g. Reduce driving speeds for conservation. Observe rubber-emergency speed limit.
h. Enlist children's co-operation in wartime traffic program.

6. Training—
   a. Train army, school bus, truck and bus, and emergency vehicle drivers to meet war-traffic conditions.
   b. Train high-school drivers for future military and essential civilian needs.
   c. Train regular and replacement, auxiliary, and military police in traffic control.
   d. Train other essential war-traffic personnel.

Many of these items are difficult of accomplishment, especially the maintenance of sufficient personnel by state and local agencies to discharge fully their vital responsibilities. Successful execution of the program requires continued planning to secure the vital co-operation of non-governmental agencies to mobilize public participation and support. Publicity through all available channels is necessary, for without it, many elements of the program cannot be carried out. Intelligent planning of this publicity is a prerequisite to success.

GROUP-RIDING PROGRAMS

Merl T. Calef, Traffic Engineer,
Gary, Indiana

Why, many impatiently ask, do we Americans have to double-up or quadruple-up with others in our own private cars? America has over 27,000,000 automobiles. Is that not enough for all? Why gas rationing? Why tire rationing?

Our reply to all such questions must be that our country is at war—not just a little border skirmish, but a gigantic war for our very existence as a free nation as we have been from the beginning—and this war must be won by our armed forces on land, at sea, and in the air.

You hear the word "logistics" used more now than during the first World War. Logistics is that science which treats of *moving*, or *supplying*, armies and conducting campaigns. The words "moving" and "supplying" tell the whole story—and we do this moving on RUBBER.

In 1918, the year of the ending of the first World War, the U. S. A. had 6,146,817 registered automobiles and trucks. Today we have this number increased by five-fold. Almost every ounce of war material from source to battle line at some time rides on rubber tires.

Since Pearl Harbor the Japs have controlled over 90% of our supply of crude, natural rubber. Hitler's U-boats are doing their best to sink every shipment to us from South America, our one lone remaining source of natural, crude rubber.

Today America is a "have not" nation as to crude rubber supply, and also a "have not" nation as relates to operating plants for producing sufficient synthetic rubber to replace that supply lost to the Japs and Hitler. Until very recently we have been a "have not" nation in our plans for actually getting synthetic rubber into tires on the road.

Our only salvation on both the fighting front and the home front is to conserve and save every possible ounce of rubber in our tires and tubes now on the some 27,000,000 passenger cars on the road today. Ten months ago this job looked easy, but it has been a tremendous task, involving hours of time of hundreds upon hundreds of both paid and volunteer workers —and the end is not yet in sight. America's famous ailment, "complacency," is one of the greatest hindrances to completeness in this rubber-saving program. Many say, "We've always had rubber—why all this fuss now?"

Just to bring the actual facts to your attention I have prepared Table 1, showing the types of rubber available so far, either as natural, crude or synthetic types. The synthetics include five general types. Over 1,000 rubber-like substances have been produced by chemists, but to date only the five mentioned here have any near future possibilities in helping in this national rubber-shortage emergency. These are Buna S, produced from petroleum, grain alcohol, saw-dust brine, molasses, and various other raw materials; Neoprene, produced from limestone and coke (the process largely used by the Germans) ; Butyl and Flexon, produced from similar beginnings as Buna S; and Thiokol, being made from Ethylene-chlorine, caustic soda and sulphur (the worst smelling of all). Only the first, Buna S, has large possibilities for production in a comparatively short time. In figuring the anticipated total production of Buna S and the other types, we have 534,000 tons "expected" before January 1, 1944. None of this was in storage on July 1, 1942. Few plants were past the pilot stage. If Hitler gets part of the 53,000 tons anticipated from South America this year, we'll be short there. Of reclaimed rubber, 520,000 tons are estimated for use this year. But this has to have new rubber mixed with it. Gentlemen, the picture is dark!

May I quote a few passages from our current rubber "Last Word," the report of the Bernard Baruch Rubber Committee?

