FIG. 1

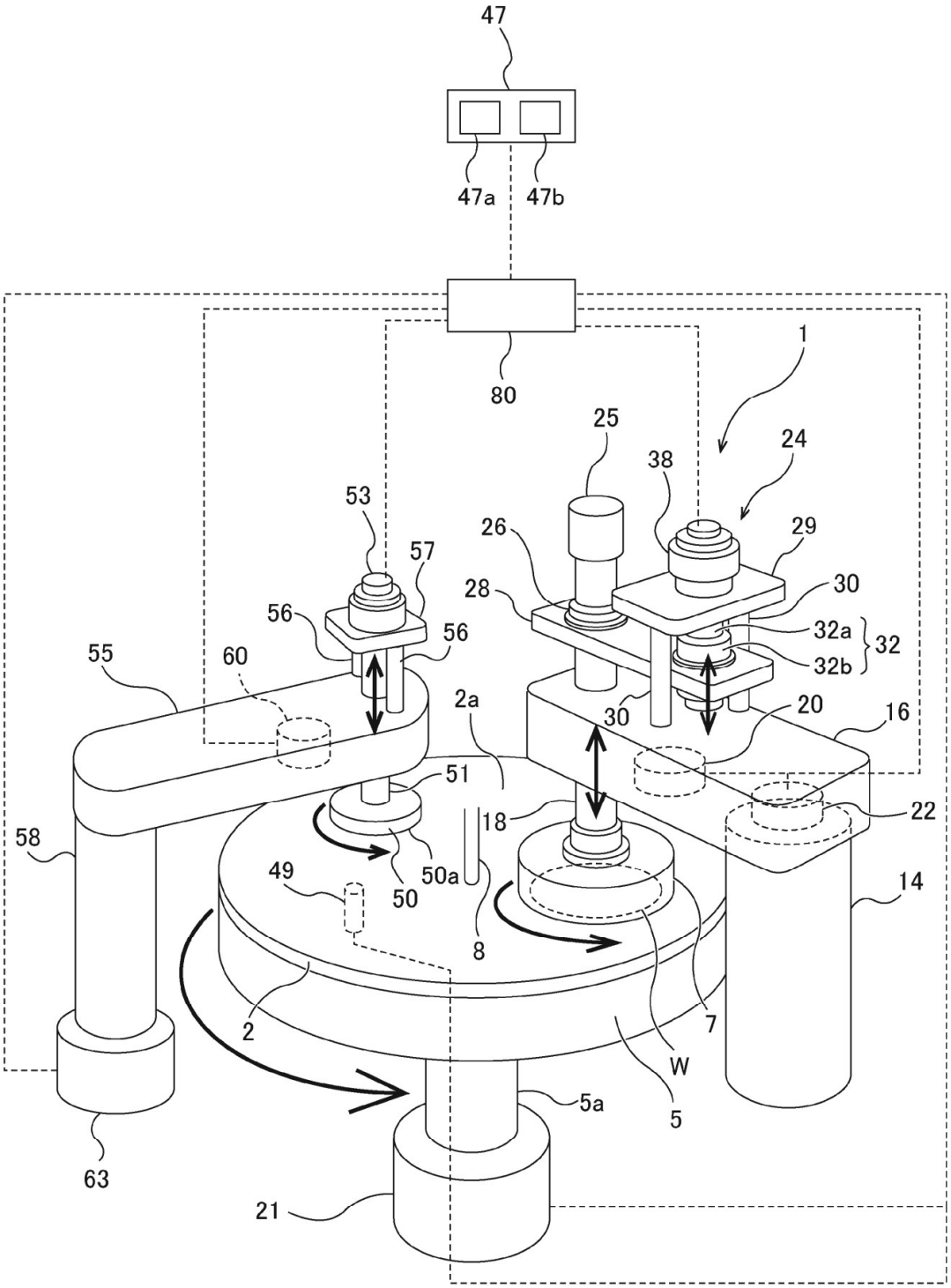

47
47a
47b
80
1
25
38
24
53
26
29
57
28
30
56
32a
32
56
32b
55
60
2a
30
20
16
51
18
22
58
49
50
50a
14
8
2
7
W
5
5a
63
21

