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ORDNANCE PRODUCTION DIFFICULTIES AND THEIR SOLUTIONS

by

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The subject of this talk as it has been announced to you, if comprehensively treated, would embrace a very broad field of information -- Ordnance Production Difficulties and their Solutions. There are, of course, many difficulties and they exist largely in proportion to the activity of the Ordnance Department. Since munitions production and supply activities have been steadily increasing for the past several years, our production troubles have also been increasing though as greater experience is gained by the administrative and shop units, difficulties gradually become fewer. Obstacles and unforeseen delays always go with accomplishment -- without them nothing is done

You will doubtless understand that Ordnance officers cannot pretend to be production engineers. Frequently when they do attempt to be production specialists, the results are disappointing. Production engineering is one of the most exacting and difficult branches of the technical sciences, calling for a meticulous degree of knowledge and experience. The wide diversity of information which must be the production engineer's, the knowledge of machine tools, the ability to supervise the design and use of the great bulk of accessory equipment which is so frequently an almost insurmountable obstacle to any production program, requires many years of practical education. Of all the branches of engineering, well qualified men are least available and consequently are more in demand among production engineers.

The most that an Ordnance officer on a production assignment can hope to do efficiently is intelligently to administer a production program He must depend upon civilian assistants for the mass of engineering effort which forms the major portion of such an activity.

It is undoubtedly recognized that the subject assigned to me is too comprehensive for any single individual to discuss other than in the most general terms I have, therefore, been instructed to confine this discussion to Production Engineering tooling up and Production of the Rifle, Caliber .30, M1. There again we have a subject too widely diversified for one person in a brief talk of this kind adequately to convey essential information to a group audience, especially if they are not very intimately in contact with the actual work.

It is really very hard to decide just how to get into this subject in a manner calculated to have a concrete significance to you. I do not want to fall back upon the old standbys of tooling, namely tools, jigs and fixtures. These highly essential accessories mean everything to the tool engineer and even more to an operating shop; to one who does not live with them every day, they sound very abstract and intangible.

Perhaps you would like to have reviewed the background of the universal effort to produce a semi-automatic rifle for military use. As you doubtless know, a semi-automatic rifle is one which, in contrast to the usual hand operated type, is self-actuating, deriving power for operation from energy generated by the propellant powder. There has been an intense interest in this development for thirty years. In every major power throughout the world, the most eminent arms engineers have bent their efforts to the successful design of a weapon of this type. Before 1900, Paul Mauser, probably the most successful arms designer ever known, designed and built a semi-automatic rifle. There are in the Ordnance Department many models produced at home and abroad by the best known arms designers in the world, each one of which has its novel points of interest. Many of these weapons had no chance of success but there are numerous others which missed being completely successful by the narrowest margin.

If you are interested in one of the much discussed features of this type of weapon, the basic principle of self-operation embodied in any automatic weapon, I shall review them briefly. First there is the gas operated type, as exemplified by the [illegible] and others, in which a portion of the explosive gas is tapped off the barrel and caused to act on a piston which transmits this applied force to the breech mechanism.

There is the recoiling barrel type in which the barrel is permitted to move rearward, transmitting its energy of recoil to the breech action.

We have the blowback and retarded blowback types in which the breech action is not locked, or is only partially locked, and the rearward pressure of the powder is applied directly to the face of the bolt to actuate it.

There are several other means of operating automatic weapons but the three as given above are most typical and widely used.

One of the earliest and best qualified designers in this field was a Danish engineer by the name of Bang -- a very appropriate name for a gun designer -- whose efforts to produce a semi-automatic rifle probably date back almost to the same period when Mauser was working on his design. Of course there is no definite history of when these various efforts were initiated.

Mr. Bang's design, one of the first with which the Ordnance Department worked, was regarded as being a very highly promising type. In 1914, the Ordnance Department purchased two of his weapons, experimental models, of course, and tested them extensively. From the standpoint of their operation they were almost completely successful. In the matter of appearance and adaptability to military uses, they were not suitable. Later on, during the World War, an arms engineer for the Ordnance Department working on this project revised the design of the Bang semi-automatic rifle in an attempt to make it adaptable to military use. His efforts were not successful. Later two more designs of this weapon were completed with the same object in view, they were not successful. Each one of these various designs was very close to the goal.

There have been two great obstacles which have retarded the success of these undertakings. The principal one was that of materials. It is really only in comparatively recent years that the general use of alloy steels has been recognized as good engineering practice. For years we did not know of alloy steels, for many years after they became practicable, it was not regarded as good engineering practice to prescribe them generally throughout an article of design.

