500 PLANES A DAY

A Program for the Utilization of the Automobile Industry for Mass Production of Defense Planes

By WALTER P. REUTHER*

England's battles, it used to be said, were won on the playing fields of Eton. This plan is put forward in the belief that America's can be won on the assembly lines of Detroit.

In an age of mechanized warfare, victory has become a production problem. The automotive workers for whom I speak think our industrial system a productive giant capable of any task, provided it is not forced into battle with one hand tied behind its back. They also believe that we need send no men to a future conflict with the Axis powers if we can supply enough machines now to our first line of defense in Britain. The machines we and the British need most are planes, and the survival of democracy depends on our ability to turn them out quickly.

The workers in the automotive industry believe that the way to produce planes quickly is to manufacture them in automobile plants. The automotive industry today is operating at only half its potential capacity. This plan proposes that the unused potential of the industry in machines and men be utilized in the mass production of aircraft engines and planes. It is our considered opinion that it would be possible, after six months of preparation, to turn out 500 of the most modern fighting planes a day, if the idle machines and the idle men of the automotive industry were fully mobilized and private interests temporarily subordinated to the needs of this emergency.

Time, every moment of it precious, its tragic periods ticked off by bombs falling upon London and the Midlands, will not permit us to wait until new mass production factories for aircraft and aircraft engines finally swing into action late in 1942. Emergency requires short-cut solutions. This plan is Labor's answer to a crisis.

Mr. William F. Knudsen says that airplane production is 30 percent behind schedule. It will continue to be behind schedule so long as we continue to rely on the expansion of existing aircraft plants, and on the construction of new plants. Expansion of existing aircraft plants means the expansion of plants utilizing the slow and costly methods of an industry geared to hand-tooled, custom-made production.

New plants cannot be built and put into operation in less than 18 months. In 18 months Britain's battle, for all her people's bravery, may be lost, and our own country left to face a totalitarian Europe alone.

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Packard and other companies are still digging the ditches and pouring the concrete for their new airplane engine factories. The Axis powers will not wait politely until these factories are finished.

New plants, when finally erected, must be filled with new machinery and this new equipment largely duplicates machinery already available in our automobile plants. The machine industry is overtaxed. The emergency of war cannot be met in the normal time necessary to construct new plants and equip them with the required production machinery.

We propose, instead of building entirely new machines, to make the tools required to adapt existing automotive machinery to aircraft manufacture.

We propose to transform the entire unused capacity of the automotive industry into one huge plane production unit. Production under this plan would not replace the output of the aircraft industry proper, which would continue to construct the large bombers and planes of special design.

Fifty Percent of Automobile Industry's Potential Capacity Is Unused

No industry in the world has the tremendous unused potential productive capacity of the American automotive industry, and no industry is as easily adaptable to the mass production of planes. A careful survey will show that the automobile industry as a whole is not using more than 50 percent of its maximum potential capacity if that capacity were properly coordinated and operated to the fullest degree.

The automotive industry could produce 8,000,000 cars a year. It is producing approximately 4,000,000. These unused plant reserves, as shown by the figures given in the Federal Trade Commission's report on the motor vehicle industry, are greater than the total motor plant capacity of England, Germany, France, Italy, Russia and Japan combined. Adapted to plane production, this unused potential capacity would give us world plane supremacy within a short time.

At present the automotive industry never operates at more than 80 to 90 percent of its maximum potential capacity, and then only for a few months each year. The rest of the year it operates on reduced schedules, and many plants shut down completely. If automobile production were spread evenly over a 12-month period, it would be possible, without reducing the total output of automobiles, to convert a large portion of this machinery to the manufacture of planes.

During the automotive year ending August, 1940, Nash used only 17 percent of its productive capacity; Dodge used 36½ percent. Nash, working at maximum capacity, could have manufactured its total output for the 12 months in 49½ working days; Dodge, in 111 working days. Chevrolet, the largest single producer of motor cars, turned out over a million cars during the last model year, and yet used less than 50 percent of its potential productive capacity. The main Chevrolet Motor plant at Flint, Michigan, produced 380 completed motors per hour at the peak of the 1937 production season, utilizing all four of its complete motor machining and assembly lines. At the present time, at the peak of the 1940 production season, the Chevrolet

Flint plant is producing 282 motors per hour, with one motor line standing completely idle, while the three remaining lines are operating on a two-shift basis. Since 1937, Chevrolet has built a new motor plant in Tonawanda, New York, which at the present time is producing 65 complete motors per hour, with a plant capacity of 90 motors per hour. This would indicate that at the peak of the production season Chevrolet is only building 347 motors per hour, with an actual capacity of 470 motors per hour. With an unused capacity of 123 motors per hour at the peak of the production season, it is obvious that Chevrolet has an unused reserve which becomes tremendous during the month of reduced operating schedules.

