TRAM PRIORITY - HOW AND WHEN WILL IT HAPPEN?

Background

Part of the policy of the Labour Government is to change the modal share of passengers using cars versus public transport - in other words, strategies are to be developed to increase the patronage of the public transport system. This to be achieved by providing a competitive and efficient alternative to private transport.

There are many factors involved in making public transport more attractive to the community and therefore increasing ridership. These include the quality of the vehicles, location of stopping places, frequency of the service, route coverage, i.e., the distance between origin of journey and boarding of vehicles, service punctuality and travel time on the vehicle.

Travel time itself is made up of a number of factors, these include loading time, vehicle acceleration and deceleration, maximum speed, and external factors such as delays caused by interference from other vehicles and traffic signals. Analyses of several recent peak period delay studies indicates that these delays average approximately 32% of running time in the morning peak and 43% in the evening peak.

The Government's intention is that traffic priority will be provided for public transport vehicles so that travel times and their variability will be markedly improved.

Historically, tram services were constructed in arterial streets in the early 1900s because, in general, the other traffic using roads was reasonably light and did not interfere with these new, modern services. Even so, one can quote examples from the early 1920s of the Tramways Board complaining in its annual report of congestion and resultant delays to trams in Collins Street. Even in those early times recognition of the advantages of separation was given, hence Victoria Parade, Dandenong Road, etc. Unfortunately, when the opportunity was there to provide the same treatment in Royal Parade and Flemington Road it was not taken.

In more recent years, since the Second World War, with the very rapid increase in the use of motorcars, problems of traffic interference have been much more acute. This interference has been one of the reasons for the demise of tram systems around the world.

In Europe one reaction to this has been the development of LRT and with the LRT has come increased emphasis on separation for the light rail vehicles. This has been achieved by a combination of subways, separate right-of-way with physical separation in medians, and in narrower streets using such devices as concrete barrier kerbing or raised tracks. In Melbourne, only 10% of tram tracks are in their own right-of-way, whereas in many European cities over 50% of tracks are in separate right-of-way. For example, the percentage of separated track in Gothenburg is 85% and in Hannover 70%.

In other locations, separation has been achieved by regulation and lane marking. For example, in Zurich motor vehicles are kept off the tram tracks by regulation and the use of broad white lines. There is very good acceptance of and compliance with these regulations and I have seen a queue of cars extending up to a mile in length with not one of those cars impinging on to the tram track.

Here in Melbourne we have gradually been developing techniques in some ways similar to the European system, but in other ways along different lines.

For some years we have been investigating providing active signal priority for public transport vehicles, in particular buses, at isolated intersections. These experiments have met with mixed success. For instance, the first experiment in active bus priority in Oriel Road at Bell Street showed worthwhile savings in bus delays and delay variability but some motor traffic delays increased. This was due to a number of factors including the complexity of the intersection and the phasing, some technological limitations on the detection equipment, and a general lack of expertise in the area of active priority.

An experiment with active tram priority in a linked signal system in Victoria Street, Richmond, has also met with very limited success, again because of technological limitations in detection and signal systems and because of a lack of expertise in the area.

More recently, with the planned introduction of linked traffic signals, considerable thought has been given to the inclusion of public transport priority in the linked signal system. We are now hopeful that by using various dynamic control techniques this can be achieved with very little detriment to the other road users.

Active tram priority should minimise tram delays by initiating priority phasing if, and only if, it is required. Misdirected priority is of little value to trams and may worsen operating conditions by encouraging extra traffic and this may lead to a reticence to consider higher levels of priority.

Active tram priority does of course require special tram detection. Much effort is being directed towards obtaining suitable, reliable equipment. The actual number and location of the detectors is of considerable importance also.

New signal control systems are able to accommodate a range of active priority techniques. These include:

1. Phase extensions, where detection of an approaching tram extends the green phase;

2. Early starts, where tram detection causes the green phase to commence earlier;

3. Flexible window stretching. This is a technique which utilises phase extensions and early starts together to obtain the maximum benefit from them. I will discuss this technique in more detail later;

4. Tram actuated right turn phases, where a right turn phase to clear right turners from a tram's approach is called only upon tram detection;

5. Tram extended right turn phases, where tram detection extends a right turn phase;

6. Tram suppressed phases, such as suppression by peak direction trams of a contra-peak right turn phase;

7. Extra tram phases. These can effectively shorten the cycle time seen by trams at multi-phase sites where there are free approach conditions;

8. Tram actuated right turn bans. These could be initiated following the advance detection of an approaching tram but should only be activated when a red signal is being displayed.

9. Multi-level priority, for instance, ordering priority demands for crossing tram routes.

There are also a number of passive priority techniques such as right turn bans, hook turns, double cycling, reducing cycle times, and linking signals for tram progression. These techniques often tend to benefit tram and motor traffic. They can be introduced in isolation or, where tram flows are high and demands for priority are likely to be frequent, they can be introduced in conjunction with active priority measures to reduce the amount of active priority needed to minimise tram delays.

Guidelines for the type and level of priority to be implemented at particular sites are currently being developed by a consultant engaged by RoSTA.

Let me return to explain more about flexible window stretching. The concept was developed by Dr McGinley of my staff and is discussed in a paper about active priority in linked traffic signal systems which he intends publishing. The window stretching idea is simple. Whereas initial linking designs limit the duration of phase extensions and early starts so as to

a. preserve the progression trend in the linked street, and
b. ensure that a minimum cross street time is available,

normal window stretching sets the level of phase extensions and early starts by making the very conservative assumption that both are called in one cycle. Flexible window stretching, on the other hand, allows a maximum extension whose duration is equal to the sum of the phase extension and early start that would have been allowed in normal window stretching. Naturally, most trams would not require the full extension available. In these cases, the residual extension is made available as early start after the next red, if required.

Flexible window stretching has not yet been applied in the field but its effects have been simulated for the Sydney Road route. Provided delays caused by right hand turners can be overcome, tram signal delays at a typical intersection can be reduced to only about one second, with considerable reduction in the travel time variability. Even so, if compared with "no priority", the green split would remain virtually unchanged and the progression trend in the linked street would be preserved. (See Table 1 attached.)

Like spatial priority, signal priority will reduce average tram delays and, most importantly, delay variability. Reduced travel time variability, by reducing the incidence of tram bunching, will decrease passenger waiting time and improve passenger comfort. Compared with the existing situation, judiciously implemented signal priority should have very little detrimental affect on motor traffic, and implemented in conjunction with linking will normally result in improved operating conditions for trams and traffic alike.

As I indicated earlier, peak direction trams on average are delayed between 32% and 43% of their actual running time. Depending on the length of the tram route, this corresponds to between 15 and 30 minutes delay. For the North Balwyn route (which runs along High Street, Kew, Bridge Road and Flinders Street) these delays average about 25 minutes out of a total journey time of approximately 60 minutes.

Whilst it is difficult to accurately separate this figure into traffic interference delays and signal delays because of obvious interactions between the two, it would appear that about 10-12 minutes delay on this route caused primarily by traffic signals could be greatly reduced by traffic signal priority measures.

This interaction leads me to another important point. It is precisely for this reason that spatial priority measures (i.e., safety zones and tram lanes) are needed, not only for the reduced traffic interference that will occur, but also to ensure that the benefits of signal priority are realised. It is perhaps a fairly obvious conclusion that creating free approach conditions for trams at signalised intersections using spatial priority reduces the level of active signal priority needed to minimise overall tram delays. In general, the benefits of signal priority and spatial priority implemented together exceeds the sum of the benefits of either type of priority implemented alone.

Spatial priority

In Melbourne we have used separate rights-of-way such as previously mentioned in Victoria Parade, Dandenong Road and some other streets. We have also used barrier kerbing and safety bars in Nicholson Street and Flemington Road and there has been a fairly widespread use of safety zones.

Studies of these separation experiments have shown that tram delays, and especially their variability, have been considerably reduced and that travel speeds for motor traffic have also been improved. For instance, in Flemington Road in-bound in the morning peak, average tram travel times decreased by over 16% and maximum travel times by over 26% when safety bars were installed. At the same time motor traffic speeds increased by over 33% (see Tables 2 and 3 attached for details). In addition, safety bars and safety zones have improved safety for boarding and alighting passengers and for pedestrians crossing the road. We are now proposing to extend these measures by road marking and regulations to define separate tram lanes.

