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UNATTENDED VIDEO SURVEILLANCE SYSTEMS FOR INTERNATIONAL SAFEGUARDS

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Abstract

The use of unattended video surveillance systems places some unique requirements on the systems and their hardware. The systems have the traditional requirements of video imaging, video storage, and video playback but also have some special requirements such as tamper safing. The technology available to meet these requirements and how it is being applied to unattended video surveillance systems are discussed in this paper.

Introduction

Video cameras and monitors have been used for years by security personnel for realtime surveillance applications. The development of low cost video recording eventually led to time lapse video recording which is utilized in banks and other businesses to deter robberies or to provide identification after a robbery. In these applications the video equipment is monitored and operated by personnel who periodically check the equipment for proper operation. If a failure occurs, backup equipment can be placed into service or repair personnel can be called immediately. Periodic preventative maintenance is also performed to replace marginal parts of the system performance.

However, application of video surveillance equipment to nuclear facilities in international safeguards imposes more stringent requirements on the systems. These systems are, in most applications, unattended and thus require reliability, long life, low maintenance, system redundancy, and tamper safing, in addition to high video storage capacity, special video imaging and video playback analysis capabilities. The additional need for the system to be low cost and operable by nontechnical personnel further impacts the design.

All of these requirements are important in the development of unattended video surveillance systems, but this paper will

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be limited to four major areas of concern and how they are being implemented today, and their expected future implementation. These areas are video imaging, video storage, video playback and system tamper safing. Systems under development will be used to illustrate how the technology currently is being applied.

Video Imaging

Until about 1975 all television cameras used vacuum tube type imaging devices that had a light sensitive compound or solid state imaging surface. These devices use a scanning electron beam to read the image information from the imaging surface. The camera imaging tube is subject to wear out phenomena characterized by decreasing output with time and random failures such as shorted elements or burned out filaments.

The charge coupled device (CCD) became the first solid state imaging element that would permit the design of a completely solid state television camera. Such a camera (See Figure 1) was used in a portable battery operated TV surveillance system (See Figure 2) developed for the International Atomic Energy Agency. Important features of CCD cameras are the small size, light weight, low power, and instant-on design. This camera is completely solid state, thus providing the ability to power strobe the camera and recorder to extend battery life. The camera's instant-on capability permits shorter duty cycles for recording than would be possible with tube filaments which require a warm-up time. A CCD imaging device offers longer imaging pickup life since it is not subject to the deterioration of filaments or the decrease of cathode emission due to aging of the camera tube.

The CCD camera is an example of advanced technology that is capable of improving the reliability and the operational performance of an unattended video surveillance system. Lab tests of this type of camera have shown no perceptible degradation of imaging performance over extended time periods of operation. However, these cameras do not offer all of these attractive features without sacrificing other desirable characteristics. Disadvantages of current CCD imaging devices are higher cost, lower resolution, and less light sensitivity in the visible light region. For example, the CCD camera used in the battery system will produce a full video output for scenes with 1.1 footcandles illumination while a newvicon tube in a similar camera will produce a full video output with only 0.2 footcandles on the scene.

New solid state imaging devices will soon be available that will offer increased resolution and increased sensitivity. Some structures as large as 484 by 384 imaging elements have been described in technical papers. These television imaging devices offer horizontal resolution of 260 TV lines and vertical resolutions of 350 TV lines. This type of imaging resolution is very close to the present bandwidth capabilities of video recorders utilized to store the images.

Video Storage

The video frame contains a tremendous amount of information. Much of it is redundant from the standpoint of frame to frame images and could be thrown away if it were possible to discriminate the changes between successive images. Presently all of the video information must be stored because the discrimination must be done by the human. An analog video image can be stored on magnetic tape or disc. The image can be digitized and a stream of digital words stored in a digital format on magnetic tape, disc or in a solid state memory. Since it requires about two million bits of storage to hold one broadcast quality video frame, solid state memories are useful only for temporary storage of a frame or, at the most a few frames of video information. Magnetic discs, because of track width limitations, are generally capable of storing only 200 to 500 images. An unattended television surveillance system may need to store 200 images in a single day depending upon its recording interval. Hence it appears that magnetic video tape must be used for any system that must store thousands of video frames over long time periods. Video recording on magnetic tape to date has been a segmented type of recording using either transverse or helical scanning of a slow moving tape. The video information, because of its tremendous bandwidth and information, requires high tape writing speeds. Video recording on magnetic tape meets this requirement through a combination of a moving tape and moving video recording heads. Some unattended systems have utilized time lapse recorders modified to record several frames of video information and then stop. Stopping and starting such a system causes losses of video information due to the positioning of the tape. The result on playback is annoying video signal dropouts between each recorded surveillance event. The new technology being developed for unattended systems attempts to eliminate these annoying glitches.

