Remarks by Lieut. Col. Miles Introducing
Colonel Julian S. Hatcher
October 20, 1937.

Gentlemen: This morning we have Colonel Julian S. Hatcher of the Ordnance Department, who will speak to us on "The Manufacture of Small Arms Ammunition."

I might say that the best possible index of a man's standing in any particular line of manufacture for the Army can best be arrived at by the comments which you hear about him from the corresponding people in commercial life. I can assure you that I have never heard any remark concerning Colonel Hatcher from the men in the small arms industry which has not been highly laudatory. Colonel Hatcher is one of the few real experts in the Ordnance Department. He has assisted the Department of Justice in his line in aiding that Department in the detection of crime. He has a fine background as an author, and we are extremely proud of him in the Ordnance Department.

I take great pleasure in introducing Colonel Julian S. Hatcher.

Col. Julian S. Hatcher
Oct. 20, 1937

90

THE MANUFACTURE OF SMALL ARMS AMMUNITION

Gentlemen: I am very glad indeed to be with you today. I am not here to detect any crime, as Colonel Miles might have inferred, but Colonel Jordan has asked me several times before to come down here and talk to you and say a few impromptu words regarding the manufacture of small arms ammunition, with the idea of bringing out the fact that the manufacture of ordnances in time of war is not all plain sailing.

The idea is to explode some theories that certain people sometimes have. I'll illustrate that. We had some reserve officers, for example, who brought that out very well last year. I was in the Baltimore Ordnance district in industrial mobilization work, and naturally the work of having all the different manufacturers in that district prepared for their war orders in Ordnance was under our office. At very frequent intervals we had meetings of the reserve officers who were assigned to that office. Those reserve officers assisted in that work and were thoroughly familiar with it, but we did have at that time reserve officers come in from other branches, chaplains, engineers, infantry and various other branches, who were not concerned with our industrial mobilization work. I was discussing some of our work one day, and one of the visiting officers got up and said, "Can I say a word?" He said, "There is no use your going into this sort of thing, this getting these commercial plants to do this. That has all been

taken care of. The Government has taken care of that." He said, "They have arranged so that all the commercial plants in this country are going to make everything we need as soon as we have any mobilization. Let me illustrate. Over here in Curtis Bay on the edge of Baltimore the du Pont Company has a plant that makes paint, and the minute a war starts, the very day after mobilization, the Government will get smokeless powder out of that plant. They have all the plans arranged. The minute there is a mobilization those people will start delivering powder." I think the gentleman who said that happened to be a chaplain in the chaplain's reserve. Well, that's very splendid. Of course I wasn't going to stop and argue with him. We had our business with our own reserve officers to go ahead with, and they all knew what the proposition was, so I said, "Thank you very much for the information." So we went ahead. But actually I knew all about that plant over in Curtis Bay. I had been over there a number of times. Two of our reserve officers were employees in the plant, and what the plant did was to take black sand that comes from India in ships and put it through a series of chemical processes so they got titanium oxide out of it to make white paint with. And there was not a single piece of machinery in the plant that had any relation to smokeless powder. In the war plans du Pont did not contemplate using that plant for any of our work at all. That shows how easy the ordnance problem is when it is viewed from some other viewpoint and not from the viewpoint of the manufacturer who is going to do the job or the Ordnance officer who is trying to make industrial mobilization plans.

Now today we are goint to talk about small arms ammunition. Small arms ammunition is a very simple thing. You can see it right here (pointing to board). To make small arms cartridges you start out with strips of brass about five inches wide and about an eighth of an inch thick. You punch out of those strips of brass little disks about the size of a twenty-five cent piece, and after those disks are punched out they are hollowed out into cups. That little cup you see there is the beginning of a small arms cartridge. Those cups are put through various draw presses that draw them out longer and longer until finally they reach the shape of a tube approximately the same diameter as the cartridge case. You can see all those stages on this board if the light is good enough for you to see them. Then those tubes are trimmed off to the right length and shaped down to form a cartridge in this form (displaying cartridge). The same thing is done with a bullet. You get thin strips of copper with some zinc in it called "guilding metal," and you punch out disks. Those disks are drawn into long tubes. The tubes are trimmed off to the right length, some lead is put in, and those (indicating on bullet) are smashed over tb the base to hold the lead in place and you have your bullet.

After this is done you are ready to load the cartridge except that you have to have a primer in the base of it to set the powder off, of course. The primer is punched out of a sheet of copper or brass in exactly the same way as these other things are punched out into a little cup. They are right here. I doubt if you can see them from where you

are. Those are filled with a mixture of some substance similar to fulminate mercury that will go off when struck a blow, and those primers are placed in the base of the cartridge case. The cartridge case is filled with powder and the bullet put in, and you have a finished cartridge.

The operations are really very simple. They are done on an automatic machine, with very few operators. The machines turn out large quantities of the stuff, and it would seem, therefore, that it would be quite a simple job to get all of those we need in time of war. But we have two or three problems connected with that. One of the problems is the fact that in modern war the amount of material needed is so tremendous that it not only means that there is a terrific job to get the number of cartridges we need, but the amount we wanted in the last war was so great that it would use up all the brass in the country to make them and leave no brass for anything else. Those were the requirements that were sent over to this country by the A.E.F. The requirements were for 5,000,000,000 rounds of cartridges a year, or a little over that. I think 5,700,000,000 was the figure. In other words, 5,700,000,000 cartridges a year were enough to use up all the brass in this country. They didn't get that many cartridges. When we started at war we had a war reserve of 200,000,000 rounds of ammunition, and we wanted to get for each year of that war approximately 5,700,000,000 cartridges. We had at that time the Government arsenal at Frankford capable of turning out 100,000,000. We also had five cartridge plants in this country, and in order to be in shape in case a war ever came up

we had been in the habit of giving those cartridge plants a million rounds of cartridges every year to manufacture of Government contract. The cartridge plants we had at that time were Remington, United States, Winchester, Western Cartridge Company, and Peters Cartridge Company (Listed plants on blackboard). We had all those, and when we got into the World War we were very fortunate in that for several years those plants had all been making cartridges for the allied governments in Europe; and after three years of grief trying to make those cartridges they had gotten up to a production of about 7,000,000 cartridges a day. They were not making our type of cartridges. They were making the European type, which is almost exactly similar to ours. It seemed that it would be quite simple. With our own Frankford Arsenal making 100,000,000 rounds a year and with these other people manufacturing, it seemed it would be quite simple to get all the cartridges we needed. We got all we could. We ordered cartridges from these people up to their limit (indicating plants listed on blackboard). We also ordered cartridges from other people. There was a copper company, National Brass and Copper Tube Company, making brass and copper tubes which looked almost exactly like these cartridge cases as they are drawn out and before they are tapered. That company was making those in very large quantities, it is a big plant, and it seemed quite simple that they could make cartridge cases, so they were given an order. The Crown Cork and Seal Company in Baltimore were making bottle caps, which are stamped out of thin sheet metal and look very much like some of these cartridge cups, in a more flattened form when

they are finished. Those people said they had had experience stamping out metal and they thought they could make cartridges. They were given an order to make cartridges, and they built a large plant for the purpose. We also gave orders to the Dominion Arsenal in Canada and we gave an order to the British Government for 4,000,000,000 rounds.

