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FREEWAY TRAFFIC ACCIDENT ANALYSIS AND SAFETY STUDY
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FREEWAY TRAFFIC ACCIDENT ANALYSIS AND SAFETY STUDY

Compiled by
Texas Transportation Institute
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1. Barnett, J., "Freeway operation--observations reveal good and poor highway design", Civ Eng (NY) 31: n 1, Jan 1961, p 35-8.

Study of modern highway design deals with reappraisal of capacity needed on freeways, with entrance and exit ramps, interchanges; avoiding excessive use of guardrail, need for more complete data on accident reporting; importance of cooperative effort among designers, engineers and city officials in planning and preliminary design.

2. Bowman, B.H., "Ohio Turnpike study indicates interstate accident potential", Driver Education News 1: n 10, pp 3, 5 October 1958.

A two-year study has been made of all accidents experienced on the main traveled lanes of the Ohio Turnpike. The conclusions arrived at should be of interest since they undoubtedly indicate what to expect on the Interstate Highway System.

The accident rate established for the winter months was much higher than that for the summer months. The winter season has an accident rate of 206, while the summer months maintained a rate of but 98.

It became very apparent that grades had a very direct relationship to accidents. This is not new information, but when the grade restrictions are as rigid as those on the Ohio Turnpike it is rather startling.

Sixty-two percent of all accidents occurred under "dry" pavement conditions. "Snowy or icy" conditions prevailed during 26 percent of the accident occurrences. "Wet" pavement existed when 12 percent occurred.

Light conditions at time of accident occurrences was given consideration. The hours of darkness account for 48 percent of all accidents. One and eight-tenths percent of the occurrences were experienced at night in areas that were illuminated by roadway lights.

Twenty-eight percent of the accidents reported were of the rear-end collision variety.

Taking the 62 rear-end collision accidents alone, 5 percent of them resulted in fatalities, 60 percent caused personal injuries, and 35 percent were property damage accidetns. These percentages illustrate the severity of the rear-end collision type accidents at high speeds.

Important Turnpike structural characteristics are minimum width between travel lanes--56 ft; width of outside shoulder--10 ft; width of inside shoulder--8 ft; minimum sight distance--900 ft; and minimum width of 124 ft between the outside edges of the outside shoulders.

3. Carver, A. H., "Two-way radio skyway of highway engineering", Western Construction 29: n 12, Dec 1954, p 47-9.

   Description of first use of radio band for highway work in Northern California which grew to total of 21 land stations and 38 mobile units; special vehicle outfitted with 60-w f-m radio station with radio receiver; California Highway Radio System now comprises 78 base stations, 28 fixed relays, 23 control stations, 9 portable stations, 11 microwave stations and 650 mobile radio stations.

4. Crittenden, Bradford M., "The police job on the super roads", Traffic Safety 64: n 4, April 1964, p 25-26, 37.

   The wide, smooth, super roads that criss-cross the continent have added a new dimension to American living. But they have also bred a host of special problems.

   What is unusual about these new roadways, the Interstate System specifically and controlled access roads in general?

   Two things. Their operational and safety advantages are so great that the motoring public naturally gravitates toward them. Thus all of the problems that were scattered over all of the highways and byways of the states will tend to concentrate on these relatively few miles of super highway as the usage increases.

   Second, the motorist suffers from a new malady on these super roads. We might loosely diagnose it as "containment."

   Containment is the other side of the coin we identify as "controlled access." Controlled access obviously is an enormous advantage to the dirver. No more cross traffic to worry about. No stop signs, no stop and go lights. Less tension. Greater driving ease. More constant speed. Better hourly mileage average.

   To gain this advantage, the motorist has to give up immediate contact with the outside business world. "Next off ramp, 35 miles" reads the sign. Or on the toll roads, "Next roadside service--35 miles."

   So, for the next 35 miles, he can't buy gas, he can't eat a meal, he can't get a doctor, he can't get a flat tire fixed, he can't find a rest room. He may even find that there is no shoulder to pull off onto.

   This is it. He's on his own. He is contained on this road, with no help in sight, no friends, no protection.

Stripped of dramatization, the situation is one in which a driver can find himself in various forms of difficulty without any ready means of solving his problems himself.

What is the responsibility of the policing agency in these circumstances?

What does the motorist have a right to expect? Or, what are we, in the traffic police field, prepared to offer the motorist?