FIG. 2

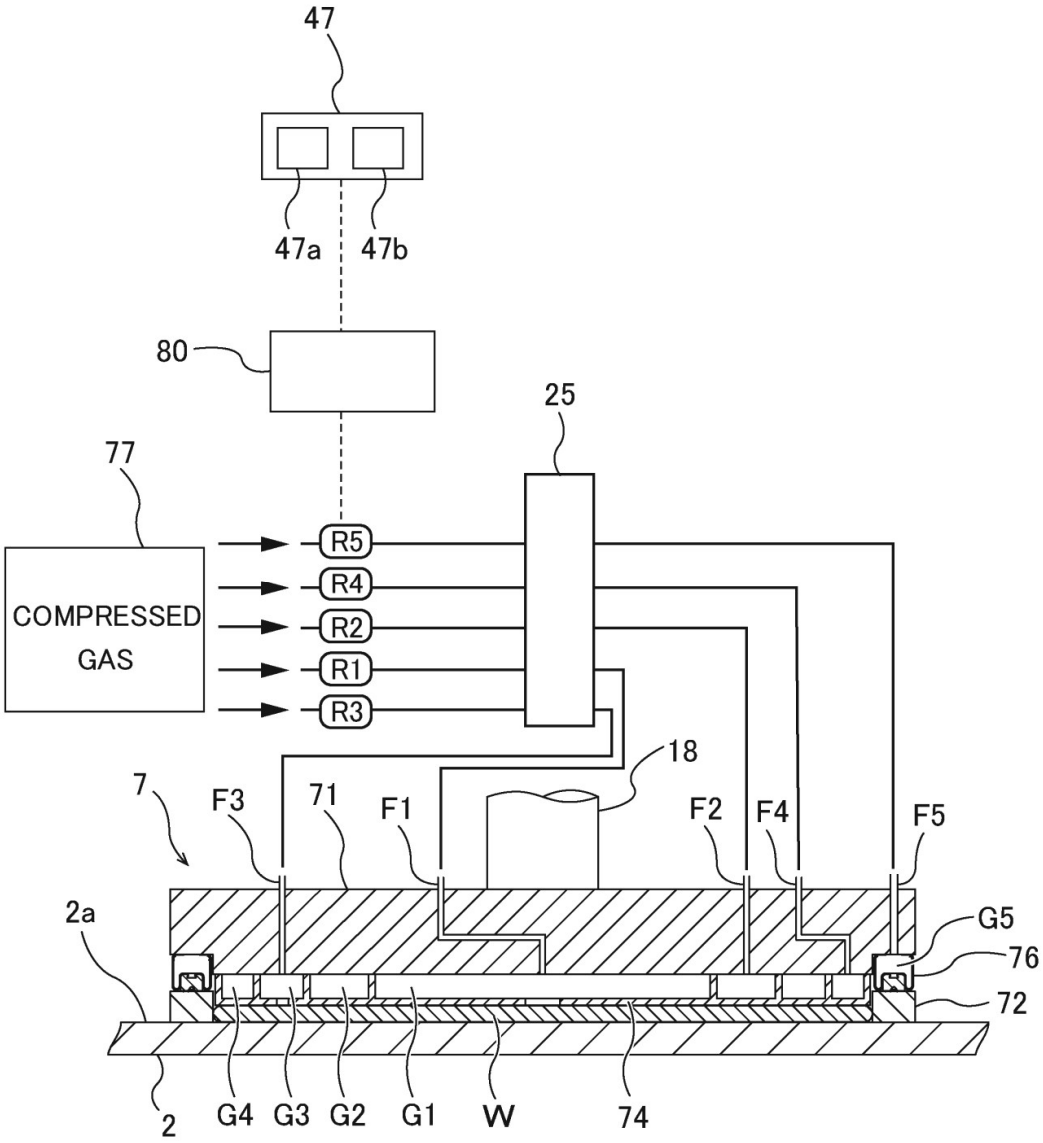

47
47a
47b
80
25
77
COMPRESSED GAS
R5
R4
R2
R1
R3
18
7
F3
71
F1
F2
F4
F5
2a
G5
76
72
2
G4
G3
G2
G1
W
74

FIG. 3

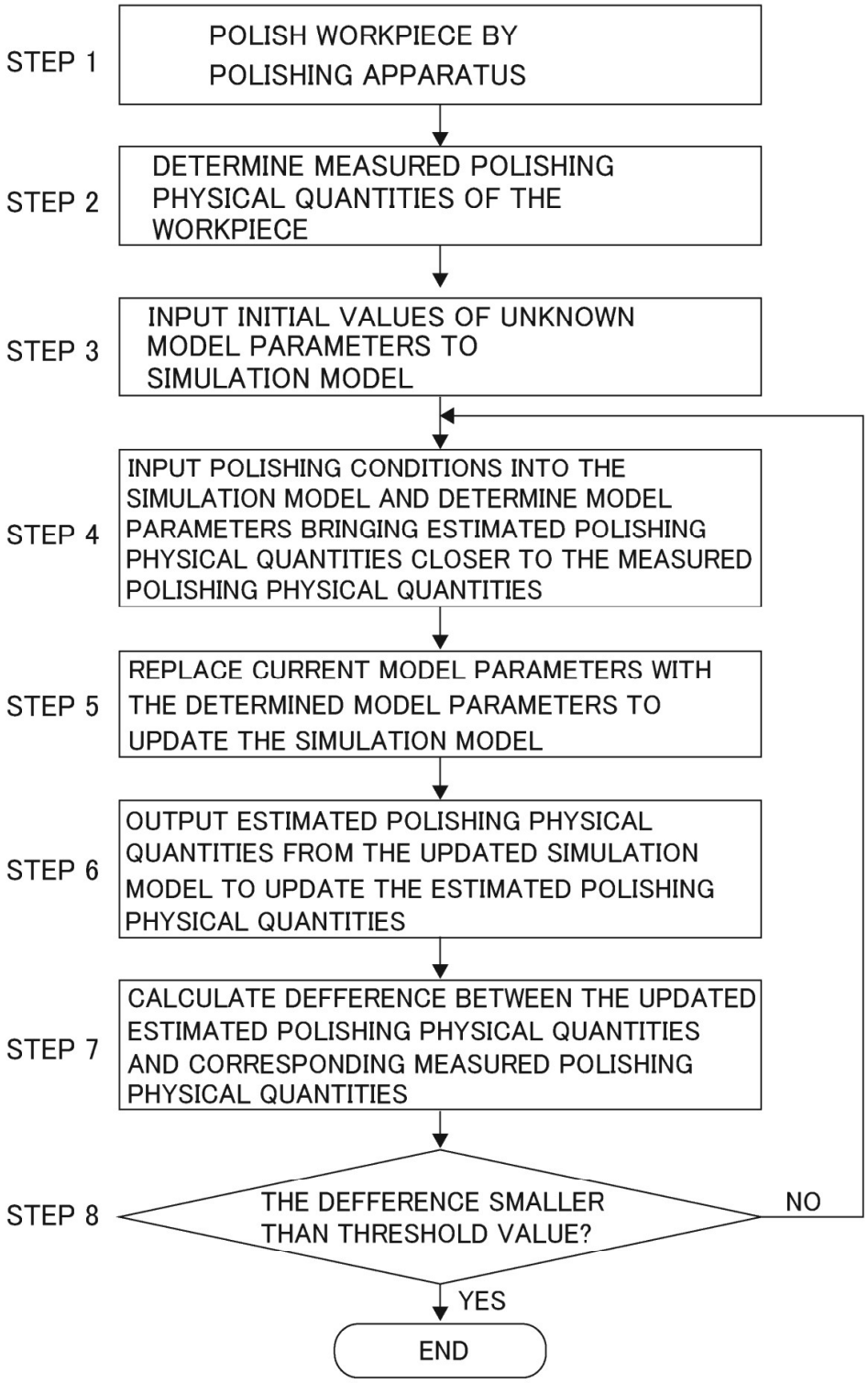

STEP 1
POLISH WORKPIECE BY POLISHING APPARATUS
STEP 2
DETERMINE MEASURED POLISHING PHYSICAL QUANTITIES OF THE WORKPIECE
STEP 3
INPUT INITIAL VALUES OF UNKNOWN MODEL PARAMETERS TO SIMULATION MODEL
STEP 4
INPUT POLISHING CONDITIONS INTO THE SIMULATION MODEL AND DETERMINE MODEL PARAMETERS BRINGING ESTIMATED POLISHING PHYSICAL QUANTITIES CLOSER TO THE MEASURED POLISHING PHYSICAL QUANTITIES
STEP 5
REPLACE CURRENT MODEL PARAMETERS WITH THE DETERMINED MODEL PARAMETERS TO UPDATE THE SIMULATION MODEL
STEP 6
OUTPUT ESTIMATED POLISHING PHYSICAL QUANTITIES FROM THE UPDATED SIMULATION MODEL TO UPDATE THE ESTIMATED POLISHING PHYSICAL QUANTITIES
STEP 7
CALCULATE DEFFERENCE BETWEEN THE UPDATED ESTIMATED POLISHING PHYSICAL QUANTITIES AND CORRESPONDING MEASURED POLISHING PHYSICAL QUANTITIES
STEP 8
THE DEFFERENCE SMALLER THAN THRESHOLD VALUE?
NO
YES
END

FIG. 4

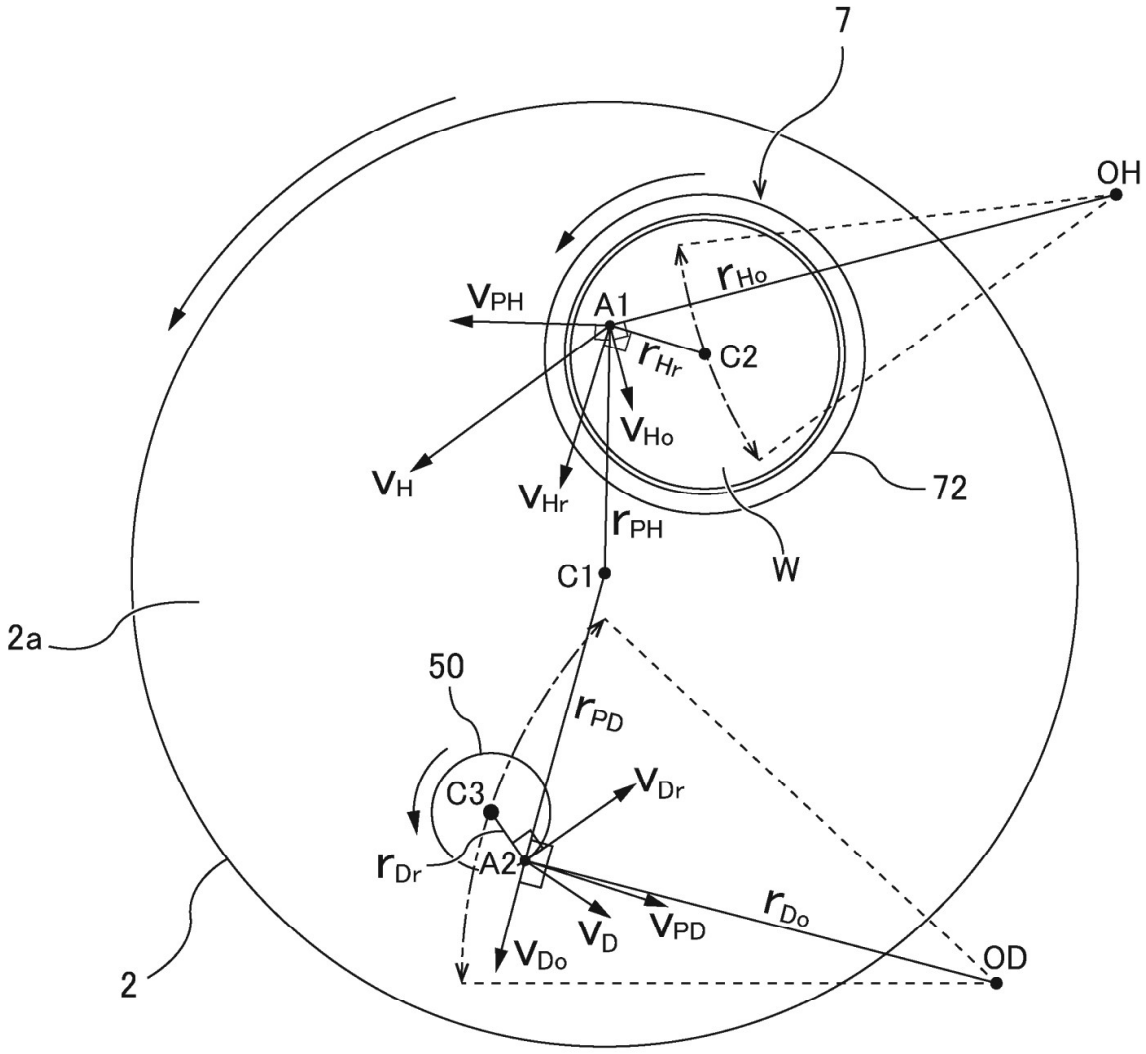

7
OH
r_{Ho}
v_{PH}
A1
r_{Hr}
C2
v_{Ho}
v_H
v_{Hr}
72
r_{PH}
W
C1
2a
50
r_{PD}
v_{Dr}
C3
r_{Dr}
A2
r_{Do}
v_D
v_{PD}
v_{Do}
OD
2

