

# THE SELECTION AND TREATMENT OF ALLOY STEELS FOR AUTOMOBILES.

BY

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[This paper treats of the various kinds of alloy steels and their applications in the automobile industry. Attention is called to the necessity of selecting steels which will do most efficiently the particular work for which they are intended.]

A POPULAR remark during the last few years has been to the effect that the steel business has advanced and changed rapidly and that the incentive is found in the manufacture of automobiles. This condition still continues and the evolution within the construction of the car itself is no less rapid. Design, materials, style and selling methods are all involved.

Curiously enough, it would seem at first glance, the choice of materials is involved in all of these four branches of the industry and not in the one or two as would seem natural.

The reasonable use of materials is to be the theme of this paper. Many considerations are involved in looking back to the beginning of the automobile industry and it seems necessary to do this in order that the evolution may be followed as far as materials are concerned.

At the beginning every faculty of designer and builder was focused on the production of an operative machine. Materials were disregarded so long as they would help build the vehicle and were obviously steel, brass, aluminum or wood. All were too busy to regard the quality. Generally speaking there was available from the stand-point of the automobile builder Bessemer steel, open-hearth steel and cast or crucible steel. Variations within these classes were regarded as unimportant and heat treatment was an unknown term: certainly only theoretical at the best and therefore useless to a practical man.

Now these same men have among them those who state that the heat treating department of the works is the most important

of all. This is not so with all yet; there are some who still balk at talk of critical points, recalcence, pyrometers and the like. The evolution is rapid however and this class will soon disappear.

After a year or two the cars operated very well; at least well enough to run long enough to break parts, crank shafts, axles and steering parts. Then a little attention was directed toward steel. There seemed to be no clear idea of a cure. If a steel part broke with an appearance of brittleness good old wrought iron was tried as a sure cure. If bending occurred tool steel was tried in some cases and medium carbons (0.50 per cent.) in others; it being understood that high carbons were stronger but brittle. The natural or annealed state was the only one known to the automobile industry at this time.

At about this time nickel steel was mentioned as a possibility. It had been used, or as some said "advertised as used" for bicycle construction. But generally it was regarded as something fancy and not worthy of the consideration of hard headed men. It was expensive, hard to work and no good anyway in the opinion of many.

So when alloys came along in earnest and were offered systematically by steel agents they had a hard time making any progress. The high prices quoted were laughed at. There seemed to be no chance that alloys would ever be given a fair trial. After some little time and persistence by the steel agent, alloy steels were tried and proven good even at 15 cents per pound. Some designs required alloy steels to stop breakage the result of small dimensions, sharp corners where fillets should be and similar mistakes. In this way the alloy, or perhaps the high quality carbon steel, had a chance to make good in a spectacular way. These instances helped the spread of high grade steels until now the pendulum has swung too far and alloys are used where they need not be and money is thereby wasted. There is indication of a notion that an alloy steel is a cure-all; and that if needed in one part that it must be a fine thing in all parts.

Unfortunately the art of heat treatment has not spread as fast as alloy steels have and many cases exist where very expensive steels have been put into cars in an annealed or forged condition; which is absolutely unreasonable. The alloy steel is no cure-all and must be used intelligently, if any compensation for increased cost is to be realized.

A case in point is found in an engine crank shaft. It is large for the duty. If it is made of an alloy treated up to 100,000 lbs. per sq. inch or more, when 60,000 lbs. would suffice there has been no gain to the automobile and there has been a money waste. It is not generally understood that a high elastic limit adds nothing to the stiffness or rigidity of a part. It does add to resistance to fatigue but with the case in point the shaft is over size and fatigue cannot take place in the absence of bending.

The same general condition applies to gears of all kinds. It is not the rule, by any means, that gears of smallest section are made of the strongest steels. This should be so and is so in one very marked case. On the other hand many very heavy gear sets, duty considered, contain steel of greatest strength and all out of proportion to necessity. This is unreasonable as it is obvious that strength should be a function of design. A bridge or a building is calculated to a nicety, as yet automobiles rarely are. Knowledge of steel is not yet sufficiently wide-spread. The history of the automobile is short and there has not been time enough to disseminate knowledge of so many special steels and special treatments. Then too an air of mystery regarding special steels and secret treatments has been fostered in some circles in such a way as to befog the issue and retard the spread of truth.

