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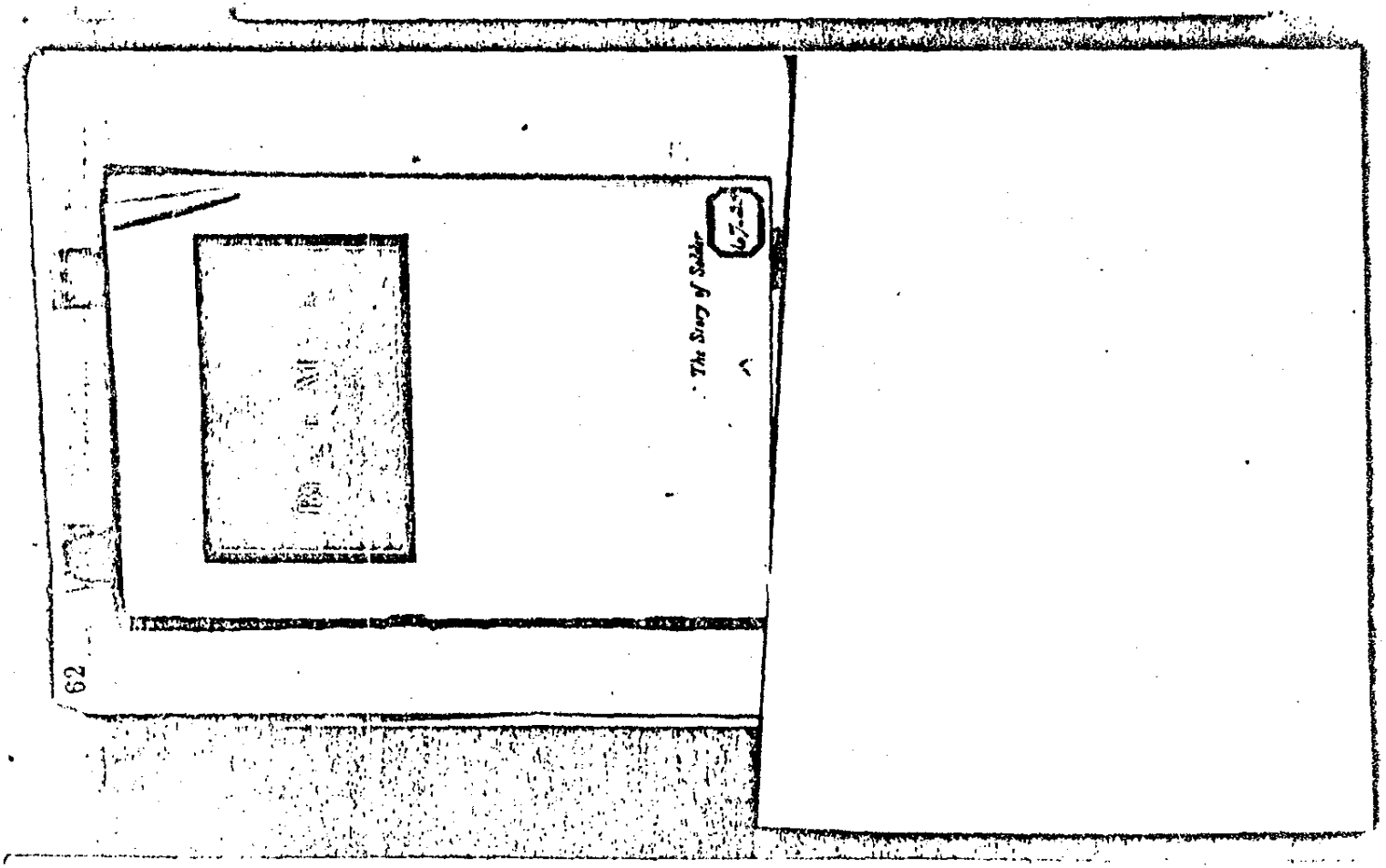

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BLACK MAGIC

An Interesting and Authoritative Story of Solder

NATIONAL LEAD COMPANY

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BLACK MAGIC

1. Solder—the Wonder Alloy

DID it ever occur to you that the joining together of two pieces of pure tin or two pieces of lead with solder had a touch of black art in it? Solder is made of tin and lead. Now, if you tried to join two pieces of pure tin by running molten tin along the seam you would naturally melt the tin you wished to solder.

"Ah," you say, "I have it! The lead melts at a lower temperature, and that's why lead is used for the purpose."

But that's the queer part; it takes a higher temperature to melt lead than tin—170 degrees higher.

"Then how in ——" Patience! This is how. It is due to black magic, that magic which nature uses now and again. If we mix the tin and lead together, the alloy melts at a lower temperature than does either metal by itself. That is why a lead and tin solder is so useful. It can be used to solder tin things together and lead things, also, without melting the objects to be joined.

In practice it is not often necessary to join pure tin to tin, but the solder principle is used in joining what are known as tin plates, which are thin sheets of steel

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coated with tin. It is otherwise required to join lead to lead, as in plumbing and electrical work.

Just how useful is this little joint of nature's can be to some degree appreciated if we just contemplate for a moment the number of soldered things we use every day. Millions of automobiles owe their smooth body surface to the fact that the joints are filled up flush to the surface with solder, to say nothing of the fact that the radiators are soldered and that soldered gasoline tanks enable us to carry our fuel, while various bearings need lubricating oil from millions of soldered cans. Millions of people ride in these cars and eat millions of meals that daily draw upon soldered tin cans for delicious dainties and substantial courses. Tin roofs are made of sheets of tin plate soldered together, and to the electrician solder is a constant companion. He uses it to join his wires together everywhere, whether in the complicated windings of a motor or generator, or merely where a couple wires happen up to something or other.

