PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

EP.0052122

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3:
H04N 7/18, 5/32; G01N 23/04

A1

(11) International Publication Number: WO 81/03594

(43) International Publication Date: 10 December 1981 (10.12.81)

(21) International Application Number: PCT/AU81/00068

(22) International Filing Date: 3 June 1981 (03.06.81)

(31) Priority Application Number: PE 3854

(32) Priority Date: 3 June 1980 (03.06.80)

(33) Priority Country: AU

(71) Applicant *(for all designated States except US):* COMMONWEALTH OF AUSTRALIA [AU/AU]; Anzac Park West, Canberra A.C.T. 2600 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only):* BROWN, Gregory, Cleave [AU/AU]; 18 Hedderwick Street, Essendon, Vic. 3040 (AU). QUINN, James, Dominic [AU/AU]; 31 Bennett Parade, East Kew, Vic. 3102 (AU). SILVA, Stanley, Robert [AU/AU]; 8 Barbara Street, Doncaster East, Vic. 3109 (AU). WILLIAMS, David, William [GB/AU]; 3 Bournian Avenue, Strathmore, Vic. 3041 (AU). WU, Kenneth, Kwan, Mow [AU/AU]; 29 St. Georges Road, Toorak, Vic. 3142 (AU).

(74) Agent: CLEMENT HACK & CO.; 140 William Street, Melbourne, Vic. 3000 (AU).

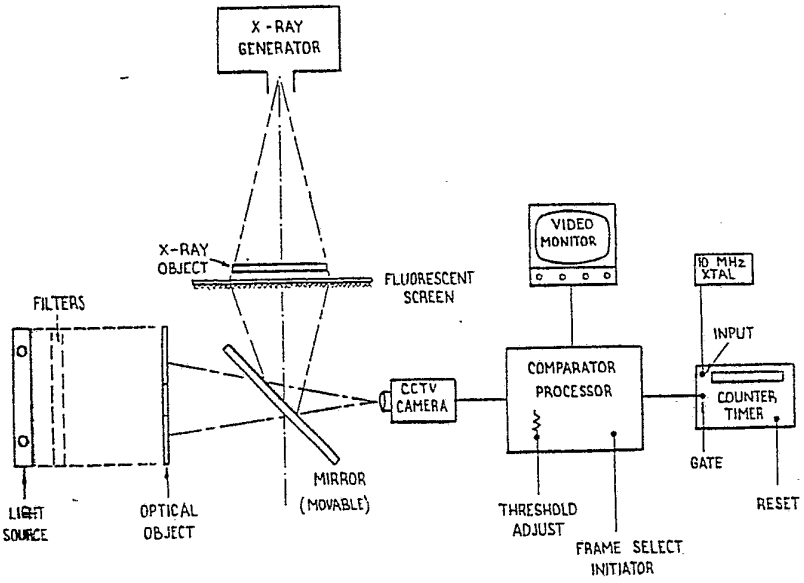
(81) Designated States: AU, CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, NL (European patent), SE (European patent), US.

Published
With international search report
With amended claims and statement

(54) Title: IMAGE ANALYSIS SYSTEM

(57) Abstract

Image analysing method and system, and in particular method and system for analysing X-ray radioscopic images of the contents of an article of mail to detect the presence of improvised explosive devices (IED's). The system comprises a CCTV camera to scan the image and provide video signals (CV), and signal processing means (1) to compare the level of said video signals (CV) with a predetermined threshold value and to provide an output pulse (D) when said signal intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image, and in particular, as applied to the detection of IED's, to provide an output pulse (D) when the signal intensity is less than said predetermined threshold value, and means (4) to count said pulses for a particular zone on said image and provide an output signal (Y) indicative of the extent of dark areas on the image and as an indication of the presence of an IED.



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	**KP**	Democratic People's Republic of Korea
AU	Australia	**LI**	Liechtenstein
BR	Brazil	**LU**	Luxembourg
CF	Central African Republic	**MC**	Monaco
CG	Congo	**MG**	Madagascar
CH	Switzerland	**MW**	Malawi
CM	Cameroon	**NL**	Netherlands
DE	Germany, Federal Republic of	**NO**	Norway
DK	Denmark	**RO**	Romania
FI	Finland	**SE**	Sweden
FR	France	**SN**	Senegal
GA	Gabon	**SU**	Soviet Union
GB	United Kingdom	**TD**	Chad
HU	Hungary	**TG**	Togo
JP	Japan	**US**	United States of America

"IMAGE ANALYSIS SYSTEM"

Technical Field

This invention relates to an image analysis system, and particularly, but not exclusively, an image analysis system to form part of a system for the detection of improvised explosive devices (IED's), and more particularly to improvements in such detection techniques involving the use of X-ray fluoroscopy.

Although the inventive image analysis system has been developed primarily to analyse an X-ray radioscopic or radiographic image of the contents of an article of mail under investigation for the possible presence of an IED, the system also has applications, such as;

the analysis of satellite photographs, for example to estimate the area of ground under tree cover (dark areas) or non-vegetated areas (light areas);

automatic video surveillance systems to detect the presence of an intruder in the area under surveillance;

analysis of radioscopic or radiographic images in general; and analysis of colour images by the use of infra-red, ultra-violet, and other forms of filters.

BUREAU OMPI INTERNATIONAL

However, The bulk of the remaining description, including the preferred embodiment, will be directed to the particular application of the image analysis system as part of a system for detecting IED's.

Background Art

Historically there are several techniques and devices employed in the detection of IED's, the principal ones being X-ray fluoroscopy and vapour trace detection. The former technique has involved visual examination of an X-ray image, and is dependent on the sustained alertness and interpretative ability of a human operator, whilst the main problem with vapour trace detection techniques is that they can be readily countered by suitable containment of the explosive device, and furthermore they are incapable of detecting some of the types of explosives commonly used.

The use of X-ray fluoroscopy techniques are still the most feasible because of the following advantages that they offer.

1. Penetration of covering material to reveal internal contents.
2. Detection based on distinctive densitometric and geometric properties of IED components.
3. Independence from chemical characteristics of explosives, such as the escape of volatiles.
4. Potential capability for virtually certain detection combined with extremely low incidence of false alarms.
5. Additions to explosive can be considered and exploited to ensure a virtually unique response to X-ray fluorescence.

BUREAU OMPI INTERNATIONAL

6. The technique is competitive with most other techniques with regard to cost, compactness and portability.
7. Both technological and scientific advances with regard to X-ray sources, image pattern recognition techniques and microprocessors can be adapted.
8. The technique also offers flexibility in being able to cope with any new IED designs.

However, the three main disadvantages associated with existing X-ray fluoroscopy detection techniques are:

(a) The radiation health hazard associated therewith unless the apparatus is suitably designed.
(b) They do not have a primary locating capacity.
(c) Insofar as, as discussed previously, they require sustained alertness and interpretative ability of a human operator, they may be impractical and inefficient in a high throughput situation as in mail handling.

Although the present invention is not used in a detection system specifically directed to overcoming the first disadvantage (a) referred to above, it can be eliminated by the use of relatively low energy X-rays, limitation of dose and incorporation of effective shielding in the design of the detection system.

Furthermore, although the present invention is not used in a detection system specifically directed to overcoming the second disadvantage (b) mentioned above,

BUREAU OMPI INTERNATIONAL

which particularly relates to the capacity to search for and locate an IED the position of which is not known, it should be noted that almost all IED detection techniques can only detect when in close proximity to the IED, with the exception of some techniques based on vapour trace detection which have some limited capability in this regard.

The present invention, amongst other applications, can be incorporated in a detection system designed to overcome the third disadvantage (c) mentioned above, and having as its objective to produce a more practical and efficient system for analysing an image produced by X-ray fluoroscopy whilst coping with the throughput speeds of normal mail processing, that is, a technique and system operating on a real time basis.

As applied to the detection of IED's the present invention involves identification and therefore detection by image analysis of explosive devices in situations where a number of apparently similar items are present, by utilising the particular characteristic qualities of the radioscopic images produced by such explosive devices. The radioscopic image of a lethal IED possesses a minimum proportion of dark area caused by the presence of X-ray absorbing material essential to the operation of the IED, and in particular a lead azide primer charge, present in the most commonly used commercially available detonators required to detonate an explosive charge. In such an application the present invention involves discerning the presence of such a material as distinct from the radioscopic images produced by other items present, which in the case of mail processing may be various types of paper clips. It is important that these articles be distinguished from an IED and the article of mail in question not diverted.

BUREAU OMPI INTERNATIONAL

As such items are present in relatively large numbers in mail the lack of such a capability would mean a relatively large amount of the mail would be necessarily diverted for special attention thus seriously inhibiting the rapidity and efficiency of the mail sorting operation.

As applied to the detection of IED's, the present invention utilises the above characteristic of the fluorescent image produced by an IED by employing a closed circuit television (CCTV) camera which provides video signals from which the extent of dark areas of the images produced may be measured in terms of the duration of any signal whose intensity is less than a predetermined value. A signal designating the category of each item displayed in the image frame as either safe, or potentially harmful, is generated based on the total area count and is immediately available on completion of a scan of one complete image frame on the CCTV camera.

Disclosure of the Invention

The invention may therefore envisage an apparatus for analysing images comprising a CCTV camera to scan said image and provide video signals, and means to process said video signals so as to provide an indication of the duration of any signal whose intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image.

The invention may also envisage a method of analysing images, comprising the steps of scanning said image with a CCTV camera to produce video signals, and processing said signals so as to provide an indication of the duration of any signal whose intensity varies from a

BUREAU OMPI INTERNATIONAL

predetermined value as a measure of the extent of dark or light areas on the image.

In one application of the invention as incorporated in an apparatus for the detection of improvised explosive devices, an X-ray fluorescent image of the contents of the article under investigation is produced, which is then analysed in accordance with the invention to provide a measure of the extent of dark areas on the image likely to result from the presence of an IED.

With the above application of the invention a total pulse count, recorded within the scan time, which is below a predetermined threshold count indicates that the dark area of the image density is below that normally associated with a lethal IED, and thus indicates that the article is safe. However, above threshold counts merely indicate the possibility of an IED being present in the article under investigation and further checks can then be carried out either by way of visual examination or by the application of more sophisticated analysing equipment.

In summary, the invention as applied to the detection of IED's, basically rests with an electronic system utilising a CCTV camera to rapidly clear any large number of articles, such as mail, as being safe, whilst if the throughput amount is relatively small a trained operator may be sufficient to clear any items detected as being possibly harmful, whilst in systems involving a relatively large number of articles more sophisticated analysing equipment may be utilised to screen the possibly harmful articles detected by the system of the present invention.

Brief Description of the Drawings

One preferred form of the invention, particularly as applied in a system for the screening of mail, will

BUREAU OMPI WIPO INTERNATIONAL

PCT/AU 81/00068

now be described with reference to the accompanying drawings in which;

Figure 1 is a view of an actual radioscopic image of the contents of a pre-prepared envelope containing electric detonators and a number of other items commonly present in mail,

Figures 2A and 2B are graphs representing measurements along line X-Y of the radiograph of Figure 1 as recorded on a photodensitometer,

Figure 3 is a schematic layout of the apparatus of this preferred form of the present invention,

Figure 4 is a series of optical test patterns produced from the photodensitometer traces of Figures 2A and 2B,

Figure 5 is a schematic illustration of the basic circuitry for processing the video signal provided by the CCTV camera,

Figure 6 is a detailed circuit diagram for the video buffer and synchronising separator in the circuitry of Figure 5,

Figure 7 is a detailed circuit diagram for the video buffer and comparator in the circuitry of Figure 5,

Figure 8 is a detailed circuit diagram for the clamp drive and window reset in the circuitry of Figure 5,

Figure 9 is a detailed circuit diagram for the horizontal and vertical window generator in the circuitry of Figure 5,

Figures 10A to 10C together form a detailed circuit diagram for the dark area counter and comparator in the circuitry of Figure 5,

BUREAU CMPI WIPO

Figure 11 is a detailed circuit diagram for the double field counter in the circuitry of Figure 5, and

Figure 12 is a detailed circuit diagram for the output mixer in the circuitry of Figure 5.