At the beginning of the automobile art the steel industry was old. Alloys and heat treatments were no mysteries to the steel metallurgist. Makers of armor plate, gun tubes, propeller shafts and other important specialties had been using many grades of steel and many treatments to meet peculiar needs. This knowledge had not and does not spread readily to makers of small arms, sewing-machines, bicycles or typewriters and they all need it to some extent.

Some reason for this is found in the "old fashioned" selling methods of many steel companies. Most salesmen are not furnished with accurate knowledge of the steels they sell or if they are they are forbidden to use such knowledge on possible customers. They use a line of argument that contains no metallurgical information and is too often far from the truth. There are large numbers constantly engaged in this way so it is no wonder that little real progress is made by aid of the salesman. Fancy names and fancy prices for common steel is their specialty.

It is a pleasure to feel that such methods are giving way to

others and better. The steel works engineer, metallurgist or chemist is now placed in contact with the consumer. His wants are learned and supplied without secrecy or mystery. The opportunities of change and improvement are pointed out and advance in the art will be rapid. As it is now there is but little knowledge, among consumers, as to the relative importance of analysis and heat treatment or of the importance of casting, rolling, hammering and cold working of steels. Consequently many consumers are in doubt as to what to believe, the truth as expounded by the conservative metallurgist or the near truths about the special alloys of the salesman.

Before taking up the finer steels it is well to study the history of what preceded them in the automobile art.

At the outset carbon steels were mostly considered and known as machine steel. Such steel was available and cheap, or at least low in first cost. Such steel is not always cheap, as much of it tears in machining to such an extent that work is ruined or will not permit the cutting of a thread at all because of its softness. Such machine steel is of about the following composition. It is not strictly speaking machine steel but there is so much of it on the market, so called, that it must be recognized. Carbon 0.08 to 0.13 per cent., phosphorus 0.08 to 0.10 per cent., manganese 0.40 to 0.60 per cent. and sulphur 0.06 to 0.08 per cent.

Machine steel, so called, as found in steel warehouses is not all alike by any means. This lack of uniformity is discovered by the user whose judgment usually is that the steel is no good anyway and does not behave twice alike in the machine shop.

The best machine steel, then existing, in stock, was of about the following composition with carbon from 0.18 to 0.25 per cent., with other elements like the foregoing analysis. Such steel machines smoothly and cuts a keen thread. A slight increase in carbon coupled with the other elements given makes a very marked difference in machining quality. A third quality of machine steel found on the market at the time in question was between the other two in carbon contents and much higher in manganese, analyzing about as follows: carbon 0.12 to 0.18 per cent., phosphorus and sulphur about 0.08 per cent., and manganese from 0.60 to 0.90 per cent. The manganese contents made for smooth cutting and the steel was a good one for carriage axles, which must be machined very rapidly, and other similar uses.

These machine steels were all characteristic of Bessemer output and were put into the early automobiles. They answered the purpose until the machines began to wear fairly well and poor (weak) design developed. High carbons were tried and wrought-iron was tried all in a blind unreasoning way. Some troubles were cured but some could not be cured by any change of material known at the time. The details of design were such as to cause failure with any material. Failure was delayed but not prevented.

One grade of steel, common then and now, known as screw stock deserves notice, as it plays a more important part in automobile construction than it ought to. It is close to machine steel and is sometimes sold as such. The approximate analysis is as follows: carbon 0.08 to 0.12 per cent., phosphorus 0.12 to 0.18 per cent., manganese about 0.50 per cent., sulphur about 0.10 per cent. The dominant element, that makes for easy cutting, is phosphorus, which is twice normal for Bessemer steel. More steel of this quality than of any other composition, can be put through an automatic screw machine in a given time, and turn out a fine product. But the drawback is phosphorus, which causes brittleness in steel and makes it unsafe for automobile construction. Except in screws of no importance or parts carrying no load, it should not be used. Important screws are now made of alloy steels heat-treated. Connecting-rod and engine-base screws for example. The above screw stock after casehardening, as it often is, shows a coarse brittle grain even with the best of treatment. No hardened parts of this quality should be used.

At the present time little steel high in phosphorus finds its way into automobile construction. Basic Open Hearth steel is mostly used and this is uniformly below 0.04 per cent. in both phosphorus and sulphur.

