CERN VERSION OF FILTER*)

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(presented by W. Krischer)

The CERN version of FILTER is a routine of about 2000 FAP instructions. The purpose of FILTER is:

a) to compute the road parameters used by GATE, i.e. at the beginning of each slice the starting y - value, starting tangent, tangent increment per scan line, bin-width and road-width;

b) to improve the road parameters, using information already gathered along the road;

c) to separate interesting tracks from background and other tracks;

d) to compute master points for our spatial reconstruction program.

For a certain fixed number of scan lines, called a "slice", a track is considered to be a parabola, i.e. to have a constant tangent increment. The increment of tangent per scan line we call DDTAN. The slice length, a program parameter, is at present set to 32 scan lines. For highly curved tracks, and for short tracks we use a half slice mode, i.e. at present 16 scan lines.

GATE collects all points lying in the roads as defined by FILTER, and builds up the histograms $\Sigma 1$, $\Sigma\Delta x$ and $\Sigma\Delta y$, where $\Sigma 1$ means the point

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*) See also CERN 63-34, Proceedings of the "Programming for HPD and other Flying Spot Devices" Conference, Paris, October 1963, pp. 125-127.

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count per bin, Δx the distance from the beginning of the slice and Δy the positive y distance from the road edge. At the end of each slice FILTER is called.

FILTER searches at first the point-count histogram for pulses. It uses three thresholds, a background, an area and a width constant. All three parameters are functions of how many scan lines constituted the slice, which bin-width was used, etc. If a pulse (of p bins-width) is found we get the abscissa x of the master point in the form

$$\bar{x} = x_{beg} + \frac{\sum_p \Delta X}{\sum_p 1} ,$$

where x_{beg} is the abscissa at the beginning of the slice. The expression

$$\frac{\sum_p \Delta y}{\sum_p 1}$$

represents the mean y distance from the parabolic road edge. From the y value of the upper road edge at the slice end, the tangent (at the slice end) and the DDTAN, the equation of the parabola $y = y_p(x)$ used in that slice is known. The ordinate of our master point is then

$$\bar{y} = y_p\ (\bar{x}) - \frac{\sum_p \Delta y}{\sum_p 1}$$

At the beginning of each track FILTER starts off with the road constructed by fitting a circle through the three rough digitizings. When at least two master points have been found "track following" can be started. Depending on the magnitude of DDTAN, we use either a circle or a parabola for extrapolation. We postulate that the extrapolated curve passes through the point (x_2, y_2) with that tangent y_2', with which this master point has been found, and that it has at the point (x_1, y_1) and the tangent y_1', the tangent of slice 1, see Fig. 1.

The tangent used in slice 3, y'_{3p}, is then the weighted mean of

1) the tangent obtained by extrapolation, and

2) the tangent of the circle through the rough digitizings.

The weighting factor on the latter tangent decreases like $\frac{1}{n}$ (where n is number of found points) and is zero after 5 points have been found. The roads are always centred around the predicted y value, using as a correction the difference between the last found y value and the centre of the road. With this new tangent we compute the new DDTAN, extrapolate linearly the old one and use their weighted sum as the DDTAN for the next slice.

If a point (x_{3f}, y_{3f}) has been found in the next slice

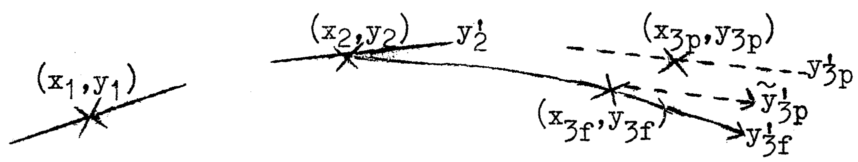

Fig. 1

we correct at first y'_{3p} - let us call this $\tilde{y}'_{3p}$ taking into account the difference $x_{3f} - x_{3p}$ and using DDTAN. We now fit a parabola through the points (x_2, y_2) and (x_{3f}, y_{3f}) using y'_2 and get the following simple formula for the tangent at (x_{3f}, y_{3f}).

$$y'_{3f} = 2\,\frac{y_{3f} - y_2}{x_{3f} - x_2} - y'_2$$

The next extrapolation is then based on the corrected tangent y'_{3c}, the weighted sum of y'_{3p} and y'_{3f}, where the weight on y'_{3f} decreases with the number of master points found.