Now let's see what happened when we went ahead to make those cartridges. It was a simple thing. We had been making them for years in our own arsenals. Everybody knew how to make them. Frankford was making a hundred million a year at that time. Every other company in this country which could make them was given an order for a million cartridges a year. In the meantime they had gone ahead with tremendous orders for the governments which were at war over in Europe and were supposed to be able to switch right over into our cartridges in very large quantity production. I say they were making 7,000,000 rounds of cartridges a day. I didn't say those cartridges were all good or all satisfactory cartridges, because they weren't. Lots of those cartridges were being thrown in the scrap heap as fast as they were made because they weren't good.

We started right in to make those cartridges and the first thing we did right at the beginning of war when we ought to have known all about cartridges and not had any trouble at all was to run into trouble. Frankford Arsenal was supposed to make 100,000,000 a year, and during the whole war they turned out 70,000,000 rounds. I will put Frankford on the board. I was putting down the commercial plants before. Frankford turned out 70,000,000 rounds. They turned that many out during the whole war, from April, 1917, to December 31, 1918, and they were supposed

to be turning out 100,000,000 a year. Why didn't they turn out any more? One reason is that right after the war started, in May, 1917, people who were using them began to notice that these Frankford cartridges wouldn't go off. They would pull the trigger, there would be a click when the hammer of the gun fell, nothing would happen, and about the time they opened the bore of the rifle the gun would go off and blow somebody's eyes out -- a hangfire. They had never had anything like that happen in Frankford. They called all the engineers of all the commercial plants together and they did everything they could to overcome that. The result was that they shut down Frankford Arsenal for four months in the middle of the war, threw away six months' production of Frankford Arsenal cartridges, and adopted an entirely new primer.

Frankford Arsenal wasn't the only one that had that trouble either. The trouble was experienced with several of the other plants. Several of the other plants had to shut down on account of primer trouble. The reason did not appear at the time why they were having trouble with Frankford Arsenal primers, and they did not know why until after the war was over. They had very fine chemists go right after the trouble to see what they could find out, but instead of finding the trouble they adopted a different primer and went ahead with the manufacture. They found out after the way that the primer had sulphur and potassium chlorate and antimony sulphide in it. Those were the main ingredients of the primer. Those primers were mixed up in a wet mixture like flour being mixed into a biscuit dough. Then they were loaded into the little primer cups that you see in the base end of the cartridges, and great trays of those were placed in the dry houses and dried out. The dry houses were steam heated houses, made out of concrete, and they are kept at a

certain temperature for some days to dry those primers out. In the stress of war production when they tried to step their production up as fast as they could, they stacked these houses full ofprimers. They put far more in than they had ever put in before. They were anxious to dry them out in a hurry so they turned on more heat and those primers soured. The sulphur reacted with some of the other constituents and formed sulphuric acid in the primer. The primers were all right when tested in the proof house at Frankford. However, a few weeks later the action of that acid had progressed and by the time the primers got out to the army they were giving those hangfires. If they had given trouble right away, as soon as they had them in the proof house, it would have been simple, but that is not the way small arms ammunition functions. It's a tricky thing. It seems to be all right at the arsenal but when you get it out with the troops something has happened to it in the meantime. To illustrate how tricky it is, for example, when I was at the Frankford Arsenal they had a man who was very skilled in mixing primers. As I told you, they mix it up like we do biscuit dough, in a wet mixture. He was kneading this with his hands one day when one of the officers in the small arms division walked into the dry house and was looking around to see what was going on, and the fellow who was kneading the mixture said, "This doesn't feel right. I have never known this mixture to feel like this before. Let's get out of here." He let go of the stuff he was kneading, they both went out, and no sooner had they both gotten out than the roof went off. He felt that that stuff didn't feel right under his fingers and was canny enough to say,

"It doesn't feel right. Let's get out of here." It is tricky stuff. Making these primers is not like building a jack-knife. When you get the jack-knife built according to the drawing and sharpened you can be confident you've got a jack-knife. But when you get the cartridge made according to the specification you're not confident you've got a cartridge that is right, as by the time it gets out to the troops something may have happened to it. I'm going to quote a word or two from a Government publication that was published right after the World War, "The History of the Manufacture of Small Arms Ammunition." Incidentally, I remember very well when this book was written because they called in everybody who had anything to do with small arms ammunition and asked them lots of questions, and I remember giving these people lots of information out of our files. They wrote:

"Inasmuch as most of the manufacturers were in production on foreign contracts, it appeared to be a comparatively simple matter to turn these vastly augmented facilities and the invaluable experience to immediate production of our own ammunition. That this did not happen, that real quantity production did not occur until late in 1917, that up to then we had produced less than half a billion cartridges of all types, caused a good deal of apprehension in the public mind, unfortunately not in a position to have the faintest comprehension of the difficulties involved: of the necessity for developing a cartridge interchangeable into rifles and seven different types of machine guns; of the need for obtaining new machinery and modifying old to produce such a cartridge, of the repeated changing of specifications to meet the abilities of then existing manufacturers in order that quantity production might begin at the earliest possible moment; of the imperious need of training with all possible haste of army officers and civilians; of a general knowledge of operation in connection with manufacture; the theory of ballistics; the full knowledge of instruments and equipment used; method of conducting inspection, nomenclature, and general information concerning paper work of inspecting this ammunition which calls for more rigid inspection than most types of ordnance material; of the difficulties of designing and developing new types of special cartridges for piercing armor plate; of the stupendous task of obtaining new facilities, including dry plant capacity, new machinery, raw material, and rarest of all, skilled labor for the production of an additional

million cartridges yearly to meet the requirements of an army increased far beyond their original conception; of problems presented by the shortage of brass; of the labor difficulties due to competition and inefficiency, insufficiency, indifference, strikes, and high turnover (that was during the war, incidentally); of the problem presented by the necessity of preparation of special gauges in the face of a serious lack of tool makers, gauge makers and all types of skilled workers, of the delay and inconvenience of a failure of appropriations to come through in time; of all these obstacles and hundreds more the layman was either totally ignorant or only vaguely conscious."

They go on to state:

"The specifications were of necessity changed many times to meet the various troubles which arose from time to time. One of the earliest obstacles encountered was with primers. In October and November of 1917 both Remington and Western were experiencing considerable trouble with hangfires and eventually changed their primer and adopted a different type to overcome this difficulty."

