

EP 0 607 694 A1

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 31 0449

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | CLASSIFICATION OF THE APPLICATION (Int.Cl.) | | | | | | |
|--|---|--|---|-----------------|----------------------------------|----------|-----------|---------------|------------|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | | | | | | | |
| D, X | US-A-5 045 645 (HOENDERVOOGT ET AL.) | 1, 6, 7, 9, 10 | G06K11/16 | | | | | | |
| D, Y | * column 2, line 43 - column 6, line 18; figures 1,2 * | 2-5 | | | | | | | |
| X | EP-A-0 511 406 (SEIKO INSTRUMENTS INC.) * column 2, line 47 - column 4, line 58 * * column 6, line 19 - column 7, line 35 * * column 8, line 56 - column 11, line 14; figures 1-5 * | 1, 6, 7, 9, 10 | | | | | | | |
| Y | US-A-5 136 125 (RUSSELL) | 2-5 | | | | | | | |
| A | * column 2, line 66 - column 6, line 61; figures 1-3 * | 1 | | | | | | | |
| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.) | | | | | | |
| | | | G06K | | | | | | |
| <p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 33%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>27 April 1994</td> <td>Seample, M</td> </tr> </table> | | | | Place of search | Date of completion of the search | Examiner | THE HAGUE | 27 April 1994 | Seample, M |
| Place of search | Date of completion of the search | Examiner | | | | | | | |
| THE HAGUE | 27 April 1994 | Seample, M | | | | | | | |
| CATEGORY OF CITED DOCUMENTS | | T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons R : member of the same patent family, corresponding document | | | | | | | |
| X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document | | | | | | | | | |

