

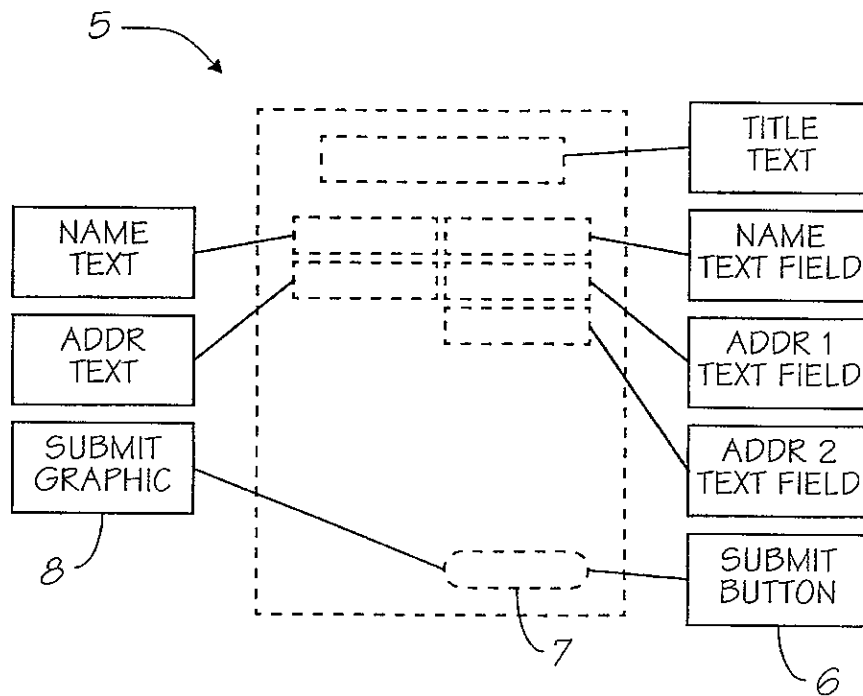
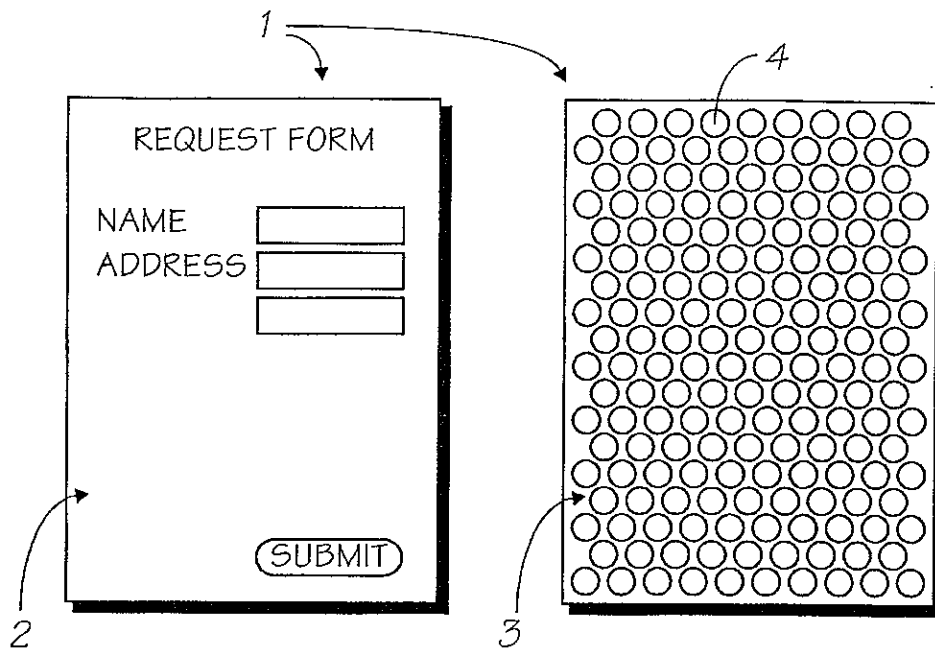


FIG. 1

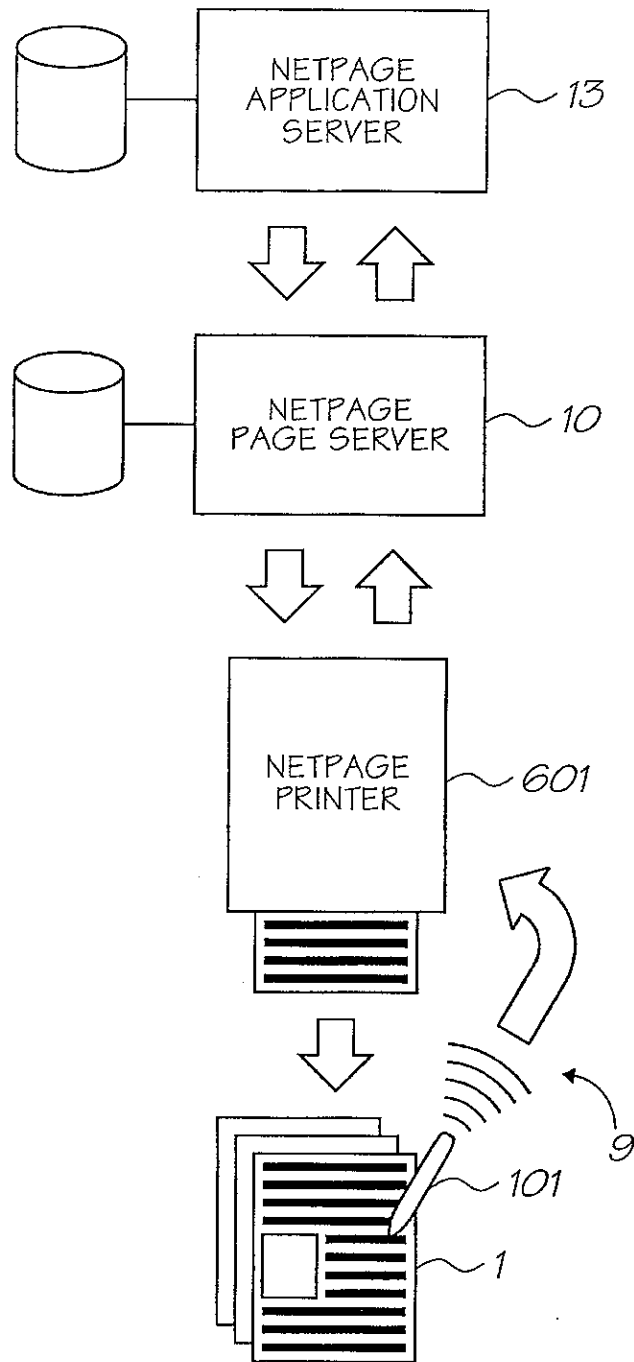


FIG. 2

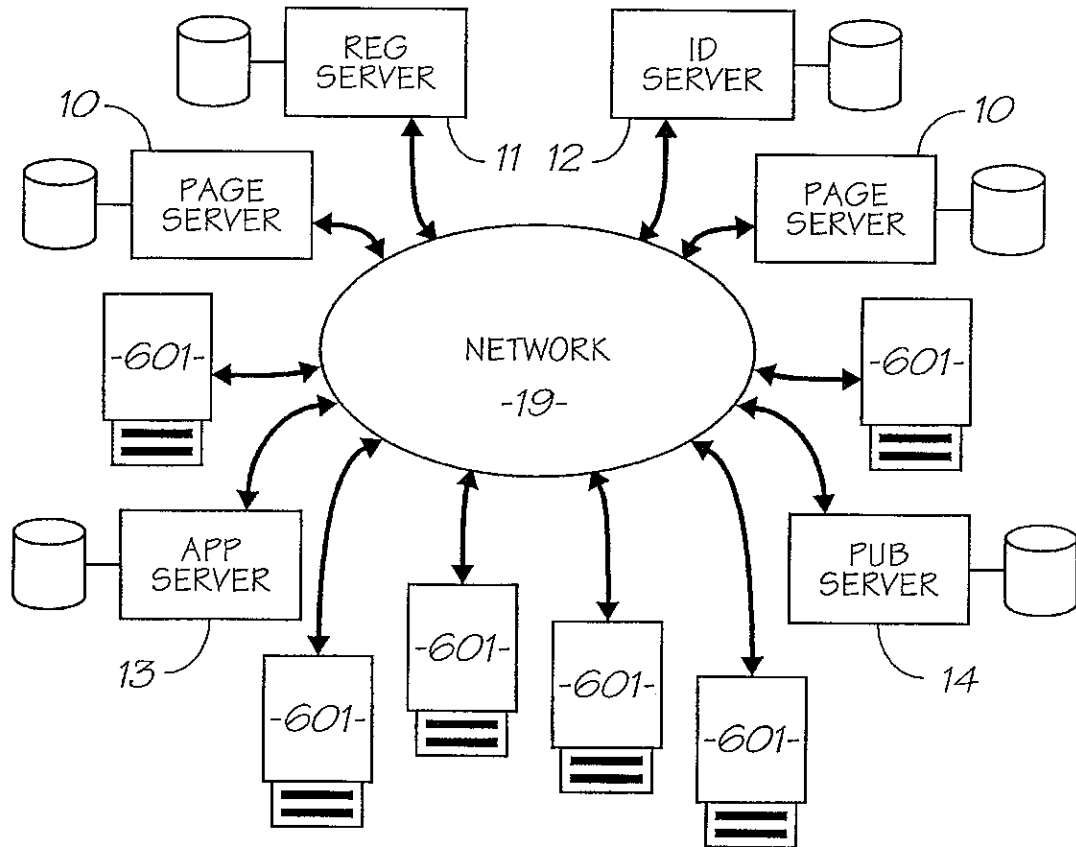


FIG. 3

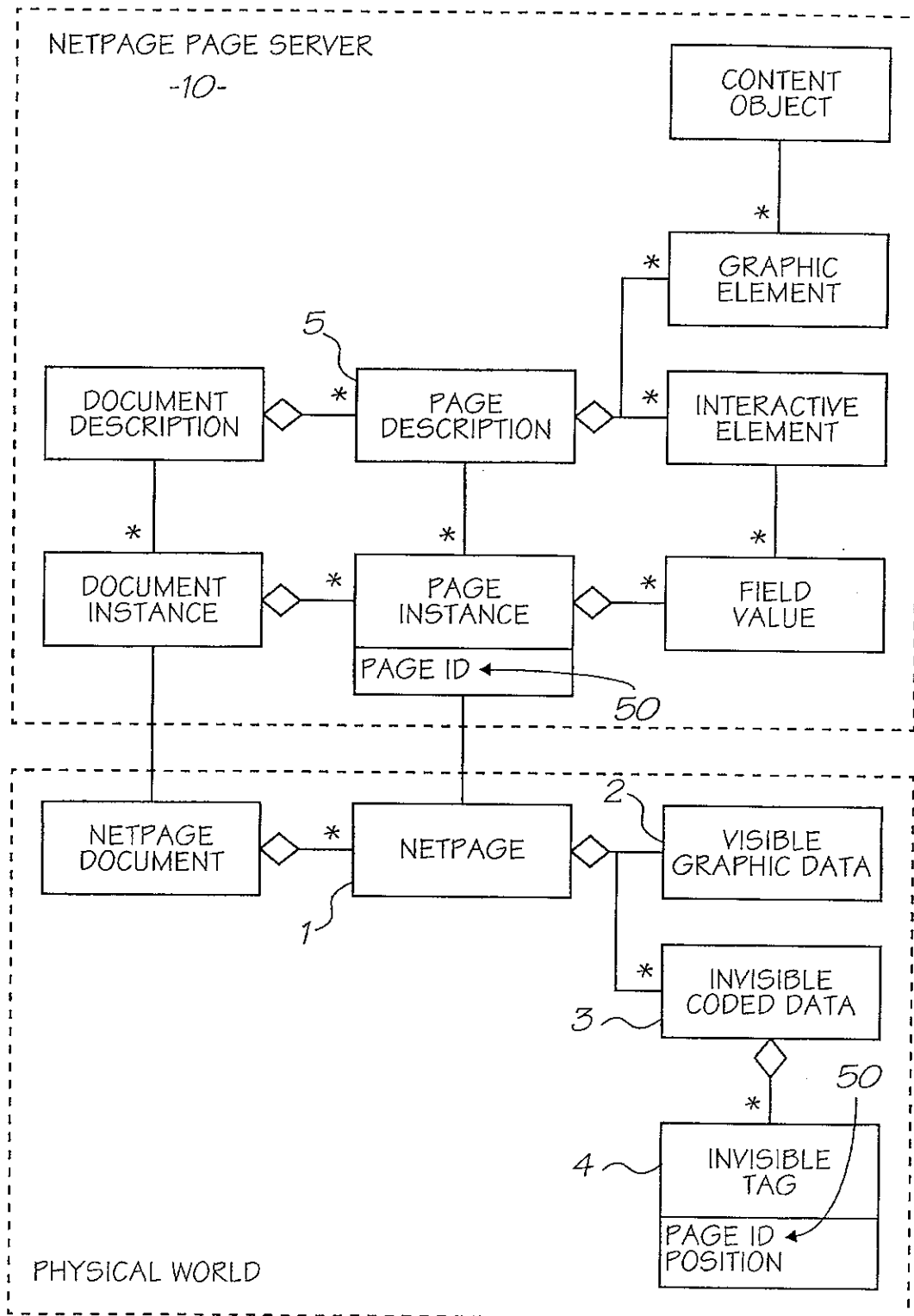


FIG. 4

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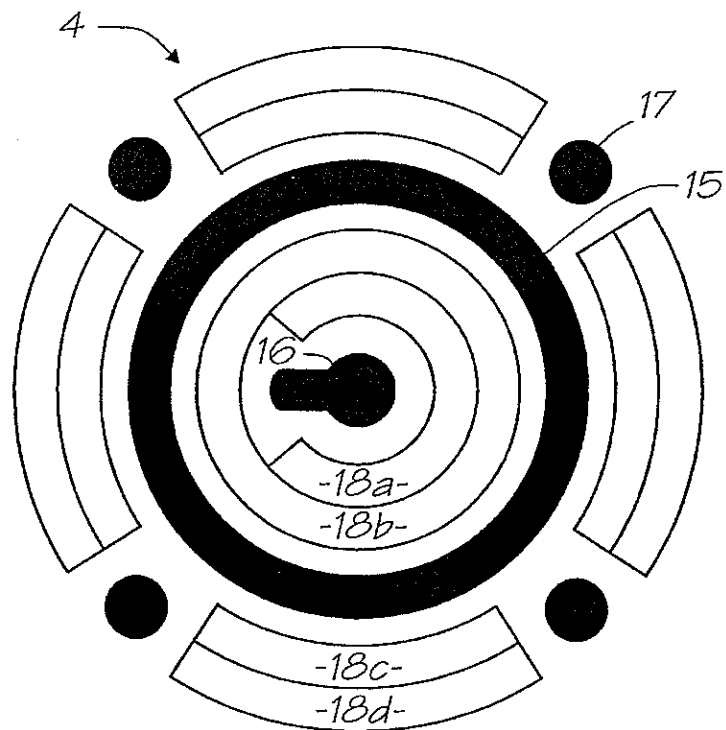


FIG. 5

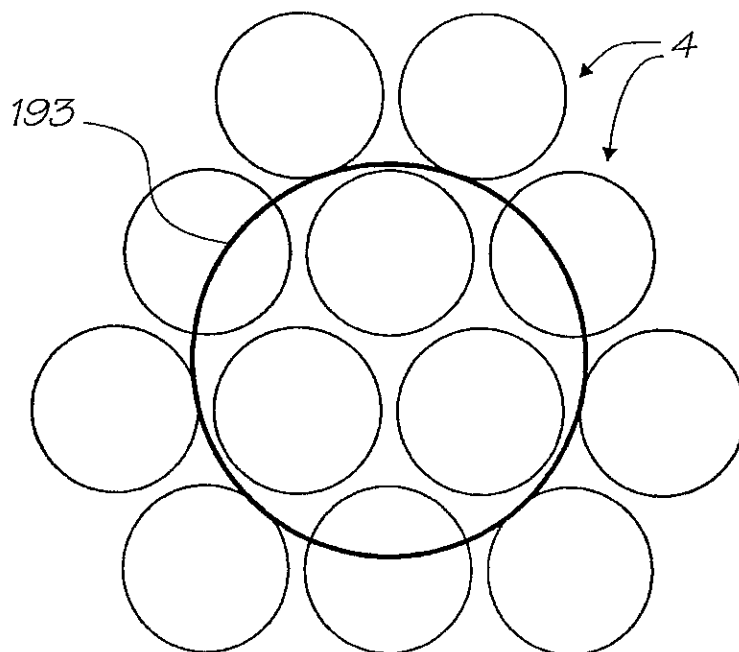


FIG. 6

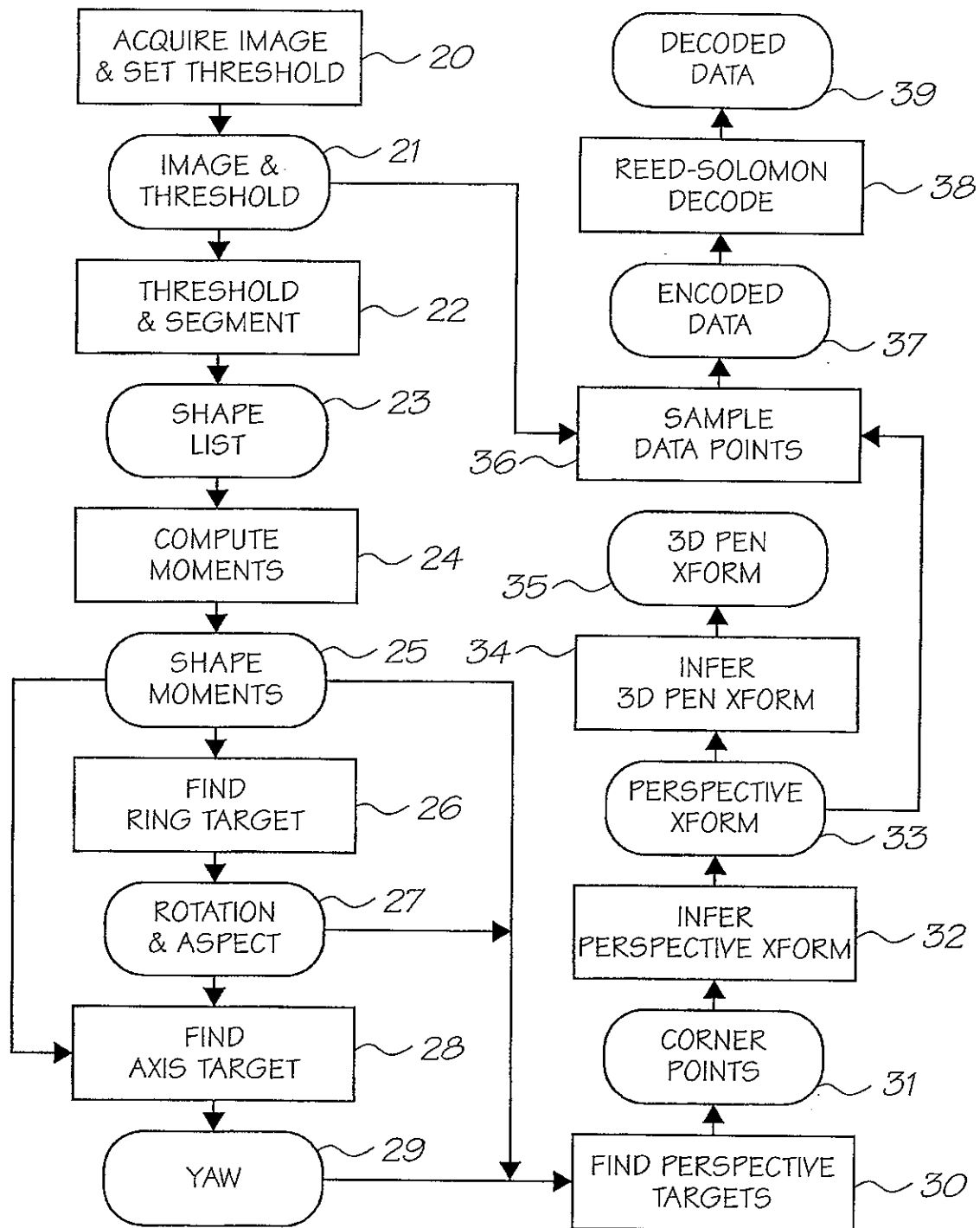


FIG. 7

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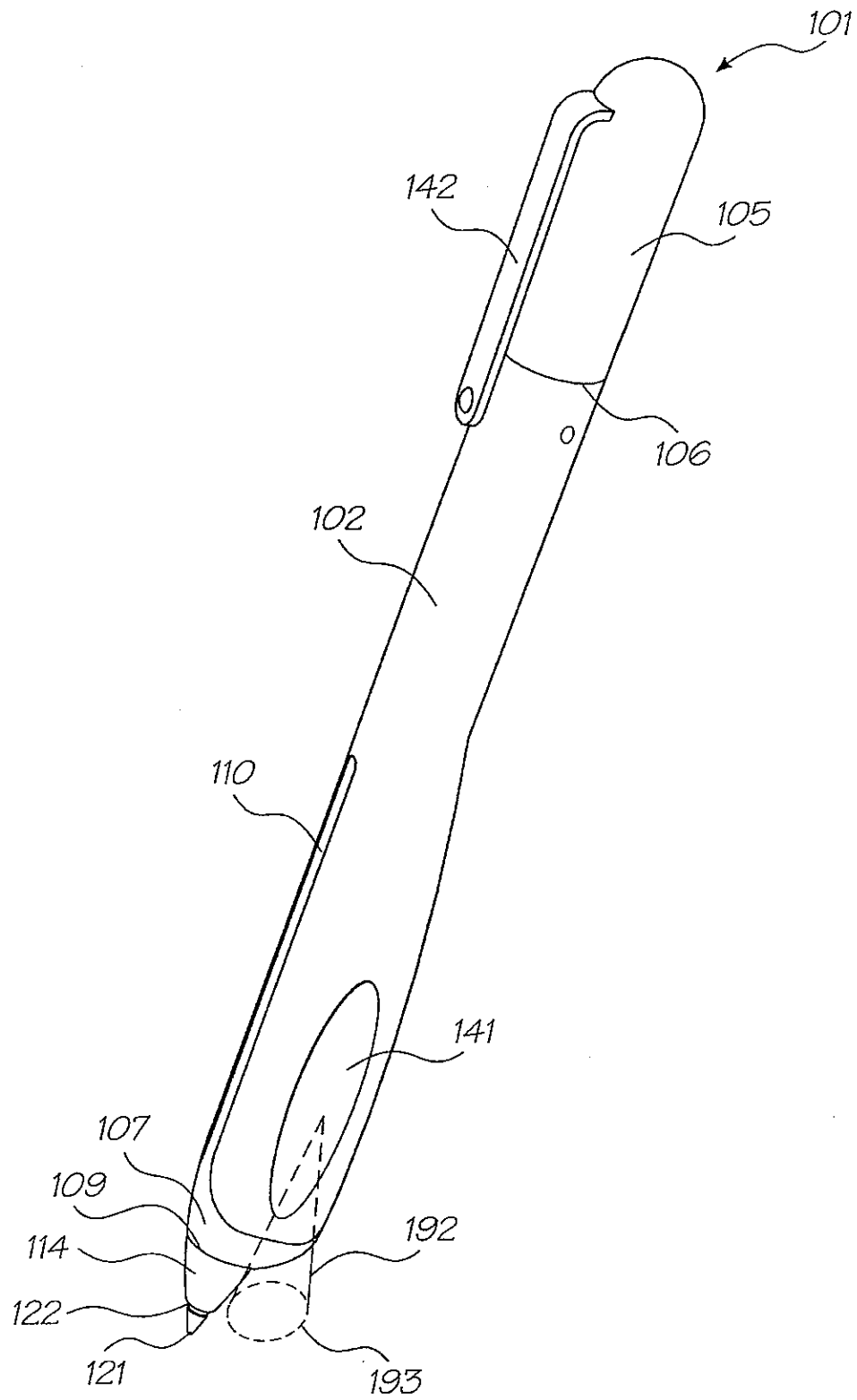


