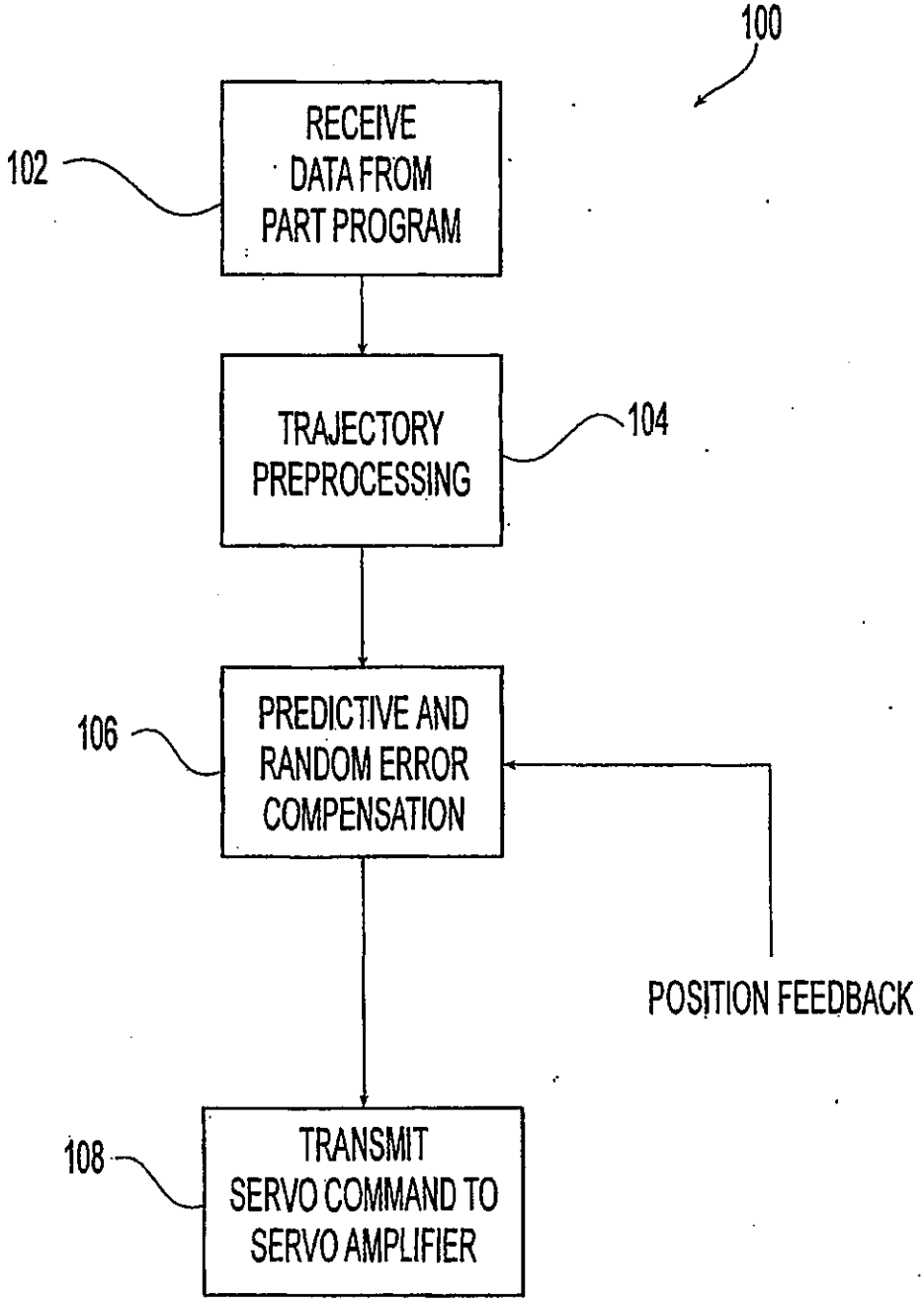

100
RECEIVE DATA FROM PART PROGRAM
102
TRAJECTORY PREPROCESSING
104
PREDICTIVE AND RANDOM ERROR COMPENSATION
106
POSITION FEEDBACK
TRANSMIT SERVO COMMAND TO SERVO AMPLIFIER
108

Fig. 1

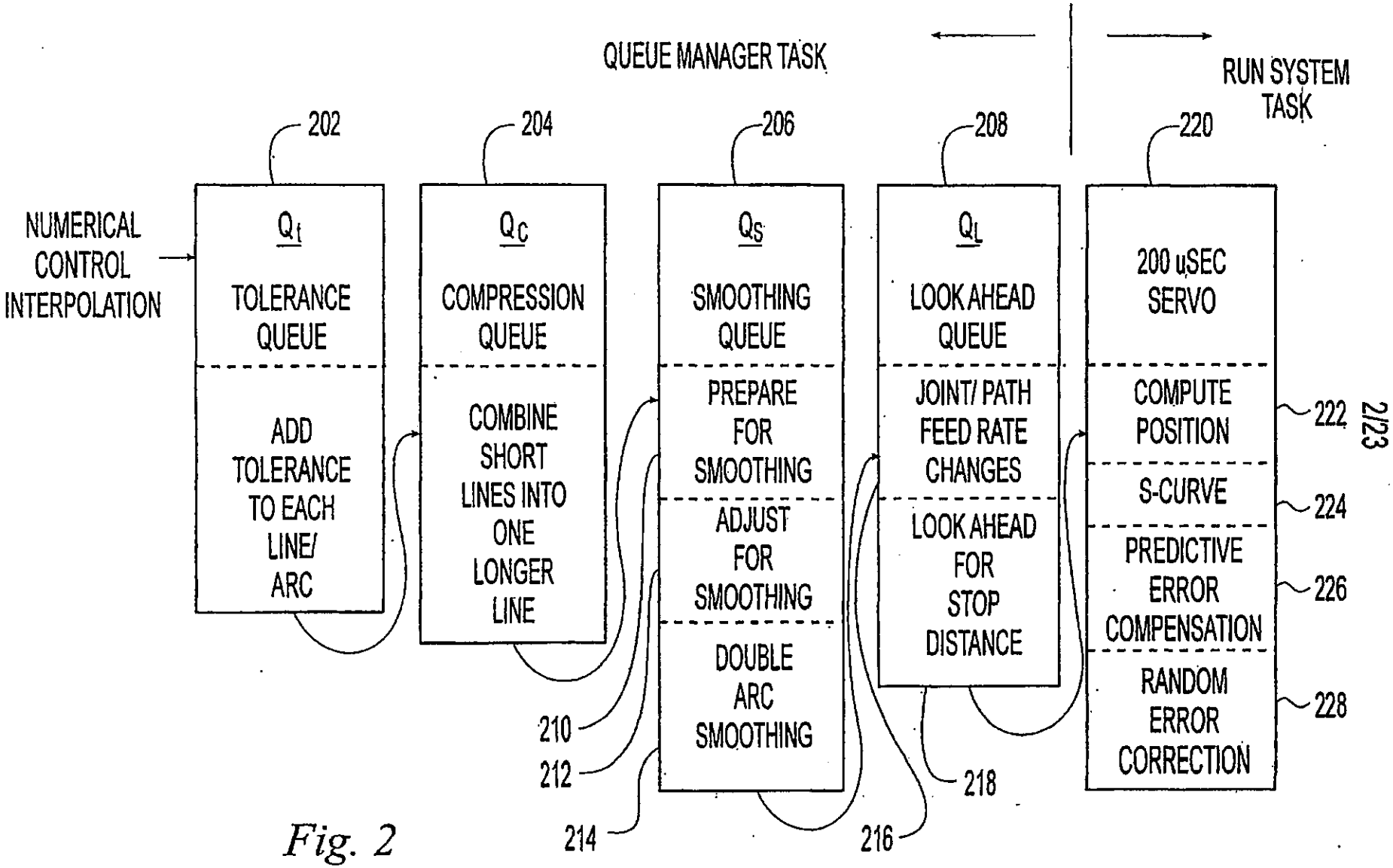

QUEUE MANAGER TASK
RUN SYSTEM TASK
NUMERICAL CONTROL INTERPOLATION
202
204
206
208
220
Q_t
TOLERANCE QUEUE
ADD TOLERANCE TO EACH LINE/ ARC
Q_C
COMPRESSION QUEUE
COMBINE SHORT LINES INTO ONE LONGER LINE
Q_S
SMOOTHING QUEUE
PREPARE FOR SMOOTHING
ADJUST FOR SMOOTHING
DOUBLE ARC SMOOTHING
Q_L
LOOK AHEAD QUEUE
JOINT/ PATH FEED RATE CHANGES
LOOK AHEAD FOR STOP DISTANCE
200 uSEC SERVO
COMPUTE POSITION
S-CURVE
PREDICTIVE ERROR COMPENSATION
RANDOM ERROR CORRECTION
210
212
214
216
218
222
224
226
228