EP 0 607 694 A1

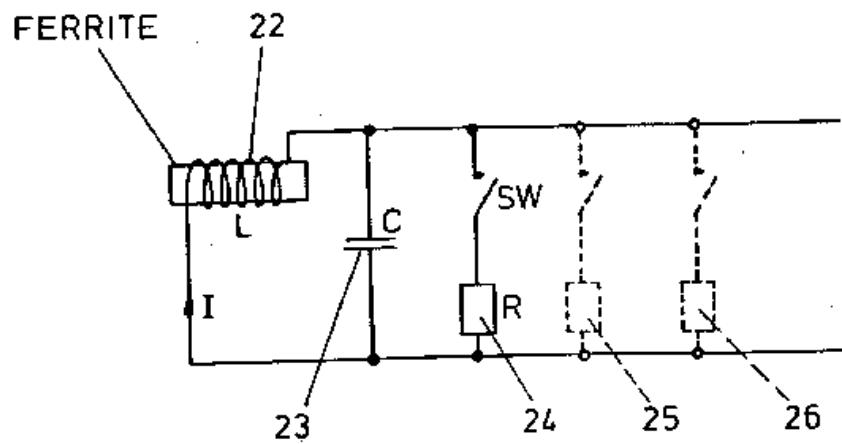


FIG. 2

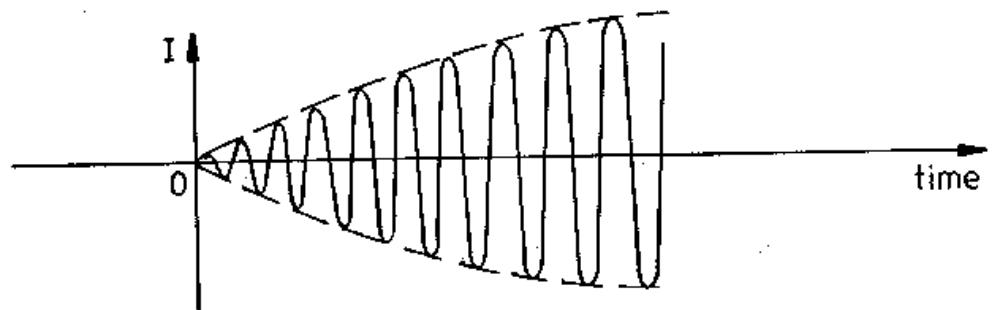


FIG. 4

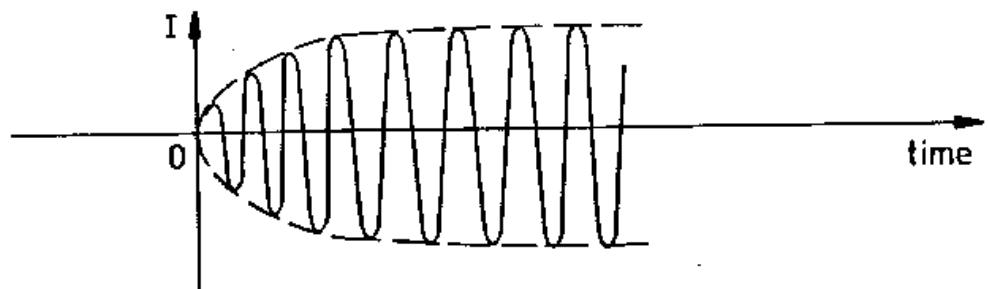


FIG. 5