FIG. 8

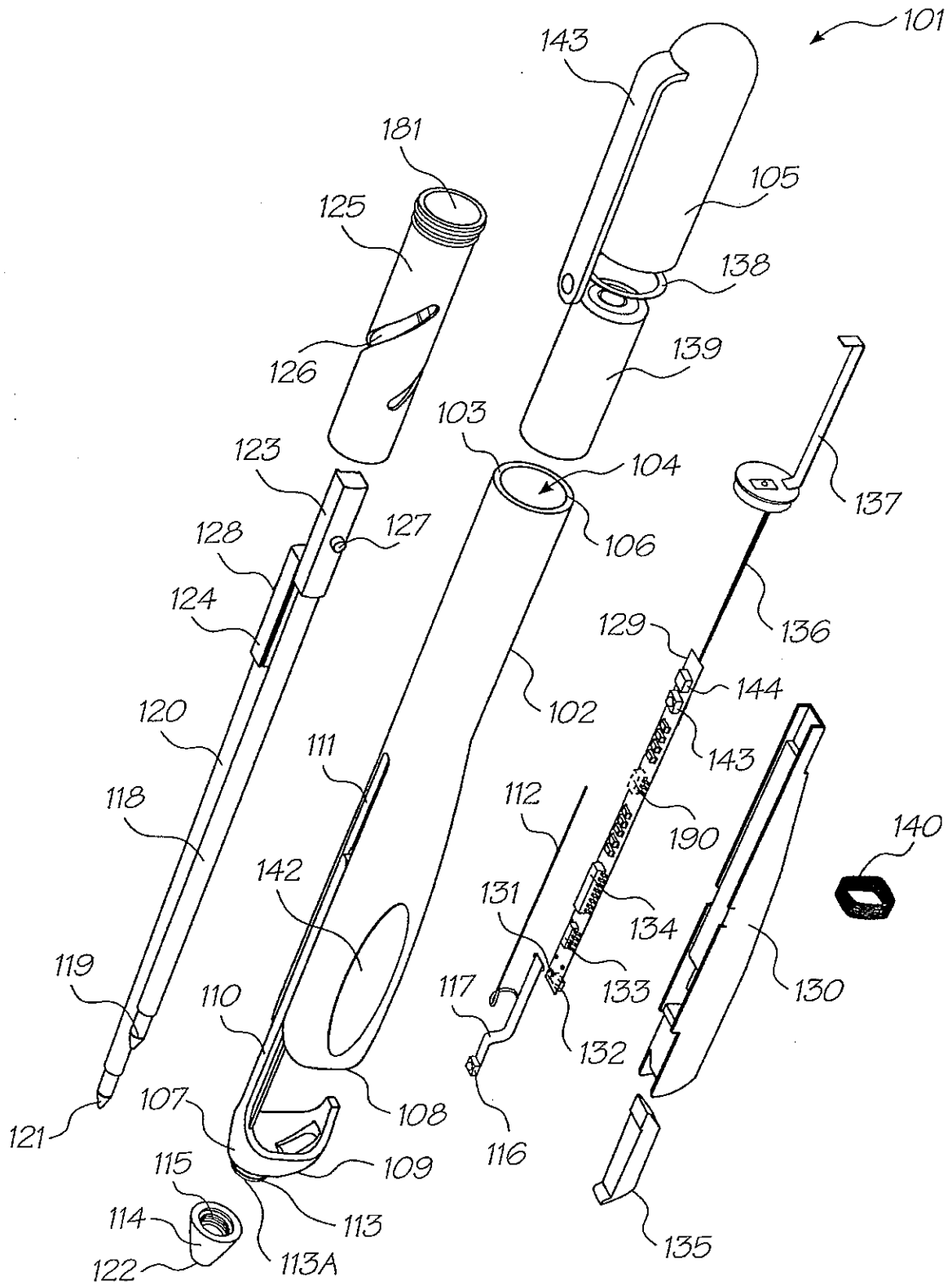


FIG. 9

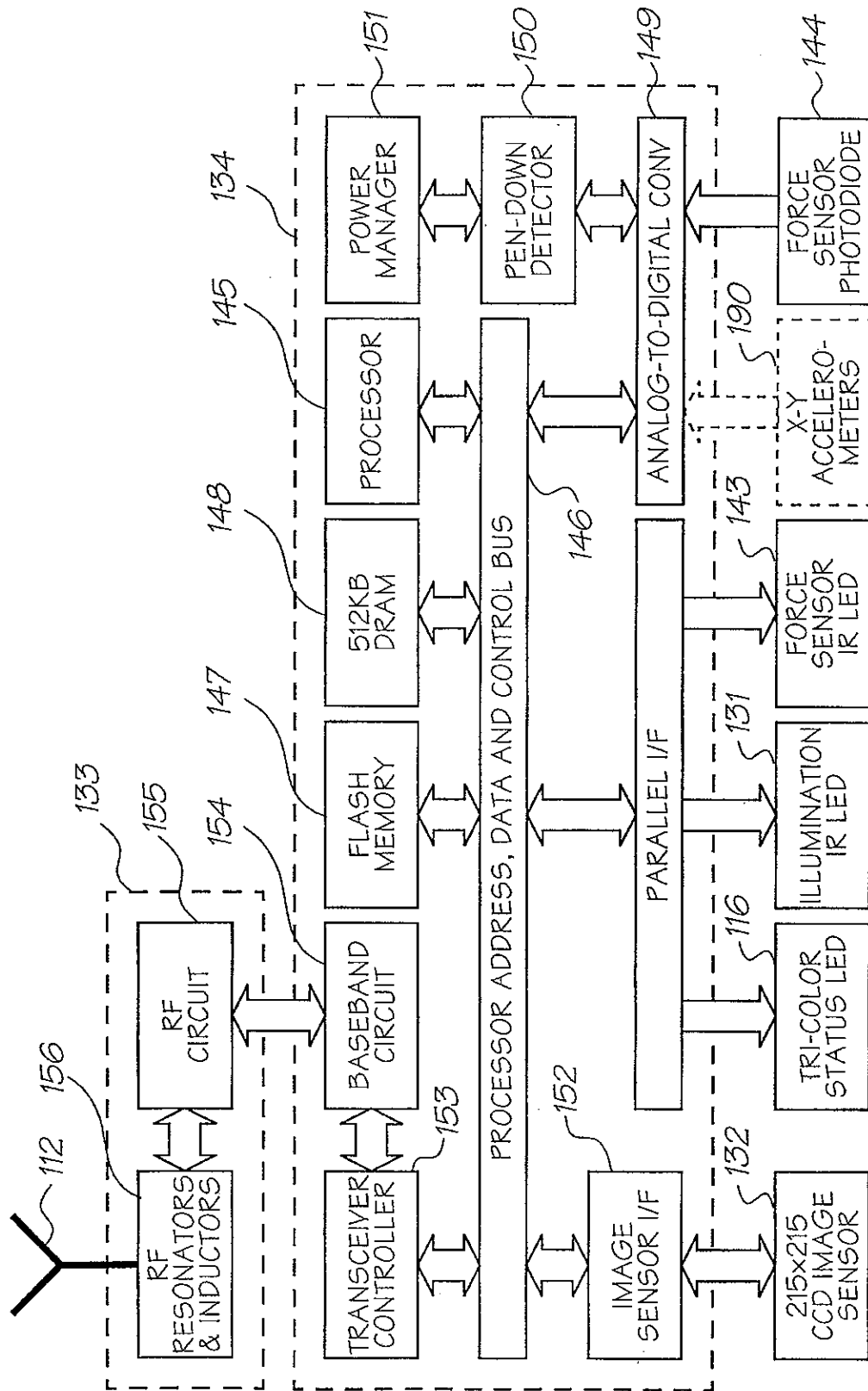


FIG. 10

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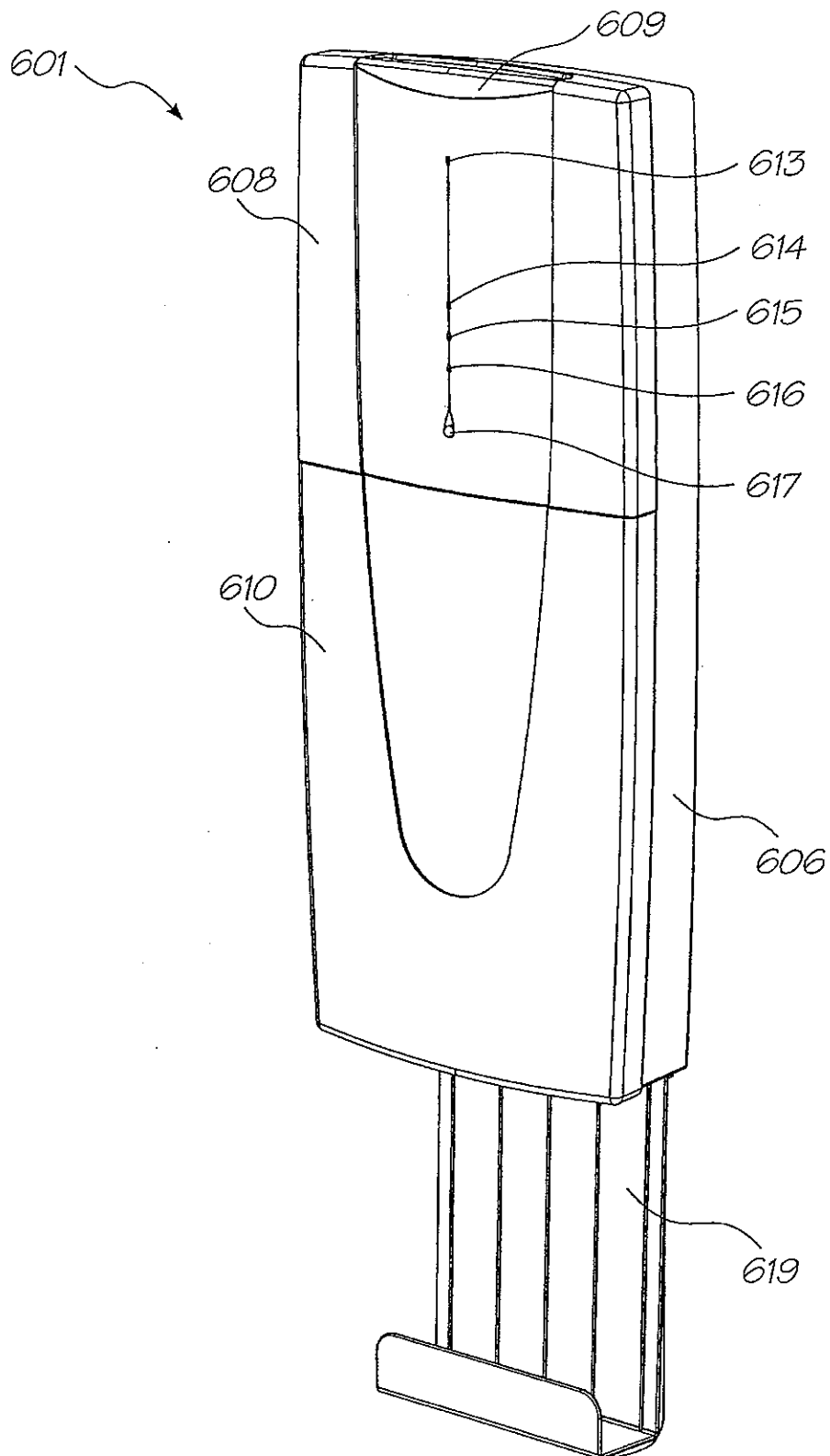


FIG. 11

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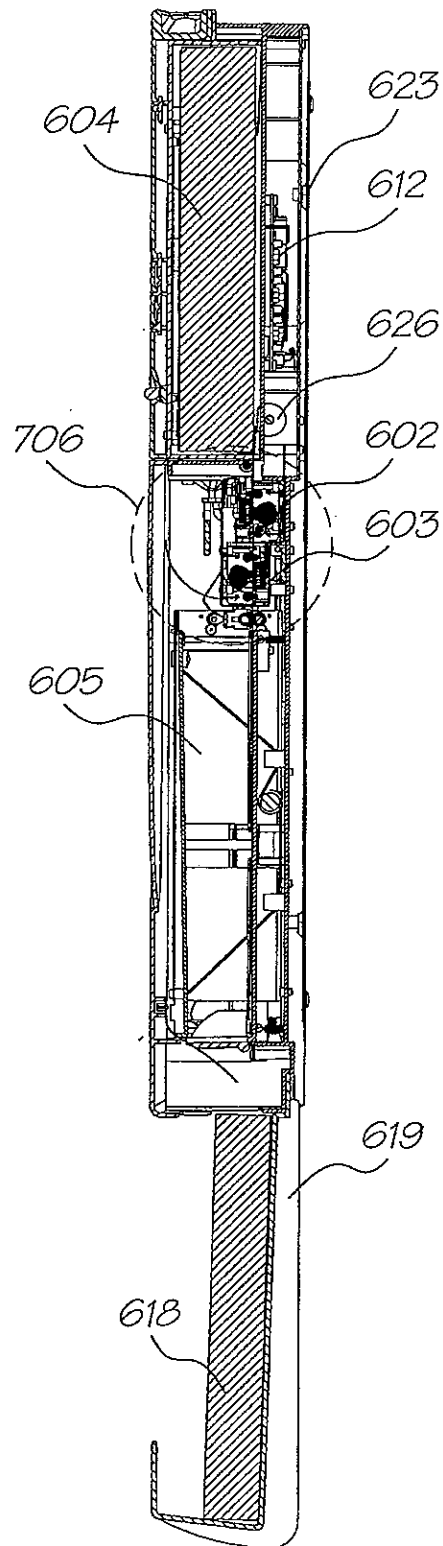


FIG. 12

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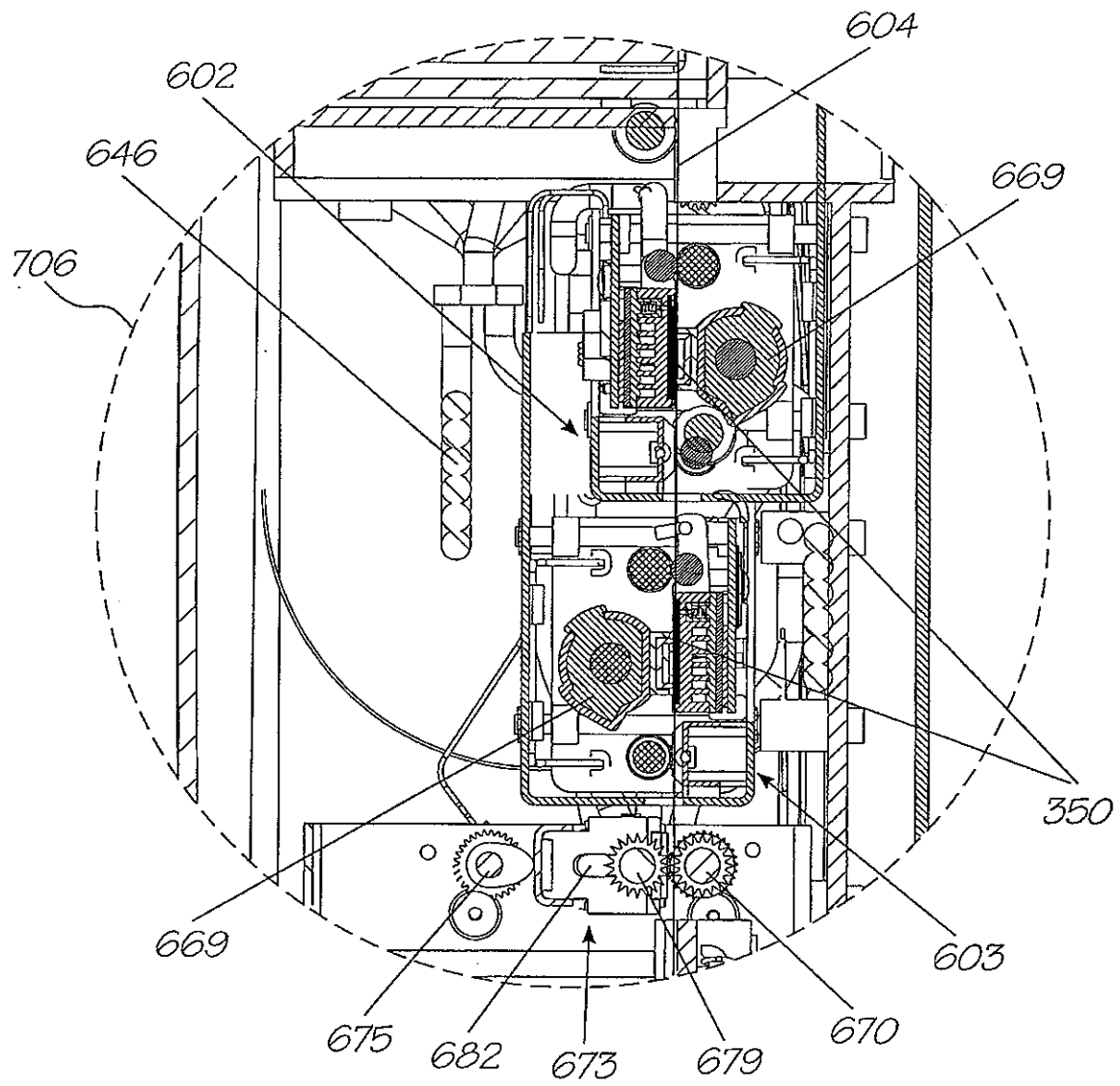