"We find existing conditions so dangerous that unless measures are taken immediately this country will face both a military and a civilian collapse. The naked facts present a

TABLE 1

TYPES OF RUBBER, MATERIAL SOURCE, SUITABILITY FOR TIRES AND TUBES—AND TENTATIVE SUPPLY

Types	Made From	Manufacturing Efficiency	Tread Wear	Carcass Failures	Suitability		Supply (in 1,000s of Long Tons)	
					Casings Recapped	Tubes	On Hand 1-1-'42	Expected 1-1-'44
Natural	Rubber tree and Guayule	100%	35,000 mi. at 40 m.p.h.	Average	100%	100%	578,000	53,000 (1)
Buna S	Petroleum, grains, sawdust, molasses and others	Good	90% of natural	None if 10-20% natural rubber used	Good	Apparently satisfactory	*None*	386,000 (2)
Neoprene	Limestone and coke	Good	90-125% of natural	None recently	Good	Apparently all right	*None*	30,000 (3)
Butyl	Similar to Buna S	Good	40-50% of natural	Frequent	Promising	Not very satisfactory	*None*	62,000 (4)
Flexon	Similar to Buna S	Fair	Poor—below 40%	Frequent	Promising	Unsatisfactory	*None*	..... (5)
Thiokol	Ethylene-chlorine, caustic soda, and sulphur	Anticipated fair	Poor—28%	No data	Good	Unsatisfactory	*None*	54,000 (6)
Reclaim	Mostly natural rubber	Good	Poor—20 to 25% of natural crude	Infrequent	Good	Fairly satisfactory	47,000	520,000

NOTE: Much of these data obtained from Baruch Rubber Report.
(1) Natural rubber is dependent upon Axis failure to sink shipping; (2) (3) (4) (5) and (6) "Expected" supply for January, 1944, is still problematical, as most of plants have not yet progressed beyond the "pilot production stage."
The Baruch Report shows a deficit of 211,000 long tons that must be met before January, 1944.

warning that dare not be ignored. Unless adequate new supplies (natural or artificial) can be obtained in time, the total military and export requirements alone will exhaust our crude stocks before the end of next summer, 1943.

"Tires on civilian cars are wearing down at a rate eight times greater than they are being replaced. If this rate continues, by far the larger number of cars will be off the road next year and in 1944 there will be an all but complete collapse of the 27,000,000 passenger cars in America.

"We are faced with certainties as to demand; with grave insecurity as to supply. More rubber to those who need it and less to those who don't. To dissipate our stocks of rubber (on cars or otherwise) is to destroy one of our chief weapons.

"Gas rationing is the only way to save rubber. The limitation on gas rationing, it must be kept in mind, is not due to shortage of that commodity—it is wholly a measure of rubber saving. We cannot afford to take a chance. We cannot base military offensives on rubber we do not have. Our lives and our freedoms are at stake. We dare not depend upon UNBUILT PLANTS; upon increasing the reclamation of scrap; upon bringing the tire manufacturing capacity up to equal theoretical synthetic production; upon other unproven factors."

We read, daily almost, in the press of this delay and that delay, of schedules behind on this test and that test, etc. I can only warn you that it is a long way from the chemist's test tube to the tire on the car on which you depend to get to work. It is also a long way from the Mexican sagebrush rubber plantation to the tire on which you ride to work. We must conserve and save every possible ounce of rubber.

National and State Programs

Now, what has been done, what has been the program to date to accomplish this saving of essential and critical rubber? To relate a few of the steps—early in 1942 the President created the United States Office of Defense Transportation with the Honorable Joseph B. Eastman, of the Interstate Commerce Commission, as its Director. Previously there had been set up an organization known as the Highway Traffic Advisory Committee to the War Department under the able direction of Dr. J. T. Thompson, and to this Committee Mr. Eastman delegated the job of automobile tire conservation. Dr. Thompson's HTAC soon started organizing state and municipal groups to carry this rubber-saving program right down to the "grassroots" of the entire nation. In keeping with this program, the Indiana War Transportation Conservation Committee was set up with Director Samuel C. Hadden as State Administrator and Hallie Myers, Traffic Director, as the Executive Officer. South Bend was the first Indiana city to

get started on the rubber conservation program, which was carried on there by joint co-operation of Hallie Myers' State Committee, the South Bend Chamber of Commerce Safety Division, and the City Traffic Engineer, Ernest Miller. This was the pilot swap-ride test of the State of Indiana and served as the basis of practices developed and described in the manual issued by the State Committee.