In the Unattended Video Surveillance and Recording System shown in Figure 3, video recording is accomplished by an assembly editing technique. This technique produces a sequence of video frames that can be played without the annoying dropouts. To accomplish an assembly edit, the forward motion of the tape and the rotational motion of the recording head scanner assembly is synchronized at the proper speeds before recording. Upon starting, the tape is run forward until it achieves a speed of 4.0 cm/second. The scanner assembly is rotated until it is scanning at a rotational velocity of 1800 rpm which is the usual speed for dual record head scanners recording 525 line, 30 frames/sec video signals. At the edit point on the tape the recording head is enabled and the predetermined number of video frames is recorded on the tape. The tape machine is then stopped and the tape is backed up so that it will be be able to achieve the necessary speed to record the next frames contiguous to the previous recording. This type of editing provides animated movement of objects. When no changes occur in the video image, the picture recorded shows only the changes in time-date characters.

Most video recorders of the size and electrical configuration compatible with unattended surveillance applications require modification to the recording circuitry. Sony SLO-320 video cassette recorders are being modified to perform assembly edits in the systems being developed. (See Figure 4.)

Video Playback

Surveillance tape review is easier when the video image is stable without video signal dropouts or noise bars but additional analysis aids can improve the reliability of tape reviewing. Video analysis circuits have been developed for the unattended systems shown in Figures 3 and 5. The video analysis circuits look for coded information indicating an anomalous condition. When such information is encountered, a pause command is issued to the recorder. The pause command stops the forward transport system causing the frame of interest to be continuously displayed. The tape stops but the scanning assembly continues to rotate and read the video recording track on the tape.

The video analysis circuit in the system is triggered whenever motion or tampering has occurred so that the reviewer of the tape will be alerted that something has occurred and that those frames should be examined with additional care to determine if the action was significant. Another important feature of the video analysis circuit is the capability to jog or move the tape slightly in its transport so that frame by frame review can be accomplished. This slow motion capability is accomplished by hand controllers that provide variable tape speeds.

Tamper Safing

Tamper safing means providing ways to detect system tampering rather than prevent it. Circuitry is carefully designed so that any attempts to tamper with the system can clearly be differentiated from circuit or system failures. The final determination of whether tampers have occurred is made by a careful review of the video tapes and by evaluating the system to determine whether the tamper indication recorded is compatible with the present state of system operation.

One of the most difficult areas to tamper safe is the transmission cable between the camera housing and the recording console. With today's technology, video images can be substituted on unprotected video cables making it virtually impossible to detect the substituted image. The unattended video surveillance systems developed by Sandia utilize special protection techniques on the transmission cables to detect any violation of those cables. A number of techniques have been considered and are presently being employed on the systems shown in Figures 3 and 5. These systems utilize special frequency multiplex techniques that make it difficult to substitute images into the recording system without a detection of the tampering.

New Technology

New emerging technology in the areas of memory storage capacity and optical video disc recording will have great bearing upon the development of unattended surveillance systems. Larger capacity memory storage in such devices as CCD shift registers or bubble memories may make it possible to perform some type of realtime analysis on video frames to determine whether or not that information should be stored on the magnetic media. The realtime analysis by a system microprocessor may permit the development of smart unattended video surveillance system to review and decide which video frames should be stored. The microprocessor system might also allow video compression algorithm to be implemented that would decrease the storage requirements but yet save all of the necessary information for future analysis.

