TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

COMPUTER TRAFFIC CONTROL
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BIBLIOGRAPHY (63-8)
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COMPUTER TRAFFIC CONTROL

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1. Adler, C., Jr., "Traffic-actuated signals had premier in Baltimore", Traffic Eng 20: n 3, Dec 1949, p 129, 144.

First traffic actuated signal placed in use at Falls Road and Belvedere Avenue in Baltimore Feb 21, 1928; principles demonstrated over 21 yr ago are still underlying in present day traffic actuated systems; auto horn method of control was superseded by vehicle detector system called "Electromatic"; function of electric vehicle detector unit is to note passage of each car and to convey information in form of electrical impulses to control mechanism. From Maryland Motorist.

2. "A review of developments in area traffic control", Proceedings of the First Conference, Australian Road Research Board, 1962. 1: p 416-429.

The demand for road transport in many areas in Great Britain has been increasing at a greater rate than can be accommodated by the present rate of construction of new roads in those areas. This is particularly the case in towns where the resultant increase in traffic congestion has led to proposals that co-ordinated systems of controlling traffic over large areas should be adopted so that the best use is made of the existing road network.

Some of the more important existing forms of co-ordinated area traffic control of automatic diversion schemes and large-scale linking of signals, a number of proposals which have been made for future development, and research currently being carried out at the Road Research Laboratory are described.

3. Armstrong, E. L., "National highway program--progress report", Civ Eng (NY) 29: n 6, June 1959, p 57-9.

Construction of 32,000 mi of roadway and 10,500 bridges is under way within National Highway Program; advances in engineering, photogrammetry, aerial surveying and use of electronic computers are improving quality of new roads; research work must be stepped up, new research in field of highway capacity; computer methodology for assignment of trip movement to urban street system; location of bottlenecks on rural roads; progress in research on highway safety.

4. Brooker, R. A., "Autocode programs developed for Manchester University Computer", Computer J 1: n 1, Apr 1958, p 15-21.

   Preparation of programs for automatic digital computers may be simplified by use of conversion program which enables machine itself to accept "programs" written in idealized language or "instruction code" and convert them to precise instructions which machine eventually obeys; two such programs written for Manchester University Computers are described.

5. "Chicago project conducts world's first test of electronic traffic metering", Chicago Traffic Safety Review (Citizens Traffic Safety Board of Metropolitan Chicago), September-October 1963, p 1-4.

   Traffic metering test spaces vehicles electronically on Congress expressway entrance ramp at First Avenue in Maywood. Intervals controlled electronically.

6. "Computer to direct traffic", Business Week Feb 3, 1962, 50+

   Toronto's metropolitan council decides to install the most elaborate system yet to set traffic signals for the benefit of all. First will come computer control of traffic signals. Acceptance may grow for automatic warning devices for cars, even systems to do some of the driver's job on turnpikes.

7. "Computer traffic control promises to pry loose log jams", Met Transportation & Planning 59: 26-9, Sept 1963.

8. Dennis, J. B., "High-speed computer technique for transportation problem", Assn Computing Machy--J 5: n 2, Apr 1958, p 132-53.

   Digital computer technique for solving classical transportation problem by stepping stone method; following review of stepping stone method, unique features of technique are presented which give it its high speed involving transportation problems; detailed logic of method is given.

9. "Device turns traffic lights red in emergencies", <u>News Bulletin of Public Administration Clearing House</u>, Release No. 2, Apr 6, 1954.

   Los Angeles is testing a device that changes the controls on traffic lights in the path of an emergency vehicle by making them turn red and stay that way until 5 seconds after the vehicle has cleared the crossing. The first experiment involved equipping a hospital ambulance with the device, the American Municipal Association has learned. Other trials will be made before the city decides whether or not to install the equipment on all emergency vehicles. The electronic traffic-control system, designed by engineers of North American Aviation, switches green lights to red up to ½ mile ahead, thus stopping all traffic. The system consists of two parts: a small radio transmitter in the moving vehicle that passes the word to the second part, a midget, weather-proof receiver set on intersection traffic signals.

10. Dillon, [illegible].D., "Application of electronics to work of highway department", <u>Better Roads</u> 27: n 5, May 1957, p 43, 46, 48, 52.

    Wisconsin State Highway Commission recently installed electronic computer in its headquarters office at Madison; present uses of electronics in highway work and possible future uses described; initially unit is used for calculating earthwork volumes.

11. "Electric brain times Denver traffic signals", <u>Portland City Club Bulletin</u> (Ore.) 33: n 11, p 32, Aug 15, 1957.

    In downtown Denver a master controller now regulates all traffic signals in the downtown section, keeps a constant count of downtown traffic volume and movements, and computes the direction of the largest traffic flow and alters signal light timing to lengthen green lights for that traffic.

