MAINTENANCE AND DRAINAGE FACILITIES ON SECONDARY AND RURAL HIGHWAYS

Paul Owen, Assistant Director, Division of Rural Highways
Kentucky Department of Highways

As indicated in your program the subject that was assigned me is entitled "Maintenance and Drainage Facilities on Secondary and Rural Highways." So far as I am concerned the subject is far too broad to be adequately discussed in any reasonable period of time, even if I were capable of doing this. I shall use the term Secondary Highways rather loosely since I propose that we include in this discussion any roads of less than primary importance, especially those roads in the county maintenance systems and the roads which are maintained with the aid of the Department of Highways under what is called the Rural Highway Program.

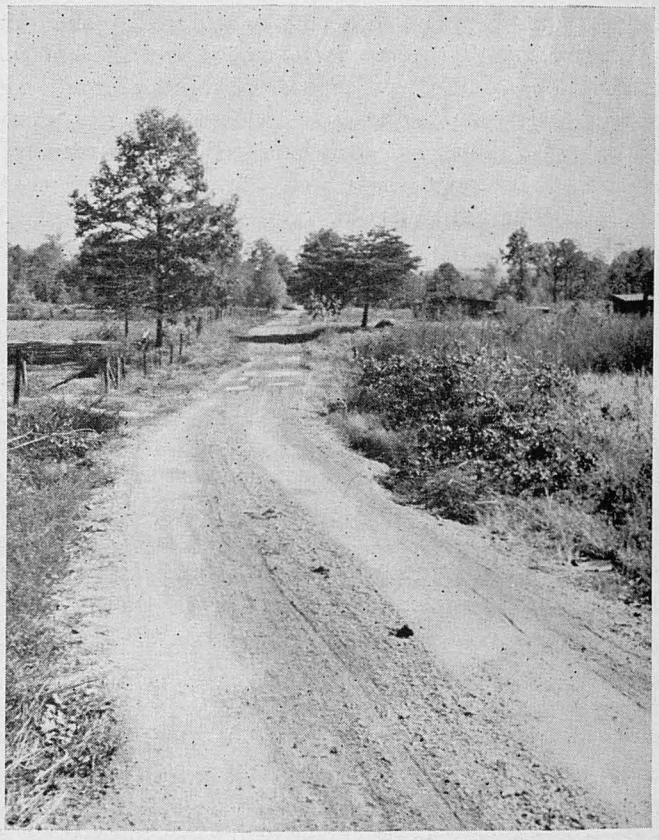
In order to touch upon the main problems that arise in the conduct of Rural and County maintenance programs let us select a few from the long list which faces every road man and look at them in about the way the men responsible for the programs must look at them. This will sometimes require two viewpoints. One will be that of the engineer. This will concern itself with the actual physical nature of the subject. The other viewpoint will be that of the road administrator. These points of view are not necessarily antagonistic but certainly they are not always parallel. I prefer to think of them rather as complementary. Since both of these viewpoints can, and frequently must, reside in the same individual, he may be called upon to assume a dual personality—a sort of Dr. Jekyll and Mr. Hyde, in-so-far as this subject is concerned. All of us, I am sure, remember the old school-boy story of the good Doctor who, by taking a special drug, was able to change into another and entirely different type of person. Mr. Hyde, the wicked engineer, deals with harsh actualities. He will readily say "No" when "No" is indicated. The benevolent Dr. Jekyll on the other hand, wishes to spread the road benefits as widely as possible and is sometimes prepared to say "Yes" when Mr. Hyde says "No". If there were no limit

to available funds and facilities for carrying out our road programs, both Dr. Jekyll and Mr. Hyde could view the subject from the same angle and we could truthfully say that the millennium in road building had arrived. But things being as they are, most of our road administrators and engineers must go on being two personalities in one body and doing the best that a compromise between the two viewpoints can effect.