The Gary Program

During the progress of the work in South Bend I accepted an invitation to visit the project. As a result, a similar plan was soon under way in Gary. On July 16 I was called from a safety conference in Chicago and asked to come home and accept the appointment from the HTAC as Gary Administrator of the program I had recommended. We immediately got busy and organized the Gary War Transportation Committee, consisting of the heads of all our industries, utilities, bus and street car lines, schools, fire and police departments, the Chamber of Commerce, and the Merchants Bureau, with the Mayor as Chairman of this general committee (mostly advisory in nature).

Using the brochures sent us by the Highway Traffic Advissory Committee and the Indiana War Traffic Conservation Committee, we organized a four-project program, one of which was the swap-ride. Let me take just a minute to picture briefly the other committee projects to you. These included the Staggered Hours Committee, the Better Use of Streets Committee, and the Public Safety and Speed Reduction Committee, and of course the Publicity and Finance Committees. In co-operation with the efficient traffic engineers brought in by Hallie Myers, several surveys were made in Gary. Peak loads of the local transit company were becoming critical, and as a direct result of our work a program of staggered hours was instituted in several of the steel mills. A war network of streets was set up with preference for these in maintenance and traffic law enforcement during the war. This network received priority attention on traffic signal changes and elimination of parking to aid in steel plant exit of workers, which is our worst problem in Gary. The Speed Reduction and Safety Committee worked with our Police Traffic Bureau with good results. We need it, too, since Gary has competed for years with other cities for the worst traffic accident record in the U. S.

Group-Riding Plan

Our 3,000 swap-ride groups have adopted approximately 3,000 different types of riding agreements. This may be due to Gary's particular location as one of four contiguous cities

with a total population of nearly 300,000, and the intercity residential and employment situation, involving thousands of workers in the steel mills, the oil refineries, and the chemical plants. No! not a rubber plant—we nearly had one at that, for there was a gigantic $100,000,000 plant started with nearly $5,000,000 spent on preliminary work and lands, when, bingo, a telegram came to defer all work—and to date it is still deferred. Perhaps that is the reason why we in Gary have a feeling that the tire situation needs tire conservation.

In order to organize car owners into riding groups, one must know from whence every car comes. We prepared three swap-ride maps, one covering the Illinois area, one the four-city area, and the third the suburban and county areas. It may be of interest to learn that three states and eleven counties supply employees to Gary's life. Each map was divided into swap-ride areas, with the same boundaries as those of the Civilian Defense Areas. It was contemplated that this would enable us to get more aid in correlating the riding groups of the various industrial plants, but we now have worked out a better way. With the swap-ride area maps, questionnaire cards were provided to each industry and business house. These cards, furnished by the State Committee, were punched for use with sorting machines, but many thousands had to be punched and sorted by hand into their various classifications providing the following data:

1. Name and address of employee.
2. Swap-ride residence area.
3. Employer's area number.
4. Method of getting to work:
    a. Walking.
    b. Bus or street car.
    d. Driving an automobile.
    d. Riding with some one else.
    e. By train, bicycle, etc.
5. Seating capacity of car and seats available for passengers.
6. Willingness of car owner to share rides with others.

The ODT suggestions were to cover only industries employing 100 or more, but we included all plants.

While these cards were being prepared for sorting and tabulating, the traffic engineers made an occupancy check of parking lots at all industries and stores and also checked street traffic. Boy Scouts were used for actual counting. In this count, 17,848 cars were checked, with a total of 32,571 riders, giving us a measuring-stick occupancy rate of 1.82. The maximum was 2.18 and the minimum was 1.37. We feel that this sampling was fair to all phases of the work.

