TIVICON TELEVISION CAMERA: A NEW FIRELINE RECONNAISSANCE TOOL; LABORATORY TRIALS

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NORTHERN FOREST RESEARCH CENTRE
INTERNAL REPORT NOR-15
APRIL 1972

CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
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INTRODUCTION

Fire suppression organizations in Western Canada have geared up to meet the challenge of taking effective action on large wildfires. This is facilitated by improved aerial and ground access, improved communications, and fire intelligence with more sophisticated suppression strategy and tactics.

Important phases in a campaign fire operation are the provision of good current fire status maps and a steady flow of intelligence from fire line to fire camp. To provide this service the Alberta Forest Service created a fireline photography and mapping team in 1968 consisting of technicians equipped with aerial cameras, portable photo laboratory with photogrammetry, mapping and reproduction equipment; the team sets up camp near the fire as part of the fire overhead organization. The team's job is to produce up-to-date maps and photo

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* Trademark of Texas Instruments Incorporated.

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mosaics of the fire and surrounding areas with a minimum of time delay.

It is also important to supply the fire boss with current pictorial records[1] of the fire illustrating such items as:

a) fire spread rate;

b) speed of fireline construction;

c) effectiveness of fireline;

d) dangerous fuel accumulations near the fireline;

e) effectiveness of the fire bombing operation;

f) unnecessary fanning of fire by low passing helicopters;

g) spot fires outside fireline;

h) possible access routes, fords, helicopter landing sites or docking facilities;

i) terrain features such as natural fuel breaks, and,

j) dangerous obstacles such as high snags or rocks.

Most of the desired information comes from infrared aerial photographs taken on the spot. However, such photographs cannot portray action. It appeared that an airborne television system (Vidicon), supplementing the aerial infrared camera, could not only provide instant moving action pictures but would allow perfectly synchronized voice recordings as well.

The Alberta Forest Service conducted a number of tests in 1968 and 1970 employing various combinations of cameras and recorders. One of the tested systems consisted of a Sony Video camera model CVC 2100 A, a

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[1] Polaroid photographs are being taken currently.

Sony Videocorder EV 200 VTR, a Sony Micro Video Monitor PVJ 3030, and a Sony 8-inch Video Monitor operated from a fixed wing Dornier DO 28 aircraft. Power was supplied by the aircraft's electrical system through a Carter Rotary Inverter model JR 1050CP 26VDC-115VDC.

While the performance of the Vidicon system was generally satisfactory, it was found that smoke and haze in the air reduced the quality of the recordings, thus raising doubts about the system's usefulness in the smoke-filled atmosphere of a major wildfire.

In the meantime a new image pickup tube, "TIVICON", appeared on the market. The spectral response of the Tivicon is from 0.45 to 1.10 microns. Considering that the infrared spectrum begins around 0.70 microns, a Tivicon should be less affected by smoke in the atmosphere than a Vidicon tube which covers the spectral range from 0.40 to 0.65 microns. The Tivicon tube is extremely light sensitive and can be operated under very low light conditions when conventional cameras and Vidicon systems are ineffective. Other desirable qualities of the Tivicon tube are its tolerance to excessive light entering the lens and its ability to be operated in a vertical position--something Vidicon tubes cannot tolerate. On the basis of these features it was decided to conduct laboratory tests to determine if airborne field tests were warranted.
At the request of the Alberta Forest Service, the Canadian Forestry Service conducted a series of laboratory tests in late 1971 to compare the light sensitivity and smoke penetration abilities of a Tivicon, a Vidicon, and a conventional still camera loaded with infrared film.

TEST PROCEDURES

Smoke Chamber Layout

A temporary smoke chamber (Fig.1, 2) was improvised in a combustion laboratory by fastening plywood sheets around a burning table to form a 4-ft wide, 8-ft deep and 22-inches high space on top of the table. A laboratory hot plate[2] (Fig. 3) positioned at the back end of the chamber simulated the heat of the fire, the front end was left open to allow camera access and illumination.

The cameras, set up on tripods, were located six feet away from the front of the smoke chamber. A column of smoke eight feet deep had to be penetrated to obtain a recording of the heat target. Four cardboard targets[3] were placed in various positions in the chamber to assist in estimating smoke uniformity and density as well as the degree of attenuation of target visibility.