This quality of steel in the vicinity of 0.10 per cent. carbon machines with the greatest difficulty, consequently a standard machine steel has been developed containing enough carbon and manganese to offset the softness. The analysis is as follows: carbon 0.20 to 0.30 per cent., phosphorus and sulphur not over 0.04 per cent., manganese 0.40 to 0.70 per cent.

This quality of machine steel handles well in every stage of manufacture and responds to heat treatment in a way that makes the product suitable for many parts of a car. This steel is a fine steel for the general run of drop forgings. It is suited for the

important members of low priced light cars, and for carbonized and hardened bevel and transmission gears in such cars as are of low power and generous gear design.

With the general use of basic open-hearth steel this type of machine steel is bound to be generally adopted. Its usefulness is very wide-spread and its cost as low as any open-hearth steel. The extra expense that is warranted is the care necessary to free from seams or other physical defects. This is done by the steel maker or the one who prepares the billets or bars for shipment. Freedom from seams insures a sound product at the finish of an expensive series of operations and is worth paying for.

Simple heat treatment will give an elastic limit per sq. inch of 60,000 lbs. This is the result of quenching at about 1500° F. in oil, then partially annealing at 800° or 900° F. Such strength is accompanied by good refinement of grain and corresponding toughness and capacity to resist shock and repeated alternate stress. The machine steels previously mentioned would not be safe under the foregoing treatment or any other; as refinement of grain does not take place to a satisfactory extent in the presence of so large a percentage of impurities.

Without a fine grain development in steel fatigue takes place very rapidly. In using this term "fatigue" the same phenomenon is in mind that is often referred to as crystallization. Cold crystallization does not take place. It is a different physical change and will be discussed later.

About the years 1893-1894 bicycle parts often failed (to quote) "while riding along the smoothest road." The fractures did not exhibit coarse crystals as a rule, particularly in cold-drawn spoke wire or tubing. But in every case there did exist an opportunity for concentration of strains, bending or vibration, at a limited section. These failures led to studies of fatigue conditions.

It was commonly thought by well trained mechanics that the softest toughest steels would resist longest under these conditions simply because of the tough quality. This was found to be not so. Tough and soft steel is weak steel having an elastic limit per sq. inch from 30,000 to 40,000 lbs. A good grade of forty (0.40 per cent.) carbon steel may have an elastic limit of 50,000 or 60,000 lbs. Such steels in an annealed condition were compared under such circumstances as to produce a fatigue break. The dead or actual load used in comparison was the same. This

load was chosen to produce a fibre stress nearly as great as the elastic limit of the weaker steel, say 25,000 lbs. per sq. inch (about 84 per cent.). This stress was only 50 per cent. of the elastic limit of the stronger steel. The weaker steel, soft and tough, broke quickly after 20,000 to 50,000 alternations of stress. The stronger steel looked upon as being brittle and hard, endured say 400,000 alternations of stress, an increase not in direct proportion to strength and quite contrary to the characteristic of toughness as measured by elongation. It is evident that the toughness was not the controlling element under fatigue conditions and that strength as indicated by elastic limit was an important factor with some other element not obvious, playing an important roll. Such an element was sought in the crystalline structure. Such structure is fairly indicated by transverse fracture for the purpose in hand. The fracture of the low-carbon tough steel is coarse grained with crystals presenting large cleavage planes. That of the higher carbon, brittle steel, showed a close grained structure with no crystals having cleavage planes of conspicuous size. That is, the steel that endured longer was strong and fine grained. These were the controlling elements.

It is for this object that all heat treating processes are practised—to produce greater strength and to refine the grain. The most reasonable steel to use in automobiles is that which will respond best to treatment or that will respond sufficiently for a given purpose, dimensions and duty considered. There is no reason in selecting a steel that will not respond somewhere in proportion to the cost of the operation; that is, the improvement must be material. Neither is it reasonable to select a steel at great cost that will respond to such an extent as to be way beyond the necessities of the case.

The treatment necessary to give a steel depends somewhat upon the physical condition of the steel as received by the consumer or user. For example, it is quite possible and often happens that bars of steel reach the manufacturer of automobile parts in a very coarsely crystallized state, this being due to the last forging or hammering operation prior to shipment by the steel mill. If this steel is to be used by the parts maker without further drop forging or other heating operations, the steel must receive a thorough annealing. In the absence of such annealing operation, which will reduce the coarse condition of it to a

properly refined condition, a single heat treatment will not produce the expected results.

