JOHN C. LODGE

FREeways TRAFFIC SURVEILLANCE

and

CONTROL RESEARCH PROJECT

TELEVISION EQUIPMENT
FOR TRAFFIC SURVEILLANCE

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FREEWAY TRAFFIC SURVEILLANCE AND CONTROL RESEARCH PROJECT

A Project of the
Michigan State Highway Department
Jointly With The
Wayne County Road Commission
City of Detroit, Department of Streets and Traffic
In Cooperation With The
U.S. Bureau of Public Roads

TELEVISION EQUIPMENT FOR TRAFFIC SURVEILLANCE

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November, 1962
FREeway TRAFFIC SURVEILLANCE AND CONTROL RESEARCH PROJECT

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This project consists of the establishment of a comprehensive system of surveillance and control on an urban freeway. The purposes of the project are to evaluate the use of surveillance, traffic control and sensing equipment; to investigate the characteristics of the freeway traffic flow which may be determined and treated by such equipment; to improve freeway traffic operation and safety by these means, as well as to conduct basic research into freeway operations by making use of this specialized equipment. For the first time, it has become possible to assemble the specialized equipment required to carry on a project of this scope.

The project is sponsored jointly by the Michigan State Highway Department, Wayne County Road Commission, and City of Detroit, Department of Streets and Traffic, in cooperation with the United States Bureau of Public Roads. The following report pertains to one of a number of individual studies to be performed. Each of the studies will be reported separately as it is completed and each will contribute to the overall objective of this study.
FREEWAY TRAFFIC SURVEILLANCE AND CONTROL RESEARCH PROJECT ON JOHN C. LODGE FREEWAY DETROIT, MICHIGAN

T.V. CAMERA INSTALLATIONS

FREEWAY STUDY AREA PLAN
SCALE 1" = 100' APPROX.
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TELEVISION EQUIPMENT FOR TRAFFIC SURVEILLANCE

Introduction

Closed circuit television has become an efficient tool for aiding in control of urban freeway traffic. Television cameras properly located can provide an observer with continuous visual information of a large area of freeway. On the John C. Lodge Freeway, 14 television cameras are spaced approximately one quarter of a mile apart so that a continuous 3.2 mile area of the freeway is under observation. From one control point it is possible to observe traffic movements, study driver behavior, determine the scope of an accident, direct rescue activities, operate traffic control devices, and visually assess the results of vehicle sensing equipment in the area.

Without this television system, it would be difficult to develop, install, and operate a lane and speed control system. Twenty months of operation on this project has proven that closed circuit television has "arrived" as a valuable tool for the traffic engineer.

Freeway surveillance proves to be one of the severest requirements placed upon closed circuit television. Tunnels, bridges, and airports have been using closed circuit television but usable pictures were not being obtained under existing low light levels. Since a major part of urban traffic problems occur at dusk or after dark, especially in the winter time, the less expensive vidicon type television camera did not seem too practical. A recent report written for the City of Chicago
stated that the necessity for a picture after dark would require the use of the more expensive image orthicon (Studio) type camera.

Probably the major breakthrough has been the rapid advance in the development of the vidicon tube pickup tube. Large, extensive projects by the military have caused a boom in the development of small closed circuit television cameras, using small vidicon tubes.

The major problem in the planning of any closed circuit television is the selection of the proper equipment which will meet the requirements of the application. The engineer has available a wide range of equipment which varies in function, performance, quality, size and cost. Existing equipment capabilities must be fitted to meet certain performance criteria which will produce an acceptable video picture in a given situation. The basic closed circuit television system consists of cameras, monitors, and a transmission system.