EP 0 607 694 A1

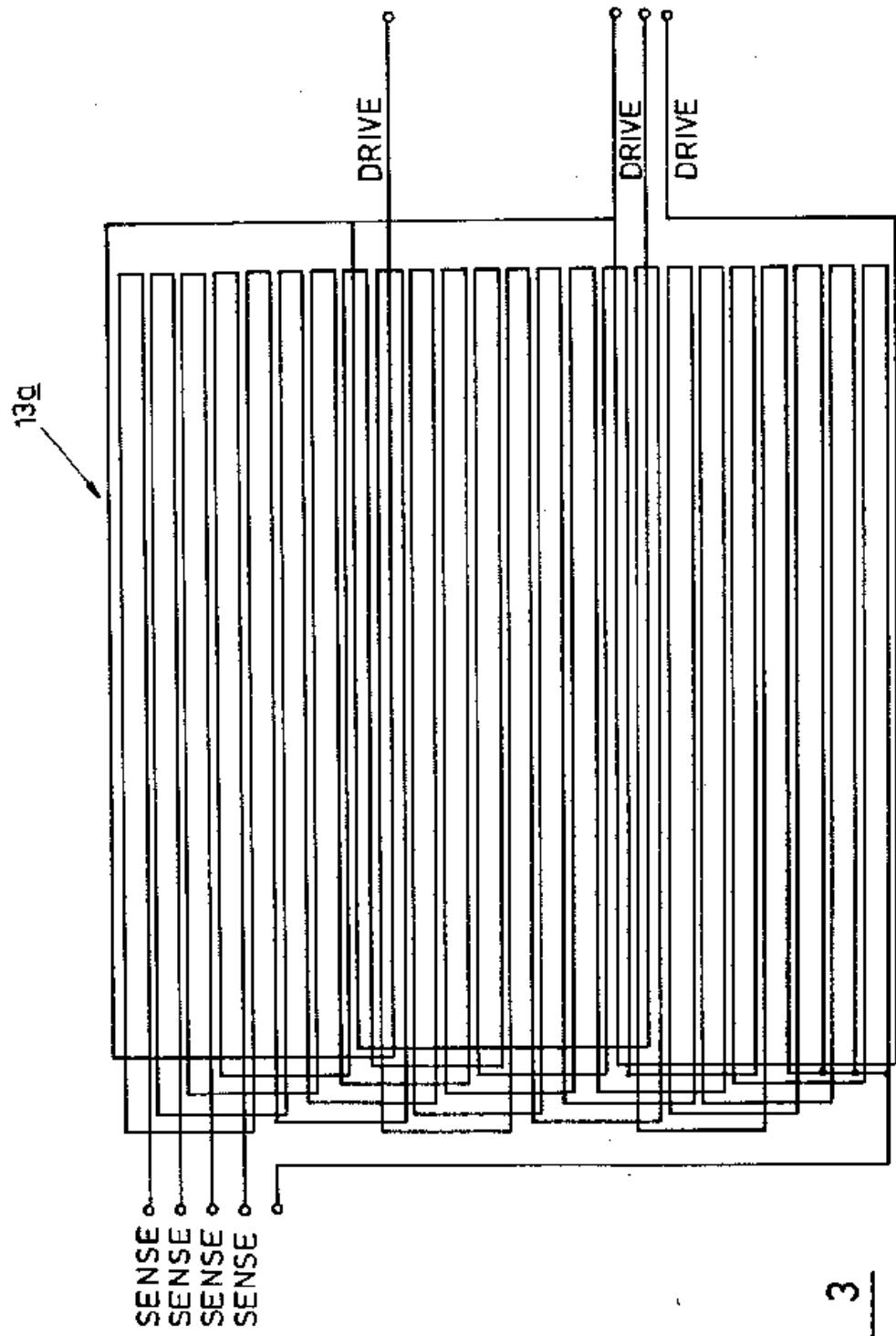


FIG. 3

EP 0 607 694 A1

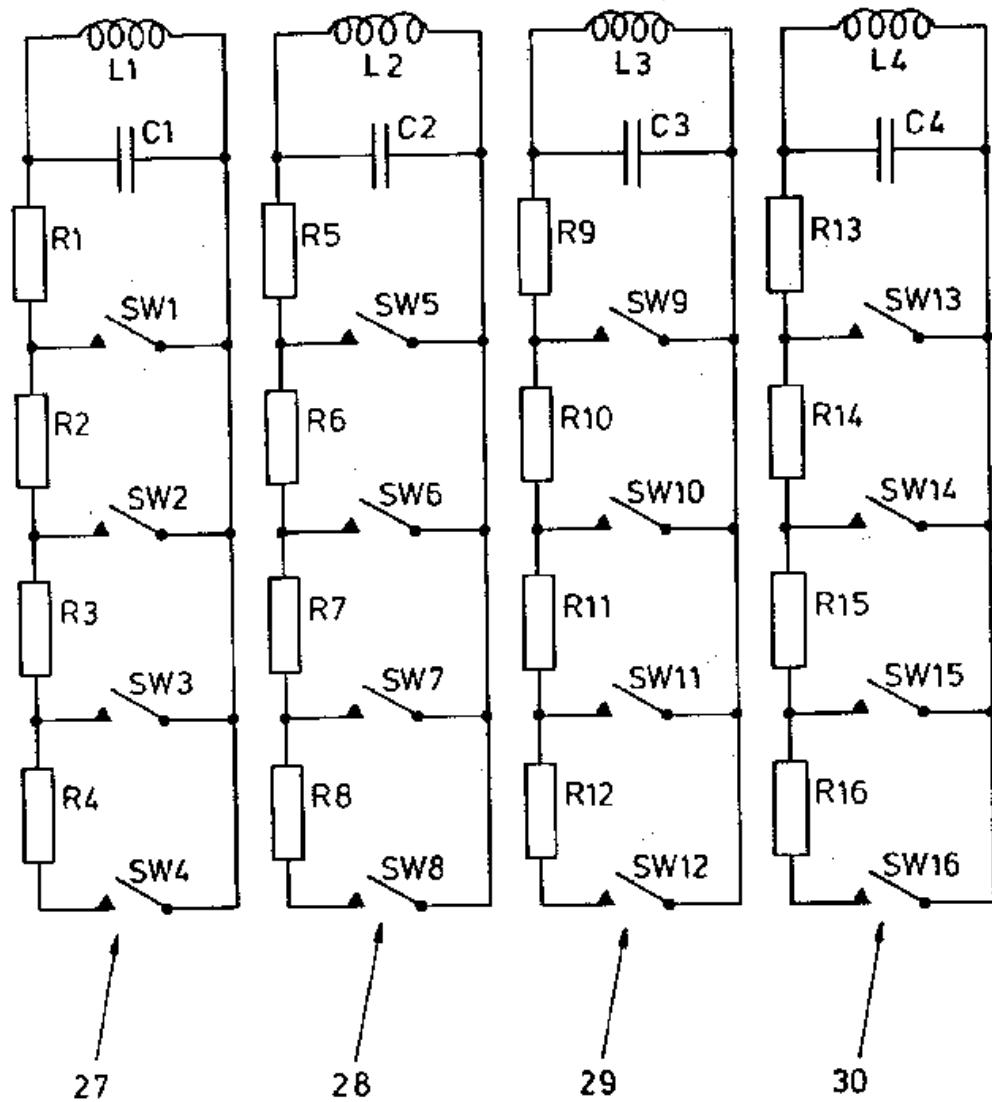
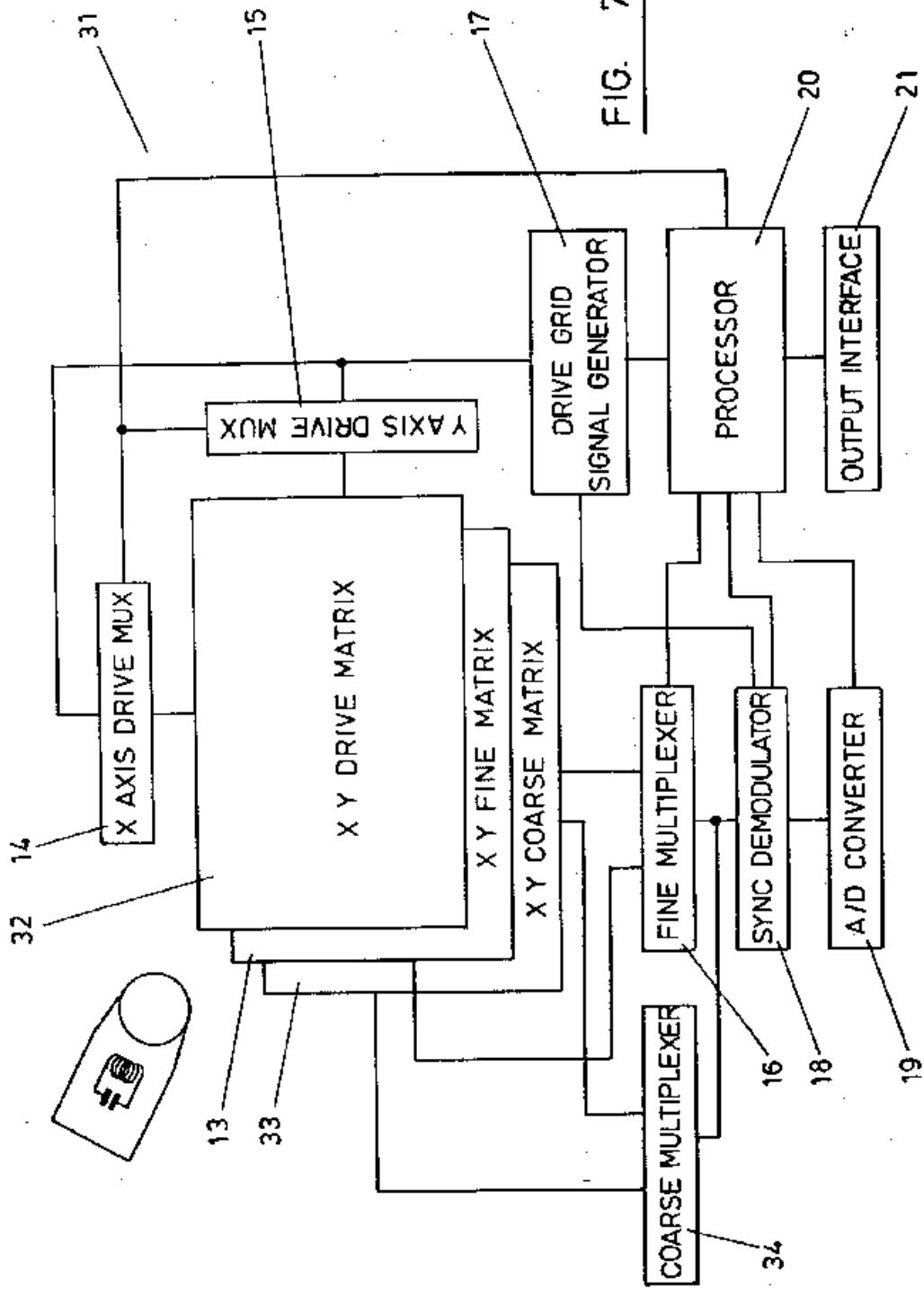