5. "Distress signals for freeway motorists", Traffic Safety 60: n 2, pp 26-27, Feb. 1962.

The American Association of State Highway Officials has just issued the statement of policy on Uniform Distress Signals for Motorists on Freeways.

A summary follows:

In an emergency on freeways, whenever possible, drivers should stop their cars on the right-hand shoulder well away from the through traffic lanes.

At night the tail lights and the interior lights of the stopped vehicle should be turned on. If the vehicle is equipped with a turn-signaling indicator having an "emergency" switch, this should be turned on so that both the right and left turn signal lights will flash simultaneously.

Where a disabled vehicle is stopped in such a position that part or all of a traffic lane is occupied, portable warning devices should be placed to the rear of the stopped vehicle to notify on-coming drivers of the traffic hazard.

Whenever help is needed a white cloth or handkerchief should be displayed from the stopped vehicle so that if readily can be seen from other vehicles on the highway. For example, the white cloth may be hung from the window next to the driver's seat so that it is conspicuous to passing motorists. In addition, when practicable, the hood of the car should be raised.

While waiting for help, motorists should remain within their cars or nearby in a safe position off the traveled way. They should not stand or walk in or near traffic lanes, or leave their cars unattended.

After observing a distress signal, passing motorists should notify the nearest police, highway, or automotive service official at the first convenient opportunity, giving the location of the motorist in need of assistance.

6. Dudek, Conrad L., "Freeway traffic surveillance and control research project; reports of the project technical committee. Study 424, Effect of incidents on freeway traffic", Lansing 1961, 1962. Michigan State Highway Department. (A project of the Michigan State Highway Dept. jointly with the Wayne County Road Commission, City of Detroit, Dept of Streets & Traffic. The John C. Lodge Freeway surveillance system.
Part I. Lane closure for maintenance. II. Effect of accident on freeway traffic flow. 27p.

7. "Electronic 'seeing eye'," <u>The California Highway Patrolman</u> 19: n 1, pp 19, p 61-64, March 1955.

"The announcement of a new electronic all-seeing eye to monitor highways was greeted with alarm by motorists and officials," stated Andrew J. White, Director of Motor Vehicle Research, Inc., of So. Lee, New Hampshire.

White said that, "It never occurred to me when I developed this new remote control monitoring device that such serious alarm would result. The development of this particular device is basically in the interest of safety and for the protection of motorists on our highways."

It is also not generally known that we have developed an electronic device that can evaluate a motor vehicle's condition while it is operating on the highway. While it is true that we have developed an electronic unit that will automatically check the speed and behavior of a vehicle up to 10 miles away and photograph that vehicle by means of camera equipment, it was not our intention to create a police state."

The first segment of the device now being constructed for installation on the New Hampshire highways will be a cooperative monitor warning the motorist that he is speeding by means of visual indication.

It is believed that this all-seeing eye monitor will, without question, reduce the number of speed violations in any district without legal enforcement. A careful survey over a period of the traffic on a particular highway that the instrument is to be installed will be checked against weather conditions on a 24 hour basis. The installation will then be made and a recheck will be accomplished and results compared.

Plans are now being drawn at our laboratories for the installation of a remote control highway monitor that will monitor a car for a 10 mile interval showing the vehicle visibly on the screen and checking the conditions of the highway and will automatically post a signal when the surface becomes coated with ice or unsafe.

An accident can be photographed when it is occurring by an automatic camera in the remote control room and such a camera can record the time, date, day and integrate same with the actual speed of the vehicle, the picture of the license plate and the car and the violation that has taken place. This monitor will also be equipped with a vehicle condition evaluation device that records on high speed magnetic tape frequencies that are analyzed through a computer that will indicate the true condition of the vehicle from the standpoint of exhaust system, front end and brakes.

The new unit will be manufactured on a new principle of radar that makes them relatively inexpensive and they can be installed in any school zone or section of a city where speeding is the main contribution to accidents.

8. Forman, A. J., "VHF-Microwaves cover New Jersey Turnpike", Tele-Tech 11: n 4, April 1952, p 48-50, 94, 96.

How five base radio stations interconnect 150 fixed and mobile units through seven microwave relays over 118-mi highway to provide for expeditious handling of information on traffic movement, emergency repairs, accidents and law enforcemtn; base stations transmit on 155.19 Mc and receive from mobile and way stations on 154.83 Mc; microwave relays operate on 960 Mc; use of RCA equipment.

