DOCUMENT RESUME

ED 081 446 LI 004 454

AUTHOR	Turner, I.
TITLE	Video Recording: Its Application to Information Retrieval.
INSTITUTION	Institution of Electrical Engineers, London (England).
REPORT NO	INSPEC-R-73-14
PUB DATE	Sep 72
NOTE	59p.; (45 references)
AVAILABLE FROM	INSPEC, The Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England (pound 1.75)
EDRS PRICE	MF-$0.65 HC Not Available from EDRS.
DESCRIPTORS	Cable Television; Indexing; Information Dissemination; Information Networks; *Information Retrieval; *Information Storage; *Video Equipment; *Video Tape Recordings

ABSTRACT

A video system appears to have considerable potential as a means of disseminating visual information via a suitable interconnection network. In addition, modern video recording offers low cost, high capacity storage so that information could be stored in a convenient, easily retrieved form. The limiting factor to the usefulness of such a system is its resolution. Since an information system needs to display text, the textual resolution of a video system is analyzed both theoretically and experimentally and the results compared. The techniques for recording video signals are outlined and the problems involved in storing information in single pictures is discussed. The cost of video storage is analyzed and the figures compared with other storage techniques. Video tape has a slightly higher cost per single frame than microform techniques. Methods of indexing the information and of controlling a video system are outlined and the nature of a video network is described. The applications of a video system to information retrieval are discussed. The resolution capability of currently available equipment represents a fairly severe limitation to the design of an information retrieval system using video techniques. With improvements in the technology it is possible that more general information retrieval systems could usefully exploit the technique. (Author)

ISBN: 0 8529 6410 2

V I D E O   R E C O R D I N G

ITS APPLICATION TO INFORMATION RETRIEVAL

I. TURNER

SEPTEMBER 1972

ABSTRACT

A video system appears to have considerable potential as a means of disseminating visual information via a suitable interconnection network. In addition, modern video recording offers low cost, high capacity storage so that information could be stored in a convenient, easily retrieved form. The limiting factor to the usefulness of such a system is its resolution. Since an information system needs to display text, the textual resolution of a video system is analysed both theoretically and experimentally and the results compared. The maximum number of easily legible characters which can be displayed on the screen of currently available equipment is found to be between 1000 and 1500 characters, depending on the bandwidth of the system and the quality of the equipment.

The techniques for recording video signals are outlined and the problems involved in storing information in single pictures is discussed. Commercially available video tape recorders do not produce acceptable playback of single pictures. It might be possible to modify an existing design to produce acceptable single picture playback. A list of commercial equipment is included as an appendix.

Assuming that the single picture problems could be overcome, the capacity (in pictures) of a number of video tape recorders is tabulated. A minimum of 37,000 pictures and a maximum of 450,000 pictures per reel are noted. The cost of video storage is analysed and the figures compared with other storage techniques.

Video tape has a slightly higher cost per single frame than microform techniques. Methods of indexing the information and of controlling a video system are outlined and the nature of a video network is described. The applications of a video system to information retrieval are discussed.

The resolution capability of currently available equipment represents a fairly severe limitation to the design of an information retrieval system using video techniques. Certain specialised systems can be defined when the document to be displayed contains less than 1500 characters. With improvements in the technology it is possible that more general information retrieval systems could usefully exploit the technique. With this possiblity in mind it is intended to maintain a watching brief on the technology.

CONTENTS

1.0			INTRODUCTION	Page	1
2.0			VIDEO FUNDAMENTALS	Page	2
	2.1		Scanning	Page	2
	2.2		Practical Systems	Page	2
3.0			RESOLUTION	Page	4
	3.1		Theoretical Considerations	Page	4
	3.2		Experimental Work	Page	5
	3.3		Results	Page	6
4.0			VIDEO STORAGE	Page	7
	4.1		The General Problem	Page	7
	4.2		Video Tape Recorders (VTR's)	Page	7
		4.2.1	Helical Scan	Page	7
		4.2.2	Transverse Scan	Page	7
		4.2.3	Applications	Page	8
	4.3		Single Picture Playback	Page	8
	4.4		Storage Capacity	Page	9
	4.5		Storage Costs	Page	10
	4.6		Access Time	Page	
	4.7		Temporary Stores	Page	12
	4.8		Direct Computer to Video Output	Page	12
	4.9		Index and Picture Identification	Page	13
5.0			EQUIPMENT	Page	15
	5.1		Equipment Types	Page	15
6.0			VIDEO NETWORKS	Page	16
	6.1		Video Transmission	Page	16
	6.2		Cable T.V.	Page	16
7.0			INFORMATION RETRIEVAL SYSTEMS	Page	18
	7.1		System Requirements	Page	18
	7.2		Applications	Page	18
8.0			CONCLUSIONS	Page	21
			BIBLIOGRAPHY	Page	23
			GLOSSARY	Page	28
			APPENDIX I	Page	30
			APPENDIX II	Page	32
			FIGURES	Page	49

INTRODUCTION

Since the early days of television broadcasting the techniques of video communication have progressed in leaps and bounds [10]. Improved components, sophistication and at the same time, reduced costs, have meant that video systems have been used in a wide range of applications. These include security, safety, education and scientific uses, [9]. In recent years the whole area of video communications has been revolutionised by the introduction of low priced video tape recorders, the competition in this field being so severe that the standard of the equipment on the market is kept very high and it represents good value for money. Part of the reason for the competition, stems from the market potential of low priced video tape recorders. Every home with a television represents a potential customer for VTR equipment and the programme material which could be replayed on it, [42]. In addition broadcasted programmes can be recorded and replayed, [1], [4], [5], [8]. The capabilities of a video system consisting of a camera, monitor, VTR and a suitable interconnection network seem ideally suited to an information system which must be able to disseminate stored information rapidly to a recipient. The object of this study was to investigate the available equipment and techniques to ascertain the viability of an information system using video techniques.

The first phase of the work involved a study of the inherent limitations of a video system and in particular examined the resolution capability in some detail. The resolution limitation was related to the number of legible characters which could be displayed on the screen at one time. This is an important aspect of any information system since most information is stored as text. A VTR is designed to replay moving sequences, which it does by storing the sequence as a number of frames which are replayed sufficiently rapidly that the eye is given the impression of continuous motion. To make efficient use of the tape, it is desirable to store each page of information on a single frame. The problem of operating a VTR in this mode is discussed.

The study went on to examine a range of possible systems to isolate the area of information dissemination most suited to video technology. While it is likely that a special system could be designed and constructed to overcome most of the limitations of commercially available equipment the main object of the study was to examine the usefulness of current available equipment which would enable systems to be constructed at very low price.
A literature survey was carried out and a bibliography is included at the end of the report.

2.0 VIDEO FUNDAMENTALS

The fundamental concept underlying video technology is that a given scene, which to the eye of an observer represents information being transmitted in parallel, is scanned in such a way that the picture content is re-organised into a serial signal so that it can be transmitted via a single channel. On reaching its destination, the video signal is synthesised into a picture. The problem with television is to be able to transmit the variation of light and shade of each element to the distant end, and there to reproduce these variations. Fortunately, because of persistence of vision, it is not necessary to reproduce all the elements simultaneously. The reproduction of the elements can follow in succession provided that the whole scene is repeated quickly enough, in the same way as a conventional motion picture system which displays 24 different frames every second and hence creates an impression of motion. To eliminate flicker in the cinema, however, it is necessary to interupt each stationary picture at least once, so that the effective repetition rate is 48 frames per second. A finite time must elapse during the examination of all the elements of a scene. However, this time must be short enough for the persistence of vision of the human eye to overcome flicker and give the impression of natural movement.

Both of these effects depend upon the number of complete pictures transmitted per second, known as the picture frequently, while flicker is dependent also on image brightness, the receiving screen phosphor and other factors. It is therefore difficult to determine a minimum value for the picture frequency but satisfactory results can be achieved with a value of 25 pictures per second, provided that the effective repetition rate can be doubled as it is in film.

2.1 Scanning

The scanning pattern used in all contemporary television systems is one of slightly slanting horizontal lines. The spot starts at the top left-hand corner of the screen and moves steadily to the right and slightly down. On reaching the right-hand edge of the picture, the spot quickly returns to the left-hand edge, just below its original starting place, changes direction again and traces the second line, just below the first. This continues until the bottom of the picture is reached, at which point the spot is rapidly returned to the top left-hand corner and retraces the pattern again.

2.2 Practical systems

All entertainment television systems currently in use employ interlace to obtain freedom from flicker while having a 25 per second or 20 per second picture repetition rate. In this system the picture is first scanned by half the number of active lines and is then re-scanned by the other half, with the second set of lines sandwiched (or interlaced) between the first. One half-scan of the screen is known as a field and the complete scan (two fields) is known as a picture. A simplified interlaced scan is shown in figure 1.

Since some time must be allowed for the spot to return across the screen from right to left and from bottom to top (the flyback or retrace time), picture information cannot be transmitted during this time and thus some information is lost.

In a practical system, the scanning spot is blacked-out during these periods.

3.0 RESOLUTION

Since most information systems must have a capability to display fairly large amounts of textual material, it is important to have a knowledge of the resolution limitations of a video system and hence a knowledge of the maximum number of resolvable characters per picture.

A video system has two distinct resolution limits. One is a spatial limit imposed by the number of horizontal lines in the raster. While the other is a temporal limit which is related to the band-width of the serial channel and to the nature of the raster. The band-width limitation manifests itself as a resolution limit on closely packed vertical lines, while the spacial limit affects the resolution of horizontal lines.

3.1 Theoretical considerations

The interplay between the two limits is best illustrated by considering a hypothetical system which uses a square tube face. If it was required to display detail with a linear dimension of the order of 1/1000 of the picture height, then the system must be capable of transmitting 10^6 bits in a given picture, since there are 10^6 areas in the picture of this size. At 25 picture frames per second the channel must be able to handle 25,000,000 bits of information per second. In practice, this is feasible, but outside the data rate range which electronics engineers consider easy. This range extends up to about 5MHz. If this figure is related back to picture content, a figure of 2×10^5 bits in each picture is obtained, which represents a linear dimension in the picture of 1/500 of the picture height.

From this is is immediately possible to infer the textual display capabilities of such a system. If a printed page is examined it is apparent that only about one quarter of the area of the page is occupied by character areas. Character areas are the rectangular areas into which each character can be fitted. In this case it can be seen that 5×10^4 bits are available for character space. From work which has been done on character formation for matrix printers and VDU's it is known that an array of 7 x 5 bits is about the minimum which will yield an acceptable resolution of a character.

This can be used to calculate that the maximum number of characters which can be acceptably displayed in one picture of video information is approximately 1400. If an 8 x 6 array for each character is used, the number of characters which may be displayed is 1000.

The above treatment is highly simplified but yields a useful approximation for the textual display capability of a video system. A more accurate representation takes into account the exact numbers involved in the line scan and also allows for lost information during the line fly back and frame fly back times (which are not negligible). The effect of this is that the band-width required for a given number of picture elements in the active area of the screen is about 20% higher than the simple calculation above predicts. This means that the result is a little optimistic of the performance of a real video system.

3.2 Experimental work

Since the prime consideration for any information system is that it must be able to display text, the main test of each video system examined involved displaying and storing the video signal of specimens of print of differing point sizes, which varied from 7 point type to in excess of 20 point type.

Samples of the two test specimens used are included at the end of this report. See Appendix 1.

The screen area was utilised in three ways, first, the sample was displayed so that the whole pagewas visible on the screen (full frame/vertical) then half of the page of arranged to fill the screen (half frame) and finally the sample was turned on its side so that it filled the screen horizontally (full/frame horizontal). This method means that the monitor must be turned on its side to read the text, the long side of the TV screen being vertical.

The display was then examined subjectively and a quality rating for each point size was selected from one of the following:

1. EXCELLENT
2. VERY GOOD
3. GOOD
4. LEGIBLE
5. LEGIBLE (hard to read)
6. ILLEGIBLE

The first rating implies that the quality of the display is that of the original text. Rating 2 is when the limitations of the video system are just perceptible. Rating 3 is when the system limitations are apparent but the display is perfectly acceptable for reading. Rating 4 is when the limitations of the video system are significant so that certain characters are badly defined. Rating 5 is when the display has deteriorated to the point where certain characters are completely undistinguishable, but the text can be read using the context of the remaining legible characters. Rating 6 is when no characters are distinguishable.

Five companies were visited and the above test carried out. Two of these companies did not have VTR's available at the time of the visit. The remaining three systems represented an excellent coverage of the range of equipment available, with low priced, medium price and high priced equipment being examined.

The systems were:

1. <u>The AKAI Systems TS - 110 DX</u>

This is a cheap, portable video system aimed at the home market, but with obvious industrial uses. The total cost for camera, video tape recorder and monitor is only £785. The camera has a zoom lens and automatic light level control feature. The VTR uses ¼" chromium-dioxide tape and has a replay time of 24 minutes. The band-width of the video tape recorder is 2MHz.