Every one knows about soldering irons, which supply the heat to melt the solder, but not every one knows that they are usually not worth at all but coppers. The copper used is better than iron as it retains and conducts the heat better and does not pit so readily. Also, the solder follows the copper and bonds with it much better than the iron used.

Neither does every one know that the soldering iron does not do all the soldering work by any means. The automobile radiator maker, for example, melts his solder in a container, then in, he makes a bath of it and sticks the radiator into the molten solder. The bath is shallow, of course, just deep enough to let the solder take the proper hold on the edges of the pieces to be joined.

Often soldering is done by machinery, as in making tin cans and closing them after they are filled, and the solder in such cases may be used in the form of little

drops or sometimes as bits of wire bent into the form of segments of a circle.

Sometimes the objects to be soldered together are so fine and delicate that the solder is pulverized and mixed with a flux, spread over the surface, and then melted with a blow-pipe or blow-torch, thus sweating the solder to the joint.

The most interesting soldering operation of all is that known by the term "wiping a joint." This is not a tinner's job but a plumber's. In the preceding instances the work to be joined was of tin, copper or galvanized iron. In joint wiping we have an example in joining lead and lead. When two pieces of lead pipe are to be made into one continuous tube, the plumber melts a piece of solder and applies it to the joint by means of a cloth pad held in his hand, deftly wiping and smoothing the readily cooling alloy around the joint. When the job is finished the pipes are solidly one, the sweated joint appearing like a slight swelling of the pipe at that point, like a snake at the exact spot of whose anatomy you can point and say, "There lies his dinner."



This old man wanted, the "tinker," worked under a disadvantage. His solder was not always available. The tinker used to make his own solder, but therefore, sometimes did not succeed "good." But the tinker of today does not make solder, preferring to leave the matter of a responsible manufacturer. The latter guarantees that the product is of a standard composition and is tested for its purity and performance, whether the solder is pure tinned solder or has pieces from time.

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As you watch a plumber wiping a joint you admire his dexterity in handling the hot mass of lead-tin alloy as if it were cold clay, but unless you are unusually keen and observative in many not occur to you that you are witnessing not only a feat of human skill but a still more remarkable and interesting feat of Mother Nature herself. To be specific, the solder that we saw the tinner and canner and the automobile radiator manufacturer using was liquid when molten, but this hot solder in the plumber's hand is plastic and allows itself to be wiped around the pipe like mass clay.

The plumber might possibly handle in the same way the solders we saw the others using, by allowing them to cool somewhat, but there is one solder he never could so handle and that is an alloy containing 63 per cent tin and 37 per cent lead. Heat such a solder so that it would flow at all, and it would run through his fingers like any liquid. It would not help to be very careful to heat it very slowly so as to catch it at a point midway between the solid state and the liquid, for there is no such point with 63-37 per cent solder. It is all solid below 358° F. and all liquid above that point.

With an alloy of tin and lead varying from that formula there comes an intermediate plastic state in which the alloy is neither a hard solid nor a free-flowing liquid. It matters not which of the two metals is in excess in the alloy, as it is heated, becomes plastic before it melts completely into a liquid, and again, as it cools, it becomes plastic before it sets solid.

What makes the difference?

It is really a case of making a pie of lead as we used to make pies of mud.

When lead and tin are fused together in the proportions of 63 per cent tin to 37 per cent lead, an alloy results that acts in many respects like a new metal. It may be melted and then cooled, either quickly or slowly, and it will still change from liquid to solid without an intermediate plastic stage, the resulting structure of the solid alloy being homogeneous.

If, on the other hand, you do the same thing with a solder containing any other proportions, say 40 per cent tin and 60 per cent lead, you will observe very different behavior. In the first place, you will observe the plastic state on heating and cooling, as described; then if you examine a cross-section of the fractured metal under a microscope you will find peculiar formations, sometimes very irregular ones. They will remind you of particles of one kind caught floating in a mass of different character and frozen there on the cooling of the mass. As a matter of fact, that is just what has happened. The first alloy, which acts like a homogeneous metal, is known as a eutectic mixture. The second alloy, which has an excess of lead, is not homogeneous but is made up of a portion of eutectic mixture and a portion of lead.

Now, as we have noted before, any alloy of tin and lead begins to melt at a lower point than either of these metals does by itself, so that, if there is an excess of one of these metals in the mixture, it naturally will remain solid a little longer than the eutectic alloy, that is, the 63-37 per cent mixture. We thus have, in the case cited, some solid lead floating in the perfectly proportioned alloy that has melted. But it is not floating like a cake of ice in water. The solid lead is dispersed or diffused through the molten alloy, like a very finely divided clay with just enough water to make stiff mud of it, which justifies the simile of making a lead pie. The mud pie and moist modeling clay are plastic because of the moistening of the finely divided solid part with a liquid, water. The solder is plastic because the solid excess lead, finely divided but nevertheless solid, is moistened with a liquid, the molten eutectic mixture.