I have already told you about the Frankford trouble with primers. Here are two other manufacturers who did nothing but make small arms cartridges who had similar trouble, but with a different primer. They didn't use the same one. "Considerable trouble was experienced with blown primers. This was finally overcome by crimping them in, as was done by the Germans and later adopted by the French and British. Failure to extract in the rifle was another impediment encountered. This was remedied by the adoption of a harder case." That is what this pamphlet says. But they did not state that where they adopted the harder case right away they found that these same cartridges began to rupture in machine guns, and immediately they were caused to go back to the softer one again. All the machine gun people were crying for softer cases and all the rifle people wanted a harder case.

"At one time gyration of the bullet in flight during firing tests retarded production." Why would a bullet gyrate in flight during firing tests when we had been making them for years in time of peace and they did not gyrate? When you start to make a thing like that you've got a small group of skilled people who make them all the time. It is the only thing they do. They overcome these difficulties and know what they are. Then suddenly you put out great quantities to vastly expanded facilities and they run into difficulties and they do not know where those difficulties come from. This is not like making a jack-knife or a razor. When you make a jack-knife or razor according to specifications it is made, but when you make this cartridge you have to make it function besides, and it's a thing full of explosives. If you make it so the explosive will go off, the cartridge may not hold the explosive in right, so you do not know whether you have it or not -- now you've got it and now you haven't.

In this same pamphlet which the Government got out, called "The History of the Manufacture of Small Arms Ammunition", there is this statement which is very significant: "More important than equipment or facilities is knowledge and experience, or what may be called 'cartridge brains'." In other words, it is a thing concerning which if you don't know all the troubles that come up, and you take men like the very fine engineers who were in charge of the Crown Cork and Seal production, they do not necessarily get very far with it.

At the beginning of the World War, three years before we went in, Remington Arms had a large order from foreign nations and one of our officers from Frankford Arsenal resigned from the Army and went with

them. (That was three years before we went into war and from time to time our officers did resign and go with these people. One resigned and went with Remington Arms.) Those people produced during the World War over 1,200,000,000 cartridges. That's quite a lot of cartridges. They produced that in spite of all their difficulties. United States Cartridge Company (they also had an officer from Frankford Arsenal who was their main guide) produced something like 684,000,000. I am remembering these figures and I may have them wrong. The Winchester Repeating Arms Company produced 468,000,000; the Western Cartridge Company, as I remember, something like 40,000,000; Peters Cartridge Company something like 84,000,000; National Brass and Copper Tube Company, 20,000,000, of which practically none were used. They all had to be scrapped. That was a tremendous company which had never been in the cartridge manufacturing business before, and they thought that they would get more production from them than from any other company in the United States. Crown Cork and Seal Company produced nothing - zero; Dominion Arsenal produced one-half million, and the British Government none. 4,000,000,000 were ordered from them but they didn't get into production by the time the war was over. That is a very funny table (indicating table on blackboard). Frankford produced 70,000,000 and Remington 1,218,000,000. There is a problem. The natural thing which occurs to you is this: If somebody said this was a Government cartridge and we got in a jam in time of war, instead of this thing going smoothly and us getting great production rightaway we had all kinds of trouble, they would say: "Ordnance Department inefficiency, or army inefficiency or Government inefficiency." But what happened? We had all these commercial firms. "They had people who

knew how to do it. When they began to run into trouble why didn't they tell each other how to do it?", you may say. They did. As soon as this thing started they formed an association of small arms ammunition manufacturers, which was more or less of a semi-government agency, and every two weeks they had a meeting in New YorkCity, which was more or less of a central point for all these people from every one of these plants. Many times British officers and people from Canada and anyone else who knew anything about the small arms business or could help; specialists from all kinds of places, such as professors from universities, etc., attended. When Remington had trouble with their primers they immediately called a special meeting and people went there from every plant. There was no holding back on account of competition or jealosy. Everybody was trying to win the war. When Remington ran into trouble United States Cartridge would send primers and engineers over to see if they could find out what the trouble was. They would call a meeting of thes small arms manufacturers association and try to find where the trouble was and all the best brains in the country were there; but even so they ran into all kinds of trouble. They ran into so much trouble that some of these people never got to first base. The National Brass and Copper Tube Company, which were manufacturers of tubes but not cartridge manufacturers, turned out cartridges which, as soon as you began shooting them in the guns, would blow up the guns. The cartridges looked fine. They didn't have high pressures. You could check the pressures. What was the trouble? When you take a brass cartridge and put it through this sort of a proposition you have to have it made very soft. If you don't have it soft it won't work in your machines. When you put it throughthe

first machine it hardens it. Then you have to soften it again by putting it in the fire, annealing it. You keep on doing that, softening it and working it and finally you get to the point where it's a finished cartridge. Then you have to stop softening the head because that has to be hard and strong. Soft brass is weak brass. Hard brass is strong brass. Soft brass will stretch, but it won't break off. It will stick to the chamber of the gun and won't extract easily. It is more like putty. It does not have great strength. In the head of the cartridge it will give way and let the gas out. We had a lot of trouble like that. They taught them how to make the head of the cartridge hard but then they began to crack on the side, somewhere from half way up to the back, and the gas would come out and blow people's eyes out. People had had trouble with that before, and they said: "Sure, we knew the cause of that. You cut these little disks so one fits into the other and it leaves a sort of crescent in the one, draws out a streak in the brass. You cannot see it but when you fire the gun it blows up and puts out your eye." So they rushed all the engineers over to this place to spread these things out so they wouldn't touch each other. They did find one or two that touched and they spread them out, but they still had the same trouble. Then they said: "It is inclusion of slag in your brass", so they had all the metallurgists at the brass mills work very hard to stop the inclusion of the slag. They said: "These people and these people get it and these people do not, and they are using the same brass. What about that?" It isn't the brass. There are all kinds of things that will do it. Running the presses a little too fast will do it. If you run the presses so you draw those too fast you overstrain the metal and that will do it. They didn't know that at the time.

At Frankford Arsenal three or four years ago they had a similar trouble with their cartridges. I see a gentleman sitting in front of me who discovered a very obscure cause of that. I am willing to admit that I do not see how he discovered it. I don't think I would ever have thought of it. In keeping that primer from blowing out they crimp it in. And in crimping that primer in, the cartridges are supported on the inside by a steel stem and if that stem were a little bit off center so that the support wasn't equal and the crimping machine crimped the primer a little harder on one side than on the other it threw a line of strain down through that brass and later on the brass would crack open in the gun. All such obscure things as that you've got to look out for in these cartridges. There are a thousand and one of them.

I could start in with the primer and tell you what might happen to that or I could start in with the bullet and tell you what might happen to that, and then the case. I could tell you, for example, that you make those primers and you think that with all the experience you've had you aren't going to have any trouble. You have your most skilled men working on them and yet the primers may blow out in your machine guns and jam your machine guns. The primers may be made of metal that you think is just the right hardness but you may get misfires or hangfires because the brass is a little too hard, or you may get punctured primers because the brass of copper that you make the primer out of (you may make it out of either) is a little too soft and your firing pin goes through it. You have nine or ten different types of firing pins in the different machine guns and rifles. Some may be sharper than others or have a different radius on the corner; some may be flat with a square edge or something like that and one acts on

a primer different from the other so you may have punctured primers in spite of everything you can do at a cartridge factory. You may get leaky primers. Around the edge of the primer gas may escape. You can get hangfires which, as I told you, caused all that trouble at Frankford. That is particularly bad in an airplane synchronized gun. It shoots holes in the propellers and propellers cannot stand many holes in them before they are weakened. Your primers may deteriorate. We have had primers made here which we thought were perfect, and have stored them for three or four years and they're all right; but send them to the tropics and store them for a couple of years and they won't shoot because some of the chemicals have reacted with some of the other chemicals.