The scanning system used is standard 405 line interlaced scanning. Although the VTR band-width is low, by using a 405 line scan the horizontal resolution and the vertical resolution were similar and the system gave surprisingly good results.

2. The Rank System (Television Systems and Research Ltd)

The system demonstrated was built from a collection of equipment aimed at the industrial market. The engineering of the equipment was robust and practical. The VTR was a ½" tape Nivico KV820, having a bandwidth of 2.5MHz. Playing time is 63 minutes. The system used a 625 line scan. The cost of the system was about £1000. Although the VTR bandwidth is only slightly higher than the AKAI system, the camera and monitor were of very high quality and the overall performance was noticeably better than the AKAI system as a result.

3. Pye Communications

The system demonstrated represented the top end of the industrial market. The VTR was a Philips LDL1251 which uses 1" tape and has a full 5MHz bandwidth. The picture stability and signal to noise ratio are very high for this machine. Playing time is 57 mins. using chromium dioxide tape. The camera used was an EL8000 unit, fully self-contained and with many automatic-control facilities in-built. The monitor used was an LDH 2110 20" monitor. The VTR performance was such that it was difficult to distinguish between direct display and recorded playback. The cost of the system would be over £3000.

3.3 Results

The AKAI System

With text specimen one displayed full frame vertically, all the text was ILLEGIBLE.

With test specimen one displayed full frame horizontally, the numbered lines were ILLEGIBLE, but the hand-written title was LEGIBLE.

With test specimen one displayed half-frame, lines 1 and 2 were LEGIBLE.

The Television Systems and Research System

With test specimen one displayed full frame vertically, all of the test was ILLEGIBLE.

With test specimen one displayed full frame horizontally, lined numbered 1 and 2 were LEGIBLE, 3 was LEGIBLE (hard to read).

The test specimen one displayed half-frame, lines numbered 1 and 2 were GOOD, 3 was LEGIBLE.

The Pye Communications System

With test specimen one displayed full frame vertically, lines numbered 1 and 2 were LEGIBLE, 3 and 4 were LEGIBLE(hard to read).

With test specimen one displayed full frame horizontally, lines numbered 1 and 2 were GOOD, 3 and 4 were LEGIBLE.

With test specimen one displayed half-frame, lines numbered 1 and 2 were VERY GOOD? 3 and 4 were GOOD.

The graph in the bottom right-hand corner of the test specimen 2 was displayed so that it filled the screen. On the AKAI system some of the detail was lost, particularly in the numbering of the axes. Both of the other two systems displayed the graph acceptably.

The paragragraph adjacent to number 3 on test specimen 1 was displayed so that it filled the screen. The playback was VERY GOOD or EXCELLENT on all three systems.

4.0 VIDEO STORAGE

4.1 The general problems

Although electronic engineering techniques can handle bandwidths of up to 5MHz with ease, recording onto magnetic tape is so difficult that 5MHz is about the best that today's technology can achieve. Hence, in any video system using a VTR, this will be the limiting factor in terms of bandwidth, and hence resolution. Magnetic tape is capable of storing about 10,000 cycles of a signal along 1" of track. Hence, if a bandwidth of 3MHz is required, the tape must pass the read head at 300 inches/sec. or at about 20 miles per hour! To achieve bandwidth of 5MHz requires a tape to head velocity of 30 miles per hour. Attempts to achieve this with conventional tape transports were only moderately successful. It is very difficult to control the tape to prevent stretch and whip, and the tape tends to bounce over the read head producing an intermittent picture. In addition to this, playing times for reels are ridiculously short. Two techniques are employed to overcome these problems. They are helical scan video recording and transverse scan video recording.

4.2 Video tape recorders (VTR)

4.2.1 Helical Scan

One or two rotating heads are mounted on a large diameter drum, which turns at a high speed. Around the drum the tape is wound helically, but it travels slower than the periphery of the drum. Because of the helical wind, the track pattern on the tape is at an angle to the edge of the tape. Thus, though the tape is transported at a relatively low speed, the head to-tape speed is relatively high. This more sophisticated arrangement is employed in closed-circuit and educational VTRs. A typical industrial quality VTR is shown in Fig 2.

4.2.2 Transverse Scan

A small-diameter drum carrying four equally spaced heads rotates at a very high speed on an axis parallel with the length of tape, which is curved by a vacuum device to the shape of the drum. Thus, as the tape is drawn pas the rotating assembly at a low speed, the heads in turn transverse it at a very high speed, and when one head passes away from the farther edge, the next head has already reached the nearer edge. Because of the longitudinal movement of the tape, there is a slight angle between tape and tracks. A broadcast quality VTR is shown in Fig 3.

4.2.3 Applications

Transverse scan recorders are employed universally in professional broadcasting organisations, where the demand is for the highest quality equipment. Only in the 1960s, when low-priced vidicon channels of good quality became available, were manufacturers able to apply the knowledge gained from these more advanced machines to the production of helical scan machines of acceptable performance.

Since transverse scan VTR's are only used for broadcast requirements, they are, therefore, inherently sophisticated and expensive. The helical scan method has become the standard technique for the intermediate and low-priced VTR's. Because of the possibilities of a mass market, and hence considerable competition in this area, helical scan recording has advanced dramatically. The result of this is that the better industrial quality helical scan VTR's have a recording performance almost as high as a broadcast quality transverse recorder, yet costing an order of magnetude less!

4.3 Single picture playback

Due to the design of all the VTR's tested, it was not possible to display a fully interlaced picture on single picture playback. The output is a picture consisting of two identical interlaced fields. This loss of vertical resolution by a factor of two severely limits the amount of text which can be displayed on a single picture in this manner. The paragraph adjacent to number 3 on test spcimen one, when arranged to fill the screen, was legible when displayed in this manner. None of the other tests yielded an acceptable display. In the case of the Philips VTR, it was possible because of the high horiztonal resolution and stability, to see that two adjacent lines were identical. The AKI system was less stable and the result was that the individual pairs were not so apparent and the picture took on a lower vertical resolution without the viewer being aware of horizontal lines. The picture produced by the Philips machine, by the virtue of its stability, showed distracting horizontal bands.

In either situation the picture quality is low, and it is apparent that, before a VTR could be used in this mode, it would need modifying to allow replay of the full picture content: this could be achieved by re-timing the video signal so that one rotation of the head drum represented a frame instead of a single field. The head drum could be slowed by a factor of two or the picture rate increased by two. The resulting picture would be stored on a single slant track on the video tape, instead of two, with the result that the horizontal resolution would be effectively reduced by two. However, the number of single pictures which could be stored on a reel of tape would be doubled. This simple relationship between capacity and picture content must always hold, since the total storage capacity of a reel of tape depends only on its surface area and the storage density obtained. An alternative method to achieve single picture playback would be to displace two heads on the head drum by one track so that in a single rotation of the head drum one head scanned a different track to the other. This technique would limit the use of the VTR to single picture playback, since incorrect interlacing would result if continuous recording were attempted.

In addition to this, when the tape is stationary so that the head drum is scanning one track, the wear which takes place on this track is very high. Magnetic tape begins to deteriorate after about 10,000 replay passes, which in single frame playback takes only 3 mins.

In a system it might be possible to overcome all of these problems by using a temporary store of some type, which is capable of storing two fields and playing them back correctly interlaced. A magnetic disc of the type used by the television broadcasting companies for 'instant' replay and slow motion playback would be a possibility for this. The VTR is continuous playback would switch the appropriate fields of video signal to the temporary storage device on command from an index track. This would reduce the tape wear problem encountered on continuous single frame playback.

Finally, no VTR had a control system which would enable the tape to be stopped so that the heads were correctly positioned over a track. This had to be done manually on all three systems by moving the tape reels by hand. None of the technical problems appear insurmountable at this stage; the question is how much would such modifications cost.

4.4 Storage capacity

The storage apacity for a reel of video tape can be estimated by relating the playing time of the tape to the frame rate of the video system.

Some typical capacities in numbers of single pictures are listed below for a variety of VTR's:

Machine	Tape Width	Tape Length	Playing Time	Capacity (Pictures)
IVC - 705	1"	2150'	60 mins	99,000
IVC - 900	1"	7500'	3½ hours	315,000
Philips LDL 1002	½"	1000'	30 mins	45,000
Philips EC 3402	1"	1800'	70 mins	105,000
Philips LDL 1251	1"	3000'	57 mins	85,000
Ampex Instavideo	½"	1200'	30 mins	45,000
Ampex VR-660C	2"	5500'	5 hours	450,000

Machine	Tape Width	Tape Length	Playing Time	Capacity (Pictures)
Ampex VPR-520 3	1"	3000'	1 hour	90,000
AKAI VT5-110	¼"	1200'	24 mins	37,500
Grundig BK 300	1"	4600'	110 mins	165,000
Sony AV 3600	½"	2000'	60 mins	90,000
Shibaden	½"	2400'	70 mins	105,000

It can be seen from the table that as a rule the wider the tape the higher the capacity per foot. This follows from the idea that the storage capacity is proportional to the surface area of the tape.

The capacity figures are ideally suited to storing scientific data bases. The individual records of such data bases are sufficiently small that they would fit easily onto one frame of the video tape. The sizes of some typical scientific data bases are listed below:-

MEDLARS	400,000 records/year
BIOLOGICAL ABSTRACTS	140,000 records/year
INSPEC	140,000 records/year
INIS	90,000 records/year
NASA (reports)	500,000 records (total)
CHEMICAL ABSTRACTS	300,000 records/year
COMPENDEX	70,000 records/year

In terms of bits, the storage capacity is truly vast when compared with computer tapes. The Ampex VR660C would have a capacity of 45,000,000,000 bits of binary information. However, it is important to realise that the reason that this sort of performance can be achieved is because a video system has tremendous redundancy and the importance of any one bit of the signal is very low indeed. A VTR works well despite having a drop out rate as high as 1 in 10,000. If a computer tape system was as poor as this it would mean that an error would occur 30 times in every second! A computer tape system would have an error rate as low as 1 in 10^9 or 1 in 10^{10}.

4.5 Storage costs

The storage costs of a video system breakdown into two areas. The first is the initial equipment cost and its subsequent maintenance cost. This is a very difficult area to qualify due to the great variability in the quality and cost of both the initial product and subsequent maintenance offered by different manufacturers. The question of equipment cost will be dealt with in a later section.

The second cost factor is that of the storage medium itself. In the case of video-recording this is the magnetic tape, its reel and a storage box. The cost of tape purchased in this way is approximately proportional to its surface area and the factor of cost per unit area (CPA) is a useful one to use as a guide.

For short tape lengths where reel costs are a large percentage of the total, the CPA can be up to 0.19 p/sq. inch and for a 2200ft reel of 1" tape the CPA can drop to 0.072 p/sq. inch. The average value is about 0.1 p/sq. inch. For a typical 1" VTR with a capacity of 90,000 pictures the cost per picture would be o.02p, and the area of tape used to store the picture would be about one quarter of a square inch. If we assume that a picture can store 1000 characters of legible text as was discussed previously, the cost of storing one character is 2×10^{-5} or using a 6 bit representation of each character the cost per binary bit is about 3×10^{-6} p/bit. This is a very low cost figure and compares favourably with other means of storing information.

Some typical cost/bit and volume/bit figures for a variety of storage media are listed below.

MEDIA	Cost/bit	Volume/bit
Magnetic Disc	2.5×10^{-4} p/bit	4.2×10^{-5} c.c/bit
Magnetic Tape	3.0×10^{-5} p/bit	2.5×10^{-5} c.c/bit
Xerox Copies	2.0×10^{-5} p/bit	2.0×10^{-4} c.c/bit
Printing	5.0×10^{-6} p/bit	1.0×10^{-4} c.c/bit
Video Tape	3.0×10^{-6} p/bit	7.0×10^{-7} c.c/bit
Micro Film	2.0×10^{-6} p/bit	3.8×10^{-7} c.c/bit
Ultrafiche	4.0×10^{-7} p/bit	2.1×10^{-8} c.c/bit

It is interesting to note that the two microform techniques are superior in both cost and volume. If video tape is to compete with either of these two technologies it must use some of its own special characteristics in an advantageous way. This will be discussed in more detail in the section on systems.

4.6 Access time

Since video tape is a serial storage medium, the access time to a given picture on the tape will be a function of the length of tape to be travelled to the required picture and the fast winding speed of the VTR. The rewind speeds of different manufacturers VTR's differ a great deal. The fastest, (IVC) can rewind 2500ft of tape in 2 mins while the slower machines can take up to 8 mins for the same length of tape. The former represents a tape speed of 20ft/sec. At the other end of the scale there will be a minimum time to move from one picture to an adjacent picture which will depend on the speed of response of the servos which will be required to accurately position a track under the read heads. No figures are available for this but it is likely that about a second would be involved due to the extreme accuracy required.

It is possible that the maximum access time could be reduced by redesigning the tape transport mechanism. However, this would be a major exercise and in any case the nature of the tape path in a helical scan VTR is such that the tape speed would be limited by the amount of tape wear which could be tolerated.

