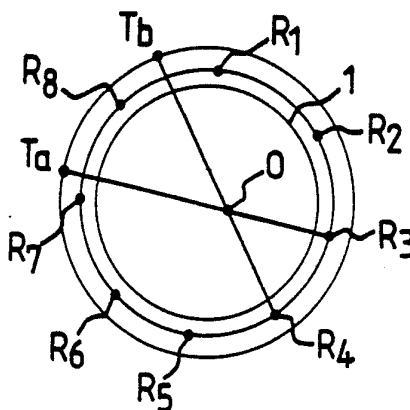




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : F41J 5/02, G01B 11/00	A1	(11) International Publication Number: WO 87/ 05688 (43) International Publication Date: 24 September 1987 (24.09.87)
(21) International Application Number: PCT/GB87/00177 (22) International Filing Date: 13 March 1987 (13.03.87) (31) Priority Application Number: 8606429 (32) Priority Date: 15 March 1986 (15.03.86) (33) Priority Country: GB (71)(72) Applicants and Inventors: FENNER, David, Fenton [GB/GB]; 2 Bishops Green, Barnston, Great Dunmow, Essex CM6 1NF (GB). WEBSTER, Stephen [GB/GB]; 102 Shortlands Road, Kingston Upon Thames, Surrey KT2 6HE (GB). (74) Agents: HOLLIDAY, Frank et al.; Marks & Clerk, Friars House, 6-10 Parkway, Chelmsford, Essex CM2 0NF (GB).		(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i>

(54) Title: DART SCORER



(57) Abstract

A dart scorer is provided with eight receivers (R_1 to R_8) around a dartboard (1). A transmitter (T) moves around the dartboard. As the transmitter reaches a position (T_a) at which it is aligned with a dart (0) and the receiver (R_3) on the opposite side, a first imaginary line for the position of the dart (0) is determined. Similarly, when the transmitter reaches position (T_b) it is aligned with dart (0) and the receiver (T_4) and a second imaginary line for the position of the dart is determined. The actual location of the dart may then be calculated from the intersection of these two imaginary lines. If transmitters (T) and receivers (R) are provided for two or more planes, the angle of incidence of the dart can be determined for use in calibrating its actual location in the darts board.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
BB	Barbados	GB	United Kingdom	MW	Malawi
BE	Belgium	HU	Hungary	NL	Netherlands
BG	Bulgaria	IT	Italy	NO	Norway
BJ	Benin	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	LI	Liechtenstein	SN	Senegal
CH	Switzerland	LK	Sri Lanka	SU	Soviet Union
CM	Cameroon	LU	Luxembourg	TD	Chad
DE	Germany, Federal Republic of	MC	Monaco	TG	Togo
DK	Denmark	MG	Madagascar	US	United States of America
FI	Finland				

DART SCORER

The present invention relates to apparatus for detecting the position of objects on a surface, and more particularly although not exclusively for detecting the positions of darts in a dartboard.

5 According to one aspect of the invention there is provided an apparatus for determining the location of an object relative to a surface comprising one or two transmitters around the edge of the surface arranged to direct radiation across the surface and two or one receivers respectively around the edge of the surface arranged
10 to detect the intensity of the radiation which has been directed across the surface, means for moving the transmitters or receivers relative to the surface and monitoring that movement such that at least two imaginary position lines extending across the surface can be identified by detecting the moments of the fall of
15 intensity of radiation as the shadows of the object impinge on the receiver or receivers, the imaginary lines connecting the position of each particular transmitter and each particular receiver at corresponding moments of reduced intensity, the intersection of the two imaginary position lines determining the location of the
20 object.

There may be further transmitters and further receivers around the surface to transmit and receive radiation respectively in two or more planes near to and generally parallel to the plane of the surface to determine location of the object in those two or more
25 planes, and computing means arranged to receive the locating data for the two or more planes from which the mean angle of incidence of the object relative the surface is computed and to provide, taking into account the angle of incidence, an output indicative of the point on the surface from which the object extends.

30 Preferably, the transmitters provide pulsed infra-red radiation.



According to another aspect of the invention there is provided a darts scoring apparatus including apparatus for determining the location of a dart on a dart board including a number of transmitters positioned around the edge of the board arranged to direct radiation across the surface of the board; a number of receivers positioned around the edge of the board arranged to detect the intensity of radiation which has been directed across the board; means for moving the transmitters and/or receivers relative to the board; and monitoring means arranged at each of the moments that a shadow of the dart impinges each receiver to monitor both the position of the transmitter then transmitting and the position of the shaded receiver to identify imaginary position lines joining the transmitters to the receivers extending across the board, and computing means arranged to compute the intersection of the imaginary lines to determine the location of the dart.

Further receivers may be arranged to receive radiation in two or more respective planes near to and parallel to the surface of the dart board to enable location of the dart in those two or more planes to be determined, the multiple plane locations providing a measure of the angle of incidence of the dart, the computing means being arranged to adjust the location provided by the intersection of the imaginary lines according to the angle of incidence to locate the point of entry of the dart into the board irrespective of its angle of entry.

The transmitters may each be an infra-red transmitter, preferably providing a pulsed output.

One embodiment of the invention comprises a darts scoring apparatus including one set of three infra-red transmitters mounted for rotation around a darts board, at least two sets of three receivers mounted around the edge of the darts board to receive radiation from the transmitters, the three transmitters

- 3 -

being spaced apart in a direction transverse to the surface of the board so as to move in separate planes which extend across near to and parallel to the surface of the board, the three receivers of each set being mounted to detect radiation respectively in the three planes, means for continually monitoring the positions of the transmitters, means responding to reductions of intensity at each receiver as they fall in turn into the shadow of the dart, means for synchronising the receipt of shadow signals and the transmitter outputs such that imaginary lines can be identified connecting respective transmitters and receivers in all three planes, computing means to determine the angle of incidence of the dart based on its relative location at the intersection of the imaginary lines in at least two of the planes and to determine the point of entry of the dart into the board based on the intersection of the imaginary lines of one or more of the planes adjusted according to the angle of incidence.