When looking at the flow charts of FILTER (Fig. 2 to Fig. 6), the following remarks might be helpful:

a) For our histograms we use three different bin-widths: 16, 8 and 4 least counts. We always start off with a bin-width of 16 least counts. The bin-width is then a function of the goodness of the pulses.

b) We always start with a road-width of 400_8 least counts. After two points have been found, we start track-following as explained above, and use a road-width of 240_8 least counts, because the resolution of our HPD is about 100_8 least counts, we cannot use smaller road-widths, if we wish to notice diverging tracks. If we have found a second track in our original road, we narrow the roads of both tracks so that they do not include the other track.

c) We always keep two histograms. Sometimes we combine them to a "double slice" histogram. The double slice mode serves two purposes; it is used for very sparse tracks and to split two diverging tracks. If we find no pulse or two pulses in the histogram, we set a flag and call GATE to process the next slice. When FILTER is called the next time for this track and if this flag is set, we combine the two histograms and look for pulses in this accumulated histogram. If we find any pulse(s), we search the old and the new histogram (with lower background constants) for pulses matching the double slice pulse(s) and compute the average point(s) if we find two double slice pulses, it is assumed that we have two diverging tracks and we follow both.

d) For the computation of ionization we keep, for each slice in which a point was found, the cosine, the number of hits and the bin-width used, all packed in one word.

e) Eventually we expect a FILTER rejection rate of less than 0.5 per hundred.

Figure captions

Figs. 2 - 6   Flowcharts of CERN FILTER Routine.

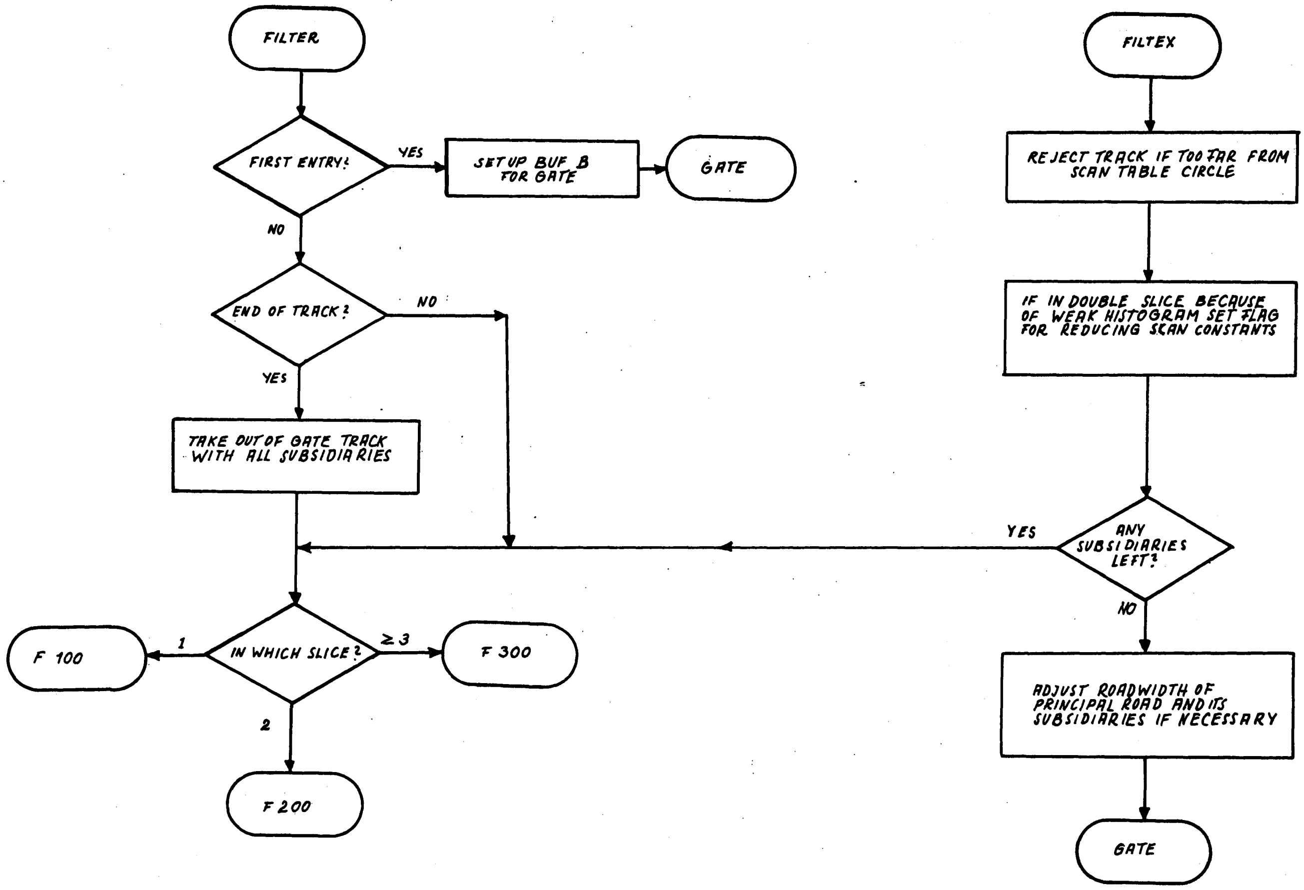
FILTER
FIRST ENTRY?
YES
SET UP BUF B FOR GATE
GATE
NO
END OF TRACK?
NO
YES
TAKE OUT OF GATE TRACK WITH ALL SUBSIDIARIES
IN WHICH SLICE?
1
F 100
≥ 3
F 300
2
F 200
FILTEX
REJECT TRACK IF TOO FAR FROM SCAN TABLE CIRCLE
IF IN DOUBLE SLICE BECAUSE OF WEAK HISTOGRAM SET FLAG FOR REDUCING SCAN CONSTANTS
ANY SUBSIDIARIES LEFT?
YES
NO
ADJUST ROADWIDTH OF PRINCIPAL ROAD AND ITS SUBSIDIARIES IF NECESSARY
GATE

