NOT FOR PUBLICATION

HIGHWAY TRANSPORT IN WAR TIME

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With dawning realization of the consequences of this total war, peacetime preconceptions of the character of highway transport in war time are undergoing amazing alteration in important particulars.

To a people, accustomed as we have been to the abundant transport facility provided by three-fourths of the entire world supply of motor vehicles, sharp curtailment of that facility in the event of war was well nigh unthinkable.

That certain adjustments would be essential could be foreseen. That there would be a substantial decrease of the accustomed recreational use of passenger cars, and an offsetting increase of business usage; that there would be among the various continuing uses degrees of essentiality, to be accorded corresponding priorities of sanction or service; that there would be a certain diversion of vehicle manufacturing capacity from civilian to military vehicle production, and from vehicle supply to the production of other war-needed supplies; these changes as long as a year ago were not beyond the bounds of reasonable expectation.

But that the great automotive industry would suddenly be brought to a complete halt in its production of vehicles for civil use; that pneumatic tires, the very sine qua non of motor vehicle transportation, would be denied to the average vehicle owner so quickly and so completely; these are developments that were certainly beyond the range of normal foresight until the early morning of last December 7.

Before the cowardly attack on Pearl Harbor, the expected problems of highway transportation were mainly those concerned with the avoidance of congestion on somewhat inadequate highways, in use by an intensified traffic of unprecendented volume. Since that event we have had to recognize that the most careful husbanding of narrowly limited vehicle resources will be our actual and vital first necessity.

From the quick and cheerful acceptance by our people of the radical adjustments made necessary by sudden curtailment of their accustomed individual mobility, our enemies may learn something of the capability of a free people for prompt and united action that will surprise more than it will please them.

Prior to the declaration of war, government action affecting highway transportation had been limited to a substantial reduction of the manufacturing quotas of motor vehicles for civilian use. The principal purposes of this early action were to reduce non-defense consumption of certain critical materials, to release productive capacity for the manufacture of military vehicles - for our own increasing armed forces and those of the nations we were determined to aid, and to convert some part of the existing and new plant capacity to the manufacture of other munitions of war. The OPM orders directing the action were effective during the summer and fall of 1941; but there was virtually no immediate effect upon the character or volume of highway transportation as observed on the roads.

Permanent automatic traffic counters installed on the roads throughout the country recorded in every month of 1941 traffic substantially greater than in the same months of the previous year. In December 1941 the traffic recorded by all counters was 12.5 percent heavier than the same month's traffic of the preceding year, and approximately the same figure represented the average increase of 1941 traffic over that of 1940, all months included.

On December 11, three days after the declaration of war against Japan, came the OPA order stopping the sale of tires and tubes, followed on December 30 by the first regulations governing tire rationing by the 9,000 three-man Rationing Boards immediately appointed. These, the first restrictive measures, have since been followed in quick succession by:

The freezing of retail passenger-car sales on January 2.

The halting of passenger-car production on February 10.

The banning of light truck production for civilian use on February 10, and the limitation of medium truck production on March 4.

The rationing of new passenger cars on March 2.

The rationing of trucks, truck-tractors, and trailers of all sizes on March 9.

A 20 percent cut of gasoline deliveries to service stations and bulk consumers on March 19 and a further cut to 33-1/3 percent effective April 16.

And finally, on April 7, the banning of all medium and heavy truck production for civilian use after April 30 and May 31, respectively.

The admonitory effect of the tire order was evidenced immediately in reduction of the traffic observed on the roads. Automatic counters, which in December recorded an increase of 12.5 percent over the corresponding month of 1940, counted in January a traffic only 1.1 percent above the January 1941 traffic, and in February a traffic averaging 7.6 percent less than that of February 1941. March figures, not yet available, will doubtless show a continued decline.

The automatic counters are located on rural roads only and most numerously on main roads. They reflect with substantial accuracy what is happening to ordinary rural highway traffic, but do not indicate the trends of urban traffic.

There are indications that the downward pull of voluntary reduction in car use is countered in the cities by the increase of traffic consequent upon heightened industrial activity. For example, gasoline consumption figures for January - reflecting total vehicle usage - showed in 36 States an increase over January 1941 of 9.75 percent, compared with the automatic counter increase of 1.1 percent. Similarly, February gasoline consumption reported thus far for 17 States showed an increase over February 1941 of 0.77 percent, compared with the automatic counter decrease of 7.6 percent.

These comparisons, indicating that urban traffic is declining less sharply than rural highway traffic, are confirmed by specific reports of city traffic thus far announced. Passenger traffic over the San Francisco bridges, for example, was up 9 percent in January over January 1941; and total traffic through the Holland Tunnel and over the George Washington Bridge at New York was up 7 percent for the same period.

It is the general observation also that passenger-car traffic is declining more sharply than traffic of trucks and busses, and this observation is supported by reports of the Pennsylvania Turnpike Commission on the toll-paying vehicles using the turnpike. Less quick than ordinary rural highways to show the effects of the restrictive orders, the turnpike in January served a traffic 15.5 percent above that of a year ago and the February report was still up 6 percent for total traffic. But the toll-paying passenger cars, which in January were up 10 percent, were up only 1 percent in February; whereas the numbers of trucks and busses were up in January 36 and 80 percent, respectively, and in February 24 and 50 percent, respectively.

These scattering indices thus far available suggest that the restrictive measures are having their first effects, where those effects would be most likely to occur - in the squeezing out of customary recreational uses of passenger cars. Road-use studies made by the State-wide highway planning surveys have disclosed a breakdown of passenger-car usage into 57.6 percent for business and 42.4 percent for recreational and social purposes. "Business purposes," as classified in these studies, include the use of cars for "shopping" and "going to work," some of which may, under present conditions, fall into the non-essential category.

The extent to which cars have normally been used for what will now be considered non-essential purposes has varied considerably among individual owners. The classification of the road-use studies placed 13.9 percent of the owners interviewed in the class of 90-100 percent "business" usage. Eighty to ninety percent "business" usage was reported

by 9.7 percent of those interviewed, 70 to 80 percent by 10.3 percent of the owners, 60 to 70 percent by 10.4 percent, and 50 to 60 percent "business" usage by 10.3 percent of those interviewed. Thus 54.6 percent of all owners interviewed reported that more than 50 percent of the use of their cars was for business purposes.