    Traffic signal calculations are made every 6 min. and the signal cycles vary from 40 sec. in light traffic to 120 sec. for heavy traffic.

    The Denver signal-light controller was designed by the city's traffic engineer. The system cost about $1,000 per intersection--not much more than the former inflexible system.

12. Electronics in traffic operations", Nat'l Research Council--Highway Research Board Bulletin 338, 1962, 99p.

This bulletin contains eight papers and a general discussion on the use of electronics in traffic operations. Included are the following:

Detection and Location of Off-the-Shoulder Vehicles.
Comments on an Electronic Highway--Some Specific Techniques and Suggestions for a Test Roadway.
Development of an Electronic Highway Aid System.
A New Vehicle Guidance and Speed Control System.
Pilot Study of the Automatic Control of Traffic Signals by a General Purpose Electronic Computer.
Traffic Pacer.
Intersection Traffic Control Through Coordination of Approach Speed.
Methods of Traffic Measurement--Determination of Number and Weight of Vehicles.

13. "Electronics traffic controller computer demonstrated by Connecticut Highway Department at Eastern States Exposition", NER3A 42: 12-13, 12-14, Sept 21, 1963.

14. "Electronic control of highways", Minnesota Highway News November 22, 1963, p 1-2.

Minnesota Highway Dept. has joined Michigan and 10 other State highway departments in operation of nation's first experiment in electronic control of freeway traffic.

15. "Electronic traffic surveillance and control", Nat'l Research Council--Highway Research Board n 10, 76p.

The five papers or reports included in this book were presented at the 42nd Annual Meeting of the Highway Research Board on the subject of electronic traffic surveillance and control.

16. "Electronic traffic control system", Commonwealth Engineer 43: n 9, p 291, April 2, 1956.

A traffic system using an electronic brain is in use at Slough, a busy town near London. It is the first of its kind in Britain, and probably in the world. Side crossings on the main street are controlled by a new system of light signals linked together electronically in such a way that pedestrians can cross more safely and traffic can move faster than formerly.

Pedestrians wishing to cross press a button provided at each signal and receive their directions by a green-lit "Cross" or a red-lit "Wait" sign. Drivers, once they have entered the controlled length of road, should not normally have to stop again before leaving the system, which extends 650 yards. The traffic moves forward in steady waves and the pedestrians cross safely between the waves. This is accomplished by the novel arrangement of a number of traffic signal components.

In addition to the pedestrian press buttons, there are vehicle-actuated pads in the roadway near each signal and, at one end of the system, a vehicle-counting device. These pads feed messages into the master controller, which controls the lights so that they operate in a progressive pattern, which varies according to the volume of traffic on the road at the time. At peak periods the longest waiting time for a pedestrian will be about 45 seconds, approximately the same as that for the driver waiting to enter the system at either end. During slack periods the maximum wait will be less.

17. Elektrotechniek en verkeersbeveiliging," Ingenieur 70: n 22, May 30, 1958, p E57-66 (discussion) E66-7.

Electrical engineering and traffic safety; Principles of traffic control by means of automatic traffic signals, G. H. ter Beest; Automation and traffic safety, J. M. Scheffer.

18. Gerlough, D. L., "Simulation of freeway traffic by an electronic computer", Nat'l Research Council--Highway Research Board Proc 35: 1956, p 543-547.

The electronic computer offers promise of becoming a powerful tool in studying the flow of traffic on freeways. To program such a problem for the computer the engineer must quantize time and distance. For input data he must have as a minimum a distribution (measured or assumed) of desired speeds and a distribution of input time-spacings. Additional phenomena which may be handled included vehicle length, following practices, passing practices, and time within system. For the

treatment of such problems there are available two markedly different approaches each of which is discussed.

Exploratory studies indicate qualitative agreement between results and expected behavior.

19. Gerlough, D. L., "Traffic inputs for simulation on a digital computer", Nat'l Research Council--Highway Research Board Proc 38: 1959, p 480-492.

The relative merits of observed inputs and generated inputs are discussed. It is pointed out that where generated inputs can be used, they have a decided advantage from the standpoint of computer time.

A method of generating Poisson inputs is described. Several sets of inputs have been generated by this method and tested statistically. The results of these are given.

Time spacings of vehicles entering a system are approximately exponential. Methods of adjusting the exponential to obtain greater realism are discussed. Methods of computer generation are described.

20. Glennie, A. E., "Automatic programming", Data Processing 1: n 1, Jan-Mar 1959, p 26-9.

Simplified techniques for programming of electronic digital computers; how computer may be arranged to recognize instruction in written English and convert these into more detailed instructions needed to operate machine; examples are given from automatic code already in use.

