The Role of Television in Traffic Control

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Detroit, like almost every other American city engaged in an expressway construction program, has been seriously concerned over the fact that although there were few accidents on these high speed facilities the effects of such accidents and the resultant congestion were both disturbing and far reaching. These multi-million dollar arteries designed and constructed to move large volumes of traffic rapidly and with a minimum of interference cannot operate efficiently unless some positive means can be developed to handle accidents quickly and to prevent the sudden and large scale build-up of congestion.

Traffic engineers in Detroit have spent considerable time studying the causes of accidents and congestion and are convinced that these facilities are properly designed. They have concluded, however, that the successful operation of expressways demands a traffic control plan to handle a problem that is unique to this type of facility. They have found that just as expressway driving is an entirely new experience for the driver, so the problems encountered on these facilities are entirely different from those found on surface streets. In an attempt to develop some reasonable and effective means of traffic control for expressways, traffic engineers in Detroit considered the use of special signal systems, lane and ramp controls, human observers to augment expressway patrols, radio dispatched emergency vehicles and many other devices. It was determined that the key to any successful plan for combatting accidents and congestion on expressways was television.

The decision to recommend television was based on the belief that it would perform two vitally important functions: (1) It would permit the immediate detection of accidents and congestion at the point of their occurrence and in sufficient detail to allow the observer to evaluate the situation. (2) It could be incorporated into an over-all plan which would enable the observer to dispatch police, fire and emergency vehicles instantaneously and to permit almost simultaneously the control of lane and ramp movement.

The results of the entire experiment were satisfactory to the point where qualified observers firmly believe that television may truly be the key to the most effective type of expressway traffic control. In fact, it may have many other applications in traffic management and in research connected with highway design.

● THE opening of expressways in Detroit and in other sections of the country has received the full approval of the driving public, if the exceptionally heavy volumes using these high speed facilities can be taken as an indication of public endorsement (see Figure 1). For example, 24-hour volumes of 117,000 vehicles have been recorded on Detroit's John C. Lodge Expressway while volumes on the Edsel Ford have reached a 24-hour mark of 115,000. In Los Angeles, the California State Highway Department estimates that 178,900 vehicles use the Hollywood Freeway in the vicinity of Beaudry Avenue on an average weekday, and 113,800 vehicles travel the Arroyo Seco Freeway in the vicinity of Solano Avenue during an average weekday. While highway and traffic engineers should derive

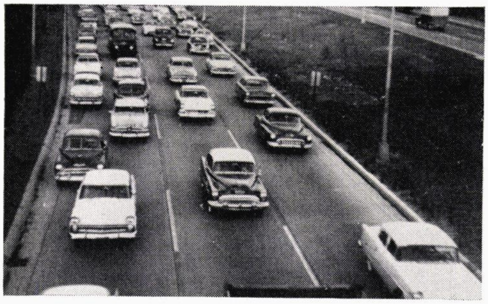

Figure 1. This view of a connecting ramp between the Lodge and Ford Expressways is typical of peak-hour activity on these new Detroit facilities.

Figure 2. An example of modern expressway construction is seen in this aerial view of the interchange connecting Detroit's Ford and Lodge Expressways. Engineered for safe and rapid movement, this unique feature accommodates twelve distinct movements.

some satisfaction from this fact, their main reaction is one of deep concern over the problems which have been created since opening these facilities to the public. It is said that nothing succeeds like success so it was probably inevitable that more and more motorists would crowd on to these facilities after experiencing the advantages of safe, rapid and uninterrupted travel.

As the reputation of these highways spread, however, traffic volumes reached levels well above the highest estimates made prior to their construction. This has been particularly true during rush hours. With such heavy volumes, it is obvious that traffic flow must be free and rapid since even a momentary stoppage can, under these conditions, be very serious. In fact, this is borne out by what has happened in Detroit.

Although Detroit's expressways are much safer than the major arterial routes, an ordinary rear-end collision during a rush hour period on one of these facilities can and does have a more far-reaching effect upon traffic than the most serious collision occurring on a surface street. The instantaneous build-up of congestion behind such an accident reaches staggering proportions. In a matter of minutes and often within seconds after such a collision, sizeable segments of the expressway system become inoperative.

Generally speaking, traffic engineers in Detroit and elsewhere are convinced that except in some isolated instances these facilities are properly designed. They have been engineered for maximum safety and rapid movement (Figure 2). A further requirement for successful operation, however, is a traffic control plan which will help authorities handle accidents quickly and prevent the sudden and large-scale build-up of congestion.

Considerable time and effort have been expended by the Department of Streets and Traffic in Detroit in an attempt to develop some reasonable and effective means of traffic control for expressways. Traffic engineers considered the use of special signal systems, lane and ramp controls, human observers to augment expressway patrols, radio-dispatched emergency vehicles, and many other devices. It was believed that the key to any successful plan for combatting accidents and congestion on expressways might be television.

The inclination toward television was based on the belief that it would perform two vitally important functions:

First, it would permit the immediate detection of accidents and congestion at the point of their occurrence and in sufficient detail to allow the observer to evaluate the situation.

Secondly, it could be incorporated into an over-all plan which would enable the observer to dispatch police, fire, and emergency vehicles instantaneously and to permit almost simultaneously the control of lane and ramp movement.

At the time traffic engineers in Detroit arrived at this decision, the Michigan Bell Telephone Company independently and from another direction had reached the same conclusion. Their belief that television might have an application in the control of expressway traffic was based upon studies prompted by the company's desire to exploit all the possibilities in this new area of communications. On that basis Michigan Bell representatives approached Detroit's traffic engineer and proposed the undertaking of a joint experimental project.

Staff personnel of both agencies worked for several months conducting tests during hours of daylight, dusk, and total darkness. Additional tests were made at locations ranging from 20 to 100 feet above the roadway to determine optimum elevation for camera location. The experiment was conducted during rain, fog, and periods of inclement weather. In some instances cameras were operated from fixed positions. In other instances, remote controls installed at the monitoring point permitted the traversing and elevating of cameras. Various sizes and types of lenses were used.

On the technical side, experimentation was conducted by the Michigan Bell Telephone Company with different kinds of equipment in an all-out effort to establish whether television could meet satisfactory performance requirements and in an attempt to determine what type of maintenance would be required to keep the equipment operative.

