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An Airplane is Not a Rabbit

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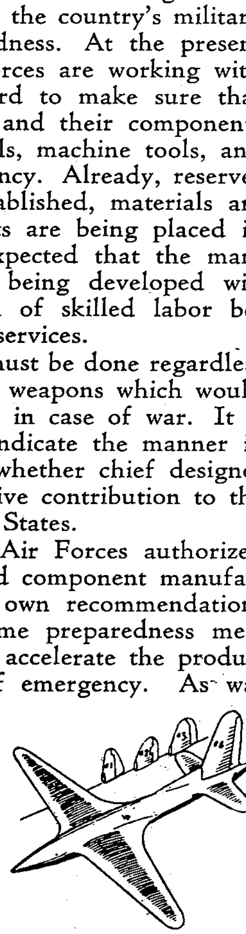
THE RATHER OBVIOUS biological fact that airplanes will not reproduce themselves is one of the major headaches of the men who are charged with the responsibility of maintaining the country's military potential in a state of preparedness. At the present time, the Navy and the Air Forces are working with the Army-Navy Munitions Board to make sure that the manufacturers of airplanes and their components shall not lack facilities, materials, machine tools, and manpower in case of an emergency. Already, reserves of machine tools are being established, materials are being stockpiled, and war plants are being placed in stand-by reserve. Also it is expected that the manpower mobilization plans now being developed will insure an equitable distribution of skilled labor between industry and the armed services.

However, all of these things must be done regardless of the nature of the specific air weapons which would have to be produced in volume in case of war. It is the purpose of this article to indicate the manner in which the individual engineer, whether chief designer or draftsman, can make a positive contribution to the military security of the United States.

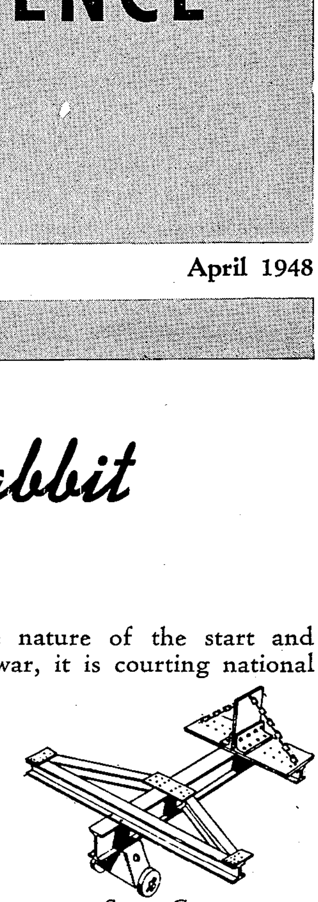
In 1946, the Navy and the Air Forces authorized study contracts with aircraft and component manufacturers to obtain the industry's own recommendations concerning the feasible peacetime preparedness measures which would substantially accelerate the production of air weapons in case of emergency. As was expected, all the companies pointed out the need for a supply of resources such as the facility, machine tool, and material programs already under way. However, when it came to the "internal preparedness" measures, nearly all of the aircraft companies stated that the first step would have to be **redesign for volume production, even on the models currently in peacetime production** (not including carry-over World War II models).



Aerodynamics Group
Dream Airplane

Drawings by C. W. Miller, Aerodynamics Department, North American Aircraft Corp.

In view of the probable nature of the start and prosecution of any future war, it is courting national suicide to plan to devote vital time and skill, after we are attacked, to the redesigning and retooling of air weapons currently in peacetime production. This situation poses the obvious question: "If we spend millions to develop air weapons which are of value to the country **only in case of war,** why do we authorize the peacetime production of models whose design **is not not ready for immediate use in case of war?"**



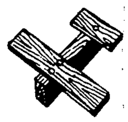
Stress Group
Dream Airplane

Actually, the apparently short-sighted design policy of most aircraft companies can be traced directly to the development and procurement policies of the Air Forces. This "policy" is really not a positive policy at all, but rather the costly lack of a clearly defined internal responsibility. In simplified terms, the Air Forces engineering divisions interpret their own responsibility to end when they have awarded and administered the basic research and construction contracts for two or three experimental models **having the maximum possible performance.** The procurement divisions interpret their responsibility to be the securing of the **maximum number** of airplanes **within limited budgets.** As a natural result, a minimum of re-engineering expense is allowed under the production contract to correct the basic lack of "producibility" in the experimental model. Neither division is given, or accepts, the responsibility for the "producibility" of the design.