Fig. 2

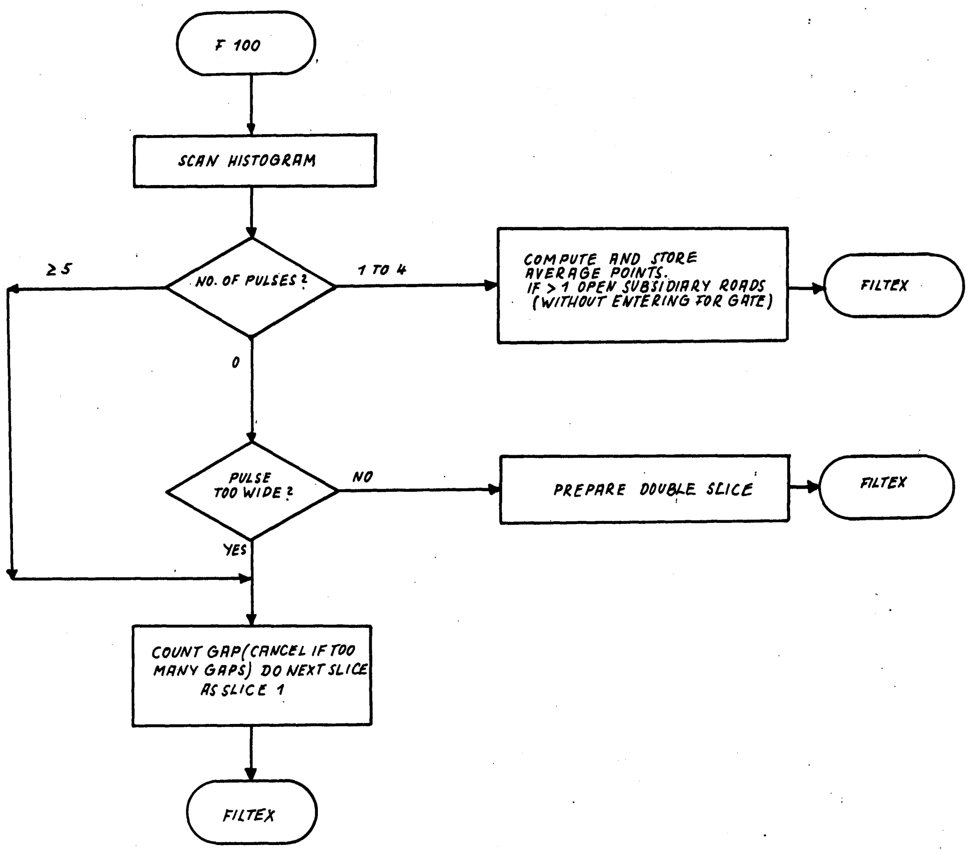
F 100
SCAN HISTOGRAM
NO. OF PULSES?
≥ 5
1 TO 4
COMPUTE AND STORE AVERAGE POINTS. IF > 1 OPEN SUBSIDIARY ROADS (WITHOUT ENTERING FOR GATE)
FILTEX
0
PULSE TOO WIDE?
NO
PREPARE DOUBLE SLICE
FILTEX
YES
COUNT GAP (CANCEL IF TOO MANY GAPS) DO NEXT SLICE AS SLICE 1
FILTEX

