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SOME INDUSTRIAL PROBLEMS OF TO-DAY.

R L Hallett May 6, 1938.

In my brief talk to-day Colonel Jordan has asked me to cover three main subjects which in themselves are quite different but which are related to fields of industry with which I have been closely connected for many years.

These main subjects are - first: the tin situation principally as it affects theeconomic position of the United States in tin supplies for industrial and military uses; second: bearing metals for automobiles and other motor vehicles, including airplanes, and third: paint with special reference to its use in the protection of ships, industrial structures and equipment of importance to the War and Navy Departments.

With the time at my disposal it will not be possible to discuss these subjects in great detail, but I will try to give you a comprehensive understanding of each of them and I feel that presenting the subjects in this general way will be more important to you than a longthy discussion of technical facts and figures which are always available and which you can obtain whenever circumstances require.

TIN

I will first briefly describe the world tin situation and will then more completely discuss the economic position of the United States in regard to this metal.

Tin is a natural chemical element and is a metal of great importance to all civilized highly developed industrial

nations. Tin is important in many industries which continuously contribute to our peace activities and is also extensively required for military purposes in time of peace and to a much greater extent in time of war.

The tin consumption of the United States during some recent years, which are typical of normal industrial activities, may be classified as follows:

Tin Plate and Terne Plate	38.3%
Solder	18.7
Bearing Metals	10.1
Bronze	6.0
Tinfoil	5.9
Collapsible Tin Tubes	4.6
Various Tin Chemical Compounds	4.8
Tin Oxide	1.5
Tin Coatings(other than Tin Plate)	3.9
White Metal Alloys	1.4
Type Metal	.5
Tin Castings	.8
Various other alloys	.7
Miscellaneous	2.8
	100.0%

This table indicates the importance of tin in various industries and it will be seen that the consumption of tin in tin plate, solder, bearing metals and bronze represents 73.1% of the total tin used for all purposes. These four classes of tin products are obviously of great importance in many industrial operations and tin for these purposes is practically indispensable for military operations in which tin plate containers are necessary for maintaining food supply, bearing metals are vital in the operation of ships, motor vehicles and airplanes, bronzes are required for many kinds of equipment and for munitions, and solder is used for purposes almost too

numerous to mention.

During recent years the tin production of the world has varied from something over 90,000 long tons at the bottom of the depression in 1933 to slightly more than 200,000 long tons in 1937. During these same years the virgin tin consumption of the United States has varied from about 61,000 long tons in 1933 to about 86,600 long tons in 1937. These statistics show that the United States consumes approximately half of all of the tin produced in the world and the serious economic position of the United States is due to the fact that substantially no tin is produced on the North American continent. A very small amount of tin is recovered from the gold placer mines of Alaska and an almost infinitesimal amount comes from occasional prospects in different places, but practically speaking, the United States is entirely dependent on other parts of the world for its tin supply.

The principal tin producing districts of the world in the order of their importance are - Malaya, Bolivia, Dutch East Indies, Siam, China and Nigeria, with much smaller and comparatively unimportant production from Australia, Great Britain and Burma. Malaya, including the Federated and Unfederated Malay States, is now producing about 39%, Bolivia about 18%, Dutch East Indies about 20%, China about 5%, Siam about 8% and Nigeria about 5% of the total production of the world and these major producing districts represent about 90% of the total tin production.

The location of the tin mines in these various countries is only part of the economic picture because the smelting of the tin ore to produce refined tin is done in a few very large efficient smelting plants which are located in England, Straits Settlements, Dutch East Indies, Holland and Belgium and the actual source of the refined tin metal is in these countries where the tin ore is smelted. This complicates the situation concerning the availability of tin in time of war because the securing of a tin supply requires operation of the mines in the places where they are located, the transportation of the tin ore to the great smelting districts and the transportation of the refined tin metal to localities where it is consumed.

There is authentic occurrence of tin minerals in many places in the United States, widely scattered and located in a number of different states. Considerable publicity has been given to some of these tin occurrences and in a few places considerable sums of money have been expended in an endeavor to develop tin supplies. The failure to develop producing tin mines in the United States is not due to any lack of perspective, technical knowledge or aggressiveness on the part of American industrialists but is solely due to the fact that even after many years of most intelligent and continuous search no commercial tin deposits have been found.

Many of the claims concerning the value of American tin occurrences have been made through ignorance or to promote the sale of prospects or aid in the flotation of stock in connection with properties which have never been developed sufficiently to warrant any conclusion that they have even the promise of becoming commercial sources of tin supply.

Because tin mineral actually does occur in some places in the United States it may be reasonable to find that many people who are not familiar with mining or the tin industry, including some legislative and executive officials, may readily accept the idea that all that is necessary is to spend sufficient money for development to change some of these slight tin occurrences into important tin producing mines.

Although it is probably obvious, I would like to comment that there are in this country very large industrial operators vitally interested in tin who would welcome without reservation the development of a domestic tin supply. Many of these operators have spent large sums of money in prospecting, examining and developing all tin prospects in this country which have even the slightest indication of having commercial value. There has been no lack of effort and no lack of financial resources and some of these large operators with staffs of the most experienced mining engineers and metallurgists have made every possible

attempt to find tin in commercial quantities.

The tin prospects most frequently mentioned, such as those in North Carolina, South Dakota, Virginia and some other states, have been examined many times and private interests have investigated them at great expense by prospecting, drilling and in some cases by extensive underground mining, often requiring the work of large field parties of engineers for long periods of time. In our own files we have engineering reports on practically every occurrence of tin in this country and in Mexico, most of which have been examined by our own engineers at great expense.

There has never been and there does not exist to-day, any point of view on the part of tin industrialists in this country which would make them in any way favor the suppression of any possible domestic tin supply and the interests of American industrial operators would be greatly advanced by the development of domestic sources of tin.

BEARING METALS.

I will not try to discuss the problems involving the use of bearing metals for all kinds of machinery bearings but will briefly mention some of them and will more fully describe the use of bearing metals in motor vehicles and airplanes.

Generally speaking bearing metals most widely used may be divided into four classes according to composition which we might designate as tin base alloys, lead base alloys, lead hardened with small amounts of other elements and lead-copper bronzes.

Stationery machinery bearings are of many different kinds and operate under many different conditions varying from high speed and light pressure to low speed and heavy pressure. I will only comment that bearing metals of the proper class and formula may be selected to meet any bearing requirements in this field.

