Progress with Roads

By HENRY R. FREEMAN

"Our road is not built to last a thousand years, yet in a sense it is. When a road is once built, it is a strange thing how it collects traffic, how every year as it goes on, more and more people are found to walk thereon, and others are raised up to repair and perpetuate it, and keep it alive*."

THE volume of information and discussion concerning postwar planning is indicative of the importance and interest in this subject. Much of the material published relates to public works and, in many cases, to the specialized field of highway construction. It may be of interest to consider in restrospect some of the historical developments in roads and road building which have shaped the progress of civilization; and to trace the progress of this field of engineering from the humble trails of primitive eras to the gigantic undertakings of the present time.

The importance of roads in social and economic progress has been recognized by many historians. Adam Smith, in his *Wealth of Nations*, said, "Good roads . . . . by diminishing the expense of carriage, put the more remote parts of the country more nearly upon a level with those in the neighborhood of the town. They are upon that account the greatest of all improvements." This estimate was also subscribed to by Macaulay, who wrote in his *State of England in 1585*, "The chief cause which made the fusion of the different elements of society so imperfect, was the extreme difficulty in passing from place to place." Even a cursory study of the civilizations of the past shows that when empires were growing and thriving, roads were constructed and maintained to all sections of the domain. When they were on the decline, roads deteriorated and fell into disrepair. But, though empires have grown, flourished and faded away, mankind as a whole has steadily progressed upward. Accompanying this upward human progress has been the

*Robert Louis Stevenson, *Vailima Letters*. Address to the Chiefs on the opening of the Road of Gratitude (Samoa), October, 1894.