Among the first problems that arise for consideration is whether or not public funds should be spent for the maintenance of certain types of roads. In other words, are they maintainable within any reasonable interpretation of the word? We have as an example the so-called road, more or less a trail, partly in the creek bed, partly on the rocky hillside and partly along the ridge. It has no shape, no ditches, no well defined roadway and little if any drainage structures. Mr. Hyde, our engineer, promptly says that it cannot be maintained and that any funds spent on it, unless it be for complete reconstruction, will be wasted. Dr. Jekyll, the administrator, may agree that it looks like a tough proposition but he feels that any help he can give the unfortunate residents on the road will be worth something. However, he knows that his funds are extremely limited and that he cannot scatter them unwisely. He must weigh the probable benefits against the cost and he may come up with a compromise by sending his grader over the road if complaints become too frequent. He knows that he has not accomplished anything of lasting benefit for the road itself but feels that he may retain a reasonable amount of good will until funds become available to make real improvements.

Then we have a second type of road which our engineer, Mr. Hyde, would call non-maintainable. This is surfaced with what is variously called "chunk rock", "slab rock" and "cobble stone". Such a road may be useful throughout the year but it cannot be travelled with any degree of comfort. Mr. Hyde advises a major operation but Dr. Jekyll has a different idea. When Mr. Hyde's back is turned he may send the grader onto it. However, he will do this but once. The grader man calls in from Peewee Village and says he has broken the circle and please send help. Dr. Jekyll jumps into his car and rushes out to see the trouble. He finds a little moist earth on the old surface and here

and there a scattering of rock slabs yanked from their resting places among which he must thread his way. He gets the grader repaired and hoping to make things a little better for his unfortunate constituents, sends his trucks to the quarry for a few tons of crushed stone. The stone pleases everyone but Mr. Hyde, but after a few weeks Dr. Jekyll discovers to his chagrin that the stone performed about like marbles on a sidewalk, rolling about and ending up in the ditches, if any. In desperation he turns the road over to Mr. Hyde.



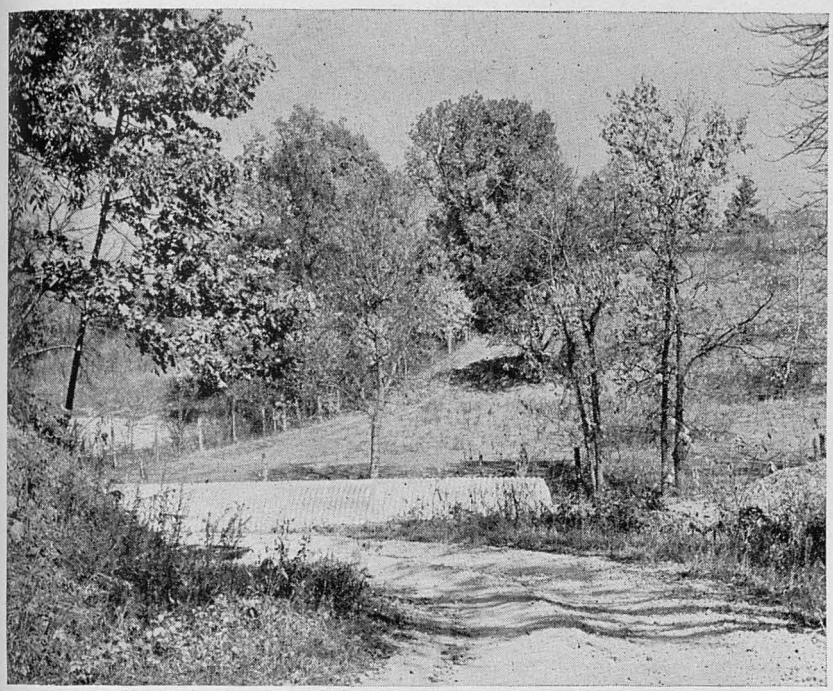
Because of its position with respect to the surrounding topography, this rural highway acts as a drainage way in times of heavy rainfall. Reconstruction on present standards will provide greater width, ditches, and other drainage facilities to make the road stable and permanent.