FIG. 5

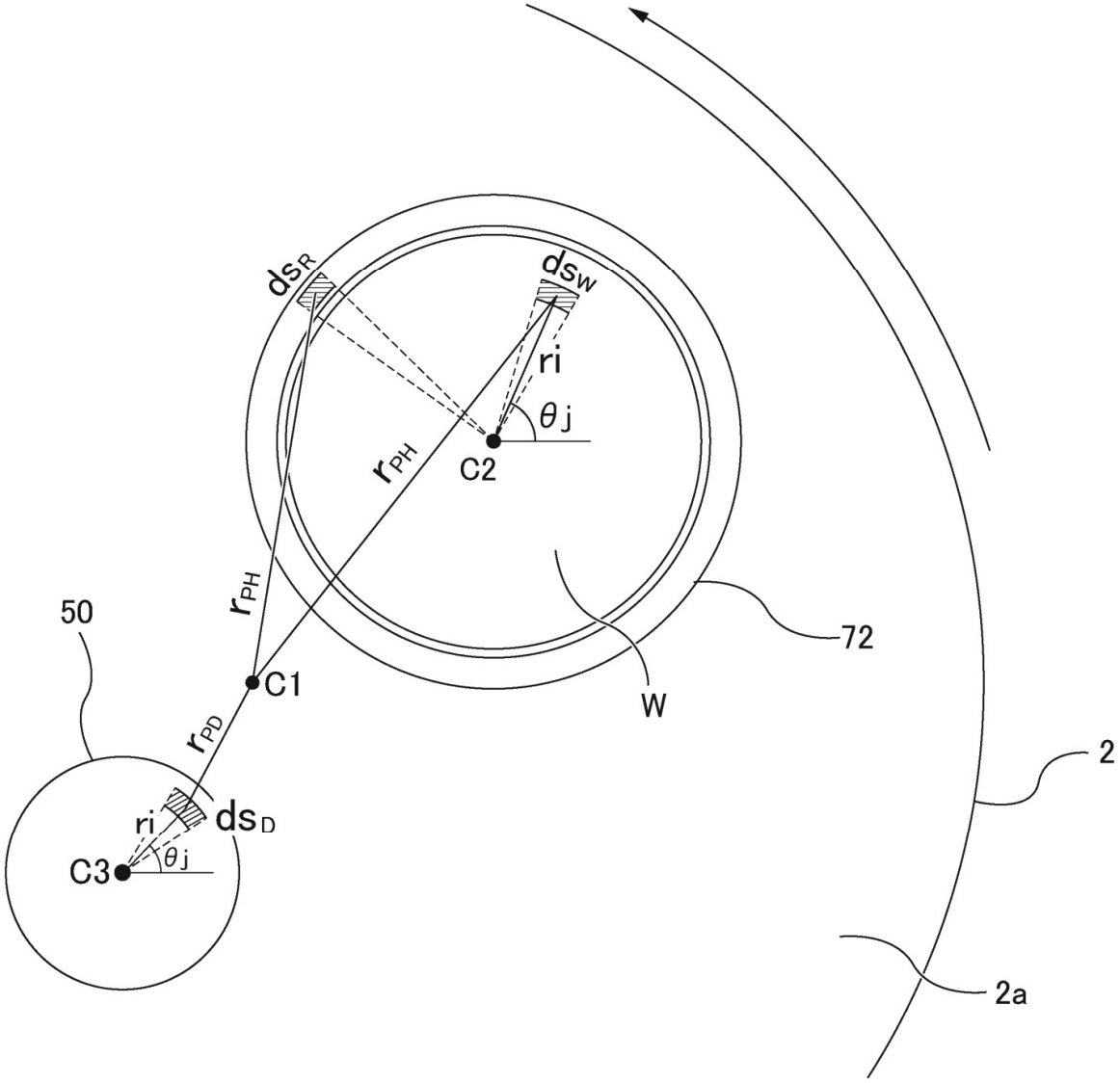


FIG. 6

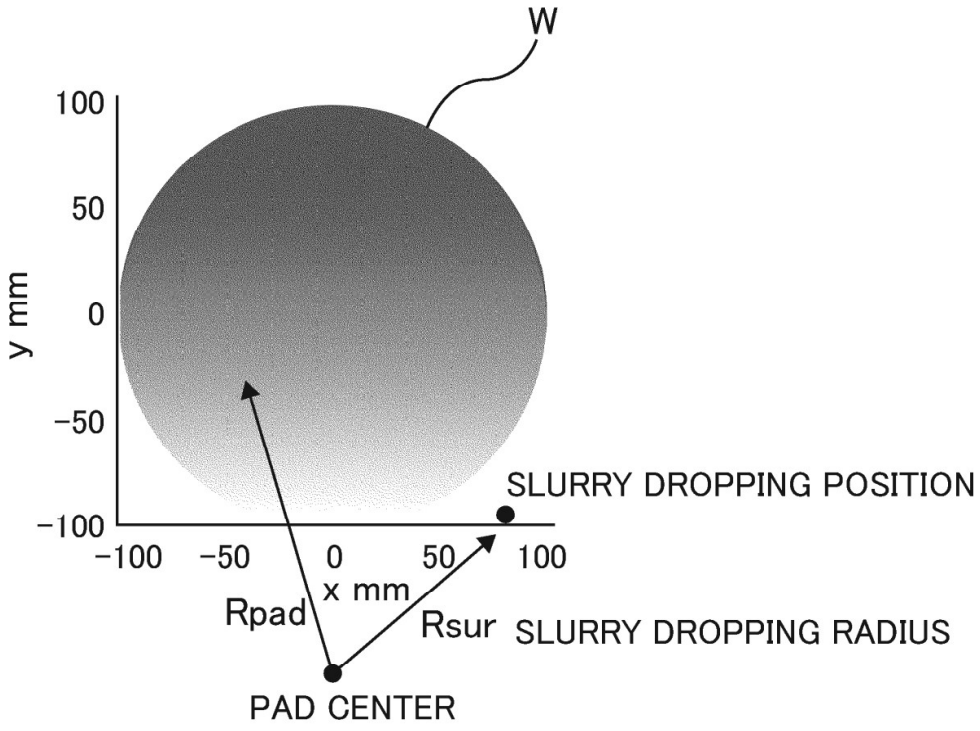

W
100
50
0
−50
−100
y mm
−100
−50
0
50
100
x mm
SLURRY DROPPING POSITION
Rpad
Rsur
SLURRY DROPPING RADIUS
PAD CENTER

FIG. 7

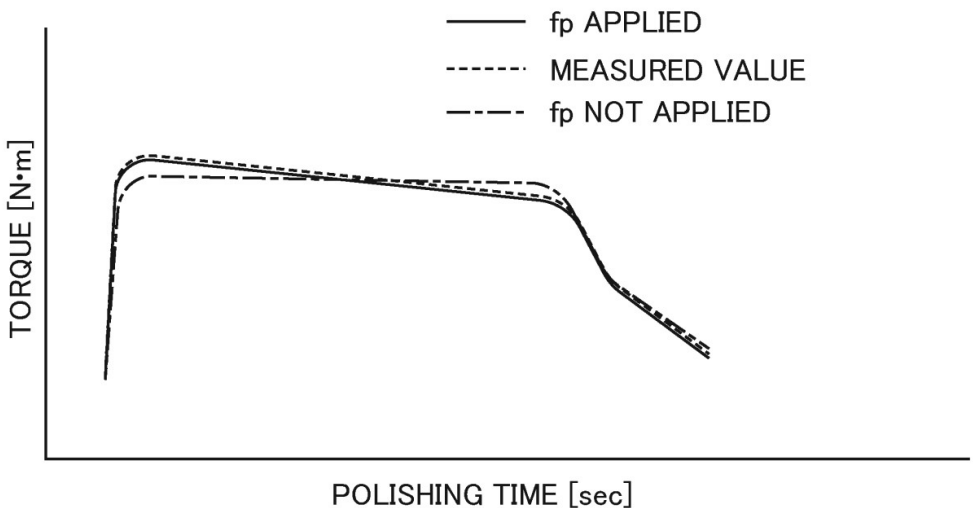

fp APPLIED
MEASURED VALUE
fp NOT APPLIED
TORQUE [N•m]
POLISHING TIME [sec]