On the other hand, 6.4 percent of those interviewed in the road-use studies admitted no use of their cars for business purposes, and 26.5 percent acknowledged that 30 percent or less of their car usage was for "business" purposes, and upwards of 70 percent for recreational and social purposes. It is this latter class of usage that will first be sacrificed as, in the coming months, popular realization of the need for utmost conservation of all our transportation resources brings public condemnation of all non-essential travel.

But if there is much in our past habits of highway travel that can be yielded to war time necessities, there are large elements of the total highway transport that are in the highest degree essential. Means for the continuance of these essential movements must be safeguarded.

The extent to which vital war industry is dependent upon highway transport has not been sufficiently appreciated. Realizing this, the Michigan State Highway Department, at the suggestion of the Public Roads Administration and other national transportation agencies, has recently made a survey of the uses of highway transportation by Michigan war industries.

The survey canvassed the managements of 1,250 manufacturing corporations engaged in the production of war materials, all located in Michigan. The replies, received from 749 of these corporations, show clearly how dependent are these vital industries on highway transportation, both in the movement of their in-and-out-bound freight and in the home-to-work travel of their employees.

A summary of these replies, as recently published by the Michigan State Highway Department, reveals the following:

"Incoming Freight.

520 plants - 70% of the total - receive half of their incoming materials by truck

281 plants - 38% of the total - receive 90% of their incoming materials by truck

100 plants - 13% of the total - receive all of their incoming materials by truck

"Outgoing Freight.

561 plants - 76% of the total - ship half of their products by truck

316 plants - 42.6% of the total - ship 90% of their products by truck

112 plants - 15% of the total - ship all of their products by truck

"Plant Size and Freight Movement by Truck

The significance of these data in relation to the mass production process is revealed when the proportion of truck use for incoming and outgoing freight is observed in plants of various sizes.

726 plants with less than 5,000 employees - 98% of the total number of plants - use trucks to a greater extent for shipping their products than for receiving their materials.

13 of the 15 plants with 5,000 or more employees - or 2% of the total number of plants - use trucks to a greater extent for receiving materials than for shipping products.

"These figures and percentages indicate the functional organization of Michigan industries for mass production. The smaller plants, for the most part, fabricate parts. The larger plants, although they make their own parts to a greater or less degree, are the central coordinating units to which parts are shipped for assembly into the finished product."

The extent to which these Michigan plants are dependent upon highway transportation for the daily travel of their workers is shown by the survey finding that of the 434,684 persons employed at the 749 plants, 326,649 or 75 percent come to work in automobiles carrying less than two persons per car.

At the Glenn L. Martin Airplane Factory near Baltimore there is an even greater employee use of automobiles for home-to-work movements. The Martin plant is located about seven miles from the Baltimore City limits, and although it lies directly on a main railway line, the railway brings none of the employees to their work. Of approximately 30,000 workers employed at the time of a recent inquiry, only 350 were conveyed to work by bus, and the remaining 29,650 were transported in passenger automobiles at the rate of 2.85 persons per car.

At the Maryland Drydock Co., and Bethlehem-Fairfield Shipbuilding Co., Baltimore, at the Sparrows Point plant of the Bethlehem Steel Co., at the General Electric Company plant at Erie, Pa., the Navy Yard at Philadelphia, the Fleetwings plant at Bristol, Pa., and Curtiss-Wright plant at Columbus, Ohio, where similar investigations have been made, it is found that the privately owned automobile is the principal dependence for employee home-to-work movements, the employees thus served ranging between 53 and 97 percent of the total number of workers, and the service per car from 1.7 to 3.28 persons.

In many cases the worker's dependence upon the automobile for transportation is due to the fact that the new or greatly enlarged plant by which he is employed is located beyond reach of any mass transportation facility as presently equipped. Often, in the case of new plants, and likewise the new military establishments, the location is not even served by a main highway, and the new activities bring to

the former local roads on which they lie, a daily flood of thousands of vehicles in place of the hundreds or only scores that formerly used them. It is this fairly typical condition that stamps the improvement of both military and industrial access roads as preeminently important among highway construction projects actually essential to the furtherance of the war effort.

But it is being realized more and more, that if the existing and even the enlarged capacities of access streets and highways are to afford adequate service to the greatly increased local wartime movements, definite and prompt measures must be taken to transfer to mass carriers as much as possible of the worker travel, and reduce the number of passenger cars employed in service of the remainder by increasing the number of passengers per car. And these changes are made the more imperative by the necessity of conservation of vehicles and tires and reduction of motor fuel consumption.

Under the leadership of the Michigan State Highway Department, measures to accomplish these ends have recently been demonstrated at Pontiac, Michigan, with such good effect that Director of Defense Transportation Eastman has asked the Highway Traffic Advisory Committee to the War Department, and affiliated committees of the various States, to direct similar efforts in all States and principal cities. The plan calls first for a radical staggering of school, business and mercantile hours and the shift hours of industry, to spread traffic peaks and enable mass carriers to handle as much as possible of the daily flow; after which it seeks to

reduce the remaining passenger car movement by inducing industrial and office workers to share the use of fewer cars, and by discouraging all unnecessary car use. It is expected that Mr. Eastman will shortly ask the governors of the several States and mayors of all principal cities simultaneously to inaugurate such efforts as a nation-wide movement.

Except in the local situations mentioned, the war has not thus far developed the greatly increased traffic volumes on main rural highways that, but for the various restrictive measures, would probably have been generated. Movements of military vehicles form an increasing element of the traffic on such main routes, and thanks to the efficient and helpful cooperation of State and city officials and the State highway traffic advisory committees, these movements are normally made with a minimum of interference with civil traffic.

In many instances it is found necessary to make long highway movements of vehicles or loads not permitted by existing State regulatory laws. In some cases these movements are such, in dimension or weight, as to tax the capacity of the highways, and have to be specially routed over highways adequate for their accommodation. Examples are the planned regular movement of Ford Bomber parts from Ypsilanti, Michigan to Texas plants for assembly. These movements - too bulky and light for efficient rail handling - will be made in especially designed vehicles exceeding in length and width the regulation limits of most of the States enroute. Another case is the recent movement of an experimental passenger-carrying trailer built for the Director of Defense Transportation

at Elkhart, Indiana, and moved from there to Washington - the 45-foot length of which also exceeded State legal limitations. State officials have generally responded promptly and helpfully to requests for special permits to facilitate such movements. The recent two-day delay of a truck shipment of army scout cars is fortunately exceptional.