21. Gobiet, G. and G. Oberdorfer, "Automatic traffic control systems", Elektrotech u. Maschinenb 78: n 14, 1961, p 446-51. (In German).

Automatic signal control systems are discussed under the following headings: (1) electro-mechanic systems, (2) electronic-electromagnetic systems, (3) fully electronic systems, and (4) co-ordinated control systems.

22. Goode, H.H., "The application of a high speed computer to the definition and solution of the vehicular traffic problem", J Operat Res Soc Amer 5: n 6, 1957, p 775-93.

Mathematical models employed in operations research are analytic or numerical and deterministic or stochastic. A stochastic model for traffic studies is discussed, a treatment of intersection problems by a computer is examined, and the capacities of various types of computer are compared. It is considered that computers are useful for solving day-to-day traffic problems, offer possibilities of finding solutions on a simulation basis to complex congestion situations and provide a means of determining the most suitable way for area control of traffic in urban areas.

23. Goode, Harry H., Carl H. Pollmar and Jesse B. Wright, "The use of a digital computer to model a signalized intersection", Nat'l Research Council--Highway Research Board Proc 35: 1956, p 548-557.

A method for modeling a signalized intersection on a digital computer is developed and used to estimate delays as a function of cycle time, furn fraction, green time and cars per hour. The method is compared with other techniques and a prognosis is made for its future use.

24. Granger, Bill, "Why Metro bought a traffic computer", Civic Administration August 1963, p 59.

Used to control 100 traffic lights in a three-square-mile downtown area and plans are made to control 700 lights with the computer in less than two years.

25. Grimsdale, Richard L., Ronald W. Mathers and Frank H. Sumner, "An investigation of computer-controlled traffic signals by simulation", Proc Institution of Civ Eng 25: paper 6645, pp 183-191, June 1963.

Some experiments in computer-controlled traffic signals have been done using the Mercury digital computer at Manchester University. The road network which contained the traffic signals was simulated on the same computer. The object of the experiments was to investigate some methods of centralized computer-control of traffic signals and in particular the provision of signals indicating the best routes between points in the network.

The idea behind the control methods, designed to eliminate traffic jamms, was to limit entry of vehicles to insure freedom of movement for vehicles in the heart of the network. It is suggested that in practice the first control wherein the entry

limits were made the same for all sources but dependent on the congestion, and the third type of control wherein the limits were kept constant at a figure sufficient to allow a reasonable flow rate in normal circumstances, may be used in conjunction in such a way that the control operation is divided into two separate periods. The first period, called the "learning" period, would be devoted to finding a suitable limit to impose on vehicle entry. Following this would be the second period, the normal working period, when the system operated with the constant vehicle entry limits calculated in the first period.

The operation of the method of routing control proved successful in the model, although the improvement in flow rates was not great. It is possible thatthe time-saving thresholds, below which changes in advice are not considered (at present constant at 10 percent), could be made variable to prevent the routing advice for a journey being changed too frequently.

26. Hassel, E.W., "VHF radion coordinated traffic light control systems", Inst Radio Engrs--Trans on Vehicular Communications PGVC-7, Dec 1956, p 1-9.

How radio coordinated traffic light control permits elimonation of conventional multiconductor cable which must tie together all traffic lights in system; features of systems using v-h-f carrier modulated with a-f control tones which permits radio coordinated system to perform same as with use of cable and which offers additional benefits; conventional traffic light control equipment used.

27. "Improved road traffic signalling detector", Engineer 188: n 4892, Oct 28, 1949, p 500.

Improvements made in design of "Autoflex" vehicle detecting system introduced by Siemens and General Electric Railway Signal Co; in its improved form pneumatic electric detector derives its increased sensitivity from mechanical simplification obtained by using electric interlock to prevent actuation of signals by vehicles crossing mat in wrong direction.

28. Livesley, Robert K., "The place of digital computers in civil engineering", Proc. Inst of Civil Eng 15: papger n 6402, pp 15-34, January 1960.

The paper describes the development of automatic digital computers with particular reference to their present and possible future use in civil engineering practice. Three applications of computers, the elastic analysis of square floor slabs, the analysis and design of steel frameworks, and the design of a dual-carriage motorway, are discussed in some detail; but these are included largely as illustrations from which general conclusions can be drawn. The paper concludes with a discussion of some of the practical points which arise when solving engineering problems on computers

29. Malfetti, James L., "Electronic techniques for traffic control and safety", State Government 31: n 8, p 240-244, Autumn 1958.

Dramatic postwar progress in the application of electronic controls to the operation of ships and planes, as well as in automation, transportation, computing and a thousand other applications, inevitably suggested a role for electronics in the management of highway traffic for the reduction of accidents.