Best Mode for Carrying out the Invention

Feasibility investigations have been carried out to determine an optimum X-ray energy for use with routine mail packages of varying thickness, generally greater than 3 mm. The X-ray characteristics required produce a low beam attenuation in paper, while retaining a sufficiently high attenuation in metal to enable the detection of high X-ray dense material characteristic of IED construction.

A test object was devised, as shown in Figure 1, which consisted of two X-ray simulated electric detonators, one of which was partially flattened, together with a number of other metal articles including paper fasteners and electrical copper leads, all arranged on a thin card support. Two radioscopic images of the test object were produced, the first taken of the test object alone and the second including 20 mm thickness of zinc oxide impregnated copying paper. This type of paper has a high X-ray absorption. Irradiation conditions were the same in each case using X-rays generated at 77 kV and filtered with a sheet of lead 0.34 mm thick. The exposure conditions were 720 mAs at 1000 mm source to film distance.

Measurements on the radioscopic images along section X-Y in Figure 1 were recorded on a photodensitometer, the resulting graphs are shown in Figures 2A and 2B. The ordinates correspond to the percentage of light transmitted through the radiograph and hence provide a quantitative measure of the X-ray absorption

BUREAU OMPI INTERNATIONAL

PCT/AU 81/00068

for a given component of the test object. The linear resolution of these graphs approximates to that of a CCTV camera with an image size of 300 x 400 mm and a resolution of 0.7 mm.

The densitometric traces show the transmission factor of the radioscopic image to exceed 10% on four occasions, during the two tests, reference numbers 4 and 5 in Figures 2A and 2B, due in each case to the high X-ray absorption of the simulated ASA primer charge containing lead azide in the electric detonator. Further measurements show a reading of up to 10% is obtained for the central regions of a paper fastener. However readings for wire paper clips and staples are significantly lower than 10% transmission.

These figures indicate that a selection parameter operating on intensity alone can discriminate between mail articles containing electric detonators and the more commonly found commercial mail inclusions. However, the transmission factor cannot be used to discriminate between paper fasteners as viewed end on and the ASA of electric detonators.

A further effect evident on comparison of the two traces is the decreased signal to noise ratio when the test object included the copying paper. This is due to the X-rays being scattered within the bulk of the paper. Some of this scattered radiation falls on parts of the film or screen normally occluded by such components as the lead azide. The effect of X-ray scatter produced in materials like paper can limit the effectiveness of a discriminator when applied to increased thicknesses of materials.

The largest section of a lead azide plug is some 6 mm diameter and 4 mm in length. The projected image of rotation of the ASA is not significantly

BUREAU CEPI WIPO INTERNATIONAL

PCT/AU 81/00068

smaller. A smaller area of image can be expected if the detonator is deformed as in the crushed detonator. These results indicate that the discriminator must be extremely sensitive and fast.

A screening apparatus suitable for the screening of high volume mail is shown in Figure 3 and comprises three main functional blocks; firstly the X-ray imaging system producing an image on the fluorescent screen, secondly the closed circuit television (CCTV) system viewing this image and thirdly the electronic comparator - counter system.

The X-ray image system consists of an X-ray generator and an X-ray fluorescent screen. Two types, a Du Pont Cronex E 2 screen covering an area of 250 x 250 mm and a Sirius HSF screen of 385 x 385 mm have been used successfully to date. The optimum fluorescent screen for any application can be chosen in terms of area to be covered, X-ray energy used and the type of CCTV image sensing tube used. Objects to be examined are irradiated by X-rays which pass to the fluorescent screen and form a radioscopic image. Thus a visual image with grey scale information corresponding to the X-ray attenuation over a relatively large area is obtained on the fluorescent screen. The quality of this image depends on the energy of X-rays that are used. As far as the fluorescent screen is concerned this is a linear process, the brightness of visible radiation being proportional to the intensity of X-radiation. The use of an IED screening device is envisaged using an X-ray energy of 80 to 150 kV.

A standard CCTV camera is used to transduce the optical image produced on the fluorescent screen to an electronic signal. The type of image sensing tube in

BUREAU CENTRAL WIPO INTERNATIONAL

PCT/AU 81/00068

the camera chosen will depend on the X-ray dose used, and should be compatible with the fluorescent screen. Low X-ray dose systems will require more sensitive image sensing tubes to detect the low light level images obtained from the fluorescent screen. Such camera/image sensing tube systems which also produce standard CCTV signals are readily available, although expensive. A bandwidth better than 7 MHz, giving a line to line resolution finer than 550 lines, will be required from any camera used to survey objects up to 300 x 400 mm. A National WV - 240 N with a 17 mm vidicon was used for the optical tests. An Ikegami CTC 5600 G with a 25 mm Newvicon has been used successfully to date. The greater sensitivity of the Newvicon has allowed the X-ray experiments to be performed successfully.

The composite output from the CCTV camera is fed to the comparator system. Operating at high speed the comparator provides an output signal for areas of the fluorescent screen which are darker than the preset darkness (image intensity) threshold. A window area of the fluorescent screen is selected to be analysed, by virtue of command signals generated within the comparator.

The output of the comparator system is fed to the gate input of the counter/timer and used to interrupt the internal 10 MHz clock when the counter/timer is in the totalize (summation) mode. Thus the counter/timer will count and accumulate at 10 million counts per second while the comparator signal is present.

A control circuit is used in the comparator system to select a single video frame for image analysis. The resulting count is held and displayed in the counter/timer. This count and display sequence

BUREAU CMPI WIPO

is completed in 40 ms. The displayed count is proportional to the area of the fluorescent screen within the window darker than the preset darkness threshold and the maximum count ranges to approximately 240,000 for a single frame.

The video monitor is able to be switched to display

(i) the CCTV camera video

(ii) the comparator output.

This switching displays the areas of the fluorescent screen which are darker than the preset threshold. For field use it is proposed to switch the display to the comparator output when any item fails to pass the test, drawing the attention of the operator to the unit. Within the selected area of the fluorescent screen the article being analysed is readily observed on the monitor. A more detailed description of the comparator counter system will be described later. The relationship between counts and area depends upon the magnification factor of fluorescent screen image to vidicon image. The requirement is to scan a 300 x 400 mm image which should include the largest standard mail envelope of size 285 x 385 mm. Each count will then represent 0.5 mm^2 of such a field.

The first experimental electronic circuitry designed to comply with the required specifications of the mail IED discriminator has been constructed. This device was tested for performance both in reliability and accuracy and also for development of controls needed to facilitate operation in general usage.

The system shown in Figure 3 enables both X-ray and optical testing to be carried out with a minimum of disruption by having the camera lens

BUREAU CHEI W.IPO INTERNATIONAL

PCT/AU 81/00068

focussed either on the fluorescent screen or on the optical test pattern when the mirror is removed.

Although the camera will ultimately be examining the radioscopic image on the fluorescent screen, for the initial testing sequences there were many advantages to be derived from using simple optical tests to prove the performance and stability of the discriminator circuits and the system as a whole. Optical tests do not need the stringent and restrictive safety requirements associated with the X-ray facilities in the laboratories.

The fact that a relatively small proportion of the total image area has to be measured using the discriminator places stringent requirements on its performance. Accordingly tests were performed on the electronic comparator-counter systems of the device to determine its suitability for such precise measurements. The high contrast optical test patterns which were used in conjunction with a CCTV camera to provide video signals with the best possible characteristics are illustrated in Figure 4. The implications of results obtained are summarised in the conclusions.

Test pattern (a) is a series of grey level areas approximating to the size of a detonator and having optical densities of 3.0, 1.2, 0.8 and 0.38 respectively. This pattern was used to demonstrate grey level discrimination by the comparator. Pattern (b) is an opaque square, approximating in size to the X-radioscopic image of the lead azide priming charge in a detonator. This was successively rotated and the count recorded to confirm that the discriminator was not directionally biased. Pattern (c) is an opaque circle 3 mm diameter to assess the performance of the counting

BUREAU OMPI WIPO INTERNATIONAL

of the system firstly for small areas and secondly as a test for comparison of counts obtained for fragments of different shape being equal to the original area.

The optical test patterns were mounted on a white opal screen backlit by two 15 watt white fluorescent tubes. This produced a high contrast image with an average background illumination of 350 lux. This level of illumination is within the operating range of the camera.

The reproducibility of area measurements corresponding to an average count of 5450 in a total field of 200,000 counts was investigated using test pattern (b). This is a larger proportion of the field than would normally be operative but is a good test for the general accuracy that can be expected from this device. A standard deviation for fifty readings of 21 counts was obtained, which indicates a 99.6% probability for any reading to repeat more closely than $\pm$ 1% of the average reading. A normal distribution of readings is assumed and the relationship $\sigma^2 = \frac{1}{n-1}\left[\sum_{i=1}^{n} (x_i - \bar{x})^2\right]$ was used for the calculation of σ, the standard deviation for a set of n counts x_i (i = 1, n). The averages of four similar sets of fifty readings varied by less than 0.3%, further indicating the repeatability of the device.

Smaller areas, test pattern(c), corresponding to 10-20 counts of course do not show this level of repeatability. Errors of up to 50% of the average can be expected in normal operation. A most important fact however, is that the system shows a remarkable freedom from background noise, with a zero reading invariably resulting for an image field with no feature sufficient to trigger the device. With an object that produces

BUREAU OMPI WIPO INTERNATIONAL

average reading corresponding to 10 counts there was no evidence that the device would fail to provide a significant count when required. Thus the reliable trigger and counting capabilities that are evident in the earlier test, although not sufficient to produce accurate area measurements on a 10 count object, are sufficient to ensure reliable detection because they always give a significant count.

Turning to Figures 5 to 12 of the drawings, the circuitry for processing the video signal comprises the following functional blocks.

1. High speed video buffer and comparator.
2A. Horizontal and vertical window generator.
2B. Clamp drive and window reset.
3. Double field counter.
4. Counter board.
5. Video buffer and synchronizing pulse separator, OR
   Video synchronizing pulse generator.
6. Output mixer.

In the video buffer and synchronizing pulse separator 5, the input video signal CV is fed to a synchronizing pulse separator which provides both horizontal and vertical synchronizing pulses. A video isolation amplifier 2N3642 and 2N3645, feeds the input video pulses B and C to the output mixer circuits 6.

In the video buffer and high speed comparator 1, the input video signal CV is applied directly to a video buffer 2N6515 and 2N3906, which provides a low impedance drive to the high speed comparator MC10116. A clamp 2N6515 is used to provide DC restoration keyed to the back porch of the horizontal synchronizing pulse.

BUREAU CMPI WIPO INTERNATIONAL

The buffered and clamped video then passes to the high speed comparator MC10116. An ECL to TTL level translator MPS4258 drives the schmitt gates 74LS13 providing the digitized video D and $\overline{D}$.

The DC reference input to the comparator MC10116 is taken from a multi turn potentiometer 10K grey scale threshold supplied from +5 Volts.

In the clamp drive and window reset 2B, the timing signal K required by the keyed clamp and a reset WR for the window generator 2A are provided by monostable integrated circuits 74LS221. The horizontal synchronizing pulse H is delayed and shaped to produce a clamp drive pulse K (occurring during the back porch) and a reset pulse WR for the window generator.

In the horizontal and vertical window generator 2A, the window gating signal W for the counter circuits is generated by delaying and shaping the horizontal and vertical synchronizing pulses H and V. Control of these delays allows adjustment of the size and position of the window in the horizontal and vertical directions.

These signals are then combined to give a gating signal W for the counters and window signal WV for the video mixer 2N6515 within the output mixing circuit 6.

In the double field counter 3, the input video signal 5 consists of odd and even fields transmitted in sequence. An odd and an even field are required to make a complete video frame.