Optical disc recording provides a new means of storing the video information in either analog or in digital formats. This storage medium has a capacity of about 54,000 frames per disc side. An optical disc recorder would ultimately have fewer parts, probably be more reliable and offer many features of reviewing video frames not possible with magnetic tape presently, such as, infinite still frame playback and random access of different cameras stored on one disc. Optical disc recording is a proven laboratory technique at the present time but requires high power gas lasers to accomplish the recording. The development of the laser diode will make an optical disc recorder a reality for surveillance systems. A number of companies are presently developing the technology needed for realtime field recordable optical discs.

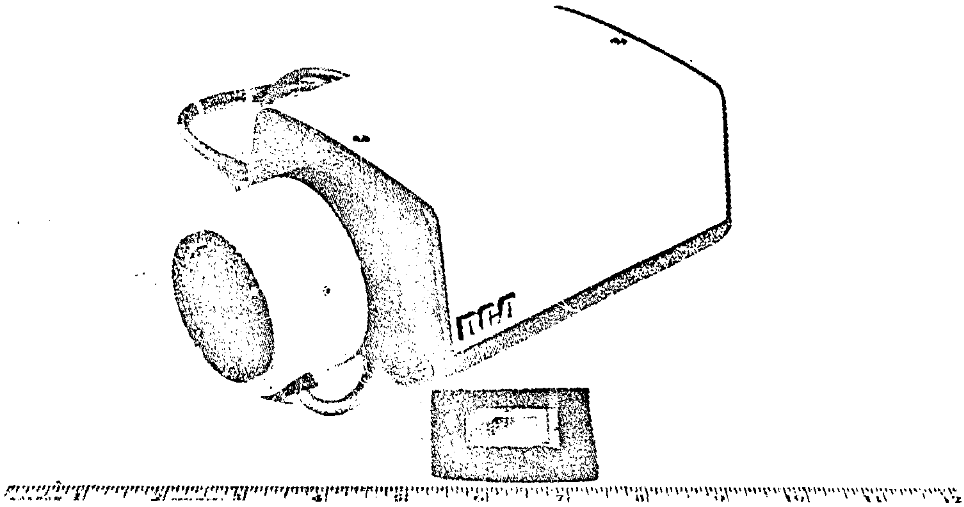

Figure 1. A CCD Imaging Device and the Small Video Camera designed to use the CCD Device.

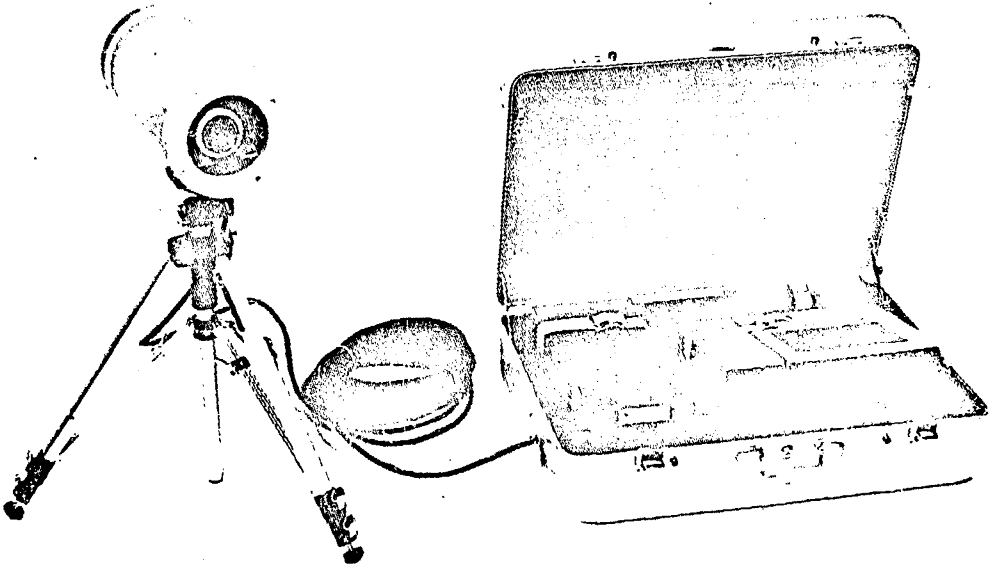

Figure 2. The Portable Battery Power Surveillance and Recording System.