Following preliminary conferences between engineers of the Department of Streets and Traffic and representatives of the Michigan Bell Telephone Company, the television experiment was set up with a 3-fold purpose:

1. To determine what was needed in television equipment and installation technique to produce a picture that would give usable information.

2. To determine as nearly as possible the type of accessory equipment and personnel which in combination with the television equipment would allow the expressways to operate at maximum efficiency.

3. To determine how maximum use could be made of the available facilities in aiding and controlling traffic within the area covered by the television cameras.

The experiment started with the selection of one high accident location on each of the two expressways to be covered by the television cameras, and also the selection of a central control room located in a building in the central business district. The equipment was installed and the experiment went into operation on June 17, 1955 (Figure 3).

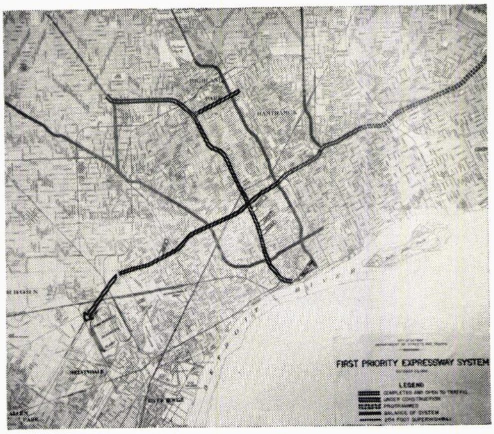

Figure 3. This map of Detroit shows the primary expressway system designed to serve the "motor capital." Over nine miles of system are now in use. The balance of the system is either under construction or in the planning stages.

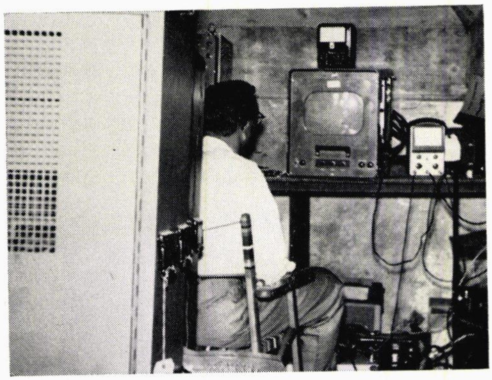

Figure 4. An interior view of one of the temporary field locations manned by Michigan Bell technicians during the expressway television experiment. These particular quarters were located beneath the Merrick pedestrian bridge.

In any permanent installation it would not be necessary to man individual camera installations. During this experiment, however, crews were stationed at each camera for two reasons (Figure 4). First of all, the equipment was installed on a temporary basis on pedestrian and vehicular bridges. To safeguard the equipment it was necessary to assign manpower to each installation. Secondly, since it would be necessary to make adjustments in camera set-up, it was necessary to have crews stationed at the camera sites. Direct telephone communication between camera locations and the monitoring room was made possible through the installation of direct telephone lines between these points. Originally all adjustments at the camera location were made manually. Later, as it will be pointed out, remote control systems were installed which permitted automatic adjustment for certain camera features.

The tests to determine what was needed in equipment and installation technique were of two general types. One type of test was made to determine what was needed to produce a good television picture. The other tests were made to determine what accessories were needed to make the best use of the picture as delivered by the television equipment.

The first cameras put into operation were fixed in both movement of camera and variation of lens possibilities. Experience obtained in the early stages of the experiment indicated that for proper evaluation of a specific situation we were often calling on field crews to turn the cameras around so that we could view the activity in the opposite direction. Keeping in mind the fact that cameras would be unattended in any permanent installation, Michigan Bell technicians recommended experimentation with what they call remote control "pan and tilt." Such controls would permit the operator in a control room to rotate the camera either horizontally or vertically.

Figure 5. A Michigan Bell technician checks the interior of the special housing encasing a camera used during the experiment. The top of the housing has been removed and the entire camera housing tilted forward. Note the windshield wiper mounted on the window in the lower center of the photograph.

In the meantime we had been testing various types of lenses. We found that for general observation, a lens of small magnification covered the greatest area. When trouble occurred, however, we were unable to get sufficient detailed information with a lens of this power to know what action to take.

For example, when a back-up occurred on one of the exit ramps within the view of our cameras we could not tell whether the cause was inability of the surface street system to absorb the exiting traffic or whether it was trouble on the ramp itself in the form of a stalled car or accident.

The solution to the problem of course, was the remote control auto-zoom (telescopic) type of lens which all television baseball fans know as the device that puts the armchair viewer alongside the outfielder when he catches that long fly ball.

We felt that conditions warranted a test of the zoom lens, and so, shortly after the installation of the "pan and tilt," the zoom lens with remote control was added. Of special note is the fact that for effective use the zoom lens requires the use of "pan and tilt." In use, the zoom lens corroborated our original contentions and also demonstrated additional uses.

Operating experience gained during the early stages of the experiment led us to consider and test other accessory equipment for the camera: for rainy days a windshield wiper for the window of the box that protected the camera, for variations in light conditions an automatic iris, and to compensate for the variations of the automatic zoom lens an automatic focus (Figure 5). Later discussion will indicate the results of these tests.

As experimentation progressed, it was decided that we should use available equipment in the manner most likely to be employed if we were installing a permanent system. With the cameras separated as they were—one on the Lodge Expressway and one on the Ford—it was difficult to visualize how several cameras might be coordinated. For this reason, the camera on the Ford Expressway was moved to a location on the Lodge Expressway