FIG. 12a

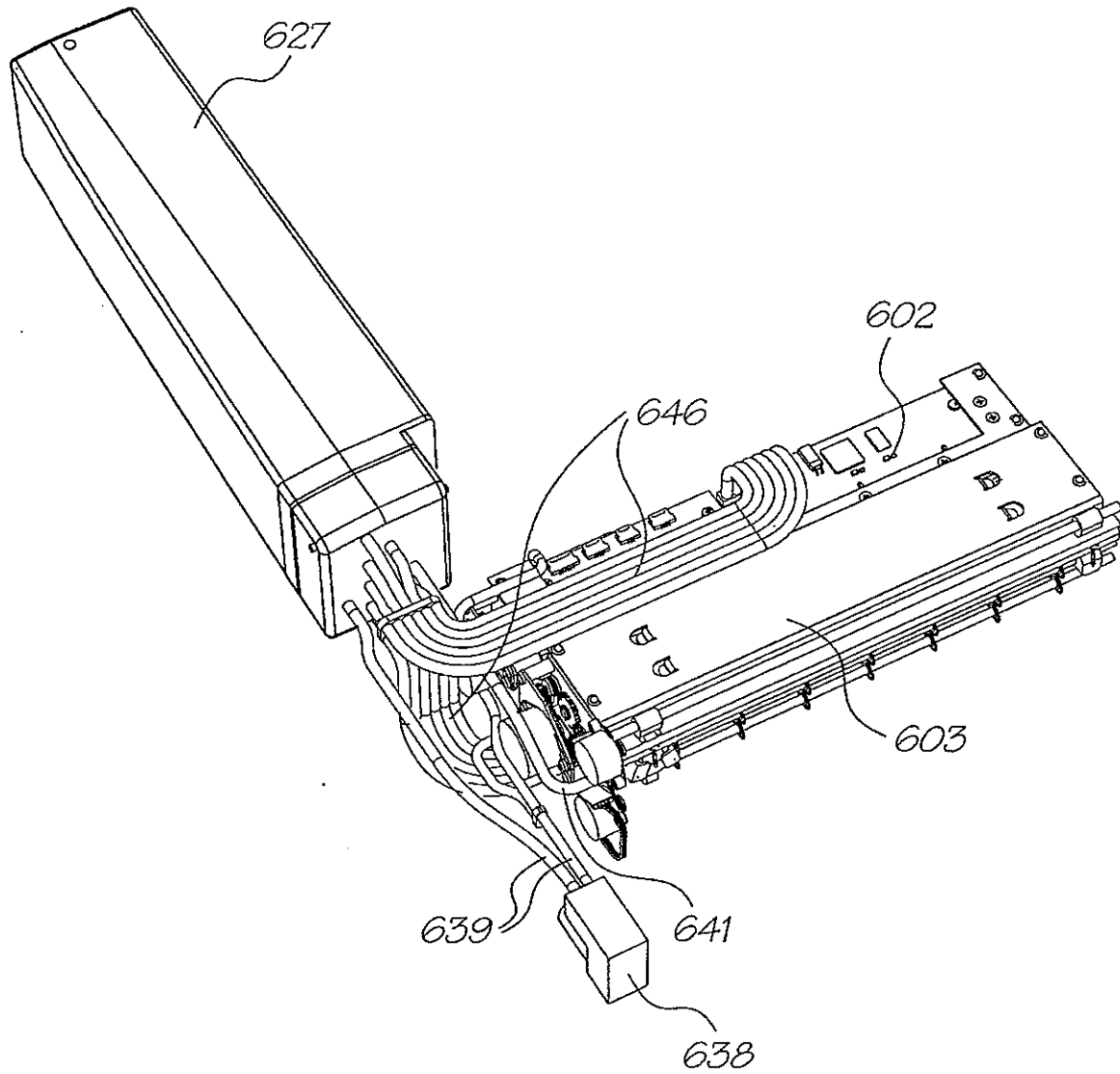


FIG. 13

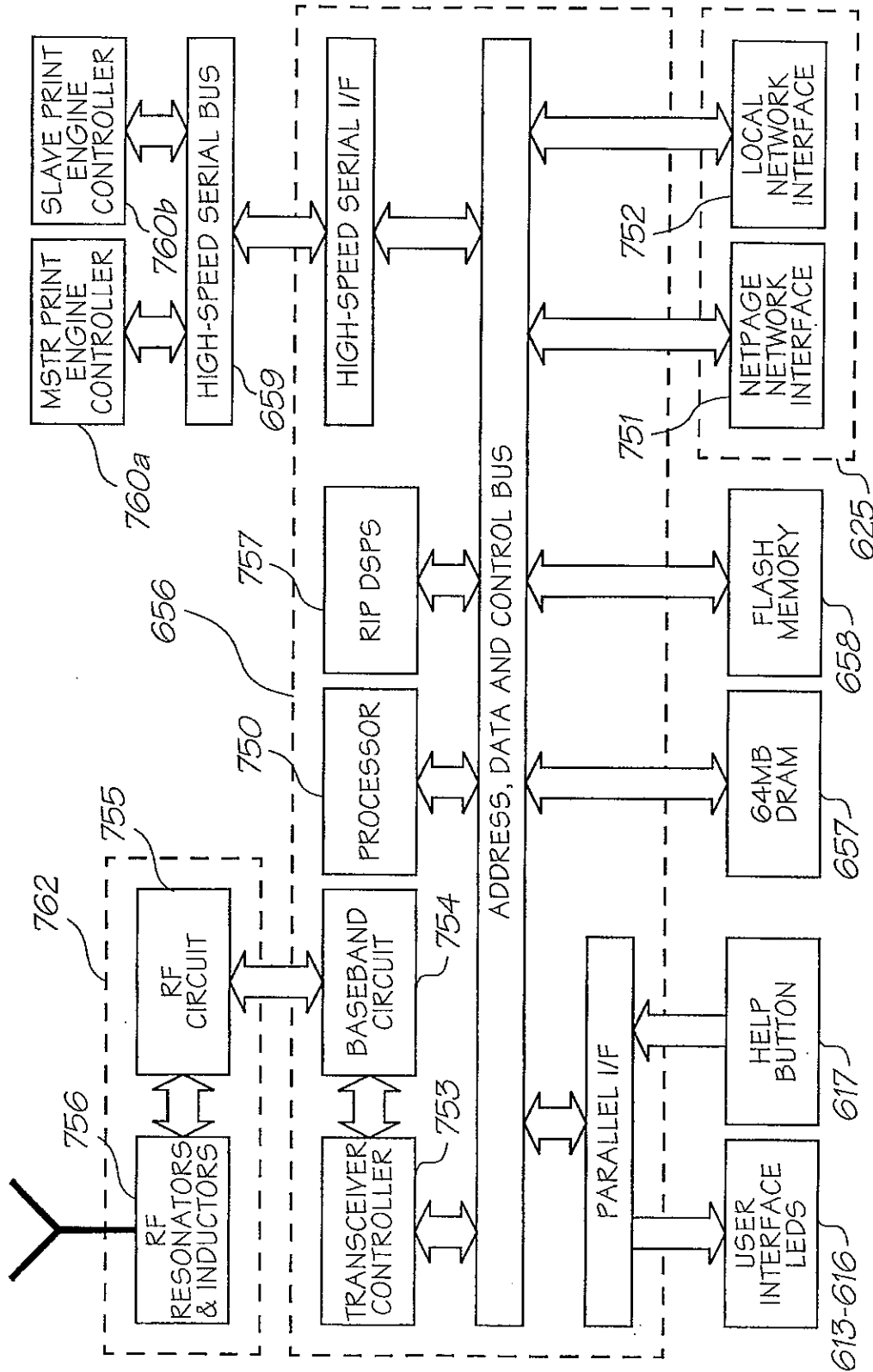


FIG. 14

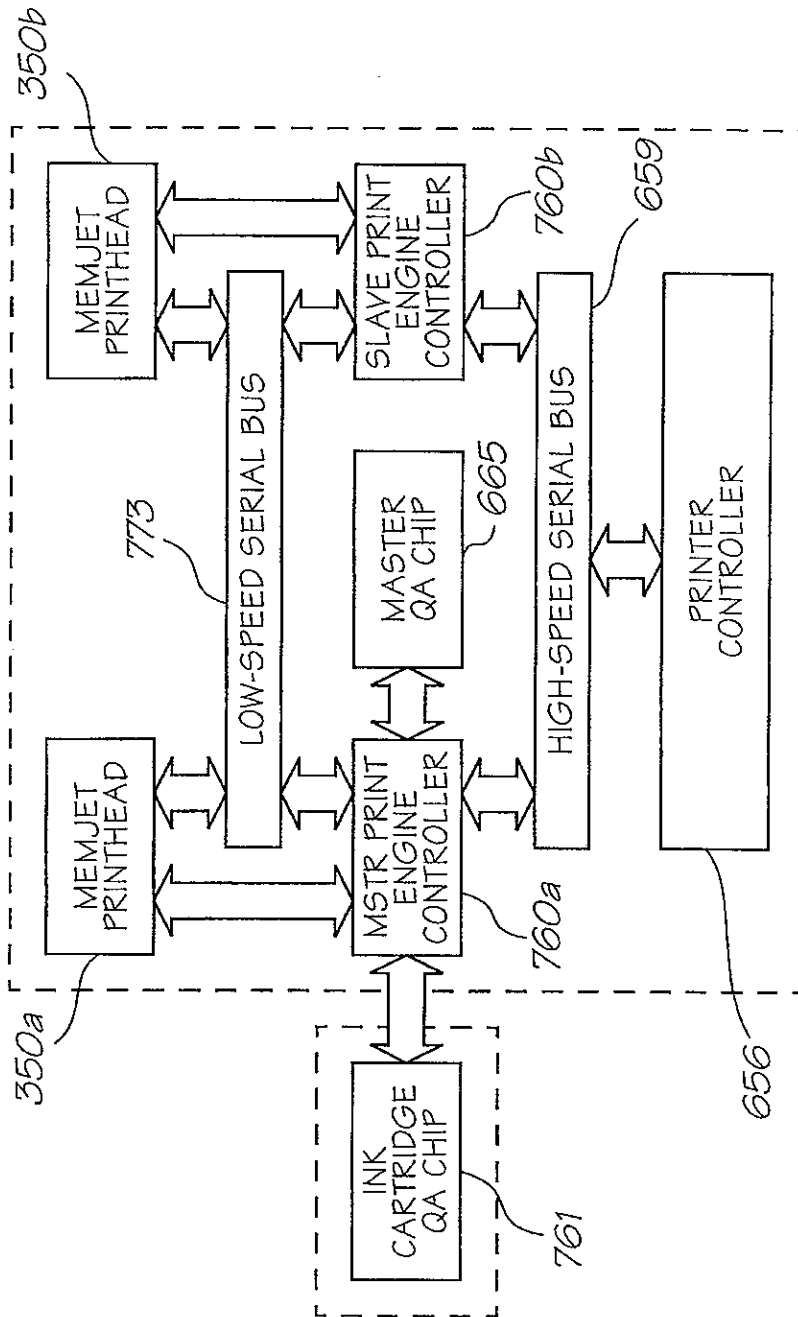


FIG. 15

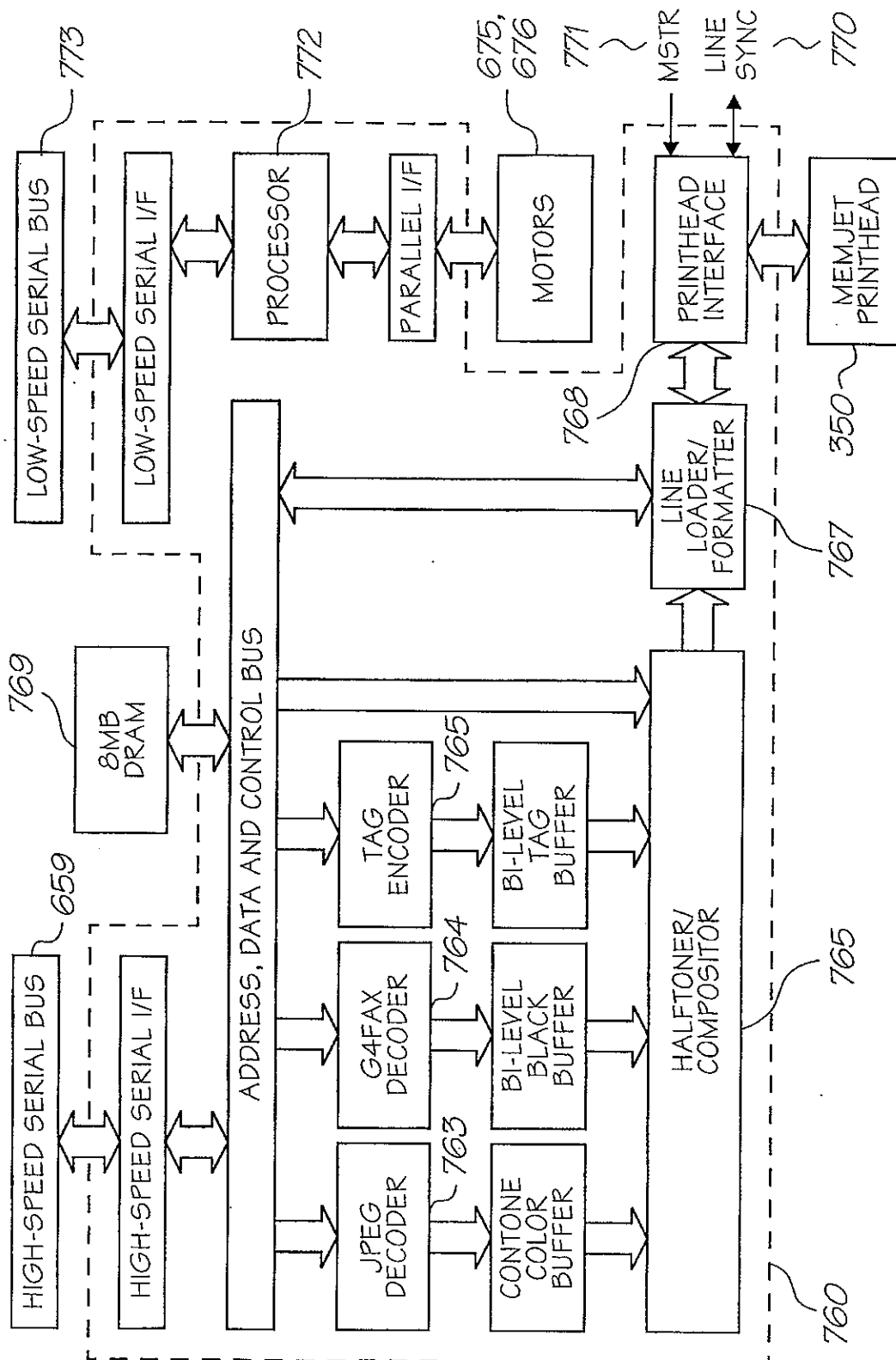


FIG. 16

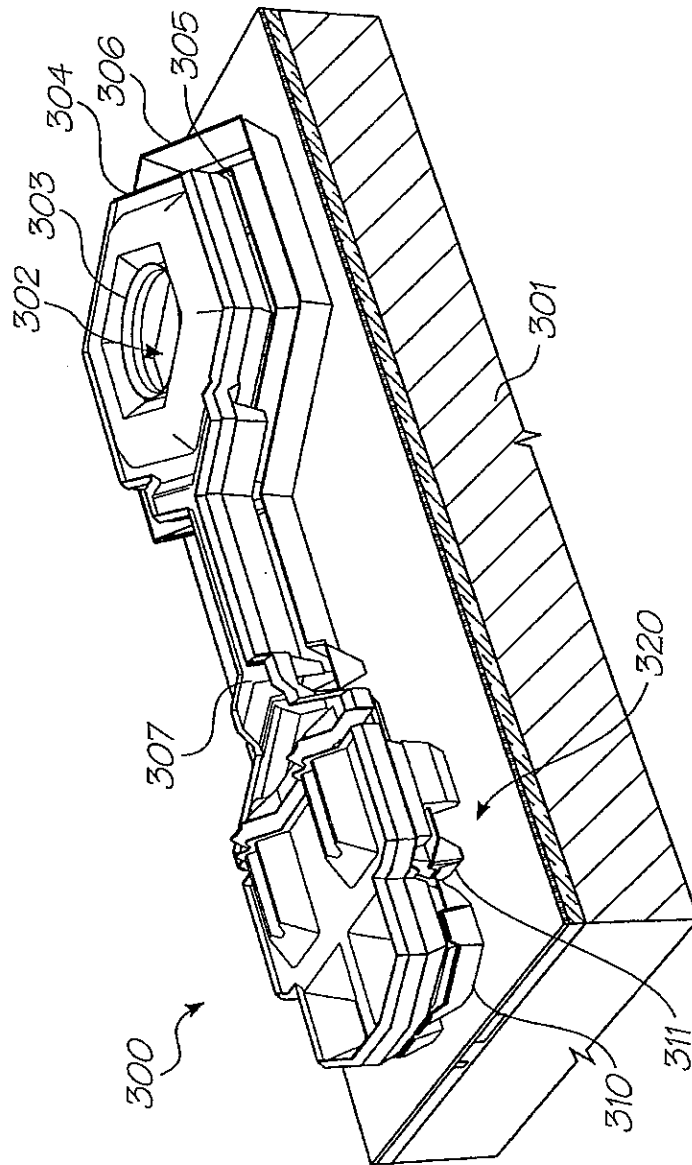


FIG. 17

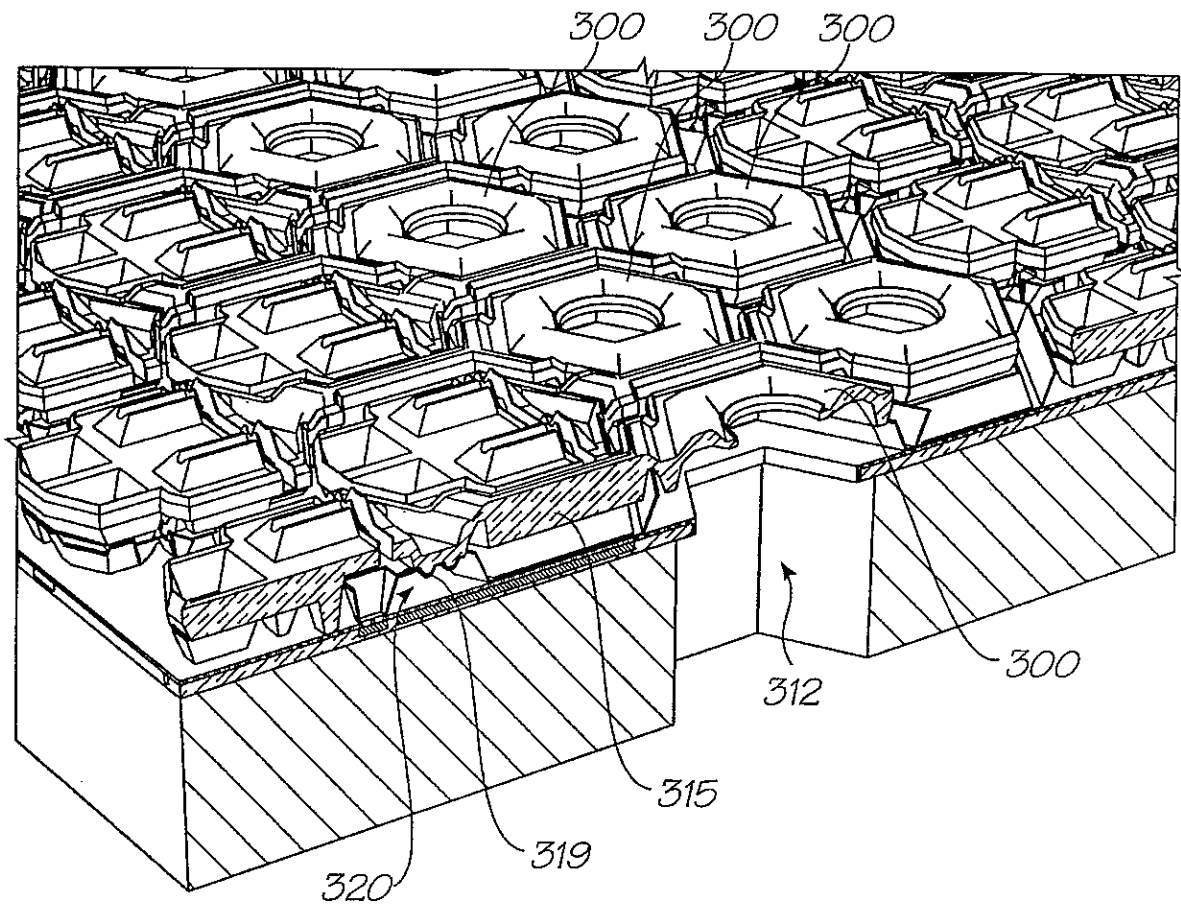


FIG. 18

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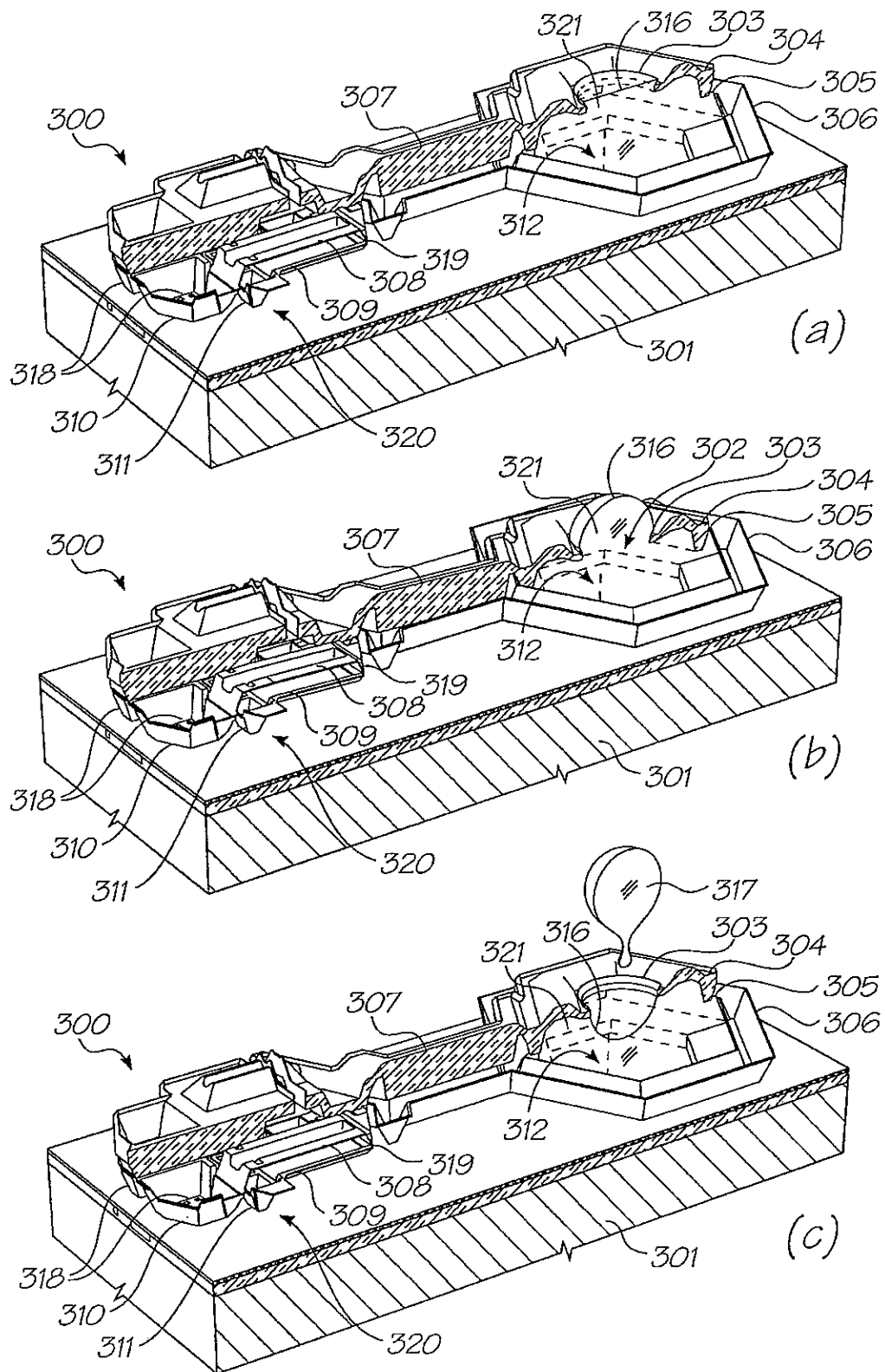