We had one of the big commercial cartridge companies just three or four years ago sell us millions and millions of rounds of .22 cartridges that were put through all the tests that all the cartridge manufacturers knew anything about and in a year or so they wouldn't shoot. It was a commercial manufacturer. It wasn't the Ordnance Department. One of the obscure troubles that may occur with primers is illustrated by the fact that out in Camp Perry in 1930 they had National Match ammunition that suddenly became very high pressures, damaging guns, or threatening to damage guns, and they couldn't understand why. They withdrew the ammunition from service right then. Several years later they found out that in that particular cartridge they had adopted the European type of primer instead of the American type. The European type has a hole straight through the case from the primer to let the gas into the powder very easily. In the American primer the gas has to go around under the anvil of the primer. I'm going to draw a little sketch to illustrate what I mean.

Here's a primer cup, very greatly enlarged. This is the head of the cartridge here. In the head of the cartridge there is a little ridge, and up here is your primer mixture. You will find that when this hits, it mashes that down on that little point and crushes it and causes it to go off. They had two little holes there for the flame to go through. That's the European type of cartridge case, this being the inside of the cartridge and down here being the powder. Our type of cartridge case is made just a little different (drawing sketch on board). It has a little piece of brass inside of it separate from the cartridge case called the anvil that you mash the primer mixture down with when the firing pin hits it. Here's your primer mixture and here is the anvil. There are little holes through the anvil and in the middle of the cartridge case there is a venthole where the gas can go into the powder. In our own primer, gas comes around there, through here, and down (illustrating). It has to turn a corner. Everybody thought that you would get much more uniformity and accuracy if you used the European type where the gas had a straight shoot. All the tests at Frankford showed that it was far better. They put it out at Camp Perry and they began to get high pressures. The answer seems to be that sometimes the gas was breaking the powder grains in pieces. It had such a straight shoot at the powder grains, they were brittle, and it mashed them into little pieces. We make powder finer and it burns more quickly and causes high pressures. Those are some things that can happen to primers.

What can happen to cartridge cases? Almost everything in the world. The cartridge case has got to hold the powder,gas in. It has to be strong around the head. It can't crack. If it cracks, it lets the gas out. One of the troubles is that when the cartridge case is manufactured it is

constructed at the mouth to hold the bullet in. It has to hold that bullet very tight, and the brass has to be fairly hard at that point to hold the bullet tight, or something else has to be done, such as calendering the bullet. They used to make the case very hard at that point to keep the bullet from coming out or pushing in, either one of which will cause a malfunction in a gun. That hard brass placed in storage at high temperature is subject to cracks. All kinds of brass objects do it. You will often find the handle of the Gillette razor cracked. It isn't only the cartridge that does it. We had a great deal of trouble getting away from that season cracking. They knew at the time of the war that if they heated that up in a flame very hot so it was quite soft before the bullet was put in, it wouldn't season crack. If you did that, when you put the bullet in it would crumple down, or if you made it hard enough so it didn't crumple down the bullet wouldn't have enough strength in there. It would be out of line. It would push in or pull out in a machine gun from the very violent action of the gun. The difficulty was keeping a balance in between, soft enough so that it wouldn't crack and hard enough so as to hold the bullet. They ran into a great many season cracks. I happened to have some guns during the early part of the World War that used British cartridges. The British cartridges I used in those guns were about one-third season cracked. So we werenot the only offenders. You could take a lot of them and just shake them out on the ground. I told you something about those body slits and what will cause them.

One of the great troubles we have with cartridges today is their sticking in the rifle. You take this cartridge and make it real hard and it

will extract easily in a rifle. If you make it real soft it will stick in a rifle. So you say, "Make it hard." But as I said before, if you make it real hard it will rupture in a machine gun, so you are up against it there. You would have to make two kinds of cartridges, one for rifles and one for machine guns, or your cartridge is a compromise. If you make them very soft for machine guns so that they won't rupture you may have the rim pulled off because the cartridge is so hard to get out of the gun when it gets hot. The extractor will pull the rim right off.

The same way we can have all kinds of troubles with bullets. I can tell you a whole lot of troubles that are not only common, but a lot of uncommon ones that you do not expect to have. You make cartridges for years and years at a place like Frankford and all of a sudden a trouble will jump out at you that you never heard of and you don't know the reason for it. Those things multiply themselves in time of war when you have a lot of new hands on the job who do not have cartridge experience and cartridge brains. We must have cartridge brains and cartridge experience, as it says in this book. We had a great dealof trouble with the .45 caliber pistol cartridges during the World War. I'll just mention one that hangs over to the present day. Once in a while during the World War we had a great many of them stick in the barrel of the revolver or automatic pistol. When you got ready to shoot and pulled the trigger the bullet would go half way down the barrel of your pistol or revolver and stop. You didn't know it was in there even. You would cock your gun and shoot again; the next one, if it were a good strong one, would make a bulge in the barrel or even split the barrel, or sometimes you'd see two stuck in a barrel. The second didn't have enough pep to push the first

one out. That seems silly. The reason for it was that this company, United States Cartridge Company (they are the ones that had the trouble) used a certain kind of wax to waterproof their bullets. They put the wax in the mouth of the cartridge. Other people at present use shellac or a mixture known as N.R.C. compound, which is like a shellac or varnish. Those people were using a wax that seemed fine but when you got those cartridges in a real hot sun (quite a bit of wax was used in some of them) that wax would run down into the powder charge. There isn't much powder in one of those .45 caliber cartridges -- four or four and one-half grains -- and about three grains of the powder would be consolidated with wax. The remainder would be enough to blow the cartridge into the middle of the barrel and cause trouble.

There's one more thing I want to say about this whole business and that is that in industrial mobilization or going out to get manufacturers to manufacture war materials the reasonable and proper thing to do and the thing that any sensible man would do would be to go out and see who has the machinery to do the job. They would not go out and give to a man who has textile machinery, for example, to weave cloth, the job of making shells because he hasn't the right machinery. They find the fellow who has cartirdge machinery. You don't make it on a lathe and you don't make it on a drill press. You make it on special machinery. You make it on a cartridge loading machine or a cartridge priming machine or a cartridge heading machine, or a cartridge trimming machine, or something like that which is automatic and special. You put out those things in quantity. They run on conveyor belts and drop into hoppers without anybody's hands to help, and they're absolutely special. When you go out to find a man who is going to make cartridges you can't find anybody who has this kind

of machinery except the cartridge manufacturer himself, so that you are absolutely limited to doing one of two things: to go into an existing cartridge manufacturer or to go to anybody else who never did manufacture cartridges and get him to start from the ground up. Here (indicating on blackboard) we have an example of what happened when we did that -- we did not get anywhere.

