Numerous methods are employed throughout industry to measure the depth of carburized cases on steel, largely because there is apparently no standardized procedure which is acceptable to all. Articles have been published describing various “approved” or “standard” procedures, but generally each company or industry has preferred to apply its own particular technique based on its own interpretation of case depth and the availability of either shop or laboratory equipment.

Until approximately seven years ago, the heat treating division of Caterpillar Tractor Co. encountered inconsistencies in case depths on test bars which were not always explainable. Each such instance involved considerable extra expense because of additional testing and destruction of piece parts. An analysis of the problem revealed that very often the fault was in the manner of determining case depth rather than in the carburizing operation. At that time, therefore, we set out to define the most applicable and economical manner of checking this metallurgical quality and standardizing accordingly. The objectives which would have to be met for our use were as follows:

1. Determinations must be accurate and repetitive. The method must eliminate differences of judgment between people making the determination, something we found to be the greatest problem in our previous practices.

2. Determinations must be made quickly so that “in process” heats can be checked at any time without delay.

3. The procedure must be simple so as not to demand highly skilled technicians, a requirement particularly important during week-end or holiday operation.

4. Equipment should be relatively inexpensive and durable, and cost of individual determinations be as low as possible. Importance of the latter consideration is attested by the fact that we average 250 determinations a day.

5. The method used should represent a measure of the control of the carburizing process, and not attempt to evaluate other variables such as material or design of the piece.

6. The determination should indicate a case depth which would find acceptance under a broad interpretation of the term “effective” depth of case.

A number of approaches were tried during the investigation for a method which would meet these requirements. Thus, test bars of carbon and alloy steels were etched or heat tinted to resolve the carburized case for its measurement with a special scale. Brinell or equivalent low-power magnifications in conjunction with appropriately calibrated lineal divisions were used to measure the case on fractured or polished and etched transverse sections. Two other ideas studied were hardness tests on step-ground and tapered bars and transverse sections; and the microscopic examination of carburized, and of carburized and hardened bars which had been tempered at 1100° F. in cast iron borings.

In keeping with our stated objectives, we decided on a combination of the first two methods, regulated so as to control the known variables and made to conform easily with all of our needs. After many years of its use we are well pleased with the results, and confident that any troubles we may encounter are not due to the method of checking case depth.

The following describes the procedure we employ, which is actually very simple to apply after a brief initial instruction.
Description of Test Bars — Test bars are procured from a mill heat of known characteristics and in sufficient quantity to last a number of years. The cold finished bars are 7/16 in. square and 3 3/4 in. long, and a hole is drilled near one end on those which require suspension in the furnace. Chemical composition of the bars is: 0.17 to 0.20 C, 0.80 to 0.90 Mn, 0.17 to 0.22 Si, 0.040 S, 0.020 P, 0.12 Ni, 0.08 Cr, 0.02 Mo, 0.05 Cu, 0.15 total Ni plus Cu; all but the first three are maximum values.

The A.S.T.M. grain size is No. 1 to 4, with a maximum spread of two numbers. The test bars are run with the production parts in every furnace charge and at regular frequent intervals on continuous furnaces. Test bars which have been checked for case depth in the manner to be described are used to accept or reject production material with which they have been carburized. Use of test bars of uniform carburizing characteristics is necessary in order to isolate the variable being checked to that of the carburizing routine itself.

Hardening of Test Bars — After cooling from carburizing to at least a "black" heat, bars are loaded into a small Hevi-Duty electric furnace equipped with a circulating fan. Up to 20 pieces are loaded at one time in an alloy pan. This furnace is used for this work only and is maintained at 1440° F. ± 5° F. at all times. Heating time is held to 22 min. ± 30 sec., and no protective atmosphere is used. Test bars are then quenched until cold in a full flow of water at 75° F. ± 5° F.

Fracturing and Etching — The bars are broken transversely at approximately their midpoint and etched in 10% nital for 8 sec. Care must be exercised to use fresh nital which has not been exposed to air for more than 2 hr. The etched fracture is rinsed in water and dried with compressed air, resulting in a clear, definite line of demarcation between case and core.

Reading Case Depth — The instrument we developed for determining depth is of a simple, inexpensive design, yet it has eliminated the difference between individuals making the determination and the natural inclination of people to "interpret" the case measurement as they may happen to see fit. The principal parts of this instrument are an illuminated Bausch & Lomb Brinell microscope (magnification 10X),
and a dial indicator mounted on a metal base. When the test bar is placed in the instrument, the hairline of the microscope is zeroed to its edge. The bar is moved so that the hairline coincides with the first free ferrite. The case depth is then read directly on the dial indicator.

From our investigational work it was found that a reading to the first grain of free ferrite would coincide closely with a 0.40% carbon content and a hardness of Rockwell C-50. On this instrument accuracy of repetitive readings, between individuals as well as between different readings by the same individual, is within 0.001 in.

Figure 3 (reproduced at the same magnification the operator receives in the instrument) clearly shows the darker case depth.

It is recognized that the methods described in this article could not be applied to all shops as a means of production control, because some equipment is necessary, although it is by no means elaborate or expensive. However, it is with some hope of standardization that this description has been prepared, since there certainly is a need in industry for closer measurement as well as uniformity in methods employed. Perhaps variations from the foregoing would at least permit us all to "speak the same language" and make comparisons from the same basic beginning. If there were enough interest in standardization, it would not be difficult to make test bars and reading instruments available, just as standard methods and equipment for hardness measurements have been available for many years.

Current Russian Metallurgical

In continuation of the survey of contemporary Russian metallurgy, presented in the August 1951 and March 1953 issues of Metal Progress, five additional books published in the Soviet Union in the period 1947 to 1951 are here appraised. The first three are of special interest because they give a comprehensive and detailed description of both ferrous and nonferrous metals and alloys in production as of 1950-51. The other two are concerned with nonferrous industries, one extensively describing nickel and copper (a few critical issues excepted) and the other dabbling with a number of the so-called "rare metals", including molybdenum, titanium and the transuranics.

SOVIET METALS AND ALLOYS