Television for Use Under Rugged Environmental Conditions

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A variety of applications has been made of television equipment under extreme environments. The generally desirable characteristics of these equipments are examined. Design features of a system built for rugged usage are described.

Industrial television equipment was originally designed to provide a tool for visual communication. These early systems were adequate for monitoring smoke stacks, data transmission, plant security and many "general observation" uses. With the possible exception of a system designed especially for power plant furnace observation, little attention was given to developing a closed-circuit system that would perform under typical rugged environments found in both military and industrial applications.

The strategic advantage of using portable closed-circuit TV in combat areas has brought a Jules Verne approach to the solution of some of the design concepts. The increase of military usage and certain severe industrial uses focused attention on the need for ruggedized industrial TV systems.

Types of Packaging

There are three main types of system packaging (Fig. 1), each with its advantages and disadvantages.

In Type 1, the self-contained camera has the advantage of requiring only a single coaxial cable between the camera and the monitoring receiver besides requiring a minimum of equipment. For rugged environments, however, the number of tubes and the complexity of the circuits make the camera too sensitive to vibration and shock. Since all the controls are on the camera, it is inconvenient if not impossible to adjust the system while in operation.

Type 2 uses the camera and master monitor. This packaging is more practical for use in rugged environments, chiefly since there is a minimum of parts in the camera and all the controls are removed to the control point at the master monitor. Some of the circuits perform common functions for both the camera and the control monitor, and therefore a monitor must be used at this point whether required or not.

The Type 3 system, of three separate units, is extremely flexible and has the advantage of remoting the camera and the camera control from the monitor. Thus a simple panel at the monitor gives remote operation not only for the camera accessories but the camera control unit as well. This system also allows for the selection of any type or size of monitor desired.

The Type 3 system continues to gain

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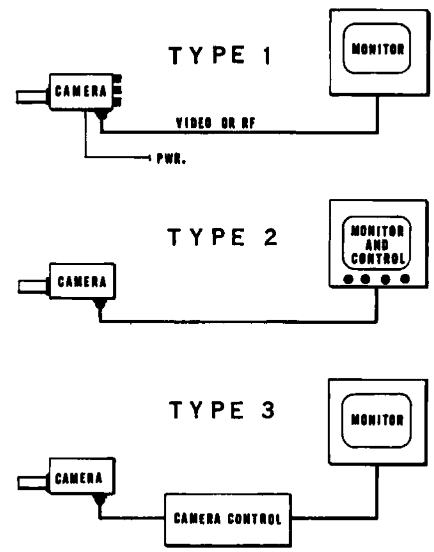

Fig. 1. Three main types of system packaging:

Type 1 — Advantages	*Disadvantages*
Simplicity Low power consumption Minimum equipment Low cost of basic system	Inconvenient to adjust Servicing difficult Not very adaptable to multiple camera or switching systems Usually noninterlaced system Difficult to ruggedize

Type 2 — Advantages	*Disadvantages*
Minimum parts in camera Minimum equipment in hazardous location Easy to ruggedize camera Easy to adjust Easy to service	Expensive camera cable Integrated monitor and camera control unit Requires monitor at control point

Type 3 — Advantages	*Disadvantages*
Extremely flexible system arrangement Minimum parts in camera Minimum equipment in hazardous location Easy to service Easy to adjust Easy to ruggedize camera	Expensive cable More circuitry than Type 1 or Type 2

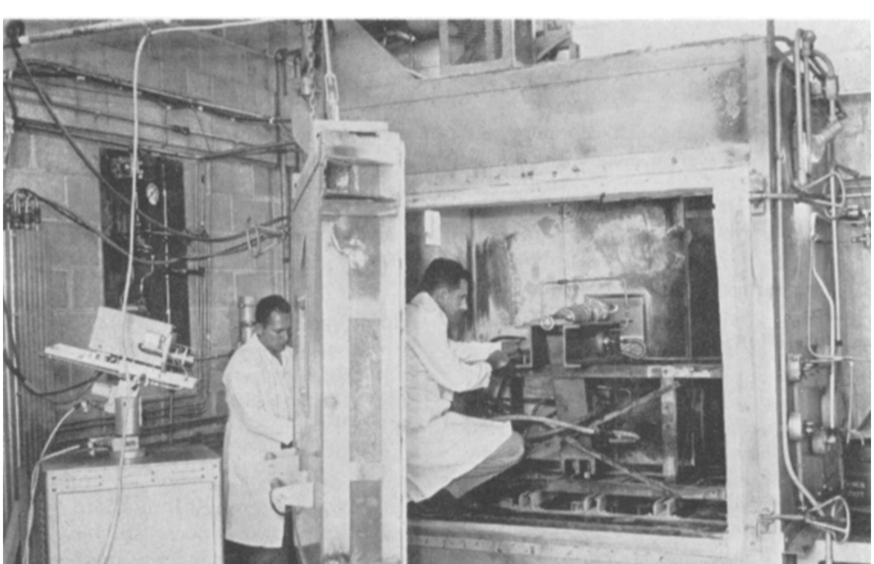

Fig. 2. KIN TEL industrial TV used at Autonetics Co. to observe high-temperature hydraulic system test.