Partial illumination of the inside of the smoke chamber was accomplished by opening an 8-inch crack at the top of the plywood enclosure allowing reflected light from the flood lights[4] in the fume hood to enter. A photo flood light[5] set up in front of the cameras provided the bulk of the lighting (Fig. 1).

Testing

During each test requiring smoke, four smoke candles[6] were lit simultaneously in the hollow underneath the burning table.

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[2] Heat target - see Appendix

[3, 4, 5, and 6] See Appendix

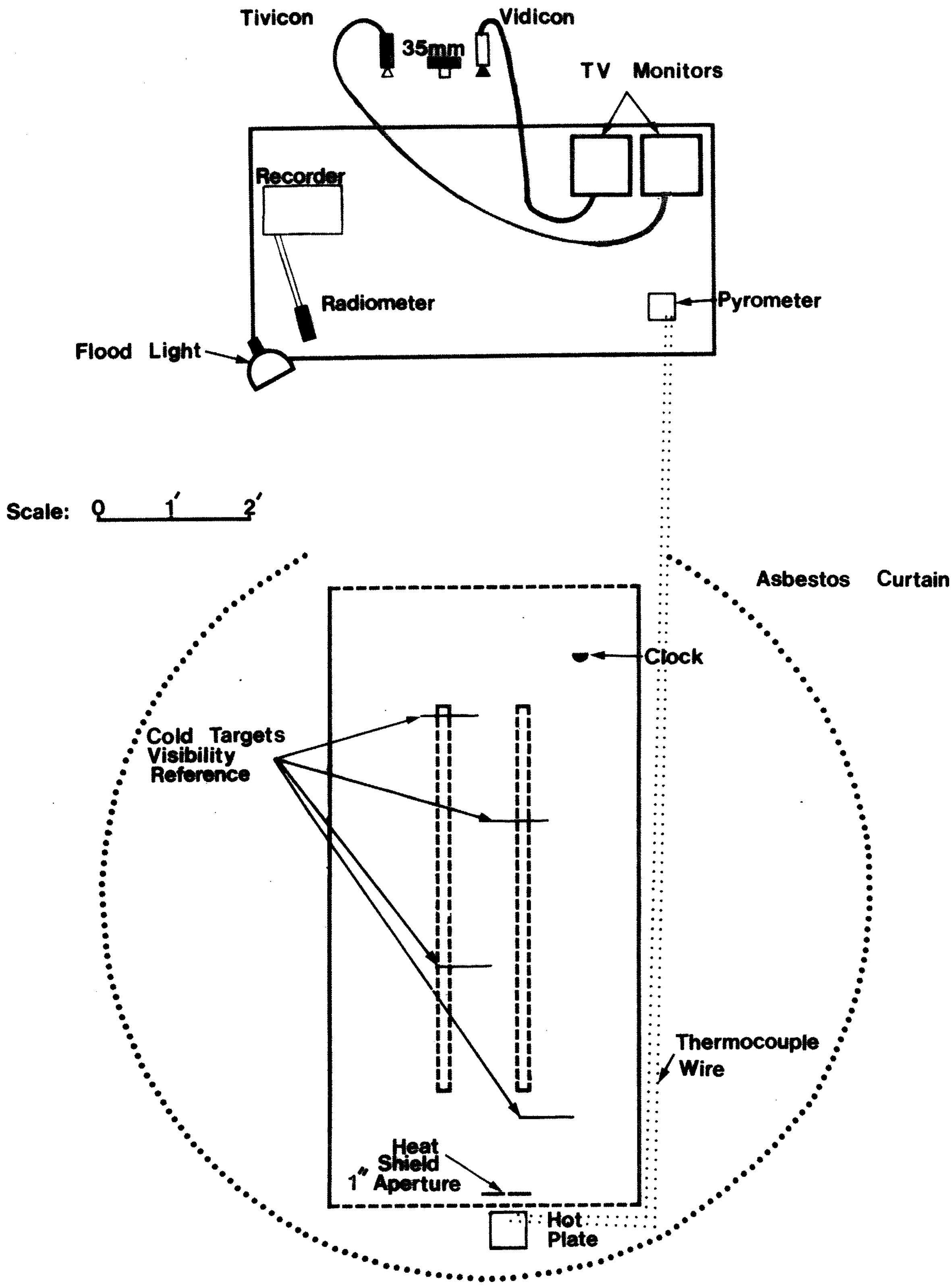

Figure 1. Tivicon Camera Test Arrangement.