Each transmitter may be a point source, or be constrained by a small aperture and transmit a divergent beam of radiation, or transmit a broadcast radiation which encompasses the whole of the surface. The transmitter may be rotated and/or translated to sweep the beam across the surface. As the transmitter passes on the opposite side of the object to the receiver the receiver will be illuminated by the transmitter, except when the transmitter is directly opposite a receiver at which time the shadow of the object will fall on the receiver. The position of the transmitter can be detected at the moment the shadow falls on the receiver. The position of the receiver is fixed and so an imaginary line connecting the transmitter at the moment of the fall of the shadow must pass through the position of the object. If two imaginary lines are determined, the intersection of the two lines fixes the location of the object.

Where a plurality of receivers is mounted at spaced locations around the surface and the transmitter circulated around the surface each receiver may be used to calculate a line of location

- 4 -

of the object. If at least three receivers are provided improved accuracy may be obtained, and allowance may be made for detecting a second object on the surface which may be masked from a receiver by the first object.

- 5 Preferably, the receivers are mounted in a circle around the surface and the transmitter moved around a concentric circle. This facilitates calculation of the object's position.

- 10 Preferably, the transmitter is mounted on an arm which is driven by a stepper motor. By counting the pulses fed to the motor the position of the arm and hence the position of the transmitter may be calculated. Preferably markers are located in predetermined positions to enable calibration of the apparatus.

- 15 According to a further aspect of the invention there is provided apparatus for determining the location of an object relative to a surface comprising a transmitter arranged to direct radiation across the surface, a receiver arranged to receive the radiation which has been directed across the surface from the transmitter, means for moving the transmitter or receiver relative to surface in a plane generally parallel to the surface and for continuously
20 monitoring the position thereof, means for responding to changes of intensity of radiation received caused by the shadow of the object falling on the receiver corresponding to the beginning and the end of the shadow, computing means arranged to respond at those moments of change of intensity to outputs of the monitoring
25 means relating to the position of the transmitter or receiver to provide two position lines extending between the transmitter and receiver at those moments and to calculate (from the relative positions of the transmitter and receiver, the angle between the position lines and the predetermined or known effective width of
30 the object) the position of the object relative to the surface.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

- 5 -

Figs 1a to 1d illustrate the method used for determining the location of an object on the surface;

Fig 2A shows a side view and partial plan view of an embodiment of the invention;

5 Figs 2B to 2F show modifications of the embodiment of Fig 2A;

Fig 3 shows a system diagram for a control and power supply circuit for the embodiment of Fig 2A;

Fig 4 shows a timing diagram for the circuit of Fig 3;

Fig 5 shows a modified control and power supply circuit; and

10 Fig 6 shows a modified timing system.

15 In Fig 1a, eight receivers R_1 to R_8 are positioned at equal intervals on a circle around a dartboard 1. It will be appreciated that fewer or more receivers may be used and they need not be equally spaced. A transmitter T moves around the dartboard. As may be seen in the embodiments described hereinafter the transmitter T preferably rotates within the receiver circle to minimise the number of obstructions or objects

20 As the transmitter T reaches a position T_a at which it is aligned with a dart 0 and the receiver R_3 on the opposite side, a first imaginary line for the position of the dart 0 is determined. Similarly, when the transmitter reaches position T_b it is aligned with the dart 0 and the receiver T_4 and a second imaginary line for the position of the dart is determined. The actual location of the dart may then be calculated from the intersection of these
25 two imaginary lines.

- 6 -

Referring to Fig 1b, the transmitter gives a divergent beam, which may in fact be a broadcast beam. As the transmitter passes directly behind the dart O, a specific receiver R will be in shadow. The position of the transmitter T as the receiver R passes into the shadow is noted. The shadow will occur in each cycle between when that receiver is first and last illuminated by the transmitter. The mid-point could be used to determine one respective imaginary line. However the arrival of the shadow is used to provide a signal for determining the position line. The width of the receiver is generally about the same as the width of a dart. If only the leading edge of the shadow is relied upon, location of the dart can be achieved based upon the arrival of the leading edge and adjustments corresponding to the proportion of the receiver which is obscured by the shadow.

Fig 1c illustrates the detection of a sloping dart. The position of the dart is detected in three planes P_1 , P_2 , and P_3 above the surface 1. Three detected positions enable the centre or axial line C of the object as well as the orientation of the dart and the point of contact with the surface to be determined. Darts vary in shape along their length and it can be seen that in plane P_2 the detected position D_2 may not be on the centre line C. This can be compensated for by having a first plane P_1 close to the surface to detect the dart tip, and a second P_3 towards the rear end of the dart. The detected position in the intermediate plane P_2 can then be ignored.

One important practical aspect provided by the embodiment is that the light emitted by the transmitters is not focussed and diverges naturally. Thus, where light from three transmitters T_1 , T_2 and T_3 are used respectively for the planes P_1 , P_2 and P_3 , the light from transmitter T_1 say, will impinge on all receivers R_1 , R_2 and R_3 respectively in the three planes. This would normally cause faulty location measurements but for the fact that signals from R_1 , R_2 and R_3 are read cyclically and in synchronism with the timed presence of outputs of P_1 , P_2 and P_3 respectively.

- 7 -

It is possible, to provide extra information for checking the accuracy or identifying one dart from another and so on, to synchronise additionally, say, the output of T_1 with the receiver R_3 . In any event an accuracy of half the thickness of a wire on the board, or better can be achieved by the described apparatus.

