REPORT OF THE

Committee on Measures for the Relief of Traffic Congestion

APPOINTED BY
THE SECRETARY OF COMMERCE

As Revised and Approved by the
Third National Conference on Street and Highway Safety

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NATIONAL CONFERENCE ON STREET AND HIGHWAY SAFETY

Report of Committee on Measures for the Relief of Traffic Congestion

Hon. Robert P. Lamont, Chairman,
National Conference on Street and Highway Safety,
Washington, D. C.

SIR: Four years ago, the Committee on Metropolitan Traffic Facilities of the National Conference on Street and Highway Safety presented an estimate of the cost of traffic congestion and an outline of the factors involved in this congestion and its reduction. It also made recommendations with which your present Committee is in substantial accord relative to organization for treatment of the problem.

Since that report was made, much progress has been made in the development, evaluation and utilization of measures for the relief of traffic congestion. Other committees of the Conference have drafted uniform state and local legislation designed to alleviate conditions so far as this can be accomplished by regulations, and have worked out standards for signs, signals and markings which should materially simplify traffic control and thereby aid in reducing congestion. Engineers and traffic analysts have been constantly at work and have devised improvements and reached definite conclusions regarding the utility of various proposals for congestion relief.

Your present Committee's recommendations are presented herewith.

By the Committee,
E. J. MEHREN, *Chairman.*

Washington, D. C.
May 1, 1930.

The Traffic Problem

That traffic congestion on the streets and highways of the United States involves tremendous daily costs in time, money, annoyance, physical injury and loss of life is a matter of common knowledge. The Committee is convinced, however, that it is not a necessary evil—that it can be alleviated and to a very large degree eliminated by careful study and judicious expenditures for immediate relief measures and permanent improvements and by sound control of land use. All cities should look forward to their future needs and plan now for coming requirements for adequate handling of the traffic problem. To this end continuing study and sound engineering advice are essential.

It should be appreciated that the present report presents only a summary of present practices in the field of traffic relief. A vast amount of data is available and is developing currently which should be correlated and made use of regularly.

In the preparation of this report, however, the Committee has been impressed with the lack of data in well organized form on many important features of the problem. It strongly urges that some central agency of the Federal Government be empowered to conduct cooperative research in this field and to coordinate and make available the results of these and similar studies.

Some of the Committee's recommendations will be applicable to virtually all communities. Some will be appropriate only in the larger cities. Each community inevitably has its individual problems and must be prepared to make rational expenditures based on its particular needs.

SUMMARY OF CONCLUSIONS

The Committee submits the following summary of its findings and recommendations:

Traffic Congestion—What It Costs

1. Conservative estimates indicate that traffic congestion is costing the people of the United States annually in excess of $2,000,000,000 and that the cost is increasing each year.

Organization for Congestion Relief

2. In view of the improvement in traffic conditions that can often be effected at costs relatively small in comparison with the

benefits, there should be increased expenditures in most communities on measures for the relief of traffic congestion.

3. Such expenditures can be made most effectively in accordance with a comprehensive plan developed by competent technical study.

4. Each municipality faced with serious traffic problems should have a traffic commission with appropriate official and citizen representation.

5. Each such municipality should have the continuing service of an engineer with specialized traffic and transportation experience.

6. All traffic plans and revisions thereof should be based upon data secured through continuing up-to-date traffic surveys.

7. Metropolitan areas should be organized for coordinated treatment of their traffic problems.

Causes of Traffic Congestion

8. There are three fundamental causes of traffic congestion:

a. Inefficient and conflicting use of available street and highway space, resulting in a disorganized, chaotic condition of traffic.

Examples of this are the mixing of all types of traffic, ineffecive traffic control, inadequate or unenforced parking regulations, and in general those matters subject to regulatory control.

b. Inadequate street and highway systems.

Examples of this are lack of sufficient arterial routes, local bypass routes, bridges and wide streets; improperly designed intersections, and uncontrolled growth of communities or groups of communities without definite street and highway plans.

c. Inadequate control of land use with respect to its economic relationship to traffic and transportation facilities.

Location of Congestion

9. Except on a few major thoroughfares connecting large centers and at a few major intersections, there is normally no serious congestion on rural highways outside of metropolitan areas.

10. Traffic congestion usually exists in the following general areas, particularly at the times of heavy daily flow of traffic:

a. In the central business districts (retail, office, theater and hotel) of nearly all cities and towns, large and small, through the existence of all three of the above mentioned primary causes.

b. In the outlying subcenters of the larger cities, in many of which conditions of congestion are approaching those of the central areas.

c. In industrial, freight terminal and similar districts, where loading and unloading requirements, turning movements, the number of large and slow-moving vehicles and other factors render difficult an orderly flow of traffic.

11. It also occurs at the following specific points:

a. At intersections of major urban and rural thoroughfares.

b. At railway grade crossings where both rail and highway traffic are heavy.

c. At highway entrances to large cities where, due to lack of coordination of road work of adjacent jurisdictions, bottlenecks are frequently found.

d. At the convergence of heavy thoroughfares where there are insufficient distributive routes.

e. At narrow bridges, underpasses, tunnels, small towns on heavy traffic routes, or other points where the number of lines of traffic are reduced, and on excessive grades and at abrupt turns on major streets or highways.

f. Where the roadway pavement is uneven or otherwise inadequate.

g. At entrances to baseball and other amusement parks, race tracks, theaters and similar places where extraordinary peak demands are placed on facilities normally adequate.

Remedies

12. Effective and lasting remedies for traffic congestion must recognize the three primary causes of congestion; that is, they must put the available facilities to the best use, provide the needed capacity requirements and properly control land utilization. They thus divide into immediate relief measures and a

program of permanent improvements, which will include control of land use. Since all growing communities face the problem of traffic congestion, they should give serious attention to both types of remedies.

13. Immediate relief measures which may be effective when adapted to the needs of the individual community are:

a. Adequate control of traffic at important intersections, by suitable standard signs, by police officers or, where warranted, by properly designed and coordinated traffic signals.

b. Standard rules governing turns, and restriction or prohibition of turns where they would otherwise unduly impede traffic.

c. Marking of traffic lanes, particularly at intersections, to induce orderly use of the available roadway space.

d. Parking regulations, properly posted, which establish the proper balance between the needs of moving traffic and reasonable opportunity to leave the vehicle at an accessible point during the transaction of business.

e. Restriction of loading, moving and unloading of certain materials, such as coal, city refuse and building supplies, to hours of light traffic.

f. Prevention of unnecessary street openings and roadway and sidewalk obstructions; control of work necessitating street openings or other obstruction to traffic on major arteries and in business districts by confining daytime work to minor repairs during hours of light traffic and to emergency work, and expediting major projects by day and night work.

g. Establishment of through highways, adequately marked, to expedite movement on a few carefully selected arterial and by-pass routes.

h. By-passing of through traffic, including local traffic not originating in or destined for the congested district, by clear marking of, and publicity regarding, optional routes.

i. Designation of one-way streets under the special conditions where this is justified—generally where the streets are narrow, and where by one-way movements in opposite

directions on parallel streets they can be better adapted to the traffic demands.

j. Separation of kinds of traffic by allocation to different lanes on wide roadways or by diversion to adjacent thoroughfares.

k. Rerouting of street cars to eliminate avoidable turns and switching and to reduce undue concentration on one or more thoroughfares.

l. Provision of protected street car safety zones where traffic warrants and roadway width permits, to safeguard car riders, speed up loading and unloading and prevent blocking of other street traffic.

m. Protection, expediting and control of pedestrian movement by adequate facilities and regulations.

n. Discouraging of vehicle cruising.

o. Utilization of staggered hours of employment in congested sections.

p. Vigorous enforcement of traffic regulations, without which other measures are largely ineffective.

14. Permanent improvements which may be necessary to reduce or prevent congestion include:

a. Creation of an adequate plan of major thoroughfares with consideration given to the appropriate use thereon of all modern agencies of transportation—rapid transit, street cars, motor buses, commercial vehicles, taxicabs and private automobiles—so correlated as to best serve the needs of the community.

b. Improvement of street and highway intersections according to the physical conditions and traffic needs, whether by (1) widened throats, increased curb radii or creation of rotary traffic distributors, such as circles, or (2) separation of grades.

c. Elimination of railroad grade crossings where frequency of train movement results in serious delays to highway traffic.

d. Widening of roadways, including arcading in special cases, to provide additional lanes of traffic and, where space considerations and traffic demands justify the heavy expendi-

tures involved, development of two-level bridges and streets.

e. Elimination of bottlenecks to provide as uniform and uninterrupted flow of traffic as possible.

f. A continuing paving program giving primary consideration to main routes and including improvement of surfaces on streets and highways which might relieve other congested routes.

g. At certain points where pedestrian movement is concentrated and such construction is feasible, pedestrian subways or bridges, preferably with ramps or escalators.

h. Street extensions and connections to permit available street systems to render effective service.

i. Provision of parallel relief routes.

j. New through arterial highways.

k. Development of by-pass routes, according to the local needs, either around congested districts or around the entire municipality.

l. Departure from traditional methods of street and highway design. Such change might involve the construction of parkways and other "freeways" for through traffic with no direct access from abutting property, and roadways in residential districts so planned as to discourage traffic other than that needed to serve the local community.

m. Development of off-street commodity loading and unloading facilities, including the requirement by ordinance that new buildings provide within property lines such space commensurate with the size and shipping demands of the building. Areas of acute congestion should be officially designated in which loading and unloading of commercial vehicles on the street should be prohibited in hours of heavy traffic.

n. Provision of playgrounds to keep children out of the roadways.

15. As an important part of the permanent improvement program, right of way required for future roadway widening or new construction should be acquired as far as possible in advance.

16. There should be sound control of building bulks in relation to use and to street widths.

The full text of the report follows.

WHAT TRAFFIC CONGESTION COSTS

Few communities are free from traffic congestion that seriously interferes, at least for substantial parts of the time, with the safe and efficient conduct of business.

Taking into account loss of time at points in areas of congestion, and the hampering effect on business and on real estate values by reason of difficult access, the Committee estimates the annual economic loss to the American public to be more than $2,000,000,000 annually. This figure includes an estimated loss of $800,000,000 from accidents, to which lack of proper traffic facilities is recognized as being a large contributing factor.

ORGANIZATION FOR CONGESTION RELIEF

In view of the improvement in traffic conditions that can often be effected at costs relatively small in comparison with the benefits, it is probable that nearly every community can afford increased expenditures on measures for the relief of traffic congestion. This should not mean plunging into elaborate programs without careful consideration of the major factors involved, merely in imitation of other communities supposed to have similar conditions. The problem is largely one of engineering, and expenditures for the relief of congestion should be based on a comprehensive plan developed by competent technical study.

Official Traffic Commission

Aggressive and intelligent leadership is the first requisite in the execution of measures for the relief of traffic congestion, whether in cities or regional areas. This leadership should be assumed by the mayor, city manager or other head of the city administration. To be effective it must be accompanied by the definite placing of responsibility, adequate technical guidance and public support.

The formulation of traffic improvement programs and their execution touch upon the functions of many city departments, and in many cities the responsibility is divided. Coordination can be secured by the creation of an official traffic commission, which is considered desirable in most cities in excess of 25,000

population. In smaller communities the cooperation of existing local departments under the direction of the mayor or city manager or official designated by him will generally be sufficient.

The membership of such a traffic commission should include the heads of departments involved, with the addition of a member of the city council. The departments concerned with traffic ordinarily include engineering, police, fire, street, lighting, education, recreation and legal departments, city plan commission, and the public authority supervising city transit and transportation.