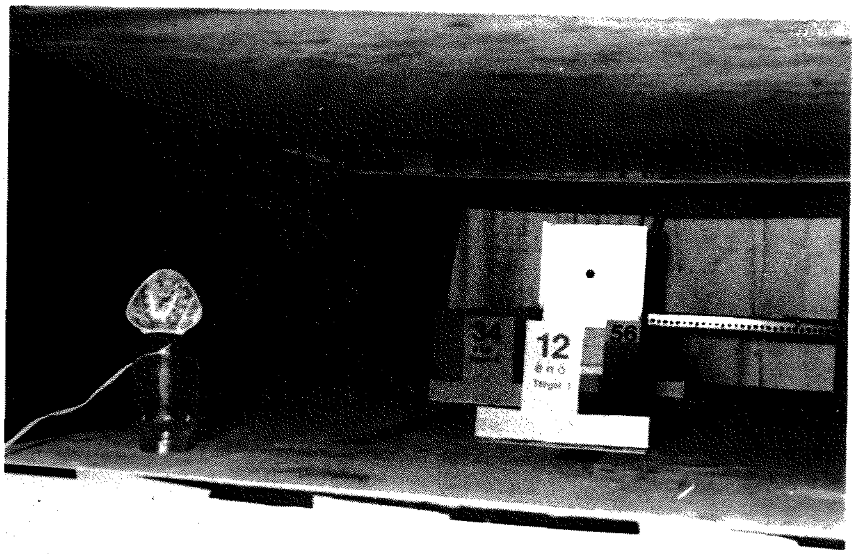

Figure 2. Smoke Chamber.

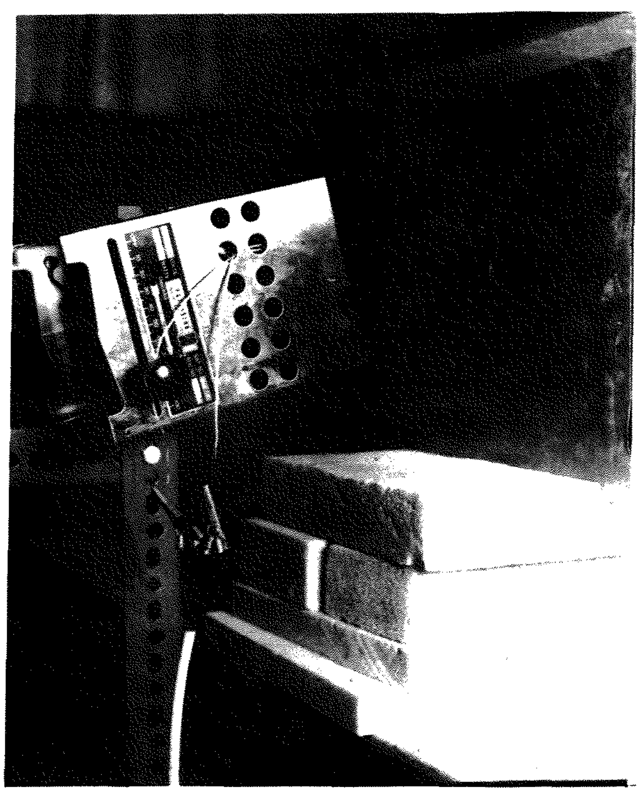

Figure 3. Heat Target and Shield.