It was natural that these developments should be of lively interest to the Safety Education Project at Columbia University, newly established under a grant from the American Automobile Association Foundation for Traffic Safety, to "explore new methods for reducing highway accidents." The Project in May 1958, invited to Arden House, Harriman, New York, leaders in electronic research, administrative officials, highway and traffic engineers, representatives of the automotive industry, and specialists in medicine, psychology and law to exchange ideas on the development and application of electronic controls to traffic safety. After three days of discussion these 55 experts reached agreements and recommendations that offer a suggested blueprint for a wide-ranging and hopeful program to reduce accidents on the highway.

30. Mayr, R., "Cologne's automatic traffic control system", Traff. Engng &Control 4: n5, 1962, p 256-9.

A network of green wave signal systems is described. When completed the network will be divided into eight automatically controlled areas and co-ordinated

by a central station. Among the devices being used are speed indicators for drivers enabling them to obtain green waves despite varying distances between intersections, and pre-signals to avoid time waste in starting up at junctions. A "breathing green wave" system which adapts automatic control to traffic needs in vehicle-actuated. The distance between pedestrian signal crossings has reduced from 500 to 250 m without impairing traffic flow. The green wave system has increased capacity at one complex intersection (the Heumarkt) by 35 per cent and accidents have fallen to anormal level.

31. Miller, Alan J., "A computer control system for traffic networks", Paper presented at the 2nd International Symposium on the Theory of Road Traffic Flow, London, June 1963. Univ. of Birmingham Graduate School in Highway and Traffic Engineering Publication No. 3, 1963, 45p.

A data-sampled system is described for the computer control of traffic in urban networks. A digital computer is fed with data from detectors placed at the approaches and stop lines for every junction. Three forms of control are mentioned in this paper: namely, timing control, quantity control, and route control. Of these, only the first is described in detail.

In the timing control system proposed, the computer scans each junction at regular intervals of h seconds (about every 2 sec) and makes a decision as to whether to change the signals or to leave them as they are. These decisions are based on estimates of the relative delays which will be incurred if the signals are changed immediately, in h sec time, 2h sec time, etc. The signals are left unaltered unless it appears that least delay will result from an immediate change. When controlling networks in which the junctions are sufficiently close to merit linking, the computer includes delays which vehicles are likely to experience one junction further on, in its delay calculations.

Both fixed and flexible systems of linking in networks are discussed, and the concept of "almost common denominators" (analogous to the natural frequencies of mechanical systems) is introduced.

To determine the effectiveness of the proposed timing control system, a program has been written to control computer-simulated traffic. Preliminary results suggest that the cost of delays saved by operating a computer control system such as that described, compared with the best existing alternatives, should exceed the additional installation and operating costs but possibly not by a great amount.

This research forms the first part of a program of research into area traffic control which it is hoped will be conducted at the Highway and Traffic Engineering School of Birmingham University.

32. "New control system to speed traffic in Lincoln tunnel south", Transport Topics No. 1476, November 25, 1963, p 43.

Traffic flow in New York-bound (south) tube to be speeded by a system using automatic devices to measure vehicle flow, traffic lights controlled by electronic computers, closed circuit television and radio-equipped catwalk cars.

33. Newell, G. F., "Statistical analysis of the flow of highway traffic through a signalized intersection", Quarterly of Applied Mathematics 13: n4, 1956, p 353-369.

The paper gives a report on some calculations of the statistical distribution of delay times due to a fixed-time traffic signal on a single-lane roadway. A model of a traffic signal is proposed leading to a set of dynamical equations describing a relation between the times at which cars leave the signal in terms of the times of arrival. Some equations are then derived for the conditional probabilities that a car will leave at any specified time if it enters at some given time; it is assumed that the time intervals between incoming cars form a set of independent random variables and that it is desired only to obtain the equilibrium solutions for which the arrival time of any individual car has a constant probability density. A procedure for obtaining approximate solutions of these equations is derived, which gives exact solutions for the special case in which the cars arrive at equally spaced time intervals. This procedure is also applied to obtain first and second approximations in the special case in which cars arrive with the maximum disorder in spacing possible for this model. It is found that to a first approximation it makes little difference what statistical assumptions are made for calculations of average delay.

34. "New type automatic stop signal forces slow down at sharp curve", The Police Chief 21: n 9, p 18, September 1954.

An electrically-operated signal to force a slow down in the speed of cars is now in operation at a sharp curve on Route 11 highway near the village of Philadelphia in upstate New York. The spot has been the scene of fatal accidents in past years.

The American Public Works Association describes the system as involving the coordinated use of a traffic light with a series of speed-measuring detector plates that have been inserted in the road. The setup is known as a vehicle-actuated speed-control signal.

It will be in effect day and night. It replaces a flashing amber light, previously used on the curve.