One of the large uses for bearing metals is in journal bearings of railroad cars and locomotives and while railroad equipment is of great importance, I will pass over this part of the subject very briefly. For a number of years there has been a rather general practice in railroad bearings in which much of the bearing metal used has been of the lead base type. The metal most generally used has been an alloy containing about 85% of lead, 10% of antimony and 5% of tin.

During the last two or three years a rather definite change has taken place in railroad bearings which has resulted in the growing use of such alloys as Satco Metal which is essentially lead hardened with small amounts of calcium and tin and lesser but important amounts of other elements. Bearing metal of the Satco type has many advantages in railroad service as it has not only the desired hardness and anti-friction characteristics under normal operating conditions, but also performs particularly well at elevated temperatures where bearing metals of other types may fail.

One of the important bearing problems in the automotive field is the main crank shaft and other engine bearings for passenger automobiles, busses, trucks and lorries. This is high speed service and during recent years with increased cylinder compression and greatly increased engine power, continuously greater duty for such bearings has been required. For many years tin base bearing metals of the Babbitt type have been extensively used in automobile engine bearings and probably such bearing metals are used to a greater extent than any other type by most of the automobile engine builders in all parts of the world at the present time.

Several years ago when engine operating conditions were not so severe, these standard tin base bearing metals met the requirements fairly well but in modern automobile engines with very

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much more severe operating conditions, many failures with the tin base bearing metals have been experienced. Such metals are not altogether satisfactory particularly when the bearings become overheated because of faulty lubrication or other abuse to which they may be subjected. The difficulties are increased by the fact that the tin base bearing metals are very expensive and close competition in automobile production has resulted in the use of exceedingly thin bearing metal linings which fail rapidly under adverse conditions.

The manufacturers of automobile engines are seeking bearing metals with desired hardness, proper anti-friction qualities and reasonable performance even when overheated or otherwise abused. A number of new bearing metals are being tried and considerable experimental work has been done with lead bronzes, cadmium hardened with nickel or cadmium hardened with silver and lead hardened with calcium and tin such as Satco Metal. Bearing metals of the Satco type in particular are growing in importance in diesel engine use as they have certain inherent advantages, especially continued performance at abnormally high bearing temperatures, which strongly recommend them.

The subject of bearing metals for airplane engines has probably been given more attention and has required more scientific development than any other bearing metal problem.

The development of airplanes and airplane engines has been so rapid with increasing speed, very greatly increased power

and much longer flight range, together with limited load-carrying capacity, requiring minimum oil consumption, that bearing metals which have been satisfactory for a short time have often soon proven inadequate and increased service requirements have forced the development of newer bearing metals to meet the needs. To-day airplane engines may be required to operate over very long distances between oil changes and general overhaul so that the bearing metals must be perfected to the greatest possible degree.

Airplane engine service differs materially from automobile engine operation in that repairs usually cannot be made as frequently, minimum lubricating oil consumption is exceedingly important and partial bearing failure must not completely cripple the engine so as to cause a disaster which not only may totally destroy a valuable airplane with loss of life, but may seriously cripple the air force when full strength is badly needed.

The principal requirements for airplane bearing metals are toughness, hardness, compressive strength, fatigue strength, some degree of plasticity to conform to shaft imperfections and evenly distribute the load, good casting qualities and resistance to corrosion from commercial lubricating oils. At the present time there are two principal types of airplane engine bearing metals in wide use. Certain special tin base alloys are most generally used in England and Europe and some of the lead bronzes are extensively used by American airplane manufacturers, although the trend in this country is now toward the British tin base type of bearing metal.

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The outstanding tin base bearing metal of the British and European type is the alloy known as Hoyt No. 11, which, in its present form is the outcome of more than 25 years of research and development. This metal contains a very high proportion of tin with comparatively small amounts of other metals added to give hardness, anti-friction qualities, resistance to corrosion by lubricating oils and other desired characteristics. The Italian Armada of twenty-four Savoia-Marchetti seaplanes, each equipped with two Isotta-Fraschini 750 HP engines which under the command of General Italo Balbo flew from Italy to America and return in 1933 had the connecting rod and main bearings lined throughout with Hoyt No. 11 bearing metal. This is a good illustration of the present European practice.

Bearing metal of the Hoyt No. 11 type is in wide use in army and navy airplanes of England, France, Italy and other European countries as indicated by the long list of prominent builders who use bearing metal of this type in airplane engines for military service. Among the British and European manufacturers who use Hoyt No. 11 in airplane engines, the following may be mentioned:

<u>England</u>

<u>Messrs. Armstrong Siddeley Motors, Ltd.</u>
"Tiger" and "Genet" radial engines

<u>Bristol Aeroplane Company</u>
"Pegasus" and "Mercury" engines

<u>Messrs. DeHavilland Aircraft Co., Ltd.</u>
4-cylinder in-line "Gipsy Major" and
6-cylinder in-line "Gipsy VI" engines

France

Messrs. Gnome et Rhone
Radial engines

Salmson
Radial engines

Lorraine Dietrich
12-cylinder in-line 'V' engines

Italy

Isotta Fraschini
12-cylinder in-line 'V' engines

Alfa Romeo
"Pegasus" and "Mercury" radial engines made under British license

Piaggio & Co.
Gnome & Rhone licensed radial engines

Czechoslovakia

Walter & Co.
Radial and in-line engines

Praga
12-cylinder in-line 'V' engines

Avia (Skoda Combine)
12-cylinder in-line 'V' engines made under Hispano license

Bata
Small sports type engines

Poland

Polish International Aircraft Works
"Pegasus" and "Mercury" engines made under British license

Roumania

Industria Aeronautica Romana
Radial and in-line engines

In the United States builders of military airplane engines have diverged somewhat from the British and European practice and perhaps to some extent have not taken advantage of bearing metal experience as rapidly as the foreign manufacturers. For a number of years the principal bearings in many American airplane engines have been made with lead bronzes which, strictly speaking, are not alloys but are mixtures of lead and copper containing from 25% to 45% of lead in the form of particles intimately dispersed through and suspended in the copper. Typical lead bronze bearings of this kind were used in the fleet of United States Army airplanes known as the "Flying Fortresses" which recently completed the flight to Buenos Aires and return.

Lead bronze bearings are still used quite extensively by American military airplane engine builders but there is a strongly developing trend toward the use of tin base bearing metals of the Hoyt No. 11 type as the more recent changes in engine design and performance requirements are beginning to demonstrate that bearing metal of the Hoyt No. 11 type is more satisfactory than the lead bronzes.