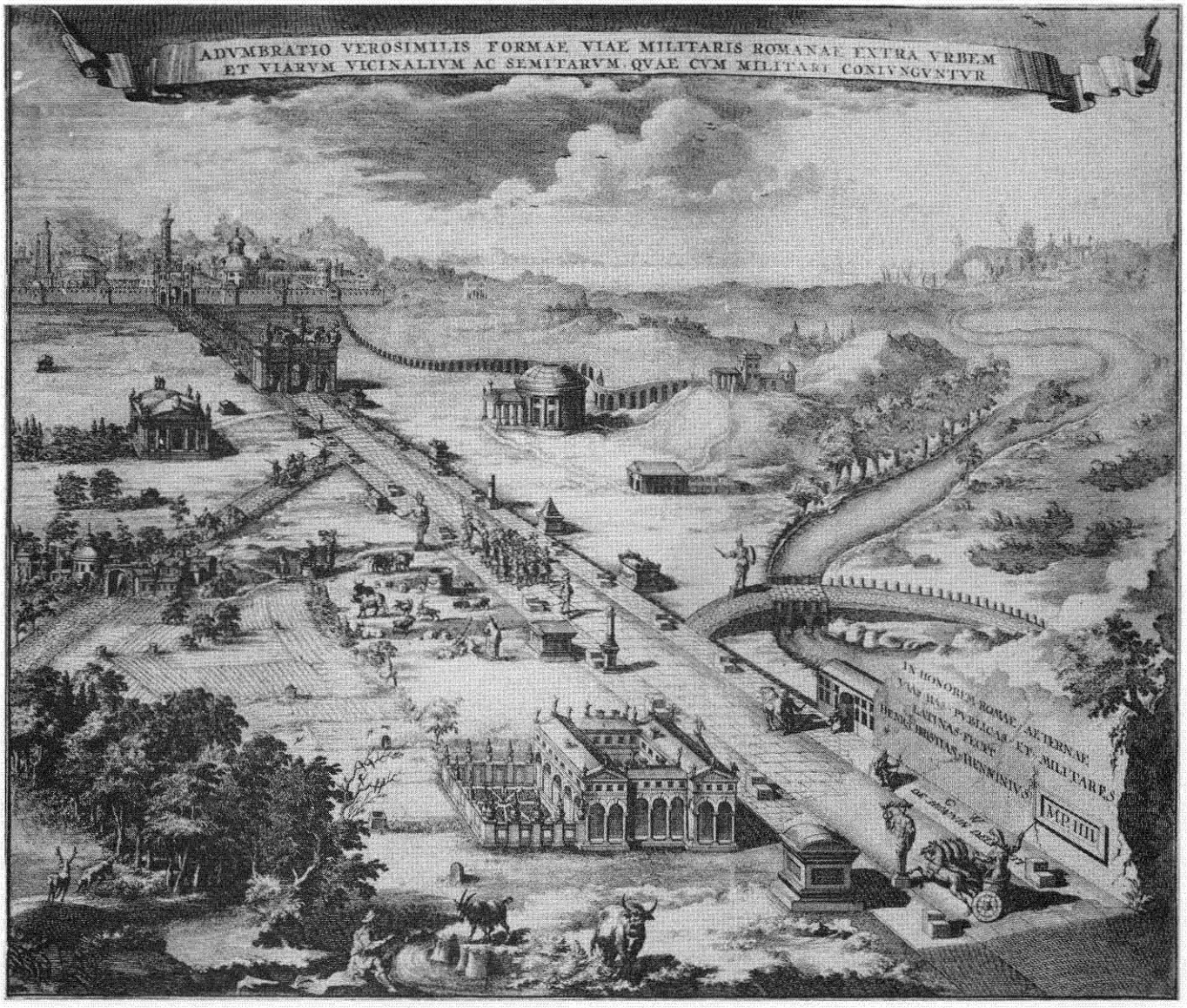
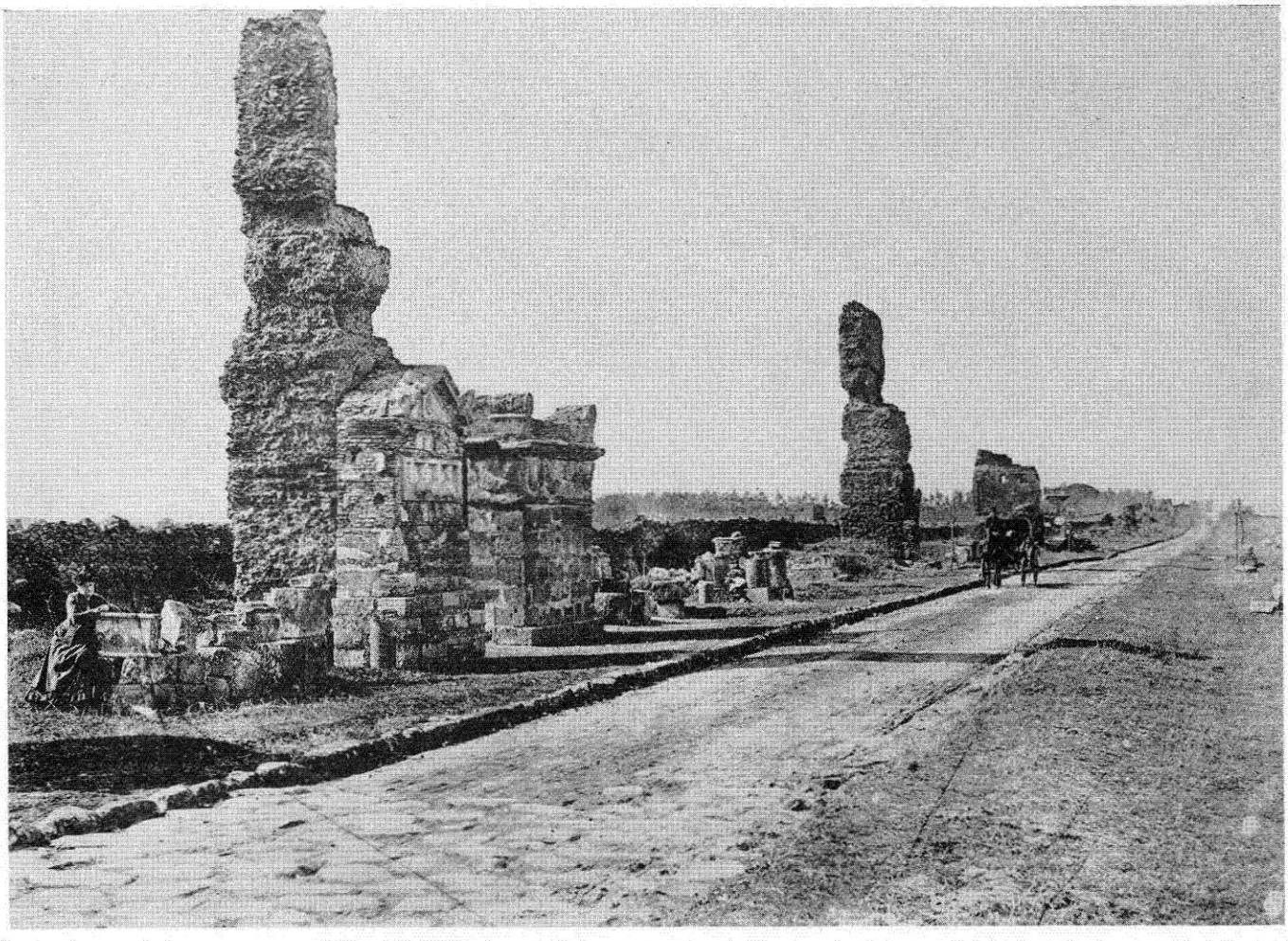


Illustration taken from "Histoire des Grands Chemin de l'Empire Romain" by Nicolas Bergier, Brussels, 1728, showing Roman military highway. (Photos on pages 4 to 7 courtesy of Public Roads Administration).