If, on the other hand, the bar or billet is to be forged, then this coarse crystalline condition matters but little and the annealing must necessarily follow the forging operation and for the same reason; to guard against a possible condition of coarse crystallization which will not be refined by a single heat treatment.

Our steel makers would do well to learn whether or not the consumer of the steel is to again forge. If not, annealing should be the final operation at the steel works in all cases. Otherwise, steel of good quality may not perform as well as it should.

It is not always possible for the steel manufacturer to know whether or not steel is to be forged again and, in view of that fact, it is the habitual practice of some of the steel mills to anneal as a final operation. No harm is done if the steel is again forged, and if not forged the steel is found, by the user, to be uniform in machining qualities and well behaved under heat treatment. Uniformity of machining quality is of far more importance in the eyes of the mechanic than is fully appreciated by many steel companies. Many thoroughly good qualities and shipments of steels are complained of and perhaps condemned because of the presence of so-called hard spots and bad cutting qualities. The machine shop cannot be expected to know that it is not the composition of the steel that is at fault and the steel maker should guard against such complaints by the relatively inexpensive operation of annealing.

These remarks apply very strongly to tool steels that are to be shaped into expensive tools, to spring steels and to the higher carbon steels in general. They apply in a lesser degree to the lower carbon steels but nevertheless are of great importance.

Many machine steels are condemned because tools are rapidly dulled in machining them and the complaint is, as a rule, that they are too hard to cut. As a matter of fact they are too soft to cut smoothly. They tear and cling to the point or edge of a tool and the cutting operation becomes more or less of a rubbing operation which creates heat and dulls the tool by softening it. Proper annealing, suited to the carbon, will correct this fault, but the machine shop manager cannot be expected to know this and probably has no facilities for annealing or other heat treatments in many cases.



Take an engine crank for example. Other considerations than strength influence the design. It must have ample diameter to furnish adequate bearing surfaces. It must be rigid and stiff. No alloy can increase this latter quality. A steel with 60,000 lbs. elastic limit per sq. inch is quite strong enough to outlast the engine. One of 200,000 lbs. elastic limit would make no better crank shaft under the assumed conditions and would cost more at first cost, in forge, in machine-shop, and in heat treatment. This is a fair example of unreasonable use of alloy steel.

To return to qualities producing endurance under alternate stress. A drop forging as it comes from the dies is likely to be in a non-homogeneous condition as the result of the process and at the best, because finished at a relatively high temperature, is likely to possess a very coarse open grain. If intended for a vital part this grain must be refined. It may be perfectly done by proper heat treatment, and it is done habitually by careful operators. The result is a homogeneous piece of metal. No other character of steel is fit to enter the construction of an automobile where it is potentially possible of much harm or much good. Carbon steels should be so treated; alloy steels must be, if fair value for money spent is to be received.

Alloy steels of expensive variety have been put into cars without heat treatment, just to say they were used. An alloy steel not suitably treated, that is in an annealed or forged state, is little if any better than good open-hearth machine steel in an annealed condition. Its endurance under fatigue test is low. Its elastic limit is low, and its structure as indicated by transverse fracture is bad. Such use of alloy steel is unreasonable and the only additional value obtained for the excess paid as compared with carbon steel is an advertising value.

On the other hand alloy steels suitably chosen and heat-treated have extricated many an engineer from real trouble. A driving shaft, having 60,000 lbs. elastic limit, for example, may have proven weak with good carbon steel. Because of the design of connecting parts a change in dimensions is often practically impossible. A solution is easy with a good 0.30 carbon, 3.5 per cent. nickel steel treated to 90,000 lbs. per sq. inch elastic limit, or if necessary a chrome-nickel of high carbon treated to 150,000 lbs. elastic limit. Such applications of alloys are worth all they cost and are reasonable in every way.

It is the alloy steel that responds best of all steels to heat

treatment. Results are obtainable that are nothing short of wonderful. Only recently a tensile strength of 300,000 lbs. per sq. inch has been reached. Coupled with such strength, say 200,000 lbs. per sq. inch, very great ductility is obtainable as indicated by elongation and reduction of area at section of rupture. Too great stress cannot be laid on this last item. It is the best measure, in a tensile test, of the degree of refinement of grain attained by heat treatment. Reduction of area will be slight if the crystals or grains are large. If the grains are large as already stated, endurance under fatigue will be little and endurance is beyond argument the most valuable asset of an automobile subjected as it is to shock and vibration at all times, while in motion, and to an extent beyond any other mechanism.