FIG. 6

EP 0 607 694 A1

FIG. 7



EP 0 607 694 A1

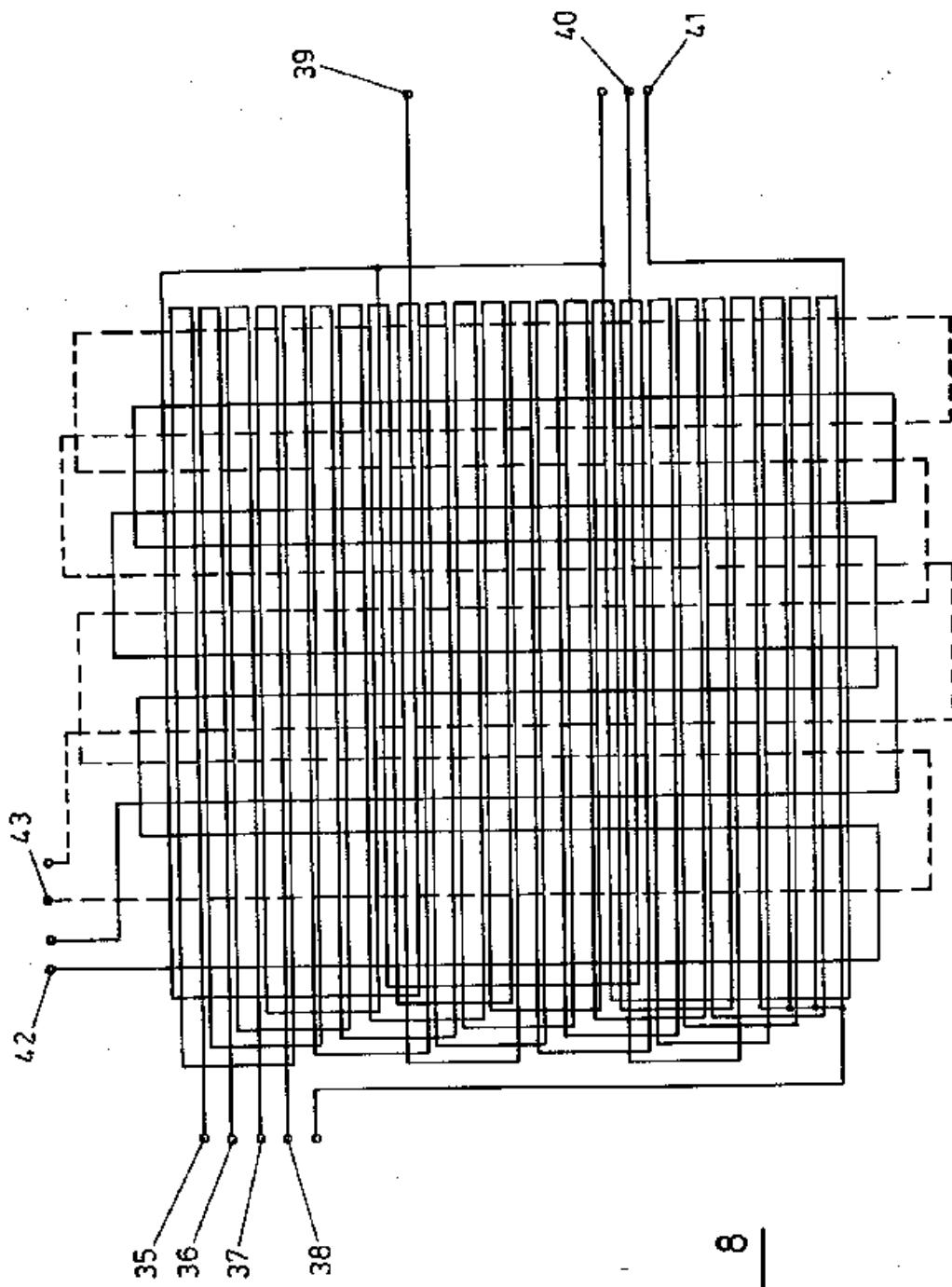


FIG. 8



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number: 0 607 694 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 93310449.9

(51) Int. Cl.⁵: G06K 11/16

(22) Date of filing: 21.12.93

(30) Priority: 22.12.92 GB 9226645

(43) Date of publication of application:
27.07.94 Bulletin 94/30

(44) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI LU MC
NL PT SE

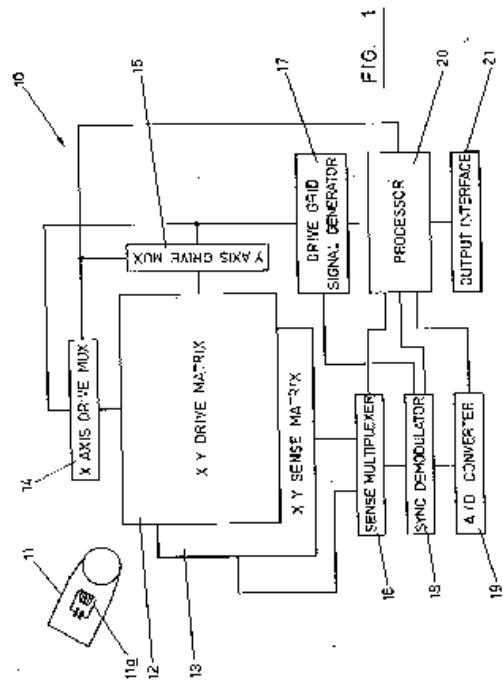
(71) Applicant: T.D.S. CAD-Graphics LTD.
Lower Philips Road
Blackburn BB1 5th (GB)

(72) Inventor: Oakley, Andrew
144 Revridge Road
Blackburn Lancashire, BB2 6EB (GB)
Inventor: Unsworth, Peter
Patchwork Cottage
5 Mount Pleasant
Town End
Slaidburn Lancashire, BB7 3EP (GB)

(74) Representative: Nelli, Alastair William
Appleyard
Lees & Co.
15 Clare Road
Halifax West Yorkshire HX1 2HY (GB)

(54) Cordless digitizer.

(57) Figure 1 shows generally at 10 a digitizing tablet and a cordless pointer 11 arranged, in use, to move over a rectangular contact surface (not shown) of the tablet 10. The digitizer 10 comprises a drive matrix 12 having a first plurality of driving conducting coils (not shown) arranged in a first orientation and a second plurality of driving conducting coils (not shown) arranged in a second orientation orthogonal to the first driving coils. A sense matrix 13 comprises a first plurality of sensing conducting coils (not shown) arranged in a first orientation and a second plurality of sensing conducting coils (not shown) arranged in a second configuration orthogonal to the first sensing coils.



EP 0 607 694 A1

The present invention relates to a graphic digitizer and a method of operating the same.

Graphic digitizers are widely used in desk top publishing and computer aided design (CAD) systems as a means of translating the location of a pointing device on a digitizing tablet into coordinates on a screen-monitor. Typically the pointing device comprises a pen-shaped instrument or stylus, or else it comprises a cursor having a substantially flat portion which is slidable over the surface of the digitizing tablet. A computer with which the apparatus is associated is able to recognise the location of the pointing device on the tablet.

Prior art systems of this kind employ a plurality of electrical conductors below the surface of the tablet which conductors have electrical signals induced in them from a magnetic field produced by a coil in the pointing device. The coil in the pointing device is conventionally energised through a cord leading from a power supply to the pointing device. By analyzing which of the conductors is experiencing an induced electrical signal, and by analyzing the magnitude and, where necessary, the phase of the induced signals, the computer is able to identify the exact location of the pointing device on the tablet.

Such prior art systems are disadvantageous in that the cord of the pointing device may restrict its movement. A suggested alternative employs one or more batteries in the pointing device to energise the coil. However, the use of batteries has the disadvantage that the pointing device must be made undesirably larger to accommodate them or else if the batteries are small they may be relatively short-lived.

A known digitizing tablet and pointing device which does away with the need for either a corded pointing device or a battery in the pointing device uses a driving grid located in the tablet to induce an electrical signal into the coil of the pointing device, thereby causing it to resonate and to induce electrical signals in one or more sensing conductors in the tablet. In order to overcome the problem of the driving grid directly inducing electrical signals into the sensing conductors, thereby making difficult the measurement of any signals induced by the pointing device, the prior art device is made to cease transmission of the driving signal and then "listen" for the signal induced from the resonating coil of the pointing device into the conductors. In order to allow any potentially confusing transient signals to subside it is necessary to wait a short while after suspending the transmission of the driving signal, before commencing the monitoring of the conductors for any signals induced by the pointing device.

A disadvantage of this system is that it is relatively slow due to the necessity to suspend transmission, wait, and then monitor each of the conductors in the tablet. Speedy processing of position data is vital for accurate real-time representation of the movement of

the pointing device.

Furthermore, once the driving signal has been suspended the signal induced in the conductors from the coil of the pointing device begins to decay exponentially which makes the accurate measurement of the signals difficult.

10 A further prior art system as disclosed in U.S. patent number 5045,645 in the name of Hoendervoogt et al, avoids the necessity to suspend transmission of the drive signal when motoring the pointer-induced signal. This is achieved by driving the pointer with a composite signal including a high frequency carrier component onto which is superimposed a much lower frequency modulating component. The pointer is provided with two tuned circuits, the first of which resonates at the carrier frequency and the second of which resonates at the modulating frequency. The two tuned circuits are connected via a diode arrangement which permits energy from the first tuned circuit at the higher carrier frequency to drive the second tuned circuit at the lower modulating frequency. A set of conductors in the tablet picks up signals induced by the second tuned circuit at the lower frequency, and processing means is arranged to translate the magnitude and phase of the signals into position data.

