safety for the traveler on the road have been made clear. However, as previously indicated, safety is a relative condition, and road design which is safe today may need modification in a few years. The engineer or highway official who designs or plans his work on the basis of bare immediate necessities and cost and does not plan for reasonable future safety and development of traffic can not hope to remain long in his position.

In conclusion, I wish to emphasize the importance of the following items:

1. The dependence of safety upon several factors, including the driver, car, speed, weather, and design of highway.
2. Location of road, i.e., relation of alignment and grade.
3. Adequate sight distance.
4. Proper superelevation of curves.
5. Extra width on sharp curves.
7. A road surface free from inequalities and not slippery.
10. Traffic lanes properly marked or defined.
11. Safe guard fences.
12. Wide bridges with safe approaches.
13. Pipe culverts of adequate length to give full roadway width between headwalls.
14. Elimination of railroad grade crossings where practicable.
15. Proper warning signs where railroad grade crossings are not removed.
16. A study of the possibility of eliminating highway grade crossings in exceptional cases.
17. Practicability of pedestrian subways.
18. Safe road intersections.

WHAT WHITNEY COUNTY HAS DONE TO ELIMINATE THE RIGHT ANGLE TURN IN ROADS

By Claude Anspaugh, Whitley County Surveyor

Three years ago the highway department of Whitley County started, as a part of their campaign for increased safety and convenience of motor traffic, a movement that we have decided is one of the greatest safety measures we have as yet under-
taken. This was the elimination of the right-angle turns in our public roads. Numerous accidents had been reported at these places where the motorist was compelled to make a right-angle turn and where, because of ice on the road or because of banks of earth at the corners of the intersections which obstructed the view, he was likely to skid in attempting to make the turn at a high rate of speed or to collide with a vehicle traveling on the other road.

The work naturally divided itself into two classes. First was the elimination of the right-angle jog at township lines. Our county, like a great many counties over the state, has numerous places where the closing corners of sections on township lines failed to meet the corners on the base line of the adjoining township. In some places this made a jog of only a few feet, and in others it made a jog of several hundred feet. In the original construction the roads were placed on the lines and where these jogs occurred they followed around the jog. Our problem was to replace the two right-angle turns by a reverse curve.

The first step is to secure the right-of-way. This costs all the way from nothing to a hundred dollars per abutting farm. Usually, by the use of a little diplomacy and the proper directing of public opinion it can be secured at a reasonable price. In most cases we have been able to get the necessary right-of-way by furnishing and building the new fence where necessary.

Sometimes the landowner feels that he is entitled to damages for the land we are taking, and when this condition is met we get the land we need at the best price we can. The highest price we have yet been compelled to pay for such ground has been $100; but in the very next case the owner of the land willingly gave the necessary amount and objected to taking any recompense whatever. Thus the cost of necessary right-of-way reaches a reasonable average.

After we have secured the right-of-way, we proceed with the construction of the work. We make a 12° curve our maximum and let the length be governed by the nature of the surrounding ground and the number and location of the buildings near the site of the proposed work. The grade is superelevated on the outer edge of the curve to the extent of about ¾ inch per foot of width. As we make the minimum width of the grades of our improved roads 24 feet, this gives us a superelevation of 18 inches. These figures are average, and are changed in different cases to meet varying conditions. If the curve is sharp and the length of the curve must be short, then we increase the amount of superelevation, and vice versa.

As an illustration I might give the figures on one specific case. We have a road running east and west through the south part of our county known as the "Illinois Road." It
is on a direct route from Rochester and North Manchester to Fort Wayne, and carries a very heavy traffic. At the point where the road crosses from Cleveland Township to Washington Township there is a jog in the closing corner of Washington Township of 277 feet. This caused the traffic going east or west to make a right-angle turn, go 277 feet, and then make another right-angle turn. This was the only condition of its kind within a distance of ten miles in either direction, and as a result scarcely a week passed that we did not have a report of at least one accident of more or less serious nature.

We decided to remedy this trouble and started the work. The owner of the land in Washington Township was a woman of unusual liberality, and she told us to take what we needed to make a proper curve on her side of the line, refusing any compensation. We started at the Cleveland Township corner and constructed a reverse curve. A 10° curve was used at each end of the tangent and the distance between curves was 500 feet. The total length of the entire cut-off was about 1,100 feet. After the grade was built and the curves super-elevated at the outer edge, drainage was installed and the entire cut-off was graveled. The total cost of the work, including engineering and inspection as well as labor and material, amounted to $450. We were fortunate in this project in that there was no expense for purchase of right-of-way or damages. In the two years since these right-angle turns were removed we have not had a single accident reported at this place. We feel that the money spent here was about the best investment the county has made in the line of promoting safety on public highways.