TABLE 1 - TEST CHART

TEST NO.	CAMERA	F-STOP	SHUTTER SPEED	HEAT TARGET TEMPERATURE	LIGHTING	PURPOSE OF TEST	REMARKS
1	Tivicon Vicicon Pentax[8]	5.6 1.8 1.8,2.8,4	N/A N/A 1/15	1,030°F 1,030°F 1,030°F	Ambient[7] (reflected & incident light) 1 Foot candle at heat target	Light sensitivity test without smoke	Satisfactory picture. Underexposed. Satisfactory picture at F2.8
2 (Fig.4)	Tivicon Vidicon Pentax	22 8 4	N/A N/A 1/15	1,450°F 1,450°F 1,450°F	Ambient + photo flood light	Smoke penetration test without filter on Tivicon	On Tivicon, heat target obscured for 10 seconds only. On Vidicon, heat target invisible during 45 seconds
3	Tivicon Vidicon Pentax	4 (with filter) 1.8 4	N/A N/A 1/15	1,450°F 1,450°F 1,450°F	Ambient + photo flood light	Smoke penetration with corning A1529 red filter	As test No. 2 As test No. 2 As test No. 2
4	Tivicon Vidicon Pentax	2.8(no filter) 1.8 2.8	N/A N/A 1/15	1,450° 1,450°	Ambient only	Smoke penetration using ambient light only	Backlighting (Fig.5) for 5 seconds
5	Tivicon Vidicon Pentax	2.0 (no filter) No recording No recording	N/A	1,450°F	Ambient only	Smoke penetration increased F stop on Tivicon	Larger "F" settings did not prolong the visibility of the heat target in heavy smoke
6	Tivicon Vidicon Pentax	1.4 (no filter) No recording No recording	N/A	1,450°F	Ambient only	Smoke penetration increased F stop on Tivicon	
7	Tivicon Vidicon Pentax	1.4 (no filter) 1.8 No recording	N/A N/A	1,450°F 1,450°F	Total Darkness	Heat target resolution through smoke in total darkness	Heat target disappeared when smoke chamber was saturated with smoke

7 Ambient light = reflected light from fluorescent ceiling fixtures
8 All exposures with Pentax with red filter Wratten No. 25

With the TV cameras in operation, the rising smoke entered the smoke chamber through two 2-in x 5-ft slots in the burning table, gradually filling the smoke chamber. Full uniform smoke saturation could only be achieved for a few seconds.

During operation both TV cameras were connected to a video tape recorder and a monitor. With both monitors located side by side the performance of each camera could be readily observed.

Exposures with the Pentax 35 mm camera were taken as the situation demanded it.

A total of seven tests were completed under various lighting configurations and camera settings. (Table 1).

RESULTS

Light Sensitivity Test

The Tivicon camera produced a clear detailed picture at a light level of less than one foot-candle (lowest possible reading on light meter[9] - one foot candle). At that reading the Vidicon camera did no longer resolve any details on dark objects. The Pentax, loaded with infrared film, produced a readable print at F 2.8 and 1/15 of a second.

NOTE: Aerial reconnaissance cameras employed by the Alberta Forest Service, K20 and EAGLE IX, have a maximum aperture-shutter

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9 See Appendix.

speed combination of F 4.5 - 1/125 and F 6.3 - 1/50 respectively, which means that neither of these could have obtained a usable picture under the light conditions existing in the test laboratory.

Smoke Penetration Tests

Tivicon camera: The heat target was discernible on the monitor through smoke too dense to be penetrated by the unaided eye. However, when the smoke chamber was saturated with smoke the Tivicon camera was also rendered ineffective and could not resolve the target.

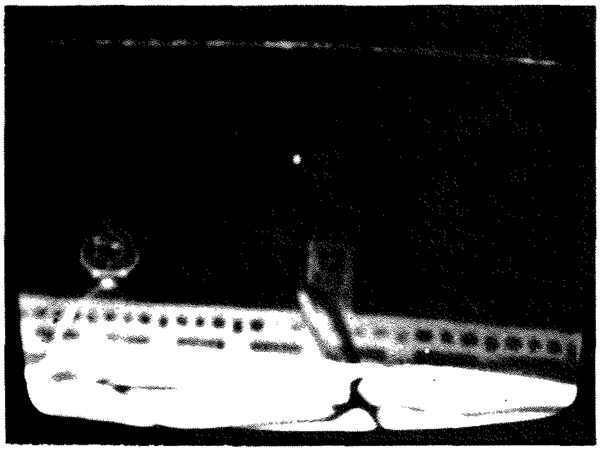
Vidicon camera: Slight amounts of smoke, discernible to the unaided eye, obscured the targets. (Fig. 4).

Pentax camera loaded with infrared film: Its capability to resolve detail through smoke was better than the Vidicon camera but less than the Tivicon camera.