The availability of automotive production facilities for plane production in Chevrolet is again shown in the case of the Chevrolet drop forge plant in Detroit, the largest drop forge shop of its kind in the world. If this shop were operated at full capacity, it could produce all the drop forgings required for the production of 500 airplane motors per day, and still supply the Chevrolet company with sufficient drop forgings for 1,000,000 Chevrolet cars a year. Skilled labor to operate this shop at full capacity is available. Other forge shops, including the Buick and the Dodge forge shops, are also working at far less than capacity. (See appendix for shop equipment and production schedules.)

Automobile Motor Building Facilities Can Be Adapted to Make Plane Motors

Are the facilities used in manufacturing automobile motors adaptable to the manufacture of airplane motors? The answer is that they are.

Both the automobile and airplane motors are combustion engines, essentially the same mechanism for generating power by exploding gas. Both motors contain cylinders, carburetors, pistons, crankshafts, camshafts, valves, spark-plugs, ignition systems, etc.

The same basic machinery is utilized in the manufacture of these basic parts common to both motors. True, there are differences between the automobile and the airplane engine, as there are differences of a lesser degree between the engine of the Chevrolet and the engine of the Cadillac. These differences between different engines are produced by adding certain tools, dies, jigs or fixtures to the basic machine in order to make a difference in the product. The same "tooling" process adapts the same basic machinery to the production of the airplane engine. Graphic proof of this statement is even now being supplied by General Motors. Many of the most difficult and precise parts of the Allison aviation engine are being manufactured in the Cadillac plant in Detroit, much of it with retooled Cadillac machinery. The new Allison plant in Indianapolis, still in process of expansion, is being used largely for assembly.

The experience of General Motors in making Allison parts with retooled Cadillac machinery should also dispose of the bugaboo of "tolerances." "Tolerances" are the allowable fractional variations in size of engine parts, and they must be far finer in the plane engine than in the automobile engine. But these more precise dimensions can be obtained by more precise tooling.

When the contemplated airplane motor plants are completed, it will be necessary to equip them with the same kind of basic production machinery already standing idle half of the time in the nation's automotive factories. This basic machinery will be duplicated, and after it is duplicated it will still be necessary to construct the special tools, dies, jigs, and fixtures required to adapt this machinery to the manufacture of plane engines.

In the process of duplicating basic machinery, lies the most serious delay. This lag, which from all indications may continue, may well defeat our national defense program. An additional burden is placed on the already over-loaded machine tool industry. We propose to short-cut the process by building only the tools, dies, jigs, and fixtures necessary to convert idle automotive machinery into plane engine machinery. A few special machines will be necessary, but these will be but a small part of the total equipment. In this way a job that will otherwise take at least 18 months can be done in six months.

Certain basic machines are necessary to build both automobile and aircraft types of engines. These include gear cutters, gear shapers, screw machines, bullards, drill presses, punch presses, broaching machines, turret lathes, various types of milling machines, various types of lathes and Fay machines, lapping machines, various types of grinding machines, die casting machines, forge presses, header machines, foundry equipment, welding and riveting equipment.

Automobile Industry Adaptable for Stamping of Wings and Fuselage

The plane has three main parts: engine, wings and fuselage. Just as there is unused capacity for the production of motors, so there is unused capacity for the production of the wings and fuselage. The large body plants and the parts plants have metal stamping equipment now used for stamping out parts for the body of the automobile which can be adapted to stamping out the parts which make up the wings and fuselage of the plane. Proof of this is provided by the tentative plans being made by the automotive industry at the suggestion of Mr. Knudsen to manufacture parts of the wings and fuselages for large bombers.