The access times discussed could introduce intolerable delays to an on-line system.

4.7 Temporary Stores

Due to the high capital cost of a VTR of adequate performance for textual display and because of the special communication possibility of a video system, it would seem desirable to maintain a central VTR which could service many users via a video communications network. If amulti-access situation occurs with a single VTR, only one user can be viewing a given picture at any one time. This is clearly an undesirable situation. To overcome this it would be necessary to provide a sufficiently large number of single picture storage buffers to cope with the peak demands on the system. The VTR would output a selected single picture to the temporary store and would immediately be switched to service another user. The temporary store would be able to give a user unlimited viewing time without committing the VTR. Such temporary stores already exist in broadcasting systems which use them to provide storage of 20 seconds or so of programme, so that 'instant replay' can be given without halting the main VTR which is recording the programme. Single picture magnetic discs have been developed by the Japanese who hope to incorporate them in home television as a gimmick to enable the viewer to 'freeze' an address or a selected sporting scene as he desires.

Finally it would be possible to use a storage tube monitor at every user terminal so that every user had an inbuilt store. These tubes have a limited storage time of 15 minutes or so before the picture quality deteriorates. This would probably be sufficient for the needs of most users.

4.8 Direct Computer to Video Output

In section 3.1, the concept of a bit structure in the video picture as a way of quantifying the information content was discussed. It is possible, however, to construct an actual binary representation of a scene in the core store of a controlling computer. In this way messages could be output directly from the computer to the television monitor, This would enable transient information to be stored in the computer and also provide the means of carrying out a dialogue with the computer without the need for an additional printing device at the user end. The technology for doing this is already well developed and many manufacturers have both television hardware and software available. For machines such as the ICL 1900 series which uses a 24 bit word, about 6K words of store are required to construct 1000 characters on the screen.

The temporary storage device would again be needed so that large amounts of core store are not committed to an individual user.

4.9 Indexing and picture identification

Assuming that single picture playback of sufficient quality is possible, it is necessary to be able to select a given picture, move to it and display the picture. This means that each picture must have associated with it a coded marker of some sort. This marker could be a single mark so the picture identification would be achieved by counting marks up or down from a previous known position. This technique, often referred to as blip counting is ideal for human controlled situations such as a semi-automatic microfilm reader but would be unsuitable in a machine controlled situation since a counting error which could be caused by interference, mains voltage variations or a variety of other reasons, would not be detected and from that time onwards incorrect pictures would be selected. It is better to use a picture identification system which involves absolute addresses. In this technique each picture marker is a code which uniquely defines the picture. The codes would probably be 17 of 18 bit binary numbers enabling more than 100,000 pictures to be addressed. If the binary numbers are sequential on the tape it would be possible to use a blip counting technique to home in on the correct frame, followed by a check of accuracy using the value of the binary number. These numbers could be stored on the linear tracks which run along the edges of the tape and which at present are used for audio tracks and servo tracks to enable the tape to be correctly positioned with respect to the head rotor during normal recording and playback.

The 18 bit numbers would need to be represented in serial format on a single track since there is insufficient room at the edge of the tape to define 18 parallel tracks. In any case, 18 parallel read channels would be extremely expensive. On a typical 1" machine 90,000 pictures are stored on 2150 feet of video tape which means that the longitudinal spacing of the tracks is 0.28 inches. If the 17 bit code is recorded at say 200 bits/inch it would stretch 0.085 inches long the tape leaving a gap between codes of 0.2 inches. Thus, it should be possible to use the 17 bit groups as markers for blip counting and by reducing the tape speed when near the selected picture the 17 bit codes could be read to find the exact picture. Once at the correct position the tape could be stopped and final positioning done by a fine servo. This could detect one or the code bits (say the last) and use this to exactly position the tape with respect to the read head drum. This last head must be able to read the tape at very low speed and would therefore need to be of a flux sensitive type.

Due to the nature of the tape path in a helical scan VTR it would not be possible to position the code marks near the scan line to which they relate, since the read heads for these code marks must be positioned away from the helical scan drum. This would cause problems when editing. Optical marking is a possibility which would have many advantages over magnetic recording such as cheapness but since it is not easily erasable, editing would be difficult.

No commercially available VTR possesses the features mentioned above. To implement them on a commercial machine would be possible but would require some development work.

5.0 EQUIPMENT

5.1 Equipment types

A survey of equipment manufacturers was carried out using the normal directories as source material. Sixteen major manufacturers of video equipment were located in this manner. Many of the companies were distributors for overseas manufacturered equipment and, in fact, it would appear that there is no British manufactured VTR in existence. The VTR market is dominated by the Americans and the Japanese, although Grundig and Philips from West Germany and Holland respectively represent very keen competition in the field.

All intermediate and low priced VTR's manufactured in the world use the helical scan technique in one form or another. Some manufacturers wrap the tape completely round the head drum in what is called the alpha format. Others effectively guide a loop partially round the head drum in what is called the omega format. The tape width used varies from ¼" in the AKAI system to 1" in the AMPEX, IVC and Philips machines. Most machines used ½" tape. The 1" tape machines are the highest quality and, due to the larger surface area of the tape, often yield longer playing times.

A list of manufacturers and their products is given in Appendix 11.

6.0 VIDEO NETWORKS

6.1 Video Transmission

The video signal from a camera or a VTR consists of two types of information. The first is an analogue waveform which represents the variations of light and dark along each line in the picture, and the second is timing information which synchronises the camera's scan with that of the monitor.

The analogue variations do not occupy the full signal swing available. At some level defined as the 'black-level' the spot at the monitor is at zero intensity and therefore the picture is black at points where the signal reaches this level. Information transmitted at signal levels below 'black-level' is interpreted as timing information and pulses in this region are used to instruct the receiver to perform a line flyback or frame flyback. In this way the receiver is made to scan in synchronism with the transmitting device and hence reconstruct a meaningful picture.

This waveform can be transmitted along a cable as a voltage which varies proportionally with the signal or it can be used to modulate a carrier signal of a higher frequency than any component in the signal and the resultant modulated waveform transmitted. If the carrier wave is a radio frequency the signal can be transmitted between transmitter and receiving aerials as in the case of normal television broadcasting.

The advantage of using a modulated carrier wave is that the receiver can be tuned to a particular carrier frequency, when it will reject other signals on different carrier frequencies. Thus, many video signals can be transmitted at the same time and a receiver can select any desired signal by tuning to its carrier frequency.

6.2 Cable T.V.

For general radio-wave broadcasting, only a limited range of carrier frequencies are available. This is because the authorities in each country allocate certain frequency bands to radio, some to television, some to the police, ambulance and fire services and so on.

In all, about 50 channels are available for television broadcasting. This means that specialised video communications cannot use radio methods since the number of free channels would be quickly used up.

This problem can be overcome by the use of hard-wired links using coaxial cables. Any carrier frequency can be used without fear of interference with normal broadcasting, and the total number of channels available is over one hundred/cable with no limit to the number of cables which could be used. [19].

Cable TV networks have been built in the USA and subscribers to the systems can select programmes from a choice of about 40. [13], [20], [30]. The Americans have named this cablecasting.

A cable network could be used as the dissemination means of an information retrieval system, [16]. One essential difference exists between broadcasting and an information service and that is that the broadcast is received by a very large number of people whereas an information service would need to send the video signals to individual subscribers. The problem is similar to the case of the normal telephone network, although it is magnified by the high bandwidth required by the video signal. [45]. However, the problems are not insurmountable and video switching centres similar to normal telephone exchanges could be built and trunk video lines capable of handling 500 simultaneous video signals could be built using microwave techniques. However, the cost of a nationwide network would be perhaps an order of magnitude more expensive than the telephone network.

On a smaller scale the techniques of closed circuit television are well established and small networks involving ten or less monitors are easily constructed using commercially available equipment such as that supplied by TELENG LTD (see equipment manufacturers). The cost of a simple video network is typically £1 per metre inclusive of amplifiers, repeaters etc,

7.0 INFORMATION RETRIEVAL SYSTEMS

7.1 System Requirements

Any information retrieval system must possess certain characteristics if it is to fulfil a minimum retrieval function.

These are:-

1 A large rapid access store

2 An indexing system

3 A visual display

4 A user communications interface

5 A control unit

These requirements are satisfied in a conventional library in the following way. The store is provided by the books kept on the shelves. The indexing system is provided by a catalogue to the books. The visual display is provided directly by the books. The communications interface is provided either passively by a note on how to use the library or by discussion with the librarian. The control unit is the librarian.

These characteristics can be achieved in a simple computer controlled video system as shown in fig. 4. The storage function is achieved by using a VTR; the indexing system is stored in the computer memory; the visual display is a video monitor; the communications interface is provided by a teletype and a data link to the computer and the control unit is the central processor unit (C.P.U.) of the computer.

Such a system would provide its user with a powerful information retrieval system. It would provide the librarian with a useful back-up facility to his normal resources, unfortunately at high cost. To share the basic cost of the computer and video store and to exploit the transmission capability of a video system it would be desirable to connect many video work-stations via a suitable network to a central data base, consisting of the computer and the VTR. The essential features of such a system are shown in fig. 5.

A system of this type would be ideally suited to medium and large scale industries with a requirement for 10 - 15 work-stations. The cost per channel would show a reduction in proportion to the number of channels used, until the system became performance limited due to an excessive work load. Without performing an extensive experiment, it is impossible to predict the sort of demand that would be made on particular systems.

An extension to the simple network system is necessary if the work-stations are large distances apart. This would be the case for a regional or national information centre, when it would be impractical to provide a long distance video channel from each user to the central data base.

Groups of work-stations would be interfaced to a local exchange which would communicate with the central data base via a trunk line. See fig. 6. Signals from different work-stations would be multiplexed on to the trunk lines as required.

A diagram of a complex central unit is shown in Fig. 7. Such a unit would be able to satisfy a users information needs in a multitude of ways.

The communications interface, which would be under the control of the CPU would handle digital and video traffic. All major functions of the system would be under the control of the CPU. The librarian would be able to control the CPU to a certain extent and at the same time responding to requests for information. He could communicate with the CPU via a teletype. On receipt of a request for data the CPU would perform a search through its index file to locate the information. The appropriate storage device would be activiated and the video signal transmitted to the inquirer.

The storage devices shown in the diagram are as follows:-

1	MICRO-VIDEO	An automatic microfilm store with a video camera as output.
2	CORE TO TV	A digital buffer which can be filled from core store and output as a video signal to reconstruct text, graphics, etc.
3	VTR	A video tape recorder which can output single pictures, moving sequence and audio to the inquirer.
4	MASS STORE	A digital store which can be used to output data directly via the digital data channel or via the CORE TO TIV buffer
5.	BOOK STORE	Conventional book store selection done manually by the librarian, video output from TV camera.

As has been mentioned previously, the limit to such a system will be decided by the resolution of the video equipment.

7.2. Applications

Having described possible systems configurations it is important to investigate the possible applications of these and compare them with existing information retrieval techniques.

Since the output is fully graphic the type of material which can be stored and replayed is limited only by the resolution of the system. It has been demonstrated previously that the resolution limit is such that only about 1000 characters can be displayed with high definition, which imposes a severe limitation on the type of document which can be handled. An alternative is that the information is re-configured into 1000 character pages. However, this would impose a severe restraint on the versatility of the system. Also large documents would involve storing many pictures on the VTR. The delays between picture selection would almost certainly prove irritating to the user and browsing would be very difficult.

It would seem reasonable, therefore, to use a video system only when the basic item to be retrieved consists of about 1000 characters or less. This restricts the use of video equipment to a few highly specialised systems. Examples of systems currently being operated which use video equipment (although not VTRs) are airport departure information systems, cheque validation in banks, hospital patient record retrieval and stock record retrieval. These systems use a special document camera which outputs to the selected user. However, in this systems retrieval of the source document is usually manual.

One application of particular relevance to INSPEC would be to display the abstracts of documents. The number of characters in an abstract is such that a video system would be able to display the text with high clarity. A system of this type would, however, be simpler if the abstracts were stored on microfilm, which has a lower cost and higher resolution than video tape, and displayed by projecting the required image so that it can be scanned using a video camera. An example of this class of system is the Project Intrex experiment at MIT [43], [44] or the IDP video system (see Fig. 8.).

Video tape recording does not compare particularly favourably with microfilm techniques when single picture storage is concerned, due to the problems I have discussed earlier. Therefore, to justify using video tape in a video system instead of some other graphic storage medium, it would be necessary to exploit the full potential of video tape. This means that its key tasks should make use of its ability to repaly moving pictures and the ease with which it can be erased and re-recorded. It is very difficult to define a retrieval system which operates in this manner or the use to which it would be put. The editing operations which take place in a TV studio are probably the nearest to the ideal use of video tape.