However, the required application for a special permit always involves some difficulty, much of which would be avoided if all States would agree to a "floor" of weight and size limits substantially above the lowest limits now in force in individual States, to be applicable to all movements without special permit, for the duration of the war.

An agreement of this nature recently reached by New England and Middle Atlantic States would serve as a reasonable pattern for general adoption. This agreement provides for the unhindered movement of vehicles conforming to the following limitations:

Width	96	inches
Height	12½	feet
Single vehicle length	35	feet
Combination vehicle length	45	feet
Weight per inch width of tire	600	pounds
Axle load	18,000	pounds
Gross load		
2-axle vehicles	30,000	pounds
3-axle vehicles	40,000	pounds
Semi-trailer combinations	40,000	pounds
Other combinations	40,000	pounds

A general agreement upon such limits would substantially reduce the number of special permits now required.

Against the day when emergency may require quick marshalling of available truck and bus resources for public or military service, an inventory of such vehicles has been taken in all States by the

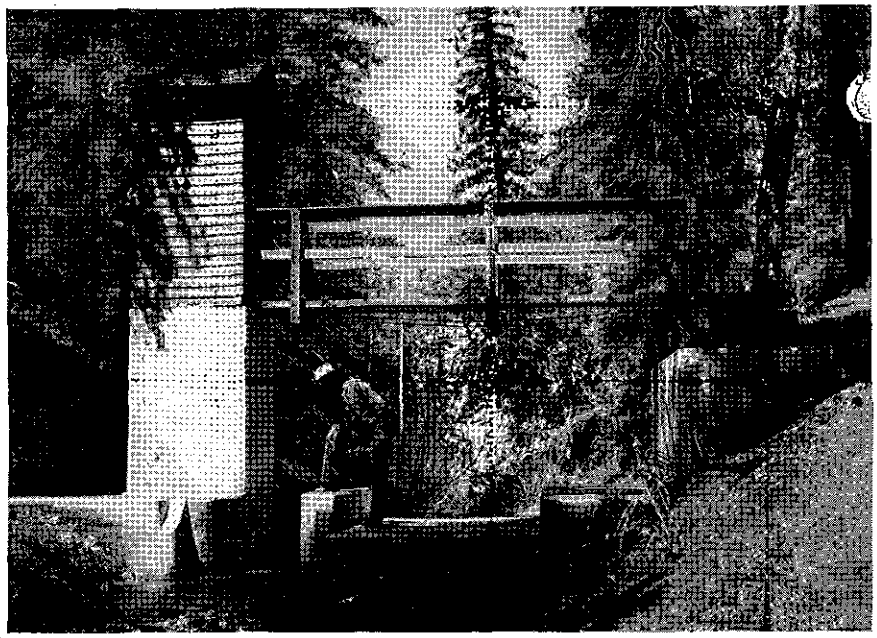
Highway Traffic Advisory Committee to the War Department with the aid of State motor vehicle administrators, the Public Roads Administration and Work Projects Administration. Conducted by means of a questionnaire, the inventory effort met with a truly remarkable voluntary response by approximately 90 percent of the vehicle owners affected. The results of the inventory are now being statistically tabulated by the Work Projects Administration at New York, and a file of all reporting owners is already available in each State.

The statistical summaries will afford information as to the number and character of vehicles of each class available for use in any area, and the State files, similarly classified, will facilitate communication with owners of the vehicles in case of need. These files will shortly be transcribed for the use of State representatives of the Office of Defense Transportation who will serve to coordinate all essential vehicle requisitioning.

In further preparation for possible emergency other measures are desirable, particularly in areas subject to direct enemy action. Among these are the selection of alternates supplementary to the principal routes of travel to which traffic may be instantly diverted according to plan in case of any obstruction of the main route, the planning of separate routes for civil and military traffic in emergencies, and other similar measures. Such planning requires the advance preparation of maps and orders ready for instant publication and execution, and calls for the cooperation of State and city

highway and police authorities with Civilian Defense and military representatives in each area. Pioneer work of this nature has been done by the New York Metropolitan Defense Transport Committee, and similar undertakings wherever necessary will shortly be launched at the combined initiative of the Office of Civilian Defense and the Highway Traffic Advisory Committee to the War Department, with the aid of the Public Roads Administration and, it is hoped, of the several State highway planning surveys. It is highly important that adequate plans of this sort be carefully prepared and proved in practice test in order that highway transport shall not fail to meet the most crucial of wartime tests if they should come in actuality.

of stream flow, which prevails perhaps 90% of the time. Excessive rates, which occur rarely and need not be measured with great accuracy, are handled by broad-crested weirs adjacent to the flume. One of these, 6 ft wide and 1 ft deep, is placed at an elevation of 2 ft above the flume floor, with a wall separating it from the flume. After water depths in the pool upstream of the structure exceed 2 ft (about 1.18 ft in the flume at the piezometers), flow is measured in both flume and weir, a single depth being recorded in the stilling well. A second weir, simply a broad step at a higher elevation, is designed to handle the possible maximum flood—about 600 cu ft per sec in the station illustrated. These weirs must of course be calibrated in the field. Discharges for the whole structure are rated for depths in the single stilling well.



GAGING STATION FROM UPSTREAM
Cylindrical Flume Transition Appears at Left

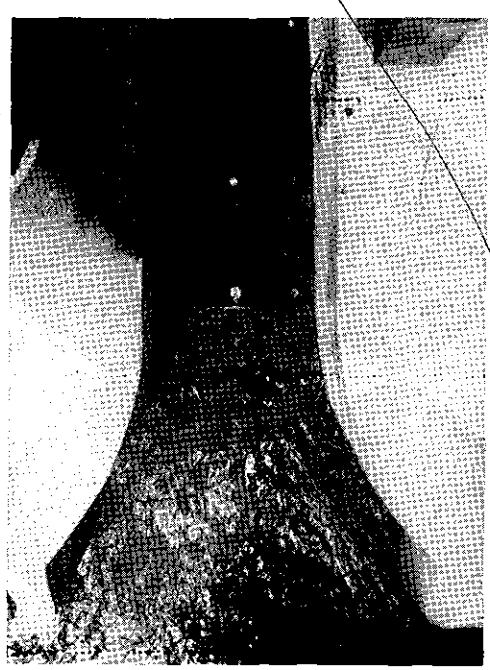
Since March 1940, when this gaging station was installed, the recorded stream flow has not been great enough to permit complete calibration of the broadcrested-weirs. Some discharges have been measured through the lower weir, however, and ample data have been obtained for the flume to bear out the results of laboratory model tests and to demonstrate the accuracy with which discharges may be computed from recorded water depths.