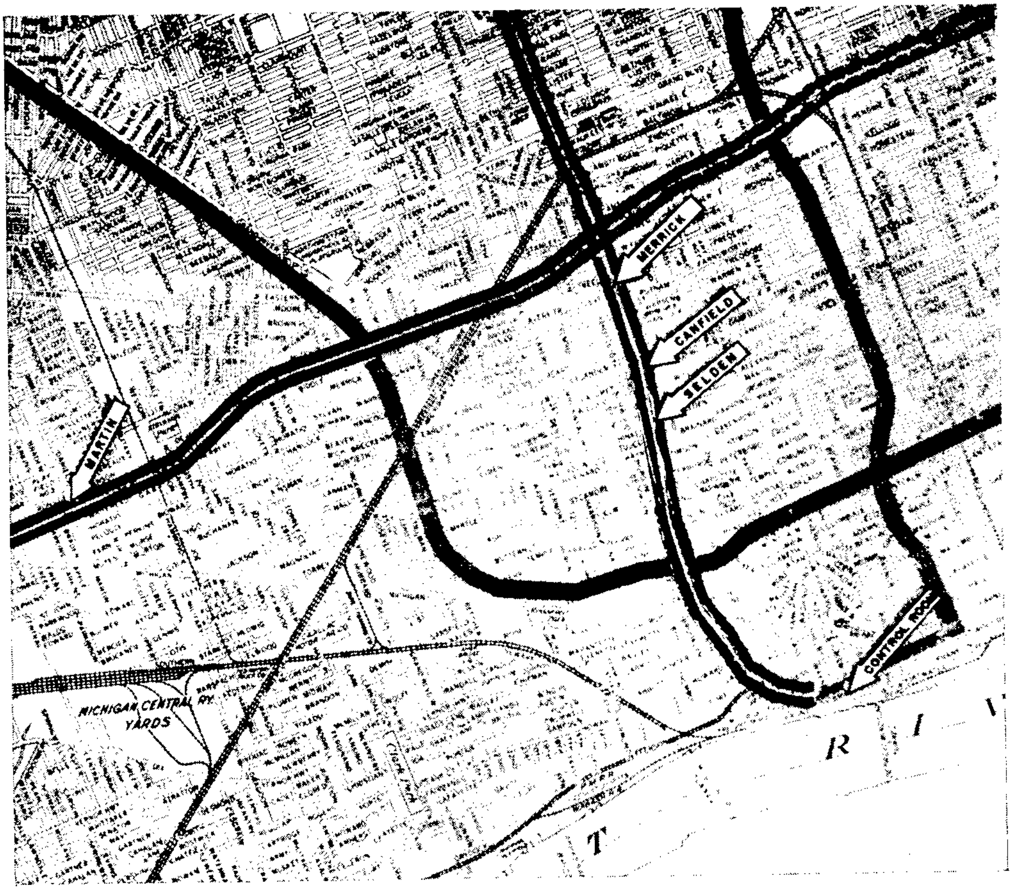

Figure 6. This spot map pinpoints the camera locations from which the experiment was conducted. As noted in the text, the Martin location was maintained only during the early part of the experiment.

just south of the one already there. A third camera was added so that we had one continuous stretch of a little over a mile of expressway under observation (Figure 6). The accessory equipment was installed in such a way that each camera was different and thereby permitted continuous comparisons. All three cameras were wired into a selection switch in the central control room.

Camera #1 on the Merrick bridge (Figure 7) was equipped with: 1. Remote control "pan and tilt"; 2. Remote control zoom lens; 3. Remote control focus; 4. Weatherproof housing; 5. Windshield wipers.

Camera #2 on the Canfield bridge (Figure 8) had no accessory equipment. In fact, during bad weather it had to be operated from its service truck.

Camera #3 on the Selden bridge was equipped with: 1. Remote control "pan and tilt"; 2. Weatherproof housing; 3. Windshield wipers.

When this accessory equipment had been installed, it was then decided that tests should be conducted to determine what effect elevation of the camera above the roadway might have on camera range. To get some idea of the effect of height without disturbing the existing camera installations, an additional camera was installed atop a building immediately adjacent to the John Lodge Expressway. The camera thus located was approximately 100 feet above the surface of the expressway, and we were able to get a full and unobstructed view of the roadway (Figure 9). Tests were conducted at this site during

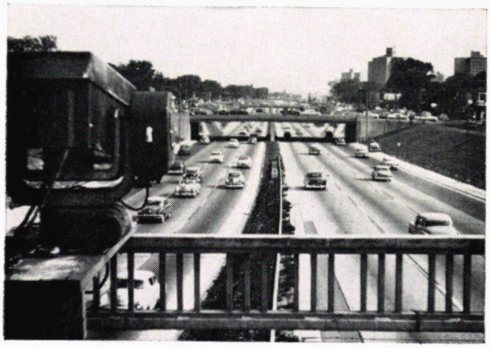

Figure 7. A view of the Lodge Expressway looking south from atop the Merrick bridge. As noted in the text, the camera at Merrick was equipped with special remote controls.

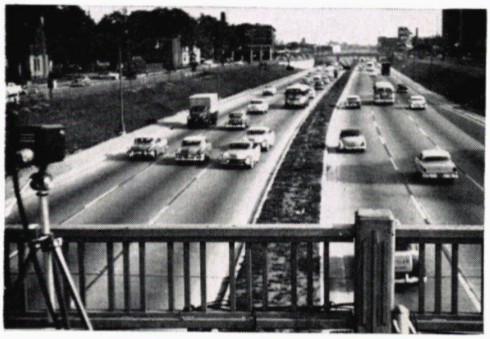

Figure 8. This view of the Lodge Expressway looking south from the Canfield bridge shows television camera without any auxilliary controls.

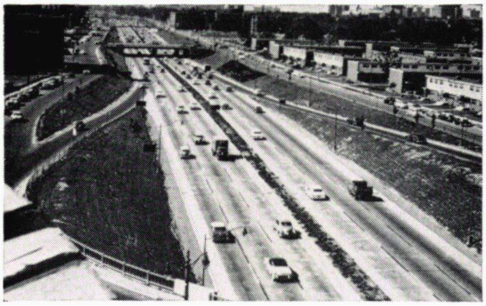

Figure 9. Looking north on the John Lodge Expressway from atop the Wonder Bread Building located just south of the Grand River bridge crossing this expressway. The first height tests were conducted from this point. At this point cameras were approximately 100 feet above the roadway. It was determined that the view from such a point was not practical for traffic control purposes.

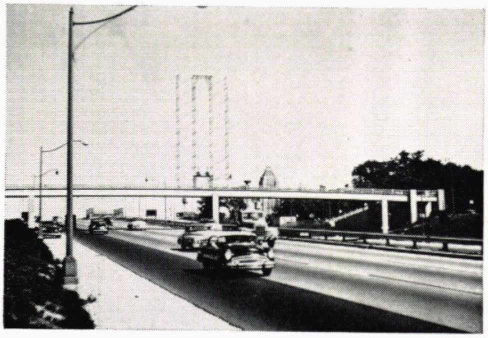

Figure 10. Considerable testing to determine the effect of elevation upon camera range was conducted from this specially erected tower located atop the Merrick pedestrian bridge. A motorized elevator located between the two towers allowed the camera to be raised from the surface of the bridge to points up to 45 feet above the bridge surface.

both hours of daylight and darkness. From these tests it was evident that increased elevation resulted in greater camera range. At the same time, however, it was also evident that the picture obtained during daylight at this elevation included so much that the detailed information necessary for our purposes could not be obtained. Moreover, the picture obtained at night was wholly unacceptable. These first tests, however, led us to believe that there was some optimum height and in an effort to determine what this might be, additional tests were conducted at the Merrick location. For these tests we erected a 3-section scaffolding on the Merrick bridge with an electrically operated elevator in the center section (Figure 10). With this equipment we were able to conduct both day and night tests at heights ranging from 20 to 60 feet above the surface of the road.