The lead bronze bearings have given good service in many ways but they have certain inherent disadvantages such as difficulty in remelting and casting the metal, the necessity for the use of very hard shafts and larger clearance needed between shaft and bearings which results in excessive lubricating oil consumption and sometimes causes bad vibration. The Hoyt

No. 11 tin base bearings on the other hand may be used with unhardened shafts and they operate with minimum oil clearance which greatly reduces oil consumption and is important in connection with the limited oil supply which airplanes are able to carry.

PAINT.

We all realize that the general subject of paint is a very broad one including paint products of many kinds used for the protection and decoration of an almost unlimited number of structures, buildings, vehicles and a multitude of objects familiar to all of us and more or less important in our industrial operations and in our daily lives. The general facts about paints and painting are available in reference form when required and I am not going to take time to discuss the complete subject of paint as I think your particular interest lies primarily in the use of paint for the protection and to only a slightly lesser extent for the decoration of structures and equipment which are under the supervision of the War and Navy Departments.

Probably the most important use of paint in connection with military operations is on steel ships which represent exceedingly large investments and which must permanently be kept in perfect condition not only to preserve such valuable equipment and give it the fine appearance of which a great nation may be proud but also to insure that the ships of the Navy will always be in perfect condition so that they will function with the greatest efficiency whenever required.

The fundamental problem in the painting of steel ships is the permanent protection of the steel against corrosion. Steel is a wonderful construction material without which modern navies could not exist but with all its unique and marvelous qualities which render it invaluable for the purposes for which it is used, steel

has one great weakness because the natural elements will corrode and destroy it more rapidly than almost any other material. For this reason the painting of steel ships is not only important, but is really vital because they can be preserved in no other way. The painting of steel ships has received the greatest consideration and the most scientific study through all the years since steel was first used in ship construction.

The problem of ship painting may briefly be stated as being divided into three rather distinct divisions requiring different paint materials for the three quite different purposes. The first and fundamental problem is to select the paint for the priming coat which must be applied directly on the steel surface to furnish the greatest possible protection against corrosion and permanently preserve the steel. The second requirement is for paint to be applied over the priming coat to aid in the protection of the steel and also to give a fine decorative appearance to the finished painted surface. The third requirement is for anti-fouling paint for the outer coating below the water line to prevent the adherence of marine growth which forms very quickly, particularly in some waters and which when present to any considerable degree greatly retards the speed of a ship with the result that fuel consumption becomes very excessive and of even more importance - the efficiency of the ship is greatly reduced perhaps even to a disastrous extent when maximum speed may be required in naval operations vitally important to our national welfare.

For very many years the navies and also the merchant marines of the world have relied on red lead paint as preeminently the outstanding paint for use next to the steel for protection against corrosion. At the present time the United States Navy specifies that the priming coat on all steel ships shall be pure red lead paint or paint containing a large proportion of red lead with pure red lead paint favored where maximum protection is required.

There are two generally accepted practices in regard to the paint to be used over the red lead primer for the white or light colored finishing coats on ships. One practice consists in the use of pure white lead paint, if a white color is desired, or tinted to a gray, tan or other color as required. The other practice involves the use of white or tinted paint containing a large amount of titanium pigment, either in the form of Titanium Dioxide or Titanium-Barium pigment, together with some other hite pigments. Titanium Dioxide is the white oxide of titanium and Titanium-Barium pigment is a composite white pigment with titanium oxide precipitated on and coalesced with a blanc fixe (barium sulphate) base. At the present time the United States Navy is using finishing coat paint of the titanium pigment type although many ships of the American merchant marine use white lead paint for the finishing oats.

Both the red lead paint used next to the steel and the hite or tinted paints used for finishing coats have linseed oil

type vehicles.

Anti-fouling paint to prevent the adherence of marine growth is essentially paint which permanently remains fairly soft and contains oxide of mercury and oxide of copper which are the toxic poisons required to prevent the adherence of barnacles and other forms of animal and vegetable marine life.

The painting practice used in the British Navy is quite similar to the American practice as all British Navy steel ships receive two coats of red lead paint next to the steel followed by finishing coats of paint made with a high proportion of white lead with some other white pigments. The finishing coats are used either for a white finish or tinted to the British Navy colors known as "Mediterranean" or "Battleship Gray". The super-structures and interiors of both the United States Navy and British Navy ships are painted substantially in accordance with the practice followed for the exteriors.

Unfortunately I am not accurately informed concerning the exact painting procedure followed by the navies of France, Germany and Italy, but the navy ships of these countries have been protected with red lead paint in the past and I think it is reasonable to assume that a similar practice is being followed at the present time.

Many steel merchant ships of different nationalities are protected with paint in a very similar way to the painting practice mentioned for the ships of the different navies. I have recently had a direct communication from la Compagnie Génerale Transatlantique (French Line) telling me that the "Normandie" has

the entire hull protected with red lead paint. I mention this fact because the painting of a ship as famous as the "Normandie" is of considerable general interest.

Of great importance to any industrial nation and to our War and Navy Departments perhaps second in importance only to the painting of ships, is the painting of steel bridges and other important steel structures.

For very many years - in fact since the construction of the famous Brooklyn Bridge in 1883 - the City of New York has maintained and been responsible for a very large number of steel bridges connecting different sections of the City. For a long time the building and maintenance of these bridges has been the responsibility of the New York City Department of Plant and Structures and for a long period of years these bridges have been painted with red lead and white lead paints. The present standard painting practice of the Department of Plant and Structures consists in two coats of red lead paint on new steel followed by two coats of white lead paint tinted to the New York City standard gray color. The bridges are maintained by the use of these same paints and any damage to the old painted surfaces is repaired by using red lead paint for spot repair next to the steel and tinted white lead paint for the finishing coats. I particularly mention this practice of the New York City Department of Plant and Structures because it probably represents the longest continuous experience in any structural steel painting.

The Port of New York Authority which is responsible for the maintenance of the steel bridges over the Hudson River between New York City and New Jersey is following a somewhat similar practice which includes the use of two coats of red lead paint next to the steel followed by finishing coats of white lead paint tinted to a gray color. Aluminum paint has also been used for finishing coats on some bridges. The new George Washington Bridge was painted with two coats of red lead paint followed by white lead paint tinted to a gray color and the recently built Triborough Bridge was painted with two coats of red lead paint with aluminum paint for the finish. The Port of New York Authority is now going through what might be considered as large scale testing of these two types of finishing coat paint and I believe they have not as yet developed a standard practice.

Two other bridge structures which have become famous examples of modern bridge building are the new Golden Gate Bridge and the new San Francisco-Oakland Bay Bridge in California. The steel towers on the Golden Gate Bridge were painted with two coats of red lead paint which was followed by a coat of tinted white lead paint containing a small amount of zinc oxide with a finishing coat of International Orange paint. The International Orange finish was used to make the towers outstandingly visible to airplanes and ships which so frequently pass this structure across the Golden Gate.