15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 9999

the pointing device.

Furthermore, once the driving signal has been suspended the signal induced in the conductors from the coil of the pointing device begins to decay exponentially which makes the accurate measurement of the signals difficult.

10 A further prior art system as disclosed in U.S. patent number 5045,645 in the name of Hoendervoogt et al, avoids the necessity to suspend transmission of the drive signal when motoring the pointer-induced signal. This is achieved by driving the pointer with a composite signal including a high frequency carrier component onto which is superimposed a much lower frequency modulating component. The pointer is provided with two tuned circuits, the first of which resonates at the carrier frequency and the second of which resonates at the modulating frequency. The two tuned circuits are connected via a diode arrangement which permits energy from the first tuned circuit at the higher carrier frequency to drive the second tuned circuit at the lower modulating frequency. A set of conductors in the tablet picks up signals induced by the second tuned circuit at the lower frequency, and processing means is arranged to translate the magnitude and phase of the signals into position data.

in a first configuration and at least some others of the coils are arranged in a second configuration, substantially orthogonal to the first configuration.

In a preferred arrangement at least some of the coils of the sensor means are arranged such that for each coil portion of the first winding orientation, there is a coil portion of the second winding orientation.

The drive means may comprise at least one electrical conductor. Preferably the drive means comprises a plurality of electrical conductors.

In a preferred arrangement the drive means comprises a number of first electrical conductors in a first configuration and a number of second electrical conductors in a second configuration, substantially orthogonal to the first configuration.

Preferably at least one of the electrical conductors of the drive means comprises an electrically conducting coil in use.

In a preferred arrangement, the position indication device comprises a tuned circuit.

Preferably the position indication device comprises at least one inductance and at least one capacitance.

Preferably the apparatus includes signal generation means arranged to provide an electrical signal to the drive means.

Preferably the drive means is arranged to induce an alternating electrical signal into the conductor of the position indication device which signal has a frequency substantially equal to a resonant frequency of the tuned circuit of the position indication device.

In a preferred arrangement, the apparatus is arranged to measure a resonant frequency of the position indication device and to cause the drive means to induce an alternating electrical signal in the conductor of the position indication device which signal is substantially equal to the measured resonant frequency.

Preferably the apparatus is arranged such that, in use, the drive means induces an electrical signal in the conductor of the position indication device whilst measuring means are measuring the electrical signal induced in the sensor means by the position indication device.

Preferably, in use, at least one first conductor of the drive means is arranged to induce an electrical signal in a conductor of the position indication device which conductor of the position indication device is arranged to induce an electrical signal in at least one sense coil which at least one sense coil is arranged substantially orthogonal to the at least one first conductor of the drive means.

The apparatus may comprise a plurality of position indication devices arranged in use to indicate positions relative to the reference surface. In a preferred arrangement more than one device may be used at substantially the same time to indicate positions relative to the reference surface.

Where more than one position indication device is being used to indicate positions relative to the reference surface the drive means may be arranged to induce alternating electrical signals of different frequencies in the respective position indication devices.

In a preferred arrangement, the apparatus includes a plurality of signal generation means arranged, in use, to generate electrical signals of different frequencies.

Preferably the apparatus is arranged to measure a resonant frequency of each position indication device and to cause the drive means to induce an alternating electrical signal in an electrical conductor of each respective position indication device which signal is substantially equal to the measured resonant frequency of the respective position indication device.

According to a second aspect of the present invention there is provided digitizing apparatus comprising a reference surface and a plurality of position indication devices arranged, in use, to indicate positions relative to the reference surface, the apparatus comprising drive means arranged in use to be inductively coupled to electrical conductors of the respective position indication devices, and sensor means arranged in use to be inductively coupled to electrical conductors of the respective position indication devices, the drive means being arranged, in use, to induce electrical signals of different frequencies in the conductors of the respective position indication devices, and the conductors of the respective position indication devices being arranged, in use, to induce electrical signals of different frequencies in the sensor means.

The apparatus may be arranged such that more than one position indication device may be used to indicate positions relative to the reference surface at substantially the same time.

The sensor means preferably comprises at least one coil of electrically conducting material in use.

According to a third aspect of the present invention there is provided digitizing apparatus comprising a reference surface and a position indication device arranged in use to indicate a position relative to the reference surface, the apparatus comprising drive means arranged in use to be inductively coupled to an electrical conductor of the position indication device, and sensor means arranged in use to be inductively coupled to an electrical conductor of the position indication device, the drive means being arranged in use to induce an electrical signal in a conductor of the position indication device and a conductor of the position indication device being arranged in use to induce an electrical signal in the sensor means, wherein the apparatus further comprises means to measure a resonant frequency of electrical signal in the conductor of the position indication device, the appa-

ratus being arranged, in use, to cause the drive means to induce an electrical signal of substantially the measured resonant frequency into the conductor of the position indication device.

Preferably the apparatus includes means to filter out electrical signals induced directly into the sensor means by the drive means.

According to a fourth aspect of the present invention there is provided a position indication device for use in indicating a position relative to a reference surface of digitizing apparatus, the position indication device being arranged in use to have an electrical signal induced in at least one electrical conductor thereof, wherein the position indication device is arranged in use to induce an electrical signal into a sensor means of digitizing apparatus, the position indication device comprising function indication means arranged in use to indicate a function of the position indication device by influencing a condition of the electrical signal induced in the position indication device.

Preferably the function indication means comprises at least one switch wherein the or each switch operates so as to influence a condition of the electrical signal induced in the position indication device.

Preferably the function indication means is arranged to influence a rate of rise of an electrical signal induced in the position indication means.

In a preferred arrangement, the function indication means is arranged to influence a rate of rise of an electrical current induced in the position indication means.

Preferably the position indication device comprises at least one tuned circuit.

The function indication means may influence the condition of an electrical signal induced in the position indication device by switching at least one resistance across the tuned circuit.

In a preferred arrangement, the function indication means influences the condition of the electrical signal induced in the position indication device by influencing a Q-factor of the or each tuned circuit.

There may be a plurality of function indication means in the position indication device.