Fig. 2

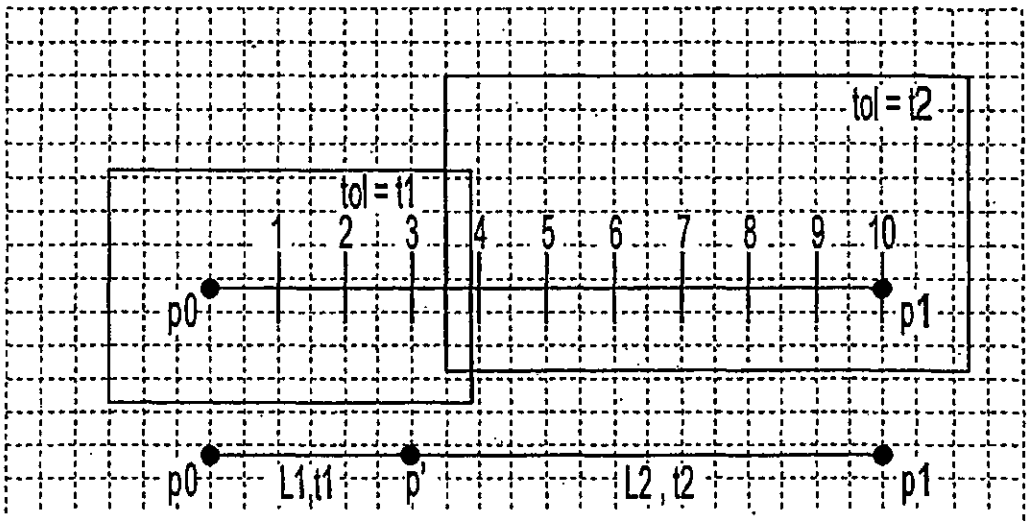

tol = t2
tol = t1
1
2
3
4
5
6
7
8
9
10
p0
p1
p0
L1,t1
p'
L2 , t2
p1

Fig. 3a

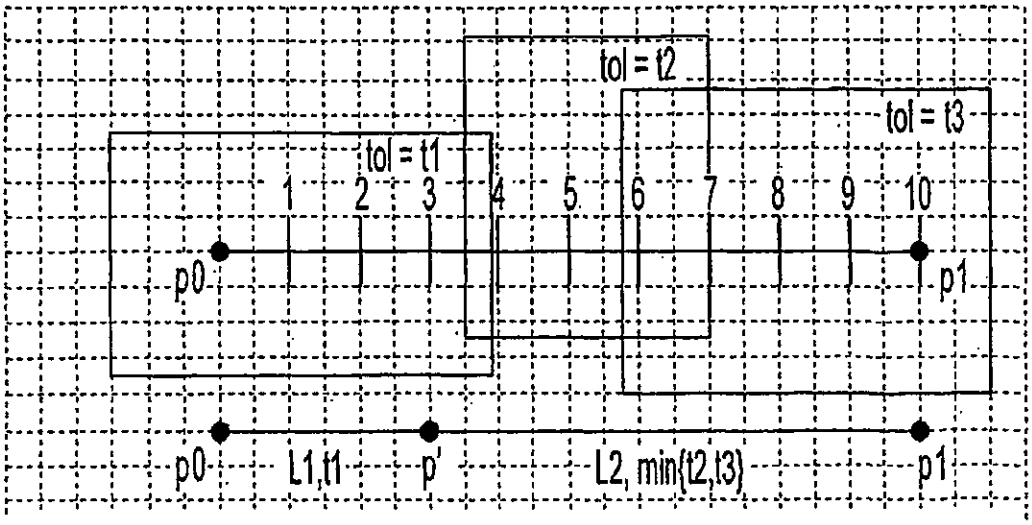

tol = t2
tol = t3
tol = t1
1
2
3
4
5
6
7
8
9
10
p0
p1
p0
L1,t1
p'
L2, min(t2,t3)
p1