The application of these system characteristics and accessories including limitations and advantages as experienced on this project will be discussed in detail.
Camera Characteristics

Vidicon Tubes:

One of the first and most important decisions which has to be reached in planning the closed circuit television system on a freeway is the selection of the proper camera pickup tube. In the present state of the art, this resolved itself into a choice between a vidicon or an image orthicon type camera tube. The image orthicon tube is considerably larger than the vidicon tube and costs approximately 25 times as much per hour for replacement. Present vidicon tube replacement costs are about $.08/hour compared to approximately $2.00/hour for the image orthicon tube. Image orthicon tubes generally have greater sensitivity and are not subject to lag or smear with moving objects, require less operator attention to adjust camera output under varied light conditions and can accommodate a large contrast range. Although new developments in the image orthicon field have reduced the cost of cameras to approximately $20,000, the cost is still prohibitively high for use in closed circuit television.

The development of vidicon tubes to a point where night application is now practical has made the use of the vidicon camera a practical tool. The vidicon camera also requires less circuitry, is easier to set up, and has a better signal to noise ratio under good light conditions. The disadvantage of sensitivity has been largely overcome with the newer, better vidicon tubes and the lag or smear of the moving object is noticeable only at night when the headlights have a tendency to provide a smear as the vehicle image moves across the monitor screen.
Experience with the 16 camera chain in operation has shown that the tubes can operate or have operated over twelve months on a 14-hour per day basis and are still providing high resolution pictures. Until the image orthicon type camera becomes considerably more economical, a choice of basic camera type will not be too difficult for normal traffic application. All specifications pertaining to cameras in this report will refer to the vidicon type camera.

**Scanning:**

A second major selection in basic camera characteristics is the choice of types of scanning. Two major scanning systems are random interlace and positive interlace. Random interlace cameras cost from $1,000 to $2,000 while positive interlace cameras cost from $3,500 to $5,000. Random interlace cameras have approximately 13 tubes compared to over 30 tubes for the positive interlace. Normally maintenance costs of electronic equipment will be proportional to the number of tubes. In complex systems with many accessories, the difference in total maintenance cost may be nominal. Because of the big difference in cost, the two systems will be discussed in detail.

The picture on a television screen is produced by the rapid movement of a beam of electrons which is viewed as a spot of light moving from the left to the right in horizontal sweeps and successive sweeps are formed from the top to the bottom forming a complete picture. As this small dot of light rapidly sweeps the screen, it varies in intensity to produce the range of color from black to white and a special material on the picture tube retains the image for a fraction of a second so that a complete picture is apparent. The light sweeps horizontally
across the picture tube 15,750 times a second and sweeps from the top to the bottom 60 times a second. This results in the dot producing $262\frac{1}{2}$ sweep lines as it moves from the top to the bottom. As it again sweeps the screen required for a complete picture, it now starts a half a sweep late and the resulting second $262\frac{1}{2}$ sweep lines interlace or go between the first $262\frac{1}{2}$ lines. If the interlace is perfect, a picture consisting of 525 sweep lines is developed. All expensive broadcast equipment and positive interlace closed circuit equipment provides this interlace in its transmitted signal.

Positive interlace requires that the camera have an absolute $262\frac{1}{2}$ relationship between the vertical and horizontal drive circuits. This is usually accomplished by having one base oscillator operating at 31,500 cycles per second and special countdown circuits are used to obtain the horizontal frequency of 16,750 cycles per second and the vertical frequency of 60 cycles per second. Such countdown circuits should count more than seven steps in any one stage if good stability is to be attained. Generally speaking, the positive interlace cameras are also better constructed and usually have horizontal resolutions higher than those produced by the random interlace cameras.

An economical and simple scanning system known as non-interlaced or random interlace sweep involves the use of a separate horizontal and vertical oscillator with no tied relationship between the two frequencies. If both the camera and monitor have completely isolated sweep circuits, successive vertical
sweeps or fields will not be exactly on top of each other or exactly interlaced. Actually, each 260 some odd sweep lines will show that adjacent lines appear to be moving closer and farther apart with respect to each other. In the resultant picture, it will appear to have considerably more than 262 lines but probably something less than 525 and will be varying between these two figures.