To this day long stretches of roads built by the Romans 1900 years ago are still in use. This view shows the Appian Way in Italy, circa 1912.

progress in roads. Whether the chicken of social and economic advancement came before or after the egg of better roads is of little moment. What we are really interested in is the historical progress of roads.

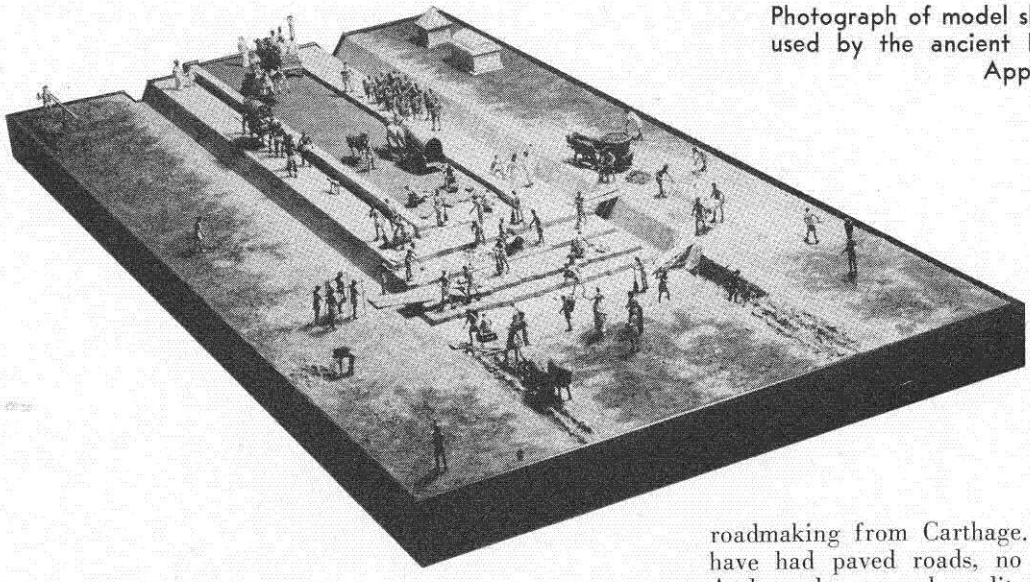
WILD GAME TRAILS

Probably the first roads were the game trails made by wild beasts. Of course this is conjecture, as no road of this type could endure as such; but it is substantiated by explorations in the less civilized countries of today. In the depths of Africa, for example, the elephant trails provide easy paths through otherwise impenetrable forests. And in the early colonization of America, explorers and later settlers followed Indian trails which in turn followed buffalo roads and other game paths. It would be natural for primitive man to follow these paths, for they led him to his primary needs, food and water. Moreover, he was without adequate tools to hew his own roads through the underbrush, even though he might have had the inclination.

As primitive man became fixed in his abode, his early paths became more permanent. Continued passage of man and his domesticated beasts of burden between homes and early settlements gradually beat down the soil and gave us what must have been our first real roads. As definite roads between settlements emerged, it is probable that they first appeared on the higher ground or ridges. This may have been for one or all of several reasons. Water gathered in the valleys, forming bogs and swamps. Trees and underbrush grew thickest in the valleys, making it difficult to clear a road with primitive tools. The more open higher ground gave the traveler greater vision, reducing the danger from ambush by enemies. At any rate, history's oldest recorded roads are along the higher ground in southeastern England, following for the most part the crests of the hills, and are known as ridgeways. Evidence points to the fact that these early roads were of Neolithic date and were made by the people who, during the Bronze Age, built the sun temple at Stonehenge.