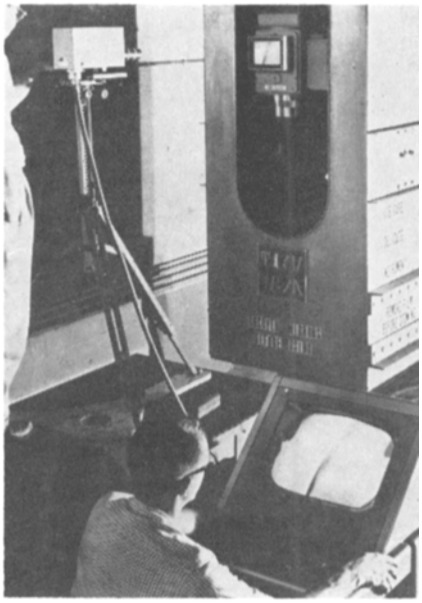

Fig. 3. Observation of schlieren apparatus during wind tunnel tests of ballistics models.

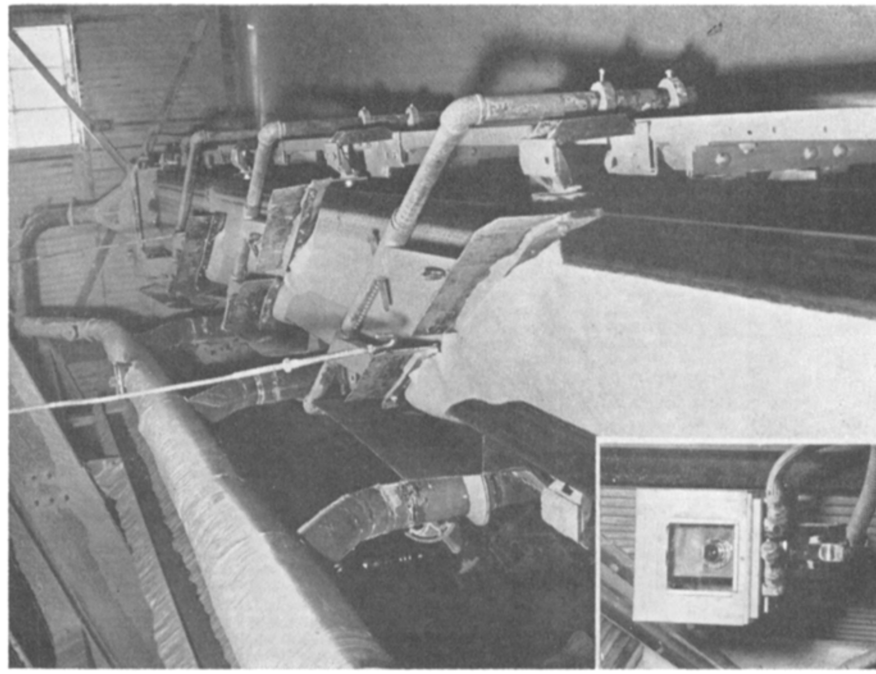

Fig. 4. Dustproof housing and camera at American Pot Ash & Chemical Co.

the approval of equipment manufacturers because it makes it possible to treat each unit according to where it is to be used; for example, the camera may be located at a point where vibration and dust present a problem and the control unit might be subjected only to dust and the monitor located at a remote point free from any contamination. The expense of special packaging is thus minimized.

Use of Standard Equipment

In many instances a standard TV camera may be isolated from a rugged environment and accomplish the same results as if it were placed in the actual environment. Such is the case in the installation in a hydraulics test laboratory (Fig. 2). The TV system is used to view high-temperature hydraulic circuits and equipment in a testing oven room. Safety requirements and the nature of the tests prevent personnel from being in the oven room. The camera is located within the oven room while the control unit and monitor are located in the adjacent control room. The camera is mounted on a special pan and tilt unit to attain greater range of visibility in a hazardous test area.

Tests at temperatures up to 1200 F and down to −105 F are conducted in this laboratory. Permanent electrical wiring, push-pull rods and motorized valves are employed to control, test, and record data. Tests too difficult to observe directly are monitored by this system. A similar installation involves observation of models in a wind tunnel (Fig. 3) through a schlieren optic system. In each of these applications a rugged atmosphere is observed using standard unprotected equipment.

Isolating TV Equipment

Other methods have been used for isolating the camera from rugged environments. For example, a dustproof housing (Fig. 4) was designed to isolate cameras used for observation in a dust-contaminated area. An acoustical housing (Fig. 5) was developed to permit the use of TV cameras in high-noise areas. A heavy-duty pan and tilt unit, designed as a companion unit (Fig. 6), permitted remote positioning of the camera in a high-noise atmosphere.