An overhead suspension-type traffic light has been installed at the curve, and speed-measuring detector plates have been built into the road, flush with the pavement. The signal facing traffic coming into the village will be normally red. But it will change from red to flashing amber when cars drop in speed to below 25 mph., thus permitting a cautious movement of traffic around the curve. If approaching cars do not slow to below the 25 mph. mark, the light will stay red. In this way, motorists will be forced to cut their speed to observe the stop signal.

The detector plates send electric impulses that control the colors of the signal. When the speed of the cars falls below 25 mph., the plates relay an electric impulse that changes the light from red to amber.

35. Olson, P. L. and R. W. Rothery, "Driver response to amber phase of traffic signals", Operations Research 9: n 5, Sept-Oct 1961, p 650-63.

Observations, lending no support to hypothesis that drivers tend to 'take advantage' of long amber phase by treating it as extension of green; results of study are compared with other investigations pertaining to amber phase lengths, and implications of this work for design of amber phases are discussed.

36. "Radar apparatus gives green light to street most crowded with cars", Traffic Engineering 24: n 11, p 425, August 1954.

Radar, which has had plenty of practice guiding planes through the air and ships over the sea, has been put to work on another transportation problem--preventing delays for harried motorists caught at traffic-jammed intersections.

A New Haven, Connecticut, firm, Eastern Industries, Inc. (Automatic Signal Division), has already installed a radar setup to direct cars and trucks at a corner in Norwalk, Connecticut, and now reports similar equipment will be sold shortly to help stop tie-ups on overworked streets and highways all over the country.

The radar is used as a detecting device to control red and green traffic lights, sensing how many cars are moving into the intersection from each direction and rotating the lights accordingly.

37. "Radio controls traffic signals", Eng News-Rec 166: n 10, Mar 9, 1961, p 53-4.

Washington, D.C. has radio control at 825 of its more than 1000 signalized intersections; Detroit has radio controls at 50 intersections; New York City, which is testing radio controls at 8 intersections, plans to install them at 50 crossings next year; system consists of electronic programming equipment in centrally located station, radio transmitter and antenna system at strategically located positions, and combination receiver-decoders for traffic signals at street intersections.

38. Radzikowski, H.A., "Development, use and exchange of electronic computer programs", AASHO Proc Dec 1-5, 1958, p 418-431.

Almost three years ago, interest was first centered in the potentials of the electronic computer as a highway tool. It became apparent that if we were to accelerate the use of the electronic computer in highway engineering and administration, it would be necessary to minimize duplication in the development of electronic computer programs.

It takes considerable time to determine whether the use of a program for a particular highway function

is feasible. Another period of time is consumed in reviewing the basic theory and in determining the appropriate mathematical solution. Time is also consumed in determining minimum input data requirements and the form in which it should be furnished the computer. It is also necessary to devise and diagram the actual steps necessary to perform the calculations in the form of a flow chart and finally, it is necessary to establish the form in which the results of the computation should be tabulated. These steps cover about two-thirds of the work necessary to develop an electronic computer program. The remaining one-third of the work is in translating the instructions for the solution of the problems into machine language, in code on punched cards or tape and in "de-bugging" the coded program.

In order to avoid duplication in the above described two-thirds of the program development task, the Federal Highway Administrator established an electronic computer program library in the Division of Development of the U.S. Bureau of Public Roads. A total of 180 electronic computer programs from 17 State highway departments, the Bureau of Public Roads, 20 consultants, the Corps of Engineers, the Massachusetts Institute of Technology, and other organizations covering a wide range of applications in the fields of highway and bridge engineering are now listed in the library. Of this number 84 programs are in the field of highway location and design including earthwork quantity computation, 62 are in the structural field, 11 in traffic, 5 in soils, 4 in hydraulics, 1 on cost accounting and 13 largely in quantity computation, bid analysis, trigonometry and geometry. Electronic Computer Program Library Memorandum No. 4, listing all of these programs, accompanies this report.

Today, 42 State highway departments and an even larger number of highway engineering consulting firms are using electronic computers in their day-to-day operations. This remarkable progress is a tribute to the unity of the highway profession and the willingness of State highway departments and consulting firms to pool their efforts for the common good. It is an accomplishment of which we can all feel proud.

39. Rice, P. W., "Traffic control in Evansville, Ind. in 1955", Am City 70: n 12, Dec 1955, p 111, 113, 115.

Present traffic difficulties enumerated; in effort to modernize traffic control system, electronically interconnected traffic controllers are to be installed; f-m radio controlled method eliminates need to excavate under streets or need for overhead cables for interconnection; disruption of traffic load is held to minimum; other advantages.

40. "Robot traffic cops to change signals", Bull New York City Dept. of Traffic 2: n 2, pp 1-2, October 1954.

A robot traffic signal which calculates mathematically when to switch lights from red to green and from green to red will be installed at selected intersections in New York.