9. "Freeway operations. New information on emerging responsibilities", Institute of Traffic Engineers, Washington, D.C., undated, pp88.

This booklet is based on information and ideas presented in 12 regional seminars held in the U.S.A. It contains the following chapters: (1) The freeway concept. (2) Driver characteristics and training. (3) Speed characteristics. (4) Accidents (5) Regulations and regulatory signs. (6) Directional signs (7) Geometric design elements. (8)Freeway connections. (9) Traffic operations during construction. (10) Motorist services. (11) Police and emergency services. (12) Freeway maintenance. (13) The future operational challenge.

10. Godley, P.F., J. R. Neubauer, and D.R. Marsh, "New Jersey Turnpike--unique highway communication system", Am Inst Elec Engrs--Trans 72: pt 1 (Communication & Electronics) n 8, Sept 1953, p 360-9.

Turnpike reaches from Deepwater, N.J., to George Washington Bridge; extension expected for connection with New York State Thruway; length will then be 130 mi; radio system gives coverage for mobile units over entire distance, plus telephone and teletype interconnection of three police stations with State Police Headquarters; details of communication system.

11. Hafstad, L.R., "Research as applied to traffic engineering", Gen Motors Eng J 22: n 1 Jan-Feb-Mar 1958, p 12-18.

New approaches to traffic safety should include research with regard to driver and his motivations, stimuli and responses, as well as road and car; considerations of statistics show that role of driver is important in traffic safety; table shows violations most commonly reported; research can increase safety by improving driver competence.

12. Hartigan, Mike, "Emergency traffic patrol", Illinois Highway Engineer 13: n 4, Fourth quarter 1961, p 9.

Illinois Div. of Highways traffic patrol on Northwest, Edens, and Congress Street Expressways.

13. Hirsch, Phil, "Radar reduces accidents", Public Works 86: n 7, pp 83-84, July 1955.

Radar has been showing what it can do in Hammond, Indiana. Results indicate that this electronic wonder may be one of the most-valuable accident deterrents developed yet.

The best evidence that radar is effective comes from a comparison of Hammond's accident statistics during the last eight months of 1953 (before use of radar) with figures for the same period of 1954.

During the 8-month period in 1953, a total of 2,285 accidents were recorded. These accidents resulted in 10 deaths and 625 injuries. For the same period of 1954, there were 1,958 accidents, three fatalities, and 322 injuries.

A dramatic change in the accident picture took place

on Indianapolis Boulevard, from Sumner Street to the city limits. This is the stretch known as "Murder Mile." The police captain recalls that during one 30-day period on this thoroughfare, five persons died within 100 feet of each other.

An average of 3.8 persons a year had been losing their lives on Indianapolis Boulevard during the 20 years preceding the installation of radar. In 1954, there was one fatal accident, caused by an intoxicated pedestrian rather than a careless motorist.

The transformation on Calumet Avenue has been even more startling. This road, which runs through a largely unimproved section just inside the city limits, had accounted for 129 fatalities in 20 years, an average of more than six deaths a year.

During the first 8 months radar was in use, the fatality rate dropped to zero. Both Calumet Avenue and Indianapolis Boulevard are radar checked at least once a day.

Before the new equipment was put in service, police conducted an extensive public-relations program. The Hammond Times ran a long series of articles which, among other things, emphasized that radar is foolproof. Pictures of one of the most-common dodges--metal foil on the car's aerial and a grounding chain hooked to the rear bumper--were shown not to work. One practice was encouraged, however: a motorist flashing his lights to warn those coming of the presence of radar. The Hammond Times editorialized: "If flashing lights will cause motorists to decrease their speed, we're all for it...We're sincere when we say that our radar equipment is aimed at reducing the accident hazard, not in jamming up the traffic court."

14. Howes, W.F. and R. D. Miles, "Aerial photography applied to traffic studies", Road School, Purdue University, Lafayette, Ind Proc 1963, 190p.

15. May, A. D. Jr., "Congress Street Expressway surveillance project", Road School, Purdue University, Lafayette, Ind, Proc 1963.

16. McGlade, Frank, "Interdisciplinary approach to road safety research," Traffic Engineering and Control 3: n 12, pp 730-732, April 1962.