The choice between positive interlace and random interlace is usually one of money and maintenance since the complexity of the positive interlace usually doubles or triples the circuitry of the camera and increases the cost of maintenance.

The primary difference from the standpoint of the average observer between random interlace and positive interlace is that the picture appears steadier with positive interlace. The random interlace picture may appear to be somewhat watery. A second difference which is harder to discern in the average traffic picture is the difference in vertical resolution or the ability to discern the difference between horizontal lines as they increase in number. This might be explained if the camera were directed at a series of horizontal lines or say a venetian blind where the slats were increased in number until you could no longer count them. In positive interlace closed circuit television, this number would be approximately 375 horizontal lines in the height of the picture. In random interlace this number will vary from approximately 200 to 300. If the horizontal and vertical oscillator can be kept completely isolated so that they do not synchronize upon each other, a vertical resolution of nearly 300 lines can be obtained.
In the cheaper random interlace cameras, the two frequencies will synchronize on each other and successive fields will trace on top of each other with no interlace. The resultant picture caused by this line pairing will be composed of 262 or 263 sweep lines instead of 525 and the vertical resolution will be approximately 200 lines. Loss of resolution due to line pairing is actually greater than the difference noted between positive interlace and a good random interlace.

The choice of a monitor which has no crosstalk or feedback between the vertical and horizontal oscillators is extremely important to keep pairing from occurring. Even in a home television receiver which receives a near perfect interlace type signal from the broadcast station, pairing is quite common. In various experiments and demonstrations, it was found that the monitor was more often responsible for the pairing than the camera. In fact, several demonstrations with supposedly interlaced cameras being used, produced pairing because of the monitor being used.

Original specifications for the TV project did not necessarily require a positive interlace camera. Successive observations between the two types of cameras did not prove that the difference in vertical resolution between 300 line and 375 lines was significant enough to require positive interlaced cameras. The cameras were set to view the freeway from a bridge which crossed the freeway and traffic was viewed for a distance of 1700 feet. The difference in resolution between the random interlace and the positive interlace camera did not vary the detail noted by more than a few feet on the freeway. In other
words, if a stalled vehicle could be determined at 1600 feet in the positive interlace camera. It could be seen at 1500 feet in the random interlaced camera provided the monitors were of such quality that line pairing did not occur.

Many other requirements in the specifications were generally found or could only be guaranteed in the higher grade cameras. Therefore, the lowest bid as supplied by General Electric Company was based upon their positive interlace, TE-9 transistorized camera. Additional studies will be conducted to determine whether positive interlace is a necessary characteristic.

**Scanning Rates:**

One decision not too difficult to make at the time of the project, but which might be considered at a later date involved the choice of scanning rates. All United States commercial broadcast television is 525 scanning lines per frame or picture or as mentioned 262½ scanning lines per field. With proper interlace, this gives a positive vertical resolution of about 375 lines. Vertical resolution is directly proportioned to the number of sweep lines forming the picture and is equal to approximately 65% of the number of sweep lines. While it is easier for manufacturers to provide high horizontal resolution, it appears that the greatest limitation to overall readability lies in the lack of vertical resolution. There does not seem to be much justification for horizontal resolutions exceeding 600 lines unless the vertical resolution is increased proportionately. It is possible to obtain closed circuit television
with scanning rates of 619 or 825 lines per frame. This would increase the vertical resolution to approximately 420 lines or 550 lines respectively. This type of equipment was not demonstrated in operation on the freeway since it was not commercially available from United States firms. Such cameras are available from French firms and are presently being built for the military by some U.S. firms. These cameras will be available from American camera manufacturers in the near future but may be more costly. Such equipment, if available, should certainly be studied before final specifications of a large complex system are written.

**Horizontal Resolution:**

The lower cost random interlace cameras easily produce horizontal resolutions of from 300 to 400 lines. This equipment is primarily used with standard broadcast television receivers to provide an economical closed circuit television system. They are generally used in limited applications under ideal light conditions.