8.0. CONCLUSIONS

A video system has considerable potential as a means of information dissemination. In addition the technology of video tape recording offers a means of storing visual information and retrieving it. The usefulness of a video system is limited by its resolution. This limit will be imposed by the video tape recorder since its bandwidth is inherently lower than other component parts of a video system. When related to the display of text, between 1000 and 1500 characters can be displayed with acceptable legibility in one picture, by commercial systems using a 625 scan. These figures were confirmed by experiments in which three commercial systems were examined. The three systems were representative of the cheap, medium and high priced areas of the market.

To exploit the capacity of a VTR it is necessary to store each piece of information on a single picture. This means that the VTR must be capable of replaying one picture at a time. Many commercial VTR's have stop frame replay facilities but the resolution is halved when in this mode. It would be possible to modify a VTR so that single picture replay at high resolution could be achieved.

The storage capacity of a number of commercially available VTR's was calculated and found to be in the region of 37,000 to 450,000 pictures per reel of video tape. Using the notion of one page of text to one picture on the video tape, it was possible to estimate the approximate cost of storage. Expressing the figures in new pence/bit, it was found that video tape had an estimated cost of 3×10^{-6} p/bit, compared to costs of 2×10^{-6} p/bit for conventional microfilm techniques and 4×10^{-7} p/bit for ultrafiche copies. Video tape storage therefore cost more than both of the microform techniques. In addition the costs of a VTR and monitor to replay the video tape were found to be considerably higher than a microfilm viewer of comparable display quality.

The access time to any picture on a reel of video tape will depend on the length of tape to be traversed. For the worst case situation when the full tape length must be traversed, the delay time is likely to be in excess of two minutes. The minimum access time which will occur when adjacent tracks are accessed, will be governed by the response time of tape position servos. This is likely to be of the order of a second or so.

To enable a given picture to be selected it must be identified by the control logic. This could be done using the audio tracks of a VTR to store appropriate codes.

An information system using a few monitors and a simple cable interconnection between the central VTR and the monitors would be easy to implement, however its cost would probably be higher than a system implemented using the distribution of microfilm copies to a number of microfilm readers. A hybrid system involving a microfilm store and a cable television communications network might be an attractive alternative system for small industrial users who cannot use microfilm distribution techniques, due to a demand for very high currency.

Large systems are entirely limited by the need for a comprehensive nation wide communications network. The cost of establishing such a utility would need to be borne nationally. To this end the GPO are considering plans for establishing such a video communications network. However, it is unlikely that these plans will be realised in this decade.

Nothwithstanding the restriction imposed by the need for a comprehensive video network, it is difficult to define a range of useful systems. The main obstacle to system design is the fairly severe resolution limit. The few successful applications in operation at the present are extremely specialised and not versatile. It is conceivable, however, that the technology will improve over the next few years or so, to the point where the resolution limitations are significantly reduced. Should these developments occur, the restriction on the type of document which could be handled would be removed and a whole range of useful versatile systems could be defined.

The potential of video systems for information retrieval remains unaffected by these conclusions and to this end a close watching brief on the technology will be maintained during the coming years.

BIBLIOGRAPHY

1. C. P. GINSBURG
Video Recording: The Imminent Revolution
Int. Broadcast Eng. (GB) No. 86 P.37-42 (April 1972)

2. D. K. FIBUSH (Ampex Corp., Redwood City, Calif, USA)
System Design consideration for a dual-transport cassette videotape recorder
J. Soc. Motion Picture and Televis. Eng. (USA) Vol. 81, No. 1 P.48 (Jan 1972)
(Smpte winter TV conference, Abstracts, Dallas Tex., USA, 5-5 Feb 1972)

3. D. M. ZWICK (Eastman Kodak Co., Rochester, N.Y. USA)
Some technical aspects of the film-television Interface
J. Soc. Motion Picture and Televis. Eng, (USA) Vol. 81, No. 1 P.47 (Jan 1972)
(SMPTE Winter TV Conference, Abstracts, Dallas Tex., USA, 4-5 Feb 1972)

4. R. THEILE, H. FIX, K. E. GONDESEN (IRT, Munich, Germany)
Technical aspects of television program production on film or Videotape
J. Soc. Motion Picture and Televis, Eng. (USA) Vol. 81, No. 1 P.46 (Jan 1972)
(SMPTE Winter TV Conference, Abstracts, Dallas Tex., USA, 4-5 Feb 1972)

5. K. G. LISK, C. H. EVANS
Colour television film recording from a shadow-mask picture tube
BR. Kinematgr. Sound & Telev. (GB) Vol. 53, No. 12 P.422-8. (Dec. 1971)

6. R. F. DUBBE (3M Co., Camarillo, Calif., USA)
Chromabeam - A new method for transferring television to colour motion picture film
Proceedings two day seminar on novel Audio-Visual imaging systems, New York, USA, 23-24 Sept 1971 (Washington, D.C. USA Soc. Photographic scientists and Engrs. 1971) P.18-22

7. L. E. WEAVER, London, England: Peregrinus Ltd., (1971)
(O 901 223 115) Television Measurement Techniques

8. P. MOUNTAIN
The Fuji CVR System
BR. J. Photogr. (GB) Vol. 119, No. 22 P.462-3. (2 June 1972)

9. Video in Research and Engineering.
IND. Photogr. (USA) Vol. 21, No. 4 P.18-19, 38 (April 1972)

10. SMPTE Winter TV Conference, Abstracts.
J. Soc. Motion Picture and Television Eng. (USA) Vol. 81, No. 1 (Jan 1972)

11. J. A. PISYOR (Eastman Kodak Co., Rochester, N.Y. USA)
A portable film system for demonstrating benefits of using film for television
J. Soc. Motion Picture and Televis. Eng. (USA) Vol. 81,

No. 1 P.46 (Jan 1972)
(SMPTE winter TV conference, Abstracts, Dallas Tex. USA
4-5 Feb 1972

12. E. S. BUSHY (Ampex Corp. Redwood, Calif, USA)
A tape format for quadruplex cassette/cartridge VTR's
J. Soc. Motion Picture and Television. Eng. (USA) Vol. 81, P.48 (Jan 1972)
(SMPTE Winter TV conference. Abstracts, Dallas, Tex. USA?
4-5 Feb 1972

13. R. P. GABRIEL
Cable television and the wired city
Electron & Power (GB) Vol. 18 P.121-4 (April 1972)

14. T. MURAYAMA, Y. YAMAMOTO, M. SOMEYA (Tokyo Shibaura Electric Co. Ltd., Japan)
The Optimum Gap Structure of VTR Magnetic Head. Bull. Jap. Soc. Precis. Eng. (Japan) Vol. 5 No. 4 P.113-14 (Dec. 1971)

15. C. E. ANDERSON (Ampex Corp., Redwood City Calif. USA) The Role of Video-Magnetic Recording Installation in Automation Fernesh - & Kino -Tech) (Germany) Vol. 2B, No. 1 P.22-4 (Jan. 1972) in German

16. J. ROWE
New CCTV facility at the NSW Institute of Technology
Electron Aust.
(Australia) Vol. 33, No. 11 P.20-1 (Feb. 1972)

17. S. P. ROBINSON, L. S. HORST
(Teledyne Camera Systems, Arcadia, Calif., USA)
Color film recording from TV
Soc. Photo-Opt Instrum Eng. J (USA) Vol. 9 No. 6 P.196-200 (Aug-Sept 1971)

18. G. E. LAMP, JR., C. L. TOWNSEND (IOWA State Univ., Ames, USA) Off - Campus Instruction via video tape
Proc. IOWA ACAD. SCI. (USA) Vol. 78, No. 1-2 P.18-19 (Oct 1971)

19. M. M. FERGUSON
Broadband Cable Television Systems and Associated Services for the future 19th Internation Congress on Electronics, Rome, Italy, 27-30 Mar 1972 (Rome, Italy, Rassegna Internazionale Elettronica Nucleare 1972) P.319-26.

20. F. H. BELT
Cable TV-Where it is and where it's going
Pop. Electron Incl. Electron world (USA) Vol. 1, No. 1 P.26 -30 (Jan 1972)

21. W. HABERMANN (Inst. Rundfunktechnik, Muchen, Germany)
Method for Estimating the one time stability of inclined recording equipment Fernesh - Kino-Tech (Germany) Vol. 25, No. 12 P.442-6
(Dec. 1971) In German

22. S. D. BECKER (Sampex Corp., Redwood City, Calif., USA) Contact Copying of Transverse Track Video Tape Recording Fernesh - & Kino-Tech (Germany) Vol. 25 No. 12 P.435-8 (Dec. 1971) in German

23. M. G. SHULMAN, V. A. KOSTIN, E. N. NIKONOV, M. P. BARONIN Small size video Tape Recorder Type VK - ½. Tekh. Kino & Telev. (USSR) No. 1 P.38-45 (Jan. 1972) In Russian

24. M. KANEKO, J. NISHIDA A high Resolution Video Signal Printing System.National Tech. Rep. (Japan) Vol. 17, No. 6 P.696-701. (Dec. 1971)

25. R. H. MCMANN, R. WALKER (CBS LABS., Stamford, Conn., USA) Las Beam Recorder for Color TV Film Transfer Proceedings two day Seminar on Novel Audio-Visual Imaging Systems, New York USA, 23-24 Sept 1971 (Washington, D.C. USA: Soc. Photographic Scientists and Engrs 1971) P.24-7

26. R. J. ELKUS (Ampex Corp., Mountain View, Calif., USA) Ampex Instavision and the Audio Visual Communications Concept Proceedings two day Seminar on Novel Audio-Visual Imaging Systems, New York, USA, 23-24 Sept 1971 (Washington, D.C. USA: Soc. Photographic Scientists and Engrs. 1971) P.51-8

27. J. J. REIS Instrumentation Applications of Videotape Recording.EID-Elektron, Instrum. (USA) Vol. 7 No. 11 P.9-14. (Nov. 1971)

28. J. J. REIS Unusual Applications of Videotape Recorders. Res. Develop (USA) Vol. 23 No. 2 P.24-6 (Feb 1972) 19121

29. W. BRUCH (AEG Hannover, Germany) A Color Video-Disc System J. Soc. Motion Picture & Televis. Eng. (USA) Vol. 81, No. 4 P.303-6 (April 1972)

30 G. M. WALKER Special Report: Cable's Path to the Wired City is Tangled Electronics (USA) Vol. 45, No. 10 P.91-9 (8 May 1972)

31 G. FORESTER Technical Aspects of the Philips VCR-System 19th International Congress on Electronics, Rome, Italy, 27-30 Mar 1972 (Rome, Italy: Rassegna Internazionale Elettronica Nucleare 1972) P.505-15.

32. H. MAEDA (Matsushita Res. Inst. Tokyo Inc., Japan) Jaeu (Japan) Vol. 4 No. 4 P.54-7 (1971) Video picture printer-an all-electronic TV still picture printer using fibre optics picture tube

33. J. W. CHRISTENSEN (Columbia Broadcasting System, Stamford Conn. USA)
EVR: Characteristics of Silver and Non-Silver Films, Electron Beam Recording and Optics; and their relation to System Performance
Proceedings two day Seminar on Novel Audio-Visual Imaging Systems, New York, USA. 23-24 Sept 1971 (Washington D.C. USA. Soc. Photographic Scientists and Engrs. 1971) P.36-7

34. E. A. YAVITZ (Eastman Kodak Co., Rochester, N.Y. USA)
A Universal Input to Video Cassettes and Television Systems
J. Soc. Motion Picture & Televis. Eng. (USA) Vol. 81 No. 1 P.47 (Jan 1972)
SMPTE Winter TV Conference. Abstracts, Dallas Tex. USA, 4-5 Feb 1972

35. G. W. JONES (Communications Centre, Dallas, Tex. USA)
Behind the Scences of Electronic Film/Tape Post-Production
J. Soc. Motion Picture & Televis. Eng. (USA) Vol. 81 No. 1 P.46-7. (Jan 1972) (SMPTE Winter TV Conference), Abstracts, Dallas, Tex. USA, 4-5 Feb 1972)

36. R. R. STOKES (Bell Telephone Labs., HOLMDEL N. J. USA)
Picturephone Service Proceedings two day Seminar on Novel Audio-Visual Imaging Systems, New York, USA, 23-24 Sept 1971 (Washington D.C. Soc. Photographic Scientists and Engrs. 1971) P.84-6

37. R. W. MCCAUGHERN, D. M. CAUGHEY, H. ROMBEEK, W. S. DAVIDSON (Bell-Northern Res., Ottawa, Ontario, Canada)
A Video Simulation Facility
IEEE Trans. Comput, (USA) Vol.C-21, No. 7 P.738-40 (July 1972)

38. R. W. BAYLIFF
Teldec Videodisc
Int. Broadcast Eng. (GB) No. 86 P.34, 6-7 (March 1972)

39. 22nd International Symposium on Computer-Communications Networks and Teletraffic. Abstracts
New York, USA: Polytechnic Inst. Brooklyn (1972)

40. A. HARRIS
Kodak Enters Video Recorder/Player Market
Pop Electron. Incl. Electron World (USA) Vol. 1, No. 6 P.46 (June 1972)