Mr. Hyde will probably propose one of three methods to deal with the situation. He may suggest that all of the stone be rooted up and crushed on the road with a traveling crusher. This will give a surface that can be maintained by ordinary methods. Or he may prefer to utilize the bearing value of the old rock base. To do this he may recommend that a cushion of earth be provided by ditching and shaping the shoulders and at the same time placing a uniform layer of earth over the old surface. The earth cushion and the surface need not be extremely heavy but should be sufficient to thoroughly stabilize. If the road is rather important and has good drainage structures, adequate right-of-way and is so located as to be of permanent value Mr. Hyde may advise a bituminous treatment. This should consist of an adequate prime followed by a mix of sufficient depth to withstand stripping and to provide a reasonable amount of leveling for the irregularities of the old base. Whatever the method used, the road is now maintainable and everyone is happy, even the irascible Mr. Hyde until he views the hole that has been knocked in his budget.

We come now to the well improved county road which everyone would like to have taken over for state maintenance. That is everyone except Mr. Hyde who would be required to maintain it. It is here that Mr. Hyde sometimes is very effective. Neither the blandishments of influential citizenry nor the reasoning powers of legal minds can budge him. He has seen the road. Yes, it is a good little road. But it only has 40 feet of right-of-way, and through the village of Dingus the distance between buildings is just 23 feet. Then there are those right angles on three corners of the old Jackson farm. (Jackson didn't want his cornfield ruined but did want the road in front of his home.) The old steel bridge over Cow Creek wouldn't hold up a patrol grader leaving out of consideration the possibility of ever taking a shovel or tractor over it. A new bridge would cost $50,000 and where would we find money to match Federal Aid if funds were diverted to all of the old county bridges that need repair? Now if you can get those houses back in the village of Dingus and can get a new right-of-way through the Jackson place and if the Fiscal Court will agree to use Rural Highway funds to build a new bridge then we might be able to do something with that road. Yes, Mr. Hyde at last has his day.

Now we may ask, which of these viewpoints and attitudes is correct? Paradoxical as it may seem, both are in some degree correct and every decision made in such cases must be a reasonable compromise between long time benefits and immediate necessity. Mr. Hyde wants his task done in the best possible manner. He knows that over the years sound construction principles incorporated into his roads will pay big dividends in both savings to his budget and in public benefits. Any interference with those principles causes his engineering conscience considerable pain. The Dr. Jekyll viewpoint is equally sincere. It attempts to do everything humanly possible to get immediate road benefits to the largest number of people. There is a danger in both attitudes. Mr. Hyde is prone to forget the human values involved. He refuses to accept the limitations which are inherent in human beings, especially that segment of humanity known as the Public. His motto is "Do it right and let the critics howl". Dr. Jekyll faces even greater danger in that his good will is likely to lead him into costly mistakes. He is particularly susceptible to half-baked ideas or at best, compromises with sound principles. The well balanced road administrator will accept the best in both viewpoints and incorporate the resulting ideas into his road policy.

The maintenance of surfaces is a major problem that faces all road administrators. While the idea is abroad among the public that "Permanent Type Surfaces" will solve all maintenance troubles, the engineer knows that there is no such thing as a "permanent" surface. Like man himself and all of his creations, road surfaces begin to grow old the moment they are placed in service. In the rural and secondary program we are largely concerned with traffic bound surfaces of either crushed stone or gravel and bituminous treated surfaces. A large percentage of our traffic bound roads have never had sufficient material applied to build up substantial bases. This means that freezing weather each year brings a return of surface break-ups which require extensive patching. Nothing less than the application of large quantities of material at these points is of any value. This practice will doubtless finally result in the stabilization of the surface providing we have not neglected the possibility of ground water being the cause of the trouble. A wet-weather spring is



Reconstruction on rural highways should take into account not only increased width and improved alignment, but all factors that affect the permanency and safety of the road. Here drainage has been improved and a sharp curve will be eliminated as new construction projects the road across the low land in the center distance.

not particular about the point at which it makes its appearance and roads are sometimes subject to these visitations after heavy rains. The only sensible solution in this case is to remove the cause of the trouble by installing a subgrade drain or by relocation of the road.