FIG. 19

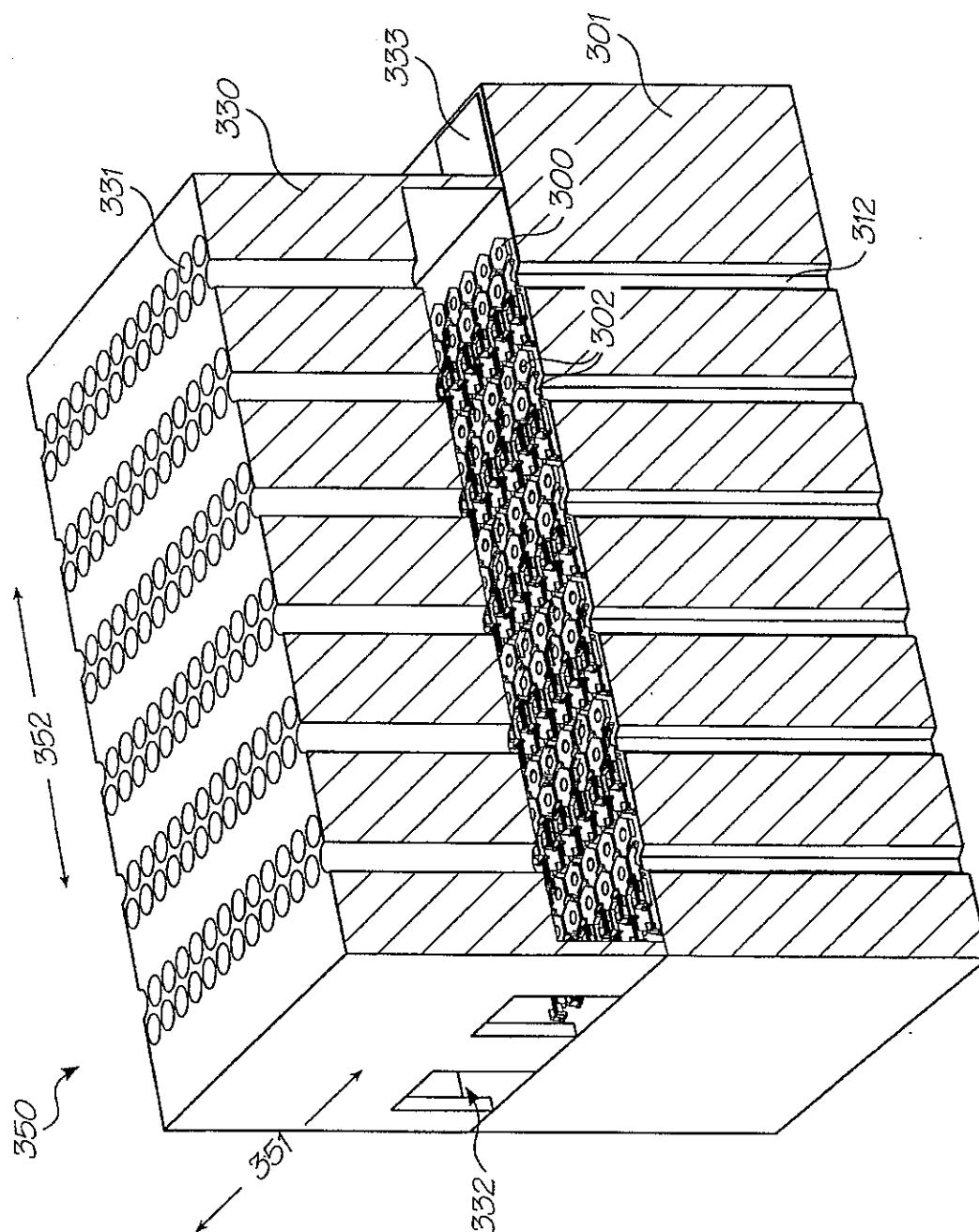


FIG. 20

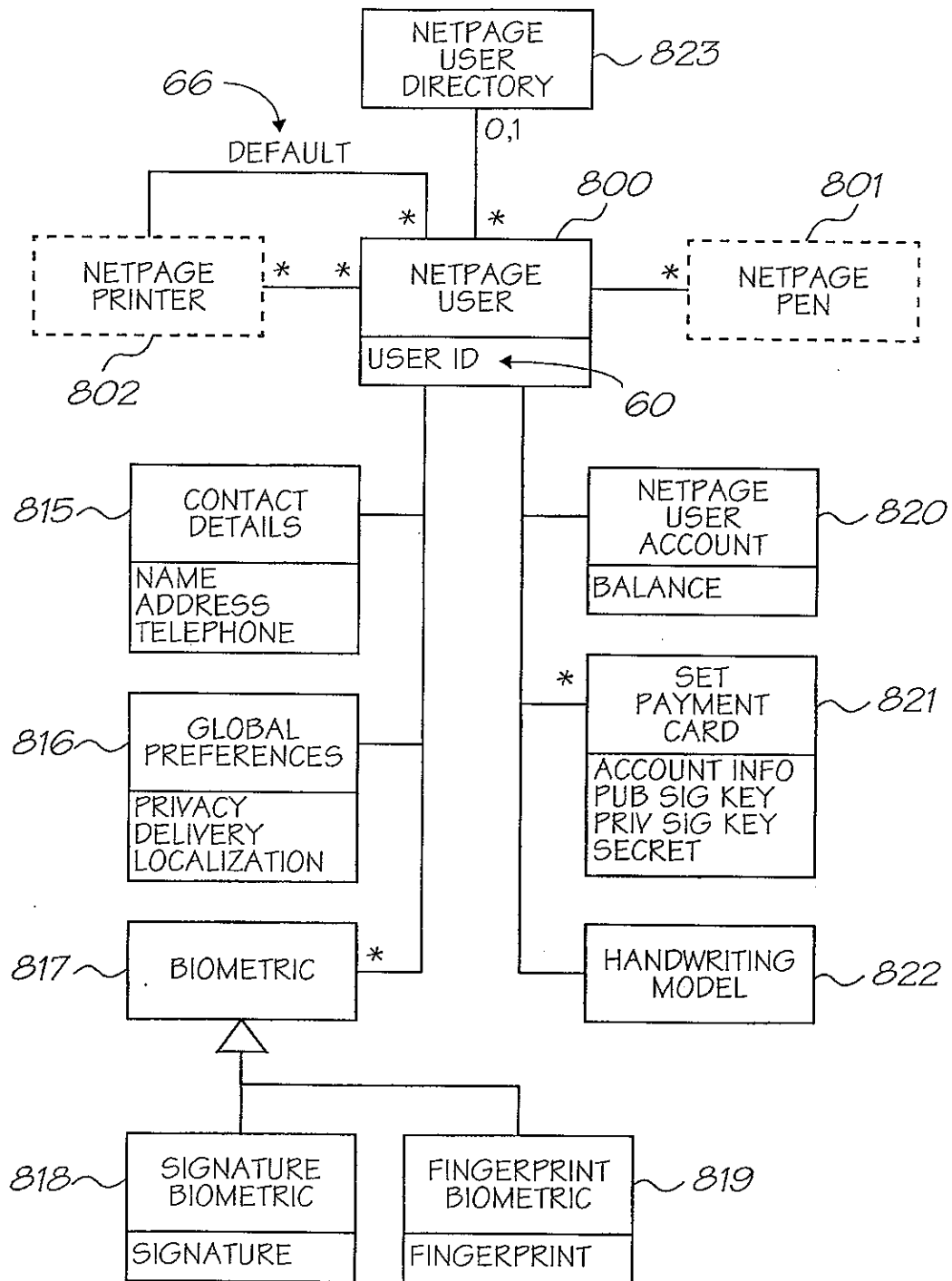


FIG. 21

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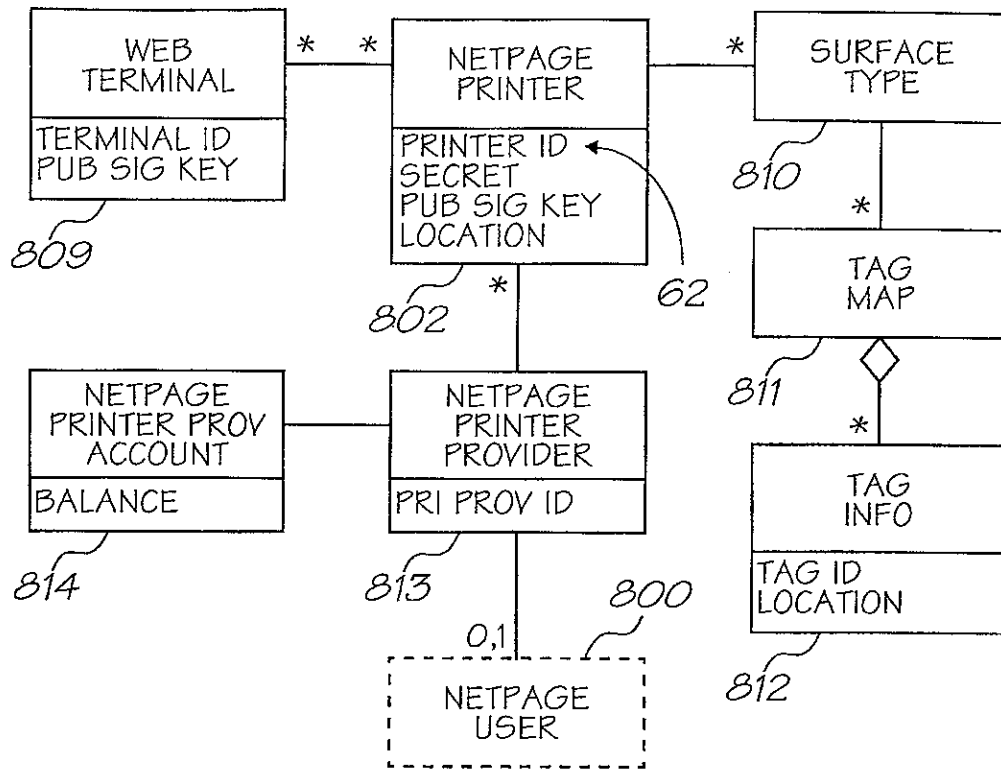