Road Intersections

The second class of this work is the eliminating of right-angle turns at road intersections. The results to be attained are, of course, the removal of obstacles which obstruct the view of the driver approaching the intersection, and an increase in the width of roadway available in making the turn. As in the former case, the first step here is to secure the necessary additional right-of-way. The cost varies with the individuals with whom we are dealing. Sometimes they ask damages to a considerable amount and sometimes they donate the ground required.

An arrangement so frequently made with the landowners that it has become almost a standard is for the county to furnish and erect as many iron corner posts set in concrete bases, 3 feet square by 4 feet deep, as are necessary. These posts are made of railroad rails usually 8 feet long. Each post installed costs an average of $12. All work is done by the men working under the county highway superintendent.
These corners are rounded by making the edge of the righthand way at each intersection the arc of a circle, using the straight sides of the road as tangents. The distance we go back from the intersection to start the curve depends upon the amount of traffic the road carries and the number of obstructions to be removed to provide a clear view of the road intersected. In places where there are banks of earth at the corners which must be removed, we start the curve as much as 100 feet back from the intersection each way. In other places where the roads carry light traffic and the view is not obstructed, we have made our distance of starting the curve as little as 40 feet from the point of intersection. The road grade is then widened to conform with the right-of-way line and graveled. The necessary drainage structures are provided.

I can illustrate this type of work as to cost and methods of construction by explaining one particular job done in 1927. We have in the northern part of our county several summer resorts. At certain seasons of the year the roads leading to and from these resorts carry tremendous traffic. In a traffic count conducted by myself one Sunday afternoon last summer a half mile from the entrance to one resort, the traffic reached a maximum density of one vehicle every six seconds for a half-hour period. This corresponds to a rate of 600 per hour.

To reach this resort it is necessary to make two right-angle turns after leaving State Road No. 9. At each of the places where the turn is to be made another public road intersects the east and west road at right angles. These two factors combined made these points frequent sources of accidents.

To remedy this condition we started back 100 feet each way from the point of intersection and made the right-of-way line the arc of a circle tangent to the road line at these points. At each of the curves so formed we erected four railroad iron posts set in concrete, as compensation to the landowner for the ground used. This permitted us to cut down the banks of earth at the corners. The road grade was then widened to conform to the widened right-of-way, the necessary additional gravel was placed, and drainage provided.

The cost of this work has averaged $125. It varied in different cases as the cost of right-of-way or the amount necessary to pay for easements varied. The distance we had to haul the material used made a difference in the costs of different projects.

Our first experiment in this type of work met with such popular favor that at the present time a high percentage of the square turns at the road intersections have been eliminated. The work of getting rid of those that remain is going forward as rapidly as the finances of the county highway maintenance department will permit.
Local Sentiment

The cost of right-of-way easements has steadily decreased. In the beginning the individual land owner felt that he was being imposed upon and he set his price accordingly. Now, however, the land owner when approached on this subject will rarely even name a price. "Go ahead with the work and do what you think is the right thing" expresses the usual attitude of land owners involved. Public sentiment is so entirely in favor of this work that the land owner hesitates to place any obstacles in its way.

We now include in the specifications for all new roads the following paragraph, "Whenever the said proposed road improvement crosses or intersects another public highway the right-of-way shall be widened at the corners so formed so that the curves will have an external secant of 20 feet, using the straight sides of the roads as tangents. The gravel wearing surface shall also be widened to correspond. This work shall be done provided the Board of Commissioners of Whitley County secure easements." And as soon as the contract for the construction of the road is let the commissioners authorize the county engineer to secure the necessary easements.

In our specifications we make twenty feet the minimum distance from the point of intersection for starting our curves, and then we get as much additional land as the location of the work justifies and the land owner will permit.

The cost of this work when done at the time the road is improved adds so little to the cost of the entire project that it is negligible. It adds so much to the completed road improvement that it will be well worth the expense, even though it did add materially to the cost of the contract.

We feel that our efforts in this respect have been well worth while. The fact that we have not had a report of a single accident at one of the intersections so improved fully convinces us that we are on the right track and encourages us to go ahead with this work as rapidly as possible.

HIGHWAY SUBSOIL STUDIES

By V. R. Burton,
Deputy State Highway Commissioner, Lansing, Michigan

Subsoil studies of various kinds have recently engaged the attention of very many highway engineers. Much of the work done, while fundamental in its line and interesting in its ramifications, is yet of little practical value to the engineer.