Fig. 3b

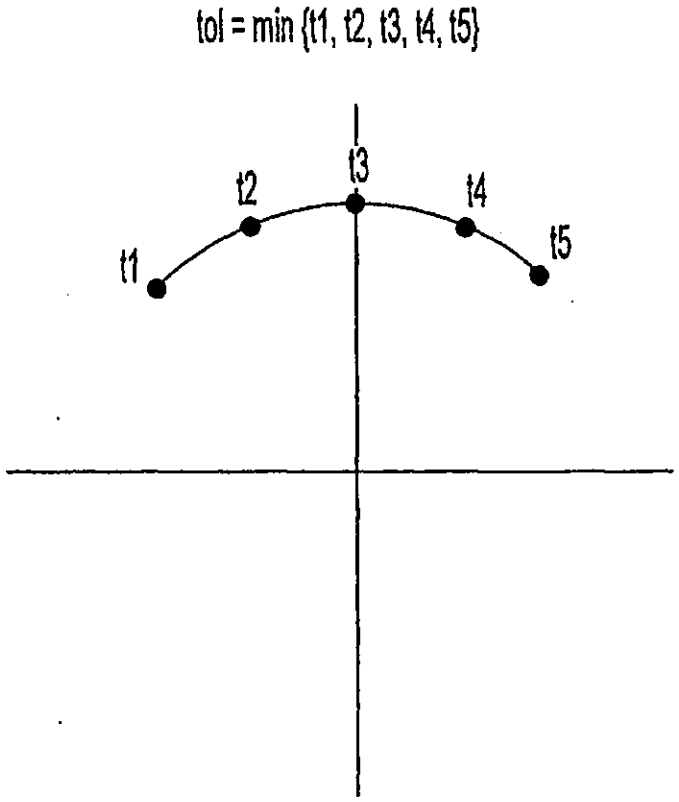


Fig. 3c

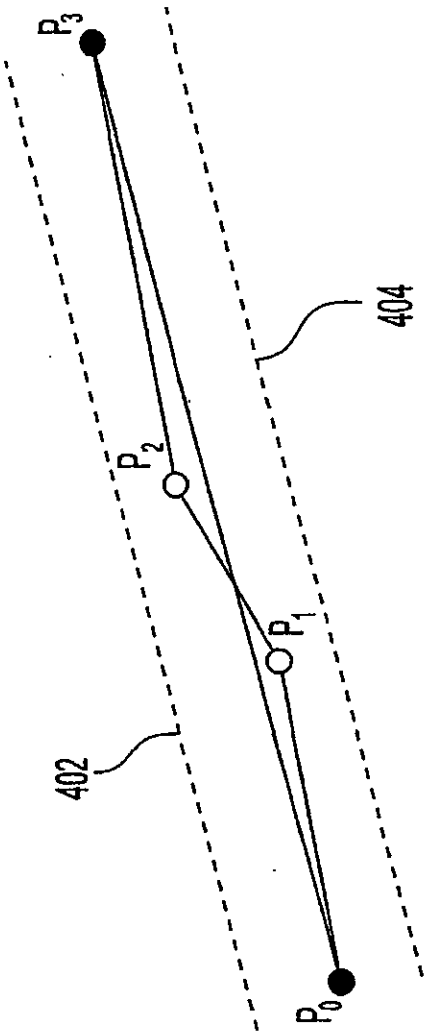


Fig. 4a

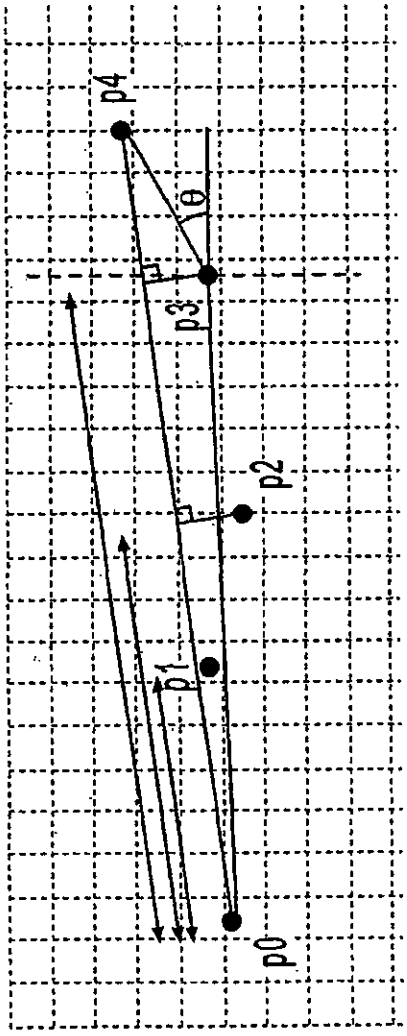


Fig. 4b

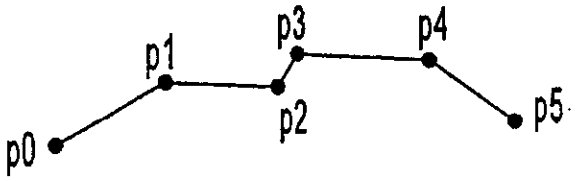


Fig. 5a

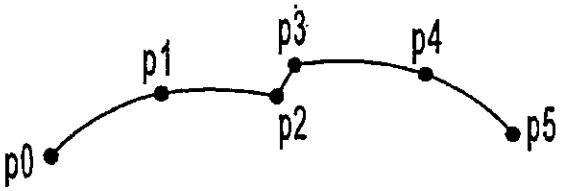


Fig. 5b

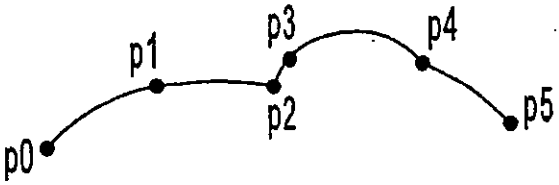


Fig. 5c