The second great obstacle to the successful design of a semi-automatic shoulder rifle lay in the clumsy and unhandy appearance which for a long time was inevitable in any design as a result of the necessity for the principal component, the receiver, to be extremely long in order to house and cover over the usual reciprocating action. Much effort was devoted to an attempt to reduce the length of the receiver and thereby lend to these designs the balanced and symmetrical appearance which is essential in any weapon to have it produce a pleasing psychological effect. First appearance in this instance, as in nearly every other, has been a primary consideration. If an individual is not pleased with the appearance of a weapon, he is not, as a general rule, interested in any other of its characteristics. That is a fundamental psychological reaction of the human disposition and it has sounded the death knell of more than one long and costly attempt to solve this problem.

While the effort to design a successful semi-automatic rifle gained a tremendous amount of impetus as a result of the World War and the knowledge we gained during that conflict of the fire power and efficiency of automatic weapons, you would perhaps be interested to learn that prior to the World War there were ten thousand semi-automatic rifles of the Mondragon type, of German design, produced in Germany for Mexico. The history of these weapons after they are supposed to have reached Mexico is not known to me.

During the World War, a tool engineer and automatic machine designer, formerly with the Brown & Sharpe Company and later employed by several other concerns producing fine tools, having heard of the desire for such a weapon became interested in his ability to produce a semi-automatic rifle. This was Mr. J C. Garand, the designer of the M1 Rifle. He partially perfected a model through his own efforts in New York City which he later presented to the Bureau of Standards in 1918. The interest in this problem at that time was rather acute so the Bureau of Standards employed him to push the development along. At the conclusion of the World War this activity was turned over to the War Department to be concentrated with other work which they were doing of a similar nature. At this time there were at least six concurrent weapons of this type being engineered at Springfield Armory.

Mr. Garand was transferred to Springfield Armory in 1919 where he continued his efforts to design a weapon to meet the ever-changing requirements of the Ordnance Department and the using services. In the course of his work, he built and tested some six designs, including one of a smaller caliber, before the question finally headed up to the point where a selection could be made from among those various types available in this country and abroad.

During the course of that development, the Ordnance Department, in order to cover this field completely, took two, and the only two, commercially made semi-automatic rifles of sporting types and made them into pseudo military types for test by the using service They were not suitable.

The method set up by the Ordnance Department for admitting to test all promising designs of this type of material has been for quite some time the plan to announce a general competitive test in which all competitors were invited to participate. There have been two such tests, one of which was held in 1919 or 1920, during which there were presented to the Board a rifle designed by Mr Garand, another designed at Springfield Armory on the style of the Bang heretofore men-

tioned, a third designed and presented by what was known as the U S Machine Gun Company, a rather completely engineered article of the general type of the Hotchkiss, and a fourth design presented by the Auto-Ordnance Corporation, producers of the Thompson Sub-Machine Gun. The results of this test were not conclusive and no selection was made.

Through various ramifications, such as changing tactical requirements, the introduction of the caliber question, and other considerations of that kind, the further crystallization of this problem did not take place until 1928 when a general competitive test was again announced in which there was the Garand .276, the Pederson .276, a Czechslovakian Caliber .30, a German type caliber .70, the Thompson caliber .70, and the Bang again presented by Mr. Bang after more than fourteen years. You will realize something of the difficulty of this undertaking when I tell you that Mr Bang came all the way from Denmark with a completed weapon ready to enter the test, and he fired one shot which resulted in the breakage of his bolt, the second most important component in the gun without which it is completely unserviceable, and having no spare was obliged to withdraw from the test and return to Denmark without further appearing in the competition.

The outcome of this test eventually resulted in the selection of the Garand Caliber .30 Rifle, now known as the M1. Action was immediately initiated for the Ordnance Department to produce a quantity of these guns for extensive service tests. Eighty of them were produced by semi-production, semi-toolroom methods in the Model Shop at Springfield Armory under Mr. Garand's direct supervision. At the completion of a successful service test, this weapon was adopted as a standard type and production was initiated at Springfield Armory.

The Armory at that time was at a very low ebb, having lived a bare hand-to-mouth existence since 1918 when the war activity ceased. There was only the barest nucleus of personnel engaged in spare part orders for the old service rifle, supplemented by the jobbing orders for machine gun spare parts and other odd orders which could be obtained.

