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THE MANUFACTURE OF STEEL

Mr. A. E. Crockett.

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Could be:
June 6, 1931.
May 4, 1932.
May 3, 1933.
May 2, 1935.
May 4, 1937.
May 5, 1938.
None of which we have.
But is since the Zephyr train.
Possibly 193

Gentlemen:

I shall forget there is a clock in the back of the room and shall have my time piece right here so if I get wound up too fast all Colonel Jordan has to do is to pull my coat tail and I will stop. Usually in addressing the class I have had a film as a reinforcement and so really talked in the dark. Today I have to come out from under cover and talk to you on iron and steel, but primarily on steel.

There have been a great many changes even since this College was founded, in the steel industry and to my mind, one of the primary reasons for the change has been due to the scientific development that has gone on in the industry. As we measure time, it is not long ago that Colonel Hunt instituted the first chemical laboratory at the old Cambria Iron Works in Johnstown Pennsylvania in 1862. They were having difficulty in the refractory of wrought iron and could not find the thing that kept them from having day after day the same grade and quality of material. They made at that time a bar which was supposed to be a very accurate bar; its finish was like the old Russian iron. When it came from the last pass in the rolls it was almost shiny. They intrdduced steam and also delayed the pass. That would hold its color for a long period but it quickly rusted. It had a tendency to become brittle and in desperation they arrived at the fact that something must be done. As a result they put Hunt there on the job and he built the first chemical laboratory in an iron mill in the United States and so designated it.

There they tested pig iron and other ores. The chemical analysis of ores is not a new thing in the industry but we did not know much beyond the fact that iron ore had a certain metallic quality, about 64%. Now that is about 62%.

From the time of Hunt on there was very little change except that there grew up a number of chemical laboratories outside of the mills. Some of them still continue. The R. W. Hunt Company still exists.

When they first went into the steel industry the chemists had a battle from the start; everybody was against them. We had men who thought that experience and special tools were adequate to make any kind of material. They knew the heat in the furnace better than any instrument could tell them, but the chemist finally found his place in the industry and that was in the 1890's when Carnegie was having a great deal of trouble. They would put ore in the Bessemer converter and it would blow off, and after much experimenting they finally found a German chemist who came over from England and found the trouble. There was too much phosphorous in the metal, and in the process, either acid or Bessemer, phosporous, unless thoroughly controlled, is one thing that will come out as slag. Then they got a steel chemist and the Bessemer converter had a wider use in the industry .

In the course of time we commenced to get a specification for steel. How are you going to get a specification unless you go back to the basic materials and even though they had put the chemist to work he did not know metals, so they brought in the metallurgist. He was looked upon at first just as the chemist had been and they formed a combination

against this whippersnapper. Soon however, some of the colleges began to train metallurgists, and Harvard University trained some in 1905 or 1909. They were young men, full of vigor and new thought but when they came up against the chemist and the old men in the industry the trouble was renewed. During the period at the end of the World War we brought a new man into the industry. The chemist and metallurgist had harmonized their interests and now we brought in a physicist - a physical chemist. He has had to go through the same experience. A lot of us have a resentment against anything that is new; we allow our prejudices to warp our better judgment. The harmonizing of these three men into the industry is a strong force and through it we came into the age of research. We have had our stone ages, our copper age and a mechanization age, and we are now getting more and more into a scientific age.

We are making only 10% of the steel in the United States yet we have 400 men either doing research work or checking qualities or anlyzing metal to produce three million tons of steel. We have stepped aside from just a pure check and balance and have set men in corners doing pure research. I must tell you about a paper written by Henning about Bessemer converters and Bessemer steel, breaking down some of the old fallacies we had about Bessemer steel. Everyone said that was wrong because it chipped easily because of free sulphur. Henning says no, and in a conclusive way, as a result of his experience with Bessemer stock.

Then in the open hearth there has been wide development from another angle - the study of the association of elements through heat. We have felt in the past that we could jam on the heat - raise the

temperatures and get a more rapid association of elements, but there is a peculiar thing. If you just watch everyday life you will find that there is a rate at which the elements of live combine and you can't force them beyond a certain point. So in steel; we found that we could not force steel simply by adding heat. At a meeting held in this city in 1918 somebody said all we had to do was to increase pressure or increase heat and temperatures and we would get the increase in metals we needed at the time. We forget that the elements - oxygen, iron, phosphorus, sulphur, etc., will only associate at a certain rate and therefore we are controlled by the laws of nature and all that science can do is to find out how that law works.