The amount of surfacing material lost on traffic bound roads is a never ending cause of speculation on the part of both engineers and laymen. Land owners frequently assert that enough lime dust is blown off the roads to insure proper treatment of the adjacent soil. The heavy clouds of dust observed in summer seem to confirm this but it is probable that the actual quantity lost in this manner is small, although it goes on day after day. Not so small are the quantities of stone rolled or

washed into the ditches. There seems to be no easy solution to this problem. Frequent patrolling will minimize the loss of loose material by restoring it to the travelled surface of the road where it stands a chance of being consolidated by traffic. The application of chemicals such as calcium chloride during the dry period of the year is of value but generally the cost is greater than the restoration of the lost material.

The question of how much to spend on patrolling is frequently a poser. Some road men seem to feel that operation of their graders is a waste of money unless there are numerous potholes in the roads and the need for action is very great. Followers of this school of thought seem to hold that patrolling is a nicety, a sort of refinement that makes travel pleasant but is really useless except in severe cases and they point to the apparent fact that once the road has been gone over it is just as good and no worse than one that has had regular attention. My own attitude is expressed by an analogy drawn from the human body. One might do without food for a considerable period of time and be restored to health after breaking his fast but if the fast were long and severe enough, unseen but none-the-less actual damage to vital organs would result. Neither would anyone think it desirable to wait until starvation overtook him before eating. So with our roads. The loss of floater material, the breaking of base and possible damage to subgrade, not to mention the loss to the road users due to neglect, is hard to justify in view of the very nominal cost of routine patrolling.

There are periods of the year when traffic bound surfaces are so hard and dry that patrolling accomplishes very little. There is no easy cure for this condition but if such surfaces are put in the best possible condition before the extremely dry period sets in each year there will be far less trouble from potholes and washboarding. The addition of material does little for these conditions and the best solution is to do some heavy cutting with the grader at the first opportunity following a rain.

Among the most neglected of all maintenance operations is ditching. There seem to be two very good reasons for this. One is cost. While it is not necessarily very expensive to open ditches with modern power equipment, the cost of picking up and disposing of the material removed is quite an item in the average

budget. Some road men have tried to solve this problem by disposing of the ditch material on the road surface. Where the surface is composed of inexpensive local material this method will work providing that the earth removed from the ditches is of a nature suitable for a binder and is free from sod, weeds, rock and other foreign matter. Unfortunately these conditions are rarely met and most of us must go on picking up the earth and hauling it away.

The second reason for neglect of side ditches is inertia. It is extremely easy to forget our ditches until we are forcefully reminded of them by the formation of guilies in the road surface on grades or by the ponding of water in level stretches.

In the Central or Blue Grass region of Kentucky the maintenance of ditches is not nearly so formidable a job as in many other sections. The natural growth of native sod which quickly takes hold of the exposed earth after construction, prevents the washing of slopes and ditches and at the same time it retards run-off. In the mountainous sections ditching of all degrees, up to and including the removal of slides, is an operation which must be considered as inevitable and it is frequently a major item of cost. Like other forms of drainage, side ditches are sometimes neglected while we bend our efforts to keep our road surfaces in good condition. This may go on for some time but eventually we may find that our neglect has cost more than we have saved. A Mr. Hyde type of road man probably will spend some time on his ditches while Dr. Jekyll would rather use the money to extend the road a little farther up Bushhog Creek.

Like ditching, the problem of proper drainage on county and rural roads is one that is frequently overlooked. Too many of our roads have far too few cross drains and too many of those we have are dangerous wooden boxes or rattletrap bridges. How many time have complaints about the condition of this or that road been answered with the excuse that the culverts will not permit us to use the grader or will not hold up the trucks which might haul in surfacing matherial? The average road user is prone to look only at that part of the road which is visible and he is frequently so happy to have some kind of a surface which will permit year round travel that he discounts the need of elaborate drainage facilities. This philosophy is extremely easy

