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Title: Russian Iron

Author (s): Norman L. Wilson

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RUSSIA IRON

This is a little research that the staff at the railroad museum did for the project. We had discovered that the boiler jackets on the old 19th century locomotives were made of Russia iron. No one knew what real Russia iron looked like since the jackets had been replaced several times over the years.

While the search for Russia iron went on I made a trip to Alaska to look at Russian artifacts and architecture. While in Sitka I noticed a pile of grey black iron that had come from the Bishop's House attic at that site. No one at that time knew about Russia iron at the NPS monument and had not treated it with any interest. I was sure that it was what we were looking for and they gave me a piece of it to return with to California.

Meanwhile the researchers at the Railroad Museum had come up with a gold engine cover from San Francisco that was made of Russia iron. This was what we used to duplicate the color and texture for the restoration of the locomotives. Later some fragments were found on one of the locomotives that were being restored including a piece with Russian stamp markings on it. As I recall even John White at the Smithsonian did not have an example of this type of iron.

It is interesting that many items from gold pans to sheet iron are advertised in the 19th century catalogs made of Russia iron. By the early 20th century it was not available and by the 1970's was basically unknown.

There are several citations of metal roofs on the Russian buildings of the early 19th century including Fort Ross. Since this metal was a wonder of the time for its properties of not rusting and not losing its protective coating when bent it was a very good alternative to other roofing metals such as tin plate, copper and zinc. Its development in Russia is interesting as well as the attempts to keep it secret. However contemporary witnesses indicate that it was a combination of careful production techniques and labor intensive efforts that kept it from becoming copied by other nations. Perhaps its end came with the revolution in Russia and the wide acceptance of galvanized metal in the last half of the 19th century. Tin plate suffered the same fate, hanging on for another 50 years in tin can production and other smaller items. Today, plastics, alloys, aluminum, etc. have replaced the older materials, but for a while Russia's secret iron was an important part of our use of metal.

Norman L. Wilson
Jan. 199[illegible]

Sheet Iron.

Common.

No.	Widths.			Length.	Per Pound.
16	24 in.	28 in.	30 in.	96 in.	$
18	24 "	28 "	30 "	96 "	
20	24 "	28 "	30 "	96 "	
22	24 "	28 "	30 "	96 "	
24	24 "			101 "	
25	24 "			101 "	
26	24 "			101 "	
27	24 "			101 "	

Refined Smooth.

[illegible]

No.	Size.		Per Pound.
24	24 x 101 inches	28 x 96 inches	$
25	24 x 101 "		
26	24 x 101 "	28 x 96 "	
27	24 x 101 "	28 x 96 "	

Charcoal Smooth.

No.	Widths.			Length.	Per Pound.
20	24 in.	28 in.	30 in.	96 in.	$
22	24 "	28 "	30 "	96 "	
24	24 "	28 "	30 "	96 "	
26	24 "	28 "	30 "	96 "	
27	24 "	28 "	30 "	96 "	

H., S., B. & Co.'s Soft Steel.

No.	Width.	Length.	Per Pound.
26	24 in.	101 in.	$
27	24 "	101 "	

Galvanized Juniata.

No.	Widths.			Length.	Per Pound.
16	24 in.	28 in.	30 in.	96 in.	
18	24 "	28 "	30 "	96 "	$0 12
20	24 "	28 "	30 "	96 "	
22	24 "	28 "	30 "	96 "	13
24	24 "	28 "	30 "	96 "	
25	24 "	28 "	30 "	96 "	14
26	24-26	28 "	30 "	96 "	
27	24-26	28 "	30 "	96 "	15
28	24	28 "	30 "	96 "	16
Nos. 22 and 24, 20 in. wide, 96 in. long, for Sap Pans,					

New Process Planished.

No.	Width.	Length.	Weight per Sheet	Per Pound A	Per Pound B
24	28 in.	60 in.	10½ lbs.		
25	28 "	60 "	10¼ "		
26	28 "	60 "	10 "		
27	28 "	60 "	9½ "		
28	28 "	60 "	9 "		
No. 23 Jacket, for Locomotives, 28 x 56, 60, 72, and 84 inches, - - - -					

PACKED IN SHEET IRON CASES OF 2-4 [illegible]

Genuine Russia.

No.	Width.	Length.	Wire Gauge No.	Weight per Sheet	Per lb.
9	28 in.	56 in.	28	7 lbs.	
[illegible]	28 "	56 "	27	8 "	
10	28 "	56 "	26	9 "	
11	28 "	56 "	25	10 "	
12	28 "	56 "	24½	10½ "	

Table

Showing the Comparative Weight and Measurements per Square Foot of Sheet Iron.

No. Wire Gauge.	Weight per Square Foot.	Square Feet per Ton.	No. Wire Gauge.	Weight per Square Foot.	Square Feet per Ton.
12	64 oz.	560	24	17 oz.	2108
14	60 "	597	25	16 "	2240
16	48 "	746	26	15 "	2389
18	38 "	943	27	14 "	2560
20	28 "	1280	28	13 "	2757
22	21 "	1706			

Number of Sheets in a Bundle.