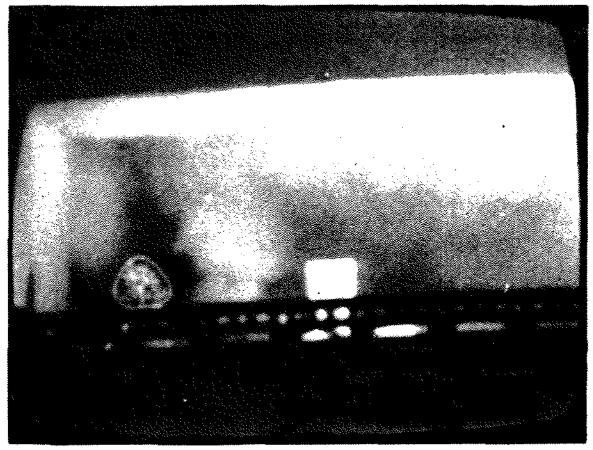
DISCUSSION

No attempt was made to correlate the smoke from the smoke candles with actual wood smoke, however, the temperature of the heat target (1,450°F) simulated the heat of a fairly hot forest fire.

The Gier Dunkle Radiometer was not affected by the smoke. It produced a uniform readout corresponding to target temperature regardless of smoke density.



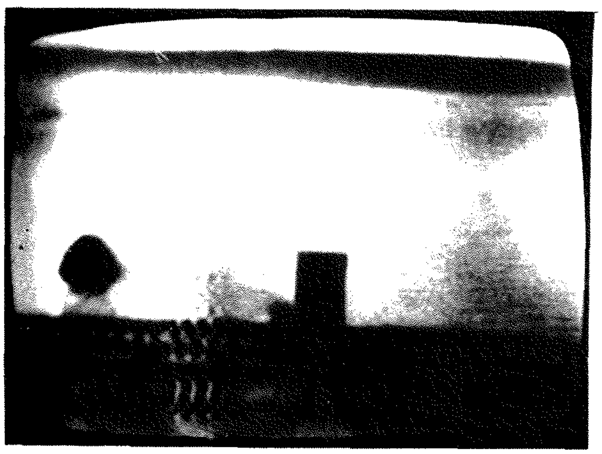
Tivicon



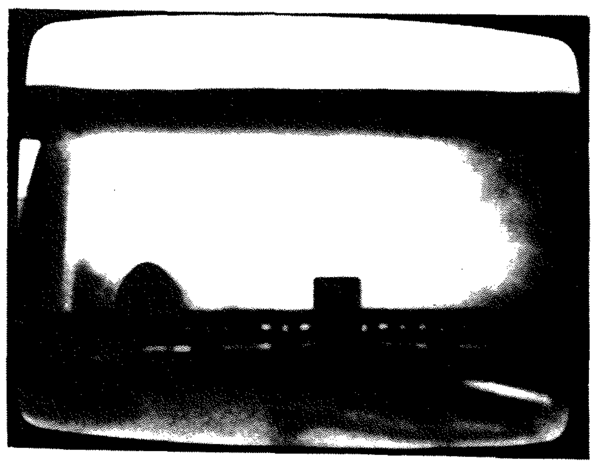
Vidicon

Figure 4.

Comparison Test No. 2 - Tivicon is less affected by front lighted smoke.



Tivicon



Vidicon

Figure 5.

Comparison Test No. 4 - Backlighting increases smoke glare. The Tivicon camera suffers less target attenuation than the Vidicon.

Back lighting the targets by opening a slit at the top of the smoke chamber and allowing the flood lights on the fume hood to shine into the back of the smoke chamber resulted in glare that obliterated most detail for all three cameras. (Fig. 5).

When the smoke was at its densest neither camera could pick up the heat target, even after all lights were switched off and the cameras set to maximum sensitivity. However, a Tivicon camera may still pick up flames through smoke on a wildfire, particularly at dusk or dawn when smoke glare is at a minimum.

The addition of a "Corning" red filter No. A 1529 to the lens of the Tivicon camera made no noticeable difference once the heat target had disappeared behind the smoke.

CONCLUSIONS

This limited laboratory test comparing the Tivicon and Vidicon Television cameras and a Pentax 35 mm still camera loaded with infrared sensitive black and white film has shown that:

1) A Tivicon camera can obtain good videotape recordings in low light conditions when a Vidicon and a still film camera are ineffective.
2) A Tivicon camera can penetrate some smoke as generated by smoke candles and can sense a hot target under conditions when neither a Vidicon nor a still camera loaded with infrared black and white film can produce evidence of the target.

3) Neither of the cameras tested can penetrate a concentrated column of 8-foot smoke emitted by smoke candles.