CLOSE COMPARISON OF RATING FORMULAS

Field rating data for the flume have agreed very closely with figures obtained by extrapolation of model results. A "field" formula for the flume, $Q = 13.95\ H^{1.276}$, was derived by fitting a logarithmic straight line by "least squares" to 10 measurements of depth and discharge obtained in July 1940. Subsequently 12 other measurements were made over a period of about 21 months. The measured discharges were compared with values computed from the original least-squares formula. All field measurements were made by means of a velocity-head rod operated by several different observers. The model formula, $Q = 14.20\ H^{1.28}$, was computed from laboratory observations of depth and discharge obtained in 1937 on a one-quarter scale model of the San Dimas flume. In both these formulas Q = discharge in cu ft per sec, and H = depth in ft, measured in the stilling well.

Considering the long period of time over which the field data were taken, these figures conform with pleasing accuracy to both field and model formulas. The model formula appears high; still, the greatest deviation of field discharges from this formula was under 4½%. As compared to the field formula, 11 observed discharges fell below, and 11 above, the computed values, and the greatest deviation of observed from computed values was 4.27%. A new rating formula, $Q = 13.953\ H^{1.276}$, fitted to all 22 points, conforms almost exactly to the original field formula. The standard error of estimate for the new formula is ±2.00%, and the correlation coefficient is +0.9999. These results seem to indicate quite conclusively that the San Dimas flume, as installed in this station, is satisfactorily accurate and stable in its discharge characteristics over a considerable range in both time and rate of flow.

Sufficient data have been obtained on discharges over the 6-ft broad-crested weir to demonstrate the approximate relation of discharges through the flume and weir to depths measured in the single well. To fit the observed values, a rating formula was prepared by the method of least squares. This formula is $Q = 9.7035\ H^{2.9477}$, in which Q is the discharge for the flume and the weir together, and H is the depth of water in the flume. The errors of these discharges are somewhat greater than those of the flume alone (standard error of estimate = ±4.56%), largely, it is believed, because of small variations in depth of water in the flume corresponding to a given depth on the weir. Such variations are to be expected and the resulting errors in discharge are a necessary sacrifice, offset by the need for only a single record of water depths. To obtain more precise data on depths and discharges over the weir, a second recorder and piezometer well would be required. At this particular station the additional precision is unnecessary, since up to August 1942, flow had passed over the broad-crested weir during only 2 of the 28 months that the station had been in operation.



VIEW OF FLUME FROM ABOVE
Note Smooth Sloping Floor and 4-Ft Entrance Width, Twice That of Flume Proper

Highway Transport in Wartime

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MOTORISTS as well as manufactures are acutely aware that war is upsetting their normal use of the highways. Researches and traffic counts here quoted indicate what has happened, what steps have been and should be taken, and what the future portends. Cooperation in reducing unnecessary highway use and in broadening truck limitations is essential. Fortunately the required solutions are known; unfortunately they have not yet been wholly adopted. This valuable summary of present status and trends has been revised and brought up to date following its original presentation before the Society's Roanoke Meeting.

PEACETIME preconceptions of the character of highway transport in time of total war are undergoing amazing alterations. To a people provided with three fourths of the entire world's supply of motor vehicles, sharp curtailment of that facility was well nigh unthinkable.

That certain adjustments would be essential could be foreseen—a substantial decrease in recreational use and an offsetting increase in business use; definite priorities of sanction or service; and a certain amount of diversion of vehicle manufacturing capacity from civilian to military production. As long as a year ago these changes were not beyond the bounds of reasonable expectation.

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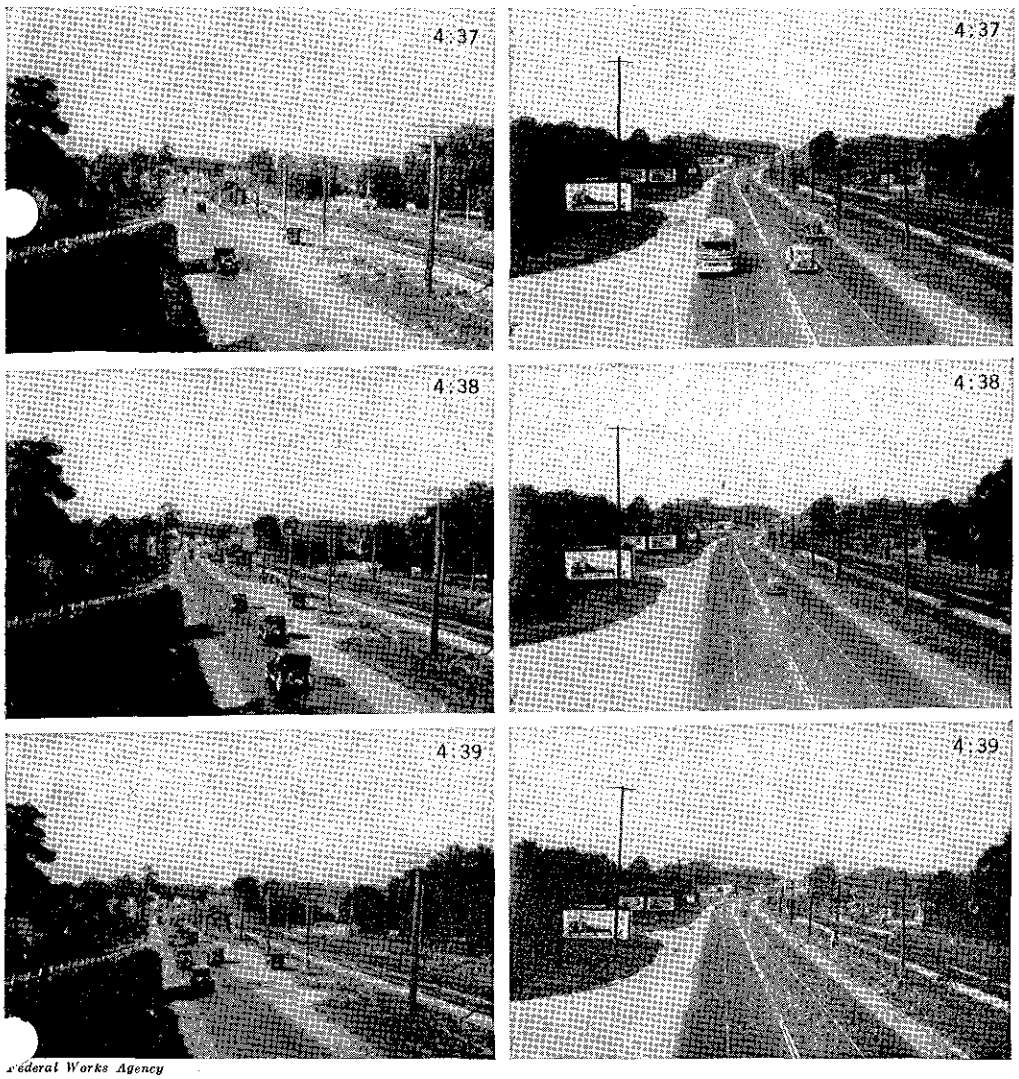
Before the cowardly attack on Pearl Harbor, the expected problems of highway transportation were mainly those concerned with the avoidance of congestion on somewhat inadequate highways, in use by an intensified traffic of unprecedented volume. Since that event we have had to recognize that the most careful husbanding of narrowly limited vehicle resources will be the first and most vital necessity.