Wire Gauge.	16	18	20	22	24	25	26	27
24 inches wide.	4	5	7	8	11	10	12	13
28 " "	4	4	6	8	10			
30 " "	6	3	6	6				

STATE OF CALIFORNIA--THE RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF PARKS AND RECREATION
PO BOX 2390
SACRAMENTO 95811

Sept. 25, 1978

Status Report on Russia Iron

Extensive research provided the California State Railroad Museum by Doctors Bhat and Zackey, metallurgists at the University of California, Berkeley, has established these facts about Russia Iron:

1. the metal is pure wrought iron with no carbon or alloys;
2. its blue-grey 'rippled' surface is attained by alternately hammering and heating stacked sheets of iron in an oxygen free furnace kept at 600° F. Charcoal was sprinkled between the layers of metal to absorb the free oxygen in the furnace thereby preventing any carbonation of the finished surface;
3. its resistance to rust is probably due to the purity of iron;
4. there is no similar metal manufactured today.

Reproduction of Russia Iron can probably be achieved with research funds totalling between a minimum of $260 and a maximum of $2,200; sheet iron, transportation, hammering, heat processing and misc. costs bring the sum to a minimum of $1,700 and a maximum of $4,500 for 1,000 sq. ft. of finished metal. At this point, funding is being discussed.

Available pieces of Russia Iron are presently being investigated for their workability and their properties when welded; methods by which it can be hammered are also being sought.

Hugh F. Smith, Researcher, CSRM.

APPENDIX.

THE MANUFACTURE OF RUSSIAN SHEET-IRON.*

A PARTICULAR kind of sheet-iron is manufactured in Russia, which, so far as I know, has not been produced elsewhere. It is remarkable for its smooth, glossy surface, which is dark metallic gray, and not bluish gray, like that of common sheet-iron. On bending it backwards and forwards with the fingers no scale is separated, as is the case with sheet-iron manufactured in the ordinary way by rolling; but on folding it closely, as though it were paper, and unfolding it, small scales are detached along the line of the fold.

In the following pages this kind of sheet-iron will be designated Russian sheet-iron. This sheet-iron is in considerable demand in Russia for roofing, and in the United States, where it is largely used in the construction of stoves and for encasing locomotive engines. I am informed that it is there named stove-pipe iron.

Russian sheet-iron has been recently subjected to chemical examination in the Metallurgical Laboratory of the Royal School of Mines, and the analytical work has been executed by my assistant, Mr. W. J. Ward. Portions of two sheets in the collection of the Museum of Practical Geology have been operated upon. These sheets differed considerably from each other in thickness, and in the following account they will, accordingly, be termed the thick and the thin sheets; the thickness of the former was 0·019, and that of the latter 0·005 of an inch.

The specific gravity of the thick sheet was 7·668, and that of the thin sheet 7·646, at 16·67° C., or 62° F.

On digesting strips of the thick sheet in dilute hydrochloric or sulphuric acid at a gentle heat, a tender, delicate black residue, of the original form and size of the strips, was obtained. This residue was examined microscopically, but not found to exhibit any special structure. It disappeared almost wholly when heated to redness with access of air, and consisted, for the most part, of easily combustible carbon. The hydrogen evolved by the action of dilute sulphuric acid upon strips of the thick sheet was passed through a solution of acetate of lead, when a minute quantity of black precipitate, consisting of sul-

* By John Percy, M.D.

RUSSIAN WEIGHTS AND MEASURES USED IN THE FOLLOWING PAPER.—Weights:—1 lb. Russian = 0·9026 lb. avoirdupois; 1 Pood = 36·1026 lbs. avoirdupois. Measures:—1 archine = 28 English inches.

phide of lead, was observed. In operating upon 130 grains of the sheet, no phosphoric acid was detected by the molybdic acid test.

The proportions of carbon in the thick and the thin sheets were ascertained by burning filings of the former and strips of the latter in oxygen gas.

By the action of hydrochloric or dilute sulphuric acid, both sheets yielded an insoluble residue, which contained silica, oxide of iron, and chromium. The proportion of chromium was found by fusing the insoluble residue with nitre, and subsequently precipitating with nitrate of mercury.

ANALYTICAL RESULTS.

	Thick Sheet. Per cent.	Thin Sheet. Per cent.
Carbon*	0·060	0·305
Sulphur	Trace	None
Phosphorus	None	None
Manganese	Not sought for	0·008
Copper	Present, but the proportion was not ascertained.	0·025
Chromium	0·035	Present, but the proportion was not ascertained.
Ignited insoluble residue	0·047	0·108
	Containing 0·035 of chromium.	Containing 0·063 of silica.

The occurrence of the peculiar carbonaceous mass, left after the solvent action of dilute hydrochloric or sulphuric acid, may reasonably be accounted for by the method of manufacturing Russian sheet-iron, to be described in the sequel. The sheets are interstratified with charcoal powder, and bound up in packets, each of which is subjected to repeated hammering. Hence, it is easy to conceive how fine particles of charcoal should be beaten in over both surfaces of each sheet; and, if this be so, a relatively larger proportion of carbon should exist in the thin sheet, as is the case. Yet that some of the carbon is combined, may be inferred from the fact that distinct hardening occurs after heating the metal to redness and immersing it while hot in water, and especially in mercury. (See Note at the end.)