As a matter of every-day use, all tin-lead solders are

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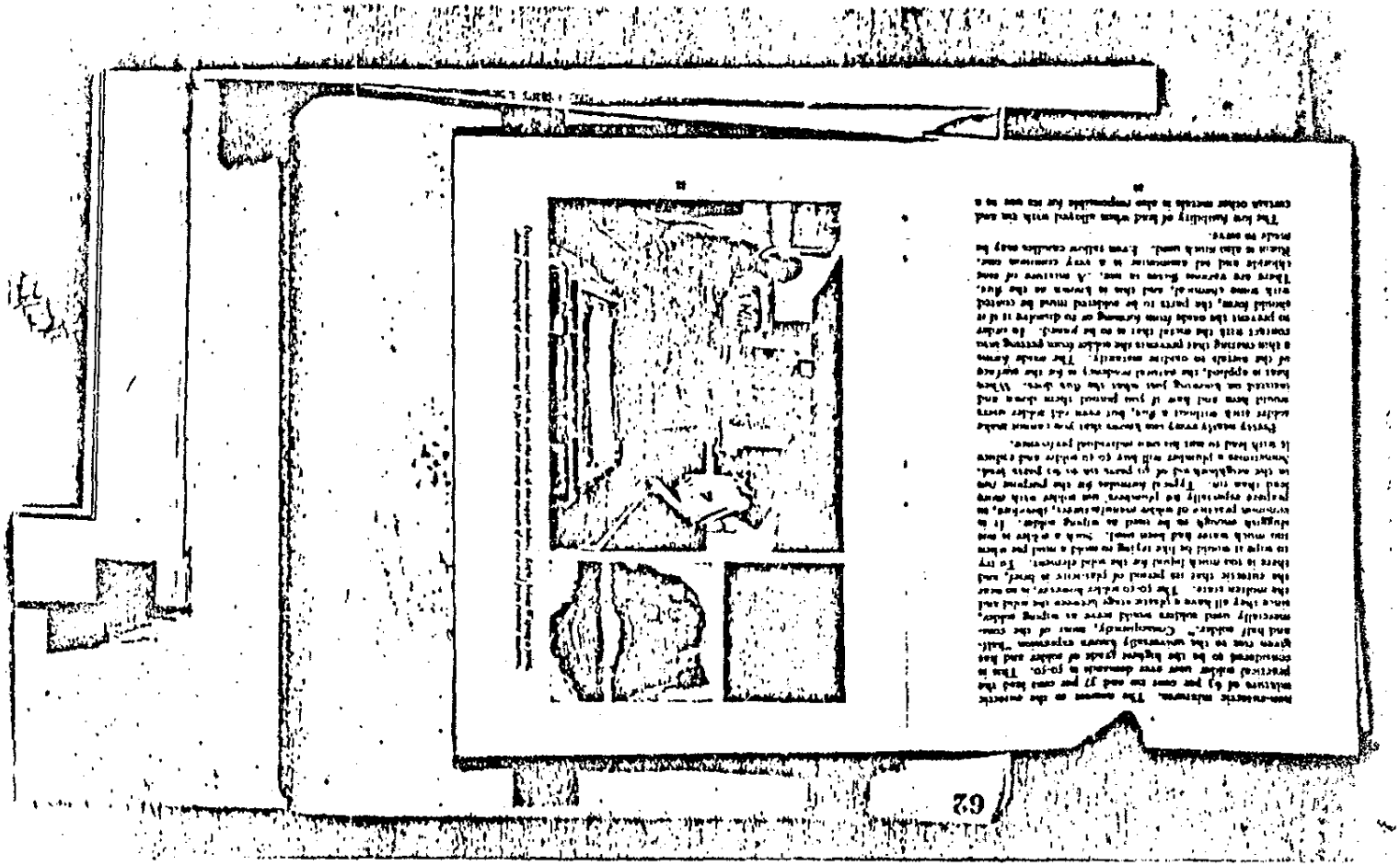


special solder that forms the heart of automatic fire-sprinkler systems. Alloy lead melts at 620° F. and tin at 450° F., when they are put together in an alloy, as has been stated before, the fusing point is reduced to 338° F. By introducing bismuth, which itself, like lead, will stand many heat than tin without melting (504° F.) alloys can be made that will fuse at very low temperatures, and, by the addition of cadmium, which itself melts at 610° F., an alloy can be made that melts even as low as 158° F.

This fact is utilized in the automatic fire-sprinkler, a device of modern ingenuity the idea of which is to make the fire put itself out—the acme of efficiency, one would say! Water is conducted through a building by means of pipes that have sprinkler devices at proper intervals. The sprinklers are kept from operating when all is well by means of valves. These valves are so designed as to be normally open, but they are kept closed with a solder of fusible alloy such as the one described. When fire breaks out, the heat at a certain degree melts the easily fusible solder, and the valves are freed and automatically take their normal open position, letting the water rush out thru the sprinkler nozzles.

The sprinkler manufacturer varies the fusibility of his alloy according to the requirements of the fire regulations in the community where his installation is being made. Alloys in use vary in fusibility from 160° to 212° F. A typical formula is: Lead 25 per cent, bismuth 50 per cent, tin 12½ per cent, cadmium 12½ per cent. Bismuth and cadmium, the very effective in lowering the melting point, are very much more expensive than tin and lead, and are therefore used as sparingly as possible.

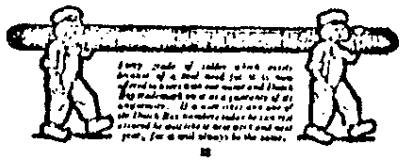
2. Our Line of Solders

Dutch Boy Solders

To meet the wide range of requirements we manufacture under the Dutch Boy trademark a complete line of solder. Each grade is suitable for certain kinds of work and is designated by number. We also manufacture solder without trademark in any form or composition desired. Details are given on the following pages.

Until the introduction of solder under the Dutch Boy trademark, names of solders meant nothing, not even in our company's practice, with the one [illegible] exception of our old "Warranted Half-and-Half." That was just what it represented itself to be. As for our other "half-and-halfs," we would not put our name on them, for they were at least technical misrepresentations, tho of course we did everything possible in our literature and otherwise to explain to buyers that these traditional names of "Commercial Half and Half," "Strictly Half-and Half," etc., were misleading and did not designate true 50-50 solders.