The suspended structure other than the towers received three coats of red lead paint followed by a finishing coat of International Orange paint.

The San Francisco-Oakland Bay Bridge which had an estimated cost of $55,000,000 had the steel work painted with three coats of red lead paint with a finishing coat of aluminum paint. It was originally estimated that the painting work on this bridge would require 110,000 gallons of paint.

Such practice as I have described for the painting of steel ships and steel bridge structures applies equally to all other steel structures and equipment which must be preserved for extended or even short periods of time.

Another general field of painting is in connection with wooden buildings and wooden structures of different kinds. The painting of wood surfaces presents a different problem from the painting of iron and steel because wooden surfaces do not rust and corrode through chemical action when exposed to the weather but wood does fail through mechanical weather action which causes warping, cracking and slow disintegration of the wood structure.

Painting is, therefore, required to preserve wood surfaces and of course also to decorate them because, particularly in the case of residence buildings, decoration is quite frequently more important than preservation as residences are often repainted to improve their appearance when they still are sufficiently well painted to preserve the surface.

There are two general schools of painting in connection with wooden buildings, one of which is the use of pure white lead paint, either white or tinted as desired and the other is the use of

paints containing white lead with other white pigments and these paints also are used either white or tinted.

White lead is the oldest white pigment and has been used in paint for many generations. It is the only white pigment which alone can be used to make entirely satisfactory paint for wood surfaces. Many millions of gallons of white lead paint are applied every year on wooden buildings in this country and a well established procedure has been developed. In general three coats of paint on new wooden structures and two coats of paint for repainting are to be recommended although where the greatest economy is necessary and the most satisfactory results may be partly disregarded, some fairly satisfactory work is done with two coats of paint on new buildings and one coat for repainting when old paint is in good condition.

The other school of painting which makes use of white lead together with other white pigments in paint for exterior application, requires a high proportion of white lead as one of the essential pigment ingredients and in modern practice such paints almost invariably contain fairly large proportions of titanium pigment in the form of either Titanium Dioxide or Titanium-Barium pigment. In some of these paints lesser proportions of zinc oxide are also used.

The vehicles for exterior paints including both pure white lead paint and also mixed pigment paints containing white lead and other white pigments are essentially linseed oil with some turpentine and drier.

These comments refer principally to exterior painting and of course the painting problems are innumerable and cover requirements of all kinds such as interior flat finishes, interior enamels, automobile finishes and industrial coatings of many kinds. I will not attempt to go into the details of these various painting problems or discuss the paint products and materials that are used as I feel this rather comprehensive outline of paint and painting I have given you is what you would like to have presented for your general information.

R. L. Hallett.

May 6, 1938.

Inserted Comments to Attached Lecture by Dr. R. L. Hallett,
National Lead Company

No. 1.

Colonel Jordan, Gentlemen - as usual, such courteous introductions make the performance of the speaker even more difficult than it might have been without it.

This morning I will try to interpret what I think Colonel Jordan had in his mind when he asked me to talk to you again this year. These three subjects, as he has told you, are not very definitely related; you might almost say are hardly related at all, and as he has also told you, it is because of our particular experience in all of them and your interest in all of them that he has combined them for the program today. I am going to try to cover the three subjects first rather broadly and then instead of trying to have in my own mind further details that you would like to know and present to you I would rather leave it to you to bring out questions for discussion of any details that you would like to cover further.

No. 2.

These are exact figures covering a period of several years which include years of somewhat reduced activity, medium activity and fairly high industrial activity, so I think they are a pretty fair picture of the present requirements of tin. This simply shows the purposes for which tin is used, for the United States as a whole under such industrial conditions as exist at the present time and probably will continue.

No. 3.

I will next refer to the second table (table on board) which shows the percentage production from the important producing districts of the world and gives a very good idea of where tin is and where it can be obtained, bearing in mind that the tonnage consumption of the world in various countries varies greatly, depending on the industrial conditions or war conditions; in other words, depending on conditions which influence the need of tin for the different purposes.

Before we pass this table I would like to make a few further comments concerning it. For quite a number of years, beginning about at the bottom of the depression, an attempt was made to control the production of tin because the prices had fallen to a point where tin could not be profitably produced and the supplies had risen to what for tin were enormous figures, so that from a commercial position tin

was suffering along with every other basic commodity of the world. There have been many attempts at cartel control of raw material supplies or basic commodities produced. In almost every case they have failed. There was an attempt to control the rubber supply. It failed completely because there were not enough nations went into it. There has been some attempt to control coffee; there has been a steel cartel in Europe; there have been other attempts, I should say largely unsuccessful and in nearly all cases they have failed because it has been impossible to get a sufficiently large percentage of the production into the cartel to make it effective. Tin, however, is in a unique position. You will see that practically all the tin of the world comes from Malaya, Bolivia, and the Dutch East Indies, with China, Siam, and Nigeria adding the other tonnages that are in themselves individually important. You will note that those countries in which tin is produced are the, we might say, less civilized countries in our world today. They are countries in which there are no industries. In other words, they are countries which consume practically no tin themselves. There is a unique position in tin in that all of it is produced in countries which have no tin requirements and consume no tin and it is used in great important industrial countries that produce no tin. The tin cartel was set up and the control committee was formed, finally with complete support of the government's controlling the countries in which the tin is produced. If you depend on individual mines, individual operators, to support a cartel it might be done but it is difficult. Here was a case where all they had to do was control the exports because tin had to be shipped from the countries producing to the countries consuming and it was an easy thing for each government to control the exports. That is exactly what they have done and they have created a very successful control of tin, so much so that from, I think, ninety to a hundred pounds per long ton in London tin rose to about two hundred seventy pounds per long ton in less than two years. In the face of restricted industrial activities, gentlemen, that is a real accomplishment. There are pros and cons for that sort of thing but from the point of view of the people who were trying to do it it was a real accomplishment. That control exists today. I think you would be interested in the basis of the operation. They took substantially, I think, 1929 production from each country, that constituted the base figure for each country; then they established a percentage quota for each country, which was very low for a while. The committee meets regularly, they occasionally change the percentage quota and there has been some readjustment of the base tonnage. That substantially is the way it operates. Each country has a quota under which it can continue and it is a definite monthly tonnage quota for export. Each country, through its own government management, has the responsibility of distributing that quota among the individual producers, the individual mines as the case may be.