These are all the people we had during the World War: United States Cartridge Company, Peters Cartridge Company, National Brass & Copper Company, Crown Cork & Seal Company, Frankford, Remington, Winchester, Western Cartridge Company, Dominion Arsenal, and the British Government. United States Cartridge Company, National Brass and Copper Company, and Crown Cork and Seal Company have gone out of business and are closed up. The Peters Cartridge Company does not count. Winchester and Western have combined. Dominion Arsenal is a foreign firm. Of course the British Government doesn't count. So where are you? We have left Frankford, Remington, Winchester and Western, and those (indicating on blackboard) are all the people we had before.

That's about the story. I've been given forty-five minutes to talk and I have talked fifty, so I'm going to stop. Thank you for your attention.

Colonel Miles: Whether you call it "cartridge brains" or "know how" it all amounts to the same thing. I think Colonel Hatcher has brought home very forcibly the necessity for cartridge brains.

We will now take a ten minute recess and reassemble at the sounding of the bell, at which time Colonel Hatcher will be very glad to answer any questions you may put to him.

Colonel Miles: In opening this conference I failed to mention the fact that Colonel Hatcher is the head of the Ordnance School at Aberdeen, and I know the thought that runs through your mind the minute I say that. We should have more men with the practical bent which Colonel Hatcher has in charge of our technical schools. Colonel Hatcher will be very glad now to answer any questions which may come to your mind.

Colonel Hatcher: May I correct Colonel Miles? I will be very glad to try to answer any questions.

Q. You didn't mention anything about powder. Did you have any difficulties with powder, and at the present time what is the possibility of obtaining powder in a future emergency?

A. We had less difficulties with powder than with almost anything else. The principal difficulty was to get an adequate supply of small arms powder. The question of getting powder for small arms is not as serious as that of getting cannon powder because the small arms cartridge, as you can appreciate, uses a very great deal less powder than the cannon -- one charge of 12-inch powder, which is essentially the same in composition basically as the small arms powder. Small arms powder will load a very large quantity of cartridges. Now I can say that there is a special office of the Ordnance Department established at Wilmington, Deleware, in the du Pont Building at the present time working on a powder plan. There have been plans on powder but there is a new plan now being prepared to take care of what you asked about.

Q. Colonel, in your talk it seems to me that you emphasized the vagaries of the cartridge and the primer and the possibility that even with the best plans over a period of time something might happen to it which even the best minds could not contemplate. What effect does that have or would it have on the creation of large war reserves of ammunition as against preparation of machinery to manufacture cartridges on a large scale? By that I mean, if it is true that it is still doubtful that a given lot of cartridges would last in good condition, say, for ten years, what effect would that have on us of creating now a large reserve which we are all talking about in the matter of war procurement as against establishment capable of expanding to meet immediate emergencies?

A. The great trouble about establishing very large war reserves is the fact that a small arms cartridge is a perishable article and eventually will deteriorate, and I don't believe that we'll ever establish a reserve of small arms ammunition large enough to carry us through any war. No matter what happens, if we have a war we will have to manufacture.

Q. Has anything ever been done toward attempting to cast brass cartridges?

A. Not that I know of. The various cartridge cases require very good physical properties. A cartridge case has to be strong and it is so very, very thin at the mouth that I don't see how it could be cast. But I'll ask some of the people that have been in contact with this later than I have if anything has been done on that. I don't see how it could be done.

Q. What about the use of copper for the small arms ammunition cases? We use that case for the .22, why couldn't it be used for the .30 and .45 caliber case?

A. What would be the advantage?

Q. I take it from the discussion of brass that it is very brittle. Copper is more homogeneous.

A. Copper would not have the strength. There would be no great advantage in using copper. The great problem in getting brass is almost the same thing even when you talk of copper because copper is of the main part of brass. A copper cartridge case has plenty of strength for a .22 where you have a very small charge of powder in a very small chamber, but it would not have the strength for the head of a cartridge in one of the .30 calibers because copper does not harden up the same way brass does in working. We have tried various other materials for cartridge cases. We have tried steel. At the time of the World War we made steel cases. It was much too heavy. There is a difference in the weight of steel and the weight of brass. The trouble with steel is that it's very much harder to work than brass. Brass is a very remarkable, wonderful thing to work into these complicated shapes. It draws easily. After you get it drawn into this cartridge case shape you can force it down into this small neck and it hardens very beautifully under cold working in the press. When you form the head of the cartridge case it is as soft as putty so you can draw it, then the minute the press hits, it hardens up very hard and very strong. It is a most admirable and wonderful material to use. At the time of the World War the Germans ran out of copper and therefore out of brass. In order to have cartridge cases they had to use what material they could get. They could get steel so they used steel cartridge cases. Steel cartridge cases rust. It is very difficult to make steel soft. Steel does not work as easily as brass, and it is hard on tools. The tools that you use to make brass

cartridge cases will not last when you make steel cartridge cases, so you have your problems just the same with steel as you do with brass. When you get them made they'll rust. They copper coated them to keep them from rusting and they rusted through the copper coating because that wasn't good enough. We did the same thing. At the end of the World War we were making experimentally, steel cartridge cases.

Q. What about aluminum?

A. Aluminum cartridge cases have been a very attractive idea because it is a lighter material and would relieve the weight on the soldier. When I was at Frankford we did quite a bit of work with aluminum and once we tried making aluminum cartridge cases. We had the Aluminum Corporation engineers working with us. Aluminum cases did not have the necessary strength. You've got to have a good strong cartridge case. There's a gap in the cartridge case that has to be bridged over, and that gap has powder pressure at 50,000 pounds to the square inch inside of it. If you have anything like soft brass or copper or aluminum, it will flow out of there like putty and let your gas out. Colonel Waldmann was at Frankford after I was. I am quite positive that while he was there they did some work on aluminum.

Colonel Waldmann: I do not know what they have done since I was there. The aluminum people came around and were very keen about our using aluminum, so we gave them something easy. We gave them a .45 caliber case. They had worked on it about two years before I left, and at the time I left they hadn't made a successful .45 case so I don't know where they are on the .30.

Colonel Hatcher: The .45 case has 12,000 pounds of pressure to the square inch and the .30 caliber has 50,000 approximately. The .45 does not have the extraction trouble that the .30 does. The .30 cartridge just can't

be extracted. It would be wonderful if you put the copper in and it would stay there. For the .30 caliber case, it would squeeze out against the wall of the chamber and would not spring back. The brass has the elasticity that copper doesn't have. If you had copper cases you couldn't extract them. The same thing is true of aluminum. They have never made aluminum strong enough or hard enough for a .30 caliber case or even for a .45, which has very much less pressure in it and does not have the extraction difficulties of the .30. When I last heard, they were not able to do anything with it although the engineers of the Aluminum Corporation still have that idea in their mind and the Ordnance Department still plays with them on it.