It does not increase costs to provide over 500 lines or horizontal resolution with the camera since it only requires higher quality video amplifiers in the camera and monitor circuits. Horizontal resolution is proportional to the frequency handling capabilities of all amplifiers in the camera chain. The frequency band width necessary for a particular resolution may be roughly calculated by multiplying the number of sweep lines per second by the number of light changes required per sweep. Since standard broadcast television uses 525 sweep lines and produces a complete field 30 times per second, the picture is formed by 15,750 horizontal sweeps.
per second. To produce a horizontal resolution of 600 lines, the sweeping dot of light must go through light change cycle 600 times for each sweep or \(15,750 \times 600 = 9,450,000\) cycles per second. A megacycle is one million cycles and the above changes would be designated as 9.45 megacycles. In actual practice, 600 lines of horizontal resolution can be obtained from amplifiers rated at over 8 megacycles. Since most monitors available for closed circuit television have video circuits capable of passing 8 megacycles, additional costs are found only in the video circuits for the camera.

If the resolution is to be increased above this amount, additional circuits such as aperture correction will be necessary and are usually found on higher priced cameras.

Tests indicated that the difference in resolution from 300 to 550 lines is worth the additional cost. Therefore it was specified that the cameras would deliver 550 lines of horizontal resolution. Actually the camera in operation delivers considerably over 600 lines and at the time of installation many of the cameras were delivering pictures exceeding 700 lines of horizontal resolution.

**Video-band Width:**

Video-band width is the technical name used to designate the ability of an amplifier to handle a range of frequencies necessary to produce a picture. A video amplifier is actually an ultra hi-fi amplifier. The hi-fi fan, who is familiar with figures 0 to 20,000 cycles for his audio amplifier will appreciate the capabilities of an amplifier that will amplify all frequencies from 0 to 8 megacycles (8,000,000 cycles) ±\(\frac{1}{2}\)db. The need for band width is directly proportional to desired
horizontal resolution, as shown in the discussion on horizontal resolution. Generally a camera's capabilities is shown by lines of horizontal resolution. Line amplifiers and monitor capabilities are shown in band width. Naturally all components must have equal capabilities or the output will be only as good as the information passed by the poorest amplifier.

In the equipment installed on the John C. Lodge Freeway, the amplifiers are operating close to 10 megacycles as was proven by the fact that pictures exceeding 700 lines of horizontal resolution were obtained. With the present state of the art, any specifications written which exceed 8 megacycles will considerably limit the amount of equipment which can be bid for a project.

Transistorization:

A third major selection of basic camera characteristics is the choice between a camera using vacuum tubes and one using transistors. When the original specifications were written, there was not much of a choice. Only three transistor cameras were available and none seemed to meet desired requirements. Since then there has been rapid transitions to transistorized cameras, and one company included their new transistorized camera as an alternate bid. Performance tests proved the superiority of the transistor camera which is now being used on the project.

Transistorization has made it possible to provide a fully interlaced camera in one small unit. Previous tube type cameras were forced to use two units so that one unit containing the pickup tube could be small enough for most applications.
Besides the greater size, the thirty some vacuum tubes created a heat problem and greater failure rate. The transistorized camera has overcome the liabilities of size, heat, and maintenance cost of the interlace cameras.

Our maintenance record has shown transistor failure to be negligible. With 59 transistors in each camera there has been approximately one transistor failure per month in the whole system. Nearly as many vacuum tube failures occurred in the monitors with only 25% as many components. Operational experience with this camera has proven that any future installation should be studied for the possibility of using transistorized cameras.

Figures 1 through 6 show pictures of the camera in present use. The camera is 5½" in diameter, and 11 3/4" long. Figure 5 shows the cover removed and the layout of all parts on three plug-in boards. These boards are completely wired and all transistors are plug-in for easy maintenance. Figure 6 shows the camera with plug-in boards removed and access to the vidicon tube and three accessory drive motors. One motor drives the turret, the second drives the iris on the lens in use, and the third drives the vidicon tube back and forward for focus. Each motor is remotely controlled from the Control Center by the operator.