Various citizen groups and business interests, such as the motor clubs, chamber of commerce, safety council, retail merchants, real estate boards, insurance interests, street railway and bus companies, truckmen, building owners' associations, and others, are also vitally affected, and their various viewpoints can best be met by inclusion on the official traffic commission of representatives of these various groups. Certain persons will also be desirable members because of their individual qualifications. In general, it is believed that a commission with about one-third official and two-thirds citizen representation will be most effective.

The traffic commission should be a permanent body, holding regular meetings at stated intervals. It should have adequate funds, appropriated as are funds for other departments.

In communities which do not at present have an official commission and have not become aroused to the need for comprehensive study of the problem, action toward the organization of an official commission can often be stimulated by the various interests concerned with traffic. To accomplish this they may have to finance a preliminary survey and conduct some of the other preliminary work which would normally be directed by the official commission.

Need for Continuing Engineering Study

Continuing technical assistance can best be obtained through the employment by the city of an engineer with specialized traffic and transportation experience. The number of engineers thus qualified is as yet small, and it is important that great care be exercised to appoint the best man available. As an alternative or preliminary arrangement, particularly applicable to smaller

cities, it may be necessary in some cases for the commission to utilize the services of the engineering staff of one of the existing departments, or of outside consultants.

If a city traffic engineer is appointed, he may report to the official commission, but should preferably be attached to an existing city department. It is obviously imperative that there be cooperation between his office and the departments or divisions of the city government with which he comes in contact.

Traffic Surveys

The Committee on Metropolitan Traffic Facilities brought out in its report prepared in 1926 the need for a comprehensive traffic survey as the basis for all plans, whether for immediate relief measures or for permanent improvements. It was shown further that because of constantly changing conditions the survey should be kept up to date and all revisions or amplifications of the improvement plan should be based upon recent information. That Committee pointed out that, in most cities, there will be needed (1) a transit plan, (2) a street and highway plan, and (3) a traffic control plan, all of which must fit into and support each other. A fourth plan which is necessary is a plan for adequate control of land use in relation to traffic and transportation facilities.

Your present Committee wishes to emphasize that one type of survey is required for intelligent application of regulatory measures, while different types of studies are needed to formulate the transit plan, the master plan for the street and highway system, and the land use plan.

Aggressive action should immediately follow traffic surveys and studies looking to the early carrying out of recommendations, so that there may be avoided the possibility of criticism that facts are out of date. The recommended traffic commission can be of great aid in preventing the pigeon-holing of traffic surveys and recommendations.

Regional Areas

Generally speaking, there is no problem of traffic congestion on the open highway well away from the city and town, but there

is a growing problem throughout the areas adjacent to the larger cities. The Committee on Metropolitan Traffic Facilities noted this and pointed to the need for cooperative action among the local units affected.

The securing of such cooperation has its difficulties because of the heterogeneous character of the local units involved—cities of various sizes, villages, townships and counties—and the varying degrees to which the problems have become serious and recognized as serious in these different political units.

In a number of regional areas, however, committees or commissions representative officially or unofficially, or both, of these local units have been worked out and are functioning successfully, and it is recommended that effort be made to bring about such concerted action in all regional districts.

WHAT IS CONGESTION?

Traffic congestion implies an uncomfortable overcrowding of street facilities. The resultant friction reduces the permissible speed of vehicles and pedestrians below that to which they feel entitled.

There is not complete agreement as to what constitutes an acceptable rate of traffic flow consistent with the demands of safety and an equitable consideration of the rights of others. There is in evidence, however, an increasing impatience with the rate of travel in metropolitan areas and an insistence on average speeds approaching those possible on highways in unpopulated districts. In view of the more restricted operating conditions on city streets and the greater degree of driving caution required, there must be a realization that, except where congestion exists, speeds on city streets are in the main high enough and cannot and should not be increased except on streets designated for high speed traffic. However, in many specific cases speeds now unreasonably low because of improper and inadequate regulation or lack of proper facilities can be increased.

Serious and aggravated wastage of time occurs in certain sections of overcrowded metropolitan areas during periods of maximum traffic concentration. The present overcrowding is too often only an indication that street space is being used in disorganized

and inefficient fashion. The maximum capacity of the street system for the movement of vehicles, persons and merchandise has not been reached, except in relatively few areas. Where congestion is not the result of inherent deficiencies in the street system, the application of accepted principles of traffic planning and control may be expected to bring results more than commensurate with the cost.

Traffic congestion is not a hopeless problem, and by proper study and judicious expenditure of funds can be materially alleviated.

CAUSES OF CONGESTION

There are many elements in traffic congestion. Outstanding among these are the growth of population and increase in the number and use of motor vehicles. In the last analysis, however, these elements create congestion by reason of three fundamental causes: (1) Inefficient and conflicting use of available street and highway space, (2) excessive demands upon inadequate street and highway systems, and (3) unduly intensive use of land out of proportion to its contribution, by taxation, benefit assessments or otherwise, to the provision of necessary traffic and transportation facilities.

Inefficient and conflicting use of available street space is a condition which, although it can never be entirely eliminated in the average city, is subject to marked alleviation by effective traffic control systems, parking regulations and other control measures.

Inadequacy of the street and highway system developed without definite and farsighted planning results in the concentration of traffic on a limited number of routes with attendant congestion. It should be realized that the present street systems were never constructed for modern traffic needs. Under present conditions these highways may be entirely unsatisfactory, yet analysis would reveal that, in many cases, their utility may be greatly increased by carefully planned improvements at critical locations, and at costs much less than the losses due to the continuance of present conditions.

Mass transportation vehicles, both street cars and buses, private

and commercial vehicles and pedestrians are individually and as groups seriously affected by street congestion, and themselves in turn are contributing factors to this condition. Each of these classes has a definite place in the traffic plan which must be considered, and a proper allocation of street space must be determined upon. The lack of such planning results in confusion, disorderly movement and congestion.

Simultaneously with the application of measures for the better use of existing streets, and of improvements in street widths, street design, and intersection treatment, municipalities will be very shortsighted if they fail to approach courageously the proper economic relationship of land uses to traffic and transportation facilities. Prevention in most cases is more sensible and less costly than relief. Much can be accomplished, through wise city planning and effective zoning ordinances and building codes, to establish and maintain sound relationships between traffic and transportation facilities on the one hand and building bulks, extent of lot use, character of occupancy and grouping on the other.

As an important contribution to this end and as an example to all concerned the Committee considers that federal, state and municipal governments should give prompt consideration to the problems of traffic congestion that will arise through the erection of new buildings for governmental use. Plans for the location and construction of such structures should recognize the need for adequate street service adjacent to these areas, easy access to the buildings, requirements of employees for off-street parking, congestion incident to unit grouping and the needs of the general area in relation to such buildings or groups of buildings.

LOCATION OF CONGESTION

In approaching the matter of location of congestion, it should be realized that there are (1) areas of varying sizes in which the multitude of conflicting traffic demands produce congestion, the relief of which will probably require a number of remedial measures, and (2) points of congestion, where one or more localized remedies may accomplish relief.

Areas of Congestion

Every residential, retail business and manufacturing district has its own peculiar traffic problems, occasioned by the demands of moving vehicles on rail and rubber, the demands of standing vehicles, the necessity for commercial vehicle loading and unloading and the requirements of pedestrian movement. As the volume of each increases the problem becomes more complicated until the resultant friction produces a condition of congestion. The character of the district determines to a considerable extent the degree of congestion and the time and place of maximum traffic concentration.

Rural Districts

In rural districts traffic congestion has not in general become a serious matter except at or near the gateways to the larger cities and on a few major highways connecting the larger population centers, and at points of limiting traffic volume, such as intersections with other major highways, grade crossings of railways carrying heavy rail traffic and at other locations of less than normal traffic capacity.

Smaller Cities

Within the smaller cities and villages these conditions may or may not at present be acute, but regardless of the present degree of congestion, these municipalities will be remiss in their duty to the public if they fail to provide adequately for the present and future needs of both local and through traffic.

Central Business Districts and Subcenters

In the larger cities, congestion is usually most pronounced in the central business district and on the main highways leading thereto. At the same time subcenters are being developed for the convenience of patrons who do not care to travel to and in the more congested areas. While spreading of activity over larger areas may produce a desirable flattening of the peak traffic load at the center, it may foster in turn an undesirable degree of congestion or traffic concentration in the new subcenter, which will continue to become worse unless definite plans are made to procure adequate traffic and transportation facilities in the decentralized business areas. On the other hand, it would seem desirable

for the protection of central business areas that every reasonable means be used to provide for continued ease of travel to and in such areas through the provision of adequate street and transportation facilities, improved methods of traffic control and regulation, and sound control of land use.

The real problem in the central business districts, as concerns passenger travel, usually consists in rapidly moving large numbers of persons over a limited street system during rush hours, when the demands of business require that about one quarter of the total must be moved in only about two hours of the day. The location of railroad, motor bus and other passenger terminals is an important factor in city traffic congestion and merits special study.

In addition to the passenger travel there must be added the traffic of commercial commodity vehicles. These vehicles are as essential as passenger vehicles to the conduct of business, but in many cases the time of their maximum use coincides with the period of greatest use of passenger-carrying vehicles.

Freight Terminal Districts

Freight terminal congestion is a most important economic item in a metropolitan area, and is due primarily to a concentration of activities during the normal business day, whereas a large part of such operations could be conducted during off-peak hours. Delays are produced by unfortunate location of the terminals, lack of adequate street space allocated to commercial traffic in the neighborhood of terminals and lack of space to stand while waiting to receive or discharge a load. In a few large cities prolonged terminal delays have so greatly reduced the economic advantage of motor truck operation as to cause retention of horse-drawn vehicles, which in turn add to the volume of the slow-moving traffic on the street and further intensify congestion.

Modern practice is tending toward the motorization of railroad freight terminals and toward the relocation of the terminals outside the congested districts.

Points of Congestion

There are, of course, innumerable specific and sometimes isolated points of congestion. With the growth of traffic and the

development of property at these points they often join with other points near by and expand into areas of congestion.

Intersections

Intersections are almost invariably the points of greatest congestion on streets and highways. Intersections at grade involve the use of the same areas of street surface by crossing traffic streams, which must of necessity greatly decrease the capacity of the two intersecting streets.

The intersection, as ordinarily designed, is the greatest single obstacle to increased traffic flow. In the Boston traffic survey * 87.5 per cent, in San Francisco † 75 per cent and in Philadelphia ‡ 83 per cent of all traffic delays were intersection delays. It has been computed that the capacity of an ordinary grade intersection may be no more than 30 per cent, and it cannot equal 50 per cent of the combined normal capacity of the two intersecting streets.

Railroad Grade Crossings

Grade crossings with railways in many cases contribute extensively to traffic delays,§ and are important factors in the accident problem, having caused 2,485 deaths or approximately 8 per cent of a total of 31,000 highway fatalities in 1929.

Another Committee of the National Conference is reporting on the subject of protection of railway grade crossings and highway intersections, and that Committee is considering the safety aspects of such crossings. Your present Committee desires to emphasize the seriousness from the traffic congestion standpoint of intersections of major highways and crossings at grade of highways with railroads carrying frequent train movements which block the highways.

City Gateways

Other congestion factors are the lack of sufficient trunk highway facilities to take care of accumulations of traffic approaching a

* "The Street Traffic Control Problem of the City of Boston," 1928.

† "The Street Traffic Control Problem of San Francisco," 1927.

‡Philadelphia Traffic Survey—Report No. 2, by Mitten Management, Inc., 1929.