According to a fifth aspect of the present invention there is provided a method of indicating the position of a position indication device relative to a reference surface of digitizing apparatus, the method comprising causing drive means to induce an electrical signal in the position indication device, whilst sensing an electrical signal induced in sensor means by the position indication device which sensor means includes at least one electrically conducting coil in use.

Preferably the method includes sensing an induced electrical signal in a plurality of coils. The method may include sensing an induced electrical signal in a plurality of coil portions wherein the coil portions comprise a plurality of coil portions of a first

winding orientation and a plurality of coil portions of a second winding orientation, each coil portion of the first orientation being paired with a coil portion of the second orientation.

Preferably the method includes inducing an electrical signal in the position indication device by drive means which drive means are separate from the sensor means.

According to a sixth aspect of the present invention there is provided a method of indicating positions of a plurality of position indication devices relative to a reference surface of digitizing apparatus, the method comprising causing drive means to induce electrical signals of different frequencies in the respective position indication devices, whilst sensing electrical signals induced in a sensor means by the position indication devices.

The method may comprise a method of indicating the positions of a plurality of position indication devices at substantially the same time.

According to a seventh aspect of the present invention there is provided a method of indicating the position of a position indication device relative to a reference surface of digitizing apparatus, the method comprising causing drive means to induce an electrical signal in the position indication device whilst sensing an electrical signal induced in sensor means of the digitizing apparatus by the position indication device, the method further comprising measuring a resonant frequency of the position indication device and causing the drive means to induce an electrical signal of substantially the measured resonant frequency in the position indication device.

Preferably the method includes measuring a resonant frequency of a tuned circuit of the position indication device.

The method may include measuring a background electrical signal in the sensor means, which background electrical signal is not induced in the sensor means by the position indication device.

Preferably the method includes removing from the electrical signal in the sensor means, a portion of electrical signal which is directly induced in the sensor means by the drive means. The method may include separating an electrical signal induced in the sensor means by the position indication device from an electrical signal induced in the sensor means by the drive means by a consideration of the phase of the two signals.

According to an eighth aspect of the present invention there is provided a method of operating a position indication device, arranged in use to indicate a position relative to a reference surface of digitizing apparatus, the method comprising causing drive means of the apparatus to induce an electrical signal in the position indication device whilst sensing an electrical signal induced in a sensor means by the position indication device, the method further com-

prising indicating a function of the position indication device by influencing a condition of an electrical signal induced in the position indication device by the drive means.

Preferably the method includes operating at least one switch on the position indication device wherein the or each switch operates so as to influence a condition of the electrical signal induced in the position indication device.

In a preferred arrangement the method includes influencing a rate of rise of an electrical signal induced in the position indication device.

Preferably the method includes influencing a rate of rise of an electrical current induced in the position indication device.

The method may include influencing a rate of rise of an electrical current induced in at least one tuned circuit of the position indication device.

Preferably the method includes switching at least one resistance across the tuned circuit.

In a preferred arrangement the method comprises influencing a Q-factor of a tuned circuit of the position indication device.

The invention also includes any combination of the features or limitations referred to herein.

The invention may be carried into practice in various ways but specific embodiments will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 shows schematically a digitizing tablet and a pointing device according to an embodiment of the present invention,

Figure 2 shows a circuit of a pointing device for use with the digitizing tablet of figure 1.

Figure 3 shows in more detail a portion of the digitizing tablet of figure 1.

Figure 4 represents an electric current signal in a circuit of figure 2 in use.

Figure 5 represents an electric current in the circuit of figure 2 in alternative use.

Figure 6 shows a circuit of an alternative pointing device for use with the digitizing tablet of figure 1.

Figure 7 shows schematically an alternative embodiment of digitizing tablet, and

Figure 8 shows in more detail a portion of the digitizing tablet of figure 7.

Referring particularly to figure 1, this shows generally at 10 a digitizing tablet and a cordless pointer 11 arranged, in use, to move over a rectangular contact surface (not shown) of the tablet 10.

The digitizer 10 comprises a drive matrix 12 having a first plurality of driving conducting coils (not shown) arranged in a first orientation and a second plurality of driving conducting coils (not shown) arranged in a second orientation orthogonal to the first driving coils. A sense matrix 13 comprises a first plurality of sensing conducting coils (not shown) ar-

ranged in a first orientation, and a second plurality of sensing conducting coils (not shown) arranged in a second configuration orthogonal to the first sensing coils.

5 Drive multiplexers 14 and 15 are arranged, in use, to supply selectively electric current to any of the first drive coils (hereinafter referred to as the X drive coils) or to any of the second drive coils (hereinafter referred to as the Y drive coils) respectively.

10 Current induced in any of the first and second sense coils (hereinafter referred to as the X and Y sense coils respectively) is routed to a sense multiplexer 16. An amplifier (not shown) amplifies the level of the signals received in the sense coils.

15 In use, when the drive multiplexers 14 and 15 route alternating electric current into the X or Y driving coils (not shown) of the driving matrix 12 the associated changing magnetic field induces a voltage signal in a tuned circuit 11a of the pointer 11. The substantially sinusoidal drive signal is produced in a drive multiplexer signal generator 17 and is generated by a programmable signal source which is locked to a stable reference frequency.

20 The resultant current in the pointer 11 then gives rise to a magnetic field which induces a voltage signal in the X and Y sense coils of the sense matrix 13.

25 After the sensed voltage signals have been fed into the sense multiplexer they are de-modulated by a synchronous de-modulator 18. The de-modulated signals are then converted into digital signals in an analogue to digital converter 19 before being input into a microprocessor 20 which calculates the position of the pointer 11 on the tablet 10. The calculated position data is then output to a host device such as a computer (not shown) via an interface 21.

30 In more detail, the sense matrix 13 comprises a balanced array of conducting coils laid side by side, each coil being paired with an identical but oppositely wound coil, the coils being inter-connected so as to give a multi-phase output signal. The pattern of interconnection is repeated many times over the area of the tablet 10, with each complete pattern being referred to commonly as a "pitch".

35 The sense matrix 13 has two separate and independent arrays of coils which are placed orthogonal to each other to permit position sensing in perpendicular axes X and Y. The pattern of coils may be produced by conventional techniques such as etching, vacuum depositing, screen printing or wiring of a conductive material or any suitable combination of these techniques.

40 The drive matrix 12 is also formed as two orthogonal arrays, for driving in an X axis and a Y axis, and may be fabricated by the same techniques as is the sense matrix. The drive grid comprises individual coils laid side by side which coils are nominally of a pitch (or smaller) in width.