In addition, the greater number of the remaining old time key men were reaching retirement age, consequently the little knowledge left in the Armory was slowly disappearing. An extensive tooling program had not been set up since the first production of the 1903 rifle in 1900, discounting two small programs on the Pistol and Benie Mercier Machine Gun.

The Armory Administration was immediately confronted with the necessity for setting up an almost new production unit. The order of procedure was about as follows:

1. To prepare production drawings of the article to be produced. In reference to production drawings, I differentiate between that type and preliminary or model room drawings in which dimensions may be given flatly without tolerances being specified. It is perfectly feasible to use drawings which show no variation from a flat dimension in a model room where the degree of accuracy which may be expected approaches that of the gage maker's practice. A production drawing must be an entirely different requirement. It is essential that it be carefully reviewed from the standpoint of the necessity for interchangeable manufacture. All dimensions must be expressed with a suitable tolerance so related to every other dimension on a single component as to hold to a very definitely known relation which may be expected to exist in each component and between mating surfaces of related components. A production drawing must be considered very carefully by a competent engineer to insure that all dimensions are properly measured from certain important surfaces which serve as holding points, or locating points, while work is in process. As these locating points are machined away, subsequent operations must be dimensioned from other surfaces in order to have the finished dimensions definitely related one to another, otherwise interchangeability cannot be obtained. This condition may be clearly illustrated by the example of a drilled hole into which a plug must be inserted. The production part having the smallest drilled hole must be large enough to receive the plug having the greatest diameter.

2. Having made production drawings, it next became necessary to determine how each component of an assembled article was to be processed. This is normally called the sequence of operations. Once having been determined, the procedure as established forms a production engineer's bible known as the book of route sheets. Each step through which a component must go from its initial operation to its finished state is shown on the route sheet related to it. The type of material, its heat treatment, and a definite measurement of its physical characteristics must be stated. The route sheet must also show for each operation the manner in which it shall be performed, the type of machine, fixture number when a fixture is required, and the designation of the gages to be used to measure the accuracy of the operation

3. Route sheets having been prepared, it next became necessary to determine the quantity of material that was required to cover a given order. The material was then placed in stock, this procedure sometimes requiring several months since all purchases of this nature are made on a competitive basis and consequently require the usual periods for advertisement, determination of awards, and times of delivery.

4. In the meantime plans were made to route work into the production shops. This was done by a unit called the Production Control Section of the Planning Division and was accomplished by the issuance of orders to the shops for processing a definite number of components through all operations in such quantities as could be reasonably handled without too much interruption of the flow of work, always with an eye to the arrival of approximately the same quantities of major components in the Assembly Room to enable complete assembly to be accomplished. Naturally, the greater the number of components in process, the more complex is the production control problem. Not so long ago at Springfield Armory, when the establishment was not only producing the Garand Rifle in small quantities but also was carrying many miscellaneous parts on a jobbing shop basis, there were fourteen thousand separate sub-orders in the production shops calling for work on different operations which had to be accounted for and scheduled by the shop production control.

The sub-orders also prescribe how much each group of operations shall cost and how many machine hours may be consumed in the process.

While all this preliminary work was being done in one section, another was busy determining what the procedure of manufacture was to be, the capacity of the machines to be used, how the components to be processed were to be secured and located in the holding fixtures for machining operations. Immediately plans were started to lay out and complete designs of suitable jigs and fixtures to support and accurately locate each component while it is in its various steps of fabricating. In passing, a jig is a special vise designed to hold work in process for drilling and reaming operations. A fixture is a special vise for holding work while in process of being milled or broached. A tool is any kind of cutting device used to remove metal or other material from a part in process.

One of the first necessary steps before beginning the design of new equipment was to survey a very large quantity of machine tool accessories on hand, previously used in other types of manufacture. At Springfield Armory there were great

quantities of tools, jigs, and fixtures which had been used for years in the manufacture of the 1903 Rifle and the manufacture of machine gun parts, and those which had been placed in storage here from war time commercial plants The necessity for this survey was to determine the suitability of the equipment on hand to adapt it to the manufacture of a new article for economical and time saving reasons

The importance of these considerations will be understood when you understand that a weapon of the Caliber .30 M1 type has some two thousand operations on its various components and in general each operation required a device to hold the work, either a jig or a fixture, a tool to cut the work, and a gage to measure the finished operation There are, therefore, in general three items of accessory equipment which must exist for each operation -- a jig or a fixture, a cutting tool, and one or more gages You may see, therefore, that to process through an article of this type, there would be required some five or six thousand separate items of accessory equipment, each one of complicated and expensive design, and each requiring many hours of design time and tool room time for its completion The magnitude of this undertaking may be brought home to any one by the statement made by one of the largest and most experienced and best equipped tooling concerns in the country in consulting with Springfield Armory on this question. Their estimate was that roughly they would require twenty thousand hours of engineering study to plan this production and two hundred thousand hours of engineering and design time to prepare the tool equipment necessary to begin operation.

