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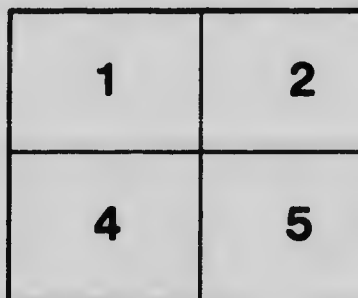
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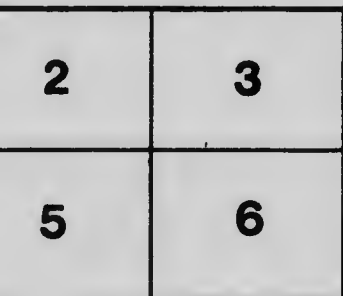
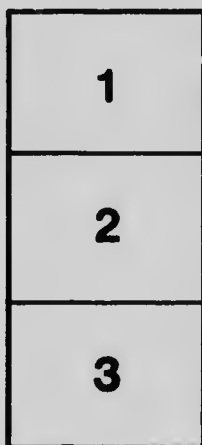
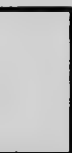
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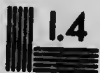
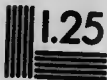
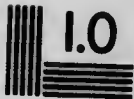
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PARTIAL RESTORATION ON  
AND W. R. LANG

CHEMICAL INDUSTRY, Vol. XXV.)

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**THE DETERIORATING EFFECTS OF  
"ACID PICKLE" ON STEEL  
AND THEIR PREVENTION  
BY "BAKING."**

BY

HERBERT A. BAKER AND W. F. BAKER

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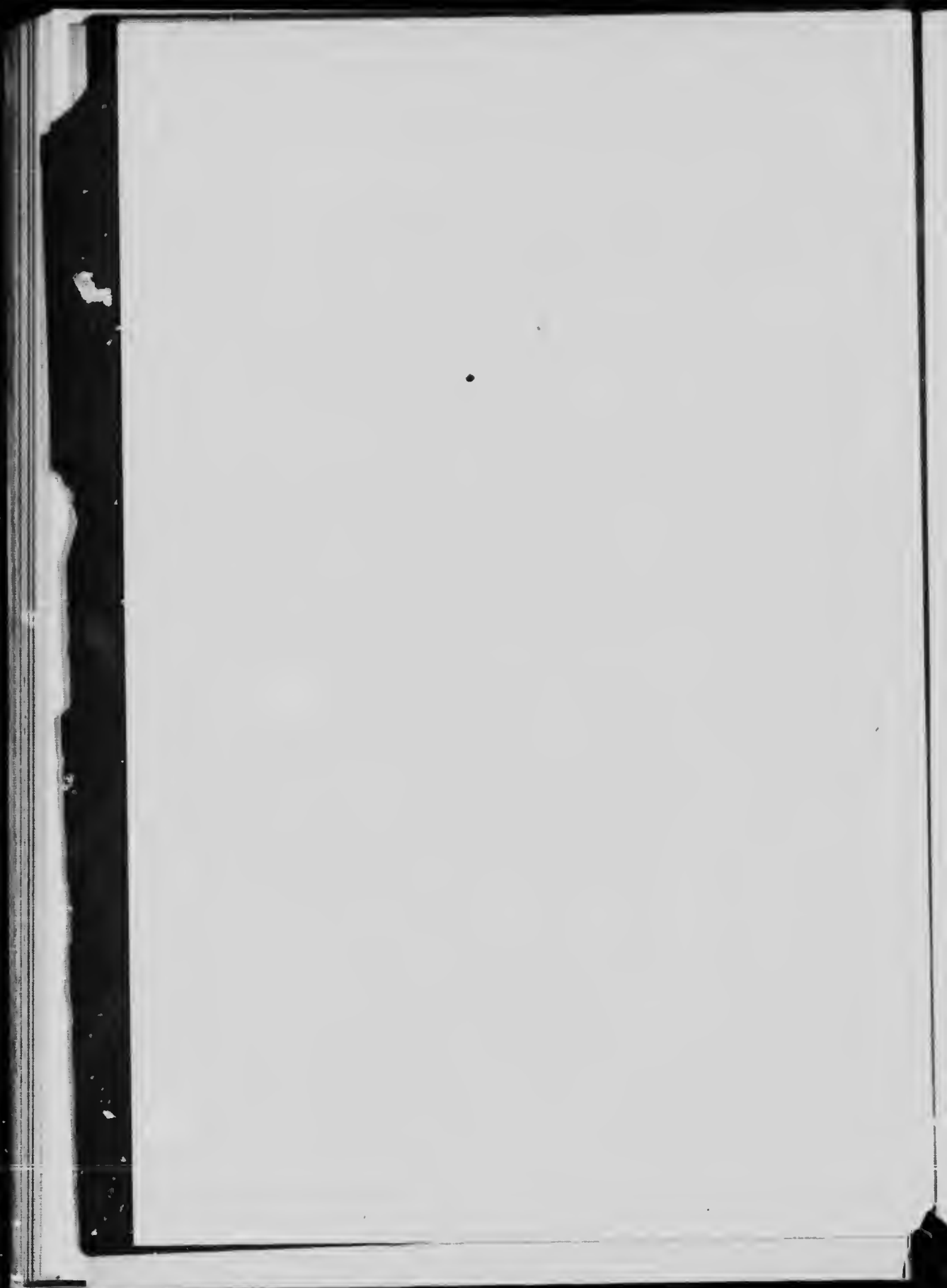
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### THE DETERIORATING EFFECT OF "ACID PICKLE" ON STEEL RODS, AND THEIR PARTIAL RESTORATION ON "BAKING."