While these figures represent actual statistics, I think you should take them as meaning principally that they indicate the places from

which tin in large quantity at competitive cost can be produced. These countries would not have dominantly reached these high production figures unless they were economically able to compete against any other source in the world.

What I want to bring out, however, is that any one of these is operating under restriction and in time of necessity, let's say in time of war, any one of them could have these productions increased enormously. Malaya, Bolivia and the Dutch Indies could be called on for perhaps twice their present tonnage production very quickly, and in time for even larger amounts. In other words, the production in amount is not dependent on the ore reserves, it is dependent only on the size of the mills and the mines capable of cleaning and concentrating the ore for shipment to the smelters. With just those comments I will go on.

No. 4.

Gentlemen, I have made those comments in just that way because the question of the American tin supply has been a very greatly confused issue for a long time. Congress has made at least one very extensive and costly investigation. I understand they are considering going all over it again. There have been claims that there are occurrences of tin which could be developed to meet the entire needs of this country. I am frank to say there has not been a property mentioned in any such way as that that we ourselves have not thoroughly examined. Usually the people who talk about those things have not spent anything to look at them, to really examine them. It is one thing to drive over property and read a lot of reports that date back to 1880 and reports of the United States Geological Survey; it is another thing to put a party of a dozen men into the field and keep them a month with a drilling rig and actually find out what is in those properties. That is what we have tried to do for every property which has been presented with any degree of even suggested value. No one has any thought of preventing investigations which might be to the value of this country but I would like to leave with you the thought that as far as the men best informed in this industry are concerned there is only one safe procedure for the United States and that is to realize, and realize fully, that our tin has got to come from one of those sources.

Next, gentlemen, I will try to briefly cover the subject of bearing metals in the form I think it may be of the greatest interest to you.

No. 5.

I might simply comment, gentlemen, that over a long period of years this question of anti-fouling paints, their efficiency and their

toxic poisons, has been studied in very great detail, resulting in what I think has almost become the standard of the world in accurately determining the amount of oxide copper and oxide of mercury required in anti-fouling paint for different types of waters in different parts of the world; so that to a considerable extent the guesswork on anti-fouling paints has been removed. These typical paints of the United States Navy reflect the work that has been done in that connection. Anti-fouling paints are consistently rather soft because even the most efficient toxics that have been found are only partly successful; by that I mean are completely successful only for a certain period of time. I know there are some Navy men in the room so I hesitate to try to speak with too great assumption of accuracy, but I believe the ships of the United States Navy are repainted on the average of about every eight months to keep them in perfect condition. Perhaps I am a little bit wrong in the figures, perhaps they are not drydocked quite that often, but the efficiency of these toxics is partly due to the fact that they are slightly soluble in sea water and they maintain a poisonous condition at the surface of the paint on which the marine growth will not develop. Eventually this toxic poisonous effect becomes lessened and finally marine growth does begin to form so that at proper intervals ships must be drydocked and scraped and repainted. That is one reason why the anti-fouling paints are always rather soft, so that when they go into drydock they may be scraped quickly and with less consumption of time and labor. Nevertheless, they must be form of paints which will continue to adhere closely to the hull of the ship throughout the service period required - a rather nicely balanced problem but I think being handled today fairly well.

No. 6.

Gentlemen, it would be imposing on your time entirely to say anything more about the painting practice of the American Navy because the Navy Department publishes it in every detail in the Navy booklet entitled "The Painting and Cementing of Vessels", which they get out at frequent intervals and keep up to date.

Colonel Jordan, I would like to comment that I have been a little bit surprised over a period of years by the fact that the United States Navy publishes in a large booklet what certainly appears to be every detail of the painting practice in the Navy for every purpose, and it is almost beyond possibility to get any information from any other navy in the world. I tried two or three years ago to check up with some of my very good friends in England on the British practice. They told me at that time it was impossible to give me anything, and these are people in the largest industrial paint circles in England, very intimate friends of mine. However, in preparing this paper I wrote one of my good friends again and asked him what he could tell me. He gave me the information which I have given you today, which is of course not detailed formulas (which I was not even

free to ask for) but an authentic statement of their practice. I just make that comment in passing. We do not seem to feel the necessity of the great secrecy that some other nations do. I think probably we are right and they are wrong, but it has interested me.

No. 7.

You probably know that International Orange, which now has practically international acceptance, is simply a brilliant orange which has been adopted as the best warning signal for airplanes, and it is being used quite extensively.

Discussion following Lecture by Dr. R. L. Hallett, National Lead Company, New York, New York, May 6, 1938 - "Tin, Bearing Metals and Paint".

Q. Sir, in case the world situation indicated the necessity for our smelting tin in this country, would you care to express an opinion upon the length of time required for us to get the tin smelting industry for, let us say, Bolivian ores into production?

A. I think I can answer that with a very reasonable degree of accuracy because during the World War we did just that, and our Company is the one that built the first and largest tin smelter in this country. It just so happened that during the year that we put up that smelter I was assigned to the job for my entire time. At that time we were getting all of the tin for this country from the smelters in Liverpool, Malaya, and Singapore, and the need was quickly recognized for a more adequate and certain supply. Under complete Government priority orders, working almost without regard to cost, we put up and had ready for operation that tin smelter in from three to four months. It was a fairly large plant because our tin requirements are large. There is no use putting up a tin smelter that will only furnish half your supply. Furthermore, that smelter was built to melt Bolivian ores. It is just something given us by nature that we can not help, but the ores of Malaya are very pure. A simple smelting operation reduces the ore to metal and a very simple refining makes a pure ore - largely accounting for the very high reputation of so-called Straits tin. On the other hand, the ore from Bolivia is the

most impure ore in the world, requires far more intricate smelting and refining methods, so that a smelter to smelt Bolivian ore is a much more complicated plant than one to smelt Malayan ore. Even after the smelter was finished it took some little time before it was operating smoothly and performing satisfactorily, but I think that within from four to six months, and perhaps even a somewhat shorter time, we could get into operation a smelting plant to smelt and refine Bolivian ore. I would like to make just one other statement here. It just so happened that our Company for quite a period of years had been heavily interested in the tin mines of Bolivia and in the Williams Harvey Smelting Company in Liverpool, so much so that we had complete details and complete intimate contact with everything. When we started to build the tin smelter in Brooklyn early in 1918 we brought over from England exact detailed working drawings of every unit and item of a tin smelter. We brought over their engineers and their operating superintendents. Our plant was put up here under those conditions which, you can easily understand, were ideal for the most rapid work. It was very fortunate that we had that contact. We still have it. I hope we continue to have it because we have not had a tin smelting industry in this country since 1922. In another few years (and almost now) we will have lost the technique of tin smelting. There are only two or three of us still active today who took part in the tin smelting industry in this country at the time we had it. We will not be here forever, and again it will be necessary to bring to this country the necessary knowledge. Generally informed metallurgists can not build a tin smelter. They

have to have the details. Some of them are highly confidential. I simply must make those comments when you ask me how long it will take. If we can do it under the favorable facilities we had before we could do it in two or three months; otherwise it would all be a question as to how long you would have to operate it after it was built before you could make suitable tin.