In combination with height tests, we also conducted some tests on lens magnification. In a full scale operation the camera lens would have to be set at some optimum magnification. The tests were conducted during daylight and at night. The conclusion arrived at from these tests was that both optimum height of camera and desired magnification of lens were a function of the size and distance from the camera to the most critical spot within range of that particular camera.

Mention should also be made of the fact that during the time of the entire experiment we had all possible weather and light conditions except for snow. We had fog, torrential rain, bright sunlight, and as mentioned before nighttime artificial lighting. Under most conditions we had an excellent picture, and under the worst conditions we had a usable picture (Figure 11).

In an effort to make the experiment approximate as closely as possible what we visualized as a permanent system, we conferred with the traffic division of the Detroit Police Department and the expressway maintenance section of the Wayne County Road Commission and set up procedures whereby both of these agencies would be informed the moment trouble was observed on the monitors. The purpose of these conferences was to allow the rapid dispatch of police vehicles and emergency service trucks maintained by the county to the trouble spots. As a result of these conferences a direct telephone line was installed between the control room and the police signal bureau which permitted the observer at the monitor to notify the police dispatcher as soon as trouble was observed. The dispatcher in turn assigned police cars and notified the county's emergency vehicles. This was at best an improvised and makeshift arrangement but the results were most interesting and satisfactory (Figure 12). We maintained a day-to-day log in which the details of this activity were recorded and a few excerpts from it will illustrate how television can be put to use.

Figure 11. This view of the monitors shows them in use during the experiment and provides an example of the detail which can be obtained from this type of observation.

Figure 12. An interior shot of the monitor and control room. In the foreground, observers are studying expressway traffic movement on the monitor sets while a Michigan Bell engineer checks line equalizer equipment in the background.

Tuesday, June 21, 1955:

5:00 p.m.	Noticed congestion under Warren bridge on northbound Lodge in right lane and determined that the cause was a sideswipe accident.
5:03 p.m.	Called police dispatch.
5:10 p.m.	Police scout car arrived.
5:14 p.m.	Vehicles moved to east shoulder.
5:15 p.m.	Normal traffic flow resumed.

Tuesday, June 28, 1955:

4:20 p.m.	Movement of traffic in right merging lane called attention to stalled truck below Merrick bridge.
4:22 p.m.	Called police dispatch.
4:29 p.m.	Police scout car arrived.
4:29 to 4:45 p.m.	Police commandeered another truck and asked driver to haul crippled truck out the Milwaukee exit. Process of hauling truck slowed traffic until 4:45 (because Milwaukee exit was also the temporary terminal exit for the expressway at that date).

Wednesday, August 10, 1955:

5:15 p.m.	Noticed traffic backing up from interchange, but withheld action because the cause was not in camera range.
5:25 p.m.	Asked police dispatch to investigate cause.
5:30 p.m.	Back-up so bad, could not wait for police report. Therefore, asked police to

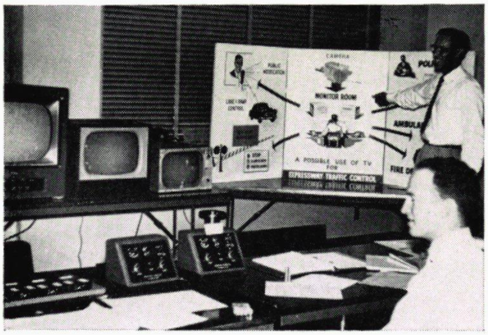

Figure 13. A view of the monitor room showing remote controls for pan and tilt and the auto-zoom lens on the table in the foreground. The chart in the background suggests a possible application for television in traffic control on expressways.

	close Bagley and the Abbott entrance ramps.
5:45 p.m.	Effect of closing of ramps apparent at Canfield and Selden cameras.
5:50 p.m.	Back-up dissipating enough to call police dispatch to open Bagley and Abbott ramps.
5:50 p.m. (30 seconds)	Traffic from opening of ramps in view of Selden camera.

From the day-to-day watching of how traffic behaves and from the experience gained in trying to provide help for trouble conditions, a picture was formed of the type of accessory equipment and personnel which would be needed in combination with the television equipment to allow the expressways to operate at maximum efficiency (Figure 13). They are as follows:

1. Lane and Ramp Control: This would involve the installation of signs and signals controlled from the monitoring point. Lane controls utilizing signals installed on bridge facings could be used to warn traffic on the expressway of trouble ahead and could also be used to clear lanes for the movement of emergency vehicles. Signals controlling lane movement could also be employed in the detouring of traffic around congested areas. Ramp controls could be used to prevent the build-up of congestion by temporarily closing entrances and re-directing traffic over surface routes to points beyond the congested area. An integral part of the ramp control feature would be a warning system that would extend a short distance into the surface street system feeding the ramps so that rerouting of traffic could be done in an orderly fashion. In connection with this idea of ramp control, let me say that one of the by-products we obtained from this experiment was that service drives immediately adjacent to expressways are of untold value during times when sections of the expressway become inoperative.

2. Adequate Expressway Patrol: Adequate and specially trained police personnel assigned solely to patrol work on expressways and tied in by radio with the television control center. From experience gained during the experiment we found that the saving of even seconds of time was extremely important in the control of congestion on these facilities.

3. Adequate General Purpose Emergency Trucks: These trucks are in radio contact with the television control center. Again, time is the important factor in such things as the removal of crippled vehicles or the immediate application of salt in advance of icing conditions.

4. Public Information: Telephone communication between the monitoring point and news rooms in major radio stations should be established so that warnings and informative bulletins relating to expressway conditions could be relayed to the public. Authoritative surveys indicate that approximately two out of every three automobiles in a major metropolitan area are equipped with radios in working order. The transmission of information from the monitoring point to drivers could be done quickly and would probably materially reduce the build-up of congestion.