FIG. 8

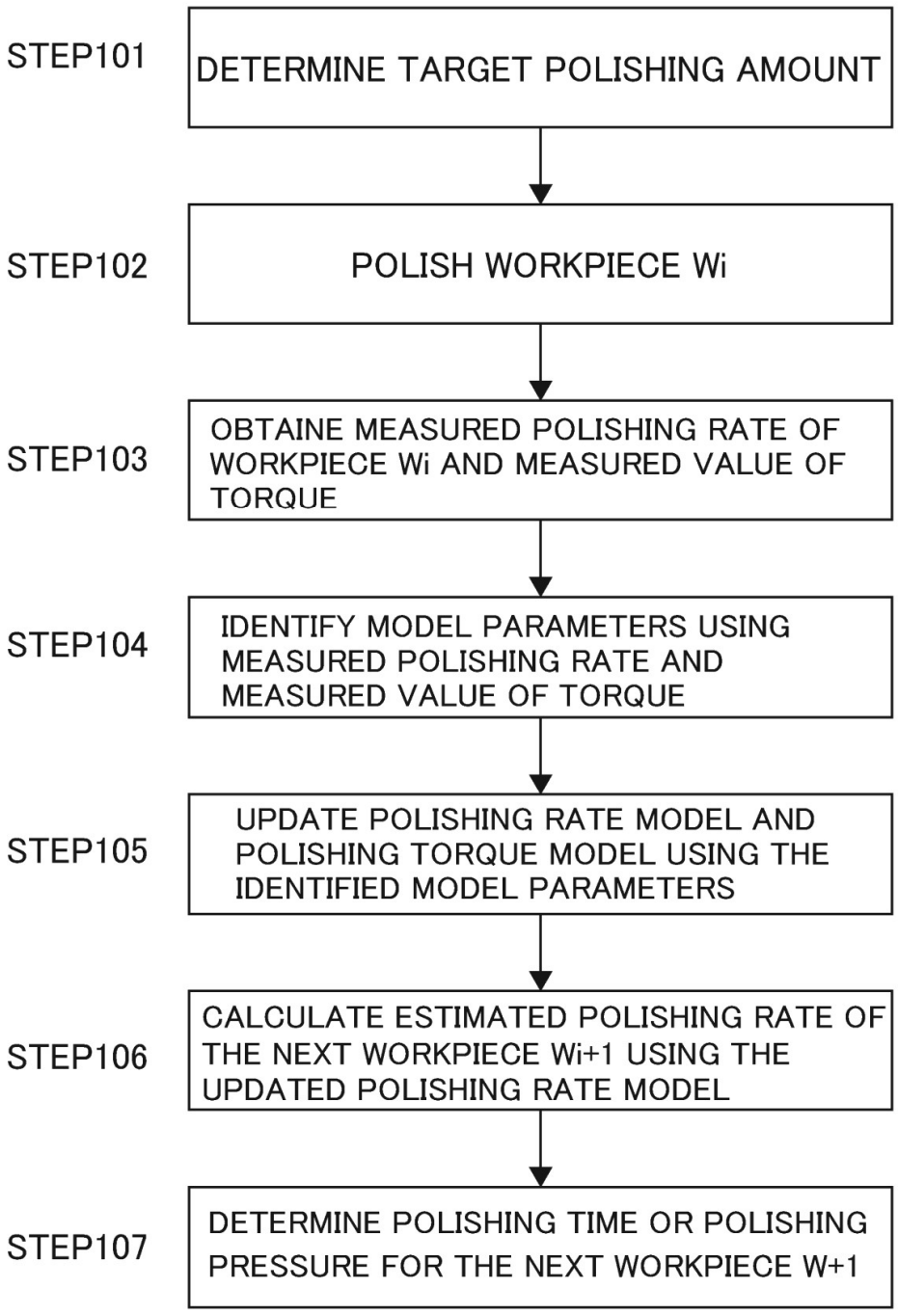

STEP101
DETERMINE TARGET POLISHING AMOUNT
STEP102
POLISH WORKPIECE Wi
STEP103
OBTAINE MEASURED POLISHING RATE OF WORKPIECE Wi AND MEASURED VALUE OF TORQUE
STEP104
IDENTIFY MODEL PARAMETERS USING MEASURED POLISHING RATE AND MEASURED VALUE OF TORQUE
STEP105
UPDATE POLISHING RATE MODEL AND POLISHING TORQUE MODEL USING THE IDENTIFIED MODEL PARAMETERS
STEP106
CALCULATE ESTIMATED POLISHING RATE OF THE NEXT WORKPIECE Wi+1 USING THE UPDATED POLISHING RATE MODEL
STEP107
DETERMINE POLISHING TIME OR POLISHING PRESSURE FOR THE NEXT WORKPIECE W+1

FIG. 9

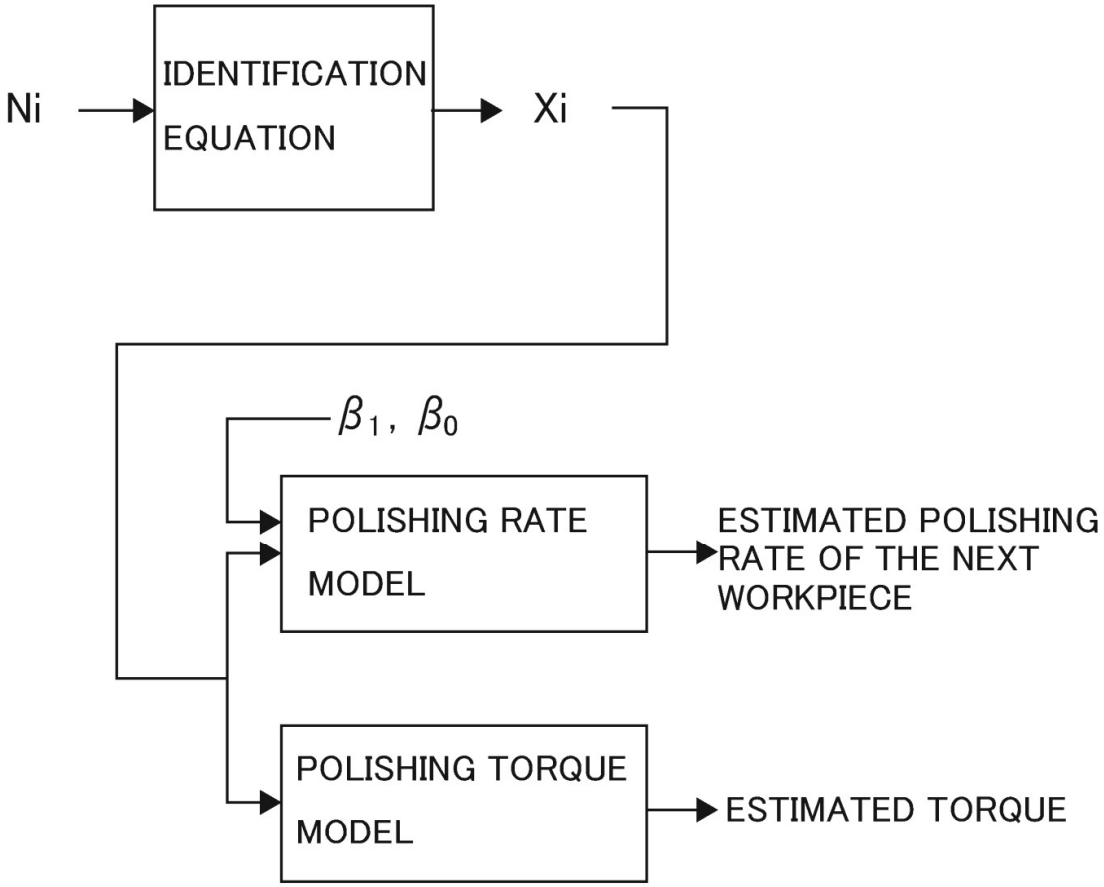

Ni
IDENTIFICATION EQUATION
Xi
β_1, β_0
POLISHING RATE MODEL
ESTIMATED POLISHING RATE OF THE NEXT WORKPIECE
POLISHING TORQUE MODEL
ESTIMATED TORQUE