§ "Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio," by U. S. Bureau of Public Roads and County Commissioners in Cuyahoga County, Ohio. 1928, page 60 and Table 17.

large city and the division among several jurisdictions of authority over different sections of a continuous route. A single suburban municipality, by failing to join its section of such through route properly with the sections on either side or by failing to provide a roadway of adequate width and character, may produce a bottleneck which greatly lessens the capacity of the entire thoroughfare.

Convergence of Heavy Thoroughfares

At or near the entrances to metropolitan areas trunk line highways are often merged with the local street system of even less capacity, superimposing through traffic * upon the normal local traffic flow. That this through traffic is a considerable proportion of the whole is confirmed by the Boston survey,† which states that 20 per cent of the business district traffic is through traffic, and by studies in Chicago,‡ which indicated this factor to be 34 per cent of the total. At Lancaster, Pa., on the Lincoln Highway, the through traffic was found to constitute more than half of the total traffic in the central business district.

Urban street systems are often a series of disconnected routes, ill-planned for such traffic volume and not partaking of the flexibility of the rural highway to expand with growing traffic. In the City of Detroit "there is not . . . a single street that offers a direct route from east to west across the entire city." § Only ten street connections of about a quarter of a mile each, it is pointed out, are required to provide three continuous thoroughfares across the city, averaging twenty miles in length each.

Trunk line highways between important centers are frequently of insufficient capacity for existing uses, especially at subcenters. Yet very often nearby highways are all but deserted. Traffic is suffering from a high degree of concentration on a few routes to the neglect of other equally available, but less well known highways. In the Cleveland survey,¶ a time differential of 22

* "Routing Through Traffic," by Harold M. Lewis—*Annals of American Academy of Political and Social Science*, Sept., 1927.

† "Report on the Street Traffic Control Problem of the City of Boston." 1928.

‡ Chicago Street Traffic Survey, 1926.

§ "City of Detroit Vehicular Traffic Report," 1928.

¶ "Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio."

minutes favoring the lighter traveled of two alternate 11-mile routes between the same points was found. To a considerable extent such failure of traffic to use the best routes arises from lack of a carefully planned system of direction signs, and from failure to keep the public thoroughly informed.

Bottlenecks

Bottlenecks, which similarly reduce the capacity of a thoroughfare, frequently exist at other points—narrow bridges, underpasses, tunnels or other points where the number of lines of traffic is reduced. In some instances, where the number of lines is theoretically retained, they are so crowded together by a roadway two or three feet too narrow as to require reduction of speed or make hazardous the passage of wide vehicles.

Peak Traffic Conditions

The Cleveland survey * showed Saturday traffic at city gateways to be 22 per cent and Sunday traffic 34 per cent greater than the average Monday to Friday volume. The Cook County survey † showed Sunday traffic at least 120 per cent greater than the average daily traffic on five major gateways to the city of Chicago. Sunday traffic on the state highways of New Jersey ‡ was found to be 72 per cent greater than the average weekday traffic.

This condition as to Saturday and Sunday traffic at city gateways is normally the reverse of that in congested business districts. It and other differences, however, are not indicative of a fundamental difference in the problem, but merely of a different character and concentration of traffic.

At certain points abnormal demands for relatively limited periods cause far reaching congestion on highways adequate under normal conditions. Such points are the entrances to baseball and other amusement parks, race-tracks, theatres and similar places of public assembly.

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* "Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio."

† "Report of a Study of Highway Traffic and the Highways System of Cook County, Illinois," by U. S. Bureau of Public Roads and Cook County Highway Department, 1925.

‡ Report of State Highway Engineer to New Jersey State Highway Commission.

Poor Pavements, Abrupt Turns and Heavy Grades

Other elements contribute to congestion on main thoroughfares by slowing down the traffic. These include excessive grades and abrupt turns, and sections of uneven or otherwise inadequate pavement. Inadequacy or lack of continuity of pavement surface also divert traffic to other areas which may already be heavily congested.

Other Congesting Factors

Improperly regulated or unregulated opening of the pavement for routine repairs is an annoying and productive cause of congestion, largely unnecessary during peak traffic, or even business hours. To this may be added the delays produced by storage of building materials on streets and the day-time hauling of extra heavy and bulky materials to buildings under construction. While each individual delay may seem rather insignificant, in the aggregate they far outweigh the minor inconveniences which would be entailed in the storage of materials within property lines, and the hauling of construction materials at other than peak-traffic hours.

The diverse and complicated factors in congestion in most areas and at most points where it is found indicate the need for traffic surveys and careful study by engineers trained in traffic control and future planning.

REMEDIES FOR TRAFFIC CONGESTION

Effective remedies for traffic congestion must recognize the three primary causes of congestion. This will then divide into (a) immediate relief measures, (b) a program of permanent improvement, and (c) effective control of land use. Since all growing communities face the problem of traffic congestion they must give serious consideration to all of these types of remedies.

Immediate Relief Measures

It is within the power of practically every city and town to secure a real measure of traffic relief through better use of existing facilities, although it is obviously unwise to establish too soon the maximum of restraint that may ultimately be necessary.

Naturally the steps taken by one community will not always be applicable in another, but, in general, the same guiding principles can be applied.

Intersection Control

Since the intersections are the limiting points in the capacity of a street system, one of the first measures of immediate relief to be considered, when congestion has become prevalent, is the control of traffic at these intersections by some form or forms of signal systems, by traffic officers or by both. Traffic control alone cannot completely eliminate interference at intersections, but improvement can be obtained through careful and scientific traffic control methods.

Traffic Control Signal Systems.—Traffic control lights are now in common use throughout the United States, and when properly placed and timed serve their purpose well. They are not a panacea for all traffic ills. In fact, when indiscriminately used by over-zealous public officials or as the result of prejudiced demands by citizens or neighborhood groups they may become a nuisance and a menace to safety. Stopping for traffic lights where a light is unnecessary or improperly timed irritates the motorist and encourages a contempt for traffic control and regulation.

The utility of a traffic signal system depends upon the accuracy with which its indications are adjusted to traffic requirements. Aside from the hour-to-hour changes provided in the flexible progressive system referred to below, signal timing and use need to be changed from time to time to meet changing traffic conditions. In turn, these requirements can be ascertained only by a detailed and accurate study of actual flow characteristics. Data should be collected to establish a minimum limit of traffic requiring light control. If automatic signals are installed at intersections where this minimum limit is reached only at intervals during the day, the stop and go aspects should be operated only during those intervals, but at all other times the signals should be made to give a flashing warning.

Traffic signals can seldom at the heavier intersections eliminate the desirability of police supervision, particularly where

there is a large volume of pedestrian traffic or vehicle turns. They do, however, relieve the traffic officer of his mechanical duties of starting and of stopping traffic flow and thereby permit him to give his time to the enforcement of traffic law, to the warning of drivers and to the control of pedestrians.

One of the principal advantages of control lights, compared with police control, is the opportunity presented to coordinate the flow of traffic throughout an entire area. In the heavy traffic flows in the congested areas, it is no longer sufficient to consider an intersection by itself.

The Committee of the American Engineering Council on Street Traffic Signs, Signals and Markings completed and distributed in 1929 a report which included recommendations on this important subject. That Committee has recently reviewed and, to some extent, revised its report in the light of recent developments, and the revised report has been endorsed by the Committee on Uniform Traffic Regulation of the National Conference on Street and Highway Safety.

The revised report outlines the methods of operating traffic control signals as manual, automatic, combined and traffic-actuated, divides them into two general classes, designated as independent and coordinated, and further classifies the different types of coordinated systems. (Copies of this report can be obtained from the American Engineering Council, 26 Jackson Place, N.W., Washington, or from the National Conference on Street and Highway Safety, 1615 H Street, N.W., Washington.)

Of the various forms of control described in the American Engineering Council report, independent control is obviously unsatisfactory except at isolated intersections. Simultaneous control, having all lights green and then red on a given street, has the inherent fault of forcing all traffic on that street to stop at intervals. It promotes a tendency to race to beat the lights, since the driver usually tries to go as far as he can before one of the lights in the string stops him.

With alternate control, in which alternate signals or groups of signals show opposite colors in the same direction at the same time, the vehicles at the front of a platoon can usually

proceed with continuous movement, but if the signals at several intersections are grouped to operate simultaneously as to color and there is enough traffic so that the platoon extends for a length of more than the shortest city block, the vehicles at the rear will be unable to reach the last intersection of the group before the light becomes red. Thus they will lose a complete time period and the capacity of the thoroughfare will be greatly reduced. On the other hand, if the colors alternate at each intersection the controlling speed with ordinary city blocks will be extremely low, and if the blocks are of varying lengths the speeds will have to be correspondingly varied. The method has the further serious disadvantage that it necessitates an even division of time between the streets at each intersection regardless of often widely different time demands of traffic on the two streets.

Flexible progressive control, in which all signals are interconnected to a master controller which maintains the same total time period at each intersection, and by which the period may be varied to meet changing traffic conditions, is by far the best both in theory and practice. Variations in block lengths, volume of cross traffic, intersection interference and safe permissible speed present a technical problem in the application of the system which requires competent engineering solution. It is most important to obtain the proper length of time period for the lights to obtain the best results in moving both vehicles and pedestrians. In general a short time period is more efficient in moving traffic than a long one. Excellent illustrations of the use of this flexible progressive system are found in the Chicago Loop district, on Carnegie Avenue, Cleveland, and, considering the severe street layout complications, in downtown Pittsburgh.

With respect to traffic-actuated control the American Engineering Council says:

"Traffic-actuated control can be used for any independent signal, and is especially worthy of consideration at multiple intersections, at intersections with variable traffic, or where conflicting movements should be handled separately, if any signal control is warranted.

"As traffic becomes heavier and more uniform on the intersect-

ing streets, the advantages of the selective principle of traffic-actuated control over fixed time signals are diminished.

"Where properly used, traffic-actuated control mechanisms to a considerable extent eliminate objections to independent traffic control signals, because unnecessary stops are reduced to a minimum and there is less tendency for traffic to avoid signalized intersections. The objection to twenty-four hour operation of signals is also removed by the minimizing of delays and thus the safety element of continuous operation is retained.

"Applications of this method of control may also be made at points where pedestrians cross a heavy traffic stream, by providing push buttons for their use."

In summarizing, as follows, its recommendations covering traffic control signal operation and installation, your Committee is in accord with the Committee of the American Engineering Council:

> Automatic traffic control signals should be installed and operated only where essential to proper movement of traffic or safety, and these should operate as stop and go signals only during those hours of the day when needed. At other times they should show a flashing warning signal.
>
> The timing and coordination of such signals are the most important factors in proper operation, and should be based on careful studies of traffic flow on the intersecting streets. The control should be sufficiently flexible to meet variations in the flow at various periods of the day.
>
> The order in which colors are displayed for vehicular traffic should be red, green and yellow, with no yellow light after the red. Pedestrians should be informed by light control when they should no longer enter the intersection.
>
> The flexible progressive system is recommended as the standard system adapted to congested areas and to major traffic streets and highways.

Regulation of Turns.—The problem of turns becomes more serious as the volume of traffic at an intersection increases.

The inside turn with the green light is the most common type of left turn and is prescribed by the Uniform Vehicle Code and the Model Municipal Traffic Ordinance. The Code and Ordi-

nance, however, recognize that under certain conditions, mainly in the case of multiple-lane thoroughfares carrying heavy traffic in each lane, special provision is needed to facilitate left turns across those lanes. They, therefore, authorize local rules permitting turning movements on a special signal indication while the through traffic is stopped. The Committee is in full accord with the requirement that under normal conditions the direct left turn with the green light should be used, the turn being made from the lane nearest the center of the roadway. If the roadway is wide enough, the inside lane should be marked for left turns.