In the volume on Iron and Steel, which I published in 1864, I stated that the mode of manufacturing the Russian sheet-iron in question was kept rigidly secret; that it was made from iron smelted and worked throughout with charcoal as the fuel; that, according to information which I had received from three independent sources, the sheets, after the completion of the rolling, were hammered in packets, with charcoal dust interposed between every sheet; and that they were subsequently assorted, and the outer ones, being inferior in quality, were thrown aside as wasters (p. 780). Two of my informants were Tunner, of Leoben, Styria, and Professor Styffe, of the Polytechnic Institution at Stockholm, when I had the pleasure of being associated with them on the Jury relating to Mining and Metallurgy

* Total carbon, inclusive of what is believed to be mechanically imbedded in the surface.

of the International Exhibition in London in 1862. Beautiful specimens of such Russian sheet-iron were exhibited on that occasion. My third informant was Mr. Septimus Beardmore, Civil Engineer, who, at my request, has personally made inquiry concerning the process of manufacture, and to whom I am indebted for the following account, which he sent to me from Russia in 1866. The description of the process was communicated to him by Mr. W. Yates, a mechanical engineer in charge of an engine-manufactory at Nijni-Sergha, in the Oural. But Mr. Beardmore, accompanied by Mr. Yates, had the opportunity of inspecting the annealing furnaces, hammers, and other machinery at Michailovskoi, where the sheets are made from rolled iron sent from the works at Kerchni-Sergha and Nijni-Sergha, the latter supplying the puddled iron. As Mr. Beardmore visited the works on the occasion of his passing through the town on Sunday, when nothing was being done, he did not witness the manipulation.

I may add that I have the pleasure of including Mr. Beardmore amongst the students who have attended the Metallurgical Lectures at the Royal School of Mines.

DESCRIPTION OF THE MODE OF MANUFACTURE BY MR. SEPTIMUS BEARDMORE.

This kind of sheet-iron is produced from the ordinary sheet-iron, which is derived from malleable iron, obtained either by puddling or by the Comtoise or Franche-Comté process, termed in Russia the Kishni process. A detailed description of this process will be found in my volume on Iron and Steel, above referred to, at p. 603. Decarburization of the pig-iron is effected in a charcoal-finery, by a particular method of manipulation; and the resulting ball is similar to that which is formed in the charcoal-finery in common use in British tinplate works. There is not much difference, it is asserted, in the quality of the iron prepared in the Russian works by puddling or by the Comtoise process; but the product of the latter is slightly preferred for the manufacture of such sheet-iron as is now in question.

Sheets of ordinary sheet-iron are wetted with a brush and dusted over with powdered charcoal. Eighty sheets so treated are piled together, one upon the other in succession, and subjected during three hours to a good red-heat in an annealing furnace. The packet of sheets is then taken out of the furnace, placed on rollers by means of a crane, and by the same means brought under a hammer weighing 60 poods, or nearly 1 ton. After having received sixty blows, equally distributed, the packet is reheated and rehammered, the sheets being examined to ascertain if any of them have become welded together. The packet is a third time annealed, withdrawn from the furnace, turned over, and hammered on the face now uppermost. It is again annealed, and hammered for the fourth and last time. The sheets are sheared, assorted into Nos. 1, 2, 3, according to their appearance, and again assorted according to weight, which varies from 6 to 14 lbs. per sheet. The dimensions of the sheets are always (?) the same, namely, 4′ 6″ × 2′ 4″.

The price (in 1860)* of the sheet-iron manufactured in the manner described is 2 roubles 50 kopecks per pood, or 25*l.* (nearly $125) per ton. The payment is by piece-work, and the men receive, per 100 sheets, 1 r. 25 k., of which the master gets 25 k., three under-masters 18 k. each, and the rest 15 k. each. In addition to the cost of labor in the after and special part of the manufacture, there are the costs for puddling and rolling, which amount to 3½ k. and 4½ k. respectively.

Mr. Beardmore states that, on conversing with a Frenchman from Bernadall's works, concerning the manufacture of this kind of sheet-iron, he was informed that two hammers are used, one weighing 40 poods and giving sixty blows a minute, and the other weighing 60 poods and giving forty blows a minute; that the former is employed first, and the latter afterwards, when the packet of sheets "est bien dressé;" that the packet, containing sixty sheets, is not turned; and that the number of blows to be given is left to the discretion of the master-workman. But with respect to the mode of producing the characteristic quality of these sheets, the Frenchman said, "C'est tout-à-fait une affaire de poudre de charbon"—*i. e.* "it is wholly a matter of charcoal-powder."

DESCRIPTION OF THE MODE OF MANUFACTURE BY PROF. PUMPELLY.

