Modifying TV Cameras for Use of Silicon Target Vidicons

by
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Introduction

This Note describes how an existing vidicon camera may be converted to utilize an RCA Silicon-Target (ST) vidicon tube. The silicon-target vidicon features performance characteristics which can extend the usefulness of existing vidicon cameras in industry, education, public service and research. The similarity in structure of the silicon-target vidicon with older type vidicons makes such conversion possible. The essentials of such conversion (target voltage, gun voltages and exposure control) are discussed in this Application Note.

General Information

To realize the maximum benefit from the characteristics of the silicon-target vidicon, it should be used in a camera designed specifically for the tube. Many uses and users can, however, benefit from the adaptation of existing vidicon cameras to permit use of the silicon-target version. The following paragraphs highlight some of the advantages and the trade-offs to be expected in conversion to silicon-target tubes. Guidance is also offered in determining whether a particular camera design is suited for conversion and information is presented on those aspects of camera modification which are absolutely necessary.

Many existing camera models can be properly modified by experienced technical people using materials available in even a modestly equipped electronics shop. A few models may prove difficult and challenging because of restrictive arrangements of printed circuit boards.

Advantages and Disadvantages of Conversion to S-T Tube Operation

Advantages

As a photosensor, silicon offers very high efficiency over a broad band of the electromagnetic spectrum ranging from an upper wavelength of about 1.2 micrometers (μm) in the near-infrared region, down through the entire visible-light band and on into the ultraviolet portion of the spectrum. Thus it can make most effective use of limited available light (both the night sky and the familiar tungsten filament light bulb produce substantial amounts of infrared radiation). At the opposite extreme, very intense light will not damage the silicon target. When overlighted, a silicon target tube may fail to produce a picture, but it will promptly recover when proper lighting levels are restored.

The broad spectral response of silicon suggests many possibilities. By use of optical filters, the one tube can be used as a highly efficient sensor in any of a number of selected wavelength bands. For example, it is as sensitive (or more so) to red light as it is to green and blue, thus can be very effective in color separation applications. Again, with appropriate filters, the infrared sensitivity of the silicon target tube can be employed and visible light excluded for use in such diverse situations as the identification of diseased plant life, the study of animal life in the "dark" and recovery of information from burned or otherwise altered documents.

Disadvantages

A major difference between silicon-target vidicons and the more conventional sulfide-type (antimony trisulfide) is that the latter's sensitivity can be adjusted by electrical means to accommodate a wide range of lighting conditions. When the silicon-target tube is used, its fixed (albeit high) sensitivity requires that light intensity reaching the tube must be controlled. This usually means that the camera lens must be fitted with an iris diaphragm — an item sometimes omitted in lower cost cameras originally equipped with sulfide-target vidicons. If automatic light control (ALC) is to be used in the camera, the control circuitry must be arranged to actuate the iris diaphragm or switch filters (or a combination thereof). Several lens manufacturers offer suitable electrified lens units to permit this (see Appendix). In those applications where the source of lighting can be precisely controlled, the need for an adjustable lens is eliminated but it should be noted that almost all photographic type lenses do contain at least a manually adjustable iris diaphragm.

When comparing the silicon-target tube with yet other vidicon forms such as the lead-oxide versions (Plumbicon*, Vistacon, etc.) or the selenide versions (Chalnicon), it will be noted that all are equally disadvantaged in that they each exhibit fixed sensitivity and a resultant need for separate control of faceplate lighting.

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*Trademark NV Philips, Netherlands

Other Differences

Performance differences between classes of vidicons can be advantageous in one situation and disadvantageous in another. Such must be judged in terms of the particular application. For example, the silicon-target tube has a very linear response characteristic (output current versus input radiant power) or, as it is termed, "unity gamma". For radiometric applications – or for contrast enhancement, such a characteristic is an advantage. Unity gamma, however, is a disadvantage where there is need for tonal fidelity (accurate gray scale) in a CRT presentation. In such cases, the higher-than-unity-gamma of the cathode ray picture tube is neatly complemented by the less-than-unity-gamma characteristic of sulfide-type vidicons.

Cameras Suitable for Conversion

A few camera characteristics cannot practically be altered. Consequently, a conversion to a silicon-target vidicon can be undertaken only if the latter matches the tube being replaced in these three respects:

Size – The nominal bulb diameters must be the same. The lengths of the **active** internal structures should be within about one-half inch (1.25 cm) of each other.