41. I. SWITZER (Maclean-Hunter Cable TV, Rexdale, Ontario, Canada)
The Cable TV System as a computer-communications network.
22nd International Symposium On Computer-Communcations Networks and Teletraffic. Abstracts, New York, USA,

4-6 Apr 1972 (New York, USA: Polytechnic Inst. Brooklyn 1972) P.28

42. A. J. HEMMINGS
The Philosopy, Markets and Future of a Video Cassette System
R. Telev. Soc. J. (GB) Vol. 14, No. 2 P.48-50. (March-April 1972)

43. DONALD R. HARINL
Computer-Driven Display Facilities for an Experimental Computer-Based Library, Fall joint Comp. Conf. 1968

44. DONALD R KNUDSON
An Experimental Text-Access System
Agard Conf. Proc. On Image Storage and Transmission Systems for the Dissemintation of Information.
Oslo Norway 9 Sept 1971

45. A fundamental study of very wideband coaxial cable transmisssion systems - Naotake IDE, Tatsuya SAWAKURI, Ichiso YAMASHITA, Norihiko OHWADA.
Review of the Electrical Communication Laboratories Vol. 19 Number 9-10 Sept-Oct 1971

GLOSSARY

Bandwidth	Section of frequency spectrum within which component frequencies of a signal can pass ideally with zero attenuation.
Black-level	The potential at any given point in the video signal path corresponding to regions of zero illumination or blackness in the scene being transmitted.
Blip Counting	A technique for position sensing based on adding or subtracting one from a location register depending on the direction that each position mark (blip) passes a sensor.
Cable Casting	Dissemination of television programme via coaxial cables instead of using radio waves.
Camera	Device for producing electric signals from a visible image.
Carrier Signals	Signal frequency which would be radiated in the absence of any modulation.
Core-Store	A binary digital computer store consisting of magnetised toroids
CPU	Central Processor Unit - the main piece of controlling electronics in a computer system.
Chromium-Dioxide Tape	Magnetic recording tape doped with Chromium-Dioxide to improve its frequency response.
Flicker	Visual sensation produced by rapidly altenating periods of light and dark when their frequency is too slow to allow peristence of vision to give and impression of continuous illumination.
Field	In an interlaced scanning raster on a camera monitor or receiver, each coverage of a raster is a field and the two interlaced fields make a picture.
Flyback	At the completion of the scanning of one line in the camera or monitor, the beam has to be deflected rapidly to the beginning of the next line. This is known as the flyback or retrace period.
Flux Sensitive (recording head)	Magnetic reproducing head in which magnetic flux due to signals recorded on the tape is detected by modulating it by high frequency saturating magnetic flux produced in part of the magnetic circuit of the head. Unlike a conventional recording head it can detect flux when stationary.

Head Rotor	In a video tape recorder; rotating drum which has one or more recording heads mounted at its periphery,
Hz	Symbol for Hertz; SI unit of frequency indicating number of cycles per second.
Interlace	The technique of interposing two fields to give a minimum flicker without increasing the bandwidth.
MHz	Million Hertz (Megacycles per second)
Microfiche	A 6" x 4" plate of photographic material on which between 50 - 100 miniature images are stored.
Microform	The general name for techniques involving the production of a miniature photographic images.
Monitor	General term for a high quality video display device.
Persistence of vision	The action of the eye's receptors does not cease instantaneously when the light stimulus is removed but rapidly diminishes over a brief period of time. If, therefore, a short light stimulus is repeated sufficiently papidly, the eye is given the sensation of continuous illumination.
Phosphor	Coating of chemical substances deposited on the face of a cathode ray tube. When bombarded by electrons the substances emit light.
Picture	Complete TV image, constructed from one or two interlaced fields. In U.S. a frame.
Raster	The pattern formed by the scanning spot of a television system.
Retrace time	See flyback.
Storage Tube	A special CRT which can store and display a picture without continuous video input.
Ultrafiche	A microform technique of very high resolution capable of storing 3000 or more pictures on a 6" x 4" film.
VDU	Visual Display Unit. A computer terminal usually capable of outputing only a limited character set.
VTR	Video Tape Recorder.
Vidicon	Compact camera tube working on the photoconductive principle.

APPENDIX 1 VIDEO SYSTEM TEST SPECIMEN 1

Important Journals from Gordon and Breach

THIN FILMS

Editor: ALLEN GOLAND

This journal has been established to provide a forum for communication between scientists of diverse disciplines who nevertheless share a common interest in thin films. Experimental and theoretical papers whose tenor is experimental rather than applied are published. Articles concerned with applications are published when they contribute significantly to the basic understanding of properties and processes. The fields covered include superconductivity, magnetism, optics, crystal growth and structure, electron emission, lattice defects, order–disorder phenomena, electron diffraction, and mechanical effects in thin films.

In addition to research papers which are published in English, French and German, the journal also contains review articles, short communications and letters to the Editor.

Four issues per volume

Subscription rates, per volume postpaid

	Libraries	Individuals
Great Britain	£15·50	£5·00
USA/Elsewhere	$40.00/£17·08	$13.50/£5·63

PHYSICS AND CHEMISTRY OF LIQUIDS — 1

Editors: IRWIN OPPENHEIM, ARTHUR PASKIN *and* C. J. PINGS

Editorial Advisory Board: C. P. CURTISS, N. E. CUSACK, P. EGELSTAFF, H. ENDO, H. EYRING,
J. FRIEDEL, K. E. LARSSON, M. MANDEL, N. H. — 2
MARCH, H. N. NACHTRIEB, I. PRIGOGINE, R. L. SCOTT, S. STEEB, N. J. TAPPENIERS, G. H. VINEYARD, J. R. WILSON

Bringing together research in the study of liquids from the different disciplines, this journal's contributions range from review articles to letters
and short communications reporting results of — 3
immediate interest: providing a single source of experimental and theoretical papers for those seeking to understand metallic and nonmetallic liquids

Published in English, German and French, *Physics and Chemistry of Liquids* aims to improve communication between workers in various areas about discoveries within the general field of liquid state.

Four issues per volume

Subscription rates, per volume postpaid — 4

	Libraries	Individuals
Great Britain	£15·50	£5·00
USA/Elsewhere	$41.00/£17·08	$13.50/£5 63

To: Gordon and Breach Science Publishers, 42 William IV Street, London W.C.2, England or 440 Park Avenue South, New York, N.Y. 10016, USA

Please enter......................................subscription(s) to the following journals ....

....

at the subscription rate of..

Name...

Address...

....

Signature..Date.................................. — 5

9 P 11

(B3) the volumes and the free enthalpies of self-diffusion for mono- and divacancies may be written as ($i = 1, 2$)

1 —— $$V_{iv}^{SD}(p) = V_{iv}^{SD}(1 - \delta_{iv} p) \qquad (3.12a)$$

and

$$G_{iv}^{SD}(p) = Q_i - TS_{iv}^{SD} + pV_{iv}^{SD}(1 - \delta_{iv} p/2) \qquad (3.12b)$$

where all defect quantities on the right-hand sides refer to zero pressure. In (3.12)

$$Q_1 \equiv E_{1v}^F + E_{1v}^M \qquad (3.13)$$

and

$$Q_2 \equiv 2E_{1v}^F - E_{2v}^B + E_{2v}^M \qquad (3.14)$$

denote the activation energies for mono- and divacancy diffusion,

$$S_{1v}^{SD} \equiv S_{1v}^F + S_{1v}^M \qquad (3.15)$$

and

$$S_{2v}^{SD} \equiv 2S_{1v}^F + \Delta S_{2v} + S_{2v}^M \qquad (3.16)$$

the corresponding entropies. By inserting (3.12) into (3.2) and (3.11) the expressions for a pressure isotherm and for the effective activation volume in the case of simultaneous mono- and divacancy diffusion are obtained.

For many materials the pressure variation of V^{SD} is estimated to be small, at least for pressures below 10^4 at (see Table II in Appendix B). It appears justified to neglect the pressure variation of the volumes in the last terms of (3.2) and (3.11). We then obtain from (3.2)

$$\ln D_{I}^{T} = K - p\left[\frac{V_{1v}^{SD}}{kT}(1 - \delta_{1v} p/2) - \frac{\partial \ln r_{1v}^{\circ}}{\partial p}\right] + \ln\{1 + D_{21}\exp(-Q_{21}/kT) \times \exp[-p(V_{2v}^{SD} - V_{1v}^{SD})/kT]\} \qquad (3.17)$$

where the quantity

2 — $$K \equiv \ln(a^2 f_{1v} r_{1v}^{\circ}) + 2\alpha\left[\ln\frac{T}{T_0} - \frac{T - T_0}{T}\right] - (Q_1 - TS_{1v}^{SD})/kT \qquad (3.18)$$

does not depend on p, since in (3.18) a and r_{1v}° are to be taken at zero pressure. Since $V_{2v}^{SD} > V_{1v}^{SD}$ we see from (3.17) that the relative contribution of divacancies to the self-diffusion coefficient decreases with increasing pressure.

With the above mentioned simplification we obtain from (3.11)

$$V_{eff}^{T} = (1 - \delta_{1v} p) \times \left\{1 + \frac{D_{21}\exp(-Q_{21}/kT) \times \exp[-p(V_{2v}^{SD} - V_{1v}^{SD})/kT]}{1 + D_{21}\exp(-Q_{21}/kT) \times \exp[-p(V_{2v}^{SD} - V_{1v}^{SD})/kT]}\right\} V_{1v}^{SD} \qquad (3.19)$$

For sufficiently high pressures the effective activation volume approaches the monovacancy value $V_{1v}^{SD}(p)$ (see equation (3.12a)).

4. ANALYSIS OF THE SELF-DIFFUSION OF LEAD

4.1 *Temperature dependence of the tracer self-diffusion coefficient*

The diffusion coefficient for the simultaneous action of a mono- and a divacancy mechanism at ambient pressure may be written as

$$\ln D_{I}^{T} = \ln D_{10} + 2\alpha\left(\ln\frac{T}{T_0} - \frac{T - T_0}{T}\right) - Q_1/kT + \ln[1 + D_{21}\exp(-Q_{21}/kT)] \qquad (4.1)$$

where Q_1, D_{10}, D_{21}, and Q_{21} refer to a reference temperature, which we choose as $T_0 = 273\,°K$.

The temperature dependence of D_{I}^{T} observed by Nachtrieb and coworkers,[10,11] Hoffman and Hudson,[9] and Miller[12] is shown in Figure 1. The classical measurements of von Hevesy, Seith and Keil[13] and the data of Okkerse[14] have not been included, since they show too much scatter. The Arrhenius plot of D_{I}^{T} is slightly curved as one expects if both mono- and divacancies contribute.

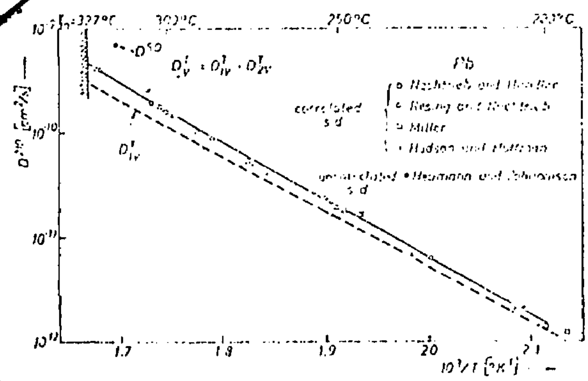


FIG. 1. Temperature dependence of the tracer self-diffusion coefficient of lead.

3

APPENDIX II LIST OF MANUFACTURERS AND THEIR PRODUCTS

COMPANY NAME:	AKAI RANK AUDIO PRODUCTS
ADDRESS:	P. O. Box 70 Great West Road BRENTFORD Middlesex
TELEPHONE:	Maidenhead 31223
CONTACT:	Mr Wells

GENERAL INFORMATION:

Japanese equipment manufactured by:

AKAI ELECTRIC CO LTD
12-14 2-chome, Higashi-Kojiya
Ohta-Ku
Tokyo
JAPAN

AKAI products are distributed by Rank Audio Products in the UK

AKAI VTR's use ¼" chromium dioxide video tape which is unlikely to become a compatible medium

PRODUCTS

VTS-110px	¼" portable VTR system Complete system comprising camera, VTR, monitor Total weight 25 lbs Cost £785 complete
VT-700	Medium performance ¼" VTR 90 minutes replay time AUTO-switched controls (allows remote operation) Cost £520 VTR only

COMPANY NAME: AMPEX ELECTRONICS LIMITED

ADDRESS: Acre Road
READING
Berks RG2 OQR

TELEPHONE: 0734-84411

CONTACT: I C Levene

GENERAL INFORMATION:

Ampex are probably the largest manufacturer of magnetic recording devices, including computer tape and disc stores. They were involved in the first attempts at video-recording for broadcast use and maintain a strong position in the market today. Unlike RCA who were also involved in the early broadcasting experiments. Ampex have diversified and produce a number of quality helical scan VTR's for use by small studios, educational establishments, industry and so on. They may very well be in a similar position in the VTR market to IBM in the computer field and thus could easily set the standards.