In Fig 1d a more detailed drawing shows how the locating accuracy of typical darts is maintained. Referring to the left hand dart in Fig 1d, the distance between the inner and centre planes P_1 , P_2 is arranged to be greater than the tapered length B of the dart, divided by $2^{\frac{1}{2}}$ (root 2). If the calculated width A of the dart in plane P_1 is less than or equal to 0.1 inches (2.5mm) divided by $2^{\frac{1}{2}}$, the orientation and position is calculated using planes P_1 and P_3 . When dimension A is greater than this, the orientation and position are calculated using planes P_3 and P_2 . The width of a dart in a plane may be calculated from the width of the shadow cast by the dart, after its position has been calculated.

Fig 2A shows the general construction of the embodiment. A dartboard 1 is mounted on a baseboard 2 by three eccentric cams 5 at its edge, the cams 5 are rotated to adjust the position of the board 1. Springs 3 urge the board against lips 4 on the cams 5. The base board 2 is mounted in a box 7 by three mounting bolts which carry the cams 5. The bolts 6 are spaced at unequal angles and provide a fixed reference or datum for the transmitter and receiver circuit.

Eight sets of receivers 8 comprising photodiodes are mounted on the front wall of the box 7. A set of transmitters 9 comprising infra-red light-emitting diodes is mounted on an arm 10 which is rotated about a centre bearing 11 by means of a stepper motor 12 mounted on the arm 10. The motor 12 has a pulley 13 which carries a belt 14 which encircles a central pulley 15. As the motor 12 rotates the pulley 13 the motor will rotate around the central pulley. The centre bearing 11 has an aperture for receiving an

- 8 -

alignment jig which can be used for aligning the receivers and transmitter prior to mounting of the dartboard.

Power and control is carried to the arm 10 by means of two slip rings 16, 17 and an optical link 18. The optical link carries control pulses for energising driving the stepper motor 12.

Fig 2B shows another construction in which the baseboard is fixed to the back wall of the box 7. A drawback of this is that the centre mounting 20 may be weak and posts, such as studs 6, may still be needed to mount protecting hoops 19. Fig 2C shows another construction in which a transparent hoop 21 is used to mount the baseboard on the front wall of the box 7, but this may diffract the light beam, causing errors in calculating the position of a dart. The hoop may have the cross-section of Fig 2E with cut-outs to allow the detector beams to pass through unaltered.

In Fig 2D, the arm 10 is rotated by a stationary non-synchronous motor 22 by means of a belt 23 encircling pulleys on the motor 22 and the arm 10. A high frequency alternator 24 on the arm is driven by a belt 26 which encircles a stationary pulley 25 to power the arm. The brushes of Fig 2A may be retained and the alternator replaced by a shaft encoder for indicating the position of the transmitter. Yet another means for avoiding the use of slip rings and an optical link, is to employ a high frequency transformer with the primary static and the secondary moving, the whole assembly being concentric.

Fig 2F shows a shielding system which may be used to protect the receivers and transmitter from stray darts. The hoops 19 are mounted on the studs 6 and increase in diameter towards the baseboard 2. The hoops are spaced apart by a few millimetres to allow the passage of light along the planes P_1 , P_2 and P_3 as indicated.

- 9 -

Fig 3 is a schematic diagram illustrating a control system for the apparatus of Fig 2, and Fig 4 shows a timing diagram for the signals at the positions indicated in Fig 3.

5 The diagram of Fig 3 shows the static and moving parts of the system as indicated. The ramp-up generator is provided to accelerate the stepper motor. When the power supply goes up the voltage controlled oscillator frequency rises under the control of the ramp generator to reach a chosen frequency. When power is established in the arm the missing pulse detector (MPD) will
10 operate spuriously until the chosen voltage controlled oscillator frequency is reached. The step commands for the motor are derived from the divide by 3 circuit until the mode is changed by the timer, whose period is greater than the ramp time. The missing pulse detector MPD is retriggerable of period greater than t and
15 less than $2t$ (see Fig 4).

Yet another embodiment utilises the alternator system described with respect to Fig 2D, driven by a motor and integral gearbox. An integrally formed plastics box houses the dartboard, transmitter and receivers. An external power supply and data
20 processor is linked to the box. A schematic of the circuitry is shown in Fig 5 and an improved timing system in Fig 6.

In operation, the dartboard is positioned approximately, held by the cams 5. Two markers are positioned on the board, for example one in the centre and another at 12 o'clock (top dead centre) on
25 the outer wire. The detector is then run and the dartboard moved using the cams until the markers are detected to be in their correct positions.

In use, the set of transmitters 9 is rotated around the dartboard continuously in a stepped manner by the stepping motor at about 60
30 rpm. The transmitter is activated to give a pulse of broadcast or wide beam radiation on each step. The sets of receivers 8 detect

- 10 -

the received light from infra-red light-emitting diodes in the transmitter 9 and pass this information to a central processor. The intensity of light received by each detector reduces significantly the moment that particularly detector falls in the shadow of the dart. It can be seen that the studs 6 may be detected and provide continuous recalibration of the apparatus, their position being known.

There are three transmitters in each set positioned to rotate respectively in planes P_1 , P_2 and P_3 (Figure 1c) and corresponding three receivers in each set of receivers positioned in the three planes.

During a game of darts because of the speed of rotation, the dart can be rapidly located and its location determined. When a second dart is thrown new data about it can be distinguished from information of the first dart. In practice one revolution of the transmitter is usually sufficient to identify and calculate where a dart has landed. The position of the darts may also be calculated after all darts have been thrown.