Q. Just one more question in line with the question Captain Mahoney asked previously about a war reserve of ammunition. Why would it not be feasible to lay aside a war reserve of good cases, properly made in the quiet of peace-time construction? That would at least eliminate the difficulties that seem to have come up under the stress of war.

A. There has been quite a bit of study on that. A committee several years ago studied the making of components. The trouble is that the cartridge case is also a perishable article, like the Gillette razor stem, and when laid aside it is liable to crack. By the time you are ready to use it it's liable not to be so good.

Colonel Miles: I'd like to ask Colonel Hatcher a question. Had the war continued, do you think they would have cut down on the 5,700,000,000 cartridges required, or to what extent do you think they would have met that program had the war continued?

A. I thought at the time and I still think that those requirements were based on safety first. In other words, ask for a whole lot, ask for everything you can possibly need. It doesn't seem to me that we ever

needed anything like that number of cartridges. The war reserve at the beginning of the World War was 200,000,000, and the total requirements from the time war broke out to June 30, 1918, were approximately 2,600,000,000. Those were the requirements, and on June 30, 1918, requirements of 3,700,000,000 more were set up. Actually, during the whole World War, from the declaration of war until December 31, 1918, the total amount of ammunition manufactured and obtained was less than half our requirement and we had no shortage of ammunition. We had, in fact, it seems to me, about 1,500,000,000 rounds of it left at the end of the war. We got less than half our requirements and we had more than half of that left, and therefore I do think the requirements were much overstated.

Q. In this new division, the Anti-Aircraft the daily load is about 96 3/10 tons of .50 caliber ammunition. How do the same difficulties come up in making the .50 caliber as with the .30?

A. Not quite, because the .50 caliber is not used in hand rifles and you can make it especially for machine guns. The difficulties are along the same lines. I should say though, that there are a lot of troubles that you don't have with the .50 that you have with the .30 just on account of having to make compromise cartridges. The problems are about three-fourths the same. I want to state that we had approximately 19 kinds of .30 caliber ammunition during the World War. We had .30 caliber ball, tracer, incendiary and armor piercing; and .303 British. We had that in several different times to use in the vickers gun. We had the 8 mm. French, .762 Russian, which was practically the same cartridge but was used in the machine guns, and we had the 11 mm. We had 19 different kinds of .30 caliber ammunition, and right here is another one (indicating). That's the clip for the semi-automatic

shoulder rifle. The cartridge for that rifle is the same as our regular cartridge but it must be put up in special clips or else it won't work in the rifle.

Q. With respect to semi-automatic rifles, there have been troubles with extraction, etc. with the cartridge cases, and I am under the impression that there has been serious consideration on the part of some individuals at least to the use of special ammunition which might be used for that weapon alone or for that weapon and the automatic machine guns. Could you give us any information on that, special ammunition for the semi-automatic rifle or for the automatic machine gun to get away from the extraction trouble we have had?

A. At the time of the World War we had a cartridge that looks just like the one we have now. As you know, it was a .30 caliber cartridge model of 1906. The one we have now has a heavier bullet with a bullet tail on it, which was designed primarily for machine guns. The way that bullet came up is given in the pamphlet on "The History of Small Arms Ammunition" which states that in 1918 it was decided that a heavier bullet was desirable as this would be more destructive in machine gun barrage firing. Frankford Arsenal set to work in August, 1918, to develop a new model, having a greater length and with a bullet weight of 180 grains instead of 150. Tests of these proved their superiority. During the World War the machine gunners in France wanted a bullet that would go further and because they wanted a bullet that would go farther we gave them one. We now have the ammunition with a heavier bullet than the 1906, with a greater kick on the shoulder, with more extraction difficulties and with no advantage to the rifleman at all. It may be an advantage to the machine gun. It will be ex-

tremely easy if we want to do so to make this old 1906 cartridge, which is absolutely as good for everything except long range machine gun work. There is no reason why not. In fact, it's better in some ways because its velocity is a little higher. There's no reason why we couldn't use that or the M1, whichever we want to. It is merely a question of tactical consideration which we want to use. If we use two kinds it creates a supply difficulty of having two kinds of rifle ammunition. If we use one kind it means that the rifleman is shooting a cartridge that punishes him unduly and causes extraction difficulties that could be gotten away from. Does that answer your question?

Q. Yes. That makes me recall now that the question was not of a special cartridge but of the use of the 1906 in the rifle, maintaining the M1 for machine guns.

A. You might be interested to know that the Ordnance Department has recently manufactured quite a few, I think it's 10,000,000 rounds of that old ammunition. I don't mean old ammunition -- it is brand new -- but it is that reduced power type. That is splendid ammunition and the reason they made it was because we still had some of that old war time 1906 ammunition left over. We have had some of it almost up to the present time. Now it is all gone, and the only ammunition that is available is the M1 high powered machine gun ammunition that is really used in rifles and everything. Some people here may be able to correct me. Colonel Buyers may tell me I'm wrong, but this is the story as I have it: they wrote in here from the Army, from corps areas, etc., and wanted to know what they could do about rifle ranges, which were restricted, and those where the bullets went too far. They wanted ammunition that didn't go any farther than the 1906 and they asked if that could be made. I believe they were told it could be

made and the Ordnance Department was ordered to make it. Is that right, Colonel Buyers?

Colonel Buyers: I believe so. I did not have the ammunition; I had the rifle.

Colonel Hatcher: That's the story as I understand it, and as the result of that we have made recently 10,000,000 rounds of that lighter ammunition that you are speaking of. It's actually in existence. I was not in the Ordnance Office when it was done but the story percolated to me.

Q. Most of my question has been asked by Captain Leonard but on this semi-automatic, wouldn't that simplify the supply problem, by the automatic rifle being able to use the machine gun ammunition? Isn't most of the kick taken up by the operation of the bolt mechanism?

A. If you are speaking of the recoil of the semi-automatic rifle, it is very nearly the same as Springfield. The recoil is taken up by the bolt mechanism, by the muzzle attachment that traps some of the gas and directs it back against the piston rod. The idea that the bolt mechanism of the semi-automatic rifle in working backward bakes up some of the recoil is not a valid one. It generally does not take it up. In some rifles it increases the recoil.

Q. You have stated that we don't have the number of ammunition factories today that we had twenty years ago. From a procurement planning viewpoint, would you say that we are worse off than we were twenty years ago, or have we taken steps to correct this situation, if it can be corrected?

A. We are worse off than we were twenty years ago. We are taking what steps we can to correct the situation. The steps that we are taking are, briefly, to plan for having two large groups of manufacturers. One

group of manufacturers controls about half the small arms ammunition manufacture in this country, and that group is the Western Cartridge Company which controls Western and Winchester, two of the remaining factories out of the group that I spoke to you about. The other group is duPont, which controls Remington. You have two small arms ammunition manufacturing groups in this country, duPont-Remington and Western-Winchester, and the plan is to allocate about half of our war requirements to each of those two large groups and to have them build new factories to make that material. As soon as mobilization starts, those two large groups would instantly proceed with the plan to establish a number of new factories for making small arms ammunition and try to operate them, try to spread out their talent thin enough to operate them properly. That's the only way we see to do it at the present time.