This device is an intricate controller, working on electrical impulses produced by the number of cars rolling over heavy rubber pads set in the roadway. These pressure detectors respond to the cars' weight by squeezing wires together and shooting electfical impulses to close a circuit in the control box of the signal.

Eight rubber pads will be installed at a distance of from 200 to 300 feet from the signal depending on the geographical location of the intersection. Underground wires connect the pads to the control box.

Certain maximum and minimum time limits are set by an adjustment of the control box dials so that, if traffic is very light during periods of the day and night, there will be no unnecessary waits by motorists for light changes.

For a short time engineers will adjust the dials on the machine to determine how the traffic will flow. After engineers set the dials, the robot, which costs $10,000, will take over like a traffic cop.

41. Rockwell, T., C. Algea, and G. Chubb, "Human factors research in the use of electronic devices as traffic aids", Traffic Safety September 1962, p 10-16.

Currently the Ohio State University is studying the

use of electronic devices as traffic aids. While techniques of vehicle guidance are being investigated concerning both longitudinal and lateral control, human factors studies are also being conducted on what aids the driver needs. Human Factors is concerned with the contribution that man makes to any man-machine system. Unless systems are designed with the knowledge of human response, the most elaborate machine components of the man-machine system are limited. Until the driver is replaced in our present highway system, he is one of the major limiting factors in system improvement. If the use of electronic guidance devices are to be effective, we must know how the driver will respond to guidance information, the variation in his response and his acceptance of such assistance. In addition, the use of electronic devices must seek to relieve rather than add restrictions to the present driving task. Until we learn more about the driving task, optimum design of highways and vehicles is not possible.

42. Schuremen, L. R., "Electronic computer in highway engineering", ASCE--Proc 85: (J Highway Div) n HW3, Sept 1959, Paper n 2146, p 37-61.

Electronic computers, their functional components, and operation; procedure for use in solution of engineering problems and especially highway engineering problems.

43. Sehgal, T. R., "Use of electronic computers in road traffic research", J. Sci Industr Res., New Delhi 21A: n 9, 1962, p 424-9.

Computers are important aids to statistical analysis when a formula requires working out over wide ranges of the variables involved, when insight into a problem can be obtained by simulating field conditions by means of a model, and in traffic control. An example of simulation of road traffic is given, based on one of a number of programmes developed on a Mercury Electronic Computer by the Computing Unit at the University of London.

44. Smeed, R. J., "Traffic flow", Operation Research Quart. 8: n 3, p 115-23, discussion, 142-8, 1957.

This paper forms part of a symposium on the dynamic instability of transport systems held by the Operational Research Society. Traffic delay is considered at intersection controlled by fixed-cycle signals when the intersection capacity is great enough for the traffic which arrives (a) at equal intervals, (b) at random; graphs show the relation between delay and traffic flow obtained by calculation. The correlation between delays experienced by successive vehicles arriving at an intersection is low for small traffic flows but increases rapidly as flow increases.

Traffic behavior, when an interaection becomes overloaded, is illustrated by practical examples which show that drivers in urban areas tend to choose alternative routes while holiday traffic tends to form queues. A theoretical example shows how a vehicle parked near an intersection for 20 min may result in a queue which takes 140 min to clear. Traffic jams at roundabouts may result from inconsiderate driver behavior, vehicles parked close to the exits, or pedestrian crossings. This paper was prepared at theRoad Research Laboratory, Harmondsworth.

45. Stark, M.C., "Computer simulation of street traffic", Nat'l Bureau of Standards, Wash., D.C., Technical Note 119, November 1961. U.S. Government Research Reports PB 161 620, 94pp.

An element-by-element computer simulation of the volume and movement of traffic on a nine-block section of 13th Street N.W., in Washington, D.C. is described. A stochastic process is used, in which the input parameters defining the operating and physical characteristics of the cars are controllable within narrow ranges. The computer reviews each simulated car every quarter second and moves it according to rules for movement which are applied by 37 main routines and sub-routines of the computer program. The simulation run on the computer produces two outputs. The quarter-second car positions are plotted on an oscilloscope and photographed, which result in a moving picture like an animated cartoon, so they can be seen in real time. The other output is a series

of tables issued by the computer. These tables catalog all vehicles as they enter the model, clock and count them as they pass a key intermediate point, and finally, check them out at the end of the course, counting them again and noting their individual running times.

46. "Study of electronic devices as traffic aids: annual report", Transportation Engineering Center, Report No. 202-1, Engineering Experiment Station, Ohio State Univ., Columbus 10, Ohio, July 1962, 152p.

A coordinated program of research on the use of electronic devices as traffic aids has been pursued by the Ohio State University's Engineering Experiment Station, since 1959. Two earlier reports have been issued. The following accomplishments of the past eight-month period are provided in the following.