As we have said, preference varies with the individual. One person uses a solder with a great deal of tin on the same work for which another person chooses a solder with much less tin. It is evident, therefore, that more than one grade may be used for the same purpose, depending on the user. This fact had opened up the



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opportunity for plausible excuse for misrepresentation.

The conditions existing at the time we adopted our Dutch Boy series and abolished the meaningless "half-and-half" tradition probably came about in this way. For generations solder containing 50 per cent tin and 50 per cent lead was generally considered the best solder for all general purposes and "half-and-half" was its usual designation. Anything else was considered worthless. Manufacturers found, however, that many users had perfect success with solder containing a little less tin (as long as the user did not know of the difference in formula) and the manufacturers began to make so-called "half and half" at a slightly lower pace. Generally these off grades carried a modifying adjective such as "literally" half and half (probably borrowing the idea from "literally" fresh eggs) or "Commercial" half-and-half (borrowing again, maybe, from the chemical trade's "commercially pure" which, as the uninformed know, does not mean really pure).

Thus it came about that the riddle, "when is half-and-half not half-and-half?" was promptly answered by: "Generally."

These conditions were irritating to us, because we recognized that some of these so-called half-and-half formulas were good, legitimate formulas and had an excellent reason for existing yet we could not in honor put our name on them, for they were not half-and-half solders as they seemed to claim and we could not link our name with deception. We were therefore barred from fathering with our name several worthy grades of solder.

Finally when we did decide to do something about it we went the whole distance and took a step which the solder world thought would be disastrous, but which, on the contrary, has proved to be a most fortunate move. We threw the whole crew of misleading brands overboard and adopted instead our Dutch Boy series.

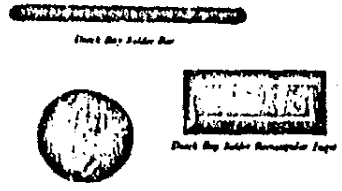
This policy has resulted in the following advantages:

(1) Every grade of solder which exists because of a real need for it is now offered to users with our name and trademark on it as a guaranty of its uniformity. If a user likes any one of the Dutch Boy numbers today he can rest assured he will like it next week and next year, for it will always be the same.

(2) Our brands mean what they say. All ground for complaint on that score has been abolished.

(3) Every dealer who takes on the Dutch Boy series at once gets for himself all the advantages which accrue from our prestige, our advertising, the uniformity of the wares, and our advanced stand on the subject of accurate naming of solders.

The Dutch Boy line of bar solders is complete, ranging from No. 111, which is real "Half-and-Half," to No.



Dutch Boy Solder Bar

Dutch Boy Solder Round Ingot

Dutch Boy Solder Rectangular Ingot

The Dutch Boy line of solders is complete, ranging from No. 111, which is real "half-and-half," to No. [illegible], which is commonly the most used wiping solder. It is sold in convenient bars or ingots. Dutch Boy solder Nos. [illegible] are made in bars, Nos. [illegible] and 111 are made in bars and No. [illegible] in round ingots. Reproduction of these three forms are shown above.

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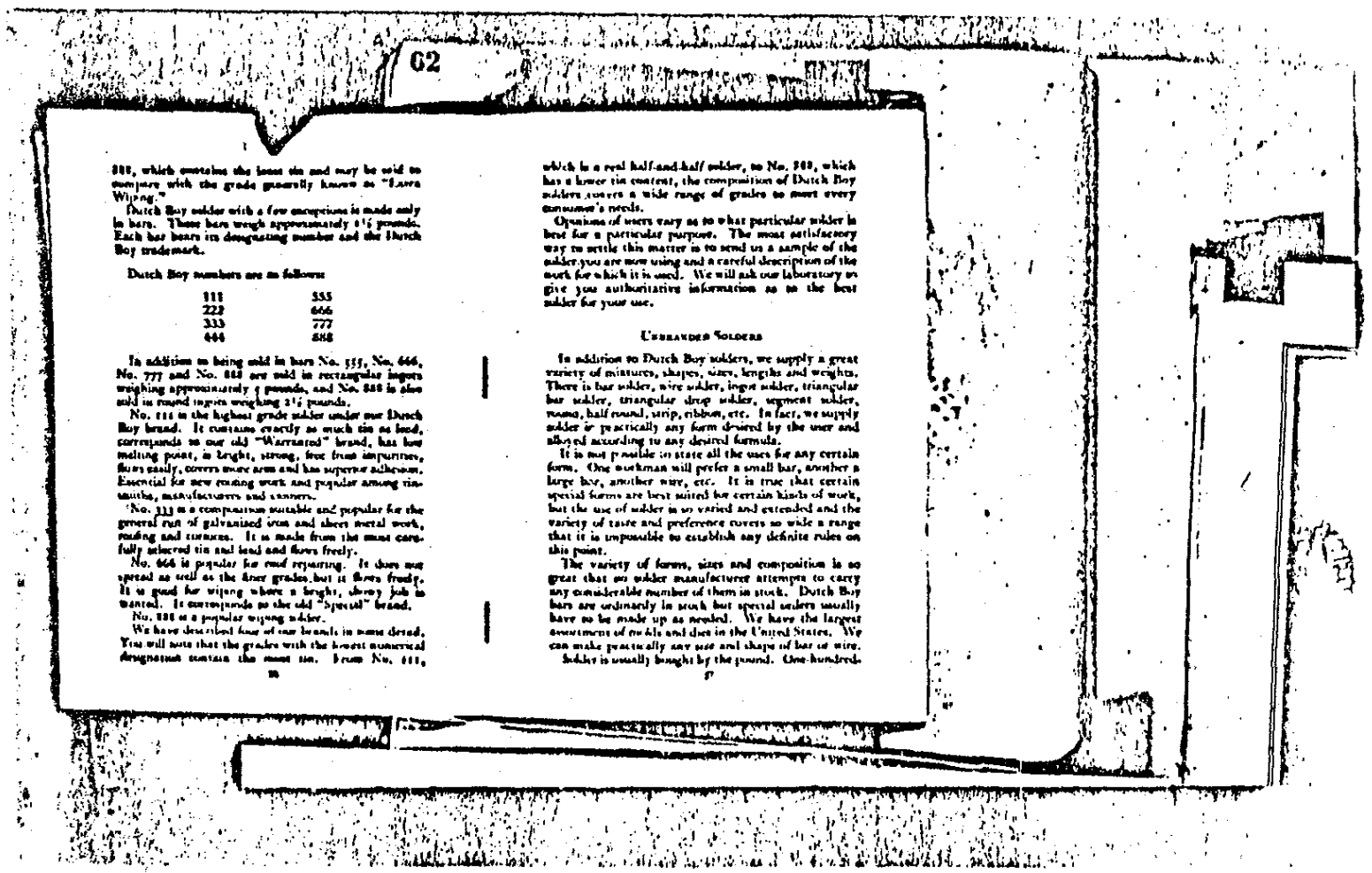