Pumpelly, Professor of Mining Engineering at Harvard University, U. S. A., with whom I have the pleasure of being personally acquainted, has recently published the following description of the process, as he saw it practised at the works belonging to the Demidoff family, situated at Nijni-Tagilsk, on the eastern flank of the Oural Mountains:—

"Through the courtesy of Mr. Nistki, I was shown through the works, and had an opportunity of seeing the process of manufacture of the celebrated Russian sheet-iron, which has, I believe, never been described. The magnetic ore is roasted at the mine, in heaps of 10,000 or 16,000 tons, to remove the little sulphur it contains. It is then smelted in charcoal blast-furnaces. After being puddled, the iron is rolled into plates about 2½ feet long, 6 inches wide, and ¼ inch thick. These, after being heated in a furnace with a very reducing flame, are quickly

* With the Exchange at par; *i. e.* with the rouble worth 3*s.* 2*d.*, ten kopecks per pood is about 1*l.* (say $5) per ton. One rouble = 100 kopecks.

brushed, to remove any foreign substance that may have fallen upon them, and are then passed between rolls, the upper one of which is unconnected with the lower, rolling only by friction. By the time the sheet is cooled, it is about 16 inches wide. Packages of three sheets are now laid in the furnace, and then rolled again, after the upper sheet has been brushed and charcoal-powder thrown between them to prevent adhesion. If thin iron is desired, the sheets are subjected to a third heating, in packages of four or six, and rerolled, after which they are trimmed to the proper dimensions. They are now sent to the forge, where they are heated and hammered three times, in packages of from sixty to eighty. After the first hammering, each sheet is swabbed with a wet mop, to harden the surface (it is said that tar is sometimes used for this purpose). Two packages, one hot and one cold, are now mixed in alternate sheets, to produce the greenish color in cooling, and the mixed package is then passed backward and forward under a large hammer, and, after this, is again mixed and rehammered. The superiority of the Russian product is due in great part to the cleanliness of the work, and to the carefulness and skill of the workmen. Every sheet that is at all spotted is thrown into the second or third class, and the difference in value between these and the first quality is deducted from the pay of the workmen. The clippings of the sheets are worked up into fine iron, and loss of material by the whole process is reduced to from 12 to 15 per cent. The fireproof bricks used in heating furnaces are made from a fine quartz sand, which is merely sprinkled with lime-water before being moulded and burned, a method of making fire-bricks which might be useful, in many cases, to our own metallurgists."*

The well-known Dinas bricks are composed of silica and lime; and a description of the mode of manufacturing them will be found in the first volume of my work on Metallurgy, published in 1861.

DESCRIPTION OF THE MODE OF MANUFACTURE BY HERBERT BARRY.

The latest published account of the process of manufacturing this kind of Russian sheet-iron in the Oural which I have met with is that of Mr. Herbert Barry, and is as follows:—

"The refined iron is hammered under the tilt-hammer into narrow slabs, calculated to produce a sheet of finished iron two archines by one (56 inches by 28 inches), weighing, when

* "Across America and Asia. Notes of a Five Years Journey around the World, and of a Residence in Arizona, Japan, and China." By Raphael Pumpelly, Professor in Harvard University, and sometime Mining Engineer in the service of the Chinese and Japanese Governments. London, 1870. Pp. 421.

finished, from 6 to 12 lbs. These slabs are called *balvanky*. They are put in the reheating furnaces, heated to a red-heat, and rolled down in three operations to something like a sheet, the rolls being screwed tighter as the surface sheet gets thinner. This must be subsequently hammered, to reduce its thickness and to receive the *glance* (*i.e.* polish or glaze). A number of these sheets having been again heated to a red-heat, have charcoal, pounded to as impalpable powder as possible, shaken between them through the bottom of a linen bag. The pile, then receiving a covering and a bottom in the shape of a sheet of thicker iron, is placed under a heavy hammer; the bundle, grasped with tongs by two men, is poked backwards and forwards by the gang, so that every part may be well hammered. So soon as the redness goes off, they are finished, so far as this part of the operation goes. So far, they have received some of the *glance*, or necessary polish. They are again heated, and treated differently—in this respect, that, instead of having the powdered charcoal strewed between them, each two red-hot sheets have a cold finished sheet put between them; they are again hammered, and, after this process, are finished, as far as thickness and *glance* goes. Thrown down separately to cool, they are taken to the shears, placed on a frame of the regulation size and trimmed. Each sheet is then weighed; and, after being thus assorted in weights, the sheets are finally sorted into first, second, and third, according to their *glance* and freedom from flaws and spots. A first-class sheet must be like a mirror, without a spot upon it. One hundred poods of *balvanky* make seventy poods of finished sheets; but this allowance for waste is far too large, and might easily be reduced. Four heats are required to finish. The general weight per sheet is from 6 to 12 lbs., the larger demand being from 10 to 11 lbs.; but they are made weighing as much as 80 lbs., and may then almost be called thin boiler-plates, being used for stoves, &c. Besides the finished sheets, a quantity of what are called *red sheets* are made, which are not polished, and do not undergo the last operation.

"Taking the Michailovskoi works, which are the largest sheet-iron ones in the empire, I found that the power running the sheet-rolls was equivalent to forty horses, the rolls making seventy to eighty revolutions a minute. The hammers used are powerful, having the surface of the stroke very large, just the contrary shape there to the ordinary tilt-hammer. A gang turns out in a shift from 450 to 600 sheets. In the central works, where they make sheet-iron from puddled iron, they *roll* it into the necessary size, and then roll this *balvanky* into half-ready sheets, with the same sort of rolls as are used in the north, but which, however, run much slower; the finish being given also by hammers in the same manner, but leaving out the final part of the operation of placing cold finished sheets between the hot unfinished ones. The hammers are not so heavy, and the heating furnaces are not so well constructed and do not regulate the flame so well. The trimming, sorting, &c., is carried out just in the same way. The waste is really greater in the central works than it *should* be in the north, as the hammered iron does not leave such a raw edge as the puddled. A fact that proves the superior manufacture of the north over the other parts of the empire is, that whereas in the former sheet-iron is the best-paying, in the latter it is the worst business. For the uses which sheet-iron is put to, ductibility is of the first consequence; and no sheet-iron is of passable quality that will not bend four times without breaking: some made in the Oural I have bent as much as nine times without showing the break. Coupled with this quality, the *glance* must be taken into consideration, as good polished iron will not take so much paint as the inferior polished.