FIG. 10

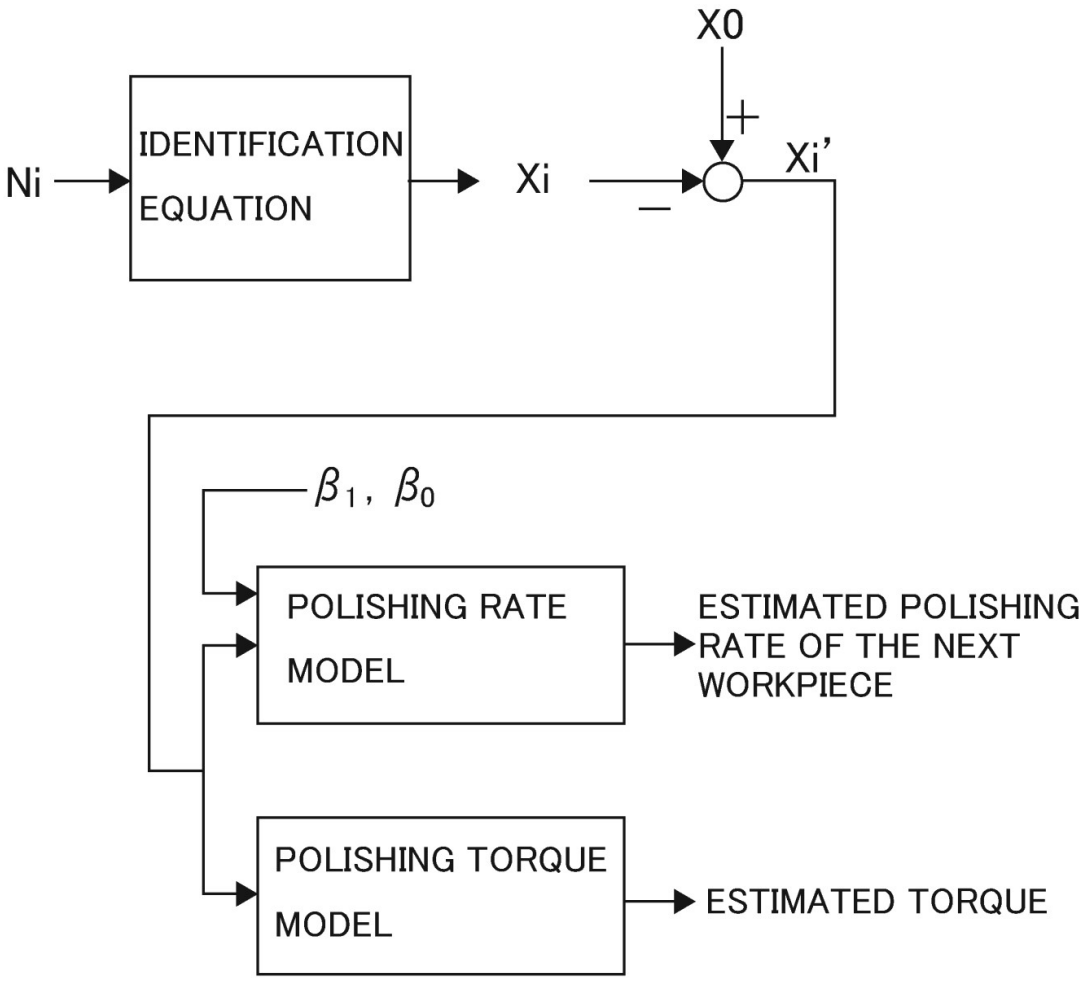

X0
+
Xi'
Ni
IDENTIFICATION EQUATION
Xi
−
β_1, β_0
POLISHING RATE MODEL
ESTIMATED POLISHING RATE OF THE NEXT WORKPIECE
POLISHING TORQUE MODEL
ESTIMATED TORQUE

FIG. 11

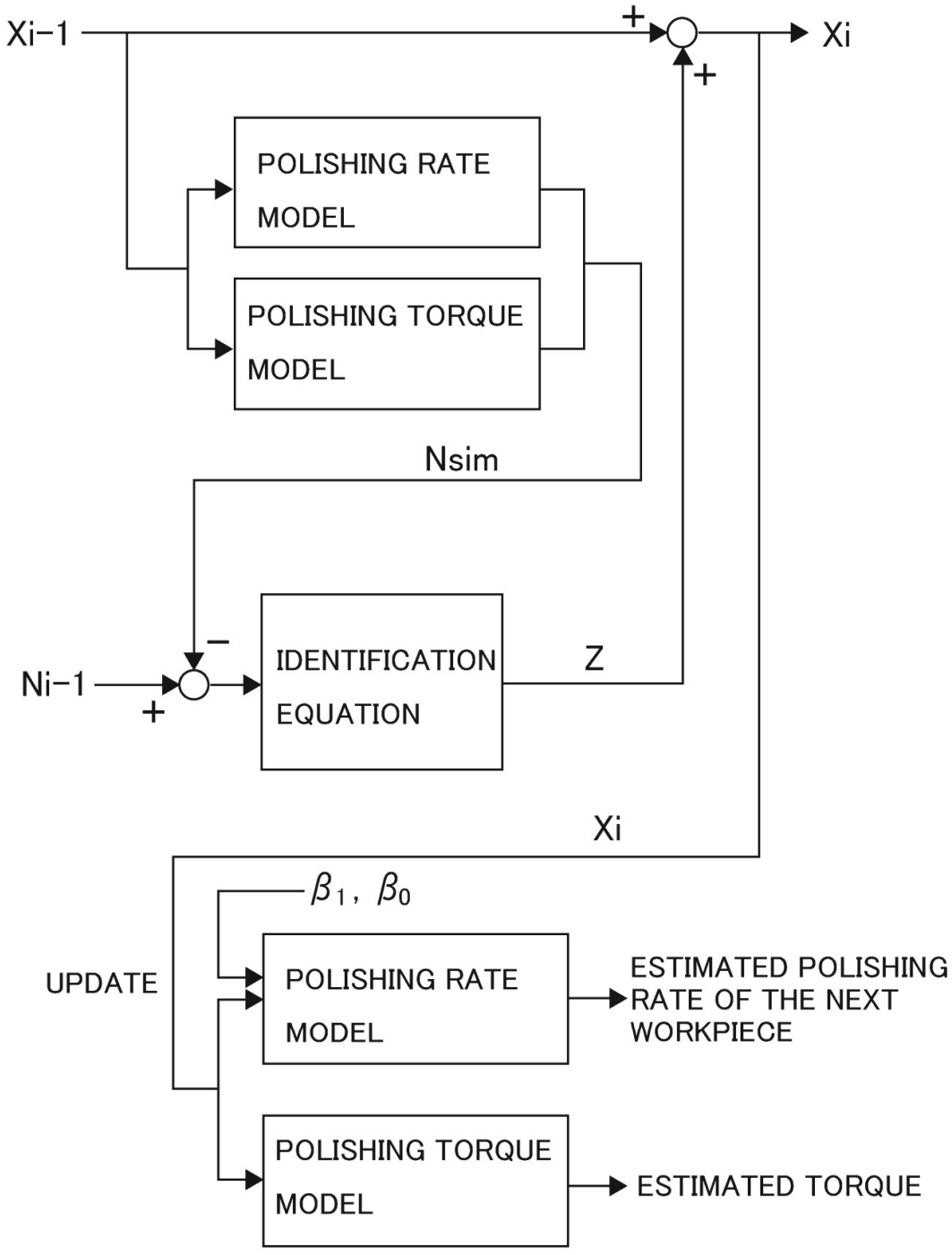

Xi-1
+
+
Xi
POLISHING RATE MODEL
POLISHING TORQUE MODEL
Nsim
−
Ni-1
+
IDENTIFICATION EQUATION
Z
Xi
β_1, β_0
UPDATE
POLISHING RATE MODEL
ESTIMATED POLISHING RATE OF THE NEXT WORKPIECE
POLISHING TORQUE MODEL
ESTIMATED TORQUE