JULY 4, 1927 JULY 4, 1942

TRAFFIC CHANGES IN 15 YEARS—PICTORIAL RECORD AT SAME POINT ON U.S. 1, BELTSVILLE, MD. Same Day of Year, Same Time of Day, Count Showed 23% Less in 1942 Than in 1927

SIGNIFICANT TRAFFIC CHANGES

Permanent automatic traffic counters installed on the roads throughout the country recorded in every month of 1941 traffic substantially greater than in the same months of the previous year. The December 1941 traffic, 12.5% heavier than in the preceding December, represented about the average increase of total 1941 traffic over 1940.

But beginning December 11, three days after the declaration of war against Japan, various restrictions on the sales of vehicles and tires were successively adopted with significant traffic results. January traffic was only 1.1%

above the previous year, and that of February averaged 7.6% less. In March and April gasoline deliveries to the Atlantic States were cut, first by 20% and later by 33⅓%, but the April automatic recorder counts showed traffic reductions little greater in these states than in the nation as a whole. For the entire country, the April reduction was 15.8%; the Middle Atlantic States dropped only 16.8%; and only in the South Atlantic States, down by 21.4%, was there any marked evidence of a possible effect of the cut in gasoline supply. Vehicle operators everywhere were showing a willingness to reduce voluntarily the amount of their driving by almost as much as the 20% required by the initial cut in gasoline supply in the Atlantic States.

After May 15, however, this condition was changed sharply. The 50% gasoline supply cut and card rationing which then became effective in the East produced a marked change in the traffic volumes recorded in the rationed area. For the last two weeks of May the counters recorded traffic 45% below that of the same period of 1941, whereas in the unrationed area the traffic dropped by only 15.9%.

CITY TRAFFIC ALSO AFFECTED

The automatic counters reflect with substantial accuracy what is happening to ordinary rural traffic, but do not indicate the trends of urban traffic. There is some evidence that urban traffic has been reduced much more in the rationed area than in the unrationed. Over the Hudson River crossings at New York, traffic in the latter half of May was down approximately 30% below that of the corresponding period in 1941. The San Francisco bridges, in sharp contrast, reported in May a combined traffic increase of 8%. Yet in the same month California's rural traffic decreased more than 27%.

A somewhat clearer indication of the change in the rationed area is given by an analysis of the results from automatic recorders in Connecticut. On "recreational routes" traffic declined 53% in the first four weeks of June below the volume for the same period in 1941. On "through routes" the corresponding decline is reported as 49%; on "local roads" it was 36%; and on "suburban routes," only 29%. These figures compare with an average decline, for all rural roads, of 42% in the same period.

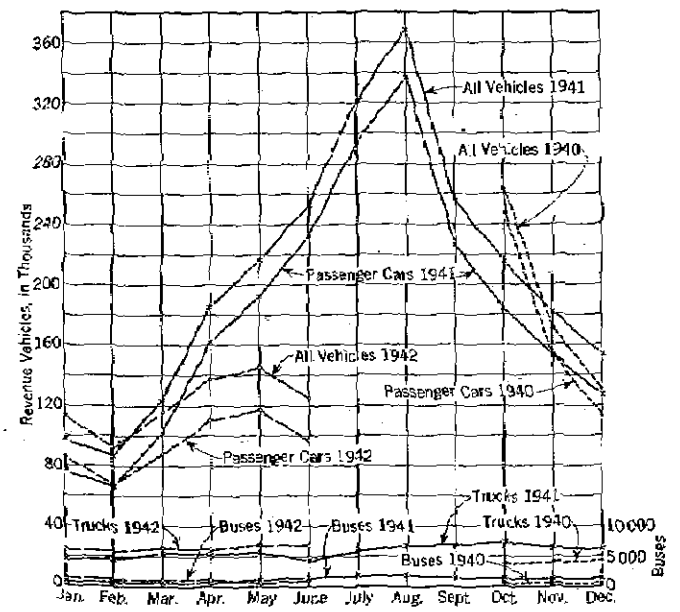


FIG. 1. PENNSYLVANIA TURNPIKE TRAFFIC, OCTOBER 1940 TO JUNE 1942

It is the general observation also that passenger-car traffic is declining more sharply than that of trucks and busses. This conclusion is supported by reports of the Pennsylvania Turnpike Commission (Fig. 1).

RECREATIONAL TRAVEL SQUEEZED OUT

These scattered indices suggest that the restrictive measures are having the effect that might be considered

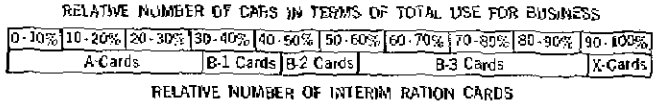


FIG. 2. GRAPHIC ANALYSIS OF ALL PASSENGER CARS IN RATIONED SEABOARD AREA
Use for Business Purposes vs. Gasoline Ration Cards

most likely—the squeezing out of the customary recreational uses of passenger cars.