Most of these roads are identified today by level stretches of short sparse grass through fields where the rest of the grass grows thicker and taller. The mass action of centuries of travel so compacted the soil that even today vegetation cannot grow with any luxuriance. Where traffic was confined to one narrow course, the track shows up as a groove worn into the ground. The depth of the grooves varies, but on one hard limestone hill near Gloucestershire and Worcestershire the road was cut down in places to a depth of 10 feet. One authority estimates that this wearing down took place at the rate of two inches per century. In his opinion, the road would have been started about 10,000 years ago and was used for 6,000 years.

It is thought by some authorities that these early ridgeways and the later harrow-ways (which followed the easier slopes between the valleys and the ridges) were a part of an early trade route over which tin was transported from the west of England to boats which took it to the coast of France on its journey to the center of civilization around the Mediterranean. This conjecture seems



Photograph of model showing engineering methods used by the ancient Romans in constructing the Appian Way.

plausible because man in his upward climb gradually emerged from the stage of direct appropriation into the pastoral and agricultural stages in which it was necessary that he have a fixed abode. And a corollary to his becoming fixed as to place of habitation is the certainty that he would have to import materials and supplies which were scarce or non-existent in his territory, giving of his own surplus in exchange. At any rate, from the dawn of history there have existed general routes along which flowed traffic for the purpose of trade. Some of these, in addition to the one across England for tin, were the routes across central Europe to the Baltic for amber, routes across Arabia to Afghanistan for lapis lazuli, and the routes across Asia to China and the Far East for silks and spices. Originally travelled by individuals seeking to replenish their own supply of the necessary commodity, and later probably by groups who were sent to obtain a supply for a tribe or clan as they are in Australia today, these routes were established and generally located. Later as trade became a business and large groups of men and animals, or caravans, travelled together, the routes became localized and more nearly approached our conception of a road.

As far as we know, none of these prehistoric roads were improved as we think of improvement today. At the dawn of history, what we have so far termed roads were nothing more than general trails outside the limits of the towns and cities, where the road was beaten out by the traffic itself. And hand in hand with that lack of improved roads goes the fact that no prehistoric civilization left any great imprint of its might.

ROMAN, CHINESE AND INCAN ROADS

Credit for making the first improved road generally is given to the Romans; but there were improved roads before them. The oldest known paved road was built by the Egyptian King Cheops, about 3000 B.C. He needed a solid track over which to convey the limestone blocks of which he built his huge pyramid. The builders of Mesopotamia and Chaldea must have needed paved roads for transportation of their building materials over surrounding soft ground. Short paved roads were built in early times in Crete, the island of Skyros, and at Cyrene. But all of these early paved roads were short and usually served a special purpose. The credit for the first improved system of roads belongs either to the Romans or to the Carthaginians. The latter are reported to have made a system of stone paved roads in the fifth century B.C., and it is said that Rome learned its art of roadmaking from Carthage. But though Carthage may have had paved roads, no physical evidence remains. And so the general credit for the first improved road *system* goes to the Romans. Alexander the Great conquered the known world, but with no roads the empire fell to pieces soon after his death. The Romans also built a great empire by conquest but kept it after the conquest. And the main reason for its long existence was the system of paved roads which linked the heart of the empire at Rome with the outermost reaches of the conquered territory. To this day, 1900 years after they were constructed, long stretches of the roads built by the Romans are in existence, and still in use (although not acceptable for modern motor traffic).

China also had its early system of paved roads, undoubtedly a cogent reason for the greatness of the early empire. The imperial system was paved with large flat stones and included bridges across rivers and tunnels through mountain crests. Slopes of the mountains were climbed by broad flat stairways with steps low enough to accommodate burdened mules, but there is no indication of wheeled vehicles. Connecting this 2,000-mile imperial system were hundreds of miles of well-kept earth roads and bridle paths.

In the western hemisphere the most remarkable of the early roads, considered by some authorities to be one of the engineering marvels of the world, is the Inca road system of Peru. The main road traversed some of the roughest country in the world and extended for 2,000 miles from Ecuador to Central Chile. One modern writer says that it makes "the famed Roman roads appear like mere lanes in comparison." It crossed 15,000-foot mountain ranges by easy grades, tunneled through mountains, crossed deep chasms on suspension bridges, shallow lakes on causeways, and was surfaced for much of its length with a sort of asphalt. In addition to the main north and south road in the mountains, a parallel road extended along the sea coast, and the two were connected by frequent laterals.