on the conscience of the harrassed road administrator of the Dr. Jekyll type who is trying to stretch his road dollars to the utmost. As a temporary expedient the neglect of drainage may sometimes be justified but as a continuous policy it will certainly prove disastrous. Adequate drainage is not a luxury. It is a basic fundamental of road life that cannot be ignored. Sooner or later deficiencies will prove costly. Since it is not always possible to replace sub-standard drainage at the most desirable time, many engineers and road administrators have devised a policy of keeping on hand a reasonable supply of drain pipe which is placed as rapidly as the old structures fail.This method will in time bear fruit and it is probably a sensible solution as regards small drainage structures where funds are insufficient for a program of wholesale replacement. Many of the roads which our counties are trying to maintain are not built up to a standard which would justify large expenditures for drainage. Probably the best policy in this case is to wait until the road is improved to some reasonable standard and install adequate drainage at that time. But in this policy lies a great danger. Many roads are not brought to adequate standards all at once. Like Topsy, they just "growed". If we permit them to just grow there is the temptation to neglect the drainage need even when the point has been reached at which it becomes essential. While on this subject of drainage I would like to point out that even though it may not be possible to provide adequate drainage on a road at least we can take the simple precaution of seeing that our roadway is maintained with a suitable crown and elevation to prevent ponding of water on the traveled surface.

For small cross drains the installation of ordinary concrete or metal pipe is the only sensible solution. In regions where water from coal mines is encountered the deterioration of drain pipes from chemical action is sometimes very rapid. Metal pipes without bituminous coating have been known to last only a few seasons. The best quality of concrete is also attacked and if drainage installations are to be considered as permanent great care must be used to see that they will withstand the effect of such waters before needless loss is occasioned. Dry stone masonry culverts or culverts built of stone with wooden spans are, at the best, only temporary expedients which will give way under unusual loads or by reason of decay.

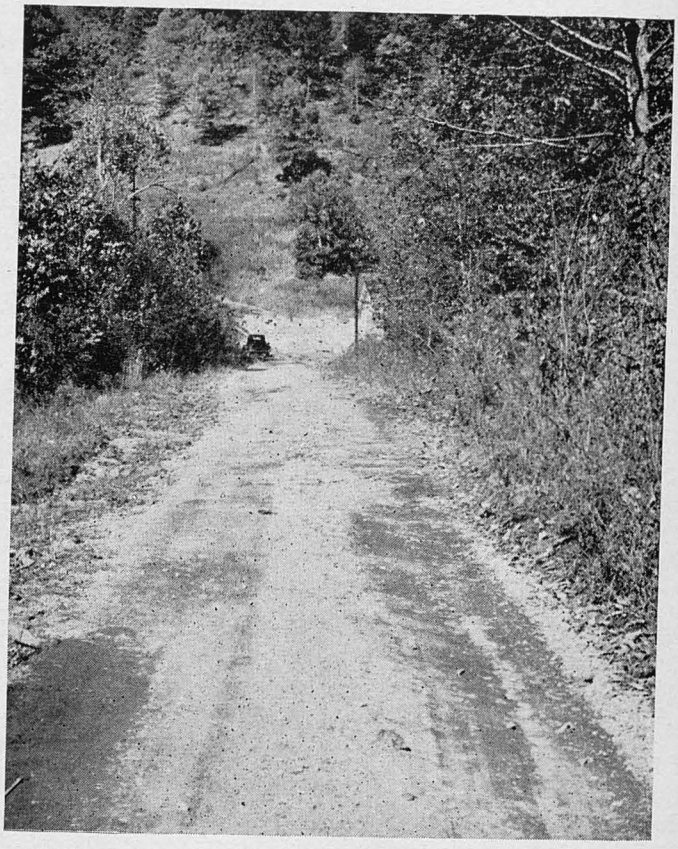
One of the commonest mistakes made in laying pipe is the failure to provide sufficient earth cover. Heavy traffic will rut down to the pipe and eventually it will be broken. If head room for this purpose is lacking it is better to go to some trouble to provide for the escape of the water either by ditching or by raising the grade to give head room. Some of the new type deformed metal pipes will provide ample water-way with a minimum of head room requirements.