Attention has been called to the relative endurance of 0.10 and 0.40 per cent. carbon steels under fatigue test. Under the same dead load a specimen of 0.30 per cent. carbon, 3.5 per cent. nickel heat-treated will endure several million alternations of a 25,000 lbs. per sq. inch fibre stress, and a specimen of 7.5 per cent. nickel has endured one hundred million without rupture with the fibre stress at about 50,000 lbs. per sq. inch. The tensile tests give no indication of any such difference in endurance unless it be in the reduction of area coupled with a high elastic limit. These figures are always large with good endurance. The reduction of area is a measure of fine grain, so it would seem that this quality may be the most influential in determining endurance.

There is good chance for theorizing and reasoning along this line. With the theory of cold crystallization set aside, a reasonable cause for breakage must be found. Steel may be considered as made up of crystals which interlace and adhere. If a test specimen were made up of crystals whose faces equalled the diameter of the specimen, there would be the exaggerated condition of all adhesion and no interlacing. One cleavage plane extending across the specimen. It is easy to conceive that the separation of surfaces once started would jump at once across the specimen and rupture would occur. There would be only adhesion to overcome. It is equally plain that were the same specimen made up of an infinite number of crystals, that a separation started at the periphery would meet with an interruption before being of finite size; after which a fresh start might recur at another point to meet with similar interruption. In this way

an infinite number of starts would be necessary to bring about rupture. In other words there would be no chance for a continuous fracture along any one line or surface, and rupture would be delayed indefinitely.

A fibred piece of steel endures better than one not fibred although both may be of very fine grain. It is easy to conceive that if "fibre" is all the name implies, that an incipient fracture formed in one fibre could not continue across the space between fibres and would thus stop. Wrought-iron breaks under fatigue as in an axle or shaft. The fracture always shows crystals. Is it not possible that a fatigue break can take place only where crystals exist, and that because crystals are at a given section, fracture takes place there?

It is easy to understand how a progressive fracture may proceed along the faces of a series of crystals as in the splitting of granite by means of wedges driven into a row of holes. It is not easy to conceive the splitting of good fibrous hickory or elm except with and along the fibre. Splitting across the fibre is impossible, there could be no continuous fracture and therefore no rupture.

A fatigue break has been described as "progressive inter-molecular rupture." It would seem more probable to be "inter-crystalline" inasmuch as the molecules, of a given composition, are doubtless all of a size, regardless of heat treatment or physical treatment. On this theory, heat treatment would cause no difference in behavior under fatigue; which would be contrary to fact.

Another phase of fatigue is, that such breaks rarely if ever occur unless strains concentrate at or near one plane or section. If strains be distributed as in a beam of uniform strength, fatigue does not occur. A generous fillet or a taper retards fatigue almost indefinitely. A sharp corner causes it to occur very quickly.

Design and material both play an important part, and the two must be considered simultaneously if good engineering is to be attained. If a design be adequate with poor material, it is folly to buy better. If design be suited for the best, then only such may be used otherwise bending and breaking will occur at once. These statements seem too simple for reiteration, but it is a sad fact that both simple truths are violated in automobile construction.

There is one form of heat treatment as old as the hills, that is little understood by many that have practised it longest, namely, "casehardening." It is easy to turn out coarse or fine grained product. The fine grained is desirable (as in good tool steel), the coarse grain is not, as in burned tool steel. Too few realize that a low grade steel after carbonizing is no longer low grade. It has had money spent on it to improve it and if the low carbon was pure steel; the high carbon exterior, the result of carbonizing, is pure high carbon steel; therefore, good tool steel and must be treated accordingly.

No tool dresser would heat tool steel in boxes for ten hours at a temperature of  $1700^{\circ}$  F., then quench in water at that temperature and expect a tool to do good work. Yet this is exactly what is done in many otherwise well regulated plants, and the steel is blamed if the parts so treated are brittle. So treated the crystals are large; the steel is brittle.

If used for ball or roller bearings, the polished surface is friable and crystals spawl out thus starting pits and fractures. Suitable refining treatment improves this condition and makes a success out of a possible failure.