FIG. 12

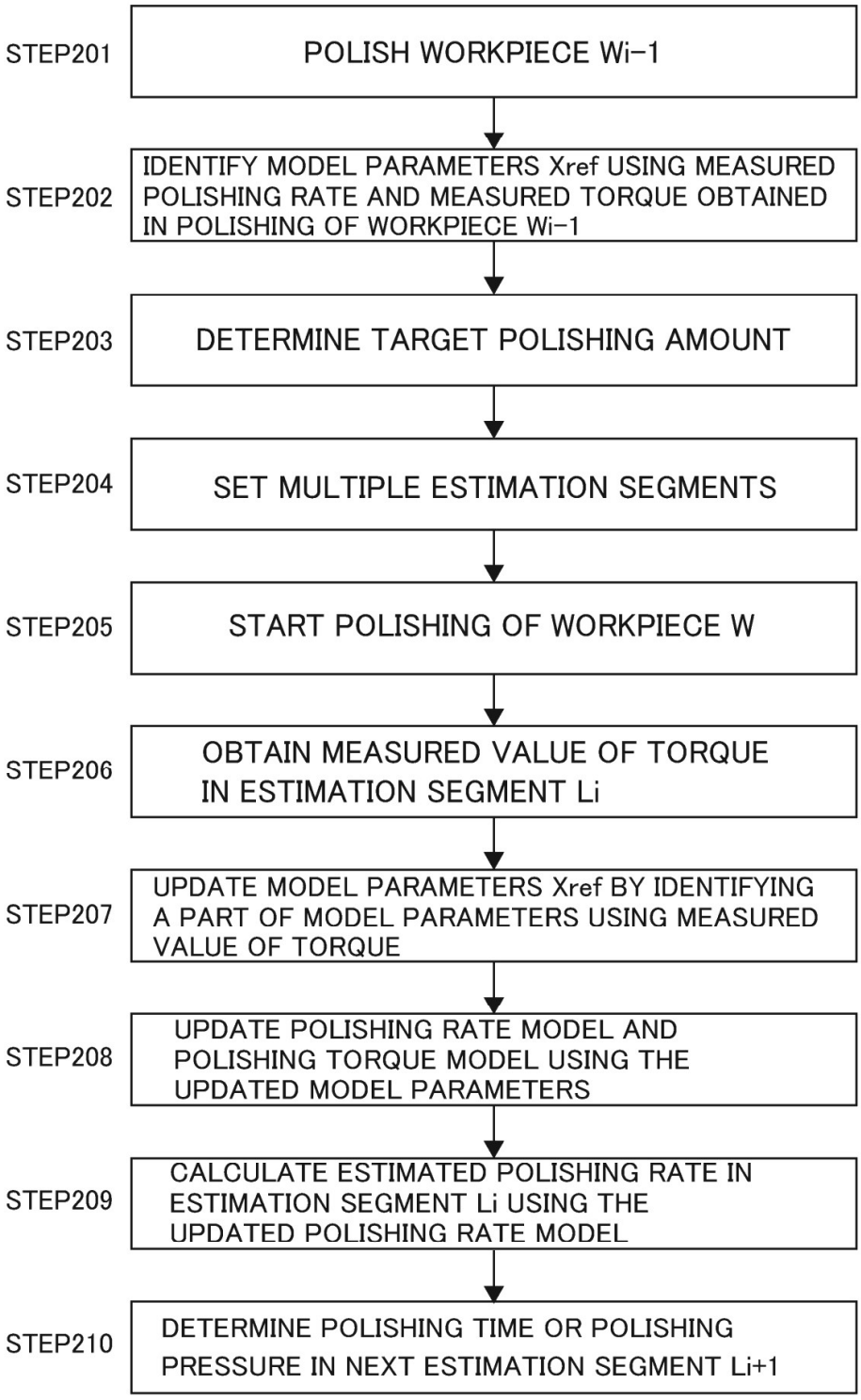

STEP201
POLISH WORKPIECE Wi-1
STEP202
IDENTIFY MODEL PARAMETERS Xref USING MEASURED POLISHING RATE AND MEASURED TORQUE OBTAINED IN POLISHING OF WORKPIECE Wi-1
STEP203
DETERMINE TARGET POLISHING AMOUNT
STEP204
SET MULTIPLE ESTIMATION SEGMENTS
STEP205
START POLISHING OF WORKPIECE W
STEP206
OBTAIN MEASURED VALUE OF TORQUE IN ESTIMATION SEGMENT Li
STEP207
UPDATE MODEL PARAMETERS Xref BY IDENTIFYING A PART OF MODEL PARAMETERS USING MEASURED VALUE OF TORQUE
STEP208
UPDATE POLISHING RATE MODEL AND POLISHING TORQUE MODEL USING THE UPDATED MODEL PARAMETERS
STEP209
CALCULATE ESTIMATED POLISHING RATE IN ESTIMATION SEGMENT Li USING THE UPDATED POLISHING RATE MODEL
STEP210
DETERMINE POLISHING TIME OR POLISHING PRESSURE IN NEXT ESTIMATION SEGMENT Li+1

FIG. 13

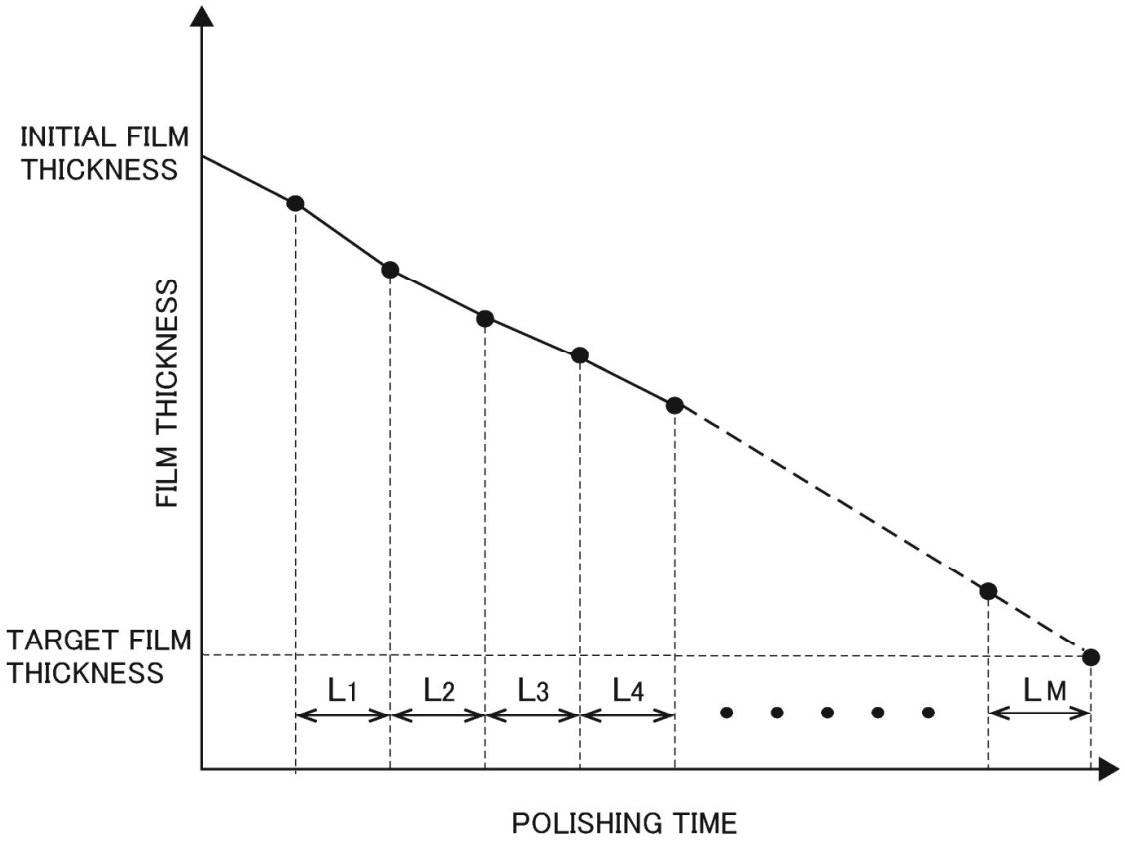

INITIAL FILM THICKNESS
FILM THICKNESS
TARGET FILM THICKNESS
L1
L2
L3
L4
LM
POLISHING TIME

FIG. 14

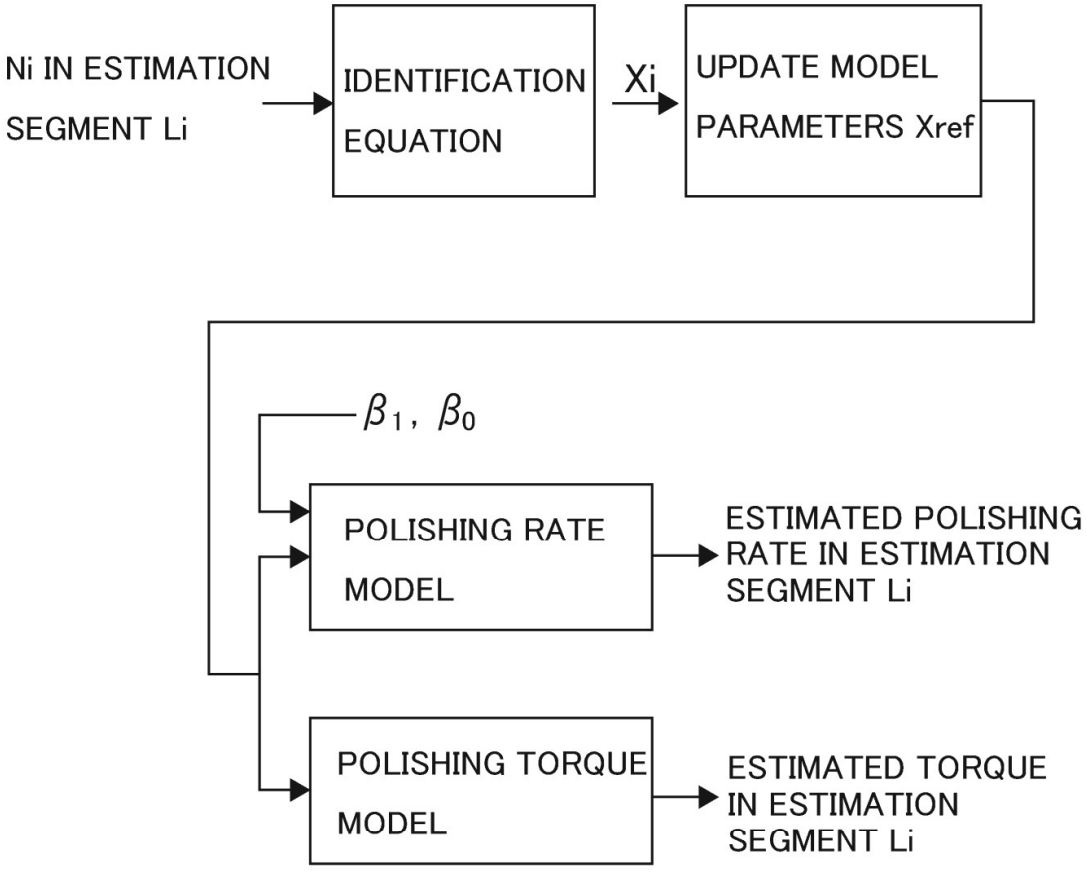

Ni IN ESTIMATION SEGMENT Li
IDENTIFICATION EQUATION
Xi
UPDATE MODEL PARAMETERS Xref
β_1, β_0
POLISHING RATE MODEL
ESTIMATED POLISHING RATE IN ESTIMATION SEGMENT Li
POLISHING TORQUE MODEL
ESTIMATED TORQUE IN ESTIMATION SEGMENT Li