Products:

VPR - 5800 1" Colour VTR

VPR - 5203 1" monochrome version of the 5800

VPR - 7903 1" production colour VTR (very high performance)

VR - 660C 2" portable professional standard VTR

VR - 7003H 1" studio VTR

VR - 5103 1" low priced semi-portable VTR

INSTAVIDEO - complete portable video system

COMPANY NAME: EMI ELECTRONICS LTD
TELEVISION EQUIPMENT DIVISION

ADDRESS: Hayes
Middlesex

TELEPHONE: 91-573-3888

CONTACT: Barry McCurdy

GENERAL INFORMATION:

EMI Manufacture a special CCTV system based on a camera called 'Surveyor'

PRODUCTS:

'Survey' very heavy duty CCTV camera

COMPANY NAME: E.O.S.D.
MARCONI ELLIOTT LIMITED

ADDRESS: Basildon
Essex

TELEPHONE: Basildon 22822

CONTACT: Mike Richmond

GENERAL INFORMATION:

The Electro-optic Systems Division of Marconi-Elliott Ltd manufacture cameras and monitors of all types. They have a distributorship for Ampex VTR's.

PRODUCTS:

Complete systems.

COMPANY NAME: GRUNDIG
GRANT & TAYLOR

ADDRESS: CCTV Division
Arlington House
South Mimms
Potters Bar
Hertfordshire

TELEPHONE: South Mimms 2288

CONTACT: J E Hunter

GENERAL INFORMATION:

The only German Company involved in video recording on an international scale. They produce three VTR's of very high performance for professional use, and one VTR of low performance. All of the professional VTR's use the same basic transport mechanism and therefore have similar recording performance. However they differ in the complexity of their control functions. The low performance VTR is for domestic and educational use.

PRODUCTS:

BK 300	lowest price professional VTR in the range
BK 200	professional quality VTR
BK 201	professional quality VTR with editing feature
BK 100	domestic and educational VTR

COMPANY NAME: IKEGAMI TSUSHINKI CO. (ITC)
DIXONS (TECHNICAL)

ADDRESS: 3 Soho Square
London W1

TELEPHONE: 01-437-8811

CONTACT: Mr Reynolds (Rep)

GENERAL INFORMATION:

Dixons are a London based distributor of video equipment of all types. They are sole distributors for ITC video equipment which includes cameras, monitors, VTR's and studio control panels. Dixons operate a very competitive and go ahead rental scheme and will hire out complete production video outfits, at one end of their range, down to a single lens at the other.

PRODUCTS:

TVR 3113E 1" studio quality VTR £990

TVR 3014E 2/3" industrial quality VTR £375

COMPANY NAME: INTEGRATED DATA PRODUCTS

ADDRESS: Clock Tower Road
Isleworth
Middlesex

TELEPHONE: 01-568-0151

CONTRACT: Mr B J Haynes (Managing Director)

GENERAL INFORMATION:

I.D.P. is a subsidiary of K.G.M. Electronics which manufactures video equipment of all types. In particular they have specialised in information systems and were the contractors who supplied London Airports air traffic control with a complete video information system. They are extremely knowledgeable about the problems of the display of text and use CCTV systems of high band width to achieve adequate resolution.

PRODUCTS:

The I.D.P. Microfiche Data Retrieval System. This system consists of a transmitter unit and several monitor/control units. Any monitor/control unit can be given remote control of a video/microfiche viewer. The system is capable of zooming in to fine detail.

See Fig 8

COMPANY NAME: INDUSTRIAL VIDEO SYSTEMS LTD

ADDRESS: 43 Malden Way
New Malden
Surrey

TELEPHONE: 01-942-9635

CONTACT:

GENERAL INFORMATION:

IVS are a go ahead manufacture and distributor of video equipment. They have agencies for Sony and Shibaden and Philips as well as producing their own range of cameras and monitors.

Their aim is to be able to select the best equipment to suit a users needs from the most suitable manufacturers.

PRODUCTS:

All video products.

COMPANY NAME: INTERNATIONAL VIDEO CORPORATION

ADDRESS: Liverpool Victoria House
Cheapside
Reading
Berks RG1 7AG

TELEPHONE: 0734-585421

CONTACT: Mr Powell

GENERAL INFORMATION:

IVC are amongst the top names in video recording. Their product range is aimed at the high quality market and presumably most of their equipment goes to production studios making TV advertisements and so on. Their equipment is expensive but beautiful engineering and presumably represents value for money in terms of reliability.

Their product range includes every conceivable item of production video equipment.

PRODUCTS:

IVC - 800	series VTR's range of 6 VTR's £1275-£4050 There is colour capability on the higher priced VTR's
IVC - 901	portable very high performance VTR £5615
IVC - 961	portable VTR with electronic editing £6750

COMPANY NAME: PLESSEY COMMUNICATION SYSTEMS LIMITED

ADDRESS: Tolworth Rise
Surbiton
Surrey

TELEPHONE: 01-337-6666

CONTACT: J Cooley

GENERAL INFORMATION:

Plessey communications manufacture a small CCTV system for use by shops and supermarkets for various observation tasks.

PRODUCTS:

Plessey 3-channel miniature CCTV system.

COMPANY NAME:	PYE BUSINESS COMMUNICATIONS LTD
ADDRESS:	Orchard Road Royston Hertfordshire
TELEPHONE:	Cambridge 45191
CONTACT:	Alan Brown

GENERAL INFORMATION:

Although sold under the Pye name all of the VTR's are manufactured by Philips in the Netherlands.

PRODUCTS:

LDL	1200	Professional quality 1" VTR
LDL	1002	Educational and domestic ½" VTR
EL	3402	Portable high quality 1" VTR
LDL	1251	Colour video recorder 1"
LDL	1000	Portable version of LDL 1002

COMPANY NAME: RCA LIMITED

ADDRESS: Lincoln Way
Sunbury On Thames
Middlesex

TELEPHONE: Sunbury on Thames 85511

CONTACT: Mr D F Craddock
Area Manager
Broadcast Systems Divisio

GENERAL INFORMATION:

RCA were responsible (along with Ampex) for the introduction of video recording to broadcasting. Unlike Ampex, RCA have concentrated solely on the broadcast market with the result that their equipment is exotic and high priced.

PRODUCTS:

TR-70 Colour Video Tape Recorder

TR-60A Compact Colour Video Tape Recorder

TRC-100 Video Tape Cartridge Recorder (for commercials)

COMPANY NAME:	SHIBADEN (UK)
ADDRESS:	61/73 Watford Way Hendon London W4
TELEPHONE:	01-202-8056
CONTACT:	J R Gordon (Engineers)

GENERAL INFORMATION:

Shibaden are a Tokyo based firm specialising in video equipment of all types. Their VTR's are of intermediate quality for business and educational use. The equipment is reasonably priced.

PRODUCTS:

SV-800EC	Complete ½" VTR system incorporating 9" monitor. Cost £480
SV-707E	Complete ½" self-contained portable camera/VTR combination. Cost £510
SV-700EC	½" VTR with monitor £500
SV-7000ED	½" VTR with electronic editing £650

COMPANY NAME:	SONY (UK) LIMITED AND CENTRAL SERVICE DIVISION
ADDRESS:	Pyrene House Sunbury Cross Sunbury On Thames Middlesex Ascot Road Feltham Middlesex
TELEPHONE:	Ashford (Midd) 50021/9
CONTACT:	Mr T McArthur Commercial & Industrial Divisional Manager

GENERAL INFORMATION:

Sony is probably the most well known and respected Japanese manufacturer of video equipment. Their product line is aimed mostly at the industrial and educational user rather than broadcasting. However in its field it represents the highest quality equipment available at reasonable cost.

PRODUCTS:

EV 310E	1" VTR 50Hz with colour capability cost £1195
CV-2100 ACE	½" medium quality VTR cost £389
CV-5600P	½" colour capable VTR cost £745
AV-5000A	½" high performance VTR with colour capability cost £865
AV-3400	portable ½" VTR cost £435
EV-320CE	high performance colour 1" VTR cost £1850
AV-3600	½" VTR (525 lines) cost £389
DVK-2400 ACE	complete portable ½" VTR cost £235

COMPANY NAME: TELENG LIMITED

ADDRESS: Arisdale Avenue
South Ockendon
Essex RM15 5TR

TELEPHONE: South Ockendon 3477

CONTACT: Mr D Walker

GENERAL INFORMATION:

Teleng are one of the leading manufacturers of closed circuit television ancillaries. They provide line plant, wide band amplifiers, repeaters, adaptors, sockets, plugs, monitoring equipment, cables, power supplies, converters, boost repeaters and so on.

They do not deal in any type of basic video equipment such as cameras and monitors.

PRODUCTS:

Video communications networks.

COMPANY NAME: TELEVISION SYSTEMS & RESEARCH

ADDRESS: P. O. Box 70
Great West Road
Brentford
Middlesex

TELEPHONE: 01-568-9222

CONTACT: Mr Crooks

GENERAL INFORMATION:

TS & R are an off-shoot of Rank Audio Visual and as such distribute the equipment manufactured under the name of Top Rank television. This includes CCTV equipment and studio systems. In addition they market the Nivico KV820 ½" VTR.

PRODUCTS:

Nivico KV820 ½" VTR medium price VTR for commercial and educational use. Cost £365

COMPANY NAME: VIDEO SYSTEMS LIMITED

ADDRESS: Delbow Road
Central Way
Feltham
Middlesex

TELEPHONE: 01-890-5252/5766

CONTACT: J R Little

GENERAL INFORMATION:

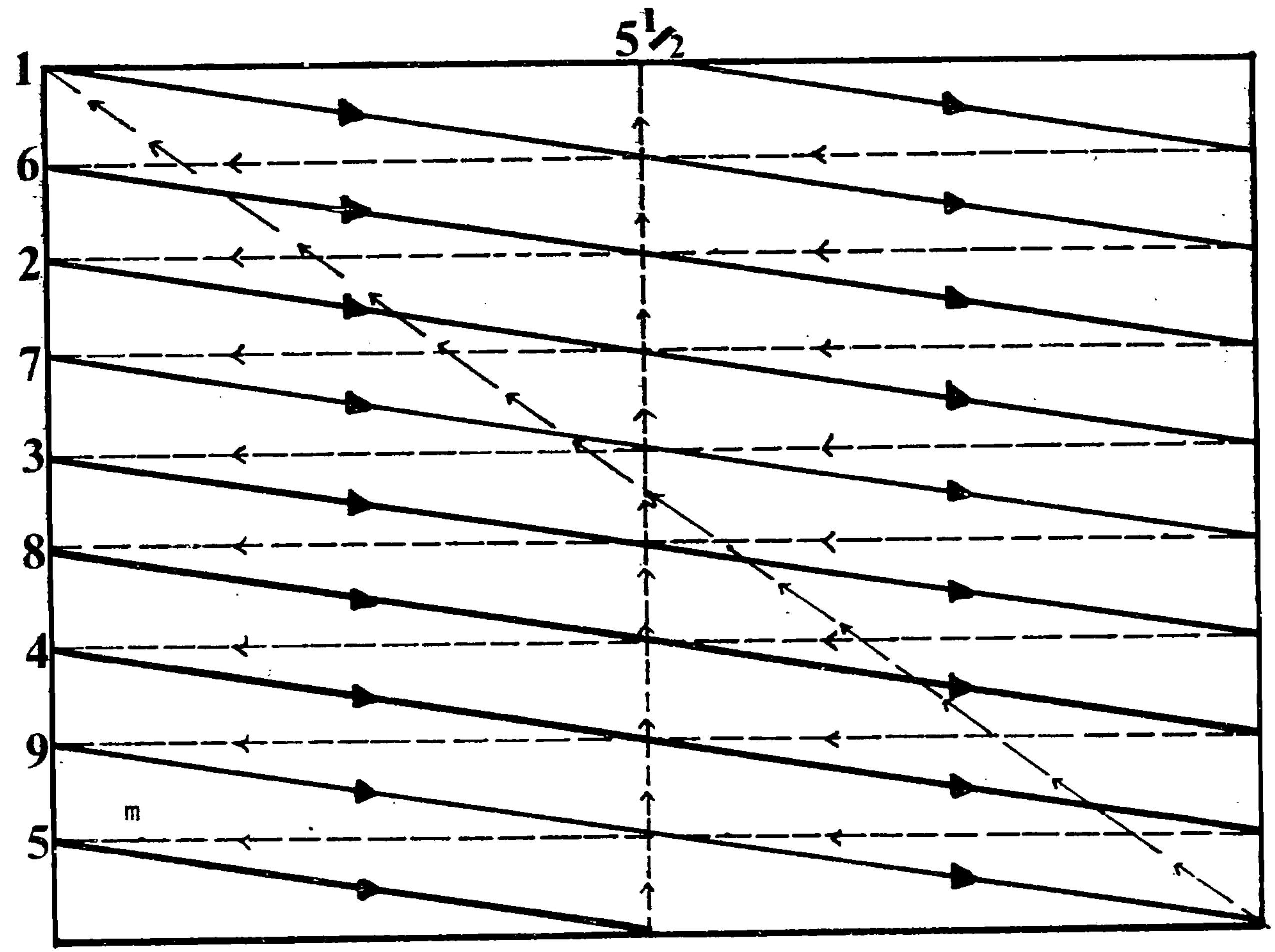
Video systems are a small firm which markets a range of video products. Their equipment is of indifferent quality.