"The most renowned trade mark in the world for sheet-iron being *Iakovleff* is by no means a proof that it is superior to that of all other makers; and, in fact, it is not so. There are other makers equally as good, and I find, beyond any doubt, that the best sheet-iron in Russia is made at Pastuchoff's works, a small concern in the government of Viatka; and even at Michailovskoi I have seen sheet-iron equal in every respect to Iakovleff's. For sheet-iron made from puddled iron, I assume the only large makers to be the Vuickss Works and Demidoff; and I much prefer the manufacture of the former, as it is much softer."*

DESCRIPTION OF THE MODE OF MANUFACTURE, COMMUNICATED TO THE AUTHOR BY N. DE KHANIKOF.

Towards the end of the last year (1870), I had the pleasure of making the acquaintance of Mr. N. de Khanikof, an eminent Russian man of science, while he was temporarily residing in London, and I asked him whether he could give me any information concerning the manufacture of the kind of sheet-iron here in question. In reply he stated that although he had a personal interest in ironworks in Russia, yet he had no knowledge of the subject, but that he would communicate with a friend who was engaged in its manufacture, and endeavor to procure from him a trustworthy account of it. Shortly afterwards I received a letter from Mr. N. de Khanikof, dated February 6th, 1871, enclosing the following description in German, which he had obtained from Mr. Kokcharof. I have great pleasure in publicly acknowledging my obligation to Mr. N. de Khanikof for his kindness and promptness in this matter.

* "Russian Metallurgical Works, Iron, Copper, and Gold, concisely described." By Herbert Barry, late Director of the Estates and Iron Works of Vuickss. London, 1870; pp. 29 *et seq.*

The manufacture of glazed sheet-iron is carried on at the ironworks which are situated on both flanks of the Oural Mountains. The sheets are derived from pig-iron smelted with charcoal, and converted into malleable iron in a charcoal-finery. The malleable iron is rolled into plates of an ordinary trade size, namely two archines (56 inches English) long, and one archine (28 inches) broad. At some ironworks it was attempted to use puddled iron, but without success, as the sheets so obtained did not possess the same soundness.

There is nothing particular in the rolling of the sheets, except that it is conducted very carefully and quickly, so that a gang of workmen in an ordinary shift of twelve hours will turn out from 500 to 600 sheets.

The chief peculiarity of the Russian method of manufacturing sheet-iron consists in communicating to the surface of the sheets by a particular process a mirror-like glaze of a brown or smoke-gray color.

The rolled sheets are sheared and arranged in packets to the number of fifty or sixty, and sometimes a hundred in each packet, the surface of each sheet having been previously wetted with water and dusted over with charcoal-powder. Each packet is enclosed in waste sheets, and heated in an annealing furnace during five or six hours, after which it is taken while hot to the hammer; and each sheet before cooling is freed as quickly as possible from the remaining charcoal-powder. The sheets are again arranged in packets, and hammered with a particular hammer, named in Russian "razgonnyj molot." This hammer weighs 60 poods (about 2166 lbs. English), and gives from fifty to sixty blows a minute; and its striking face is 14 inches wide and 6 inches long. Each packet is hammered uniformly over its whole surface, and after cooling is annealed. After this second heating, the packet is rehammered under the same hammer during from ten to fifteen minutes, and is again annealed; and the annealing and hammering are again repeated from four to five times. After the last annealing, the packet is hammered during from twenty-five to thirty minutes under the so-called glazing-hammer, which weighs from 40 to 50 poods (1444 to 1805 lbs. English), and of which the striking face is from 16 to 17 inches long, and from 20 to 21 inches wide. After this last operation the packet is opened, and the sheets are sheared for the last time and assorted, according to weight and external appearance.

The yearly production of this kind of sheet-iron in the Oural is 1½ million of poods (about 24,182 tons English). The sheets are usually two archines (56 inches) long and one archine (28 inches) wide, and weigh from 10 to 12 lbs. Russian (1 lb. Russian = 0·90264 lb. avoirdupois).

Two articles have been published concerning this manufacture in the Russian Mining Journal, one in vol. iii, 1835, and the other in Nos. 3 and 4 of the year 1870. But I have not had the opportunity of seeing either of those articles, which are written in the Russian language.

DESCRIPTION OF THE MODE OF MANUFACTURE BY CAPTAIN N. MESHTCHERIN.