The proposed new regulations, which are expected to be introduced before September this year, provide for full-time and part-time tram lanes and a new regulation, 515, makes it illegal for motorists to obstruct a tram.

There has also been a strengthening of the regulation which gives trams right-of-way over right turning vehicles in intersections. The proposed line-marking and initial signing proposals for tram lanes and regulation 515 are shown in attached Fig.1.

Full time tram lanes will be designated with a broad continuous yellow line and a tram lane sign. As the separation is full-time and safety zones will be provided at stops, the yellow line will normally be reinforced with concrete safety bars.

Part-time tram lanes will be designated by a broad yellow line with the time of operation of the lane depicted under the sign. Outside these specified hours, the new 515 regulation will apply.

At most other locations without tram lanes, regulation 515 will apply. This will be designated by broken yellow lines. Under this regulation, motorists may use the tram tracks freely under normal conditions, but must move to the left when a tram does come along.

Under both this regulation and the strengthened regulation about right turning from tram tracks, motorists preparing to do a right turn must not obstruct a tram and therefore must either move to the left or abort their turn when a tram arrives - unless there is alternative road marking.

Of course, at many signalised intersections in narrow streets it will be necessary to allow traffic to share the tram track area at all times so that traffic capacity can be reasonably preserved and so that right turns can be permitted. These exclusions to regulation 515 will be indicated by standard pavement arrows, usually in conjunction with white, rather than yellow, clearance lines.

Let me now elaborate on how we see some of these new regulations being applied.

On streets where there are always two adjacent traffic lanes, safety zones and full time separation are proposed, see Fig. 2 and 3. This will improve tram operations and safety for passengers and crossing pedestrians and, in most cases, reduce delays to motor traffic and make traffic signals easier to link.

In some cases where traffic demands, especially right turning volumes, are high it may be necessary to carry out additional roadworks in conjunction with the separation to preserve a reasonable level of service for traffic.

Where pedestrian signals are to be installed at mid-block stops in wide streets, it is intended that the split pedestrian crossing layout be adopted, see Fig.4. This layout, in which the tram carriageway is unsignalised, has already been field tested. It results in lower delays for trams, pedestrians, and motor traffic than a full width pedestrian crossing and also makes it much easier to link traffic signals in both directions.

Where there are two lanes between the tram tracks and the kerb, but one is used for off-peak parking, see Fig.5, safety zones are proposed at all stops. In locations where there is considerable delay to off peak services, we believe full-time separation should be introduced. This would considerably improve tram operations and, because there would still be two lanes at intersections, would not significantly alter traffic capacity. Most CBD streets would fall into this category.

In other streets of the same cross-section where off-peak delays are only minor, part time tram lanes operating during clearways, as well as safety zones, are proposed, see Fig. 6. In this situation, regulation 515 would operate off peak.

The most difficult situation is when tram tracks are in a narrow street with room for only one traffic lane alongside the tram tracks - if parking is prohibited. In these cases we see the regulation applied as follows:

First of all, at congested locations with peak period clearways where right turns are required, a section of part-time tram lane over the congested section, followed by a length of shared roadspace, would be introduced, see Fig.7. The area of shared roadspace will ensure that traffic capacity is reasonably maintained while preventing trams from being delayed by more than one red light. The length of tram lane will ensure that motorists will be able to keep clear of approaching trams and, unlike regulation 515 applied at congested locations, will prevent motorists from becoming trapped on the tram tracks unable to observe the law. For this proposal to be satisfactory it is essential that the traffic signal operation be designed in conjunction with the set back, etc., so that traffic is assisted in clearing the intersection approach so that tram delays and motor traffic delays are minimised.

Where right turns are not necessary and the intersection is not critical to route capacity, the tram lane continues to the stop line, see Fig. 8. Some T-junctions, junctions with collector roads and pedestrian operated signals would generally fall into this category. Again, regulation 515 would replace the tram lane in off peak conditions.

In uncongested locations, or in congested locations without clearways, it is intended that regulation 515 will apply all day with a length of shared track near signalised intersections, see Fig. 9. Although it is desirable to introduce clearways over short sections to ensure continuity, and in some cases to alter the hours of clearway operation, this approach minimises the impact of priority on local businesses.

There will be some locations where a critical downstream intersection causes congestion with queues back through other intersections at which a safety zone with a single adjacent lane could be appropriate. Provided right turns were not required at the upstream site, traffic conditions would not deteriorate as a result of the safety zone installation since conditions would continue to be controlled by the critical downstream intersection, see Fig.10. However, trams and tram passengers would derive substantial benefits.

In the detailed study of each tram route being undertaken by a consultant for RoSTA, a number of "high profile" sites, where detailed investigations and probable major roadworks are to be conducted, are being identified.

One such site already investigated is Kew Junction where it is proposed that roadworks are to be carried out in Princess Street to increase the number of effective through lanes from one to two and at the same time provide a protected turning/loading bay for buses. This will naturally improve conditions in Princess Street but will also improve conditions on other legs, especially High Street, by allowing more green time to be redirected to High Street.

In addition road widening will take place near the Kew Post Office to allow for the construction of safety zones.

One other high profile treatment is the protection of tram termini. It is usually difficult for a tram to move into a terminus - particularly during PM peak periods. It is also difficult and dangerous to leave them, both in AM and PM peak situation. They are also particularly dangerous for passengers because motorists tend not to be as alert to their obligations regarding boarding/alighting passengers. A suggested treatment involves track relocation and pavement widening to protect the terminus with a safety zone and safety bars whilst still retaining two lanes of traffic both ways, see Fig.11. This is similar to the treatment recently completed in the Glen Iris terminus in High Street.

In some situations where trams face stop signs it may be possible to construct roundabouts. Roundabouts are characterised by much lower delays for trams and motor traffic than traffic signals. They have an excellent safety performance and may often reinforce local area objectives, see Fig.12.

I believe these spatial priority measures, implemented in conjunction with a proposed publicity programme, will enable sensible, safe, enforceable operations in off peak as well as peak conditions. At the same time, the strategy focuses on peak period operations when tram operational problems are greatest.

The regulatory measures are to be implemented by September 1983, however where major road works are required detailed investigation and appropriate construction time will cause some delays. Even so, by around mid 1984, when active tram priority is scheduled to be introduced in conjunction with the signal linking programme, Melbourne's tram services should be vastly improved. At that stage the 60 minute terminus to terminus tram trip of today might be completed in less than 40 minutes and, what's more, the service should be punctual and reliable.

Because of the Government's programme for linked traffic signals we believe that the total programme for tram priority can be introduced to provide substantial benefits for passengers but at the same time other road users will receive some benefits in reduced overall travel time.

ACKNOWLEDGEMENTS

I wish to thank the Tramways Board for permission to present this paper. My thanks are due to many people who have contributed directly and indirectly to the formulation of the programme described in this paper, but I would be remiss if I did not particularly mention the help in preparing this paper that I received from Jackie Dempster, Michael Fraser, Frank McGinley and Julius Roe. Despite this assistance I take complete responsibility for any errors that may be in the paper and would like to stress that any opinions are my own and not necessarily those of the MMTB.

SCHEME	cycle (s)	normal main street period (s)	normal cross street period (s)	minimum cross street period (s)	maximum extension/ early start (s)	core (s)
l. no priority	120	72	48	32	0	48
ii. basic W.S.	120	72	48	32	8	32
iii. F.W.S.	120	72	48	32	16	16
iv. F.W.S. (max.priority)	120	56	48	32	32	0

SCHEME	DELAY		EXTENSIONS			EARLY STARTS			TOTAL PRIORITY	GREEN SPLIT
	avge per tram (s)	std dev'n per tram (s)	avge called (s)	avg called per cycle (s)	% cycles	avge called (s)	avge called per cycle (s)	% cycles	avge per cycle Extn + Early Start (s)	avge towards main street (%)
i. no priority	9.6	14.7	0	0	0	0	0	0	0	60
ii. basic W.S.	4.1	8.4	4.3	0.2	5	7.3	1.4	19	1.6	61
iii. F.W.S.	1.1	3.5	8.1	0.7	9	11.7	1.8	16	2.5	62
iv. F.W.S. (max. priority)	0.2	1.7	16.8	2.7	16	20.7	1.7	25	4.4	61