The camera uses one miniature vacuum tube to amplify the extremely weak video information received from the vidicon tube. Vacuum tubes have a lower noise level than transistors and have an advantage for amplifying weak signals. Records show that this one tube, type 6021, lasts less than one year and has a higher failure rate than any other component. Present design has eliminated this vacuum tube.
Figure #1

Transistorized camera with 6" telephoto and 1½" wide angle lens mounted on turret. The small size of the camera is readily seen when compared to the standard desk telephone.
Figure #2

Transistorized camera with cover removed exposing components.
Figure #3

Camera with cover removed showing the three separate component boards. The rear plate has provisions for input-outputs and field adjustments.
Figure #4

Closeup of the only vacuum tube used in the camera. The tube is used in the first stage of the video output.
Figure #5
Camera stripped of three boards which contain all circuitry for power video and synchronization. View shows ease of removing parts for maintenance purposes.
Figure #6

Closeup of camera with all component boards removed, showing focus, turret and iris motors.
Ambient Operating Conditions:

Specifications required that the camera be capable of operating within specifications under the following ambient conditions:
Temperatures +10 to 100 degrees F.; humidity, 10% to 100%; altitude, 0 to 10,000 feet. It was also required that no arcing would take place or that the equipment would not be damaged if it was turned on or operated between the temperatures of -10 degrees F. and 130 degrees F. The cabinets for which the cameras were to be installed were designed to be heated in the winter and ventilated in the summer.
Specifications on vidicon tubes indicated that the tube will not produce a good picture if temperature went below 70 degrees F. The vidicon tube generates some heat and is enclosed in the camera. It was found that the cameras produced a very satisfactory picture with cabinet temperature down to 32 degrees F. by leaving camera power on continually. When the system is not in operation, the vidicon tube is remotely capped while the turret and camera power remains on. This method of operation has required less maintenance as the camera components are always heated. In the large camera enclosures used by the project, it has been very difficult to provide enough heat to maintain a cabinet temperature above 60 degrees F. at all times. If the camera power can be left on at all times, the cabinet surrounding the camera would not have to be heated until the temperature drops below freezing.
Camera Encasement:

The camera itself must be in a practically air tight case. In order to properly ventilate the camera housing in which the camera is installed, a fan has to circulate air past the camera. In spite of the installation of filters, large amounts of salt spray and dust are collected inside the housing. This foreign material can enter the camera through the adjustment openings (Figure #3) on the rear plate of the camera and cause serious damage. This foreign material must be kept out of the camera working parts, and any future case design should eliminate the condition.

Sensitivity:

This item is a rather difficult requirement to specify and to check in terms of physical qualities; however, if the camera can deliver one volt of video in the vidicon tube when the scene brightness is below 10-foot lamberts and the latest, most sensitive vidicon tube is used, adequate night pictures will probably be obtained. Actual observations of equipment operating at night on the proposed site will be the only true method of indicating whether all of the circuits have been properly designed to give the best night pictures. Several cameras produced good pictures in the project area with a scene brightness of less than 2 foot lamberts. This night picture was only available if lens with an aperture opening of greater than F2.5 were used. Night visibility is not entirely due to sensitivity alone. Oncoming headlights can affect automatic gain controls in the camera which can materially reduce seeability. Other characteristics such as gamma correction, types of lens, etc.
influence the total picture and are discussed as follows.