A survey of the large body plants will show that their equipment for pressing and stamping metal parts are also not being used to full capacity. Murray Body, Briggs and the Fisher Body plants show a 50 percent overall unused capacity in their pressrooms. Striking is the example of the Fisher Body plant in Cleveland, which contains one of the largest pressrooms in the industry. At present it is operating at but 40 percent of capacity, although automobile body production is now at its peak. In 1936-37 this plant made all the stampings for Chevrolet bodies, employing 9200 employes. Today it employs but 3500, for Fisher has built a new plant at Grand Rapids, Michigan, further adding to body capacity. (See appendix for equipment in the Cleveland Fisher plant.)

Technical problems are involved, of course, in constructing new dies to stamp the lighter aluminum alloys used in plane production. That these problems are not insuperable is shown by the fact that Murray and Briggs are already stamping wing parts for Douglas bombers.

Skilled and Production Labor Available in the Automobile Industry

Skilled labor is necessary to turn out the tools and dies required to adapt these various types of automotive machinery to plane production. The auto industry has the largest reservoir of skilled labor in the world. More than 25,000 tool and die workers, jig and fixture men, pattern makers, draftsmen and designers, and allied craftsmen are employed in the auto industry at the peak of its tooling program.

Tooling is even more seasonal than production. Each year thousands of the industry's most skilled craftsmen work at top speed for a few months to complete the necessary tooling work to adapt the old machinery to the new models. When the tooling program is completed, only a skeleton crew of these skilled craftsmen are retained for maintenance and duplicate tooling. Three or four thousand skilled craftsmen are shifted to ordinary production jobs while more than 10,000 are laid off entirely until their labor is needed for the next tooling season. During the past five years more than half of the tool and die makers in the industry, or more than 10,000, averaged less than six months work per year. At the present time there are approximately 3,000 tool and die makers unemployed in the auto industry; some 2,500 have been transferred to ordinary machine-tending production jobs. Many of the remainder are on a short work week.

In addition to the men who are unemployed, those working on production and those employed only part time, there are at least 2,000 tool and die men who have permanently gone into production jobs because of the short work year in the tool and die industry. These mechanics could be combed out of production departments and made available again for tool and die work.

Thus in manpower, as in machines, we have unused capacity; the highly specialized and valuable skills of 7,500 tool and die workers are available to do the necessary tooling for the plane production program here outlined.

Fisher Body Corporation, a division of General Motors, is now working on wood models for a new body design. Chrysler also is working on new models, for which some die work is likewise under way. If the automobile industry goes ahead with plans for new models, it will absorb unemployed tool and die workers. However, if the introduction of new models in the auto industry could be delayed for six months, from 12,000 to 15,000 skilled mechanics could be made available to build the necessary tools, dies, jigs and fixtures for the production of an all metal pursuit ship on a mass production basis.

The tool and die shops of the automotive industry, like the tool and die workers themselves, are partially idle. The 90 tool and die jobbing shops in the Detroit area affiliated with the Automotive Tool and Die Manufacturers Association employ 7,000 tool and die workers when operated at full capacity. In addition to these shops in the Association, there are some 75 additional tool and die shops which employ 1,500 tool and die workers at capacity production. And, in addition to these independent enterprises, there are large tool and die departments within the auto, body and parts plants proper. These are known as "captive" tool and die shops. These great "captive" tool and die shops have

a capacity beyond the available manpower if all the skilled men in the entire industry were employed on a full-time basis.

A typical example of the tremendous unused capacity of these captive shops is that of Fisher Body No. 23 at Detroit. This is the largest tool and die shop in the world. It builds the sheet metal dies, welding bucks and fixtures, and special machinery for all Fisher Body plants in the General Motors Corporation. In 1931 Fisher Body Plant No. 23 employed 4,800 tool and die makers at the peak of the tooling program. In 1940 Fisher Body Plant No. 23 employed 1,400 tool and die makers at the peak of the tooling season. In December, 1940, this plant employed only 175 tool and die makers and even these few were on a reduced work week.

As important as the tool and die worker is the engineer who designs the tools and dies. Here, too, the same situation repeats itself. There are in the Detroit and metropolitan areas about 2,100 designing engineers. Their drawings would be needed for the new tools and dies required to adapt automotive machinery to plane production. Designing engineers, like tool and die workers, are largely unemployed between tooling seasons. Here, too, a six months delay in new automobile models would make available an ample supply of the necessary skilled men.

Just as there is no shortage of skilled labor in the automobile industry, so there is no shortage of unskilled labor. Despite the defense program, there is a minimum of 100,000 former automobile workers unemployed or on WPA, not to speak of the thousands of young people in automobile production areas who would welcome an opportunity to work in plane production.