Q. I would like to know what progress has been made in recovering tin from scrap, tin coating, tin bearings, etc.?

A. Frankly, very little progress has been made in recovering tin, pure tin, of virgin tin ingot quality, for the simple and only reason that it costs very much more to get it back out of mixed scrap than it does from virgin tin ore, and in our commercial world which must be run essentially on sound commercial economics that is not possible. However, most all the tin that goes into use for any purpose comes back in some way. There is some satisfactory tin comes back from tin plate, from the detinning of tin plate. Some fairly pure tin comes back that way. However, after you have put tin into solder-bearing metals, bronzes, and they come back to the junk smelter and are reduced, we get a mixed metal. We do just as little on that mixed metal as we possibly can to convert it into some salable alloy. We may have a solder element come back that has a little antimony in it which spoils it for solder. We take the antimony out at fairly high cost, get a solder base, maybe very low content, sweeten it up with a little pure tin, and the lowest cost is a good copper going back into the market. We could not take the lead and tin and separate

them because it would cost very much more than to bring virgin pig lead and virgin tin. That is the best answer I can give you. Metallurgically it would be possible perhaps to get back some pure tin from recovered scrap. Commercially it is utterly out of the question and even metallurgically it would be very very difficult; in some cases impossible; in others it could be done but it would be done at quite high cost.

Q. I would like to ask about paint, Doctor. In 1934 we painted one of our posts completely under P.W.A. labor with a new type of paint known as Malita. Many of the quarters were over a century old. They were very thickly crusted with paint. Nevertheless, we put this coat of paint on top. The following spring the paint had come off almost universally in great big thick patches down to the very bare woodwork; made all the houses look as though they had smallpox. We could not get the rest of it off. The explanation was given that the new paint, when put on, had a different expansion coefficient than the old paint, which was probably a lead base or something of that nature, and that consequently it expanded during the winter at a greater rate than the old paint, curled up on the edges, and came off in patches about a foot in diameter. When painting with a newly developed paint should one be careful to analyze the relationship between that and the old paint?

A. I am going to try to answer that in as commonsense way as I can. In the first place, paint is not a solid material. It has

no defined measurable physical concept; it has no expansion coefficient of elasticity; it isn't that kind of thing. It is a plastic material. I do not think there is any such thing as feeling that two paints must be similar to be applied one over another with satisfactory results. My answer is that they must both be soundly good paints within themselves. Then I think you will have no trouble. But, if they lack adhesion, if they become so brittle after they get old that they no longer are sufficiently plastic to follow the surface movements, then you may have trouble. They may pull away from the paint under them; they may pull the old paint off with no fault of the old paint, but there is not any sound reason to think that one thoroughly good paint may not be applied over another thoroughly good paint even if they vary greatly in composition.

Colonel Jordan: This occasion was at Fort Monroe, sir, so if you ever go down there I hope you will inspect some of those buildings.

Q. I looked up the formulas of paints that were being bought at one time that seemed to consist of about ten per cent ground sand. The idea was advanced, since it was a house paint, that it really was all right - that was one way of making paint. Was that a good buy for the Government - that kind of paint with sand in it?

A. You mean as part of the pigment ten per cent was silicon?

Q. Yes sir, that is what they called it - silicon.

A. Frankly, I have never seen a proper place for those so-called ex-standards, which is what they are, in paint. They have no hiding power. I mean, the refractive index is so close to that of

linseed oil that they are quite transparent when they are put in the oil, but some manufacturers have stated that a small amount is of some advantage. I think I would simply like to answer you by saying that the United States Government, through the Bureau of Standards, (and they do a very large amount of the work on paint and have adopted many Federal specifications) has adopted a specification supposed to be acceptable to all Government departments for exterior paint not requiring but permitting not to exceed ten per cent of such material. I can only say to you that that paint is good delivery under the Federal specification. While I have never seen any real advantage in adding it, and of course it is always cheaper than the other pigments, I think I have seen no great disadvantages in it. I would like to be in the position of supporting the Federal specification because they have seen fit to do it after, I think, very careful consideration and sound judgment, so I would not have any serious criticism of the ten per cent maximum permitted by the Federal specification.

Colonel Jordan: If you were painting your own house you would not use it?

A. I would not, Colonel.

Q. I understand that a number, well all, of a type of recent pursuit planes have been grounded, motor failures, due to silver bearings. Would you care to say anything about the advantages or disadvantages of this silver bearing?

A. Colonel Jordan, while I have tried to follow as closely as I could most of the technical lines our company is interested in

necessarily I have not been able to follow some quite as closely as others. Bearing metals is one that I feel I am not quite as familiar with as one of my associates and I, therefore, brought Mr. H____ with me and I am going to ask him to answer any questions on bearing metals.

Mr. H.____: On the question of the new silver bearings, to overcome the difficulty you mention I understand they are doing some work in plating the silver along with lead out on the bearing back, the lead having anti-friction properties, in the hope that this will overcome that trouble. It is still, you might say, in the laboratory stage. I do not think it is in production yet; more or less experimental.

Q. Would you care to comment, Doctor, on the percentage of known reserves in metal in those (indicating chart on board) various countries?