These are the major recommendations for paralleling equipment and methods of procedure resulting from the experiment. We know, of course, that there are other ways and means to provide the efficiency of expressway operation that we are striving for, but the foregoing reflects the experience gained from our experiment. Only a full-scale installation will provide the final answers.

It appears to us that there is a very urgent need to study any traffic control device that offers the promise which television holds out to us. In fact, when we look to the future, the need for such a device would appear absolutely necessary. Many economists tell us that the United States will continue to enjoy unparalleled prosperity. Such a future, of course, means that automobile and truck registrations will continue to increase each year. This possibility takes on added significance considering the current widespread emphasis that has been placed upon road and highway construction. The road and highway programs which will be adopted in the immediate future will include plans for the construction of expressways in or near every large urban area in the country. Traffic engineers and highway officials should expect these new facilities to provide the answer to at least a portion of the traffic problem. We now know, however, that expressways induce high traffic volumes and that they cannot operate continuously without some type of control. Highway and traffic officials should not continue to encourage the construction of expressways and freeways as the answer to our traffic problems without recognizing the fact that some means of control is necessary to insure the continuous operation of these super facilities. Limited access highways were designed to provide a means of carrying through-traffic and as a means of separating such traffic from local traffic. Expressways should be built to provide for this separation of through and local traffic and to reserve thereby our residential and local business streets for the specific local needs of the area in which they are found. Realization of these plans depends obviously on the ability of the traffic engineer and other traffic authorities to keep these through-arteries operative, particularly during periods of peak demand. On the basis of the experience we have had in Detroit during our television experiment, we are firmly convinced that television is the key to the most effective control plan possible for keeping movement on these facilities free and rapid.

In our discussion so far we have outlined the reasons for inaugurating the experiment and have given some of the actual results which we obtained. You will note that the results have been most satisfactory from a traffic engineering point of view. However, there are two other questions which need to be answered.

First, has the television industry developed equipment which is capable of performing the service we require without frequent breakdown and without the need for a costly maintenance program to keep such a system in operation?

Secondly, if the answer to question one is in the affirmative, are the costs of such a system reasonable or do they put television out of the reach of traffic control agencies?

During the period of Detroit's experiment, problems relating to equipment were handled by the Michigan Bell Telephone Company. Their engineers did an excellent job in providing us with quality performance at all times. What their problems were and how they were solved, I am not qualified to say. Because this is a very important point to consider, however, the Bell Telephone Company assigned Mr. Roy Head, one of their television engineers, to report on the problems he encountered as engineer in charge of this project. His report constitutes the following section of this presentation.

TECHNICAL ASPECTS

The following is a discussion of the technical aspects involved in the application of industrial television to the traffic control experiment conducted on the expressway system of Detroit, Michigan.

During the experiment interval, the television circuitry passed from a very basic viewing system to a more complicated arrangement consisting of multiple camera locations and assorted switching equipment. At the same time several basic requirements of the television equipment accessories were realized and were put into effect where practicable.

The following were found to be fundamental requirements of a single television camera designed to view one section of highway for the purpose of immediate and detailed scrutiny of a traffic problem:

1. High resolution (at least 450 lines).
2. Weatherproof housing.
3. Remote movement control (pan and tilt).
4. Variable focal length lens (25 to 150 mm).
5. Automatic iris.
6. Controlled focus.
7. Elevated camera mounting.

These requirements became evident during the first phase of the Detroit experiment. This experiment consisted of two cameras located on pedestrian bridges (about 20 feet above the road bed) at high accident locations on the expressway. The locations were several miles apart and in no way related. Viewers for the two cameras were placed in a centrally located

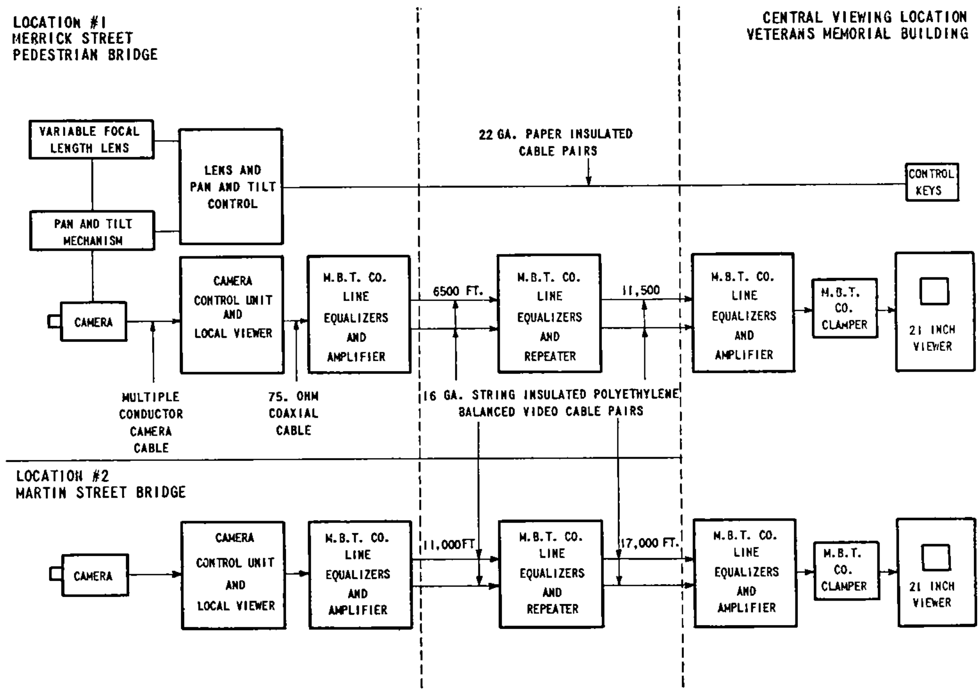

Figure 14.

building of the City proper. Figure 14 is a block diagram illustrating the arrangement.

At the conclusion of the first phase of the experiment all of the above mentioned fundamental requirements, with the exception of automatic iris and elevated camera mounting, were incorporated in at least one of the two systems.

High resolution was obtained through the use of a camera system utilizing interlace scanning and having video amplifiers of better than 6-megacycle bandwidth. Some sacrifice of resolution was realized through the necessary use of a 150-foot connecting cable between the camera and its associated control unit.