The real key to the whole design problem lies in the policy and practice of these military engineering divisions. In most cases, an airplane model has its inception with the Air Staff's strategic planners, who visualize a certain kind of probable mission and the corresponding performance characteristics which will be needed. It is the job of the engineering divisions to notify manufacturers of what is desired and to evaluate the resultant design proposals submitted by the manufacturers. This first step is the one which really creates and fixes most of the problems encountered at later stages of the design development.

The invitation to submit a design proposal goes into considerable detail about the performance characteristics which are desired, but the only reference to producibility is a routine paragraph buried in a voluminous "Designer's Handbook". In reality, the inclusion of this paragraph is only lip service, because all the manufacturers know that when a point-by-point evaluation of their design proposal is made for the purpose of awarding an experimental contract, the suitability of the design for volume production will receive a maximum 30 points out of a possible 1000. Despite the many delays in World War II airplane production because of the lack of engineering suitable for volume production (the B-24 at Willow Run, for example), the Air Forces are still using exactly the same weight for producibility in all design competition evaluations as was used before World War II.

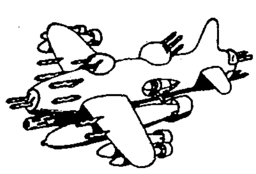
In other words, the manufacturer's design division has no incentive to call in experienced production men for their advice and assistance. In fact, there is actually an incentive to keep the production men away, because some of their producibility suggestions may require added airframe weight. This added weight in turn means decreased performance and reduced chances of winning the design competition. Yet, at this stage of the model development, the general configuration and the basic structure become pretty well fixed, and, except for correction of technical defects, will not be greatly changed through the subsequent experimental and low production stages. The net result is a model which can be built at low peacetime rates without too much trouble, but which has to be more or less completely redesigned in case of war before those "excluded" production men can build them in quantity.



Production Group
Dream Airplane

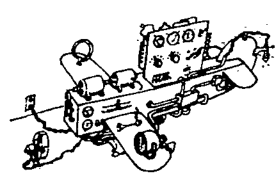
At this point let us try to pin down this elusive "producibility" factor. The sketches on these pages are taken from a "running gag" which constantly circulates through the engineering departments of nearly all aircraft companies. Although obviously exaggerated, they do help to accentuate the design engineer's initial dilemma, even before the problem of producibility is considered. So many things must go into the airplane, and yet it must still fly better than any comparable airplane. Once the aerodynamics and the configuration are determined and the weight of equipment plus load is set, about the only variable left which can affect performance is the weight of the **airframe** itself. When **performance** is essentially the only basis for evaluation of a company's (and therefore its design engineers') ability, every possible weight-saving device is used.

For example: The fuselage of a reciprocating-engine fighter plane includes the tail surfaces, the pilot's seat, the flight and engine controls, and radio and other equipment. Structurally it is roughly a hollow tapered cylinder with fins on one end, and the stress requirements can be met by designing the whole assembly as one unit, with stringers running the whole length of the ship without splices, and with the circumferential ribs and skins being as free of joints and splices as possible.



Armament Group
Dream Airplane

Now consider the effect of such a design on the production organization. Because of the "unit" design the entire assembly must take place in one large "jig" which can locate and hold all the individual pieces exactly in place until they can be riveted together. Only a very limited number of men can work efficiently on one such jig at a given time, and the total elapsed time required to complete a cycle through the jig is very long. This problem becomes even more acute after the structural work is complete and the thousands of equipment items and controls must be installed in the cramped quarters of the fuselage.



Electrical Group
Dream Airplane

At low production rates, of one or two per week, such a situation is not critical, but a rate of 100 per week with semi-skilled labor has been shown to be impossible under such conditions. In other words, there just wouldn't be enough tool and die makers to make the elaborate jigs, nor enough floor space to house them, nor enough skilled labor to use them, if it became necessary to increase production 100 times while still using the "unit" design and the corresponding production methods necessitated thereby.

What, then, does producibility really involve? On our fuselage example, if producibility were to be introduced into an existing "unit" design inherited from the "performance only" experimental stage, the following **major design changes** would be **necessary** before high production rates would be possible.

1. The splitting off of a tail cone which could be bolted to the main fuselage **after** separate horizontal and vertical stabilizers had been bolted to the cone and after all of the internal rigging and wiring had been easily installed in this empennage "sub-unit".

2. The splitting of the fuselage into at least two side panels (and possibly a top and bottom), each of which could be easily assembled by itself in a sub-assembly jig, and most of the wiring and equipment easily installed while completely accessible.

3. The breakdown of wiring and plumbing design drawings into units which correspond to the structural sub-assemblies mentioned above.

