loadings developed by the expressway include:

a. Arrange service roads to permit collection and distribution of expressway traffic via as many local streets as necessary or possible.

b. Widen, resurface, repair or replace old pavements on major feeder streets.

c. Straighten and eliminate jogs and offset streets and extend and connect interrupted streets.

d. Adjust street grades to modern standards.

e. Channelize street intersections and abnormal pavement areas.

f. Increase radius of curb returns to facilitate right turns at intersections.

g. Establish one-way streets to increase their traffic carrying capacities.

h. Correct improper parking and loading and develop off-street parking and truck loading facilities.

i. Arrange sidewalk improvements to accommodate pedestrians and bus loading at points of concentration.

j. Anticipate and provide for convenient interchange of transit passengers between busses operating on the expressway and on local streets by arranging suitable bus loading zones or turn outs on both.

k. Encourage greater use of mass transit vehicles.

l. Coordinate the timing of traffic signals at street intersections.

m. Arrange for strict local enforcement of appropriate traffic, parking and loading regulations and other traffic controls required.

PUBLIC UTILITIES

1. General Considerations.

Public utilities provide services which are essential to the every day activities and welfare of all residents of an urban area. Whether utilities are privately or publicly owned and operated, interruption or costly changes in such facilities are of concern to the public who must pay the ultimate cost either directly or indirectly.

The location of existing and future public utilities is therefore an important factor in expressway design, from the preliminary location studies onward to the preparation of final plans. In relation to design, each location will present its own set of conditions and will constitute a problem demanding original investigation. It is important that the replacement in at least equal condition of all utilities affected by the expressway and their proper maintenance during construction, be treated as an essential element of the expressway design.

The future expansion of utility lines as well as future changes in population, traffic patterns and land use and development must be foreseen so far as such foresight is possible. It is a proper function of expressway design to work closely with planning bodies and all other agencies whose activities bear on future urban development, so that provision for possible future expansion may be included in present construction. There is probably a point of diminishing returns in speculations as to growth that appears distant in time, but it must be remembered that an expressway is an enduring improvement, which should be designed for a long period of usefulness.

2. Responsibility for Utility Changes made Necessary by Expressway Construction.

The principle usually incorporated in franchises and in street and highway codes authorizing utilities to occupy space in city streets or highways is that the utilities are granted permission to occupy their positions subject to the provision that, in the event the future improvement of the street or highway necessitates the removal or relocation of the utility, the resultant expense must be borne by the utility company. This principle was also applied to expressway construction at first.

In connection with expressway construction, the amount of utility disturbance is apt to be considerably greater than in the case of ordinary street or highway improvement. Expressways are most often above or below existing street grades thus materially affecting existing utilities or setting up barriers to the systematic expansion

or enlargement of existing utility systems. Extensive relocations are often necessary in order to eliminate utility lines running longitudinally within the expressway limits, the tenancy of such position being usually prohibited. The principle of placing all responsibility for removals or relocation of existing facilities on the utility company or agency is therefore not an equitable one.

Definite provisions setting up the specific responsibilities of the utility and the state have now been written into several state laws. These laws require that the state shall pay for all or specific parts of the cost of relocating or maintaining public utility facilities disturbed by expressway construction.

It is therefore incumbent upon the expressway designer to so locate the expressway, subject to other controlling factors, that the disturbance of existing public utilities and the special provisions which must be made for them in connection with the expressway, will be kept to a minimum consistent with other controlling factors of expressway location and design.

However, the location of utilities in relation to the expressways must be such that there shall be a minimum of interference with the functioning of the expressway once it is completed, and that the desirable esthetics of the expressway are preserved. For this reason it is desirable to set up some standards or rules to govern the location of utilities along or across expressways. Suggested rules for such location are set forth in the following sub-section.

3. General Rules for Location of Utilities Along or Across Expressways.

The following general rules are becoming recognized as being good practice for the location or relocation of utilities in relation to expressways:

a. All new public utility facilities, both aerial and underground, located longitudinally with the expressway, shall be excluded from the expressway right of way. They may be located in the outer highways if such are provided paralleling the express roadways.

b. All existing public utility facilities, the maintenance of which would disturb traffic or damage planted or landscaped areas, shall be relocated when the expressway is constructed.

c. Utility crossings of the expressway shall, wherever possible, be made at grade separation structures.

d. Where crossing between grade separation or stream structures is necessary, such crossing shall be underground except in special cases cited below. Any necessary manholes or points of access shall be located outside the permanent right-of-way of the expressway or at points where servicing of the utility will not require access from the express roadways. Cases requiring large or heavy structures to accommodate the utility facility under the expressway shall be subject to special study and individual decision. New underground crossings for additional services or for replacements shall be installed under the expressway roadways, shoulders and division strip either by boring, jacking or other approved methods. In general a conductor casing of sufficient length to clear the width of expressway should be required.

e. Where the expressway passes over a street or highway on a grade separation structure where no traffic interchange is involved, it is permissible to carry aerial utilities through on the underside of the structure provided the utility facilities are of minor character. This is generally construed to mean not more than a total of five wires or cables. In the case of trolleys, both trolley wires and aerial power feeder wires must pass under the structure. No poles shall be located in the street within the projected width of the ordinary right-of-way width of the expressway.

f. Where the expressway passes over a street or highway on a grade separation structure, when no traffic interchange is involved and when no grade change on the existing street is involved, aerial facilities may be permitted to remain in place and pass under the expressway structure, provided the tops of poles do not extent above the elevation of the expressway. This case applies when the existing street is in deep cut or valley below the express-

way.

g. Where the expressway passes under a street or highway with little or no grade change on street, no poles or other aerial facilities shall be permitted within the limits of the ordinary right-of-way width of the expressway.