Toward the end of the year 1869, I was favored with a letter from a Russian mining engineer, Captain N. Meshtcherin, containing a much more circumstantial and satisfactory description of the mode of manufacturing the kind of sheet-iron which is the subject of these pages than any of the foregoing, and than any which, so far as I am aware, has hitherto been published. The description is illustrated by hand-sketches and prefaced with the following remarks, which I present with only a few slight verbal alterations:—

"Sir: In your work, entitled 'Iron and Steel,' I noticed at p. 730, in the article on Russian Sheets, your remark that 'the method of their manufacture is,' you believe, 'kept rigidly secret, and the manufacture of such sheets is a desideratum in this country.' Having, during about three years, been engaged in Siberia as a mining engineer of the Russian Government, and having been acquainted with that branch of iron industry, I thought that it would be of some interest to you to have information concerning the methods of procedure which are used in manufacturing such sheet-iron in Russia. The process is freely open to the inspection of all foreign travellers, as well as to natives of the country, but very little is known of it in Western Europe, chiefly because foreigners are ignorant of the Russian language, and also on account of the remoteness of the places of manufacture from Western Europe.

* * * * *

"I beg to remain, yours, &c.,

"N. Meshtcherin,

"Russian Mining Engineer, Captain.

"*63 Berners Street, Oxford Street, London, 16th November, 1869.*"

I may add that I had also the pleasure of making the author's personal acquaintance.

The manufacture of sheet-iron in Russia is chiefly confined to the ironworks on the eastern side of the Oural Mountains. The malleable iron, which is the subject of this manufacture, is derived from pig-iron, obtained by smelting the following ores with charcoal in cold-blast furnaces—namely, magnetite, carbonate of iron (*sphaero siderite*), and red and brown hæmatite. The conversion of the pig-iron into malleable iron is effected either in the charcoal-finery or in the puddling furnace.

The puddle-balls, intended for the manufacture of sheet-iron, are rolled into bars 6 inches wide and ½ inch thick. The iron should be more crystalline than fibrous, and should contain sufficient carbon to render it more like steel than iron. The machinery required consists of one or two pairs of rolls and two kinds of hammers. Reheating is conducted in furnaces of particular construction. The rolls are driven by water-wheels, and should make not fewer than fifty revolutions a minute. The hammers are also put in motion by cams on the axles of water-wheels. The hammer-heads are of wrought-iron, with striking faces of steel. Each anvil consists of a solid block of white cast-iron. It is necessary that the hammers and anvils should be so made in order that they may have the requisite hardness, in default of which the surfaces of the sheets would not acquire sufficient brightness or polish. One kind of hammer is used for widening, and the other for smoothing, the sheets: both are raised to the height of 23 inches, and give from thirty-five to forty blows a minute.

Fig. 594. Fig. 593.

Fig. 593. Side elevation of the first kind of Hammer for widening the sheets, of the Anvil, and of the Cam-wheel.

Fig. 594. End elevation of the Hammer-head and Anvil.

(The scale is given under Figs. 595 and 596. The numbers indicating dimensions are English feet and inches.)

Fig. 596. Fig. 595.

Fig. 595. Side elevation of the second kind of Hammer for smoothing the sheets, of the Anvil, and of the Cam-wheel.

Fig. 596. End elevation of the Hammer-head and Anvil.

(The drawings for all the wood-cuts have been made by Mr. W. Prim.)

The reheating furnace is represented in Figs. 597-8-9-600, and it is hoped that its construction will be clearly understood from a careful examination of those figures. Wood is the fuel used. It will be perceived that this furnace differs widely from the reheating or annealing furnaces employed in this country. The fireplace extends under the bed of the reheating chamber from end to end, and the gaseous products of combustion enter that chamber through a series of five similar and equal openings in the bottom on each side.

Fig. 597.

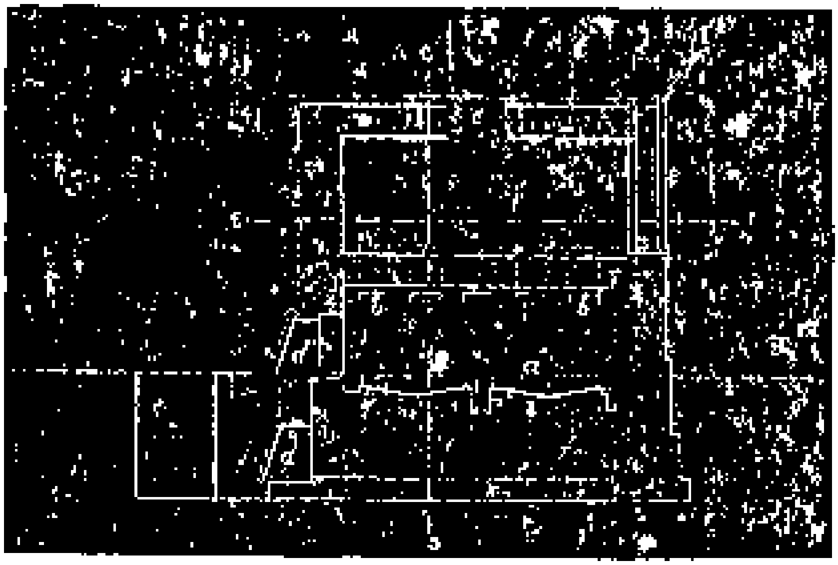


Fig. 598.