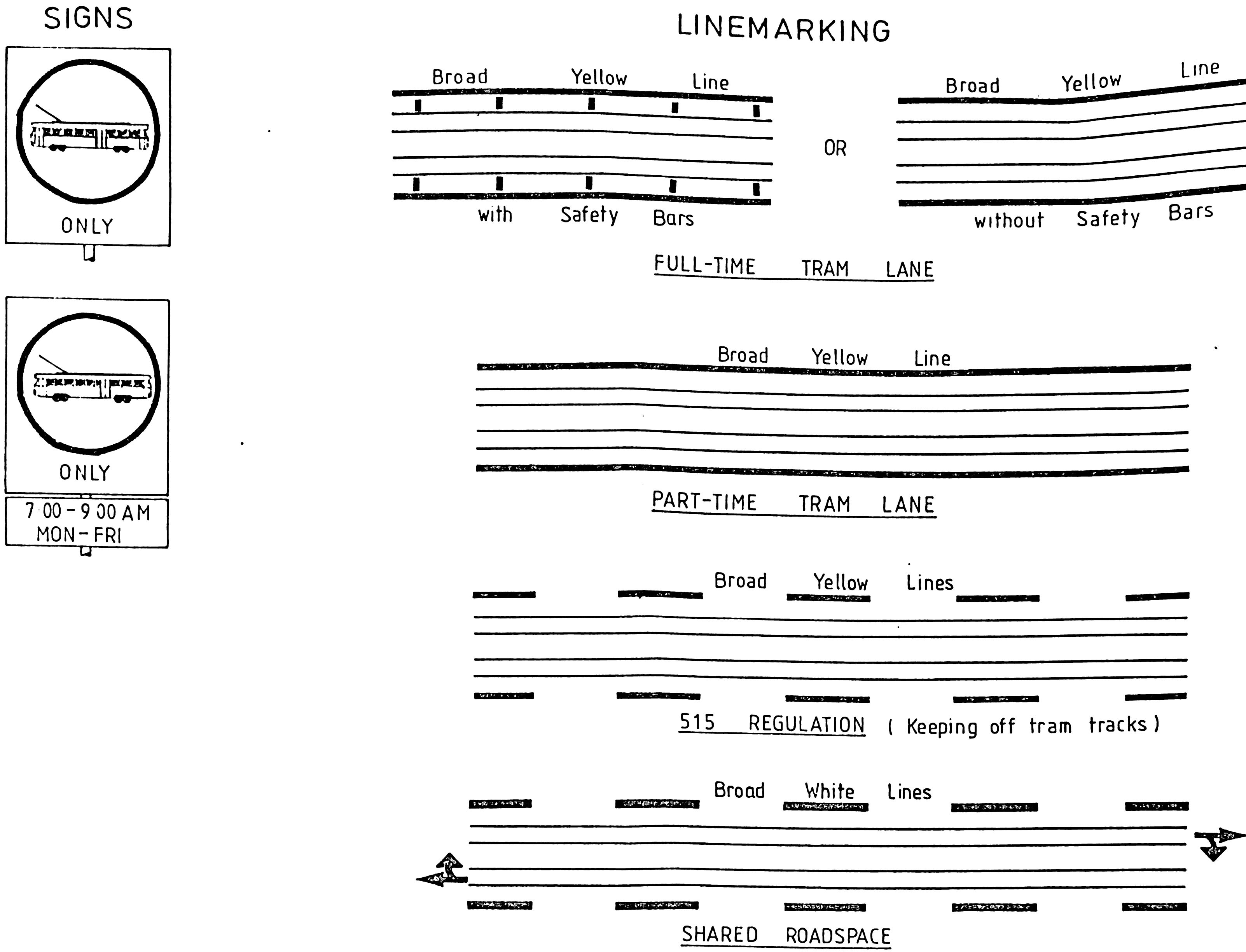
TABLE 1: Simulated effects on trams and motor traffic of window stretching alternatives for Sydney Road

	Before (sec.)	After (sec.)	Change (sec.)	Change (%)
AM-inbound	443 (526)	370 (389)	-83 (-137)	15.5% (26.0)
AM-outbound	369 (562)	295 (326)	-74 (-236)	20.1% (42.0)
PM-inbound	407 (517)	333 (394)	-74 (-123)	18.2% (23.8)
PM-outbound	418 (622)	342 (408)	-76 (-214)	18.2% (34.4)

TABLE 2: Tram travel times in Flemington Road
(2 hour average)
( ) indicates maximum

	BEFORE (MARCH 1980)			
	City bound AM (7-9)	Outbound AM (7-9)	City bound PM (4-6)	Outbound PM (4-6)
Haymarket/ Wreckyn	40	28	20	19
Wreckyn/ Gatehouse	35	37	35	28
Gatehouse/ Abbotsford	17	26	26	17
Abbotsford/ Racecourse	16	24	18	14
Overall	21	28	23	18
	AFTER (OCTOBER 1981)			
	City bound AM (7-9)	Outbound AM (7-9)	City bound PM (4-6)	Outbound PM (4-6)
Haymarket/ Wreckyn	32	40	20	22
Wreckyn/ Gatehouse	36	24	36	24
Gatehouse/ Abbotsford	27	23	24	19
Abbotsford/ Racecourse	24	34	37	13
Overall	28	28	30	16

TABLE 3: Motor traffic speeds (km/h) in Flemington Road central carriageway before and after safety bar installation