In order to maintain, as much as practicable, the video response (and thus resolution), a standard broadcast quality video circuit was incorporated between each camera and viewer.

These video circuits were made up of 16-gauge, polyethylene insulated, balanced telephone cable pairs associated with appropriate amplifiers and equalizers which established a circuit bandwidth of 4.0 megacycles.

The decision to use wire line facilities in lieu of microwave for the video transmission circuits was brought about by the fact that video wire facilities existed in the vicinity of the camera and viewer locations.

Figure 15 illustrates the video transmission circuit. At the viewing location the video transmission circuits were each terminated in high quality viewers having 6-megacycle bandwidth video amplifiers.

With the above circuit arrangements, resolution of each overall circuit (camera to viewer) was maintained at between 350 to 450 lines throughout the experiment, consistent with individual adjustment and system operation.

To allow traffic observation through periods of rain, fog, and inclement weather, weatherproof housings were installed on each camera. These housings were insulated and equipped with dust filters, cooling fan, and heating element under thermostat control. Also provided were electric windshield wipers on the inside and outside of the lens window. Windshield wiper operation was remotely controlled from the central viewing location by means of Bell Telephone Company wire control circuits.

Remote movement control of the camera

and weatherproof housing in both traverse and elevation (pan and tilt) was also possible by means of telephone control circuits to the central viewing location.

It soon became apparent, even with remote movement control of the camera direction, that sufficient detail of a traffic problem was not available with a single lens providing full view of the expressway road bed. The solution to the problem was to install a variable focal length lens which provided a continuous range from about 25 mm (1 inch—20-degree viewing angle) to 150 mm (6 inch—4-degree viewing angle). With the 25-mm focal length it was possible to view the full width of the expressway (8 lanes) for a distance of at least 1200 feet depending upon existing weather and light conditions.

In the event of a traffic incident, a "close-up" view was possible by changing the focal length of the lens in the 150-mm direction. However, with the longer focal length the associated angular viewing field narrowed to a point where it became necessary to move the camera in order to center the field of action on the viewing screen.

From the above association of lens focal length change and camera movement, it was necessary to provide centralized control of the lens focal length (known as "zoom") as well as camera direction (pan and tilt). In addition to the lens zoom control, a lens far and near focus control and lens iris control were installed at the central viewing location. These controls were necessary for use in conditions of darkness where tracking of the lens focal length change and lens focus was not possible due to an extreme iris setting. Under ordinary light conditions, tracking of these elements was good and did not require adjustment.

During both phases of the Detroit experiment the need was felt for a suitable means to automatically change the lens iris to compensate for changing light conditions. In this respect, two distinct categories of light change had to be compensated for. Normal daytime variations due to changing weather conditions required iris changes in the order of about four F stops. However, the change from bright sunlight (F 16 or F 32) into total darkness (F 1.5 or F 1.9) placed a more stringent requirement on an automatic iris system.

Limited trials with an automatic iris system consisting of a variable density film driven between the optical lens and the television camera tube indicated that automatic iris light compensation under both conditions was entirely possible. However, for operation in total darkness, some fixed change should be considered for the camera tube beam and target potentials to obtain maximum results.

In the first phase test interval some thought was given to night operation since many of the winter days would place the expressway in darkness during the peak traffic hours. For this reason, a few night tests were conducted using fixed 25-mm and 51-mm lenses with the iris open wide (F 1.5 or F 1.9). Lighting on the roadway was incandescent and in the order of 0.8 candlepower. Lack of experience and time allowed only general conclusions to the extent that night viewing was possible, but not in any way near the detail of day viewing.

Night testing during the second phase of the experiment was divided into two main categories: lighting and elevation.

Due to the fact that the brief night viewing tests conducted during the first phase interval left something to be desired in detail observed, thought was given toward developing a means of increasing the available light. It was decided that to increase the roadbed lighting by any great degree would be unreasonable. This left the alternative of changing the type of light being used. Therefore, in an attempt to provide lighting of a color that best suited the television camera tube, incandescent fixtures (yellow light) were changed to mercury vapor (blue light). Comparison tests of similar stretches of roadbed, illuminated by incandescent fixtures and mercury vapor fixtures, respectively, proved the mercury vapor lighting to have some advantages.

As in the early night tests, fixed lenses were used with maximum iris settings for the above observations.

One trial was conducted for the purpose of evaluating the variable focal length lens during night operation. As was anticipated, the amount of available light to the camera tube was restricted by the variable lens to the extent that the results were unsatisfactory. The maximum lens opening possible with this lens was F 2.7. From this it follows that for night operation, encompassing a variable focal length lens, some improvement will have to be made in the lens itself or in the sensitivity of the television camera tube. It is possible