Method of electrical (tube) focus

Method of electrical deflection

Tables I and **II** list a large number of camera tubes which can be matched in all of the foregoing respects by at least one of the existing RCA silicon-target vidicons.

Specific Modification Considerations

Once the initial conversion requirements of tube size and focus/deflection method are met, the following items should be reviewed in the camera to be adapted, and if necessary, the indicated modification performed:

Target Voltage
Heater Circuit
Gun Voltages
Focus Current
Deflection Circuits
Optical Adjustment

Target Voltage

The silicon target is designed for operation at a specific voltage. Particular care must be observed in meeting this requirement, especially when converting cameras originally designed for sulfide-type vidicons.

At present, the operational target scanning potential for RCA silicon-target camera tubes is eight volts. The camera should supply this voltage value with a tolerance of ±5%, and may optionally make provision to lower this voltage to aid in installation adjustments. It is especially important to remember that the target voltage, as with any electron tube electrode voltage, is valued with respect to the cathode of that tube. Many camera circuit designs do NOT connect the vidicon cathode directly to reference ground or "earth", consequently it is necessary to analyze the cathode circuit and, in some cases modify it before attempting revisions in the target supply circuit.

Possible Cathode Circuits

Figures 1 through **5** present various cathode circuit configurations, one of which should be found in the camera being adapted. The reader should study these partial schematics and determine which applies to his camera, then proceed with the steps described for that particular circuit.

The vidicon cathode circuit shown in **Figure 1** needs no modification. Proceed to the Target Circuit discussion and the modification in **Figure 8**.

The circuit of **Figure 2** also does not require modification. The blanking transistor is normally driven to saturation during the active scanning interval and therefore the vidicon cathode at that time is at ground potential (or a few tens of millivolts positive). A dc voltmeter reading of several volts from cathode to ground should not be misinterpreted. Such a reading is the averaged value of the blanking pulses. Use of a direct-coupled oscilloscope will confirm that the cathode is grounded during active scan time. Proceed to the Target Circuit discussion and the modification in **Figure 8**.

The circuits shown in **Figures 3, 4,** and **5** each require modification. Each circuit contains a resistor, R_K (usually 5 kΩ to 25 kΩ) which carries the vidicon cathode current. Since the cathode current can vary widely as the camera BEAM control is adjusted or as the vidicon ages, the voltage drop across R_K will also vary widely. This voltage, V_K, is part of the circuit between vidicon cathode and target, and its variations reflect directly as variations in the target voltage. Such variations must not be allowed to occur when a silicon-target vidicon is used in the camera.

Any of these circuits, **Figures 3, 4,** and **5,** may be modified by two general methods. The choice of method is basically one of convenience taking into consideration the physical locations of the various circuit sections and the restrictions or requirements imposed by a particular printed circuit board arrangement.

Method 1 – If it is feasible to run a single wire from point "K" in **Figures 3, 4,** or **5** to the target circuit components, do so and then complete the circuit in accordance with **Figure 9.** Except for this interconnection, no alterations are made in the cathode circuits.

Method 2 – If a direct interconnection of the cathode and target circuit regions is not practical, the alternative is to employ a dc clamp circuit at the cathode and to then construct a revised target circuit taking into account the chosen cathode clamp voltage value, V_C.

Figure 6 shows the essential portion of **Figures 3, 4,** or **5** with the addition of a clamping diode, D, whose anode connects to a **well regulated** voltage source V_C. V_C should be such that the current in R_K is at least 0.5 mA. Thus if R_K = 30 kohms, $V_C \geqslant 1/2 \times 2 \times 10^4$ mV or 10 V and the vidicon cathode voltage will be clamped at this value (during active scan time) as the cathode current varies from zero to 0.5 mA. After modifying the cathode circuit in accordance with **Figure 6**, proceed to the Target Circuit discussion and the modification shown in **Figure 10** carrying the value for V_C determined above into the calculation of target reference voltage.

Target Circuit Considerations

The essential elements of the target circuits to be found in a vidicon camera are shown in **Figure 7**.

In the actual camera, the elements within the dashed enclosure of **Figure 7** will be physically close together. The vidicon target circuit involves a load resistor, R_L, (values vary widely) and most always a decoupling circuit, R_D-C_D. Both R_L and R_D are frequently in the range of 1 to 10 megohms. The ASC (automatic sensitivity control) circuit may consist of just another series resistor – if so, its resistance will be of the order of 10^9 ohms (1 gigohm). More complex ASC arrangements may be found where a direct-coupled high voltage regulator transistor is controlled by the rectified and filtered video signal fed back from a point in the video amplifier. In either case, the ASC arrangement should be disconnected and a 1/4 to 1/2 watt resistor of from 100 kohms to 1 megohm should be put in its place.