Q. I wanted to ask Colonel Hatcher what he thought the possibilities were of our enemies springing on us a high velocity ammunition in a next war which would make some of our tank armor obsolete?

A. I don't think there's much chance of it. We have had quite a bit of talk about that for some years. I know a number of years ago we heard rumors of a high velocity ammunition in Europe. There was an inventor over there who had rifle ammunition which was supposed to shoot about twice as far as ours. We paid him to come over here and demonstrate his invention. He did have high velocity ammunition that shot approximately -- well, it didn't shoot twice as far as ours. His story was that his ammunition shot 6,000 feet and he had the system of making any gun do it, all very mysterious and wonderful! Our ammunition goes, as you know, at about 2600. He came over here with his gun and demonstrated a

velocity, I think, of about 3800. He even had one that went up around 4,000. It wasn't the 6,000 he claimed, but still that was high. The way he did that was to make his bullet shaped like an umbrella. He had a tapered barrel for the gun and his bullet was something like this. It had fins on it like an umbrella. I'm going to draw you a good picture of it. Here is a bullet here. I'll draw this before I put the fins on because I can do it a little better that way. Now he had a couple of sets of fins on this bullet, and he had a tapered barrel that he fired it through. In the back end of the barrel you get a great deal of area for your gas to work, but if it goes forward those fins smash down in the tapered barrel, and if it comes out they are smashed all the way down. He did get about this much velocity, which can be attained without all those fins, incidentally. We have done it. But when we shoot an ordinary bullet at the velocity of 2600 against armor plate it just disappears in a cloud of lead vapor. But if you shoot this bullet at about 4,000 or 5,000 velocity, much higher, the lead bullet will suddenly come to a point where it goes through the plate. Instead of evaporating into lead vapor it goes straight through the plate. If you could get all your lead bullets up to about 6,000 you would be able to shoot through tank armor with them. Unfortunately when you get them to the high velocity, retardation is very greatly increased and after they go about 150 yards or so they are down to where your other bullet is. You can make a light bullet that will go very fast in the way of an armor piercing bullet and within 150 yards that bullet is better than your regular bullet. But when you get this one out beyond 150 yards it would slow down. The old bullet is good -- the new and faster one is slowed down when you get out beyond that. We've put a great deal of

thought and work and experimented a great deal on a high velocity bullet. That system of having wings on the bullet and having the tapered barrel is absolutely impracticable. It's a laboratory thing. You can do that in a laboratory but you'll never do it in war production. You can make a light bullet, and make it very fast for armor piercing, and that will give you superiority at very close range. At 300, 400, 500 yards you won't be any better off. Right now I do not see anything in the offing.

Colonel Jordan: Colonel Hatcher, have you specifically said anything about the life of ammunition in storage here in the United States?

A. I have not. The life of ammunition at the time of the World War was unknown. It was supposed that ammunition would last from five to ten years in storage. They thought ten years would be about an average. Ammunition actually lasted anywhere from no years up to about twenty years, depending on different things. It was thought at the beginning of the World War that the limiting factor of ammunition would be the chemical that was in it, namely, the powder. That being a chemical, a nitro cellulose composition, they thought it would deteriorate. The old powders we had before the war, the small arms powders, were supposed to have a life of somewhere around ten to twenty years. At about the time of the war duPont got an improved military rifle powder which is different in composition from the other, and as far as we know none of that powder has deteriorated sufficiently to cause ammunition to be thrown away. In war ammunition, the powder has been the least of our troubles. We had some old type powder that deteriorated. It was dried by water drying, instead of the regular type of drying. It was dried in a hurry and some did deteriorate, to be sure, but our present type of powder apparently is the thing that we have to worry about the least. It will probably

last twenty or more years in ammunition. But the thing that does deteriorate in ammunition is cartridge cases; also bullets and primers. Those things have a variable life, depending on season cracking, corrosion and deterioration. The primers have a variable life, which is perhaps fifteen years on our present types of ammunition made under peace time conditions in the United States. War time ammunition was variable. Some would crack right away and some would last a long time.

Q. I have two minor questions. First, just what is the Ordnance Department's dividing line in small arms ammunition, and second, how do the difficulties in the larger calibers compare with those you mentioned in the small arms?

A. The small arms ammunition at the present time takes in the .50 caliber and everything below that. It does not take in the .37 mm. At times they have had that in the small arms division, but that is not considered a small arms ammunition. They experiment from time to time with guns that are somewhere in between the 37 mm. and the .50 caliber, such as the 2 centimeter gun, Lincoln and others. At times they have had those assigned to the small arms division and at times assigned to the Artillery Division. They are generally considered to be Artillery weapons. They have had all kinds of difficulties with other ammunition, as well as with small arms ammunition, but strange as it may seem they have never had as much real difficulty in making artillery ammunition. They have not had as many strange difficulties sneak up on them as they have in the small arms ammunition. The shell is a shrapnel case, and all that sort of thing is turned out on a lathe out of steel and when you get it finished it is subject to certain difficulties, such as if it is an armor

piercing shell it is subject to breaking on the armor plate instead of going through. A high explosive shell is subject to having seams in the base which will allow gas to get in to your high explosive charge and cause it to blow the gun up. To prevent that they put a copper cover over the base of all the shells. It seems to me they either weld it or solder it on or cap it into a groove, or fasten it on in different ways. They have had difficulties with loading them, of course. You load those shells either with high explosive or with shrapnel. They have had difficulties with loading thehigh explosive shells. They get _____ in the charge so when they fire them they may blow the gun up. They have had difficulties with the fuses. The fuses may fail to function and leave the shell lying on the field, or malfunction in the bore of the gun may blow the gun up. All those things they do have, but they never had the troubles with the cartridge cases and primers that they have had in the small arms ammunition. The method ofmaking the big shells is more of a one by one job. Each big shell is a separate job of its own, and it has attention right straight through, whereas cartridges are made on automatic machines by the billions and I think that may have something to do with it. If you gave each separate cartridge the same attention you give a big shell you might not have so many difficulties with it.

Q. Apparently then most of the trouble is due to season in storage. Could that be corrected by keeping it under uniform temperature?

A. The more uniform the temperature the less trouble you have with small arms ammunition. It doesn't correct all the troubles by any means because a great deal of ammunition that was put out during the time of the World War, no matter what you did to it, would blow guns up right away.

But as far as the deterioration of the ammunition in storage is concerned, it deteriorates far less under uniform temperature conditions. Extremes of heat or cold are bad for it, especially changes. With that idea in view, considerable effort has been made to have the bulk storage of ammunition in places where it does not have the greatest temperature changes. A good deal of attention has been given to storage where it doesn't meet temperature changes in extreme.