In casehardened parts two qualities of metal are to be dealt with, and the best practise demands treatment that will refine both grades. The interior of two are the original carbon and the exterior a carbonized layer of a higher carbon. The refining temperature of the lower carbon is higher and one treatment must reach this. The other temperature, correct for the high carbon, will not undo the refinement of the lower carbon. Thus by two treatments both qualities are fully refined and the composite structure is a good one. Alloy steels are subject to the same laws, and it is only necessary to be acquainted with the critical points of the various compositions to get the best results.

Transmission gears and main drive bevel gears are successfully made of carbonized steel, both carbon and alloy. The quality selected must be referred to design and duty. The duty of constant mesh gears running in oil is relatively easy if the dimensions be generous. The duty of clashing transmission gears is never easy and may be awful with a dragging clutch or careless manipulation by the car driver, and with clashing taking place under loaded or partially loaded conditions.

With equally good design the bevel driving gears do not need the same or as good steel as the transmission gears. It is com-

mon and good practice to make the large bevel gear of good carbon steel and the driving pinion meshing with it of an alloy steel.

The character of the treatment and resulting condition of the steel is of vastly more importance than the composition of the steel used. The best of alloy steel may be so handled in treating as to produce a weak and inferior part. Similarly by the best of treatment good open-hearth machine steel may be so well handled as to make a most excellent main drive pinion or other part.

It is true that the best must be produced for a few designs, but such are much in the minority at this time. There has been very little real close designing as yet. Empirical knowledge and data as to available materials are not yet exact. The art of heat-treating is not uniform and wide-spread among producers of automobile parts. A liberal margin of safety against uncertainty and non-uniformity is still the rule.

There is one practice in vogue among purchasers of alloy steels that does not seem to be founded on good reason. It is that physical requirements are specified in face of the fact that the steel is to be forged and heat-treated before being used in a car. Its final condition may bear no relation to its purchased condition. It may be carbonized for example. If steel be purchased on chemical analysis, the control is sufficient. With a known composition heat treatment may be intelligently directed without reference to original tension test characteristics.

If to be used as purchased, the matter is different and physical characteristics must be known. Elastic limit, reduction of area, elongation and tensile strength, in the order named, are desirable. If these physical tests be demanded then complete chemical analysis must not be. The steel manufacturer cannot produce if tied hand and foot. It is proper to specify chemical analysis as to impurity, that is phosphorus and sulphur, and also as to the dominant elements; nickel, chrome-nickel and so on. Even in these elements, manufacturing tolerances must be allowed. The practice of limiting all elements and coupled with physical requirements is wrong and often leads to the absurd situation of specifying an impossibility.

Even at the best, with the one writing the specifications knowing exactly what has been the practice in one steel works; it is not certain that in another works the result would be quite

the same. Some works use melting processes, casting methods, and forging methods that may easily modify physical characteristics as compared with practices in other works.

With a given quality of automobile in view, the number of grades of steel necessary to construct it is few, namely, a good all-around forging steel, a steel of slightly better quality to be used for gears, a spring steel and a steel suited for the pressed sheet-steel portions of it.

These steels, properly handled and heat-treated, each part for its peculiar duty, will produce a car of very high grade so far as the steel portions are concerned.

The car of extreme design, racing or otherwise, one that has been designed to strip off the last pound of weight, must be handled differently. Such a car is the exception and must be treated accordingly.

If an order be accepted at all under such unfair restrictions, it must be at an advanced price to cover probable difficulties. This simple fact is so well known to the steel producer that it is apparently absurd to state it, but it is not well known by the steel consumer and needs repeating for their benefit.

To sum up, the attempt has been made to indicate that alloy steel is better than plain carbon steel, that is, stronger and more enduring; that the design of some cars is such as to necessitate the use of the strongest alloy steel and that the design of others is such that an alloy steel is superfluous and money wasted.

That steel that is good for one purpose is bad for another and really that the term "good steel" is meaningless unless it be understood "for what." Pure steel, meaning freedom from impurities, means something always. It insures that such steel will give "good" results if the composition is suitable for a purpose and if the steel be treated to develop proper physical characteristics for the duty to be performed. Several steels (compositions), may be available that will perform a given function perfectly if properly selected and treated. No consumer need be tied to one maker, one composition nor one method of treatment. Several of each are always at hand that will give satisfaction. Reasonable use of steels can only be reached along lines as broad as this.