FIG. 15

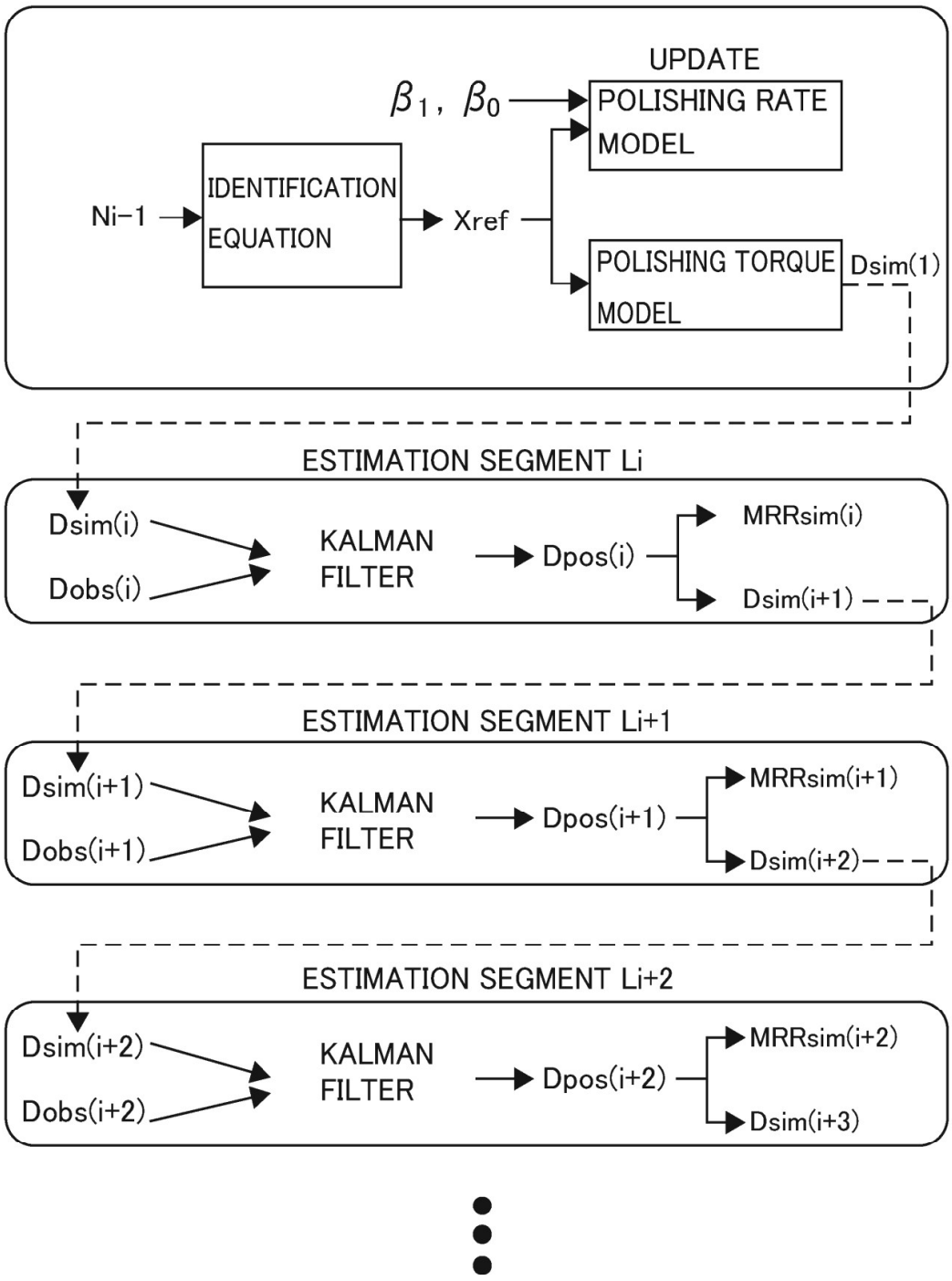

UPDATE
β1, β0
POLISHING RATE MODEL
Ni-1
IDENTIFICATION EQUATION
Xref
POLISHING TORQUE MODEL
Dsim(1)
ESTIMATION SEGMENT Li
Dsim(i)
Dobs(i)
KALMAN FILTER
Dpos(i)
MRRsim(i)
Dsim(i+1)
ESTIMATION SEGMENT Li+1
Dsim(i+1)
Dobs(i+1)
KALMAN FILTER
Dpos(i+1)
MRRsim(i+1)
Dsim(i+2)
ESTIMATION SEGMENT Li+2
Dsim(i+2)
Dobs(i+2)
KALMAN FILTER
Dpos(i+2)
MRRsim(i+2)
Dsim(i+3)

FIG. 16

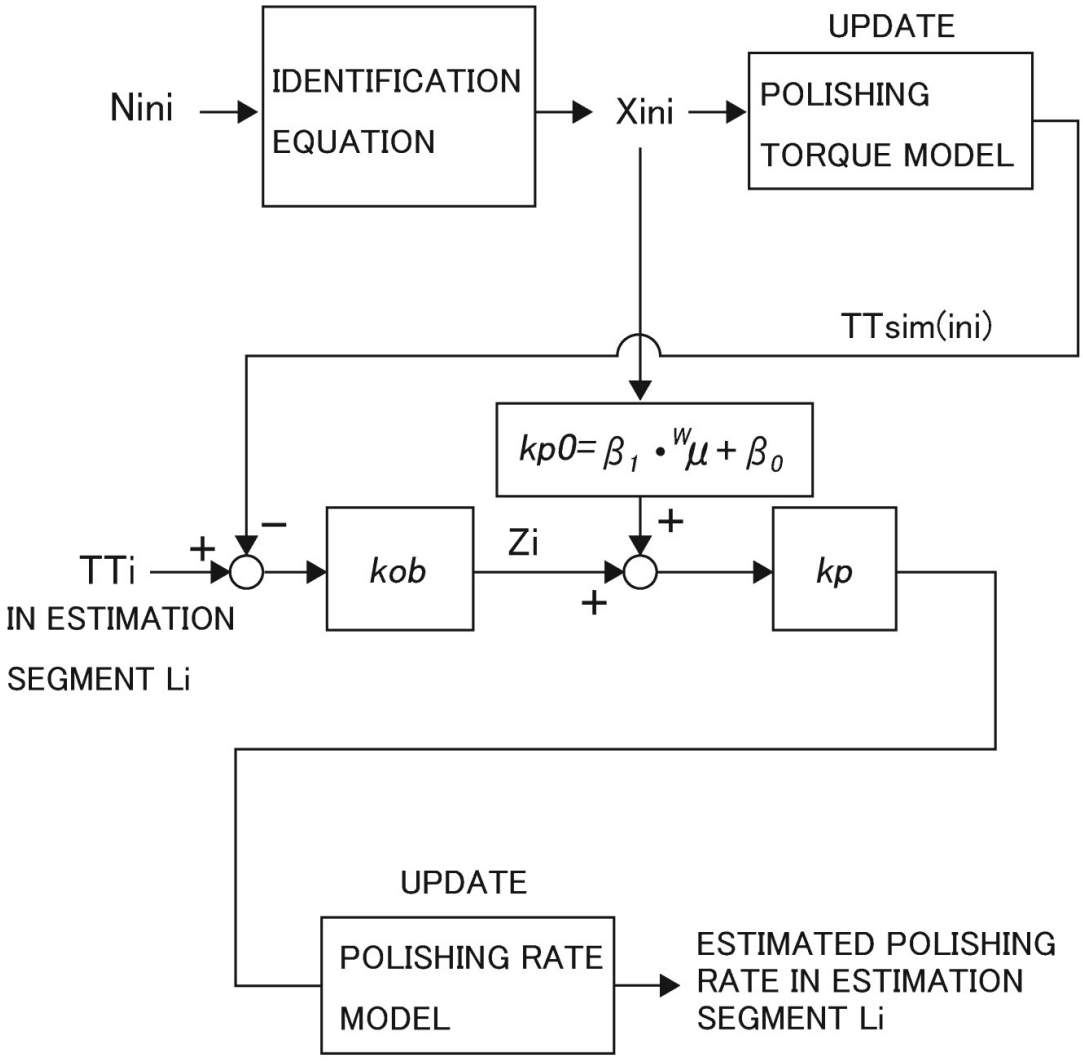

Nini
IDENTIFICATION EQUATION
Xini
UPDATE
POLISHING TORQUE MODEL
TTsim(ini)
$kp0=\beta_1 \cdot {}^{w}\mu+\beta_0$
TTi
IN ESTIMATION SEGMENT Li
kob
Zi
kp
UPDATE
POLISHING RATE MODEL
ESTIMATED POLISHING RATE IN ESTIMATION SEGMENT Li