In the Atlantic Seaboard area subject to gasoline rationing, the planning surveys showed that 60.5% of all normal travel by passenger cars was for business purposes, 15.5% for social purposes, and 24.0% for recreation. As the average total travel within the states concerned was found to be 8,612 miles, the average mileage required for business purposes was approximately 5,200.

It is interesting to compare this estimated normal business mileage with the average rate of 5,050 miles annually permitted by the interim-plan ration cards (Table I).

TABLE I. DATA ON INTERIM-PLAN GASOLINE RATION CARDS OF VARIOUS DENOMINATIONS ISSUED, AND AVERAGE ANNUAL MILEAGE (AT 15 MILES PER GAL. OF GASOLINE)

STATE	% OF RATION CARDS OF VARIOUS TYPES					TOTAL NO. OF CARDS	AVG. ANNUAL MILEAGE PERMITTED
	A	B-1	B-2	B-3	X		
Me.	26.1	9.5	21.2	38.4	11.4	156,035	5,152
N.H.	34.1	10.6	11.1	34.0	10.2	95,010	4,891
Vt.	31.8	10.4	11.5	34.2	12.0	76,632	5,057
Mass.	25.1	9.3	11.2	43.6	10.8	750,851	5,404
Conn.	23.3	12.9	13.3	32.0	7.9	383,739	4,737
R.I.	27.5	11.8	12.5	41.3	6.9	150,945	4,931
N.Y.	30.0	7.7	10.3	42.3	9.7	644,405	5,104
N.J.	30.3	9.8	10.8	41.6	7.5	893,443	4,959
Penn.	29.3	10.0	10.7	41.8	8.2	985,805	5,031
Del.	31.2	10.5	11.6	39.5	7.2	58,586	4,892
Md.	28.4	8.0	10.0	46.8	11.8	324,518	5,405
D.C.	24.7	10.2	14.9	38.6	11.6	137,170	5,272
W.Va.	36.9	13.0	11.8	30.2	9.1	20,095	4,685
Va.	27.8	11.0	11.9	41.5	7.8	425,737	5,032
N.C.	32.6	11.6	11.5	34.5	9.7	496,830	4,900
S.C.	33.6	10.2	10.7	36.0	9.5	249,618	4,902
Ga.	32.7	10.5	11.0	37.3	8.5	382,660	4,889
Fla.	31.4	9.2	9.0	39.2	11.2	340,172	5,104
Average	29.6	9.7	11.1	40.5	9.0	7,554,780	5,050

In computing the annual mileage rates shown in this table, the value of the ration card unit was taken at 3 gal and the mileage per gallon at 15. On these assumptions the A-card permitted travel at the annual rate of 2,340 miles; the B-1 card, 3,660 miles; the B-2 card, 4,842 miles; the B-3 card, 6,318 miles; and the X card, which was unlimited, was conservatively assumed at 10,000 miles.

Road-use studies of 12 representative states in the rationed area permitted a breakdown into percentages of the total number of passenger-car owners performing various percentages of their total travel for business purposes, as follows:

PASSENGER-CAR OWNERS	BUSINESS TRAVEL	PASSENGER-CAR OWNERS	BUSINESS TRAVEL
9.3%	0–10%	10.8%	50–60%
7.9%	10–20%	10.4%	60–70%
8.9%	20–30%	10.5%	70–80%
9.9%	30–40%	10.1%	80–90%
10.3%	40–50%	11.9%	90–100%

Although, for various reasons, a direct comparison of this classification with Table I cannot be made with entire propriety, such a comparison is nevertheless shown Fig. 2. This graph tends to indicate that the ration cards were issued in excessive numbers in the A and B-3 classes, and possibly in deficient numbers in the B-1, B-2 and X classes.

The principal difficulty encountered in the interim rationing period was due to the fact that ration cards were apparently issued for a mileage in excess of that obtainable with the quantity of gasoline actually for sale. Compare the figure of 4,306 miles (a cut of 50% in the normal annual 8,612 miles) with the 5,050 miles permitted by the ration cards at 15 miles per gal. This defect has been corrected by the coupon rationing plan now in effect. This plan contemplates that holders of ration books will be able henceforth to obtain the full amount of gas provided by their stock of coupons at the currently fixed value.

RATIONING VS. VOLUNTARY TRAVEL REDUCTION

Clearly what has already occurred in the rationed area is the squeezing out of substantially all of the more frivolous passenger-car use. The more universal necessity of rubber conservation may eventually require a somewhat similar sacrifice the country over. Whatever may be the possibilities of synthetic rubber production, the necessity for a conservative use of tires will remain. Whether this will be done by means of universal gasoline rationing or, outside of the presently rationed area at least, by a sufficient voluntary reduction in car use, will depend largely upon the success of the campaign for voluntary reduction now being waged throughout the country.

Launched in May, this campaign appears now to be making substantial progress toward its goal. The plan calls first for a radical staggering of school, business, and mercantile hours, and the shifting of hours of industry, to spread traffic peaks and enable mass carriers to handle as much as possible of the daily traffic flow. Next—and this is where the plan will meet its crucial test—it seeks to reduce the remaining passenger-car movement by inducing industrial and office workers to share the use of fewer cars, and by discouraging all unnecessary car use. Failure will mean only that the same result must be obtained by compulsion; and this should insure a reasonable final success for the voluntary plan.

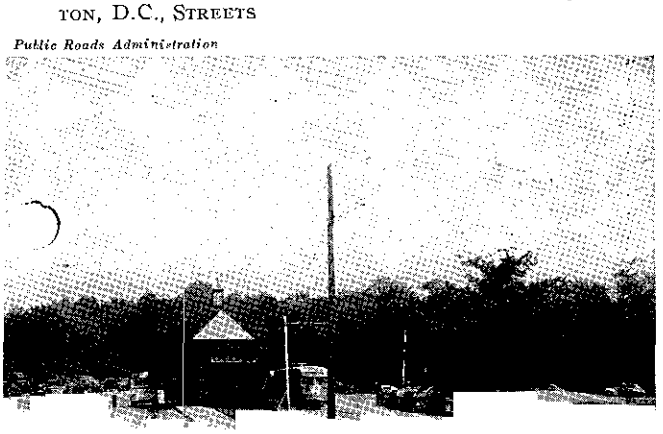
How great is the need for such conservative measures, whether voluntary or enforced, is shown by the results of tire-condition surveys. At four West Virginia industrial war plants, it appears that 30 to 60% of the tires now on the workers' cars will be completely worn out within the next six months. At one plant 80% of the present vehicles will be off the road by reason of tire wear within a year.