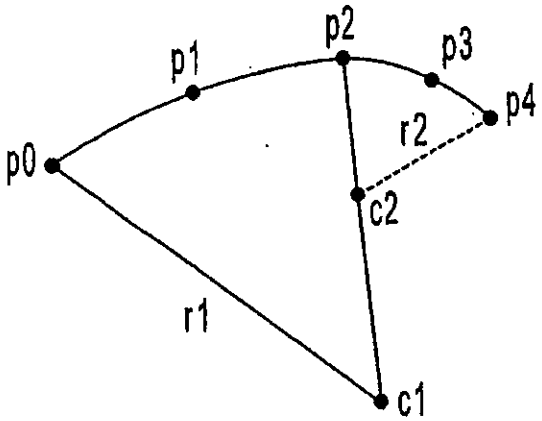


Fig. 5d

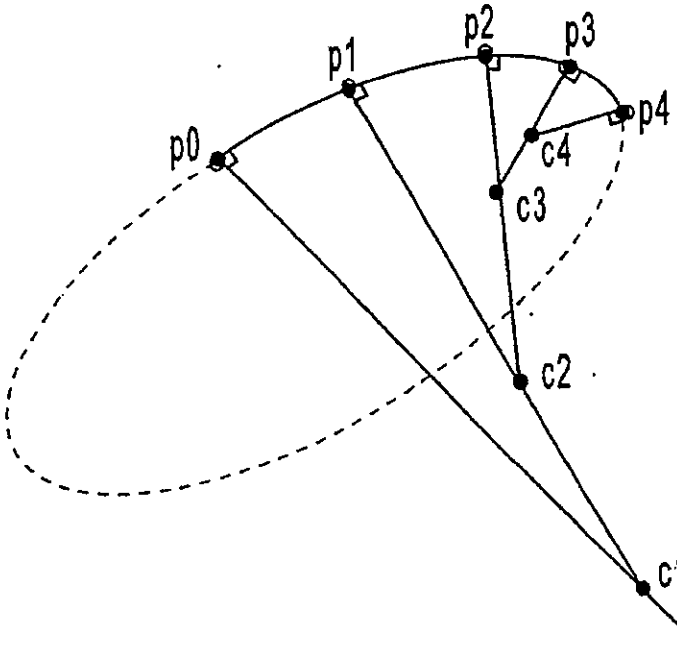


Fig. 5e

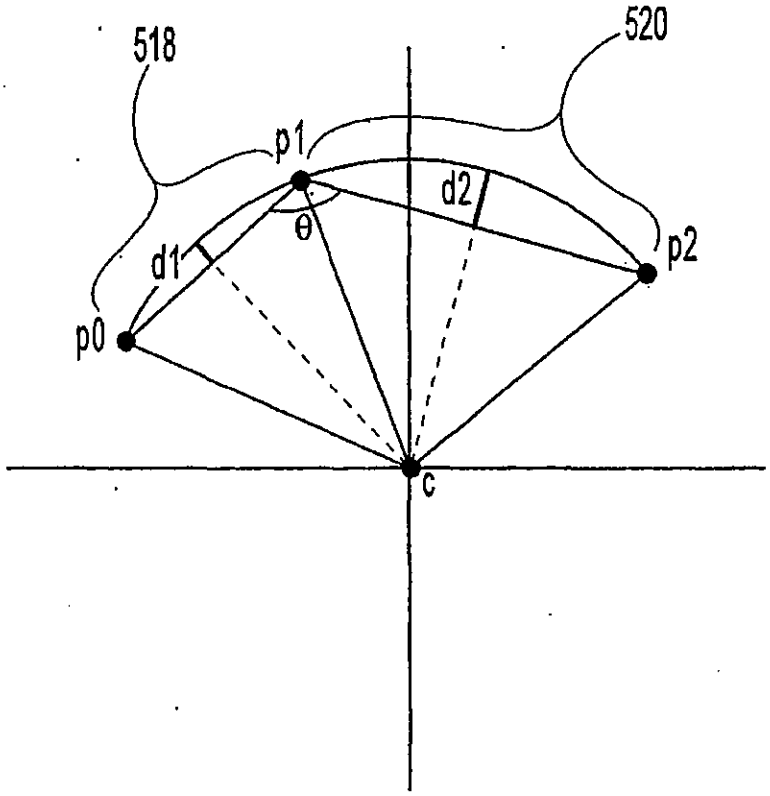


Fig. 6

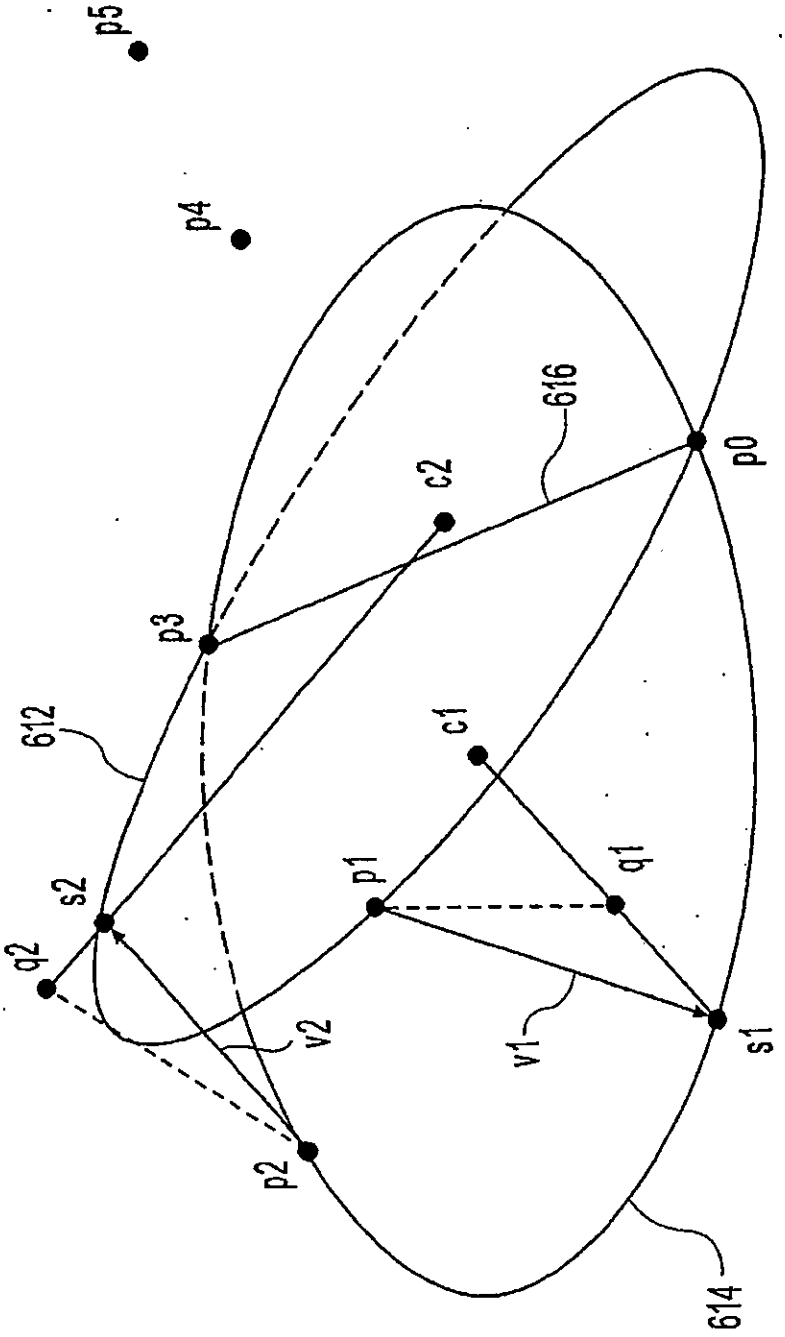


Fig. 7

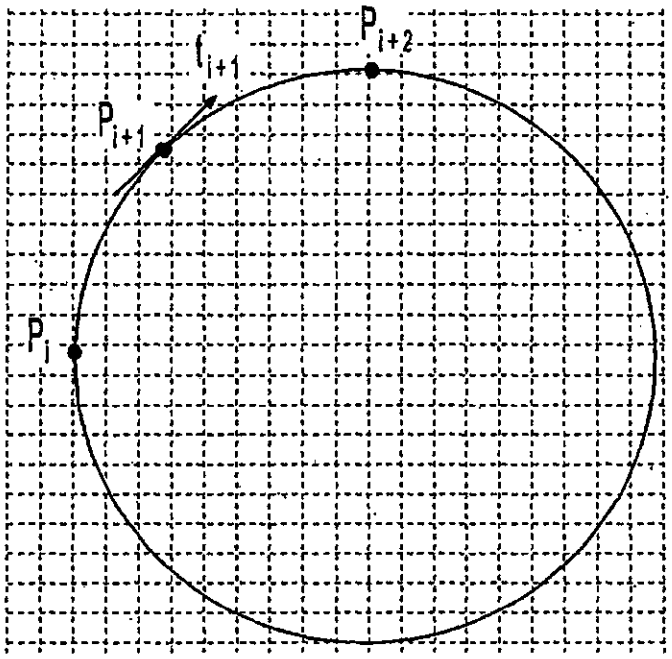


Fig. 8

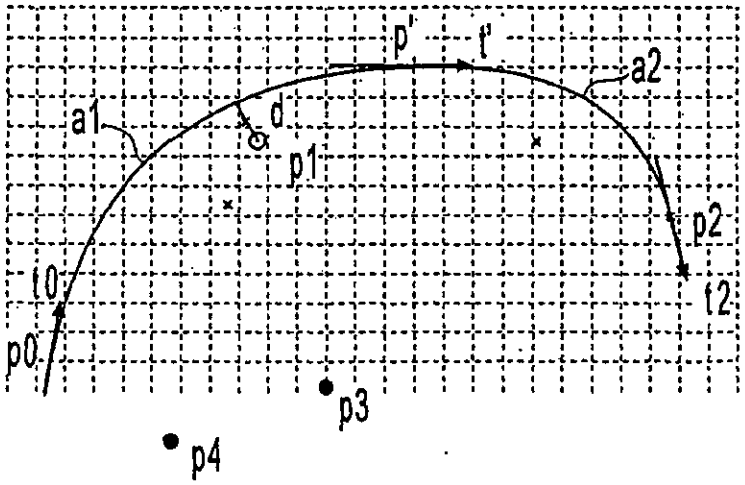


Fig. 9