The double field counter 3, when initiated provides a gating signal F to the counter circuits for the duration of one odd and one even field. This counter may be activated by a manual push button manual start count or by an external TTL compatable signal input S.

BUREAU OMPI INTERNATIONAL

PCT/AU81/00068

In the video output mixer 6, the video signals B and C from the isolating amplifier 2N3642 and 2N3645 within the synchronizing separator and buffer 5 or $\overline{D}$ from the high speed comparator 1 are combined, as required, with a video signal WV, representing the window position, to provide a suitable display on the video monitor.

In the counters and comparator 4, the signals D from the comparator 1, W from the window generator 2A, and the signals F from double field counter 3 are combined in the 74LS00 NAND'S. This combined signal is used to switch pulses from a crystal clock oscillator 74S00 into the totalizing counter 74LS90(X6) and the presettable down counter 74LS192(X6). The clock frequency may be chosen to directly scale the counters if required.

A digital readout is provided by decoding the totalizing counter within the decode and drive T1L308(X6). Logic circuits 74LS00(X5) detect a borrow signal BS on the presettable down counter to indicate a totalized count greater than that preset in the down counter.

Output signals indicating, processing complete/next item N and count above limit/sample divert Y are provided for interfacing to external equipment. When signal Y occurs a signal X appears and illuminates LED thus giving a visual indication of the occurrence of signal Y.

Regulated voltages of +5 and -5 are supplied by a conventional power supply (not shown) comprising mains transformer, rectifier and regulator circuits.

BUREAU OMPI WIPO INTERNATIONAL

PCT/AU 81/00068

All integrated circuits (chips) in the circuitry described above, with the exception of the TlL308's and MC10116's are as manufactured by National Semi-Conductor Corp. of Santa Clara, California, U.S.A. The TlL308's are as manufactured by Texas Instruments Inc., of Dallas, Texas, U.S.A., and the MC10116's are as manufactured by Motorola Semi-Conductor Products Inc., of Phoenix, Arizona, U.S.A.

Thus the control outputs to hold/divert ports are activated for images containing areas darker than the preset level and producing a count (proportional to actual area) greater than the preset value. The system may work with equal facility on the inverse image, by measuring areas lighter than the preset intensity value and diverting for area counts less than the limit.

As previously suggested the range of mail testing rates accommodated include those representing low volume numbers received by a single small establishment, through to the high volume ratings of the automatic processing as required by postal authorities. The former is illustrated by a recent analysis of incoming mail received at a small registry, where a daily average of 150 articles is handled and of which a summary appears

BUREAU OMPI

PCT/AU 81/00068

in the following table.

Addressed to:	Thin<5 mm	Thick>5 mm	
Registry	146	6	
Names Person	248	38	
Library	140	50	
	570	94	664
	(81%)	(13%)	
Rolled papers	13		
Parcels	19		
Stores	3 parcels	(5%)	35
			699
Daily average	- 140 articles	(nom.	700)

Mail received during a period of one week was surveyed as a guide to the volume of testing necessary should a monitoring system be required. The size of a piece of mail is taken as (flat size) x (thickness); however, thickness is the critical parameter and the 5 mm criterion is based on the diameter of a commercial detonator (6 mm diameter) being included in a rudimentary design of IED.

Briefly the results show that 81% of the mail is less than 5 mm in thickness. However thicknesses as low as 3 mm need to be checked if the safe mail is to comply with the RARDE (Royal Armament Research and Development Establishment of United Kingdom) specifications for lethal letter bombs.

A more recent analysis of mail, using a conveyor belt, CCTV and visual monitoring of the X-ray image has shown that only two percent of the mail contained material of similar X-ray density to ASA. It is anticipated that the present

BUREAU OMPI WIPO

invention would assess these articles as requiring further examination, thus passing 98% of the mail as safe for normal processing.

The assumptions made here to arrive at the figure of 2% of mail not passed by the present invention is based on a low or no count for pins, wire staples and paper clips and the registration of a significant count for articles such as paper fasteners, bull-dog clips and binders showing X-ray contrast. This estimate is based on an examination of 3101 articles over a 16 day period which produced 64 articles of mail showing X-ray dense inclusions (giving 2.06%).

An illustration of the high volume screening required by the postal authorities is given by reference to the automatic processing systems used by Australia Post. The Toshiba mail culling machine has a processing rate of 16,000 articles per hour.

The need for automatic X-ray screening of culled mail being processed at this speed is demonstrated in the following table. It gives the numbers of articles which would on the criterion of thickness alone require X-ray examination with the present invention. This situation is described in terms of the time available for testing if continuous processing of all mail is to be maintained.

BUREAU OMPI WIPO INTERNATIONAL

PCT/AU 81/00068

Safe Mail Passed %	Separated for X-ray test %	Required Testing Rate tests/hr	Required test/min	Time Available Sec.
80	20	3200	54	1.1
90	10	1600	27	2.3
92	8	1280	22	2.8
94	6	960	16	3.8
96	4	640	11	5.6
98	2	320	6	11.3
99	1	160	3	22.5

The Toshiba culling machine has a preliminary article-thickness test set by Australia Post to 5 mm. The thicker mail articles are culled from the main flow of mail to receive individual handling with respect to stamp cancellation etc.

When used in conjunction with letter bomb screening devices a thickness monitoring system becomes a preliminary screening device. When set at 5 mm, as mentioned, it should reject a package containing a commercial detonator (6 mm diameter) in a rudimentary design of IED. However a setting of 3 mm is needed to comply with the specifications of RARDE for the possible thicknesses of lethal letter bombs. The suggestion here is that for the amount of explosives to be in a form to represent a lethal charge the thickness of the letter can be as low as 3 mm.

Therefore the modus operandi adopted in the two situations of high and low volume screening would differ.

CEI WIPO

In the case of the low volume situation, where the processing time is not a critical parameter, all the mail would be examined by X-ray screening, that is, there being no advantage to apply a thickness test. However, for high volume screening where a very high percentage of the mail is thin, there are some advantages in passing thin mail as safe. The rest of the mail would then be tested for X-ray contrast by the present invention and passed as safe or directed for further testing.

If the figure of 2% of mail not passed by the present invention is assumed to be applicable to all mail situations then the above table shows the time available for further testing of this mail would be 11 seconds if continuous processing is to be maintained at 16,000 articles per hour.

The analysis of densitometric traces from the feasibility study indicate there is characteristic X-ray contrast from components of IED's which should enable mail to be separated into two mail categories,

(a) safe mail which contains a minimum of X-ray material and so will not contain some essential components of an IED,

(b) doubtful mail which contains material which causes sufficient contrast in the X-ray image to prevent it being cleared by the present invention.

Present work has indicated that an optimum X-ray energy of about 80-150 kV is applicable to mail screening. However thick parcels, or packets and parcels with a considerable thickness of metal oxide impregnated paper (say >10 mm of such paper), could reduce the contrast range of their X-ray images, thus necessitating an increase in X-ray voltage. More sensitive X-ray registering systems could limit any required increase in voltage.

BUREAU CTTI WIPO INTERNATIONAL

PCT/AU81/00068

The optical tests have shown that the comparator can respond to a threshold image intensity, and can differentiate between a range of grey levels as required, when the camera is operating within the specified illumination range. However experiments have shown that a more sensitive CCTV camera, such as a high sensitivity commercial vidicon marketed under the name, NEWVICON, is more suitable for X-ray work. In the specified illumination range both the accuracy of count and repeatability (for a given area) are of an encouragingly high order.

Briefly, an X-ray mail screening system has been constructed, the performance of which is in accord with design objectives. Testing of the comparator under low X-ray intensity conditions is planned. The comparator works most satisfactorily under high-dose/high-light-level illuminated screen conditions and there is little doubt that it will be just as satisfactory under low-dose/low-light-level fluorescent screen conditions.

Finally the X-ray examination of in-coming mail to the applicants establishment where the invention has been developed has shown for a total of about 3000 articles processed, only 2% have shown X-ray image contrast above a critical threshold value (which would indicate the possible presence of an IED). If this figure should be a reasonable average for other mail systems there would be a time period of 11 seconds available for testing of doubtful mail by a computer aided detector system, if continuous processing of mail is to be maintained. Present results indicate the value of the present invention as a "stand-alone" system for mail systems of relatively small throughput.

BUREAU OMPI WIPO INTERNATIONAL

PCT/AU81/00068

The present invention has been described above in the preferred embodiment as applied to analysing an X-ray radioscopic image in a system for detecting IED's, but, as discussed previously, the invention can be used to analyse other forms of images for the purposes of determining the nature and extent of particular characteristics of the image about which information is required.

INTERNATIONAL

CLAIMS

1. An apparatus for analysing images comprising a CCTV camera to scan said image and provide video signals, and means to process said video signals so as to provide an indication of the duration of any signal whose intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image.

2. An apparatus as claimed in Claim 1, wherein the means to process said video signals are means to provide and count pulses during selected parts of said video signals.

3. An apparatus as claimed in Claim 1 or 2, in combination with means to provide an X-ray radioscopic image of the contents of an article under investigation.

4. An apparatus as claimed in Claim 3, wherein the article is an article of mail, and the apparatus is used to detect the presence of an improvised explosive device within said article of mail.

5. An apparatus as claimed in Claim 1 or 2, wherein said image is a photograph.

6. An apparatus as claimed in Claim 1 or 2, wherein said image is that of an area or space in the field of view of, and for surveillance by, said CCTV camera.

7. An apparatus as claimed in Claim 1 or 2, wherein said image is a colour image produced by a filter.

8. An apparatus as claimed in any one of the preceding claims, wherein the means to process said video signals consist of means to compare the level of said video signals with a predetermined threshold value and to provide an output pulse when said signal intensity is less than said predetermined threshold value, and means to count said pulses for a particular zone on said image and provide an output signal indicative of the extent of dark areas on the image.

BUREAU OMPI WIPO INTERNATIONAL

9. A method of analysing images, comprising the steps of scanning said image with a CCTV camera to produce video signals, and processing said signals so as to provide an indication of the duration of any signal whose intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image.

10. A method as claimed in Claim 9, wherein said signal is processed by providing and counting pulses during selected parts of said video signals.

11. A method as claimed in Claim 9 or 10, wherein said signals are processed by comparing the level of said video signals with a predetermined threshold value and providing an output pulse when said signal intensity is less than said predetermined threshold value, and counting said pulses for a particular zone on said image to provide an output signal indicative of the extent of dark areas on the image.

12. A method as claimed in any one of claims 9 to 11 as applied to analysing an X-ray radioscopic image of the contents of an article under investigation.

13. A method as claimed in Claim 12, wherein the article is an article of mail, and the method is applied to detecting the presence of an improvised explosive device within said article of mail.

14. A method as claimed in any one of Claims 9 to 11, as applied to analysing a photographic image.

15. A method as claimed in any one of Claims 9 to 11, as applied to surveying an area or space in the field of view of, and for surveillance by, the CCTV camera.

16. A method as claimed in any one of Claims 9 to 11, as applied to analysing a colour image produced by a filter.

BUREAU OMPI WIPO INTERNATIONAL

AMENDED CLAIMS
(received by the International Bureau on 28 September 1981 (28.09.81))

1. An apparatus for the detection of IED's, comprising means to produce an X-ray image of the article under investigation, means to scan said image and provide video signals, and means to process said video signals so as to provide an indication of the duration of any signal whose intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image.

2. An apparatus as claimed in Claim 1, wherein the means to process said video signals are means to provide and count pulses during selected parts of said video signals.

3. An apparatus as claimed in any one of the preceding claims, wherein the means to process said video signals consist of means to compare the level of said video signals with a predetermined threshold value and to provide an output pulse when said signal intensity is less than said predetermined threshold value, and means to count said pulses for a particular zone on said image and provide an output signal indicative of the extent of dark areas on the image.

4. A method of detecting IED's, comprising the steps of producing an X-ray radiographic image of the contents of the article under investigation, scanning said image with means to produce video signals, and processing said signals so as to provide an indication of the duration of any signal whose intensity varies from a predetermined value as a measure of the extent of dark or light areas on the image.