The quality and quantity of accident research must keep abreast of the ever-expanding traffic complex, otherwise road safety progress will be based on opinion and not scientific fact and irreparable damage done in terms of lives and money lost.

There has been a tendency to oversimplify the traffic accident problem, with a concomitant oversimplification of traffic accident research. The development, discernment, and application of sophisticated traffic accident research is precluded by the availability of persons competent to perform research, interpret research findings, and put such findings into application. This raises several questions: (1) Who will perform such research? (2) Who will interpret and disseminate research findings? (3) Who will apply them properly since lack of personnel is the crucial problem?

There are several facets to this problem: (1) There is a dearth of skilled researchers with special preparation in safety education and accident prevention techniques. (2) There is a lack of safety education and accident prevention specialists, and the few specialists in this field lack a broad educational background in related fields of knowledge. (3) The multi-variate nature of the traffic accident problem--man vehicle, and environment--necessitates the involvement of many scientific disciplines, if traffic safety research is to be productive.

The first two shortcomings are inextricably interwoven. Traffic safety, as a body of knowledge, is a newly emergent discipline. Consequently, the safety specialist must necessarily borrow theories and research findings from other disciplines and attempt to apply them to the study of accidents. He has difficulty in doing this because of his lack of basic knowledge of the other disciplines. Conversely, scientists from other disciplines are not aware of the need for their esoteric knowledge in traffic accident research nor are they schooled in safety knowledge and research techniques peculiar to accident prevention work. These two problems form a vicious cycle; one negatively complements the other.

The quality and quantity of traffic accident research must keep abreast of the ever expanding traffic complex. A more unified, coordinated inter-disciplinary approach is essential to accomplish this objective. Attainment of this goal could be implemented by the following: (1) Establishment of a central coordinating agency. Some efforts in this direction have already been initiated by the Federal government. Its role needs to be further defined and expanded, however. Such an agency should be staffed with well qualified personnel from various disciplines whose responsibilities would be to: (a) determine areas of needed traffic accident research; (b) stimulate interest in doing traffic accident research among individuals, and organizations, through professional associations and other means; (c) develop channels of support for individuals and organizations conducting traffic accident research; (d) evaluate research reports; (e) disseminate research findings that relate to traffic safety. (2) Expansion of the role of colleges and universities in traffic safety education and research by: (a) establishment of centers for safety education and research in colleges and universities to : (i) preparation in behavioral and social sciences. (3) Give traffic safety specialists more preparation in research design and methods for applying research by: (a) granting advanced degress and graduate assistantships for study and research in traffic safety; (b) co-ordination of study and research in traffic safety with other departments, such as behavioral and social sciences; (c) dissemination of traffic accident research findings resulting from school sponsored research to central co-ordinating agency and interested persons and groups.

17. Moskowitz, Karl, "Freeway accidents", California Highways and Public Works 41: n 3-4, Mar-Apr 1962, pp 9-15.

The average traffic volume on California freeways in 1959 was 35,800 vehicles per day, ranging from 4,000 to 210,000. This volume produced 8,800 million (8.8×10^9) vehicle-miles of travel involving 10,000 accidents in 1959. During the three-year period 1957-59 (with mileage and travel increasing each year), there were 21,047 million vehicle-miles and 24,834 accidents. Because this is more experience than has been available in many other jurisdictions, it is thought that some facts regarding these freeways would be of interest.

The accident rate, injury-accident rate, and fatality rate on rural state highways other than freeways are about 2½ times as great as the corresponding rates on rural freeways. Urban freeways have a lower fatality rate, but a higher rate of nonfatal accidents than rural freeways.

Direct comparisons of urban freeway accident rates with other urban arterials are almost impossible to make, mainly because data on urban arterials are so difficult to obtain.

The fatality rate on freeways was just half that on all other streets and highways, rural and urban.

If the 8.8 x 10^9 vehicle-miles of travel on freeways had been subjected to the hazards encountered on ordinary roads and streets at the rate of 5.66 per 100 million vehicle-miles, they would have resulted in 497 deaths, instead of the 248 that did occur. In other words, freeways then operating in California saved about 248 lives in 1959.