MODERN ROAD EVOLUTION

By far the greatest era of road building the world has ever seen is the present. Its development parallels social, political and economic advances which were considered wild dreams even in the early days of our own machine-age. Following the decline of the Roman Empire and during the Middle Ages, road building and transportation were at a low ebb. Apparently most land travel was done on horseback and so paved roads were considered unnecessary. As the wheeled vehicle came into use, it became necessary to do something to stop dust in dry weather and prevent mud in wet. Gravel and loose

rock were first used, but were not satisfactory. A hard surface of some kind was needed. It was not until the 18th century that this advancement came. Then Tresaguet in France and Telford and McAdam in England and Scotland developed methods of hand-placing broken stone of comparatively small but uniform size on a prepared road bed or subgrade. With some modifications, this type of surfacing has come down to us in the form of our present macadam pavement.

The use of macadam pavements quite revolutionized road building in Europe in the 18th century and proved entirely adequate for slow-moving, horsedrawn traffic, but with the advent of fast-moving machine traffic the early macadam surfaces failed, and it was necessary to build a more homogeneous pavement. The development progressed to the present hard surfaced road, made basically of sand and rock, but held together by some cementing agent in an integral surface, as seen in our cement or asphaltic concrete paved roadways. Some form of cement or asphalt road may be found in almost every part of the world today.

AMERICAN ROADS

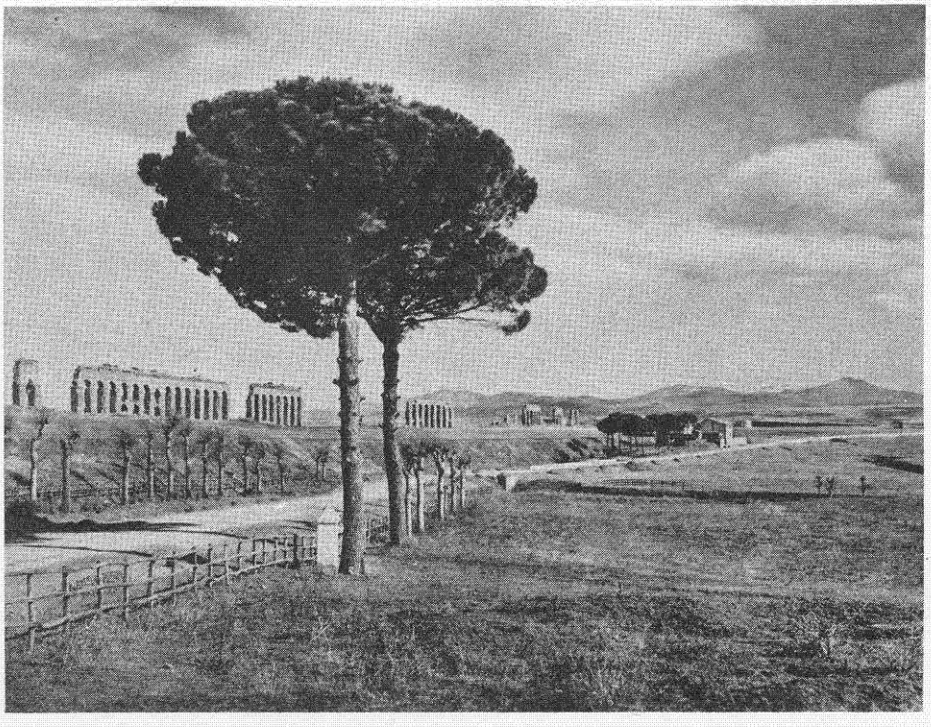
Anthropologists tell us that, in its prenatal existence, the embryo exhibits the entire life history of its species. In the same manner, the entire history of the development of the road can be seen in the growth of our American road system. Early settlers in our country found only game paths and Indian trails, which they appropriated to their own use. As more colonists came and settlements grew up in the interior, many of these early trails were widened and cleared, becoming regularly traveled roads. Braddock's road and Boone's wilderness road are examples of early made roads which followed earlier Indian and game trails. As the frontier pushed further westward and the Pacific coast was settled, regular trade routes appeared. Who has not heard of the Santa Fe Trail or the Oregon Trail or the Overland Route? In the early days, these were not roads as they are today, but just general routes entirely comparable to early historic trade routes of Europe and Asia.

Settlement of the country continued and trails and routes were crystallized into roads, just as dusty and muddy as European roads of the Middle Ages. American roads were ready for paving almost as soon as those of Europe. Outside the cities and larger towns, however, paving of country roads did not take place as soon as in Europe. An English traveller as late as 1891 reported, "The greatest surprise in my visit to the United States was the poor condition of a majority of the roads!" The principal reason for this condition in America was the development of the steam train. The vast distances in our country and the comparative speed and cheapness of travel by rail or water made paved rural highways appear to be unnecessary luxuries away from the larger centers of population.

