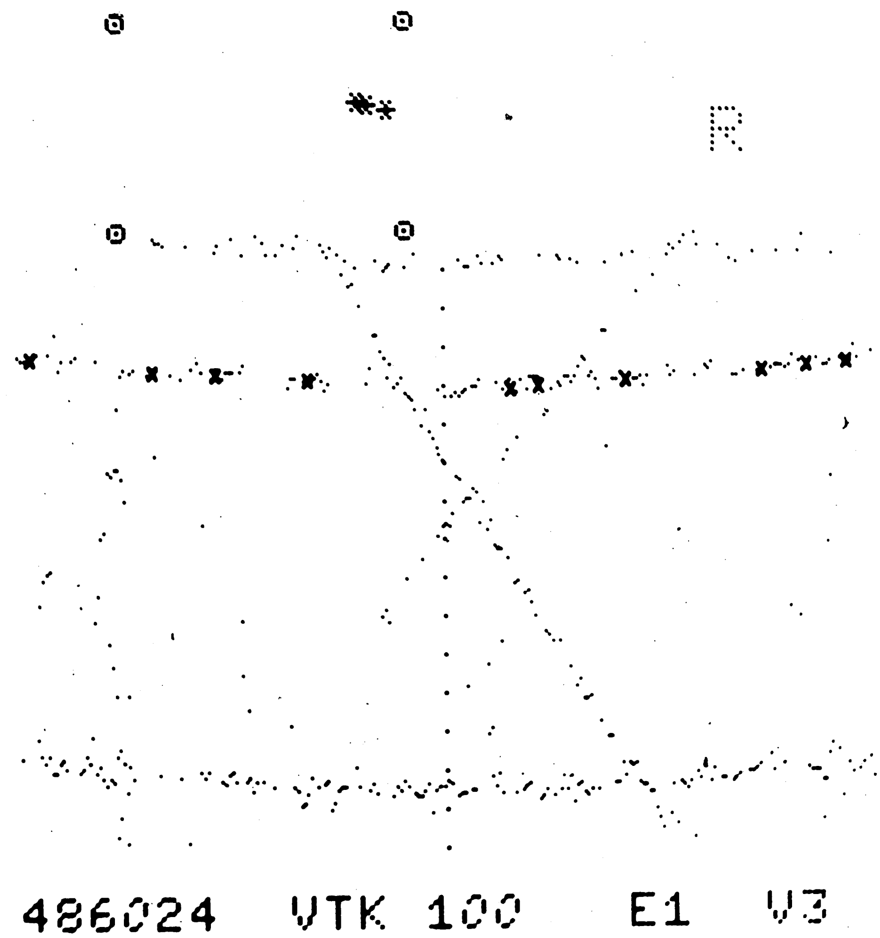

Figure 3

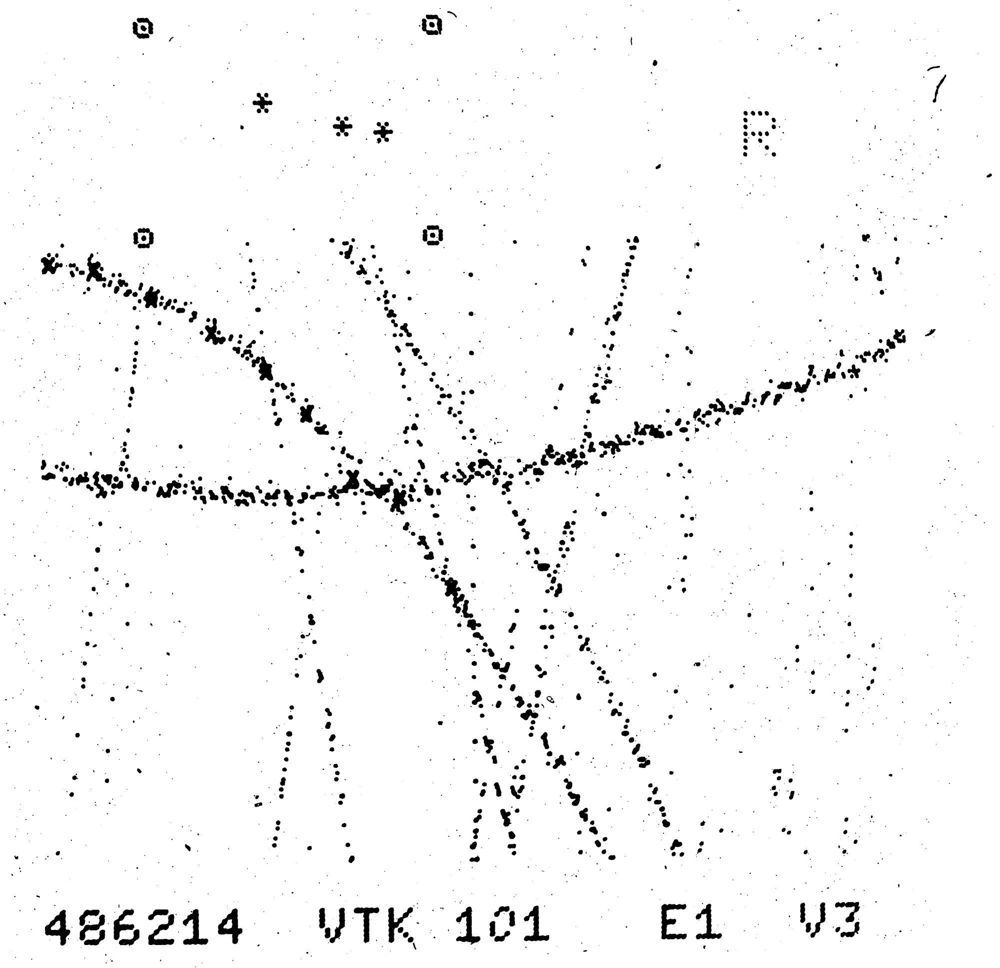

Figure 4

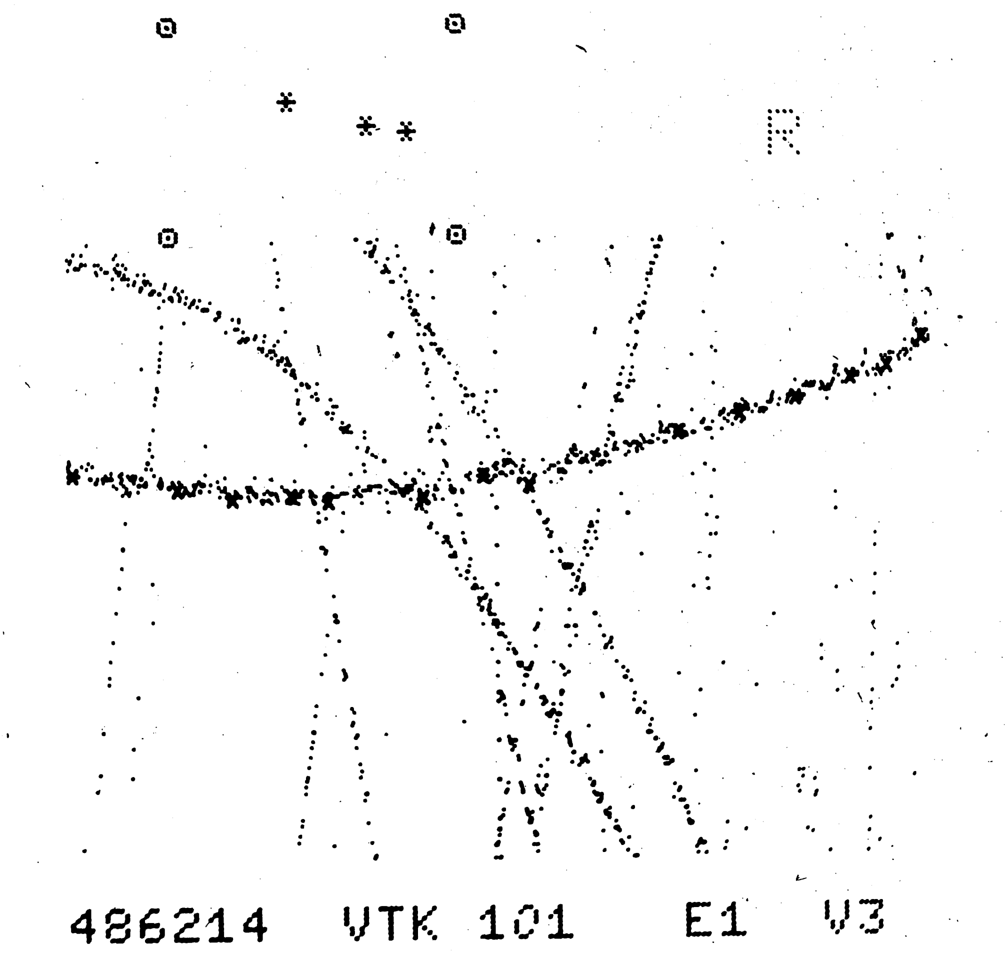

Figure 5

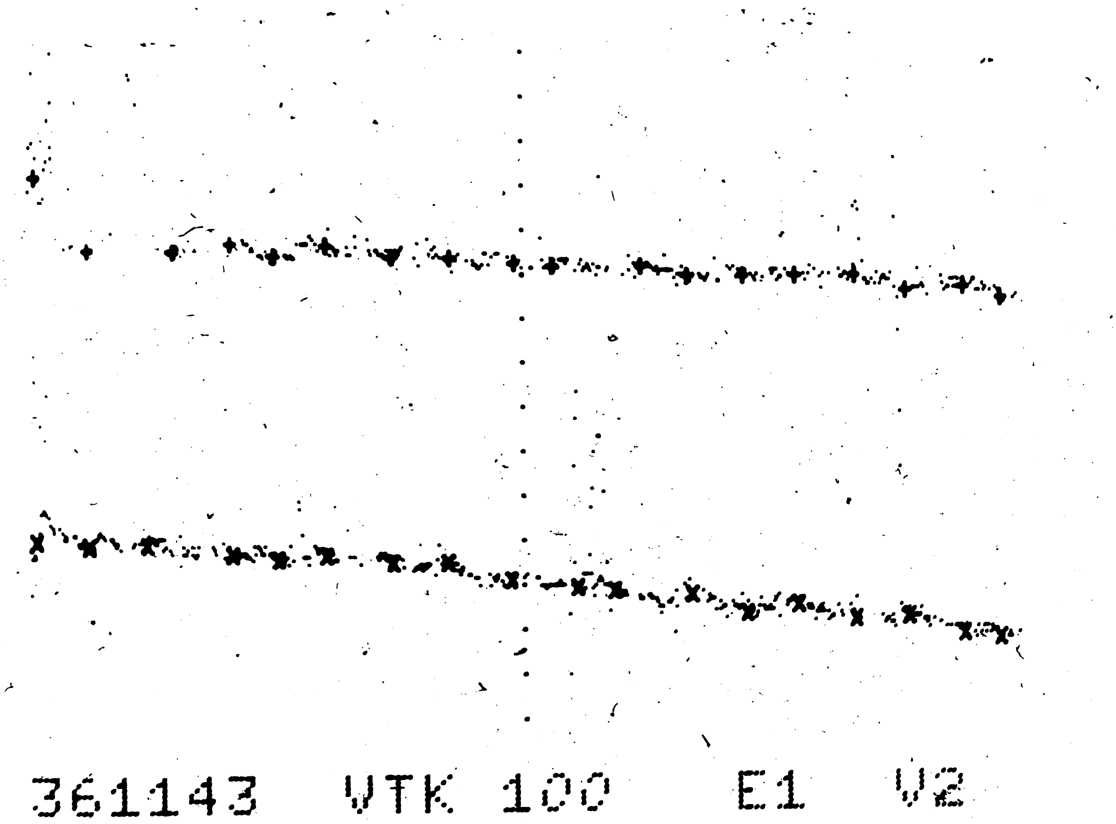

Figure 6

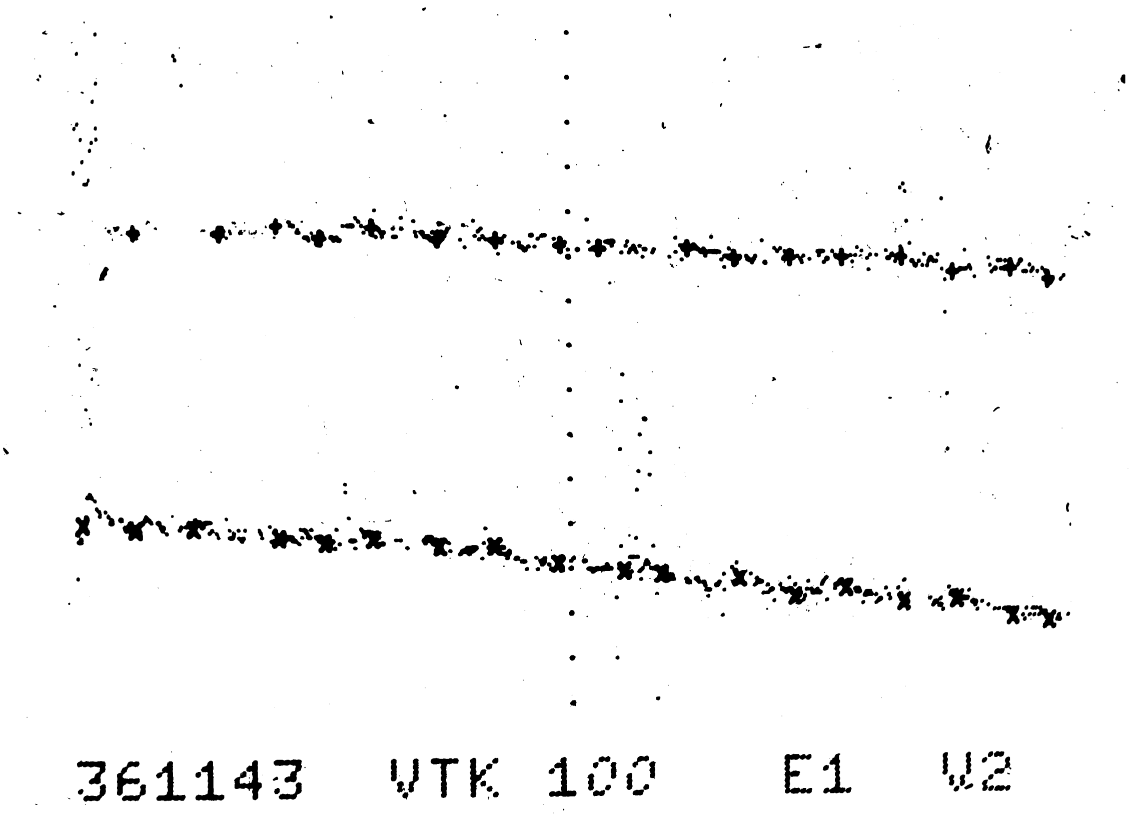

Figure 7

DISCUSSION

TYCKO: Are most of the rejections due to the smoothing criteria ?

BURD: Nearly everything.

TYCKO: If you increased the limit to 6μ, would they all go away ?

BURD: I hope so.

TYCKO: If it were 6μ, you would then be doing like a Franckenstein and you could compare with that.

MACLEOD: If one track in nine has to be looked at, how much of the overall time do you spend thinking about this one track ?

HOUGH: The time is raised by a factor of 2.

MACLEOD: You are processing 600 events per shift, and you are spending 4 hours of this shift thinking about 10% of the tracks. Why is this faster than taking a dump for the 10% and looking at them off-line later ?

BURD: The main reason is to see what FILTER is doing.

MACLEOD: Will it be part of the production system ?

BURD: If it degenerates to a small percentage, it will be taken away.

CALKIN: Does the 600 events per shift include processing through FOG-CLOUDY-FAIR ?

BURD: No, just HAZE, and then out onto tape.