Another common and rather serious mistake is the use of pipes too small to carry ordinary heavy rainfall. Determination of proper size should be based on the size of the area drained, its shape, its slope and the surface condition. This is matter for the drainage engineer or at least for the application of common sense based on observation of run-off during heavy rainfall. Pipes smaller than 18 inches in diameter are of little value as cross drains because of the difficulty of keeping them cleaned out.

Pipes placed with outlets high up on the side of fills or anywhere above the natural stream bed are certain to bring on scouring and under-cutting which will cost more to repair than proper installation. Pipes placed too low will quickly fill up with silt and be useless unless frequently cleaned out. The best installation is at the natural flow level of the stream.

The question of salvage of pipe drains is of considerable importance. If the location and grade line of a road are adequate for its foreseeable life then only should pipes be anchored down with permanent type headwalls. In most cases on county and rural roads the best policy seems to be to leave the pipe ends free to enable them to be easily extended or removed at a future date. There are, of course, exceptions to this such as "L" headwalls which are useful at the inlets on steep grades or anchor headwalls where pipes are liable to be pulled apart by earth pressure.

Where the stream flow at a particular point clearly calls for a drainage structure larger than that which may be obtained with small pipe the problem of costs becomes acute. The easy way out would be to keep on maintaining the old structure. The ideal way would be to construct a suitable reinforced concrete culvert. Between these two extremes there should be a compro-



Improper and inadequate maintenance resulting in poor drainage and erosion is responsible for the rapid deterioration of this rural highway.

mise plan which will provide low maintenance cost, safety, long life and a reasonable salvage value in case of relocation. This is where the larger size concrete or metal pipes or plate arches prove their value. Either type is easy to install with unskilled workmen and because there are no complicated forms to build and no curing period is required, structures may be put into service very quickly.

On many of our county roads the problem of large structures has been solved very satisfactorily by the installation of low-water fords. These are exactly what the name implies. They provide easy passage at all time except during periods of extreme high water. Where this condition lasts only a few hours the inconvenience is very little but they will not give adequate service where flood conditions are frequent and of long duration. In installing this type of structure care should be taken to prevent scouring due to eddies formed by the structure itself. Where the current is swift the sides of the ford should be given a gentle slope to fit the stream flow. The under-drains should be required to carry normal low-water only and the whole structure must be installed at a grade level sufficiently low to prevent the accumulation of drift. Failure to observe these precautions may result in washouts.

Creosoted timber structures have been used with considerable success on many of our county and rural roads. The first cost is considerably higher than that of untreated timber but the longer life and low maintenance costs have proven economical in the long run.

Kentucky is blessed, or cursed—depending on the viewpoint —with a vast mileage of running streams. More miles, we are told by some, than any other state. This means that bridges are vital to our road systems.

The last complete road inventory (made in 1938) gave a total of 7537 bridges in Kentucky, not including bridges within cities of over 5000 population. 2408 of these were on state maintained roads and all but 80 of this classification were in good or fair condition. On roads outside of the state system this survey showed 5129 bridges. 27% of these were rated as good; 44% fair and 29% in poor condition. The major portion of all of these Rural-County bridges, even those rated as good, were one-way bridges.

The average bridge of this kind would stack up about as follows: A light steel truss resting on old stone masonry piers and abutments. The roadway would be about 14′ in width. The floor, wooden plank. The age, about 50 years. The bridge has been painted perhaps once since erection. The load capacity will probably be less than five tons.

Because such bridges were built of steel (a very reliable and resilient material) they have withstood almost total neglect and heavy overloading. But many of them will not remain much longer in service unless immediate steps are taken to repair them. Rust and scaling have taken heavy toll of the steel, especially at the ends of the batter posts where they are frequently splashed with mud covered with vegetation or damaged by wandering vehicles.

Good maintenance practice would be to clean up these bridges with sand blasts, chippers or wire brushes and give them thorough paint jobs. Damaged places should be repaired with new sections, either welded or riveted in place. There is no easy way to do this. Either it must be done properly or the bridge may soon be written off as a complete loss.