It is very interesting to note that rear-end collision accounts for only one-sixth of the fatal accidents on California freeways in 1960. Here, of course, is one of the things that is different about fatal accidents. The rear-end or side-swipe is the most prevalent type of accident on freeways, but as the layman surmises, it is not often fatal.

Although trucks are involved in a small percentage of all fatal accidents on freeways, they are involved in a disproportionate share of rear-end fatal accidents.

Of the 43 fatal rear-end collisions on California freeways in 1960, trucks were involved in 21. In 11 accidents, a truck was hit from behind. Two of them involved stopped trucks, and eight of them involved trucks going very slow, well below any speed limit. Raising the speed limit would have no effect on their speed. In 10 accidents, a truck overtook the other vehicle and could not or did not stop in time.

Freeways are comparatively safe roads, but they are not foolproof. Their principal advantage is the elimination of cross traffic conflicts. Two-thirds of fatal accidents on freeways involve only one vehicle. One-third of fatal accidents occur between midnight and 5 a.m., while only one-twentieth of the travel occurs during those hours.

For a prudent driver, the probability of being involved in a fatal accident is very much less than the over-all statistics indicate, and the over-all rate is 2.26 fatal accidents per 100 m.v.m.

18. Noble, C.M., "Electronic controls in turnpike operations", Am Highways 34: n 3, July 1955, p 8-9, 21-2.

Facilities installed on turnpike for increasing efficiency and effectiveness of administration, policing, toll collection and maintenance operations; design details of radio communication system; developmants in toll recording, tabulating, and electronic speed meters.

19. Platt, F.N., "Operations analysis of traffic safety. Part IV. Proposed fundamental research on driver behavior", Traffic Safety 57: n 6, 1960; Res Rev 4: n 4, p 4-7; Internat Rd Saf Traff Rev 8: n 4, 1960, p 37-41.

An operations analysis of traffic safety was established theoretically in the first three parts of the paper. This part describes an approach for experimental research to verify the theory and obtain constants for the equations. This research should provide information: (1) for developing driving simulator requirements; (2) for evaluating current driver training practices and for developing new techniques; (3) on the physical and psychological reactions of drivers under actual driving conditions; (4) on the effect of different kinds of vehicles and vehicle equipment on driver actions; (5) on the effect of environment on driver actions. It should also: (6) provide an evaluation of the traffic flow theory, relating driver actions to various traffic densities and movements; (7) provide an opportunity to study the whole problem of traffic safety, changing one major variable at a time; and (8) lay the ground work for a mathematical programming approach to the safety problem. The proposed research would study safety with no direct references to accidents or casualties and would study driver, vehicle and environment relations simultaneously rather than as separate components.

20. Ranabauer, A., "La nueva columna de telecomunicacion para autopista SH 50", Revista de Obras Publicas 102: n 2875, Nov 1954, p 538-47.

New telecommunication unit on highway SH50; reconstruction of telephone units installed on German highways for emergency calls of drivers; arrangement and performance of apparatus.

21. "Report on road safety experiment conducted on Wellington-Wanganui Highway. Transport Department New Zealand, 1956, 22p+.

A 110-mile stretch of road was selected by the National Roads Board and the Transport Department of New Zealand in 1955 for studying a number of measures for making an existing road as safe as possible without major reconstruction. Some before-and-after studies are reported. The measures were: (1) Intensified traffic control (2) Physical improvements, e.g., road markings and warnings. Road markings included "no-passing" lines and "spacing bars" i.e. lines across the centre of the carriageway at 80-ft intervals to indicate a suitable headway for vehicles travelling at 40 m/h. (3) Enforcement. (4) Publicity and education. (5) Accident investigation. It was concluded that it was difficult to gauge accurately how much each or any of these contributed to safety, but in general the activities were successful. Recommendations are made on: The design and placement of spacing bars on the carriageway, larger traffic signs, stop signs, reflectorized road edge delineators, investigation of accidents, enforcement, night patrols. Appendices. These include a description of the highway, traffic characteristics, analyses of accidents and an accident report form.

22. Shoop, S., "Television aids for motorway control", Road Tar 18: n 1, March 1964, p 17-18.

Traffic control on John C. Lodge Freeway, Detroit.