An underwater housing (Figs. 7 and 8) makes it possible to use the camera hundreds of feet below the surface of the water. Special cable and remote lens iris and focus control add flexibility to this system. Underwater mercury vapor lights and underwater pan and tilt units are available.

The first efforts to "ruggedize" a standard camera employed special mounting and shielding of the camera preamplifier tubes such as the 4BQ7's. Naturally the search for a more rugged camera led to the use of subminiature tubes. Direct soldering of tube leads and special tube clamps made it possible to produce a camera that would withstand ambient noise levels up to 160 db. A word of caution should be noted here. It is not sufficient to know the ambient noise level in decibels when evaluating the performance of a TV camera in high-noise environments. The power noise spectrum varies depending upon the application. A camera may work very well when used at a rocket test stand at a noise level of 160 db, but that same camera may produce noise bars or microphonics when used in a jet engine test cell where the noise level is the same. It is generally

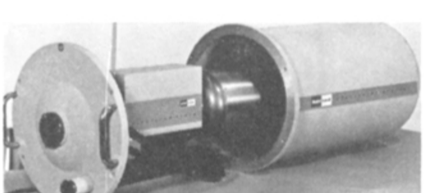

Fig. 5. Acoustical housing to shield camera in high-noise areas.

Fig. 6. Heavy-duty pan and tilt head with camera in acoustical housing.

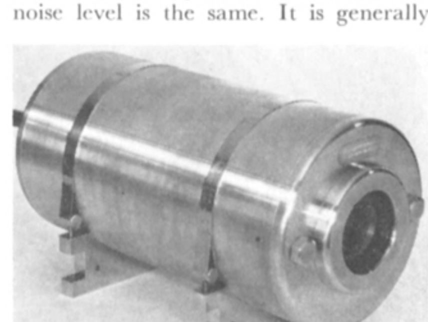

Fig. 7. Brass underwater housing.

Fig. 8. Camera used underwater on "Wide Wide World" TV show, in cooperation with TV Branch of U. S. Navy Bureau of Ships.

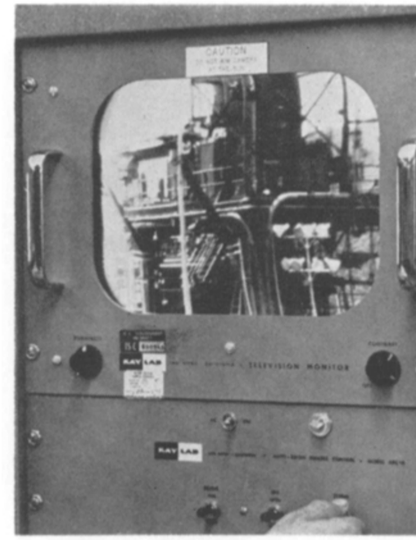

Fig. 9. High-noise rocket test stand installation at Rocketdyne Div., North American Aviation, Inc.

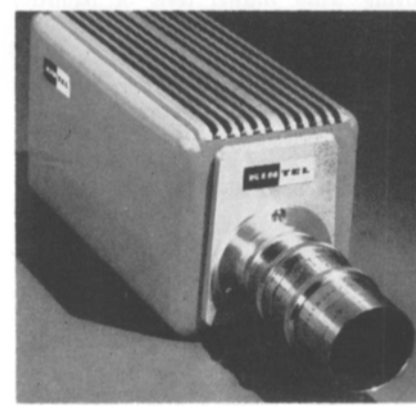

Fig. 10. Small rugged camera for special applications.

impractical to analyze the noise spectrum; however, performance comparisons have been used as a normal criterion.

These special design techniques have made possible good performance of vidicon cameras in areas subjected to an average white noise level of 175 db and shock in the three planes of 15 G's. Figure 9 shows a typical high-noise rocket test stand installation. Military research and development programs continually demands closed-circuit television cameras that will withstand ever-increasing rugged conditions.

A New Ruggedized Camera

No one camera can be designed to operate unprotected in all environments, but presently available equipment will solve many problems of remote observation in rugged environments. A small rugged camera for special application has been designed (Fig. 10).

This camera weighs approximately 4 lb and is $3\frac{1}{2}$ by 4 by 8 in. in size. It is completely dustproof and splashproof; in fact, the camera can be immersed in shallow water if the lens is properly sealed. Experiments indicate that this camera can withstand temperatures from −55 C to +170 C and will still operate satisfactorily when the temperature returns to the operating limits of the vidicon. Present operating limits of the vidicon are from −40 C to +60 C. In the future, vidicons should be available with extended temperature limits. This camera can be fastened to a missile frame and can withstand the vibration and shock encountered, and is capable of producing a picture with a horizontal resolution in excess of 600 lines.

Where high-quality pictures are not mandatory, the smaller $\frac{1}{2}$-in. vidicons offer great promise for further miniaturization of ruggedized television cameras.