While the tool engineers were initiating and engineering designs of tools, jigs, and fixtures, the gage designers were beginning their studies of the necessary gage equipment Gages are in a sense set apart from the other accessory equipment. In the first place, they must be extremely accurate Consequently, they require very accurate design and workmanship, design and workmanship which must be performed by especially qualified men who comprise separate units both in the engineering section and in the tool room Not infrequently there must be two gages for one operation, one to show the minimum dimension and one to show the maximum dimension

As the tool engineers were engaged on the foregoing undertaking, the equipment section of the engineering branch surveyed the machine tools on hand to determine their suitability for immediate use on the new production problem Quite frequently they were found to be not suitable and new equipment was required At Springfield Armory the machine tool

equipment on hand at the inception of manufacture of the M1 Rifle had been installed at the Armory for at least twenty years, much of it had been installed and in use for thirty years, and some of it antedated the Civil War. The great bulk of it was equipped with accessory equipment designed to manufacture the Springfield rifle; the balance of it was equipped with miscellaneous tools and equipment designed for the manufacture of miscellaneous items of machine gun parts. It was a tremendous undertaking to survey this equipment, to determine whether it could be used in processing parts of the new article.

An important consideration which entered into this study was that of modernizing our methods, adapting to them the many new processes of machining which had come into existence in the last twenty years, processes such as internal and surface broaching, formerly merely a theory and a hope, coining instead of forging and machining for certain parts. By coining, I mean cold forming of shapes under tremendous pressures in dies similar to those used for hot forging. It was shortly determined that a great deal of new equipment was necessary and desirable

It then became necessary to select types of machines, to canvass the market and determine that these machines were available, to prepare specifications for them, to obtain money for their purchase, to advertise for them, to select from those proposed to be furnished suitable types, to make awards and await deliveries, a long drawn out and time consuming procedure, often extremely unsatisfactory.

There have been some differences in policy with respect to classes of machines heretofore regarded as standard machines and those classed as special machines There has been some question of the advisability of tooling on so-called special equipment Some years ago, before the tremendous impetus given the machine tool industry by the production of automobiles, the term "standard machines" was considered to embrace milling machines, lathes of the plain and turret types, profilers, drill presses, and automatic and hand screw machines. In the present day of high production methods, broaches, multiple automatic drilling and boring machines, automatic profiling machines, and many other new types are produced in great quantities by many manufacturers and are considered fully standard In fact, a production program not tooled on them is not abreast of the times.

In this connection, there are some operations on the 1 Rifle which have been referred to as impossible or very difficult. You may find it of interest to know that each of these operations was tooled by the designer of the gun, sometimes by the design of a special fixture, sometimes by the construction of a special machine. In each instance these are the operations being produced at the highest rate and with the least difficulty.

While equipment was being selected and purchased, the engineering branch undertook to plan for the installation of equipment in a manner calculated to permit of economical flow of work from machine to machine and from shop to shop as regulated by the size of the orders impending and the necessity for keeping other work in process to sustain a reasonable working force. I refer to the necessity for having a component go in to the first shop in which it was initially processed and then flow from there in a logical sequence from operation to operation, with the least handling and the least delay, on to its final operation and thence to its point of final assembly. The difficulty of planning that particular phase of such an undertaking can readily be understood especially when it was necessary to start with a small order and throw work into shops already occupied with other types of work, not necessarily flowing in a logical order. In planning production lines, the movement of machinery throughout a large plant becomes a colossal undertaking, especially when new arrangements had to be made while other current processing was kept in operation. I make particular reference to this type of procedure for Springfield Armory because the usual thing in starting a new production line is to shut down or have available a separate plant in which it may be planned to place either old or new equipment, suitably arranged to provide for the proper sequence of operations for new production effort.

In referring to tooling as a whole, the usual conception at Springfield Armory of how it should be accomplished has been that designs should be completed and accessory equipment fabricated in our own tool rooms. When you contemplate the number of hours of engineering and processing time necessary on accessory equipment, it will be realized what an extremely great length of time is necessary to complete all this work in one engineering section and one shop. Furthermore, the effort is confined within one group, resulting in the application of ideas and practices which perhaps have not kept pace with the most modern and best known methods.