FIG. 17

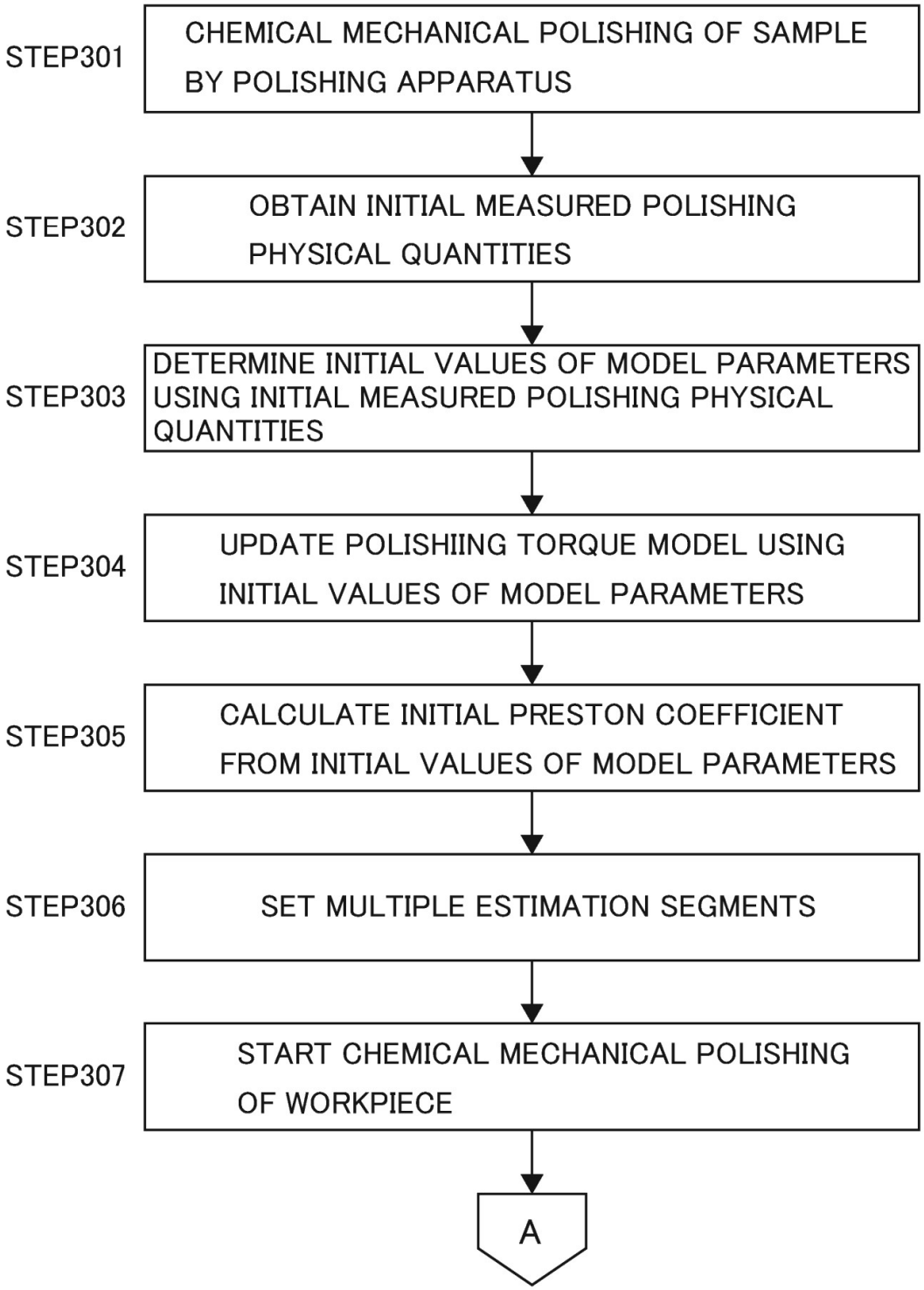
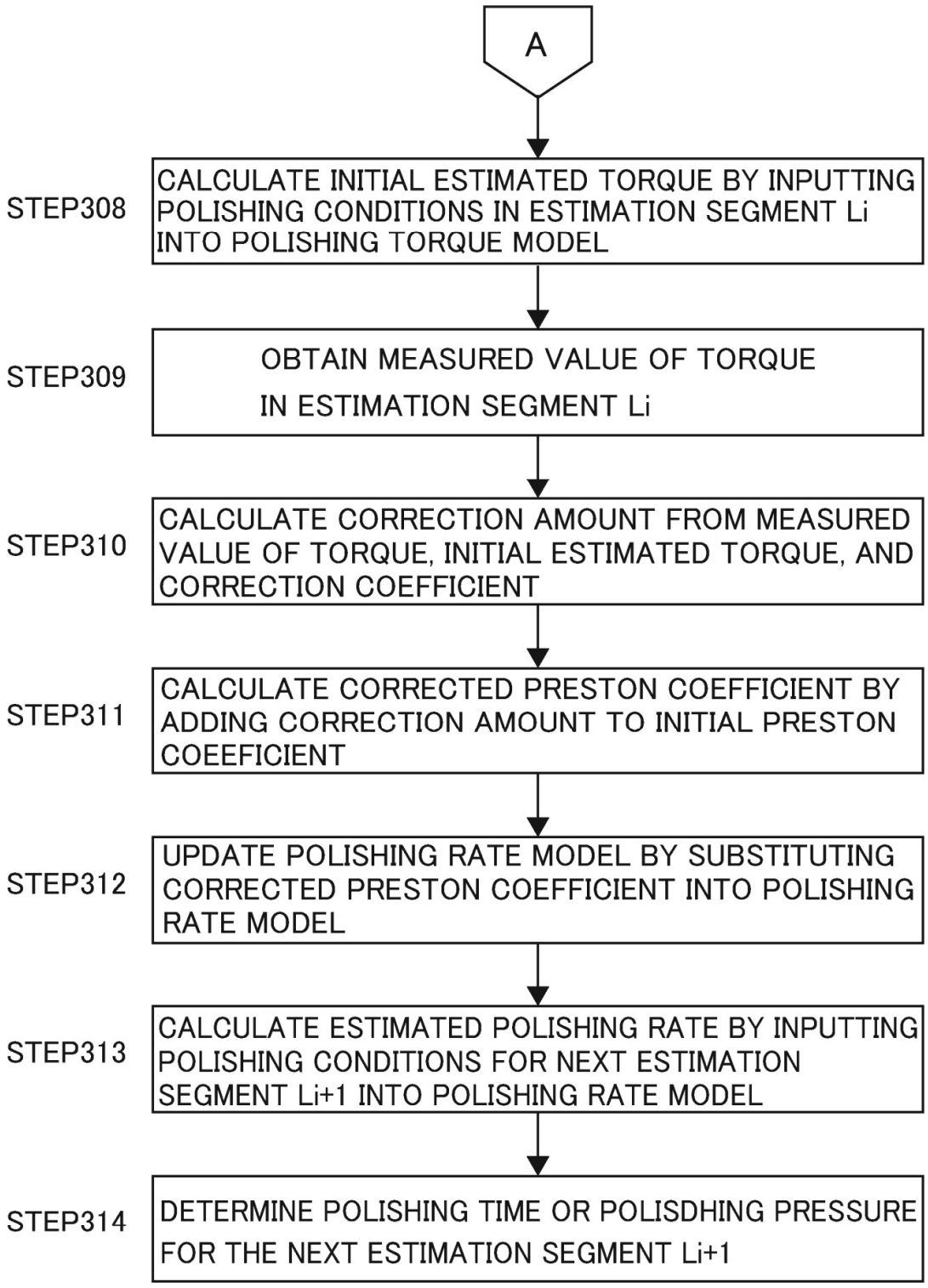

STEP301
CHEMICAL MECHANICAL POLISHING OF SAMPLE BY POLISHING APPARATUS
STEP302
OBTAIN INITIAL MEASURED POLISHING PHYSICAL QUANTITIES
STEP303
DETERMINE INITIAL VALUES OF MODEL PARAMETERS USING INITIAL MEASURED POLISHING PHYSICAL QUANTITIES
STEP304
UPDATE POLISHIING TORQUE MODEL USING INITIAL VALUES OF MODEL PARAMETERS
STEP305
CALCULATE INITIAL PRESTON COEFFICIENT FROM INITIAL VALUES OF MODEL PARAMETERS
STEP306
SET MULTIPLE ESTIMATION SEGMENTS
STEP307
START CHEMICAL MECHANICAL POLISHING OF WORKPIECE
A

FIG. 18


A
STEP308
CALCULATE INITIAL ESTIMATED TORQUE BY INPUTTING POLISHING CONDITIONS IN ESTIMATION SEGMENT Li INTO POLISHING TORQUE MODEL
STEP309
OBTAIN MEASURED VALUE OF TORQUE IN ESTIMATION SEGMENT Li
STEP310
CALCULATE CORRECTION AMOUNT FROM MEASURED VALUE OF TORQUE, INITIAL ESTIMATED TORQUE, AND CORRECTION COEFFICIENT
STEP311
CALCULATE CORRECTED PRESTON COEFFICIENT BY ADDING CORRECTION AMOUNT TO INITIAL PRESTON COEEFICIENT
STEP312
UPDATE POLISHING RATE MODEL BY SUBSTITUTING CORRECTED PRESTON COEFFICIENT INTO POLISHING RATE MODEL
STEP313
CALCULATE ESTIMATED POLISHING RATE BY INPUTTING POLISHING CONDITIONS FOR NEXT ESTIMATION SEGMENT Li+1 INTO POLISHING RATE MODEL
STEP314
DETERMINE POLISHING TIME OR POLISDHING PRESSURE FOR THE NEXT ESTIMATION SEGMENT Li+1