One of the following revised target circuits must be used – the proper one having been determined in the analysis and discussion made in the proceeding section on cathode circuits.

The revised target circuit shown in **Figure 8** is for use with the cathode circuits of **Figures 1** or **2**.

Resistance R_Z is not critical, the range shown should not be inconvenient, and in many cases a suitable resistor will be left after removing the rest of the ASC circuit. Target Control "P" should be set so its slider voltage is at least one volt greater than V_Z (so the Zener regulator is functioning). Such a control is usually already in the camera; keeping it should do no harm and in fact can be convenient for low target voltage preliminary adjustments (see discussion on alignment in a following section). If desired, the target control can be wired around and target supply voltage provided from a fixed source.

The revised target circuit shown in **Figure 9** is for use with the unaltered cathode circuits of **Figures 3, 4,** or **5** under the conditions described under **Method 1** in the discussion of those figures.

Resistance R_Z can be any value in the range shown. Frequently, a suitable resistor will remain after removal of the ASC circuits.

Capacitor C_C can be 20 microfarad or more and doubtless will be a polarized unit. When this circuit is used with a cathode circuit such as in **Figure 3** or **4**, the lower end of C_C should be connected to a low voltage (50 V or less) bus – either plus (+) or minus (–) making sure to properly polarize the capacitor. Such connection will prevent difficulty when point Z changes polarity (with respect to ground), a condition which may occur when the vidicon beam control is operated over its full range. If **Figure 5** represents the cathode circuit in the camera being adapted, the lower end of C_C may be grounded (make certain the negative lead is the one grounded).

The revised target circuit shown in **Figure 10** is to be used with cathode circuits represented by **Figures 3, 4,** or **5** when modified in accordance with **Figure 6** and **Method 2** in the previous discussion.

The vidicon cathode (during scan) is clamped at voltage V_C (determined previously). The Zener voltage of CR should regulate at V_Z, and should be chosen to be eight volts greater than V_C. **Figure 10,** otherwise, is the same as **Figure 8,** the discussion of which should now be reviewed.

Heater Circuit

A few cameras of those originally using vidicons with 600 mA heaters (see **Table I**) need modification to reduce the heater current supplied to the vidicon to the 100 mA value required by present-day silicon-target tubes. Most cameras use a fixed voltage supply which needs no modification. This aspect can be readily checked by temporarily wiring in a No.47 (or 40 or 1847) pilot lamp rated at 6.3 V and 150 mA. If the filament supply circuit attempts to feed 600 mA this will immediately be evident without burning out an expensive vidicon tube.

Gun Voltages

RCA silicon-target vidicons use electron gun structures which are virtually identical with those used in its sulfide-type tubes. The silicon target, however, requires that the voltage be restricted on the field mech, grid number 4. For specific values, refer to the applicable tube bulletin. Cameras operating at the higher grid 4 (and grid 3) voltages permissible with other camera tube types, must be altered. The following is recommended.

1. For those cameras originally using vidicons with internally connected grids 3 and 4 (see **Tables I** and **II**), determine whether the voltage supplied to these electrodes is within the allowable maximum for grid No.4 of the silicon-target vidicon tube to be used. If, as will usually be the case, the existing camera voltages are low enough, the silicon tube can be substituted without voltage change. It will be necessary, however, to provide interconnection (at the tube socket) between the separately connected grids 3 and 4 of the silicon tube.