The end of a turn at throwing may be determined when a large object, for example the players hand, is detected by casting a recognisable large shadow on the detectors. Preferably, a count of the number of darts is made at the end of each turn to ensure that none of the darts has fallen out, possibly requiring a re-calculation of the score obtained. Allowance may also need to be made for a dart changing its angle of orientation in the board during the detection procedure.

Before a game the accuracy of the calibration may be checked simply by throwing a dart into the board and checking the accuracy of the result provided by the apparatus. The positions of the darts, and hence the score, are preferably displayed on a Visual Display Unit. A keyboard input may be provided for variation of any indicated entry, eg cancellation of a foul throw, and means

- 11 -

provided for automatically displaying a game result.

5 A "touch pad" may be provided adjacent or part of the dartboard within the area being scanned by the described apparatus to take instructions, for example the type of game being played and especially the target score. The pad may be touched with a dart or the like whose location is detected by the apparatus and the appropriate commands relayed to the central processor.

10 The transmitters and receivers are normally completely unlicensed, thus using the broadcast radiation which is received from any direction in the wide angle receivers so formed. This makes the required components comparatively cheap.

15 It is also to be noted that detection at the receivers is of the changes of intensity of illumination, rather than particular amplitudes. Ambient light conditions are rarely constant, changing with time of day in daylight and at mains frequency in artificial lighting. The use of capacitance coupling in the detection circuitry enables variant ambient lighting to be distinguished from the shadow/non-shadow detection of the pulsed signals from the transmitters. Thus the darts are readily located
20 in varying daylight or artificial lighting, despite normally varying at mains frequency. Pulsed infra-red is used in the described embodiments and changes in the received intensity falling inside a wide arc of illumination produced by a moving source used to locate the shadows of the darts as the basis of
25 determining their locations.

It is of course possible to have one or more stationary sources of radiation and moving detectors. Instead of monitoring the rotational position of the transmitter at all times as described above, the incidence of the shadows in relation to the
30 instantaneous positions of the receivers is continuously monitored. As the position of the transmitters is known, being fixed, the imaginary lines of location are determined by the

- 12 -

moments in time, hence the position of the receivers, at which the shadows fall on the receivers.

In the embodiment described, one set of three transmitters are used and eight sets (twenty four) receivers. This enables
5 locations in the three planes P_1 , P_2 and P_3 and provides a reasonable compromise of cost and absolute accuracy. As a minimum however a single transmitter and a single receiver can be used, the transmitter or the receiver being moved. In this arrangement, two position lines are determined by monitoring the beginning and
10 the end of the shadow. Thus, one line extends "tangentially" across the surface of the object and connects the receiver to the transmitter at the moment the leading edge of the shadow falls on the receiver. The other line extends "tangentially" across the opposite surface of the object and connects the receiver to the
15 transmitter at the moment the trailing edge of the shadow leaves the receiver. The positions of the transmitter and receiver are known at those two moments and provided the effective diameter or width of the object is also known or has been predetermined, its location on the surface can be computed. Darts are not
20 necessarily of the same diameters so as a practical minimum for locating darts and the like, it is possible to use either one transmitter and two receivers or one receiver and two transmitters, although such arrangements could not always accurately locate darts sticking in the board except when their
25 longitudinal axis is at or near 90° to the plane of the board. For applications for locating, say, plugs in a board which have known effective diameters and are always at 90° to the surface of the board, the minimum components mentioned above could provide data for accurate and reliable location of the plugs.

30 Embodiments of the invention may be used to locate a drill of a drilling machine in respect of a surface in which the drill must drill holes or even the position of a drill in respect of say its own bedplate. The incident angle of the drill can also be determined using two or more planes of location, in the same

- 13 -

manner as the angle of dart is measured. The longitudinal movement or position of the drill can be determined as it enters say the three planes P_1 , P_2 and P_3 or more planes. As the drill moves or is positioned further forward from its support it will cast shadows progressively in the various planes for detection by the receiver or receivers corresponding to the planes to determine its distance from the surface.

In the described arrangement a "touch pad" was mentioned and one embodiment of the invention comprises a touch pad on its own for use in addressing a computer, or for use as a key board for a machine, such as a typewriter, calculator or an engineering cutting tool. The touch pad is marked out in the usual way with symbols, numbers and the like on its surface. The transmitters and receiver are suitably positioned around its surface. If a pointed instrument, similar to a dart say, is manually held against the surface of the touch pad or in some cases simply held close enough to the surface to cast shadows on the receiver or receivers in the manner described above in relation to the darts scorer, the relative location of the instrument on the touch pad is determined and the appropriate instruction relayed to the typewriter, calculator or whatever. Naturally, as the arrangement of transmitters and receivers can provide the location data very rapidly, the instrument could be used to write or draw on a touch pad or similar and the location data used to continually control a cathode ray tube or other a visual display to provide an image of the writing or drawing as it takes place.

CLAIMS

1. Apparatus for determining the location of an object relative to a surface comprising one or two transmitters around the edge of the surface arranged to direct radiation across the surface and two or one receivers respectively around the edge of the surface arranged to detect the intensity of the radiation which has been directed across the surface, means for moving the transmitters or receivers relative to the surface and monitoring that movement such that at least two imaginary position lines extending across the surface can be identified by detecting the moments of the fall of intensity of radiation as the shadows of the object impinge on the receiver or receivers, the imaginary lines connecting the position of each particular transmitter and each particular receiver at corresponding moments of reduced intensity, the intersection of the two imaginary position lines determining the location of the object.
2. Apparatus according to Claim 1 in which there are further transmitters and further receivers around the surface to transmit and receive radiation respectively in two or more planes near to and generally parallel to the plane of the surface to determine location of the object in those two or more planes, and computing means arranged to receive the locating data for the two or more planes from which the mean angle of incidence of the object relative the surface is computed and to provide, taking into account the angle of incidence, an output indicative of the point on the surface from which the object extends.
3. Apparatus according to Claim 1 in which the transmitters provide pulsed infra-red radiation.
4. A darts scoring apparatus including apparatus for determining the location of a dart on a dart board including a number of transmitters positioned around the edge of the board arranged to direct radiation across the surface of the board; a number of receivers positioned around the edge of the board arranged to

- 15 -

5 detect the intensity of radiation which has been directed across the board; means for moving the transmitters and/or receivers relative to the board; and monitoring means arranged at each of the moments that a shadow of the dart impinges each receiver to monitor both the position of the transmitter then transmitting and the position of the shaded receiver to identify imaginary position lines joining the transmitters to the receivers extending across the board, and computing means arranged to compute the intersection of the imaginary lines to determine the location of the dart.