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888, which contains the least tin and may be sold in comparison with the grade generally known as "Extra Wiping."

Dutch Boy solder with a few exceptions is made only in bars. These bars weigh approximately 25 pounds. Each bar bears its designating number and the Dutch Boy trademark.

Dutch Boy numbers are as follows:

111	555
222	666
333	777
444	888

In addition to being sold in bars No. 555, No. 666, No. 777 and No. 888 are sold in rectangular ingots weighing approximately 5 pounds, and No. 888 is also sold in round ingots weighing 2½ pounds.

No. 111 is the highest grade solder under our Dutch Boy brand. It contains exactly as much tin as lead, corresponds to our old "Warranted" brand, has low melting point, is bright, strong, free from impurities, flows easily, covers more area and has superior adhesion. Essential for new roofing work and popular among tinsmiths, manufacturers and canners.

No. 333 is a composition suitable and popular for the general run of galvanized iron and sheet metal work, roofing and furnaces. It is made from the most carefully selected tin and lead and flows freely.

No. 666 is popular for roof repairing. It does not spread as well as the finer grades, but it flows freely. It is good for wiping where a bright, showy job is wanted. It corresponds to the old "Special" brand.

No. 888 is a popular wiping solder.

We have described four of our brands in name detail. You will note that the grades with the lowest numerical designation contain the most tin. From No. 111,

which is a real half-and-half solder, to No. 888, which has a lower tin content, the composition of Dutch Boy solders covers a wide range of grades to meet every consumer's needs.

Opinions of users vary as to what particular solder is best for a particular purpose. The most satisfactory way to settle this matter is to send us a sample of the solder you are now using and a careful description of the work for which it is used. We will ask our laboratory to give you authoritative information as to the best solder for your use.

Unbranded Solders

In addition to Dutch Boy solders, we supply a great variety of mixtures, shapes, sizes, lengths and weights. There is bar solder, wire solder, ingot solder, triangular bar solder, triangular drop solder, segment solder, roana, half round, strip, ribbon, etc. In fact, we supply solder in practically any form desired by the user and alloyed according to any desired formula.

It is not possible to state all the uses for any certain form. One workman will prefer a small bar, another a large bar, another wire, etc. It is true that certain special forms are best suited for certain kinds of work, but the use of solder is so varied and extended and the variety of taste and preference covers so wide a range that it is impossible to establish any definite rules on this point.

The variety of forms, sizes and composition is so great that no solder manufacturer attempts to carry any considerable number of them in stock. Dutch Boy bars are ordinarily in stock but special orders usually have to be made up as needed. We have the largest assortment of molds and dies in the United States. We can make practically any size and shape of bar or wire.

Solder is usually bought by the pound. One-hundred-

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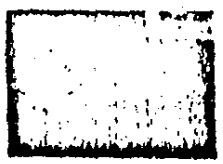
Solder being cast into bars for convenient use

pound and 250-pound boxes or 100-pound reels or 50-pound spools are the usual units, altho other multiples of fifty pounds are not uncommon.

Following is a brief description of the forms of solder in common use:

Tinners' Bar. This is a bar 12 to 14 inches long, ½ to ¾ inch wide and ½ inch thick and is cast in an open mold. Because the weight and shape of this bar make it convenient to carry to the job or to lay flat on the workman's bench, it is popular with tinners. As the hot iron or tool is applied to the bar, just enough solder is melted and retained on the iron to feed to the seam.

Triangular Bar. The triangular bar is usually about 14 inches long, ¼ inch, ⅝ inch and ⅞ inch on each side. It is cast in a closed mold or pressed thru a die and cut to the required length. It was once much used in tipping or closing the vent holes in the tops of tin can caps, and still is to an extent, but it has been largely replaced by wire solder.



Tinners' bars being removed from mold

Mixer Bar. This bar is rectangular in shape, usually about 14 inches long, ½ to ¾ inch wide and ¼ to ⅜ inch thick. It is cast in an open mold or pressed thru a die and cut to length. It is widely used in the manufacture of gas meters. Its size and rectangular shape are such as to permit the melting of just enough solder to close the seam without waste. The soldering tool used with this bar is shaped like a hatchet with a sharp soldering edge and is known as a hatchet copper.

Ingot Solder. Solder ingots are rectangular in shape, approximately 5 inches by 2 inches by 1½ inches and usually weigh from three to five pounds. This is a convenient shape for remelting in the plumber's wiping-metal pot. They are of such size that, if the metal in the pot needs to be increased, one ingot may be added and melted without chilling the entire contents of the pot below a satisfactory working temperature. Solder ingots are shipped in boxes.