SUMMARY OF LINEMARKING & SIGNS *Fig 1*

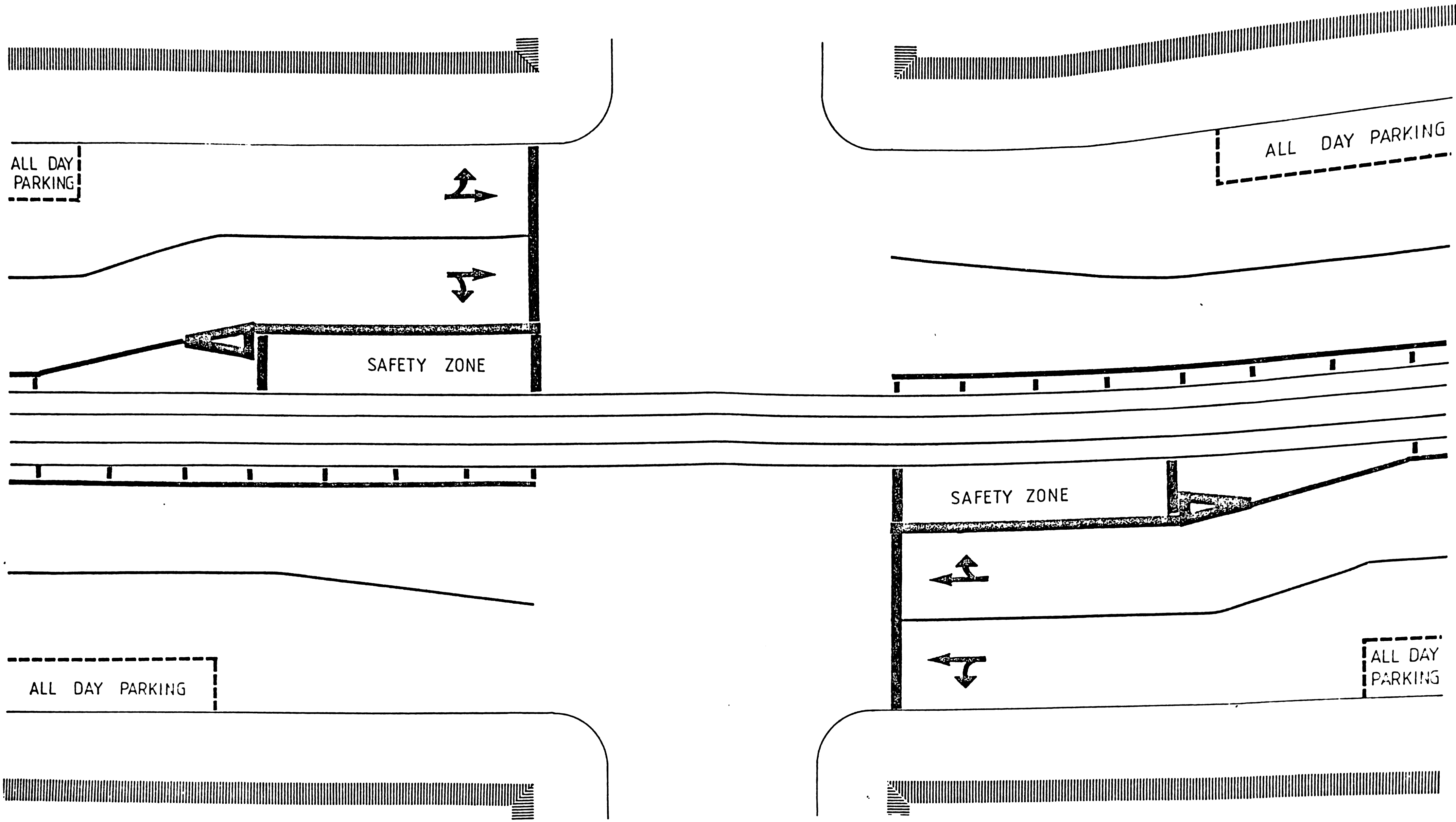


Fig 2

WIDE STREETS APPROACH SIDE SAFETY ZONES WITH TWO LANES PLUS PARKING

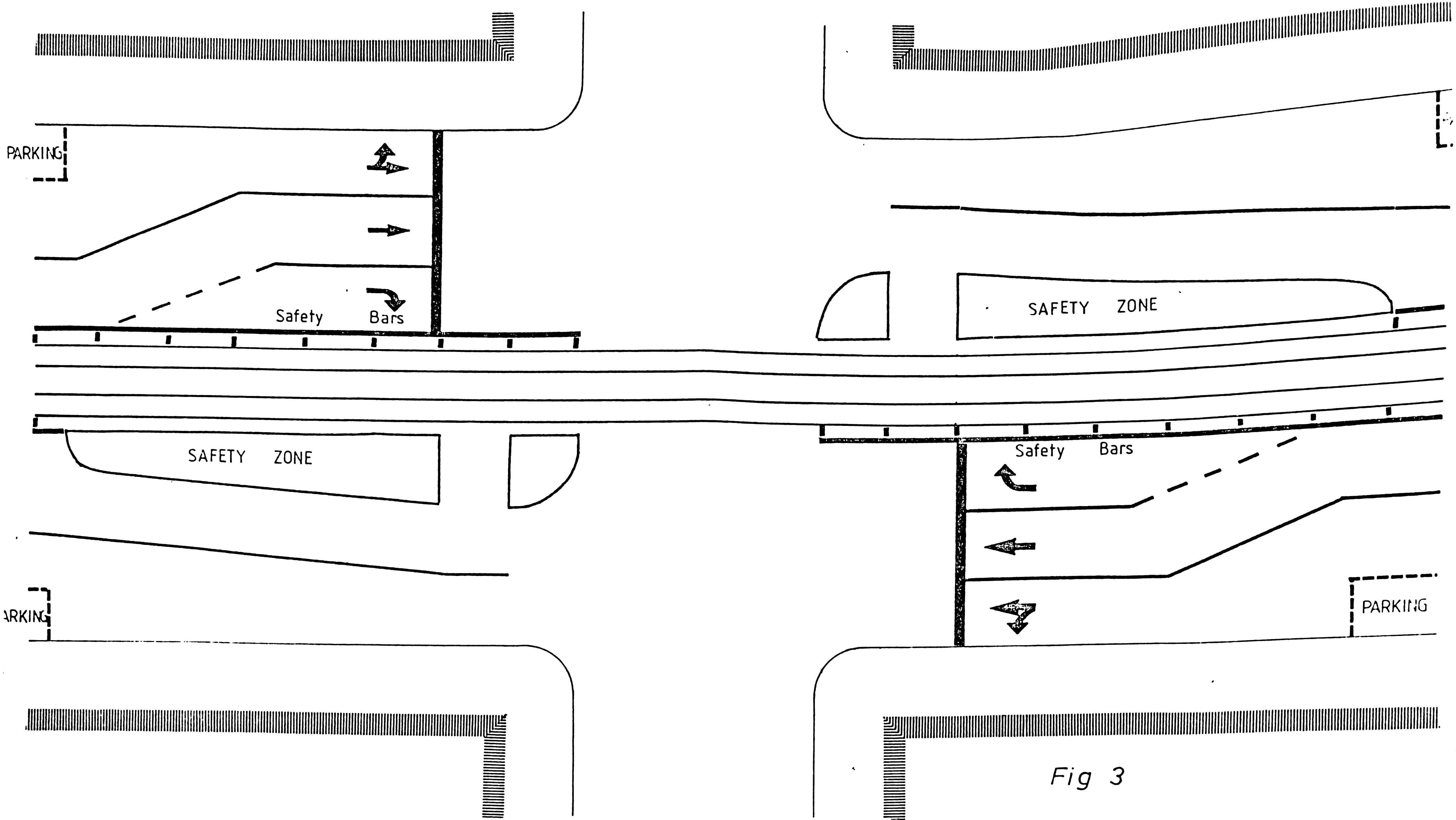
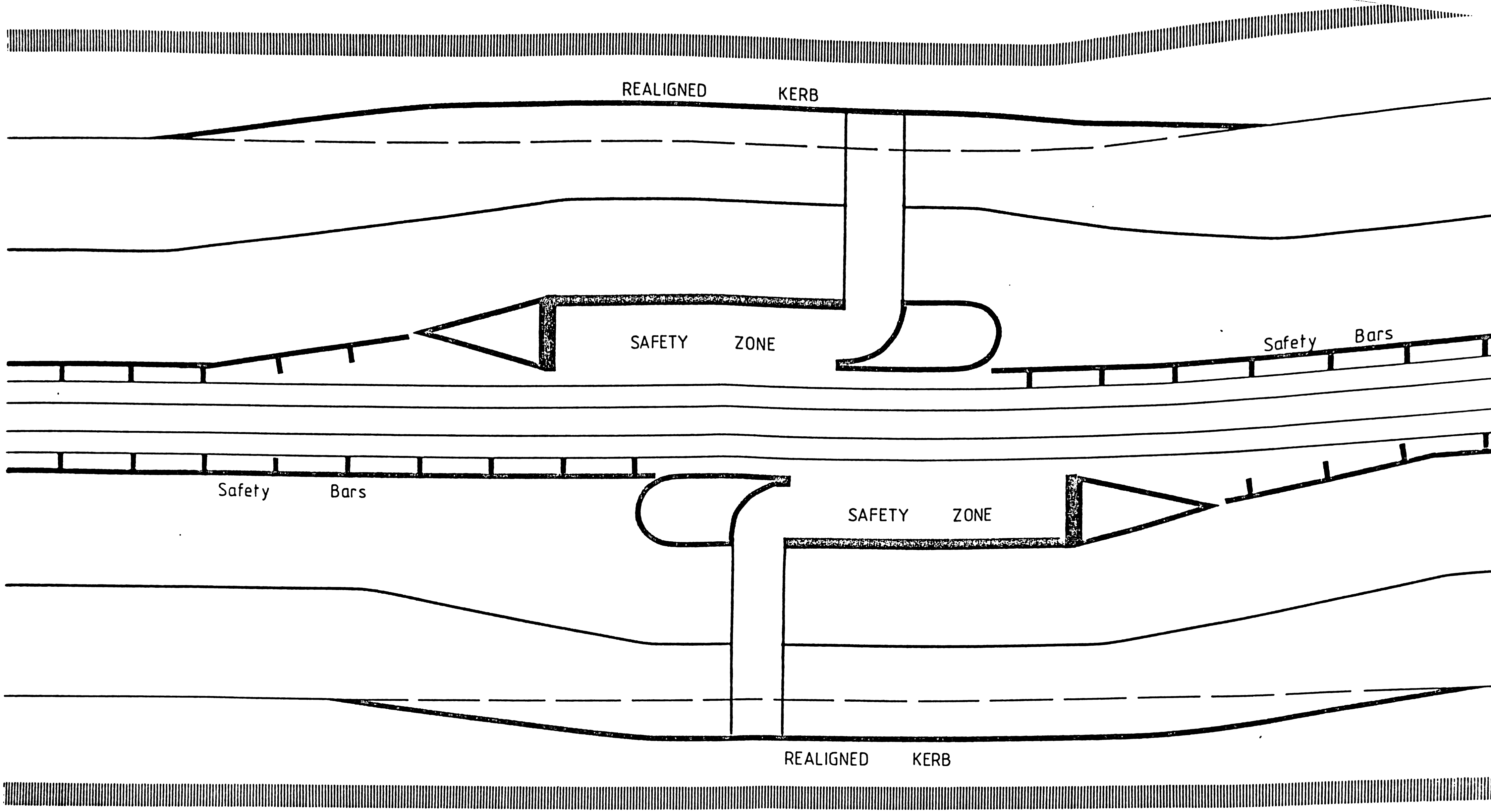