4) It was obvious that reflected light (glare) from the artificial smoke was a major factor - but attenuation of the heat target was not appreciably lessened when all lights were switched off.

In order to evaluate a Tivicon television system as a fire line reconnaissance tool it will be necessary to conduct a series of airborne tests under natural smoke and light conditions. Test times should be at dawn and dusk when smoke-glare is at a minimum.

ACKNOWLEDGEMENT

We wish to express our gratitude to Mr. Doug. J. Paulsen, Sales Manager, Spectronics Ltd., of Edmonton, who let us use his Tivicon camera and Video recorder to conduct this test.

REFERENCES

Cheney, N.P., Hooper, R., MacArthur, D.A., Packham, D.R., and Vines, R.G. 1968. Techniques for the Aerial Mapping of Wildfires; Autralian Forest Research, Vol. 3, No. 4. 1968.

Skaggs, Frank L., Horak, Joseph B., Stephens, Craig P., and Gilblom, David L. (Year unknown but 1969 or later). A Broadband Image

Pick-up Tube with high near infrared sensitivity. Paper presented at "Electro Optical Systems Design Conference". (Mr. Frank L. Skaggs is Manager, Image Sensing Devices, Optoelectronics Department, Texas Instruments Incorporated, 13500 North Central Expressway, Dallas, Texas).

Texas Instruments Corporation Incorporated.

Bulletin CB-108 Optoelectronic systems from Texas Instruments, Sept. 1970.

Bulletin CB-141 Optoelectronics from Texas Instruments.

Bulletin CB-142 Tivicon image tubes from Texas Instruments, Sept. 1971.

List of Materials

1) Cameras

CAMERA NAME & MODEL	LENS	ACCESSORIES	FILM	RECORDER (NAME & MODEL)	REMARKS
Tivicon camera:[10] GBC CCTV Total darkness camera Model CTC 5000 Ser. 1972 Man. Ikegami Tsushinki Co., Japan	Cosmicar television lens, F1.4/25 mm	A 1529 Corning red filter	N/A	AKAL, Model VT 110 ¼-inch portable VTR tape recorder	
Vidicon camera: Sony Videorover II Model AVC 3400	F1.8 12.5 to 50 mm Zoom	N/A	N/A	Sony Videocorder model AV 3600 ½ inch recorder	
Pentax camera:	1.8 Takumar	Wratten 25 red filter	Kodak High speed infra red HIE 135-20 black & white		Estimated sensitivity range of film .72 to .9 microns

[10] Tivicon tubes can be mounted in most high quality standard separate-mesh TV cameras to convert them from Vidicon to Tivicon. Test model was converted to Tivicon by Spectronics Ltd. of Edmonton.

APPENDIX

2) Other Instruments and Material

a) Smoke chamber. Three plywood sheets 3/8" x 4 x 8. One of these cut in half to create an opening for back lighting.

b) Heat target (one)

550 watt laboratory hot plate "Precision Scientific Co., Chicago, Cat. No. 61560 Ser. 10-012 with infinite heat range 100° to 1,500° Fahrenheit.

c) Heat Target Shield (one)

20-gauge galvanized tin, 1' x 1' with 1" circular hole in centre.

d) Cardboard targets (four)

Pieces of gray cardboard ranging in size from 3.5" x 6" to 11.5" x 6" with "LETRASET" lettering in the sizes .5" (No. 42), .9" (No. 44) and 1.5" (No. 60) on each.

e) Photo flood light (one)

GE 600 W DYH Tungsten Halogen Quartz lamp on 9" matte reflector.

f) Projector Flood Light (three)

Westinghouse 71-14 150 Watts

g) Smoke Candles (twenty)

"Superior One Minute Smoke Candles" from Safety Supply Co. of Edmonton. (800 cubic feet of smoke per minute each).

h) Radiometer (one)

"Gier Dunkle" DR 100 (to check heat target temperature) with Bausch and Lomb Strip Chart Recorder 500 micro volts Model VOM 7.

i) Thermocouple (one)

Chromel-Alumel .015 x 12" (to check heat target temperature) with:

j) Pyrometer (one)

Thermo Electric Co. Potentiometer-Pyrometer Mini Mite, Model 80200 1.6 to 44.0.

k) Lightmeter (one)

Seconic Studio, Brockway, photographic light meter sensitive to one foot candle.

i) Alarm clock (one)

(Glass removed to eliminate glare).