45 The drive multiplexers 14 and 15 are arranged to

route excitation current into any of the X drive coils or Y drive coils. The operation of these multiplexers is controlled by the micro-processor 20 and the drive multiplexers utilise field effect transistors (not shown) to switch current into the drive coils.

The purpose of the synchronous de-modulator 18 is to reject any extraneous noise and unwanted background signals. The de-modulation clock is derived from the drive matrix signal generator 17. The de-modulation clock circuitry provides both phase and quadrature clock signals to enable phase and quadrature data to be discerned from the sensed signals.

The drive matrix signal generator 17 is coupled to a power amplifier (not shown) which boosts the available current for the driving signal. The circuitry also provides clock signals for the de-modulation circuitry.

The micro-processor 20 is at the heart of the digitizing tablet and it interfaces with and controls the drive matrix signal generator 17, the analogue to digital convertor 19, the synchronous de-modulator 18 and the sense multiplexer 16.

Figure 2 shows schematically a circuit of a pointer for use with the digitizing tablet of figure 1. The pointer comprises an LC tuned circuit including a coil 22 and a capacitor 23. In parallel with the tuned circuit are switched resistors of which 24, 25, 26 are examples. When the pointer is in the form of a stylus or pen the resistors are switched either axially by the stylus tip or radially using buttons (not shown).

In use, an alternating magnetic field at a frequency f_1 caused by the excitation current in a coil of the drive matrix 12 acts on the tuned circuit of the pointer 11, the resonant frequency of which is f_1 . This causes the tuned circuit to resonate and the magnetic field produced by the coil 22 induces a voltage signal into the sense matrix 13 of the tablet 10. The resistors 24, 25, 26 are switched into the circuit so as to alter the Q-factor of the LC tuned circuit.

The operation of the tablet 10 and pointer 11 will now be described in more detail, again with reference to figures 1 and 2.

The X and Y drive coils (not shown) are superimposed in the tablet 10. The drive coils can be selected individually and, if required, in a random fashion by the drive multiplexers 14 and 15. When driving the X drive matrix 12 the Y sense matrix 13 is connected to the synchronous de-modulator 18 via the sense multiplexer 16. Conversely, when driving the Y drive matrix 12 the X sense matrix 13 is connected to the synchronous de-modulator 18 via the sense multiplexer 16.

The balanced array of each of the X sense coils and Y sense coils is such as to produce a nominal null in the sensed signal when the respective orthogonal drive coil is excited and no pointing device is present. This is due to the fact that any signal induced in one of the clockwise sense coils directly by the orthogonal drive coil, will be induced in an equal and opposite

sense in the corresponding counter clockwise sense coil. However, when the pointer 11 which is excited by a drive coil at its resonant frequency is placed in proximity to a sense coil it retransmits a magnetic field which induces a voltage signal in the sense coils according to its position relative to the sense coils.

The proximity of any metal objects (not shown) to the sense coils may upset the nominal balance of the sense matrix. In addition, because of the magnetic topology of the matrix, and in particular due to the finite length of the coils, the balance of the sense matrix can be upset, particularly at the edges of the tablet 10. These problems are overcome in the following two ways.

Firstly the voltage signal induced into the sense matrix 13 via the pointer 11 at its resonant frequency F_1 is inevitably phase-shifted by 90° as compared with the voltage signal induced directly from the drive matrix 12. The directly induced voltage signal is therefore largely rejected by the synchronous de-modulator 18.

Secondly, the micro-processor 20 makes a background measurement from the sense matrix 13 with the driving frequency "off tune" i.e. away from the resonant frequency of the tuned circuit of the pointer 11. From this information the micro-processor 20 can extract the signal values which are purely due to the effect of the pointer 11.

Figure 3 shows the arrangement of a Y portion of the sense matrix 13a and a Y portion of the drive matrix 12a. The sense matrix 13a is of a four-phase non-overlapping type. The technique of operation is suited to many types of commonly used matrix topologies and is particularly suited to topologies in which sense coils are arranged so that there is nominally a null sense voltage when no pointer is present.

The Y sense matrix shown has an interconnected pattern which repeats several times across the surface of the tablet 10, each repeat being commonly referred to as a pitch. The number of pitches needed in a tablet is dependent upon the width of each pitch and on the size of the tablet. The sense matrix 13 permits the microprocessor to determine with high resolution the position of the pointer within a pitch. This is achieved as follows.

Four-phase signals from the sense coil are amplified and de-modulated by the synchronous de-modulator 18 to generate DC voltage levels. The DC voltage levels are proportional to the amplitude of the AC signal which is being de-modulated from the sense coils. The DC voltage levels are then converted into digital values by the analogue to digital convertor 19 and are then sent to the micro-processor 20. The micro-processor 20 undertakes a vector summation on the four numbers (representing the four differently phased coils) and from this the exact position of the pointer 11 with respect to the four coils, i.e. within a particular pitch, is determined.

However, the signals from the sense matrix alone cannot determine the absolute position of the pointer 11 on the tablet 10 since the micro-processor 20 cannot know from this information alone in which of the pitches the pointer is inducing the signals.

In order to determine the pitch in which the signals from the pointer are being induced, it is necessary to excite selectively the appropriate drive coils. The number of drive coils is equal to or greater than the number of pitches. For example to determine the pitch in the X axis the micro-processor 20 selectively energises the X drive coils and determines the peak amplitude and phase of the signals induced in the Y sense coils for each selected X drive coil. From this amplitude and phase information the X pitch is determined.

Conversely by selecting the Y drive coils and analyzing the X sense coils the Y pitch is determined.

The drive signal to the drive matrix 12 is of a programmable frequency. The drive matrix signal generator 17 can lock onto the central frequency of the tuned circuit of the pointer 11. This is accomplished by phase and quadrature de-modulation of the sense signals using conventional radio techniques. The benefit of this is that the tuned circuits of the pointers need only be tuned to within say plus or minus 10% of their intended resonant frequencies, which reduces production time. In addition, as the tuned circuit of the pointer 11 ages, its resonant frequency changes. This is compensated for by employing the above described technique.

Because the drive signal frequency may be made to match the pointers resonant frequency accurately the directly induced sense signals (i.e. from the drive matrix 12) which are 90° out of phase with the pointer induced signals may be more effectively rejected by the synchronous de-modulator 18.