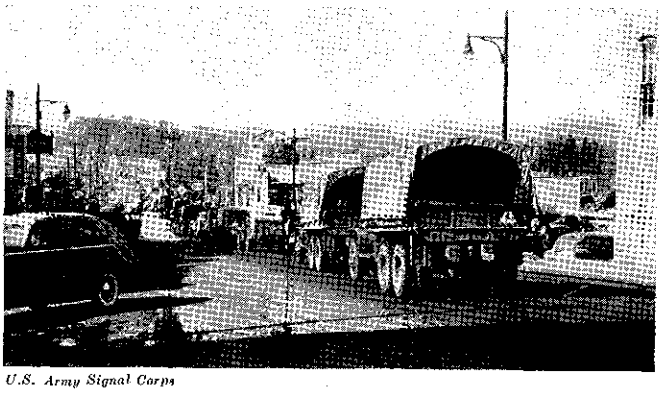
Continued use of these cars is a vital necessity. Substitute mass transportation is already taxed to capacity, and voluntary car sharing has already raised the normal car occupancy of less than two persons to a minimum of 2.6 persons at one plant, a maximum of 4.2 at another, and an even 3 persons at the other two plants.

A recent survey canvassed the managements of 1,250 manufacturing corporations engaged in producing war materials, all located in Michigan. Replies from 749 (Table II) show clearly how dependent are these vital industries on highway freight transportation. Furthermore, 75% of the 434,684 employees of these plants were found to be coming to work in automobiles carrying less than two persons per car.

COMMUTERS PARK CARS AT SUBURBAN TROLLEY TERMINUS INSTEAD OF INCREASING CONGESTION ON WASHINGTON, D.C., STREETS

Public Roads Administration





U.S. Army Signal Corps

MILITARY MOVEMENTS SHOW MINIMUM CONFLICT WITH CIVIL TRAFFIC THANKS TO OFFICIAL COOPERATION AND ADVANCE PLANNING

TABLE II. HIGHWAY FREIGHT TRANSPORT SERVICE FOR 749 MICHIGAN FIRMS

Incoming Freight			Outgoing Freight		
No. of Plants Concerned	% of Total Plants	% of Materials by Truck	No. of Plants Concerned	% of Total Plants	% of Materials by Truck
520	70	50	561	76	50
281	38	90	316	43	90
100	13	100	112	15	100

HIGHWAY IMPROVEMENTS HELP

In many cases the dependence of industry upon highway transportation, particularly for the daily home-to-work travel of its employees, is due to the fact that new or greatly enlarged plants are located beyond reach of any adequate mass transportation facility. An airplane factory near a large Eastern city is a case in point. Rapid expansion has now more than tripled its pre-war employment. A year ago workers, drawn mainly from the nearby city crowded the narrow access roads. A main railway line has never been able to handle the daily influx. A few months ago, when the employees totaled approximately 30,000, just 350 were conveyed to work by bus; most of the rest came in private automobiles occupied by an average of 2.85 persons per car.

By vigorous effort this situation is now greatly improved. Several new access roads of greatly enlarged capacity have been or are being built, all financed largely with federal funds. Seventy-five hundred workers, about a sixth of the present employees, are being transported in approximately 100 buses, many converted from sightseeing use. A far greater number still come in automobiles, but the number per car has been increased to a present average of 4.4. As a result about 8,700 cars now convey to and from work more workers than were formerly moved in 12,000 cars.

Often, as in this case, new war plants or military establishments occupy locations not even served by a main highway. Local roads have to serve a daily flood of thousands of vehicles in place of hundreds or only scores as formerly.

But it is being realized more and more that if existing and even enlarged capacities of access streets and highways are to afford adequate wartime service, prompt measures must be taken to transfer to mass carriers as much as possible of the worker travel, and to ~~reduce~~ increase the number of passengers per car.

Public Roads Administration

THIS EXPERIMENTAL ODT COMBINATION IS LONGER THAN LAW ALLOWS IN MANY STATES

INTERSTATE TRAFFIC LIMITATIONS

Except in special areas, the war has not thus far developed the greatly increased traffic volumes on main rural highways that, but for various restrictive measures, would probably have been generated. Movements of military vehicles form an increasing element of the traffic on such main routes. Thanks to the efficient and helpful cooperation of officials, these movements are normally made with a minimum of interference with civilian traffic.

In many instances it is necessary to move over the highways for long distances vehicles or loads not permitted by existing state laws. In dimensions or weight, some of these movements tax highway capacities, and must be specially routed. Examples are the planned regular movement of Ford bomber parts from the factory to distant plants for assembly. Too bulky and light for efficient rail handling, these will be moved in especially designed vehicles exceeding in length and width the regulation limits of most of the states en route. Another case is the recent movement of an experimental passenger-carrying trailer, whose 45-ft length also exceeded state limitations.

Application to state officials for special permits always involves some difficulty. Much of this would be avoided if all states would agree to a "floor" of weight and size limits substantially above the lowest now in force, to be applicable without special permit for the duration of the war. Such an agreement reached within the past year by the New England and Middle Atlantic states I recommended for general adoption at the Society's Roanoke Meeting. Later Commissioner of Public Roads MacDonald endorsed it. Subsequently, the Governors of all the states were asked, through the Council of State Governments, to proclaim the adoption of complete license reciprocity, with suggested "floor" limits of size and weight as wartime policy.

Unfortunately this appeal has met with far from universal approval. In 19 states one or more statutory limits lower than those proposed are still enforced unless special permits are obtained. It appears that only by the issuance of a Presidential Executive Order will it be possible to achieve a more complete accord. This latter method, proposed by the American Association of State Highway Officials, has recently received the favorable vote of 47 of the 48 state highway departments.