10 5. A darts scorer according to Claim 4, in which receivers are arranged to receive radiation in two or more respective planes near to and parallel to the surface of the dart board to enable location of the dart in those two or more planes to be determined, the multiple plane locations providing a measure of the angle of incidence of the dart, the computing means being arranged to adjust the location provided by the intersection of the imaginary lines according to the angle of incidence to locate the point of entry of the dart into the board irrespective of its angle of entry.

20 6. A dart scoring apparatus according to Claim 4 in which each transmitter is an infra-red transmitter.

7. A dart scoring apparatus according to Claim 5 in which the transmitters are infra-red transmitters.

8. A dart scoring apparatus according to Claim 6 in which each transmitter is arranged to produce a pulsed output.

25 9. A darts scoring apparatus in which the transmitters are arranged to produce pulsed outputs.

30 10. A darts scoring apparatus including one set of three infra-red transmitters mounted for rotation around a darts board, at least two sets of three receivers mounted around the edge of the darts board to receive radiation from the transmitters, the three transmitters being spaced apart in a direction transverse to the

- 16 -

surface of the board so as to move in separate planes which extend across near to and parallel to the surface of the board, the three receivers of each set being mounted to detect radiation respectively in the three planes, means for continually monitoring the positions of the transmitters, means responding to reductions of intensity at each receiver as they fall in turn into the shadow of the dart, means for synchronising the receipt of shadow signals and the transmitter outputs such that imaginary lines can be identified connecting respective transmitters and receivers in all three planes, computing means to determine the angle of incidence of the dart based on its relative location at the intersection of the imaginary lines in at least two of the planes and to determine the point of entry of the dart into the board based on the intersection of the imaginary lines of one or more of the planes adjusted according to the angle of incidence.

11. Apparatus for determining the location of an object relative to a surface comprising a transmitter arranged to direct radiation across the surface, a receiver arranged to receive the radiation which has been directed across the surface from the transmitter, means for moving the transmitter or receiver relative to surface in a plane generally parallel to the surface and for continuously monitoring the position thereof, means for responding to changes of intensity of radiation received caused by the shadow of the object falling on the receiver corresponding to the beginning and the end of the shadow, computing means arranged to respond at those moments of change of intensity to outputs of the monitoring means relating to the position of the transmitter or receiver to provide two position lines extending between the transmitter and receiver at those moments and to calculate (from the relative positions of the transmitter and receiver, the angle between the position lines and predetermined or known effective width of the object) the position of the object relative to the surface.

1/5

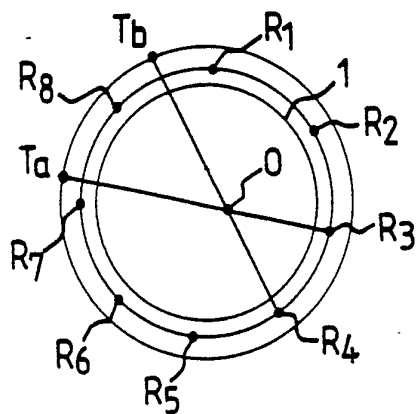


FIG. 1a.

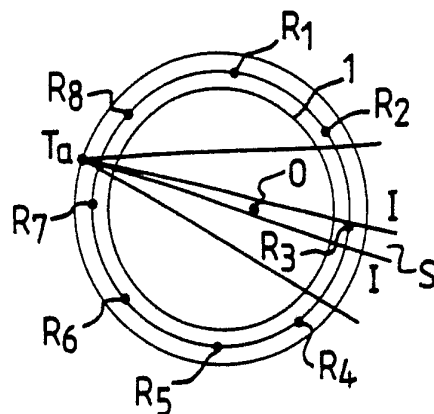


FIG. 1b.

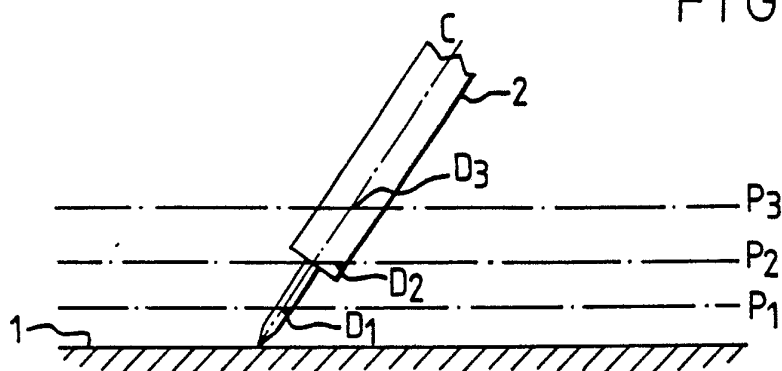


FIG. 1c.