FIG. 22

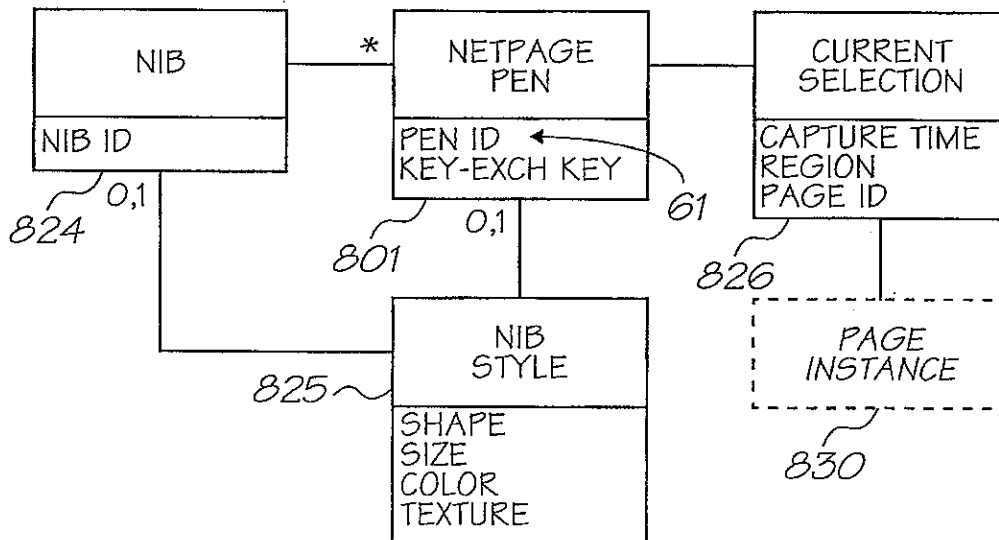


FIG. 23

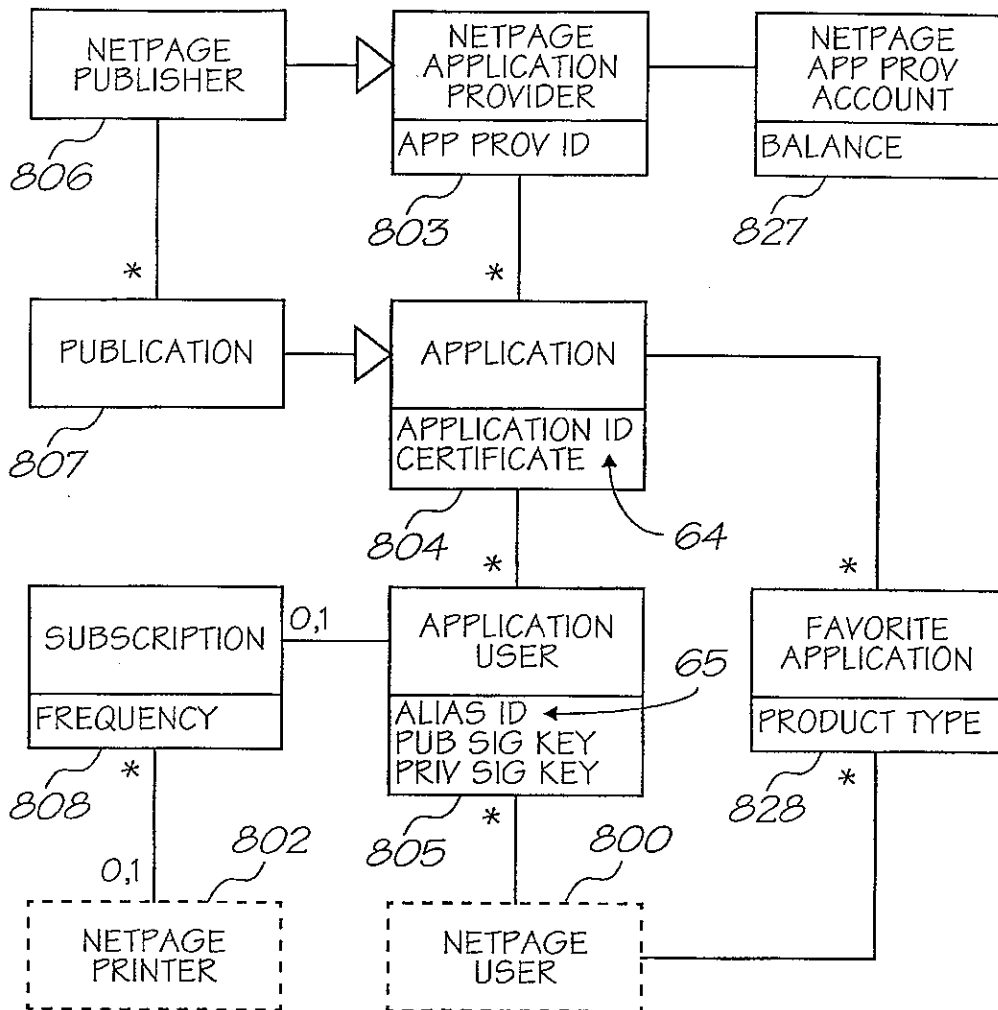


FIG. 24

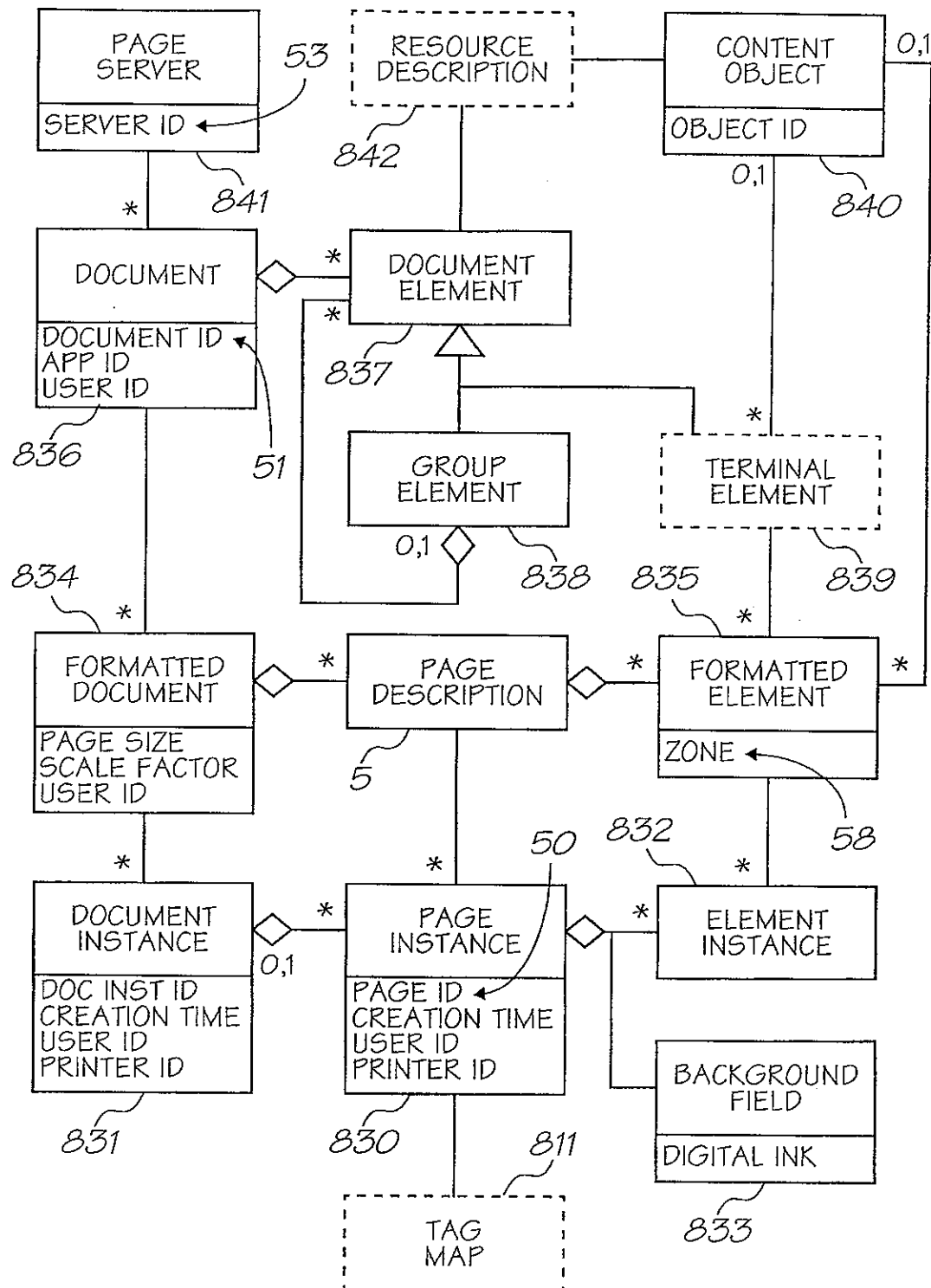


FIG. 25

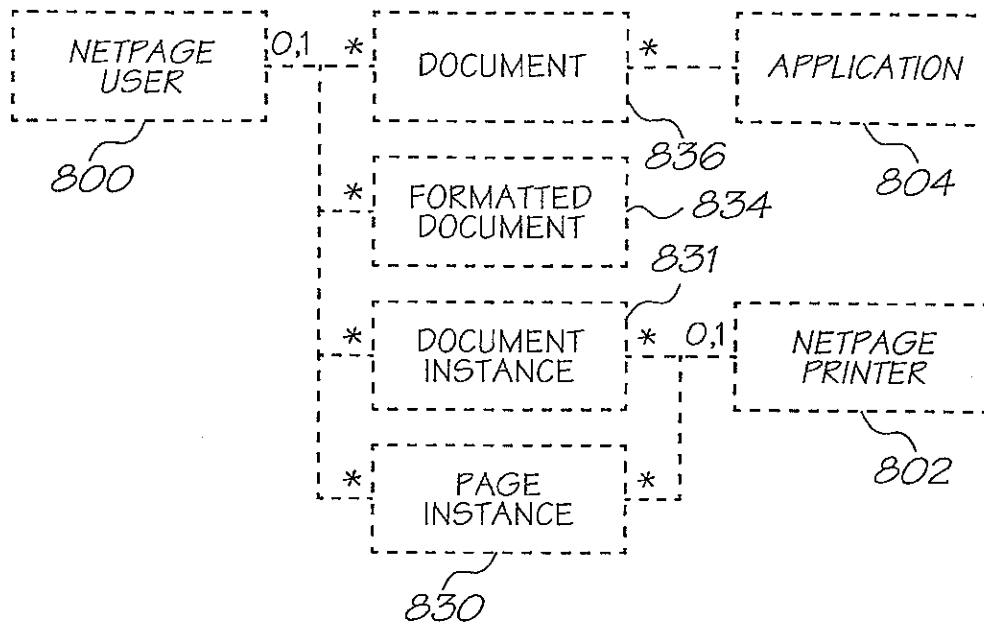


FIG. 26

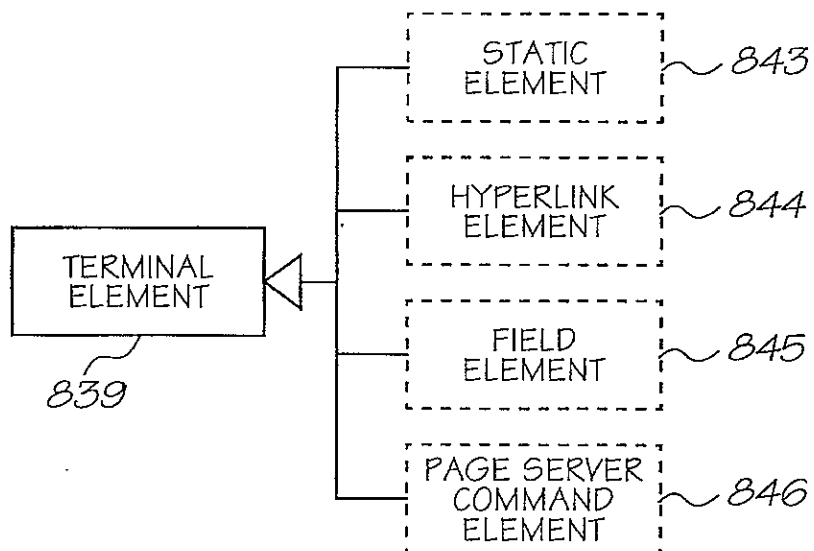


FIG. 27

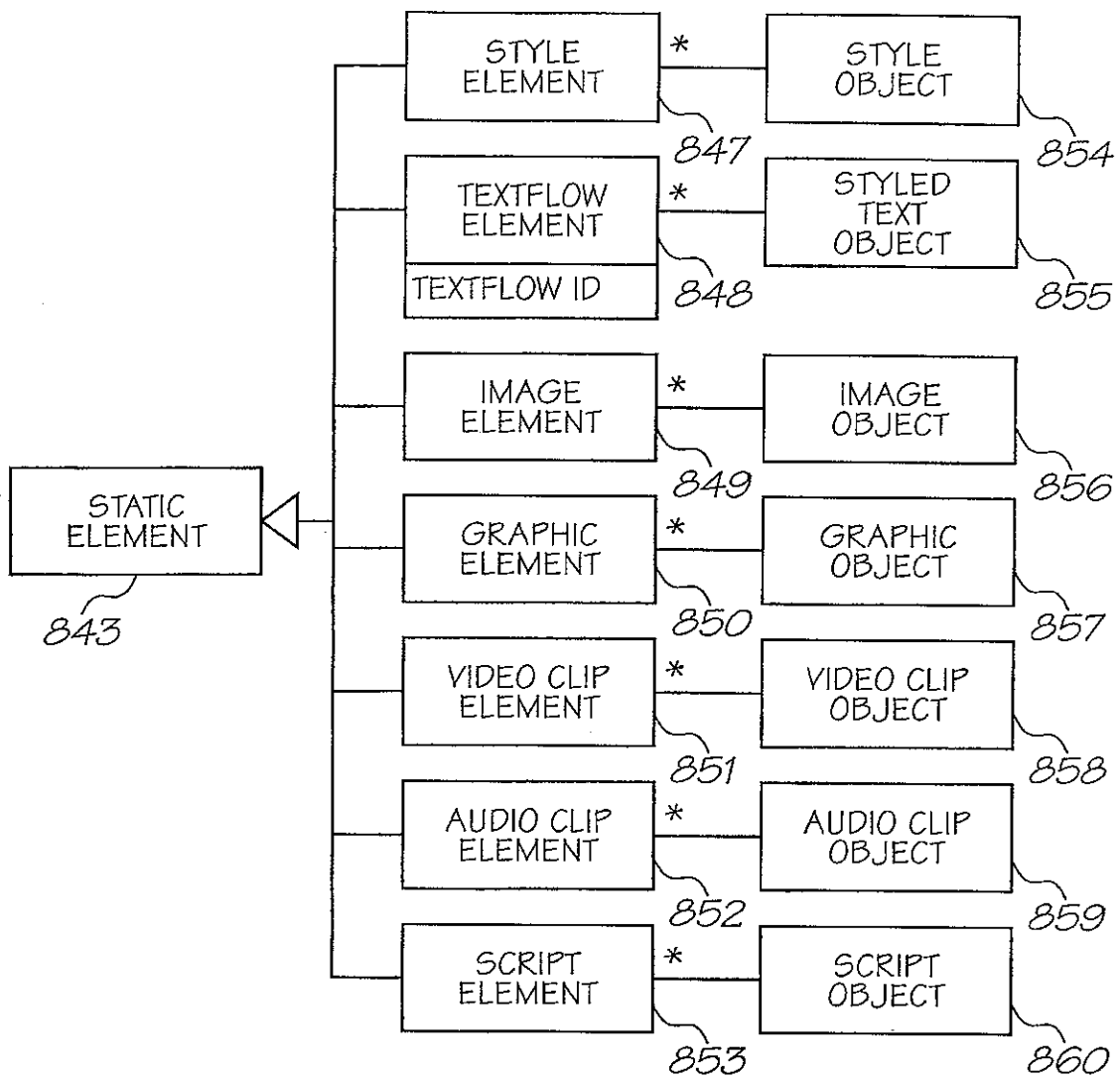


FIG. 28

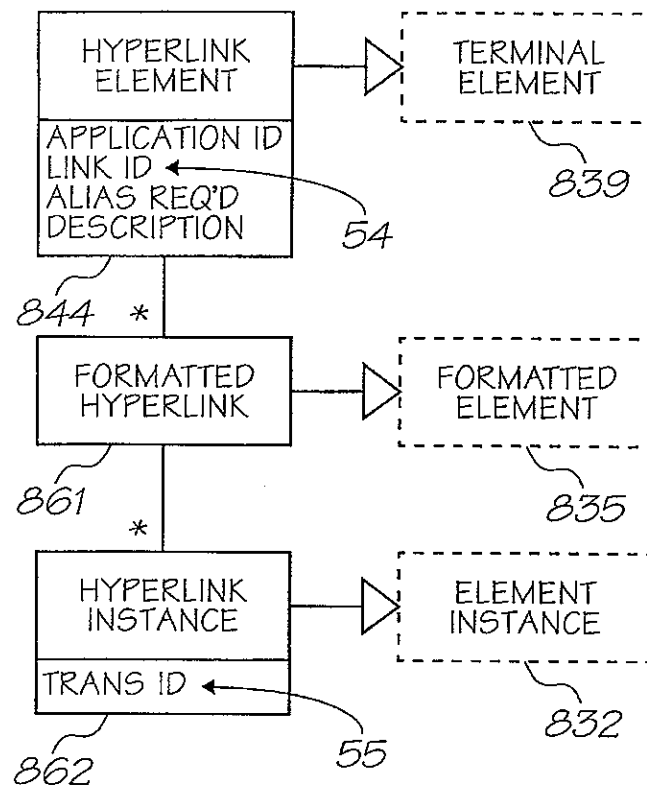


FIG. 29

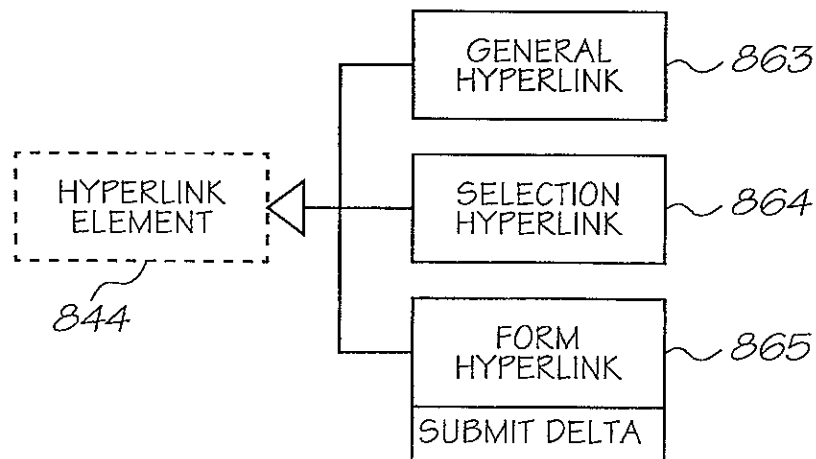


FIG. 30



FIG. 31

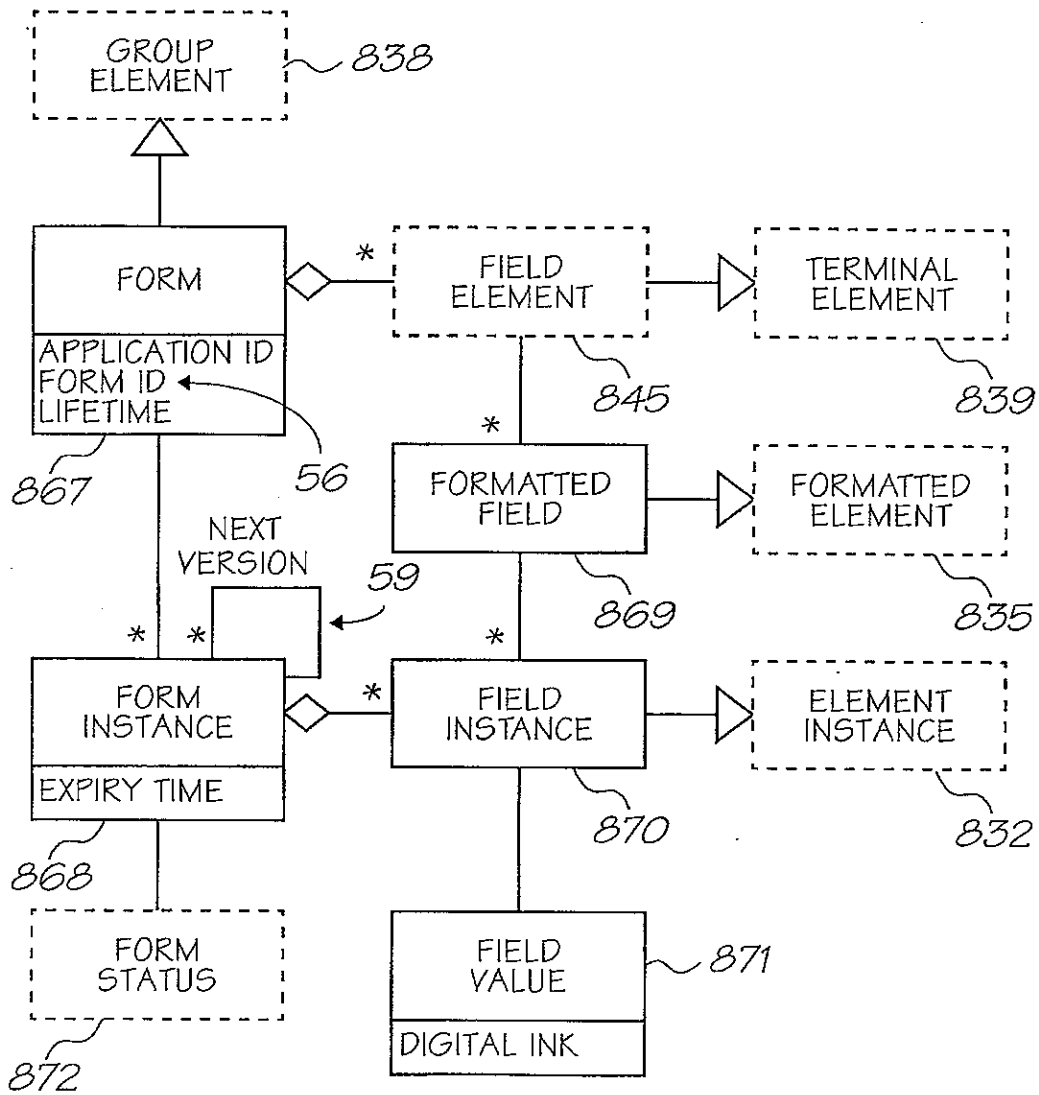


FIG. 32

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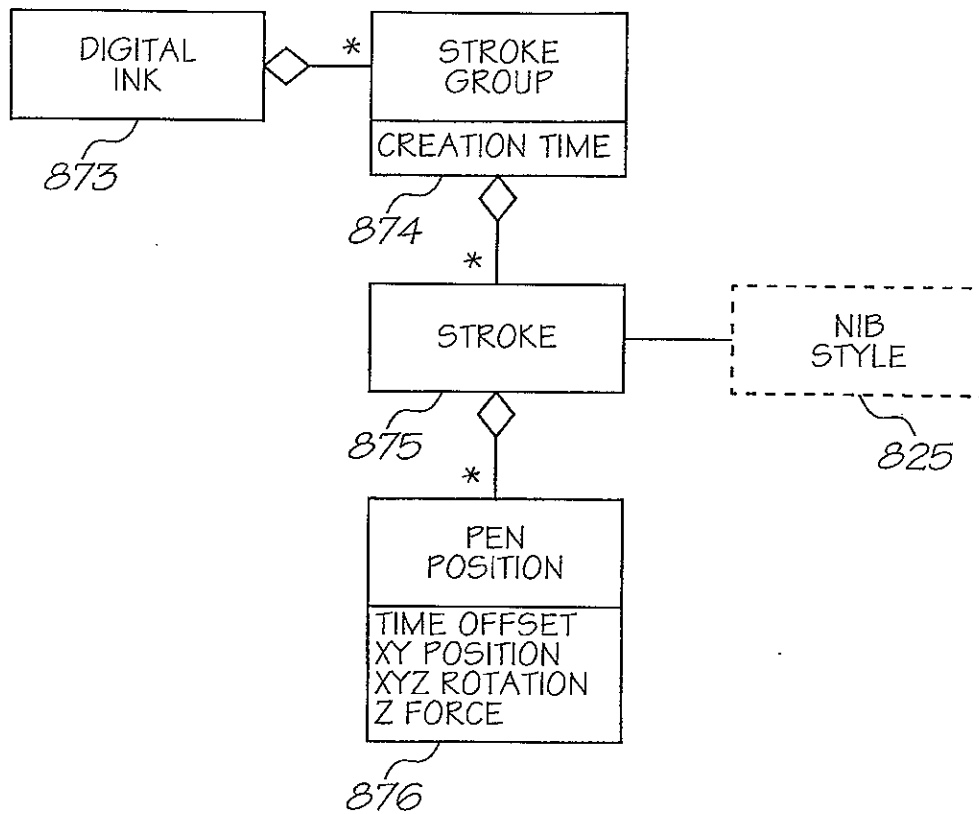