PRODUCTS

Cameras, monitors and anciliaries.

TV SCANNING

2:1 INTERLACE



Solid Lines - SCANNING

Dotted Lines - FLYBACK

FIELD RATE

2 X PICTURE RATE

NEED 50Hz TO AVOID FLICKER

FIELD RATE 50Hz

PICTURE RATE 25 Hz

KEEPS BANDWIDTH DOWN

FIG.1

FIG. 2 NIVICO ½" INDUSTRIAL VTR

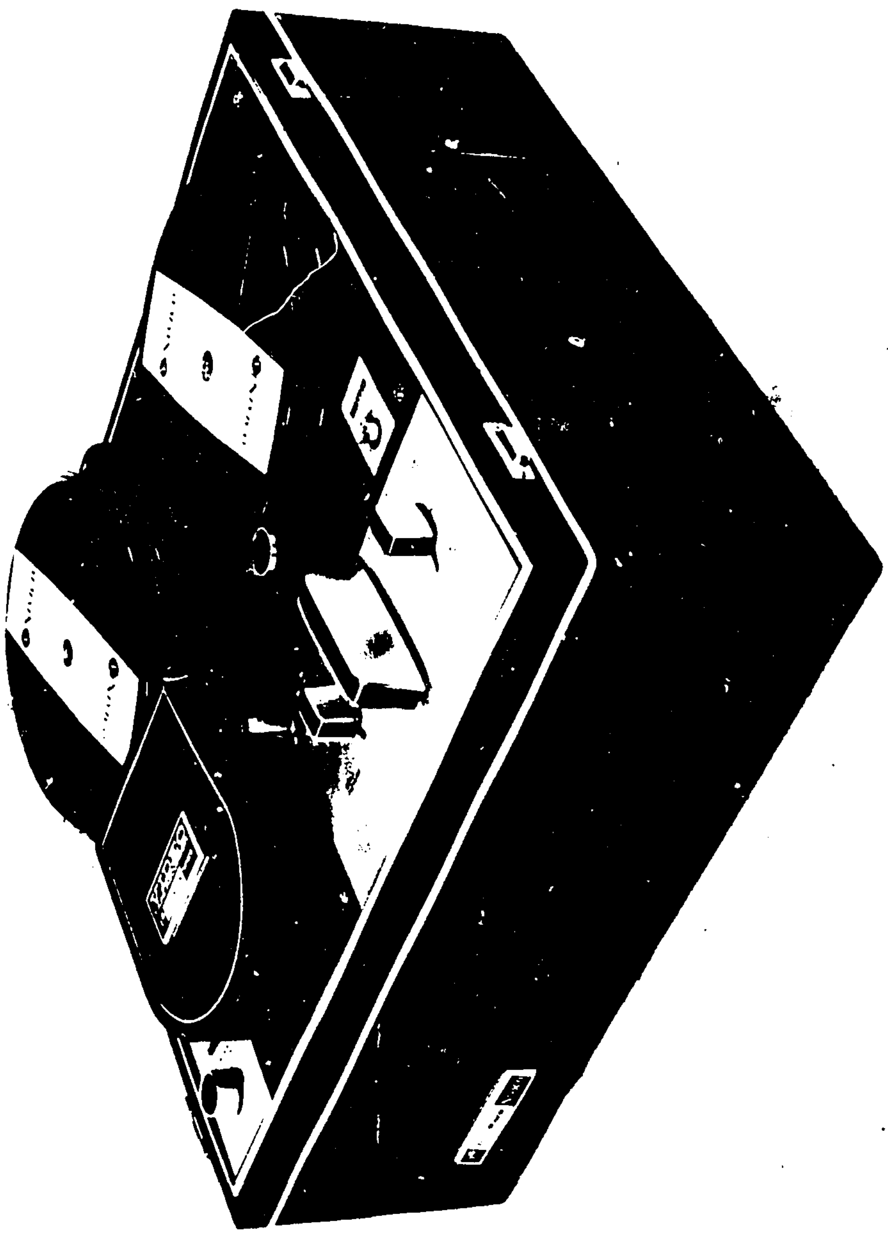
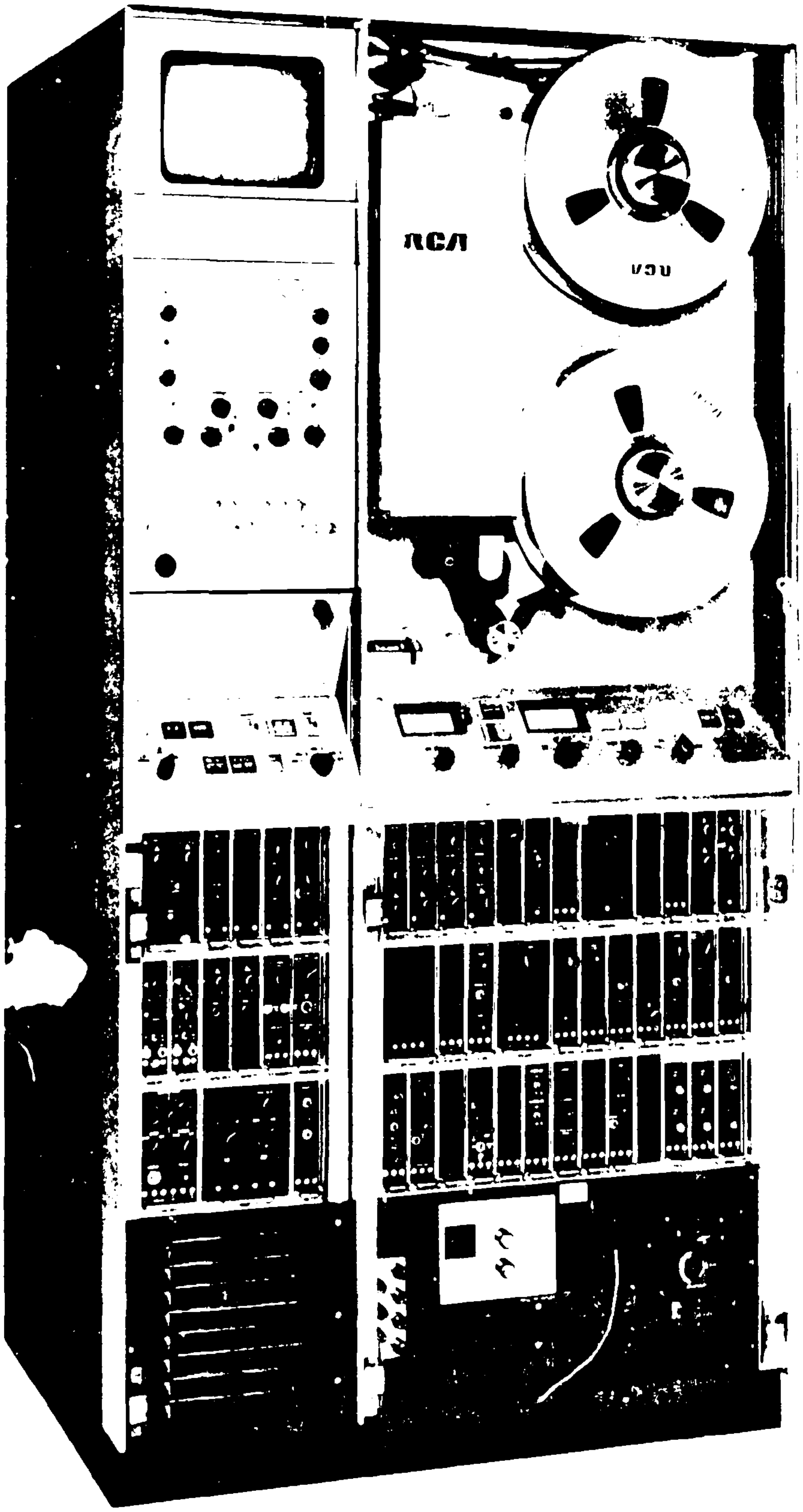
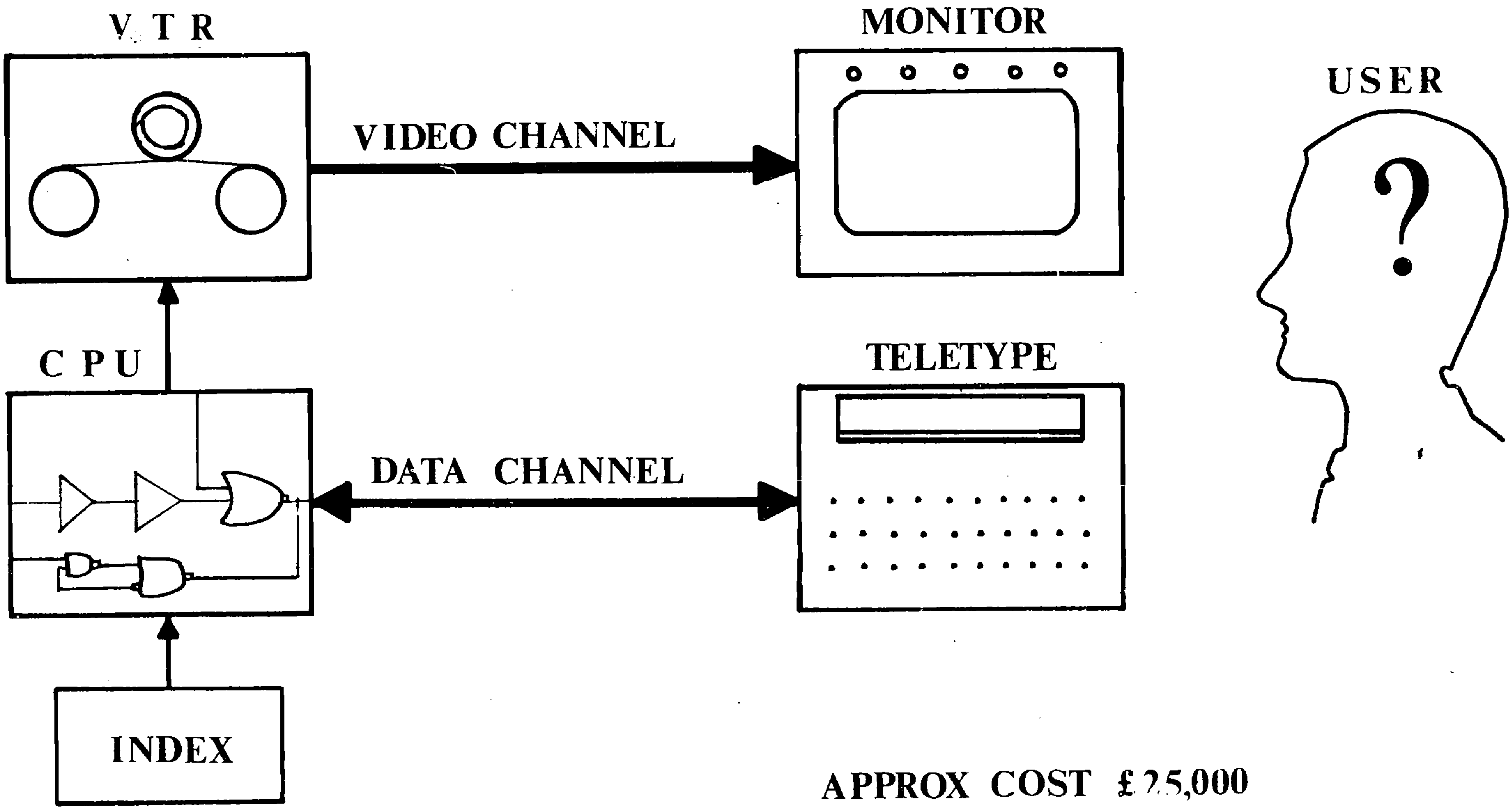