The Program in Operation

We propose that the President of the United States appoint an aviation production board of nine members, three representing the government, three representing management and three representing labor. We propose that this board be given full authority to organize and supervise the mass production of airplanes in the automobile and automotive parts industry.

The first task of the board would be to organize a staff of production and tooling engineers and assign them to make a plant-by-plant survey of the industry to determine the capacity of each plant, and the extent to which it is being utilized. The next task of the board would be to break down a blueprint of the type of plane chosen for mass production into its constituent parts and allocate the various parts of the engine, wings and fuselage among the different automotive plants in accordance with their unused capacity and the kind of work to which that unused capacity is being adapted. Work is to be parcelled out with an eye to spreading it as widely as possible, for much quicker results will be obtained if each plant has to cope with but one or two probelms of design and tooling. As contrasted with the present method, which dumps half a hundred technical problems into the lap of one manufacturer who must build an entire engine or plane, this method has all the advantages of division of labor.

The production board should have power to allocate the tooling and designing necessary among the various tool and die shops in accordance with their capacity and their specialized qualifications.

Power to appoint inspectors for each plant in accordance with its part in the general plan should be given the production board and there should be close inspection of each part manufactured before its release.

We propose the establishment of a central motor assembly plant to which all complete parts shall be shipped after they pass inspection.

The automotive industry has unused floor space as it has unused men and machines. We suggest that the Hupmobile plant in Detroit (a plant which produced only 371 cars in 1939, and which at the present time is completely idle) be leased by the government for a central motor assembly plant. The plant is large enough for five assembly lines with a daily total production capacity of 500 complete aircraft engines a day. The plant could be operated on a three 7½ hour shift basis and the unused machinery now in the building could be placed in other plants in accordance with the general production plan.

Similar methods can be applied to the manufacture and assembly of the wings and fuselage, and here, too, there is ample unused floor space for new assembly lines. Six complete floors of a building one block long and a half block wide are available at Fisher Body Plant No. 21, Detroit, which formerly made bodies for Buick. (This work has now been transferred to Fisher Body Plant No. 1 at Flint, Michigan.) Several floors are also available at the Fisher Body Plant No. 23 in Detroit, and there is also floor space available at the Briggs Highland Park plant and at the old Ford Highland Park plant.

Outstanding example of idle floor space is the Murray Body Corporation in Detroit, the third largest body making corporation in America. Since its loss of the Ford body contract, Murray is not producing a *single* automobile body. There are 234,375 square feet of floor space in Building 107 in Murray Plant No. 1, 300,000 square feet available in Building No. 121 and 20,000 square feet available in Building No. 129. This available space will probably be needed for the contract Murray has obtained to stamp the metal parts and assemble the wing sections for Douglas bombers, but there is still 200,000 feet more of modern floor space in the Murray plant which is now being used for storage. This could be turned to the uses of this production program.

Similar is the situation at the Fisher Body plant in Cleveland. The third, fourth and fifth floors of this building are now being used for storage, and could easily be made available for assembly lines. This plant at one time made all metal stampings for Chevrolet bodies. Additional floor space is also available in the Cleveland area.

A final assembly plant would also be needed for the job of assembling the engine, wings and fuselage into the completed plane. For this purpose we suggest the construction of cheap flat hangars in the open space around the Wayne County airport. Completed engines, wings and fuselage would be trucked from the sub-assembly plants to these hangars and the completed planes could be flown from the airport. Similar flat hangars could be erected for final assemblies at the Cleveland airport.

We suggest that the sub-assemblies and the final assemblies be placed under the control of men carefully selected upon the basis of skill and experience from the various assembly staffs in our motor car and body plants, and that these picked men be used as the core of the assembly staffs to be developed under this plan. Provisions for protecting the seniority of these men must be guaranteed.

The first few thousand planes produced will not meet 100 percent performance requirements, for in mass production of planes as in mass production of automobiles a few thousand jobs must always be run before the "bugs" (technical problems of machining and assembly) are worked out. This is not serious since the first few thousand planes will more than meet the requirements as training ships.

Management Responsibility and Labor Cooperation

The automotive industry workers believe that this plan is the only one which offers hope of quick production of planes. It seeks solution of our problem not in the costly and lengthy work of erecting entire new plants, but in the efficient organization of existing idle man-power, machines, skill and floor space.