Although not all plants have turned in their reports, nevertheless a total of 41,051 questionnaires were turned back to us, indicating that 17,360 persons (43%) use street cars and buses to get to work, 16,006 get to work in cars, and the remainder by other means. These cards were sorted and tabulated in part by machines in the steel mills, but we did use successfully a fine co-operating group of women from the AWVS and from several other groups.

Now it is with this 16,006 automobiles that we are concerned, and with the other approximate 15,000 cars in Gary, all of which are, more or less, being used to transport war workers to and from their jobs. Plant Transportation Committees in most instances have done a fine job, while in others it is sincerely believed that the management has not yet foreseen the possibility of its employees without cars trying to get to work to produce war material. Some organizations like the railroads, which do mostly or wholly a switching and short intercity run, have problems of shift work and men-on-call day and night with all kinds of odd hours. This makes efficient ride-sharing next to impossible.

Other results to date are both pleasing and discouraging—discouraging because there seem to be so many who say "Oh, we'll get by" and do not realize that such an attitude aids the Axis and tends to hinder their own work—eventually, if not now. Most of the plants have done a marvelous job.

Publicity

Our publicity work was on a rather broad front. Bill boards, plant posters, plant bulletins, newspaper headlines, stories, editorials, cartoons, and plant employee meetings—all were used. Our *Post-Tribune* carried almost daily stories during the progress of the work. But our greatest publicity came from the Baruch Rubber Report release and the gas rationing system, although it is considered by several that the gas rationing has actually delayed many swap-ride groups; but it did start a very considerable number. Every car owner received his "A" card, and the boards were necessarily generous with war workers and many others in the issuance of "B" and "C" gas ration cards. We have found many sincere persons actually not realizing the difference between gas rationing and tire rationing. In the Calumet District we are right in the heart of the petroleum refineries, possibly the largest in the world. Gasoline is plentiful in Gary, but rubber is in an entirely different supply pattern—there just is not enough to go around, and it is becoming less and less. The province of swap-ride groups, in co-operation with tire rationing boards, is to continue to get these war workers to their jobs—not just now, but until a rubber tire supply is actually in existence in every city and hamlet.

Results

Following are some of the outstanding, as well as average, plant swap-ride efforts:

Plant A. Now has over 2,400 swap-ride groups out of a total of 6,766 cars. The work is not yet completed. Weekly shift changes in 24-hour operating plants wreak havoc with these group-riding programs, and will continue to do so until there is a greater shifting of employees to departments where there can be interdepartmental riding groups organized.

Plant B. With 287 cars in September reduced to 166 in November, a saving of 121 cars, or 42%, has raised their occupancy rate from 1.9 to 3.11. One hundred and fifteen groups were organized here and developed a saving of 12,000 tire-miles daily.

Plant C. Compared to the September check of 523 cars, this plant with 124 ride groups has reduced cars to 437, with 87 cars apparently out of the picture. Only 33 cars are operating with a lone driver. Most of these are in single-employee-ride zones or with top executives using their own cars alone in irregular hours. These 271 cars off-duty every day mean a saving at this plant of 37,100 daily tire-miles, a reduction of 51.8%, and give an occupancy rate of 3.48. Right here let it be explained that we are using two different occupancy rates as checks, the first being the actual, i. e., the total riders divided by total of all cars in use, while the second rate is the ratio between riders in swap-ride cars and the actual number of cars employing swap-ride plan. This latter gives us the efficiency of the carrying capacity of different plant cars and aids us in keeping track of the vacant seats available in any given area.

Plant D. A new war industry, starting from scratch this last summer, enrolls new employees in riding groups as they accept employment. From the time our Committee started work this plant has taken on hundreds of new workers and has reduced the cars at least by 100. They now have 191 cars carrying 726 persons daily, with some 200 cars off-duty each day. In this plant the daily tire-miles saved amount to 24,000.