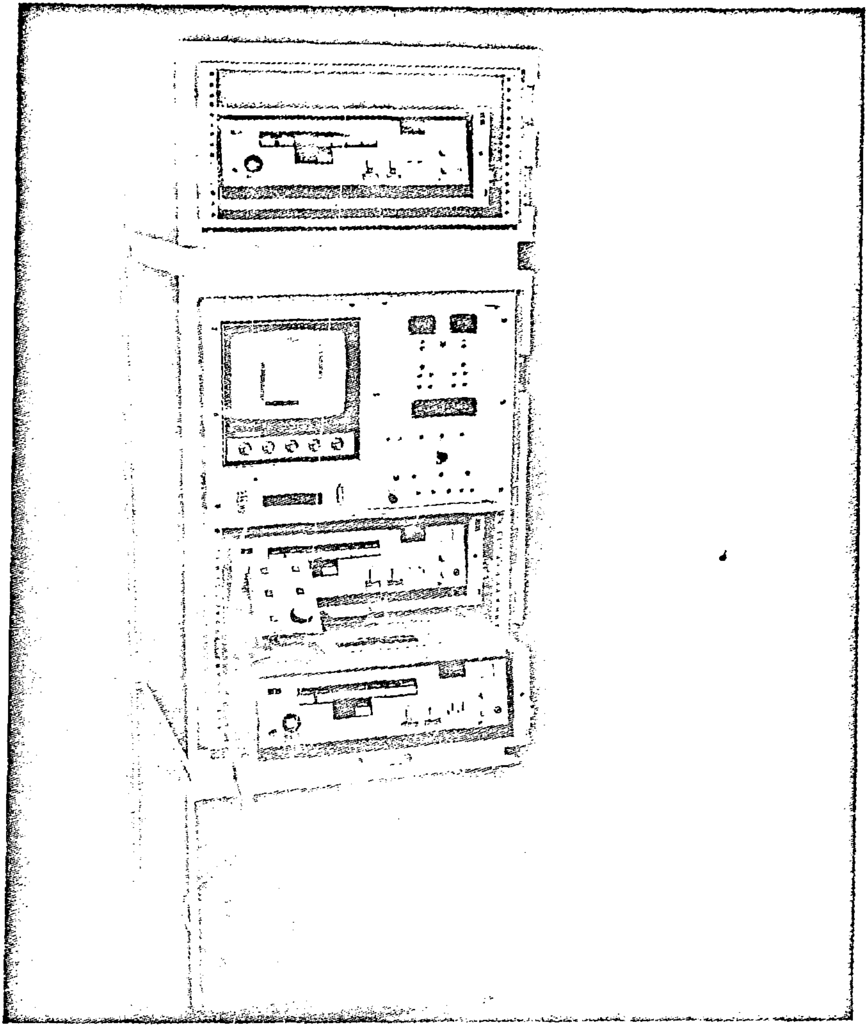

Figure 3. A Modular Designed Unattended Video Surveillance and Recording System.