**Automatic Target Control:**

In several tests on the freeway, it was determined that automatic target control was an absolute necessity for use on a freeway. In the daytime a picture with scene brightness of approximately 5,000 foot lamberts exists and at night this light will be less than 2 foot lamberts. The automatic target control actually varies the gain or output of the vidicon tube, depending on the brightness of the picture. Without this operation during the daytime, an operator would have to change the aperture of the camera lens or manually regulate the gain control every time the sun went behind a cloud or a shadow fell on the picture area. If the camera was set for a good picture on dull days, the picture would be overly bright and smeared when the sun came out. During the daytime, the picture brightness can vary from 5,000 foot lamberts to as low as 100. At nighttime, however, it is possible that the automatic target control can be a liability. The overall night level of the area is constant because of street lighting.

Some of the tests made with various manufacturer's cameras showed that cameras with an apparent high resolution and high specifications did not necessarily give the best night picture. In fact, one of the poorest night pictures observed had a camera which claimed 2,000 to 1 automatic target control and 600 lines of resolution. As a result of these observations, it was determined that the automatic target control might be actually reducing the overall picture
sensitivity at night. If the automatic target control circuit is sensitive enough to react to the light received from a few headlights, it could cut the overall sensitivity down reducing visibility to balls of light from the headlights. Since the headlights are moving, no harm seems to be obtained if the sensitivity of the camera can be kept at a maximum at night and allow the image of the headlight to smear. As a result specifications were written so that the camera be provided with a switch which would remotely disable the automatic target control circuit for nighttime operation. This should be provided in any future project because of the great variation observed in nighttime operation of the various cameras. A camera was provided with a switch to turn off the automatic target control at night. The camera was operated with ATC at night producing a good picture and no noticeable difference could be determined when the ATC was turned off. The particular automatic target control circuit used apparently makes use of the average light available to the vidicon and not to the light available in a small area as from a headlight. At the present time there is no means of switching off the automatic target control at night.

**Gamma Correction:**

Gamma correction is the characteristic installed as a special circuit which expands or increases the ratio between bright and dark objects. Generally, the output from a camera pickup tube would produce a flat or dead picture. In other words, the dark or blacks and white or light colors would all appear in various ranges of gray. The gamma correction circuit is
actually an expansion circuit that makes the lighter colors whiter and the darker colors blacker and in reality returns the picture to nearer its original range of color. At nighttime, there is not a normal range in color between black and white. All of the area has a very small range between the different shades of gray. Multiplying or amplifying this range of color would not normally be observable to the average person. However, the brightness of the headlights is many times brighter or whiter than any other part of the picture. To amplify this range, only amplifies the problem caused by the headlights. In going over the specifications of the various cameras, some successful and some not, it appeared that the gamma correction circuits might have an effect on reducing night visibility. As a result of these observations, it was determined that the cameras should be supplied with facilities to change gamma correction and materially flatten the ratio of the brights to the dark. It was believed that this reduction would be advantageous at night and would not materially reduce the picture quality in the daytime. After the cameras were delivered, one camera was wired by the factory and made available for trial making use of a lower gamma factor and which theoretically would produce better night pictures. On the General Electric camera used, however, no noticeable difference was determined and it was again converted to standard operation. A change of gamma correction in the cameras used involves only a change of one resistor and one condenser and does not take long to accomplish. This item should be observed on any camera before it is delivered
since it might still be possible that a camera constructed of a different circuitry might be improved with a change in gamma correction.

Aperture Correction:

Aperture correction is another term which adds to the confusion of the myriad of new terms confronting the prospective purchaser. This feature, which can be easily confused with aperture control of the lens, is actually a camera circuit used to accentuate changes in the output of the vidicon tube.

The image formed on the face of the vidicon by the lens is 3/4 inches wide and 1/4 inch high. The video intelligence is taken from this image by a process similar but in reverse to the method of producing the picture at the monitor. A beam of electrons are directed at the back of the vidicon face which is also a photoconductor layer and as this small beam sweeps the picture, the current varies proportionately to the light on this particular section of the image.