Having learned that lesson we are now putting men to work to find out if possible what changes can be effected by the combination of elements we have disregarded in the past. We are coming into a new period in America. In the late mechanization age, if a bar 1" square would do a certain service then to get a higher value of stress all we had to do was increase the size of the bar. One of the best illustrations is in the seamless tube. We believe if we could get material that would stand 250,000 pounds a square inch that we would have a material as strong as that which was formed and welded. In those days we were puncturing the earth for oil at 4900.026 feet. Well, somebody wanted to go to 7500 feet for oil and we got Grade B material that ran 164,000 pounds to the square inch. It was thought there should be a proportionate increase in the weight of carbon to be added and that worked out well in Grade B material. Putting it out in casting we could set it down to 7500 feet and be free

from the possibilities of rupture at the joint, and then industry demanded that they be put down to 9000 feet. So we got a Grade C and in that moment when we changed over to that stronger material we found we had to decrease our carbon and in a certain related portion increase our manganese. Mr. Frank Yount of Texas said he wanted to go to 11 or 12, or maybe 15,000 feet. Could we get a metal that would do it? We then got out a Grade D material in tubing that runs from 110,000 to 125,000 pounds per square inch and they had set a casting at 11,233 feet at Odessa.

That work has been the direct result of science in the industry enabling us to find out how elements would function one with the other. While we were developing our carbon steel and learned to appreciate the value of silicon as a strengthener of metal we learned it was possible to roll silicon steel and roll it advantageously. There was an idea we could not go over 1½% in manganese - it would explode. That is past and gone. We know more about the association of elements.

All these years we have been fighting a battle against corrosion and one of the great elements we thought would help would be copper. Then we got over into chromium and nickel, and particularly when we got into stainless steel we felt we had a metal that was strong and non-corrosive and that our trouble was at an end. That is one of our great difficulties - we seem to feel that we can with one stroke arrive at a panacea for all ills and our troubles will be over. In the stainless steels in many instances they did a wonderful piece of work. I can see the circulars distributed at Tulsa several years ago in which they made the statement: "At last your problems are over. Use 18.8 for

purposes and high temperatures and you have solved the corrosion problem." Recently in research made by the University of Michigan for the Timken Bearing Company it was found that there was certain brittling of the materials that go into steel at high temperatures and therefore they were not so sure the pipes would not burst. There were certain pipes that did burst in Texas refineries. They are trying to get something tougher and finer and they are making progress to a point where they will take temperatures up to 2000° and get away with it. If you can prevent stainless steel from becoming scratched, and it takes a good deal to scratch it, - if you can keep the polish in good order, you are pretty safe from corrosion starting. But we can't always control dents and scratches, and these have a great influence in the corrosion of metal. I am making that statement not from direct experience but from reports that have come into the Engineering Society at several meetings.

Originally the tensile strength of metal was the controlling factor as to the acceptance or rejection of metal. The first testing machine was a testing of a bar. Some one went to a loading platform and piled on that platform a load of stone or pig iron or anything that would give weight and then would watch what took place when the bar broke. Then came the testing machine and with it the chance to study what was happending as the load was applied, and they commenced to recognize the yield point. Today the yield point is without doubt receiving more attention so far as the ultimate use of metal is concerned than the breaking stress. Metal is only good as long as it is elastic but the minute you get a permanent set in that metal there is

nothing to say how long it will stand its capacity. That was proven very conclusively in some tests that were made by sustained loads beyond the yield point, and that is one of the reasons why they are predicating factors of safety on the yield point rather than on the ultimate value of the metal. Then came more mechanical methods of finding out how loads were sustained, why they could be applied by studying the grain structure, etc. I might say here that the microscope did not come into the industry very early. It was not until the World War that the microscope had any set place in the steel industry. Today we have our microscope for stydying grain structure, size and uniformity, etc. Five years ago there were men who would recognize what grain growth meant in steel but it was not until last year when a paper was read at the Metal Society that particular understanding was had on the subj ct. People began to advertise "controlled grain". Today there is a further step, particularly with steel under high temperatures, i.e., grain creep. We have had to have something to define the conditions of steel and today we have grain creep. That is, as temperature is applied in steel and load is applied there is a certain tendency or movement, and all steel subjected to load is adjusting itself against it. So we have grain creep and they have been able in this research made at the University of Michigan for the Timken people, to make a curve of the rate of grain creep at given temperatures. They found that up to 1150 to 2500 degrees carbon steels and alloy steels had the same relationship but when you get beyond that temperature then alloy steels were more effective and the rate of grain creep much slower. Therefore in the higher temperatures it is recommended that the