Plant E. Curious to learn the potential life of cars as reflected in the owner's estimate of the life of his tires, we made a "Gallup Poll" of tire life in a plant which would afford a fair cross-section of all of Gary's 30,000 automobiles. This check was made in November so that two months can now be deducted from the tire life then estimated. These factual data should provide an excellent and convincing argument to some of the die-hards that their cars will be out of commission in ¼ to ⅕ of the time that they would be otherwise were

they swapping rides with four or five other car owners. Here are the facts in this survey of tire life:

23% have 6 months to go)
44% have 9 months to go) Total of 67%, or ⅔.
19% have 15 months to go
14% have some 18 months or more to go.

Assume now, two months later, an average life of 6 months for the first two divisions comprising this survey list. If these car owners will arrange swap-ride groups, either intraplant or intracity, with four persons per car, these tires will last four times as long as under the single rider status. This shows that these cars can be run two years under the swap-ride program as compared to six months otherwise. Now I doubt if the most optimistic patriot pictures the war as being over in six months. But there certainly is the possibility that it will be over in two years. So, by group-riding, their cars can be made to last for the possible duration, whereas otherwise some two-thirds of the employees in this Plant E probably will have to walk or get to work otherwise not later than this coming autumn. This, we believe, is an excellent selling point to put over further group-riding in any plant or any city. Our swap-ride maps show that these 2,687 cars included in the tire-life survey travel a daily mileage of some 34,090 miles. Cut that mileage to one-fourth and there is a substantial rubber saving.

It is hoped that Gary will have at least 6,000 swap-ride groups when our campaign is completed—if ever. One thing is certain—in a shift-turn operation there is nothing static in the situation except the non-static condition. Plant Transportation Committees, and their Plant Executives, must realize that their save-rubber program must last for the duration, or at least until our national rubber supply is adequate.

To aid in organizing and filling up cars as an interplant program, we have set up a file in the Gary Administrator's office with the 298 swap-ride areas indexed and with a folder for each participating plant or business house. If there are riding groups with empty rider spaces in their cars, we place a red tab on the index card of this area, so that at a glance we can tell if more car room is available in the area. This facilitates quick replies to telephone calls or personal calls to the Administrator's Office by representatives of the Plant Transportation Committees. Our own file provides a clearing house for all plants. Plants are adopting this file for their own offices, and when these are all completed the work will be greatly eased for all concerned.

One plant with thousands of employees has set up ten divisions within its own plant with swap-ride wardens heading the work of contacting every car user in that plant. As soon as this supplemental work is completed, they will also have a

ride-area warden to co-operate with similar wardens of other plants and business firms. Eventually every area will have ride wardens from every plant. These men can handle the work of correlating riders and will be given OCD certificates for their work.

We feel that the seriousness of this rubber shortage, even for men in war-production plants, is going to necessitate the continuance of the Gary War Transportation Committee's work until the supply of both natural crude and synthetic rubber is sufficient to maintain every war worker's car so that its owner can do his share in production of war material. If this is not done, and the rubber supply remains as critical as today, we can foresee the moving into city homes, within walking distance of our industrial plants, of hundreds of our industrial workers, or the additional alternative of employee housing projects provided by the industry and/or the government.

From our experience in Gary and knowledge of other cities' work, we can say that results can be had, satisfying results too, by the operation of these swap-ride programs. They are necessary. They are patriotic measures. They are the one and only method we can see to keep America rolling on rubber, so that America and our Allies may exert every effort to win this war and our eternal freedom.

BRIDGE AND CULVERT FLOW AREAS

F. William Greve, Professor of Hydraulic Engineering,
Purdue University

Captain Petty has asked me to review briefly some of the hydrological factors which influence the size of culverts and small bridge openings. No distinction will be made hereafter between these two types of waterway, and, for the sake of clarity, references to culverts will also be applicable to small bridge openings.

A culvert is a right-of-way. The flow through it differs fundamentally from the traffic on a highway in that hydraulic flow is subject to the laws of nature in contrast to the movement of vehicles, which is under the control of man. Congestion of human traffic on a road will, at the worst, cause inconvenience and doubtless much profanity; while at a culvert, congestion will produce ponding of water which, in turn, may cause not only the inconvenience of a flooded roadway, but also property damage incident to submerged adjacent lands, erosion of the bed and banks of the stream, and possible destruction of both culvert and highway.