Wire Solder. Wire solder is pressed or extruded as explained on page 25. Perhaps the biggest use for solder wire is in connection with automatic can-making machinery, which is capable of very high speed in the making and soldering of cans. Wire solder is also used for tipping or closing the vent holes in the tops of tin cans. These holes, which are perhaps ⅛ inch in diameter, are left open during the cooking or processing so that vapors and steam may escape. After the cans have cooled, they pass on endless belts before a workman who applies a pointed iron to the vent holes, bringing the solder wire to the point of contact and thus melting just enough solder to close the vent. Wire solder is used in many other different ways and can be supplied in a wide variety of sizes varying from 1/16 to 11/64 inch. About fourteen sizes, ranging from 1/16 to 1/8 inch, are most in demand, the 1/16 inch and 1/64 inch sizes being the most popular of all. The table on the next page shows the various standard sizes that can be supplied. Wire solder is shipped in reels of 100 pounds, spools of 50 pounds and coils of 25 pounds.

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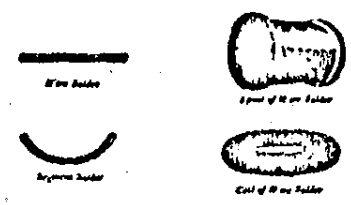
SOLDER WIRE GAUGES

(In Parts of an Inch)

Number of Wire Gauge	Brown & Sharpe F-Full	Brown & Sharpe S-Scant	Birmingham or Stubs F-Full	Birmingham or Stubs S-Scant
22	.02534 or	1 40 F	.028 or	1 32 S
21	.02846 "	1 32 S	.032 "	1 32 -
20	.03196 "	1 32 -	.035 "	1 32 F
19	.03589 "	1 32 F	.042 "	3 64 S
18	.0403 "	3 64 S	.049 "	3 64 F
17	.04525 "	3 64 S	.058 "	1 16 S
16	.05082 "	3 64 F	.065 "	1 16 F
15	.05706 "	1 16 S	.072 "	5 64 S
14	.06408 "	1 16 F	.083 "	5 64 F
13	.07196 "	5 64 S	.095 "	3 32 F
12	.08081 "	5 64 F	.109 "	7 64 -
11	.09074 "	3 32 S	.12 "	1 8 S
10	.10189 "	7 64 S	.134 "	9 64 S
9	.11443 "	7 64 F	.148 "	5 32 S
8	.12849 "	1 8 F	.165 "	11 64 S
7	.14418 "	9 64 F	.18 "	3 16 S
6	.16202 "	5 32 F	.203 "	13 64 -
5	.18194 "	3 16 S	.22 "	7 32 F
4	.20431 "	13 64 F	.238 "	15 64 F
3	.22942 "	7 32 S	.259 "	17 64 S
2	.25763 "	1 4 F	.284 "	9 32 F
1	.2893 "	9 32 S	.3 "	19 64 F
0	.32495 "	21 64 F	.340 "	11 32 S
00	.3648 "	23 64 S	.380 "	3 8 F
000	.40964 "	27 64 S	.425 "	27 64 F
0000	.46 "	29 64 S	.454 "	29 64 S

Acid Core Wire Solder. This is a combination of solder and a chemical flux. It is nothing but a tube or hollow solder wire, the hollow interior of which is filled with a chemical flux. The flux is put in while the wire is being extruded. When this product is used, the two operations of fluxing and soldering are performed at the same time. Acid Core Wire Solder is excellent for general work, or wherever wire is considered the best form in which to use solder. It can be supplied in three sizes—1/8 inch, 5/64 inch and 1/16 inch in diameter. It is shipped in coils and on 1, 5, 10, 15, 25 and 50 pound spools.

Rosin Core Wire Solder. This solder differs from Acid Core Wire Solder only in that its flux is rosin instead of a chemical, as in the latter case. Rosin Core Wire Solder is considered superior to Acid Core Wire Solder for radio and fine electric work, because the rosin flux it contains will not spread and run as will the acid flux. Radio and similar electric work is thus spared the



Wire solder is pressed or extruded as explained on page 15. Solder segments are formed by winding wire around a cylinder and cutting the wire into curved pieces in that generally these pieces form a circle. Wire solder, with the exception of Acid Core and Rosin Core Wire Solder, is shipped in one pound coils, 50 pound spools and 25 pound coils. The coil resembles the spool shown above.

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damage that results from a sputtering of flux. Resin Core Wire Solder is also supplied in these sizes—$\frac{1}{16}$ inch, $\frac{1}{8}$ inch and $\frac{1}{16}$ inch in diameter. It is shipped in coils and on 1, 5, 10, 15, 25 and 50 pound spools.

Segment Solder. Solder segments are formed by winding wire around a cylinder and cutting the wire into curved pieces so that generally three pieces form a circle. These segments were at one time used in great quantities in the sealing of the caps of tin cans. The segments were placed around the edge of the can cap and an iron run around, either by hand or by machinery. Nowadays segments are used comparatively little for this purpose, solder-hemmed caps or the capping bar having taken their place. Where machinery is used with the segments the copper is shaped like the opening and is called a capping copper. The workman turns this copper the entire circumference of the cap opening and the molten solder follows it along and sweats into the joint. The present market for segments is more in miscellaneous manufacture where it is difficult to use a bar and hand tool.

Solder Drops. Drops are formed by cutting triangular bars into small slices. The range in size is from large drops several inches long to very small particles weighing but one seven-thousandth of a pound. They are used in a great variety of work and are economical and efficient, as each drop is planned to be just large enough to do one unit of work. Each cutter is cut to the specifications of the buyer who specifies the desired number of drops to the ounce. Shipped in boxes.