alloy steel be used but there should be a reasonableness in the use of the metals. The study should be continued of the relationship between manganese and nickel and manganese and ore and other alloys that are used. In other words, it is my thought that we are not at the end of our efforts in reseaach in steel or its possibilities. Many times I have told students when they asked "Are we at the end of research in this field", that we have only commenced to scratch the surface.

So much for the trend, possibilities and development in science. There are a great many changes going on in the steel industry today in methods of rolling. The automobile has brought about a tremendous demand for sheets that are strong; sheets that are easily worked or framed that will withstand high shock. The old hot rolled sheet as we have known it in the past is gradually disappearing and we are coming into cold rolling. I don't remember whether the class last year went to see the metal or not. There we have exerted pressure up to three million pounds against a sheet being rolled cold. A sheet is changed from 1/4 inch thick to one - the last demand I have seen is for one rolled to .005 cold without any intermediate annealing. That sheet when it comes into service can be drawnxx in form and the edges will not crack. There is another thing they want it for - a gasket cover. They feel there is a heat resisting value in the steel they could not get in copper or any other substance and they are asking for steel that is .005" thick. That to my mind is one of the most wonderful steps that has taken place in the steel industry. When you have steel in the form of a ribbon that was 115 feet long originally and pull it out to

eight or ten thousand feet and it holds its form, does not widen out and is true to diameter, that is a big step in the development of the iron and steel industry.

I speak of that particularly from the rolling angle; now we come to the fabricating side. For years and years all structure was fabricated on rivet spacing - for tanks, boats and barges, etc. They were all talking about rivets. Today, through advancement by research and constant practice we are substituting welding for that. Last week the welding people had their annual meeting in Chicago and in that meeting, judging from the paper read and talks given, there is a feeling that there has been great progress in welding, but they have only scratched the surface. There is a changeover from castings to rolled structures that will ultimately be welded. That affects you very much. Basically, of course, pig iron will not make much change except that we will be able to use light structures. Some of them feel they will be able to gain lost ground but it looks to me as if the burden of increased demand is upon the mill rather than upon the foundry. That seems to be the tendency.

That is the development. The work that is being done will unqeustionably change many of the basic figures that we established ten years ago or even five years ago. I will not go into the machine side and the influences going on there. Time will not permit. I do want to emphasize in closing, however, that science is coming into its own in the United States. The best part of it is that what we have discovered we have put into practice and in that we lead the world.

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Q - Is grain creep a refinement?

A - It is fatigue rather than an element of grain structure/ It is a change in the relationship of the grain structure. It is an adjustment rather than any refinement. When you get to 2000° there is bound to be certain change but it is more an adjustment than a refinement.

Q - You spoke about tubing and oil wells going deeper all the time. What is the possibility of alloys in that tubing?

A - There has been some little tendency to alloy but alloys of manganese are treated from the manganese standpoint rather than from nickel or other things. They have been able to do that by controlling the relationship between carbon and manganese and molybdenum . In other words your manganese is always a cleanser and purifier and so far they have done ahead on that and not so much to alloy. One company has but in the main it is manganese.

Q - When stainless steel first came out (most of our rifle barrels are made of that) we thought we had a very good thing but it did not work out. Do you attribute that to the fact that the interior of the bore is never smooth?

A - I am taking the statement of the stock room man. He said if you have any scratching you will have trouble with rust. We have never been able to get away from the good old elbow grease to keep a rifle bright.

Q - I understand a great deal of piping is stitch welded. Has any such been used for casings.

A - One company is making quite a point of stitch welding pipe for casings but the major portion of the old people feel they should use seamless.

Q - What is stitch welding.

A - It is flat fused at the weld - just as if it had been stitched.

Q - Are these new processes being more or less controlled by patents through a particular organization but available through license?

A - They are available through license. We have a patent on a certain phase of cold welding - to determine the thickness of the sheet as it leaves the roll. We haven't refused to license anybody to use it. It has been patented but is controlled under license.

Q - Would you case to discuss the basing point system and its effect on prices.