Fig 3

WIDE STREET - DEPARTURE SIDE SAFETY ZONES AND SEPARATED RIGHT TURN LANE



WIDE STREETS MID-BLOCK SAFETY ZONES LAYOUT
WHERE PEDESTRIAN SIGNALS ARE INSTALLED

Fig 4

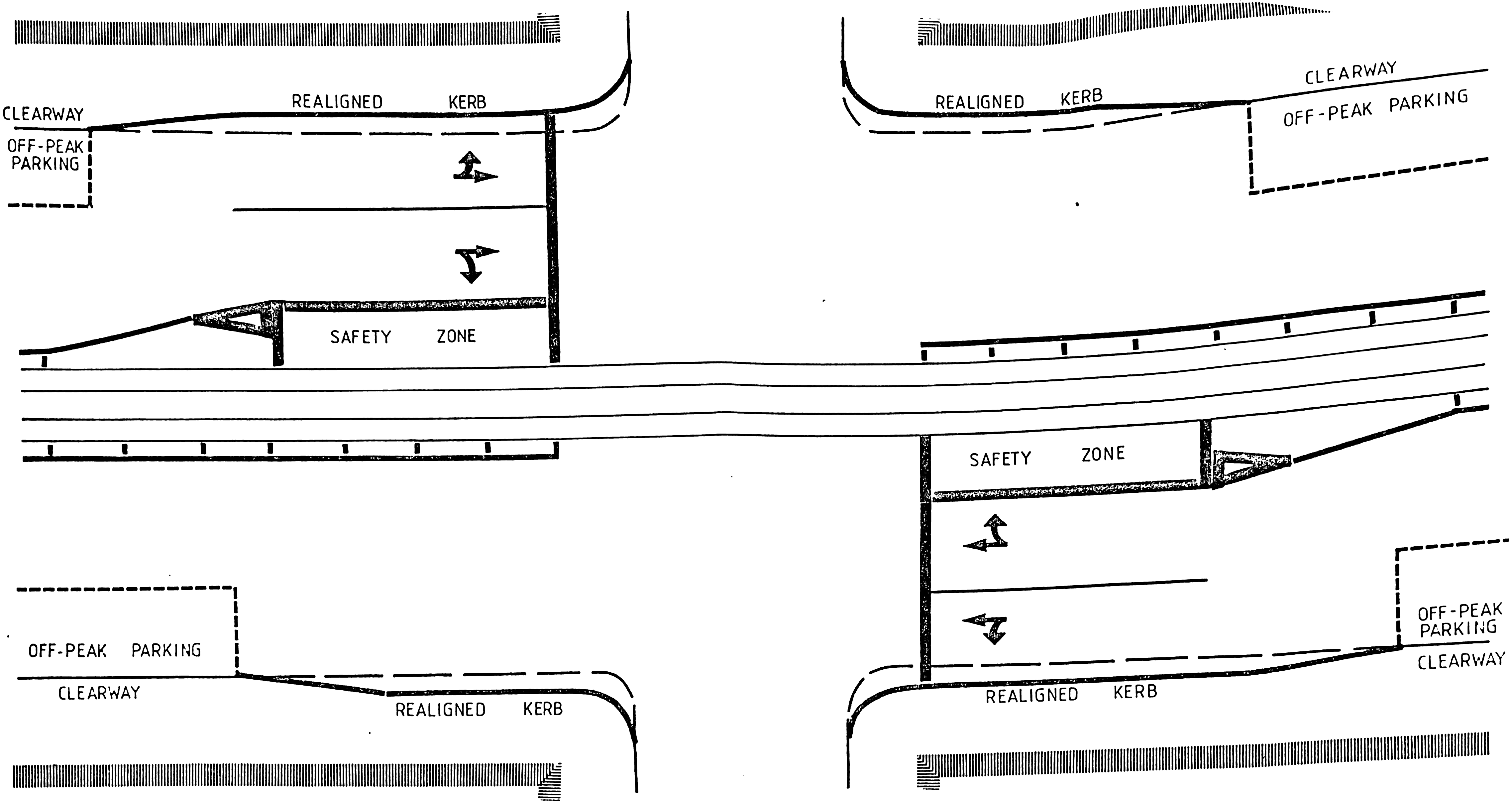


Fig 5

STREETS WITH TWO LANES WHEN CLEARWAYS OPERATE AT LOCATIONS OF CONSIDERABLE DELAY.