Paving of the American road system did not receive much backing until the bicycle and, almost immediately thereafter, the automobile, captured the fancy of the travelling public in the 1890's and early 1900's. But from that time on the improvement of America's road system has proceeded at an increasing tempo, first by grading and oiling, then by the construction of macadam pavements, and finally by the construction of concrete surfaces. It may be surprising to those who are accustomed to speed smoothly over our highly developed county and state roads today, to learn that the first mile of rural concrete pavement in the United States was constructed only 36 years ago in 1908, in Wayne County, Michigan. Today there are over 400,000 miles of paved roads in the United States, exclusive of city streets. In 1908, a transcontinental trip made in from 60 to 90 days was a fast trip for a non-professional driver.

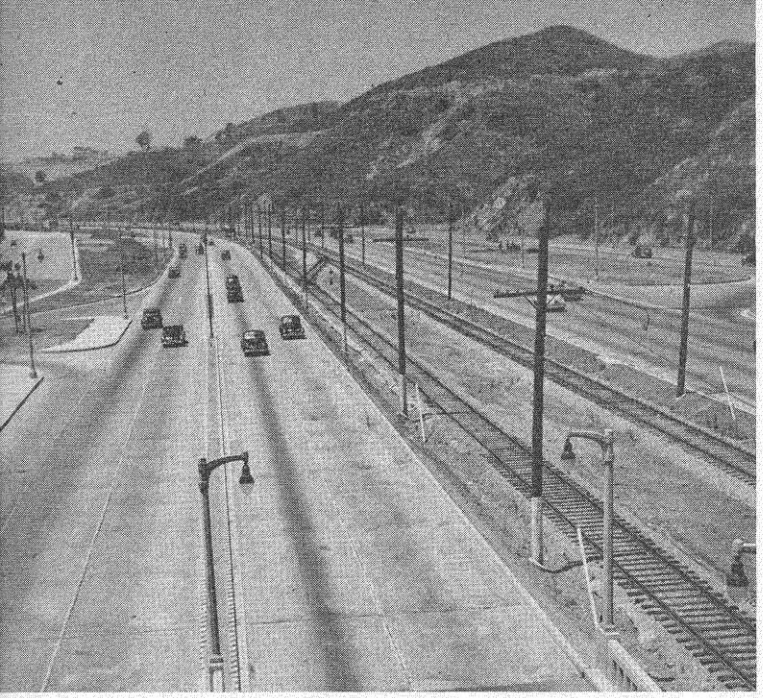
ROADS OF THE WEST

The tremendous increase in road facilities throughout the United States is typified by the progress made in California toward improvement in transportation. The early use of the automobile brought home the fact that, although there were many well improved roads in the state, they were in isolated and unrelated groups around the larger centers of population. There were no improved



AT RIGHT:

Another view of the Appian Way in Italy, showing the great Roman Road as it appears in the 20th Century.



Cahuenga Pass Freeway—part of southern California's system of modern roadways.

routes joining these larger centers and unifying them into a homogeneous commonwealth. The first step toward correcting this situation in California was taken by the state legislature in 1895 when an act "to create a Bureau of Highways and prescribe its duties and powers and to make an appropriation for its expenses" was passed. The bureau, consisting of three "good road" enthusiasts appointed by the governor, purchased a team of horses and had a special wagon made. During the remainder of 1895 and 1896 they drove over 7,000 miles through every county in the state, studying existing roads and methods of improvement. In 1896 the bureau recommended a system of state highways embodying the basic features of the highway system of today.

Beginning with 65 miles of state road in 1895 (the Placerville-Lake Tahoe Road), the state system has steadily grown to where it now includes approximately 14,000 miles of highway. The continual expansion and improvement of roads has required large expenditures of money. Early construction was financed by meager appropriations by the state legislature, supplemented occasionally by county aid from sympathetic boards of supervisors. However, such appropriations were not adequate to permit the rapid expansion of the system required by the increasing number of motor vehicles. In 1910 the people of California voted $18,000,000 in bonds for paving two main trunk highways extending from Mexico to Oregon. In 1916 an additional $15,000,000 was voted and in 1919 another bond issue was voted for $40,000,000. Even an authorization of some $73,000,000 over a period of nine years did not fulfill the demands for more and better paved roads.