Capping Bar. This is a small bar about $\frac{3}{8}$ inch by $\frac{3}{8}$ inch by 12 or 14 inches and weighs about $\frac{1}{2}$ pound. It is used by canners in soldering on caps when segments are not used.

Solder Slabs. Slabs are made in various sizes, the most popular being that used by the sealing manufacturer for his solder bowls. This size is 36 inches long by 3 inches wide by 1 inch thick. Many slabs are made with a small hole in one end for a hook. Such slabs are suspended above the bath and are fed mechanically into the bath at a certain rate of speed. Thus the temperature of the bath may be maintained uniform at all times. Slabs vary in weight from fifteen to thirty-five pounds. In addition to the size mentioned above, slabs measuring 24 inches by 3 inches by $\frac{3}{4}$ inch and 18 inches by 3 inches by $\frac{3}{4}$ inch are popular.

Pulverized Solder. Many articles to be soldered are so small and delicate that they have to be soldered with pulverized solder by means of a blow pipe. Pulverized solder is manufactured by spraying or blowing molten solder against a plate of iron or steel. The fine particles resulting are known as pulverized solder, or sometimes as solder dust. In soldering with this material a small quantity of the dust is sprinkled on the surface, after the application of the flux, and is then melted with a blow torch or blow pipe, thus sweating the solder on to the joint.

Tape or Ribbon Solder. In some classes of work it is found desirable to heat the parts to be soldered with a blow torch and then to apply the solder to the heated parts. Wires in electric motors and generators are soldered in this manner and are spoken of as being "bonded." For such uses solder is supplied in tape or ribbon form. It is manufactured by the pressing or extruding operation in the same way as wire solder. It can be drawn into thin ribbons of almost any width or thickness specified by buyer. It is shipped on spools and reels.

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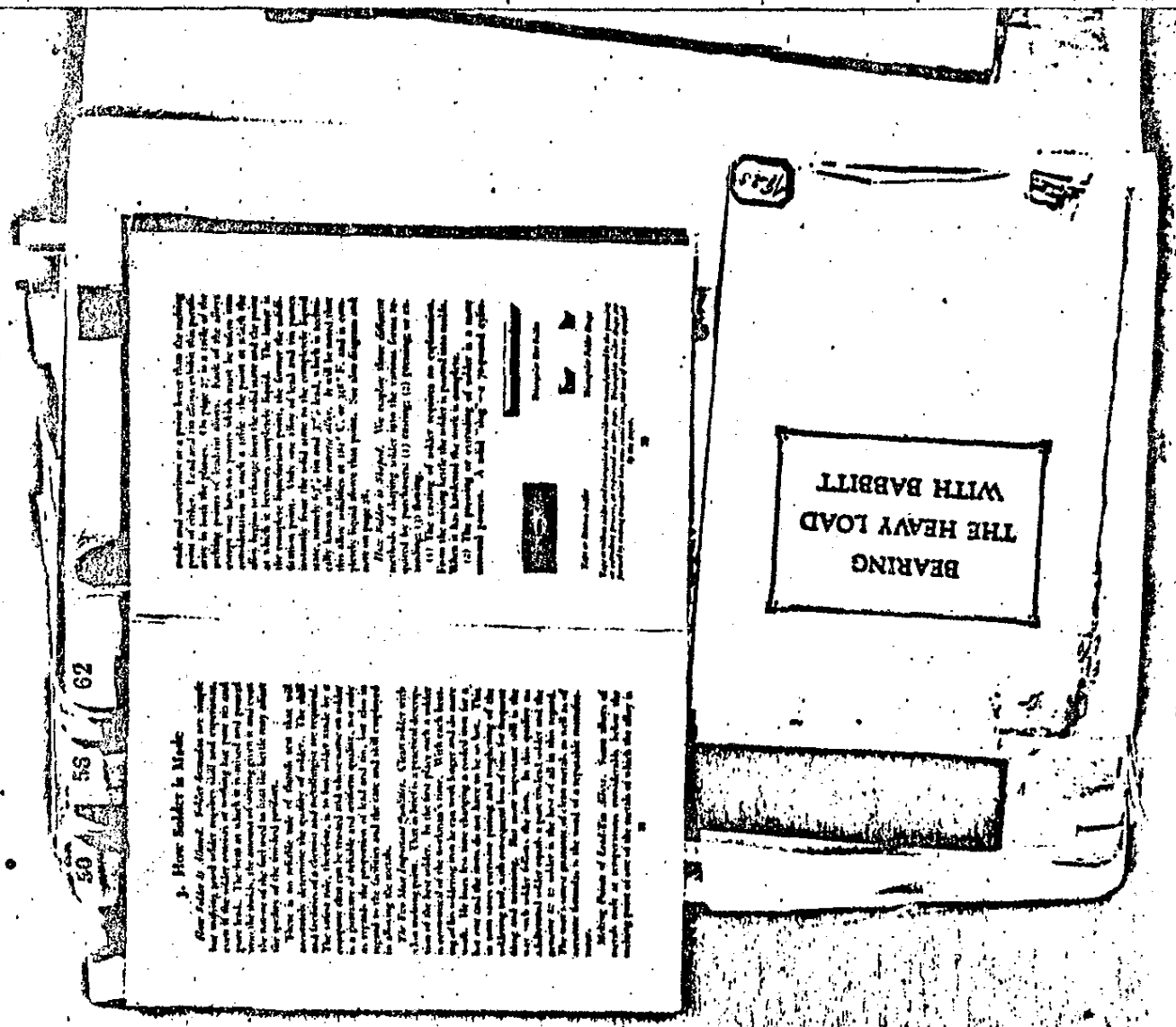