The floors of such a bridge if constructed of wooden plank, are sure to be a source of continual trouble. If wooden stringers are used they will be liable to dry rot and dangerous conditions may result. Traffic loosens the plank flooring and the slapping produced by passing vehicles is a characteristic annoyance to rural dwellers. This condition sometimes leads to fantastic proposals such as the installation of concrete flooring. This probably would impose on the bridge a dead load greater than its rated capacity. The best treatment is to install a floor of 2 x 4 timbers placed on edge. If the stringers are of the steel I-beam type, steel anchor plates are a necessity. These little gadgets are merely thin plates with a notch which hooks under the upper flange of the steel stringers. Through holes in the plate and by the use of special double ended nails, the plates are fastened to the flooring providing a positive anchorage to the stringers. The use of this type of floor will not provide an easy escape from maintenance costs since such floors are subject to the same forces of destruction that attack other wooden structures. Creosoted material will be useful in this connection. Open steel grid floors have

proven satisfactory on old steel trusses. They are comparatively light and require little maintenance although the first cost is high. However, they are not suited to rural locations since animals are unable to find secure footing on them and generally refuse to venture onto them.

There is a new type of floor using corrugated metal plates welded across the stringers and filled with bituminous material. This floor has not yet been used by the Kentucky Department of Highways but we have favorable reports on it from other sources.

The problem of when to change the type of a road is sometimes troublesome to road administrators. To blacktop or not to blacktop? That is the question. There appears to be no sure-fire formula for this since the governing factors vary greatly in each case. A careful study of these factors is the only reasonable approach to the problem. They are generally listed about as follows:

1. Does road use justify the cost?
2. Is the road location good enough to insure a reasonable life expectancy?
3. Will the present surface provide sufficient base to support an expensive new surface?
4. Are the drainage structures adequate and do they have a reasonable life expectancy?
5. Will a comparison of the present maintenance costs with the expected costs justify the change?
6. After a review of the preceding factors, can the use of funds for what might be termed a "luxury" improvement be justified in the light of pressing needs elsewhere?

The first four of the above factors are basic. Roads which cannot meet these requirements need not be considered. If the traffic on a road is rather light, even though it is suitable for treatment in all other respects, the answer to the last question will be the controlling factor. As traffic increases the maintenance of traffic bound roads becomes more and more difficult. At a concentration of about 250 vehicles per day under average conditions, the cost of proper maintenance becomes burdensome. Change of type is definitely indicated at this point.

In many cases it would be economical to change type at far lower traffic concentrations. This will depend on conditions in each individual case. Here is where cost records will prove of value. If the annual cost of maintenance is known from the records a ready comparison may be made with the costs of the proposed change of type and subsequent maintenance. Changing to blacktop is not a cure-all and will not eliminate maintenance costs but in certain cases the reduction in annual costs may be sufficient to equalize the high first cost within a reasonable period of years.

There are reasons other than those I have given for the bituminous treatment of roads. Safety may be an important factor. So also may be public health and convenience. When these items become important enough they will overbalance other considerations. We engineers, being the Mr. Hydes of the road building industry, frequently ignore or belittle such considerations, I believe this is a mistake for however great may be our responsibility for the development of sound engineering practice, we cannot afford to overlook other avenues of service to the community.

At the beginning of this paper I suggested that my subject was far too broad for adequate discussion in any reasonable period of time. I think it is obvious to everyone that I have touched lightly upon only a few of the many problems that road administrators must face. Any one of these problems merits a great deal more consideration than we are able to give to it here.

Forgetting for a moment the routine aspects of our jobs let us remember that in our roles of road administrators we have two great responsibilities. One is to bring to our work a comprehension of and an insistance upon the application of sound engineering principles. The other is to keep in mind always that we are engaged in the public service and that every citizen, even the most humble, has a right to the benefits which society may expect to receive from our efforts. If we are able to do this I am sure we shall achieve a happy balance between the technical necessities of our work and the human values which are bound up in this most fascinating and important of all of civilizations great achievements, this job of providing transportation for mankind.