h. Where the expressway passes under or over a street or highway at a grade which requires material grade change of the existing street, utility facilities shall be located underground for the entire length of the grade change.

i. No poles or other aerial facilities shall be located within the permanent right-of-way of the expressway or within traffic interchange areas. (See exceptions listed below).

j. Long distance high voltage transmission and heavy primary electric aerial facilities, also underground telephone and telegraph crossings, where expressway is in deep cut, shall be the subject of special study and individual decision shall be made as to their disposition.

k. In the design of bridges crossing the expressway, reasonable provision shall be made for the future expansion of utility facilities in order to safeguard the policy that utility facilities should be underground now and in the future. No rental charges should be made for such normal number of facilities.

l. Gas and water facilities passing under expressways or over expressways within grade separation structures should be constructed of extra long life materials not subject to leakage. Valves should be installed each side outside the permanent right-of-way limits. Traps, drips, blowoffs, etc. should be located outside the expressway right-of-way when feasible. When not feasible it should be subject to special study and individual decision.

m. Stream crossing structures should be utilized freely to carry water and gas mains under expressways, due regard being given to required waterway capacity. In this case no special provision for long-life proof materials need be made.

n. Where large water and oil pipe facilities are involved, special galleries of suitable design and size should be considered, having due regard for maintenance and replacement problems.

o. Where the expressway crosses pipe facilities (water, gas, oil, gasoline, sewer), where no structure is involved and where the grade elevation of the utility is such that it need not be relocated, the utility shall be rehabilitated, if required, with long life materials of adequate strength.

p. Storm sewers and sanitary sewers which pass under the expressway should be constructed or reconstructed of materials of long-life and adequate strength.

q. Where it has been determined as necessary for utility facilities to cross under an expressway the crossing should be made as nearly normal to the expressway center line as possible. Long, diagonal crossings are not desired.

r. Existing utilities which cross the expressway right-of-way at a number of points within the same general area should be combined, so far as practicable, to reduce to a minimum the total number of crossings.

4. Effect of Types of Expressways on Public Utilities.

Expressways crossing an urban area may accomplish grade separation with the existing street system in three different ways: (1), by being constructed at a grade above the normal ground level, (2), by construction at normal ground level, the grade of existing streets being depressed or elevated across the expressway, or, (3), by construction below normal ground level. It is probable that each of these types will be used at times within an urban area and possibly each will find use on one expressway project. The economies of the various types will be further discussed in the Section, "Economies of Design". The effect of the various types of expressway construction on public utilities or how they are affected by public utilities will now be discussed.

a. Elevated Expressways.

a-1. On Elevated Structure - In general, elevated structure expressways offer the least interference with existing and proposed utility facilities.

It is possible to continue both longitudinal and transverse utility lines in place without change except where there might be interference with footings. Future changes and additional crossings of utilities are readily possible. However, the high cost of this type of structure would seldom warrant its use purely from the standpoint of accommodation of utilities. Nevertheless, in a heavily built-up area, the caring for utilities must be an important consideration in the determination of the type of expressway to be used.

a-2. On Fill - The use of expressway sections constructed on fill is usually dictated by such considerations as balancing cut and fill, surface drainage conditions, or other economic factors. However, the use of fills may be advisable in some cases to avoid extensive revisions of public utilities. This applies particularly where large sewers, storm drains or water mains cross the expressway alinement. Reinforcement of such utilities may be required in these cases to sustain the additional loads due to expressway fill. The existence of such utilities obviously becomes an important factor in locating the expressway.

Fill or embankment design, while less damaging to utility services, is usually less desirable from the viewpoint of the neighborhoods traversed.

b. Expressways at Grade.

Construction of expressways at grade will permit the continuance of existing utilities across the expressway without interruption except as follows:

1. Where utilities are in a street which is depressed to pass under the expressway.

2. Where a street passes over the expressway and it is deemed desirable to relocate the utility facility over the expressway in the grade separation structure and approaches.

3. Where utilities are overhead and come within the provisions of general rules (d), (h), (i), of subsection (3) hereof.

c. Depressed Expressways.

c-1. In Open Cut - Open cut design, since it seems to offer the most advantages in a built-up metropolitan area, will probably be the cross section often used It will be the most damaging to existing utilities, most of which are subsurface, and the ability to extend future utilities across the expressway. Where streets cross over the expressway, provision can usually be made to carry gas, water or sewer pipes and electrical conduits in the grade separation structure, sometimes with minor necessary adjustment of grades. Such utility lines must be adequately protected by proper structural measures. Storm drain pipes when flow grade lines permit can sometimes be carried across the structures in a similar manner by a change of cross section from circular pipe to elliptic, to occupy the reduced headroom available in the bridge structure. Where sewers and storm drains or other utilities are too deep or large to be relocated in the bridge structure, it may be necessary to redesign and rebuild extensive portions of the existing systems. Such cost would usually be a proper charge against the expressway project.

c-2. In Tunnel - In tunnel sections, it is especially desirable that ventilating and lighting or other necessary utility facilities be so located that they may be maintained and repaired without delays or interference with traffic. Tunnel sections will usually occur only where deep cover is available, and conditions as to utilities will not ordinarily be less favorable than in open cut sections.

ECONOMICS OF EXPRESSWAY

1. Economic Need of Expressway.

Most cities when laid out, were not planned for motor vehicle traffic and the result is that many suffer with traffic congestion on main thoroughfares. This congestion is magnified by the use of the streets for parking of vehicles.

One consequence of the congestion is uneconomical operation of motor vehicles for the inhabitants of the city as well as for those who live outside of it but for whom the city is the economic and social focal point.

Another consequence is blighted