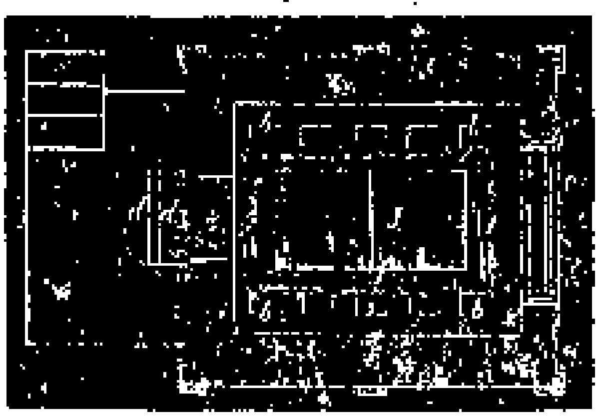


Fig. 597. Longitudinal section of the Reheating Furnace on the line A B, Fig. 599.
Fig. 598. Horizontal section on the line E F, Fig. 597.

In the construction of these furnaces there is one principle which must be rigidly observed, namely, the complete exclusion, as far as practicable, of free atmospheric air from the reheating chamber, in order to prevent superficial oxidation of the sheets. With this view, not only must the walls be made impervious to air, but the fire and ash-pit doors (*d d*), as well as the end door (*e*), must be made to fit as tight as possible. Tight fitting of the doors (*d d*) is secured by the arrangement shown in the figures.

The puddle-bars, 5 inches wide and ½ inch thick, are cut into pieces 29 inches long, which weigh about 15·35 lbs. avoirdupois (10 lbs.?—J. P.). These pieces are heated to redness and cross-

Fig. 599.

Fig. 600.

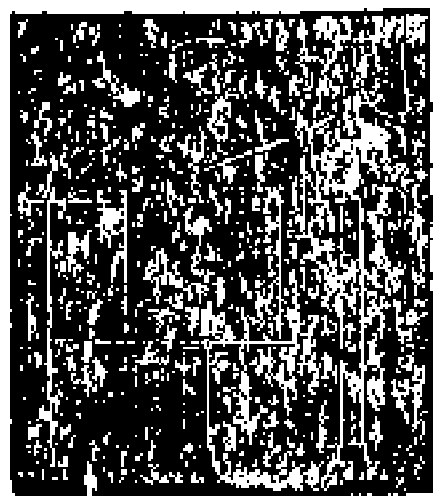


Fig. 599. Transverse section on the line C D, Fig. 597.
Fig. 600. End elevation, where the sheets are put in.

THE FOLLOWING LETTERS, WITH DESCRIPTIVE REMARKS, APPLY TO FIGS. 597-8-9-600.

- *a*, Grate.
- *b b b b*, Flues leading from the fireplace into the reheating chamber.
- *c*, Chimney, which, in the original sketches, is shown as made of riveted ironplate.
- *d d*, Fire and Ash-pit Doors; they are made of cast-iron, and are hinged at the top; and to each door a hook is affixed, by which it may be conveniently opened.
- *e*, Counterpoised Door.
- *f*, Packet of Sheets, surrounded by logs of wood.

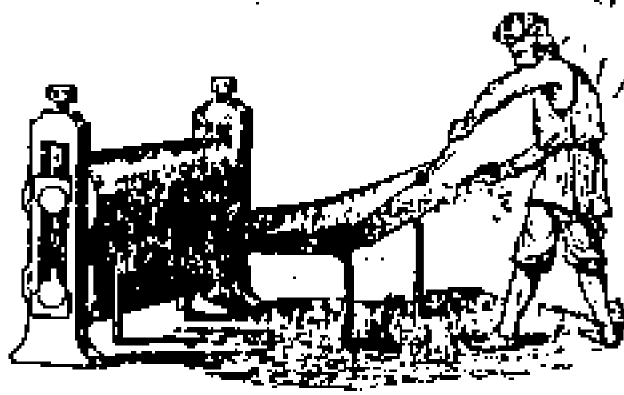
rolled into sheets about 29 inches square (see Fig. 601); and in order to become thus extended, they require to be passed through

Fig. 601.

The shaded part represents a piece of puddle-bar cut for rolling, and the dotted lines the form and dimensions of the resulting sheets.

the rolls about twelve or fourteen times. The sheets thus produced are arranged in packets of three in each, heated to redness, and rolled, each packet passing through the rolls about ten times. But, just before rolling, the surface of each packet is cleaned with a wet broom, usually made of the green leaves of the silver-fir, and powdered charcoal is strewn between the sheets, in the manner shown in Fig. 602.

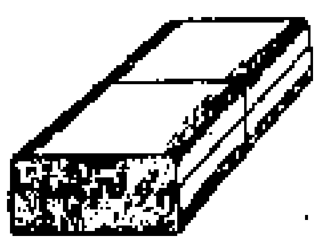
Fig. 602.



Diagram, not to scale, showing the manner of strewing the charcoal-powder between the sheets.

The sheets obtained from this rolling are sheared to the dimensions of 28 inches by 56 inches. Each sheared sheet is brushed all over with a mixture of birch charcoal-powder and water, and then dried. The sheets, so coated with a thin layer of charcoal-powder, are arranged in packets containing from seventy to a hundred sheets each; and each packet is bound up in waste sheets, of which two are placed at the top and two at the bottom, as shown in Fig. 603. A single packet at a time

Fig. 603.