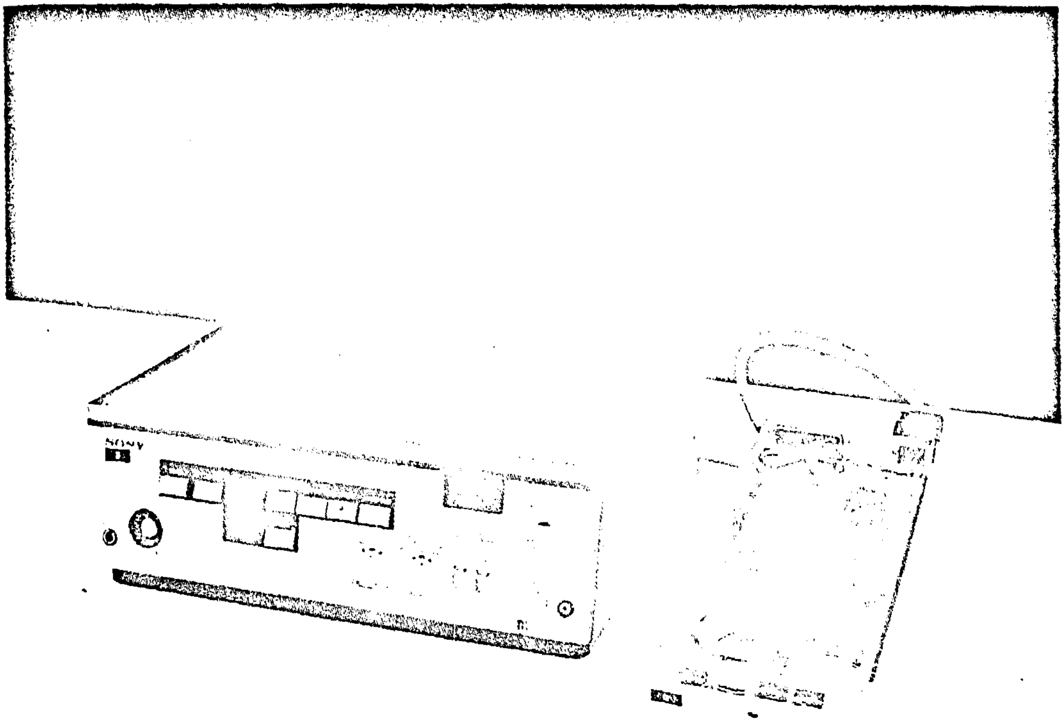

Figure 4. The Sony Model SLO-320 Video Recorder.

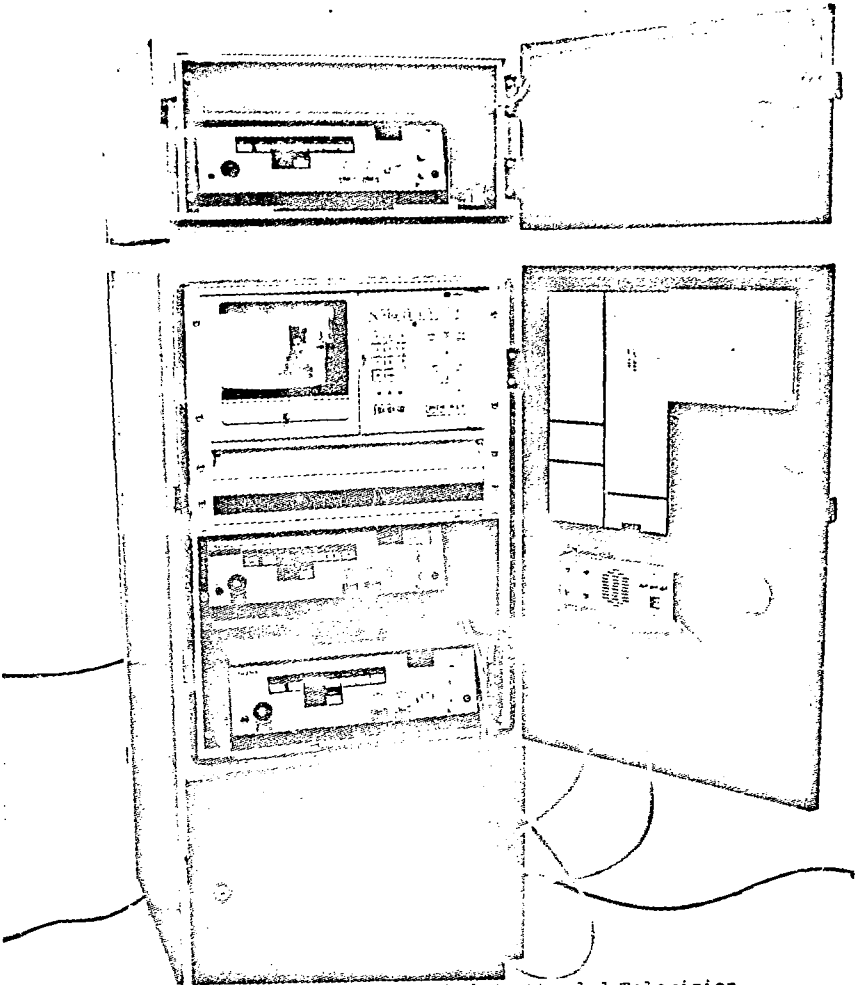

Figure 5. A Microprocessor Controlled Unattended Television Surveillance and Recording System.