5. A method as claimed in Claim 4, wherein said signal is processed by providing and counting pulses during selected parts of said video signals.

BUREAU OMPI WIPO INTERNATIONAL

6. A method as claimed in Claim 4 or 5, wherein said signals are processed by comparing the level of said video signals with a predetermined threshold value and providing an output pulse when said signal intensity is less than said predetermined threshold value, and counting said pulses for a particular zone on said image to provide an output signal indicative of the extent of dark areas on the image.

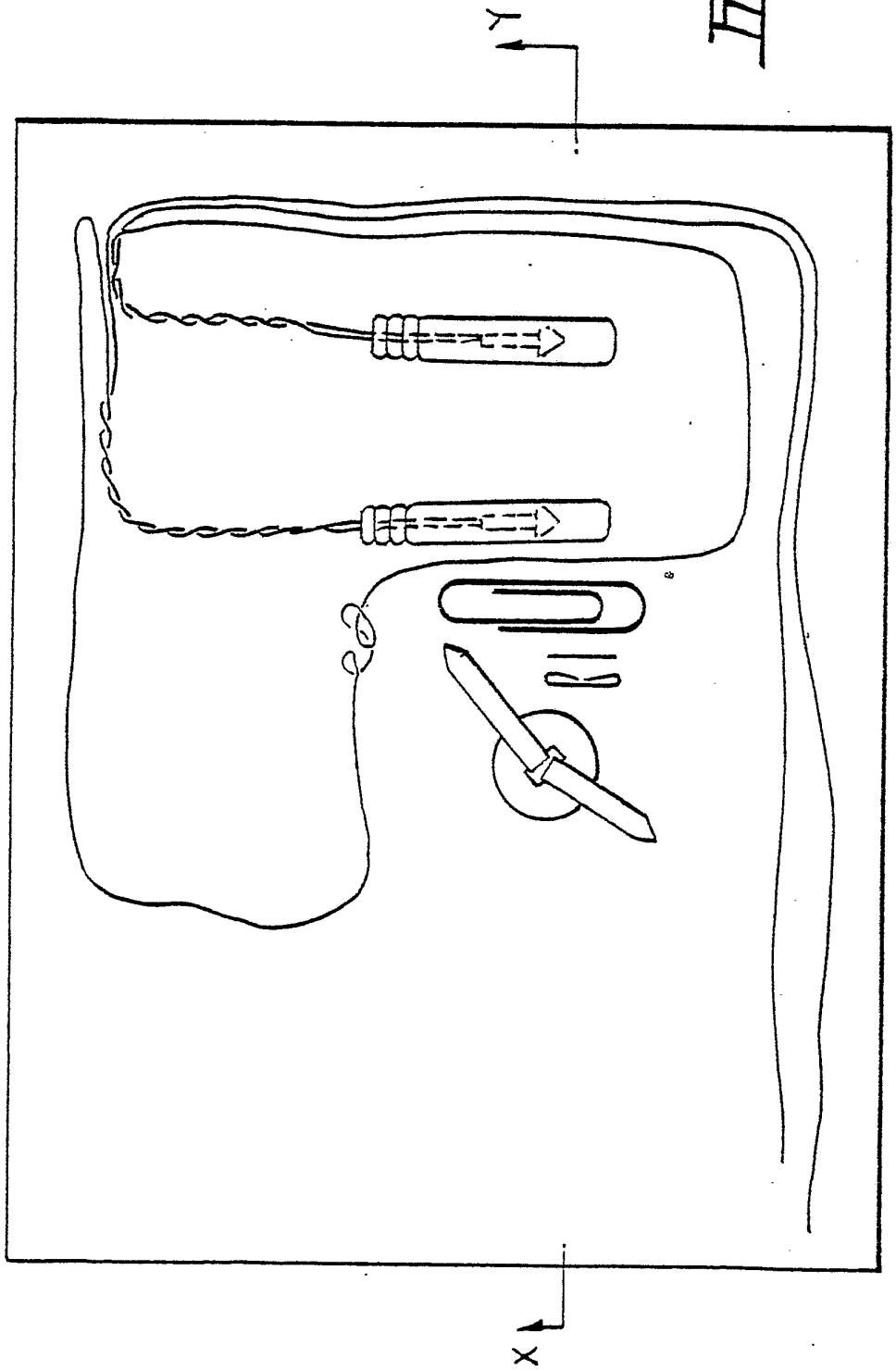
BUREAU OMPI WIPO INTERNATIONAL

STATEMENT UNDER ARTICLE 19

The effect of the amendments to the claims of this application is to direct all claims to the particular application of the invention to the detection of IED's, and the inclusion of the step, and the means for carrying out the step, of producing an X-ray radiographic image of the contents of an article under investigation. Such amendments will require alterations to the introductory section of the description where reference to more general applications of the invention will need to be deleted, and the statements corresponding to the original main apparatus and method claims will need to be altered to conform with the new claims. It is believed that by directing the invention to its particular application to the detection of IED's, rather than the original more general applications, serves to highlight those features which distinguish the invention as claimed from more general systems as disclosed in the cited references.

BUREAU OMPI WIPO INTERNATIONAL

Fig. 1



BUREAU
CMH
WIPO

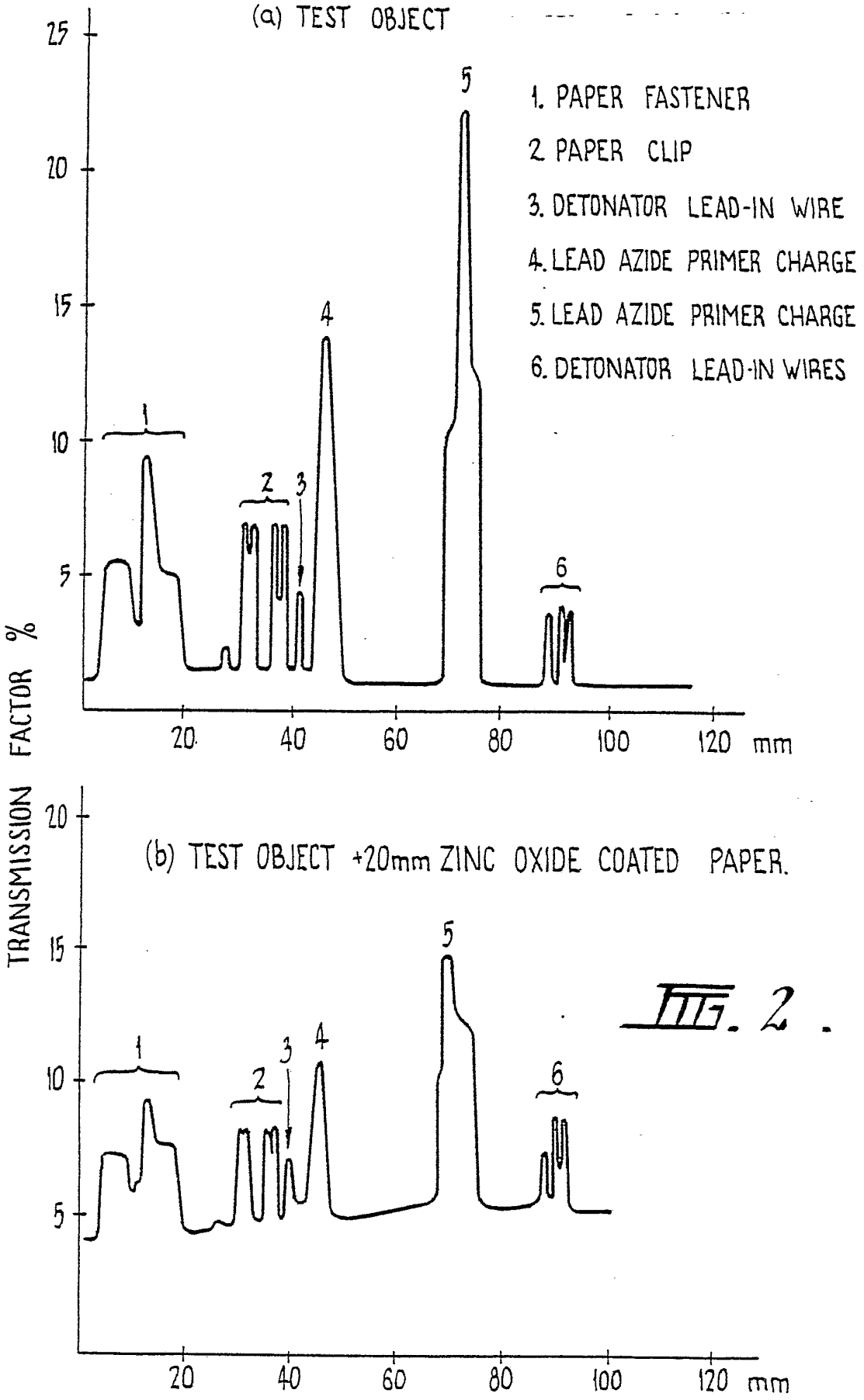


FIG. 2.

BUREAU CPI WIPO

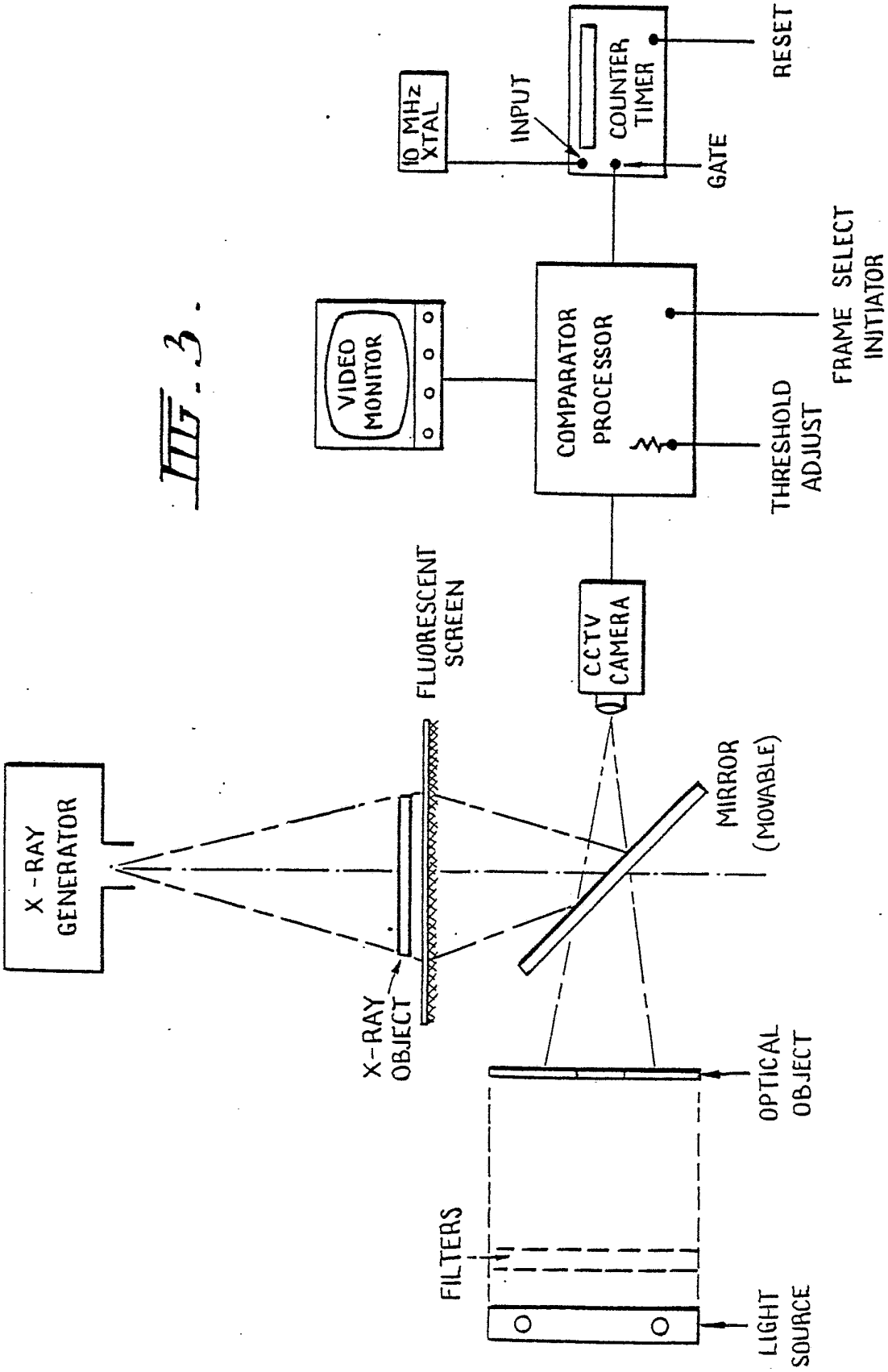


FIG. 3.