The left turn can be eliminated with benefit at some heavy traffic intersections, since the volume of left turns is usually a small percentage of the total traffic at the intersection. Even the heaviest volume of left turns is seldom more than 10 per cent of the total intersection traffic and, therefore, deserves less consideration than the through traffic. Left turns should be prohibited, however, only at extremely heavy traffic intersections, where the physical layout of the intersection precludes the making of such turns without unreasonable interference with the other traffic, or where traffic conditions warrant treatment of intersections in groups, as in the Loop district of Chicago.

Right turns should be prohibited only in extreme cases. They should be made with the green light, with due regard to the right of way of pedestrians proceeding lawfully. Right turns become a cause of congestion largely because of conflict with pedestrian traffic. This conflict can usually be dealt with satisfactorily by police supervision. When the pedestrian volume becomes extreme, the elimination of right turns may be justifiable, but the economic possibilities of a pedestrian bridge or subway should be considered as an alternative.

Turning around in central business districts and on through traffic streets, whether at intersections or in midblock, may interfere seriously with traffic and should in general be prohibited.

Traffic Lanes, Lane Markings and Direction Signs

On main roads and streets capable of carrying more than two lanes of traffic and on which there are large volumes of traffic, greater efficiency will be attained by marking definite traffic

lanes. Traffic studies have shown that with increased roadway width there is a tendency of vehicles to travel at a greater distance from the curb or edge of the roadway. Lane marking tends to organize the traffic into well defined streams and lessens the danger of collision in overtaking and passing other vehicles.

Lane marking is particularly useful on approaches to intersections to facilitate prompt movement on signals and to indicate the proper position of vehicles for right and left turns. In addition to the customary lane markings, direction signs, arrows or other indications painted on the pavement to explain the use of each lane at intersection approaches may often facilitate orderly flow.

Lane marking is now practiced by all state and many county and city highway departments. Westchester County, New York, after several years' experience, reports that it is thoroughly satisfied that lane marking gives almost 100 per cent usefulness of pavements.

The accepted width of lanes is ten feet for moving traffic and eight feet for parked vehicles where provisions for parking are made. Many existing roadways, of course, are of odd widths, which may necessitate slight variations from the standard lane widths, but in such cases the standard widths should be followed as closely as possible.

Permanent lane markings can be built into new pavements by longitudinal expansion joints or by narrow strips of distinctively colored materials. It is recommended that an even number of lanes be indicated wherever possible. This permits, on a roadway with four free-moving lanes, two outside lanes for slow-moving traffic and two inside lanes for fast traffic. When three lanes are provided, signs should be erected requiring all vehicles to drive on the right and use the center lane for passing only.

In urban districts where there are peak periods of traffic in alternate directions, it has been found effective to mark the middle lanes so that they can be used during peak periods in the direction of maximum traffic. This method is now being used successfully in Cleveland in moving large volumes of traffic into the central part of the city in the morning and out again in the evening. On one of the free-moving four-lane boulevards in

Cleveland there are nearly 4,000 vehicles going eastward and only 800 going westward between 7:30 and 9:00 a. m. During this period three lanes are made available to eastbound traffic and one to westbound traffic. In the evening, traffic conditions are reversed, and three lanes are then assigned to westbound traffic. The Philadelphia-Camden bridge is another excellent illustration of the handling of peak movements by utilization of an odd number of lanes in the direction of maximum traffic. In this manner greater flexibility and full utilization of present street facilities to meet changing traffic conditions are provided. This plan, however, requires careful preparatory education and, at least for some time, thorough police supervision.

Delay can be avoided by the proper installation of direction signs for the routing of foreign traffic through cities and towns, particularly in congested districts. The continuation of numbered United States highways through municipalities should be marked at frequent intervals with the standard markers adopted by the American Association of State Highway Officials. The markers should be conspicuously placed and illuminated or equipped with reflectors so as to be clearly visible both day and night. On all state and county highways carrying markers the routes through municipalities should be similarly indicated.

All traffic signs for a given purpose should be uniform in design and construction. The Committee recommends that the findings of the Committee of the American Engineering Council on Street Traffic Signs, Signals and Markings for urban districts and those of the American Association of State Highway Officials for rural highways be adopted as standard practice. Unnecessary signs should be eliminated.

Control of Parking

Parking is defined in the Model Municipal Traffic Ordinance as "the standing of a vehicle, whether occupied or not, upon a roadway, otherwise than temporarily for the purpose of and while actually engaged in loading or unloading, or an obedience of traffic regulations or traffic signs or signals."

Parking causes congestion by reducing the available roadway width for moving vehicles and also by reducing safe speed because

of vehicles moving into and out of parking spaces and waiting for available parking space.

Congestion due to parking is generally encountered in the central business sections of cities and towns, in business subcenters located on important thoroughfares, and in other sections of passenger vehicle concentration where there are lacking adequate off-street storage facilities, such as apartment house districts and the vicinity of large commercial or industrial establishments or places of amusement.

Terminal facilities for vehicles in these areas are essential to the transaction of business, but parking on the street is an uneconomic practice when the cost of resulting congestion exceeds the benefits accruing to the comparatively small number of vehicles that can be accommodated at the curb.

The solution of the parking problem lies in the establishment of a proper balance between the use of the streets for moving and standing vehicles with appropriate attention to the provision and use of off-street storage facilities. (Off-street facilities are discussed at some length on page 66.)

Coincident with the formulation of regulations governing parking, *provision must be made for adequate enforcement.*

Parking or standing of vehicles may, in a general way, be divided into three classes:

(1) Short time parking. Studies by the Department of Commerce and surveys in a number of cities reveal that a majority of the vehicles are parked for a period of one hour or less.

(2) Long time parking, by office workers, store and factory employees and professional persons who drive to work and leave their vehicles on the street during the day. Taxicab stands produce an effect similar to long time parking.

(3) Commercial vehicle loading and unloading.

Virtually every city and town has areas designated for:

(1) No parking. This ranges from the spaces in front of fire hydrants, driveways, public buildings, etc., to extensive areas in central business districts during business hours of some cities, such as Chicago, Boston, Pittsburgh, Philadel-

phia and Detroit. In other cities there is prohibition of parking in these areas during rush hours. In many cities all-night parking is prohibited.

(2) Limited parking. Time limits are usually found desirable in all important shopping districts. While the time limits vary in different communities and sections of the same community from a few minutes to three hours, in the majority of cases the period appears to be one or two hours.

(3) Unlimited parking. In all cities there are areas of light traffic where there is a minimum of objection to unlimited parking.

When the parking of vehicles interferes with the free movement of traffic to such an extent that serious congestion results, prohibition of parking is recommended as an immediate traffic relief measure. The volume and type of traffic demand should determine whether such prohibition of parking shall extend over the entire day or be confined to certain hours, such as the rush-hour traffic period.

Where perpendicular or angle parking is practised, changing to the parallel type will often relieve congestion. Any such change, however, should take into account the effect in terms of increased traffic lanes. If there will be no such increase, the change will not be warranted. On the other hand, a change in the angle of parking may accomplish the desired result.

Where angle parking is employed it is recommended that stalls be painted on the pavement to insure even spacing and afford accommodation for a maximum number of vehicles.

Limited parking—that is, restriction of the length of time each vehicle may be parked—is merely a convenience measure and an effort to divide available parking facilities more equitably among those desiring parking space. It does not add to the traffic capacity. In fact, it may intensify traffic congestion by increasing the number of vehicles pulling into and out of parking spaces.

Double parking or standing on the outside of a line of parked vehicles, although generally prohibited, is a common practice. It is a serious cause of traffic congestion and the Committee

strongly recommends rigid enforcement of the prohibition. It should be noted that abuse of time limits for parking is conducive to double parking by commercial vehicles whose drivers can find no curb space for necessary loading and deliveries, and by private operators making brief visits to shops and stores.

Where parking space is likely to be fully used, there should be areas set apart solely for loading and unloading of taxicabs, private automobiles and commercial vehicles. Vehicles should not be permitted to stop for loading or unloading except adjacent to the curb, nor should they be permitted to stop in or adjacent to intersections, alongside of safety zones, or at other places where stopping will impede movement in a traffic lane. It is universally accepted that parking should be prohibited near fire hydrants, in front of public building entrances, in curb loading zones, between safety zones and the sidewalk. In addition, parking, stopping or loading should be prohibited in heavy traffic areas for a sufficient distance from intersections to permit adequate reservoir space in the roadway at intersection stops and to promote pedestrian safety. The Model Municipal Traffic Ordinance provides stopping, standing and parking restrictions or prohibitions as contemplated in this paragraph.

Elimination of all parking during the day on main thoroughfares demands careful consideration of such factors as its effect on retail trade, interference of parking with other street uses, available off-street parking facilities or parking space on nearby side streets, and the classification of the users of the parking space as to time and purpose.

Surveys in several cities have shown that the relative number of patrons arriving at downtown offices and stores from the curb-parked automobile is not as large a proportion of the total as is ordinarily believed. The data for the six cities in which such surveys have been made show a range from a maximum of 11.1 per cent in San Francisco to a minimum of 1.6 per cent in Chicago, with Detroit 10.4, Philadelphia 9.0, Boston 7.7 and Pittsburgh 2.8 per cent.

Relief of traffic congestion by prohibition of parking in congested areas or on congested streets has demonstrated its success in several cities, such as Chicago, Philadelphia, Cleveland and

Pittsburgh. In Chicago parking is prohibited in an area of approximately 80 blocks from 7.00 a.m. to 6.00 p.m., except Sundays and holidays. It is reported from Chicago that the elimination of double parking and maneuvering in and out of parking spaces made it possible to shorten the time periods of the traffic signal system and thus increase the speed of traffic movement from 14 to 55 per cent. It is further pointed out that there have been a decrease in parking arrests and facilitation of fire department vehicle movement, cleaning of streets and movement of commercial vehicles. Retail merchants support the plan, though many of them originally opposed it, and additional mercantile establishments have located within the restricted area.

It is also reported that street car speeds in Philadelphia were increased 10 per cent and motor vehicle speeds about 20 per cent by the prohibition of parking on Chestnut and Walnut Streets; and that in Cleveland, on an important street in the downtown district where parking at the curb exists during the midday periods, the prohibition of parking during the morning and evening peak traffic periods increased the speed of traffic 15 per cent.

On some thoroughfares traffic flow has been materially facilitated by prohibiting parking on one side of the street during the morning rush hour and on the opposite side during the evening rush hour, thus providing an additional lane for moving traffic in the direction of greatest flow. Such a plan will obviously be ineffective unless fully enforced.

In connection with the prohibition of parking, facilities for off-street storage should be increased in proportion to this demand, as discussed later in this report.

In smaller communities, as the business district usually occupies a relatively small area and the delay to moving vehicles is consequently of less duration, greater liberality in parking privileges may be permitted. However, this should never, in any community, be allowed to reduce the space for moving traffic to less than two lanes. In these smaller communities, congestion can be reduced and trade facilitated by inducing merchants and their employees to refrain from leaving their cars throughout the business day in street space that might otherwise be used by their patrons.

The Committee particularly emphasizes that the prohibition of parking in appropriate cases requires rigid enforcement of the regulation if it is to become an effective measure for the relief of traffic congestion, and merits the whole-hearted support of the property owners adjacent to the prohibited parking area as well as that of the public.

Limitation of Collections and Deliveries

It seems highly undesirable that all collections and deliveries incidental to the business activities within a central district of a city should be carried on within the short business day of approximately eight hours. Merchants, owners of buildings and others interested in the welfare of a neighborhood should make all possible effort to prevent the utility work incident to the operation of the building from interfering with the daytime convenience of the customers and tenants. With this in mind, coal deliveries, ash collection, rubbish removal and receiving or distributing of incidental supplies, such as towels, bottled water, heavy merchandise or the deliveries incidental to repair work, should all be cared for in the hours between the closing of business activity on one day and the reopening on the day following. Some readjustment is necessary, but it is a relatively inexpensive way in which to afford more adequate street space for customers or tenants, or other necessary business-day activities. The time and operating-cost savings possible would seem to indicate the economic advisability of such a procedure.