Fig. 3

SIS/R/10238

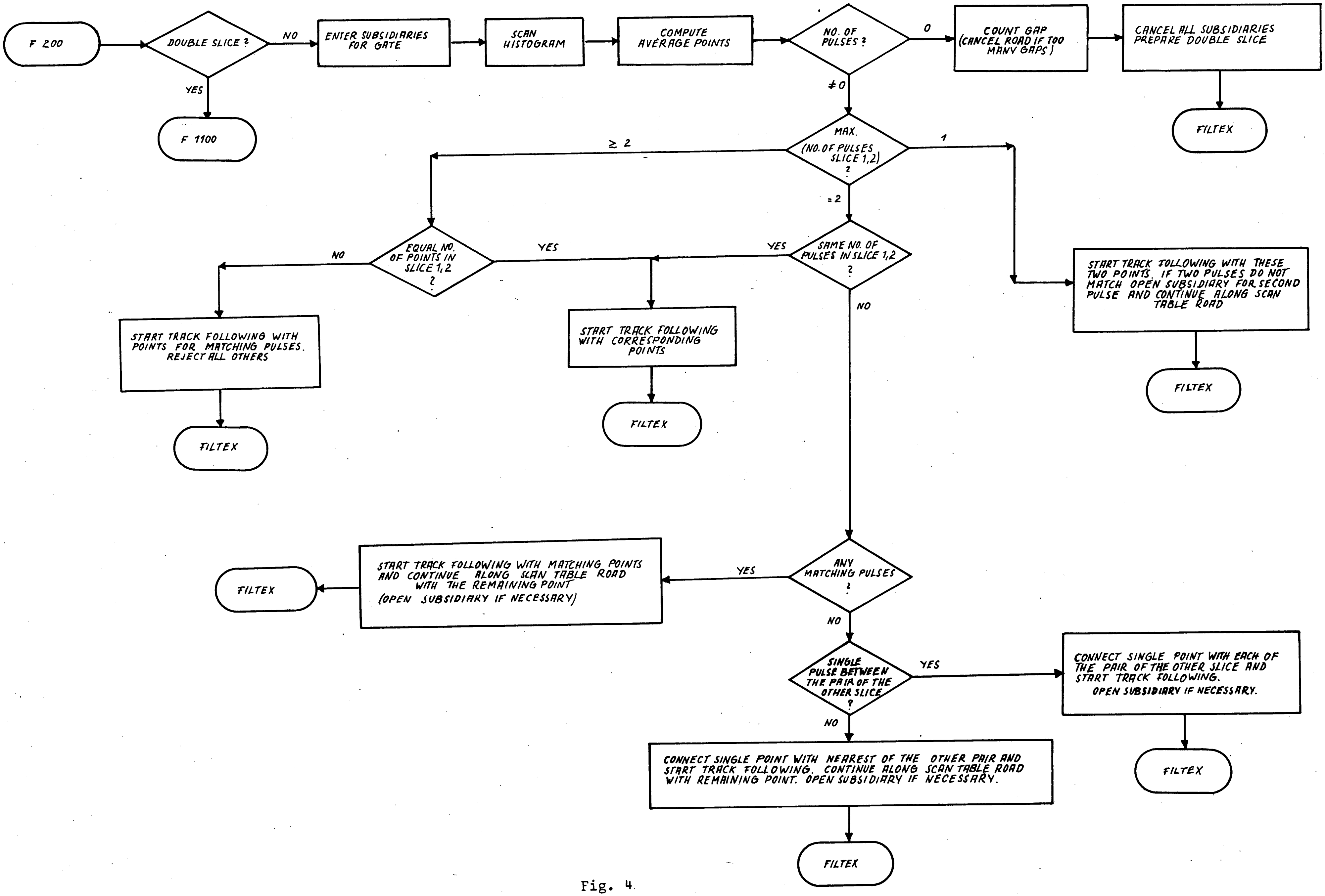

Fig. 4

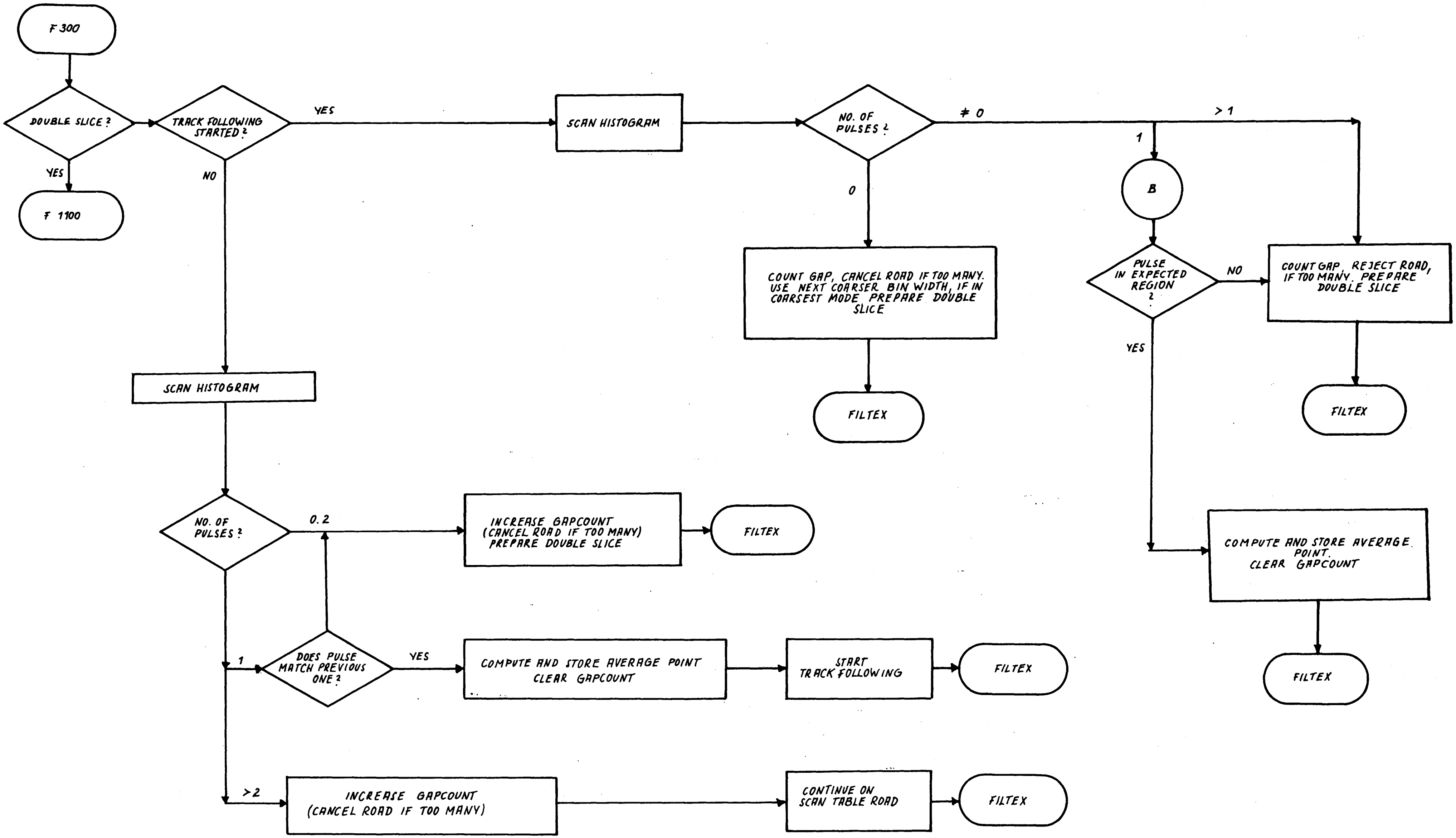
F 300
DOUBLE SLICE ?
YES
F 1100
TRACK FOLLOWING STARTED ?
YES
NO
SCAN HISTOGRAM
NO. OF PULSES ?
≠ 0
0
> 1
1
B
PULSE IN EXPECTED REGION ?
NO
YES
COUNT GAP, REJECT ROAD, IF TOO MANY. PREPARE DOUBLE SLICE
FILTEX
COUNT GAP, CANCEL ROAD IF TOO MANY. USE NEXT COARSER BIN WIDTH, IF IN COARSEST MODE PREPARE DOUBLE SLICE
FILTEX
COMPUTE AND STORE AVERAGE POINT. CLEAR GAPCOUNT
FILTEX
SCAN HISTOGRAM
NO. OF PULSES ?
0, 2
1
> 2
INCREASE GAPCOUNT (CANCEL ROAD IF TOO MANY) PREPARE DOUBLE SLICE
FILTEX
DOES PULSE MATCH PREVIOUS ONE ?
YES
COMPUTE AND STORE AVERAGE POINT CLEAR GAPCOUNT
START TRACK FOLLOWING
FILTEX
INCREASE GAPCOUNT (CANCEL ROAD IF TOO MANY)
CONTINUE ON SCAN TABLE ROAD
FILTEX