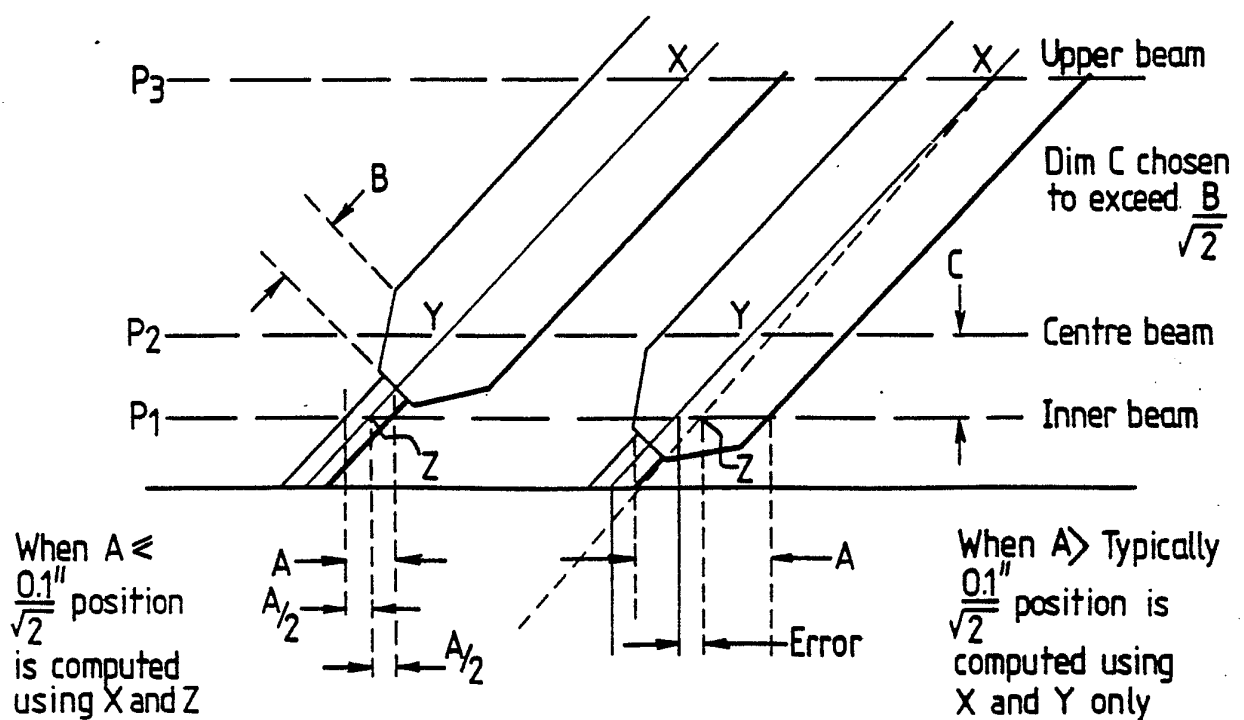


FIG. 1d.

2/5

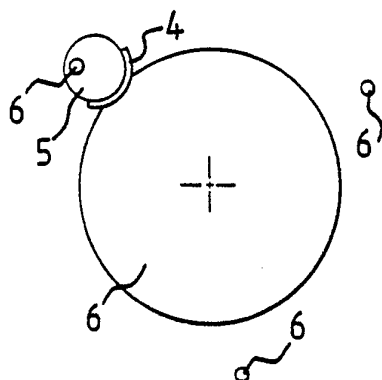


FIG. 2A.

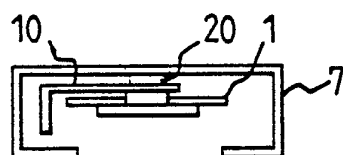
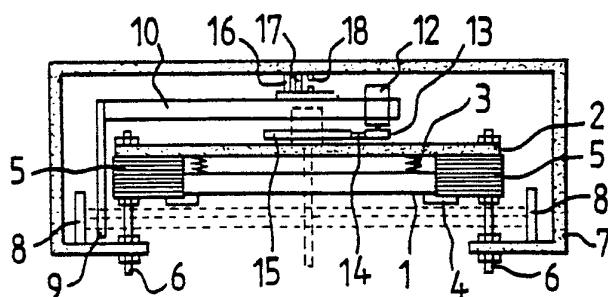


FIG. 2B.



FIG. 2C.

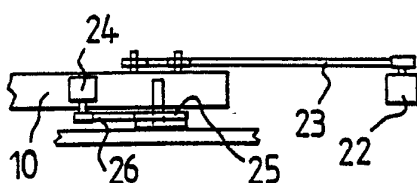


FIG. 2D.



FIG. 2E

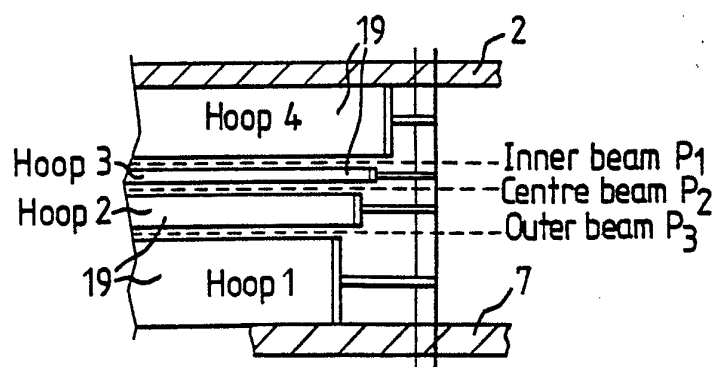


FIG. 2F.