By dividing the parts among many manufacturers, the greatest possible number of minds is brought to bear on the production problems involved.

Though we propose payment of a fair profit to each manufacturer in accordance with his share in the work, we can foresee the fears this plan may arouse on the part of some managements. They may prefer a method whereby the government finances entire new engines and aircraft plants. Aviation companies may look with misgiving on a production program that would inevitably cut the cost of planes by putting their production on a mass production basis. But we believe the average management executive would not put forward these selfish considerations at a time of crisis.

Labor offers its whole-hearted cooperation. All that Labor asks is intelligent planning, a voice in matters of policy and administration, recognition of its rights, and maintenance of its established standards.

The merit of our plan is that it saves time, and time is our problem. Normal methods can build all the planes we need—if we wait until 1942 and 1943 to get them. This plan is put forward in the belief that the need for planes is immediate, and terrifying. Precious moments pass away as we delay. We dare not invite the disaster that may come with further delay.

Appendix I

NUMBER OF CARS AND TRUCKS PRODUCED IN U. S. AND CANADA

NAME OF COMPANY	SEPT. '36 THRU AUG. '37	SEPT. '39 THRU AUG. '40
Chevrolet	1,149,662	1,044,100
Pontiac	235,065	224,475
Oldsmobile	199,569	196,732
Buick	220,214	291,021
Cadillac-LaSalle	45,668	38,032
General Motors Truck	56,410	52,275
Plymouth	552,610	412,545
Dodge	378,510	304,455
DeSoto	81,390	69,660
Chrysler	103,210	83,680
Ford-Mercury	1,279,003	913,900
Lincoln	32,803	22,681
Graham	21,067	2,547
Hudson-Terraplane	125,207	97,632
Hupmobile	300	371
Nash-Lafayette	86,695	57,216
Packard	121,301	90,674
Studebaker	104,931	114,682
White-Indiana	14,035	12,727
Willys	65,302	32,930
* Grand Total	5,068,803	4,228,706
Total General Motors	1,906,588	1,846,815
Total Chrysler	1,115,720	869,980
Total Ford	1,311,716	936,581
Total "Big 3"	4,334,204	3,653,376

* Grand total also includes production of Diamond T Truck, Federal Truck, Int'l Harvester, Mack Truck, Reo Truck, Stutz and miscellaneous not listed separately.
Source: Ward's Automotive Reports.
Note: Canadian production represents approximately 4% of the total production.

Appendix II

PRODUCTION POSSIBILITIES OF MAJOR PLANTS

Name of Plant	Percentage of Production Capacity From Sept. '39 thru Aug. '40	Possible Increased Output Over Year Ending August, 1940	Total Output at Peak Capacity on Basis of Two 8-Hour Shifts per Day 50 Weeks in Year	Work Days Needed to Build 12 Months Total Production on Basis of Two 8-Hour Shifts per Day at Peak Production	12 Months Total Production From Sept. '39, thru Aug. '40	Highest Past Production of Completed Motors Per Hour	Present Production of Completed Motors per Hour
Cadillac	22	134,768	172,800	66	38,032	36	36
Dodge	36½	530,745	835,200	108	304,455	174	174
Studebaker	31	221,318	336,000	103	114,682	70	70
Plymouth	43	552,255	964,800	128	412,545	201	172
Chrysler and DeSoto	24	494,660	648,000	75	153,340	135	87
Oldsmobile	54½	163,268	360,000	167	196,732	75	73
Willys-Overland	17	207,070	240,000	41	32,930	50	50
Hudson	40	118,368	216,000	135½	97,632	45	32
Pontiac	51	217,125	441,600	147	224,475	92	78
Nash	17	288,384	345,600	49½	57,216	72	63
Chevrolet	49	1,091,900	2,136,000	147	1,044,100	445	347
Buick	42	430,479	721,500*	121	291,021	185	179

* Note: On basis of 13-hour day.

Appendix III

FACILITIES AVAILABLE FOR PLANE PRODUCTION IN THE CHEVROLET FORGE PLANT, DETROIT

The following equipment in the Chevrolet Drop Forge plant at the present time—the peak of the plant production program—is operating at approximately 60% of capacity used.