4. The inclusion of bolt angles or other suitable means for quickly and accurately joining the sub-assemblies together in a "mating" or master jig.

The volume of engineering work and elapsed time involved in such a redesign for producibility is only part of the story. Tooling must be redesigned and rebuilt to the new drawings and the manufacturing process almost completely replanned. This takes **time,** a priceless commodity during a war.

Without producibility, the desired quantities of fighting air power simply cannot be produced. Does it, then, make sense to wait for the astronomical production demands of war before starting after one of the major prerequisites of such production?

It is apparent that a basic change of military engineering division policy will have to take place before the bulk of the airplane companies will voluntarily do away with the "Iron Curtain" which now exists between their advance design and production staffs. Specifically, the military engineering divisions will have to be given the direct responsibility of seeing to it that producibility actually receives equal weight with performance in design proposal evaluation, and making sure that any experimental airplanes incorporate as much of the producibility concept as possible. After all, an experimental airplane (not a basic research project) is supposed to be a prototype of a usable air weapon. To the extent that producibility is sacrificed in an experimental model to gain performance, the

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further their sale. Actually, the chip or thread removed during the engraving of lacquer-coated records is highly inflammable. Abnormal temperatures and humid atmospheres may affect record materials to some extent. If one lives where abnormal conditions exist, these factors should be checked.

Naturally, one might wonder which of the three systems of recording is the best; that is, whether the mechanical, the optical, or the magnetic system inherently is best. Or perhaps, whether lateral is better than vertical. It is the writer's judgment that the capabilities of all systems are "about equal", but that the skills acquired by the proponents of each of the systems vary somewhat from time to time. This phase of the matter leads to conflicting opinions. At the moment the highest quality seems to have been obtained under carefully controlled conditions while the record was being played back at the outside edge from an original, lateral-cut, lacquer-coated disc. This effect does not eliminate the possibility that the future may produce a different system with striking results, or that the performance may be readily duplicated on a commercial basis. It is interesting to note that in 1929 the ambitious California Institute of Technology glee club produced a recording of its alma mater song. Those of us who bought a copy of that record were sadly startled to learn that all record concerns had not acquired the art of recording with equal skill. This record quickly found the junk pile. It contained far too much distortion.

Optical methods are particularly well adapted to the cinema, since its primary problem is one of synchronizing sound and picture. Further, photographic techniques are known by the movie industry and it is but a step from such techniques to their application for sound recording. However, these methods are cumbersome and expensive for the use of non-technical personnel. The layman wants a simple machine requiring very little technical skill for operation—possibly only an on-off switch.

A glance at the history of recording will show the very important part which electrical amplification has played in its development. The importance of electrical amplification lies mainly in its ability to handle all frequencies in the audible spectrum and to offer a means for correcting a deficiency in any part of the system by the use of simple electrical correcting networks. Just as the invention of the vacuum tube and the vacuum tube amplifier has played an important part in the development of radio, it has influenced the development of recording more than any other single contribution.

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Air Staff and the entire nation are actually being misled, as they **can never get such an airplane in large quantities.** The many individual experimental superweapons found in Germany gave added proof to an often quoted but all too seldom recognized truism: "No nation has ever won a war with a handful of laboratory samples, even though the samples individually surpass any other weapon in the world."

It would appear that nothing can be done until the military engineering divisions are properly set up to handle their full responsibility. However, at least a start has been made within the aircraft industry toward breaking down the "Iron Curtain" which excludes production men from the inner sanctum usually reserved for the advance design engineers. Several models now in the experimental stage have actually been designed from the beginning with the basic structural needs of producibility given full consideration.

How is it possible to incorporate producibility without adding so much weight that all design competitions are lost? Although a strong, farsighted management is essential for their successful combination, the understanding and broadmindedness of individual engineers can go a long way toward achieving the same effect.

It was found that when the production men were fighting with the engineers to get the experimental design **revised** to incorporate some producibility in the production version, most of the changes resulted in a weight increase. The production men had their hands full trying to protect their own interests, and "never mind what it does to the weight". However, when the production men **worked with the designers** at the time the original design was **created,** the production men came up with as many weight-saving ideas as weight-increasing ideas. The result was a high-performance airplane that could be produced in quantity in case of an emergency, with no major redesign or retooling problems.

The best solution is a change of military engineering and procurement policy which will encourage the top management of all companies to follow through in this manner. In the meantime it is suggested that the designer let this one thought come to mind each time he sets pencil to paper: "You have to draw it only once, or maybe twice. Somebody else may have to duplicate it in metal a thousand times in a hell of a hurry, and your life and his may well depend on how fast it can be done."