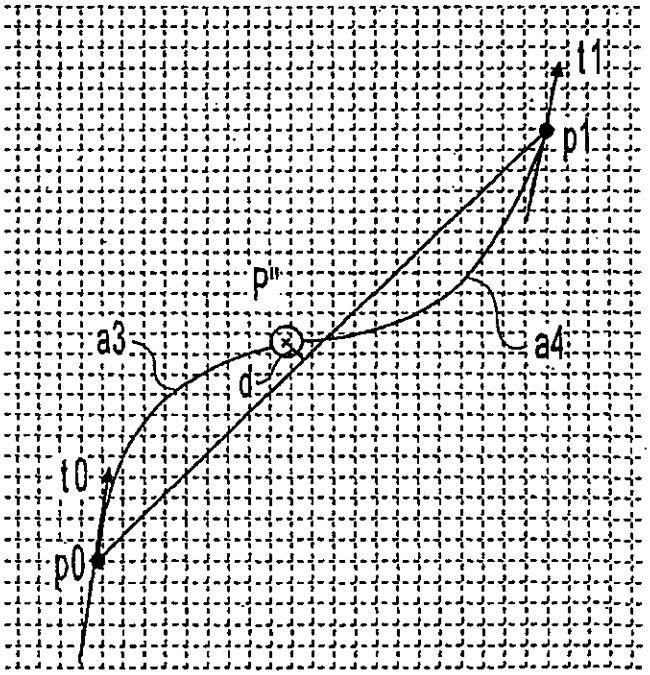


Fig. 10

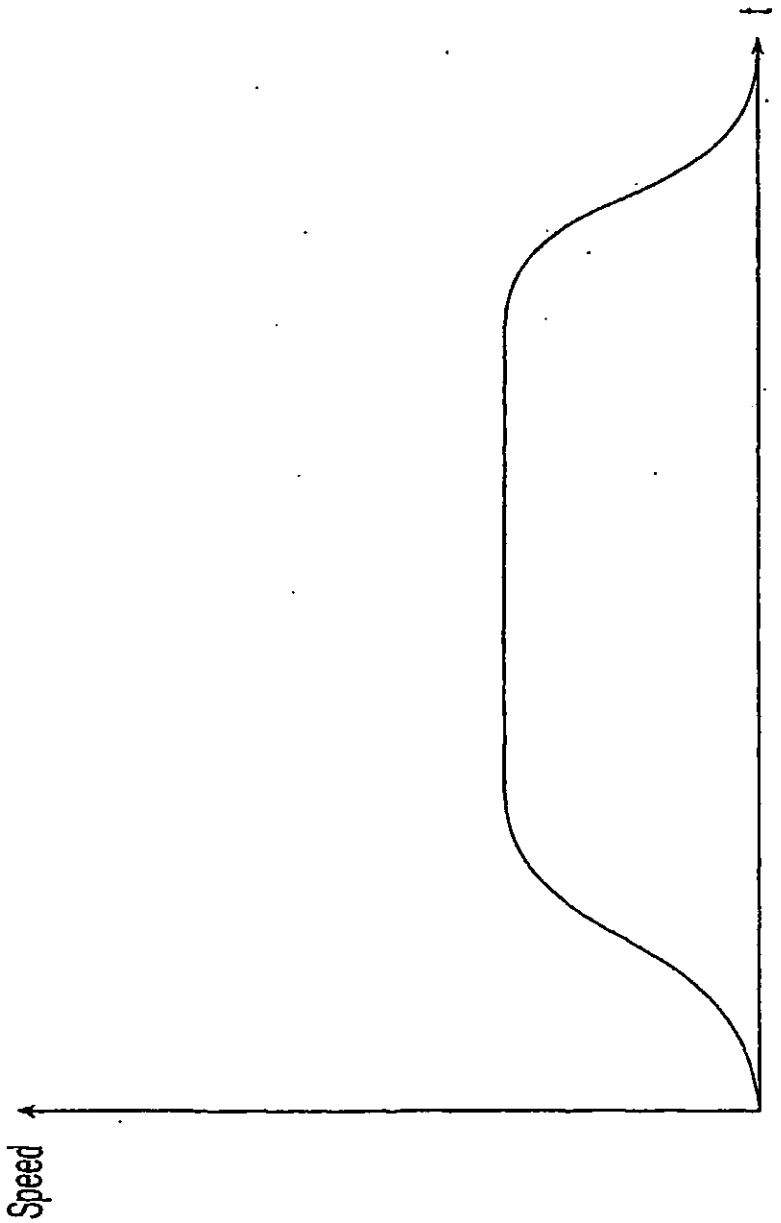


Fig. 11

Fig. 12a

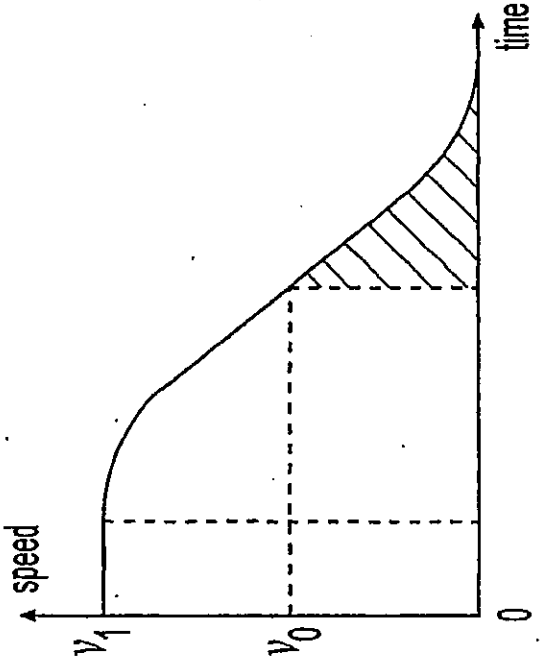
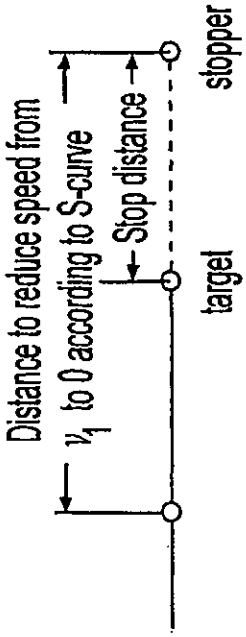


Fig. 12b



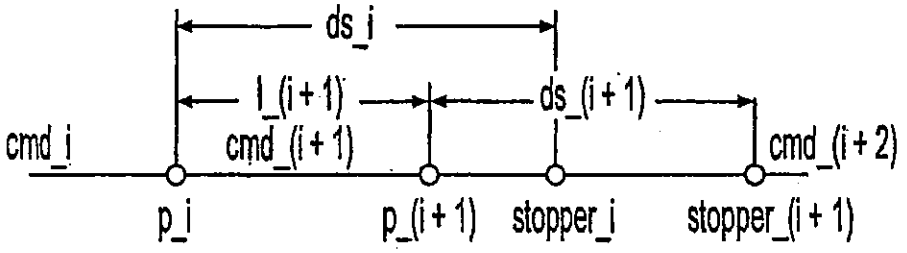

ds_i
l_(i+1)
ds_(i+1)
cmd_i
cmd_(i+1)
cmd_(i+2)
p_i
p_(i+1)
stopper_i
stopper_(i+1)