23. "Specification for on the spot investigation of road accidents" Bundesminister fur Verkehr. Verkehrsblatt 11: n10, 1957, p 231-9. (In German)

Thorough on-the-spot investigation of accidents is advocated to determine sites, reasons for occurrence at particular sites, and means of prevention. This specification describes the official documents recommended for recording relevant facts: (1) accident maps, (2) accident report card index, and (3) collision diagrams. Specimen copies of these are reproduced as a supplement.

24. "The fallacy of fatals", Traffic Safety 60: n 4, April 1962, p 8-11, 46.

New insurance industry figures bolster all-accident approach; motor-vehicle accident problem nationally is sum of many accident problems regionally, and locally. Accident prevention programs must be tailored to fit specific area problems.

25. "Traffic and safety", New Jersey Highway Authority 1963 Annual Report, Garden State Parkway.

Reports and observations of an increased number of trespassing pedestrians prompted an intensive educational and

enforcement campaign to eliminate such traffic hazards. Among other things, detailed records of pedestrian incidents were kept and released to the press for publication aimed at deterring the practice of hitchhiking, discharging car-pool passengers along the roadways, and other such illegal and unsafe activities.

Also aiding in this effort was the helicopter service engaged by the Authority early last year. Radio communication with State Police patrols on the ground enabled helicopter observers to spot and report pedestrians at once.

...The helicopter patrols contributed to improved handling of traffic ingengeral as the aerial surveillance permitted immediate spotting of bottlenecks and fast remedial action via the radio word relayed to State Police on the ground.

26. "Traffic surveillance devices to be installed in Lincoln Tunnel", Traffic Engineering 34: n 6, March 1964, p 21-22.

The Commissioners of the Port of New York Authority have authorized a new tunnel traffic policing and control system in the South Tube of the Lincoln Tunnel. The total system, estimated to cost $322,000, uses newly developed electronic traffic surveillance instrumentation as its front line component. The complete new system has four main components:

(1) A traffic surveillance system of vehicle detectors display and control devices constantly measuring traffic conditions throughout the tube and informing police at control centers about those conditions;

(2) a system of closed circuit television enabling police at control centers to view any part of the tunnel roadway;

(3) two-way radio communication between control centers and police in the tunnel; and

(4) a unique new mono-rail, mono-wheel transportation system for moving tunnel police along the 22" wide catwalk to any point in the tunnel at speeds up to 30 mph.

27. "Traffic violators watch out! You'll appear on television", Public Works Engineers News Letter 22: n 10, p 4, April 1956.

Parking violators in Philadelphia are going to appear on television, according to a traffic proposal recently placed before city officials. The plan would use a closed-circuit television system to spot peak-hour parking violators so that the policemen can be dispatched immediately. The proposed system would be installed on Walnut and Chestnut Streets where buses will soon replace trolley cars. The city plans to reserve one lane during the morning rush hours for the buses. Illegal parking in these lanes would create traffic snarls. Here's how the TV traffic aid would work;

TV cameras would be mounted either on poles or on the sides of buildings at intersections three blocks apart. It would take about 12 cameras to police Walnut and Chestnut Streets between 24th and 7th Streets. Pictures picked up by those cameras would be received on six TV monitor sets in City Hall--three to cover Chestnut and three for Walnut.

One monitor for each street would keep a continuous watch from one end of the street to the other. It would pick up the picture between 7th and 10th for say, 15 seconds, then switch to the section between 10th and 13th for another 15 seconds, and so on down the six camera locations on each street. Should one of these sets catch a motorist or a delivery truck pulling over to the curb to stop or park, thus tying up a lane of traffic, a second monitor would be tuned in to the scene of the infraction. It would stay tuned to the spot until the operator contacts a tow truck by radio and the bottleneck is eliminated.

Before Philadelphia makes a decision, a pilot project will probably be set up with a single camera at Broad Street and either Chestnut or Walnut. Either intersection is one of the most highly concentrated traffic areas of Philadelphia.

Other cities now either conducting pilot projects or initiating studies on closed-circuit TV as an aid in traffic control include Detroit, New York, Baltimore and Chicago.

28. Turner, G., "Emergency telephones for London-Yorkshire Motorway", Post Office Elec Engrs' J 52: pt 4, Jan 1960, p 243-5.

Roadside facilities enabling motorists to call for assistance, provided at 1 mi intervals on part of London-Birmingham route; system contacts county police station, but does not connect to public network; special signal system devised; principle of operation; station identification circuit; layout of control panel at police station; diagram of control circuit.