FIG. 33

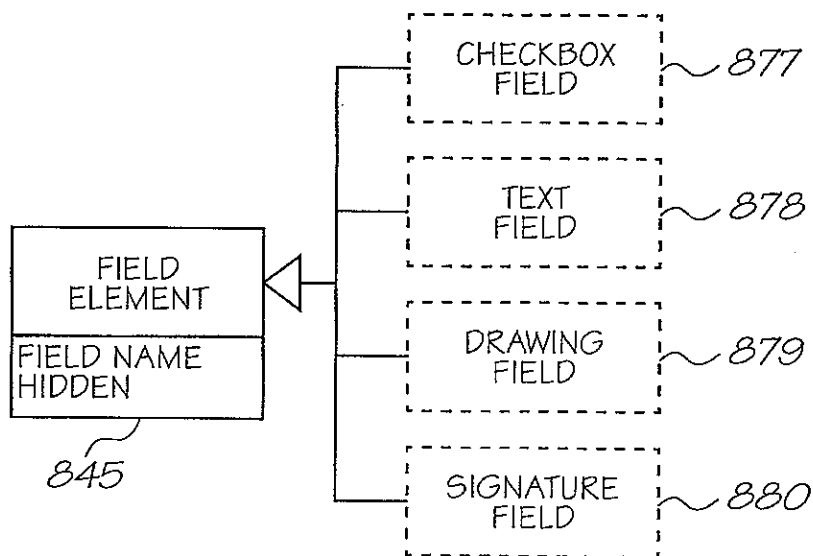


FIG. 34

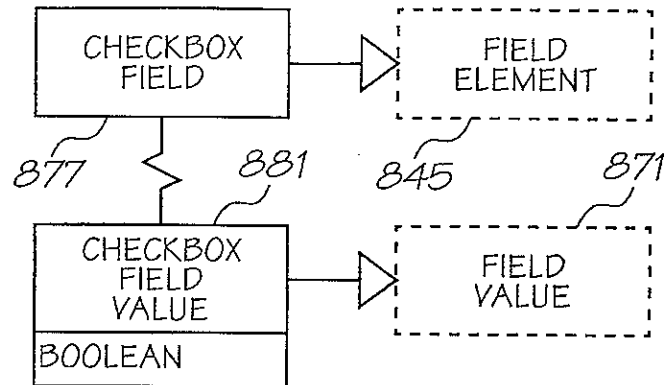


FIG. 35

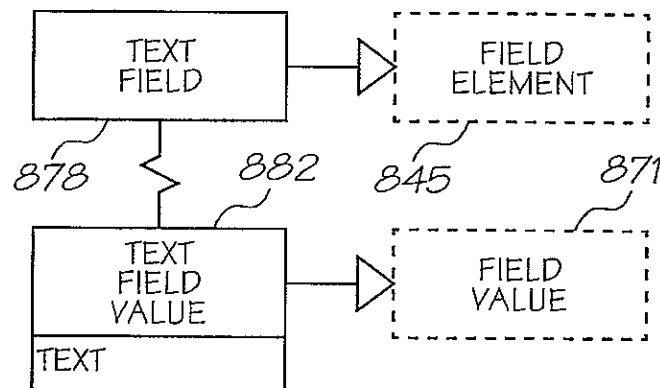


FIG. 36

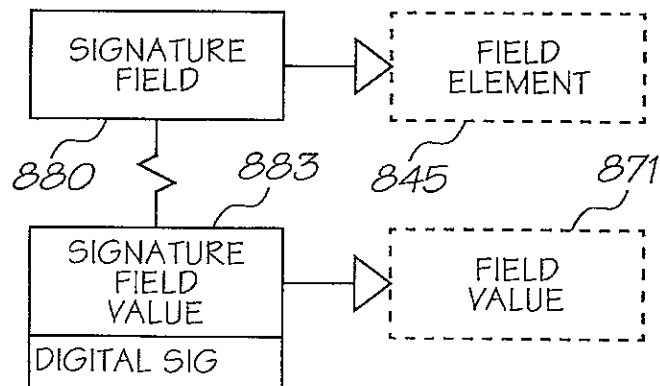


FIG. 37

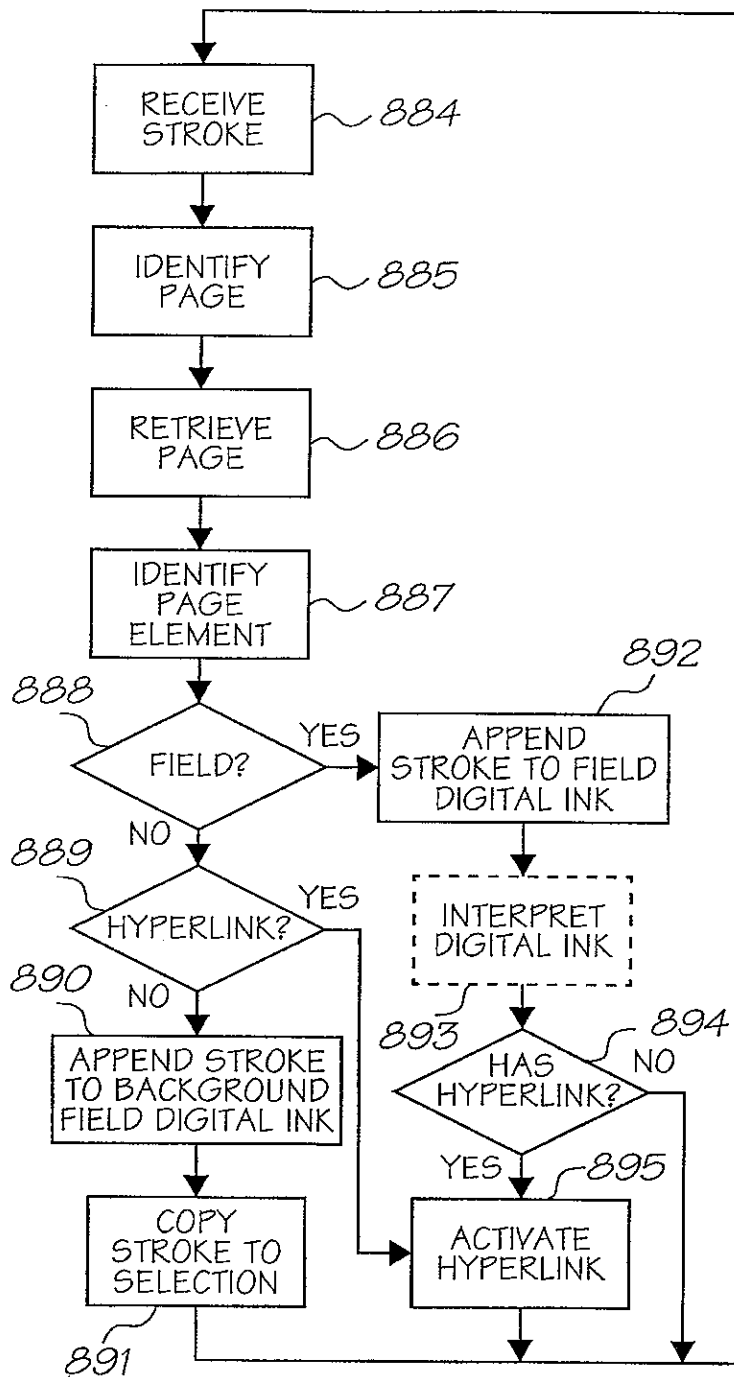


FIG. 38

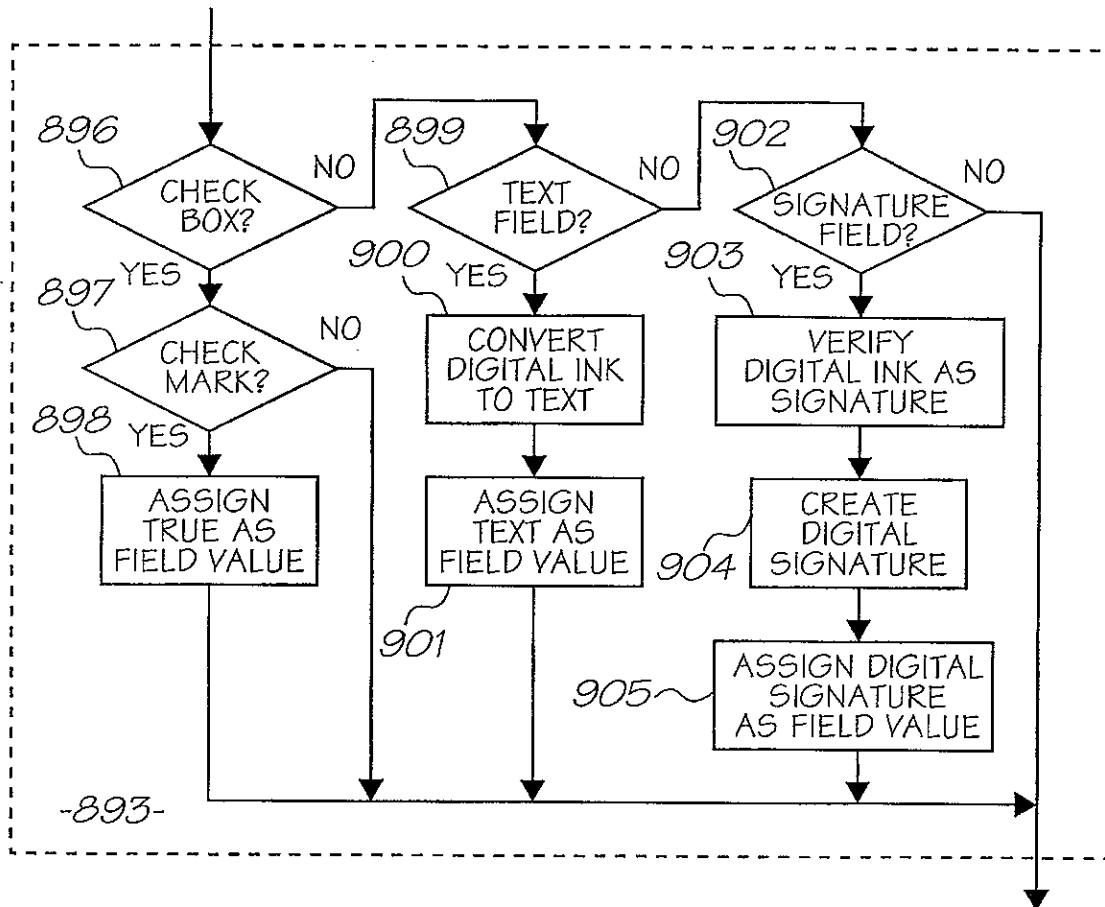


FIG. 38a

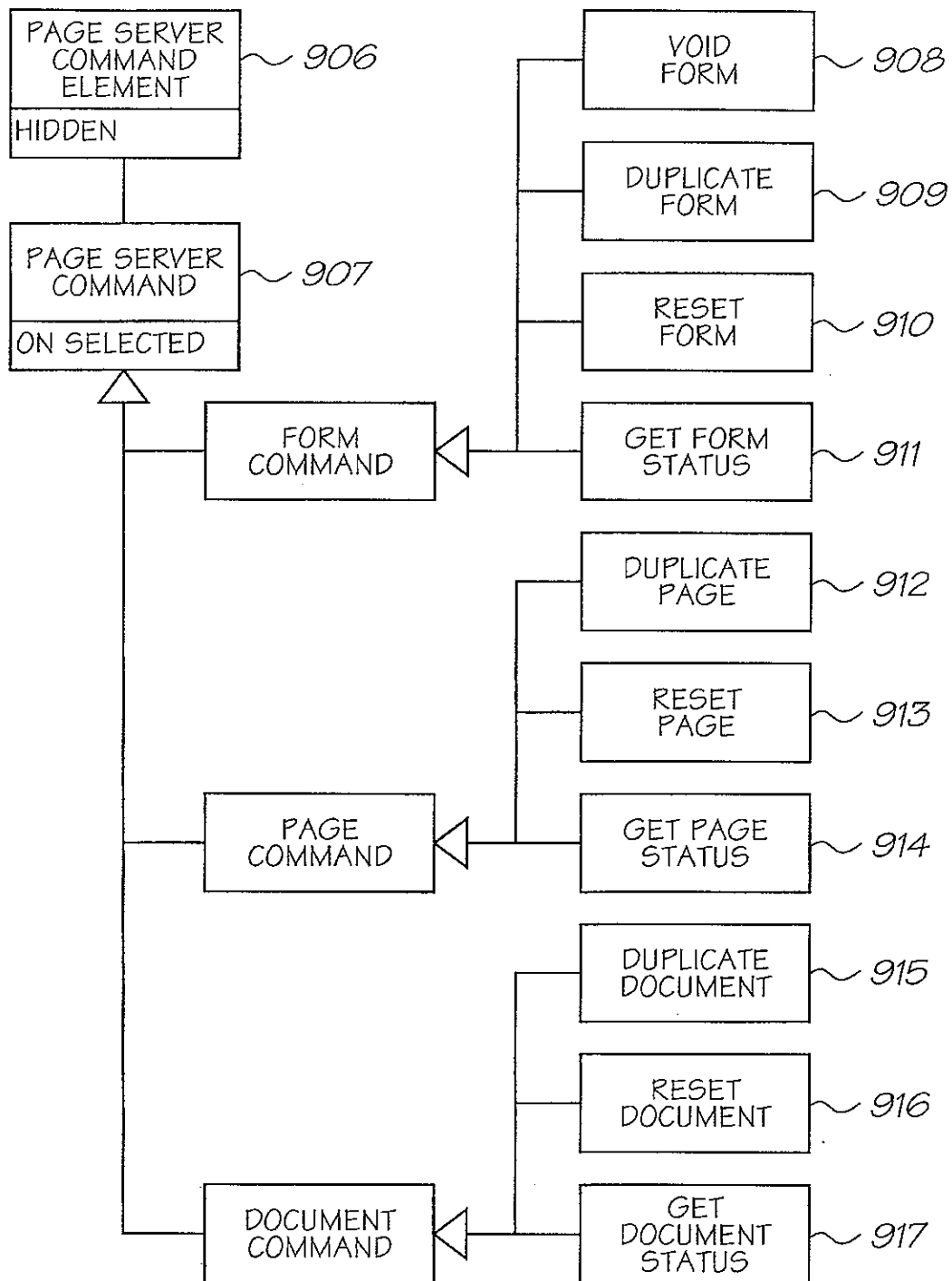


FIG. 39

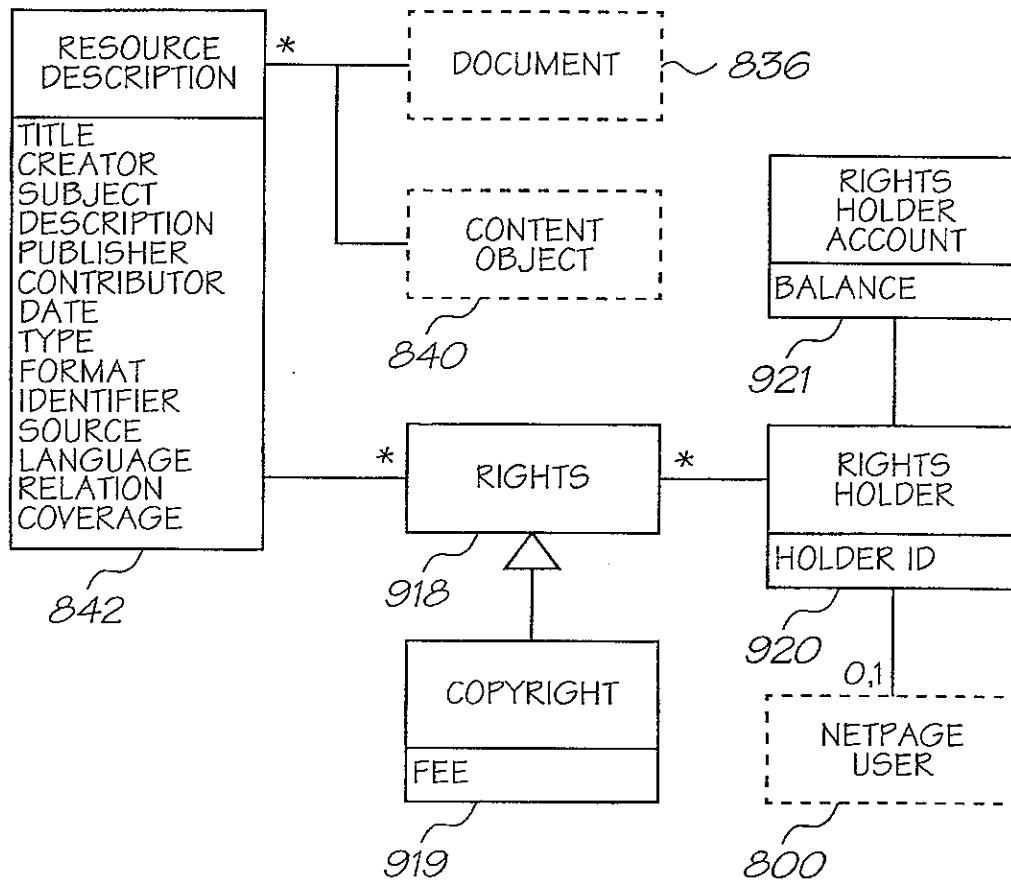


FIG. 40

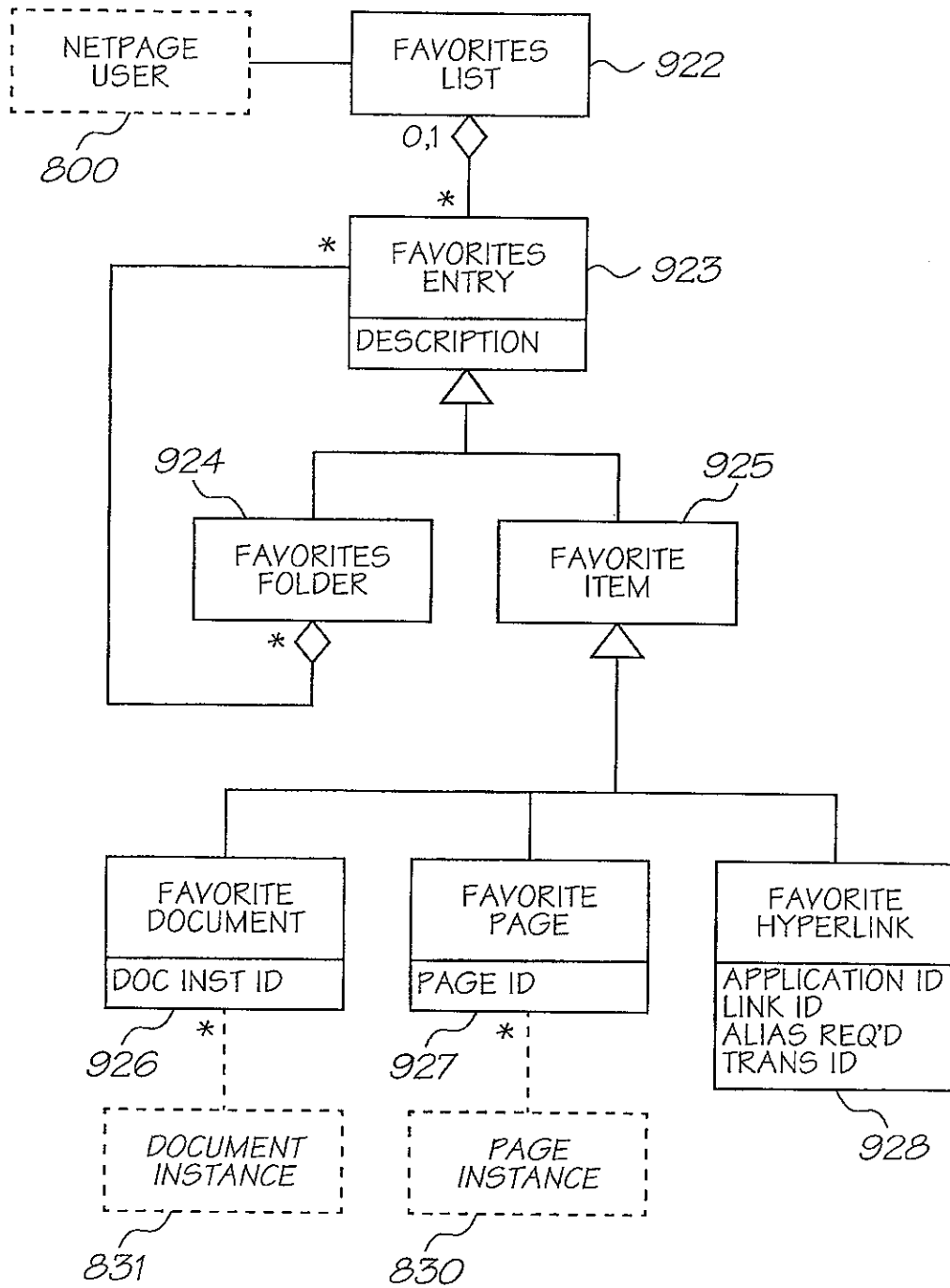


FIG. 41

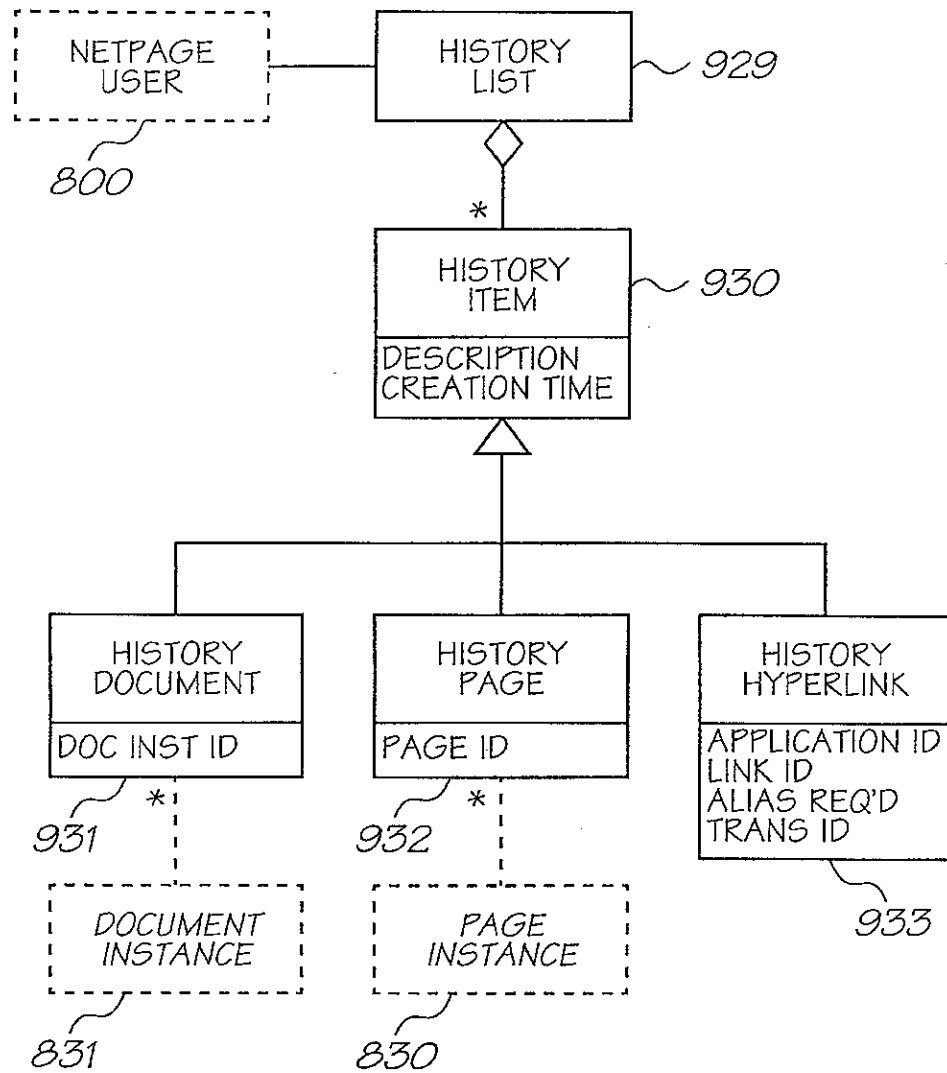


FIG. 42

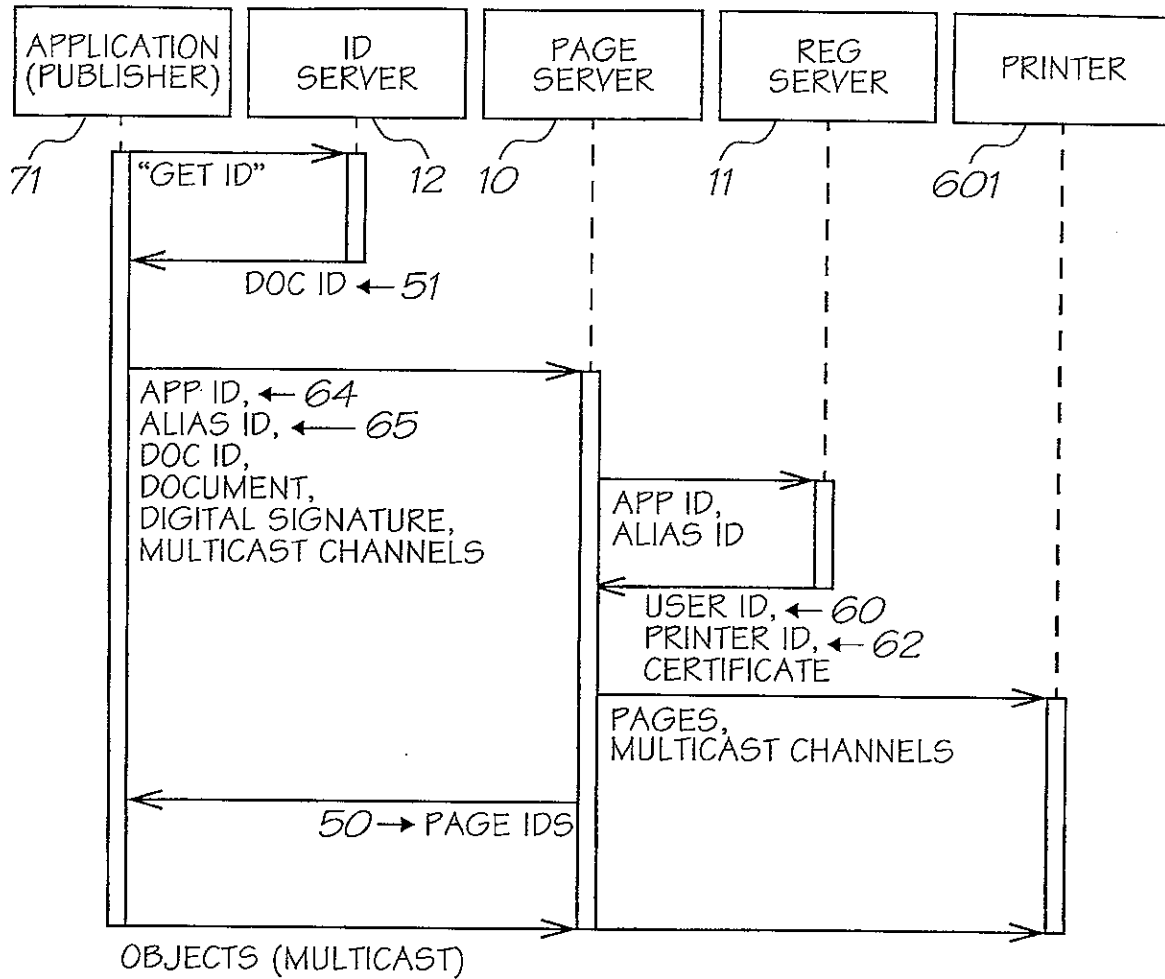


FIG. 43

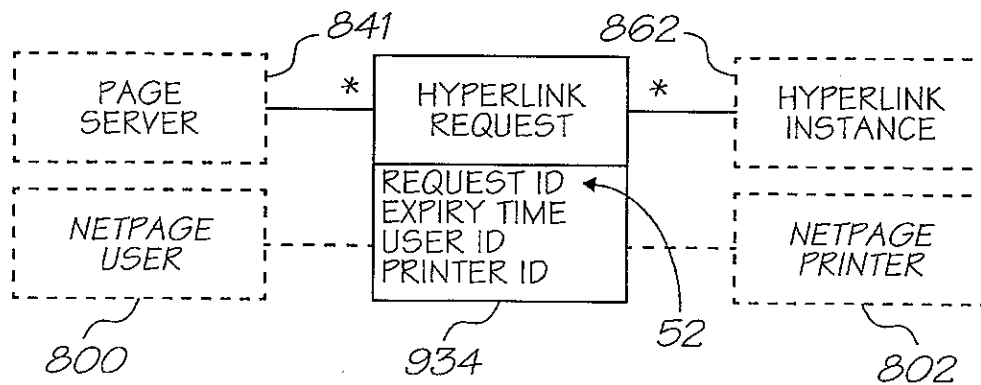


FIG. 44

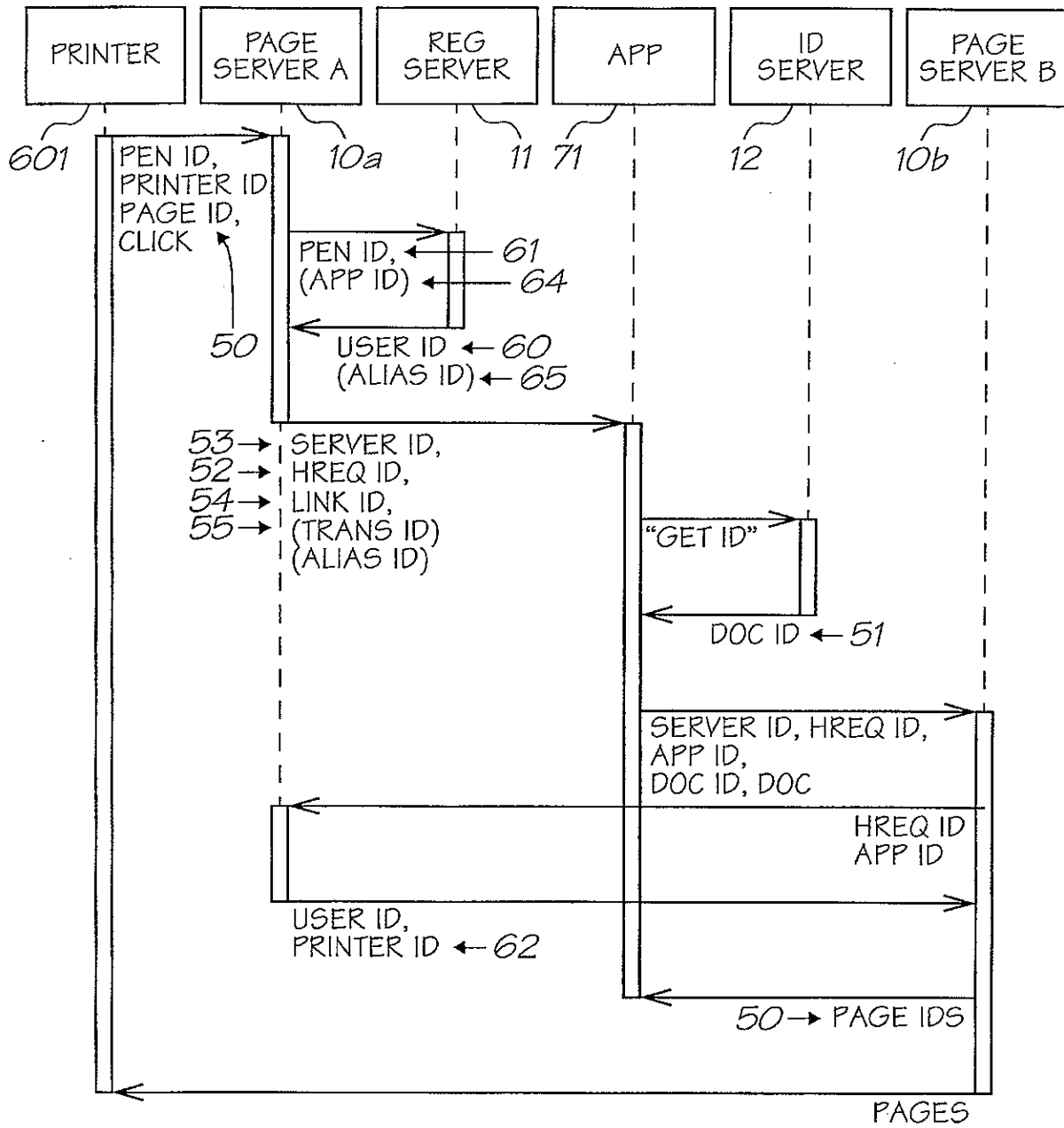


FIG. 45

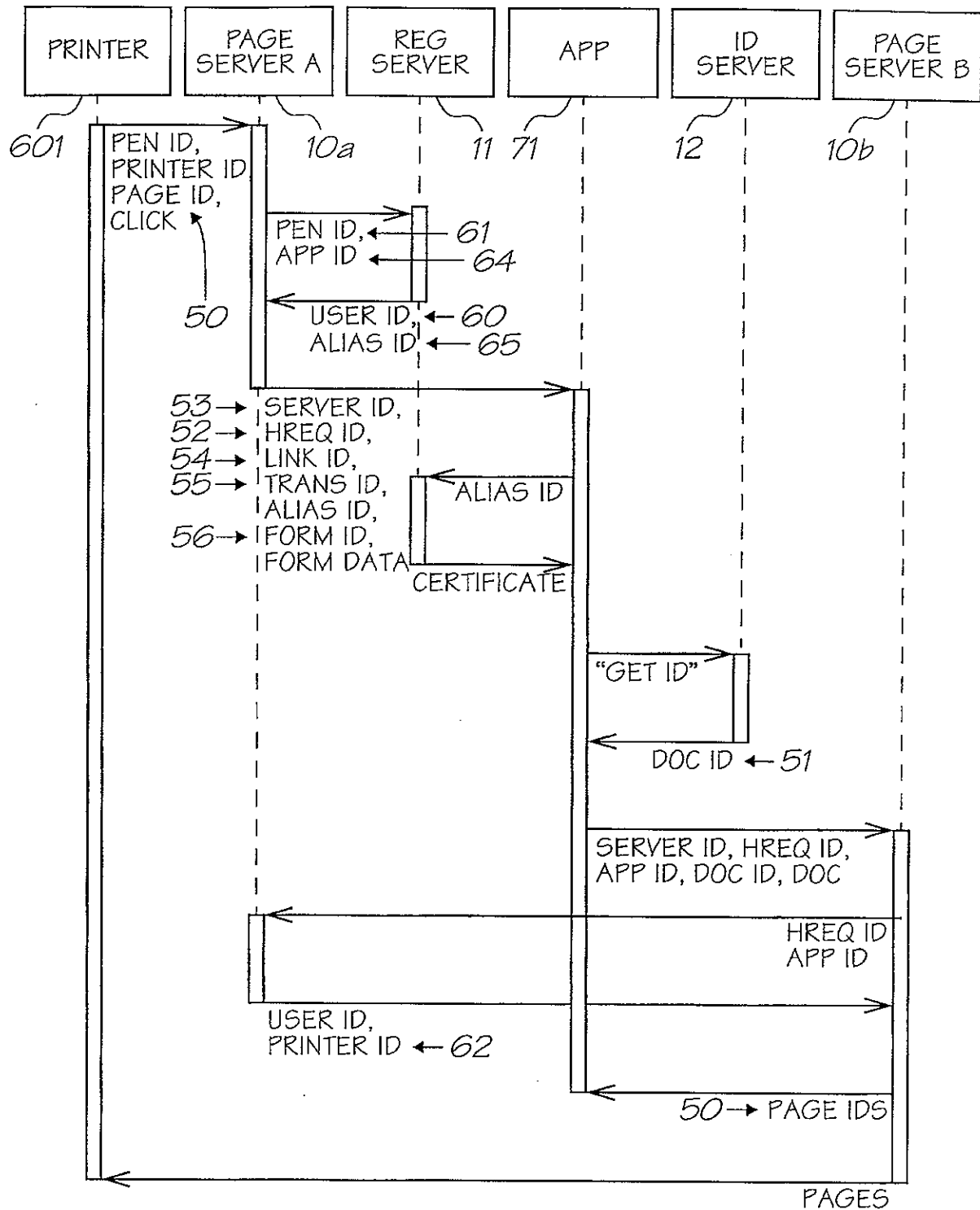


FIG. 46

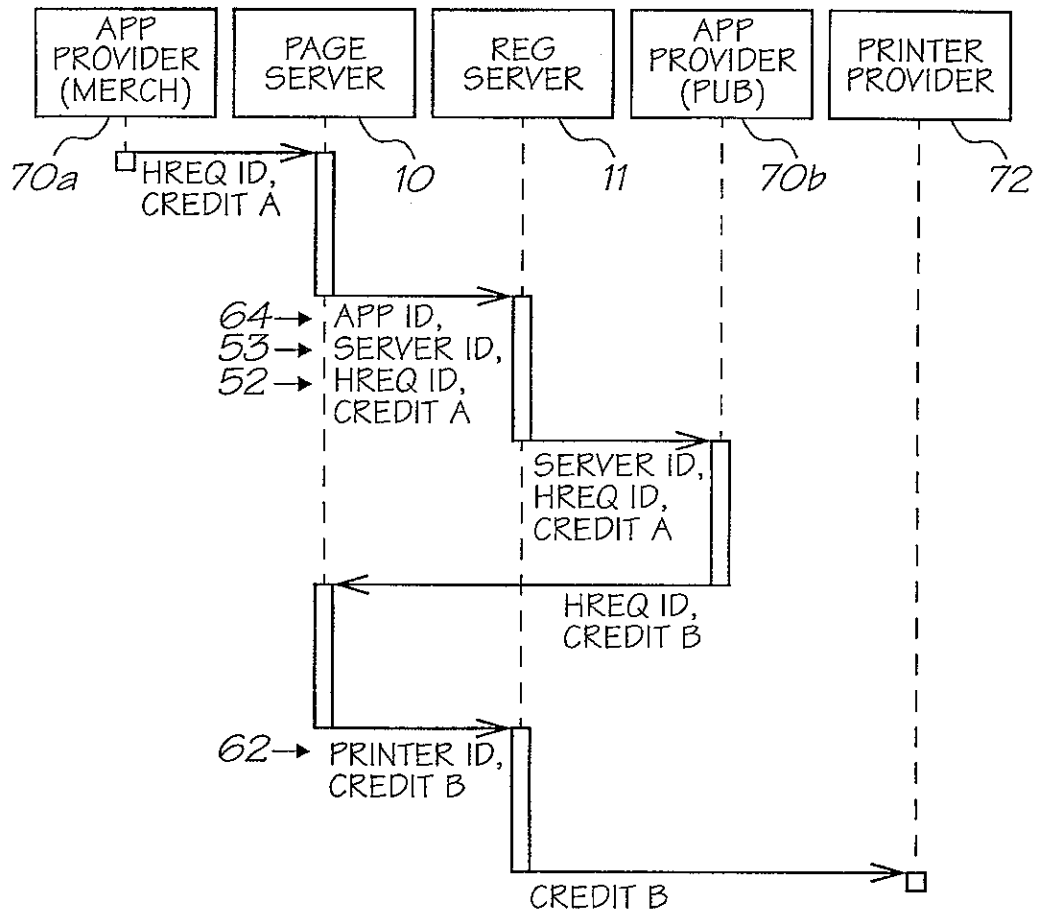


FIG. 47

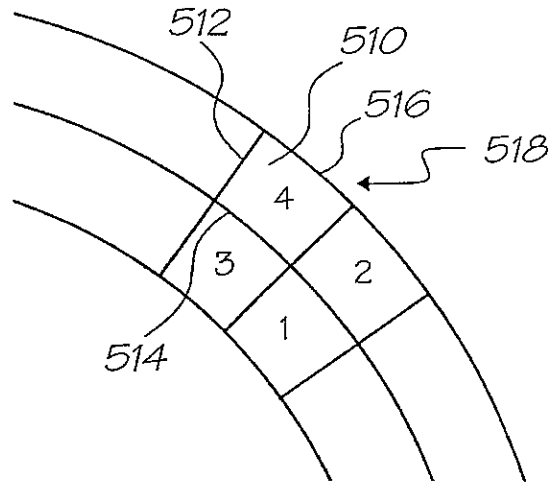


FIG. 48

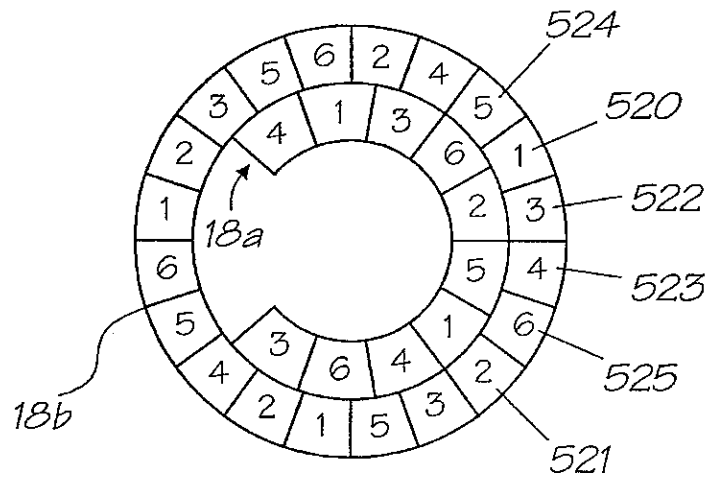


FIG. 49