BEARING
THE HEAVY LOAD
WITH BABBITT

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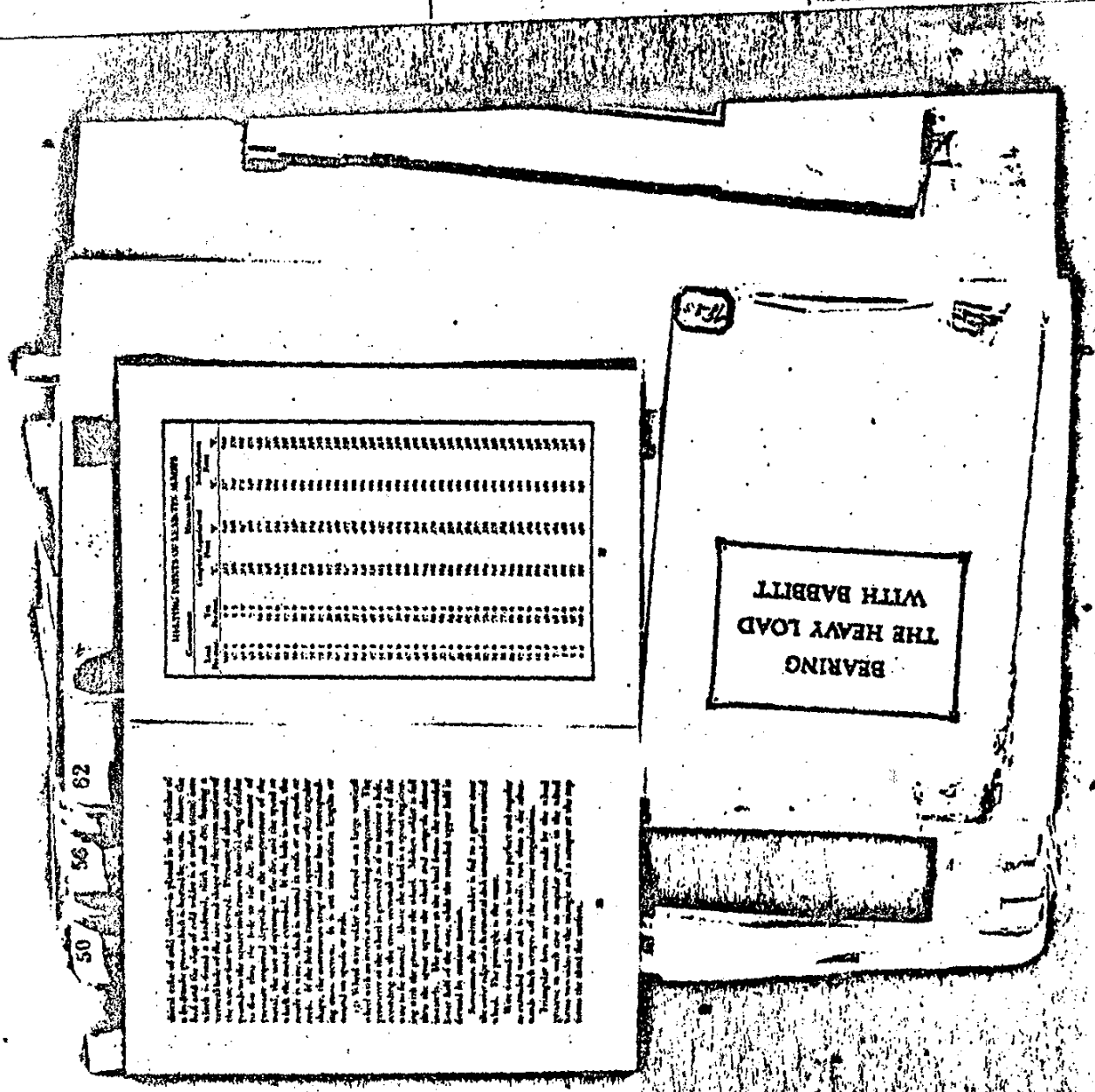
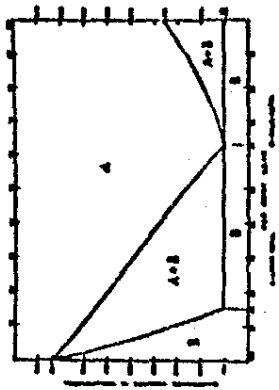


MELTING POINT DIAGRAM



NOTE—

4. Solder Defects and Failures

Excess of Antimony—A small amount of antimony is mixed in some solders to give brightness. Frequently so much antimony is used that the solder becomes hard and brittle and loses much of its strength.

Zinc—When zinc is present in solder, it can be detected by the sluggishness of the molten metal, by irregular waves and lumps on the surface and by a dull, yellowish white color. The slightest percentage of zinc will make the solder worthless and cause the soldering tool to blacken.

Copper—Copper to the extent of one-twelfth of one per cent will not injure solder but more than that will make it absolutely worthless. Copper in solder makes the molten metal unusually sluggish.

Iron—The effect of iron in solder is the same as that of copper. Iron will also cause dark streaks and smears.

Sulphur—Sulphur can be detected by its odor and by the dull surface it produces.

Other Foreign Substances—Bismuth, mercury and cadmium mean decreased strength but these metals lower the melting point of the solder. Mercury destroys the cohesion of solder and makes working difficult. Arsenic makes solder brittle. Phosphorus makes solder too liquid.

Avoiding Defects—Solder defects like those mentioned are by no means uncommon. The solder is, of course, not always defective by intention, for, as stated before, the greatest skill and special equipment are required for solder making. There is a great deal more to the process than mere mixing. The metals themselves must be refined and refined until they are free from impurities, either in the way of foreign metals or of dirt. Throughout the manufacture of solder, the same care and thoroughness must be exercised.

Solder made by the user from scraps is seldom satis-

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