Careful and thorough studies of the possibilities of night deliveries and the restriction of the above mentioned types of traffic during heavy traffic periods are recommended. As a logical first step, areas of acute congestion should be designated in which commodity loading and unloading is prohibited during the peak traffic periods. City governments may well initiate the movement through the development of night collections of garbage, ashes and refuse in congested business areas.

The commercial advantage of night trucking is also evident to many business concerns. In New York, Chicago, Pittsburgh and other cities, for instance, some department stores send out-of-town customers' purchases to subcenters at night for delivery

by local truck the following day. Many large department stores make most of their retail deliveries from warehouses located outside the congested area.

By rearrangements in freight terminal and warehouse opening and closing hours and an extension of time for the receipt of merchandise at the ultimate destination, a large volume of this traffic could move in off-peak hours.

Control of Pavement Openings and Obstructions

The movement of traffic may be seriously impeded unless proper regulations govern the repairing of streets and highways, street openings and the storage of building materials.

Minor street or highway repairs should be made during the light traffic periods of the day or during the night. Where extensive repairs must be made in the central business section or on arterial highways the work should be carried on continuously, twenty-four hours per day, until completed.

Complete or even partial closing of an important street for repairs usually disrupts the traffic distribution system of an entire area and causes serious congestion with resulting economic losses to vehicle operators as well as serious losses to business on the street being repaired. Proper handling of street repairs requires close cooperation between traffic officials and officials in charge of street construction and repair.

All work involving pavement openings should be completed with the least disturbance to traffic and in a minimum amount of time. Storage of building materials on streets or highways or the encroachment on street surface for construction purposes should be allowed in congested sections only where no other alternative is possible.

Most cities still permit an accumulation of sidewalk obstructions within and near intersections. At these points where the greatest possible sidewalk capacity is needed there is often a grouping of hydrants, poles, newspaper stands, rubbish boxes, drinking fountains and mail boxes. Many of these could well be moved back 50 feet or more from the intersections, to points where the sidewalk surface is more adequate. Trolley poles can often be entirely removed by substituting attachment to the buildings.

The Committee recommends the elimination of unnecessary physical obstacles within the paved surface of the roadway, such as traffic light pedestals at intersections, street railway center poles, kiosks and, where possible, center columns in underpasses and center girders or trusses on highway bridges.

Through Highways

A method of increasing the capacity of a street under favorable conditions is its establishment as a through highway, at which traffic on the cross street must first stop and then use caution in entering or crossing.

The first rule which should govern the establishment of through highways is that only streets of present or potential dense traffic, in comparison with cross traffic, be selected. The two types of thoroughfare for which such protection is particularly desirable are arterials from the central section of the city to the outlying sections of relatively dense population, and by-pass routes. The principle is not generally applicable in the central business sections of cities.

Too elaborate a system of through highways is not recommended. Except under special conditions, not more than one of a series of streets closely parallel should be established as such, as the necessity for frequent stops within short distances on the cross streets proves irritating to drivers and impairs the authority and reasonableness which the regulation should manifest.

The through highway stop rule in the Uniform Vehicle Code and the Model Municipal Traffic Ordinance requires the intersections to be marked adequately with legible stop signs. Unless these signs are of such character or are so located as to be clearly visible at night, they should be illuminated or provided with effective reflecting devices.*

Rerouting of Through Traffic

The rerouting of through traffic to bypass congestion centers should be directed by changes in route markers or numbered routes. Publicity and educational campaigns on the part of traffic officials and civic associations are of assistance.

* See report of American Engineering Council Committee.

Foreign traffic generally follows route markers wherever possible. In many cases it will be found beneficial to reroute this traffic if it is now traveling over congested streets. This results not only in less inconvenience to the drivers of these vehicles but also enables the freer use of the congested streets by local traffic. This plan is coming into favor with merchants, as they see that the removal of through traffic which does not desire to do business in the district helps free the streets for those who do wish to buy. It is usually desirable, however, to indicate optional routes so that the out-of-town motorist may drive into the business district if he wishes to do so.

It is more difficult to route around the congested area the local through traffic; that is, the local traffic which neither originates in nor is destined for that area. The use of certain routes in routine daily driving often becomes a matter of habit. The establishment of through streets by-passing the congested area will tend to divert this traffic, as it will not usually enter the congested area if offered the opportunity to avoid it. Thus, checks taken in May, 1929, in the central business district of Chicago showed that in the maximum rush hour the number of "through" vehicles that moved north along Michigan Avenue, a business street of the district, was 30.5 per cent of the total number of private automobiles using this street. For the total of all streets leading out of the district 33.8 per cent of the outbound private automobiles were "through" vehicles.

One-Way Streets

Proper care should be used in the establishment of one-way streets because of the diversion of traffic, the possibility of creating new congestion points and the effect upon business. On narrow streets, where two-way movement is hazardous, the one-way rule may be very desirable. In many cases, however, it will be found that the elimination of parking will permit two-way traffic and be more satisfactory.

Several conditions govern the successful operation of the one-way rule. The direction selected should be in accordance with normal requirements and be based upon observations of traffic flow. Easy ingress and egress must be provided for the vehicles

desiring to use the street designated as one-way. The reverse flow, prohibited on this street, needs to be furnished a substitute parallel route immediately adjacent to the original street. Under normal conditions, it is undesirable to require one-way vehicular movement on a street where two-way street car movement is permitted. The one-way rule, if adopted, should be effective at all times and suitable signs erected to indicate the proper direction of traffic.

Segregation of Traffic

It is desirable to segregate slow-moving commercial traffic from light, fast-moving passenger car traffic as fully as possible, whether by restriction of the slower vehicles to the lane nearest the curb on the same street or by use of separate streets. Many cities now prohibit the movement of commercial vehicles over certain boulevards, usually in park areas.

The same principle, except as to vehicles making pick-ups or deliveries within the block, can be applied to streets serving highly developed residential districts where the proportion of automobile ownership is high. A special route reserved for passenger car traffic only will go far toward increasing traffic speed between business and residential districts and, at the same time, reduce congestion on other streets.

Commercial vehicles should not be barred from any streets until satisfactory alternate routes are available. Companies which operate commercial vehicles, however, can render valuable assistance by giving more attention to routing.

In the majority of small cities and towns there may be little opportunity or occasion for segregation of traffic. In some instances, however, where a street railway line occupies the main thoroughfare, it is quite feasible and will be found advantageous to encourage the motor vehicle traffic to use the parallel thoroughfare a block away.

Mass Transportation Vehicles

Mass transportation vehicles carry the largest percentage of all persons entering congested central districts of the larger cities, as indicated in the following table:

SUMMARY OF SURFACE PASSENGER VEHICLES AND PASSENGERS ENTERING CENTRAL BUSINESS DISTRICTS BY EACH TYPE IN 10 CITIES, DURING YEARS 1924–1928

Type of Vehicle	Percentage of Total Vehicles	Percentage of Passengers Carried
Automobile	90.3	32.3
Street car	8.5	61.6
Motor bus	1.2	6.1
	100.0	100.0

Because of the special public service in which these street cars and buses are engaged, necessitating frequent stops for receiving and discharging passengers, their resultant average speeds tend to be lower than those of privately operated motor vehicles. The lower speeds of street cars, which operate in the nominal high speed lane, result in reducing the average speeds of motor vehicles because of the necessity to stop while passengers are boarding and alighting at points where safety zones are not established. Street cars are the largest of the passenger-carrying vehicles on the streets, and, therefore, require a larger proportion of street space than indicated in the table. In addition, turning vehicles of this type occupy more street space and time than other passenger vehicles.

Inasmuch as street cars and buses use such a small proportion of the street area in relation to the number of persons transported, when compared to the street space occupancy of passenger automobiles, their more economic use of the roadway will generally outweigh the congestion apparently produced by them; but there are in many communities changes which can be made in street car and bus operations which will be of general benefit to the operating companies, their patrons and other traffic.

Rerouting of Street Cars and Buses.—The use of the same roadway for heavy movements of street cars and motor vehicles often results unsatisfactorily for both types of vehicles. The ideal situation would be the allocation of these two transportation facilities to separate exclusive roadways. This condition can generally be accomplished only by extensive rearrangement, but sometimes a street car line can be moved with advantage both to motor traffic and to street railway passengers to another street, concentrating two or more lines on one street. This serves to segregate traffic to the advantage of both types of vehicles.

Routing street cars straight through the congested business district will cause the minimum of interference with other traffic. When it is deemed necessary to turn them back within this district it should be accomplished by loops rather than by switching movements, and if feasible the loops should be "clockwise" so as to require only one left turn.

It should be noted that prohibition of left turns at congested intersections, the value of which is pointed out elsewhere in this report, may be largely nullified if street cars are so routed as to require left turns at those intersections. Furthermore, because the street car occupies the center of the street, right turns by street cars also may have a serious effect on traffic congestion, not ordinarily true of right turns by motor vehicles. Study should be made to reduce to a minimum the number of all turns by street cars in the congested business districts.

Many of the larger cities have street car lines on practically every important arterial route leading to the central section of the city, and frequently these lines are on adjacent parallel streets. Where certain of the lines can be eliminated without impairing street car service and without exceeding the capacity of the remaining lines, improved transportation service and increased operating efficiency will result.

Complete cooperation on the part of merchants, building owners, citizens and public officials is necessary to the success of any rerouting of street cars, since these interests are largely responsible for much of the convergence of routes in the central districts.

Skip-stop systems have been employed with considerable success in many cities. They result in higher average speeds for both surface cars and motor vehicles, decreasing the number of stops without imposing undue burdens on car riders.

Urban and interurban buses should be so routed as to eliminate or minimize their use in districts and at intersections where their size and inability to make turns without encroaching on other traffic lanes would cause congestion.

Safety or Loading Zones for Street Car Passengers.—Much can be done in central districts by distributing and efficiently locating the main street car loading centers throughout the area. Safety zones for passengers entering and alighting from street cars

become virtually essential under heavy traffic conditions, for the three purposes of safeguarding the street car patrons, expediting the loading and unloading of street cars and permitting the motor traffic to continue to flow while the street car is standing. Most communities are in accord with the provision in the Uniform Vehicle Code and the Model Municipal Traffic Ordinance that, in the absence of designated safety zones, motor vehicles must stop behind the nearest door or running board of a street car standing to receive or discharge passengers and may not proceed until all of the passengers have reached a place of safety. It is assumed, of course, that no safety zone can be established unless there is or is created sufficient space to the right of such zone for a line of moving vehicles.

The American Engineering Council Committee recognizes two types of satisfactory safety zones—a raised platform adequately protected against collision at the approach end, or a marked space without platform adequately protected at the end and along the sides. It does not recommend zones without platform and marked by portable signs, and with respect to safety zones indicated by merely marking a space by lines on the pavement, it states that "this type of so-called safety zone is dangerous and is not recommended."

Where safety zones are established permanently at intersections, pedestrians should exercise due regard for the needs of motor traffic and should, where practicable, be required to enter and leave the zone only at favoring light intervals, by means of crosswalk space.

The definition of safety zone in the Model Municipal Traffic Ordinance does not include the adjacent car track space, and permits driving to the left of such zones. Driving to the left should generally be permitted as necessary to efficient traffic movement. Prohibition of driving to the left of the zone causes confusion and danger in addition to slowing up traffic movement, because it forces traffic using the car tracks to filter back into the adjacent lane and requires all traffic to make a rather sharp turn out of the direct line of travel.