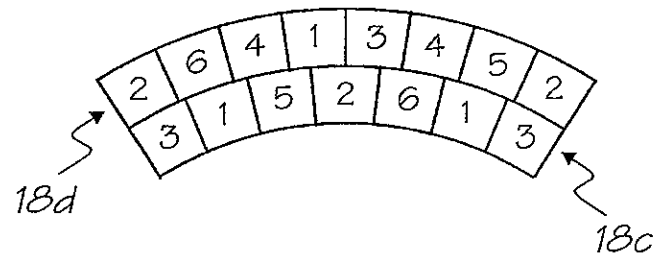


FIG. 50

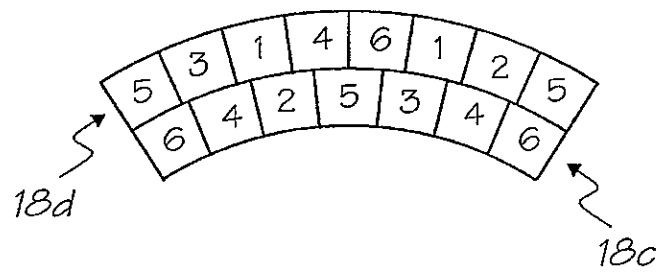


FIG. 51

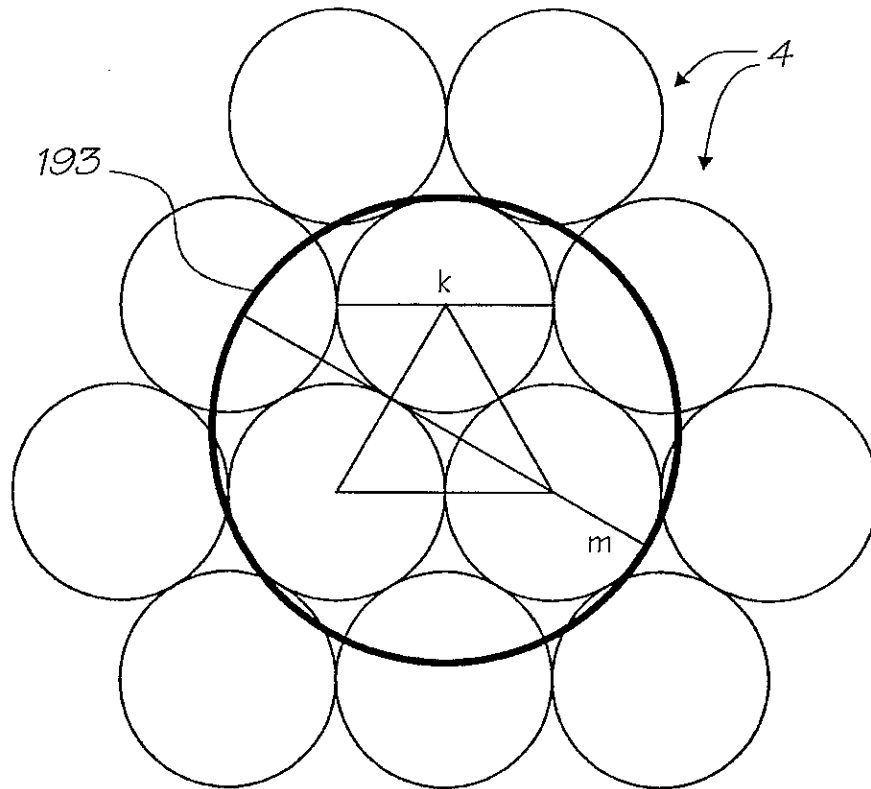


FIG. 52

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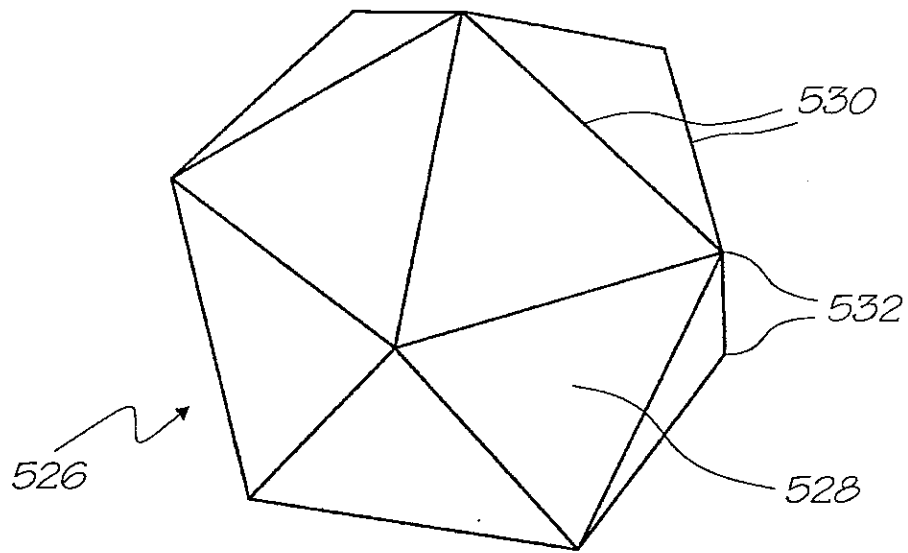


FIG. 53

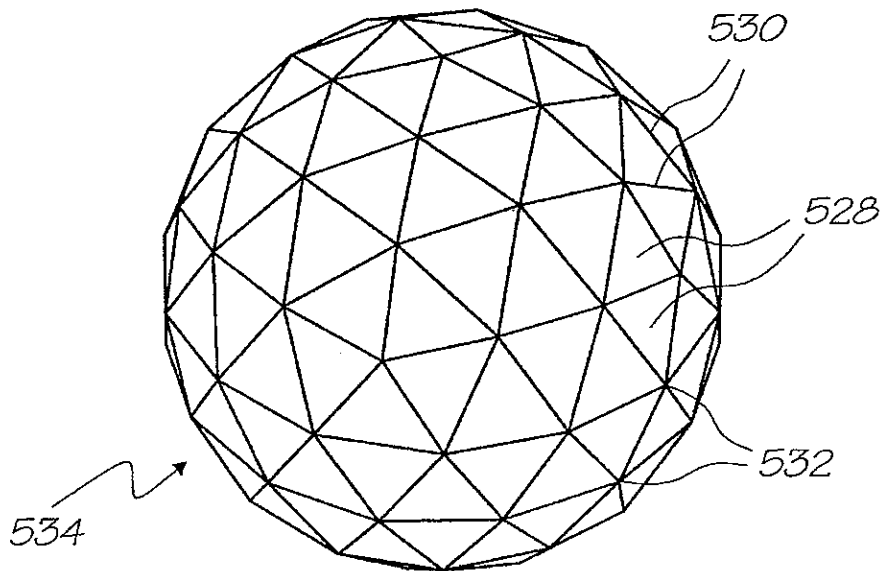


FIG. 54

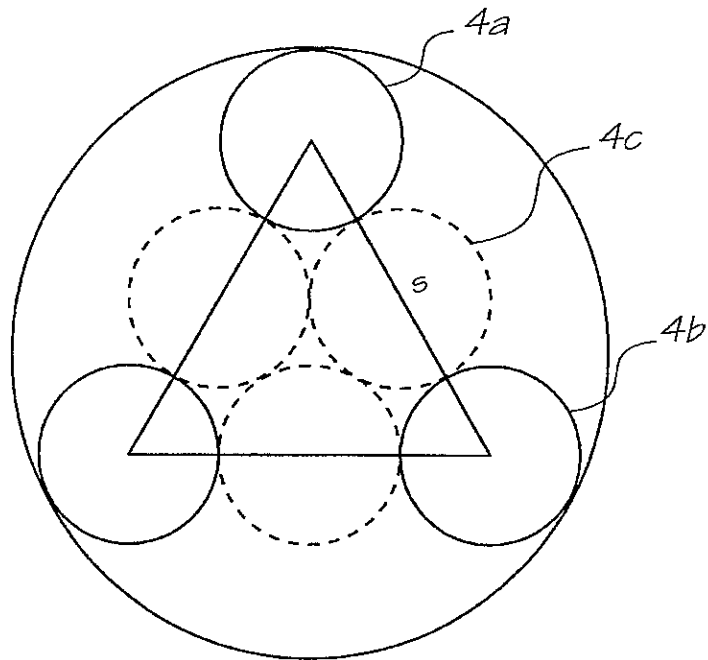


FIG. 55

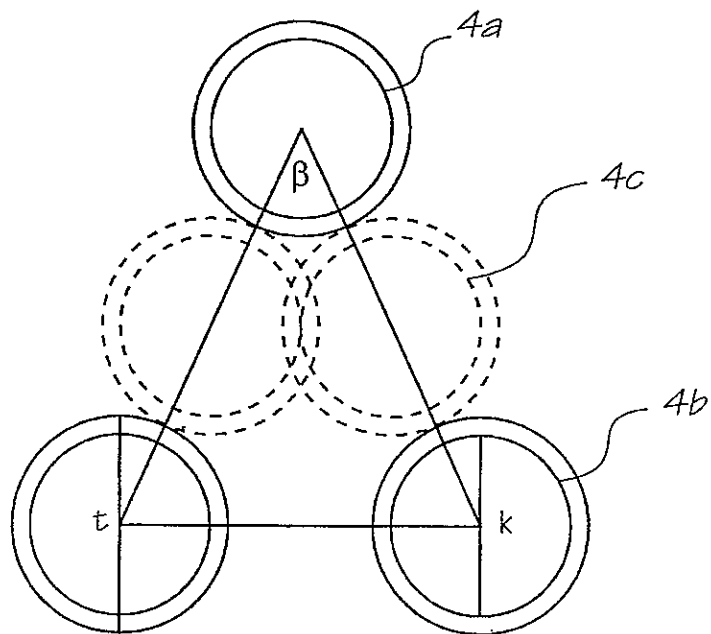


FIG. 56

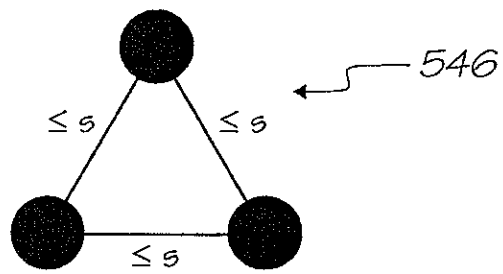


FIG. 57

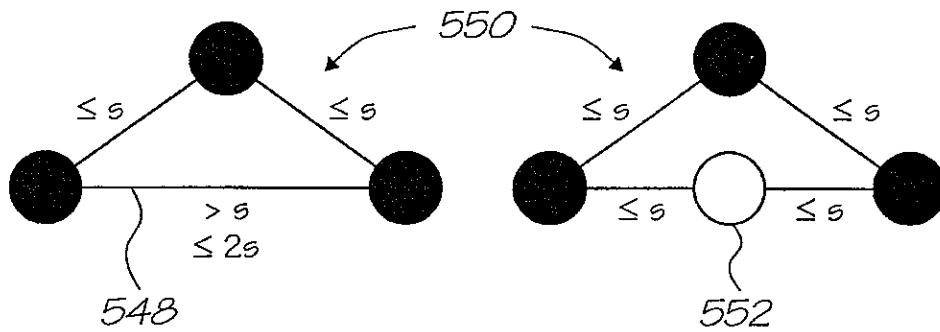


FIG. 58

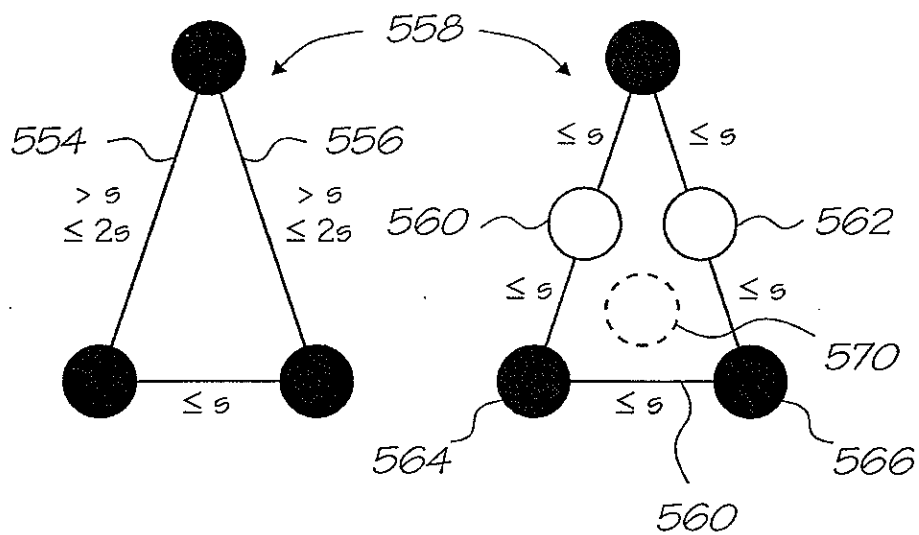


FIG. 59

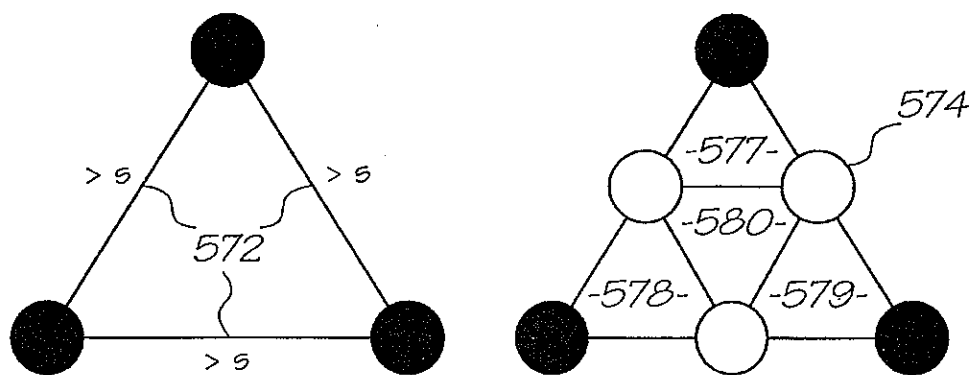


FIG. 60

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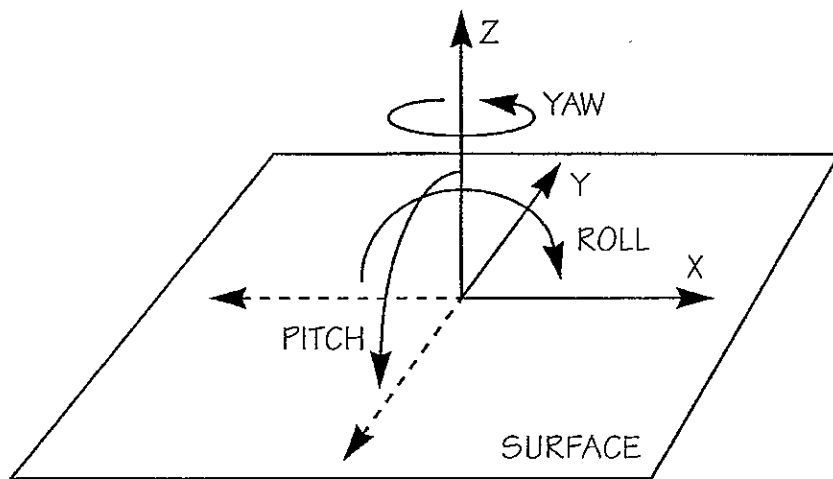


FIG. 61

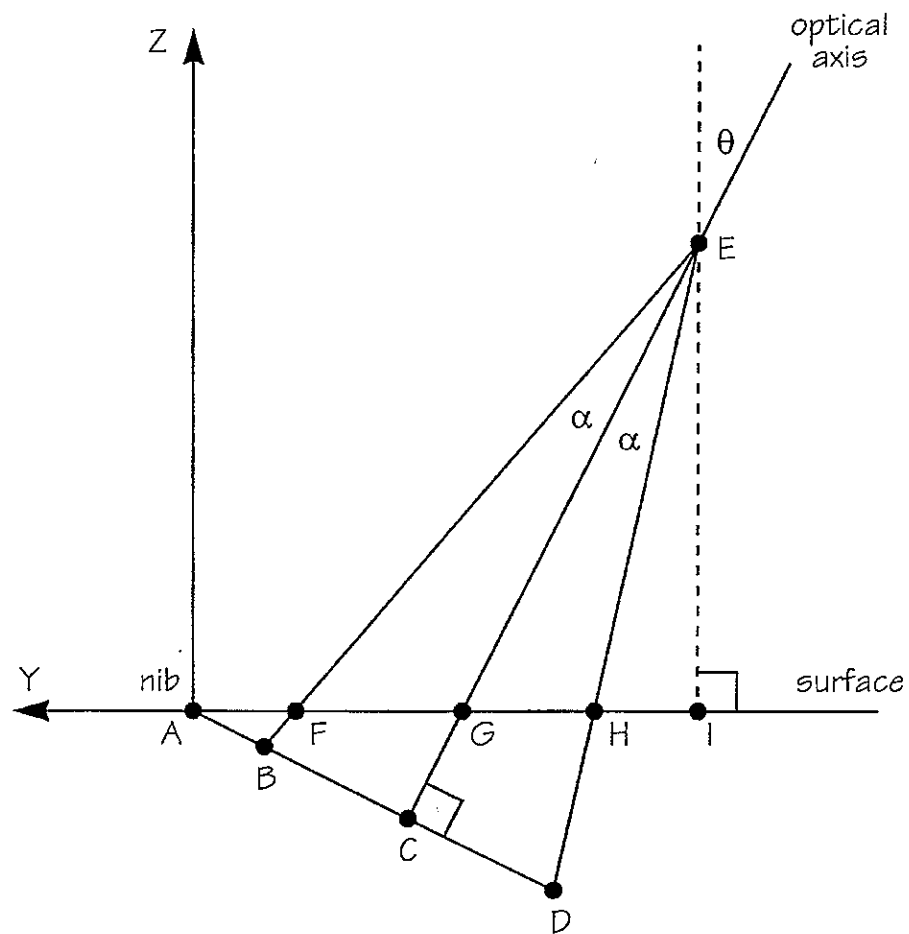


FIG. 62

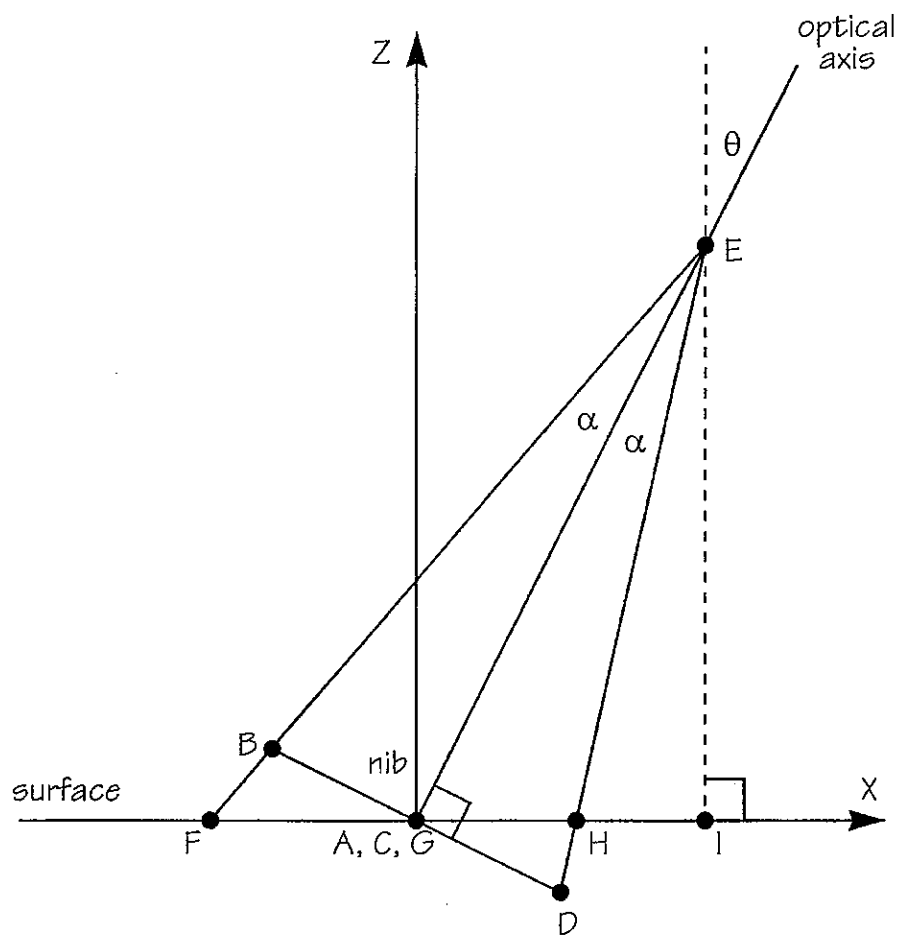


FIG. 63

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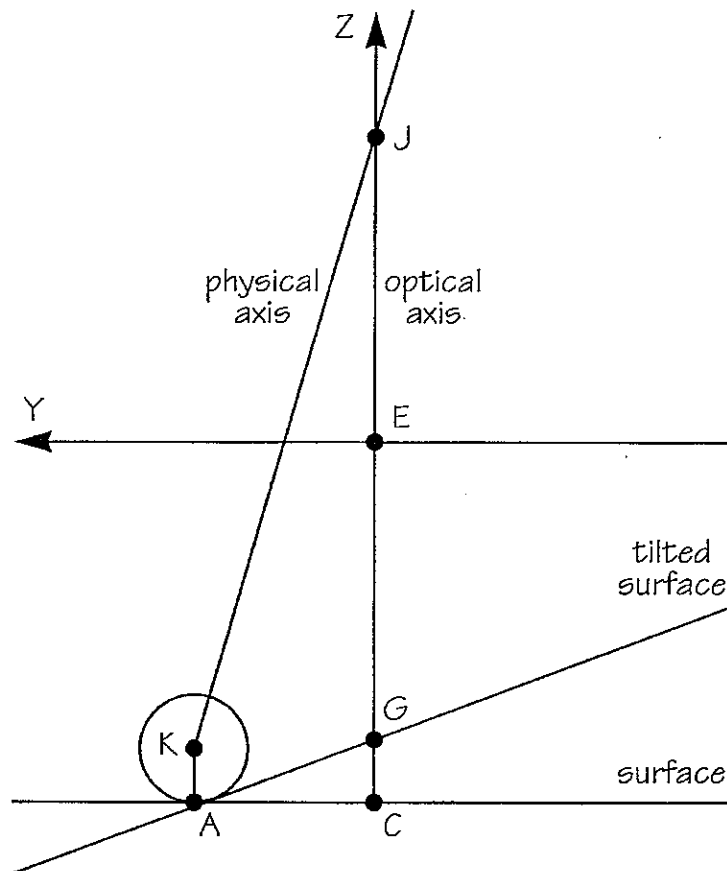