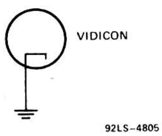

FIGURE 1

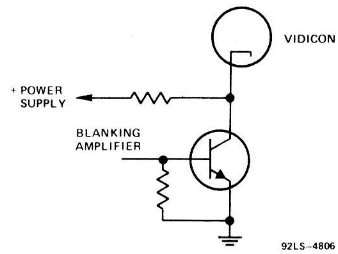

FIGURE 2

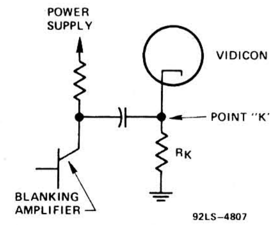

FIGURE 3

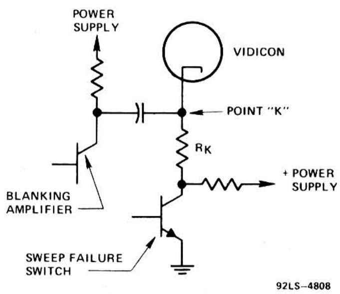

FIGURE 4

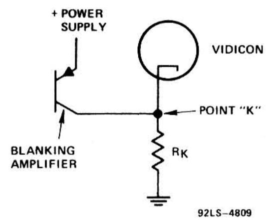

FIGURE 5

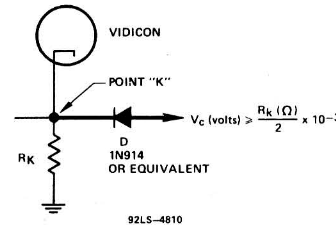

FIGURE 6

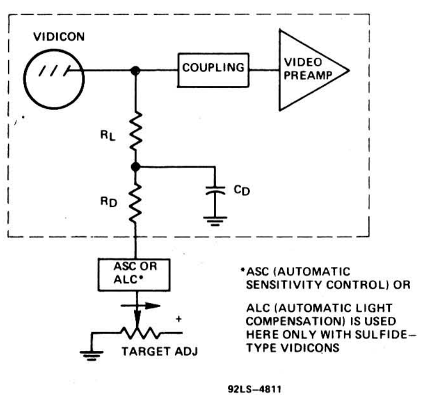

FIGURE 7

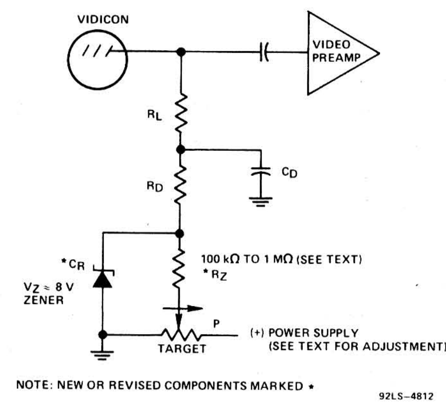

FIGURE 8

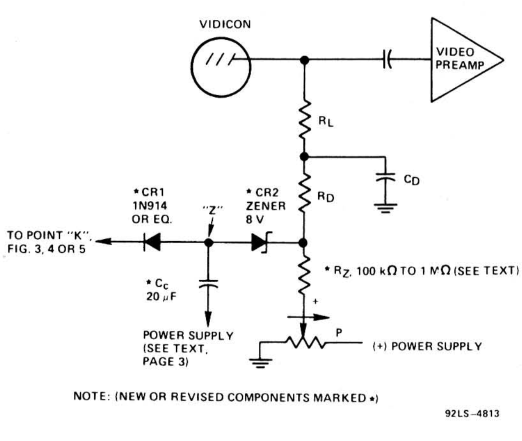

FIGURE 9

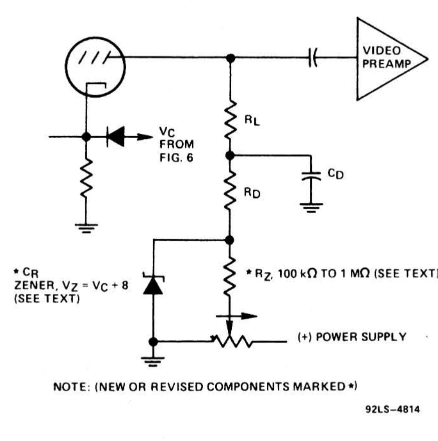

FIGURE 10

2. For cameras originally using "separate mesh" tubes, grid No.4 voltage is customarily the highest value employed and is usually set at no less than 500 V. When it is reduced, the grid No.3 voltage must also be lowered. As a first step, both grid No.4 and grid No.3 voltages should be lowered proportionately – maintaining a constant ratio between them. Further adjustment of the ratio of these two voltages is discussed in the section on Final Operating Adjustments. Grid No.2 most often operates at between 250 and 350 V. Neither this nor the grid No.1 circuit need any modification.

Focus Current
If as a result of the previous section, the grid No.3 voltage has been changed, it will be necessary to also change the focus coil current. The required change in focus current is proportional to the square root of the grid No.3 voltage change. The focus current supply circuit should be studied to determine the type and extent of any change needed, but a final choice of new circuit constants should be deferred pending a final choice of grid No.3 voltage as described in the section on Final Operating Adjustments.