BUREAU INTERNATIONAL

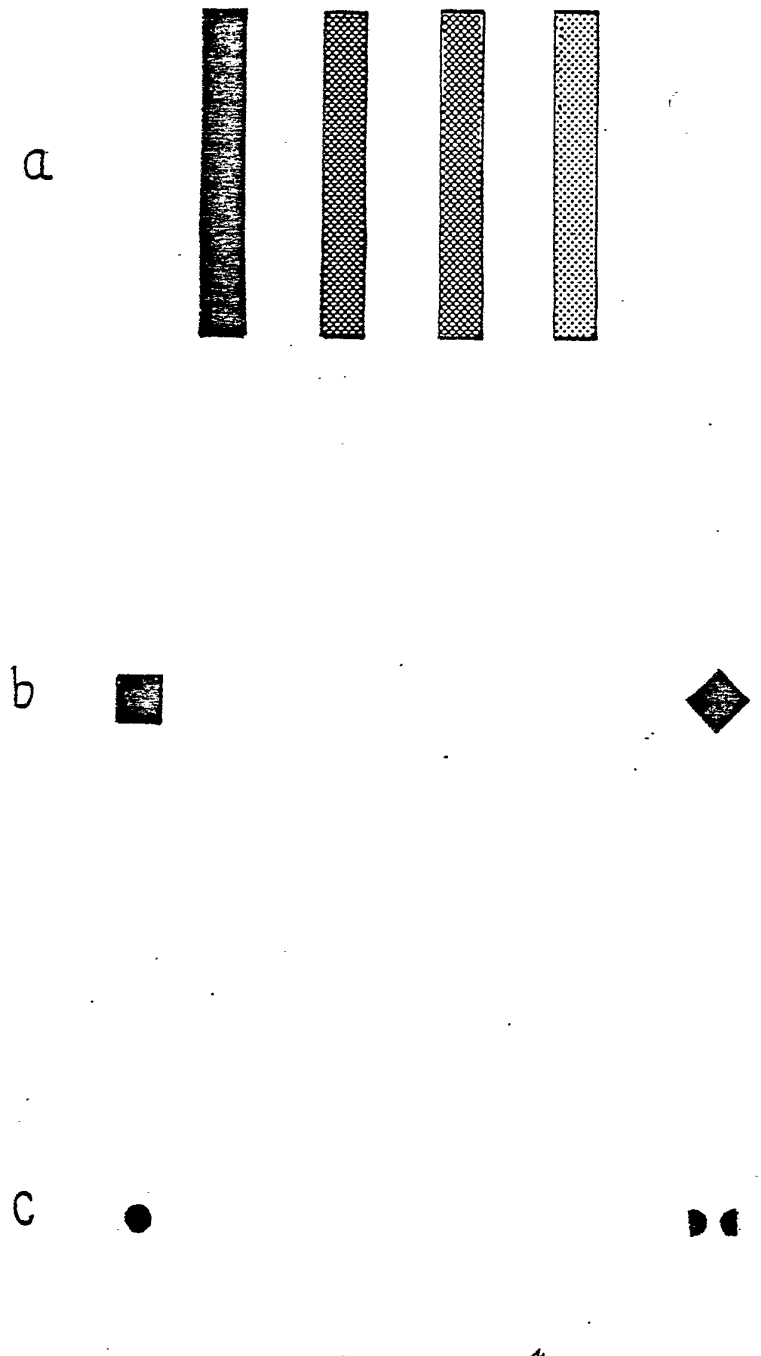


FIG. 4.

BUREAU OMPI

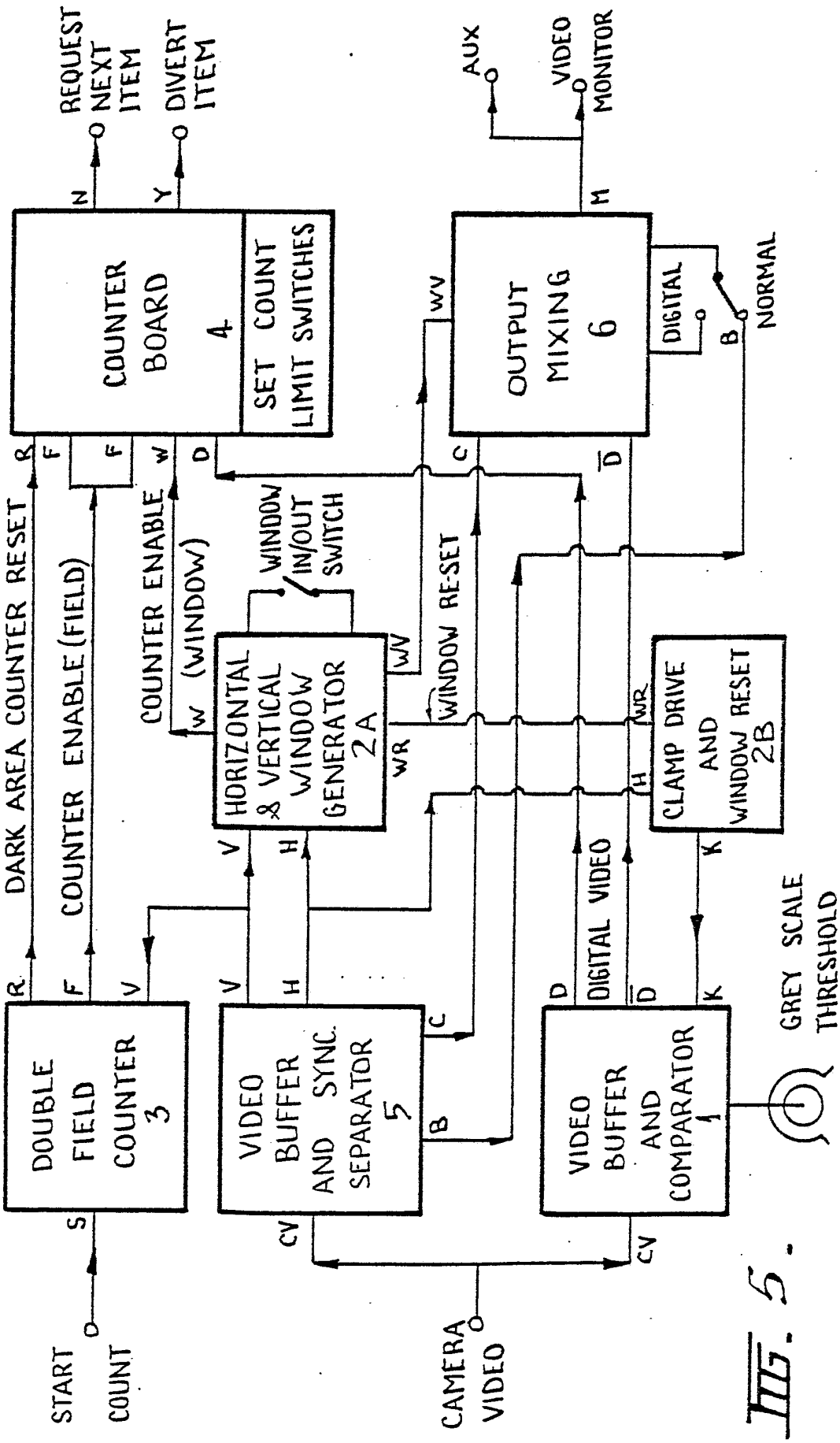


FIG. 5.

BUREAU OMPI

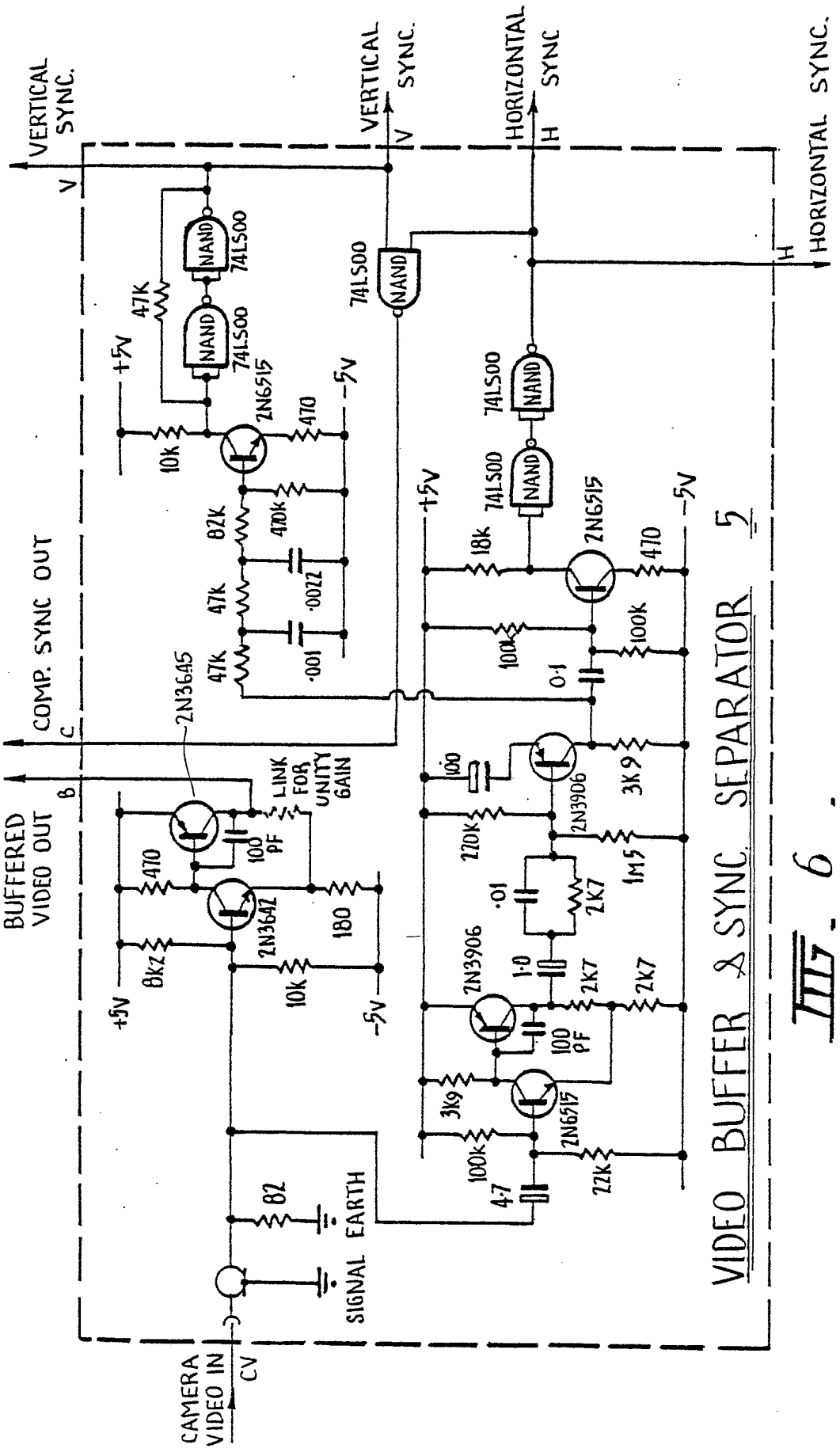

VERTICAL SYNC.
V
VERTICAL SYNC.
V
HORIZONTAL SYNC
H
HORIZONTAL SYNC.
H
COMP. SYNC OUT
C
BUFFERED VIDEO OUT
B
CAMERA VIDEO IN
CV
SIGNAL EARTH
LINK FOR UNITY GAIN
VIDEO BUFFER & SYNC. SEPARATOR 5
NAND
74LS00
2N6515
2N3645
2N3642
2N3906
+5V
-5V
47K
10k
470
82K
470K
.0022
.001
18k
100K
0.1
100
3K9
270K
1M5
2K7
1.0
100 PF
100K
4.7
22K
82
180
8K2

FIG. 6.