The financing of road construction with bond issues was recognized as inadequate. Several states formulated the policy of obtaining money for roads by taxing gasoline used in vehicles operating on the highways. Oregon instituted this procedure in 1919 and California in 1923. By means of the gasoline tax all the state highway work, most of the county road work, and much of the city street work has been financed.

One of the most progressive steps in the development of our modern highway system is the introduction of the freeway or limited access road. This type of design has been brought about through pressure created by the ever increasing volume of motor traffic, just as the original highways were made necessary by the progressive demands for this same means of transportation. These relatively high speed arteries appear to offer material advancement over our previously conceived ideas of transportation. One can even speculate as to their competition in some degree with air transportation. Or it might be better to say they offer the link which will draw surface and air transportation closer together.

There are still a number of unsolved, unknown, or untried factors concerning freeway design. What are the possibilities in relation to mass transportation? What added features must be included if the freeway is to be used for mass transportation? What speeds may be expected both from the standpoint of safety and from that of postwar automobile and truck design? How far will freeways go in competition with short haul airways? They are exceedingly expensive, so we are concerned with the extent to which they are economically justified. There are, no doubt, many enthusiasts who believe they know the answers, but the more conservative require a more complete demonstration before venturing to write the ultimate formula.

As all types of modern transportation methods progress and develop, we are impressed with the idea of

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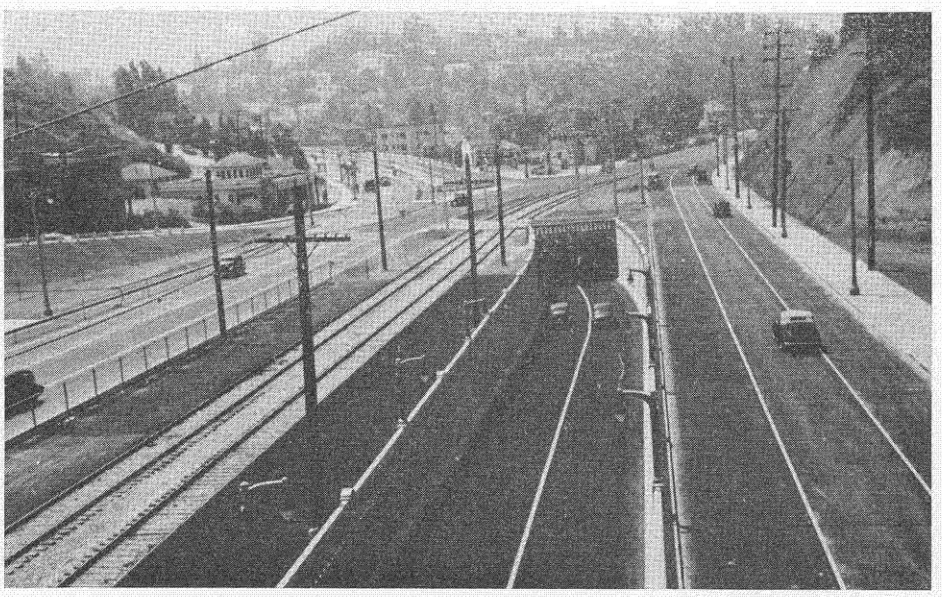

At Right:

In Cahuenga Pass, modern treatment of grade separation and highway intersection.

prepared by E. L. Furlong, and an exceptionally fine skeleton (*Figs. 1 and 2*) the first of its kind, has been mounted by William Otto, preparator in Vertebrate Paleontology.