Number of Machines	Size of Machines	Types of Machines
19	1,500 lbs.	Steam Hammer
29	2,500 lbs.	Steam Hammer
12	3,500 lbs.	Steam Hammer
9	5,000 lbs.	Steam Hammer
6	12,000 lbs.	Steam Hammer
15	1,000 lbs.	Board Hammers
11	2,000 lbs.	Board Hammers
5	3,000 lbs.	Board Hammers
1	250 ton	Forge Press (Hydraulic)
1	950 ton	Forge Press (Hydraulic)
2	1,000 ton	Forge Press (Hydraulic)
3	1,600 ton	Forge Press (Hydraulic)
11	1,500 lbs.	Board Hammers

In addition to the hammers and presses listed, numerous large and small upsetting (header) presses are available. If the above equipment were used at full capacity, this plant alone could produce all the necessary drop forgings required for the production of 500 airplane engines per day, and still supply the Chevrolet Motor Car Company with sufficient forgings for 1,000,000 Chevrolet cars in the coming year. Skilled hammermen are available to operate these forge hammers at full capacity.

In addition to the Chevrolet Forge plant, there are many other forge plants, such as the Buick Forge plant, Dodge Truck and Forge, etc., which have considerable unused capacity.

Appendix IV

FACILITIES AVAILABLE IN AUTOMOBILE INDUSTRY FOR STAMPING METAL SECTIONS FOR WINGS AND FUSELAGE

The following stamping presses in the Cleveland Fisher Body Plant are at the present time—the peak of the body production season—operating at less than 50 percent of capacity.

Number of Machines	Type of Machines
74	Double Crank Presses
19	Toggle Presses
26	No. 78 Single Crank Presses

Numerous small blanking and stamping presses

To appreciate the full significance of the above list of equipment, one must realize the tremendous size of these presses, their cost, and the time it would require a new plant to get delivery of such presses. A big Toggle pr[illegible] for

example, stands 40 feet from the base to the top of the press and is large enough to hold and operate a draw or flange die which itself weights from 70 to 80 tons. Such presses cost from $150,000 to $175,000 and it would require years to get delivery of the number and type of such press equipment that is now standing idle more than 50 percent of the time at the Cleveland Fisher plant.

Present employment in the Fisher Cleveland press room reflects the extent to which the presses are now idle. There are 600 men on the day shift, 300 on the afternoon shift, and 67 on the midnight shift.

In addition to Cleveland Fisher Body, every major body plant in the automobile industry has unused press room capacity which can, with the necessary special dies, be adapted to plane production.

Appendix V

REPLY TO OBJECTIONS

Virtually all of the criticisms of the program have been anonymous—aircraft and automotive industry executives refusing, for some reason, to lend their names to their printed views. The criticisms do not in any case run against the feasibility of the program. By and large, they indicate either a sad lack of imagination or an insistence by automotive interests to continue with "business as usual." However, since some misconceptions of the program have gained credence it is advisable to discuss and dispose of these matters.

BOMBERS OR PURSUIT SHIPS

It has been wrongly assumed that the program contemplated the production only of pursuit ships. Our reference to the possible production of 500 fighting planes a day was used only to indicate the over-all productive capacity of an automobile industry whose idle machines and idle men were fully mobilized and whose private interests were temporarily subordinated. The productive capacity we have indicated can as readily be adapted to the production of medium-sized or heavy bombers. If these latter types are built rather than pursuit ships, the daily production would be scaled down in proportion to the increased amount of work required on each plane. Nevertheless, our program could build many more bombers, large or small, than are now being built or are contemplated, and in much shorter time.

MAN-HOURS REQUIRED

Some sources in the automobile industry assert our plan is impractical because of the relatively small percentage of machine hours in manufacturing an automobile as compared with the total man hours required to build a plane.

These sources contend that out of 18,000 man-hours necessary to build a pursuit ship, 10,000 are devoted to construction of air frames, work on which is usually done by hand. In attempting to prove their point, these sources simply multiply 10,000 man-hours by 500 planes a day which gives them a tremendous and impressive figure. It would be as logical to take the number of

hours required to custom-build a Chevrolet car by hand and then multiply this figure by Chevrolet's daily production and use that tremendous figure to prove that Chevrolet could not possibly produce 6,000 cars a day. Custom-building of an automobile, it has been estimated, requires 1,100 man hours of work. This means that it would have required 4,400,000,000 man hours to produce the 4,000,000 cars of the 1939 model. To carry the contention of our critics on this score to their logical conclusion: it would have required 2,200,000 men working 40 hours a week fifty weeks a year to produce last year's 4,000,000 automobiles.