Fig. 5

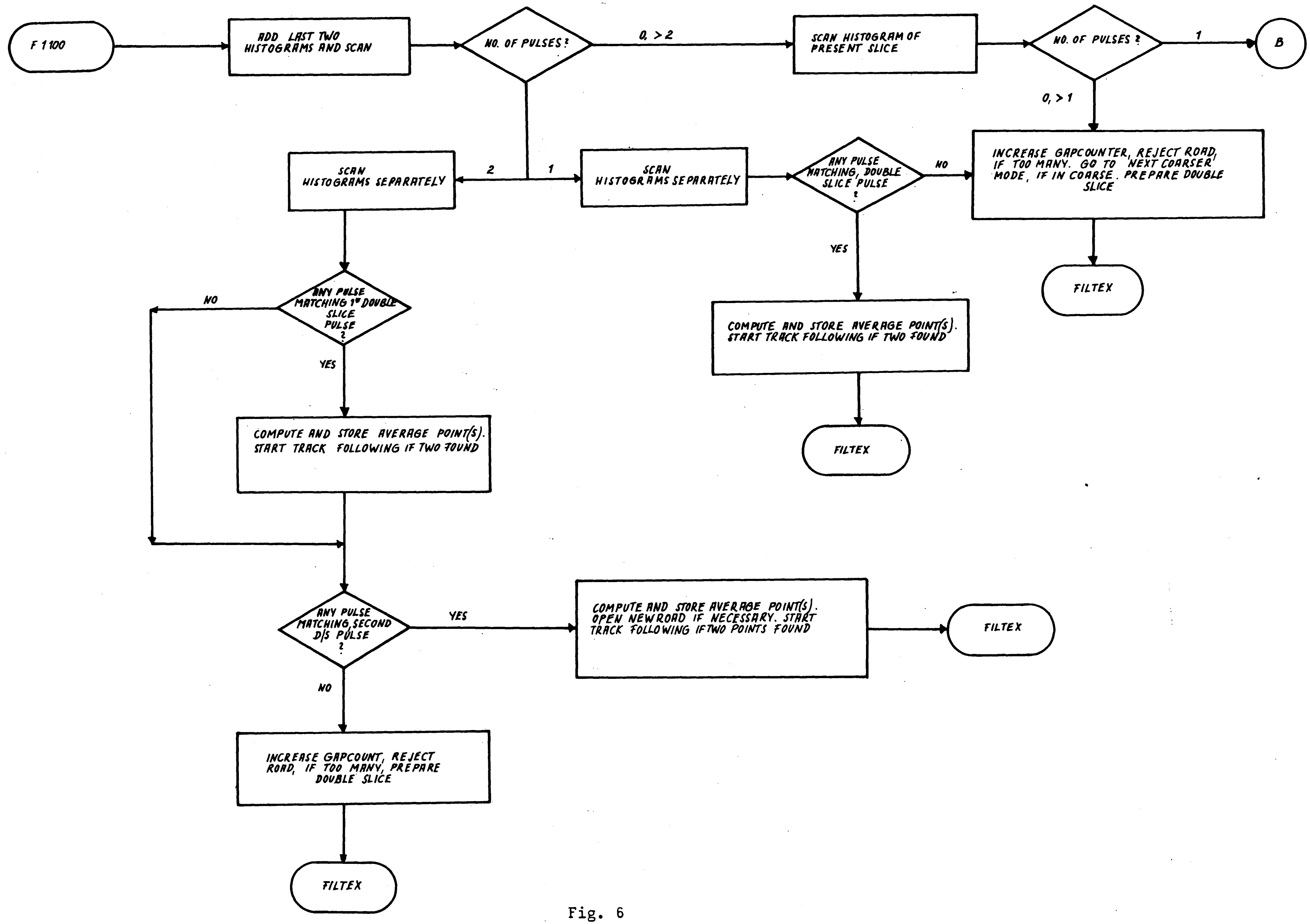
F 1100
ADD LAST TWO HISTOGRAMS AND SCAN
NO. OF PULSES ?
0, > 2
SCAN HISTOGRAM OF PRESENT SLICE
NO. OF PULSES ?
1
B
0, > 1
INCREASE GAPCOUNTER, REJECT ROAD, IF TOO MANY. GO TO NEXT COARSER MODE, IF IN COARSE. PREPARE DOUBLE SLICE
FILTEX
2
1
SCAN HISTOGRAMS SEPARATELY
SCAN HISTOGRAMS SEPARATELY
ANY PULSE MATCHING, DOUBLE SLICE PULSE ?
NO
YES
COMPUTE AND STORE AVERAGE POINT(S). START TRACK FOLLOWING IF TWO FOUND
FILTEX
ANY PULSE MATCHING 1st DOUBLE SLICE PULSE ?
NO
YES
COMPUTE AND STORE AVERAGE POINT(S). START TRACK FOLLOWING IF TWO FOUND
ANY PULSE MATCHING SECOND D/S PULSE ?
YES
COMPUTE AND STORE AVERAGE POINT(S). OPEN NEW ROAD IF NECESSARY. START TRACK FOLLOWING IF TWO POINTS FOUND
FILTEX
NO
INCREASE GAPCOUNT, REJECT ROAD, IF TOO MANY, PREPARE DOUBLE SLICE
FILTEX

Fig. 6

DISCUSSION

STRAND: Does the track following scheme use only the two previous master points, or the complete previous history of the track on which to base its prediction?

KRISCHER: The extrapolation uses only the two previous master points and tangents, but these tangents are corrected using information on the track up to that point.

BURREN: Do you have experience with highly curved tracks, i.e. stopping tracks?

KRISCHER: The program works satisfactorily on these tracks.