3/5

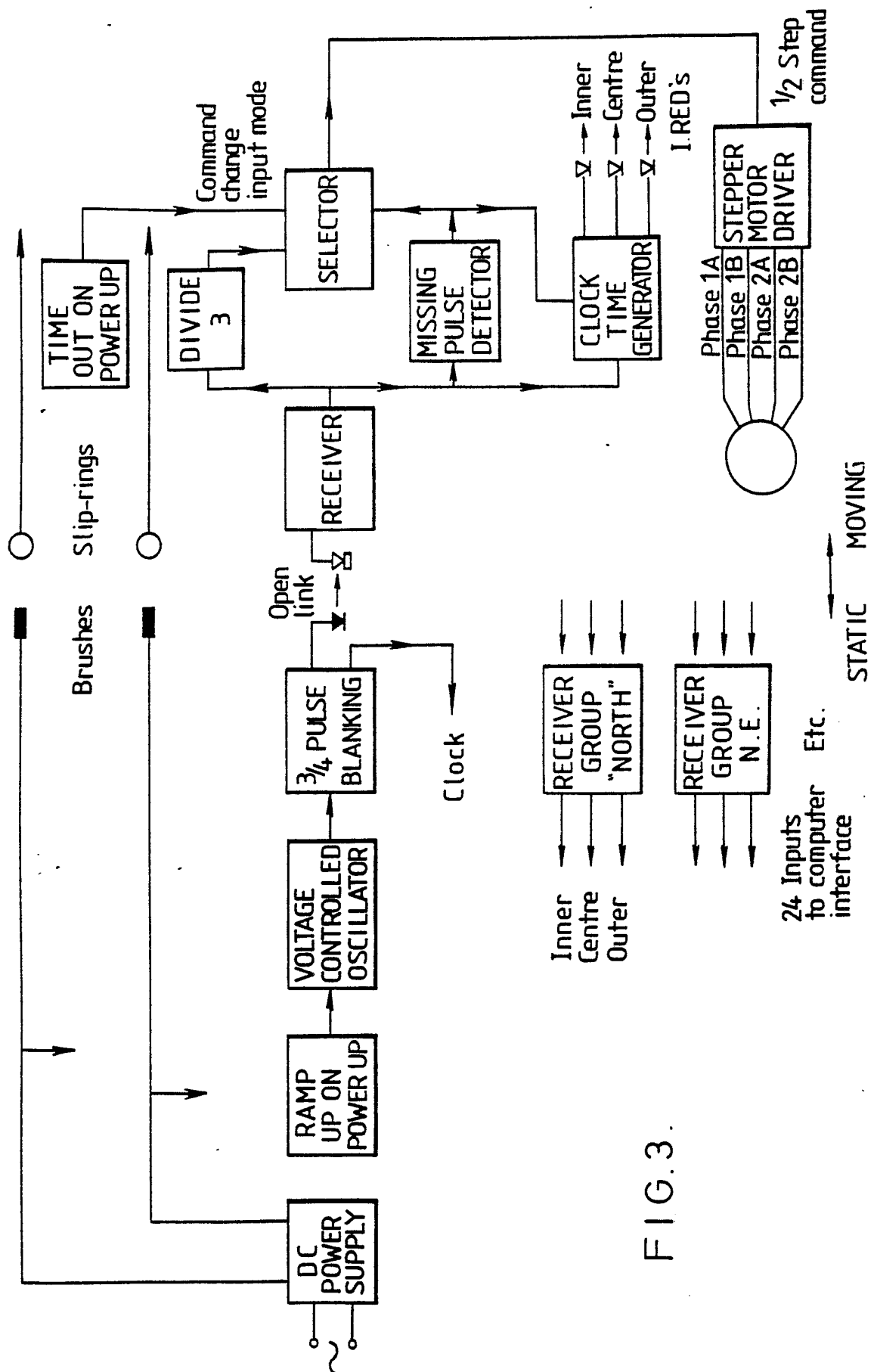


FIG. 3.