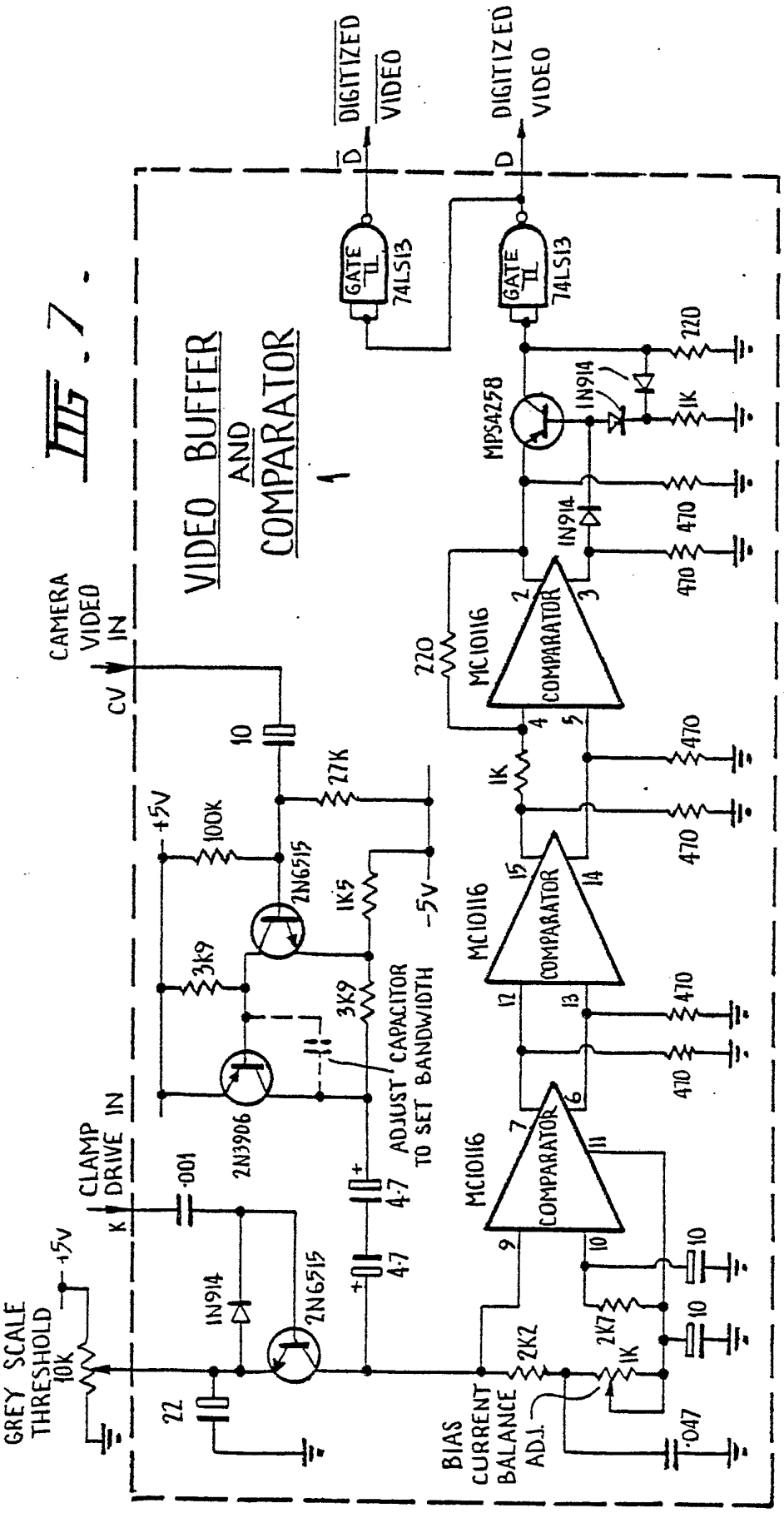

VIDEO BUFFER AND COMPARATOR 1
CAMERA VIDEO IN
CV
CLAMP DRIVE IN
K
GREY SCALE THRESHOLD
10K
+5V
-5V
100K
27K
10
3K9
1K5
2N6515
2N3906
IN914
.001
22
4·7
ADJUST CAPACITOR TO SET BANDWIDTH
BIAS CURRENT BALANCE ADJ.
2K2
2K7
1K
.047
MC10116
COMPARATOR
220
470
MPS4258
GATE TL 74LS13
DIGITIZED VIDEO
D

FIG. 7.

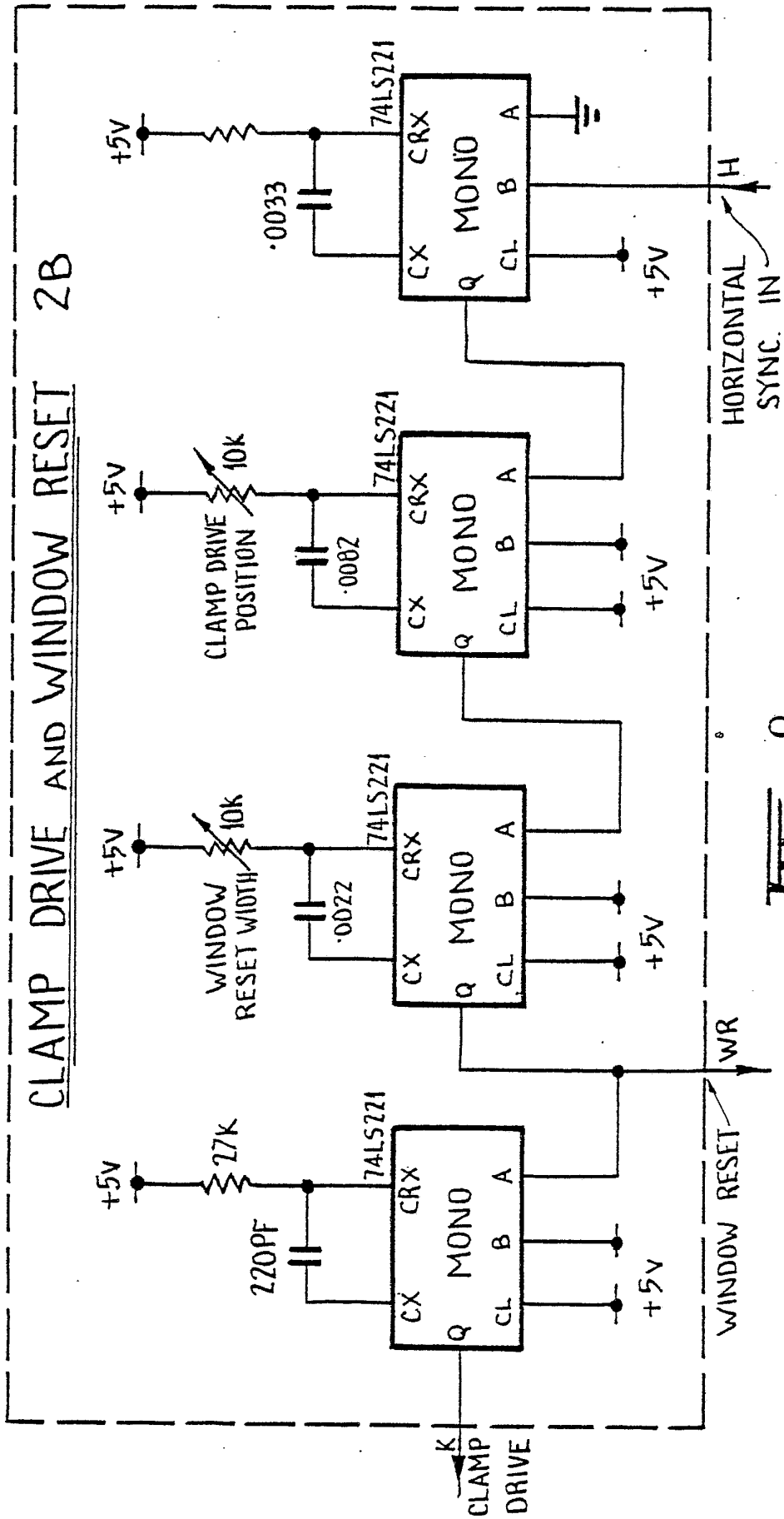

CLAMP DRIVE AND WINDOW RESET 2B
74LS221
MONO
CRX
CX
CL
Q
A
B
+5V
.0033
.0082
.0022
10k
27k
220PF
CLAMP DRIVE POSITION
WINDOW RESET WIDTH
HORIZONTAL SYNC. IN
H
WR
WINDOW RESET
K
CLAMP DRIVE

FIG. 8.

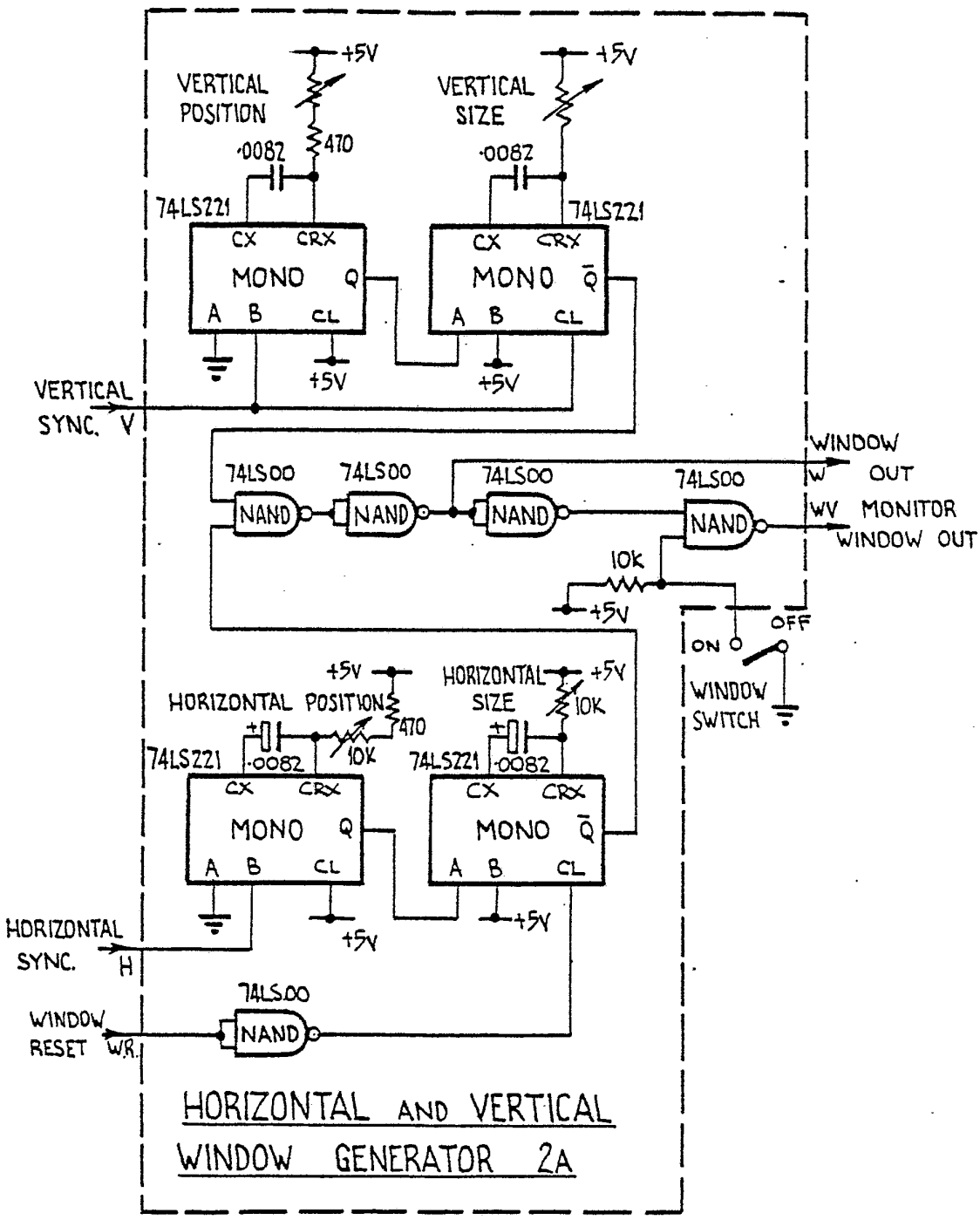


Fig. 9.