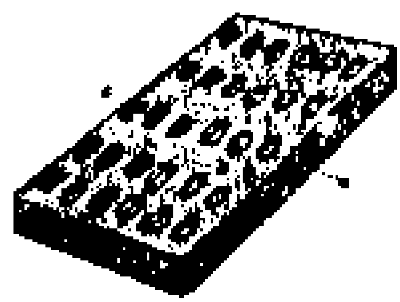


Packet of sheets bound up in waste sheets.

is reheated, with logs of wood about 7 feet long placed round it, as represented in Figs. 598, 599, the object of which is to avoid, as far as possible, the presence of free oxygen in the reheating chamber. The gases and vapors evolved from heated wood contain combustible matter which would tend to protect the sheets from oxidation in the event of free oxygen finding its way into the reheating chamber.

The packet is heated slowly during five or six hours, after which it is taken out by means of large tongs and hammered under the first kind of hammer (see Figs. 603, 604). The packet is moved so that the blows fall in the order indicated in Fig. 604. After this treatment, the surface of the packet presents a wavy appearance, as the striking face of the hammer and the face of the anvil are both rather narrow. When the packet has travelled about six times under the hammer, in the manner specified, from *a* to *b* (see Fig. 604), it is removed; and immediately afterwards completely finished sheets are arranged alternately between those of the packet. The packet thus composed, which

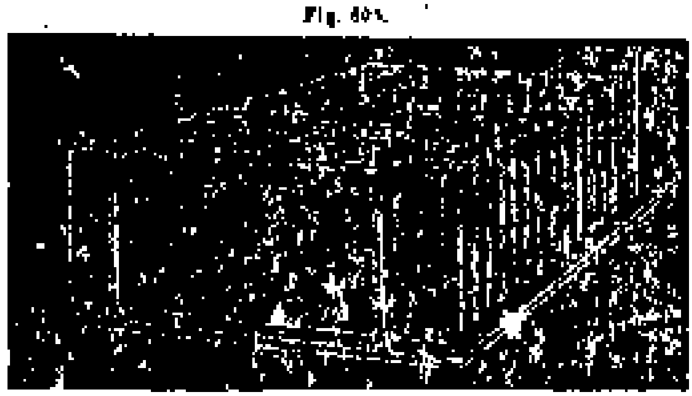
Fig. 604.



Perspective view of a packet of sheets, showing the order in which the blows of the hammer are given.

contains from 140 to 200, or twice the number of sheets in the packet subjected to the first hammering, is hammered under the second kind of hammer (see Figs. 595, 596,) in the same manner, but not to the same extent, as the first packet. Instead of being moved to and fro six times from right to left, it is moved so only twice. By this treatment, if the hammering be carefully executed, the sheets acquire a perfectly smooth surface; but this result would not be obtained without the interposition of the smooth-faced finished plates in the manner above described. After the second hammering the packet is opened, the surface of each sheet is again cleaned with a wet broom, and the sheets are set separately in a vertical rack, in order to cool, as shown

Fig. 605.



in Fig. 605. These sheets are next sheared to the dimensions of 28 inches by 56 inches.

The actual cost of manufacturing these Russian sheets is about 12*l.* 15*s.* per ton, to which must be added general charges, which raise the amount to 16*l.* or 17*l.* per ton, exclusive of profit. The average price of sheet-iron at the fair of Nijni-Novgorod is about 22*l.* or 25*l.* per ton.

Although it must be admitted that not one of the foregoing descriptions of the mode of manufacturing Russian sheet-iron is complete in every respect, yet it is hoped that a careful and comparative study of the whole will enable the manufacturer of sheet-iron to obtain all the information which he may desire on the subject. Details which have been omitted, even in the most comprehensive of these descriptions, will be found in the others.

If an attempt should be made to manufacture similar sheet-iron in this country, it would, probably, not be necessary exactly to imitate the Russian process in every particular. Thus, instead of employing such an annealing furnace as has been described, the method commonly pursued at tinplate works, namely, annealing in covered cast-iron vessels, might be adopted.

NOTE.

Since the foregoing pages were in type, the following additional observations have been made:—

Strips of the thick and thin sheets were heated to redness in a current of dry hydrogen, when steam, having a slight empyreumatic odor, was evolved from the end of the glass-tube in which the experiment was made. By this treatment the strips acquired the characteristic color and dull aspect of unpolished iron. The surface of the thick plate, when magnified about fifty diameters, was seen to be reticulated with minute cracks; while here and there were small pits, which contained black matter resembling charcoal. On one or two of the strips raised lines, also reticulated, were observed, which were doubtless the impression in relief of the cracks upon the sheet in contact with which it had been hammered. The cracks seemed to penetrate to a certain common depth, to which they opened on bending, leaving a central portion free from cracks, as though the metal below the level of the cracks differed in quality from that which was above it. The surface of the thin strips, which had been exposed to the action of hydrogen in the manner described, was much more finely granular and more uniform than that of the thick strips, and the cracks were both fewer and smaller than those in the latter.

The production of steam by the action of hydrogen shows that the iron was more or less superficially oxidized. The empyreumatic odor was probably due to the presence of a little oily matter, as the strips experimented upon had not been previously scoured or otherwise cleaned.

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