If adopted, these limits would permit vehicles having the following characteristics:

Width	96 in.	Axle load	18,000 lb
Height	12½ ft	Gross load:	
Single length	35 ft	2-axle	30,000 lb
Combination length	45 ft	3-axle	40,000 lb
Weight per in. of tire width	600 lb	Semi-trailer	40,000 lb
		Other combinations	40,000 lb

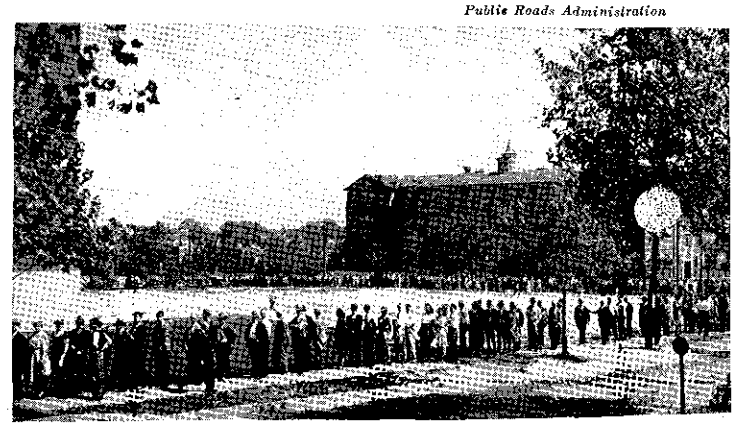
Against the day when an emergency may require quick marshaling of available truck and bus resources for public or military service, an inventory of such vehicles has been taken in all states. Conducted by means of a questionnaire, the effort met with a remarkable voluntary response from approximately 90% of the vehicle owners. The results are now being tabulated. These summaries will afford information as to the number and character of the vehicles of each class available for use in any area. The state files, similarly classified, will facilitate communication with the vehicle owners in case of need.

In further preparation for a possible emergency, other measures are desirable, particularly in areas subject to direct enemy action. Among these are the selection of alternate routes supplementary to the principal routes over which traffic may be instantly diverted according to a prearranged plan, the planning of separate routes for civil and military traffic in emergencies, and other similar measures. Such planning requires the advance preparation of maps and orders ready for instant publication and execution, and calls for the cooperation of state and city highway and police authorities with Civilian Defense and military representatives in each area.

Pioneer work of this nature has been done by the New York Metropolitan Defense Transport Committee, and similar undertakings wherever necessary will shortly be launched at the combined initiative of the Office of Civilian Defense and the Highway Traffic Advisory Committee to the War Department, with the aid of the Public Roads Administration. It is highly important that adequate plans of this sort be prepared and proved in practice tests in order that highway transport may not fail to meet the most crucial of wartime tests if it should come.

Efforts described here have been initiated and presented by many public agencies. Credit is due to the Public Roads Administration, the Statewide Highway Planning Surveys, the Highway Traffic Advisory Committee to the War Department, the West Virginia State Road Commission, the Michigan State Highway Department, and the Work Projects Administration.

Public Roads Administration



LINE OF APPLICANTS FOR GAS-RATIONING CARDS WAS SEVERAL BLOCKS LONG IN WASHINGTON, D.C.

Control Surveys for Military Mapping

U.S. Coast and Geodetic Survey Speeds the Establishment of Important Reference Network

By C. L. GARNER, M. AM. SOC. C.E.

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SUCCESSFUL execution of a military mission depends upon careful preparation for any turn of events. Though at present we are not threatened with invasion, prudence directs collection of all information that would be essential to the successful repulse of such forces. Military mapping has now been extended to areas only partly covered previously. Hard pressed to keep the control surveys ahead of the mapping crews, the U.S. Coast and Geodetic Survey has had to plan its work carefully so that limited crews could cover the many districts as climate permitted. This paper was originally presented by Captain Garner before the Surveying and Mapping Division at the Society's Roanoke Meeting.

AS recently as a year ago, the War Department was planning the development and completion of strategic maps covering important coastal and border areas of the country. Four federal agencies agreed to cooperate in the program, which was put into effect in December 1941. Since that time the Coast and Geodetic Survey has worked closely with the War Department both in mapping and in the extension of the necessary triangulation and level control.

Experience indicated quite definitely that an increased demand for mapping and control would accompany the approach of the scene of conflict to our shores. Requests for control data, mostly from military sources, have increased enormously during the past three years, and to meet emergency requirements the Survey has taken advantage of every opportunity presented to build up its organization to the limit of its resources.

EXPOSED TRIANGULATION STATION
Shifting Sand Dunes Occasionally Destroy Monuments in This Area

The needs so far exceeded the resources for accomplishing the field work that it became necessary for the Survey to establish a policy of priority in the selection of areas. The policy adopted was designed to meet the needs of the military establishments for war mapping or other defense projects in so far as possible. Therefore, upon adoption of the four-agency program, the Survey was in a position to enter into the work immediately and for more than a year its work has been limited almost entirely to projects desired by the military establishments.

The Corps of Engineers has been most cooperative, for without the funds which it has transferred to the Survey for projects in Alaska and the United States, it would have been impossible for the Bureau to maintain its organization of trained technical personnel.

It is regrettable that it takes a crisis to bring us face to face with conditions that need remedying. Since control is a prerequisite for mapping, it should be established in advance in all regions so that the data will be available whenever actual mapping operations are undertaken. Only rarely has it been possible to do this. As with the war mapping, the control has frequently been called for at about the same time as the mapping itself, and obviously this prevents the orderly and systematic procedure necessary to efficient operation. Should large-scale mapping of any of several fairly large areas, in which triangulation monuments have not yet been established, be called for next month or even next year, one can well understand that it might be impossible to furnish the necessary control in a short period of time.

Upon acceptance of the program in December, field parties already organized were immediately dispatched to the priority areas in North Carolina, Virginia, and Maryland, and in January to California, to push the control during the winter. An unusually favorable winter season permitted very good progress and the projects in Maryland, Virginia, and California have already been completed. The parties there, together with additional ones, moved north to take up work in Pennsylvania, New York, New Jersey, northern California, and Washington for the spring and summer.

The control for this work was necessarily designed to meet all requirements for topography, whether by ground methods or by photogrammetry. Along the coast the control stations had to serve for hydrographic and coastal defense surveys. Only by such thorough coordination of surveys is maximum usefulness obtained.

TRIANGULATION NETWORK EXTENDED

The determination of latitudes and longitudes for large numbers of marked points on the ground is generally accomplished by the process of triangulation, which has the almost unique virtue of checking itself as the work proceeds. Of course the initial determination of latitude and longitude must be obtained from astronomical observations. Theoretically, there would seem to be even greater possibilities than have already been developed in this method of locating objects from instrumental observations made at two or more known points. When it comes to the practical application of the work, however, there are a

EARLY EARTHENWARE MONUMENT RECOVERED IN MARYLAND
Such Urns Were Frequently Used 75 to 80 Years Ago