BUREAU C.P.I. INTERNATIONAL

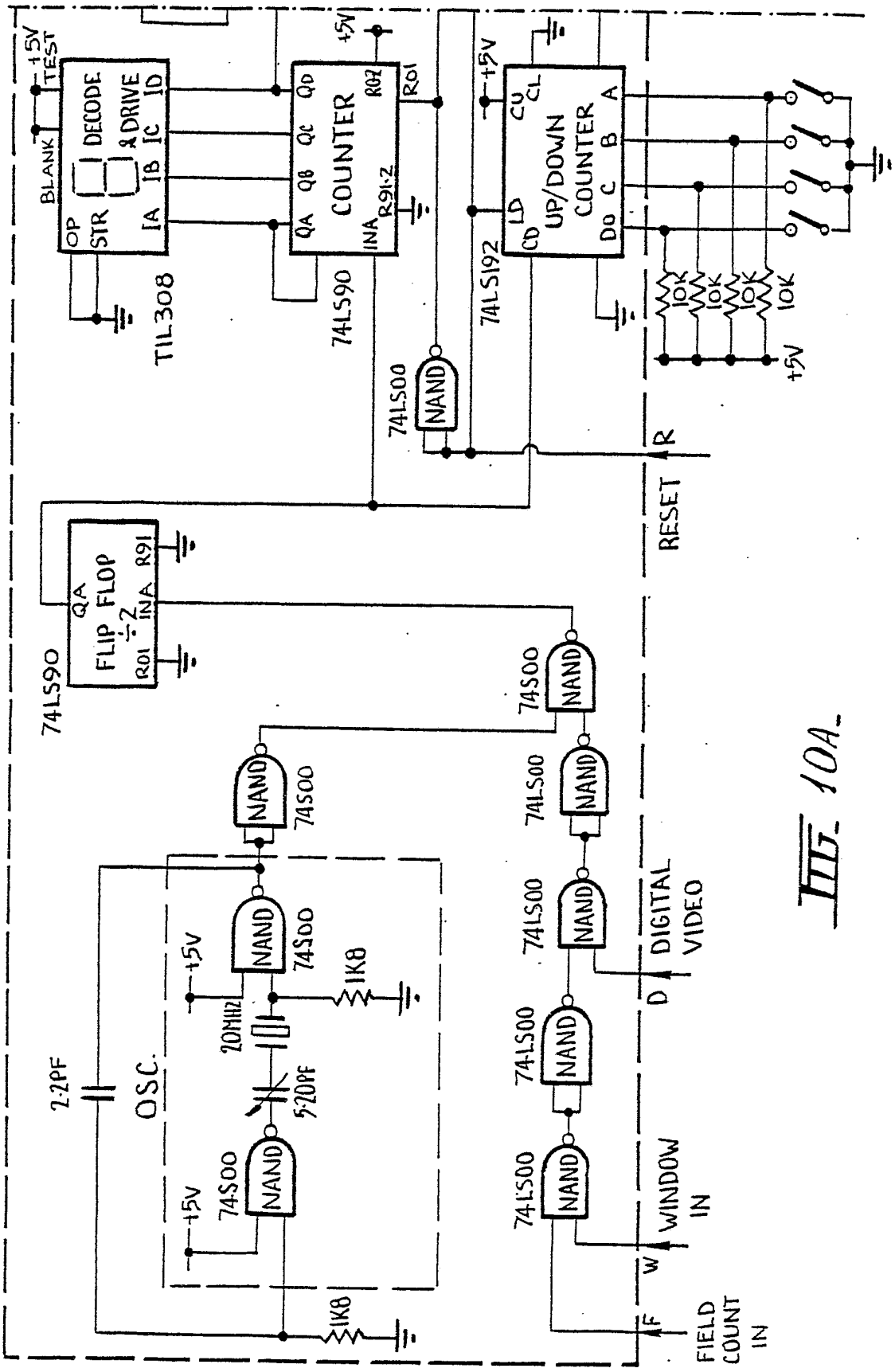

+5V
TEST
BLANK
DECODE
& DRIVE
OP
STR
IA
IB
IC
ID
TIL308
COUNTER
QA
QB
QC
QD
R01
R02
INA
R91-2
74LS90
+5V
74LS192
UP/DOWN
COUNTER
CU
CD
CL
LD
A
B
C
D
74LS00
NAND
10K
R
RESET
FLIP FLOP
÷2
QA
INA
R91
R01
74LS90
74S00
74LS00
OSC.
2·2PF
20MHz
5-20PF
1K8
DIGITAL
VIDEO
D
WINDOW
IN
W
FIELD
COUNT
IN
F

FIG 10A.

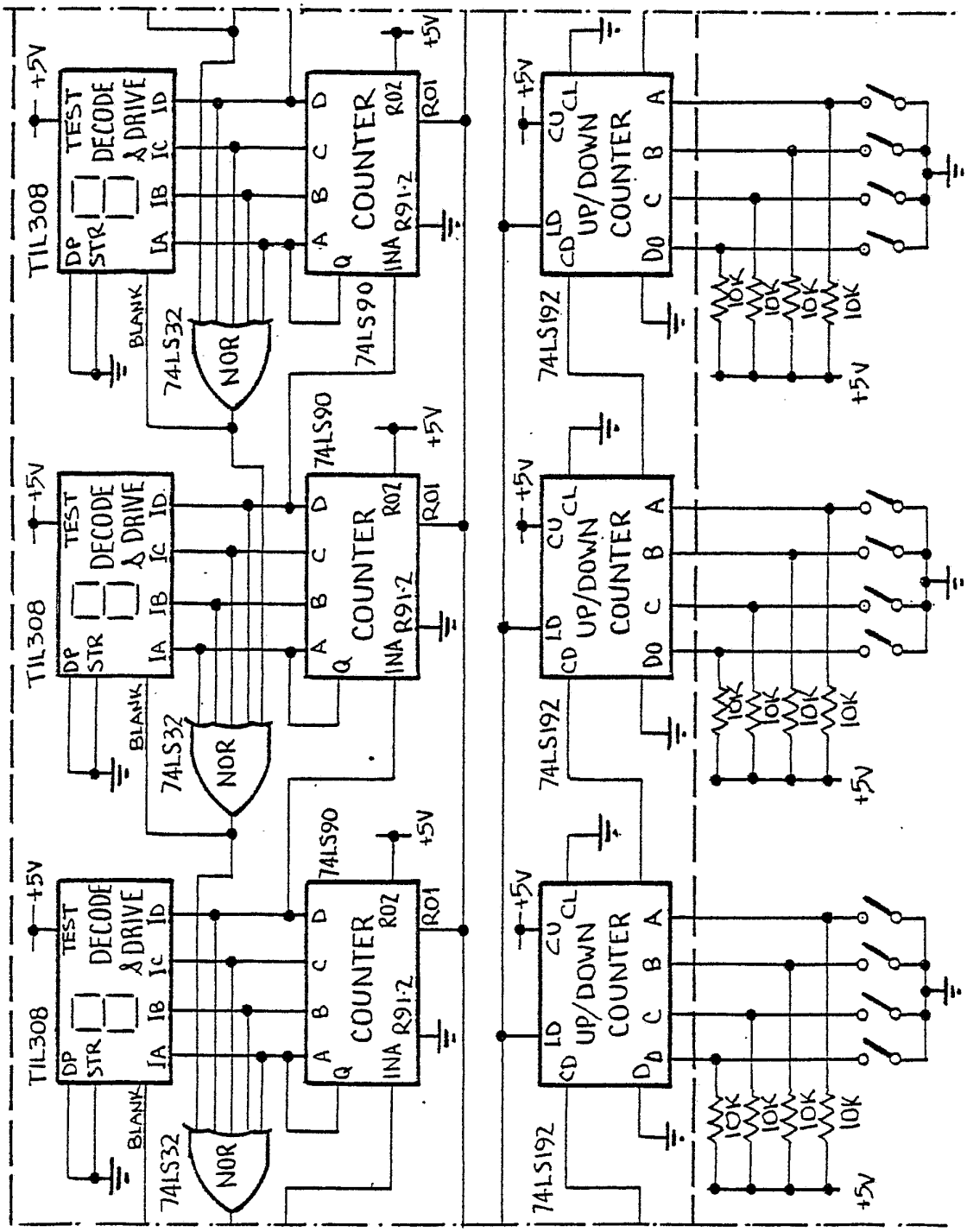


FIG. 10B.