BY HERBERT A. SKEFF AND W. R. LANG.

It is the universal practice in wire manufacture to "pickle" the steel rods in order to remove the black scale of oxide before drawing them into wire. This has long been known to deteriorate the quality of the rods, but it has been found that, if the rods are "baked" at 250° F. for some hours after this treatment, they are in a great measure restored, and can then be drawn into wire. The following physical tests were made in order to find out quantitatively the amount of such deterioration and subsequent restoration of the rods. The work was done on samples taken in the different stages of the process of manufacture at the Imperial Steel and Wire Company's plant at Collingwood, Ontario, at the suggestion of the manager, Mr. J. A. Currie. Samples of three different coils of rods were taken in the following stages:— (1) Before treatment with acid; (2) after acid cleaning; (3) after rusting; (4) after lime coating; (5) after baking. Table I. shows the tensile strength, percentage elongation over 8 ins., and percentage contraction of the rods; the strength of the bath, time immersed, and time of baking are also given.

The tests were made with a Riehle machine, by the kind permission and with the assistance of the staff in the Engineering Department, University of Toronto. It may be observed that the ultimate strength remains throughout the process as constant as can be expected of that kind of test. The percentage elongation over 3 ins. rather unexpectedly remains constant, but the sudden drop in the ability to contract to a small "neck," before breaking, occurs immediately after acid treatment, and remains practically constant until after "baking," when a marked recovery in this property occurs, the three rods agreeing well in this behaviour. It is important to note that on this property of "necking in," or contracting in area on stretching, depends the property of drawing well through

TABLE I.

Rod	Strength in lb. per sq. in.			Elongation over 8 ins.			Percentage contraction.		
	A	B	C	A	B	C	A	B	C
Before treatment .....	65,700	59,700	69,100	per cent. 16	per cent. 13	per cent. 12	per cent. 63	per cent. 66	per cent. 47
After acid cleansing .....	61,400	59,700	64,200	per cent. 16	per cent. 13	per cent. 13	per cent. 38	per cent. 44	per cent. 44
After rusting .....	62,800	57,000	64,700	per cent. 17	per cent. 14	per cent. 11	per cent. 38	per cent. 47	per cent. 41
" lime coating .....	65,700	59,700	67,000	per cent. 16	per cent. 14	per cent. —	per cent. 37	per cent. 47	per cent. 54
" baking .....	66,700	58,000	67,000	per cent. 16	per cent. 13	per cent. —	per cent. 57	per cent. 66	per cent. —

The strengths of acid used, at 100° C., were: A, 38 per cent.; B, 11 per cent.; and C, 10 per cent.; and the times of immersion in the baths: A, 1 hr.; B, 45 mins.; C, 1 hr. 10 mins. All the rods remained in the "baker" for about 4 hours.

the die, which is a conical hole in a block of tungsten steel.