Q. Has there been any recent development toward getting away from the corrosion in the link belts for aircraft ammunition?

A. At the present time most of the ammunition, particularly that which has recently been stored in Hawaii, could not be stored for any length of time loaded in the belts without a corrosion taking place between the link and the case. That would cause a malfunction of the gun. I haven't run into anything recently along that line. I have been out of touch with small arms ammunition manufacture for a few years. We used to give them a very severe salt spray test. That will rust more quickly than anything else. That system of testing is called the "freeze" test. Our links were macadam plated or Parkerized, which was supposed to rust-proof them. What recent troubles they have had or what they have done to correct them, I don't know. Maybe someone knows. Did you have any experience with that up at Frankford, D'Espinosa?

Captain D'Espinosa: I don't believe they are made at Frankford now. I think they are made at Rock Island Arsenal.

Colonel Hatcher: Yes, they were making them at Frankford before you went there but I believe most of them are made at Rock Island now.

Colonel Miles: Are there any questions by the faculty?

Colonel Best: I understand that in 1936 the Marine Corps had about 1% misfires.

A. They ran into quite a bit of difficulty. That's one of those difficulties that are run into with M1 ammunition that I was telling you about. They go along and make ammunition for several years. Everything seems fine, and then all of a sudden they have troubles with it, making it exactly the same way. In 1928 they issued ammunition to the Marine Corps and they found that the bodies were cracking and that was the proposition that Colonel Waldmann discovered the cause for at Frankford that I was speaking of a while ago. I don't know what the story was on misfires in 1936. Do you happen to know anything about that, Waldmann?

Colonel Waldmann: That 1% sounds awfully high to me.

Colonel Hatcher; It sounds mighty high all right. One cartridge out of a hundred. There are all kinds of reasons for misfires. One reason for a misfire is putting grease in the rifle which hasn't got a thing to do with cartridges. If you dip a rifle in a vat of melted cosmolin before you put it into the storage depot and then it is sent out to the troops and they wipe the outside of the bolt and slosh it over with gasoline on a paint brush and do not take the bolt apart, you will get more than 1% of misfires. There are so many things that might have happened that I really don't know what the answer is to that. You can be sure that there was no such percentage of misfires when the ammunition went out from Frankford and the primer was the same as used for many years. But something happened to that primer mixture so there is a deterioration.

Colonel Miles: Are there any other questions?

Q. Colonel, could you give us some idea as to the ability of the United States to produce small arms ammunition as compared with some of the major foreign powers and their ability to produce the same product? Is that question in order here?

Colonel Hatcher: Do you mean the facilities that now exist?

Q. Yes, sir, that is what I mean.

A. Well, there's quite a different spirit existing in the United States than in foreign nations. In foreign nations there are a very large number of firms who are encouraged by governments to sell ammunition of all kinds and war weapons of all kinds to any nation that will buy anything to kill someone with, and munitions firms not only flourish but are very, very much encouraged. In this country you know that munitions manufacturers are not encouraged and we have practically no firms that are known as really munitions manufacturers. A lot of people think duPont is. They make about 1% of their product in the form of powder. The rest is paint, all kinds of chemicals, plastics, etc. We do not have any true munitions firms here. In Europe they have them by the hundreds -- big ones. Those people have factories and they sell cartridges of all kinds to everybody in the world. If a man in Peru wants a cartridge he can go over there and get their cartridge. They are ready to make it; they know how to sell it. From that point of view there are some foreign nations that are way ahead of us in ability to produce small arms cartridges. There is absolutely no comparison. That's the reason for it. We'll never get that way for the simple reason that the small arms cartridge business has been going down hill. For many, many years, back before

the World war there were no regulations as to firearms. The country was not as thickly populated as it is now and there were more places for the average man to shoot. As time went on, firearms began to get more and more regulated so now the man who has a gun with him is a subject of suspicion. Both the gun makers and the ammunition makers have a business that hasn't its future before it. It has its past behind it but no future in front of it. In this country the ammunition business is going to continue to go downhill; that condition is going to continue to exist and as long as it does exist we are going to have a hard row to hoe in making small arms cartridges or having facilities existing for them.

Those factories they have over in Europe are just wonderful. We just wish we could have something like that in this country. I have been very fortunate and have been through a number of those foreign factories and have seen the machinery. They specialize in making cartridges for any nation in the world that wants to buy them. There are firms over there that specialize in making cartridge machinery for anybody who wants to start up a factory. Say somebody in Russia wants to establish an arsenal. They know where to go to get the machinery, to Germany or Switzerland. We have nothing like that in this country.

Q. I'd like to stand up in the defense of difficulties of artillery ammunition manufacture. Much of it is not fired in peace-time small arms. I think there is one reason why it is not appreciated. To illustrate, take the manufacture of the 1.1 cartridge case of the Navy which Frankford Arsenal is now making.

Colonel Hatcher: You are getting almost down to small arms.

Q. Some two years ago the Navy asked the Army to make the case as they were not able to make it very well here at the Gun Factory. So Frankford made the case and were successful in the manufacture of it. Just yesterday I was asking the Artillery people about it. It seems that Frankford is now having trouble and they are going down to the Gun Factory to learn how to make it. In other words, we developed it and the Gun Factory took the practice over and were successful in it, and now we can't make it.

A. That's absolutely true. Did I not state that making ammunition is not all plain sailing? There are many headaches. That 1.1 is possibly twice as big as the .50 caliber in dimensions. What about it, Captain Rice? Will you tell us something about the manufacture of artillery ammunition and the difficulties in the larger ones?

Captain Rice: Just one other point. The manufacture of primers enters also into artillery ammunition and we have now gone as far as possible to small arms primers to overcome our difficulties. We are taking the .50 caliber primer as a basis for most of the artillery primers. The main reason for that is that production in peace time is so small that we cannot get continuous manufacture. However, the small arms department at Frankford Arsenal is in continuous production and they have a primer which functions, we adopt it. Our war-time problem will be very difficult because we'll have to rely on the same know-how that the small arms department do to furnish our primers.

Colonel Hatcher: As a quantity production proposition the primer is not hard. The primer is a tiny thing. It has its troubles, we have

troubles with it, but when you are going good you can turn out untold millions of them in just a small place because they are so small. You have these automatic machines that just stamp them out in a hurry. In the old days after all these artillery primers of different kinds, the caps, etc., were initiated the thing started to go off in the fuse. Each time a man got one which did that he would draw himself up a primer and you had a lot of them that were a whole lot alike. As Captain Rice said, we've done the very sensible thing of changing all those fuses and things that have primers and that have those caps in them and are making them all the same caps that we have in the small arms. That's a very sensible thing to do because we're always going to have those things in quantity production of small arms and the number used in artillery is just a drop in the bucket compared with what is used in small arms. You can take them right out of production and use them, but that doesn't mean we aren't going to have trouble with them sometimes. However, it does mean that it is a sensible thing to do.