Since the beam also sweeps this picture in 525 lines, it can be seen that the size of the beam must be very small if high resolution is obtained. Actually, the size of the electron beam cannot be infinitely small and the output is not perfect as desired. A camera producing 600 lines horizontal should be able to reproduce the image of a picket fence with 600 slats shown on the 3/4 inch width. If the electron beam was infinitely small, the voltage output would vary in amplitude exactly as the light change of the pickets on it would form a square wave.
Actually, the beam has dimension and as it sweeps from light to dark light level, the output changes gradually and the resultant output wave is rounded in shape.

Aperture correction is an electronic circuit which reshapes the wave and squares it to the desired shape.

The resultant output is a sharper picture and if resolution exceeding 400 lines is desired, such circuitry is required.
Automatic Light Control:

Automatic target control as specified earlier is capable of reducing the output of the vidicon tube to levels which can be handled by the subsequent amplifier circuits. However, in order to obtain good nighttime pictures, the lens used must be opened to F2.5 or greater. No camera was found capable of automatically adjusting to the complete range of light from night to bright sunlight with the lens wide open. There is also a possible danger that the vidicon could be permanently damaged if the lens was opened to F2.5 or greater and happened to focus on a reflection of bright sunlight from a parked vehicle or other reflective surfaces. Observations would indicate that ideal pictures during the daytime are obtained on most cameras if the lens are set between F8 or F11. The specifications were, therefore, written to require that a lens aperture change should be accomplished by remote iris control of at least two lens in a turret or that the introduction of a neutral density filter should be accomplished. Several cameras studied were available with a neutral density filter which could be rotated between the lens and the vidicon tube and reduce the amount of light available to the camera. This appears to be a simple method of reducing the light level by remote control or in the case of some equipment, this filter control was connected to a light cell at the camera site. The cameras on the project use an iris drive
motor which is contained in the small camera package. As the lens rotates on the turret, it engages a small gear connected to the iris drive motor. This motor, which is remotely controlled from the Control Center, allows the operator to change the iris on any lens which is being used. Iris control does provide the most flexibility of any system that was demonstrated. It is now possible to install four lens on the camera and be able to switch from one lens to another and to close or open the iris as necessary for night or daytime operation.

Normally, only two lens are used on a camera. It would have also been possible to use four lens in a turret, two of which were set for nighttime operation and two of which were set for daytime operation. While this method satisfies most conditions, it would not allow optimum settings during cloudy days or dusk, and it would not give a blank position now used to blank out the vidicon tube when the camera is not in use. Blanking out of the vidicon tube seems to be mandatory in the use of closed circuit television. Other agencies have had problems with images actually burning on the screen. This results in the camera transmitting a picture that it has seen for a period of time even when it is not directed at the scene. The problem only results if a camera is permanently stationed and looks at a target for a considerable time. Since it is possible to change the camera scene by remote turret control, this is not a problem in this particular case.
Lens:

One of the first problems presented in the choice of camera equipment was the selection of lens to be used in observing traffic operations. A most interesting device having a lot of appeal is the zoom lens which is presently available from several lens manufacturers. This lens is capable of showing a general picture with a standard lens view as would normally result from a regular lens on a camera and of "zooming in," on a particular target by remote control for a closeup at the desire of an operator. While one particular zoom lens is available at an F2.7 rating, this aperture setting is only available when the lens is in its normal setting. As the setting is changed to a zoom position or closeup position, the aperture setting is reduced to F5 or F6 which means that it would obtain no pictures at all during nighttime operation. The inability of the zoom lens to handle low light conditions, in telephoto position, ruled out this device.

After considerable investigation, it was found that lenses were available in a telephoto type down to F2.3 or actually F2.0. At the present time one inch or 25mm lens at F1.5 are used throughout the project. This provides a consistent normal field of view from each bridge and gives the operator a standard field for estimating velocity and travel times of vehicles through the area. A telephoto lens of 6-inch or 150mm for closeups of an actual occurrence that the operator wishes to investigate is also used. This lens is a F2 and is of considerable size in relation to the camera. (See Figure 7). These lenses were originally delivered with click stops for