A. Those reserves are entirely a matter of public record. Every prominent tin mining country in the world gives out an annual report and in almost all cases they publish their reserves. For instance, I can tell you that the Bolivian tin reserves today are at least more than a normal year's output of tin. Let me comment there that this is not a question of the reserves that actually exist. These are very large mines and in these deep mines the development of reserves is enormously expensive. It means that your mining operations have got to be carried way ahead of your present ore recovery, your present stocking of ore for present use; so that to develop a reserve from the conservative engineering point of view your vein has to be cut on

four sides, measured and sampled. Then you have a reserve. Up to that point you haven't. If it is only cut on three sides you have a reasonable estimate that there is quite a lot there. If it is only cut on two sides we do not give it more than twenty-five per cent of what is indicated. So you can see that in deep mining, which is very expensive with tunnels and raises and drifts, the development of an ore reserve is an expensive thing because it is all work and we have to handle the underground water with pumping in all the new work. The ore reserve is not carried beyond the present working levels any more than conservative good judgment makes sure that the mine is in shape to go ahead with. I would say that while we know the present developed ore reserves, that is no indication of what is in the ground. I think you can see that it is a compromise between what we can afford to do in sound business. Mining is not speculative. It is just as sound a business as a manufacturing plant if you run it the right way. At least I can say that in Malaya, Dutch East Indies, and Bolivia there is no lack of tin ore reserve today to be any threat that we would not be able to get enough tin or that it can be recovered only at a very high cost, as far as we can see into the present future. China has a very large ore reserve. We had some engineers go over the Chinese tin districts several years ago, ten years ago or longer. It was when China was having her own internal troubles with her different war lords, etc., We found some very valuable tin districts but we decided not to go into them because of their internal political situation. Now their external political situation is so much worse than the internal that

it has even shot to pieces their own domestic operation. However, China is capable of a very much higher percentage than the five per cent shown here (indicating chart on board).

Q. Doctor, we have a problem in economy for using lead-free paint for the protection of certain ammunition components. Will you give us the benefit of your experience as to the better type of paint to use for that purpose?

A. Why must it be lead free?

Q. On account of certain explosives we use which are very liable to react with lead to form very sensitive salts.

A. The Federal Government has considered paint for a special purpose which seems to me is almost a direct answer to your inquiry, although the objective was a different one. There are certain sulphur compounds, particularly hydrogen sulphide which is one form of sulphur gas given off in certain places, certain sulphur water wells and springs (not very many but there are a few). There are certain places in the country that still permit sewage disposal into a flowing stream where locally there is little concentration of sulphur, and some of the gas wells give off some sulphur. Hydrogen sulphide, sulphur in this form, (and, by the way, this is quite different from sulphur from burning fuel because the sulphur in oil and coal which is always present to some extent when the fuel is burned is turned to sulphur dioxide which has no effect on the color of paint) will discolor the lead because lead sulphide is black. The Federal Government has developed what they call a gas-proof paint. It simply is titanium

pigment and zinc oxide. There is a standard Government specification to cover it. I think the best answer I can give you is, as I have always advised whenever a lead-free paint is required (usually for this sulphur condition; now you for a different purpose) to suggest that standard Government specification for gas-proof paint. It is not as durable as the other Government specifications which do contain lead and they say so definitely. They say when lead can not be used this is the best recommendation they can make. I can simply refer it to you, and if you like I can give you the number, althoughtI do not have it right here.

Q. Aluminum paint is frequently used in covering surfaces of storage tanks containing gasoline to prevent rapid evaporation. I am curious to know the reaction of aluminum paint in the absorption of the sun's rays; why that particular paint should be better than other paints?

A. That is just slightly scientific but very clear. Let me just say first that aluminum paint has never been found satisfactory next to steel. It will not prevent rust and corrosion, but by putting a satisfactory primer, such as red lead primer, next to the steel and then putting aluminum paint over it some quite good results have been obtained, and you see a great deal of it. You ask about the painting of gasoline and oil tanks. It is a question of very simple physics. Heat is in the form of wave vibration in the atmosphere, just as light is. There is very little difference between heat and light, visible light. Visible light has certain wave lengths, as they are called,

between the top and bottom of the visible spectrum. In other words, light that you can see. When the waves get longer, then at the bottom of the visible spectrum they simply become heat waves. There is a very close analogy between light and heat in fundamental physics. Here is the point: Certain surface materials reflect both light and heat and certain surface materials absorb both light and heat. For instance, the brightest white that you can find and the brightest that we know of is pure sublimed magnesium oxide, which will reflect ninety-eight per cent of all the light waves or heat waves that strike it. Let's go to the other extreme and take black. A dense black will absorb practically all the light or heat waves that strike it. That is the one and only reason why white clothing is comfortable in a tropic sun and black clothing is the most uncomfortable that you can wear. A really white suit or uniform in the tropical sun will reflect upwards of eighty per cent of all the heat waves that strike it and a black suit under the same conditions will absorb ninety-five per cent of all the heat that strikes it. Let's apply that to your oil tank. If you put a black paint on your oil tank you will absorb practically all the heat of the direct sunshine and you will get maximum evaporation of the liquid in the tank. If you put a pure white paint on you will get minimum heat absorption and minimum evaporation. As you go in between, you will get an in between result, depending on the light reflection of the particular color you use. In other words, starting with white you go through a series of light grays, medium dark grays, all the way down to black and you proportionately increase the heat

absorption and increase the rate of evaporation as the rate gets darker. Aluminum paint ranks not as a pure white paint but as a light gray. It has a fair heat reflection, comparable to a white paint tinted with a little black material to a gray color that corresponds about to the gray color of aluminum paint. It has a fairly high heat reflection but not as high as pure white.

Q. I understand the Italian navy has developed an anti-fouling paint that is practically permanently anti-fouling. Our Navy naturally has been trying to find out what it has been all about but has been unsuccessful. Can you tell us anything about that?

A. May I ask you if in any way you are referring to the so-called Moravian paint, or do you know it by that name?

Q. I do not know it by that name, but I think the information is probably correct in saying that their anti-fouling paint is nearly permanent.

A. Well, Colonel Jordan, I happen to know something about it.

Colonel Jordan: Do you want this secret?

A. I will just comment at the moment that our laboratory is cooperating with the Navy Department on that particular paint; and, frankly, that is all I can say about it.

Colonel Jordan: I am very glad to know that the Navy is on its toes, sir.

Q. In relation to the production control measures that you spoke of in connection with tin, did Bolivia come wholeheartedly into that?

A. Bolivia was one of the countries most vitally interested. Yes, Bolivia came in without any resistance. What complicated the situation a little was that Nigeria and, I think, Siam and Burma (Siam anyway) were not in the original agreement. They were not very big producers. As soon as the restriction was put in they became very much larger producers than they had been before and they were taken in, perhaps through pressure. They were given a higher quota when they went in than they would have had if they had been taken in originally. Bolivia was in it from the beginning.

Q. Can you tell us whether Japan has any concessions for control of tin in the Dutch East Indies; to what extent they control it, and whether they belong to the cartel?

A. Japan has no control, as far as I know, of tin in the Dutch East Indies. The principal tin supplies, I think those which make up almost the entire supplies, in the East Indies of any degree of importance are on the islands of Banka and _____, which are owned by the Dutch government. Up to this time Japan has had no economic importance in tin production. What is going to happen in China, I think you gentlemen know more about than I do. Japan's hope of getting a tin supply lies in China, not in the Dutch East Indies, I feel sure.