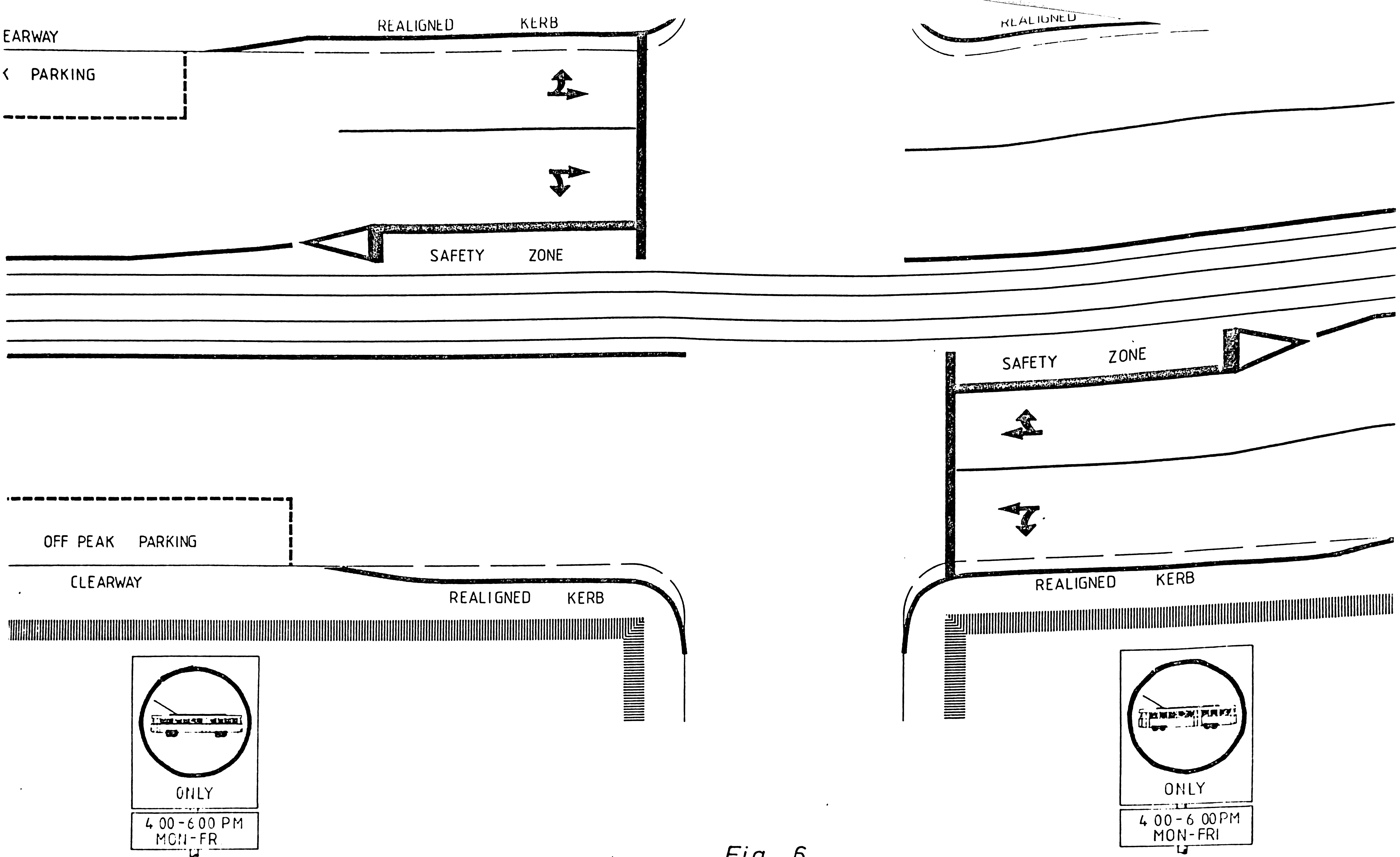


Fig 6

STREETS WITH PEAK DELAYS & MINOR OFF-PEAK TRAM DELAYS

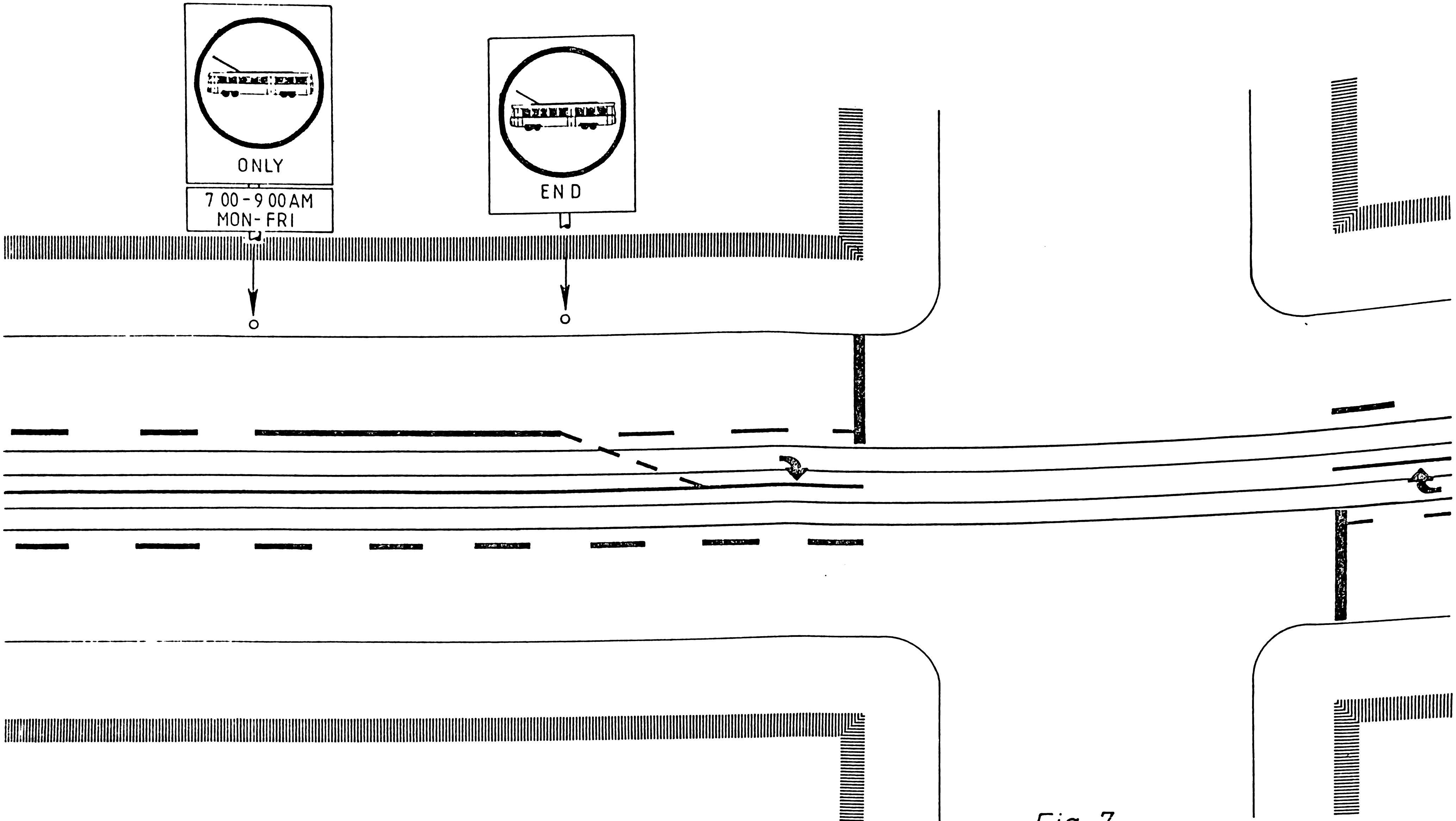


Fig 7

NARROW STREETS – CONGESTED LOCATION WITH PEAK CLEARWAYS:
BACK TRAM LANE, ACTIVE TRAM PRIORITY REQUIRED TO CLEAR RIGHT TURNERS