4/5

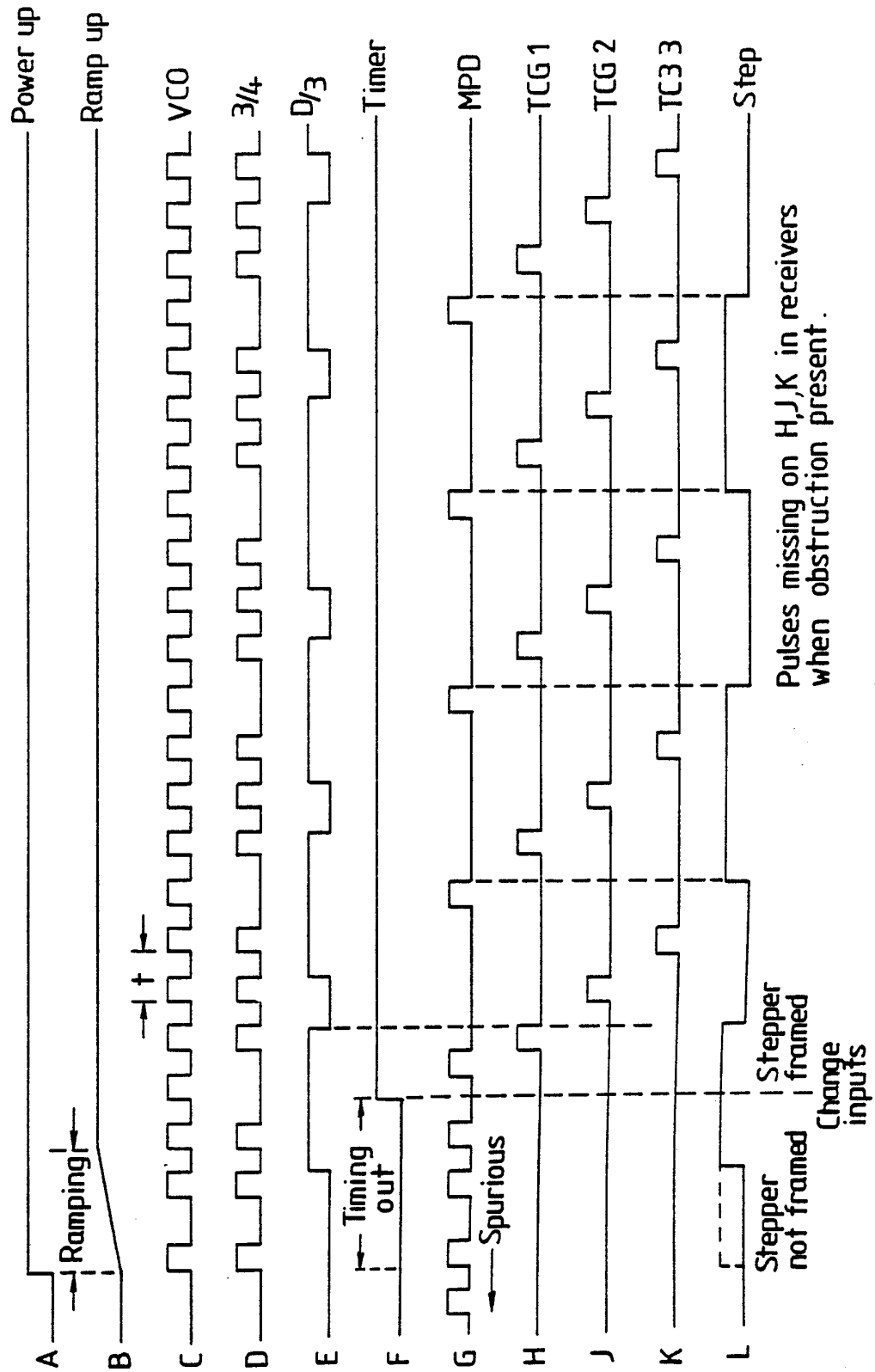


FIG. 4.

5/5

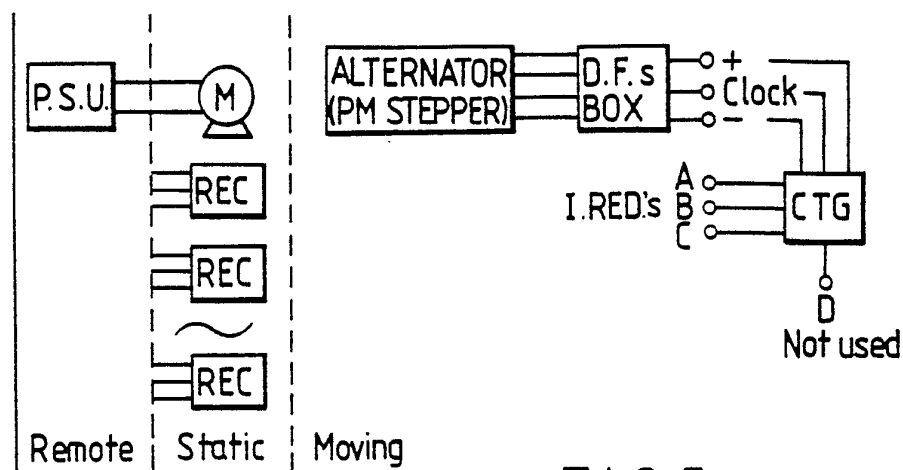


FIG.5.

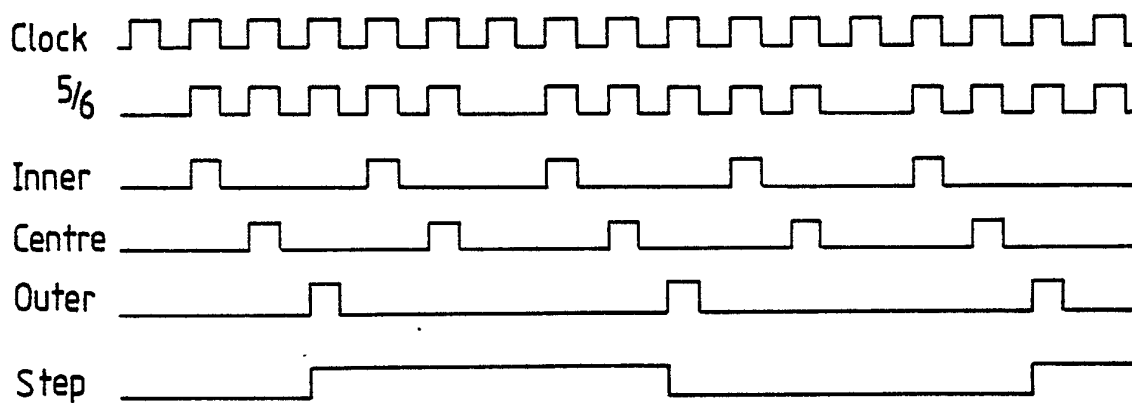
Improved timing system

FIG.6.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00177

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : F 41 J 5/02; G 01 B 11/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	F 41 J; G 01 B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	GB, A, 2159269 (FUSCONE) 27 November 1985, see abstract; figures 1,2,5-7	1,2,4,5 10,11
A	--	
A,P	EP, A, 0182397 (MUSSELMAN) 28 May 1986	
A	--	
A	US, A, 3047723 (KNAPP) 31 July 1962	
A	US, A, 3727069 (CRITTENDEN) 10 April 1973	

* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "Δ" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
4 June 1987	- 8 JUL 1987	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	M. VAN MOL	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 87/00177 (SA 16493)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 24/06/87

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2159269	27/11/85	None	
EP-A- 0182397	28/05/86	None	
US-A- 3047723		None	
US-A- 3727069	10/04/73	None	

For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82