The persons who argue thus speak of mass production quantities but use the mathematics of custom-built production methods. It is an elementary fact that the number of hours spent doing things by hand as compared to the number of hours spent operating machines (machine-hours) varies in ever increasing proportion to the extent that mass production techniques are introduced into the production process. The number of hours spent in building an automobile is less than one-sixth of what it was when the industry started, and as the over-all man hours decrease the machine hours increase in percentage as compared to the work done by hand. One can go into a modern continuous strip steel mill and see this in its sharpest form.

FLOOR SPACE REQUIRED

This mistake of thinking of mass production of planes in the mathematics of custom-built hand production also raises the question of the practicality of providing the neecssary floor space for assembly work. Another elementary fact is that the number of days necessary to complete the production cycle (in machining and fabricating industries such as autos and aircraft) is shortened in proportion to the extent that mass production technique is applied. The shorter the production cycle the less floor space is needed. This is true because the number of jobs in the process of production is held at a minimum. If the Chevrolet Motor Company had to build 6,000 cars a day by the same methods that are now being used to build planes, the total man power and floor space of the entire automobile industry would not be adequate to turn out its present production.

Our original report cited the availability of floor space—785,000 feet—at the Hupmobile plant, in Detroit, for the assembling of motors. A further striking example of available floor space is the Reo plant at Lansing, Michigan, which has the following vacant space: Mt. Hope Avenue plant, 553,237 square feet; Building No. 4800, 247,931 square feet; Building No. 4700, 104,247 square feet. In Reo's main plant 500,000 square feet is fully equipped with production machinery. Starting January 13, 1941, Reo will be producing five motors per day in a plant that at one time produced 160 truck and 125 passenger cars in one eight-hour shift.

DIFFERENCES IN ENGINES

Doubts have been expressed on the adaptability of automobile production machinery to production of aircraft motors because of the reduced weight of aircraft motors. These doubts are without foundation.

The reduced weight of an aircraft motor per horsepower as compared with automobile motors is secured firstly by the difference in the design of the motor and secondly by the fact that all parts of an aircraft motor are reduced to a minimum weight by removing all surplus metal. This is done by a process of machining. The same basic machinery is used to machine parts for an aircraft motor as for an automobile motor, excepting that a more complete and precise machining job is done in the case of the aircraft motor. The available machinery in the automobile industry can be retooled to turn out aircraft motors of 1,000 or 2,000 horsepower of either the air-cooled or liquid-cooled design.

The objection has also been raised that aircraft engines must be made in more precise dimensions than automobile engines. As our program points out, more precise parts are obtained by more precise tooling.

SHORTAGE OF ARMAMENTS

Any possible bottlenecks in armaments, instruments, etc., is not a legitimate criticism of our plan. Such bottlenecks can be met if production of such armament, instruments, etc., is spread over existing industries whose machine capacities and production facilities are adaptable to such production. The pooling of such productive capacity with central assembly plants using the same approach we suggest for aircraft production will make it possible to eliminate any possible bottlenecks in armaments, instruments, etc.

SIMILARITY OF BASIC MACHINERY

In our program we state that basic machinery used for automobile production can be adapted for producing aircraft parts. We point out that precise and difficult parts of the Allison engine are being made in the old Cadillac plant in Detroit with machinery which duplicates existing unused automobile plant machinery. These statements have been challenged in some quarters. Herewith is a list of machinery, newly constructed and installed in the Allison division in Detroit, which duplicates existing automobile plant machinery:

Grinding machines: Cincinnati centerless, Exlo internal and external, Bland, Norton, Landis, Blanchard, Brown and Sharpe, (Bryant) and Held. (These machines are used to produce the following parts which are common to both aircraft and automobile motors: camshafts, crankshafts, bearings, connecting rods, wrist pins.) Milling machines: Milwaukee, Cincinnati, Sunstrand and Brown and Sharpe. Keller machines: Wickes lathes, Greenlee lathes and Cincinnati lathes. Spline machines: Sunstrand, and Brown and Sharpe. Hones: Exlo and Wickes.

PRESENT USE OF FACILITIES

It is argued that the facilities of the automobile industry are already being employed for production of aircraft parts. Our surveys indicate that not ten percent of the available facilities are being brought into play for defense purposes. The present plans do not contemplate the coordination and full use of facilities which alone can produce a large number of planes within a comparatively short period.