Fig. 13

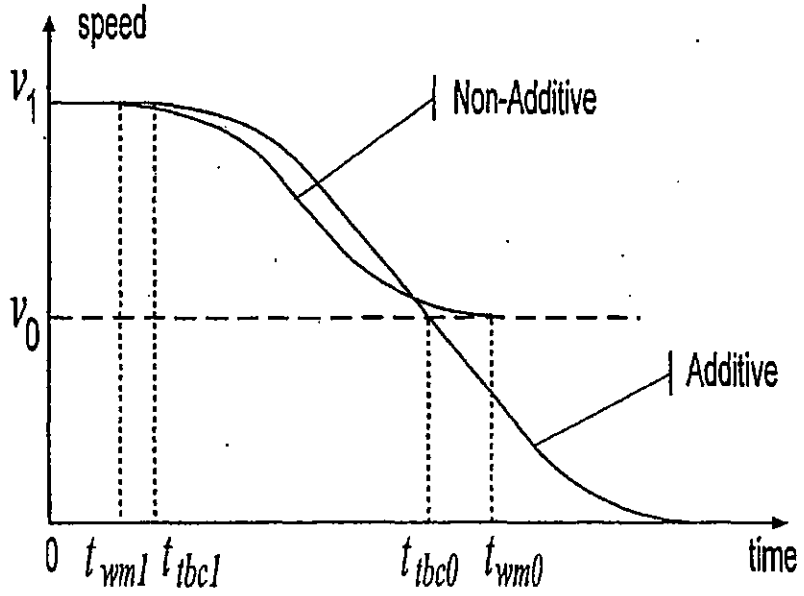

speed
v_1
v_0
Non-Additive
Additive
0
t_{wm1}
t_{tbc1}
t_{tbc0}
t_{wm0}
time

Fig. 14

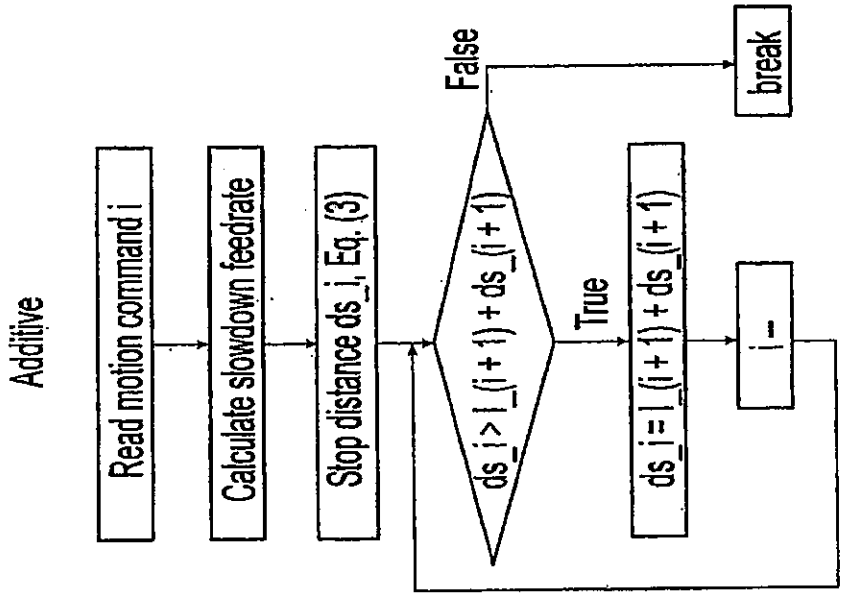

Additive
Read motion command i
Calculate slowdown feedrate
Stop distance ds_i, Eq. (3)
ds_i > l_(i+1) + ds_(i+1)
False
break
True
ds_i = l_(i+1) + ds_(i+1)
i--

Fig. 15

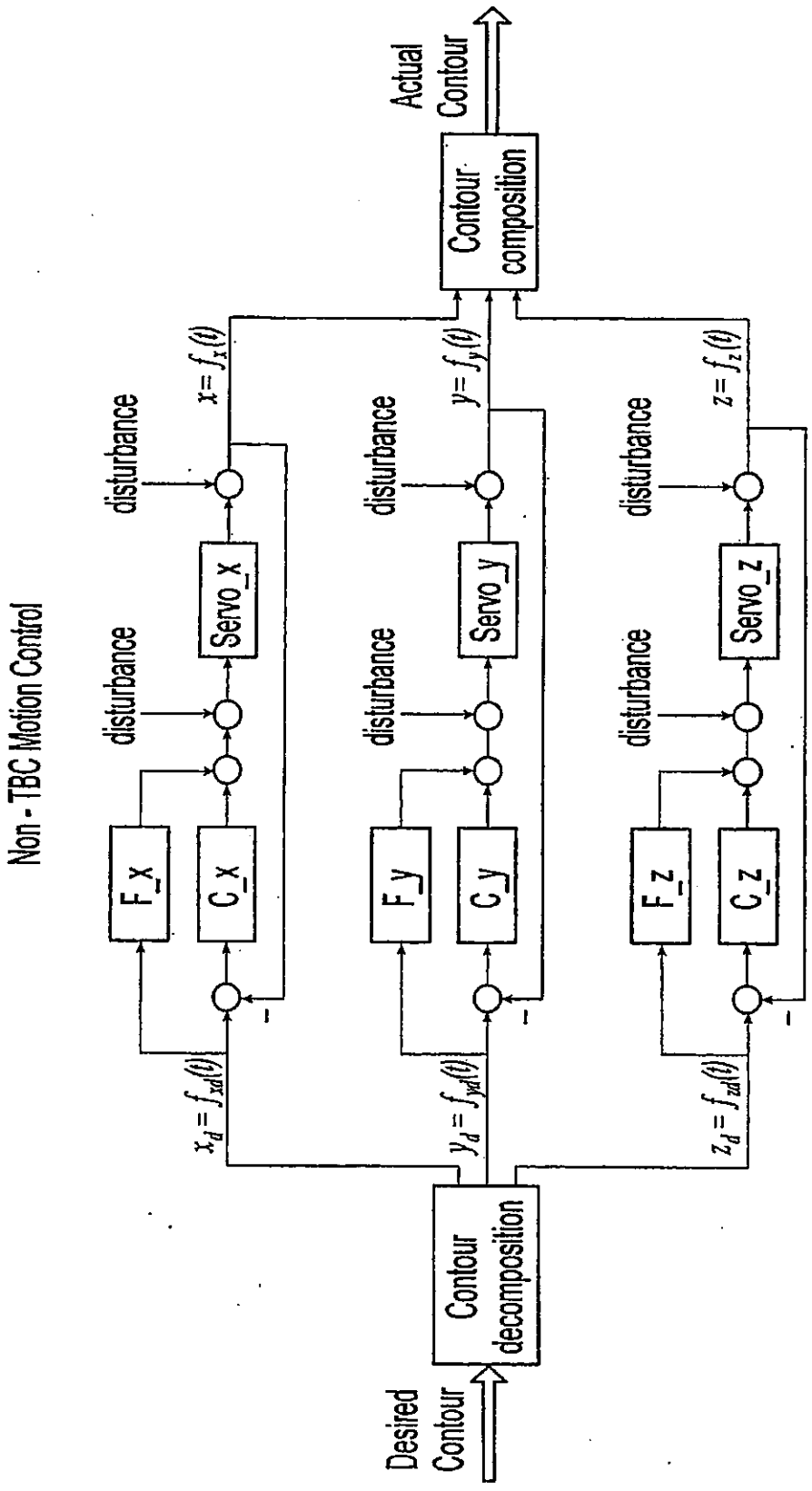

Non - TBC Motion Control
Desired Contour
Contour decomposition
$x_d = f_{xd}(t)$
$y_d = f_{yd}(t)$
$z_d = f_{zd}(t)$
F_x
C_x
F_y
C_y
F_z
C_z
disturbance
Servo_x
Servo_y
Servo_z
$x = f_x(t)$
$y = f_y(t)$
$z = f_z(t)$
Contour composition
Actual Contour

Fig. 16

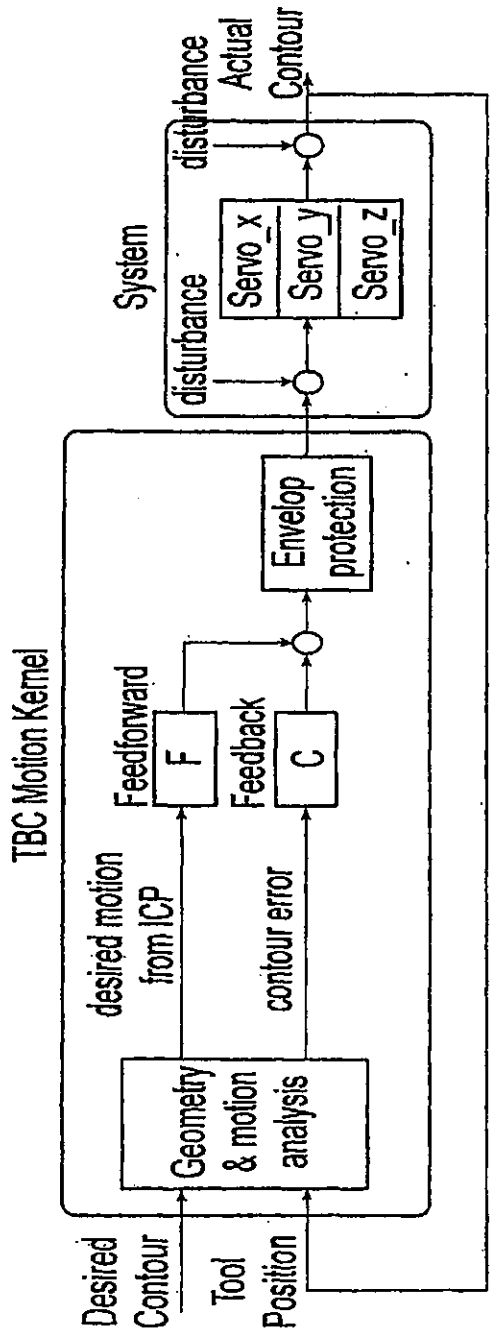

Desired Contour
Tool Position
TBC Motion Kernel
Geometry & motion analysis
desired motion from ICP
contour error
Feedforward
F
Feedback
C
Envelop protection
System
disturbance
Servo_x
Servo_y
Servo_z
disturbance
Actual Contour