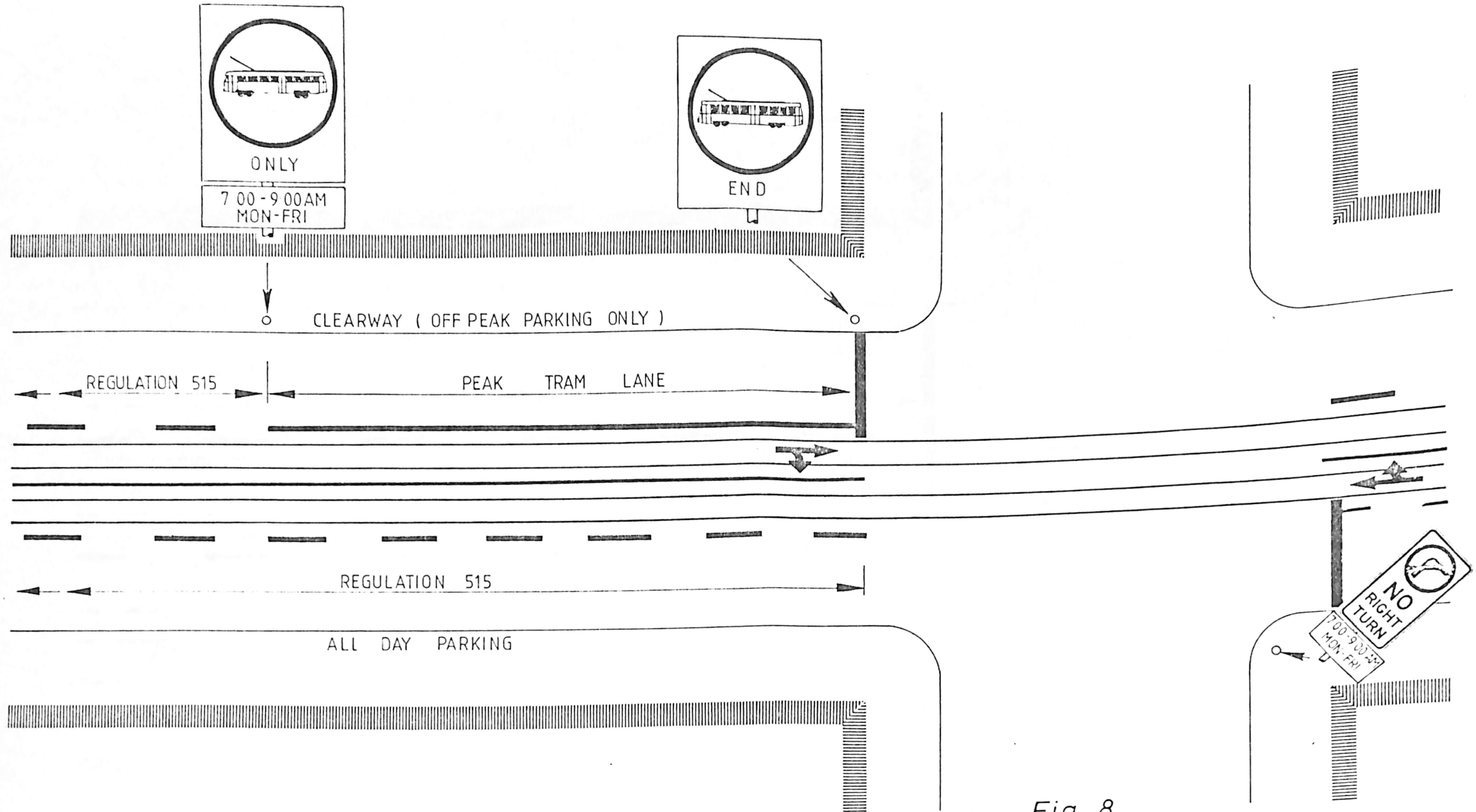


Fig 8

NARROW STREETS - CONGESTED LOCATION WITH PEAK CLEARWAYS : CONTINUOUS TRAM LANE WHERE RIGHT TURNS NOT REQUIRED

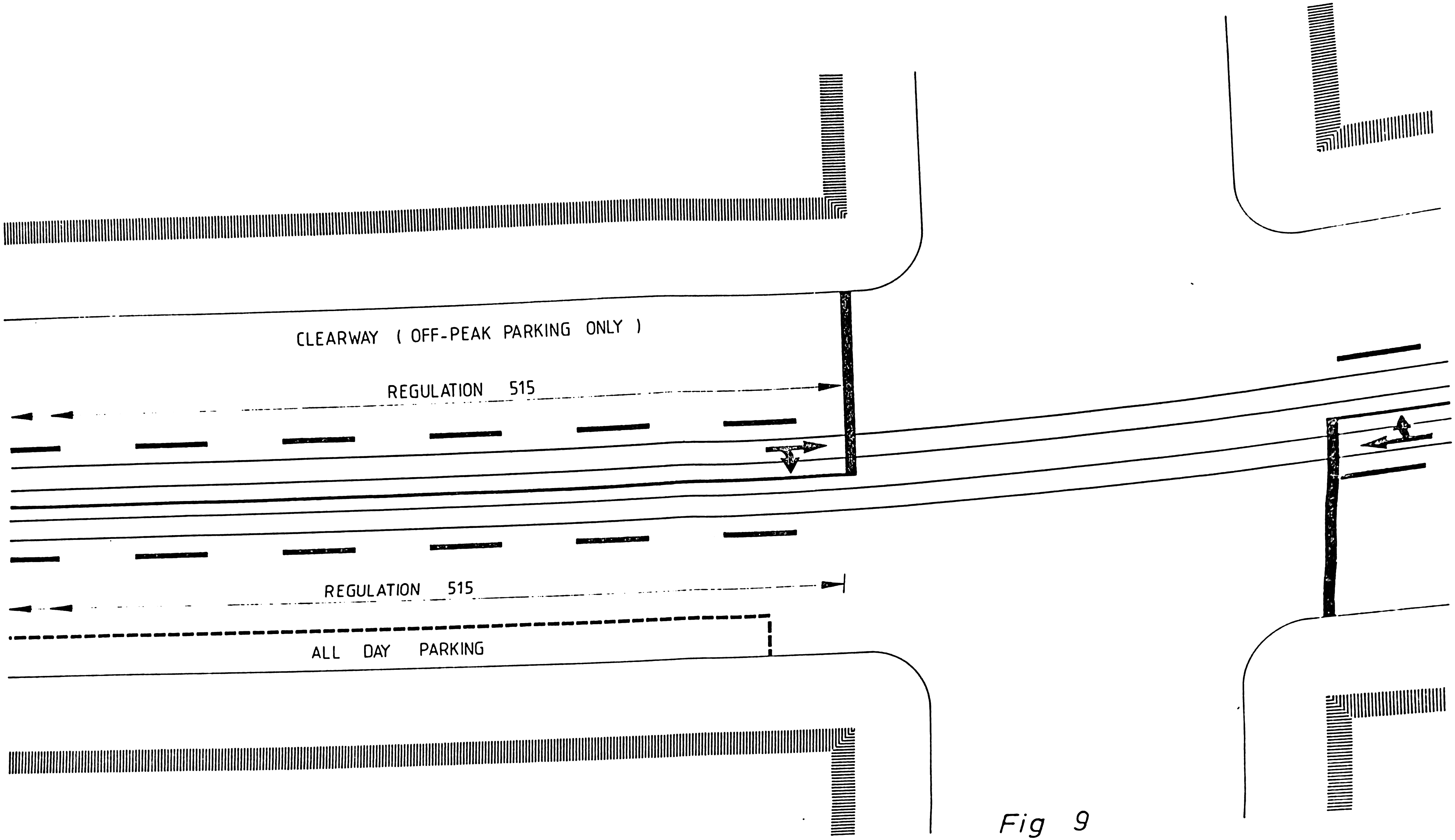
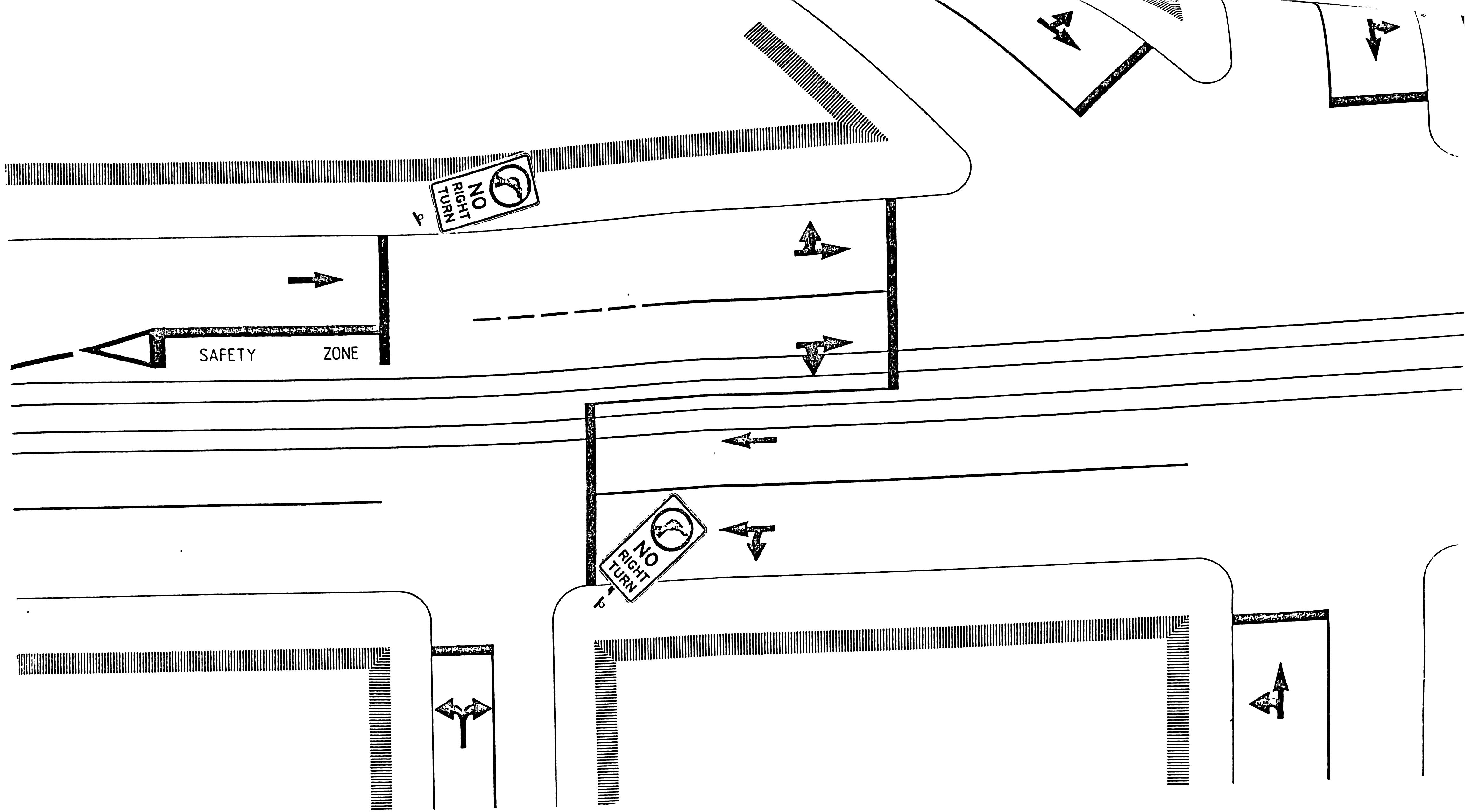