1. Progress in traffic dynamics with a view to the design of logic system can be summarized as follows:

(a) The IBM 1620 computer was programmed to simulate car-following and platoon dynamics through the use of the Hermann Equation which states that acceleration is proportional to the ratio of relative velocity and head $A = C(RV/H)$. The behavior of the first car is specified and motion of the following cars depends on time lags and bounded acceleration rates. Simulation continues until a collision or a stable platoon situation is reached.

(b) The Block Systems Dynamics have been analyzed for a servo-mecahnism approach. Such a system activates blocks in a highway after the vehicle passes these blocks. Use of servo-mechanisms with the block system considered was found to be unsatisfactory over the range of velocity and traffic conditions normally encountered in highway traffic.

(c) The logic circuits and electronic circuitry of a rear zone of influence control system have been developed.

(d) The mathematical model of the passing maneuver for the two-lane highway is written in terms of computer operations. It encompasses the velocities, platooning, and acceleration.

(e) A system for measuring and recording highway data has been developed. This system is based on a fine wire stretched across the highway.

2. The driving task has been examined with a view to the design of electronic systems. The following results involving the driving task were obtained:

(a) The early model of the driver-vehicle system placed the role of the driver as that of an error signal amplifier in a linear continuous feedback control system. Further research has shown that the driver reacts to both velocity and acceleration and is better explained as an integrator as well as an amplifier on the error signal.

(b) Driving simulator studies for the single-lane car-following situation show that the driver makes changes on the basis of decision points. These decision points may be a subconscious phenomenon.

(c) Driver variability studies were conducted on the stopping of a vehicle. Fatigue, driving experinece, and the type of stop were investigated. Although interesting relationships were found with experience and type of stop, the general hypothesis that drivers will attempt to minimize the rate of change of deceleration and will not exceed a maximum deceleration was supported.

3. A study of the application of electronic control devices has been initiated and has investigated possible use in various highway situations, and under various degrees of application. The need for specific criteria for the use of electronics is pointed out.

47. Twiss, F.E., "Centralized control of a metropolitan signal system", Traffic Engng 32: n 10, 1962, p 20-3.

The system used in Wash., D.C., is described. By combined radio and underground wire communications, a master controller supervises the signals at 780 intersections. It is operated from a punched standard computer tape. A 7-day programme changes signals from normal operation to cycles suitable for peak-hour traffic and makes other signal changes to suit special conditions.

48. Ward, Kenneth L., "Will laser replace radar in speed measurement and signal control?" Traffic Digest and Review 11: n 4, p 17, April 1963.

The laser, not even invented until 1960, alreadyis the subject of numerous research programs aimed at developing it for use in many fields, including traffic law enforcement, and traffic engineering.

"Laser" is a coined word obtained from a functional description--Light Amplification by Stimulated Emission of Radiation. Basically, laser amplifies and concentrates light energy into a narrow beam. Translated into practical terms, this means that most of the light energy is utilized and high levels of energy can be transmitted and focused into extremely small areas.

Some daylight frequency radar--the laser--may replace radio frequency radar in police and traffic engineering. Laser light can be focused in such a narrow beam that it is much more accurate than conventional radar.

The laser may some day enable police to pinpoint individual speeds at an accuracy presently unattainable. For example, through precise aiming it could differentiate between approaching and receding vehicles on two-lane roads. It could, on multilane trafficways, differentiate between vehicles traveling in the same direction, but in different lanes. Vehicle size would offer no problem--one and only one vehicle would be detected at a time.

Laser devices could measure traffic density and vehicle speed, making them invaluable for traffic control.

Efficient use of trafficways is vital. Various surveillance devices are being studied for future application. While the laser is, for the most part, still in the laboratory stage, it is an example of what can be taken from other technologies and applied to the broad field of traffic.

49. Wardrop, J. G., "The capacity of roads", Operational Research Quarterly 5: n 1, pp 14-24, March 1954.

The capacity of a road may be defined as the flow of traffic which moves at the minimum acceptable speed. The arbitrary element in this definition is that there is no obvious way of deciding what the minimum acceptable speed should be.

A method is outlined for measuring the capacity of town streets in terms of mean running speed and total traffic flow. A similar method applicable to rural roads is described.

Controlled intersections in towns are of the utmost importance in determining capacity. On main routes in central London about 35 percent of traveling time is consumed in delays caused by intersections.

It is shown that delay at signalized intersections increases rapidly with increasing flow and that there appears to be a definite limit to the flow. The limit is reached when the average number of arrivals per signal cycle is equal to the maximum number discharged while the light is green. Under this condition small random fluctuations in traffic produce large increases in delay. Because of the large variations, empirical methods are not satisfactory. The fact that vehicles are so confined in their movements at a signal means that synthetic methods can be applied, using a mathematical model for the behavior of the traffic, either theoretically or by simulation. By use of the computing methods, it is possible to compare the delay-flow curves for a fixed time and a vehicle-actuated signal and to determine the settings which will give the least overall delay for fixed-time signals.