The tablet 10 is also able to determine whether and which buttons have been pressed either on the stylus, the circuit of which is shown in figure 2, or if it is used, on a cursor, a circuit of which is shown in figure 6. For example buttons on the stylus or cursor may be used to provide different information to a computer, such as for different thicknesses or colours of a line drawn on a monitor by moving the pointer across the tablet, or for entering co-ordinate points on the tablet into the computer.

Referring again to figure 2, which shows schematically the circuit of a pointer in stylus form, the circuit comprises coil 22 and capacitor 23 which together form an LC tuned circuit. Figure 5 shows the rate at which the current I in the tuned circuit rises when the circuit is subjected to a magnetic field at the tuned circuits resonant frequency. The rate of rise of the current is found by analyzing the induced signal. This is accomplished by sampling the waveform at various periods after the drive signal has been applied. Button information is encoded by switching various ones

of the resistors 24, 25, 26 across the tuned circuit. The effect of switching the resistance across the tuned circuit is to dampen the Q-factor of the circuit. This damping results in a lower amplitude of induced signal but more importantly a more rapid rise of amplitude. For example figure 5 represents the induced current in the tuned circuit when one of the resistors 24, 25, 26 has been connected across the tuned circuit. The number of switches that can be accommodated in this way is dependent upon the resistor weighing and the resolution of the system.

An alternative pointing device, the circuit of which is shown in figure 6, is the cursor. If it desirable for the cursor to have many button-functions the cursor can have more than one tuned circuit 27, 28, 29, 30. Each individual tuned circuit operates in the same manner as the circuit described above. In the example of figure 7 the configuration allows 16 buttons but greater or smaller numbers of buttons may be accommodated by deleting or adding tuned circuit blocks as required.

By generating and driving signals of different frequencies it is possible to have more than one pointing device in use on the tablet at the same time. The separate drive signals are made to match accurately the resonant frequencies of the different pointers and in this way the signals induced in the sensor means by the different pointers may be interpreted separately. A plurality of signal generators may be employed to generate the different frequency signals.

Figures 7 and 8 show respectively a schematic diagram and a matrix arrangement for an alternative embodiment of tablet 31. The structure of the tablet 31 is very similar to that of the tablet 10 with the following differences:

Firstly the drive matrix 32 consists only of two X drive coils and two Y drive coils (as shown in figure 8). Secondly the drive coils which were used in the tablet 10 (shown in figure 3) are in this embodiment used as coarse sense coils in a coarse sense matrix 33 and are fed into a coarse sense multiplexer 34. The multiplexed coarse sense signals are then sent to the synchronous de-modulator 18 along with the multiplexed fine sense signals from the fine sense multiplexer 13.

Referring also to figure 8, this shows Y fine sense coils 35, 36, 37, 38 and Y coarse sense coils 39, 40, 41. The arrangement of the coarse coils 39, 40, 41 is that of the drive coils of figure 3. In this embodiment separate X drive coils 42, 43 are provided. The tablet also comprises X coarse and fine sense coils and Y drive coils (not shown) which are orthogonal to their counterparts shown in figure 8 and are superimposed thereon. In more detail each axis is provided with drive coils (e.g. 42, 43) arranged orthogonally with respect to their associated sense coils (e.g. 35, 36, 37, 38). Each drive coil is laid out in a zig-zag fashion forming clockwise and counterclockwise loops result-

ing in repeated flux reversals across the tablet surface. Due to the flux reversals in the drive coils (42, 43) null points exist, i.e. points at which the signal induced in the pointers tuned circuit from one (clockwise) portion of a drive coil is equal and opposite to that induced by another (counter-clockwise) portion of the same coil. To overcome this problem a plurality of drive coils are provided, i.e. in this case two for each axis. The most appropriate drive coil on which to drive is selected by the processor 20 based upon the strength of signals induced in the fine sense coils from the pointer.

A number of coarse sense coils (39, 40, 41) are provided, i.e. at least one coil for each pitch in both X and Y axis, in order that the relevant pitch over which the pointer is located, may be identified. Voltages are induced into the coarse sense coils by the resonating pointer in a similar manner to those induced in the fine sense coils 35, 36, 37, 38. The coarse sense signals are multiplexed into the synchronous de-modulator 18 and are converted into digital form by the analogue to digital converter 19. By analyzing the amplitude and polarity of the coarse sense signals the processor 20 determines which pitch the pointer is above. By using the method described in relation to figure 1 the process identifies where, in a particular pitch, the pointer is located.

The above described invention provides a digitizing tablet and a cordless pointer in which no suspension of the transmission of a drive signal is required during reception of a sensed signal, and in which it is not necessary to transmit a composite drive signal containing a high frequency carrier component.

Claims

1. Digitizing apparatus comprising a reference surface and a position indication device arranged in use to indicate a position relative to the reference surface, the apparatus comprising drive means arranged, in use, to be inductively coupled to an electrical conductor of the position indication device, and sensor means arranged in use to be inductively coupled to an electrical conductor of the position indication device, the drive means being arranged, in use, to induce an electrical signal in a conductor of the position indication device, a conductor of the position indication device being arranged in use to induce an electrical signal in the sensor means, wherein the sensor means comprises at least one coil of electrically conducting material in use.
2. Apparatus according to claim 1 wherein the sensor means comprises at least a first coil portion which is wound in a first winding orientation and at least a second coil portion which is wound in

a second winding orientation, opposed to the first winding orientation.

3. Apparatus according to claim 2 wherein the sensor means comprises a plurality of coils wherein a number of the coils comprise first and second coil portions.
4. Apparatus according to claim 3 wherein at least some of the coils are arranged in a first configuration and at least some others of the coils are arranged in a second configuration substantially orthogonal to the first configuration.
5. Apparatus according to claim 3 wherein at least some of the coils of the sensor means are arranged such that for each coil portion of the first winding orientation, there is a coil portion of the second winding orientation.
6. Apparatus according to any of the preceding claims wherein the drive means comprise at least one electrical conductor.
7. Apparatus according to any of the preceding claims wherein the drive means comprise a plurality of electrical conductors.
8. Apparatus according to claim 6 or claim 7 wherein the drive means comprises a number of first electrical conductors in a first configuration and a number of second electrical conductors in a second configuration, substantially orthogonal to the first configuration.
9. Apparatus according to any of claims 6 to 8 wherein at least one of the electrical conductors of the drive means comprises an electrically conducting coil in use.
10. Apparatus according to any of the preceding claims wherein the position indication device comprises a tuned circuit.

EP 0 607 694 A1