Fig. 17

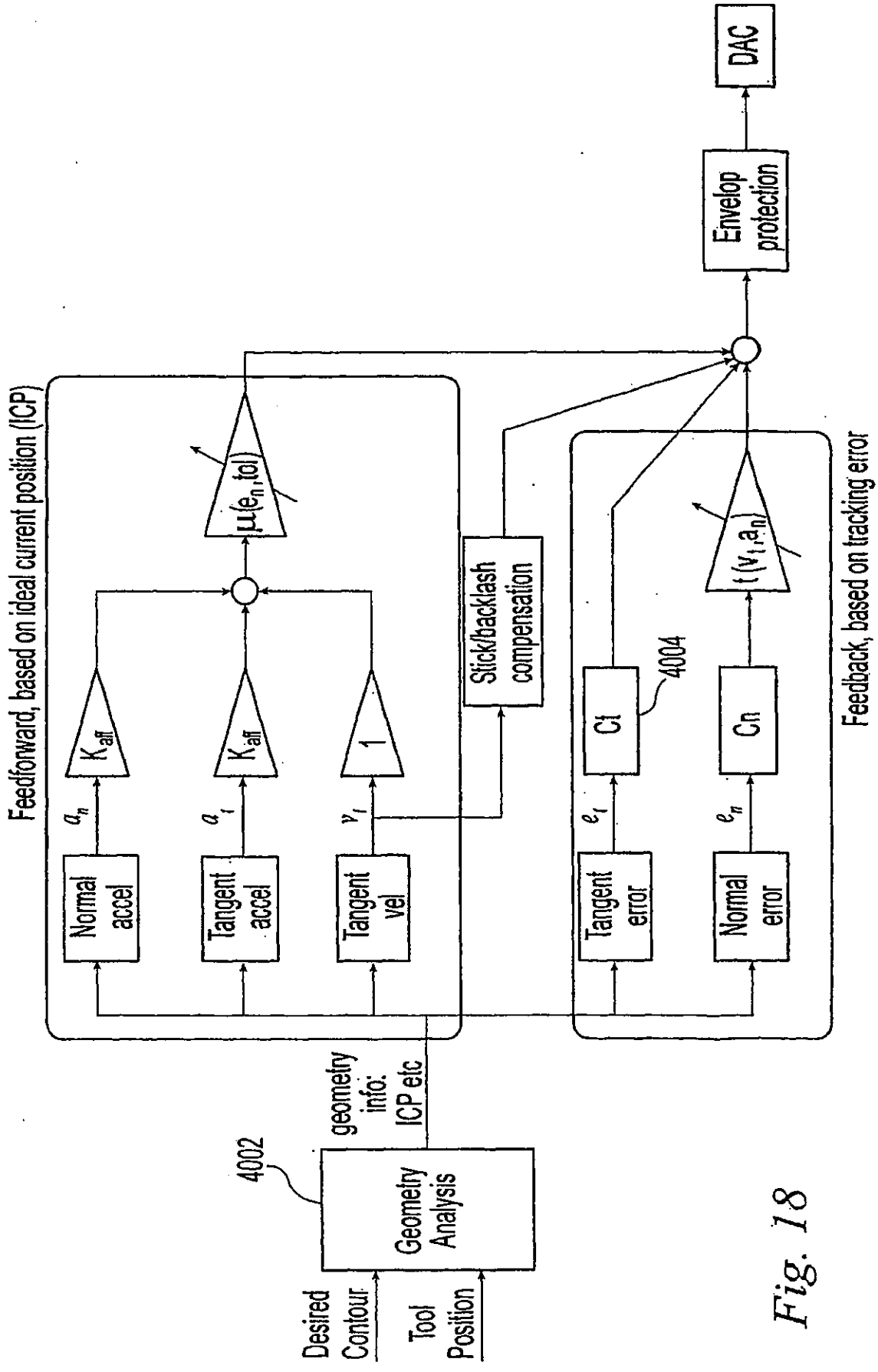

Desired Contour
Tool Position
4002
Geometry Analysis
geometry info: ICP etc
Feedforward, based on ideal current position (ICP)
Normal accel
Tangent accel
Tangent vel
a_n
a_t
v_t
K_{aff}
K_{aff}
1
$\mu(e_n, tol)$
Stick/backlash compensation
Feedback, based on tracking error
Tangent error
Normal error
e_t
e_n
Ct
Cn
4004
$t(v_t, a_n)$
Envelop protection
DAC

Fig. 18

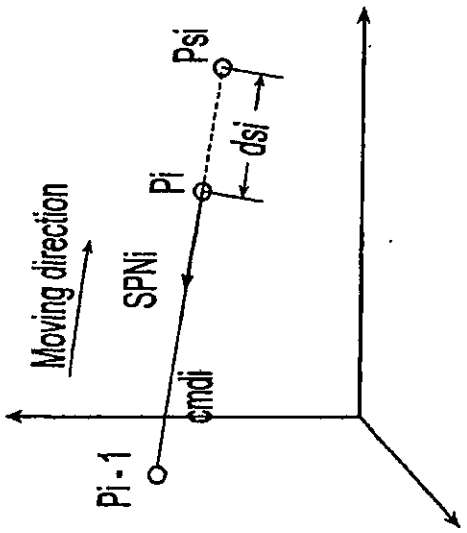


Fig. 19

Fig. 20

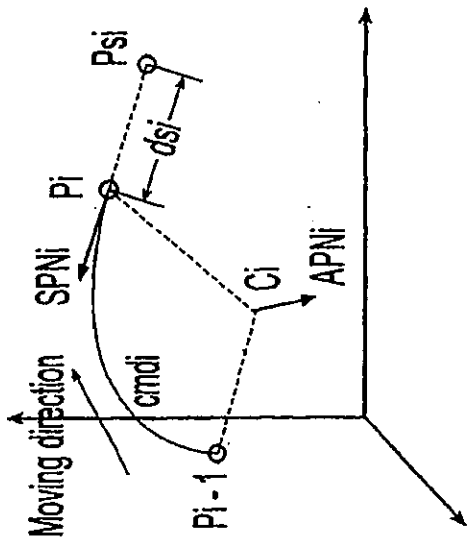
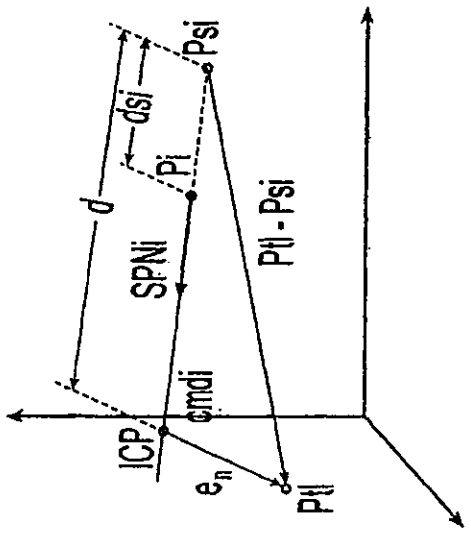