It is inadvisable to have a curb bus stop and street car safety zone on the same side of the intersection.

Pedestrian Facilities and Control

There are definite economic as well as safety aspects to the problem of pedestrian convenience and movement. In some congested business districts the traffic problem involves the pedestrian even more than the vehicle. Thus in downtown Philadelphia it was found that 34 per cent of the persons crossing intersections did so in vehicles, while 66 per cent crossed on foot. On State Street in Chicago the number of pedestrians is more than twenty times the number using the street in automobiles. At six intersections in downtown Pittsburgh 63.5 per cent were pedestrians, 27.3 per cent were in street cars, 8.1 per cent in automobiles and taxicabs and 1.1 per cent in buses.

These figures indicate the great importance of pedestrian movement and the necessity for the most careful attention to that aspect of the problem. Opinion is divided on the question of whether pedestrians should be required to obey traffic control signals as vehicle operators are required to do, regardless of the presence or absence of other traffic; but it is generally agreed that if pedestrians are permitted to proceed against stop signals, they should be required to do so only in such manner as not to interfere with vehicle traffic lawfully proceeding. The Uniform Vehicle Code and the Model Municipal Traffic Ordinance provide the lesser restriction as the minimum requirement of the pedestrian, but also include an alternative provision under which municipalities may establish the more positive control.

In any event, it is obvious that there is need for much greater cooperation than exists at present between pedestrians and motorists. Motor traffic making turns has a tendency to disregard the prior right of way of pedestrians proceeding on a green light, and when signals change, drivers frequently overlook the necessity for permitting pedestrians who have lawfully entered the intersection to reach a place of safety. Pedestrians far too generally disregard the traffic signals, either by proceeding heedlessly through lines of lawfully moving vehicles, or by crowding out in such manner as to retard the vehicle flow.

To foster cooperation between pedestrians and motorists, attention should be given to the provision of adequate sidewalk widths, elimination of sidewalk obstructions and the timing of traffic

signals, particularly police signals, to meet the needs of pedestrian as well as vehicle movement. Tallies made at intersections show that a much smaller percentage of pedestrians proceed against the red light with short signal time periods than with long ones.

In special cases a separate pedestrian light interval may be desirable, as described in the American Engineering Council Committee's report.

Furthermore, to prevent pedestrians from being caught in the middle of the street by light changes, it is possible to use a special signal indication to show the amount of interval remaining in any phase of the signal time period. In this way, if the green interval plus the vehicle clearance interval is fifty seconds and pedestrians require ten seconds to cross the street, the signal for pedestrians to stop can be given at the end of forty seconds, and the last pedestrian should reach the opposite side just as the vehicles start. This plan of control operates successfully in Pittsburgh and Detroit.

Physical segregation of motorist and pedestrian by bridges or subways is the only complete solution of the problem. The economic utility of this means is limited, however, to a relatively small number of intersections. The subject is discussed further under the general heading of "Permanent Improvements."

Cruising Vehicles

Reduction of vehicle cruising can best be accomplished by eliminating the reasons for such cruising, inasmuch as it has generally been considered not practicable or desirable to attempt to prevent it by law. In the case of the private automobile, the operator is cruising because of his inability to find parking space, and the remedies are enforcement of limited time parking restrictions and provision of adequate off-street storage space.

The cruising taxicab presents a more complex problem, inasmuch as there is reason to doubt whether the public would be satisfied if it were deprived of an opportunity to hire passing cabs and were required to communicate with established stands. It appears, however, that in many cities there is an excessive amount of cruising and that the public would be better served if more

stands were established and the taxicab companies were persuaded to maintain a sufficient number of cabs at these stands to meet all calls under reasonably normal conditions. In the uncongested areas ample space in the street can well be reserved for taxicabs where they will not unduly interfere with traffic, and the Model Municipal Traffic Ordinance so provides. In congested areas they should be established off the street where possible.

Staggered Hours

There are possibilities of reducing volumes of traffic attendant upon business and theatre opening closing hours by the staggering of these periods. Considerable study and conference between the groups interested is a prerequisite, however, to the adoption of such a program.

The plan is also subject to certain sharp limitations. In the case of an elongated business area, staggering of hours by an interval of fifteen minutes at the opposite ends of the area might be very effective for the traffic in one direction, while for that in the other direction it would merely further concentrate the flow.

Enforcement of Traffic Regulations

The effectiveness of control regulations depends to a very large extent upon proper enforcement of such regulations. Effective enforcement requires complete cooperation of traffic officials, police officials and the courts. The establishment of arbitrary regulations which are not of benefit to the general public, lax or discriminatory enforcement of regulations by police officials, political interference or the failure of the courts to work with police officials will result in failure of enforcement and thereby render relatively ineffective the regulations that have been established. Inadequate ordinances and lax enforcement now common in most cities constitute serious causes of traffic congestion, confusion and danger on streets and highways, and also materially reduce the efficiency of signals.

The Committee recommends that enforcement of traffic regulations be placed under the control of a special division of the police department, and that traffic officers be properly and effi-

ciently trained in expediting the movement of traffic and in the enforcement of traffic regulations. The cooperation of all police officers with the regular traffic officers is essential.*

The Committee believes that the great majority of the public is willing to obey regulations which are reasonable, provided they understand the purpose of such regulations and the benefits to be derived therefrom. Proper education of the public in these respects, through the press and the activities of civic organizations, will go far toward establishing respect for and obedience to required traffic control methods.

PERMANENT IMPROVEMENTS FOR TRAFFIC RELIEF

The development of a program of permanent improvements requires consideration of several related and controlling features, involving the existing layout of the city and any city plans already prepared, especially the transportation plan and the street and highway plan.

The general layout of a city—the topographic and physical features and the unguided growth and location of business, industrial and home areas—has a very important relation to the volume of traffic which must be served by its transportation facilities, and inadequate attention to this has contributed largely to traffic congestion. Rearrangement of the layout in accordance with a comprehensive plan, and continuous planning to take care of future needs, would greatly relieve traffic congestion.

The transportation plan is of primary importance to the general city plan and to proper city development. The concentration of business and industry in comparatively small areas necessitates the transportation of large volumes of people, and the solution of traffic problems must involve the consideration and correlation of all types of transportation. The importance of mass transportation facilities in the ultimate solution of traffic congestion problems is frequently not given sufficient consideration. An adequate transportation plan must provide for appropriate use of all modern agencies—rapid transit, street cars, motor buses, taxicabs and privately owned automobiles.

* See Report of Committee on Enforcement, National Conference on Street and Highway Safety.

The street and highway system is the backbone of the city plan. Experience has shown that the creation of a master plan of streets and highways with proper distribution of major and minor thoroughfares is essential.

The progressive development of such systems of streets and roads will involve continued research and careful planning. The actual construction projects will extend over a period of years and necessitate large expenditures.

Physical Changes in Existing Roadways

When the efficient use of existing facilities under proper control methods does not provide satisfactory traffic service, an increase in traffic facilities must be brought about either through physical changes in existing roadways, the opening of new roadways or both. In a growing community it is not sufficient to meet the needs of today, but there must be developed and maintained a margin of surplus capacity to meet abnormal conditions and keep pace with future growth. This requires a knowledge of present and an estimate of future traffic, the amount and location of roadway surface necessary to accommodate this traffic and an inventory of existing streets and roads. From these facts the necessary improvements in and additions to the existing facilities can be determined.

Among the most important of the physical changes in existing roadways may be mentioned (1) improvement of intersections by throat widenings and other localized changes, by circles or other rotary traffic distributors, or by grade separations; (2) elimination of railroad grade crossings; (3) roadway widenings, including, in special cases, arcading of sidewalks and the construction of double-deck streets and bridges; (4) elimination of bottlenecks; (5) a continuing paving program, and (6) provision of pedestrian subways or bridges where pedestrian movement is concentrated.

Improvement of Highway Intersections at Grade

There is little possibility of physical improvement of seriously congested intersections without some major change, such as a separation of grades. The cost and other features of such improvements may render them generally impracticable in central

business districts. There are, however, three other possibilities for the facilitation of traffic at these intersections—first, rounding off the corners to a longer radius of curbs; second, throat widening, and third, rotary traffic distribution.

Greater Curb Radii.—The length of radii for curbs has been mainly a matter of circumstance. A number of lengths and combinations may be found in the modern city at the various intersections. It is the recommendation of the Committee that curb radii be standardized at not less than 20 feet. If the sidewalk on either intersecting street is so narrow that a long radius would seriously cut down the sidewalk space at the midpoint of the curve, it may be preferable to use such a radius and provide the needed space by arcading the corner of the building.

Throat Widening at Signalled Intersections.—In the middle of a block all traffic is, of course, generally straight, regardless of its source or destination, and has little pedestrian interference. On the other hand, the intersection must handle pedestrians and right and left turns of vehicles in addition to through traffic. Since turning requires a slower rate of speed and frequently a wait, the general movement at the intersection can be improved if the turning cars are segregated so as to minimize delay to through traffic. At least three lanes in each direction are required to accomplish this segregation, and in order to provide the extra lanes it will generally be necessary to widen the throat at the intersection. When the equivalent width of sidewalk used for throat widening is needed for pedestrian use, arcading becomes necessary. If there is no safety zone at the near side of the intersection, the elimination of parking, stopping and loading a proper distance back from both the near and far corners will frequently serve the same purpose.

The proper use of such widening requires lane marking and ample signs, and education of the public to the idea of segregation. As required by the Uniform Vehicle Code and the Model Ordinance, left turns should be made only from the inner lane and right turns from the outer lane. As all vehicles awaiting change in traffic signals are able to approach the intersection more closely, a greater volume of vehicles will be cleared in the favoring light interval.

Throat widening thus offers relief where widening throughout the block is impossible or unnecessary, and also acts progressively as an initial step in possible future widening of the street.

Rotary Traffic Distributors at Grade Intersections.—Rotary distribution of traffic and consequent reduction of conflicting movements can be effected at grade intersections of highways by the creation of traffic "circles," so-called, which may be of several types—circular, elliptical, triangular, diamond-shaped or modifications thereof.

The Committee is of the opinion that where sufficient space is available, adequate traffic circles, as thus defined, frequently offer a means for expeditious movement and distribution of traffic at intersections, especially where a large volume of turns is involved. Vehicles can enter and traverse the circle without the necessity for the operation of traffic control signals, thus permitting a continuous fluid movement of traffic.

The need for such treatment exists particularly at intersections of more than two streets where traffic control signals could not be efficiently operated. They will also often be desirable in modified forms at intersections of two streets where the traffic is not sufficient to warrant automatic traffic signals, but at which there might otherwise be a serious accident hazard. This treatment has already been used in the planning of new residential areas, and there appears to be an increasing tendency to continue this development. Use of one of the special modifications of the circle will often be found desirable at the intersection of a predominately arterial highway with a minor street at which there would otherwise be the necessity to stop the through traffic flow to permit the safe passage of intermittent cross street vehicles.

Traffic circles should preferably be located on level ground, as depressions, rises and appreciable grades offer construction difficulties and dangers in use. Poorly designed circles have often proved unsatisfactory. The determination, therefore, of the exact size and design of the circle and the roadway widths are matters for competent engineering analysis at each particular intersection. The circle should be well signed and illuminated and well supervised until the public is thoroughly familiar with its use.

Circles do not provide for the entire elimination of conflicting traffic movements, but do offer an improvement which in many cases may be satisfactory. They can be constructed at much less expense than grade separation.