Colonel Rogers: I want to express the appreciation of those of us in the Planning Branch who have been working with raw materials for the very definite way in which the speaker expressed himself with regard to the lack of tin in this country. As you know, the Government itself has been faced with many efforts to develop a tin supply where

apparently no tin supply existed. A good deal of money has been expended. That is not only true of tin, it is also true of other materials. I wonder perhaps at the fact that the class is as clear in their conception of our problem in raw materials as they are in view of the information that at times is given them from sources which, we may say, have perhaps something to gain by a favorable expression of opinion. In other words, we have a parallel example in manganese. Of course, we have had many attempts to bring forth the favorable situation of this country in manganese. I believe the opinion of the class with regard to that is fairly well settled. I want to ask a question definitely with regard to the control of tin. In view of the fact that this country is a very large user of tin, would it not be desirable, if we could, to in some way exert a considerable portion of control in the distribution of the tin industry? And, if that is so, in the face of the uneconomical operation of smelters in this country as based on past history, would the establishment of smelters here be advisable in view of the fact that we would have to go outside and would probably have to contend with the operation of this cartel? I wanted to get the speaker's opinion upon that point.

A. The answer to that is just a little involved as it covers slightly more than one phase. In the first place, it seems obvious that to a country that consumes fifty per cent of all the tin in the world and produces none that a cartel of this kind is operating to our disadvantage. I think that does not need any further comment. However, whether we did or did not have a tin smelting industry in

this country it would be necessary to draw our tin ore supplies from countries that are strictly and fully in the cartel. Next, all of the countries in the cartel are entirely independent of us and we have no influence with them except through diplomatic relationships. In other words, they are not countries that are in any way dependencies, protectorates, and all the things that the British Empire exercises in all kinds of degrees over many parts of the world which enables her more or less to exert different kinds of influence. I think we have no political influence whatsoever except through diplomatic relations with any of the countries in the tin cartel, and they are Government activities. The tin cartel is now Government supported, and that is the only reason that it has been successful. If it had been private operation combined, I do not think it would have been any more successful than the attempt at rubber, copper, coffee, etc. Next, it would be quite possible to operate a tin smelting industry in this country but it would have to be subsidized, either by direct subsidy to the smelting operation or by putting a tariff on refined tin and no tariff on tin ore. That can always be done but if that were done it would simply raise the cost of tin to all American consumers for all purposes, because if it is a straight out subsidy whichever way you do if you are going to subsidize anything you have to increase the cost unless the Government is going to permanently pay part of the cost, and that is certainly contrary to any thought I have to sound economics. However, I will not get into that at all. The tin situation is so far from clear. It would be necessary to purchase tin under the cartel price,

which is substantially the price of London metal exchange. If it were smelted here it would be at a higher cost than if it were smelted in Liverpool and brought here so that to the consumer tin would actually cost more than it costs now. I can not see that having a smelting plant here would in any way enable us to have any influence in the price control of the tin producing countries. The only thing, perhaps, in favor of the tin smelting industry here is that in time of necessity when we could not get it abroad we would be able to produce it ourselves. Beyond that I can not see any very clear advantages in our attempting to be more in tin production than we are now. I do not know whether that is a fair answer to your question or not.

Colonel Rogers: It is a very fair answer. In view of the very comprehensive statement you have made, I would like to add another question. In view of this situation as it exists now, the fact that a tin smelter can not be established here economically, is there any other apparent answer than the establishment of what we call a war reserve as a matter of safety for the industrial activities of this country?

A. I think that is the most commonsense, logical, and perhaps in the long run the cheapest way to protect ourselves against a tin shortage. It would mean, of course, an interest carrying charge on the investment in the tin reserve. Beyond that I do not see that it introduces any great difficulty and it has the advantage of, under existing conditions as they are now or as they may be, enabling the large consuming tin industries of America to obtain their supply in

the world markets which are most economical for us.

Colonel Jordan: I might add for the information of the class that I attended a conference with Mr. Cornish, who is the Chairman of the National Lead Company and who just passed on the last day or so: Colonel Harris was there, and we asked him that question flatfooted: should we have smelters in this country? Mr. Cornish was just as emphatic as he could be. He said: "No". The question was asked: "Why do you say no?" He said: "If you have smelters in this country you have got to pay the American rate of wage and that will make the total cost more than what you will have to pay if you buy it from England after it has been smelted and transported across the ocean." He said by all manner of means just exactly what our speaker has said - put in a reserve.

Colonel Miles: Doctor, have the Philippine Islands been surveyed carefully for tin?

A. Yes, I thin't so.

Q. No show?

A. No indication of a tin supply in the Philippines.

Colonel Jordan: One member of the class said something about Fort Monroe. I want to tell something about Fort Monroe, too. I became at one time Corps Area Ordnance Officer of the Third Corps, and one of my jobs was to inspect the Coast Artillery down at Fort Monroe. I inspected the Coast Artillery carriages, and I have never seen as many coats of paint on anything in my life as I saw on those carriages. Every time they heard that an inspector was coming they

would wildly dash for the paint shop, get some paint, and smear it on. One particular carriage had fourteen coats of paint on it and under the fourteenth coat of paint was the finest coat of red rust that I have ever seen. Well, this particular battery got its sentence. That paint was scraped off down to the naked metal and we started in with red lead again to build up, and by the time we got through all of the sea coast carriages at Fort Monroe had been given the same treatment. I hope they are in good shape today. Red lead is the thing to put on metal. What other color you put on after that is immaterial, but I will tell you when you are chargeable the Commanding General of the Third Corps Area is going to hold you responsible for the proper condition of those carriages and you are going to see that there is no red rust down underneath all the paint. At least I did.

Dr. Hallett, I want to tell you how much we appreciate your coming here and talking to us, sir. I can not express enough the gratification of the school for what you have told us, sir. Thank you many times.

Dr. Hallett: Colonel, may I say that the suggestions you gave me in advance were the very greatest help because I did not know just what you wanted until you told me. It helped me very greatly.

Colonel Jordan: I hope what has been said here about bearing metals particularly is going to be of some future interest to our people in the Air Corps, because I can always visualize that bearing burning out and the aviator stopping in midair, getting out, and replacing the

bearing. That has always been a wonderful picture to me. We have got to get a bearing metal that will be satisfactory for the Air Corps, whether it is that Hoyt eleven that they talk so much about, which the Italians have been using or whether it is something else we are going to develop. We have got to get a bearing metal that will do the job. I think it is in the offing.