To avoid the arbitrary factor of "minimum acceptable speed" and to obtain a firm basis for decisions, the author suggests that capital investment and profit must be taken into account, balancing the cost of improved or new roads against the financial benefits to be expected from savings in time and materials.

50. "Washington, D. C., to install world's largest radio traffic control system", Municipal South 6: n 5, pp 33-34, May 1959.

Central control for traffic lights at 86 intersections in Washington, D.C., is provided for in a $167,000 contract executed by commissioners of the District of Columbia.

It is considered the world's largest radio traffic control system.

The use of radio will save the District of Columbia and public funds in excess of $2 million.

The system of radio traffic control will provide a compatible, flexible and reliable method of centrally coordinating and synchronizing traffic lights through use of the most recent advances in electronics.

By the transmission of tones, the system controls standard controller functions such as dial selection, off-set selection, off-set synchronization and any other special conditions which the local controller is capable of instituting.

Illuminated traffic signs can be energized at dusk at interchanges, street lights can be controlled at interchanges, all functions this system can perform while eliminating the costly installation of conduits and cables at remote locations.

The system works from a central programmer, which can be set up to provide a simple clock-type device or a complex punched card or tape system, depending on the number of program changes desired.

Information from the programmer is translated by a coder into tones which are then transmitted by radio to F. M. receivers at each intersection. Here a decoder re-translates the tones to initiate the desired program or function desired, which is set up in the local controller.

A central expandable control panel shows the latest program of function transmitted to each intersection or function, and also provides manual control of selected functions.

The system is easily expandable to enable more than 1,000 group or intersection selections, with up to 18 control functions per intersection.

51. Webster, F. V., "Traffic signal settings", Great Britain Dept Sci & Indus Research--Road Research Laboratory--Tech Paper n 39, 1958, 44p.

Delays at intersections controlled by traffic signals have been investigated using electronic computing machine to simulate traffic conditions; formula for average delay per vehicle on single approach to intersection controlled by fixed time traffic signals has been derived; formulas have been deduced for cycle time and green times which give least delay to all vehicles using intersection.

52. "What effect signals? Lab to find out", Automotive News n 3780, p 45, October 10, 1960.

A basic psychological study of how drivers are influenced by the signals they receive from other cars has been undertaken by Battelle Memorial Institute for the United States Bureau of Public Roads.

According to Dr. Charlotte Christner, Battelle psychologist in charge of the study, driving today is "principally a matter of information handling and decision making."

The study will attempt to define the problem of communication between vehicles. To do this the psychologists will make a detailed analysis of the driving task, investigate the kinds of information the driver needs to make decisions and determine ways to transmit this information. In addition, they will try to establish standards of driver performance and develop a plan for future experimental research.

According to Battelle psychologist Horace W. Ray, the amount of information a driver has to handle may affect his performance significantly. The available evidence indicates that dangerous situations may occur when there are too many signals from too many cars in too short a time, such as on a crowded highway with many intersections, or when there are many signals over a long period of time, such as on a long trip over heavily traveled roads.

At the other extreme, when there are too few signals over a long period of time, such as on a long trip over a lightly traveled superhighway, a driver may become drowsy or inattentive.

Future research may be directed at specifying the amount of information a driver can handle and at what rate and for what period of time. This may make it possible to determine the relationship between the information received by the driver and the efficiency of the traffic flow. Finally, the findings may be applied to specify highway problems.

53. Wiley, T. T., "Electronics and traffic control. A panel discussion" (Wiley-Chairman) 1958 Proceedings, 28th Annual Meeting. Miami Beach, Florida, November 10-13, 1958: Institute of Traffic Engineers: Washington, D.C., undated pp 146.

54. Wooldridge, Thompson Ramo, "Study of the traffic signal system in a portion of the District of Columbia, Final report 1: Study techniques and results by F. A. Wagner, J. B. Rudden, and D. L. Gerlough. Canoga Park, Calif. 1963 1 v (various pagings) Processed. Submitted to the District of Columbia, Dept. of Highways and Traffic under the terms of Agreement 1919, April 5, 1963. In cooperation with U. S. Bureau of Public Roads.

Purpose of the study was to simulate on a computer, a grid system of signalized streets and to compare various signal timing plans assuming total delay as a measure of effectiveness. The area selected as a pilot area by personnel of the D.C. Dept. of Highways and Traffic is bounded by Upshur Street, Euclid Street, Rock Creek Park, and the U. S. Soldiers' Home.