FIG. 3 RCA COLOUR VTR TYPE TR-60A



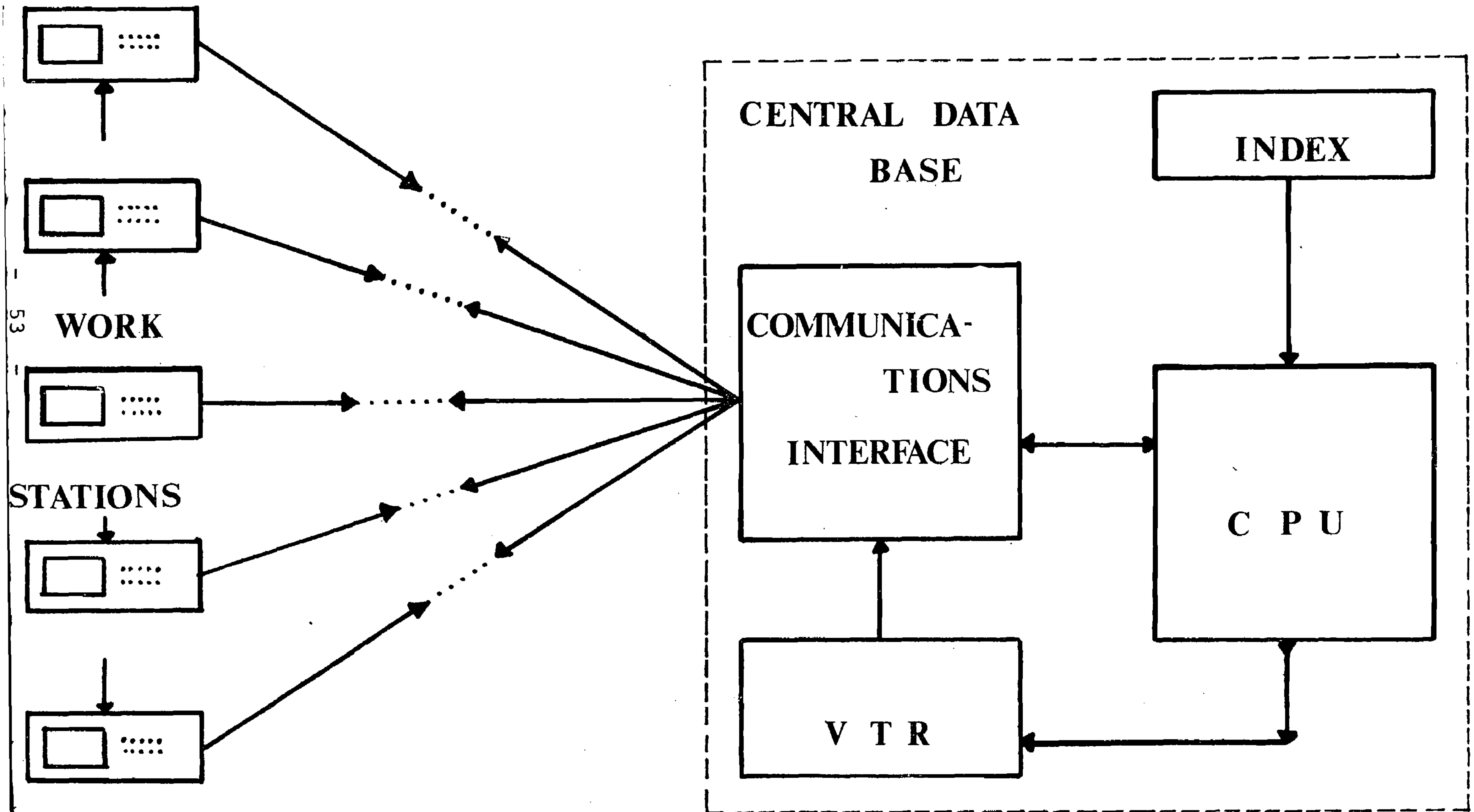
THE SIMPLE SYSTEM



APPROX COST £25,000

FIG. 4

THE SIMPLE NETWORK



THE COMPLEX NETWORK

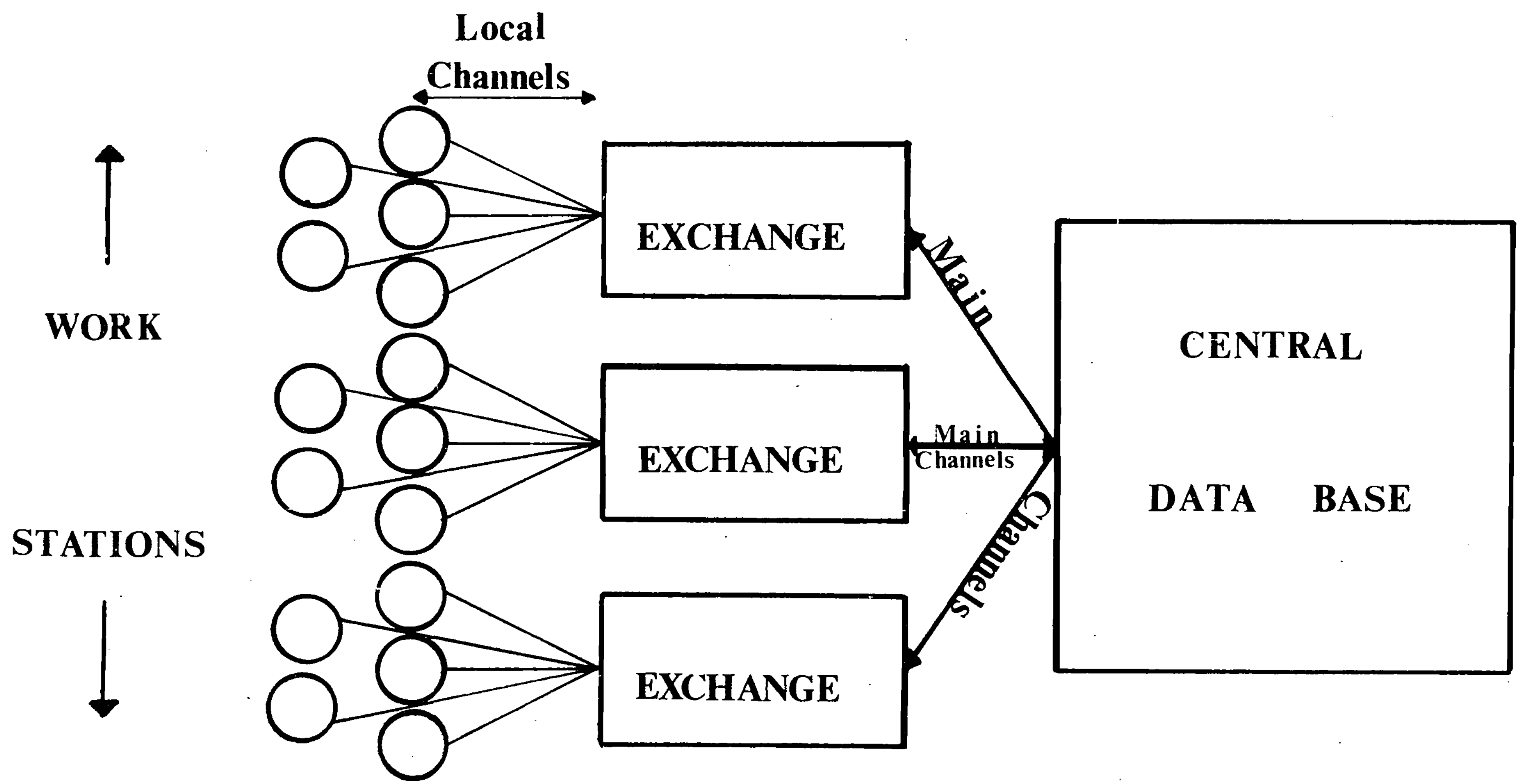


FIG. 6

FIG. 7

THE CENTRAL UNIT

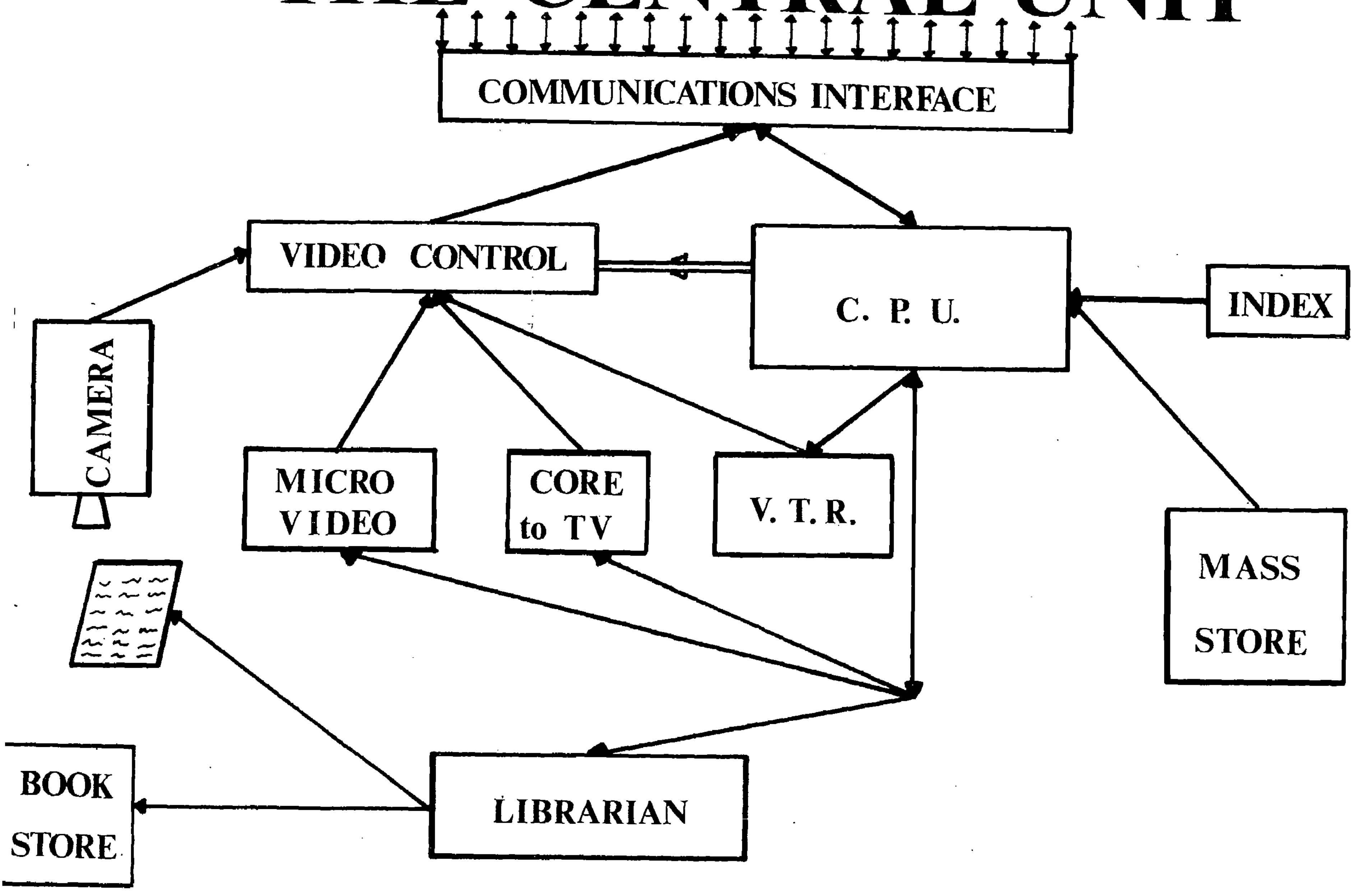
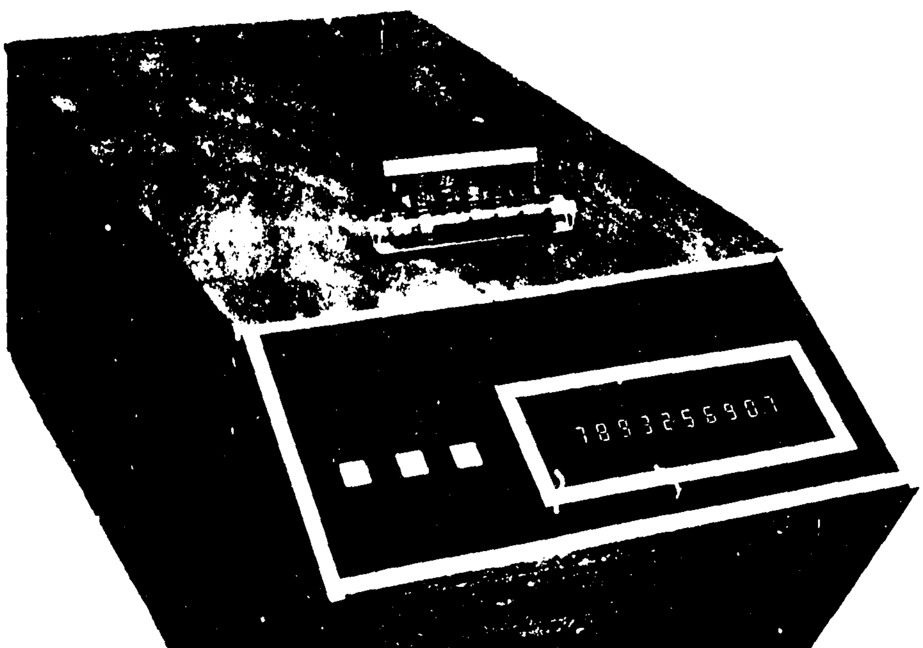


FIG. 8 MICROFICHE DATA RETRIEVAL SYSTEM

RECEIVER UNIT



TRANSMITTER UNIT