Grade Separation at Highway Intersections

Separation of grade offers the only permanent and completely satisfactory solution to intersection difficulties. It is expensive and requires a large amount of available ground space but, if properly designed, is very effective. Account must be taken of the possibility of an adverse effect on abutting property, but long approaches at slight grade and use of the adjacent squares as approach ramps give the corner buildings two street levels.

A limited number of grade separations in central business districts, while involving large expenditures, would undoubtedly save their cost of construction over a period of years in eliminating traffic time loss and congestion. Grade separations are much more practicable, however, in outlying areas, where two intersecting arterials may be effectively separated, with much less expense and difficulty.

Grade separations can be made with any combination of elevation and depression, from full elevation of either roadway to full depression. In parks and other locations where land is readily available one roadway is usually depressed and the other elevated approximately half the difference in elevation necessary for clearance. The selection of type should be governed by local conditions.

Full elevation of one roadway is perhaps the cheapest type to construct, but is unsightly and not popular with abutting property owners. Where a minor street intersects an arterial, the changes in elevation should be made in the minor street and the arterial should be maintained at grade.

There is also in grade separations the possibility of any part of one roadway being elevated or depressed, allowing a few lanes of through traffic to be separated from the rest of the intersection, which otherwise remains unchanged. This particular form of separation has its advantages and is useful for carrying major arterials through minor intersections.

Elimination of Railroad Grade Crossings

Much the same considerations of cost are involved in separation of grades at railroad grade crossings as at major highway intersections.

The possibilities of design are more limited in the case of railroad grade crossing elimination, for the reason that it is usually not feasible to change the grade of the railroad materially, and the highway must be raised or lowered the entire distance to effect the separation, resulting in long approach ramps. Where the highway passes over the railroad a greater difference of elevation is required than where it passes under it. With four per cent grades the approaches for an overcrossing would require a total length of about 1,200 feet, while for an underpass this would be from 800 to 900 feet.

Roadway Widening

A satisfactory method, where possible, of providing relief on congested streets and highways is by the widening of the existing roadway. In the built-up congested areas, the decision as to the widening of a street or a highway should be based on the cost involved and the resultant economic benefits to be derived.

On streets or highways where it is proved physically and financially practicable to widen and the volume of traffic demands widening, it is recommended that such widening be in accordance with the generally accepted standards. Traffic capacity and surface width studies indicate that in general:

1. The roadway surface for all two-lane roadways should be 20 feet exclusive of space for parked vehicles, buses or traction lines.
2. The choice of any widths between 20 and approximately 40 feet for moving motor vehicles, except in a relatively few cases where the three-lane road is satisfactory, is normally uneconomical, as excess of width above 20 feet adds but little to the traffic capacity of the roadway.
3. Widths such as 22 and 24 feet do not permit parking without obstruction of the normal traffic lanes, and widths of 27 feet permit parking on only one side without such obstruction.

4. Widening of the roadway on any route beyond four lanes for moving motor vehicles exclusive of street car traffic and space for parking usually results in serious congestion at focal and central discharge points. The cost of acquiring additional right of way in highly developed congested areas, where such routes would be required, is usually excessive.

5. Space for parked vehicles, where required, must be provided in addition to the surface width designed for moving motor vehicles.

Arcading.—A method already mentioned, relatively limited in application, of increasing roadway width in existing streets is by the construction of sidewalk arcades. Examples of arcading in the United States are the Fifteenth Street Arcade and Municipal Annex Building in Philadelphia and the New York Telephone Company Building, Vesey Street, New York.

Many corners have been arcaded for the commercial advantages of better display, increased entrance space and similar reasons. Through-the-block arcades have also been built in numerous instances, giving in effect much the same results as a sidewalk arcade paralleling the street. Increased facilities for pedestrians will undoubtedly be necessary, along with additional street widths, in the future.

Double-Deck Streets and Bridges

Another extreme measure, the economic justification for which has as yet been demonstrated at only a few points in some of our largest cities, where the widening of existing streets and the opening of new streets are impracticable, is the double-deck street. The advantages of this method of increasing roadway capacity are that high-priced business property need not be acquired; segregation of traffic is effected by the use of the upper level by light, fast-moving traffic and of the lower level by commercial vehicles; the intersection problem is largely eliminated in so far as the upper level is concerned; and the increased street capacity is obtained without sacrificing the sidewalk space of pedestrians.

Chicago has for some time been using the Wacker Drive, with its upper level devoted to passenger vehicular traffic and the

lower level devoted to commercial vehicles. New York City is constructing along the west side of Manhattan Island an elevated roadway for passenger traffic.

Along with double-deck streets may be considered depressed and elevated streets. These are advantageous in providing high-speed facilities for large volumes of traffic moving from one area to another, between business and residential districts or between two large neighboring centers of population. The construction of depressed roadways, of course, is generally practicable where an entire or partial depressed roadbed location is available. Abandoned railroad rights of way, old canal or river beds, or a natural depression in the topography might be utilized in this way. Cleveland has completed plans for the construction of a depressed roadway without intersections from the city limits to the heart of the business district following railroad right of way. The New Jersey Highway Department has created a special route partially elevated and partially depressed through Jersey City to the Holland Tunnel.

The elevated roadway is usually the most practical means for getting traffic across special-use areas, such as railroad yards and industrial territory. An elevated roadway approximately one mile long is contemplated in Cleveland through a highly developed industrial area. Private interests in Detroit are building an elevated toll road over railroad right of way into the heart of the city.

Double-deck bridges are also advantageous under certain conditions. When existing bridges are too narrow for the volume of traffic, it is sometimes possible to add another deck. New York is adding second decks on both the Manhattan and Queensboro Bridges which will increase their capacities about 50 per cent.

The Havre de Grace Bridge over the Susquehanna River in Maryland, which originally was too narrow for a heavy volume of two-way traffic, has been double-decked with one-way traffic on each level.

The double-deck bridge, like the double-deck street, permits the segregation of passenger automobiles and commercial traffic, or of vehicular traffic and street cars.

Elimination of Bottlenecks

The capacity of an entire street may be limited by one or more short sections where the pavement is narrow or where there are obstructions to the free flow of traffic. The result is not only congestion in the bottleneck thus created, but also the diversion of traffic to parallel or indirect routes. Such sections should be widened and the obstructions removed in order that maximum traffic use of the entire street may be attained and congestion relieved on overburdened parallel routes.

Congestion is also created by the convergence of several main line state and county routes as they approach or enter the city. In Cleveland this convergence has resulted in as many as six important highways pouring their combined traffic into one city street. Bottlenecks created in this manner can be partly eliminated by rerouting of traffic and roadway widening, but the ultimate solution in most instances is the construction of new arterial streets and connections which will tap the state and county roads before the points of convergence, as provided for in the street and highway plan of improvement now being constructed in the Cleveland area.

Bottlenecks may also exist due to jogs in roadways, because of which traffic is required to turn into and travel some distance on another interesecting thoroughfare. Serious congestion exists at some points because of offsets of as little as 50 feet—conditions which could easily be remedied by cutting off one of the corners.

Continuing Pavement Program

Improper or unsuitable paving surface, or lack of continuous surface, serve as a definitely limiting factor upon the traffic capacity of an artery of travel, often causing traffic to concentrate upon more attractive parallel routes. The forceful prosecution of an adequate paving program, taking these points into consideration, is undoubtedly one of the most effective immediate traffic improvements any city can make.

The Street Traffic Survey made in Chicago in 1926 reported:

"The most direct physical relief that could be brought to the Chicago traffic problem would be energetic and comprehensive

paving program. If all the pavement on all streets leading from and surrounding the central business district were improved, there would be a much more even distribution of traffic, and a diversion of much traffic that now finds it necessary to go through the crowded sections of the city in order to find comfortable roadway surface."

This program should make provision for necessary increases in curb radii, reduction of crown in the center of the roadway and removal of center obstructions to the fullest extent possible.

Pedestrian Bridges and Subways

There are two general situations at intersections where the separation of pedestrian and vehicular traffic by the construction of pedestrian bridges or subways would be advantageous to both types of traffic: (1) where the volume of pedestrian traffic is sufficient to overflow on the street area or to seriously interfere with vehicle turns, and (2) where the volume of traffic on a thoroughfare is sufficiently continuous and dense to hold back pedestrians at crossings for unreasonably long periods of time.

Pedestrian bridges, however, have several serious disadvantages in the congested business areas which, to a large extent, will preclude their extensive use as a traffic relief remedy. They require long spans and expensive construction to avoid intermediate supports, and the high head room to clear trolley and utility wires as well as street cars and vehicles necessitates long stairways which encroach seriously on sidewalk space. In addition, pedestrians are generally unwilling to ascend and descend long flights of stairs to cross a roadway, although the use of ramps or escalators might solve this problem in cases where the other objections to pedestrian bridges do not exist. The use of pedestrian bridges is largely limited to passageways between buildings, a number of which are now in successful operation.

Pedestrian subways are usually more satisfactory and, with the use of ramps or escalators, will undoubtedly prove practicable. Such subways must be properly drained, cleaned, lighted, and ventilated. Otherwise they can easily become a nuisance and a menace, and unattractive to pedestrian use.

Many pedestrian subways are already in use. In Chicago a

subway under Michigan Avenue carries pedestrians to the Illinois Central Station. In New York it has been proposed to devote the present concourse of Grand Central Station entirely to the function of providing an underground connection between a large number of buildings in that area.

Subway transit construction offers possibilities for providing pedestrian facilities. In connection with the South Broad Street subway, the city of Philadelphia has just completed the construction of a pedestrian concourse under Broad Street and above the subway tracks. This concourse extends the entire width of the street (about 100 feet) and from City Hall to Spruce Street (about 1,600 feet). In connection with this work the subway railway tracks which now circle City Hall are being carried straight under the buildings and the area used by the tracks at present will eventually become part of the pedestrian concourse. This will permit unhampered pedestrian movement under the streets in the most congested section of the city.

The Committee considers pedestrian subways or bridges as desirable in some locations where the need justifies the expense and difficulties of their construction and maintenance, but such subways should not be so located as to interfere with future rapid transit construction.

New Roadways

Where essential links of a complete system of roads and streets are lacking or where sufficient traffic capacity cannot practicably be obtained by the improvement of existing routes, the construction of new roadways is necessary.

New roadways required may include (1) street extensions and connections, (2) parallel routes, (3) new through or arterial highways or parkways and (4) by-passes around congested centers and belt lines around cities.

A knowledge of the volume of traffic traveling between various districts of an area will not only permit the selection of the best possible location of the new routes from a traffic service standpoint, but will also enable the engineer to estimate the amount of traffic which will use the new route and to determine the design and width of the pavement.

Street Extensions and Connections

In heavily traveled, congested areas a relatively small amount of work in extending dead-end streets and closing "gaps" may complete the street system, provide a continuation of a heavy traffic movement, prevent the diversion of traffic to already overloaded parallel routes and eliminate an unreasonably large amount of right and left turning.

A survey in the regional area of Cleveland indicated that 27 per cent of the trips between the downtown business section of Cleveland and suburban territory were made over indirect routes. It was apparent that a considerable volume of traffic approaching the city was diverted from the direct routes to other routes which, in addition to their normal traffic, were overburdened with additional improperly routed traffic. As a remedy several important street extensions are to be built. One of the most important is the Shaker Boulevard Extension from Woodhill to Pittsburgh Avenue at East 34th Street, a distance of 2.8 miles. It will provide improved traffic service between the center of Cleveland and the eastern and southeastern sections of the area and will also relieve congestion on Woodland and Carnegie Avenues, the routes now used by this traffic. It is estimated that this route, if completed in 1931, will carry 16,000 passenger automobiles per day.