FIG. 64

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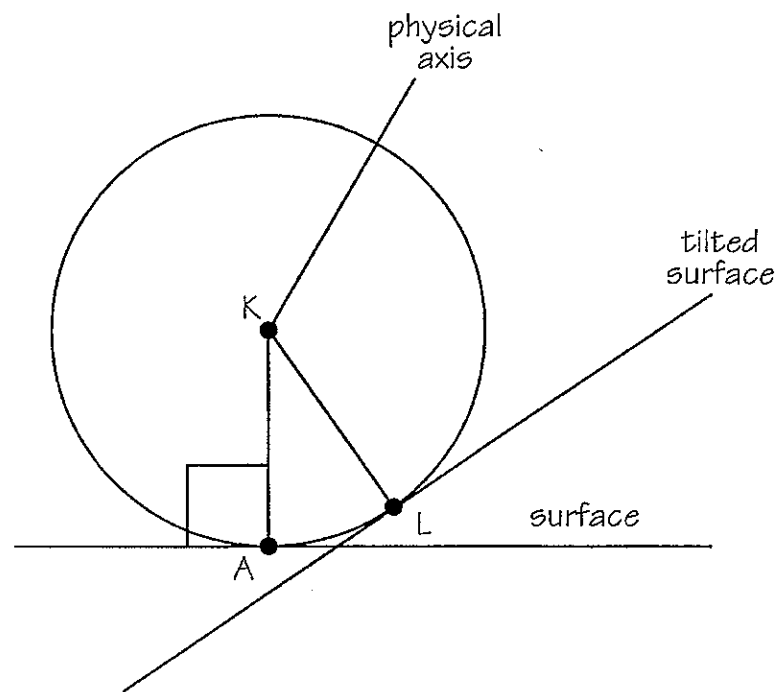


FIG. 65

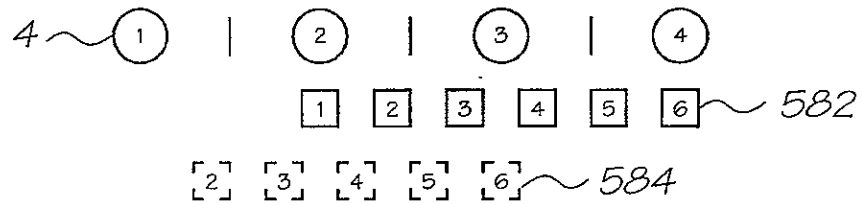


FIG. 66

| EQ<br>NUMBER | EQUATION                                                                                                    |
|--------------|-------------------------------------------------------------------------------------------------------------|
| 1            | $m = k\left(\frac{2}{\sqrt{3}} + 1\right)$                                                                  |
| 2            | $m = \frac{2s}{\sqrt{3}} + k$                                                                               |
| 3            | $u = k\left(\frac{2}{\sqrt{3}} - 1\right)$                                                                  |
| 4            | $m = \frac{7k}{3}$                                                                                          |
| 5            | $\theta = 2\arcsin\left(\frac{2}{\sqrt{10 + 2\sqrt{5}}}\right) \cong 63.4^\circ \cong 1.11 \text{ radians}$ |
| 6            | $n = 10v^2 + 2 = 10\left[\frac{\theta r}{K}\right]^2 + 2$                                                   |
| 7            | $r \leq \frac{K}{\theta} \left[ \sqrt{\frac{n-2}{10}} \right]$                                              |
| 8            | $s \geq 2k$                                                                                                 |
| 9            | $\beta = 2\arcsin \frac{k}{2t}$                                                                             |
| 10           | $s \geq 2t$                                                                                                 |

FIG. 67

| EQ<br>NUMBER | EQUATION                                                               |
|--------------|------------------------------------------------------------------------|
| 11           | $\sin \theta = \cos \phi \cos \psi$                                    |
| 12           | $2D \tan \alpha$                                                       |
| 13           | $S = T + D \tan \alpha$                                                |
| 14           | $d = D - S \tan \theta$                                                |
| 15           | $d \cos \theta (\tan(\theta + \alpha) - \tan(\theta - \alpha))$        |
| 16           | $d \cos \theta (\tan(\theta + \alpha) - \tan(\theta - \alpha)) \geq m$ |
| 17           | $\frac{d \cos \theta}{\cos( \theta  + \alpha)}$                        |
| 18           | $\cos( \theta  + \alpha)$                                              |
| 19           | $\omega = \frac{fd \cos \theta}{\cos^2( \theta  + \alpha)}$            |
| 20           | $\omega_0 = \frac{fD}{\cos^2 \alpha}$                                  |

FIG. 68

| EQ<br>NUMBER | EQUATION                                                                                 |
|--------------|------------------------------------------------------------------------------------------|
| 21           | $q = 2\alpha'n\omega\cos^2( \theta'  + \alpha')$                                         |
| 22           | $q = \frac{2\alpha'nfd\cos\theta\cos^2( \theta'  + \alpha')}{\cos^2( \theta  + \alpha)}$ |
| 23           | $q = \frac{2\alpha'nfd\cos\theta\cos^2\alpha}{\cos^2( \theta  + \alpha)}$                |
| 24           | $q = \frac{2\alpha'nfd}{\cos\theta(1 - \tan \theta \tan\alpha)^2}$                       |
| 25           | $q_0 = 2\alpha'nfd$                                                                      |
| 26           | $q = 2\alpha'nfd\cos\theta$                                                              |

FIG. 69

| EQ<br>NUMBER | EQUATION                                                                                          |
|--------------|---------------------------------------------------------------------------------------------------|
| 27           | $P_{sensed} = \begin{pmatrix} 0 \\ 0 \\ -d \end{pmatrix}$                                         |
| 28           | $P_{pivot} = \begin{pmatrix} 0 \\ S \\ R-D \end{pmatrix}$                                         |
| 29           | $\vec{V}_{pivot-sensed} = P_{pivot} - P_{sensed} = \begin{bmatrix} 0 \\ S \\ R-D+d \end{bmatrix}$ |
| 30           | $\vec{N} = M \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$                                           |
| 31           | $\vec{V}_{contact-pivot} = R \frac{\vec{N}}{ \vec{N} }$                                           |
| 32           | $\vec{V}_{contact-sensed} = \vec{V}_{contact-pivot} - \vec{V}_{pivot-sensed}$                     |
| 33           | $\vec{V}_{contact-tag} = \vec{V}_{sensed-tag} + M^{-1} \vec{V}_{contact-sensed}$                  |
| 34           | $P_{contact} = P_{tag} + \vec{V}_{contact-tag}$                                                   |

FIG. 70

| EQ<br>NUMBER | EQUATION                                    |
|--------------|---------------------------------------------|
| 35           | $\gamma_{pen} = -\gamma_{tag}$              |
| 36           | $\phi_{pen} = -\phi_{tag} - \phi_{sensor}$  |
| 37           | $\psi_{pen} = -\psi_{tag}$                  |
| 38           | $\lambda_S < \frac{\lambda_T}{2}$           |
| 39           | $P_{i+1} - P_i = \lambda_S$                 |
| 40           | $ \lambda_T - (P_{i+1} - P_i)  = \lambda_S$ |
| 41           | $\lambda_S = \frac{\lambda_T}{2}$           |

FIG. 71

| EQ<br>NUM | EQUATION                                                                                                                      |
|-----------|-------------------------------------------------------------------------------------------------------------------------------|
| 42        | $M_1 = T_{xy} = \begin{bmatrix} 1 & 0 & 0 & A \\ 0 & 1 & 0 & B \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$               |
| 43        | $R_z = \begin{bmatrix} C & -D & 0 & 0 \\ D & C & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$                       |
| 44        | $M_2 = R_z M_1 = \begin{bmatrix} C & -D & 0 & AC - BD \\ D & C & 0 & AD + BC \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ |

FIG. 72

| EQ<br>NUM | EQUATION                                                                                                              |  |  |  |
|-----------|-----------------------------------------------------------------------------------------------------------------------|--|--|--|
| 45        | $R_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & E & -F & 0 \\ 0 & F & E & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$               |  |  |  |
| 46        | $M_3 = R_x M_2 = \begin{bmatrix} C & -D & AC-BD \\ DE & CE & ADE+BCE \\ DF & CF & ADF+BCF \\ 0 & 0 & 1 \end{bmatrix}$ |  |  |  |
| 47        | $R_y = \begin{bmatrix} G & 0 & H & 0 \\ 0 & 1 & 0 & 0 \\ -H & 0 & G & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$               |  |  |  |

FIG. 73

| EQ<br>NUM | EQUATION                                                                                                                                                              |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 48        | $M_4 = R_y M_3 = \begin{bmatrix} CG + DFH & CFH - DG & EH & GK + HL \\ DE & CE & -F & ADE + BCE \\ DFG - CH & DH + CFG & EG & GL - HK \\ 0 & 0 & 0 & 1 \end{bmatrix}$ |
| 49        | $K = AC - BD$                                                                                                                                                         |
| 50        | $L = ADF + BCF$                                                                                                                                                       |
| 51        | $T_z = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & I \\ 0 & 0 & 0 & 1 \end{bmatrix}$                                                                |

FIG. 74

| EQ<br>NUM | EQUATION                                                                                                                                                                                |  |  |  |  |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| 52        | $M_5 = T_z M_4 = \begin{bmatrix} CG + DFH & CFH - DG & EH & GK + HL \\ DE & CE & -F & ADE + BCE \\ DFG - CH & DH + CFG & EG & GL - HK + I \\ 0 & 0 & 0 & 1 \end{bmatrix}$               |  |  |  |  |
| 53        | $M_p = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & J & 1 \end{bmatrix}$                                                                                  |  |  |  |  |
| 54        | $M_6 = M_p M_5 = \begin{bmatrix} CG + DFH & CFH - DG & EH & GK + HL \\ DE & CE & -F & ADE + BCE \\ 0 & 0 & 0 & 0 \\ J(DFG - CH) & J(DH + CFG) & EGJ & J(GL - HK + I) + 1 \end{bmatrix}$ |  |  |  |  |

FIG. 75

| EQ<br>NUM | EQUATION                                                                                                                                                                                                |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 55        | $M_s = \begin{bmatrix} S & 0 & 0 & 0 \\ 0 & S & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$                                                                                                  |
| 56        | $M_7 = M_s M_6 = \begin{bmatrix} S(CG + DFH) & S(CFH - DG) & SEH & S(GK + HL) \\ SDE & SCE & -SF & S(ADE + BCE) \\ 0 & 0 & 0 & 0 \\ J(DFG - CH) & J(DH + CFG) & EGJ & J(GL - HK + I) + 1 \end{bmatrix}$ |
| 57        | $P_1 = M_7 \begin{bmatrix} x \\ y \\ 0 \\ 1 \end{bmatrix}$                                                                                                                                              |

FIG. 76

| EQ<br>NUM | EQUATION                                                                                                                                                                                                            |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 58        | $P_1 = \left[ \begin{array}{c} S(CG + DFH)x + S(CFH - DG)y + S(GK + HL) \\ SDEx + SCEy + S(ADE + BCE) \\ 0 \\ J(DFG - CH)x + J(DH + CFG)y + J(GL - HK + I) + 1 \end{array} \right]$                                 |
| 59        | $P_1 = \left[ \begin{array}{c} S(CG + DFH)x + S(CFH - DG)y + S(ACG - BDG + ADFH + BCFH) \\ SDEx + SCEy + S(ADE + BCE) \\ 0 \\ J(DFG - CH)x + J(DH + CFG)y + J(BDH - ACH + ADFG + BCFG + I) + 1 \end{array} \right]$ |

FIG. 77

| EQ<br>NUMBER | EQUATION                                                                                |
|--------------|-----------------------------------------------------------------------------------------|
| 60           | $M_{p2Dinf} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{bmatrix}$        |
| 61           | $M_{p2D} = \begin{bmatrix} ai & bi & ci \\ di & ei & fi \\ gi & hi & i \end{bmatrix}$   |
| 62           | $P_2 = M_{per2D} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$                             |
| 63           | $P_2 = \begin{bmatrix} aix + biy + ci \\ dix + eiy + fi \\ gix + hiy + i \end{bmatrix}$ |

FIG. 78

| EQ<br>NUMBER | EQUATION                                     |
|--------------|----------------------------------------------|
| 64           | $\frac{ai}{S} = CG + DFH$                    |
| 65           | $\frac{bi}{S} = CFH - DG$                    |
| 66           | $\frac{ci}{S} = ACG - BDG + ADFH + BCFH$     |
| 67           | $\frac{di}{S} = DE$                          |
| 68           | $\frac{ei}{S} = CE$                          |
| 69           | $\frac{fi}{S} = ADE + BCE$                   |
| 70           | $gi = J(DFG - CH)$                           |
| 71           | $hi = J(DH + CFG)$                           |
| 72           | $i = J(BDH - ACH + ADFG + BCFG + I) + 1$     |
| 73           | $\sin^2 \theta + \cos^2 \theta = 1$          |
| 74           | $\theta = \arctan(\sin \theta, \cos \theta)$ |

FIG. 79

| EQ<br>NUMBER | EQUATION                                   |
|--------------|--------------------------------------------|
| 75           | $\frac{ci}{S} = A(CG + DFH) + B(CFH - DG)$ |
| 76           | $c = Aa + Bb$                              |
| 77           | $\frac{fi}{S} = A(DE) + B(CE)$             |
| 78           | $f = Ad + Be$                              |
| 79           | $i = AJ(DFG - CH) + BJ(DH + CFG) + IJ + 1$ |
| 80           | $i = Agi + Bhi + IJ + 1$                   |
| 81           | $A = \frac{c-Bb}{a}$                       |
| 82           | $A = \frac{f-Be}{d}$                       |
| 83           | $\frac{c-Bb}{a} = \frac{f-Be}{d}$          |
| 84           | $cd - Bbd = af - Bae$                      |
| 85           | $B(ae - bd) = af - cd$                     |
| 86           | $B = \frac{af - cd}{ae - bd}$              |

FIG. 80

| EQ<br>NUMBER | EQUATION                                                     |
|--------------|--------------------------------------------------------------|
| 87           | $A = \frac{f - \left( \frac{af - cd}{ae - bd} \right) e}{d}$ |
| 88           | $A = \frac{f(ae - bd) - e(af - cd)}{d(ae - bd)}$             |
| 89           | $A = \frac{aef - bdf - aef + cde}{d(ae - bd)}$               |
| 90           | $A = \frac{-bdf + cde}{d(ae - bd)}$                          |
| 91           | $A = \frac{-bf + ce}{ae - bd}$                               |
| 92           | $C = \frac{ei}{ES}$                                          |
| 93           | $D = \frac{di}{ES}$                                          |
| 94           | $a = \frac{e}{E}G + \frac{d}{E}FH$                           |
| 95           | $b = \frac{-d}{E}G + \frac{e}{E}FH$                          |
| 96           | $g = \frac{-e}{ES}H + \frac{d}{ES}FG$                        |
| 97           | $h = \frac{d}{ES}H + \frac{e}{ES}FG$                         |
| 98           | $E = \frac{eG + dFH}{a}$                                     |
| 99           | $E = \frac{-dG + eFH}{b}$                                    |

FIG. 81

| EQ<br>NUMBER | EQUATION                                                                                                                                                                                                                  |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 100          | $ES = \frac{-eH + dFG}{g}$                                                                                                                                                                                                |
| 101          | $ES = \frac{dH + eFG}{h}$                                                                                                                                                                                                 |
| 102          | $\frac{eG + dFH}{a} = \frac{-dG + eFH}{b}$                                                                                                                                                                                |
| 103          | $\frac{FH}{G} = \frac{ad + be}{ae - bd}$                                                                                                                                                                                  |
| 104          | $\frac{-eH + dFG}{g} = \frac{dH + eFG}{h}$                                                                                                                                                                                |
| 105          | $\frac{FG}{H} = \frac{dg + eh}{dh - eg}$                                                                                                                                                                                  |
| 106          | $\frac{FH}{G} \times \frac{FG}{H} = \frac{(ad + be)(dg + eh)}{(ae - bd)(dh - eg)} = F^2$                                                                                                                                  |
| 107          | $F = \pm \sqrt{\frac{(ad + be)(dg + eh)}{(ae - bd)(dh - eg)}}$                                                                                                                                                            |
| 108          | $E = \pm \sqrt{1 - F^2}$                                                                                                                                                                                                  |
| 109          | $\phi = \arctan(E, F)$                                                                                                                                                                                                    |
| 110          | $\frac{1}{F} \times \frac{FH}{G} = \frac{H}{G} = \left( \pm \sqrt{\frac{(ae - bd)(dh - eg)}{(ad + be)(dg + eh)}} \right) \times \frac{(ad + be)}{(ae - bd)}$ $= \pm \sqrt{\frac{(ad + be)(dh - eg)}{(ae - bd)(dg + eh)}}$ |
| 111          | $\frac{H}{G} = \frac{H}{\pm \sqrt{1 - H^2}} = \frac{1}{\pm \sqrt{\frac{1}{H^2} - 1}}$                                                                                                                                     |

FIG. 82

| EQ<br>NUMBER | EQUATION                                                            |
|--------------|---------------------------------------------------------------------|
| 112          | $H = \frac{1}{\pm \sqrt{\frac{1}{\left(\frac{H}{G}\right)^2} + 1}}$ |
| 113          | $G = \pm \sqrt{1 - H^2}$                                            |
| 114          | $\psi = \arctan(G, H)$                                              |
| 115          | $\left(\frac{ei}{ES}\right)^2 + \left(\frac{di}{ES}\right)^2 = 1$   |
| 116          | $\frac{S}{i} = \frac{\pm \sqrt{d^2 + e^2}}{E}$                      |
| 117          | $C = \frac{e}{E} \times \frac{E}{\pm \sqrt{d^2 + e^2}}$             |
| 118          | $C = \frac{e}{\pm \sqrt{d^2 + e^2}}$                                |
| 119          | $D = \frac{d}{E} \times \frac{E}{\pm \sqrt{d^2 + e^2}}$             |
| 120          | $D = \frac{d}{\pm \sqrt{d^2 + e^2}}$                                |

FIG. 83

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| EQ<br>NUMBER | EQUATION                                                            |
|--------------|---------------------------------------------------------------------|
| 121          | $i(1 - Ag - Bh) = IJ + 1$                                           |
| 122          | $\text{sign}(i) = -\text{sign}(1 - Ag - Bh)$                        |
| 123          | $\gamma = \arctan(D, C)$                                            |
| 124          | $S = \frac{di}{DE}$                                                 |
| 125          | $S = \frac{ei}{CE}$                                                 |
| 126          | $\text{sign}(FH) = \text{sign}\left(\frac{ad + be}{ae - bd}\right)$ |
| 127          | $J = \left  \frac{gi}{-CH + \text{sign}(FH)DFG} \right $            |
| 128          | $J = \left  \frac{hi}{DH + \text{sign}(FH)CFG} \right $             |
| 129          | $I = \frac{(i - Agi - Bhi - 1)}{J}$                                 |

FIG. 84

| case | C,D        | E,F | G,H | ai           | bi            | ci         | di       | ei       | fi       | gi            | hi           |
|------|------------|-----|-----|--------------|---------------|------------|----------|----------|----------|---------------|--------------|
| 1a   | $\pm 1,0$  | 1,0 | 1,0 | $\pm S$      | 0             | $\pm AS$   | 0        | $\pm S$  | $\pm BS$ | 0             | 0            |
| 1b   | $0, \pm 1$ | 1,0 | 1,0 | 0            | $\pm(-S)$     | $\pm(-BS)$ | $\pm S$  | 0        | $\pm AS$ | 0             | 0            |
| 1c   | C,D        | 1,0 | 1,0 | CS           | -DS           | Aai+Bbi    | DS       | CS       | BS       | 0             | 0            |
| 2a   | $\pm 1,0$  | E,F | 1,0 | $\pm S$      | 0             | $\pm AS$   | 0        | $\pm ES$ | Bei      | 0             | $\pm FJ$     |
| 2b   | $0, \pm 1$ | E,F | 1,0 | 0            | $\pm(-S)$     | $\pm(-BS)$ | $\pm ES$ | 0        | Adi      | $\pm FJ$      | 0            |
| 2c   | C,D        | E,F | 1,0 | CS           | -DS           | Aai+Bbi    | DES      | CES      | Adi+Bei  | DFJ           | CFJ          |
| 3a   | $\pm 1,0$  | 1,0 | G,H | $\pm GS$     | 0             | Aai        | 0        | $\pm S$  | $\pm BS$ | $\pm(-HJ)$    | 0            |
| 3b   | $0, \pm 1$ | 1,0 | G,H | 0            | $\pm(-GS)$    | Bbi        | $\pm S$  | 0        | $\pm AS$ | 0             | $\pm HJ$     |
| 3c   | C,D        | 1,0 | G,H | CGS          | -DGS          | Aai+Bbi    | DS       | CS       | Adi+Bei  | -CHJ          | DHJ          |
| 4a   | $\pm 1,0$  | E,F | G,H | $\pm GS$     | $\pm FHS$     | Aai+Bbi    | 0        | $\pm ES$ | Bei      | $\pm(-HJ)$    | $\pm FGJ$    |
| 4b   | $0, \pm 1$ | E,F | G,H | $\pm FHS$    | $\pm(-GS)$    | Aai+Bbi    | $\pm ES$ | 0        | Adi      | $\pm FGJ$     | $\pm HJ$     |
| 4c   | C,D        | E,F | G,H | CGS+<br>DFHS | -DGS+<br>CFHS | Aai+Bbi    | DES      | CES      | Adi+Bei  | -CHJ+<br>DFGJ | DHJ+<br>CFGJ |

FIG. 85

| description               | case | condition                    | handling                                                                                                   |
|---------------------------|------|------------------------------|------------------------------------------------------------------------------------------------------------|
| zero pitch &<br>zero roll | 1    | $g = h = 0$                  | $E \leftarrow 1$<br>$F \leftarrow 0$<br>$G \leftarrow 1$<br>$H \leftarrow 0$                               |
| zero roll                 | 2a   | $b = d = g = 0$              | $E \leftarrow \frac{e}{a}$<br>$\frac{FJ}{S} = \frac{h}{a}$                                                 |
|                           | 2b   | $a = e = h = 0$              | $E \leftarrow \frac{-d}{b}$<br>$\frac{FJ}{S} = \frac{-g}{b}$                                               |
|                           | 2c   | $\frac{a}{b} = \frac{-h}{g}$ | handle via 2a or 2b                                                                                        |
|                           | 2    |                              | $G \leftarrow 1$<br>$H \leftarrow 0$<br>$F \leftarrow \text{sign}\left(\frac{FJ}{S}\right) \sqrt{1 - E^2}$ |

FIG. 86

| description                       | case | condition                      | handling                                                                                    |
|-----------------------------------|------|--------------------------------|---------------------------------------------------------------------------------------------|
| zero pitch                        | 3a   | $b = d = h = 0$                | $G \leftarrow \frac{a}{e}$ $\frac{HJ}{S} = \frac{-g}{e}$                                    |
|                                   | 3b   | $a = e = g = 0$                | $G \leftarrow \frac{-b}{d}$ $\frac{HJ}{S} = \frac{h}{d}$                                    |
|                                   | 3c   | $\frac{a}{b} = \frac{g}{h}$    | handle via 3a or 3b                                                                         |
|                                   | 3    |                                | $E \leftarrow 1$ $F \leftarrow 0$ $H = \text{sign}\left(\frac{HJ}{S}\right) \sqrt{1 - G^2}$ |
| non-zero pitch<br>& non-zero roll | 4    | $(g \neq 0) \wedge (h \neq 0)$ | handle via general solution                                                                 |

FIG. 87