A - I don't know whether I am competent to talk on basing point. There has been a great deal of misunderstanding or fallacious thought in regard to it. About all it does as I see it has been to give some people certain advantages in freight rates.

Q - Would you care to say something about the effect of stainless teel in ship construction? Will it give them longer life?

A - I know little about it. I do not think they have gone far enough yet on the matter to make any conclusive opinion possible. I do think any possibility of cutting down the amount of corrosion in metals is a mighty good thing butI don't think our experiments have gone far enough to be conclusive.

Q - Is the Navy demanding any different specification for their steels? Are they looking toward alloys?

A - They are sympathetic to anything that cuts down corrosion; they are also cutting down dead weight.

Q - I understand some of these new stream lined trains like the

ones built by Budd use stainless steel rolled very thin. I wonder how it is standing up in service. Would the corrosion be serious enough to affect the weight?

A - I was in Union Station in Chicago last week talking to the Engineer. They have a train called the Zephyr and I asked him about it. He said they knew it was economical to run that light train but for us to keep busy getting the good old steels down to a point where they could use it with greater strength. The one important thing to the railroads, to my mind, is to get metals with less dead weight than we have today.

Q - About mill scale - why don't the steel mills try to put out a product without it?

A - There are different types of mill scale. Mill scale itself is a defense against corrosion. Several years ago Speller brought out a Spellerized steel for pipes. When that steel was being rolled from the ingot down into the skelp it passed through rolls that forced it into a kneader the same as you would knead bread, and that acted as a defense against corrosion. There was no uniformity in the kneading and they have dropped that as an advertising point. There is mill scale that is oxide and is a defense against corrosion. Certain mills scales chip off and leave a raw surface and if it is subjected to certain influences it will start an active corrosion. There is an effort to keep down raw mill scale. There is also a silicate scale. Where the metal rests on the bottom of the furnace and the bottom of the furnace is made out of old crockery they have broken up and melted down to stand high abrasion, the steel will

take up a certain amount of that slag scale. If that could be applied over the whole material it would be a wonderful thing except that when the scale begins to peel off it would get in to the seats of valves. The general form of scale is iron oxide and is difficult to remove. There is a vast effort made on rolling plate; they throw salt or salt petre on these rolls and it bangs like a cannon. The last bang is not due to the salt but to the hydrogen from the water. They do attempt to cut the scale down as much as possible.

Q - What about this Met ??? corporation of America in Los Angeles who claim they cover all piping and it stops all corrosion?

A - They have been endeavoring to interest us in that. I don't know the result.

Q - Concerning that .005" cold rolled plate. How does its yield point compare?

A - About 80%. In rolling the steel you roll it in one direction and then in another, and back and forth - not all in one direction and there is no change in the elements.

Q - We have a great deal of difficulty in the storage of steel plates and I have known of instances where we have lathered them with petroleum. What do you recommend for a preservative of steel plates stored out of doors?

A - I don't know anything better than the preparations put out by the Standard Oil Company. It is a steel varnish.

Q - In Miraflores Lake in Panama there is a section of iron and steel pipe left from the French construction days on the Panama Canal. It has been there for fifty years and is in a perfect state of preservation. To what do you attribute that wonderful state of preservation?

A - They were probably made of Swedish ores and by the old charcoal blast ~~furnace~~ mills. I saw a lot of sheets at . The original markings were 1909 and they were just as good as the day they were piled there. I brought some samples home but could not tell whether it was wrought iron and soft steel or just how it was made, but it looked as if it were a Swedish ore product.

Q - I am very much interested in this thin cold rolling. I judged it was carbon steel. Could you roll it as thin as that if it were nickel or stainless steel?

A - They claim to have rolled it as thin as tissue paper but I do not know.

Q - Would you say the trend in the use of alloy steel was increasing or decreasing?

A - Increasing, I think. A few years ago in the automobile trade they thought they had to go to alloy steels but they have come back to carbon steel. They are finding new fields for it.

Colonel Jordan: In closing this talk I want to say one thing about Mr. Crockett. When we went up to Pittsburgh last year and went to the Jones & Laughlin plant Mr. Crockett was an ill man but he got up when we came. He said he just could not permit the Army Industrial College to come out there without him seeing them and he gave us a talk there that was one of the most inspiring we had ever heard, and then went back to bed. I want you to appreciate the kind of man who has talked to us today. He is a real friend.