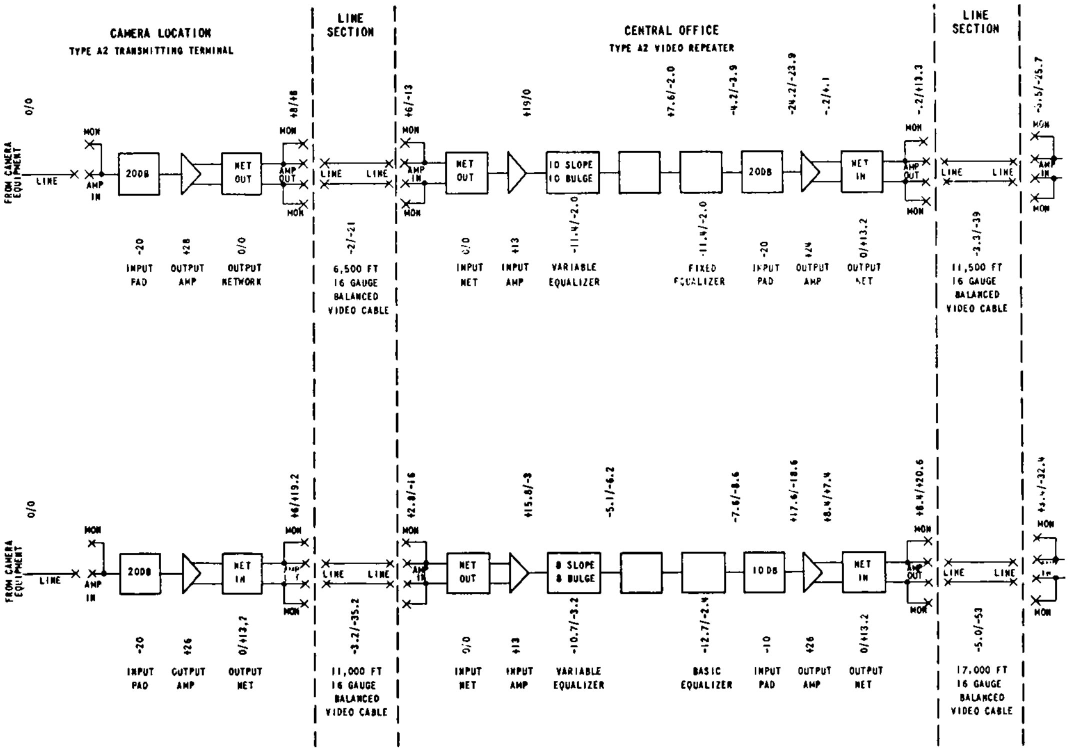

Figure 15.

that a remotely controlled 3-lens turret could to some extent replace the variable focal length lens for this operation. No tests have been made using a turret lens device for this purpose.

Further night testing consisted of elevating the camera in 5-foot intervals to a height of 100 feet above the road bed. This proved to be an advantage in that up to a height of about 45 feet above the roadbed, traffic details were increasingly better. Above 45 feet, the details deteriorated rapidly. Elevation minimized headlight glare which tended to obscure picture detail in night scenes. Reflected light from the roadbed and roof of automobiles was better utilized at the 45-foot elevation. These two advantages improved the night picture considerably.

The same tests were conducted during daylight hours and proved that an elevated camera mounting in association with a variable focal length lens provided great improvement in obtaining scene detail as well as in creating a "plan view" of the scene for traffic incident location.

The second phase of the Detroit experiment also included equipment arrangements to test the principles of a viewing system which would allow viewing of the expressway on a sequentially switched camera basis. To accomplish this, three cameras were located adjacent to each other over about a half mile of expressway. The video signal from each camera was connected to a local switching point by three video circuits of the same quality used during the initial tests. At the local switching point the three video circuits were each terminated in a coaxial relay and the relays wired so that upon operation the associated video circuit was connected through to a fourth video circuit between the local switching point and the central viewing location. Control of the coaxial relays was by means of push-button switches through telephone control circuits, from the central viewing location. Figure 16 is a block diagram illustrating this circuitry.

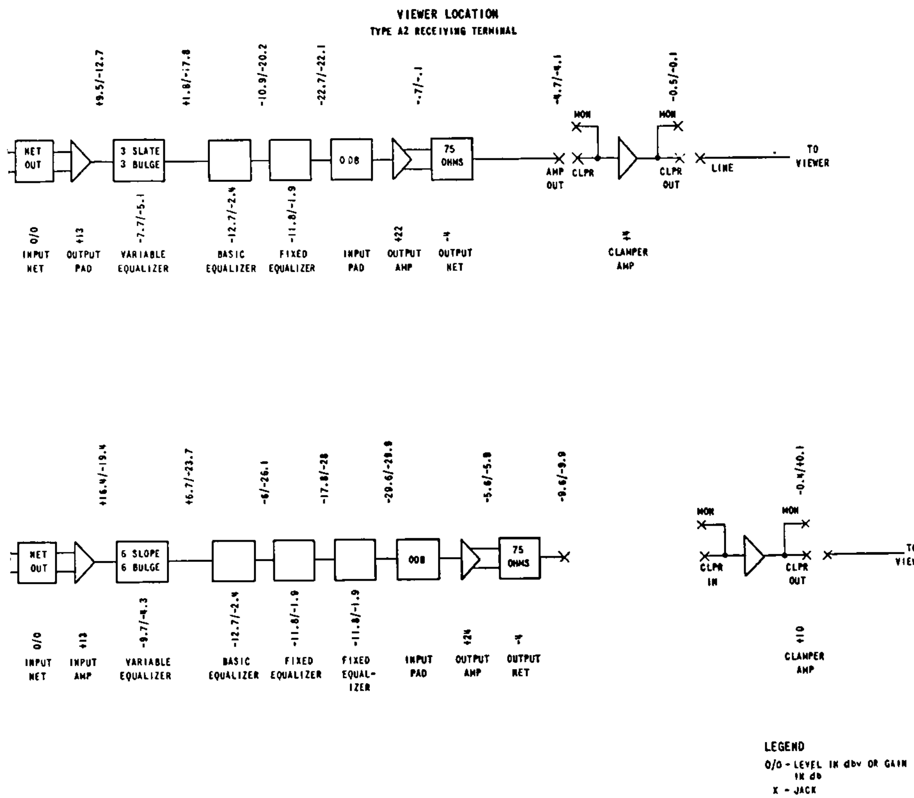

Figure 15.

With the above arrangement, tests were conducted to establish the approximate time necessary to view a traffic scene for the purpose of determining any abnormal traffic condition. Manual operation of the push-button switches in close association with a stop-watch provided the test technique. The results established a viewing interval of at least 4 seconds, which, together with the stipulation that any point on the expressway be viewed at least once every 60 seconds, set the basis for the "sequential system" described below.

The sequential scanning system is based on the assumption that viewing intervals of not less than 4 seconds are necessary for determining abnormal traffic movement. With this system it is intended that the viewer display a sequence of scenes originating at cameras placed progressively along the expessway, these scenes to overlap in the areas they covered and remain on the viewer screen for a period of not less than 4 seconds each.

Provided that any given point on the expressway is scanned at least every 60 seconds, it is evident that a maximum of 15 cameras could be associated with one viewer. For coverage in excess of 15 cameras, it would be necessary to duplicate the sequential switching arrangement and viewer.

The sequential viewer could be described as the "scanning viewer". Its sole function would be to display sequential camera scenes for the purpose of detecting abnormal traffic conditions.