The production of the M1 Rifle began in a very modest way, it gained momentum surprisingly through unforeseen conditions and is now apparently well on its way toward a fairly comprehensive program. As a result of this, the War Department has recently obtained additional funds for increasing its production Upon receipt of the directive to proceed with the additional program, the plan was formulated to call in the best known tool engineers of the machine tool manufacturers, to have them study the problem of retooling and additional tooling on this article. The idea behind this was not only to expedite and decentralize the work of designing and manufacturing accessory equipment, but also to obtain the very best advice and engineering effort throughout the country.

In the early spring of 1938 this retooling effort was started by calling in tooling engineers from all of the well known organizations throughout the country, obtaining advice and inviting them to bid on lines of machine tools fully equipped and guaranteed to produce designated components at a definite rate. As preliminary groundwork to this procedure, Springfield Armory reviewed each operation on each component of the rifle in conjunction with the best advice obtainable, and rearranged the sequence and reduced the number of operations, scheduling them to be performed in combinations and on the most modern, high production machinery Parts to be completely processed and parts to be partially processed were then farmed out to commercial tooling concerns for the supply of completely equipped, ready to operate machine tools The first of these groups of machines on the M1 Rifle is yet to be received and installed for operation but practically the entire group of components has been allocated to one concern or another for the supply of equipment to process them.

The greatest obstacle to this procedure has been the necessity for procuring on a competitive basis since that procedure requires a very great length of time for its operation In that respect, the War Department was seriously handicapped over commercial firms who launch into intensive production schedules. The commercial concern will very frequently select the machine tool manufacturer to whom he wishes to allot certain portions of his work, he will call in a representative of that firm and contract with him to tool the job on a guaranteed basis, he will give him the "go ahead", and sometimes pay a bonus for early completion. It will readily be seen that such a procedure, which may be initiated within a very short while, has a great advantage

over the system of placing orders on a competitive scheme requiring months of administrative and engineering effort.

To illustrate what it hoped to accomplish by the improvement in tooling now in progress, it is expected that the 1,100 machining operations on the M1 Rifle will be reduced by half. A comparison on operations of some important components as performed at present and as they are contemplated is as follows:

MACHINE OPERATIONS ONLY

Component	Present Method	New Method
Receiver	104	31
Bolt	48	35
Follower	17	11
Hammer	13	8
Trigger	10	8
Catch	14	4
Base	13	7
Gas Cylinder	34	26
Guard	27	20
Housing	37	24
Op. Rod Assembly and Handle	43	28
Slide, Follower	10	5

It is hoped upon the completion of the present Springfield Armory program that with the exception of the shops, which are not of modern construction, we will have a production set-up which can be considered as an outstanding example of modern machine tools and equipment.

Discussion

"Ordnance Production Difficulties and Their Solution"

by Major James L. Hatcher, O.D.

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Colonel Miles: I think that we'll be tempted to disagree that Major Hatcher does know a little more than the rest of us about this particular subject. One reason for asking for this talk was to give some idea of the multiplicity of the operations and events which take place in the production of a semi-automatic rifle.

Major Hatcher: This one point is quite interesting and ingeniously designed - very interesting from the manner of its disassembly (Demonstrating disassembly of rifle.) When I was trying to remove this component a few minutes ago that was the first move which we make in disassembly. This consists in pulling up this guard; that unlocks the whole thing and you lift out this unit as I did then. It more or less falls apart, you might say, although this one doesn't seem to be. Of course, this is one of those things that doesn't work when you want it to. A weapon should be loose and should rattle to be a good operating gun. Is there anything further that I can tell you? Some of the clumsy appearances and the difficulties of making such a weapon in such a form as to please the eye will be illustrated by this gun. This is one of Mr. Bang's original guns which he sold to the Ordnance

Department in 1914 It has been tested many times It's form of operation is the actuation of a cap placed over the muzzle of a gun which caps a certain portion of the gasses as they pass out beside the gun That action is transmitted back to the breech. This is the _____ semi-automatic gun - interesting to us who have to conend with this problem and who have worked with it for many years because it illustrates very well an advanced stage of the art at that period of time - that was about 1911. I think when this was produced by a Mexican it was manufactured in the quantity of at least some 10,000 either in Switzerland or Germany and was reasonably successful. It justifies itself but just disappeared in Mexico as many things do due to lack of system and organization.