Fig 9

NARROW STREETS - UNCONGESTED LOCATIONS
OR LOCATIONS WITHOUT PEAK CLEARWAYS: REG. 515 APPLIED



NARROW STREETS (ONE LANE PARALLEL TO TRACKS)
SAFETY ZONE AT CONGESTED NON-CRITICAL INTERSECTION

Fig 10

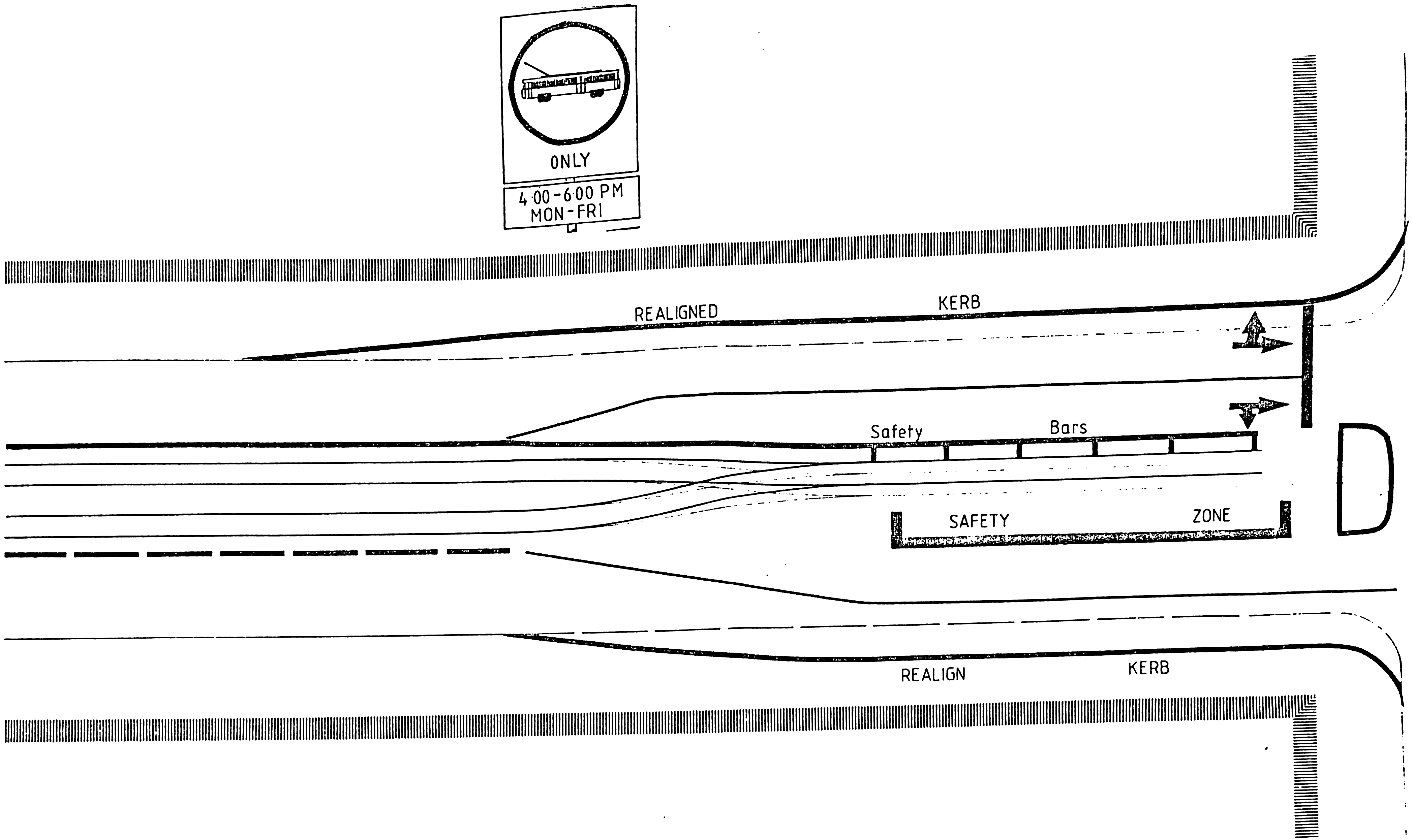


Fig 11

NARROW STREET - SUBURBAN TERMINUS TREATMENT

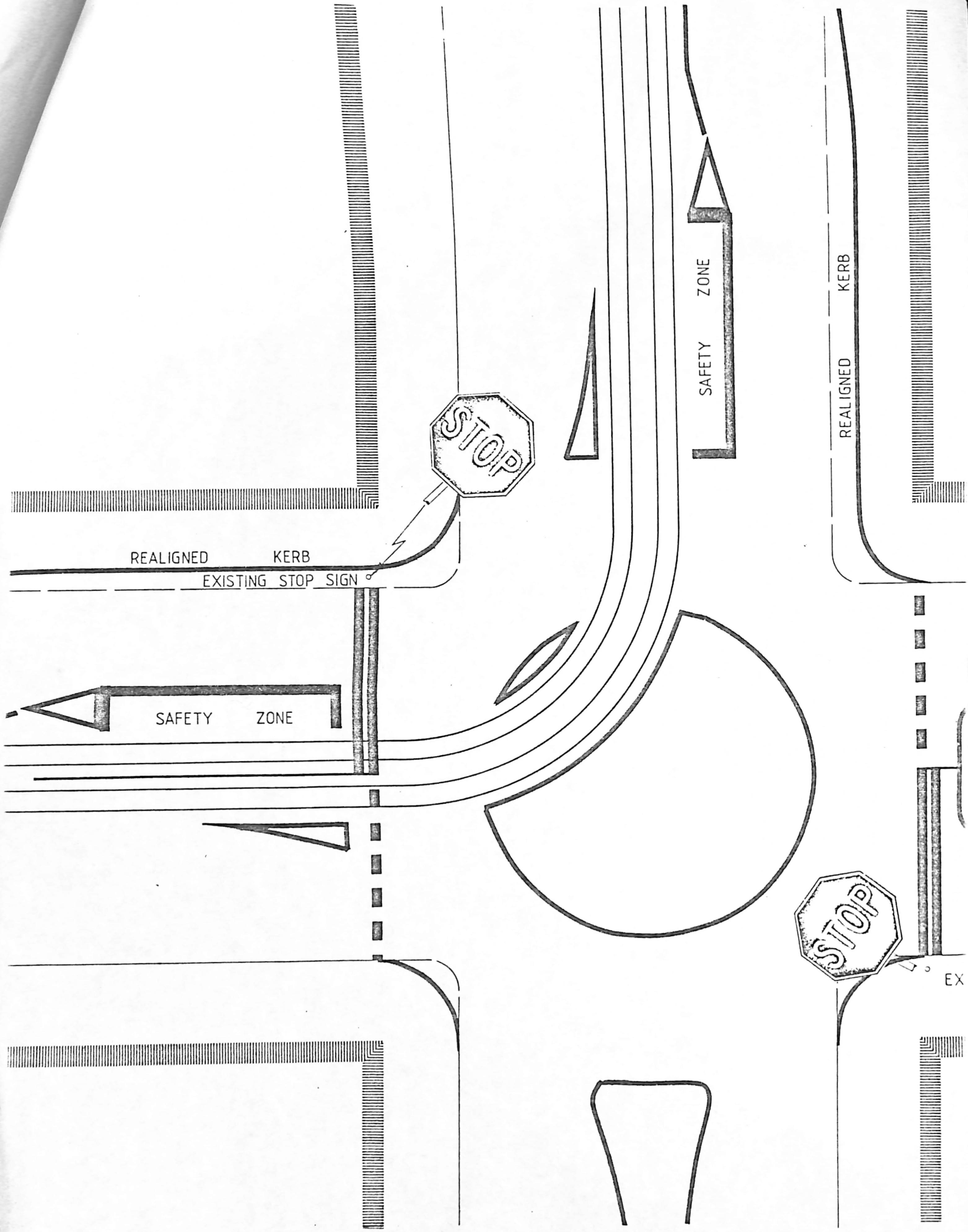


Fig 12

SINGLE LANE ROUNDABOUT TO REASSIGN PRIORITY

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CHIEF ENGINEER

TECHNICAL SERVICES MANAGER

TRANSPORTATION BRANCH

TRAM PRIORITY - HOW AND WHEN WILL IT HAPPEN ?

Two views : The operator & a municipal engineer.

Speakers: Mr. John Grigg F.I.E.Aust.,
Chief Engineer, Melbourne & Metropolitan Tramways Board.

Mr. Ian McDonald , City Engineer , Prahran.

Wednesday 20th April 1983

5.30 pm for 6 pm

THERE HAVE BEEN VARIOUS PROPOSALS FOR IMPROVING TRAM SERVICES IN THE CENTRAL AREA (ZONE 1) OF MELBOURNE USING TRAM PRIORITY MEASURES. THE ISSUES NOW ARE HOW AND WHEN WILL THE POLICY BE IMPLEMENTED. TWO POINTS OF VIEW WILL BE PRESENTED.

Royal Society of Victoria,
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