In connection with each scanning viewer, a second viewer would be provided for the purpose of observing for an extended time any scene on the scanning viewer. In practice, this "problem viewer" would display a scene only at such time as selected by the individual observing the scanning viewer. The selection

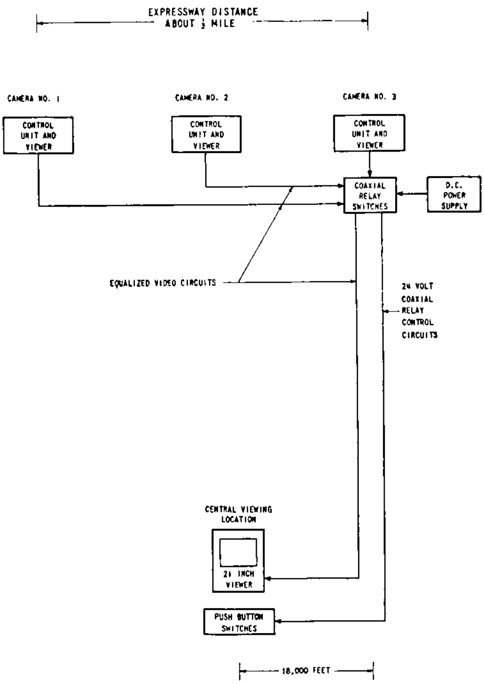

Figure 16.

would be made by depressing a push-button at the exact instant an abnormal traffic situation was noted. This would cause the same camera scene to be displayed on the problem-viewer screen and held for observation by an individual equipped to cope with detailed traffic problems. Depressing the problem-viewer push-button would not affect the sequential progression of the sequential scanning switching.

Simultaneous with the traffic incident scene connection to the problem viewer would be the connection of controls for lens focal length change and camera movement. These controls would be convenient for the problem-viewer observer, enabling him to determine those details necessary for the correction of the situation. Also under the control of the problem observer would be a group of push-buttons equipped with indicator lamps and designation strips for the purpose of changing the scene on the problem viewer to any camera scene the observer might choose. Camera movement and lens control for each camera would also be transferred. This action would give the problem observer complete coverage of the traffic problem created by any traffic incident, thus providing overall control of the situation.

Another approach to the problem of immediate detection and correction of traffic problems using television is that of connecting each camera directly to a viewer at the central viewing location. This would result in a "wall" or "bank" of viewers to be observed. In this system it was estimated that an observer could scan between 15 to 20 viewers per minute with the idea of detecting abnormal traffic conditions. As in the sequential system, the observer would be equipped with a group of selector switches and camera controls which would enable him to control individually each camera position and lens focal length.

Actual tests related to this system were confined to determining a suitable viewing screen area. For the type of viewing required in either this or the sequential system, the 21-inch screen was most popular.

The conclusion of the Detroit experiment leaves many questions in the minds of those who may in the future have to provide the "know-how" for a complete traffic control television system. Foremost among these questions is that of equipment stability with regard to unattended operation. Some tests were made in this regard and proved that 24-hour operation as well as 10-hour-on/10-hour-off operation was reliable to a high degree. It is to be expected that on any permanent installation of this nature it will be necessary to make some special circuit modifications on the standard industrial television equipment available today. It is also conceivable that some custom packaging of units will be necessary to accommodate the type of elevated camera mounting required as well as to provide for easy maintenance.

Another item of major concern is that of video signal transmission. During the Detroit experiment the first available means was utilized. It is not necessarily intended that this method of video transmission be ultimately used in a system. The type of scanning system used and length of video signal paths could determine a great savings in equipment and maintenance.

The foremost saving grace in favor of industrial television as a means of traffic control is in the fact that this medium is becoming increasingly better.

SUMMARY

It has no doubt been obvious throughout this presentation that we in Detroit are firmly convinced that television can be adapted for use in traffic control. Despite our optimistic appraisal of this medium as a traffic control device we are nevertheless realistic enough to recognized the fact that some of the plans we have formulated for incorporating television into an overall traffic control plan may not work out either in their entirety or in part. It is for this reason that we believe it necessary to conduct an expanded experiment.

As we see it, this type of experiment would tie together all the facilities we have discussed as necessary for effective over-all control of traffic on high speed facilities. This means we would install the television system, complete with lane and ramp controls, signs and signals, and a two-way communication system. We would back it up with adequate police man-power and emergency vehicles, and we would staff the control room or monitoring point with qualified observers. We propose that such a system cover several miles of expressway and be kept in operation for a period of approximately two years. It is readily apparent that such an undertaking is a rather gigantic one. However, the results obtained so far indicate that from a traffic engineering point of view it is reasonable to expect that such an experiment would be justifiable. Furthermore, as Mr. Head has indicated, the television industry has developed equipment and techniques which from a technical point of view indicate that such an experiment would be a success. Besides being effective for overall control of traffic, television offers an excellent opportunity to study the behavior of traffic at ramp connections with the expressway, at interchange points, and other critical portions of the roadway. We have stated that generally speaking, traffic engineers are convinced that our modern expressways are properly designed. However, we are aware of the fact that accidents and congestion often occur at specific locations on the expressways. Television will give us an excellent opportunity to study these locations in detail to determine whether some of our designs are improperly conceived and are therefore conducive to accidents. Furthermore, for the automobile industry and all those interested in the safety of our highways, television may well offer a means to study those various factors which lead to accidents. Television for control of traffic on expressways therefore offers a valuable by-product which may aid accident research and suggest possibilities in design.

While we do not have any definite cost figures, the estimates prepared by television experts indicate that costs would be relatively small when related to both the cost of congestion and accidents to the community and the cost of construction and maintenance of such facilities. As a matter of fact, part of the object in conducting such an experiment would be to determine the most economical way of installing and operating such a system.

I cannot help but feel that this is a very critical time for traffic engineers. Most of us have arrived on the scene in recent years and have been given street systems that were designed many years ago without any consideration for today's traffic problems. Today as we plan to embark upon a program of expressway construction designed to serve future traffic needs and solve many of our traffic problems, we should recognize the fact that the construction of such facilities will at the same time create problems which do not exist today. In the construction of such facilities we limit access and egress to provide for the uninterrupted flow of traffic, reduction of congestion, and safer movement. It seems paradoxical that the limiting of access and egress can cause greater traffic stagnation than we currently experience on our crowded surface streets. Recognition of this fact should strengthen our resolution to develop a control device which will permit these facilities to operate at maximum efficiency and to prevent the creation of such stagnation. We did not have this opportunity with respect to the surface street systems we are presently using and we all realize the problems which have resulted. It seems to me that this should spur us to examine carefully and in detail the promise held out to us by this new medium. The time and effort spent in such experimentation now may result in substantial savings in life and property and in greater ease of movement over American roads in the years ahead.