Q -- I'd like to ask you a question about the number of parts in relation to their production. I've got the impression that a great many people are of the opinion because an item has a number of parts that is indicative of its simplicity in manufacture. In my personal experience in manufacturing as an under-officer problems of production and engineering - not along the line of rifles - we found by increasing the number of parts very materially in the design, breaking it down into a greater number of parts - we greatly simplified manufacture and greatly reduced cost and I think that is an important thing to bear in mind. The number of parts in itself is not an indication of simplicity. I can give you a very good illustration. Take the

anti-aircraft mount in a coast offense and an aircraft offense that was designed to carry the trunnions all in one piece. Well, that was a very difficult thing to machine and by making the base plate one part, making the chief separate parts, you could bolt them all together. It means that you can only work on that piece as one operation at a time whereas if you break it down you can carry on a lot of operations simultaneously.

A -- That's certainly very true, sir. There is a median line which has to be followed by using good judgment and good sense. We have many illustrations of the elaborate designs which not only increase the manufacture of an article but is very uneconomical because the placement of parts involves the difficulties. It means money to replace the merest little part, it means throwing away a hundred dollars which might otherwise remain in the weapon. Most people have been for years taught to produce things by hand and make them very fine. They have never got even the high production idea that prevailed in the United States. This caused us to search for the most economical ways.

Q -- Major Hatcher, to what extent in the manufacture of a gun of this type would it be feasible to sublet the manufacture of certain parts or sublet the certain steps in the processing to an outside contractor. I'm not thinking so much of the Ordnance Department or the arsenal but a war-time program.

A -- It's perfectly feasible - as a matter of fact, we do it right now. This spring which is really almost the height of the

weapon because it actuates the weapon in one direction, it could not be produced. Mr. Durand proceeded to draw the wire and make the springs himself and then we got Wallace Barnes, specialist in springs, and they said they couldn't make that. So Mr. Durand gave them his winding fixture, his drawing machine, and now they produce about eight thousand and are searching for more. This little short spring is furnished from the outside without any difficulty and in almost any quantity required and they want the business. The only thing you have to guard against in such a program as this is to supervise their activity in such a way that they will make the parts within the drawing; that goes without saying but it isn't always easy to do. We can't do it ourselves.

Q — Have any quantitative estimates been arrived at as to the effect of this rifle on the ammunition procurement and supply?

A — Yes. When we first adopted a breech loading gun and the muzzle loading gun one of the serious problems taken into consideration was the supply of ammunition. There was quite a coterie that maintained that ammunition could not be supplied but would all be shot up. The same problem has been presented each time we have changed the weapon. It was quite a factor when we went into the use of machine guns but the ammunition has always gotten there in our past experience and it will get there in our future experience. There have been some analyses but I'm not prepared to give you particulars of them. Does that answer your question.

Q — Is the ammunition requirement going to be increased?

A -- No one knows until we go into armed conflict. There are various opinions on that subject. I think it will not increase over twenty-five per cent, if that much, simply because men don't usually shoot at nothing. I'm not speaking from my little experience. They don't fire away ammunition at nothing in spite of what they say about green troops and all that sort of thing. You gentlemen who know realize that targets are scarce like they are in deer-hunting. You just walk along looking for one. There's a point I want to mention here. You will observe the ledge of this component. This can make or break the gun and it made this gun. The length as compared to Mr. Bang's weapon is considerable. Mr. Garand used a great amount of ingenuity and went on to a tremendous amount of trouble and consumed a great amount of time in compounding that one thing. As I mentioned a bit ago it has been one of the greatest obstacles to the successful completion of such a weapon. It has drawn this program out by many years.

Colonel Miles: Any questions or remarks by any of our Ordnance Department visitors? Q -- I want to mention the vast amount of work entailed by adopting a new weapon , the tremendous amount of production study and change of production design to produce the new weapon. I think when you understand that there have been people criticized for not accomplishing something faster with two thousand jibs, 2000 gauges, 2000 tools for one rifle that weighs nine and one half pounds, you can see the magnitude of the problem.

Colonel Miles: — I think we are greatly indebted to the chief of Ordnance for permitting Major Hatcher to come here and we are greatly indebted to Major Hatcher himself for the time and effort which he must have put into the preparation of this paper and I can assure you that although the manufacture of such a weapon is an intricate proposition, frequently it is more difficult for a man of Major Hatcher's practical turn of mind to turn around and write as interesting a paper and as conclusive a paper as he has presented this morning.