BUREAU OMPI INTERNATIONAL

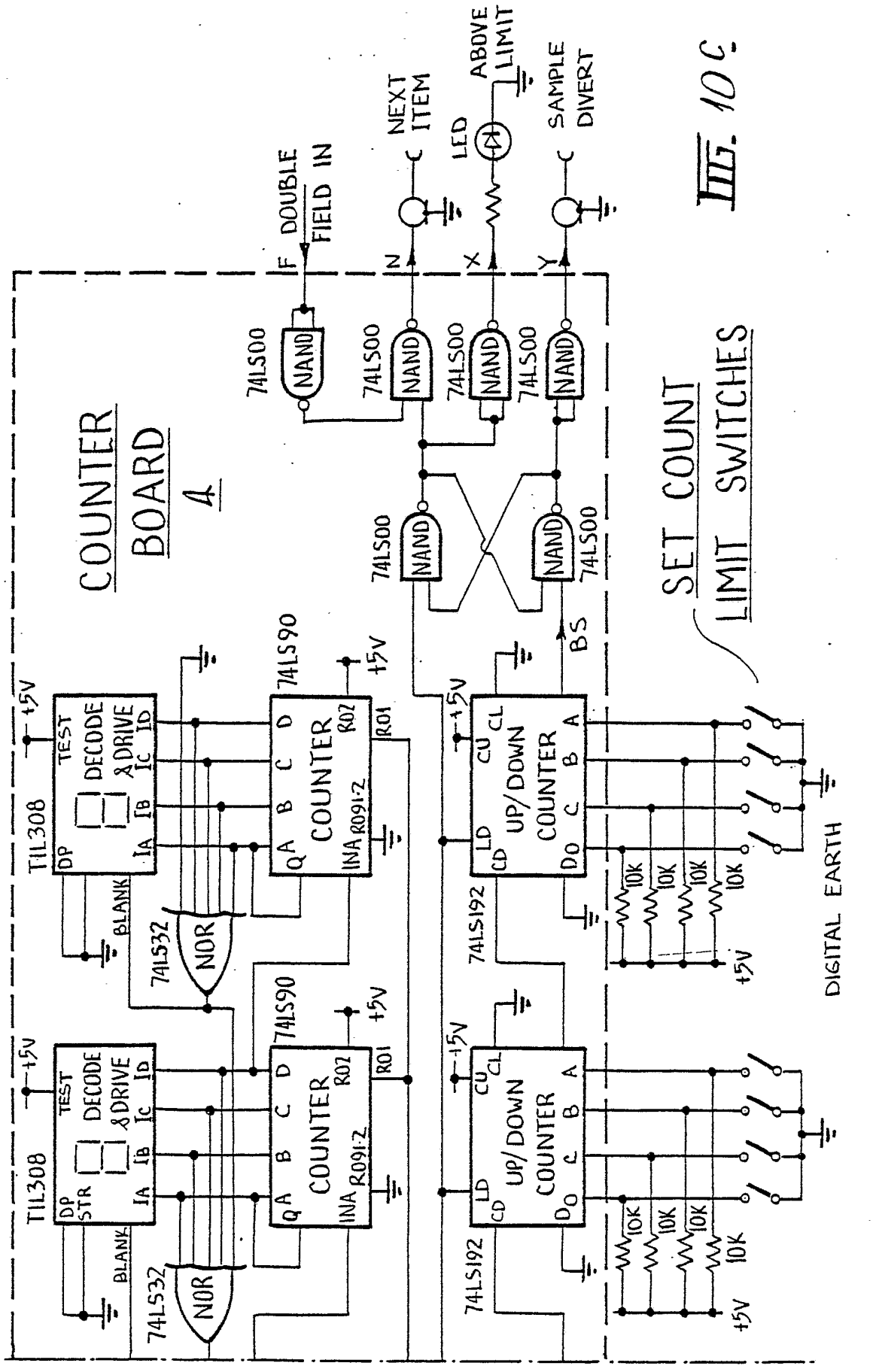

COUNTER BOARD 4
SET COUNT LIMIT SWITCHES
F DOUBLE FIELD IN
NEXT ITEM
LED
ABOVE LIMIT
SAMPLE DIVERT
N
X
Y
74LS00 NAND
74LS90 COUNTER
74LS192 UP/DOWN COUNTER
74LS32 NOR
TIL308 DECODE & DRIVE
BLANK
BS
+5V
10K
DIGITAL EARTH

FIG. 10C

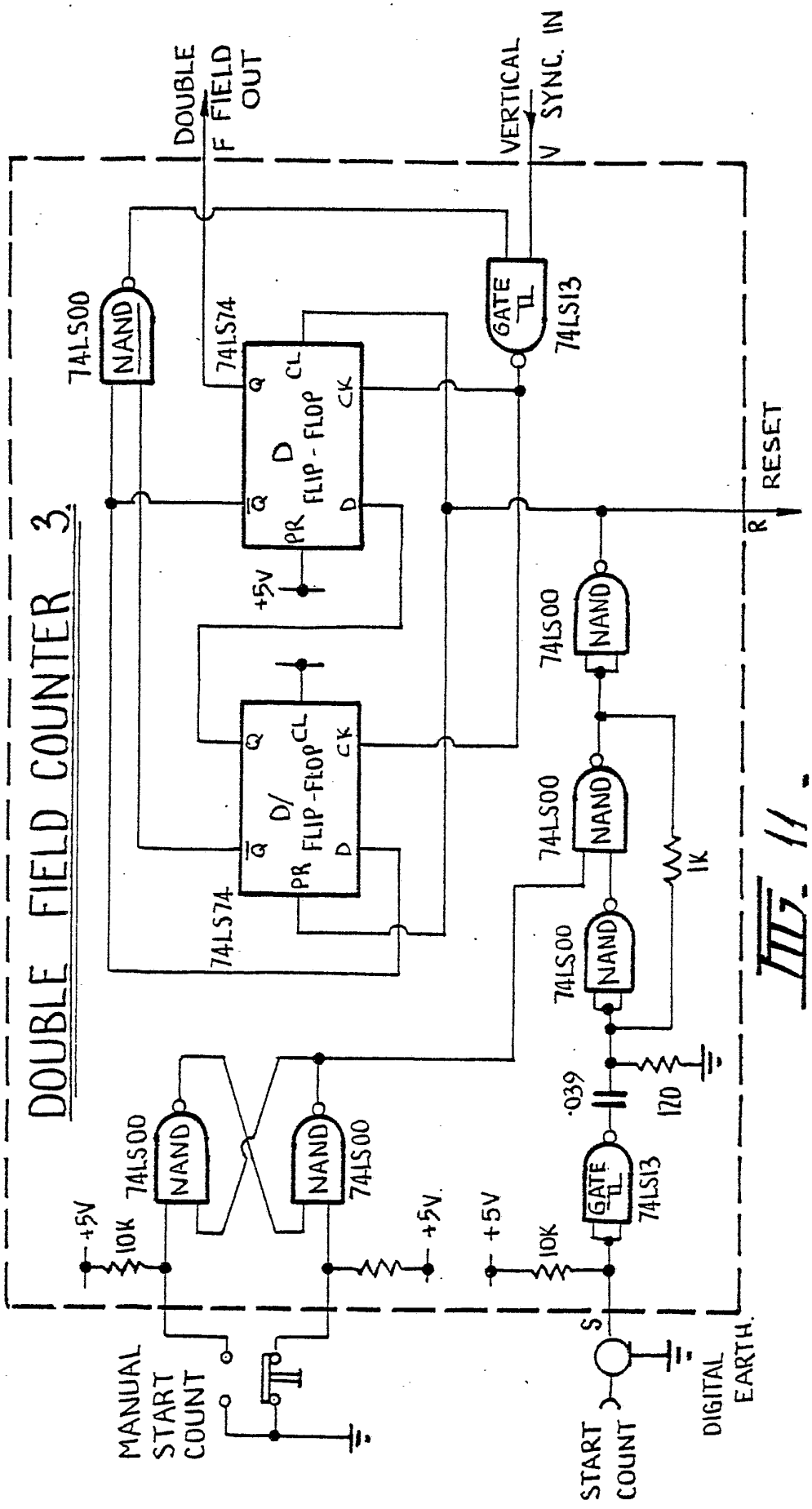


FIG. 11.

BUREAU OMPI WIPO INTERNATIONAL

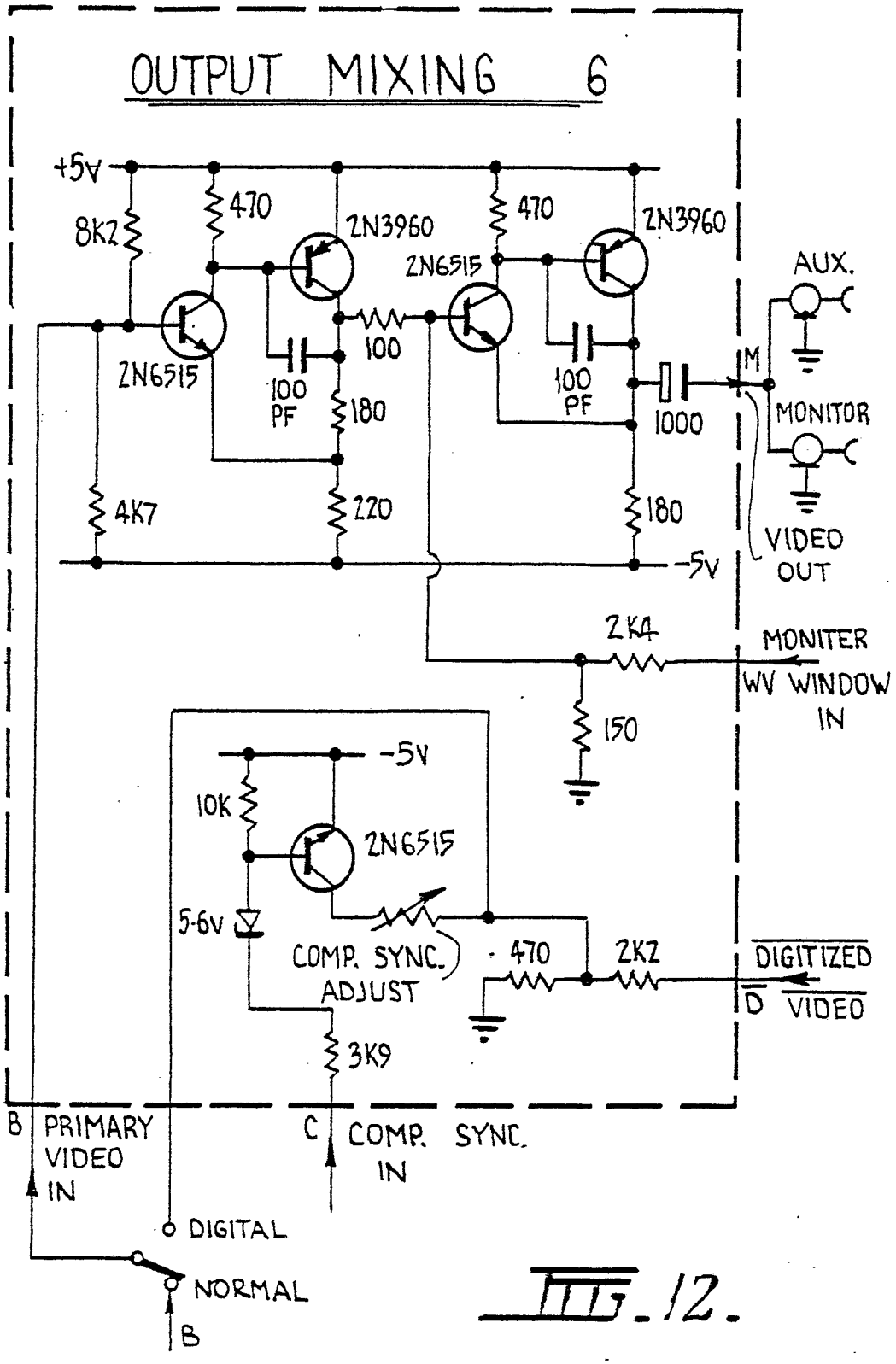

OUTPUT MIXING 6
+5V
8K2
470
2N3960
470
2N3960
2N6515
AUX.
100
M
2N6515
100 PF
180
100 PF
1000
MONITOR
4K7
220
180
VIDEO OUT
-5V
2K4
MONITER WV WINDOW IN
150
-5V
10K
2N6515
5·6V
COMP. SYNC. ADJUST
470
2K2
DIGITIZED VIDEO
3K9
B PRIMARY VIDEO IN
C COMP. SYNC. IN
DIGITAL
NORMAL
B

FIG. 12.

INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 81/00068

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.[3] H04N 7/18, 5/32, G01N 23/04

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	H04N 7/18, 5/32, G01N 23/04

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

AU:IPC as above; Australian Classification 05.42

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 4031545, published 1977, June 21, Stein et al	(1-6,8-15)
X	US, A, 4160998, published 1979, July 10, Kamin	(1,2,6,9,10,15)
X	US, A, 3884816, published 1975, May 20, See Fig. 5, Takahashi.	(1-3,6,8-12, 15)
A	GB, A, 1437970, published 1976, June 3, Nihon Denshi Kabushiki Kaisha.	
A	GB,A, 2002199, published 1979, February 14, Heimann GmbH.	
A	GB, A, 1559762, published 1980, January 23, Robert Bosch GmbH.	
A	GB, A, 1568496, published 1980, May 29, Robert Bosch GmbH.	
A	GB,A, 1246058, published 1971, September 15, see page 4, Jank.	
A	US, A, 3441667, published 1969, April 29, Novacek.	

* Special categories of cited documents: [15]

"A" document defining the general state of the art

"E" earlier document but published on or after the international filing date

"L" document cited for special reason other than those referred to in the other categories

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or 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

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
31 July 1981 (31.07.81)	06TH AUGUST 1981 (06-08-81.)
International Searching Authority [1]	Signature of Authorized Officer [20]
AUSTRALIAN PATENT OFFICE	A.S. Moore A.S. Moore

Form PCT/ISA/210 (second sheet) (October 1977)