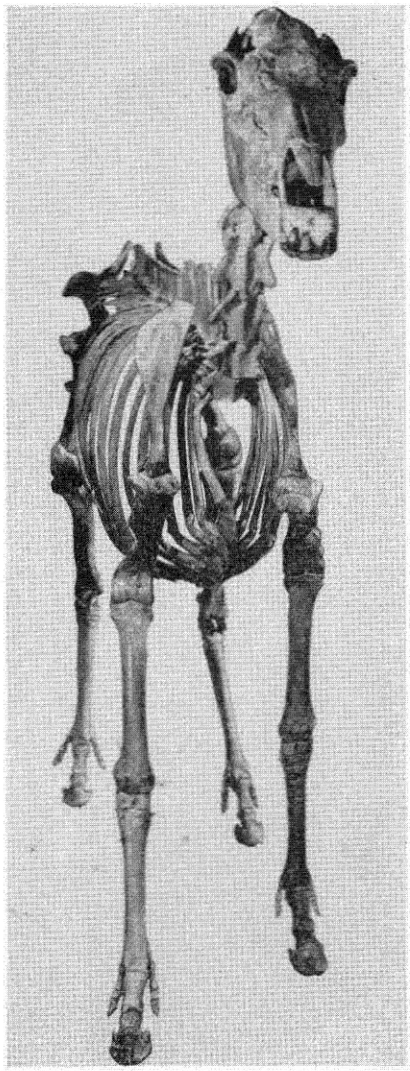

FIG. 2

The skull in this animal is of an adult male. The skeleton as it stands compares in size with that of the Burchell zebra, being a trifle over 3 feet 9 inches, or approximately 11½ hands, tall at the withers. However, the proportions of this Pliocene horse are noticeably different from those of modern *Equus*. A striking difference is seen immediately in the small size of the head. In the fossil specimen the skull is distinctly smaller in relation to the size of the body than it is in the zebra. While the body is proportionately as long as in the Burchell zebra, the sides are flatter, the chest appearing narrower and "slab-sided." The limbs are, likewise, differently proportioned, the principal bones of the fore and hind feet being very much longer in relation to the arm and thigh bones, respectively, than they are in the zebra. This extra length in the feet of *Neohipparion* caused its limbs to be some six per cent longer, in relation to the size of its body than even the highly-specialized limbs of the modern race horse. The side toes are beautifully preserved, and, as shown in the skeleton, are distinctly shorter than the middle toe. They do not touch the ground. The hoof of the third or middle digit is larger than in the zebra, and shows a small median fissure. In running, *Neohipparion* could probably exceed the speed of the zebra, at least for short distances.

The mammalian associates of *Neohipparion leptode*, when it roamed the grasslands in what is now the arid Thousand Creek region of northwestern Nevada, were the more progressive horse, *Pliohippus*, short-legged rhinoceroses, large camels, curious twisted-horned antelopes, peccaries, cats, dogs, badgers, and rodents.

Progress with Roads

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measuring space with time. Perhaps we are confronted with the need of more highly developing a mental process by which, given walking, driving and flying speed, we may arrive at the minimum of time for a given journey. Will this result in improving and increasing our mental ability, with beneficial progress?

PROSPERITY—DEPRESSION

We have seen that many of the notable civilizations of early history, the Egyptian, the Carthaginian, the Chinese, the Incan, and the Roman, during the height of their power, built hard surfaced roads over which the civilizing influences from any portion of the empire could flow to any other portion. All of these early civilizations reached a peak and declined, their road systems deteriorating with them. It is impossible to determine which was the cause and which the effect, but it is interesting to note that a decline of one element accompanied a decline of the other.

In the early 1930's the United States experienced the worst depression in its history. The depression was more than nation-wide; it was world-wide, and many able students marked it as the beginning of the end of our modern civilization. Road building decreased materially in the United States in this period. There was very little new construction, and many existing roads were allowed to deteriorate through lack of maintenance. Later, a definite increase in road building occurred, which in turn, was greatly slowed by war activity. In spite of this check, some major projects, such as the Alaska and Pan-American Highways, have been materially rushed forward, and we have a very practical hope in the years to come of greater and more extended international highway travel than ever. It has often been contended that these international highways may constitute one of the greatest civilizing influences of modern times, and it seems not too much to expect that we may still progress with roads.

Buried Voice Channels

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amount of protection desired against possible damage to the cable. Even at these depths some little trouble is caused by lightning in those areas where electrical storms are common. A number of installations have been made in which one or more copper lightning-protection or shield conductors have been buried above the cable, but these have not been completely effective. Some consideration is now being given to the use of a copper sleeve covering the normal lead sheath of the cable itself.

To determine the existence of current on the cable sheath, a recent installation was equipped with test points approximately every 3,000 feet. At these locations, two wires permanently attached to the cable sheath, 10 feet apart and insulated from the earth, were brought to the surface and terminated in a housing for the convenience of the tester who makes periodic checks of the current flowing on the cable sheath. Periodic tests are necessary, for, despite the fact that the cable is buried, there are a number of causes for changes in the effectiveness of the insulation, not the least of which are the rodents or pocket gophers previously mentioned. Only that part of the United States roughly east of the Mississippi River, exclusive of an area in the Southeast, is free from these pests.

GAS PROTECTS CABLE FROM MOISTURE

Since the paper insulation of the cable conductors readily absorbs water, every effort must be made to exclude moisture. Even a small amount of moisture reduces the insulation resistance and a little bit more may short-circuit two or more conductors and put circuits out of service. To protect the most important cables from the entrance of moisture and to provide a means of detecting