Psi
dsi
Pi
SPNi
Ci
APNi
cmdi
Moving direction
Pi - 1

Fig. 21


Psi
dsi
Pi
d
SPNi
Ptl - Psi
cmdi
ICP
e_n
Ptl

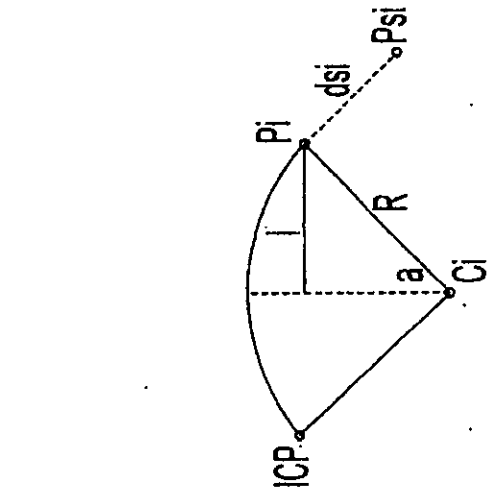


Fig. 22b

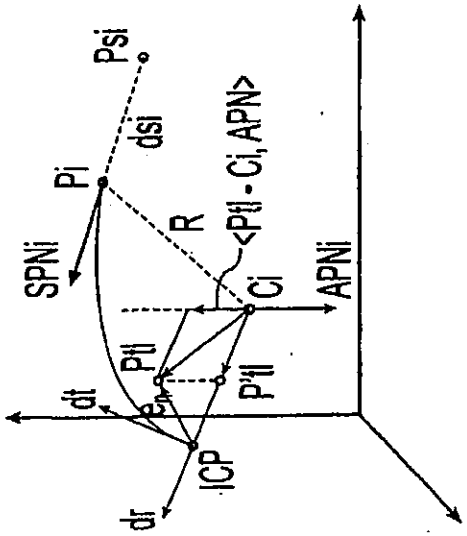


Fig. 22a

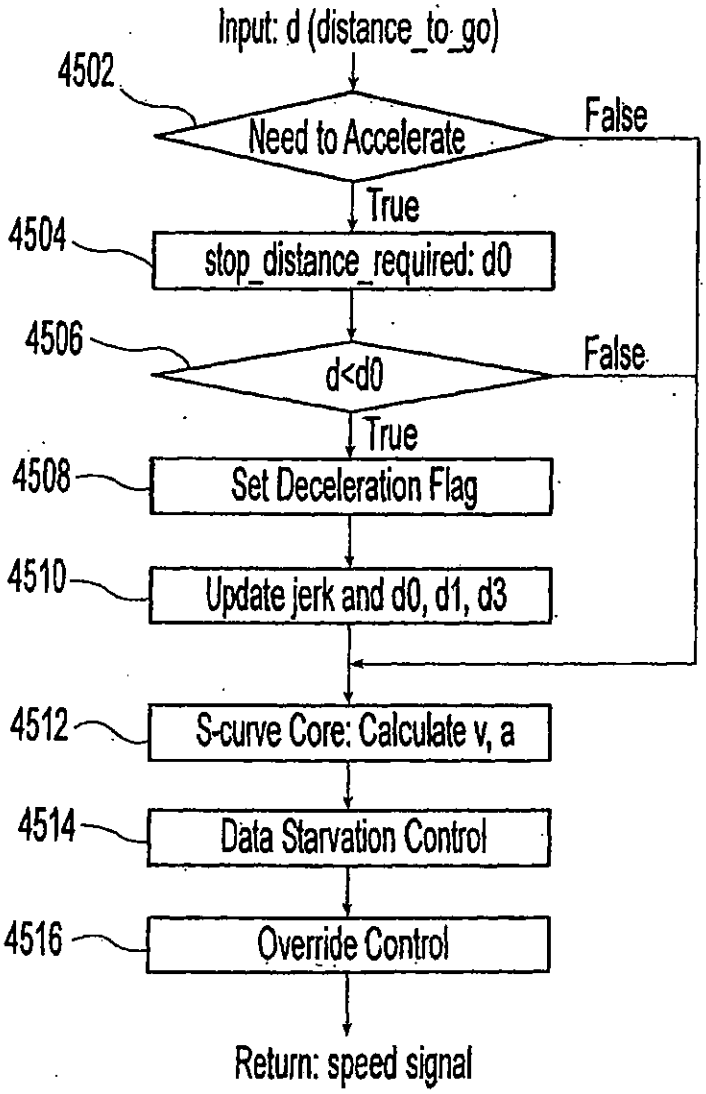

Input: d (distance_to_go)
4502
Need to Accelerate
False
True
4504
stop_distance_required: d0
4506
d<d0
False
True
4508
Set Deceleration Flag
4510
Update jerk and d0, d1, d3
4512
S-curve Core: Calculate v, a
4514
Data Starvation Control
4516
Override Control
Return: speed signal

Fig. 23

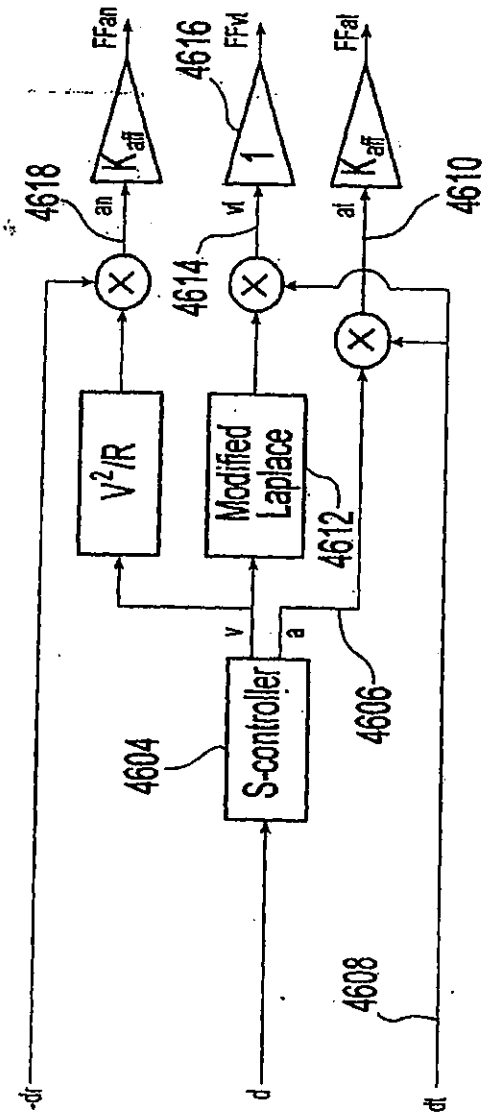

FFan
4616
FFvl
FFal
4618
an
4614
vl
al
4610
K_{aff}
1
K_{aff}
V^2/R
Modified Laplace
4612
S-controller
v
a
4604
4606
4608
-dr
d
dt

Fig. 24

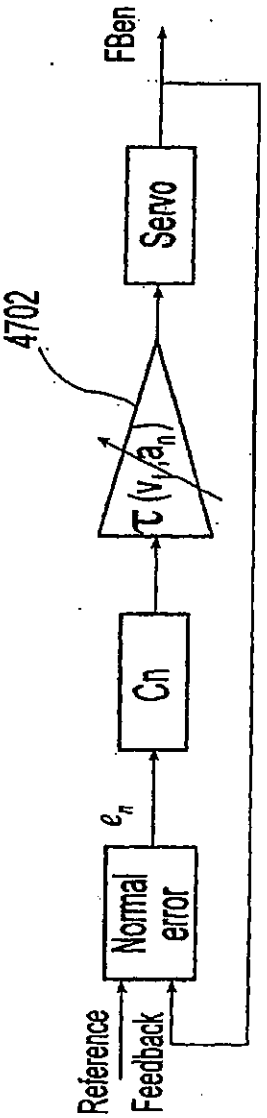

FBen
Servo
4702
$\tau(v_l, a_n)$
Cn
e_n
Normal error
Reference
Feedback

Fig. 25