Deflection Circuits
Any reduction in the grid No.3 voltage and focus field strength will reduce the amount of deflection drive required. The required reduction in deflection will usually be within the capability of the size adjustments provided.

Optical Compensation
In the silicon-target vidicon, the target is recessed behind the faceplate – rather than being a coating in the inner surface of that faceplate. To compensate for this internal spacing, the tube-and-coil structure must be moved closer to the lens. The distance involved is no more than 2 mm (0.079"). In virtually all cases, this is well within the range of the lead-screw-actuated mechanical focus adjustment provided in the camera. A possible but less desirable compensation is to prevent the tube from seating fully in the coil structure by means of a non-conductive shim ring (behind the target flange). The shim thickness should not exceed 2 mm.

Operational Adjustments
When all of the foregoing, under Specific Modification Considerations, have been satisfied, the appropriate silicon-target vidicon should be installed, placed in operation, and the following adjustments completed.

Magnetic Alignment
Because of the low target voltage employed, the S-T vidicon performance can be seriously degraded by improper alignment. This adjustment, which matches a given tube and camera, must be done each time a tube is installed in a camera. An improperly aligned tube will exhibit a very restricted dynamic range and will also exhibit substantial lag.

A satisfactory alignment adjustment is obtained by focusing on a scene and then lowering the target voltage until significant portions of the picture disappear from the monitor. At this target voltage setting, the alignment coils or magnet (s) are adjusted to maximize the area in which the scene appears and further to try to make the locations of blank regions symmetrical. This adjustment usually proceeds with the target at about 4.5 V. The process can be repeated at a slight further reduction in target voltage if the initial trial required use of a value much higher than 5 V.

When alignment is complete, restore the target voltage control to the operating setting described earlier.

Optimizing of the G3 Voltage
This discussion applies only when grids 3 and 4 are operated at different voltages, i.e., the "separate mesh" configuration.

a. For the silicon tube, grid No.4 voltage is, for the present limited to the relatively low value of 350 V. In most conversions, this is the chosen operating value.
b. The voltage on grid No.3 should always be less than that on grid No.4. The optimum ratio of these two voltages is dependent upon the design of the tube structure and the design of the magnetic structure of the deflection and focus coils.

If as a result of modification steps "Gun Voltages" and "Focus Current", a satisfactory picture results, no further adjustment should be attempted. If, however, performance at the pictures edges is seriously degraded, the G3/G4 voltage ratio should be readjusted to minimize such errors. Because of the many coil and tube combinations possible, no specific values can be recommended. In general, however, the RCA silicon-target tubes tend to prefer a higher G3/G4 voltage ratio than their sulfide-type counterparts. In arriving at an optimum G3/G4 ratio, some tedium will be encountered because at each new value for grid No.3 voltage, different adjustments of focus current and deflection drive are required.

When the final value for grid No.3 voltage has been determined, the required voltage divider circuit can be wired in, the final focus current regulator circuit changes determined and made, and the camera conversion is complete.

Table I — One-Inch Tubes

Cameras which have been designed for any of the tube types listed are likely to be readily convertible to use RCA 4532, 4532A, 4825, 4825A and similar S-T types.

Unless otherwise shown in the notes at the end of this table, tubes listed (a) have sulfide targets, (b) use 100 mA heaters, and (c) are 6.25"/158 mm long.