This deterioration and recovery at the same stages in the process is also well shown in the following bending tests, which corroborate the contraction tests:—

TABLE II.  
*Bending tests on the rods.*

	Before treatment.	After acid cleaning.	After rusting.	After lime coating.	After baking.
Rod A.	100	70	64	64	100
" B.	100	60	56	57	99
" C.	100	71	55	53	100

These figures are relative, of course, and express the ability to bend a certain number of times through a definite angle before breaking. They are the result of averaging eight or ten tests in each case. The highest number was taken as 100, and the rest calculated proportionately. The results show a break in the bending properties of the rod immediately after acid treatment, and a recovery after "baking," thus corresponding to the effect on the rods as indicated by the contraction tests.

Shearing tests were also made, but the differences were so small that no conclusions could be drawn from them.

An examination of the wires of different diameters drawn from these rods (correspondingly marked A, B, C) was also made in the same manner:—

TABLE III.  
*Tensile strength and percentage contraction of wires.*

1. *Tensile strength.*

	Wires A.		Wires B.	Wires C.
	Diam. in.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.
(a)	0.175	72,900	93,700	93,700
(b)	0.142	112,600	113,900	113,900
(c)	0.112	117,300	122,400	122,400
(d)	0.091	—	138,400	131,000
(e)	0.072	137,000	150,000	150,000

2. *Percentage contraction.*

		per cent.	per cent.	per cent.
(a)	0.175	52.0	54	47
(b)	0.142	45.0	35	36
(c)	0.112	28.5	31	52
(d)	0.091	—	36	33
(e)	0.072	20.0	37	30

It will be observed that the tensile strength of the wires tested decreases on drawing, and that the fall in contraction area is greater in A. This means that it would be necessary to draw the wires through two rods to stand no more drawing than the better wires. The only rod used was that rod A, which was treated with sulphuric acid, while rod B was treated with 10 per cent. acid. They were drawn longer than usual—and as long as possible. The result was an unnecessary amount of drawing, that only weaker acid could have done better.

Table IV. gives the results of the tests on the wires: this also was the better.

*Bending*

	Diam. in.	Wire
(a)	0-175	9
(b)	0-142	9
(c)	0-112	8
(d)	0-091	8
(e)	0-072	8

Many superintendents have observed that the deterioration to the present state of steel "cold short" is highly improbable, as the sulphur content is low before and after treatment. It is suggested that a "hydride" of steel is suggested. Several tests have been obtained, but not published. The investigation



It is observed that wires B and C have a higher strength than wire A. Incidentally the increase of strength on drawing out will be observed. The reduction in cross-section area percentage, as the diameter of the wire decreases, is not so great in B and C as in A. This means that these wires could probably be drawn through two more dies before annealing is necessary, while wire A would, in all likelihood, require more drawing. Thus B and C appear to be the better wires. The only difference in the treatment of the wires is that rod A was cleaned in 38 per cent. sulphuric acid, while rods B and C were cleaned in 10 per cent. They were all "baked" about four hours—longer than usual—and are probably restored as much as possible. The results indicate that strong acid causes a necessary amount of deterioration in the rod, and a weaker acid should be employed.

Table V. gives the comparative bending abilities of the wires. This also would indicate that wires B and C are

TABLE IV.

*Bending tests on the wires.*

	Wire A.	Wire B.	Wire C.
1. in.	91	100	100
5	90	97	100
2	89	100	83
2	—	100	80
1	86	100	94
2			

Superintendents of plants have attributed the defect to the presence of sulphur, knowing that sulphur causes "cold short." This appears to the authors to be probable, as careful analyses show no difference in sulphur content, which was 0.051 per cent. both before and after treatment. It seems much more probable that "iron sulphide" of iron is formed, as has often been observed. Several tests confirmatory of this idea were made, but not sufficiently conclusive for present purposes. The investigation is being continued.