The Major Street Plan Report of Louisville states that new connections and street improvements are needed to relieve the present concentration on the few main traffic arteries which are now approaching the point of acute congestion in certain parts of the city.

It is recommended that where congestion exists in an area, a thorough survey should be made of needed connections and the possibility of providing through streets or highways be determined.

Parallel Relief Routes

To provide relief for overcrowded routes it may be necessary to construct one or more entirely new parallel routes. The construction of such routes becomes necessary when it is impracti-

cal for either physical or financial reasons to widen existing main arteries or when further widening would produce excessive width on such arteries. The movement of traffic is to a considerable degree a problem of sorting and distribution, which can be better and more efficiently accomplished by providing an increased number of trunk line routes with simpler and more direct connection between the various sources and destinations of traffic, rather than by forcing traffic to concentrate on a smaller number of wider main highways.

New Through or Arterial Highways

A special condition of the character just outlined arises when new communities and suburbs spring up around the larger centers of population and the original highway systems are still called upon to serve the increased traffic between the new subcenters and the central district of the city. No small portion of the traffic congestion which exists today is due to the lack of a sufficient number of such radial arterial highways.

The heavy concentration on a limited number of routes is illustrated by figures from a cordon count of traffic in Philadelphia showing seven streets handling 66 per cent of the central business district traffic with North Philadelphia and 49 per cent of that with South Philadelphia.

The development of new arterial routes in congested and built-up territory may involve the construction of new bridges, elevated or depressed roadways, the purchase of costly property in some sections and unusual engineering problems. But these items may, after a careful analysis of the facts, be found to be less costly in the end than the economic losses which result from congestion or the use of roundabout routes. In Cleveland approximately 25 miles of new arterial highways have been planned to improve traffic service between the center of the city and the principal sources of traffic in the surrounding territory.

In the development of such arterial highways, consideration should be given to the possibility of the parkway or freeway type of development, with no right of access from immediately abutting property, thus facilitating safe and speedy travel on the highway and high grade development of the adjacent land.

By-Passes and Belt Line Routes

The larger centers of population during the past five years have realized the importance of relieving congestion areas by means of by-pass and belt line routes, and considerable progress is being made in such development.

One of the largest by-pass projects is that planned in New Jersey and known as the North Jersey Loop. It is needed chiefly because the Fort Lee Bridge now under construction over the Hudson River from the upper part of New York City will deliver to the New Jersey highways an unusual amount of concentrated through traffic. The proposed loop will avoid the area of congested population on the New Jersey side of the river. It will pass to the north of Hackensack, through the edge of Paterson and end in the vicinity of New Brunswick, entirely avoiding Jersey City, Hackensack, Passaic, Kearny, Arlington, Harrison, Newark and many other municipalities in that region.

Many state highway departments have constructed by-pass routes around cities and towns on main highway routes. The Tri-State Regional Planning Commission of Philadelphia is now laying out major belt line routes that will by-pass through traffic around that city.

A by-pass route may be made up of existing highways with new connecting links or if necessary may follow an entirely new location.

The development of by-passes and belt lines should be based on knowledge of existing traffic. Origin and destination studies of traffic movement assist materially in determining the necessity and the proper termini of by-passes and belt lines.

Planning of New Subdivisions

In planning street layouts in undeveloped areas, proper types of streets within the area should be provided to serve the local requirements, and this local street system should be related to the major street or highway systems of surrounding areas in accordance with a master plan. Suitable ingress and egress to and from the area is of particular importance in the case of a proposed industrial or railroad terminal development.

In planning undeveloped areas, great advances have been

made by the definite classification of the streets for the purposes to which they are to be put. A limited number of wide thoroughfares are projected for the major traffic movements. The intended business sections are designed with a view to providing suitable parking space. Areas intended for purely residential purposes have, on the other hand, been intentionally laid out with narrow streets, many of them winding or with dead ends, to discourage use by through traffic. Open spaces surrounding schools and playgrounds are located in such manner as to reduce to a minimum the necessity of street crossing by children.

Off-Street Facilities

While the improvement of existing streets and highways or the development of new ones as outlined above are obvious means for relief of traffic congestion, there are other permanent improvements of different types which can assist materially. Among those are off-street storage and loading facilities, which become virtually imperative in some areas, and the provision of ample playgrounds for the mutual protection of children and traffic.

Development of Off-Street Storage and Loading Facilities

With the constantly increasing volume of traffic in the business districts of the larger cities, the full width of existing streets is required for moving traffic. The provision of additional street space by razing of buildings is very costly but may be justified when required to provide adequate service to moving traffic. Such expenditures to provide street space for vehicle parking are clearly uneconomic, yet terminal facilities for vehicles in the business areas are essential.

There are three distinct types of vehicular transportation which desire space for parking or stopping in these areas:

(1) The privately owned and owner-driven automobile which may be parked for a short time while the owner is making a purchase or calling on a customer, or for the entire working day by business and professional men.

(2) Commercial commodity vehicles which are collecting and distributing commodities in the area.

(3) Commercial passenger vehicles, such as taxicabs, livery cars and motor buses.

Privately-Owned Cars.—The greatest demand for parking space arises from this type of transportation, and it is to serve this class that the greatest progress in the provision of offstreet parking facilities has been made. This class also contains the largest proportion of comparatively long-period storage and is, therefore, the first type of standing to be prohibited on the street. Factors essential to satisfactory provision for this class of parking include proximity to the destination of the occupant of the car, safety for the vehicle, cleanliness of surroundings and low storage cost.

Several methods of providing such service are available:

(1) Publicly owned parking space, provided either free or on a cost basis.

(2) Privately owned parking space, provided at a rental which will make profitable operation possible.

(3) Group parking space, as provided by mercantile establishments as a service to their customers, by industrial plants for employees, by office buildings as a service to their tenants and by hotels for their guests.

(4) Parking space in new office or other buildings in the basement or in other areas within the building limit undesirable for other purposes.

While municipalities in order to relieve congestion should make available for parking space all public property which is not needed for other purposes, it is doubtful if the provision of free parking space is a proper municipal function.

The development of privately owned parking space, both outdoor parking and parking garages, should be encouraged by municipal authorities through carefully considered changes in zoning ordinances and building codes as required, through uniform enforcement of parking restrictions and in other ways which will permit development of these facilities on a sound business basis and thereby attract private capital.

Commercial Commodity Vehicles.—Practically every building in the business districts of cities requires the service of commercial commodity vehicles for delivery and pick-up of merchandise and supplies. The buildings which require the greatest amount

of this service, such as the larger stores, are sometimes equipped with off-street loading and unloading points either within their property lines or in public alleys. The great majority of buildings, however, are not provided with such facilities and depend upon commodity deliveries from the curb and over the sidewalk. Deliveries in this manner seriously interfere with the movement of vehicular traffic in the street and with pedestrian traffic on the sidewalks.

Relief for resulting vehicular traffic congestion can to some extent be obtained by compelling trucks to stand parallel to the curb while making pick-ups and deliveries. Prohibition of standing with the rear of the truck to or across the curb will require some changes in delivery equipment to facilitate "side loading," but should be put into effect as soon as practicable.

The use of alleys for parking purposes should be prohibited when they are narrow, but at all times alley space should be utilized for the loading and unloading of commodity vehicles in preference to use of the street for this purpose.

The provision of off-street loading and unloading facilities for all commodities is the only satisfactory solution. Facilities of this type not only relieve traffic congestion, both vehicular and pedestrian, but also improve the delivery and pick-up service by reducing the loss from pilferage, protecting of the commodities from the elements and in various other ways. In the central business district of Philadelphia, 211 buildings have already been so constructed.

It is recommended that all cities, through modifications of their building codes, require new buildings to provide space for loading and unloading commodities within the property lines, commensurate with the size and shipping demands of the building. The provision of off-street loading facilities for existing buildings should be encouraged in every way possible, and areas of acute congestion should be officially designated in which the loading and unloading of commodity vehicles in the street should be prohibited in hours of heavy traffic.

Commercial Passenger Vehicles.—Such vehicles fall into four general classes—the local city service motor bus, the suburban

and interurban bus, the livery and sightseeing vehicle, and the taxicab.

The local city service bus normally stops only for loading and unloading passengers who travel relatively short distances. Off-street loading is, therefore, generally impracticable. As pointed out earlier in this report, the bus stops should be placed where the least congestion will result, usually beyond the far side of the intersection.

Suburban and interurban buses frequently use street space during lay-over periods between scheduled runs and also during long stops for loading. The same practice is frequently followed by sightseeing buses and livery vehicles. Usually these points are located in the heart of the business district. If serious congestion results, such use of public street space is not justified, and the bus operators should provide off-street terminals, preferably with suitable space for passenger waiting rooms.

Taxicab service is an essential transportation medium in all cities. As generally operated, however, these vehicles in many cities add greatly to congestion in the business districts. The effects of cruising in increasing the number of vehicles on the streets have been pointed out, as well as the belief that cab stands, frequently occupying space needed for moving vehicles, should be limited to the number necessary for adequate cab service.

As far as practicable off-street loading points should be provided for taxicabs and livery cars, as well as for commodity vehicles and interurban and sightseeing buses. Hotels, railway stations and similar buildings which now use cab stands on the street should be encouraged to provide space for such service within the property lines.

Playgrounds

All municipalities and school districts can well afford to provide as fully as possible for playgrounds for children which will tend to keep them from playing in the streets.

RIGHT OF WAY FOR FUTURE NEEDS

Economical future widening programs depend largely upon far-sighted policies of acquiring right of way. Where ultimate wid-

ening of streets or highways beyond the limits of existing right of way is anticipated, provision should be made now for the acquiring of necessary right of way. Where immediate acquisition involves large expenditures and where the widening may be deferred for a period of years, establishment of building set-back lines may accomplish the purpose. In new local business centers it is desirable to set the business buildings back sufficiently to allow adequate approach, parking and sidewalk space in front of the stores entirely out of the main stream of through traffic.

APPENDICES

The Committee realizes that illustrations would be of value to users of this report and is preparing appendices for later publication, including a summary of data on regional planning organization, parking practices, typical traffic survey forms and recent traffic surveys. Diagrammatic and photographic illustrations of different types of grade separations and other physical improvements will also be included.

The Committee invites those interested to submit data which may be of value in the preparation of the appendices.

PUBLICATIONS ON STREET AND HIGHWAY SAFETY

Available on Request to National Conference on Street and Highway Safety, 1615 H Street, N. W. Washington, D. C.

Ways and Means to Traffic Safety—A summary of the recommendations of all Committees and general meetings of the Conference.

Committee reports submitted to Third National Conference, May 27-29, 1930:

Traffic Accident Statistics
Protection of Railway Grade Crossings and Highway Intersections
Maintenance of the Motor Vehicle
Measures for the Relief of Traffic Congestion
Uniform Traffic Regulation, accompanied by
Uniform Vehicle Code, consisting of
- Uniform Motor Vehicle Registration Act
- Uniform Motor Vehicle Anti-Theft Act
- Uniform Motor Vehicle Operators' and Chauffeurs' License Act
- Uniform Act Regulating Traffic on Highways

Model Municipal Traffic Ordinance
Report on Street Traffic Signs, Signals and Markings

Reports of former committees and conferences:

1924	1926
Statistics	Statistics*
Traffic Control	Uniformity of Laws and Regulations*
Construction and Engineering	Enforcement
City Planning and Zoning	Causes of Accidents*
Insurance	Metropolitan Traffic Facilities
Education	Public Relations
The Motor Vehicle	Second National Conference
Public Relations	
First National Conference	

In addition to the foregoing the National Conference has available for distribution publications relative to these subjects issued by participating organizations.

*Out of print