Type No.	Notes	Type No.	Notes	Type No.	Notes
CCTV111	8	XQ1073	8	7325	1, 2
N156	10	XQ1074	8	7697	1, 2
N157	6, 10	XQ1110	3, 10	7735, A, B	1, 2
HS200	1, 2	XQ1111	3, 10	Z7856	1, 2
HS201	1, 2	XQ1160	3, 6	Z7869	2, 8
HS202	1, 4	XQ1161	3, 6	Z7870	8
HS203	1, 4	XQ1180	3, 10	Z7911	1, 2
ЛИ421	1	XQ1181	3, 10	Z7912	3, 6
ЛИ425	2, 6	XQ1240		Z7915	
P810	1, 2	XQ1241		Z7919	
P813	1, 2	XQ1290		Z7933	6
P826	1, 2	XQ1291		Z7947	3
P831	6	XQ1292		Z7951	1
P841	2	XQ1293		Z7998	2
P842		XQ1294		TV8000	
P843	2	XQ1295		P8030	3
P844		PTW1255	1, 3	P8031	3
P846	2	TD1319	1, 2	P8034	1, 2
P847		TD1320	1, 2	P8034A	2
P848	2	TD1325	1, 2	TV8050	6
P849		TD1326	1	8483	1
P860	1, 2	TD1340	2	8484, H	1, 2
P861	6	TD1341	3	8485	3
P862	1	TD1342	5	8507, A, B	3
P864	1	TD1348	3	8511	1, 6
P865	1	TD1354	1, 3	8541, A, A/X	
P866	6	TD1355	5	8566	
P867		TD1368	1, 5	8572, A, V	2
P868		TV2000	3, 10	8573, A	6
XQ1001	3	2048	1, 6	8604	
XQ1002	3	2048A	1, 6	8625	2
XQ1003	3	2049	1, 2	8626	
XQ1004	3	PTW2255	3	8758, A	1, 6, 7
XQ1030	6	TV2255	3	EM19677	
XQ1031	6	4478	1, 2	EM19706	6
XQ1032	6	4488	1, 2	EM19728	3
XQ1040		4500	1, 2	EM19730	3, 6
XQ1041		4503	3, 6	TH9806	1, 5
XQ1042		4503A	3, 6	TH9806PA	5
XQ1043		4542		TH9807	1, 5
XQ1044		4559	2	TH9807PA	5
XQ1050	3	4559A	2	TH9808	1, 5
XQ1052	3	4595		TH9808PA	5
XQ1053	3	4809		TH9811	1, 5, 6
XQ1054	3	E5001	9	TH9812	1, 5
XQ1060	3	E5063	9	TH9812PA	5
XQ1061	3	6198, A	1, 2	TH9814	1, 5, 6
XQ1062	3	7038, A, H, V	1, 2	TH9815	1, 5
XQ1063	3	M7089	2, 6, 10	TH9815PA	5
XQ1064	3	7226, A	1, 5, 6	TH9817	1, 5
XQ1065	3	7262, A	1, 6	TH9817PA	5
XQ1070	8	7263, A	1, 6	TH9833	3
XQ1071	8			EMI10667	1, 2
XQ1072	8				

Notes for Table I

1. Grids 3 and 4 are internally connected.
2. Has 600 mA heater.
3. Has 300 mA heater.
4. Has 12.6 V/75 mA heater.
5. Has 150 mA heater.
6. Tube is shorter but operates in the same magnetic structure.
7. Uses a different basing and/or socket.
8. Has lead-oxide (PbO) target.
9. Has cadmium-selenide (CdSe) target.
10. Has special photoconductor (none of those listed above).

Table II — Two-Thirds-Inch Tubes

Cameras which have been designed for any of the tube types listed are likely to be readily convertible to use RCA 4833 S-T vidicon.

Unless otherwise shown in the notes at the end of this table, these tubes (a) have sulfide targets, and (b) use 100 mA heaters.

Type No.	Notes	Type No.	Notes
20PE11	1	E5022	2
20PE13		E5061	2
XQ1270	1	TV8800	
XQ1271		8823	
XQ1300	1	8844	
XQ1310			

Notes for Table II

1. Grids 3 and 4 are internally connected.
2. Has cadmium-selenide (CdSe) target.

Appendix

Automatic Light-Control Lenses for S-T Vidicons

Brand	Catalog No.	Zoom Range	Effective F-Number	
			Open	Closed
Canon	V8X15RND	8X	1.3	360
	V6X16RND	6X	2	360
	V10X15-2ND	10X	2	360
	V10X15RND	10X	2.8	360
	13 mm f/1.5	None	1.5	360
Cosmicar	EE25	None	1.4	11
Fujinon	CF12.5A-4EE	None	1.4	196
	CF25B-4EE	None	1.4	196
	CF50B-4EE	None	1.4	196
	C10X16MD-4EE	10X	2.5	390
Lenzar	L^3TV	10X	1.8	320

Canon Optics & Business Machines Co., Inc.
3113 Wilshire Blvd.
Los Angeles, California 90010
—or—
Canon USA, Inc.
10 Nevada Drive
Lake Success, New York 11040

Cosmicar Optical Co., Ltd.
424, Higashi-Oizumi, Nerima-ku
Tokyo, Japan

Fujinon Optical Company
EP Optical America, Inc.
316 Beach Avenue
Mamaroneck, New York 10543
212 724-9834

Lenzar Optics Corp.
636 North Federal Hwy.
North Palm Beach, Florida 33408
305 842-5225